ROY'S POWERED PARACHUTE BOOK

BY ROY BEISSWENGER

2nd EDITION

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The information in this book is true and complete to the best of my knowledge. However, powered parachuting is a young sport with new and improved techniques being developed regularly. Moreover, this text is meant to only augment the instruction received from professional ground and flight instructors, as well as information published by the manufacturer(s) of the particular equipment used for flight. Flight is like any other motorsport and there are risks in the daily decisions we make when we fly. Therefore the advice and recommendations are made with no guarantee and the author disclaims any liability incurred in connection with the information presented in this book.

ROY'S POWERED PARACHUTE BOOK

BY ROY BEISSWENGER

2nd EDITION

In memory of my parents, Willi and Gayla Beisswenger.

They weren't pilots themselves, but they always encouraged me to pursue my dreams. My mother would be particularly proud that I actually completed this book. She always encouraged me to write.

Introduction

First of all, thank *you* for purchasing and reading this book. And particular thanks for reading this introduction! After all, this is my big opportunity to let you know how many awesome and helpful people I have in my life!

The focus of this book is not on teaching any particular test. The focus is to provide you with a wealth of information that before now seemed to be scattered all over the place. For example, the FAA's own Practical Test Standards (PTS) for powered parachutes lists over 30 publications they say would be helpful while preparing for your powered parachute check ride. They have a similar list of resources to help you prepare for your knowledge test. That's just too many things to try to study or even keep track of. This book may be big, but if you stacked up all of those resources, you would have a pile of books over a foot tall to study. And unfortunately (or fortunately) a lot of the content in most of those references doesn't apply to powered parachutes.

Moreover, I feel that there are significant gaps of information regarding powered parachutes. I have tried to fill in those gaps and hopefully explain some of the unique aerodynamics that keep our particular style of aircraft flying.

One of the very nice things about putting everything in one resource is that it makes it possible to cross-index information. Appendix A is an abridged version of the PTS. Not only did I edit out those things that don't apply to you, I added in references by chapter to the test topics you're responsible for during your check ride. That makes this a great study guide. Just as valuable is that the FAA allows you to take publications with you to your check ride. *Take me! Take me!* The book in your hands can get you to the answers you need should you run into a rough patch during your practical test.

While you obviously can't learn to fly solely from reading a book, this will give you the essential knowledge you need to get you started and make the learning experience that much easier –and as a result, a lot more fun!

This is a second edition of this book. It's dramatically different from the first edition. The writing is clearer and more concise. More topics are included. For example, weather is very important to powered parachute pilots and I've doubled the number of chapters dedicated to it. There's also more images, more color, a larger glossary, a larger index, and better organized tables of information.

Most of the photographs in this book I shot. The notable exception is the parachute deployment and stowing chapter. That photo shoot involved an aircraft, a model, lighting, ladders and someone who knew how to do that kind of work. Pilot Bob Heimberger gets credit for all of that. (OK, except for the model. Kim Poleski encouraged her daughter to do that!)

The FAA's Delegation and Resource Branch (AFG-970) in Oklahoma City provided me with a grounding in FAA regulations and procedures when I attended their first Sport Pilot Designated Examiner course back in 2005 when the organization was known as the Light Sport Pilot Aviation Branch (AFS-610). One of the big takeaways for me from that course was to always look up the regulations, rather than guessing or asking someone else what their guess is.

That's one of the reasons I included the text of actual FAA rules in the places in the book where they're appropriate. You'll find regulation sidebars scattered throughout the book, not just in the Regulations Chapter.

The FAA also has a lot of great resources that I leaned upon to write and illustrate this book. It took me years to write the content and draw the illustrations for the first edition. It took years more for me to produce this new edition. It would have taken longer if the FAA didn't provide lots of wonderful, public domain handbooks and other resources. If you want to find lots of great, *free* information about aviation, it's difficult to beat the FAA's website, www.faa.gov.

I wasn't trained formally in either writing or the graphic arts. Typography, illustration, page layout, and color correction are skills I've had to pick up as I go. They were worth learning, though. If I had to hire out the editing, typography and graphic work for this book, I shudder at how much it would have cost. I'm still shuddering years after the first edition and into the second.

I also need to acknowledge the help provided to me by Jim Byers who passed away in 2022. You can put wonderful work together on the computer screen, but if it costs too much to print, it won't see the light of day. Jim helped in tremendous ways. What I know about printing, I was taught by Jim.

Finally, I want to thank both the student pilots and the fellow instructors I've worked with over the years. The feedback, the knowledge, and the joy of working with similar spirits is what motivated me to write this book. I truly want there to be a better way and I hope this is part of that.

As you read and study this book, I would appreciate your feedback. Kind words are always welcome, but constructive criticism is how I can make future editions even better for the students and pilots who follow in your footsteps. You can reach me at roy@easyflight.com. I'm not always the promptest at answering email, but I try. More important, I promise that I'll read what you send me.

Thanks again for reading. If you're just beginning your journey to get your pilot certificate, good luck! I sincerely hope that I'm helpful to you in achieving your aviation goals.

Roy Beisswenger
October, 2024

Contents

Chapter 1 Learning to Fly Powered Parachutes

If you're reading this book, odds are that you're interested in becoming a powered parachute pilot. Welcome to a very elite corps of people!

Powered parachuting is more popular in the United States than nearly anywhere else in the world. But even in the U.S., where many people dream of taking flight, relatively few do. The numbers tell the story.

Of the 330 million people in the U.S., only about 600,000, or about one in 550, fly anything at all, even as a student. But as a powered parachute pilot, you will be in an even more elite group. There are only about 2,000 powered parachute pilots in the country, so only one in 330,000 is licensed to fly a powered parachute.

There are several reasons for that small number, including a general lack of awareness of the sport as well as a small number of active instructors available to provide the indispensable flight instruction.

As you read this chapter, don't get frustrated if you don't understand everything here. Some of the stuff is both introductory and advanced at the same time. Much of this will make more sense if you scan it now and review it again after you've finished reading the book the first time.

What it Takes to be a Certificated Pilot

The FAA requires three things to be a certificated pilot: knowledge, experience, and a certain level of proficiency in flying your aircraft of choice. You must pass a computerized knowledge test to show that you have the knowledge. Experience is shown by logging a minimum level of dual flight instruction from an FAA certified flight instructor (CFI) and flying solo for a minimum number of hours and operations. Finally, an FAA designated pilot examiner (DPE) will further test your knowledge through oral questioning and will test your flying proficiency through a flight test.

Learning to fly a powered parachute has often been likened to learning to drive a car but this analogy is misleading. First, nearly everyone has been a passenger in a car. That makes driving a familiar process, even if you haven't yet been behind the wheel. Most haven't been a passenger in a powered parachute and instead of the

§ 61.307 What tests do I have to take to obtain a sport pilot certificate?

To obtain a sport pilot certificate, you must pass the following tests:

(a) Knowledge test. You must pass a knowledge test on the applicable aeronautical knowledge areas listed in § 61.309. Before you may take the knowledge test for a sport pilot certificate, you must receive a logbook endorsement from the authorized instructor who trained you or reviewed and evaluated your home-study course on the aeronautical knowledge areas listed in § 61.309 certifying you are prepared for the test.

(b) Practical test. You must pass a practical test on the applicable areas of operation listed in §§ 61.309 and 61.311. Before you may take the practical test for a sport pilot certificate, you must receive a logbook endorsement from the authorized instructor who provided you with flight training on the areas of operation specified in §§ 61.309 and 61.311 in preparation for the practical test. This endorsement certifies that you meet the applicable aeronautical knowledge and experience requirements and are prepared for the practical test.


Flight Instructor Marty Poleski (in the back seat) flies with Rudy Gonzalez

two-dimensional environment a car operates in, a powered parachute operates in a three-dimensional environment that is both unusual and requires a higher degree of motor skills. But, even though more difficult than driving a car, a powered parachute is about the easiest aircraft to fly.

The purpose of flight training is to develop skills and safe habits that are transferable to any powered parachute and even to other categories of aircraft. You should also realize that the goal of flight training is to become a safe and competent pilot, and that passing required practical tests for pilot certification is only incidental to this goal.

Sport Pilot and Private Pilot Regulations

If you want to fly a two-seat powered parachute, then you will need to get a pilot certificate to fly. You have two choices for certificates. You can fly either as a Sport Pilot or as a Private Pilot. The biggest difference between the two ratings is probably the allowances for night flying. A Private Pilot can do it and a Sport Pilot can't. There are other differences that are explained in the table at the end of this chapter, along with information on ultralights.

However, the primary purpose of this chapter is to explain the process to become a Sport Pilot with a powered parachute endorsement since that's what most people are pursuing. If you're interested in pursuing night flying and a Private Pilot certificate for powered parachutes, you can learn more in *Chapter 28, "Night Operations."*

The FAA is the federal agency responsible for promoting aviation safety through regulation and education.

Role of the Flight Instructor

The FAA places full responsibility for student training on authorized flight instructors. Your flight instructor is responsible for training you in all areas necessary to operate safely and competently. The training includes more than just airmanship skills. Your instructor is also responsible for teaching you good operating practices and providing you with the tools to make good decisions about flying. A good flight instructor not only teaches you how to fly, a competent instructor will help guide you through the rest of the requirements you'll see in this chapter and be a vital partner for you obtaining your pilot certificate.

An FAA Certificated Flight Instructor (CFI) must meet broad experience requirements, pass rigid knowledge and practical tests, and demonstrate the ability to apply recommended teaching techniques. In addition, the flight instructor's certificate must be renewed every 24 months by meeting stringent FAA standards.

A good flight instructor has a thorough understanding of the learning process, knowledge of the fundamentals of teaching, and the ability to communicate effectively with the student pilot.

You should be prepared to commit considerable time, effort, and expense in pursuit of a pilot certificate. And you may be tempted to judge the effectiveness of your flight instructor solely in terms of you being able to pass the requisite FAA practical test to earn that certificate. But the evaluation through practical tests is a mere sampling of pilot ability that is compressed into a short period of time. This is analogous to a 16-year old who has just passed a driving test. The flight instructor's role is much larger than just test prep. An instructor is responsible for training the 'total' pilot.

Be aware that while all CFIs are required to meet minimum standards, that does not mean that they perform identically in real life. If things aren't working with your instructor, don't give up learning to fly. Sometimes you just need a change in flight instructors. It could be that your learning style doesn't align with your CFI's teaching style. It doesn't mean that one of you is right and the other is wrong; it may simply mean that you would progress better with a different instructor. Don't give up your dream of flight based on a poor experience with one instructor.

The Path to Becoming a Powered Parachute Sport Pilot

Becoming a Sport Pilot includes a few steps. You need to work with an instructor to complete most or all of those steps. A big part is dual flight training. That will progress to solo flight and test preparation.

The FAA requires three things to become a pilot. Those three things are knowledge, experience, and proficiency. A good CFI can help guide you through the entire process the most efficient way.

Becoming a Student Pilot

Student Pilot is a real status within the FAA that comes with its own pilot certificate. You don't need to have a Student Pilot Certificate to begin ground or flight training, but you will need one to fly solo. The FAA doesn't charge any fees for applying for a Student Pilot Certificate, but usually the certificate can be obtained faster and more conveniently by hiring a flight instructor to help you through the process. Either way, you're going to have to meet in person with someone from the FAA or with someone that the FAA has authorized to assist you with the application process. That person doesn't have to know anything about powered parachutes because a Student Pilot Certificate is a generic certificate and the person's primary function is to check your identification for the FAA and finish the application process.

The application is made online through the FAA's Integrated Airman Certification and Rating Application (IACRA) system. You can learn more about that system, sign up for an account, and begin the process of applying for a Student Pilot Certificate at **iacra.faa.gov**.

A Student Pilot Certificate doesn't do anything for you unless it is accompanied by a written endorsement from a CFI authorizing you to fly solo. That written endorsement is valid for a maximum of 90 days. The point of the Student Pilot Certificate and a solo endorsement is to give you an opportunity to build the experience required for your rating and to practice for your practical test.

> **§ 61.83 Eligibility requirements for student pilots.**
> To be eligible for a student pilot certificate, an applicant must:
> (a) Be at least 16 years of age for other than the operation of a glider or balloon.
> (b) Be at least 14 years of age for the operation of a glider or balloon.
> (c) Be able to read, speak, write, and understand the English language. If the applicant is unable to meet one of these requirements due to medical reasons, then the Administrator may place such operating limitations on that applicant's pilot certificate as are necessary for the safe operation of the aircraft.

Basic Requirements

To be eligible for a Student Pilot Certificate, you must:

- Be at least 17 years old (or 16 years old if you are applying to operate a glider or balloon).
- Be able to read, speak, write, and understand the English language.

If you can't meet one of the English requirements due to medical reasons, then the Administrator may place operating limitations on your pilot certificate as are necessary for the safe operation of the aircraft. For example, there are dyslexic pilots who have difficulty reading and deaf pilots who have difficulty speaking. Don't let a disability discourage you from becoming a pilot.

Aviation Knowledge

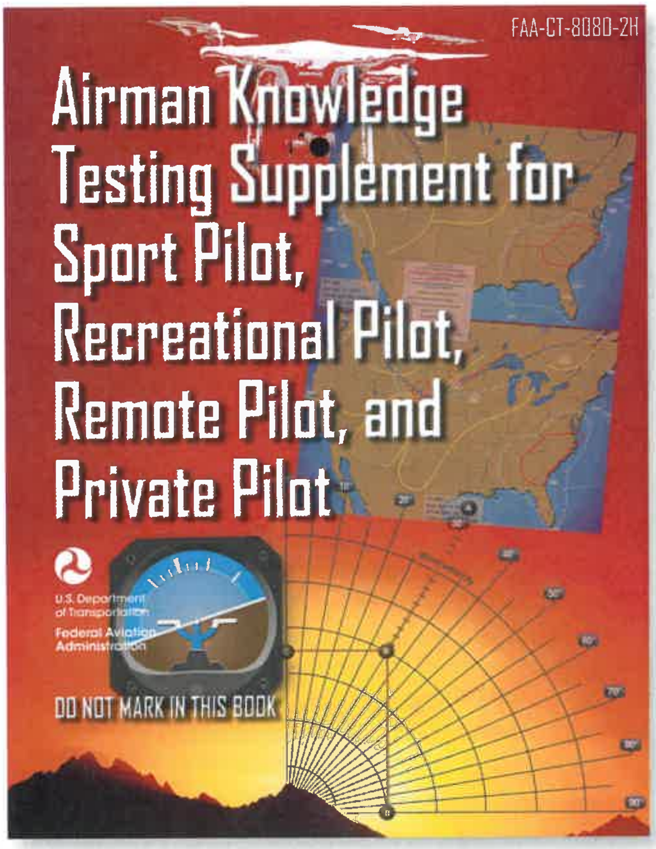
Aviation knowledge is what this book provides. This book was written to include the information that is normally tested in the Sport Pilot–Powered Parachute Knowledge Test, as well as the Practical Test; however, it won't provide the knowledge an instructor can impart on a one-on-one basis. The knowledge areas tested are listed in §61.309 of the Federal Aviation Regulations and include:

- Regulations that relate to sport pilot privileges, limits, and flight operations.
- Accident reporting requirements of the National Transportation Safety Board.
- Use of the applicable portions of the aeronautical information manual and FAA advisory circulars.
- Use of aeronautical charts for VFR navigation using pilotage, dead reckoning, and navigation systems.
- Recognition of critical weather situations from the ground and in flight, wind shear avoidance, and the procurement and use of aeronautical weather reports and forecasts.
- Safe and efficient operation of aircraft, including collision avoidance, and recognition and avoidance of wake turbulence.
- Effects of density altitude on takeoff and climb performance.
- Weight and balance computations.
- Principles of aerodynamics, powerplants, and aircraft systems.
- Aeronautical Decision Making and risk management.
- Preflight actions that include -
  - How to get information on runway lengths at airports of intended use,

data on takeoff and landing distances, weather reports and forecasts, and fuel requirements; and

- How to plan for alternatives if the planned flight cannot be completed or if you encounter delays.

§ 61.309 What aeronautical knowledge must I have to apply for a sport pilot certificate?
To apply for a sport pilot certificate you must receive and log ground training from an authorized instructor or complete a home-study course on the following aeronautical knowledge areas:
(a) Applicable regulations of this chapter that relate to sport pilot privileges, limits, and flight operations.
(b) Accident reporting requirements of the National Transportation Safety Board.
(c) Use of the applicable portions of the aeronautical information manual and FAA advisory circulars.
(d) Use of aeronautical charts for VFR navigation using pilotage, dead reckoning, and navigation systems, as appropriate.
(e) Recognition of critical weather situations from the ground and in flight, windshear avoidance, and the procurement and use of aeronautical weather reports and forecasts.
(f) Safe and efficient operation of aircraft, including collision avoidance, and recognition and avoidance of wake turbulence.
(g) Effects of density altitude on takeoff and climb performance.
(h) Weight and balance computations.
(i) Principles of aerodynamics, powerplants, and aircraft systems.
(j) Stall awareness, spin entry, spins, and spin recovery techniques, as applicable.
(k) Aeronautical decision making and risk management.
(l) Preflight actions that include—
 (1) How to get information on runway lengths at airports of intended use, data on takeoff and landing distances, weather reports and forecasts, and fuel requirements; and
 (2) How to plan for alternatives if the planned flight cannot be completed or if you encounter delays. and are prepared for the practical test.



The Airman Knowledge Testing Supplement contains the images and tables that the FAA will reference during the computerized knowledge test. This is a document that you can purchase and review ahead of the test.

You take the test at an FAA-approved testing center. The test is administered by computer. Questions are multiple choice with three options. Two of the questions are 'distractors' and one is the 'best' answer. The test you take will only have 40 questions in it, but those 40 questions are drawn from a pool of hundreds of possible questions. Those 40 questions will cover the eleven areas listed above, so it's important to go into the test with a broad base of knowledge.

Aviation Experience

Flying experience is provided and logged by a powered parachute CFI. This is where you receive your hands-on experience with a powered parachute. The FAA requires different amounts of experience depending on whether you're already a pilot and what kind of rating you want to work toward. The FAA requirements are minimums. It's not unusual for a student to need more than the minimums to become truly proficient. Changes in flight instructors, time between lessons, your aptitude and other factors can possibly increase the number of hours and operations a you'll need to prepare for the practical test or proficiency test.

Experience Needed for a Sport Pilot Rating if You Don't Have a Certificate Yet

If you don't yet have any kind of FAA rating and you want to be a powered parachute sport pilot, you will need a minimum of 12 hours of flight time in a powered parachute. This training must include:

- 10 hours dual flight training, including:
  - 1 hour of cross-country flight training
  - 3 hours of flight training on those areas of operation specified in §61.311 preparing for the practical test within 60 days before the date of the test.
- 2 hours solo flight training, including:
  - 10 of the 20 required takeoffs and landings to a full stop listed above.
  - One solo flight with a landing at a different airport and one segment of the flight consisting of a straight-line distance of at least 10 nautical miles between takeoff and landing locations

The areas of operation specified in §61.311 cover the full range of things you need to be a powered parachute pilot. They include:

- Preflight preparation.
- Preflight procedures.
- Airport operations.
- Takeoffs, landings, and go-arounds.
- Performance maneuvers.
- Ground reference maneuvers.
- Navigation.
- Emergency operations.
- Post-flight procedures.

§ 61.311 What flight proficiency requirements must I meet to apply for a sport pilot certificate?

To apply for a sport pilot certificate you must receive and log ground and flight training from an authorized instructor on the following areas of operation, as appropriate, for airplane single-engine land or sea, glider, gyroplane, airship, balloon, powered parachute land or sea, and weight-shift-control aircraft land or sea privileges:

(a) Preflight preparation.
(b) Preflight procedures.
(c) Airport, seaplane base, and gliderport operations, as applicable.
(d) Takeoffs (or launches), landings, and go-arounds.
(e) Performance maneuvers, and for gliders, performance speeds.
(f) Ground reference maneuvers (not applicable to gliders and balloons).
(g) Soaring techniques (applicable only to gliders).
(h) Navigation.
(i) Slow flight (not applicable to lighter-than-air aircraft and powered parachutes).
(j) Stalls (not applicable to lighter-than-air aircraft, gyroplanes, and powered parachutes).
(k) Emergency operations.
(l)Post-flight procedures.

§ 61.313 What aeronautical experience must I have to apply for a sport pilot certificate?

If you are applying for a sport pilot certificate with...

...

(g) Powered parachute category land or sea class privileges,

Then you must log at least . . .

(1) 12 hours of flight time in a powered parachute, including 10 hours of flight training from an authorized instructor in a powered parachute, and at least 2 hours of solo flight training in the areas of operation listed in § 61.311

Which must include at least . . .

(i) 1 hour of cross-country flight training,
(ii) 20 takeoffs and landings to a full stop in a powered parachute with each landing involving flight in the traffic pattern at an airport;
(iii) 10 solo takeoffs and landings to a full stop (with each landing involving a flight in the traffic pattern) at an airport,
(iv) One solo flight with a landing at a different airport and one segment of the flight consisting of a straight-line distance of at least 10 nautical miles between takeoff and landing locations, and
(v) 1 hours of flight training with an authorized instructor on those areas of operation specified in § 61.311 in preparation for the practical test within the preceding 2 calendar months from the month of the test.

§ 61.39 Prerequisites for practical tests.

(a) Except as provided in paragraphs (b), (c), and (e) of this section, to be eligible for a practical test for a certificate or rating issued under this part, an applicant must:
- (1) Pass the required knowledge test:
  - (i) Within the 24-calendar-month period preceding the month the applicant completes the practical test, if a knowledge test is required; or
  - (ii) ...
- (2) Present the knowledge test report at the time of application for the practical test, if a knowledge test is required;
- (3) Have satisfactorily accomplished the required training and obtained the aeronautical experience prescribed by this part for the certificate or rating sought, and ...
- (4) Hold at least a third-class medical certificate, if a medical certificate is required;
- (5) Meet the prescribed age requirement of this part for the issuance of the certificate or rating sought;
- (6) Have an endorsement, if required by this part, in the applicant's logbook or training record that has been signed by an authorized instructor who certifies that the applicant—
  - (i) Has received and logged training time within 2 calendar months preceding the month of application in preparation for the practical test;
  - (ii) Is prepared for the required practical test; and
  - (iii) Has demonstrated satisfactory knowledge of the subject areas in which the applicant was deficient on the airman knowledge test; and
- (7) Have a completed and signed application form.

...

(f) If all increments of the practical test for a certificate or rating are not completed on the same date, then all the remaining increments of the test must be completed within 2 calendar months after the month the applicant began the test.

(g) If all increments of the practical test for a certificate or rating are not completed within 2 calendar months after the month the applicant began the test, the applicant must retake the entire practical test.

§ 61.43 Practical tests: General procedures.

(a) Completion of the practical test for a certificate or rating consists of—
- (1) Performing the tasks specified in the areas of operation for the airman certificate or rating sought;
- (2) Demonstrating mastery of the aircraft by performing each task successfully;
- (3) Demonstrating proficiency and competency within the approved standards; and
- (4) Demonstrating sound judgment.

(b) The pilot flight crew complement required during the practical test is based on one of the following requirements that applies to the aircraft being used on the practical test:
- (1) If the aircraft's FAA-approved flight manual requires the pilot flight crew complement be a single pilot, then the applicant must demonstrate single pilot proficiency on the practical test.

...

(c) If an applicant fails any area of operation, that applicant fails the practical test.

(d) An applicant is not eligible for a certificate or rating sought until all the areas of operation are passed.

(e) The examiner or the applicant may discontinue a practical test at any time:
- (1) When the applicant fails one or more of the areas of operation; or
- (2) Due to inclement weather conditions, aircraft airworthiness, or any other safety-of-flight concern.

(f) If a practical test is discontinued, the applicant is entitled credit for those areas of operation that were passed, but only if the applicant:
- (1) Passes the remainder of the practical test within the 60-day period after the date the practical test was discontinued;
- (2) Presents to the examiner for the retest the original notice of disapproval form or the letter of discontinuance form, as appropriate;
- (3) Satisfactorily accomplishes any additional training needed and obtains the appropriate instructor endorsements, if additional training is required; and
- (4) Presents to the examiner for the retest a properly completed and signed application.

Experience Needed for a Powered Parachute Sport Pilot Privilege if You Have a Rating in Another Aircraft

If you are already an FAA rated pilot and you want to add a Sport Pilot privilege to your certificate, there are no minimum experience requirements. This is one of the features of the sport pilot regulations. The FAA doesn't mandate numbers of flight hours or operations in order to add privileges to fly new categories of aircraft onto your certificate.

Training requirements are at the discretion of the CFI providing the training. Your instructor is required to certify that he has *"trained you on the applicable aeronautical knowledge areas specified in §61.309 and areas of operation specified in §61.311"*

That means that your instructor certifies you to a standard, but that the number of hours and the number of takeoffs and landings required to achieve that standard are up to his or her discretion.

In practical terms, that normally means that a student who is already a pilot will need to receive approximately the same number of training hours as well as the same number of dual and solo takeoffs and landings as someone learning to fly a powered parachute as their first aircraft. That's because flying a powered parachute is radically different from other categories of aircraft. Again, this is not an FAA mandate, this is just how it works out in real-life flight training.

Demonstrating Proficiency, the 'Check Ride'

"Check ride" is not the official term for the last step in the pilot certificating process, but it is what people commonly call it. What it's really called depends upon whether the applicant already has a pilot certificate. A first-time pilot is required to take a practical test. If someone already has a pilot certificate and is training and testing to get the powered parachute sport pilot privilege added on, that pilot will need to take a proficiency check. The tests are similar and use the same standards. The difference is in who conducts the test and details in the process.

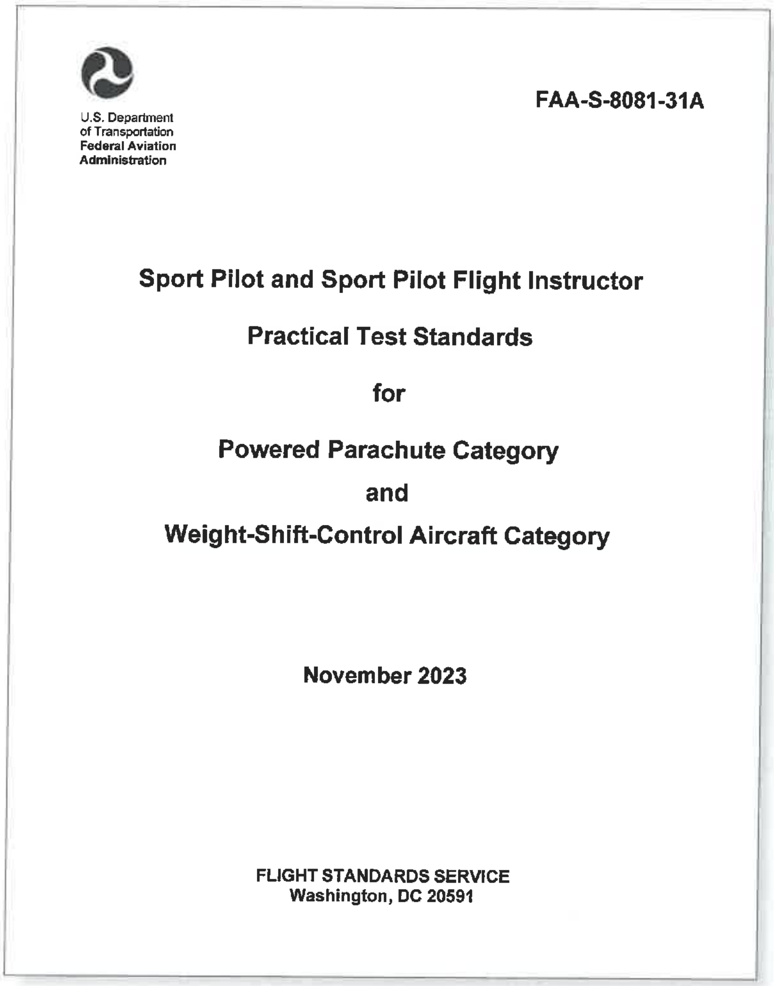
In either case, it's the last step in the process to becoming a powered parachute sport pilot. If you're ready for your check ride, that means that your CFI has reviewed your records to make sure that you've met all the prerequisites for the rating or privilege and is confident that you will pass that final test.

Practical Test

A practical test is required if your pilot certificate says, *"Student Pilot."* The practical test must be administered by a powered parachute Designated Pilot Examiner (DPE). The DPE is going to use a document lovingly called *"FAA-S-8081-31, the Sport Pilot Practical Test Standards (PTS) for Weight Shift Control, Powered Parachute, and Flight Instructor."* The examiner is of course going to use the part of the PTS that focuses on flying a powered parachute.

The powered parachute portion of FAA-S-8031 is included in this book as an appendix. You can also download the entire document from **www.faa.gov**.

When you're ready for your practical test, your CFI will assist you in finding a DPE and prepare you for your appointment with him. You will be required to provide the DPE the following:


U.S. Department of Transportation
Federal Aviation Administration

FAA-S-8081-31A

Sport Pilot and Sport Pilot Flight Instructor

Practical Test Standards

for

Powered Parachute Category

and

Weight-Shift-Control Aircraft Category

November 2023

FLIGHT STANDARDS SERVICE
Washington, DC 20591

The Practical Test Standards book for powered parachutes can be downloaded on the internet at faa.gov. It is also included as an appendix in this book. This document lists all of the areas that your examiner will ask questions about. It also describes the tasks you will have to demonstrate flying during your check ride.

- A completed application in one of the two formats below.
    - FAA Form 8710-11, Airman Certificate and/or Rating Application-Sport Pilot
    - Completed digital application on IACRA.
- An Airman Knowledge Test Report with a satisfactory grade which was taken no more that 24 months prior to the test.
- A medical certificate or driver's license
- Student Pilot Certificate
- Picture ID
- Your pilot logbook with your experience logged and appropriate CFI endorsements.

You also must provide an airworthy powered parachute. The powered parachute will probably require dual controls, but that is something to confirm with the DPE. The aircraft must also include the following paperwork:

- Registration Certificate
- Airworthiness Certificate
- Operating Limitations or Flight Manual
- Weight and Balance Data Sheet
- Maintenance Records

Before you may take the practical test for a Sport Pilot Certificate, you must receive a logbook endorsement from the authorized instructor who provided you with flight training on the areas of operation specified in §61.309 and §61.311 in preparation for the practical test. Those are the same areas mentioned earlier in this chapter. This endorsement certifies that you meet the applicable aeronautical knowledge and experience requirements and are prepared for the practical test.

The Designated Pilot Examiner

The Designated Pilot Examiner (DPE) administers FAA practical tests for Pilot and Flight Instructor Certificates. DPEs are individuals to whom the FAA delegates certain responsibilities, but are not FAA employees.

Designated to perform specific pilot certification tasks on behalf of the FAA, a DPE may charge a fee. Nearly all FAA practical tests for powered parachute ratings are administered by DPEs.

After your successful completion of the practical test, the DPE will immediately issue you a temporary pilot certificate. A permanent plastic card will follow by mail within 90 days.

Proficiency Check

If you already have a Sport Pilot or higher rating for another aircraft, you don't have to complete a practical test with a DPE. Instead, §61.321 requires you to successfully complete a proficiency check from an authorized instructor other than the instructor who trained you. That second instructor will cover the same aeronautical knowledge areas and areas of operation that a DPE would cover. Those areas are specified in §61.309 and §61.311 for powered parachutes and are listed earlier in the chapter.

The process for receiving your powered parachute sport pilot privilege is:

1. The powered parachute CFI who trained you endorses you for the proficiency test. That CFI is the 'recommending instructor.' The endorsement certifies that you have met the aeronautical knowledge and flight proficiency requirements for the additional light-sport aircraft privilege you seek.
2. You fill out your portion of FAA Form 8710-11 - Airman Certificate and/or Rating Application-Sport Pilot. The recommending instructor completes his portion of the form.
3. You or your instructor make an appointment with a different powered parachute CFI to provide the proficiency check.
4. You take and pass the knowledge and flying portions of the proficiency check from that second CFI.
5. The CFI who conducted the proficiency check will provide you with an additional logbook endorsement. This endorsement states that you successfully completed the proficiency check.
6. The CFI conducting the proficiency check completes your FAA Form 8710-11 and sends it to the FAA.
7. You won't be issued a temporary pilot certificate at the time of your proficiency check. Instead, you will receive a new plastic pilot certificate noting your additional powered parachute privilege in the mail probably within approximately 90 days. In the meantime, you can fly a powered parachute as a sport pilot using your logbook endorsement as authorization.

Tips for Passing the Tests

The two tests you will need to pass are very different and there are specific strategies for passing each one. You can study for both tests at home before you ever meet a flight instructor, although there are a lot of flying tasks on the practical test that will require that you prepare for with a certificated flight instructor.

Tips for the Knowledge Test

Preparing for the FAA knowledge test requires a combination of solid study techniques and a clear understanding of the testing format. You want to do more than just pass. Questions you don't get right will be reviewed during your check ride. Here are some strategies to help you prepare for the knowledge test:

Understand the Test Format: Become familiar with the structure of the FAA knowledge test. The test is multiple-choice with only 3 options per question and some of the questions are in the public domain.

> **§ 61.321 How do I obtain privileges to operate an additional category or class of light-sport aircraft?**
> If you hold a sport pilot certificate and seek to operate an additional category or class of light-sport aircraft, you must—
> (a) Receive a logbook endorsement from the authorized instructor who trained you on the applicable aeronautical knowledge areas specified in § 61.309 and areas of operation specified in § 61.311. The endorsement certifies you have met the aeronautical knowledge and flight proficiency requirements for the additional light-sport aircraft privilege you seek;
> (b) Successfully complete a proficiency check from an authorized instructor other than the instructor who trained you on the aeronautical knowledge areas and areas of operation specified in §§ 61.309 and 61.311 for the additional light-sport aircraft privilege you seek;
> (c) Complete an application for those privileges on a form and in a manner acceptable to the FAA and present this application to the authorized instructor who conducted the proficiency check specified in paragraph (b) of this section; and
> (d) Receive a logbook endorsement from the instructor who conducted the proficiency check specified in paragraph (b) of this section certifying you are proficient in the applicable areas of operation and aeronautical knowledge areas, and that you are authorized for the additional category and class light-sport aircraft privilege.?

Use FAA-Provided Materials: Get a copy of the *"Airman Knowledge Testing Supplement for Sport Pilot, Recreational Pilot, Remote Pilot, and Private Pilot, FAA-CT-8080-2H."* That document has the images that are referred to in the FAA knowledge test. Having the official book will allow you to become familiar with it and help you practice the questions.

Create a Study Schedule: Develop a realistic study schedule that suits your learning style. Consistency is key, so allocate dedicated time each day or week for focused study sessions.

Practice with Sample Questions: Take advantage of practice exams and sample questions. The FAA offers some sample questions, but private companies have more thorough collections of actual question used. Be careful, some private offerings include study materials for powered parachute and others don't.

Simulate Test Conditions: Practice under simulated test conditions to familiarize yourself with the testing environment. Some of the test preparation companies mimic the way the FAA test centers present the test questions.

Seek Guidance from Instructors: Consult with your flight instructor or an experienced aviation professional. They can provide valuable insights, clarify doubts, and offer guidance on specific topics.

Take Care of Yourself: Maintain a healthy balance between study and relaxation. Ensure you get enough sleep, stay hydrated, and take breaks to keep your mind sharp.

Taking the Knowledge Test

When test day comes remember to bring a few items. Those include:

- Government-Issued Photo ID
- Knowledge Test Authorization (Endorsement)
- Plotter
- Flight Calculator

You can bring a flight calculator like the ones sold by ASA and Sporty's. Only certain calculators are authorized and your smart phone isn't allowed.

You will be given two hours to take the test and that will be more than enough. Take your time since there are only 40 questions. Here are some specific strategies that will help you do well on your test.

Read the Questions Carefully: Before diving into the answer choices, take a moment to read the question thoroughly. Look for specific keywords that might indicate the correct answer.

Cover the Choices: Challenge yourself by covering the answer choices initially. Try to recall the answer before being influenced by the provided options. This method can enhance your memory and critical thinking skills.

Eliminate Wrong Answers: If you find a choice that clearly doesn't fit or is incorrect, eliminate it. Narrowing down your options increases your chances of selecting the correct answer.

Look for Qualifiers: Words like *"always," "never," "all,"* or *"none"* can be red flags. Often, these extreme qualifiers may indicate incorrect choices. Be cautious and choose options with more moderate language.

Check for Context Clues: Sometimes, one question might provide hints or context for another. Pay attention to the information given; it could help you answer related questions.

Review Your First Impression: Your gut feeling is often correct. After going through the choices, revisit your initial instinct. More often than not, it's the right answer.

Watch Out for Tricky Wording: Be wary of tricky questions with double negatives or complex phrasing. Simplify the question in your mind to ensure you understand what it's asking.

Look in Your Testing Supplement: Some questions refer you directly to your testing supplement. But sometimes you can find the answer to a question in another part of the supplement. Flipping through the supplement may inspire a correct answer if you're stumped.

Tips for the Practical Test

Preparing for your FAA practical exam is crucial for success. Happily, it's an open-book exam. You can bring this book, notes, and any other resource you want to bring. Here are some tips to help you perform well during your FAA practical exam:

Thorough Preparation: It's difficult to be too thorough in your preparations. Work with your CFI on mock check rides to challenge you and prepare you for the real thing.

Know the PTS: Familiarize yourself with the Practical Test Standards (PTS). The PTS outlines the tasks and standards evaluated.

Tab This Book: It's an open-book test, but it won't cover everything in the book. Get some post-it notes and tab the sections in this book that answer questions you know that you'll see.

Curb Your Enthusiasm: Don't get yourself too worked up for the check ride. Your examiner isn't trying to fail you, he's just trying to make sure that you understand the things the FAA wants you to understand. He's being objective.

Don't BS: Your examiner isn't going to ask you a question he doesn't already know the answer for. Slow down and look it up if you have to.

Use Your Resources: Don't try to do everything from memory. Remember, you have this book and your other resources at your fingertips. Don't be shy about saying that you just want to confirm your answer by looking in the book.

Don't Overuse Your Resources: Don't look up every answer to every question. Not only does it slow the process down, your examiner is going to get the impression that you don't know your material.

Use Checklists: Preflight inspections and passenger preflight briefings are perfect places to use checklists.

Clearing Turns: Maneuvers require clearing turns. If you forget that detail, you will fail the checkride.

Be Prepared to Talk While Flying: Your examiner will probably ask you questions during your check ride. That's partly to make sure that you know your stuff and partly to try to break your concentration.

Ultralight Flying

Everything above may sound kind of overwhelming, but it really isn't if you have a good flight instructor. A good flight instructor makes those things easier along with training you on how to safely fly. That said, there is an alternative to becoming a sport pilot. You still have to learn how to fly and you still have to understand a lot of what the FAA says that you should understand, but it doesn't require testing.

If you choose to fly a single-seat powered parachute that weighs less than 254 pounds and carries no more than five gallons of fuel, you have the attractive option of flying under the ultralight rules. These rules (also known as Part 103 - Ultralight Vehicles) allow you to fly with no pilot license and with no training requirements. There are other restrictions, both on the aircraft and on how and where you can fly, which will be discussed later.

If you choose to fly as an ultralight pilot, this book will provide you with a lot of valuable information about powered parachutes that you can't get anywhere else. Keep in mind that many of the details pertaining to regulations and procedures that are required for N-numbered machines and two-person flight may not pertain to you. On the other hand, weather, airspace rules, and other important areas do apply. I also would strongly encourage you to seek out professional instruction. Even though it isn't mandated, proper training will give you the tools to fly safely and legally. Anecdotal evidence from those who have tried to train themselves gives an almost unanimous feel that self-training is not a good idea. Even those who survived without large medical bills or repair costs indicate instruction would have given them the joy of safe flight much sooner.

Keep in mind that it isn't a great strategy to start at the ultralight level and then transition to sport pilot. That's because your hours logged in an ultralight do not count toward the flight experience required for a Private Pilot or Sport Pilot license.

Comparison of FAA Powered Parachute Ratings*

**Ultralight pilot isn't technically a rating. It's more of a way to access the sky without a rating.*

	Ultralight Pilot	Sport Pilot	Private Pilot
What kind of powered parachute can you fly?	An Ultralight Vehicle as defined in Part 103.	A Light Sport Aircraft as defined in Part 1.	Any US Registered Powered Parachute.
How many seats may the aircraft have?	1	2	No limit
How heavy may the aircraft be?	254 lbs. empty weight	Maximum Takeoff Weight (MTOW) of 1,320 lbs.	No limit
Fuel capacity	5 gallons	No limit	No limit
Maximum Cruise Speed	55 mph	120 knots | (138 mph)	250 knots | (288 mph)
How can it be powered?	No restrictions	A single, reciprocating engine	Single engine
Minimum Pilot Certificate Required	None needed.	Sport Pilot with an endorsement for powered parachutes.	Private Pilot Powered Parachute Land rating.
Does the aircraft require an N-number and Airworthiness Certificate?	No	Yes	Yes
Can you fly at night?	No	No	Yes
What time of day can you fly?	Between the hours of sunrise and sunset. May operate one half hour before sunrise and one hour after sunset as long as the ultralight is equipped with an anticollision light visible for 3 statute miles and the flight remains in Class G airspace.	Between the hours of sunrise and sunset. May operate during civil twilight as long as the aircraft has lighted position lights.	Any time. At night the aircraft must have approved position lights, an approved aviation red or aviation white anticollision light system and other minimum equipment specified in §91.205(c).
Can you fly in Class A airspace (altitudes above 18,000 feet MSL)?	Yes, if you have prior authorization from the Air Traffic Control (ATC) facility having jurisdiction over that airspace.	No.	No.
Can you fly in Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport?	Yes, if you have prior authorization from the Air Traffic Control (ATC) facility having jurisdiction over that airspace.	Yes. But first you must receive and log ground and flight training from an authorized instructor. The instructor must provide the appropriate logbook endorsement for operations in Class B, C, and D airspace.	Yes.
Can you carry a passenger or property for compensation or hire?	N/A	No.	No.
Can you fly in furtherance of a business?	No.	No.	Yes, if the flight is only incidental to that business or employment
Can you fly over congested areas?	No.	Yes.	Yes.

PART 103—ULTRALIGHT VEHICLES

Subpart A—General

§ 103.1 Applicability.

This part prescribes rules governing the operation of ultralight vehicles in the United States. For the purposes of this part, an ultralight vehicle is a vehicle that:

(a) Is used or intended to be used for manned operation in the air by a single occupant;
(b) Is used or intended to be used for recreation or sport purposes only;
(c) Does not have any U.S. or foreign airworthiness certificate; and
(d) If unpowered, weighs less than 155 pounds; or
(e) If powered:
 (1) Weighs less than 254 pounds empty weight, excluding floats and safety devices which are intended for deployment in a potentially catastrophic situation;
 (2) Has a fuel capacity not exceeding 5 U.S. gallons;
 (3) Is not capable of more than 55 knots calibrated airspeed at full power in level flight; and
 (4) Has a power-off stall speed which does not exceed 24 knots calibrated airspeed.

§ 103.3 Inspection requirements.

(a) Any person operating an ultralight vehicle under this part shall, upon request, allow the Administrator, or his designee, to inspect the vehicle to determine the applicability of this part.
(b) The pilot or operator of an ultralight vehicle must, upon request of the Administrator, furnish satisfactory evidence that the vehicle is subject only to the provisions of this part.

§ 103.5 Waivers.

No person may conduct operations that require a deviation from this part except under a written waiver issued by the Administrator.

§ 103.7 Certification and registration.

(a) Notwithstanding any other section pertaining to certification of aircraft or their parts or equipment, ultralight vehicles and their component parts and equipment are not required to meet the airworthiness certification standards specified for aircraft or to have certificates of airworthiness.
(b) Notwithstanding any other section pertaining to airman certification, operators of ultralight vehicles are not required to meet any aeronautical knowledge, age, or experience requirements to operate those vehicles or to have airman or medical certificates.
(c) Notwithstanding any other section pertaining to registration and marking of aircraft, ultralight vehicles are not required to be registered or to bear markings of any type.

Subpart B—Operating Rules

§ 103.9 Hazardous operations.

(a) No person may operate any ultralight vehicle in a manner that creates a hazard to other persons or property.
(b) No person may allow an object to be dropped from an ultralight vehicle if such action creates a hazard to other persons or property.

§ 103.11 Daylight operations.

(a) No person may operate an ultralight vehicle except between the hours of sunrise and sunset.
(b) Notwithstanding paragraph (a) of this section, ultralight vehicles may be operated during the twilight periods 30 minutes before official sunrise and 30 minutes after official sunset or, in Alaska, during the period of civil twilight as defined in the Air Almanac, if:
 (1) The vehicle is equipped with an operating anticollision light visible for at least 3 statute miles; and
 (2) All operations are conducted in uncontrolled airspace.

§ 103.13 Operation near aircraft; right-of-way rules.

(a) Each person operating an ultralight vehicle shall maintain vigilance so as to see and avoid aircraft and shall yield the right-of-way to all aircraft.
(b) No person may operate an ultralight vehicle in a manner that creates a collision hazard with respect to any aircraft.
(c) Powered ultralights shall yield the right-of-way to unpowered ultralights.

§ 103.15 Operations over congested areas.

No person may operate an ultralight vehicle over any congested area of a city, town, or settlement, or over any open air assembly of persons.

§ 103.17 Operations in certain airspace.

No person may operate an ultralight vehicle within Class A, Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport unless that person has prior authorization from the ATC facility having jurisdiction over that airspace.

§ 103.19 Operations in prohibited or restricted areas.

No person may operate an ultralight vehicle in prohibited or restricted areas unless that person has permission from the using or controlling agency, as appropriate.

§ 103.20 Flight restrictions in the proximity of certain areas designated by notice to airmen.

No person may operate an ultralight vehicle in areas designated in a Notice to Airmen under § 91.137, § 91.138, § 91.141, § 91.143 or § 91.145 of this chapter, unless authorized by:
(a) Air Traffic Control (ATC); or
(b) A Flight Standards Certificate of Waiver or Authorization issued for the demonstration or event.

§ 103.21 Visual reference with the surface.

No person may operate an ultralight vehicle except by visual reference with the surface.

§ 103.23 Flight visibility and cloud clearance requirements.

No person may operate an ultralight vehicle when the flight visibility or distance from clouds is less than that in the table found below. All operations in Class A, Class B, Class C, and Class D airspace or Class E airspace designated for an airport must receive prior ATC authorization as required in § 103.17 of this part.

Airspace	Flight visibility	Distance from clouds
Class A	Not applicable	Not Applicable.
Class B	3 statute miles	Clear of Clouds.
Class C	3 statute miles	500 feet below. | 1,000 feet above. | 2,000 feet horizontal
Class D	3 statute miles	500 feet below. | 1,000 feet above. | 2,000 feet horizontal.
Class E:		
Less than 10,000 feet MSL	3 statute miles	500 feet below. | 1,000 feet above. | 2,000 feet horizontal.
At or above 10,000 feet MSL	5 statute miles	1,000 feet below. | 1,000 feet above. | 1 statute mile horizontal.
Class G:		
1,200 feet or less above the surface (regardless of MSL altitude)	1 statute mile	Clear of clouds.
More than 1,200 feet above the surface but less than 10,000 feet MSL	1 statute mile	500 feet below. | 1,000 feet above. | 2,000 feet horizontal.
More than 1,200 feet above the surface and at or above 10,000 feet MSL	5 statute miles	1,000 feet below. | 1,000 feet above. | 1 statute mile horizontal.

Chapter 2
Flight Safety

There is a lot to learn in your training. Some of those things don't fit neatly into future chapters but are important, nonetheless. These are also things that your instructor will cover and your DPE will be checking for during your check ride.

Positive Aircraft Control

You must learn to maintain positive control of the powered parachute whenever you are flying. You will need to contend with a variety of factors that singly and sometimes in combination will work to disrupt your control of the aircraft.

- Varying loads on the powered parachute.
- Changing torque of the engine during increases and decreases of engine power.
- A variety of wind and weather conditions.
- Changes in balance of forces during turning maneuvers.

Positive control doesn't mean overcontrol. Overcontrol happens when pilots try to compensate for everything, especially wind effects. That often results in even worse flying. Your flight instructor will coach you through control of the powered parachute.

Flight Deck Management

Flight Deck Management, also known as cockpit management, includes the things you do to make sure that the equipment and documents you need for a flight are ready and accessible. In powered parachutes, that often means making sure that the aviation band radio is positioned in a location where you can adjust the volume and frequency. It also involves navigation equipment, kneeboards, and the routing of cords.

When you are flying with a passenger, it also means making sure that seat belts are fastened and that noncritical conversations are ending during critical phases of flight like takeoff and landing. That is referred to as having a sterile flight deck. It is also referred to as asking your passenger to quiet down.

Positive Exchange of Flight Controls

During flight training, there must always be a clear understanding between the student and flight instructor of who has control of the aircraft. Prior to any dual training flight, your flight instructor should brief you on the flight. That briefing should include the procedure for the exchange of flight controls. To ensure clarity and communication during the transfer of flight controls, the following exchange should occur:

Positive Transfer of Controls

1. Flight Instructor: *"You have the flight controls."*
2. Student: *"I have the flight controls."*
3. Flight Instructor: *"You have the flight controls."*

As part of the procedure, a visual check should be performed to ensure that the other person actually has control of the flight controls. When returning the controls to the flight instructor, the process is reversed. The student should remain on the controls until the instructor says, *"I have the flight controls."* There should never be any doubt about who is flying the powered parachute at any time. Numerous accidents have occurred due to a lack of communication or misunderstanding about who actually had control of the aircraft, especially between students and flight instructors. Establishing this procedure during initial training helps develop a crucial habit pattern.

Collision Avoidance

Collision Avoidance is obviously important in aviation and will be covered in several chapters. It's a big part of flying, but is especially important during higher risk activities such as:

- Taxiing at an airport.
- Airport pattern operations.
- Before and during maneuvers.
- Flying at events like fly-ins.
- Formation flying.

Elements of Collision Avoidance

The reason collision avoidance is covered in many chapters and not in one place is because there are a lot of elements to it. Here is a quick overview of the kind of tools we will cover to help you avoid the dreaded midair collision.

Know and Observe Airspace Regulations: You need to understand the different classes of airspace and the restrictions or requirements associated with each one. Then you need to familiarize yourself with the classes of airspace surrounding the region you are flying in and fly within that airspace appropriately. Stay informed about temporary flight restrictions (TFRs) and airspace closures, ensuring compliance to prevent potential collisions with emergency aircraft.

Maintain Adequate Situational Awareness: Maintaining situational awareness is critical in avoiding collisions. Be vigilant and constantly scan the sky for other aircraft. Use visual reference points, such as prominent landmarks or known airport traffic patterns, to assess the presence and proximity of other aircraft. If you are in real busy airspace, consider equipping your aircraft with an ADS-B receiver, to receive real-time information on nearby traffic.

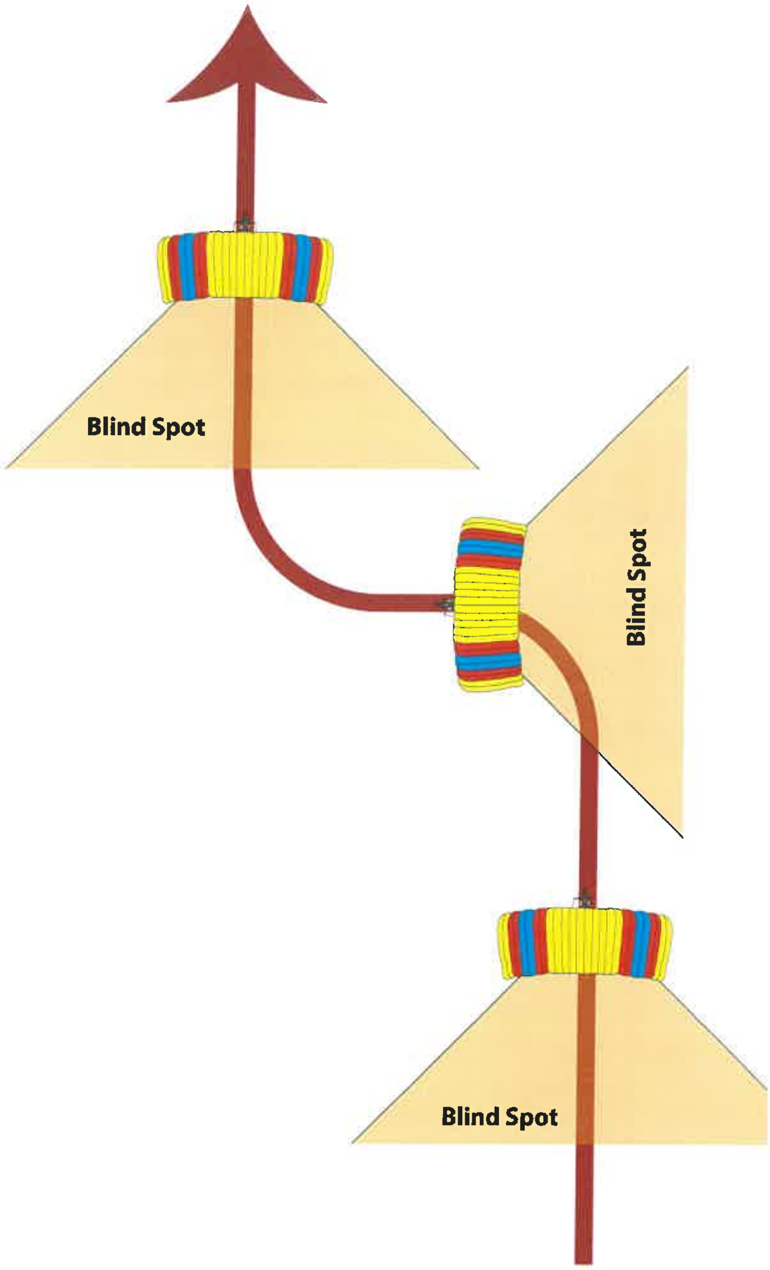
Communicate: Although you will typically operate in uncontrolled airspace, maintaining effective communication with other pilots is still important. Use appropriate radio frequencies and make position reports when flying in the vicinity of airports or known flying areas.

Optimize Visibility: Given the slower speeds of powered parachutes, maximizing visibility is crucial for collision avoidance. Ensure that your aircraft is equipped with proper lighting systems, including navigation and anticollision lights. When buying a powered parachute, look for more visible colors like yellows in the airframe and the parachute itself.

Flight Planning and Route Selection: If you base your powered parachute at an airport, try to fly away from that airport as often as you can to avoid contributing to congestion in the airspace surrounding the airport. When leaving the airport, thorough flight planning and careful route selection contribute significantly to collision avoidance. Avoid congested areas whenever possible. Stay informed about local flying clubs, flight training areas, remote control airfields and other known aviation hotspots so you can plan your flight accordingly.

Maintain Altitude Separation: Powered parachutes fly incredibly slow compared to other aircraft. That means that if you encounter another aircraft at higher altitudes where faster aircraft fly, it's harder for you to avoid a collision. Generally flying below 3,000' above ground level (AGL) will be a happier place for you. In airport traffic patterns, if local rules allow it, you should aim to be no higher than 500' AGL to avoid airplanes, who fly a standard airport traffic pattern of 1,000' AGL.

A 90 degree clearing turn allows you to see what's going on behind you in the blind spot. If the blind spot is larger, then the clearing turn should also be larger, in order to see everything.



Midair Collision Avoidance

You must always be alert to the potential for midair collisions and near midair collisions. The basic concept is called 'See and Avoid.' This concept requires that all pilots maintain vigilance. Your responsibility for continuously maintaining a vigilant lookout exists regardless of the type of aircraft you fly and the purpose of the flight. Most midair collision accidents and reported near-midair-collision incidents occur in clear sky conditions and during daylight hours. Moreover, most of these accident/incidents occur within five miles of an airport and/or near navigation aids. And yes, powered parachutes have had midair collisions.

The 'See and Avoid' concept relies on knowledge of the limitations of the human eye, and the use of proper visual scanning techniques to help compensate for these limitations.

Effective scanning is accomplished with a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field. Each movement should not exceed 10°, and each should be observed for at least one second to enable detection. Although back and forth eye movements seem preferred by most pilots, each pilot should develop a scanning pattern that is most comfortable and then adhere to it to assure optimum scanning. Even if entitled to the right-of-way, a pilot should yield if another aircraft seems too close.

Clearing Procedures

There are various types of clearing procedures, with many centered around clearing turns. The essential idea is to be certain that your next maneuver won't intersect with another aircraft's flight path. Other types of clearing procedures may be developed by individual flight instructors.

The following procedures and considerations will help you avoid collisions in various situations.

Before Takeoff: Prior to taxiing onto a runway for takeoff, scan the approach area for potential landing and departing traffic.

Climbs and Descents: Fly gentle banks left and right during climbs and descents, maintaining continuous visual scanning of the airspace.

Straight-and-level: During sustained periods of straight-and-level flight, perform clearing procedures at regular intervals.

Traffic Patterns: Avoid entering traffic patterns while descending.

Training Operations: Stay vigilant and perform clearing turns before practicing maneuvers. Call out your clearing procedures to your instructor during training, such as *"clear left, right, above, and below."*

§ 91.111 Operating near other aircraft.

(a) No person may operate an aircraft so close to another aircraft as to create a collision hazard.

(b) No person may operate an aircraft in formation flight except by arrangement with the pilot in command of each aircraft in the formation.

(c) No person may operate an aircraft, carrying passengers for hire, in formation flight.

Clearing Turns

Before attempting any advanced maneuver, ensure the area is suitable. Confirm your practice area is far from airport approaches, patterns, homes, businesses, and gatherings of people. Stay clear of places with concentrated domestic animals like dairy farms, chicken houses, horse farms or pig farms as the animals may panic due to the unfamiliar noise of powered parachute maneuvers.

Consider the space needed for each maneuver and your approach to it. Begin your maneuver at a minimum altitude of 300 feet above ground level (AGL) to allow for a margin of ±100 feet during the practical test. Falling below 200 feet AGL results in task failure, so beginning at 250 feet AGL only provides a 50-foot allowance.

Check for other aircraft in the vicinity before commencing advanced maneuvers. They might not anticipate your unusual maneuvers, and your focus on practice makes it harder to avoid a midair incident. Always use clearing turns as a safety measure to check both the sky in front and behind you. Although powered parachutes offer good visibility, there's a blind spot behind you where unexpected maneuvers might surprise aircraft following you.

A clearing turn is usually just a simple, lazy 90° or more level turn that gives you the opportunity to see what is going on behind you. Some instructors insist on more than a 90° turn. Some fly completely over the practice area, make a 180° turn and then enter the practice area on the other side. Others insist on a 360° turn before beginning. There is no right or wrong method as long as you are able to check out the entire sky around you. And don't forget to look both up and down, too! Remember, flying is a three-dimensional activity.

Whatever the preferred method, you need to learn an effective clearing procedure and use it regularly. You should execute the appropriate clearing procedure before executing any training maneuver. Proper clearing procedures, combined with proper visual scanning techniques, are the most effective strategy for collision avoidance.

Clearing turns are essential before advanced maneuvers, but unnecessary before regular turns like those in an airport traffic pattern. And finally, after you have completed your clearing turn, you aren't finished watching the sky. Part of the skill needed during advanced maneuvers is to watch the sky even while you are flying the maneuver.

Right of Way

The FAA has rules that determine who has the right of way while flying. This normally doesn't matter in the big, blue sky since there just aren't that many aircraft filling the sky. Everybody should just see and avoid while flying. But everything changes the closer you get to an airport.

§ 91.113 Right-of-way rules: Except water operations.

(a) Inapplicability. This section does not apply to the operation of an aircraft on water.

(b) General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

(c) In distress. An aircraft in distress has the right-of-way over all other air traffic.

(d) Converging. When aircraft of the same category are converging at approximately the same altitude (except head-on, or nearly so), the aircraft to the other's right has the right-of-way. If the aircraft are of different categories -

  (1) A balloon has the right-of-way over any other category of aircraft;

  (2) A glider has the right-of-way over an airship, powered parachute, weight-shift-control aircraft, airplane, or rotorcraft.

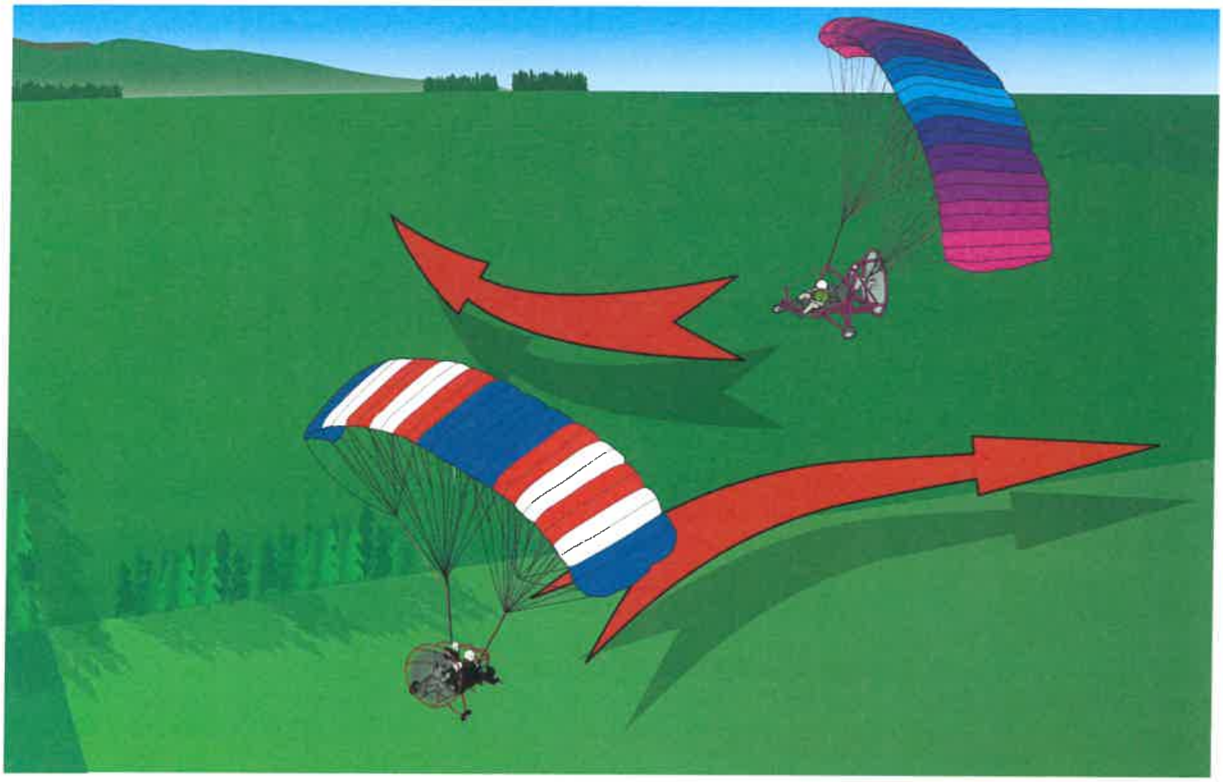
  (3) An airship has the right-of-way over a powered parachute, weight-shift-control aircraft, airplane, or rotorcraft.

However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine-driven aircraft.

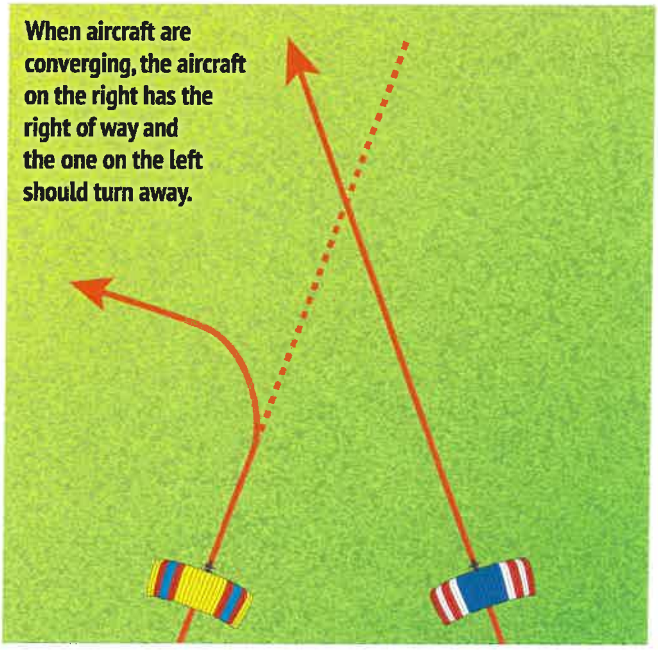
(e) Approaching head-on. When aircraft are approaching each other head-on, or nearly so, each pilot of each aircraft shall alter course to the right.

(f) Overtaking. Each aircraft that is being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear.

(g) Landing. Aircraft, while on final approach to land or while landing, have the right-of-way over other aircraft in flight or operating on the surface, except that they shall not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on final approach. When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way, but it shall not take advantage of this rule to cut in front of another which is on final approach to land or to overtake that aircraft.



When aircraft are approaching each other head-on, or nearly so, each pilot of each aircraft shall alter course to the right.



When aircraft are converging, the aircraft on the right has the right of way and the one on the left should turn away.

Right-of-way rules by aircraft, from most right of way to least.

Airports are where aircraft concentrate to takeoff, fly the pattern and land. Airports are busy places and that's where rules about who has pecking order really matter.

Generally, slower aircraft or aircraft with problems have the right of way. But not always. The rules start out by saying that when weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. If there's an FAA rule that gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear. Keep in mind that these are regulations, not suggestions!

Controlled Flight into Terrain (CFIT)

CFIT is an accident in which an airworthy aircraft, under pilot control, is unintentionally flown into the ground, a mountain, a body of water or an obstacle. In a typical CFIT scenario, the pilot is unaware of the impending disaster until it's too late.

CFIT is a larger issue for powered parachute pilots than it is for airplane pilots because we normally fly at much lower altitudes. You know, where all the terrain is. There are several steps a powered parachute pilot can take to avoid CFIT.

Begin by allowing enough room for takeoff. If you're taking off from a confined space, establish a go/no-go line for safety. If you can't get wheels up by a certain point, abort the takeoff.

Look beyond your intended launch field before takeoff to make sure that the path forward is clear of any trees, power lines, or buildings that you may not be able to clear after you have taken off.

When flying over power lines, always fly over the poles or towers. The towers are much more visible than the lines themselves and will give you a better indication of whether you can clear the obstacles or not.

When flying at low altitudes below a couple of hundred feet, be very careful.

- Do a reconnaissance flight at altitude ahead of a low pass to locate obstacles.
- Do not fly low while visibility is limited, including before sunrise or after sunset.
- Do not fly low into the east in the morning or the west in the afternoon. Haze from the sun can obscure obstacles.
- Adjust your altitude upward as winds and thermals increase.

Checklist Usage

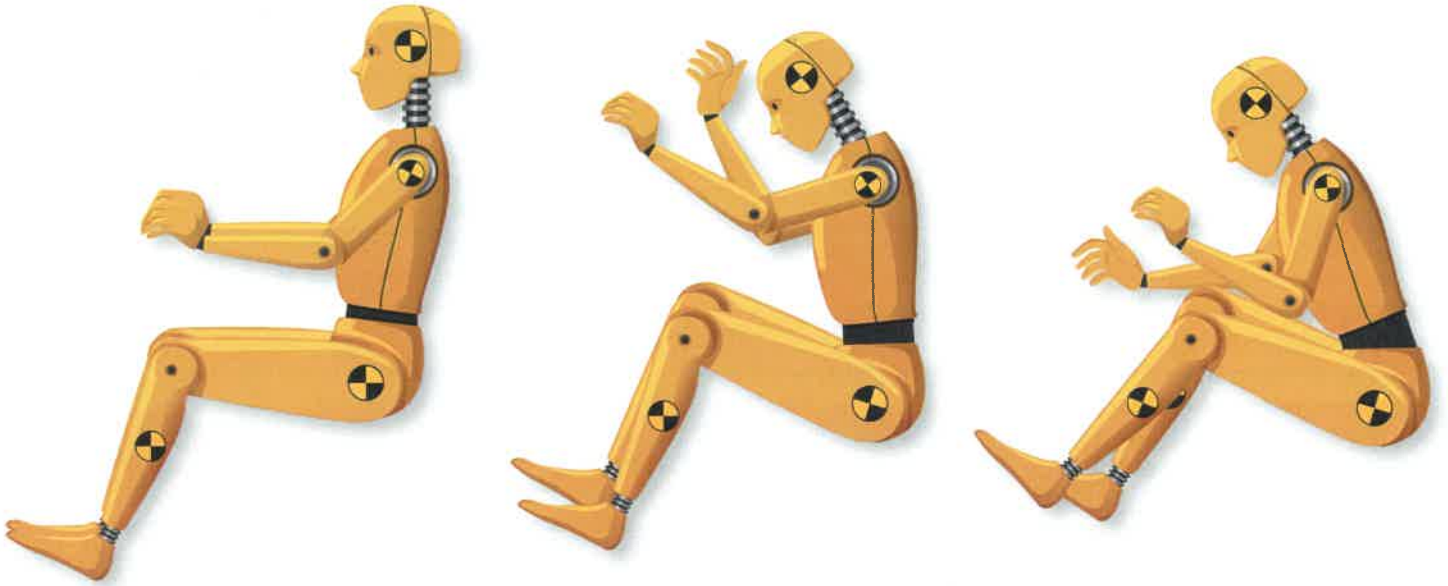
You and your passengers' safety is always the top priority in aviation, and checklists are your trusted allies in achieving it. By following a structured set of steps, you can systematically complete critical tasks, significantly reducing the likelihood of human error. In aviation, checklists can cover a wide range of procedures, including preflight inspections, Aeronautical Decision Making, engine start-up, takeoff, landing, emergency situations, and more. They serve as your reliable reference, ensuring that you consistently implement crucial safety measures.

To avoid missing important steps, always use the appropriate checklists. Those checklists provide you with a standardized framework to perform tasks consistently and accurately. They act as your comprehensive guide, ensuring that no essential steps or safety precautions are overlooked. You should not be relying on short and long term memory for repetitive tasks. By promoting a consistent approach, checklists minimize the risk of procedural variations, increase predictability, and create a more reliable aviation system overall.

Crisis Management and Emergency Situations

Checklists can play a critical role in ensuring that you can execute emergency procedures swiftly and accurately during crises. In high-stress situations, the checklist acts as your memory aid, enabling you to follow the correct protocols without relying solely on memory. By using checklists in emergencies, you maintain composure, minimize errors, and maximize the chances of a successful outcome.

CFIT is just a fancy aviation word for crashing. Don't be that guy.



Training and Skill Development

Checklists are an invaluable tool for training and maintaining proficiency. During training, they provide a structured learning framework, helping you understand and internalize complex procedures. As you gain experience, checklists act as reminders of critical steps, preventing complacency and reinforcing best practices. Regular use of checklists promotes continuous learning, proficiency, and a strong commitment to safety.

Consistent adherence to approved checklists is a sign of a disciplined and competent pilot. Embracing the power of checklists is vital in your daily operations. By incorporating checklists into every aspect of aviation, from preflight preparations to emergency situations, you can minimize the likelihood of errors and enhance your overall performance.

Notice to Air Missions (NOTAM)

Notices to Air Missions, or NOTAMs, are time-critical aeronautical information that isn't printed on aeronautical charts or other publications. That's because NOTAM information is either temporary in nature or not sufficiently known in advance to include it in those other publications. NOTAMs are considered essential to the safety of flight, as well as supplemental data affecting other operational publications.

NOTAMs are issued for various reasons, typically falling into two categories: airspace changes, which are discussed in *Chapter 25, "Airspace,"* and airport hazards, which we will cover in this chapter. Some common reasons for issuing a NOTAM include:

- Hazards, such as air shows, parachute jumps, kite flying, and rocket launches
- Flights by important people such as heads of state
- Closed runways
- Inoperable radio navigational aids
- Military exercises with resulting airspace restrictions
- Inoperable lights on tall obstructions
- Temporary erection of obstacles near airfields
- Passage of flocks of birds through airspace (a NOTAM in this category is known as a BIRDTAM)
- Notifications of runway/taxiway/apron status with respect to snow, ice, and standing water (a SNOWTAM)
- Notification of an operationally significant change in volcanic ash or other dust contamination (an ASHTAM)
- Software code risk announcements with associated patches to reduce specific vulnerabilities

NOTAM information is generally classified into four categories:

1. NOTAM (D) or NOTAMs that receive distant dissemination
2. Flight Data Center (FDC) NOTAMs
3. Pointer NOTAMs
4. Military NOTAMs pertaining to military airports or NAVAIDs that are part of the National Airspace System (NAS).

NOTAM (D)

NOTAM (D) information is issued by the FAA based on information supplied by the local authorities responsible for airport operations and infrastructure. They can be issued for all public use airports, seaplane bases, and heliports listed in the Chart Supplement U.S. Examples of reasons a NOTAM (D) would be issued include:

- Runway Closures
- Taxiway Closures
- Ramp and Apron Closures
- Construction
- Airport Beacon out of Service
- News about Obstructions
- NAVAIDs
- Communication Problems
- Control Tower Change of Hours
- Fuel Service Unavailable
- Airshows
- Skydiving
- Personnel and equipment near or crossing runways
- Airport lighting aids that do not affect instrument approach criteria, such as visual approach slope indicators (VASI).

All D NOTAMs are required to have one of the following keywords as the first part of the text: RWY, TWY, RAMP, APRON, AD, OBST, NAV, COM, SVC, AIRSPACE, (U), or (O). (See table on the next page.)

FDC NOTAMs

FDC NOTAMs are issued by the National Flight Data Center and contain information that is regulatory in nature pertaining to flight including, but not limited to, changes to charts, procedures, and airspace usage. FDC NOTAMs refer to information that is regulatory in nature and includes the following:

- Interim IFR flight procedures
- Temporary flight restrictions (discussed in *Chapter 25, "Airspace"*)

Pointer NOTAMs (P-NOTAM)

A Pointer NOTAM serves as a pointer to important information rather than providing the detailed information itself. Instead of containing all the specifics, a Pointer NOTAM directs the pilot to another source, such as an Aeronautical Information Publication (AIP) or a specific location where the detailed information can be found.

For example, if there are changes in procedures at a particular airport, a Pointer NOTAM might be issued to inform pilots about these changes and guide them to the updated information in the AIP or another relevant document. It acts as a signpost, alerting pilots to look elsewhere for the detailed specifics.

Military NOTAMs

Military NOTAMs are notifications issued by military authorities to inform civilian and military pilots about conditions that may affect flight safety within or near military airspace. These NOTAMs notify you of potential hazards, restrictions, or changes in military operations that could impact your flight planning.

Examples of Military NOTAMs include:

Temporary Restrictions: Military NOTAMs often include information about temporary restrictions or prohibitions within specific airspace due to military exercises, operations, or other security-related activities.

Special Use Airspace (SUA): Military NOTAMs may designate certain airspace as Special Use Airspace, indicating that it is reserved for military activities. This can include areas for training, testing, or other military operations.

Air Defense Identification Zones (ADIZ): Military NOTAMs may provide information about Air Defense Identification Zones, specifying procedures for aircraft identification and communication requirements when flying through these zones.

Unmanned Aerial Systems (UAS) Operations: Military NOTAMs may contain information about the presence of unmanned aerial systems (drones) conducting military operations.

Emergency Situations: In the event of military emergencies or other critical situations, Military NOTAMs may be issued to communicate relevant information to pilots, including airspace closures or restrictions.

Keyword	Example	Meaning
RWY	RWY 3/21 CLSD	**Runways** 3 and 21 are closed to aircraft.
TWY	TWY F LGTS OTS	**Taxiway** F lights are out of service.
RAMP	RAMP TERMINAL EAST SIDE CONSTRUCTION	The **ramp** in front of the east side of the terminal has ongoing construction.
APRON	APRON SW TWY C NEAR HANGARS CLSD	The **apron** near the southwest taxiway C in front of the hangars is closed.
AD	AD ABN OTS	**Aerodromes**: The airport beacon is out of service.
OBST	OBST TOWER 283 (245 AGL) 2.2 S LGTS OTS (ASR 1065881) TIL 0707272300	**Obstruction**: The lights are out of service on a tower that is 283 feet above mean sea level (MSL) or 245 feet above ground level (AGL) 2.2 statute miles south of the field. The FCC antenna structure registration (ASR) number is 1065881. The lights will be returned to service 2300 UTC (Coordinated Universal Time) on July 27, 2007.
NAV	NAV VOR OTS	**Navigation**: The VOR located on this airport is out of service.
COM	COM ATIS OTS	**Communications**: The Automatic Terminal information Service (ATIS) is out of service.
SVC	SVC TWR 1215-0330 MON -FRI/1430-2300 SAT/1600-0100 SUN TIL 0707300100	**Service**: The control tower has new operating hours, 1215-0330 UTC Monday Thru Friday. 1430-2300 UTC on Saturday and 1600-0100 UTC on Sunday until 0100 on July 30, 2007.
	SVC FUEL UNAVBL TIL 0707291600	**Service**: All fuel for this airport is unavailable until July 29, 2007, at 1600 UTC.
	SVC CUSTOMS UNAVBL TIL 0708150800	**Service**: United States Customs service for this airport will not be available until August 15, 2007, at 0800 UTC.
AIRSPACE	AIRSPACE AIRSHOW ACFT 5000/BLW 5 NMR AIRPORT AVOIDANCE ADZD WEF 0707152000-0707152200	**Airspace**: There is an airshow being held at this airport with aircraft flying 5,000 feet and below within a 5 nautical mile radius. Avoidance is advised from 2000 UTC on July 15, 2007, until 2200 on July 15, 2007.
U	ORT 6K8 (U) RWY ABANDONED VEHICLE	**Unverified** aeronautical information.
O	LOZ LOZ (O) CONTROLLED BURN OF HOUSE 8 NE APCH END RWY 23 WEF 0710211300-0710211700	**Other** aeronautical information received from any authorized source that may be beneficial to aircraft operations and does not meet defined NOTAM criteria.

Sample NOTAM (D) notices.

NOTAM Composition

NOTAMs contain the elements below from left to right in the following order:

- An exclamation point (!)
- Accountability Location (the identifier of the accountability location)
- Affected Location (the identifier of the affected facility or location)
- KEYWORD (one of the following: RWY, TWY, RAMP, APRON, AD, COM, NAV, SVC, OBST, AIRSPACE, (U) and (O))
- Surface Identification (optional—this shall be the runway identification for runway related NOTAMs, the taxiway identification for taxiway-related NOTAMs, or the ramp/apron identification for ramp/apron-related NOTAMs)
- Condition (the condition being reported)
- Time (identifies the effective time(s) of the NOTAM condition)

Altitude and height are in feet mean sea level (MSL) up to 17,999. When MSL is not known, above ground level (AGL) will be written (304 AGL).

When time is expressed in a NOTAM, the day begins at 0000 and ends at 2359. Times used in the NOTAM system are universal time coordinated (UTC) and shall be stated in 10 digits (year, month, day, hour, and minute). The following are two examples of how the time would be presented:

!DCA LDN NAV VOR OTS WEF
0708051600-0708052359

!DCA LDN NAV VOR OTS WEF
0709050000-0709050400

Obtaining NOTAMS

NOTAM information receives immediate dissemination via the National Notice to Air Missions (NOTAM) System. They are available through 1-800-WX-BRIEF, private vendors, and many websites.

NOTAMs are available in printed form through subscription from the Superintendent of Documents, from an Flight Service Station (FSS), or online at PilotWeb (**www.pilotweb.nas.faa.gov**), which provides access to current NOTAM information.

Local airport NOTAMs can be obtained online from various websites. Some examples are **www.fltplan.com** and **www.aopa.org/whatsnew/notams.html**. Most sites require a free registration and acceptance of terms but offer pilots updated NOTAMs and TFRs.

UNL (unlimited)	FOR/AT (RWY) (for or at a specific runway)	OBSC (obscured)	UNREL (unreliable)
AVBL or NOT AVBL (available or not available)	DLY SS-SR (daily sunrise-sunset)	UNUSABLE	LGTD or NOT LGTD (lighted or not lighted)
IRREGULAR SFC (irregular surface: lips, dips, bumps, holes, ruts, breaks, etc.)	BARRICADED (means any type of barricade)	U/S or OTS (Out of Service/ Unserviceable	USABLE (Used in conjunction with a restriction; not by itself)
OPN or CLSD (open or closed)	EXC (except)	WI (within)	BTN (between)
ADJ (adjacent)	NOT STD (not standard)	CHANGED TO (permanent)	NOW (temporary)

Common language and codes used in NOTAMs

Aviation Security (Terrorism)

Fencing, locks, security cameras, hangars and controlled access points are all part of securing even a general aviation airport like many powered parachute pilots base at. Just as important is vigilance. Like a neighborhood watch program, pilots are encouraged to take an interest in the airport environment, including activities that may indicate criminal intent.

While rarely tested on a knowledge or practical test, there are eight signs of terrorism that pilots should be aware of. When at the airport, you will have the opportunity to assess and identify potential threats. In general, it's a matter of knowing your airport and knowing your fellow pilots, then using that knowledge to identify anomalies or aberrant behavior. There are several activities that are possible indications of terrorist activity.

Surveillance: Someone discretely recording or observing operational activity. This may include the use of video recorders, cameras, note taking, drawing diagrams, marking maps, using vision-enhancing devices such as telescopes or binoculars, or using small Unmanned Aircraft Systems (UAS).

Elicitation: Someone trying to gain information about law enforcement, security, or other capabilities, operations, or people. Types of elicitation may involve eavesdropping, friendly conversation, and asking (direct) questions, including asking about airport operations. Elicitation may also be conducted via mail, email, and viewing websites. Other examples could include unusual or prolonged interest in or attempts to gain sensitive information about security measures relating to personnel, entry points, peak activity, hours of operations, heating/ventilation/air- conditioning (HVAC) systems, and access control aids such as alarms and locks.

Tests of Security: Attempts to measure reaction times to security breaches, including delays in response times; attempts to penetrate physical barriers, including airport perimeter fencing, rooftops, and other sensitive areas; or attempts to assess strengths and weaknesses by monitoring procedures. This may include fictitious emergency calls to the same locations or venues.

Funding: Suspicious transactions involving large cash transactions, such as when purchasing fuel or even aircraft.

Supplies: Purchasing or stealing, and storing large quantities of explosives or explosive-making materials, weapons, munitions, chemicals or biological agents etc., that may seem out of place or context. This activity is usually associated with person(s) going out of their way to avoid contact; conducting suspicious activities, keeping doors closed and windows blacked-out, as well as making unusual modifications to aircraft to disperse or release Improvised Explosive Devices (IEDs) or agents.

Suspicious People: People who just seem out of place. This may include impersonating pilots, airport line personnel, law enforcement, security, or employees of companies, including using fake badges or vehicle decals.

Rehearsal: Positioning and moving people around without actually committing a terrorist act. This may include activities such as mapping out routes, driving on uncontrolled aircraft ramps, or timing distances and traffic signals.

Deployment: Person(s) moving into position to commit a terrorist act. This is the last chance to thwart an act of terrorism.

If you notice any of these activities, it is prudent to make airport management aware of what you are seeing. Chances are, there are perfectly valid reasons for whatever you are seeing. But it's better to say something than to regret remaining silent in case something bad happens.

Other Special Emphasis Areas

The FAA has specific concerns that we should also be aware of, especially during a check ride. These topics are listed below and are detailed in specific chapters:

- Wake Turbulence and Low-Level Wind Shear Avoidance (*Chapter 13, "Winds and Turbulence"*)
- Runway Incursion Avoidance (*Chapter 25, "Operating at an Airport"*)
- Aeronautical Decision Making (*Chapter 3, "Aeronautical Decision Making"*)
- Spatial Disorientation (*Chapter 6, "Aeromedical Factors"*)
- Temporary Flight Restrictions (*Chapter 25, "Airspace"*)
- Special Use Airspace (*Chapter 25, "Airspace"*)

Chapter 3 Aeronautical Decision Making

One of the first questions a powered parachute newbie will ask is *"Are these things safe?"* That's the wrong question. The real question is, *"How safe are you flying these things?"* That's because most aircraft accidents are caused by what news reporters like to call 'human error.'

Human error is the one common factor which affects most preventable accidents. Errors are the result of either bad information or faulty decision-making processes. Most of this book provides you with good information, including ways to obtain good information like weather reports and forecasts. In contrast, this chapter provides you with tools you can use to turn that information into good flying decisions.

While 'human error' is still a commonly used term, the phrase 'human factors related' better describes accidents where a pilot makes a poor decision. From a broader perspective, the phrase 'human factors related' more aptly describes the cause of these accidents since it's usually not a single decision but a chain of events that leads to an accident.

In fact, the FAA specifically refers to a series of judgmental errors which can lead to a human factors-related accident as an Error Chain. Also known as the Poor Judgment Chain, it is a series of mistakes that may lead to an accident or incident. The two main ideas are:

1. One bad decision often leads to another.
2. As a string of bad decisions grows, it reduces the number of subsequent alternatives for continued safe flight.

Focusing on how you make decisions will make you a better and safer pilot.

What is Aeronautical Decision Making?

Aeronautical Decision Making (ADM) is a systematic approach to the mental process you use as a pilot to consistently determine your best course of action in response to a given set of circumstances.

ADM also helps you understand how your personal attitudes can influence decision-making and how those attitudes can be modified to enhance safety. It's important to understand the factors that go into decisions and how the decision-making process works. Most of aviation involves your looking outward to exterior factors such as equipment, weather, and air traffic. ADM involves your looking inward to how your own mind, perceptions, and assumptions work. This is a start toward improving your risk assessment skills.

It's estimated that approximately 80 percent of all aviation accidents are related to human factors. That makes the study of human factors part of the *"low-hanging fruit"* that will enhance your personal safety.

This is not a 'fun' chapter. Some of the tools may seem awkward to use and the chapter itself may appear daunting. But I encourage you to read through this and absorb everything you can. Introducing yourself to these concepts early on will make you a better pilot. (And the FAA likes to ask test questions about this stuff, too.)

You can learn good judgment. Of course, one way you can learn good judgment is through experience, but often those lessons are hard, expensive, or painful. Studying ADM is kind of a hack or shortcut to gaining good judgment. It's a better and safer approach than the pain of learning through the experience of making mistakes.

Hazard and Risk

Two defining elements of ADM are hazard and risk. Hazard is a real or perceived condition, event, or circumstance that a pilot encounters. When faced with a hazard, you should assess that hazard. You then assign a value to the potential impact of the hazard, which quantifies your assessment of the hazard. This assigned value is the risk.

Therefore, risk is an assessment of the single or cumulative hazard facing a pilot. Pilots assess risks differently. An example is the discovery of a small hole in the wing. The hole is the hazard. The hazard leads to the risk of the wing failing when loaded at takeoff.

The seasoned pilot may see the hole as a negligible risk. He knows a small hole won't migrate like a tear. Since it won't significantly degrade the performance of the wing, he doesn't cancel his flight.

The inexperienced pilot may see the hole as a high risk because he is unsure of the effect the hole will have on the wing. Since he may have been told that wing damage could cause a catastrophic failure, he cancels his flight.

Elements or factors affecting individuals are different and profoundly impact decision-making. These human factors can transcend things like education, experience, health, and physiology.

Another example of risk assessment is a low visibility situation. A pilot took off when the temperature-dew point spread was zero and there was fog in the area. A prudent pilot would assess the risk as high, yet this pilot did the opposite. Why did the pilot take this action?

Experience led to an improper assessment. The pilot had successfully flown into these conditions repeatedly and the fog always cleared as the morning progressed. This time, the fog increased and blocked the view of the ground. Since the pilot was anxious to fly and planned to stay in the area, he assigned much too low a risk to the hazard.

Risk Management

Risk Management is the part of the decision-making process which relies on situational awareness, problem recognition, and good judgment to reduce risks associated with each flight. The goal of risk management is to identify safety-related hazards and mitigate the associated risks. When a pilot follows good decision-making practices, the risk in a flight is reduced, often by a lot. The formal risk management decision-making process involves six steps as shown in the figure below.

While poor decision-making in everyday life doesn't always lead to tragedy, the margin for error in aviation is thin. Making yourself familiar with ADM is a much bigger deal than reading the 12 pages of safety warnings that come with a new toaster.

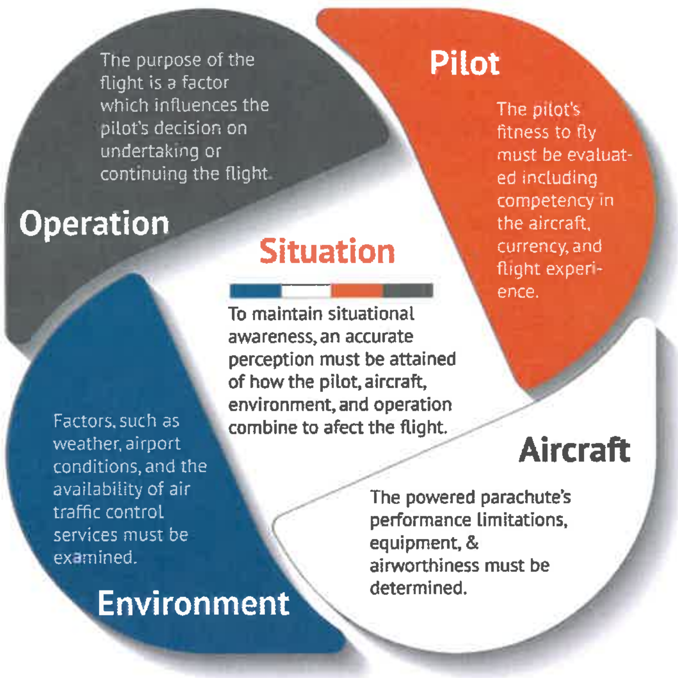
Situational Awareness

Situational awareness is the accurate perception and understanding of the factors and conditions that affect safety before, during, and after the flight. It's key to risk management. You need to stay aware of what's going on around you to identify the risks involved. Situational awareness considers these fundamental risk elements of a flight:

- The Pilot
- The Aircraft
- The Environment
- The Specific Operation

You can develop a full mental picture of what is happening by scanning for traffic, monitoring radio communications for traffic, staying aware of the weather, monitoring your engine and instruments, and staying aware of your own health and attitude.

Risk Elements



Terms Used to Explain Concepts Used in ADM Training

Aeronautical Decision Making is a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances.

Attitude is a personal motivational predisposition to respond to persons, situations, or events in a given manner that can, nevertheless, be changed or modified through training as sort of a mental shortcut to decision-making.

Attitude Management is the ability to recognize hazardous attitudes in oneself and the willingness to modify them as necessary through the application of an appropriate antidote thought.

Crew Resource Management (CRM) is the application of team management concepts in the flight deck environment. It was initially known as flight deck resource management, but as CRM programs evolved to include cabin crews, maintenance personnel, and others, the phrase crew resource management was adopted. This includes single pilots, as in most general aviation aircraft. Pilots of small aircraft, as well as crews of larger aircraft, must make effective use of all available resources to include human resources, hardware, and information. A current definition includes all groups routinely working with the flight deck crew who are involved in decisions required to operate a flight safely. These groups include, but are not limited to: pilots, dispatchers, cabin crew members, maintenance personnel, and air traffic controllers. CRM is one way of addressing the challenge of optimizing the human/machine interface and accompanying interpersonal activities.

Headwork is required to accomplish a conscious, rational thought process when making decisions. Good decision-making involves risk identification and assessment, information processing, and problem solving.

Judgment is the mental process of recognizing and analyzing all pertinent information in a particular situation, a rational evaluation of alternative actions in response to it, and a timely decision on which action to take.

Personality is the embodiment of personal traits and characteristics of an individual that are set at a very early age and extremely resistant to change.

Poor Judgment Chain is a series of mistakes that may lead to an accident or incident. Two basic principles generally associated with the creation of a poor judgment chain are: (1) One bad decision often leads to another; and (2) as a string of bad decisions grows, it reduces the number of subsequent alternatives for continued safe flight. ADM is intended to break the poor judgment chain before it can cause an accident or incident.

Risk Elements in ADM take into consideration the four fundamental risk elements: the pilot, the aircraft, the environment, and the type of operation that comprise any given aviation situation.

Risk Management is the part of the decision-making process which relies on situational awareness, problem recognition, and good judgment to reduce risks associated with each flight.

Single Pilot Resource Management (SRM) is similar to crew resource management (CRM) procedures that are being emphasized in multi-crew member operations except only one crew member (the pilot) is involved.

Situational Awareness is the accurate perception and understanding of all the factors and conditions within the four fundamental risk elements that affect safety before, during, and after the flight.

Skills and Procedures are the procedural, psychomotor, and perceptual skills used to control a specific aircraft or its systems. They are the airmanship abilities that are gained through conventional training, are perfected, and become almost automatic through experience.

Stress Management is the personal analysis of the kinds of stress experienced while flying, the application of appropriate stress assessment tools, and other coping mechanisms.

Risk Assessment Matrix

Likelihood	Severity			
	Catastrophic	Critical	Marginal	Negligible
Probable	High	High	Serious	Medium
Occasional	High	Serious	Medium	Low
Remote	Serious	Medium	Medium	Low
Improbable	Medium	Medium	Medium	Low

This risk matrix can be used for almost any operation by assigning likelihood and consequence. In the case presented below, the pilot assigned a likelihood of occasional and the severity as catastrophic. As one can see, this falls in the high risk area for effective decision-making.

Maintaining situational awareness improves as you improve your understanding of all flight related factors, their relative significance, and their future impact on the flight. When you understand what is going on and have an overview of the total operation, that means that you aren't fixated on one perceived significant factor.

As you are learning to fly a powered parachute, it is natural to become focused on certain elements of flight as you master them. Your instructor assists you by paying attention to the other elements of flight. You will know that you are progressing toward solo as you take on more of the workload and gain fuller situational awareness. You will learn to use all the skills involved in ADM to maintain situational awareness.

Obstacles to Maintaining Situational Awareness

You are more likely to fixate on a single perceived important item and reduce your overall situational awareness of the flight if you are suffering from fatigue, stress, or work overload. Distractions that divert your attention from monitoring the instruments or scanning outside the aircraft could become contributing factors in a potential accident. Many distractions begin as a minor problem, such as a gauge that is not reading correctly, but result in accidents as the pilot diverts attention to the perceived problem and neglects proper control of the aircraft.

Assessing Risk

On flight, you'll make many decisions under relatively hazardous conditions. To fly safely, you need to assess the degree of risk and determine the best course of action to mitigate that risk.

Assessing risk is not as simple as it sounds. For example, you will be your own quality control in making decisions. Most pilots are goal oriented and there is a tendency to deny personal limitations while adding weight to issues not affecting the mission. One example is giving weight to having promised to fly someone, but you are not feeling well at flight time.

There are several risk assessment models. The models take slightly different approaches,but have a common goal of assessing risk in an objective manner. The most basic tool is the risk matrix. It assesses two items: the likelihood of an event occurring and the consequence of that event.

Likelihood of an Event

Likelihood is the probability that an event will occur. You rate the event as probable, occasional, remote, or improbable. For example, if you're flying to a point 20 miles away in marginal visual flight rules (MVFR) conditions, the first thing you should consider is the likelihood of encountering potential instrument meteorological conditions (IMC). The experiences of other pilots, coupled with the forecast, might cause you to assign *"occasional"* to determine the probability of encountering IMC.

The following are guidelines for making assignments.

Probable: An event will occur often.
Occasional: An event will probably occur sometime.
Remote: An event is unlikely to occur, but is possible.
Improbable: An event is highly unlikely to occur.

Severity of an Event

The next element is the severity or consequence of your action. It can relate to injury and/or damage. In the example above, what are the consequences of you encountering IMC conditions? In this case, because most powered parachutes don't have the proper instrumentation and you probably don't have the training in any case, the consequences are catastrophic. The following are guidelines for this assignment.

Catastrophic: Results in fatalities and/or total loss.
Critical: Severe injury and/or major damage.
Marginal: Minor injury and/or minor damage.
Negligible: Less than minor injury and/or less than minor system damage.

Simply connecting the two factors as shown in Risk Assessment Matrix on the opposite page indicates the risk is high and you must either not fly or fly only after finding ways to mitigate, eliminate, or control the risk.

Mitigating Risk

Risk assessment is only part of the equation. After determining the level of risk, the pilot needs to mitigate the risk. For example, the pilot planning a 20 mile cross country flight in MVFR conditions has several ways to reduce risk:

- Wait for the weather to improve to good visual flight rules (VFR) conditions
- Delay the flight
- Cancel the flight
- Drive

One of the best ways you can mitigate risk is to use the IMSAFE checklist to determine physical and mental readiness for flying.

Prior to flight, assessing your own fitness is as important as evaluating the airplane's airworthiness.

The Decision-Making Process

Making good decisions is how you assess and mitigate risk. ADM and Single-Pilot Resource Management (SRM) skills are what you use to make those decisions. Keep in mind that not every bad situation is suited for a decision-making "*process*." For example, if your engine fails in flight, you need to immediately respond using established procedures. But more often, there is time during a flight for you to analyze any changes that occur, gather information, and assess risks before deciding your course of action.

Risk management and risk intervention are decision-making processes designed to systematically identify hazards, assess the degree of risk, and determine the best course of action. These processes involve the identification of hazards, followed by assessments of the risks, analysis of the controls, making control decisions, using the controls, and monitoring the results.

The DECIDE Model

Using the acronym "*DECIDE*," this six-step process model is one of a few continuous loop processes that provides the pilot with a logical way of making decisions. DECIDE means to Detect, Estimate, Choose a course of action, Identify solutions, Do the necessary actions, and Evaluate the effects of the actions.

Detect (the Problem) Problem detection is the first step in the decision-making process. You begin by recognizing that a change occurred, or an expected change did not occur. You use your senses to perceive a possible problem, then use your insight and experience to determine it is truly a problem. These same abilities, as well as an objective analysis of all available information, are used to determine the nature and severity of the problem. One critical error made during the decision-making process is incorrectly detecting the problem.

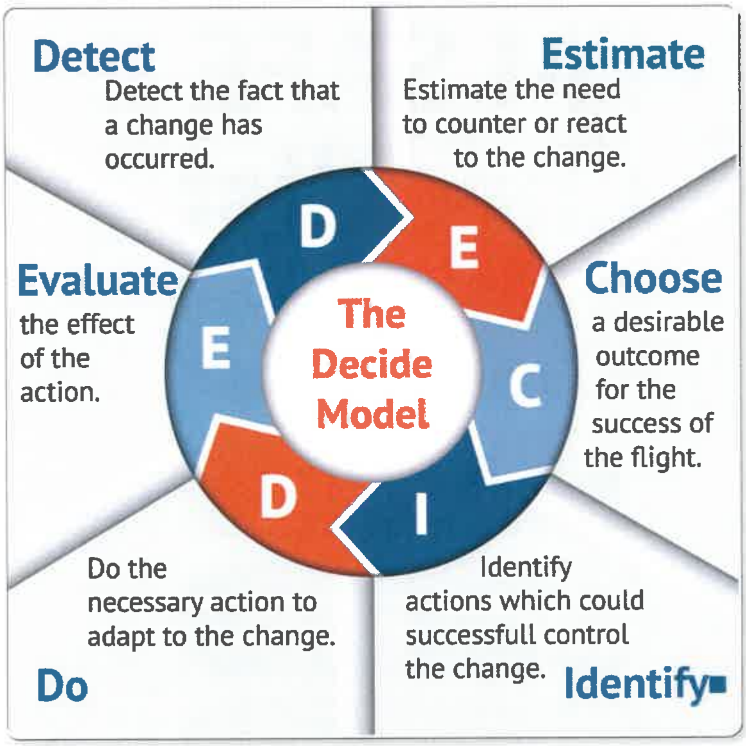
Estimate (the Need to React) After you determine the nature of the problem, it's time to estimate the impact of the change and then the need to counter or react to the change.

Choose (a Course of Action) After the problem has been identified and its impact estimated, you must determine the desirable outcome and choose a course of action.

Identify (Solutions) You then formulate a plan that will take you to the objective. Sometimes, there may be only one course of action available. It is important for you not to become fixated on the process to the exclusion of making a decision.

Do (the Necessary Actions) Now it's time to execute the chosen course of action.

Evaluate (the Effect of the Action) Finally, after implementing a solution, evaluate the decision to see if it was correct. If the action taken did not provide the desired results, the process may have to be repeated.



The DECIDE Model.

Automatic Decision-Making

In an emergency, you might not survive if you rigorously apply analytical models to every decision made since there is not enough time. Under these circumstances you should attempt to find the best possible solution to every problem.

For the past several decades, research into how people make decisions has revealed that when pressed for time, experts faced with a task loaded with uncertainty first assess whether the situation strikes them as familiar. Rather than comparing the pros and cons of different approaches, they quickly imagine how one or a few possible courses of action in such situations will play out. Experts take the first workable option they can find. While it may not be the best of all possible choices, it often yields remarkably good results, particularly if action is needed but not taken because of *"analysis paralysis"*.

The ability to make automatic decisions holds true for a range of experts, from firefighters to chess players. The expert's ability hinges on recognizing patterns and consistencies that clarify options in complex situations. Experts make provisional sense of a situation, without reaching a decision, by launching experience-based actions that trigger creative revisions.

This is a reflexive type of decision-making anchored in training and experience and is most often used in times of emergencies when there is no time to practice analytical decision-making. Naturalistic or automatic decision-making improves with training and experience, and you will find yourself using a combination of decision-making tools that correlate with your individual experience and training.

Single-Pilot Resource Management (SRM)

SRM is defined as the art and science of managing all the resources (both on-board the aircraft and from outside sources) available to a single pilot (prior to and during flight) to ensure the successful outcome of the flight.

SRM is all about helping you learn how to gather information, analyze it, and make decisions. This is not as straightforward as the training involved in learning specific maneuvers. Learning how to judge a situation and *"how to think"* in the endless variety of situations encountered while flying out in the *"real world"* is more difficult.

You can find resources both inside and outside the flight deck. Useful tools and sources of information may not always be readily apparent. You should learn to identify those resources and learn to evaluate whether there is time to use a particular resource and the impact its use will have upon the safety of flight.

Internal Resources

One of the most underutilized resources may be your passenger, even if the passenger has no flying experience. When appropriate, you can ask your passenger to assist with certain tasks, such as these:

- Confirm that the parachute is inflated and centered.
- Watch for traffic.
- Read checklist items.
- Provide information in an irregular situation, especially if familiar with flying. A strange smell or sound may alert a passenger to a potential problem.
- Listen for logic or lack of logic.

Also, the process of a verbal briefing (which can happen before or after passengers are aboard) can help you in the decision-making process. For example, if you brief your passenger on traffic that you see in the pattern, you will then pay closer attention to the traffic yourself.

When flying alone, another internal resource is verbal communication. Saying something aloud reinforces an activity. Touching or pointing at an object while communicating further enhances the probability you will do that activity. Pointing and saying improves safety, even if you are the only one listening.

It's necessary for you to have a thorough understanding of all the equipment and systems in your aircraft. Lack of knowledge, such as knowing how much fuel your engine burns per hour, is the difference between making a wise decision or a poor one that could lead to a tragic error.

External Resources

Your best external resources are other powered parachute pilots flying in the pattern. If you have a concern while preparing to fly or while flying, talk to them. For example, they can provide you with wind conditions they are experiencing if they take off before you do.

The emergency frequency (121.5 MHz) is available but should only be used in extreme situations. A more useful frequency may be the local airport's common traffic advisory frequency that other powered parachute pilots may normally be using.

Workload Management

Effective workload management ensures you will perform essential operations by planning, prioritizing, and sequencing tasks. As you gain experience, you will learn to handle future workload requirements and to prepare for high workload periods during times of low workload. By reviewing the appropriate chart and setting radio frequencies well in advance of when needed, you can reduce your workload as you approach an airport. You should also listen to airport weather and monitor the Common Traffic Advisory Frequency (CTAF) to learn what traffic conditions to expect.

Recognizing a work overload situation is also important. As workload increases, you may find that you cannot turn your attention to several tasks at once. The result is that you may begin to focus on one item. If you become task saturated, you will lack awareness of input from some of your sources, increasing your probability of error.

When you realize you are reaching work overload, you need to stop, think, slow down, and prioritize. It's important to understand how to decrease workload. Putting things into the proper perspective, remaining calm, and thinking rationally are key elements in reducing stress and increasing the capacity to fly safely. You will gain this ability with experience, discipline, and training.

Checklists

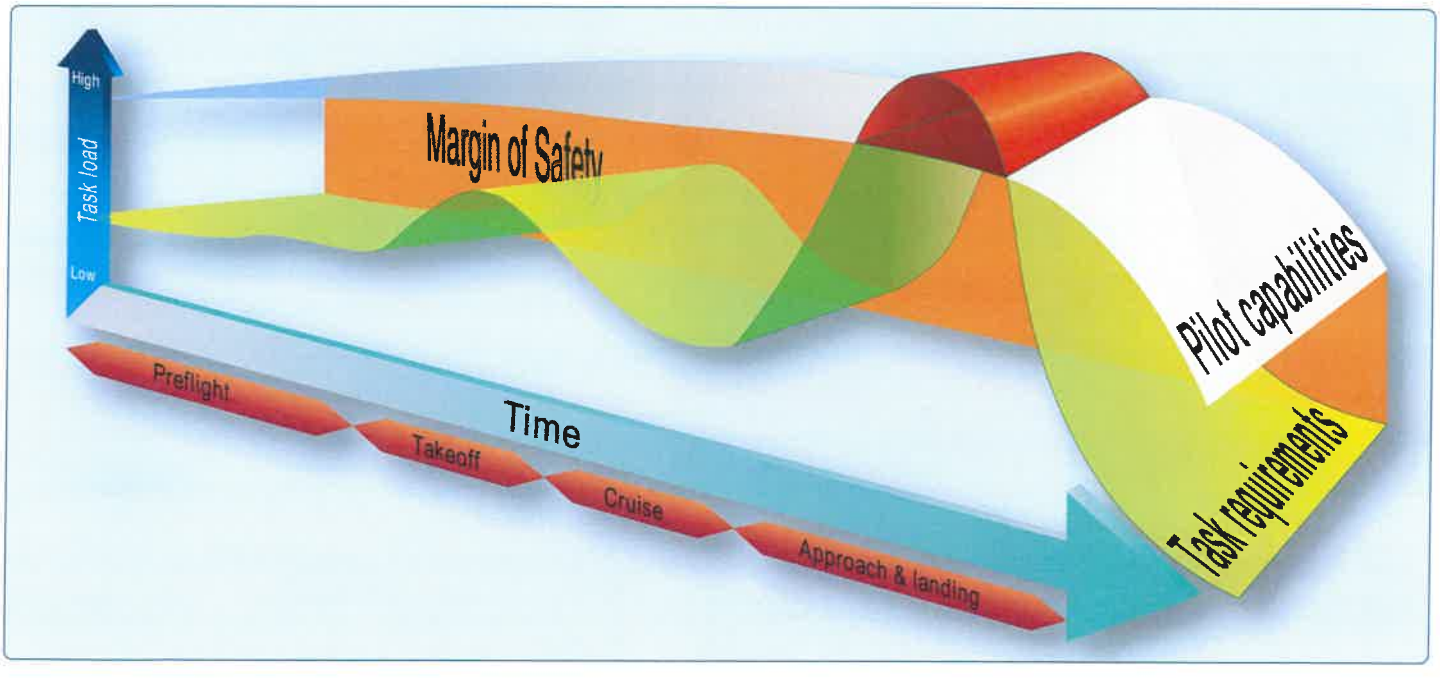
An excellent tool for managing workload is the checklist. Using appropriate checklists allow you to avoid overlooking important steps. In fact, consistent adherence to approved checklists is a sign of a disciplined and competent pilot.

On the other hand, a pilot's unjustified reliance on short- and long-term memory, regular flying skills, repetitive and familiar routes usually results in a pilot's neglect of flight planning, preflight inspections, and checklists.

Managing Risks

The ability to manage risks begins with preparation. Here are some things a pilot can do to manage risks:

- Assess the flight's risk based upon experience. Use some form of risk assessment. For example, if the weather is marginal, it's probably a good idea to cancel the flight.
- Brief passengers using the SAFETY list.
- Discuss with passengers the controls and what they do.
- Use a sterile flight deck (one that is completely silent with no pilot communication with your passenger) from the time of engine start to when you level off after takeoff.
- Use a sterile flight deck during landing.
- Keep your passenger informed during times when the workload is low.
- Consider using the passenger for simple tasks, such as looking for other traffic.



S	**Seat belts** fastened for taxi, takeoff, landing. **Shoulder harness** fastened for takeoff, landing
A	**Action** in case of any passenger discomfort
F	**Flight profile** (what to expect on takeoff)
E	**Emergency evacuation plan** **Emergency/survival kit** (location and contents)
T	**Traffic** (scanning, spotting, notifying pilot) **Talking,** (*"sterile flight deck"* expectations)
Y	**Your questions?** (Speak up!)

The Psychology of Decision-Making

No matter how many ADM tools you're armed with, you won't make good decisions if you don't have the right mindset. Being a safe pilot doesn't just happen, it takes work. And for some of us, it takes more work than others.

The FAA is very interested in safe pilots, and for good reason. They aren't necessarily worried about powered parachute pilots, they're worried about airline pilots. But we can take advantage of the FAA's interest in safety.

One of the things the FAA did was oversee an extensive research study on the similarities and dissimilarities of accident-free pilots and those who were not. The project surveyed over 4,000 pilots, half of whom had *"clean"* records while the other half had been involved in an accident.

1. **Physical Stress**
   Conditions associated with the environment, such as temperature and humidity extremes, noise, vibration, and lack of oxygen.
2. **Physiological Stress**
   Physical conditions, such as fatigue, lack of physical fitness, sleep loss, missed meals (leading to low blood sugar levels), and illness.
3. **Psychological Stress**
   Social or emotional factors, such as a death in the family, a divorce, a sick child, or a demotion at work. This type of stress may also be related to mental workload, such as analyzing a problem, navigating an aircraft, or making decisions.

The three types of stressors that can affect a pilot's performance.

Five traits were discovered in pilots prone to having accidents. These pilots:

- Have disdain toward rules
- Have very high correlation between accidents on their flying records and safety violations on their driving records
- Frequently fall into the *"thrill and adventure seeking"* personality category
- Are impulsive rather than methodical and disciplined, both in their information gathering and in the speed and selection of actions to be taken
- Have a disregard for or tend to under utilize outside sources of information, including copilots, flight attendants, flight service personnel, flight instructors, and ATC.

People in the automobile insurance industry know this, too. For some reason, the same people seem to have car accidents over and over. Deer just seem to hit some people's cars more than others. Is it really the fault of the deer?

We'll wrap this chapter up with discussions on stress, hazardous attitudes and operational pitfalls. Sure, these are things you need to know for your knowledge test. But if you take them seriously, you may be able to keep yourself out of bad situations and hospital beds.

The Impact of Stress

Stress is an inherent part of flying, and it can greatly impact decision-making and the overall outcome of a flight. While *Chapter 6, "Aeromedical Factors,"* explores stress in greater detail, here are some ways it affects decision-making:

Cognitive Impairment: Stress triggers the release of cortisol, which affects your memory and cognitive functions. It can also narrow your attention, making it difficult to process complex information.

Increased Reaction Time: Stress induces a *"fight or flight"* response, slowing down cognitive processes and physical reactions. Quick decision-making becomes challenging, impacting response time to unexpected events.

Tunnel Vision: High stress can lead to tunnel vision, where you fixate on one aspect and miss critical information. You may become less aware of your surroundings, increasing the risk of overlooking potential hazards.

Risky Decision-Making: Stress often promotes a bias towards quick decisions, even if they are risky. You may underestimate risks due to the urgency created by stress.

Emotional Influence: Heightened Emotions: Stress amplifies emotional responses, potentially clouding rational decision-making.

Fear and Anxiety: Elevated stress levels can intensify feelings of fear and anxiety, affecting a your ability to make calm and calculated decisions.

Hazardous Attitudes

Good judgment is key to proper risk assessment. Judgment is the mental process of recognizing and analyzing all pertinent information in a particular situation, a rational evaluation of alternative actions in response to it, and a timely decision on which action to take. Your own attitude can work to impair your judgment.

Attitude is your motivational predisposition to respond to people, situations, or events in a given manner. Fortunately, training can help you modify predisposition for the better.

Studies have identified five hazardous attitudes that can interfere with your ability to make sound decisions and exercise authority properly: anti-authority, impulsivity, invulnerability, macho, and resignation.

Hazardous thoughts can contribute to poor judgment. Your first step toward neutralizing hazardous thoughts is to recognize them. After recognizing a thought as hazardous, you should label it as hazardous, then state the corresponding antidote.

Antidotes should be memorized for each of the five hazardous attitudes below so they automatically come to mind when needed.

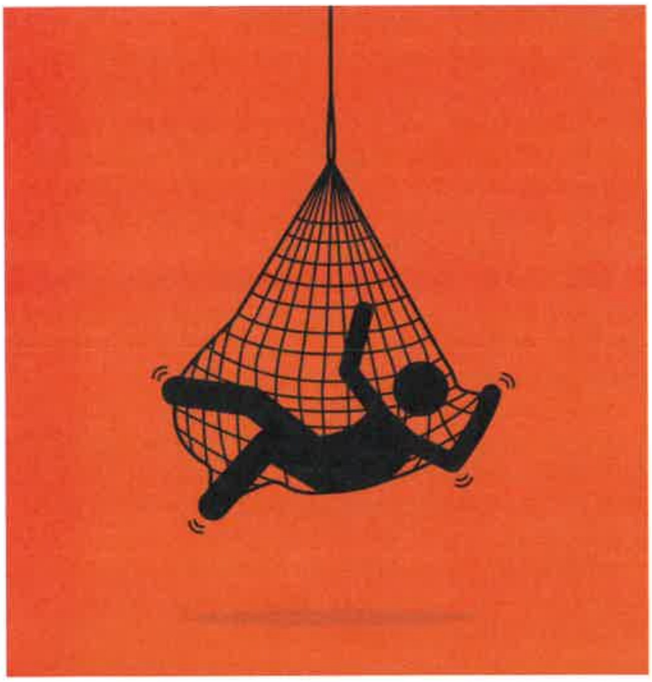
Do you know yourself well enough to know your own possible hazardous attitudes? If you don't, ask a close friend. The people you know (and who know you!) probably have a more objective take on how you behave. In addition, there are tests you can take to determine what your own hazardous attitudes may be. Simply do an internet search on *"hazardous attitude inventory test"* and you will find free assessments you can take.

The Five Hazardous Attitudes	Antidote
Anti-authority: *"Don't tell me."* This attitude is found in people who do not like anyone telling them what to do. In a sense, they are saying, *"No one can tell me what to do."* They may be resentful of having someone tell them what to do or may regard rules, regulations, and procedures as silly or unnecessary. However, it is always your prerogative to question authority if you feel it is in error.	**Follow the rules. They are usually right.**
Impulsivity: *"Do it quickly."* This is the attitude of people who frequently feel the need to do something, anything, immediately. They do not stop to think about what they are about to do, they do not select the best alternative, and they do the first thing that comes to mind.	**Not so fast. Think first.**
Invulnerability: *"It won't happen to me."* Many people falsely believe that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. However, they never really feel or believe that they will be personally involved. Pilots who think this way are more likely to take chances and increase risk.	**It could happen to me.**
Macho: *"I can do it."* Pilots who are always trying to prove that they are better than anyone else think, *"I can do it—I'll show them."* Pilots with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.	**Taking chances is foolish.**
Resignation: *"What's the use?"* Pilots who think, *"What's the use?"* do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the pilot is apt to think that it is good luck. When things go badly, the pilot may feel that someone is out to get them or attribute it to bad luck. The pilot will leave the action to others, for better or worse. Sometimes, such pilots will even go along with unreasonable requests just to be a *"nice guy."*	**I'm not helpless. I can make a difference.**

The five hazardous attitudes and their antidotes.

Operational Pitfalls

Although more experienced pilots are likely to make good automatic decisions, there are also tendencies or operational pitfalls that come with the development of pilot experience. These are classic behavioral traps into which pilots have been known to fall. More experienced pilots, as a rule, try to complete a flight as planned, please passengers, and meet schedules. The desire to meet these goals can have an adverse effect on safety and contribute to an unrealistic assessment of piloting skills. The basic drive for a pilot to demonstrate the 'right stuff' can have an adverse effect on safety, by generating tendencies that lead to practices that are dangerous, often illegal, and may lead to a mishap. All experienced pilots have been tempted by one or more of these tendencies. These dangerous tendencies or behavior patterns, which must be identified and eliminated, include the operational pitfalls shown below:



Peer pressure: Poor decision-making may be based upon an emotional response to peers, rather than evaluating a situation objectively.

Mindset: A pilot displays a mindset through an inability to recognize and cope with changes in a given situation.

Get-there-itis: This disposition impairs pilot judgment through a fixation on the original goal or destination, combined with a disregard for any alternative course of action.

Duck-under syndrome: This is a term used in aviation to describe a dangerous situation during landing where a pilot, instead of executing a standard go-around procedure and climbing to a safe altitude, attempts to land again at a low altitude after initially deciding to abort the landing. This behavior increases the risk of the aircraft coming into contact with obstacles, such as trees or buildings, and can lead to accidents and severe consequences for the aircraft and its occupants.
A pilot may be tempted to make it into an airport by descending below minimums during an approach. There may be a belief that there is a built-in margin of error in every approach procedure, or a pilot may not want to admit that the landing cannot be completed, and a missed approach must be initiated.
This isn't a normal powered parachute problem since we fly in non-instrument conditions.

Scud running: This occurs when a pilot tries to maintain visual contact with the terrain at low altitudes while instrument conditions exist.

Continuing visual flight rules (VFR) into instrument conditions: Spatial disorientation or collision with ground/obstacles may occur when a pilot continues VFR into instrument conditions. This can be even more dangerous if the pilot is not instrument rated or current.

Getting behind the aircraft: This pitfall can be defined as a pilot's allowing events or the situation to control his actions. This results in a constant state of surprise.

Loss of positional or situational awareness: In extreme cases, when a pilot gets behind the aircraft, a loss of positional or situational awareness may result. The pilot may not know the aircraft's geographical location or may be unable to recognize deteriorating circumstances.

Operating without adequate fuel reserves: Ignoring minimum fuel reserve requirements is the result of overconfidence, lack of flight planning, or disregarding applicable regulations.

Descent below the minimum en route altitude: The duck-under syndrome, as mentioned above, can also occur during the en route portion of an IFR flight.

Flying outside the envelope Here, the pilot overestimates the capability of his aircraft. This may cause the aircraft to fail or react unexpectedly to pilot input, which often is the result of the pilot's overestimating his flying skills.

Neglect of flight planning, preflight inspections, and checklists: A pilot may rely on short- and long-term memory, regular flying skills, and familiar routes instead of established procedures and published checklists. This can be particularly true of experienced pilots.

Chapter 4 Regulations

The Federal Aviation Administration (FAA) is the primary civil governing agency for aviation. State and local governments can regulate where aircraft take off and land, but flying is regulated by the federal government.

As you may well imagine, the FAA has a lot of regulations that you must be aware of and conform to. But there are also a lot of regulations that you can essentially ignore because they don't really apply to you.

FAA regulations are addressed throughout this book. For example, 'airspace' is clearly defined by the FAA, and you will find an entire chapter dedicated to it: *Chapter 25, "Airspace."* Other regulations will be highlighted in the context of other topics. This chapter discusses regulations you need to know, but which don't necessarily deserve a chapter of their own.

The Logic of Regulations

Sometimes FAA regulations don't seem to make any sense. That can be frustrating for pilots. However, regulations make more sense if you realize most of them weren't written for powered parachutes. The FAA refers to 'aircraft' in a lot of their rules, but the intent is to specifically regulate airplanes with little to no allowance for powered parachutes or other sport aircraft. In fact, many of the regulations were written decades before the FAA even officially recognized powered parachutes. That means that you end up needing to learn and do things that don't necessarily apply to powered parachute operations because you are still flying an *aircraft*.

FAA regulations are organized and referred to using a standardized system. The primary framework for FAA regulations is known as Title 14 of the Code of Federal Regulations (CFR), which specifically deals with Aeronautics and Space. Within Title 14 CFR, FAA regulations are further divided into different sections and parts, each addressing specific areas of aviation.

The individual sections of 14 CFR cover a wide range of topics related to aviation, such as regulations for pilots, air traffic control, airports, aircraft maintenance, certification, and operations. Each section is identified by a number, followed by the title and content description. For example, Section 91 of 14 CFR is titled *"General Operating and Flight Rules,"* which outlines the general regulations governing the operation of aircraft in the United States.

Within each section, the regulations are further categorized into parts. These parts are numbered and titled to reflect their specific subject matter.

When referring to a specific regulation within the FAA regulations, it is customary to cite the section and part numbers.

For example, a reference to 14 CFR 91.117 would be understood as a regulation found in Part 117 of Section 91, which pertains to the specific requirements for flight at altitudes and distances from cloud formations.

Often you will see regulations referred to in this format: 14 CFR §1.3(a). The "§" symbol stands for the section. This example refers to Part 1, Section 3, Paragraph a. A common shorthand is to refer to the whole thing above as *"Section 1.3, paragraph a."*

Sometimes the callouts will get even more precise with additional subparagraphs expressed with more sets of parentheses, numbers, and roman numerals. Here is an example of a reference that gets pretty darn specific: §61.313(g)(1)(ii). The reference is for the sub-sub-paragraph of Part 61, Section 313 that says that someone applying for a sport pilot certificate with powered parachute category privileges needs to have *"20 takeoffs and landings to a full stop in a powered parachute with each landing involving flight in the traffic pattern at an airport."*

Happily, the FAA regulations we're concerned with are (mostly) divided into logical groupings.

- Part 1 is a list of Definitions and Abbreviations
- Parts in the 20's, 30's, and 40's pertain to Aircraft
- Parts in the 60's pertain to Airmen
- Parts in the 70's pertain to Airspace
- Parts 89-107 (of course including parts in the 90's) pertain to Air Traffic and General Operating Rules

Part 1 | Definitions and Abbreviations

The definitions in Part 1 are legal definitions that pertain to the rest of the regulations that we are concerned with. A lot of them are included in the glossary of this book, but a few of them also deserve some honorable mention. If nothing else, you may see them on a test!

Category and Class

We start with definitions that mean two different, but similar things. It depends upon the context. If you're talking about pilot ratings, category refers to the type of aircraft and class is a sub-category of that. This is where a table helps.

Pilot Ratings

Category	Class
Airplane	Single-Engine Land Single-Engine Sea Multi-Engine Land Multi-Engine Sea
Rotorcraft	Helicopter Gyroplane
Glider	N/A
Lighter Than Air	Airship Balloon
Powered Lift	N/A
Powered Parachute	Land Sea
Weight-Shift-Control	Land Sea

For aircraft certification, category and class mean something different. Categories of aircraft for aircraft certification fall under Standard Airworthiness Certificates and Special Airworthiness Certificates. The actual categories may be a little foreign like Normal, Utility, and Transport, which describe how an aircraft is certified instead of what kind of aircraft it is.

For aircraft certification, the term *"class"* looks a little more familiar. For aircraft certification, class refers to broad groupings of aircraft that behave similarly. Examples include some familiar names from the table of category and class for airmen certifications.

- Airplane
- Rotorcraft
- Glider
- Balloon
- Landplane
- Seaplane
- Powered Parachute
- Weight-Shift-Control Aircraft

To be precise, you're likely reading this book to obtain a pilot certificate for Powered Parachute Land at the sport pilot or private pilot level. This certification will enable you to fly powered parachute:

- Special light-sport aircraft
- Experimental operating light-sport aircraft
- Experimental amateur-built powered parachute.

I know, I know. Why does the FAA use the same terms for similar, but not identical things? Someday I hope to find out.

Category

(1) As used with respect to the certification, ratings, privileges, and limitations of airmen, means a broad classification of aircraft. Examples include: airplane; rotorcraft; glider; and lighter-than-air; and

(2) As used with respect to the certification of aircraft, means a grouping of aircraft based upon intended use or operating limitations. Examples include: transport, normal, utility, acrobatic, limited, restricted, and provisional.

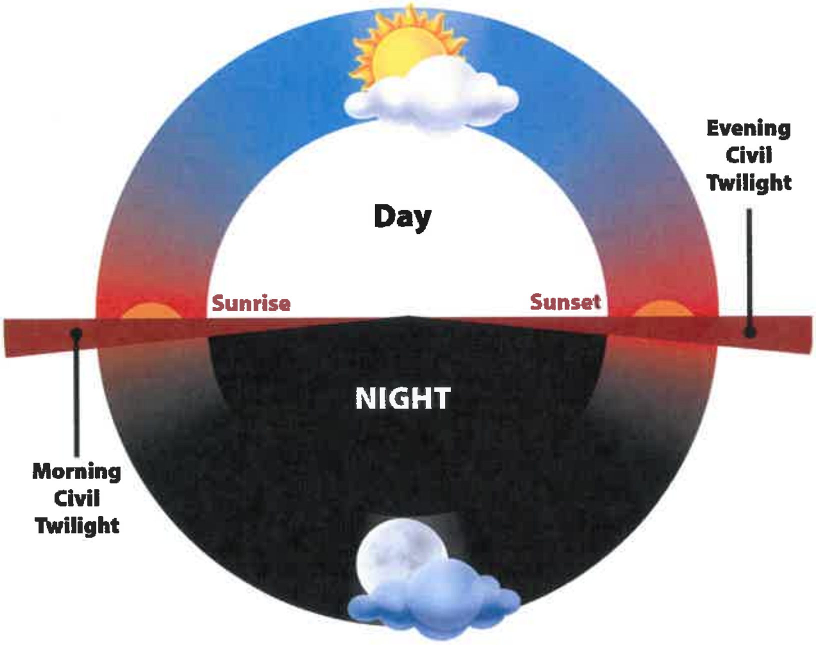
Class

(1) As used with respect to the certification, ratings, privileges, and limitations of airmen, means a classification of aircraft within a category having similar operating characteristics. Examples include: single engine; multiengine; land; water; gyroplane; helicopter; airship; and free balloon; and

(2) As used with respect to the certification of aircraft, means a broad grouping of aircraft having similar characteristics of propulsion, flight, or landing. Examples include: airplane; rotorcraft; glider; balloon; landplane; and seaplane.

Categories and Classes of Aircraft

Kind of Airworthiness Certificate	Category	Class
Standard	Normal	Airplane, Rotorcraft
Standard	Utility	Airplane, Rotorcraft
Standard	Acrobatic	Airplane
Standard	Commuter	Airplane, Rotorcraft
Standard	Transport	Airplane, Rotorcraft
Standard	Manned Free Balloon	Lighter Than Air
Standard	Manned Glider	Glider
Special	Restricted	Airplane, Rotorcraft
Special	Limited	Airplane, Rotorcraft
Special	Primary	Various
Special	Provisional	Various
Special	Special Flight Permit	Various
Special	Light-Sport	Airplane, Glider, Powered Parachute, Weight-Shift-Control, Lighter-than-Air
Special	Experimental | Research and Development	Various
Special	Experimental | Showing Compliance with Regulations	Various
Special	Experimental | Crew Training	Various
Special	Experimental | Exhibition	Various
Special	Experimental | Air Racing	Various
Special	Experimental | Market Survey	Various
Special	Experimental | Amateur-Built	Various
Special	Experimental | Light-Sport	Airplane, Glider, Powered Parachute, Weight-Shift-Control, Lighter-than-Air, Gyroplane



Light-Sport Aircraft

A light-sport aircraft is an aircraft that meets certain specifications. It really doesn't have anything to do with how it was certified. That's important in the airplane world since airplanes that were built decades before the sport pilot and light sport rules became law can be flown as light sport aircraft by sport pilots.

This is an important definition because it defines what the aircraft you can fly looks like. A light sport aircraft has everything to do with the specifications and how the aircraft is equipped. For example, a light sport aircraft can only have two seats. Any more seats and it is no longer a light sport aircraft and you cannot fly it as a sport pilot.

I left some of the points of the definition out of the definition shown above. Those were things (like floatplanes) that don't have anything to do with powered parachutes.

Night

This is an important definition because as a sport pilot, you can't fly at night. It's good to know how the FAA defines night. The explanation is a little technical, but official night begins about a half hour after sunset and ends about a half hour before sunrise.

There are web sites and apps that can provide you with the exact time for first light, sunrise, sunset and last light. An example for iOS is a free app named *"Sunrise Times."*

Powered Parachute

This definition is important and settles some controversies in the big world of American aviation. You will hear all kinds of terms describing powered parachutes. Paramotors, powered paraglider trikes, powered paraglider quads and other terms are used depending on the speaker and their background. Oftentimes they are describing lighter powered parachutes that fall under the ultralight regulations. So, it really doesn't matter how they label them since those vehicles are ultimately ultralights first.

Light-Sport Aircraft means an aircraft, other than a helicopter or powered-lift that, since its original certification, has continued to meet the following:

A maximum takeoff weight of not more than - 1,320 pounds (600 kilograms) for aircraft not intended for operation on water; ...
A maximum seating capacity of no more than two persons, including the pilot.
A single, reciprocating engine, if powered.
A fixed or ground-adjustable propeller if a powered aircraft other than a powered glider. ...
Fixed landing gear, except for an aircraft intended for operation on water or a glider...

Night means the time between the end of evening civil twilight and the beginning of morning civil twilight, as published in the Air Almanac, converted to local time.

Powered Parachute means a powered aircraft comprised of a flexible or semi-rigid wing connected to a fuselage so that the wing is not in position for flight until the aircraft is in motion. The fuselage of a powered parachute contains the aircraft engine, a seat for each occupant and is attached to the aircraft's landing gear.

Part 91 | General Operating and Flight Rules

Powered parachutes truly are flying machines for the average person. They are fun, easier to master than most aircraft, and are generally safer with their lower speeds and built-in parachute stability. All of those things are great, but powered parachutes are still aircraft, still bound by the safety regulations that other aircraft need to follow and can still hurt or even kill you if they aren't respected.

A sport doesn't have to be fast to be dangerous. For example, in horseback riding there is an average of one injury per hundred hours of riding. And a horse (of course) doesn't fly at 30+ mph.

There are basic safety precautions that you *should* follow. And if they are also cooked into the regulations, you *must* follow.

Careless or Reckless, the Big Catch-All

§91.13 *"Careless or reckless operation"* probably exists for two reasons. The first reason is that just in case someone does something that isn't quite prohibited in other regulations, but is still dangerous, the FAA has something to charge them with.

The second reason is something the FAA calls 'stacking.' Stacking is when the FAA throws the book at a pilot with the intent to plea things down to one or two charges that the pilot won't argue in court. If you get eight charges from the FAA and then the FAA Aviation Safety Inspector (ASI) says, *"But wait. We can make a deal."* keep in mind that making a deal may have been the goal all along. Also keep in mind that you should consider retaining an aviation attorney if you find yourself in trouble with the feds.

§ 91.13 Careless or reckless operation.

(a) Aircraft operations for the purpose of air navigation. No person may operate an aircraft in a careless or reckless manner so as to endanger the life or property of another.

(b) Aircraft operations other than for the purpose of air navigation. No person may operate an aircraft, other than for the purpose of air navigation, on any part of the surface of an airport used by aircraft for air commerce (including areas used by those aircraft for receiving or discharging persons or cargo), in a careless or reckless manner so as to endanger the life or property of another.

Dropping Objects

As it turns out, dropping objects from a powered parachute is not as benign as it may seem at first. Several people have been injured by aircraft dropping candy. Unfortunately, in at least one instance in powered parachuting, it was the aircraft that injured people and not the candy. In that particularly nasty case, a father and son team were dropping candy over a community event. The problem is that they dove their powered parachute too close to the ground for their 'bombing run' and didn't add power soon enough to level off and they ended up diving into the crowd with the propeller spinning.

Even without that kind of incident, a piece of candy hitting a child at 30+ mph seems like it could leave a mark. If you want to drop anything larger, even more care should be taken.

Still, dropping objects isn't illegal in itself. Just be safe when you do it.

§ 91.15 Dropping objects.

No pilot in command of a civil aircraft may allow any object to be dropped from that aircraft in flight that creates a hazard to persons or property. However, this section does not prohibit the dropping of any object if reasonable precautions are taken to avoid injury or damage to persons or property.

Formation Flying

Flying with friends is a lot of fun. A friend can be in the back seat in your powered parachute or better, friends can have their own powered parachutes. While flying with others, it's important to stay extra vigilant in order not to end up in a midair collision. Midair collisions don't happen often, but when they do, they seem to happen with people who know each other and have taken off from the same field.

When flying with friends or at fly-ins, you need to pay particular attention to the principles of collision avoidance. On top of that, you need to respect the FAA's regulations having to do with formation flying. The regulations say that you cannot fly so close to another aircraft as to create a collision hazard. And no person may operate an aircraft in formation flight except by prior arrangement with the pilot-in-command of each aircraft. Finally, (and this doesn't directly apply to sport pilots) no person may operate an aircraft in formation flight while carrying passengers for hire.

§ 91.111 Operating near other aircraft.
(a) No person may operate an aircraft so close to another aircraft as to create a collision hazard.
(b) No person may operate an aircraft in formation flight except by arrangement with the pilot in command of each aircraft in the formation.
(c) No person may operate an aircraft, carrying passengers for hire, in formation flight.

The NASA Report

If you make a mistake and break a rule, the federal government has a *"Get Out of Jail Free"* card for you. It's called making a NASA report. The idea is that if you tell on yourself, the FAA can't use that information for an enforcement action.

§ 91.25 Aviation Safety Reporting Program: Prohibition against use of reports for enforcement purposes.
The Administrator of the FAA will not use reports submitted to the National Aeronautics and Space Administration under the Aviation Safety Reporting Program (or information derived therefrom) in any enforcement action except information concerning accidents or criminal offenses which are wholly excluded from the Program.

Aircraft Used for Flight Instruction

There are times when student pilots want to learn in their own powered parachutes. Other times instructors will insist that students purchase a powered parachute before the instructors will provide instruction. There are valid reasons for both scenarios, but the aircraft must be equipped with working dual controls for the training to count.

§ 91.109 Flight instruction; Simulated instrument flight and certain flight tests.
(a) No person may operate a civil aircraft ... that is being used for flight instruction unless that aircraft has fully functioning dual controls...

PART 830 | Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records

Accident Reporting is the one set of regulations you need to know about that are Department of Transportation Regulations (Title 49) as opposed to Aeronautics and Space Regulations (Title 14). Title 14 is where every other regulation mentioned in this book finds its home.

NTSB Definitions

The National Transportation Safety Board (NTSB) requires that certain accidents and incidents be reported to them. Before getting into the details, it's good to first know what the NTSB means by the words accident or incident.

Aircraft Accident. For something to be an accident, at least the first criteria and one of the next two criteria must be met:

- The occurrence takes place between the time someone boards the aircraft with the intention of flight and the time when everyone has gotten off the aircraft.
- Someone suffers death or serious injury, or...
- The aircraft receives substantial damage.

Civil aircraft means any aircraft other than a public aircraft.

Fatal injury means any injury which results in death within 30 days of the accident.

Incident means an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

Operator means any person who causes or authorizes the operation of an aircraft, such as the owner, lessee, or bailee of an aircraft.

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§ 830.2 Definitions.

...

As used in this part the following words or phrases are defined as follows:

Aircraft accident means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. For purposes of this part, the definition of *"aircraft accident"* includes *"unmanned aircraft accident,"* as defined herein.

Civil aircraft means any aircraft other than a public aircraft.

Fatal injury means any injury which results in death within 30 days of the accident.

Incident means an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

Operator means any person who causes or authorizes the operation of an aircraft, such as the owner, lessee, or bailee of an aircraft.

Public aircraft means an aircraft used only for the United States Government, or an aircraft owned and operated (except for commercial purposes) or exclusively leased for at least 90 continuous days by a government other than the United States Government, including a State, the District of Columbia, a territory or possession of the United States, or a political subdivision of that government. ...

Serious injury means any injury which:

(1) Requires hospitalization for more than 48 hours, commencing within 7 days from the date of the injury was received;
(2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose);
(3) causes severe hemorrhages, nerve, muscle, or tendon damage;
(4) involves any internal organ; or
(5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.

Substantial damage means damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small punctured holes in the skin or fabric, ground damage to rotor or propeller blades, and damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered *"substantial damage"* for the purpose of this part.

Public aircraft means an aircraft

- Used only for the United States Government, or
- An aircraft owned and operated (except for commercial purposes) or exclusively leased for at least 90 continuous days by a government other than the United States Government, including a State, the District of Columbia, a territory or possession of the United States, or a political subdivision of that government.

Serious Incidents or Accidents include

- Flight control system malfunction or failure
- Aircraft collision in flight
- Inability of any required flight crew member to perform normal flight duties as a result of injury or illness
- In-flight fire
- Damage to property, other than the aircraft, estimated to exceed $25,000 for repair (including materials and labor) or fair market value in the event of total loss, whichever is less
- Release of all or a portion of a propeller blade from an aircraft, excluding release caused solely by ground contact
- An aircraft that is overdue for landing and is believed to have been involved in an accident

Serious injury means any injury which:

- Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received;
- Results in a fracture of any bone (except simple fractures of fingers, toes, or nose);
- Causes severe hemorrhages, nerve, muscle, or tendon damage;
- Involves any internal organ; or
- Involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.

Substantial damage means damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component.

Accident Reporting

If an aircraft is involved in an accident which results in substantial damage to the aircraft, the nearest NTSB field office should be notified immediately. In fact, an operator of an aircraft should notify the nearest NTSB office when an aircraft accident or any of the following listed serious incidents occur:

- Flight control system malfunction or failure
- Inability of any required flight crew member to perform normal flight duties as a result of injury or illness;
- In-flight fire
- Aircraft collision in flight
- Damage to property, other than the aircraft, estimated to exceed $25,000 for repair (including materials and

§ 830.5 Immediate notification.

The operator of any civil aircraft, or any public aircraft not operated by the Armed Forces or an intelligence agency of the United States, or any foreign aircraft shall immediately, and by the most expeditious means available, notify the nearest National Transportation Safety Board (NTSB) office when:

(a) An aircraft accident or any of the following listed serious incidents occur:

(1) Flight control system malfunction or failure;

(2) Inability of any required flight crewmember to perform normal flight duties as a result of injury or illness;

...

(4) In-flight fire;

(5) Aircraft collision in flight;

(6) Damage to property, other than the aircraft, estimated to exceed $25,000 for repair (including materials and labor) or fair market value in the event of total loss, whichever is less.

...

(8) Release of all or a portion of a propeller blade from an aircraft, excluding release caused solely by ground contact;

(9) A complete loss of information, excluding flickering, from more than 50 percent of an aircraft's cockpit displays known as:

(i) Electronic Flight Instrument System (EFIS) displays;

(ii) Engine Indication and Crew Alerting System (EICAS) displays;

(iii) Electronic Centralized Aircraft Monitor (ECAM) displays; or

(iv) Other displays of this type, which generally include a primary flight display (PFD), primary navigation display (PND), and other integrated displays;

...

(b) An aircraft is overdue and is believed to have been involved in an accident.

labor) or fair market value in the event of total loss, whichever is less.

- Release of all or a portion of a propeller blade from an aircraft, excluding release caused solely by ground contact
- A complete loss of information, excluding flickering, from more than 50 percent of an aircraft's flight deck displays known as Electronic Flight Instrument System (EFIS) displays or other displays of this type, which generally include a primary flight display (PFD), primary navigation display (PND), and other integrated displays.
- The operator of an aircraft should notify the nearest NTSB office when an aircraft is overdue and is believed to have been involved in an accident.

The pilot of an aircraft that has been involved in an accident is required to file an NTSB accident report within ten days.

You treat incidents differently. The operator of an aircraft that has been involved in an incident is required to submit a report to the nearest field office of the NTSB when requested.

What Isn't Reportable

If the incident doesn't involve a serious injury or fatality (as defined by the NTSB) and if the damage isn't substantial (as defined by the NTSB), then it isn't reportable. For example, while you are taxiing on the parking ramp, the landing gear, wheel, and tire are damaged by striking ground equipment. In that case, no notification or report is required to comply with NTSB Part 830.

Other examples of incidents that aren't normally considered and accident or serious incident include:

- An aircraft collision on the ground.
- The release of all or a portion of the propeller blade from an aircraft solely by ground contact.
- Damage such as:
  - Bent fairings or cowling.
  - Dented aircraft skin.
  - Small punctured holes in the skin or fabric.
  - Ground damage to rotor or propeller blades.
  - Damage to landing gear.
  - Damage to wheels, tires, or brakes.
  - Damage to engine accessories.
  - Damage to flaps or wingtips of an airplane.

Disturbing the Wreckage

Generally, you aren't supposed to bother a crash site until the NTSB or the FAA sends someone out to investigate. However, that isn't always possible. Aircraft wreckage may be moved prior to the time the NTSB takes custody to protect the wreckage from further damage.

§ 830.10 Preservation of aircraft wreckage, mail, cargo, and records.

(a) The operator of an aircraft involved in an accident or incident for which notification must be given is responsible for preserving to the extent possible any aircraft wreckage, cargo, and mail aboard the aircraft, and all records, including all recording mediums of flight, maintenance, and voice recorders, pertaining to the operation and maintenance of the aircraft and to the airmen until the Board takes custody thereof or a release is granted pursuant to § 831.12(b) of this chapter.

(b) Prior to the time the Board or its authorized representative takes custody of aircraft wreckage, mail, or cargo, such wreckage, mail, or cargo may not be disturbed or moved except to the extent necessary:

(1) To remove persons injured or trapped;

(2) To protect the wreckage from further damage; or

(3) To protect the public from injury.

(c) Where it is necessary to move aircraft wreckage, mail or cargo, sketches, descriptive notes, and photographs shall be made, if possible, of the original positions and condition of the wreckage and any significant impact marks.

(d) The operator of an aircraft involved in an accident or incident shall retain all records, reports, internal documents, and memoranda dealing with the accident or incident, until authorized by the Board to the contrary.

Other FAA Documents

There are many FAA documents besides regulations. Many of them further define regulations and some are purely informational. Some documents are produced for internal use by the FAA and others are meant both for FAA use and the general public.

Advisory Circulars (AC)

The most common supporting documents are called Advisory Circulars (ACs). ACs help explain regulations and offer assistance to individuals operating under them. For example, AC No: 61-65E, *"Certification: Pilots and Flight and Ground Instructors,"* helps Certified Flight Instructors (CFIs) with job aids like sample endorsements for their students. Unless incorporated into a regulation by reference, ACs provide nonregulatory information to the public and are not binding.

ACs are available to all pilots, with some free and others at cost. They can be ordered from the Government Printing Office. All aviation safety ACs can be obtained by following the procedures in the AC Checklist (AC 00-2) or by visiting the FAA website (**faa.gov**) and following the links to the ACs.

The AC numbering system aligns with the regulations they support. For example, FAA Advisory Circulars related to airmen are issued with numbers in the 60s, supporting the airmen regulations in the 60s. ACs related to airspace use subject numbers in the 70s, and those concerning Air Traffic Control and Operations use subject numbers in the 90s. This system ensures that the AC numbers correspond to their respective regulatory areas for easier reference and organization.

Handbooks

Handbooks focus on specific aviation activities, providing comprehensive and well-illustrated information. They're available for free in digital form from the FAA website (**faa.gov**). These handbooks are public domain, allowing private publishers to print and sell them. These resources cover various topics such as flight training, aircraft maintenance, aviation safety, and specific categories of aircraft.

Aeronautical Information Manual (AIM)

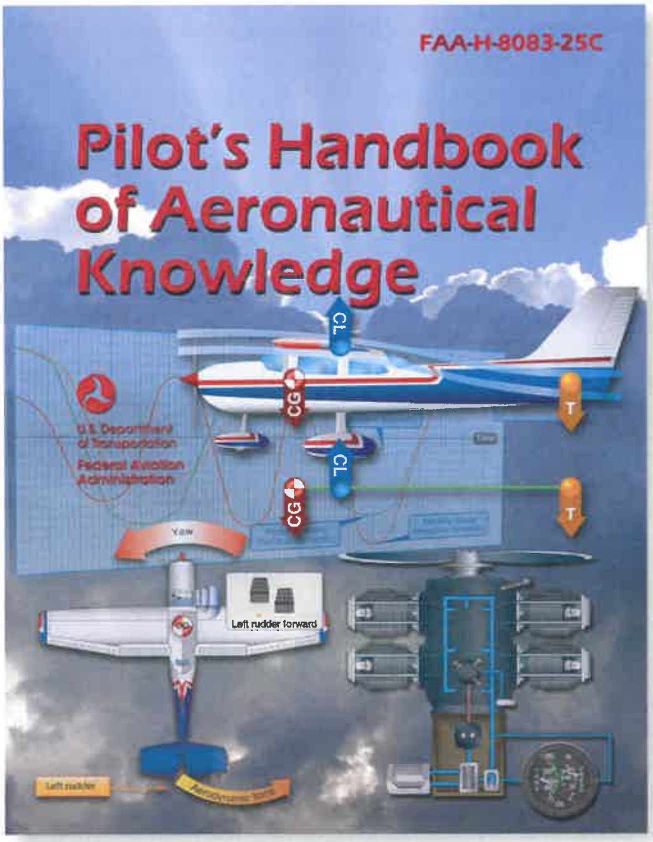
The Federal Aviation Administration publication that provides the aviation community with basic flight information and Air Traffic Control procedures for use in the National Airspace System (NAS) of the United States is the Aeronautical Information Manual (AIM). The AIM contains the fundamentals required to fly in the NAS. It's the source material for many of the FAA's other handbooks. Primarily illustrated in black and white, it may not be an exciting read, but the information is essential. When publishers print a FAR/AIM book, the AIM is the latter half. It's also available online at **faa.gov**.

Rule Preambles

A lot of information about a regulation can be found in its preamble. The preamble often explains the logic behind a particular rule or regulation. It presents the rule as originally proposed, includes a synopsis of public comments, and explains the final language used. This context helps in understanding the intent of the regulation. Although it doesn't have the force of law, the preamble can influence final judgments when laws are interpreted.

FAA Orders

Orders are primarily internal FAA documents that explain rules and procedures for FAA personnel. While publicly available, they are rarely used by the general public. Exceptions include FAA designees such as Designated Pilot Examiners (DPEs) or Designated Airworthiness Representatives (DARs), who perform specific tasks normally handled by FAA personnel. These designees need to understand the orders to ensure they perform their responsibilities correctly.



FAA Handbooks are great sources of information..

Chapter 5
Pilot Certificates and Documentation

To fly a non-ultralight powered parachute legally, you will need to earn your pilot certificate. There are two routes to becoming a powered parachute pilot. The most common route is obtaining a Sport Pilot certificate. Due to its prevalence, this chapter will focus on the Sport Pilot certificate pathway. The other option is a Private Pilot certificate, which is covered in *Chapter 28, "Night Operations."*

Sport Pilot Privileges

You will earn certain privileges with your Sport Pilot certificate. The biggest one is that you will be able to fly yourself and a passenger in a powered parachute that meets the definition of a light-sport aircraft. That means that you may be the pilot in command.

A light-sport powered parachute is an aircraft that meets the following specifications:

- A maximum takeoff weight capability of not more than 1,320 pounds. That means the powered parachute, you, your passenger, the fuel, and anything else on board.
- A maximum seating capacity of no more than two persons, including the pilot.
- A single, reciprocating engine.
- A fixed or ground-adjustable propeller
- Fixed landing gear

Your other –lesser– privilege is that you may share the operating expenses of a flight with your passenger, so long as the expenses involve only fuel, oil, airport expenses, or aircraft rental fees. But sharing means sharing. You must pay at least half the operating expenses of the flight. And expenses of the flight don't include depreciation or maintenance on the powered parachute.

Sport Pilot Limitations

The list of limitations for your sport pilot certificate is far longer than your privileges. Your biggest limitation is that you can fly only aircraft for which you have an endorsement, e.g., a powered parachute. You must get additional training and endorsements for other categories and classes of aircraft.

Following are the other important limitations to keep in mind. You may not act as pilot in command of a light-sport aircraft:

- For compensation or hire.
- In furtherance of a business.
- While carrying more than one passenger.
- At night.
- In Class A airspace.
- In Class B, C, and D airspace unless you have met additional training and endorsement requirements specified in § 61.325.
- Outside the United States, unless you have prior authorization from the country in which you seek to operate.
- To demonstrate the aircraft in flight to a prospective buyer if you are an aircraft salesperson.
- In a passenger-carrying airlift sponsored by a charitable organization.
- At an altitude of more than 10,000 feet MSL or 2,000 feet AGL, whichever is higher.
- When the flight or surface visibility is less than 3 statute miles.
- Without visual reference to the surface. (No flying above a solid cloud layer!)
- Contrary to any restriction or limitation on your U.S. driver's license or any restriction or limitation imposed by judicial or administrative order when using your driver's license to satisfy a requirement of this part.
- While towing any object.

Limitations for Pilots Transitioning from Other Aircraft

If you're already a private pilot for any other category of aircraft, most of the sport pilot limitations will still apply to you. For example, if you are a private pilot rated for airplane, you still will not be able to fly your powered parachute at night as a sport pilot.

In fact, the only limitation that doesn't apply to someone with a private pilot rating is the requirement for additional training to fly in Class B, C, and D airspace since you already received that training when you earned your private pilot certificate for another category of aircraft.

What Pilot Documents Do You Need to Fly?

The FAA requires that you carry three documents when you fly your powered parachute.

1. Pilot Certificate
2. Photo Identification
3. Medical Certificate

Pilot Certificate

Once you earn a pilot certificate, you're required to carry it whenever you pilot an aircraft. It must be in your personal possession or readily accessible in the aircraft anytime you are acting as the pilot-in-command.

Not only that, you need to be ready to present that pilot certificate to the proper authorities when they request it. Proper authorities include:

- The FAA Administrator (or any of his minions)
- The National Transportation Safety Board
- Any federal, state, or local law enforcement officer.

Photo Identification

Pilot certificates have never had anyone's photos on them except for Orville and Wilbur Wright. Therefore, the FAA requires you to carry a photo ID with you to prove that you are who you are. Most people simply use their driver's license, but other forms of ID work, too. All of the following documents work.

- Driver's License
- Government ID Card
- U.S. Military ID Card
- Passport
- Other form of identification that the Administrator finds acceptable

§ 61.315 What are the privileges and limits of my sport pilot certificate?

(a) If you hold a sport pilot certificate you may act as pilot in command of a light-sport aircraft, except as specified in paragraph (c) of this section.

(b) You may share the operating expenses of a flight with a passenger, provided the expenses involve only fuel, oil, airport expenses, or aircraft rental fees. You must pay at least half the operating expenses of the flight.

(c) You may not act as pilot in command of a light-sport aircraft:

(1) That is carrying a passenger or property for compensation or hire.

(2) For compensation or hire.

(3) In furtherance of a business.

(4) While carrying more than one passenger.

(5) At night.

(6) In Class A airspace.

(7) In Class B, C, and D airspace, at an airport located in Class B, C, or D airspace, and to, from, through, or at an airport having an operational control tower unless you have met the requirements specified in § 61.325.

(8) Outside the United States, unless you have prior authorization from the country in which you seek to operate. Your sport pilot certificate carries the limit "Holder does not meet ICAO requirements."

(9) To demonstrate the aircraft in flight to a prospective buyer if you are an aircraft salesperson.

(10) In a passenger-carrying airlift sponsored by a charitable organization.

(11) At an altitude of more than 10,000 feet MSL or 2,000 feet AGL, whichever is higher.

(12) When the flight or surface visibility is less than 3 statute miles.

(13) Without visual reference to the surface.

...

(15) Contrary to any operating limitation placed on the airworthiness certificate of the aircraft being flown.

(16) Contrary to any limit on your pilot certificate or airman medical certificate, or any other limit or endorsement from an authorized instructor.

(17) Contrary to any restriction or limitation on your U.S. driver's license or any restriction or limitation imposed by judicial or administrative order when using your driver's license to satisfy a requirement of this part.

(18) While towing any object.

...

Medical Certificate

Proving that you are medically qualified to fly as a sport pilot is as simple as having a driver's license. You may also use your FAA third class or higher medical certificate if you have one.

There are exceptions to being able to use your driver's license as your medical. And those exceptions apply to you if you lost your FAA medical for health reasons. Specifically, if you have previously applied for or held a medical certificate you may exercise the privileges of a sport pilot certificate using your U.S. driver's license only if:

- You were found eligible for the issuance of at least a third-class airman medical certificate at the time of your most recent application; and
- You have not had your most recently issued medical certificate suspended or revoked or your most recent Authorization for a Special Issuance of a Medical Certificate withdrawn.

What this means in practical terms is that:

- If you never applied for a third class medical, you're fine.
- If you have a third class medical, you're fine.
- If you once had a third class medical, but let it go without applying for a new one, you're fine.
- If you tried to apply for a third class medical and were turned down, you're screwed.
- If you had your medical suspended or revoked, you're screwed.

Now screwed isn't official FAA language, but it probably should be. Not all is lost, you but must go through the hassle and expense to solve the medical issue and get your third class medical before you can fly as a sport pilot. If you do manage to do that, the best thing to do after that is to not apply for an FAA medical ever again if all you want to do is fly as a sport pilot.

§ 61.3 Requirement for certificates, ratings, and authorizations.

(a) Required pilot certificate for operating a civil aircraft of the United States. No person may serve as a required pilot flight crewmember of a civil aircraft of the United States, unless that person:
  (1) Has in the person's physical possession or readily accessible in the aircraft when exercising the privileges of that pilot certificate or authorization -
    (i) A pilot certificate issued under this part and in accordance with § 61.19;
    ...
    (iii) A temporary certificate issued under § 61.17;
    (iv) A document conveying temporary authority to exercise certificate privileges issued by the Airmen Certification Branch under § 61.29(e);
    ...
  (2) Has a photo identification that is in that person's physical possession or readily accessible in the aircraft when exercising the privileges of that pilot certificate or authorization. The photo identification must be a:
    (i) Driver's license issued by a State, the District of Columbia, or territory or possession of the United States;
    (ii) Government identification card issued by the Federal government, a State, the District of Columbia, or a territory or possession of the United States;
    (iii) U.S. Armed Forces' identification card;
    (iv) Official passport;
    (v) Credential that authorizes unescorted access to a security identification display area at an airport regulated under 49 CFR part 1542; or
    (vi) Other form of identification that the Administrator finds acceptable.
    ...

(c) Medical certificate.
  (1) A person may serve as a required pilot flight crewmember of an aircraft only if that person holds the appropriate medical certificate issued under part 67 of this chapter, or other documentation acceptable to the FAA, that is in that person's physical possession or readily accessible in the aircraft. Paragraph (c)(2) of this section provides certain exceptions to the requirement to hold a medical certificate.
  (2) A person is not required to meet the requirements of paragraph (c)(1) of this section if that person -
    ...
    (iii) Is exercising the privileges of a student pilot certificate while seeking a pilot certificate with a weight-shift-control aircraft category rating or a powered parachute category rating and holds a U.S. driver's license;
    ...
    (v) Is exercising the privileges of a sport pilot certificate with other than glider or balloon privileges and holds a U.S. driver's license. A person who has applied for or held a medical certificate may exercise the privileges of a sport pilot certificate using a U.S. driver's license only if that person -
      (A) Has been found eligible for the issuance of at least a third-class airman medical certificate at the time of his or her most recent application; and
      (B) Has not had his or her most recently issued medical certificate suspended or revoked or most recent Authorization for a Special Issuance of a Medical Certificate withdrawn.
    ...

Maintaining Your Pilot Certificate

After you earn your pilot certificate, you will have to maintain it throughout your flying career. The FAA wants you to stay safe and its well-known that flying skills are perishable. You can't expect to learn to fly one year, not fly for years, and then jump into a powered parachute and expect to be a safe and competent pilot. Not only that, there are administrative things you should do when you move or change your name.

When Does Your Pilot Certificate Expire?

The short answer is that your permanent pilot certificate doesn't ever expire. You don't ever have to renew it. That said, there are some details you should know about.

The temporary certificate that your examiner issues you immediately after you pass your check ride is just that, temporary. Your examiner issues that so that you can begin flying right away while the FAA works on processing and issuing your permanent, plastic, green card. That card is the one without an expiration date.

That doesn't mean that the permanent pilot certificate you get is necessarily the only permanent pilot certificate you will ever get. There are reasons that you and the FAA will want the card to be updated. Those reasons include:

- When you move and change your address
- When you get an additional pilot rating
- When you change your name
- When you change your nationality or citizenship
- When you change your date of birth
- And yes, when you change your gender

> **§ 61.19 Duration of pilot and instructor certificates and privileges.**
> (a) General.
> (1) The holder of a certificate with an expiration date may not, after that date, exercise the privileges of that certificate.
> (2) Except for a certificate issued with an expiration date, a pilot certificate is valid unless it is surrendered, suspended, or revoked.
> ...
> (c) Pilot certificates.
> (1) A pilot certificate ... issued under this part is issued without a specific expiration date.
> ...

Change of Name

Changing your name on your pilot certificate is a rare requirement, but it's pretty straight-forward. To obtain a new airman certificate that reflects a legal name change, you need to visit an FAA Flight Standards District Office (FSDO) for positive identification. Bring your pilot certificate along with a photocopy of the marriage license, court order, or other valid legal document, which legally verifies your name change. The FAA inspector there will take care of the rest.

To change your nationality, citizenship, gender, or date of birth, follow the same procedure. Bring your airman certificate and legal proof of the change and the FAA inspector will take care of the rest.

Change of Address

If you move, you have 30 days to change your address with the FAA Airmen Certification Branch in Oklahoma City. You may contact them by mail, or perhaps easier, through the FAA website, **faa.gov**.

If a certificated pilot changes permanent mailing address and fails to notify the FAA Airmen Certification Branch of the new address, the pilot is entitled to exercise the privileges of the pilot certificate for a period of only 30 days after the date of the move.

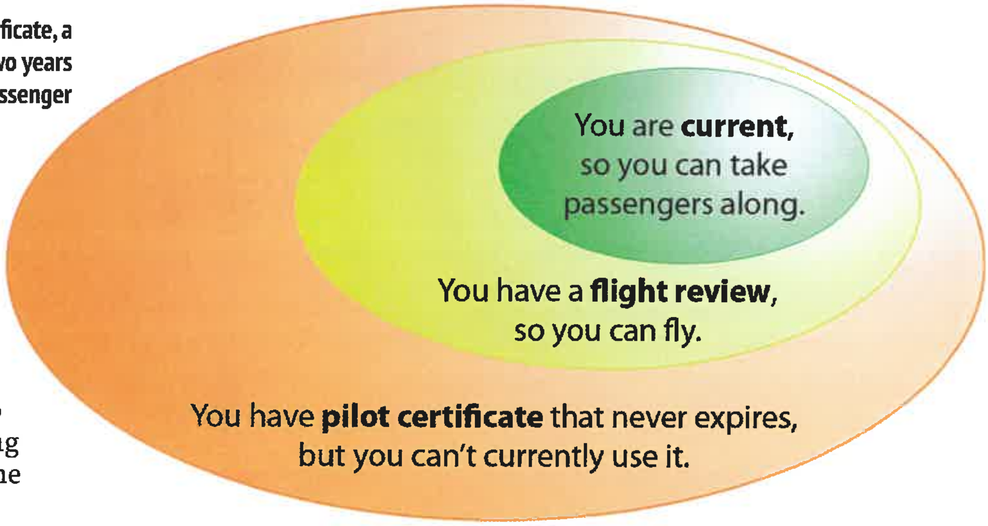
Replacing a Lost Airman Certificate

There are procedures for replacing lost pilot licenses, medicals, and knowledge reports. For lost airman certificates, you can write the Airmen Certification Branch in Oklahoma City or visit **faa.gov**. It will cost you a big $2.00 at the time of this writing.

You shouldn't have to replace a lost knowledge test report because they are also captured digitally on IACRA and available for viewing and downloading by your CFI and pilot examiner.

Replacing a lost medical certificate is explained in the regulation in the sidebar.

> **§ 61.25 Change of name.**
> (a) An application to change the name on a certificate issued under this part must be accompanied by the applicant's:
> (1) Airman certificate; and
> (2) A copy of the marriage license, court order, or other document verifying the name change.
> (b) The documents in paragraph (a) of this section will be returned to the applicant after inspection.



You have to have a pilot certificate, a flight review within the last two years and be current to take a passenger

If the need is urgent, you can also get a letter from the FAA authorizing you to fly while you're waiting for the replacement pilot certificate.

Three Levels of Ability

When you're first issued your pilot certificate, you are fully ready to go. You have your certificate, you have the equivalent of a flight review, and you are current. That means that you can take along a passenger right away. But even though your pilot certificate is virtually forever, flight reviews and currency are different things entirely. In order fly yourself, you need not only a pilot certificate, you also need a flight review which expires after two years. And if you want to take passengers with you, you need a flight review *and* you need to be current. If you look at it graphically, it looks like the image above.

§ 61.60 Change of address.
The holder of a pilot, flight instructor, or ground instructor certificate who has made a change in permanent mailing address may not, after 30 days from that date, exercise the privileges of the certificate unless the holder has notified in writing the FAA, Airman Certification Branch, P.O. Box 25082, Oklahoma City, OK 73125, of the new permanent mailing address, or if the permanent mailing address includes a post office box number, then the holder's current residential address.

§ 61.29 Replacement of a lost or destroyed airman or medical certificate or knowledge test report.

(a) A request for the replacement of a lost or destroyed airman certificate issued under this part must be made:

- (1) By letter to the Department of Transportation, FAA, Airmen Certification Branch, P.O. Box 25082, Oklahoma City, OK 73125, and must be accompanied by a check or money order for the appropriate fee payable to the FAA; or
- (2) In any other manner and form approved by the Administrator including a request online to Airmen Services at http://www.faa.gov, and must be accompanied by acceptable form of payment for the appropriate fee.

...

(d) The letter requesting replacement of a lost or destroyed airman certificate, medical certificate, or knowledge test report must state:

- (1) The name of the person;
- (2) The permanent mailing address (including ZIP code), or if the permanent mailing address includes a post office box number, then the person's current residential address;
- (3) The certificate holder's date and place of birth; and
- (4) Any information regarding the -
  - (i) Grade, number, and date of issuance of the airman certificate and ratings, if appropriate;
  - (ii) Class of medical certificate, the place and date of the medical exam, name of the Airman Medical Examiner (AME), and the circumstances concerning the loss of the original medical certificate, as appropriate; and
  - (iii) Date the knowledge test was taken, if appropriate.

(e) A person who has lost an airman certificate, medical certificate, or knowledge test report may obtain, in a form or manner approved by the Administrator, a document conveying temporary authority to exercise certificate privileges from the FAA Aeromedical Certification Branch or the Airman Certification Branch, as appropriate, and the:

- (1) Document may be carried as an airman certificate, medical certificate, or knowledge test report, as appropriate, for up to 60 days pending the person's receipt of a duplicate under paragraph (a), (b), or (c) of this section, unless the person has been notified that the certificate has been suspended or revoked.
- (2) Request for such a document must include the date on which a duplicate certificate or knowledge test report was previously requested.

§ 61.56 Flight review.

(a) Except as provided in paragraphs (b) and (f) of this section, a flight review consists of a minimum of 1 hour of flight training and 1 hour of ground training. The review must include:

(1) A review of the current general operating and flight rules of part 91 of this chapter; and

(2) A review of those maneuvers and procedures that, at the discretion of the person giving the review, are necessary for the pilot to demonstrate the safe exercise of the privileges of the pilot certificate.

...

(c) Except as provided in paragraphs (d), (e), and (g) of this section, no person may act as pilot in command of an aircraft unless, since the beginning of the 24th calendar month before the month in which that pilot acts as pilot in command, that person has -

(1) Accomplished a flight review given in an aircraft for which that pilot is rated by an authorized instructor and

(2) A logbook endorsed from an authorized instructor who gave the review certifying that the person has satisfactorily completed the review.

(d) A person who has, within the period specified in paragraph (c) of this section, passed any of the following need not accomplish the flight review required by this section:

(1) A pilot proficiency check or practical test conducted by an examiner, an approved pilot check airman, or a U.S. Armed Force, for a pilot certificate, rating, or operating privilege.

(2) A practical test conducted by an examiner for the issuance of a flight instructor certificate, an additional rating on a flight instructor certificate, renewal of a flight instructor certificate, or reinstatement of a flight instructor certificate.

(e) A person who has, within the period specified in paragraph (c) of this section, satisfactorily accomplished one or more phases of an FAA-sponsored pilot proficiency award program need not accomplish the flight review required by this section.

(f) A person who holds a flight instructor certificate and who has, within the period specified in paragraph (c) of this section, satisfactorily completed a renewal of a flight instructor certificate under the provisions in § 61.197 need not accomplish the one hour of ground training specified in paragraph (a) of this section.

(g) A student pilot need not accomplish the flight review required by this section provided the student pilot is undergoing training for a certificate and has a current solo flight endorsement as required under § 61.87 of this part.

(h) The requirements of this section may be accomplished in combination with the requirements of § 61.57 and other applicable recent experience requirements at the discretion of the authorized instructor conducting the flight review.

...

Flight Reviews

Your pilot certificate doesn't expire. But in order to use it, you must have completed a flight review within the previous 24 months. That means that if you don't think you will be flying for a few years due to work, medical, family, or any other issues, you don't have to get a flight review. But once you plan to get back into the sky, you will need to get a current flight review.

The FAA mandates flight reviews because it wants to see a regular evaluation of your pilot skills and aeronautical knowledge. Any CFI for powered parachutes may conduct that flight review for you. A flight review is supposed to be a routine evaluation of your ability to conduct safe flight. It's a proficiency-based exercise where you are required to demonstrate the safe exercise of the privileges of your pilot certificate.

This isn't something you should be stressed about. "*A flight review is not a test or checkride, but rather a training event in which proficiency is evaluated.*" By the way, that is FAA language. But let's be real. Evaluation is, by its nature, a test. But go with it. The FAA means that a flight review isn't a pass/fail event. It's a process. By regulation, a flight review must consist of a minimum of one hour of ground training and a minimum of one hour of flight training. But if you're a little rusty, your flight review may take a little longer.

The CFI is going to provide a review of maneuvers and procedures that are necessary for the you to demonstrate that you're a safe pilot. If you don't immediately demonstrate the proficiency to conduct safe flight, then more training is required. Your flight instructor will be the person who ultimately determines the total training time required for a flight review, but that will be based on how well you do.

There are things that will give you credit for a flight review. If you do one of these things in the previous 24 months, you meet the requirement for the flight review. Some common examples are:

- A practical test for an additional pilot rating or operating privilege.
- A proficiency check for an additional pilot rating or operating privilege.
- A practical test for the issuance of a flight instructor certificate
- A practical test for the issuance of an additional rating on a flight instructor certificate
- A practical test for the renewal of a flight instructor certificate
- A practical test for the reinstatement of a flight instructor certificate

Bottom line: To act as pilot-in-command of an aircraft, you must show by logbook endorsement the satisfactory completion of a flight review or the completion of a pilot proficiency check within the preceding 24 calendar months.

Currency Requirements

A flight review is what you need to stay flying. However, if you want to take passengers, there's a higher standard. The FAA wants to make sure that you're in practice before you take someone up. The official name for that is currency and that doesn't require a CFI's help, although it could. It just means getting into the sky and practicing. Then logging that practice so that you have proof of it.

"How much practice?" you ask. It's pretty minimal. You only need to log three takeoffs and landings within 90 days of taking up a passenger. And those takeoffs and landings can all be in one flight. The regulation doesn't say *"full stop"* so touch and go's work just fine.

You don't have to make a special effort to maintain currency. If you're flying regularly, then you probably are already fulfilling the FAA requirement for currency. But powered parachute flying may be seasonal for you. In that case, your first flight in the spring should be to rebuild your currency, not to take anyone flying.

For those who go on to become private pilots, there's a similar requirement for night flying. Again, three takeoffs and landings within 90 days, only they have to be done at night. And the FAA wants it to be really dark. The three takeoffs and landings only count if you do them one hour after sunset.

Bottom line: To act as pilot-in-command of an aircraft carrying passengers, you must have made at least three takeoffs and three landings in an aircraft of the same category and class within the preceding 90 days.

Example Test Scenario: Your cousin wants you to take him flying. You must have made at least three takeoffs and three landings in your aircraft within the preceding 90 days.

§ 61.57 Recent flight experience: Pilot in command.

(a) General experience.

(1) ... no person may act as a pilot in command of an aircraft carrying passengers or of an aircraft certificated for more than one pilot flight crewmember unless that person has made at least three takeoffs and three landings within the preceding 90 days, and -

(i) The person acted as the sole manipulator of the flight controls; and

(ii) The required takeoffs and landings were performed in an aircraft of the same category, class, and type (if a type rating is required).....

(2) For the purpose of meeting the requirements of paragraph (a)(1) of this section, a person may act as a pilot in command of an aircraft under day VFR or day IFR, provided no persons or property are carried on board the aircraft, other than those necessary for the conduct of the flight.

(b) Night takeoff and landing experience.

(1) ..., no person may act as pilot in command of an aircraft carrying passengers during the period beginning 1 hour after sunset and ending 1 hour before sunrise, unless within the preceding 90 days that person has made at least three takeoffs and three landings to a full stop during the period beginning 1 hour after sunset and ending 1 hour before sunrise, and -

(i) That person acted as sole manipulator of the flight controls; and

(ii) The required takeoffs and landings were performed in an aircraft of the same category, class, and type (if a type rating is required).

Pilot Logbook

Your pilot logbook is where you keep your records of flights and your endorsements. These records are critical as proof to the FAA that you're legal to fly. Your logbook is where you keep the evidence of your training hours, your endorsements to solo, your currency requirements and more.

There is no *"FAA-Approved"* logbook. You can keep your records in a spiral-bound notebook if you choose. However, private companies have created very nice accountant-style logbooks that make it easy for you to keep track of your total flight hours and have preprinted endorsements in the back that make it easier for your instructors and examiners to sign you off during the various stages of your flying experience.

You will want to maintain your logbook throughout your flying career. Along the way, you may change styles of logbooks and you may even want to keep different logbooks for powered parachute flying vs. airplane or other kinds of flying.

Flight Entries

Every flight you take should have its own separate entry in your logbook. And if you perform a cross country and land at another airport, each leg should be logged as a separate flight. So what is included in a logbook flight entry?

Your entries should be simple enough to make so that you will consistently make them. I've known pilots who have written short narratives about each of their flights including weather information, who they had as passengers, and concerns about the aircraft. But that isn't needed. The *"just the facts, ma'am"* stuff includes the following.

Every logbook entry should include this information:

- Date.
- Total flight time or lesson time.
- Location(s) where the aircraft departed and arrived.
- Type and identification of aircraft.
- Type of flying time (Dual Received, Solo, or Pilot-In-Command.)
- Conditions of the flight (day or night).

Training Time

You may log training time when you receive training from an authorized instructor in a powered parachute. In order for your training to count, the training time must be logged in a logbook, be legibly endorsed by the instructor and include the following details:

- A description of the training given
- The length of the training lesson
- The instructor's authorized signature
- The instructor's certificate number, and
- The instructor's certificate expiration date.

Solo Flight Time

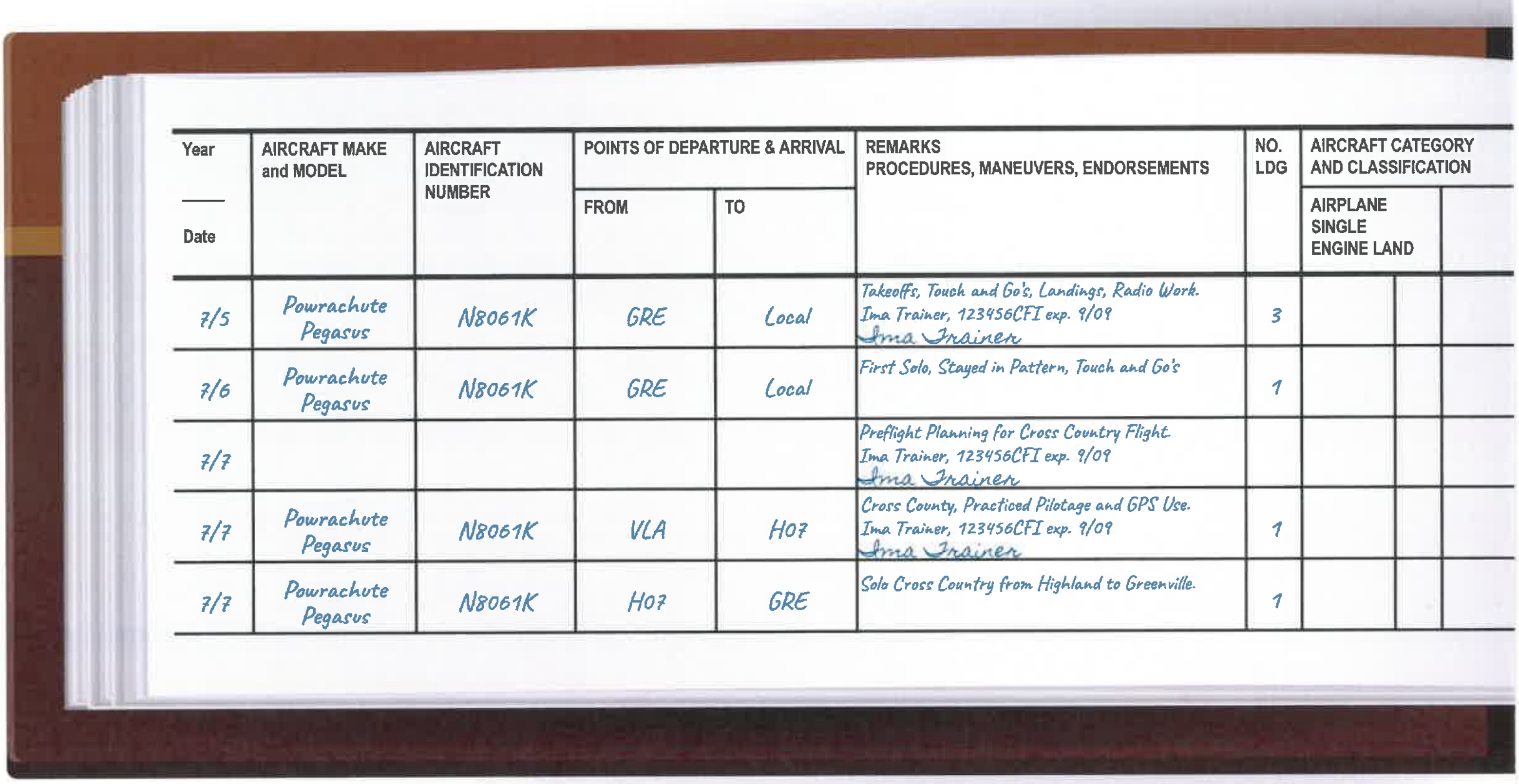
You may log as solo flight time only that flight time when you are the sole occupant of the powered parachute. In order to solo, you must first have an endorsement from your flight instructor authorizing solo flight.

Pilot-In-Command Flight Time

You may log pilot-in-command flight time when you are the sole manipulator of the controls for a powered parachute. You can do that if you are the sole occupant (with a student or sport pilot certificate) or if you are carrying a passenger after you have earned your sport pilot certificate. And yes, flight time can count both as solo and as pilot-in-command time.

N-Number Time vs. Ultralight Time

Ultralight flight time does not count towards the requirements for an FAA sport pilot certificate. In order for your time to count, you must acquire that time in what the FAA considers a powered parachute land. The powered parachute also must be registered with an FAA airworthiness certificate.



Year / Date	AIRCRAFT MAKE and MODEL	AIRCRAFT IDENTIFICATION NUMBER	POINTS OF DEPARTURE & ARRIVAL FROM	TO	REMARKS PROCEDURES, MANEUVERS, ENDORSEMENTS	NO. LDG	AIRCRAFT CATEGORY AND CLASSIFICATION AIRPLANE SINGLE ENGINE LAND
7/5	Powrachute Pegasus	N8061K	GRE	Local	Takeoffs, Touch and Go's, Landings, Radio Work. Ima Trainer, 123456CFI exp. 9/09 Ima Trainer	3	
7/6	Powrachute Pegasus	N8061K	GRE	Local	First Solo, Stayed in Pattern, Touch and Go's	1	
7/7					Preflight Planning for Cross Country Flight. Ima Trainer, 123456CFI exp. 9/09 Ima Trainer		
7/7	Powrachute Pegasus	N8061K	VLA	H07	Cross County, Practiced Pilotage and GPS Use. Ima Trainer, 123456CFI exp. 9/09 Ima Trainer	1	
7/7	Powrachute Pegasus	N8061K	H07	GRE	Solo Cross Country from Highland to Greenville.	1	

Endorsements

Endorsements are placed in the back of pilot logbooks by certified flight instructors, designated pilot examiners and occasionally FAA personnel. Endorsements mark milestones in your training that are often tied to regulatory requirements. Most logbooks have preprinted endorsements to make things easier for your flight instructor. But often a required endorsement isn't preprinted in the back of your logbook and your instructor will either hand write the endorsement or provide his own preprinted label with the endorsement information on it.

Occasions that merit endorsements in your pilot logbook include:

- Documenting that you completed your pre-solo knowledge test.
- Documenting your pre-solo training.
- Authorizing you to fly solo for up to 90 days.
- Authorizing you to fly solo in Class B, C, and D airspace.
- Certifying that you are ready to take your aeronautical knowledge test.
- Documenting a review of deficiencies identified on your aeronautical knowledge test.
- Certifying that you received the required training time within two calendar-months preceding the month of application in preparation for the practical test.
- Certifying that you are ready to take your sport pilot practical test.
- Certifying that you passed your sport pilot practical test.
- Certifying that you completed your flight review

There are many more possible endorsements for all kinds of training situations. AC 61-65H, Certification: Pilots and Flight and Ground Instructors lists 92 sample endorsements. Most of those aren't printed in the back of any logbook.

Presenting Required Documents

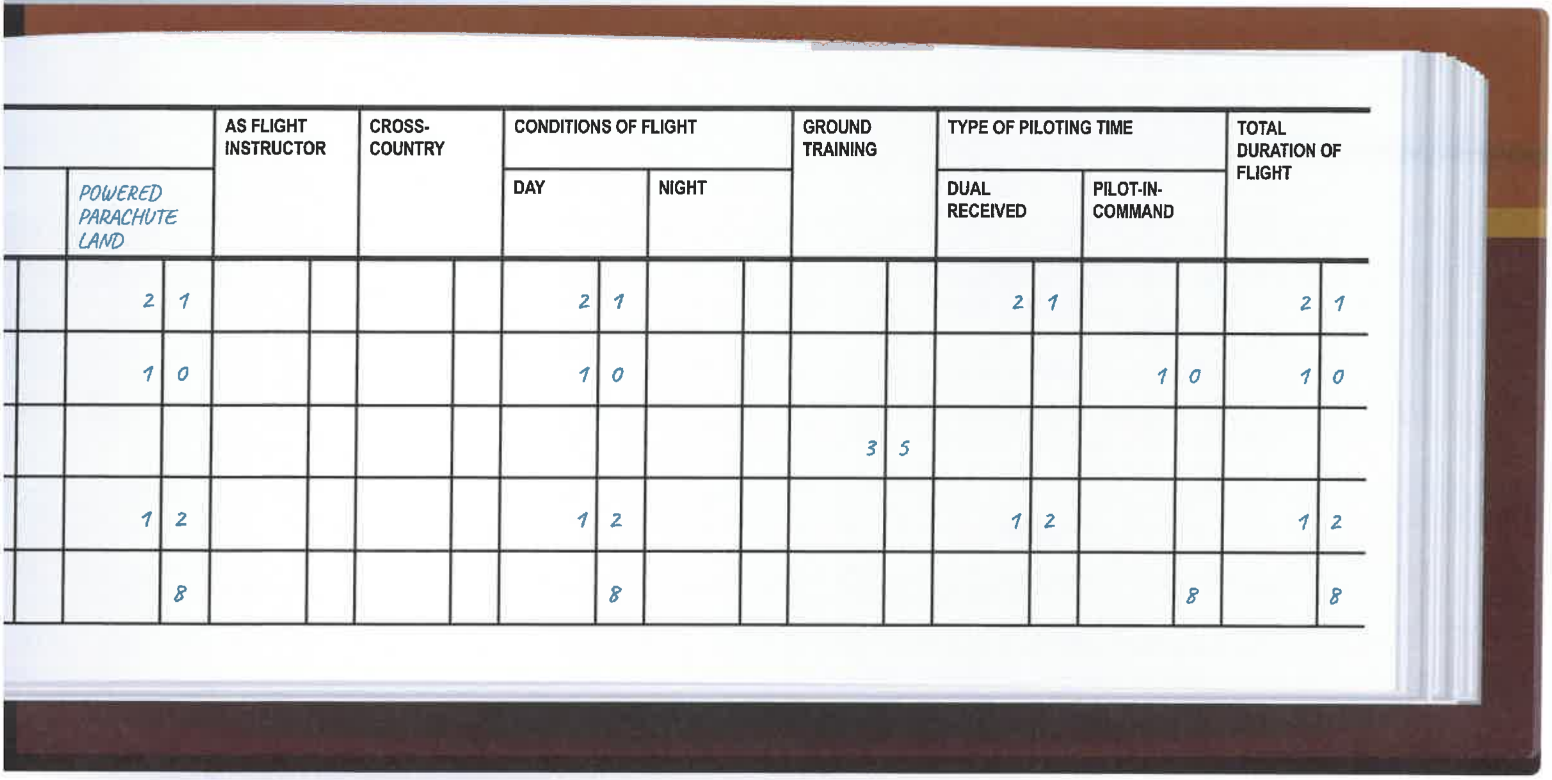
You must present your pilot certificate, medical certificate, or logbook for inspection upon a reasonable request by:

- An authorized representative from the FAA
- An authorized representative from the National Transportation Safety Board (NTSB)
- Any Federal, State, or local law enforcement officer.

Student Pilot Solo

While you are in student status, you must carry your pilot logbook and student pilot certificate or other evidence of required authorized instructor endorsements on all solo flights.

Logbook flight entries.



§ 61.51 Pilot logbooks.

(a) Training time and aeronautical experience. Each person must document and record the following time in a manner acceptable to the Administrator:
  (1) Training and aeronautical experience used to meet the requirements for a certificate, rating, or flight review of this part.
  (2) The aeronautical experience required for meeting the recent flight experience requirements of this part.
(b) Logbook entries. For the purposes of meeting the requirements of paragraph (a) of this section, each person must enter the following information for each flight or lesson logged:
  (1) General -
    (i) Date.
    (ii) Total flight time or lesson time.
    (iii) Location where the aircraft departed and arrived, ...
    (iv) Type and identification of aircraft, ...
  (2) Type of pilot experience or training -
    (i) Solo.
    (ii) Pilot in command.
    ...
    (iv) Flight and ground training received from an authorized instructor.
    ...
  (3) Conditions of flight -
    (i) Day or night.
    ...
(c) Logging of pilot time. The pilot time described in this section may be used to:
  (1) Apply for a certificate or rating issued under this part or a privilege authorized under this part; or
  (2) Satisfy the recent flight experience requirements of this part.
(d) Logging of solo flight time. ... a pilot may log as solo flight time only that flight time when the pilot is the sole occupant of the aircraft.
(e) Logging pilot-in-command flight time.
  (1) A sport, recreational, private, commercial, or airline transport pilot may log pilot in command flight time for flights-
    (i) ... when the pilot is the sole manipulator of the controls of an aircraft for which the pilot is rated, or has sport pilot privileges for that category and class of aircraft, if the aircraft class rating is appropriate;
    (ii) When the pilot is the sole occupant in the aircraft;
    ...

(h) Logging training time.
  (1) A person may log training time when that person receives training from an authorized instructor in an aircraft, ...
  (2) The training time must be logged in a logbook and must:
    (i) Be endorsed in a legible manner by the authorized instructor; and
    (ii) Include a description of the training given, the length of the training lesson, and the authorized instructor's signature, certificate number, and certificate expiration date.
(i) Presentation of required documents.
  (1) Persons must present their pilot certificate, medical certificate, logbook, or any other record required by this part for inspection upon a reasonable request by -
    (i) The Administrator;
    (ii) An authorized representative from the National Transportation Safety Board; or
    (iii) Any Federal, State, or local law enforcement officer.
  (2) A student pilot must carry the following items in the aircraft on all solo cross-country flights as evidence of the required authorized instructor clearances and endorsements -
    (i) Pilot logbook;
    (ii) Student pilot certificate; and
    (iii) Any other record required by this section.
  (3) A sport pilot must carry his or her logbook or other evidence of required authorized instructor endorsements on all flights.
  ...
(j) Aircraft requirements for logging flight time. For a person to log flight time, the time must be acquired in an aircraft that is identified as an aircraft under § 61.5(b), and is -
  (1) An aircraft of U.S. registry with either a standard or special airworthiness certificate;
  ...

Chapter 6
Aeromedical Factors

A large part of the preflight process is making sure that you, as a pilot, are in good enough physical shape for the task at hand. The final responsibility for determining if you are in proper medical shape rests with you, the pilot.

That's why you need to understand the regulations pertaining to medical factors as well as medical issues pertaining to flight. Never ignore medical factors, no matter how mild they seem. Even a common cold can pose risks during a flight, especially if you've taken any kind of medication, even over-the-counter, before flying.

FAA Medical Requirements

Medical requirements vary, depending on what kind of powered parachute you want to fly and the circumstances you want to fly it in. If you are flying an ultralight, no medical is needed. If you are flying as a sport pilot, then you just need a valid state driver's license or an FAA medical certificate. If you are flying as a private pilot powered parachute and exercising at least one privilege of a private pilot powered parachute (for example, flying at night) then you need a minimum of an FAA third class medical certificate.

Most powered parachute pilots follow Sport Pilot rules, which means they don't need a medical certificate. Instead, a valid U.S. driver's license is sufficient. However, for sport pilots relying on their driver's license as a medical qualification, it's important to:

- Adhere to all restrictions and limitations specified in their U.S. driver's license, including any requirements such as wearing corrective lenses while driving.
- Have qualified for at least a third-class airman medical certificate during their most recent application (applicable only if they've applied for a medical certificate).

- Not have had their most recent medical certificate suspended or revoked, or their most recent Authorization for a Special Issuance of a Medical Certificate withdrawn (relevant only for those who have held a medical certificate).
- Not be aware or have reason to believe they have a medical condition that would hinder their ability to operate a light sport aircraft safely.

For powered parachute pilots acting as private pilots, an FAA third-class medical certificate is required for flights that involve private pilot-specific conditions, such as flying above 10,000 feet MSL or at night. However, when conducting regular Sport Pilot-style flights, a medical certificate is not necessary.

Obtaining A Medical Certificate

If you want to fly as a private pilot, you'll need a third-class medical certificate. To get your third-class medical certificate, you'll need an examination by an aviation medical examiner (AME). These are physicians trained in aviation medicine and designated by the Civil Aerospace Medical Institute (CAMI). If you're under 40, the third-class medical is valid for 5 years, and if you're 40 or older, it's valid for 2 years.

If you have physical limitations like impaired vision, loss of a limb, or hearing impairment while learning to fly, you might receive a medical certificate valid only for *"student pilot privileges."* Pilots with disabilities may need special equipment, such as hand controls for paraplegic pilots. Certain disabilities could lead to limitations on your certificate, like *"not valid for flight requiring the use of radio"* for impaired hearing.

Once you meet all the knowledge, experience, and proficiency requirements and can demonstrate safe aircraft operation, you can receive a *"statement of demonstrated ability"* (SODA). This SODA waiver remains valid as long as your physical impairment doesn't worsen. For more information on this subject, contact your local Flight Standards District Office (FSDO).

You may not want to attempt to get a third-class medical, especially if you have one of the fifteen medical conditions considered disqualifying by *"history or clinical diagnosis"* according to FAA medical standards (14 CFR part 67). It doesn't matter when the condition was diagnosed or treated. You won't be issued a medical certificate unless you go through a process called *"Special Issuance Authorization,"* explained in 14 CFR part 67, section 67.401.

To obtain a special issuance, it's at the discretion of the FAA Federal Air Surgeon, and you must satisfactorily complete specific testing determined by the FAA. This testing demonstrates that you are safe to fly for the duration of the issued medical certificate. The specific disqualifying conditions include:

- Diabetes mellitus requiring oral hypoglycemic medication or insulin
- Angina pectoris
- Coronary heart disease that has been treated or, if untreated, that has been symptomatic or clinically significant
- Myocardial infarction
- Cardiac valve replacement
- Permanent cardiac pacemaker
- Heart replacement
- Psychosis
- Bipolar disorder
- Personality disorder that is severe enough to have repeatedly manifested itself by overt acts
- Substance dependence (including alcohol)
- Substance abuse
- Epilepsy
- Disturbance of consciousness and without satisfactory explanation of cause
- Transient loss of control of nervous system function(s) without satisfactory explanation of cause

The list above only covers mandatory disqualifying conditions. In the General Medical Condition section of the regulations, the FAA considers several other medical conditions as disqualifying, even if not explicitly stated. Conditions such as cancer, kidney stones, neurological and neuromuscular disorders (e.g., Parkinson's disease and multiple sclerosis), specific blood disorders, and other progressive conditions require FAA review before a medical certificate can be issued.

Nearly all disqualifying medical conditions can be considered for special issuance, with very few exceptions. If you can furnish satisfactory medical documentation to the FAA demonstrating the stability of your condition, there's a good chance you can qualify for an Authorization. On the other hand, if you are suffering from any of these things, you should consult your physician before flying a powered parachute, even as an ultralight or sport pilot.

Alcohol and Drugs

Alcohol, illegal substances, prescription medications, and even legal over the counter drugs can impact your safety, the safety of your passenger and the safety of those sharing the airspace with you.

Alcohol

Understanding the impact of alcohol on the human body is crucial, especially for pilots. Research consistently shows that alcohol consumption leads to a decline in performance. Pilots must make numerous, sometimes time-critical, decisions during a flight. A safe outcome depends on their ability to make accurate decisions and take appropriate actions in both routine and abnormal situations. Alcohol impairs these abilities, significantly increasing the risk of incidents during a flight.

Even in small amounts, alcohol can impair judgment, decrease the sense of responsibility, affect coordination, narrow the visual field, diminish memory, reduce reasoning ability, and lower attention span. Surprisingly, as little as one ounce of alcohol can hamper the speed and strength of muscular reflexes, diminish the efficiency of eye movements while reading, and increase the frequency of errors. Vision and hearing impairments can occur from consuming as little as one drink. It's crucial to recognize the potential consequences of alcohol consumption on your ability to pilot a powered parachute safely.

Type Beverage	Typical Serving (oz)	Pure Alcohol Content (oz)
Table wine	4.0	.48
Light beer	12.0	.48
Aperitif liquor	1.5	.38
Champagne	4.0	.48
Vodka	1.0	.50
Whiskey	1.25	.50

0.01–0.05% (10–50 mg)	average individual appears normal
0.03–0.12%* (30–120 mg)	mild euphoria, talkativeness, decreased inhibitions, decreased attention, impaired judgment, increased reaction time
0.09–0.25% (90–250 mg)	emotional instability, loss of critical judgment, impairment of memory and comprehension, decreased sensory response, mild muscular incoordination
0.18–0.30% (180–300 mg)	confusion, dizziness, exaggerated emotions (anger, fear, grief), impaired visual perception, decreased pain sensation, impaired balance, staggering gait, slurred speech, moderate muscular incoordination
0.27–0.40% (270–400 mg)	apathy, impaired consciousness, stupor, significantly decreased response to stimulation, severe muscular incoordination, inability to stand or walk, vomiting, incontinence of urine and feces
0.35–0.50% (350–500 mg)	unconsciousness, depressed or abolished reflexes, abnormal body temperature, coma, possible death from respiratory paralysis (450 mg or above)

* Legal limit for motor vehicle operation in most states is 0.08 or 0.10% (80–100 mg of alcohol per dL of blood).

The alcohol consumed in beer and mixed drinks is ethyl alcohol, a central nervous system depressant. From a medical point of view, it acts on the body much like a general anesthetic. The *"dose"* is generally much lower and more slowly consumed in the case of alcohol, but the basic effects on the human body are similar. Alcohol is easily and quickly absorbed by the digestive tract. The bloodstream absorbs about 80 to 90 percent of the alcohol in a drink within 30 minutes when ingested on an empty stomach. The body requires about 3 hours to rid itself of all the alcohol contained in one mixed drink or one beer.

You are still under the influence of alcohol when experiencing a hangover. Although you might think that you're functioning normally, motor and mental response impairment is still present. Considerable amounts of alcohol can remain in the body for over 16 hours, so you should be cautious about flying too soon after drinking.

Altitude multiplies the effects of alcohol on the brain. When combined with altitude, the alcohol from two drinks may have the same effect as three or four drinks. Alcohol interferes with the brain's ability to utilize oxygen, producing a form of histotoxic hypoxia. The effects are rapid because alcohol passes so quickly into the bloodstream. In addition, the brain is a highly vascular organ that is immediately sensitive to changes in the blood's composition. For a pilot, the lower oxygen availability at altitude, along with the lower capability of the brain to use what oxygen is there, adds up to a deadly combination.

Intoxication is determined by the amount of alcohol in the bloodstream. This is usually measured as a percentage by weight in the blood. The FAA requires that blood alcohol levels be less than .04 percent and that eight hours pass between drinking alcohol and piloting an aircraft. A pilot with a blood alcohol level of .04 percent or greater after eight hours still cannot fly until the blood alcohol falls below that amount. Even though blood alcohol may be well below .04 percent, a pilot cannot fly sooner than eight hours after drinking alcohol. Although the regulations are quite specific, it's a good idea to be more conservative than the regulations.

Drugs

Your performance can be seriously degraded by both prescribed and over-the-counter (OTC) medications, as well as by the medical conditions for which they are taken.

FAA regulations include no specific references to medication usage. Two regulations, though, are important to keep in mind. §61.53 prohibits acting as pilot-in-command or in any other capacity as a required pilot flight crew member, while that person:

1. Knows or has reason to know of any medical condition that would make the person unable to meet the requirement for the medical certificate necessary for the pilot operation, or
2. Is taking medication or receiving other treatment for a medical condition that results in the person being unable to meet the requirements for the medical certificate necessary for the pilot operation. Further, §91.17 prohibits the use of any drug that affects the person's faculties in any way contrary to safety.

The U.S. Food and Drug Administration (FDA) has approved thousands of medications, not including OTC drugs. Almost all medications have the potential to cause adverse side effects in some individuals. Additionally, herbal and dietary supplements, as well as sports and energy boosters, and other *"natural"* products, can also lead to negative side effects. While some people may not experience any side effects from a particular drug or product, others might be significantly affected.

Stimulants are drugs that excite the central nervous system and produce an increase in alertness and activity. Amphetamines, caffeine, and nicotine are all forms of stimulants. Common uses of these drugs include appetite suppression, fatigue reduction, and mood elevation. Some of these drugs may cause a stimulant reaction, even though this reaction is not their primary function. In some cases, stimulants can produce anxiety and mood swings, both of which are dangerous when flying.

Depressants are drugs that reduce the body's functioning in many areas. These drugs lower blood pressure, reduce mental processing, and slow motor and reaction responses. There are several types of drugs that can cause a depressing effect on the body, including tranquilizers, motion sickness medication, some types of stomach medication, decongestants, and antihistamines. The most common depressant is our friend alcohol.

OTC Antihistamines and Decongestants have the potential to cause noticeable adverse side effects, including drowsiness and cognitive deficits. The symptoms associated with common upper respiratory infections, including the common cold, often suppress a pilot's desire to fly, and treating symptoms with a drug that causes adverse side effects only compounds the problem. Particularly, medications containing diphenhydramine (e.g., Benadryl) are known to cause drowsiness and have a prolonged half-life, meaning the drugs stay in one's system for an extended time, which lengthens the time that side effects are present.

Tranquilizers, Sedatives, Strong Pain Relievers, and Cough Suppressants have primary effects that may impair judgment, memory, alertness, coordination, vision, and the ability to make calculations.

Antihistamines, Blood Pressure Drugs, Muscle Relaxants, and agents to control diarrhea and motion sickness have side effects that may also impair judgment, memory, alertness, coordination, vision, and the ability to make calculations.

Painkillers can be grouped into two broad categories: analgesics and anesthetics. Analgesics are drugs that reduce pain, while anesthetics are drugs that deaden pain or cause loss of consciousness.

Prescription Analgesics, such as Darvon, Percodan, Demerol, and codeine may cause serious side effects such as mental confusion, dizziness, headaches, nausea, and vision problems that should keep you out of the flight deck. On the other hand, over-the-counter analgesics, such as acetylsalicylic acid (Aspirin), acetaminophen (Tylenol), and ibuprofen (Advil) have few side effects when taken in the correct dosage and shouldn't prevent flying.

Anesthetics are commonly used for dental and surgical procedures. Most local anesthetics used for minor dental and outpatient procedures wear off within a relatively short period of time. The anesthetic itself may not limit flying so much as the actual procedure and subsequent pain.

Antibiotics are an example of drugs which can neither be classified as stimulants nor depressants, but still have adverse effects on flying. Some forms of antibiotics can produce dangerous side effects, such as balance disorders, hearing loss, nausea, and vomiting. While many antibiotics are safe for use while flying, the infection requiring the antibiotic may prohibit flying.

Remember, unless specifically prescribed by a physician, avoid taking more than one drug at a time and never mix drugs with alcohol, as their combined effects can be unpredictable. For any new medication, whether over-the-counter or prescribed, wait at least 48 hours after the first dose before flying to ensure you don't experience adverse side effects that could make operating an aircraft unsafe.

You should wait at least five times the maximal dosing interval (the time between recommended doses) before flying after taking any medication with potentially adverse side effects, such as sedation or dizziness. For example, if the dosing interval is 5 to 6 hours, you should wait 30 hours before flying. While this rule of thumb doesn't eliminate the risk of side effects—since everyone metabolizes medications differently—it provides a reasonable safety margin.

The risks associated with illegal drugs are well-documented, including their potential to cause hallucinations days or weeks after use. Such drugs clearly have no place in aviation.

FAA regulations prohibit performing crew duties under the influence of any medication that impairs safety. The safest approach is to avoid piloting an aircraft while taking any medication unless it has been specifically approved by the FAA. Medication labels normally don't mention flying or operating a powered parachute, but if a medication advises against driving or operating heavy machinery, it's best not to fly while using it. If you're unsure about how a medication may affect your ability to fly, consult an aviation medical examiner before taking to the skies.

Substance	Generic Or Brand Name	Treatment for	Possible Side Effects
Alcohol	Beer Liquor Wine	N/A	Impaired judgment and perception Impaired coordination and motor control Reduced reaction time Impaired sensory perception Reduced intellectual functions Reduced tolerance to G-forces Inner-ear disturbance and spatial disorientation (up to 48 hours) Central nervous system depression
Nicotine	Cigars Cigarettes Pipe tobacco Chewing tobacco Snuff	N/A	Sinus and respiratory system infection and irritation Impaired night vision Hypertension Carbon monoxide poisoning (from smoking)
Amphetamines	Ritalin Obetrol Eskatrol	Obesity (diet pills) Tiredness	Prolonged wakefulness Nervousness Impaired vision Suppressed appetite Shakiness Excessive sweating Rapid heart rate Sleep disturbance Seriously impaired judgment
Caffeine	Coffee Tea Chocolate No-Doz	N/A	Impaired judgment Reduced reaction time Sleep disturbance Increased motor activity and tremors Hypertension Irregular heart rate Rapid heart rate Body dehydration (through increased urine output) Headaches
Antacid	Alka-2 Di-Gel Maalox	Stomach acids	Liberations of carbon dioxide at altitude (distension may cause acute abdominal pain and may mask other medical problems)
Antihistamines	Coricidin Contac Dristan Dimetapp Omade Chlor-Trimeton Diphenhydramine	Allergies Colds	Drowsiness and dizziness (sometimes recurring) Visual disturbances (when medications also contain antispasmodic drugs)
Aspirin	Bayer Bufferin Alka-Seltzer	Headaches Fevers Aches Pains	Irregular body temperature Variation in rate and depth of respiration Hypoxia and hyperventilation (two aspirin can contribute to) Nausea, ringing in ears, deafness, diarrhea, and hallucinations when taken in excessive dosages Corrosive action on the stomach lining Gastrointestinal problems Decreased clotting ability of the blood (clotting ability could be the difference between life and death in a survival situation)

Losing Your Certificate

FAA regulations state that a refusal to take a drug or alcohol test, a conviction for a violation of any Federal or State statute relating to the operation of a motor vehicle while under the influence of alcohol or a drug, or failure to provide a written report of each motor vehicle action to the FAA (not later than 60 days after the motor vehicle action) are grounds for:

- Denial of an application for any certificate, rating, or authorization for a period of up to one year after the date of such refusal; or
- Suspension or revocation of any certificate, rating, or authorization.

Pilots must submit a written report of any motor vehicle offense involving alcohol or drugs to the FAA Civil Aviation Security Division (AMC-700) at P.O. Box 25810, Oklahoma City, OK 73125. This report should be sent within 60 days of the motor vehicle action.

§ 61.15 Offenses involving alcohol or drugs.

(a) A conviction for the violation of any Federal or State statute relating to the growing, processing, manufacture, sale, disposition, possession, transportation, or importation of narcotic drugs, marijuana, or depressant or stimulant drugs or substances is grounds for:

(1) Denial of an application for any certificate, rating, or authorization issued under this part for a period of up to 1 year after the date of final conviction; or

(2) Suspension or revocation of any certificate, rating, or authorization issued under this part.

(b) Committing an act prohibited by § 91.17(a) or § 91.19(a) of this chapter is grounds for:

(1) Denial of an application for a certificate, rating, or authorization issued under this part for a period of up to 1 year after the date of that act; or

(2) Suspension or revocation of any certificate, rating, or authorization issued under this part.

(c) For the purposes of paragraphs (d), (e), and (f) of this section, a motor vehicle action means:

(1) A conviction after November 29, 1990, for the violation of any Federal or State statute relating to the operation of a motor vehicle while intoxicated by alcohol or a drug, while impaired by alcohol or a drug, or while under the influence of alcohol or a drug;

(2) The cancellation, suspension, or revocation of a license to operate a motor vehicle after November 29, 1990, for a cause related to the operation of a motor vehicle while intoxicated by alcohol or a drug, while impaired by alcohol or a drug, or while under the influence of alcohol or a drug; or

(3) The denial after November 29, 1990, of an application for a license to operate a motor vehicle for a cause related to the operation of a motor vehicle while intoxicated by alcohol or a drug, while impaired by alcohol or a drug, or while under the influence of alcohol or a drug.

(d) Except for a motor vehicle action that results from the same incident or arises out of the same factual circumstances, a motor vehicle action occurring within 3 years of a previous motor vehicle action is grounds for:

(1) Denial of an application for any certificate, rating, or authorization issued under this part for a period of up to 1 year after the date of the last motor vehicle action; or

(2) Suspension or revocation of any certificate, rating, or authorization issued under this part.

(e) Each person holding a certificate issued under this part shall provide a written report of each motor vehicle action to the FAA, Civil Aviation Security Division (AMC-700), P.O. Box 25810, Oklahoma City, OK 73125, not later than 60 days after the motor vehicle action. The report must include:

(1) The person's name, address, date of birth, and airman certificate number;

(2) The type of violation that resulted in the conviction or the administrative action;

(3) The date of the conviction or administrative action;

(4) The State that holds the record of conviction or administrative action; and

(5) A statement of whether the motor vehicle action resulted from the same incident or arose out of the same factual circumstances related to a previously reported motor vehicle action.

(f) Failure to comply with paragraph (e) of this section is grounds for:

(1) Denial of an application for any certificate, rating, or authorization issued under this part for a period of up to 1 year after the date of the motor vehicle action; or

(2) Suspension or revocation of any certificate, rating, or authorization issued under this part.

§ 61.16 Refusal to submit to an alcohol test or to furnish test results.
A refusal to submit to a test to indicate the percentage by weight of alcohol in the blood, when requested by a law enforcement officer in accordance with § 91.17(c) of this chapter, or a refusal to furnish or authorize the release of the test results requested by the Administrator in accordance with § 91.17(c) or (d) of this chapter, is grounds for:

(a) Denial of an application for any certificate, rating, or authorization issued under this part for a period of up to 1 year after the date of that refusal; or
(b) Suspension or revocation of any certificate, rating, or authorization issued under this part.

§ 91.17 Alcohol or drugs.

(a) No person may act or attempt to act as a crewmember of a civil aircraft -
  (1) Within 8 hours after the consumption of any alcoholic beverage;
  (2) While under the influence of alcohol;
  (3) While using any drug that affects the person's faculties in any way contrary to safety; or
  (4) While having an alcohol concentration of 0.04 or greater in a blood or breath specimen. Alcohol concentration means grams of alcohol per deciliter of blood or grams of alcohol per 210 liters of breath.

(b) Except in an emergency, no pilot of a civil aircraft may allow a person who appears to be intoxicated or who demonstrates by manner or physical indications that the individual is under the influence of drugs (except a medical patient under proper care) to be carried in that aircraft.

(c) A crewmember shall do the following:
  (1) On request of a law enforcement officer, submit to a test to indicate the alcohol concentration in the blood or breath, when -
    (i) The law enforcement officer is authorized under State or local law to conduct the test or to have the test conducted; and
    (ii) The law enforcement officer is requesting submission to the test to investigate a suspected violation of State or local law governing the same or substantially similar conduct prohibited by paragraph (a)(1), (a)(2), or (a)(4) of this section.
  (2) Whenever the FAA has a reasonable basis to believe that a person may have violated paragraph (a)(1), (a)(2), or (a)(4) of this section, on request of the FAA, that person must furnish to the FAA the results, or authorize any clinic, hospital, or doctor, or other person to release to the FAA, the results of each test taken within 4 hours after acting or attempting to act as a crewmember that indicates an alcohol concentration in the blood or breath specimen.

(d) Whenever the Administrator has a reasonable basis to believe that a person may have violated paragraph (a)(3) of this section, that person shall, upon request by the Administrator, furnish the Administrator, or authorize any clinic, hospital, doctor, or other person to release to the Administrator, the results of each test taken within 4 hours after acting or attempting to act as a crewmember that indicates the presence of any drugs in the body.

(e) Any test information obtained by the Administrator under paragraph (c) or (d) of this section may be evaluated in determining a person's qualifications for any airman certificate or possible violations of this chapter and may be used as evidence in any legal proceeding under section 602, 609, or 901 of the Federal Aviation Act of 1958.

Medical Factors Related to Flying

The World Air Sports Federation (FAI) refers to pilots as athletes. Initially, I found this idea a bit presumptuous, as I typically associate athletes with runners or gym-goers rather than pilots. However, flying is far from a sedentary activity. And powered parachutes pilots are more active than other pilots while flying.

It starts with being outdoors, exposed to the weather, and getting a mild workout even before you take off. You push the aircraft around, carefully maneuver yourself into and out of a seat surrounded by controls and avionics, lift and carry your wing, spread it out, and inspect it—all before you even begin to fly.

Like other athletes, pilots need precise motor skills, reflexes, and coordination for safe and efficient flight. In addition to physical fitness, pilots must have mental resilience, sharp decision-making abilities, and the capacity to stay focused. The healthier you are, the more you can enjoy flying.

I know you've heard all of this before, but as a pilot you should...

- Not take any unnecessary or elective medications;
- Make sure you eat regular balanced meals;
- Maintain good hydration
- Ensure adequate sleep the night prior to the flight; and
- Stay physically fit.

Your general health is important to assess before a flight. However, there are also some things outside the category of general health that can impact your fitness. The following medical factors are not listed by importance, nor are they a complete list, I bring them to you in alphabetical order for easy reference. These medical factors may affect you or your passenger.

Anxiety

Anxiety can cause people to act in unpredictable and negative ways. If your future is uncertain or an unpredictable event occurs that forces you onto an unknown path, anxiety can appear. Self-realization and learned confidence through knowledge and practice are the best ways to prepare for possible anxiety attacks.

As a pilot, you need to recognize and manage personal anxiety to ensure optimal decision-making and performance during flights. Stressors such as weather conditions, unfamiliar airspace, or mechanical issues can trigger anxiety. Staying well-prepared through preflight planning and continuous training can instill confidence, mitigating anxiety. Visualizing bad situations and how you would deal with them while you are still on the ground helps after you are in the air.

Monitoring a passenger's anxiety is equally important. You should set expectations before the flight to help alleviate concerns. During the flight, maintain an open dialogue and provide reassurance. Stay attuned to signs of discomfort and address them promptly, whether through adjustments to flight conditions or offering a distraction. If your passenger becomes quiet, don't assume all is well. Instead you should check on them fairly regularly, especially early in the flight.

Carbon Monoxide Poisoning

Carbon monoxide (CO) is a colorless and odorless gas produced by all internal combustion engines. Since it attaches itself to the hemoglobin in the blood about 200 times more easily than oxygen, carbon monoxide prevents the hemoglobin from carrying oxygen to the cells, resulting in hypemic hypoxia (which we'll cover shortly). It can take up to 48 hours for the body to dispose of carbon monoxide. If the poisoning is severe enough, it can result in death.

The good news is that CO poisoning is typically not a factor in a powered parachute. Powered parachutes are normally open flight deck and the engine is behind the pilot in a pusher configuration. The biggest concern for carbon monoxide poisoning can be when running the powered parachute engine in an enclosed trailer or hanger, even for short periods of time.

Some symptoms and effects of carbon monoxide poisoning include:

- Headache
- Blurred vision
- Dizziness
- Drowsiness
- Loss of muscle power

Tobacco smoke also causes CO poisoning. Smoking at sea level can raise the CO concentration in the blood and result in physiological effects similar to flying at 8,000 feet. I have personally discovered that enjoying a cigar before a flight is a poor idea.

Dehydration

Dehydration is the critical loss of water from the body. Powered parachute pilots are particularly susceptible to dehydration, since we normally fly in an open cockpit, often exposed for hours to drying airflow over the body as well as the direct rays of the sun. The physical activity of laying out and stowing the parachute increases the chances of dehydration. Flying at high altitudes also increases the susceptibility of dehydration since the dry air at altitude tends to increase the rate of water loss from the body.

Causes of dehydration are

- High temperatures
- High altitudes
- Hot flight lines
- Wind
- Humidity

- Diuretic drinks—coffee, tea, alcohol, and caffeinated soft drinks.

The first noticeable effect of dehydration is fatigue, which in turn makes top physical and mental performance difficult, if not impossible. The symptoms of dehydration are:

- Fatigue
- Dizziness
- Weakness
- Nausea
- Tingling of hands and feet
- Abdominal cramps
- Extreme thirst

To help prevent dehydration, drink two to four quarts of water every 24 hours. Since each person is physiologically different, this is only a guide. Most people are aware of the eight-glasses-a-day guide: If each glass of water is eight ounces, this equates to 64 ounces, which is two quarts.

The key for pilots is to be continually aware of their condition. Most people become thirsty with a 1.5 quart deficit or a loss of 2 percent of total body weight. This level of dehydration triggers the "*thirst mechanism*." The problem is that the thirst mechanism arrives too late and is turned off too easily. A small amount of fluid in the mouth turns this mechanism off and the replacement of needed body fluid is delayed.

Other steps to prevent dehydration include:

- Carrying a container in order to measure daily water intake.
- Staying ahead—not relying on the thirst sensation as an alarm. If plain water is not preferred, add some sport drink flavoring to make it more acceptable.
- Limiting daily intake of caffeine and alcohol (both are diuretics and stimulate increased production of urine).

Fatigue

Fatigue is a state of physical or mental exhaustion resulting from prolonged periods of exertion, inadequate rest, or sleep deprivation. In aviation, it's a critical concern that can compromise your performance and safety. Physical fatigue can result from sleep loss, exercise, or physical work. Factors such as stress and prolonged performance of cognitive work can result in mental fatigue. Fatigue can seriously influence your ability to make effective decisions and is frequently associated with pilot error.

Several factors contribute to fatigue, including irregular sleep patterns, long working hours, high-stress levels, and monotonous or repetitive tasks. Additionally, factors such as jet lag, inadequate nutrition, and certain medications can exacerbate fatigue.

Some of the general effects of fatigue include:

- Drowsiness
- Impaired concentration
- Slowed reaction times
- Irritability
- Reduced decision-making capabilities
- Decreased ability to communicate

Fatigue falls into two broad categories: acute and chronic.

Acute Fatigue

Acute fatigue is short term and is a normal occurrence in everyday living. It's the kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep. Rest after exertion and eight hours of sound sleep ordinarily cures this condition.

Skill Fatigue is a special type of acute fatigue which has two main effects on performance:

Timing disruption. Appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integrated activity.

Disruption of the perceptual field. Concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This may be accompanied by loss of accuracy and smoothness in control movements.

Acute fatigue has many causes, but the following are among the most important for the pilot:

- Mild hypoxia (oxygen deficiency)
- Physical stress
- Psychological stress
- Depletion of physical energy resulting from psychological stress

Sustained psychological stress accelerates the glandular secretions that prepare the body for quick reactions during an emergency. These secretions make the circulatory and respiratory systems work harder, and the liver releases energy to provide the extra fuel needed for brain and muscle work. When this reserve energy supply is depleted, the body lapses into generalized and severe fatigue.

Acute fatigue can be prevented by a proper diet and adequate rest and sleep. A well-balanced diet prevents the body from having to consume its own tissues as an energy source. Adequate rest maintains the body's store of vital energy.

If you're suffering from acute fatigue, stay on the ground. If fatigue occurs in the flight deck, no amount of training or experience can overcome the detrimental effects. Getting adequate rest is the only way to prevent fatigue from occurring. Avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day.

Chronic Fatigue

Chronic fatigue, extending over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible. Continuous high stress levels, for example, can produce chronic fatigue. Chronic fatigue is not relieved by proper diet and adequate rest and sleep, and usually requires treatment by a physician.

An individual may experience chronic fatigue in the form of:

- Weakness
- Tiredness
- Palpitations of the heart
- Breathlessness
- Headaches
- Irritability
- Stomach or intestinal problems
- Generalized aches and pains throughout the body.
- When the condition becomes serious enough, it can lead to emotional illness.

Pilots who suspect they are suffering from chronic fatigue should consult a physician.

Heatstroke

Heatstroke is a condition caused by any inability of the body to control its temperature. High temperatures, high humidity, intense physical activity, and inadequate fluid intake all make it more likely that you will suffer heatstroke.

Onset of this condition may be recognized by the symptoms of dehydration, but also has been known to be recognized only by complete collapse.

Symptoms of heatstroke are:

- Throbbing headache
- Dizziness
- Rapid pulse
- Confusion
- Nausea
- Hot, dry skin
- Unconsciousness
- Seizures

If left untreated, heatstroke can have severe consequences, including damage to vital organs such as the brain, heart, and kidneys. In extreme cases, it can be fatal.

You should carry an ample supply of water and to drink regularly, regardless of whether you feel thirsty. When you begin to feel thirsty, the beginning stages of dehydration and even heatstroke have already started.

The corrective actions for heatstroke are:

- Seek emergency medical attention.
- Move the affected person to a shaded or air-conditioned area.
- Lower the body temperature by applying cool cloths or placing the person in a cool bath. Fan the individual to enhance evaporation.
- Offer water to rehydrate the person.
- Ensure clothing is loose and breathable to facilitate heat dissipation.
- Keep an eye on the person's breathing and responsiveness while waiting for medical help.

Hypothermia

Hypothermia means under heat or under body temperature. Hypothermia is also known as exposure. Hypothermia occurs when your body loses heat more quickly than it can generate, resulting in a drop in your core body temperature.

The human body is best suited for tropical or semi-tropical areas of the globe. An unprotected human cannot withstand extreme temperature changes. As the ambient temperature drops, the body's core temperature also drops. Through the process of metabolism, the body core maintains a temperature of 99º F. Heat produced by metabolism is circulated throughout the body. As long as heat loss does not exceed heat build-up, the body will function normally. But, if heat is lost from the body too quickly, this will lower the core temperature. As the body core temperature drops, so does mental and physical efficiency. Heat is lost from the body through several different vehicles:

Conduction: This the primary cause of heat loss. A transfer of heat occurs when the body comes in contact with something colder than itself.

Temperature	Signs and Symptoms
99-96°F	Intense shivering and impaired ability.
95-91°F	Violent shivering, difficulty in speaking, sluggish thinking, amnesia.
90-86°F	Shivering is replaced by muscular rigidity. Exposed skin is blue or puffy. Movements are jerky. Dulled senses, but patient still is able to maintain posture and the appearance of contact with surroundings.
85-81°F	Coma, lack of reflexes, irregular heartbeat.
Below 78°F	Failure of cardiac and respiratory centers; excess fluid in the lungs; rapid, erratic heartbeat. Death.

Wind (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes · 10 minutes · 5 minutes

When flying in an open flight deck aircraft, you are constantly exposed to the wind. The wind chill chart above can be used to determine your exposure to the cold. If your powered parachute flies at 30 mph and it is 40 °F outside, heat is going to be drawn from your body like it is 28 °F. Dressing for wind chill is critical.

Radiation: The body will continually radiate heat from exposed areas. 50% of body heat is lost from the head.

Convection: Air current blows heat away from the body faster than it is produced. This is a particular concern for powered parachute pilots since the wind chill factor in cold temperatures and a constant 30 mph wind is very chilling.

Evaporation: Sweat (or other moisture) can moisten clothing and accelerate conduction.

Respiration: In a cold environment, cold air enters the body and leaves as warm air. The body loses heat by warming the colder air.

Once body core temperature starts to drop, the body will begin to defend itself against the cold. Capillaries and smaller vessels near the surface of the skin will constrict to keep the blood from coming in contact with the cooler surface. This gives the skin a bluish or ashy color. Shivering will usually be the next major symptom. This is the body's attempt to produce heat through muscular contraction. It will usually start out mild, then progress to a more violent form. As muscles begin to cool and stiffen, muscular coordination is lost. Speech will also be slurred as mental faculties and judgment begin to slow. The pulse becomes weak and irregular as the blood cools and thickens. Unconsciousness may be only minutes away due to hypoxia. Another important fact concerning hypothermia is that fatigue will hasten its onset.

Here is the list of symptoms:

- Bluish or ashy skin
- Shivering
- Impaired motor skills
- Numbness or tingling in extremities
- Slurred speech
- Confusion or difficulty concentrating
- Fatigue
- Unconsciousness

As your body temperature continues to drop, the effects of hypothermia become more pronounced. Cognitive function declines, leading to poor decision-making and slowed reaction times. Severe hypothermia can ultimately result in unconsciousness and, if left untreated, may be fatal.

The first line of defense against hypothermia is shelter. Clothing is considered shelter, in the sense that it is your first immediate measure to retain body heat. The primary method of retaining heat is to insulate. The insulative quality of any material is dependent on the amount of trapped air in the material. An important fact to keep in mind is that when clothing becomes wet, it will loose its insulative quality. Wet clothing in wind will draw off body heat 200 times faster than wind alone. Wool is one of the best insulating materials. Wool will insulate even when it becomes wet. A general rule on dressing for cold weather is to wear a layer of cotton next to the skin (to absorb and retain moisture), followed by a layer of wool, then a water-resistant material on top. Here are some corrective actions in case you find yourself beginning to suffer from hypothermia:

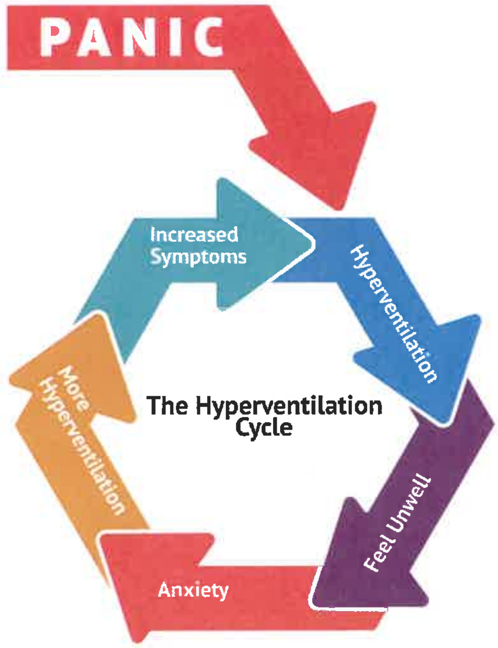
Dress Appropriately: Don't just dress for conditions on the ground. Powered parachutes are open flight deck and the wind chill caused by a combination of outside temperature, airspeed in an open flight deck, and the airflow from the propeller will speed hypothermia. Wear layered clothing to trap body heat, and ensure your outer layer is windproof and waterproof. Pay attention to extremities, such as hands and feet, and use insulated gloves and footwear.

Stay Dry: Wet clothing significantly increases the risk of hypothermia. Equip yourself with waterproof gear and carry spare clothing in case of exposure to rain or snow.

Keep Moving: Physical activity generates heat. If conditions allow, perform gentle exercises to maintain circulation and body warmth.

Consume Warm Beverages: Drink warm, non-alcoholic beverages to help raise and maintain your body temperature. Avoid alcohol, as it can contribute to heat loss.

Recognize Early Signs: Be vigilant in recognizing the early signs of hypothermia in yourself and others. Land and get out of the wind. Prompt action is key to preventing its progression.



Hyperventilation

Hyperventilation occurs when someone is experiencing emotional stress, fright, or pain, and the breathing rate and depth increase. The increased breathing then leads to an abnormal loss of carbon dioxide from the blood. The problem is some carbon dioxide is needed for respiratory, circulatory, and acid-base systems in the body. Basically, the body needs some carbon dioxide to function well.

The stress, fear or anxiety that leads to hyperventilation for pilots and passengers include things like an unexpected or extreme encounter with a thermal or turbulence. These situations and the associated feelings tend to increase the rate and size of breath, which then results in clearing too much CO_2 from the body.

Many of the symptoms of hyperventilation are like those of hypoxia, which is the lack of oxygen rather than the lack of carbon dioxide. For powered parachute pilots and passengers, hyperventilation is far more likely than hypoxia since excessive excitement is far more likely than excessive altitudes. Common symptoms of hyperventilation include:

- Headache
- Decreased reaction time
- Impaired judgment
- Euphoria
- Visual impairment
- Drowsiness
- Light-headed or dizzy sensation
- Tingling in fingers and toes
- Numbness
- Pale, clammy appearance
- Muscle spasms
- Feelings of suffocation

The feelings of suffocation can lead to even more increased breathing. Hyperventilation affects the body's oxygen-carbon dioxide ratio, leading to a condition known as respiratory alkalosis. This imbalance can result in reduced blood flow to the brain, potentially causing confusion, impaired cognitive function and even fainting.

The treatment for hyperventilation involves restoring the proper carbon dioxide level in the body. Breathing normally is both the best prevention and the best cure for hyperventilation. Here are some other strategies for dealing with hyperventilation. The good news is that recovery is usually rapid once the breathing rate is returned to normal. The bad news is that it's hard to think clearly enough to do these things when in the grip of fear and hyperventilation.

Conscious Breathing: Be mindful of your breathing patterns. If you notice rapid or shallow breaths, consciously slow down your breathing and focus on taking deep, controlled breaths.

Talk Aloud: When you talk aloud, it naturally prompts you to take regular and controlled breaths. In addition, talking aloud serves as a distraction, shifting focus away from the stressors or triggers that may be contributing to hyperventilation.

Use of a Paper Bag: In some cases, breathing into a paper bag can help restore the balance of oxygen and carbon dioxide. However, this should be done cautiously, as it is not suitable for everyone and may have risks.

Relaxation Techniques: Incorporate relaxation techniques into your preflight routine. Techniques such as progressive muscle relaxation or meditation can help manage stress and reduce the likelihood of hyperventilation.

Training and Preparedness: Through training and familiarization, you can build resilience to stressors associated with flying. Simulated scenarios and exposure to various flight conditions during training can better prepare you to handle potential stress-induced reactions.

Hypoxia

Hypoxia means not enough oxygen. Hypoxia occurs when there is a deficiency of oxygen in the body's tissues, leading to a lack of oxygen at the cellular level. The greatest concern regarding hypoxia during flight is lack of oxygen to the brain since it's particularly vulnerable to oxygen deprivation. Any reduction in mental function while flying can result in life-threatening errors. Hypoxia can be caused by several factors, including an insufficient supply of oxygen, inadequate transportation of oxygen, or the inability of the body tissues to use oxygen. The forms of hypoxia are based on their causes:

- Hypoxic hypoxia
- Hypemic hypoxia
- Stagnant hypoxia
- Histotoxic hypoxia

Hypoxic Hypoxia

Hypoxic hypoxia is a result of insufficient oxygen available to the lungs. A blocked airway or drowning are obvious examples of how the lungs can be deprived of oxygen, but the reduction in partial pressure of oxygen at high altitude is an appropriate example for pilots. Although the percentage of oxygen in the atmosphere is constant, its partial pressure decreases proportionately as atmospheric pressure decreases. As you climb during flight, the percentage of each gas in the atmosphere remains the same, but there are fewer molecules available at the pressure required for them to pass between the membranes in your respiratory system. We commonly call this effect, *"air thinning out."* Fewer oxygen molecules at sufficient pressure can lead to hypoxic hypoxia.

At sea level, atmospheric pressure is great enough to support normal growth, activity, and life. At 18,000 feet, however, the partial pressure of oxygen is significantly reduced to the point that it adversely affects the normal activities and functioning of the human body. In fact, the reactions of the average person begin to be impaired at an altitude of about 10,000 feet and for some people as low as 5,000 feet.

The most likely cause for a powered parachute pilot to experience symptoms of hypoxia would be flying too high. Unless you're a private pilot with a powered parachute rating, you legally must stay below 10,000 feet where you will have less chance of experiencing hypoxia. And the longer you stay at higher altitudes, the greater the effects of hypoxia will be.

Hypemic Hypoxia

Hypemic means not enough blood. Hypemic hypoxia occurs when the blood isn't able to take up and transport enough oxygen to the cells in the body. This type of hypoxia is a result of oxygen deficiency in the blood, rather than a lack of oxygen in the atmosphere, and can be caused by a variety of factors. It may be because there isn't enough blood volume (due to severe bleeding), or may result from certain blood diseases, such as anemia. More often it is because hemoglobin, the actual blood molecule that transports oxygen, is chemically unable to bind oxygen molecules. The most common form of hypemic hypoxia is carbon monoxide poisoning. Hypemic hypoxia also can be caused by the loss of blood from a blood donation. Blood can take several weeks to return to normal following a donation. Although the effects of the blood loss are slight at ground level, there are risks when flying up to any significant altitudes during this time.

Stagnant Hypoxia

Stagnant means not flowing. Stagnant hypoxia results when the oxygen-rich blood in the lungs isn't moving, for one reason or another, to the tissues that need it. Your arm or leg going to sleep because the blood flow has accidentally been shut off is one form of stagnant hypoxia. This kind of hypoxia can also result from shock, the heart failing to pump blood effectively, or a constricted artery. Cold temperatures also can reduce circulation and decrease the blood supplied to extremities.

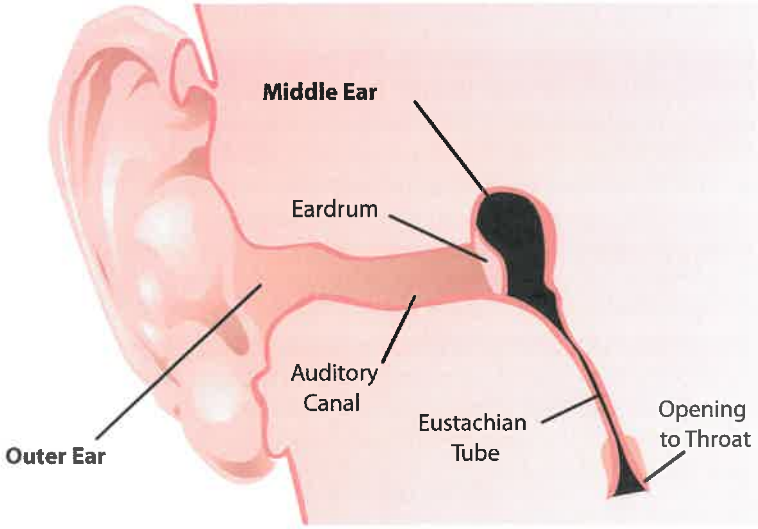
Histotoxic Hypoxia

"Histo" refers to tissues or cells, and *"toxic"* means poison. Histotoxic hypoxia is the inability of cells to effectively use oxygen. In this case, plenty of oxygen is being transported to the cells that need it, but they are unable to make use of it. This impairment of cellular respiration can be caused by alcohol and other drugs, such as narcotics and poisons. Research has shown that drinking one ounce of alcohol can equate to about an additional 2,000 feet of physiological altitude.

Symptoms of Hypoxia

High-altitude flying can put you in danger of becoming hypoxic. A couple of the first symptoms of hypoxia are euphoria and a carefree feeling. That's because oxygen starvation causes the brain and other vital organs to become impaired. With increased oxygen starvation, the extremities become less responsive and flying becomes less coordinated. Other common symptoms include:

- Cyanosis (blue fingernails and lips)
- Headache
- Decreased reaction time
- Impaired judgment
- Euphoria
- Visual impairment
- Drowsiness
- Lightheaded or dizzy sensation
- Tingling in fingers and toes
- Numbness



The eustachian tube allows air pressure to equalize in the middle ear.

Effects of Hypoxia

As oxygen levels drop, cognitive functions are impaired, leading to a decrease in situational awareness, slower reaction times, and compromised decision-making abilities. As hypoxia worsens, the field of vision begins to narrow, and instrument interpretation can become difficult. Even with all these symptoms, the effects of hypoxia can cause a pilot to have a false sense of security and be deceived into believing that everything is normal. In extreme cases, hypoxia can result in unconsciousness.

Corrective Actions for Hypoxia

To mitigate the effects of hypoxia and ensure your safety in the flight deck, consider the following corrective actions:

Descend to Lower Altitude: For a lot of reasons, you probably shouldn't be flying a low-speed powered parachute at high altitudes. But if you are and you experience symptoms of hypoxia, descend to a lower altitude where the air contains a higher concentration of oxygen. This simple action can rapidly alleviate hypoxia.

Use Supplemental Oxygen: Some people fly at higher altitudes because they are on a specific mission like the military or making an altitude record attempt. If you're going to fly up high, especially for a prolonged flights, use supplemental oxygen to maintain adequate oxygen saturation levels in your blood.

Altitude	Time of Useful Consciousness
45,000 feet MSL	9 to 15 seconds
40,000 feet MSL	15 to 20 seconds
35,000 feet MSL	30 to 60 seconds
30,000 feet MSL	1 to 2 minutes
28,000 feet MSL	2½ to 3 minutes
25,000 feet MSL	3 to 5 minutes
22,000 feet MSL	5 to 10 minutes
20,000 feet MSL	30 minutes or more

Recognize Personal Susceptibility: Be aware of your personal susceptibility to hypoxia. Factors such as age, health, and fitness can influence how your body responds to lower oxygen levels.

All pilots are susceptible to the effects of oxygen starvation, regardless of physical endurance or acclimatization. The term *"time of useful consciousness"* describes the maximum time the pilot has to make rational, life-saving decisions and carry them out at a given altitude without supplemental oxygen. As altitude increases above 10,000 feet, the symptoms of hypoxia increase in severity, and the time of useful consciousness rapidly decreases. (See Table below.)

In addition, recent consumption of alcohol, smoking, and some medications will make you even more susceptible to disorientation and hypoxia.

Finally, you should note the difference between hyperventilation and hypoxia since many of the symptoms are similar. First, the circumstances leading up to the symptoms are dramatically different. Then there is a huge difference between panic and euphoria. Finally, hyperventilation may produce a pale, clammy appearance and muscle spasms compared to the cyanosis and limp muscles associated with hypoxia.

Middle Ear and Sinus Problems

Middle ear and sinus problems arise due to changes in air pressure and can happen during rapid climbs and descents while flying. The middle ear is a small, air-filled space located behind the eardrum, connected to the back of the throat by the eustachian tube. Similarly, sinuses are air-filled cavities within the skull. Both are sensitive to pressure changes, which can lead to discomfort and complications during flight.

The primary cause of middle ear and sinus issues while flying is rapid change in atmospheric pressure. As you ascend or descend, the pressure around you fluctuates, possibly a lot faster than the air inside your middle ear and sinuses. If the air pressure in your body doesn't equalize with the pressure outside your body, your ear or sinuses become uncomfortable and can, in severe cases, lead to more significant problems.

A sinus block can occur during a rapid descent, affecting the frontal sinuses (above the eyebrows) or the maxillary sinuses (in the upper cheeks). This blockage typically causes severe pain in the sinus area, and in the case of a maxillary sinus block, it may also lead to aching in the upper teeth. Bloody mucus might discharge from the nasal passages as well.

Other common symptoms of middle ear and sinus issues during flight include ear pain, a feeling of fullness or pressure, and even temporary hearing loss. Some pilots may also experience dizziness or vertigo.

If left unaddressed, middle ear and sinus problems can compromise your flying performance. Discomfort and distraction may lead to a decrease in focus, affecting your decision-making abilities and reaction times. In extreme cases, persistent issues can even lead to more severe medical complications.

There are things you can do to reduce the discomfort of middle ear and sinus problems:

Equalization Techniques: Swallowing, yawning, and performing the Valsalva maneuver can all help equalize pressure in the middle ear and sinuses. The Valsalva maneuver is performed by taking a deep breath and then closing the mouth, pinching the nose shut, and attempting to gently exhale while keeping the airway closed. This action increases pressure in the chest, and when done correctly, it can help equalize the pressure between the inside and outside of the eardrum and sinuses.

Preflight Preparation: Make sure you're healthy before you fly, especially if you have a history of sinus or ear issues. Avoid flying with a cold or sinus infection. If you have a cold, an ear infection, or a sore throat you may not be able to use the Valsalva maneuver effectively and the unrelieved pressure can lead to damaged eardrums.

Descend Gradually: When descending, do so gradually to allow your body more time to adjust to pressure changes. Avoid rapid descents whenever possible.

If you're experiencing minor congestion, nose drops or nasal sprays may reduce the chance of a painful ear blockage. However, oral decongestants have side effects that can impair pilot performance. Before using any medication, check with an aviation medical examiner to ensure that it will not affect the ability to fly.

Motion Sickness

Motion sickness, or airsickness, is the feeling of discomfort or nausea resulting from conflicting perceptions of motion experienced during flights. Motion sickness can arise when there's a disparity between what your eyes perceive and what your inner ear, responsible for balance, senses. This discrepancy can occur during maneuvers, turbulence, or when you're focusing on instruments rather than external visual references. The inner ear—specifically the vestibular system—is reporting one spatial orientation, and the eyes are communicating a different scenario.

Symptoms of motion sickness include:

- General discomfort
- Nausea or queasiness
- Dizziness
- Paleness
- Sweating
- Yawning
- Headache
- Increased salivation
- Vomiting

Motion sickness not only causes confusion in your thinking, but it may also possibly create vertigo or spatial disorientation. This can impair your ability to concentrate, make decisions, and control the aircraft effectively. Ultimately, the nausea can lead to vomiting due to a nerve that is connected from the brain to the stomach.

A pilot may experience motion sickness during initial flights, but it generally goes away within the first few lessons. Anxiety and stress, which may be experienced at the beginning of flight training, can contribute to motion sickness.

To address motion sickness and enhance your in-flight experience, consider the following corrective actions:

Visual References: Focus on external visual references, such as the horizon, to align what you see with your body's sense of motion. Avoid fixating solely on instruments, sectionals or screens.

Controlled Breathing: Practice controlled breathing techniques to help manage nausea and anxiety. Slow, deep breaths can have a calming effect on your body.

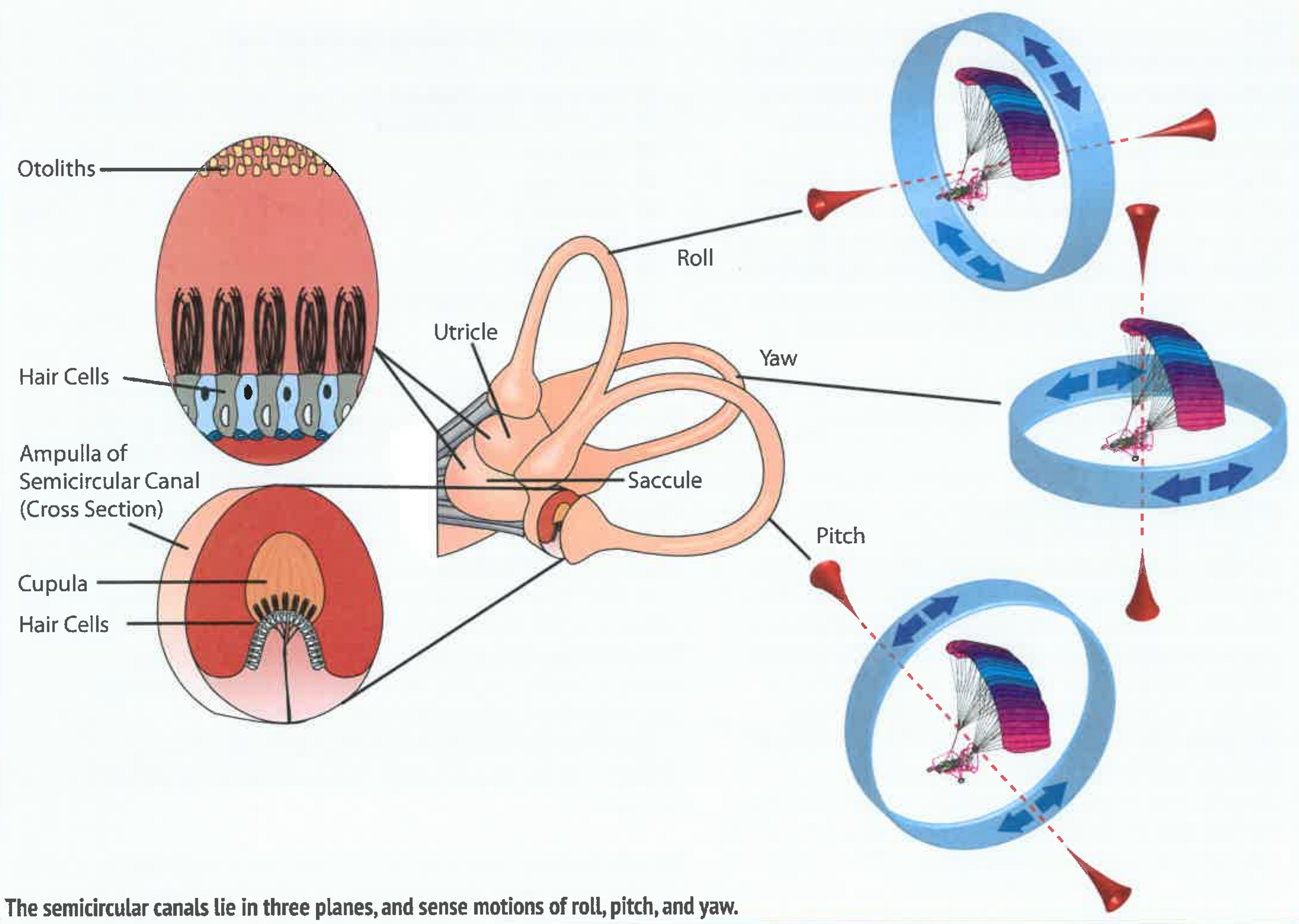
Gradual Exposure: Gradually expose yourself to the flight environment, especially if you're a new pilot. As you gain experience, your tolerance for motion will improve.

Stay Hydrated: Dehydration can exacerbate motion sickness. Stay hydrated before and during flights to maintain your overall well-being.

Limit Fatty or Heavy Foods: Avoid consuming heavy or fatty meals before flying, as these can contribute to feelings of nausea.

Be cautious about using any medications to combat motion sickness. If necessary, first consult with a healthcare professional about over-the-counter or prescription medications that may help alleviate motion sickness symptoms. Although medications like Dramamine can prevent airsickness in passengers, they are not recommended while flying since they can cause drowsiness and other problems.

It's important to remember that experiencing airsickness is no reflection on one's ability as a pilot. If you're prone to motion sickness, let your flight instructor know since there are techniques



The semicircular canals lie in three planes, and sense motions of roll, pitch, and yaw.

that can be used to overcome this problem. For example, avoid lessons in turbulent conditions until becoming more comfortable in the powered parachute, or start with shorter flights and graduate to longer instruction periods. If symptoms of motion sickness are experienced during a lesson, focusing on objects outside the powered parachute and avoiding unnecessary head movements may help alleviate some of the discomfort.

As the pilot, you should note if your passenger, who had been talking throughout the flight, gets quiet. You should ask *"how are you doing"* because getting quiet is sometimes a precursor to feelings of nausea. Inform passengers while still on the ground to let you know if their stomach begins to feel *"uneasy."* You will find a reduced rate of upset stomachs if you also let the passenger know, ahead of time, the flight maneuver you are about to make and avoid abrupt maneuvers.

Spatial Disorientation

Spatial disorientation is the state of confusion when your sensory inputs, particularly those related to orientation and motion, conflict with one another or with your perceived reality.

The body uses three integrated systems that work together to ascertain orientation and movement in space.

Vestibular system: are organs found in the inner ear that sense head position, orientation, and movement in three-dimensional space by the way we are balanced

Somatosensory system: uses nerves in the skin, muscles, and joints to sense position, movement, and tension based on gravity, vibration, and pressure.

Visual system: uses your eyes, which sense position based on what is seen

All this information comes together in the brain. Most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving. Flying can sometimes cause these systems to supply conflicting information to the brain, which can lead to disorientation. During flight in visual meteorological conditions (VMC), the eyes are the major orientation source and usually prevail over false sensations from other sensory systems. When these visual cues are taken away, as they are in instrument meteorological conditions (IMC), false sensations can cause a pilot to quickly become disoriented.

The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment. In both the left and right inner ear, three semicircular canals are positioned at approximate right angles to each other. Each canal is filled with fluid and has a section full of fine hairs. Acceleration of the inner ear in any direction causes the tiny hairs to deflect, which in turn stimulates nerve impulses, sending messages to the brain. The vestibular nerve transmits the impulses from the utricle, saccule, and semicircular canals to the brain to interpret motion.

The somatosensory system sends signals from the skin, joints, and muscles to the brain that are interpreted in relation to the earth's gravitational pull. Inputs from each movement update the body's position to the brain on a constant basis. *"Seat of the pants"* flying is largely dependent upon these signals. Used in conjunction with visual and vestibular clues, these sensations can be reliable. However, the body cannot distinguish between acceleration forces due to gravity and those resulting from maneuvering the aircraft, which can lead to sensory illusions and false impressions of the powered parachute's orientation and movement.

Under normal flight conditions, when there is a visual reference to the horizon and ground, the sensory system in the inner ear helps to identify the pitch, roll, and yaw movements of the powered parachute. When visual contact with the horizon is lost, the vestibular system becomes unreliable. Without visual references outside the powered parachute, there are situations where combinations of normal motions and forces can create convincing illusions that are difficult to overcome.

Symptoms of spatial disorientation mostly occur in instrument flight conditions and may include:

- Feeling dizzy or nauseous.
- Difficulty interpreting instruments accurately.
- Unexplained fatigue or anxiety.
- Loss of situational awareness.
- Unusual control inputs due to a false sense of aircraft attitude.

The effects of spatial disorientation can range from mild discomfort to a complete loss of control of an airplane. Misinterpreting your aircraft's attitude can lead to unintended maneuvers, potentially endangering yourself and others. Maintaining control becomes particularly challenging when relying solely on your senses, especially in instrument meteorological conditions.

Prevention is usually the best remedy for spatial disorientation. Frankly, this is not difficult since powered parachutes are normally flown in VFR conditions during the day. Flight in reduced visibility or at night when the horizon is not visible should be avoided.

If you find yourself spatially disoriented, you should maintain constant, straight-and-level flight via the throttle and remove all control input to the steering bars.

Stress

Stress is your body's natural response to challenges or demands, whether they be physical, mental, or emotional. While some stress can be motivating, excessive or prolonged stress can adversely affect your well-being and flying capabilities.

The body's reaction to stress includes releasing chemical hormones (such as adrenaline) into the blood and increasing the metabolism to provide more energy to muscles. Blood sugar, heart rate, respiration, blood pressure, and perspiration all increase. The term *"stressor"* is used to describe an element that causes an individual to experience stress. Sources of stress while you are flying can include.

Physical Stress: Noise or vibration.
Physiological Stress: Fatigue
Psychological Stress: Difficult work or personal situations.
Flight Operations: Navigating, communicating, and making decisions in real-time.
Weather Conditions: Unpredictable weather changes can create challenging flying conditions.
Time Pressure: Tight schedules, deadlines, or a need to make it to a destination before you know the wind will increase.
Technical Issues: Mechanical problems or unexpected aircraft malfunctions.
Learning Curve: Absorbing new information and skills during flight training.

Stress falls into two broad categories, including acute stress (short term) and chronic stress (long term). Acute stress involves an immediate threat that is perceived as danger. This is the type of stress that triggers a *"fight or flight"* response in an individual, whether the threat is real or imagined. Normally, a healthy person can cope with acute stress and prevent stress overload. However, ongoing acute stress can develop into chronic stress.

Chronic stress can be defined as a level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply. Unrelenting psychological pressures, such as loneliness, financial worries, and relationship or work problems can produce a cumulative level of stress that exceeds a person's ability to cope with the situation. When stress reaches these levels, performance falls off rapidly. Pilots experiencing this level of stress are not safe and should not exercise their airman privileges. Pilots who suspect they are suffering from chronic stress should consult a physician or therapist.

Symptoms of stress include:

- Physical Signs:
  - Increased heart rate
  - Muscle tension
  - Shallow breathing
  - Sweating
- Mental Signs:
  - Difficulty concentrating
  - Racing thoughts
  - Forgetfulness
  - Negative thinking
- Emotional Signs:
  - Irritability
  - Anxiety
  - Mood swings
  - Feeling overwhelmed

Understanding the Effects

The effects of stress can significantly impact your ability to fly safely. Excessive stress may lead to:

- Impaired decision-making
- Reduced situational awareness
- Inefficient communication with air traffic control and fellow pilots
- Physical fatigue and decreased reaction time

Corrective Actions

Stress management in the aircraft begins by making an assessment of stress in all areas of your life. There are several techniques to help manage the accumulation of life stresses and prevent stress overload. For example: set realistic goals; manage time more effectively; include relaxation time in a busy schedule; maintain a weekly program of physical fitness; and maintain flight proficiency.

If stress does strike in flight, you should try to relax, take a deep breath, and then calmly begin to think rationally through the resolution and decision process. Other techniques to manage stress effectively in the flight deck include:

Preflight Preparation: Adequate preflight planning can minimize unexpected challenges. Check weather forecasts, review your flight plan, and assess the overall condition of the aircraft.

Time Management: Establish realistic time frames for flight operations, including adequate time for training. Factor in potential delays or adjustments, and plan with a margin to avoid unnecessary time pressure.

Resource Management: Use flight deck resources efficiently. Familiarize yourself with the aircraft's instruments and automation systems to reduce the mental workload. Enlist your passenger to help look out for traffic at busy airports.

Communication: Maintain clear and effective communication with air traffic control, fellow pilots, and passengers. Clear communication can alleviate stress and enhance safety.

Training and Skill Development: Ongoing training and skill development build confidence and competence. The more prepared you are, the better equipped you'll be to handle challenging situations.

Mindfulness Techniques: Practice mindfulness techniques, such as deep breathing or meditation, to stay focused and calm during flights.

Seek Support: Don't hesitate to seek guidance or support from fellow pilots, instructors, or aviation professionals. Sharing experiences and learning from others can be valuable in stress management.

Stress is a natural part of being human, and a certain amount can be helpful by keeping you alert and preventing complacency. However, stress accumulates over time, and if not managed properly, it can become overwhelming, leading to negative psychological and possibly physical effects. Performance typically improves with some stress, peaks, and then quickly declines as stress levels surpass your ability to cope. High stress can impair decision-making during flight, so reducing stress in the flight deck is directly linked to enhancing aircraft safety.

Eye Health

Your vision is likely your most crucial sense when flying and perhaps even in daily life. Understanding how your eyes function and maintaining their health is essential. Vision becomes especially critical during night flights, which is why *Chapter 28, "Night Operations,"* focuses on eye function and care.

The Bottom Line

Before approaching your powered parachute, take a moment to assess your current medical, physical, and psychological condition. This reflection is the first step in evaluating your ability to conduct the flight safely. Once you're confident in your self-assessment, proceed with the preflight inspection. A good way to start is by using the *I'M SAFE* checklist from *Chapter 3, "Aeronautical Decision-Making."* Before flying, ensure both your fitness and the aircraft's airworthiness.

Chapter 7 Aircraft Certificates and Documentation

Just as you need to be fit for flight and have certain documentation before flying, your powered parachute has similar requirements. In order to fly a certain operation, whether that be flying at night, flying with a passenger, or even flying at all – both you and your aircraft have to be legal.

The FAA mandates that you carry four specific documents aboard your powered parachute when flying. A helpful acronym to remember these documents is AROW.

A	Airworthiness Certificate
R	Registration
O	Operating Limitations
W	Weight and balance

This chapter explains the main documentation your aircraft needs on board, the necessary equipment for your powered parachute, and the aircraft documentation you must keep up-to-date.

Airworthiness Certificates

An airworthiness certificate is an FAA document authorizing you to operate your aircraft in flight. An FAA representative issues this certificate only after inspecting the aircraft and confirming it conforms to regulations and is safe to fly. You must display the airworthiness certificate in your aircraft so that it is legible to passengers whenever it's operated. This certificate remains valid as long as you maintain and operate the aircraft according to federal aviation regulations. It's a permanent document you must transfer with your powered parachute when you sell it.

Airworthiness certificates are classified as either *"Standard"* or *"Special."* Standard airworthiness certificates are issued for normal, utility, acrobatic, commuter, or transport category aircraft.

Special airworthiness certificates used to be pink and you will still find a lot of them out there. Newer ones are printed on plain paper along with the operating limitations for the aircraft. Special airworthiness certificates are issued for primary, restricted, limited category, experimental, and light sport aircraft. Powered parachutes are always issued a Special Airworthiness Certificate since powered parachutes are only certificated

§ 21.179 Transferability.
An airworthiness certificate is transferred with the aircraft.

§ 21.181 Duration.

(a) Unless sooner surrendered, suspended, revoked, or a termination date is otherwise established by the FAA, airworthiness certificates are effective as follows:
   (1) Standard airworthiness certificates, special airworthiness certificates–primary category, and airworthiness certificates issued for restricted or limited category aircraft are effective as long as the maintenance, preventive maintenance, and alterations are performed in accordance with Parts 43 and 91 of this chapter and the aircraft are registered in the United States.
   ...
   (3) A special airworthiness certificate in the light-sport category is effective as long as -
      (i) The aircraft meets the definition of a light-sport aircraft;
      (ii) The aircraft conforms to its original configuration, except for those alterations performed in accordance with an applicable consensus standard and authorized by the aircraft's manufacturer or a person acceptable to the FAA;
      (iii) The aircraft has no unsafe condition and is not likely to develop an unsafe condition; and
      (iv) The aircraft is registered in the United States.
   (4) The duration of an experimental certificate issued for operating amateur-built aircraft, exhibition, air-racing, operating primary kit-built aircraft, or operating light-sport aircraft is unlimited, unless the FAA establishes a specific period for good cause.

(b) The owner, operator, or bailee of the aircraft must, upon request, make it available for inspection by the FAA.

(c) Upon suspension, revocation, or termination by order of the FAA of an airworthiness certificate, the owner, operator, or bailee of an aircraft must, upon request, surrender the certificate to the FAA.

§ 21.175 Airworthiness certificates: classification.

(a) Standard airworthiness certificates are airworthiness certificates issued for aircraft type certificated in the normal, utility, acrobatic, commuter, or transport category, and for manned free balloons, and for aircraft designated by the FAA as special classes of aircraft.

(b) Special airworthiness certificates are primary, restricted, limited, light-sport, and provisional airworthiness certificates, special flight permits, and experimental certificates.

as Special Light Sport, Experimental Light Sport, Experimental Amateur-Built and in some cases Experimental Exhibition.

Special Light Sport Aircraft (SLSA). The FAA issues a special airworthiness certificate in the light-sport category to operate a light-sport aircraft. Before the airworthiness certificate is issued by the FAA, someone from the FAA must first inspect the aircraft to make sure that it's eligible for the certificate and be in a condition for safe operation. The process involves a factory test flight.

Experimental Light-Sport Aircraft (ELSA). This is the most common certification category for powered parachutes because over two decades (roughly 1990-2005) of ultralight trainers transitioned to this category after the Sport Pilot/Light-Sport Aircraft rule took effect in 2004.

New powered parachutes can also be certificated as ELSA aircraft, but the aircraft must be assembled from a kit that matches an SLSA make and model that was manufactured by the aircraft kit manufacturer and issued an SLSA special airworthiness certificate. More often than not, the manufacturer builds the powered parachute and then lets the customer choose whether to certify the aircraft as SLSA or ELSA.

Experimental Amateur-Built Aircraft (EAB). EAB powered parachutes aren't that common, but if someone wants to build their own design, this is a way to go. A major portion of the aircraft (over 50%) must be fabricated and assembled by someone who undertook the construction project solely for their own education or recreation. The over 50% does not include the parachute, engine, instruments, or propeller.

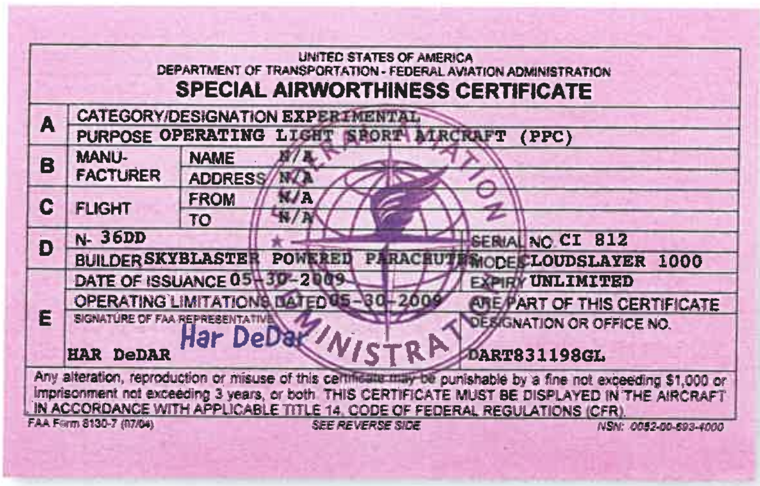
If you find an older aircraft on the market that doesn't have an airworthiness certificate, this is a way to make it legal. If you purchase it as parts, you can disassemble it and then assemble it as a kit. For it to be considered amateur built, the assembly work you do needs to be documented. There are other steps involved, but it's a way to breathe life into an old powered parachute and make it legal again.

There are advantages and disadvantages to the three different certifications. See the table on the next page. Basically, the advantages of an SLSA powered parachute are that it can be rented and used for flight instruction. On the other hand, FAA regulations are more lenient about who can perform maintenance and annual inspections on experimental aircraft.

	Special Light Sport (SLSA)	Experimental Light Sport (ELSA)	Experimental Amateur Built (EAB)
Can rent it to others.	Yes	No	No
Can use it as a trainer.	Yes	Sometimes*	Sometimes*
Who can perform maintenance on it?	Any A&P Certificate Holder Any Repairman – Light Sport Aircraft Maintenance Powered Parachute Certificate Holder Owner**	Anyone	Anyone
Who can perform annual inspections on it?	Any A&P Certificate Holder Any Repairman – Light Sport Aircraft Maintenance Certificate Holder	Any A&P Certificate Holder Any Repairman – Light Sport Aircraft Maintenance (Powered Parachute) Certificate Holder Owner who holds a Repairman – Light Sport Aircraft Inspection Certificate	Any A&P Certificate Holder Original builder who holds a Repairman – (experimental aircraft builder) Certificate for that aircraft
Who can make modifications to it?	Anyone after obtaining a manufacture approval letter.	Anyone	Anyone
Test Flight Time	Performed by the manufacturer	5 hours	40 hours
Must conform to the definition of a light sport aircraft	Yes (limited to 2 seats)	Yes (limited to 2 seats)	No (3 or 4 seats possible)

*If you own a powered parachute that is certified as experimental, you can receive instruction in it. If you are an instructor, you can train in a powered parachute that is certified as experimental as long as you don't own it OR you can apply for a letter of deviation (LODA) from the FAA.

**Owners may perform maintenance that the manufacturer specifies for them.



UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION - FEDERAL AVIATION ADMINISTRATION
SPECIAL AIRWORTHINESS CERTIFICATE

A CATEGORY/DESIGNATION EXPERIMENTAL
PURPOSE OPERATING LIGHT SPORT AIRCRAFT (PPC)

B MANU-FACTURER NAME N/A ADDRESS N/A

C FLIGHT FROM N/A TO N/A

D N- 36DD SERIAL NO CI 812
BUILDER SKYBLASTER POWERED PARACHUTE MODEL CLOUDSLAYER 1000

E DATE OF ISSUANCE 05-30-2009 EXPIRY UNLIMITED
OPERATING LIMITATIONS DATED 05-30-2009 ARE PART OF THIS CERTIFICATE
SIGNATURE OF FAA REPRESENTATIVE Har DeDar DESIGNATION OR OFFICE NO.
HAR DeDAR DART831198GL

Any alteration, reproduction or misuse of this certificate may be punishable by a fine not exceeding $1,000 or imprisonment not exceeding 3 years, or both. THIS CERTIFICATE MUST BE DISPLAYED IN THE AIRCRAFT IN ACCORDANCE WITH APPLICABLE TITLE 14, CODE OF FEDERAL REGULATIONS (CFR).
FAA Form 8130-7 (07/04) SEE REVERSE SIDE NSN: 0052-00-693-4000

FAA Form 8130-7, Special Airworthiness Certificate. This is an older version of the form, which you will still find with older powered parachutes. The newer version of this is black and white and printed on regular stock paper.

OPERATING LIMITATIONS

Operating Limitations

When the FAA issues a Special Airworthiness Certificate, the FAA representative will also issue a set of Operating Limitations. Newer powered parachutes have the Special Airworthiness Certificate and the Operating Limitations on the same document. Older aircraft have a separate document for Operating Limitations. If so, limitations need to be kept with the Special Airworthiness Certificate on the powered parachute. The issuing date on the Operating Limitations and the Airworthiness Certificate on older aircraft must match up in order for both of the documents to be valid.

The Operating Limitations are issued for each individual aircraft and will identify that aircraft by N-number, Serial Number, Manufacturer and Model. Not only that, but the limitations themselves may be customized for the individual aircraft.

The operating limitations are good for as long as the Special Airworthiness Certificate is good, often with no expiration date. However, if either document is lost, or if the owner wants to update the Operating Limitations, both documents will have to be replaced.

SLSA Operating Limitations

SLSA Operating Limitations rely heavily on the manufacturer's aircraft operating instructions (AOI) for the powered parachute. Just like the machine itself, the AOI conforms to approved ASTM standards. Since the FAA can rely on the manufacturer to provide clear instruction on the operation of the powered parachute, it doesn't issue a lot of limitations. There are only six points that the FAA makes in typical SLSA *"Conditions and Limitations"*:

1. The aircraft does not meet international standards and may not be legal to fly in other countries. Which means you will need to seek separate permission from that country to fly it there.
2. The aircraft must be operated according to all FAA regulations.
3. If the owner wants to amend the operating limitations, it must be done through a local FAA office.
4. The aircraft may only be operated per the manufacturer's AOI.
5. The pilot in command must hold a powered-parachute category and land class certificate or privilege.
6. The pilot may only conduct the flight maneuvers authorized in the AOI.

ELSA and EAB Operating Limitations

If a powered parachute is certified as an Experimental Light Sport Aircraft or an Experimental Amateur Built Aircraft, then the aircraft's operating limitations has two flight phases included. Phase 1 is the flight testing phase. This is the period of time when the experimental aircraft is test flown to make sure that it's operating properly before passengers are taken up or before it's flown in areas where it could become a hazard to others if something went wrong. The powered parachute transitions to Phase 2 operations after it has successfully had its Phase 1 time flown off and the aircraft logbook is appropriately annotated. Even after an aircraft reaches Phase 2 operations it should be brought back into Phase 1 if there is a major change to the aircraft that requires test flying once again. An example would be changing models of parachutes.

There are a lot more limitations put on an experimental aircraft than on an SLSA. That shouldn't be a big concern since many of the limitations are included because there is no AOI for the operating limitations document to refer to. In addition, many of the individual operating limitations are simply reminding you of regulations that you need to follow anyway.

Following are some of the limitations that may be found on a typical ELSA Operating Limitations document. EAB Operating Limitations are very similar.

Common Experimental Aircraft Limitations

These limitations apply in both Phase 1 and 2.

1. The aircraft does not meet international standards and may not be legal to fly in other countries. Which means you will need to seek separate permission from that country to fly it there.
2. The aircraft must be operated according to all FAA regulations.
3. The limitations do not apply if the powered parachute is flown for the government. You can install equipment and do things for the government that aren't allowed in civilian experimental operations. If you want to fly it as a civilian aircraft again, you have to bring it back to civilian standards.
4. If the owner wants to amend the operating limitations, it must be done through a local FAA office.
5. The pilot in command must hold a powered-parachute category and land class certificate or privilege.
6. If you file a flight plan, you have to make it clear that you are flying an experimental aircraft.
7. You can't use the aircraft for banner towing operations or intentional parachute jumping.

8. If you exceed the aircraft, engine, or propeller operating limitations, you must annotate the aircraft records.
9. You have to perform annual condition inspections on the aircraft.
10. Only an appropriately FAA certified repairman can perform annual condition inspections.
11. You need to replace life-limited components as prescribed by component manufacturers.
12. If you make a major change to the powered parachute, you must notify a geographically responsible Flight Standards District Office (FSDO) and get a written response from them before you can fly the aircraft.
13. The pilot may only conduct the flight maneuvers authorized in the AOI.

§ 91.305 Flight test areas.
No person may flight test an aircraft except over open water, or sparsely populated areas, having light air traffic.

§ 91.319 Aircraft having experimental certificates: Operating limitations.

(a) No person may operate an aircraft that has an experimental certificate -
  (1) For other than the purpose for which the certificate was issued; or
  (2) Carrying persons or property for compensation or hire.

(b) No person may operate an aircraft that has an experimental certificate outside of an area assigned by the Administrator until it is shown that -
  (1) The aircraft is controllable throughout its normal range of speeds and throughout all the maneuvers to be executed; and
  (2) The aircraft has no hazardous operating characteristics or design features.

(c) Unless otherwise authorized by the Administrator in special operating limitations, no person may operate an aircraft that has an experimental certificate over a densely populated area or in a congested airway. The Administrator may issue special operating limitations for particular aircraft to permit takeoffs and landings to be conducted over a densely populated area or in a congested airway, in accordance with terms and conditions specified in the authorization in the interest of safety in air commerce.

(d) Each person operating an aircraft that has an experimental certificate shall -
  (1) Advise each person carried of the experimental nature of the aircraft;
  (2) Operate under VFR, day only, unless otherwise specifically authorized by the Administrator; and
  (3) Notify the control tower of the experimental nature of the aircraft when operating the aircraft into or out of airports with operating control towers.

(e) No person may operate an aircraft that is issued an experimental certificate under § 21.191(i) of this chapter for compensation or hire, except a person may operate an aircraft issued an experimental certificate under § 21.191(i)(1)for compensation or hire to -
  (1) Tow a glider that is a light-sport aircraft or unpowered ultralight vehicle in accordance with § 91.309; or
  (2) Conduct flight training in an aircraft which that person provides prior to January 31, 2010.

(f) No person may lease an aircraft that is issued an experimental certificate under § 21.191(i) of this chapter, except in accordance with paragraph (e)(1) of this section.

(g) No person may operate an aircraft issued an experimental certificate under § 21.191(i)(1) of this chapter to tow a glider that is a light-sport aircraft or unpowered ultralight vehicle for compensation or hire or to conduct flight training for compensation or hire in an aircraft which that persons provides unless within the preceding 100-hours of time in service the aircraft has -
  (1) Been inspected by a certificated repairman (light-sport aircraft) with a maintenance rating, an appropriately rated mechanic, or an appropriately rated repair station in accordance with inspection procedures developed by the aircraft manufacturer or a person acceptable to the FAA; or
  (2) Received an inspection for the issuance of an airworthiness certificate in accordance with part 21 of this chapter.

(h) The FAA may issue deviation authority providing relief from the provisions of paragraph (a) of this section for the purpose of conducting flight training. The FAA will issue this deviation authority as a letter of deviation authority.
  (1) The FAA may cancel or amend a letter of deviation authority at any time.
  (2) An applicant must submit a request for deviation authority to the FAA at least 60 days before the date of intended operations. A request for deviation authority must contain a complete description of the proposed operation and justification that establishes a level of safety equivalent to that provided under the regulations for the deviation requested.

(i) The Administrator may prescribe additional limitations that the Administrator considers necessary, including limitations on the persons that may be carried in the aircraft.

(j) No person may operate an aircraft that has an experimental certificate under § 61.113(i) of this chapter unless the aircraft is carrying not more than 6 occupants.

Phase 1 Operating Limitations

These limitations only apply during Phase 1, the testing phase for the experimental powered parachute.

14. You can only fly the powered parachute for testing purposes. You can only test fly the aircraft over open water, or sparsely populated areas, having light air traffic during day VFR. This is also where the FAA will assign a test flight area for the aircraft.
15. Only a minimum crew necessary to fly the aircraft is allowed on board.
16. After the test flight period you need to make a statement in the aircraft records that the testing is complete and that the powered parachute flies safely.
17. You must fly the powered parachute in all configurations. This normally doesn't apply since there is only one 'configuration.'

§ 91.327 Aircraft having a special airworthiness certificate in the light-sport category: Operating limitations.

(a) No person may operate an aircraft that has a special airworthiness certificate in the light-sport category for compensation or hire except -
 (1) To tow a glider or an unpowered ultralight vehicle in accordance with § 91.309 of this chapter; or
 (2) To conduct flight training.

(b) No person may operate an aircraft that has a special airworthiness certificate in the light-sport category unless -
 (1) The aircraft is maintained by a certificated repairman with a light-sport aircraft maintenance rating, an appropriately rated mechanic, or an appropriately rated repair station in accordance with the applicable provisions of part 43 of this chapter and maintenance and inspection procedures developed by the aircraft manufacturer or a person acceptable to the FAA;
 (2) A condition inspection is performed once every 12 calendar months by a certificated repairman (light-sport aircraft) with a maintenance rating, an appropriately rated mechanic, or an appropriately rated repair station in accordance with inspection procedures developed by the aircraft manufacturer or a person acceptable to the FAA;
 (3) The owner or operator complies with all applicable airworthiness directives;
 (4) The owner or operator complies with each safety directive applicable to the aircraft that corrects an existing unsafe condition. In lieu of complying with a safety directive an owner or operator may -
  (i) Correct the unsafe condition in a manner different from that specified in the safety directive provided the person issuing the directive concurs with the action; or
  (ii) Obtain an FAA waiver from the provisions of the safety directive based on a conclusion that the safety directive was issued without adhering to the applicable consensus standard;
 (5) Each alteration accomplished after the aircraft's date of manufacture meets the applicable and current consensus standard and has been authorized by either the manufacturer or a person acceptable to the FAA;
 (6) Each major alteration to an aircraft product produced under a consensus standard is authorized, performed and inspected in accordance with maintenance and inspection procedures developed by the manufacturer or a person acceptable to the FAA; and
 (7) The owner or operator complies with the requirements for the recording of major repairs and major alterations performed on type-certificated products in accordance with § 43.9(d) of this chapter, and with the retention requirements in § 91.417.

(c) No person may operate an aircraft issued a special airworthiness certificate in the light-sport category to tow a glider or unpowered ultralight vehicle for compensation or hire or conduct flight training for compensation or hire in an aircraft which that persons provides unless within the preceding 100-hours of time in service the aircraft has -
 (1) Been inspected by a certificated repairman with a light-sport aircraft maintenance rating, an appropriately rated mechanic, or an appropriately rated repair station in accordance with inspection procedures developed by the aircraft manufacturer or a person acceptable to the FAA and been approved for return to service in accordance with part 43 of this chapter; or
 (2) Received an inspection for the issuance of an airworthiness certificate in accordance with part 21 of this chapter.

(d) Each person operating an aircraft issued a special airworthiness certificate in the light-sport category must operate the aircraft in accordance with the aircraft's operating instructions, including any provisions for necessary operating equipment specified in the aircraft's equipment list.

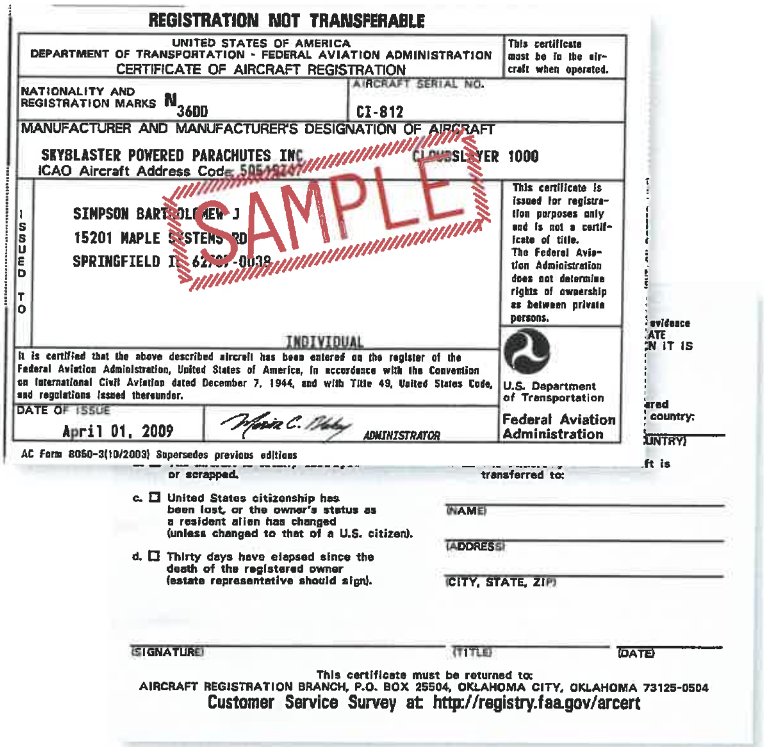
(e) Each person operating an aircraft issued a special airworthiness certificate in the light-sport category must advise each person carried of the special nature of the aircraft and that the aircraft does not meet the airworthiness requirements for an aircraft issued a standard airworthiness certificate.

(f) The FAA may prescribe additional limitations that it considers necessary.

Phase 2 Operating Limitations

These limitations only apply during Phase 2, after flight testing is complete. This is the phase you normally want to fly your powered parachute in.

18. Flying during day VFR is authorized.
19. You can't fly the powered parachute outside of the weight, airspeeds, and gravity limits tested.
20. Flight over a densely populated area is authorized for the purpose of takeoff or landing unless sufficient altitude is maintained to make a safe emergency landing in case of an engine failure.
21. You can't mount external equipment unless the equipment is mounted in a manner that will prevent in-flight jettison.


REGISTRATION NOT TRANSFERABLE

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION - FEDERAL AVIATION ADMINISTRATION
CERTIFICATE OF AIRCRAFT REGISTRATION

This certificate must be in the aircraft when operated.

NATIONALITY AND REGISTRATION MARKS N 36DD

AIRCRAFT SERIAL NO. CI-812

MANUFACTURER AND MANUFACTURER'S DESIGNATION OF AIRCRAFT

SKYBLASTER POWERED PARACHUTES INC

ICAO Aircraft Address Code

ISSUED TO

SAMPLE

INDIVIDUAL

This certificate is issued for registration purposes only and is not a certificate of title. The Federal Aviation Administration does not determine rights of ownership as between private persons.

It is certified that the above described aircraft has been entered on the register of the Federal Aviation Administration, United States of America, in accordance with the Convention on International Civil Aviation dated December 7, 1944, and with Title 49, United States Code, and regulations issued thereunder.

DATE OF ISSUE April 01, 2009

ADMINISTRATOR

U.S. Department of Transportation

Federal Aviation Administration

AC Form 8050-3(10/2003) Supersedes previous editions

or scrapped.

transferred to:

c. ☐ United States citizenship has been lost, or the owner's status as a resident alien has changed (unless changed to that of a U.S. citizen).

d. ☐ Thirty days have elapsed since the death of the registered owner (estate representative should sign).

(NAME)

(ADDRESS)

(CITY, STATE, ZIP)

(SIGNATURE) (TITLE) (DATE)

This certificate must be returned to:
AIRCRAFT REGISTRATION BRANCH, P.O. BOX 25504, OKLAHOMA CITY, OKLAHOMA 73125-0504
Customer Service Survey at: http://registry.faa.gov/arcert

AC Form 8050-3, Certificate of Aircraft Registration, front and back

Certificate of Aircraft Registration

The Certificate of Aircraft Registration is the FAA document aboard a powered parachute that identifies who the owner of the aircraft is. After you purchase, build, inherit or otherwise acquire a powered parachute, one of the things you must do is register it before you can fly it. Fortunately, this isn't normally a difficult process. After you register the powered parachute, you must keep a copy of the registration certificate on board the powered parachute. It's usually kept in the same place you display your Airworthiness Certificate and other AROW documents.

The Certificate of Aircraft Registration cannot be used for operations when:

- The aircraft is registered under the laws of a foreign country.
- The aircraft's registration is canceled upon written request of the certificate holder.
- The aircraft is totally destroyed or scrapped.
- The ownership of the aircraft is transferred.
- The certificate holder loses United States citizenship.

The Certificate of Aircraft Registration has a reverse side that should be completed and returned to the Registry:

- Within 21 days in the case of registration under the laws of a foreign country, by the person who was the owner of the aircraft before foreign registration;
- Within 60 days after the death of the holder of the certificate, by the administrator or executor of his estate, or by his heir-at-law if no administrator or executor has been or is to be appointed; or
- Within 21 days of the termination of the registration, by the holder of the Certificate of Aircraft Registration.
- If the certificate is not available for return, a statement describing the aircraft and stating the reason the certificate is not available must be submitted to the Registry.

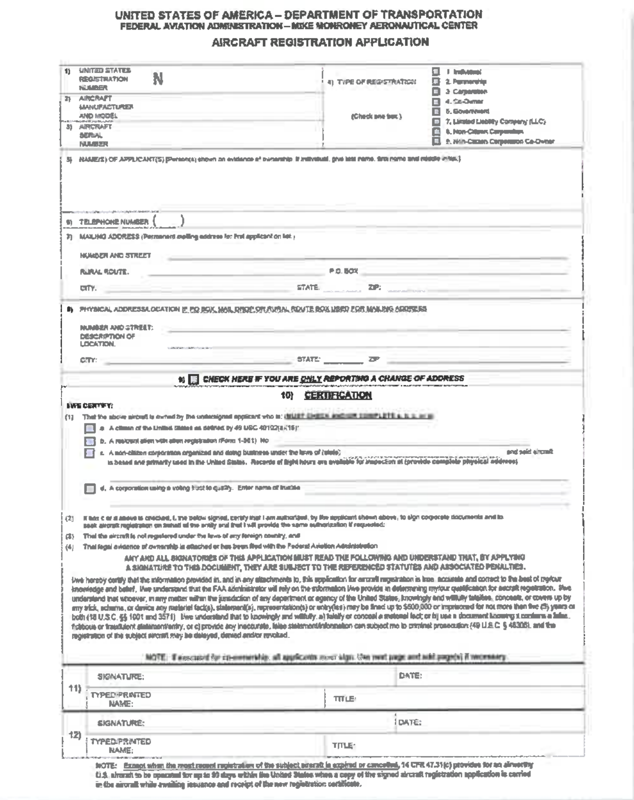
The mailing address for Aircraft Registry is:
FAA Aircraft Registration Branch, AFS-750
P.O. Box 25504
Oklahoma City, OK 73125-0504

The FAA does not issue any certificate of ownership or endorse any information with respect to ownership on a Certificate of Aircraft Registration.

Buying a Powered Parachute

When you buy a powered parachute, the seller should return the Certificate of Aircraft Registration with his name on it to the FAA by mailing it to the address above. That means that you will have to obtain your own registration for your newly purchased aircraft.

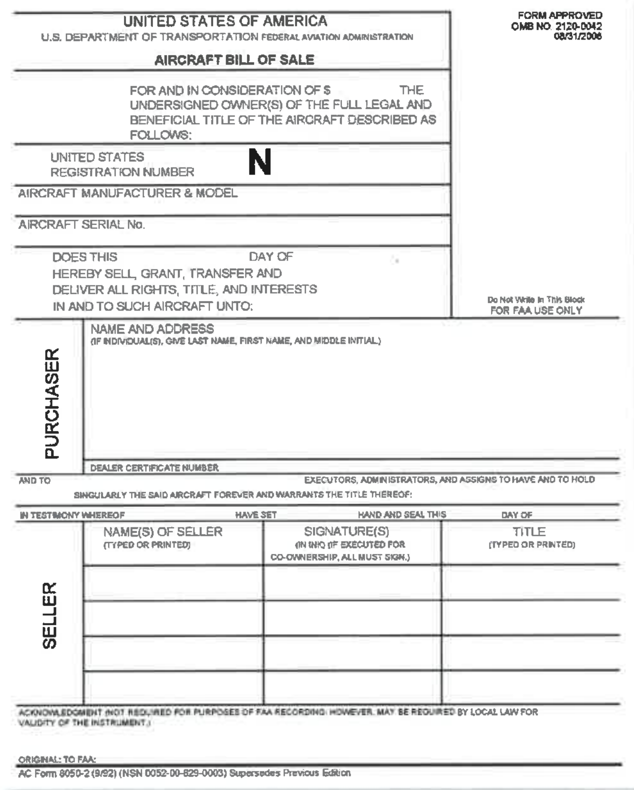
A new registration is obtained by applying to the FAA for one. That means completing an Aeronautical Center (AC) Form 8050-1.



UNITED STATES OF AMERICA – DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION—MIKE MONRONEY AERONAUTICAL CENTER
AIRCRAFT REGISTRATION APPLICATION

1) UNITED STATES REGISTRATION NUMBER N
2) AIRCRAFT MANUFACTURER AND MODEL
3) AIRCRAFT SERIAL NUMBER
4) TYPE OF REGISTRATION (Check one box)
5) NAME(S) OF APPLICANT(S)
6) TELEPHONE NUMBER ( )
7) MAILING ADDRESS
NUMBER AND STREET
RURAL ROUTE: P.O. BOX
CITY: STATE: ZIP:
8) PHYSICAL ADDRESS/LOCATION
NUMBER AND STREET:
DESCRIPTION OF LOCATION:
CITY: STATE: ZIP:
9) CHECK HERE IF YOU ARE ONLY REPORTING A CHANGE OF ADDRESS
10) CERTIFICATION
SIGNATURE: DATE:
11) TYPED/PRINTED NAME: TITLE:
SIGNATURE: DATE:
12) TYPED/PRINTED NAME: TITLE:

AC Form 8050-1, Aircraft Registration Application.



FORM APPROVED
OMB NO. 2120-0042
08/31/2008

UNITED STATES OF AMERICA
U.S. DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

AIRCRAFT BILL OF SALE

FOR AND IN CONSIDERATION OF $ THE UNDERSIGNED OWNER(S) OF THE FULL LEGAL AND BENEFICIAL TITLE OF THE AIRCRAFT DESCRIBED AS FOLLOWS:

UNITED STATES REGISTRATION NUMBER N

AIRCRAFT MANUFACTURER & MODEL

AIRCRAFT SERIAL No.

DOES THIS DAY OF
HEREBY SELL, GRANT, TRANSFER AND DELIVER ALL RIGHTS, TITLE, AND INTERESTS IN AND TO SUCH AIRCRAFT UNTO:

Do Not Write In This Block
FOR FAA USE ONLY

PURCHASER

NAME AND ADDRESS
(IF INDIVIDUAL(S), GIVE LAST NAME, FIRST NAME, AND MIDDLE INITIAL.)

DEALER CERTIFICATE NUMBER

AND TO EXECUTORS, ADMINISTRATORS, AND ASSIGNS TO HAVE AND TO HOLD SINGULARLY THE SAID AIRCRAFT FOREVER AND WARRANTS THE TITLE THEREOF:

IN TESTIMONY WHEREOF HAVE SET HAND AND SEAL THIS DAY OF

SELLER

NAME(S) OF SELLER (TYPED OR PRINTED)	SIGNATURE(S) (IN INK) (IF EXECUTED FOR CO-OWNERSHIP, ALL MUST SIGN.)	TITLE (TYPED OR PRINTED)

ACKNOWLEDGMENT (NOT REQUIRED FOR PURPOSES OF FAA RECORDING: HOWEVER, MAY BE REQUIRED BY LOCAL LAW FOR VALIDITY OF THE INSTRUMENT.)

ORIGINAL: TO FAA
AC Form 8050-2 (9/92) (NSN 0052-00-629-0003) Supersedes Previous Edition

AC Form 8050-2, Aircraft Bill of Sale.

The instructions for completing the form are on the cover page of the form and more details can be found in 14 CFR §47.31. The important details include:

- You must provide evidence of ownership of your powered parachute. That can be done by having the seller prepare an AC Form 8050-2, Aircraft Bill of Sale or an equivalent.
- There is a recording fee of $5 which must accompany the application.
- The forms and the fee must be mailed to the FAA Aircraft Registration Branch at the address above.

You should keep a copy of the completed AC Form 8050-1. That's your authorization to operate an unregistered aircraft for a period not to exceed 90 days. Your permanent registration card should arrive within those 90 days. Until then, since the aircraft is unregistered, it cannot be operated outside of the United States until a permanent Certificate of Aircraft Registration has been received.

§ 47.3 Registration required.

(a) An aircraft may be registered under 49 U.S.C. 44103 only when the aircraft is not registered under the laws of a foreign country and is -
  (1) Owned by a citizen of the United States;
  (2) Owned by an individual citizen of a foreign country lawfully admitted for permanent residence in the United States;
  (3) Owned by a corporation not a citizen of the United States when the corporation is organized and doing business under the laws of the United States or a State within the United States, and the aircraft is based and primarily used in the United States; or
  (4) An aircraft of -
    (i) The United States Government; or
    (ii) A State, the District of Columbia, a territory or possession of the United States, or a political subdivision of a State, territory, or possession.

(b) No person may operate an aircraft that is eligible for registration under 49 U.S.C. 44101-44104, unless the aircraft -
  (1) Has been registered by its owner;
  (2) Is carrying aboard the temporary authorization required by § 47.31(c); or
  (3) Is an aircraft of the Armed Forces of the United States.

(c) Governmental units are those named in paragraph (a) of this section and Puerto Rico.

Building a Powered Parachute

If you decide to build a powered parachute either from an Experimental Light Sport Aircraft (ELSA) kit or as an Experimental Amateur Built (EAB), you will have to establish your ownership of the aircraft, get it registered, and get an airworthiness inspection.

Instead of a bill of sale, you will need to establish ownership for a newly created aircraft by completing an AC Form 8050-88A (Affidavit of Ownership Light-Sport Aircraft Manufacturer's) or its equivalent, evidence from the manufacturer of ownership of an aircraft (kit-built or fly-away), AC Form 8050-1, and a $5.00 registration fee.

Weight and Balance Document

We will spend a lot of time discussing aircraft weight and balance in *Chapter 18, "Flight Controls and Trimming."* However, it's important to mention here that every powered parachute requires a weight and balance document on board.

For powered parachutes, this is a simple one-page document that includes:

- N-Number
- Serial Number
- Empty Weight (The total weight of the complete powered parachute along with all permanently installed accessories and equipment.)
- Max Gross Weight (The maximum authorized weight as specified by the wing manufacturer.)
- Useful Load (The difference between maximum gross weight and empty weight.)
- Wing Make and Model
- Settings for different pilot weights.

This document should be changed when you add accessories and equipment or change models of wings.

Pilot Privileges and Limitations vs. Aircraft Operating Limitations

Sometimes the pilot is more capable than the powered parachute. For example, a sport pilot may fly at twilight, but if the powered parachute doesn't have position lighting, then only daytime operations between sunrise and sunset are allowed. On the other hand, a powered parachute may be fully equipped for night flight, but a sport pilot cannot fly beyond twilight. Night operations are reserved for pilots with a private pilot powered parachute rating.

§ 47.31 Application.

(a) Each applicant for a Certificate of Aircraft Registration, AC Form 8050-3 must submit the following to the Registry -
  (1) An Aircraft Registration Application, AC Form 8050-1, signed by the applicant in the manner prescribed by § 47.13;
  (2) The original Aircraft Bill of Sale, AC Form 8050-2, or other evidence of ownership authorized by § 47.33, § 47.35, or § 47.37 (unless already recorded at the Registry); and
  (3) The fee required by § 47.17.

(b) The FAA rejects an application when -
  (1) Any form is not completed;
  (2) The name and signature of the applicant are not the same throughout; or
  (3) The applicant does not provide a legibly printed or typed name with the signature in the signature block.

(c) After compliance with paragraph (a) of this section, the applicant for registration of an aircraft last previously registered in the United States must carry the second copy of the Aircraft Registration Application in the aircraft as temporary authority to operate without registration.
  (1) This temporary authority is valid for operation within the United States until the date the applicant receives the Certificate of Aircraft Registration or until the date the FAA denies the application, or as provided by paragraph (c)(2) of this section.
  (2) This temporary authority is not available in connection with any Aircraft Registration Application received when 12 months have passed since the receipt of the first application following transfer of ownership by the last registered owner.
  (3) If there is no registration number assigned at the time application for registration is made, the second copy of the Aircraft Registration Application may not be used as temporary authority to operate the aircraft.

The graphic on the opposite page shows a comparison between the privileges and limitations of a sport pilot and differently equipped aircraft. Below that is a comparison between the privileges and limitations of a private pilot and differently equipped aircraft.

Required Instruments and Equipment

Your powered parachute is required to have specific instruments and equipment before you can fly it as a sport pilot. Some of this equipment is defined by regulation. Equipment requirements may also be listed in the operating limitations for the specific powered parachute.

§91.205 has a complete list of equipment requirements for standard category aircraft, which really does not include powered parachutes since powered parachutes are light sport aircraft and experimental aircraft certified with U.S. special airworthiness certificates.

So while §91.205 doesn't apply for daytime operations, it is incorporated by reference for night operations in experimental aircraft operating limitations.

Unless equipped for night flying, most all powered parachutes are not equipped with airspeed indicators or compasses. Some powered parachutes don't even have fuel gauges other than a sight tube mounted on or near the fuel tank.

Lighting

If you want to take full advantage of your powered parachute after the sun sets, you need to have position lights. This is a basic safety feature that allows other aircraft to see and avoid you.

Also important, but less well known, is the requirement for you to light your aircraft up after you land on a runway and before you taxi on a runway or taxiway. After you land on a runway and while you're stowing your parachute, you want to be seen. Strobe lights can be distracting while

§ 91.205 Powered civil aircraft with standard category U.S. airworthiness certificates: Instrument and equipment requirements.

(a) General. Except as provided in paragraphs (c)(3) and (e) of this section, no person may operate a powered civil aircraft with a standard category U.S. airworthiness certificate in any operation described in paragraphs (b) through (f) of this section unless that aircraft contains the instruments and equipment specified in those paragraphs (or FAA-approved equivalents) for that type of operation, and those instruments and items of equipment are in operable condition.

(b) Visual-flight rules (day). For VFR flight during the day, the following instruments and equipment are required:

(1) Airspeed indicator.

(2) Altimeter.

(3) Magnetic direction indicator.

(4) Tachometer for each engine.

(5) Oil pressure gauge for each engine using pressure system.

(6) Temperature gauge for each liquid-cooled engine.

(7) Oil temperature gauge for each air-cooled engine.

(8) Manifold pressure gauge for each altitude engine.

(9) Fuel gauge indicating the quantity of fuel in each tank.

...

(12) If the aircraft is operated for hire over water and beyond power-off gliding distance from shore, approved flotation gear readily available to each occupant and, ... at least one pyrotechnic signaling device. As used in this section, "shore" means that area of the land adjacent to the water which is above the high water mark and excludes land areas which are intermittently under water.

(13) An approved safety belt with an approved metal-to-metal latching device, or other approved restraint system for each occupant 2 years of age or older.

...

(c) Visual flight rules (night). For VFR flight at night, the following instruments and equipment are required:

(1) Instruments and equipment specified in paragraph (b) of this section.

(2) Approved position lights.

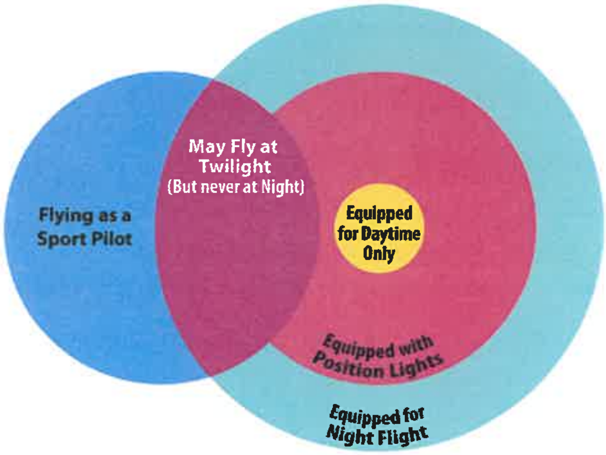
(3) An approved aviation red or aviation white anticollision light system on all U.S.-registered civil aircraft. Anticollision light systems initially installed after August 11, 1971, on aircraft for which a type certificate was issued or applied for before August 11, 1971, must at least meet the anticollision light standards of part 23, 25, 27, or 29 of this chapter, as applicable, that were in effect on August 10, 1971, except that the color may be either aviation red or aviation white. In the event of failure of any light of the anticollision light system, operations with the aircraft may be continued to a stop where repairs or replacement can be made.

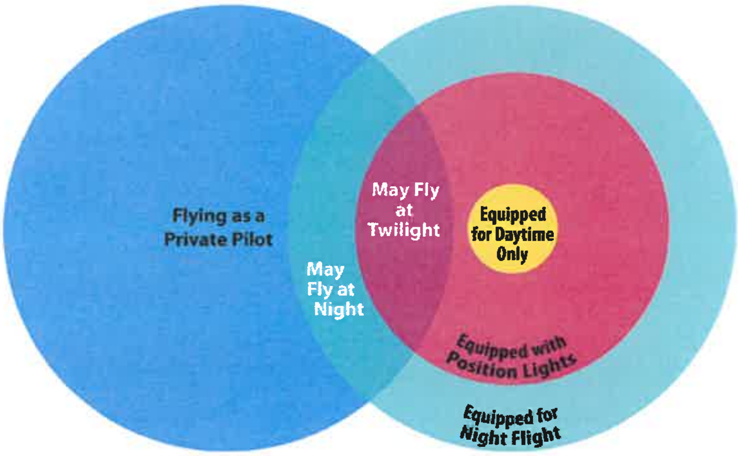
(4) If the aircraft is operated for hire, one electric landing light.

(5) An adequate source of electrical energy for all installed electrical and radio equipment.

(6) One spare set of fuses, or three spare fuses of each kind required, that are accessible to the pilot in flight.

...





stowing your equipment, so I recommend that you operate at a minimum your position lights, your landing lights (if equipped) and specific lights to help you stow your parachute.

§ 91.209 Aircraft lights.
No person may:
(a) During the period from sunset to sunrise (or, in Alaska, during the period a prominent unlighted object cannot be seen from a distance of 3 statute miles or the sun is more than 6 degrees below the horizon) -
  (1) Operate an aircraft unless it has lighted position lights;
  (2) Park or move an aircraft in, or in dangerous proximity to, a night flight operations area of an airport unless the aircraft -
    (i) Is clearly illuminated;
    (ii) Has lighted position lights; or
    (iii) is in an area that is marked by obstruction lights;
  (3) ...
(b) Operate an aircraft that is equipped with an anticollision light system, unless it has lighted anticollision lights. However, the anticollision lights need not be lighted when the pilot-in-command determines that, because of operating conditions, it would be in the interest of safety to turn the lights off.

Inoperative Equipment

Not all aircraft are perfect all of the time. So we're going to discuss the procedures and limitations for determining if your powered parachute, with certain inoperative instruments and/or equipment, is still airworthy or in a condition for safe operation.

Honestly, it's better (and often easier) to simply maintain your equipment if something breaks. But if certain equipment does become inoperative, there are procedures in the regulations for either removing or placarding inoperative equipment. The types of equipment you may want to placard might include:

- Lighting if you are flying daylight-only
- ADSB-Out if you aren't flying into controlled airspace
- Dual controls if you aren't providing flight instruction

§ 91.213 Inoperative instruments and equipment.
...
(d) ... a person may takeoff an aircraft in operations conducted under this part with inoperative instruments and equipment without an approved Minimum Equipment List provided -
  (1) The flight operation is conducted in a -
    (i) Rotorcraft, non-turbine-powered airplane, glider, lighter-than-air aircraft, powered parachute, or weight-shift-control aircraft, for which a master minimum equipment list has not been developed; or ...
  (2) The inoperative instruments and equipment are not –
  ...
    (iii) Required by § 91.205 or any other rule of this part for the specific kind of flight operation being conducted; or
  ...
  (3) The inoperative instruments and equipment are -
    (i) Removed from the aircraft, the cockpit control placarded, and the maintenance recorded in accordance with § 43.9 of this chapter; or
    (ii) Deactivated and placarded "Inoperative." If deactivation of the inoperative instrument or equipment involves maintenance, it must be accomplished and recorded in accordance with part 43 of this chapter; and
  (4) A determination is made by a pilot, who is certificated and appropriately rated under part 61 of this chapter, or by a person, who is certificated and appropriately rated to perform maintenance on the aircraft, that the inoperative instrument or equipment does not constitute a hazard to the aircraft.
  ...

The equipment you're required to have operational is listed in §91.205. That means if you have it installed, it has to work. For powered parachutes certified with special airworthiness certificates, §91.205 isn't a list of what you are required to have installed. So if it isn't there, it doesn't have to work. I know this can be confusing. The best resource for your aircraft is your Pilot's Operating Handbook (POH) (if you're flying a SLSA) or your operating limitations (if you're flying an experimental.)

An aircraft with inoperative instruments or equipment as provided in paragraph (d) of §91.205 is considered to be in a properly altered condition acceptable to the Administrator.

Pilot's Operating Handbook (POH)

Certified powered parachutes typically come with documentation and manuals that you must be familiar with to fly the aircraft. Even experimental aircraft use parachutes, engines, and other components that have their own documentation.

Operating handbooks are reference books developed by the manufacturer that provide specific information about a particular aircraft or subject. They contain basic facts, information, and/or instructions for the pilot about the operation of an aircraft, flying techniques, etc., and are intended to be kept at hand for ready reference.

For powered parachutes, you should have a manual for the complete aircraft along with specific manuals for the engine and parachute. You should probably have other specific information for your flight instruments, propeller, radio, and other equipment installed on your aircraft.

Originally, Pilot's Operating Handbooks followed whatever format and content the manufacturer felt was appropriate, but this changed with the acceptance of ASTM standards for light sport aircraft. The ASTM standard titled, *"Standard Specification for Required Product Information to be Provided with Powered Parachute Aircraft"* established a standardized format for all powered parachute *"AIRCRAFT OPERATING INSTRUCTIONS."*

The POH for an SLSA powered parachute contains the following sections:

- General
  - Pictures/illustrations of the powered parachute
  - Approved components like engines, propellers, wings
  - Approved fuel, oil, coolants, etc.
  - Definitions and Abbreviations
- Limitations – Approved maneuvers, engine operating limits, etc.
- Emergency Procedures – For events like engine failure.
- Normal Procedures – Directions for preflight, takeoff, landing, etc.
- Performance
  - Fuel range
  - Takeoff and Landing Distances
  - Effects of density altitude and total weight
- Weight and Balance
- Systems Description
  - Overall aircraft
  - Controls
  - Instruments
  - Included equipment
- Handling, Service, and Maintenance – Approved maintenance procedures and manuals
- Additional Information including
  - Aircraft Speed (Maximum and minimum)
  - Total Aircraft Flight Weight (Maximum and minimum)
  - Environmental Restrictions (such as wind, crosswind, and extreme heat and cold)
- Supplements
- Data Location and Contact Information – Including address of the manufacturer's facility

Pilot's Operating Handbooks (POHs)

Placards are used to depict aircraft limitations.

Placards

Most aircraft display one or more placards that contain information having a direct bearing on the safe operation of the aircraft. These placards are located in conspicuous places and include messages such as:

- Fuel Tank Capacity
- Passenger Warning
- No Step
- Registration Number
- *"Special Light Sport"* marking
- *"Experimental"* marking
- Throttle

Instrument Markings

Most powered parachutes use digital instead of analog instruments. Therefore, instrument markings are rarely used on powered parachute panels. Instead, the digital instruments are programmed to flash a warning signal when a temperature, RPM or other parameter is exceeded.

Flight Training Supplement

A powered parachute Flight Training Supplement (FTS) is often prepared by test pilots, flight instructors, and/or aircraft designers for a particular make and model of powered parachute. An FTS is written to help a pilot transitioning from another powered parachute to learn about the features and characteristics specific to the particular make and model of powered parachute.

An FTS is provided to supplement the information provided in a POH but does not replace it. Some portions of a POH may be mirrored in an FTS. But an FTS provides more detailed information than is practical to include in a POH.

Airworthiness Directives (AD)

AD's do not apply to powered parachutes directly, but it's a good idea to know what they are. They are directives issued by the FAA pertaining to a particular model of aircraft, powerplant or component of a Standard Category aircraft. Powered parachutes are certified as Experimental or Special Light Sport Aircraft and not as Standard Category aircraft.

Safety Directives (SD)

Safety Directives are issued against an SLSA or component by the original aircraft manufacturer. SDs are issued to correct known safety issues with an aircraft or component. Compliance with safety directives is considered to be mandatory for SLSAs and optional for ELSAs.

Typical instructions within a Safety Directive are:

- List of tools required for the task
- List of parts needed
- Type of maintenance (line, heavy, overhaul)
- Level of certification needed
- Detailed instructions and diagrams
- Inspection and test methods

Aircraft Maintenance

Maintenance is defined as the preservation, inspection, overhaul, and repair of an aircraft, including the replacement of parts. Regular and proper maintenance ensures that an aircraft meets an acceptable standard of airworthiness throughout its operational life.

Maintenance requirements vary for different powered parachutes. Powered parachutes and their engines need some type of preventive maintenance every 25 hours of flying time or less, and minor maintenance at least every 100-hours. The kinds of operations, climatic conditions, storage facilities, age, construction of the powered parachute, the engine, and other components all influence how often maintenance is required. Manufacturers supply maintenance manuals, parts catalogs, and other service information that you should use while maintaining your aircraft.

Maintaining Experimental (ELSA and EAB) Powered Parachutes

Virtually anyone can work on and maintain an experimental powered parachute. You don't need any training and you don't have to be supervised by anyone to work on an experimental aircraft.

Make sure that you're confident that you can perform a repair before you work on your powered parachute. If you have someone else work on your ELSA or EAB powered parachute, you should have confidence in their training and expertise.

Maintaining Special Light Sport Aircraft (SLSA) Powered Parachutes

The manufacturer of an SLSA powered parachute describes the level of training and expertise required for someone allowed to perform a particular maintenance task in the maintenance manual for that make and model of powered parachute. Owners can perform quite a bit of maintenance on some models of powered parachutes without any particular FAA maintenance certification. However some tasks require specialized training and certification. Advanced engine maintenance tasks normally need higher levels of training, sometimes over and beyond basic FAA ratings.

You need to refer to the powered parachute's maintenance manual when performing repairs or maintenance to an SLSA powered parachute because it documents the special tools, parts, detailed instructions, standards of completion, and the level of certification required to perform the tasks.

§ 91.405 Maintenance required.

Each owner or operator of an aircraft -

(a) Shall have that aircraft inspected as prescribed in subpart E of this part and shall between required inspections, except as provided in paragraph (c) of this section, have discrepancies repaired as prescribed in part 43 of this chapter;

(b) Shall ensure that maintenance personnel make appropriate entries in the aircraft maintenance records indicating the aircraft has been approved for return to service;

(c) Shall have any inoperative instrument or item of equipment, permitted to be inoperative by § 91.213(d)(2) of this part, repaired, replaced, removed, or inspected at the next required inspection; and

(d) When listed discrepancies include inoperative instruments or equipment, shall ensure that a placard has been installed as required by § 43.11 of this chapter.

§ 91.417 Maintenance records.

(a) ..., each registered owner or operator shall keep the following records for the periods specified in paragraph (b) of this section:

(1) Records of the maintenance, preventive maintenance, and alteration and records of the 100-hour, annual, progressive, and other required or approved inspections, as appropriate, for each aircraft (including the airframe) and each engine, propeller, rotor, and appliance of an aircraft. The records must include -

(i) A description (or reference to data acceptable to the Administrator) of the work performed; and

(ii) The date of completion of the work performed; and

(iii) The signature, and certificate number of the person approving the aircraft for return to service.

(2) Records containing the following information:

(i) The total time in service of the airframe, each engine, each propeller, and each rotor.

(ii) The current status of life-limited parts of each airframe, engine, propeller, rotor, and appliance.

(iii) The time since last overhaul of all items installed on the aircraft which are required to be overhauled on a specified time basis.

(iv) The current inspection status of the aircraft, including the time since the last inspection required by the inspection program under which the aircraft and its appliances are maintained.

(v) The current status of applicable airworthiness directives (AD) and safety directives including, for each, the method of compliance, the AD or safety directive number and revision date. If the AD or safety directive involves recurring action, the time and date when the next action is required.

(vi) Copies of the forms prescribed by § 43.9(d) of this chapter for each major alteration to the airframe and currently installed engines, rotors, propellers, and appliances.

(b) The owner or operator shall retain the following records for the periods prescribed:

(1) The records specified in paragraph (a)(1) of this section shall be retained until the work is repeated or superseded by other work or for 1 year after the work is performed.

(2) The records specified in paragraph (a)(2) of this section shall be retained and transferred with the aircraft at the time the aircraft is sold.

(3) A list of defects furnished to a registered owner or operator under § 43.11 of this chapter shall be retained until the defects are repaired and the aircraft is approved for return to service.

(c) The owner or operator shall make all maintenance records required to be kept by this section available for inspection by the Administrator or any authorized representative of the National Transportation Safety Board (NTSB). In addition, the owner or operator shall present Form 337 described in paragraph (d) of this section for inspection upon request of any law enforcement officer.

(d) When a fuel tank is installed within the passenger compartment or a baggage compartment pursuant to part 43 of this chapter, a copy of FAA Form 337 shall be kept on board the modified aircraft by the owner or operator.

§ 91.403 General.

(a) The owner or operator of an aircraft is primarily responsible for maintaining that aircraft in an airworthy condition, including compliance with part 39 of this chapter.

(b) No person may perform maintenance, preventive maintenance, or alterations on an aircraft other than as prescribed in this subpart and other applicable regulations, including part 43 of this chapter.

(c) No person may operate an aircraft for which a manufacturer's maintenance manual or instructions for continued airworthiness has been issued that contains an airworthiness limitations section unless the mandatory replacement times, inspection intervals, and related procedures specified in that section or alternative inspection intervals and related procedures set forth in an operations specification approved by the Administrator under part 121 or 135 of this chapter or in accordance with an inspection program approved under § 91.409(e) have been complied with.

(d) A person must not alter an aircraft based on a supplemental type certificate unless the owner or operator of the aircraft is the holder of the supplemental type certificate, or has written permission from the holder.

§ 91.407 Operation after maintenance, preventive maintenance, rebuilding, or alteration.

(a) No person may operate any aircraft that has undergone maintenance, preventive maintenance, rebuilding, or alteration unless—

(1) It has been approved for return to service by a person authorized under § 43.7 of this chapter; and

(2) The maintenance record entry required by § 43.9 or § 43.11, as applicable, of this chapter has been made.

(b) No person may carry any person (other than crewmembers) in an aircraft that has been maintained, rebuilt, or altered in a manner that may have appreciably changed its flight characteristics or substantially affected its operation in flight until an appropriately rated pilot with at least a private pilot certificate flies the aircraft, makes an operational check of the maintenance performed or alteration made, and logs the flight in the aircraft records.

(c) The aircraft does not have to be flown as required by paragraph (b) of this section if, prior to flight, ground tests, inspection, or both show conclusively that the maintenance, preventive maintenance, rebuilding, or alteration has not appreciably changed the flight characteristics or substantially affected the flight operation of the aircraft.

§ 91.419 Transfer of maintenance records.

Any owner or operator who sells a U.S.-registered aircraft shall transfer to the purchaser, at the time of sale, the following records of that aircraft, in plain language form or in coded form at the election of the purchaser, if the coded form provides for the preservation and retrieval of information in a manner acceptable to the Administrator:

(a) The records specified in § 91.417(a)(2).

(b) The records specified in § 91.417(a)(1) which are not included in the records covered by paragraph (a) of this section, except that the purchaser may permit the seller to keep physical custody of such records. However, custody of records by the seller does not relieve the purchaser of the responsibility under § 91.417(c) to make the records available for inspection by the Administrator or any authorized representative of the National Transportation Safety Board (NTSB).

§ 91.421 Rebuilt engine maintenance records.

(a) The owner or operator may use a new maintenance record, without previous operating history, for an aircraft engine rebuilt by the manufacturer or by an agency approved by the manufacturer.

(b) Each manufacturer or agency that grants zero time to an engine rebuilt by it shall enter in the new record -

(1) A signed statement of the date the engine was rebuilt;

(2) Each change made as required by airworthiness directives; and

(3) Each change made in compliance with manufacturer's service bulletins, if the entry is specifically requested in that bulletin.

(c) For the purposes of this section, a rebuilt engine is a used engine that has been completely disassembled, inspected, repaired as necessary, reassembled, tested, and approved in the same manner and to the same tolerances and limits as a new engine with either new or used parts. However, all parts used in it must conform to the production drawing tolerances and limits for new parts or be of approved oversized or undersized dimensions for a new engine.

YEAR: 2009 DATE	RECORDING TACH TIME:	TODAY'S FLIGHT	TOTAL TIME IN SERVICE	Description of Inspections, Tests, Repairs and Alterations Entries must be endorsed with Name, Rating and Certificate Number of Technician or Repair Facility. (See back pages for other specific entries.)
5/30	75.0 Hrs		75.0 Hrs	Replaced Spark Plugs with NGK BR8ES.
				Checked Electric Starter Gear.
				Lubricated Control Cables.
				Lubricated Exhaust Ball Joints.
				Replaced Muffler Springs w/ Rotax Part #938-790.
				Checked Propeller Ballance and Tracking.
				Cleaned and Oiled Air Filter.
				Checked Fuel Filter.
				Checked and Adjusted Carbs.
				Replaced Gearbox Oil.
				Hugh Jorgan Hugh Jorgan 1234321 RLSA-I PPC

YEAR: DATE	RECORDING TACH TIME:	TODAY'S FLIGHT

Sample maintenance logbook entry.

Maintenance Logbook Entries

Anyone who maintains, performs preventive maintenance, alters, or performs an aircraft inspection on a powered parachute must make an entry in the maintenance record of the aircraft or component. The entry must include:

1. A description of the work.
2. The date of completion of the work.
3. The time in service of the aircraft (in hours).
4. The pilot's name, signature, certificate number, and type of certificate held.

Signing the logbook after performing maintenance constitutes a 'return to service' for that aircraft or component.

Aircraft Inspections

The airworthiness of a powered parachute can be determined by a preflight inspection and a review of the maintenance records. The powered parachute owner is responsible for maintaining a powered parachute in an airworthy condition. That includes making sure that certain inspections are performed on the aircraft and correcting any defects detected between those required inspections. That doesn't mean that the owner must perform the work himself. Usually the work is hired out, particularly for complex aircraft.

Which inspections are required and when, depends on how the powered parachute is being used. All aircraft need to be inspected at least once each 12 calendar months. If the aircraft is being used commercially (including flight instruction) it also needs an inspection after every 100-hours of operation. What is the difference between those two inspections? Nothing, except for the kind of logbook entry made in the logbook.

All inspections should follow the manufacturer's current maintenance manual, including the Instructions for Continued Airworthiness concerning inspections intervals, parts replacement, and life-limited items as applicable to the powered parachute. An inspection checklist may not be available for your make and model of powered parachute. This can happen if you have an older model of powered parachute or your aircraft is amateur built. If that's the case, you should contact the manufacturer (if possible) and visit user groups in order to find an inspection checklist for a powered parachute similar to your own. Then you can modify the checklist to match your aircraft as best as possible.

Annual Inspection

Every powered parachute must have at least an annual inspection. Who can do the inspection depends on how the powered parachute was certificated. There are five different levels of inspectors which are all either certificated mechanics or repairmen. They are:

1. Airframe and Powerplant (A&P) Mechanic who holds an Inspection Authorization (IA)
2. Airframe and Powerplant (A&P) Mechanic
3. Repairman–Light Sport Aircraft Maintenance (RLSA-M): Powered Parachutes
4. Repairman–Light Sport Aircraft Inspection (RLSA-I): Powered Parachutes
5. Repairman–Experimental Aircraft Builder

YEAR: 2009 DATE	RECORDING TACH TIME:	TODAY'S FLIGHT	TOTAL TIME IN SERVICE	**Description of Inspections, Tests, Repairs and Alterations** Entries must be endorsed with Name, Rating and Certificate Number of Technician or Repair Facility. (See back pages for other specific entries.)	YEAR: DATE	RECORDING TACH TIME:	TODAY'S FLIGHT
5/30	40.3 Hrs		40.3 Hrs	I certify that this aircraft has been inspected on			
				5-30-2009 in accordance with the scope and detail of			
				Appendix D to Part 43 and was found to be in a			
				condition for safe operation.			
				Willi Stroker Willi Stroker 1234321 RLSA-I PPC			

Sample Annual Inspection logbook entry.

Maintenance/Inspection Rating Held	Who can perform annual inspections on these aircraft? Special Light-Sport Aircraft (SLSA)	Experimental Light-Sport Aircraft (ELSA)	Experimental Amateur-Built (E-AB)	Experimental Exhibition (EE)
Airframe and Powerplant (A&P) Mechanic who holds an Inspection Authorization (IA) See §65.91	Yes	Yes	Yes	Yes
Airframe and Powerplant (A&P) Mechanic See §65.71	Yes	Yes	Yes	Yes
Repairman - Light Sport Aircraft Maintenance (RLSA-M): Powered Parachutes See §65.107(c)	Yes	Yes	No	No
Repairman- Light Sport Aircraft Inspection (RLSA-I): Powered Parachutes See §65.107(b)	No	Yes, If the Repairman OWNS the powered parachute	No	No
Repairman - Experimental Aircraft Builder See §65.104	No	No	Yes, If the Repairman BUILT the powered parachute	No

A&P Mechanics (with or without an Inspection Authorization) can work on and perform annual and 100-hour inspections on all four of the common kinds of certified powered parachutes. Those are:

- Special Light Sport Aircraft (SLSA)
- Experimental Light Sport Aircraft (ELSA)
- Experimental Amateur Built (EAB)
- Experimental Exhibition (EE)

Repairman-Light Sport Aircraft Maintenance (RLSA-M): Powered Parachutes certificate holders may work on and inspect any SLSA or ELSA powered parachute. Note that their training and certificate must specifically include powered parachutes.

Repairman-Light Sport Aircraft Inspection (RLSA-I): Powered Parachutes certificate holders may inspect each ELSA powered parachute that they own. Note that their training and certificate must specifically include powered parachutes. In addition, the certificate must include each ELSA aircraft that the certificate holder owns by N-number in order to be qualified to inspect it.

Repairman-Experimental Aircraft Builder certificate holders may inspect any EAB powered parachute that they've built, whether or not they still own it.

A powered parachute may not be flown unless the annual inspection has been performed within the preceding 12 calendar months. A period of 12 calendar months extends from any day of a month to the last day of the same month the following year.

All powered parachutes used for flight instruction for hire, when provided by the person giving the flight instruction, must have received a 100-hour inspection. This inspection must be performed by an FAA-certificated A&P Mechanic or a Repairman-Light Sport Aircraft Maintenance with a Powered Parachute authorization. An annual inspection, or an inspection for the issuance of an Airworthiness Certificate may be substituted for a required 100-hour inspection.

Parachute Inspection

Even though repairmen with A&P and even RLSA-I credentials can inspect a parachute, some owners find it useful to have a parachute rigger, repair facility, or even the manufacturer inspect the parachute annually or after so many hours of flight time.

Parachute lines can stretch with time, and parachute material can weaken and become less porous. The inspections for that involve specialized equipment as well as training that may be beyond the abilities of the sport aviator. If that's the case, sending the parachute out for the inspection is a good idea.

For SLSA powered parachutes, the manufacturer often requires sending the parachute to a parachute manufacture or to a designated repair facility after two years or 100 hours of use, and subsequently every 100 hours or annually.

ADS-B Out Inspection

Some owners are installing transponders or ADSB-Out devices on their powered parachutes. This allows powered parachutes to fly in the following airspace:

- Class A, B, and C airspace
- Class E airspace at or above 10,000 feet MSL
- Within 30 nautical miles of a Class B primary airport (the Mode C veil)
- Above the ceiling and within the lateral boundaries of Class B or Class C airspace up to 10,000 feet
- Class E airspace over the Gulf of Mexico, at and above 3,000 feet MSL, within 12 NM of the U.S. coast.

Sport pilots and most powered parachute pilots generally avoid flying in much of this airspace. However, with the right equipment and proper training, some of it can be safely navigated.

§91.413 requires that before a transponder may be used, it shall be tested and inspected within the preceding 24 months. That inspection must be done by a specialized avionics shop.

Inspection Entries

All mechanics or repairmen conducting Annual, 100-Hour, Transponder, and GPS-Out inspections must record a logbook entry in the powered parachute logbook. The entry should follow the language mandated by the operating limitations for that aircraft. A sample Annual Inspection entry can be found in the graphic on the preceding page. The entry must include:

- The language mandated in the operating limitations.
- The date.
- The aircraft's total time-in-service.
- The name, signature, certificate number, and type of certificate held by the person performing the inspection.

Becoming an Aircraft Inspector

There are good reasons for becoming qualified as an inspector, even if you're only flying your machine recreationally. In fact, there are two types of inspection ratings that are geared specifically to the amateur builder or sport pilot. As an inspector, you can save hundreds of dollars annually by performing your own annual inspections. Being an inspector also offers you the convenience of performing the inspections when the timing suits your schedule and the minimal training needed to do the work helps you better understand your powered parachute.

Repairman–Light Sport Aircraft Inspection (RLSA-I)

The most common inspection rating for powered parachutes is the Repairman–Light Sport Aircraft Inspection rating. The holder of a repairman certificate (light sport aircraft) with an inspection rating may perform the annual condition inspection on a light sport aircraft that:

- Is owned by the holder of the certificate;
- Has been issued an ELSA airworthiness certificate; and
- Is in the same class of light sport aircraft for which the holder has completed the training specified. The training is a 16 hour course that is geared to the category of aircraft you want to inspect. In our case, powered parachutes.

The 16-hour courses are offered nationwide for groups of up to 16 students. You only need to take this course once for powered parachutes, and you won't need to repeat it regardless of how many powered parachutes you buy or sell. However, if you purchase an ELSA airplane or weight-shift-control trike, you'll need to retake the course for that category and reapply to the FAA for that inspection rating.

After you complete the 16-hour training course, you will need to make an appointment with the local Flight Standards District Office (FSDO) to apply for your certificate. They will ask you to bring with you at a minimum:

- Aircraft Registration and Airworthiness Certificate for each ELSA powered parachute you own and would like to be able to inspect.
- Your course completion certificate from the 16-hour course.
- A photo ID.
- A completed application for the rating. (FAA Form 8610-2 or electronic equivalent.)

During your FSDO appointment, the FAA representative will complete your application for the rating and issue you a temporary certificate which looks much like a temporary pilot certificate. After a few weeks, you will receive your permanent certificate in the mail, which again looks very much like your permanent pilot certificate.

Each time you buy or sell a powered parachute, you will need to make an appointment with the FSDO in order to update your certificate so that it reflects the exact powered parachutes you're able to inspect. That's because the rating will be issued to you for only those N-numbered aircraft you own and have asked to have listed on the certificate.

Repairman–Experimental Aircraft Builder

If you build your own powered parachute and get it certificated as an Experimental-Amateur Built aircraft, you will have the opportunity to become the inspector for that particular aircraft. There is no requirement to attend any additional schooling. The holder of a repairman certificate (experimental aircraft builder) may perform condition inspections on the aircraft constructed by the holder in accordance with the operating limitations of that aircraft.

To be eligible for a repairman certificate (experimental aircraft builder), an individual must

- Be the primary builder of the aircraft to which the privileges of the certificate are applicable;
- Show to the satisfaction of the Administrator that the individual has the requisite skill to determine whether the aircraft is in a condition for safe operations; and
- After you complete the amateur-built powered parachute, you will need to apply directly to the FSDO for the repairman certificate. That certificate will be for only that particular aircraft and listed by N-number.

The repairman/inspector status is not transferable to anyone else. If you sell the powered parachute, you may still do the annual inspections for it. However, anyone else wanting to do the inspections will have to have at least an A&P Certificate.

Repairman–Light Sport Aircraft Maintenance (RLSA-M)

The RLSA-M certificate is a professional-level certificate. Not only does it allow the holder to inspect any ELSA certificated aircraft the holder is rated for, it also allows the holder to inspect and repair SLSA aircraft.

The RLSA-M for powered parachutes applicant must attend a minimum 104-hour class. The class trains the repairmen to do work on powered parachutes. Right now, a student can get combined training for airplane, powered parachute and (optionally) weight-shift-control aircraft in longer 139 to 158-hour courses.

After you complete the 139 to 158-hour training course, you will need to make an appointment with the local FSDO to apply for your certificate. They will ask you to bring with you at a minimum:

- Your course completion certificates from the training course.
- A photo ID.
- A completed application for the rating. (FAA Form 8610-2 or electronic equivalent.)

During your FSDO appointment, the FAA representative will complete your application for the rating and issue you a temporary certificate which looks much like a temporary pilot certificate. After a few weeks, you will receive your permanent certificate in the mail, which again looks very much like your permanent pilot certificate.

A&P Mechanic

Becoming an airframe & powerplant mechanic is well beyond the scope of this book. But an A&P mechanic can work on and inspect your powered parachute. However, an A&P is supposed to be familiar with whatever aircraft or system he's working on. Initial unfamiliarity with powered parachute airframes, two-stroke engines, and parachutes may make the A&P uncomfortable with working on or inspecting your powered parachute.

65.107 Repairman certificate (light-sport aircraft): Eligibility, privileges, and limits.

(a) Use the following table to determine your eligibility for a repairman certificate (light-sport aircraft) and appropriate rating:

To be eligible for	You must
(1) A repairman certificate (light-sport aircraft)	(i) Be at least 18 years old, (ii) Be able to read, speak, write, and understand English. If for medical reasons you cannot meet one of these requirements, the FAA may place limits on your repairman certificate necessary to safely perform the actions authorized by the certificate and rating, (iii) Demonstrate the requisite skill to determine whether a light-sport aircraft is in a condition for safe operation, and (iv) Be a citizen of the United States, or a citizen of a foreign country who has been lawfully admitted for permanent residence in the United States.
(2 A repairman certificate (light-sport aircraft) with an inspection rating	(i) Meet the requirements of paragraph (a)(1) of this section, and (ii) Complete a 16-hour training course acceptable to the FAA on inspecting the particular class of experimental light-sport aircraft for which you intend to exercise the privileges of this rating.
(3) A repairman certificate (light-sport aircraft) with a maintenance rating	(i) Meet the requirements of paragraph (a)(1) of this section, and (ii) Complete a training course acceptable to the FAA on maintaining the particular class of light-sport aircraft for which you intend to exercise the privileges of this rating. The training course must, at a minimum, provide the following number of hours of instruction: (A) For airplane class privileges–120-hours, (B) For weight-shift control aircraft class privileges–104 hours, (C) For powered parachute class privileges–104 hours,

(b) The holder of a repairman certificate (light-sport aircraft) with an inspection rating may perform the annual condition inspection on a light-sport aircraft:
  (1) That is owned by the holder;
  (2) That has been issued an experimental certificate for operating a light-sport aircraft under § 21.191(i) of this chapter; and
  (3) That is in the same class of light-sport-aircraft for which the holder has completed the training specified in paragraph (a)(2)(ii) of this section.

(c) The holder of a repairman certificate (light-sport aircraft) with a maintenance rating may–
  (1) Approve and return to service an aircraft that has been issued a special airworthiness certificate in the light-sport category under § 21.190 of this chapter, or any part thereof, after performing or inspecting maintenance (to include the annual condition inspection and the 100-hour inspection required by § 91.327 of this chapter), preventive maintenance, or an alteration (excluding a major repair or a major alteration on a product produced under an FAA approval);
  (2) Perform the annual condition inspection on a light-sport aircraft that has been issued an experimental certificate for operating a light-sport aircraft under § 21.191(i) of this chapter; and
  (3) Only perform maintenance, preventive maintenance, and an alteration on a light-sport aircraft that is in the same class of light-sport aircraft for which the holder has completed the training specified in paragraph (a)(3)(ii) of this section. Before performing a major repair, the holder must complete additional training acceptable to the FAA and appropriate to the repair performed.

(d) The holder of a repairman certificate (light-sport aircraft) with a maintenance rating may not approve for return to service any aircraft or part thereof unless that person has previously performed the work concerned satisfactorily. If that person has not previously performed that work, the person may show the ability to do the work by performing it to the satisfaction of the FAA, or by performing it under the direct supervision of a certificated and appropriately rated mechanic, or a certificated repairman, who has had previous experience in the specific operation concerned. The repairman may not exercise the privileges of the certificate unless the repairman understands the current instructions of the manufacturer and the maintenance manuals for the specific operation concerned.

Chapter 8 Aircraft Structure

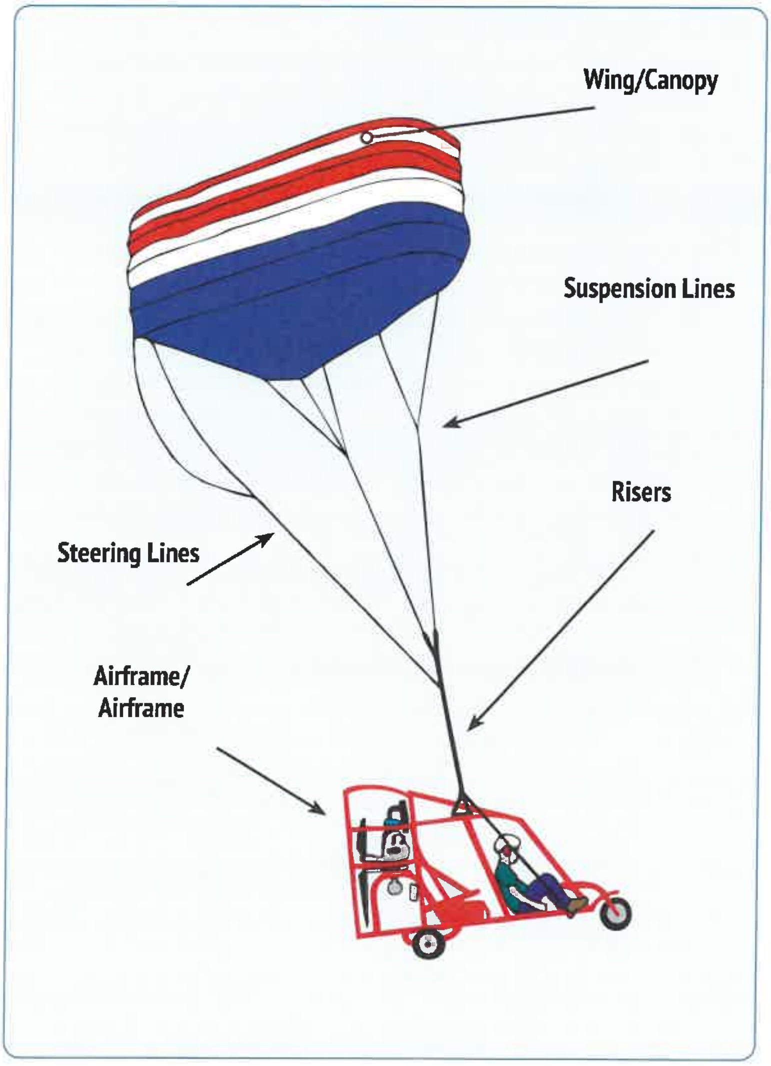
Although powered parachutes come in an array of shapes, sizes and prices, the basic design features are fundamentally the same. Powered parachutes consist of an airframe (often referred to as a airframe), a ram-air inflated wing, and a combination of suspension lines and risers connecting the wing and airframe together.

The Airframe

The modest looking powered parachute is far stronger than any other light aircraft. They're stronger because powered parachute designers have the deck stacked in their favor. Before someone ever starts designing a airframe, they already know that the wing is only going to weigh about 20-30 lbs. The wing has no metal or wood ribs, no rivets, no bolts, no paint, no ailerons, no flaps, and no bomb racks. Nor does it need them. That means that a powered parachute airframe designer has that much more of a weight allowance to work with for the rest of the machine.

To make matters even better, the forces that a powered parachute airframe must endure are rather straightforward. The forces from the wing are carried straight through the risers to the rest of the airframe. All of the main forces on the airframe are tension forces, which are structurally easy to deal with. The rest of the forces are compression forces, which are also simple for any structural designer.

Significantly, there are no cantilevered forces like those on a typical wing attachment. More importantly, there is little repetitive loading and



Parts of a powered parachute.

Powered parachutes equipped with dual controls allow both the flight instructor and the student pilot to control the engine speed.

unloading of any structural airframe members since the flexible wing acts as a dampener and soaks up a lot of the rough air that the powered parachute may fly through. That eliminates the need to worry excessively about metal fatigue.

One might wonder then why powered parachutes aren't lighter than they are. The reasons are rather straightforward.

First, a powered parachute needs more power than a hard-winged aircraft. A parachute is not what aeronautical engineers consider an efficient wing. There's a lot of drag associated with the aerodynamically dirty design and brute force is the best way to deal with that shortcoming. That results in larger engines and stronger (heavier) structures to support those engines.

Designers have also used the weight allowance to build more safety and protective features into powered parachutes. Much of the newer equipment is designed so that if the machine tips over or is in an accident, the pilot will be all right and even the machine shouldn't be damaged. Big suspension systems are popular, as are big tires and frontal bar systems.

Finally, overbuilding machines is something of a marketing decision. When one manufacturer uses one size of cable or tubing, their competitor goes to one size bigger. The next competitor then puts on bigger tubes to outdo both.

Although side-by-side configurations exist, in most powered parachutes the pilot and passenger are seated in a tandem (fore and aft) configuration. The pilot flies from the front seat in order to reach the steering bars, throttle control, ground steering control and magneto switches, and to keep the Center of Gravity (CG) in balance. Some machines have complete dual controls for the back seat. Still, you cannot fly from the back seat without someone in the front seat because it would throw off the CG too much.

Dual flight controls are required for training although not all powered parachutes have full dual controls. That still may not be a problem depending on the configuration of the airframe, the provided controls and the flight instructor. Flight training can still be accomplished if the flight instructor can adequately control the aircraft during training from the rear seat during takeoff, flight, and landing. While in the rear seat, the flight instructor needs to have positive control of the aircraft at all times by being able to physically pull on the steering lines and using a dual control throttle.

Like airplanes and other aircraft designs, not all powered parachutes are adequately configured to conduct flight training. The powered parachute

Most modern powered parachutes are equipped with 4 point harnesses for both pilot and passenger

flight instructor should determine his or her ability to control each individual powered parachute from the back seat with the controls provided.

Pilots steer most powered parachutes by pushing steering bars mounted in front of them with their feet. Pilots come in all sizes and it's important that a pilot can properly reach the steering bars. If the steering bars are too far away from the pilot, then steering authority is compromised. If the steering bars are too close for a taller pilot, the pilot's legs may cramp up. Some manufacturers use an adjustable front seat to ensure pilots with varying leg lengths can comfortably reach the steering bars. Others have fixed seat positions and make the steering bars adjustable. Powered parachutes can be outfitted with a variety of seat belts, from simple lap belts to four-point harness systems that securely fasten each occupant into their seat.

Most powered parachutes have three wheels, or a tricycle gear configuration, although some have four. There is no convention for ground steering systems. Ground steering may be a steering bar connected to the nosewheel that moves left and right. Other powered parachutes have a tiller device for ground steering. Some have side mounted bars that move fore and aft to steer the front wheel, some have steering wheels and yet others have no provision at all for wheel steering.

Components of an Airframe

Most powered parachute airframes are manufactured with aircraft-grade tubing and hardware although a few manufacturers are building fiber-composite airframes. The airframe's tubular construction means light weight and ease of replacement if tubes are bent. The airframe includes one or more seats, flight controls, and an instrument panel. The airframe also incorporates the engine, the fuel tank, the propeller, and points of attachment for the wing and steering lines.

Powered parachute airframes are typically constructed using a combination of materials that balance strength, weight, and durability to ensure the safety and performance of the aircraft. The primary materials used in powered parachute airframes include metals and fasteners.

6061-T6 Aluminum is the alloy most commonly used in the construction of powered parachute airframes due to its excellent strength-to-weight ratio and corrosion resistance. The T6 temper signifies that the aluminum has been solution heat-treated and artificially aged, enhancing its mechanical properties.

4130 Chromoly Steel: is a high-strength steel alloy commonly used for structural components like tubing for the main frame rails. It offers good weldability and is well-suited for applications where a balance of strength and weight is essential. Some airframes are constructed completely from welded 4130 steel.

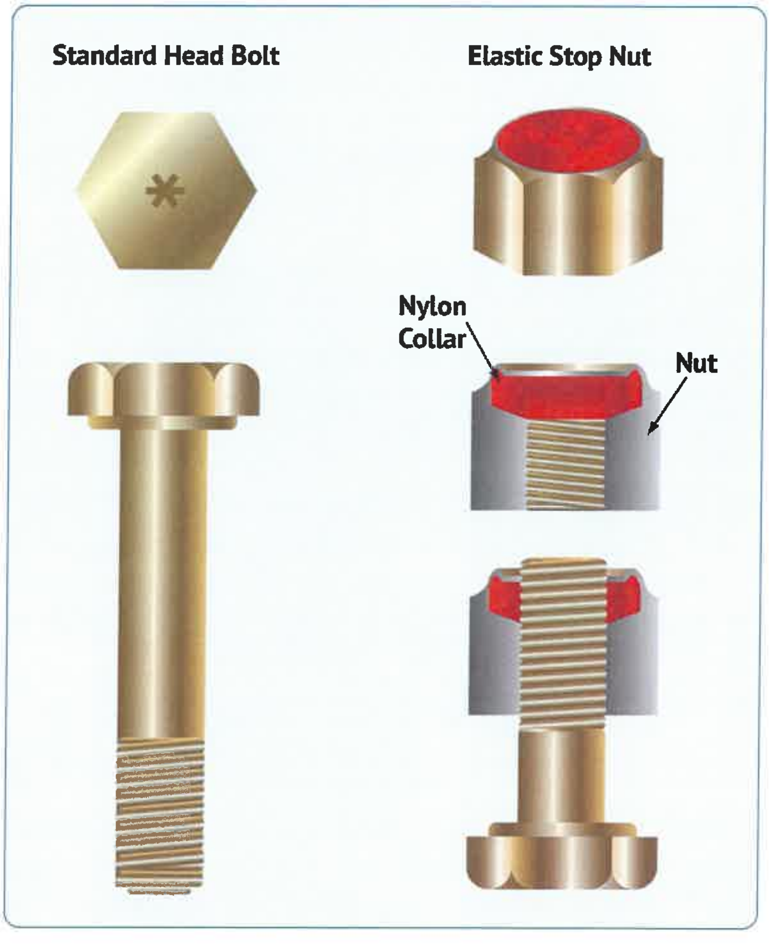
Aircraft-Grade Bolts: The tubes in an airframe are connected using fasteners fabricated from cadmium- or zinc-plated corrosion resistant steel.

Self-Locking Nuts: Aircraft-grade locknuts are used to prevent loosening due to vibration and ensure the stability of critical connections. The elastic stop nut (or nylock) is a standard nut with the height increased to accommodate a nylon locking collar. This nylon collar is very tough and durable and is unaffected by immersion in hot or cold water or ordinary solvents, such as ether, carbon tetrachloride, oils, and gasoline. It will not damage bolt threads or plating.

Washers: Aircraft-grade washers are used to distribute loads and protect the integrity of the materials being fastened.

Center of Gravity Adjustments

The center of gravity (CG) in a powered parachute significantly influences the powered parachute's stability and performance. The center of gravity represents the point at which the aircraft's mass is concentrated, and it must be within specified limits for safe and stable flight. The center of gravity needs to be set so that the front wheel of the aircraft is slightly higher in flight than the rear wheels. Improper CG adjustments will either load or unload the parachute, causing either poor performance or an unstable aircraft.



Airplanes adjust the loading in the aircraft to achieve the proper CG by calculating weights and positions for passengers, cargo and fuel for a flight. Powered parachutes instead adjust the attachment of the parachute wing to the airframe to suit the loading for a particular flight.

Each manufacturer has specific procedures in the Pilot's Operating Handbook (POH) to adjust the CG of the airframe, so that the airframe is suspended by the wing properly. There are two common types of wing attachment systems: center of gravity adjustment tubes, or a bracket with a few fore and aft riser attachment points. These systems perform the same task. Both adjust the wing's position on the airframe relative to its full center of gravity (including airframe and payload) for a flight. The CG adjustment is primarily based on the weight of the occupant in the front seat. The rear seat occupant's weight typically has little impact on determining the center of gravity (CG) position because the rear seat is usually positioned close to the wing's attachment point, minimizing its influence. To maintain optimal performance, the aircraft should fly with a slight nose-up attitude, as specified in the aircraft's POH.

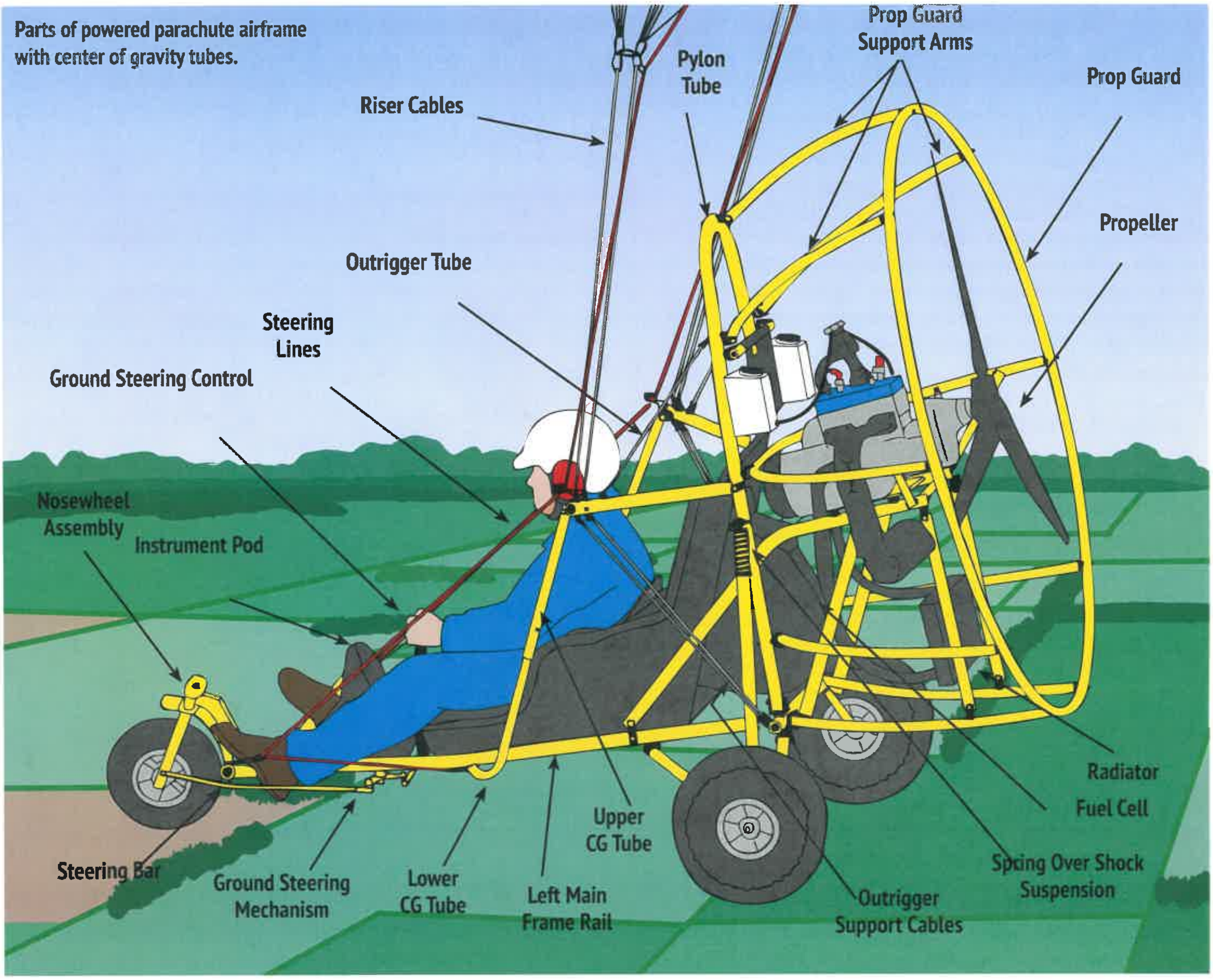
Center of Gravity Adjuster Tubes

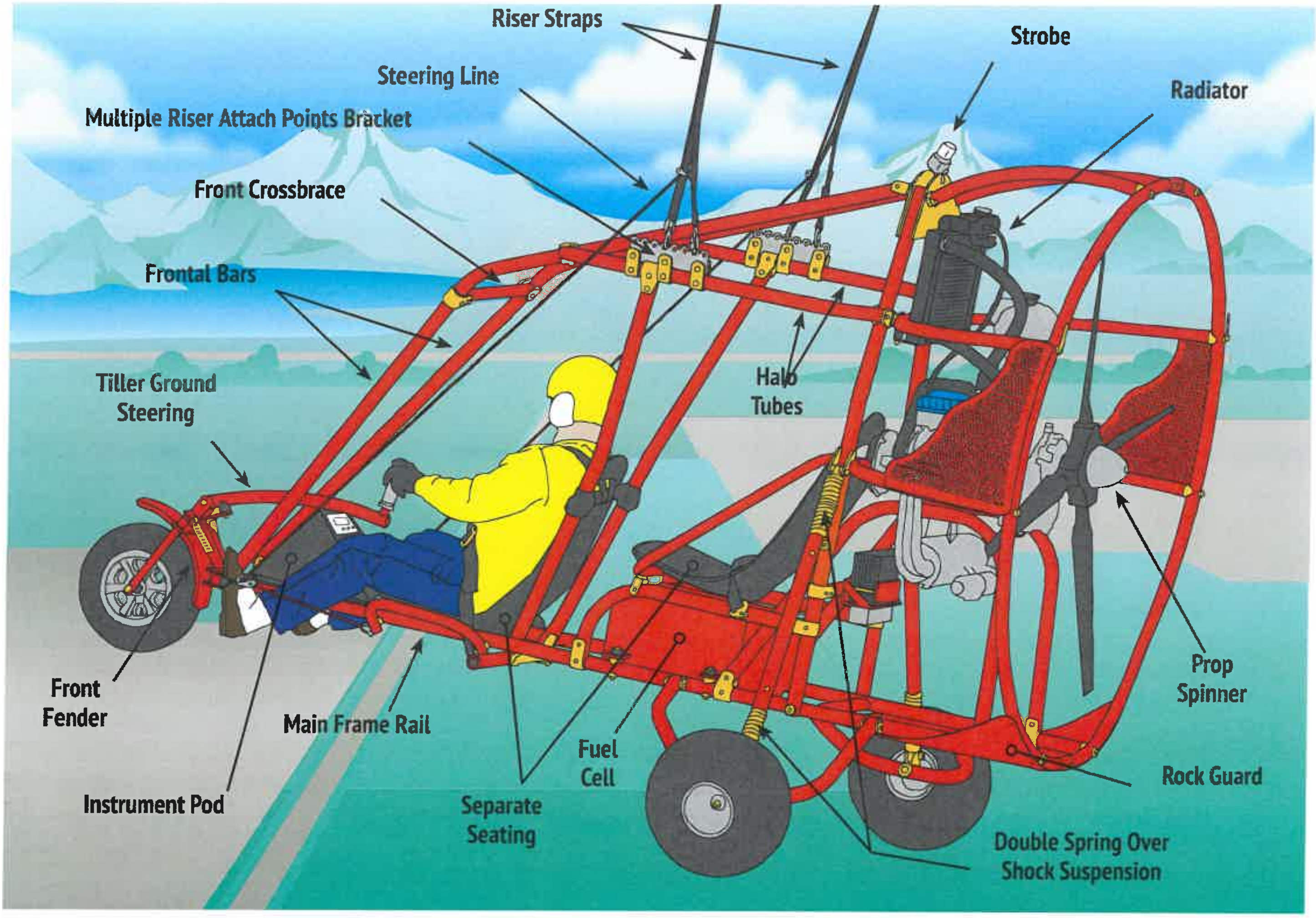
The term *"CG tubes"* refers to the two tubes that telescope out from the main frame rail to the outside end of the outrigger tube. (See below.) By extending the tubes out, the attachment point for the parachute moves rearward (for a lighter pilot). When you push the tubes together, the attachment point for the parachute moves forward (for a heavier pilot). The telescoping tubes are pinned in place with a bolt or clevis pin once that CG adjustment is made.

Multiple Attachment Points Bracket

The attachment point bracket on the airframe is another method to select the fore and aft wing attachment position for proper CG adjustments. Always refer to the POH or the weight and balance data sheet onboard the aircraft for weight and balance information specific to the powered parachute you are flying. This is discussed in more detail in *Chapter 18, "Flight Controls and Trimming."*

Parts of powered parachute airframe with center of gravity tubes.





Parts of powered parachute airframe with multiple attachment points bracket.

Wings and Components

The powered parachute wing is unique, as compared to a fabric wing on an airplane, in that when it is not inflated it loses its ability to produce lift. When a powered parachute wing is inflated or pressurized, it becomes semi-rigid and is capable of producing lift and supporting a load. Rather than being bolted to the fuselage like an airplane, the parachute wing is attached to the airframe by lines and risers.

The Wing

The parachute is essentially a specialized wing, fully flexible and shaped by how the fabric is sewn, the tension from the suspension lines, and the pressurization of air within the wing. Even so, the shape of a powered parachute wing will adjust slightly in response to different gross weights.

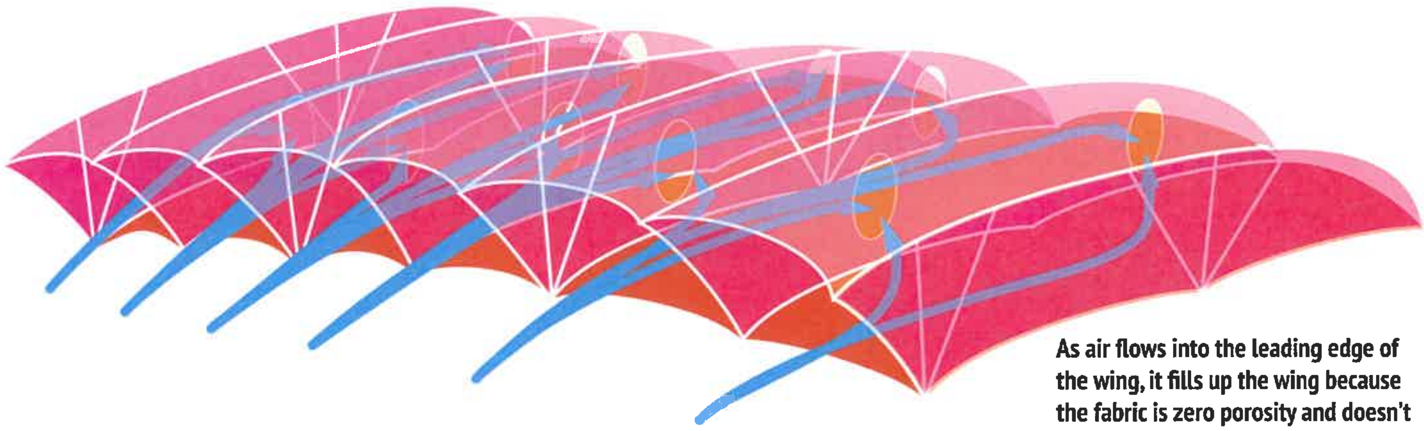
There's no argument that the modern parachutes that we fly look flimsy. After all, they're just bags of air. And if you've ever felt the thin cloth that they're made of, you might even have more doubts. Fortunately, your impressions would be far from the truth of the matter.

The fabrics, lines, production processes, and even the threads that are used in powered parachute wings are often the same materials and processes used in the sport parachuting world. That's great news because a sport parachute must take a far greater shock loading than a powered parachute ever has to.

In engineering it's called jerk force. Jerk force occurs when there is an almost instantaneous force applied to an object. Jerk force is the force that a hammer puts on a nail when you take a solid swing. It's also the force that occurs on a skydiver's parachute when it instantly turns into a wing right after spending many cozy minutes all neatly folded up in a backpack.

When a skydiver pulls the ripcord and the chute deploys, every square inch of fabric, every thread, every line, every everything is stressed terribly, and parachute designers know that. Those designers build the wings to take those kinds of stresses. Those of us in the powered parachute world who will never stress our chutes in that way get a wing that is that much stronger than we really need. All of this just because the design work has already been done for the other sport.

Some wing designs have their roots in the paragliding industry instead of the skydiving industry. Still, those parachutes are also built to take a great static load and most are tested to prove that they are structurally sound.



As air flows into the leading edge of the wing, it fills up the wing because the fabric is zero porosity and doesn't allow air to seep out. Meanwhile, the crossports cut into the fabric ribs allow the air to pressurize the wing evenly.

Design and Construction

No matter how good the materials used in parachute construction, a parachute can be ineffective or even dangerous if not designed properly. There are very few good parachute designers in the world and there are even fewer that have any familiarity with powered parachutes.

Many parachute designers come from the sport of skydiving which in some ways is probably far more demanding than the design of powered parachute wings. After all, opening loads and packing considerations are two areas critical to that endeavor that do not apply at all to the sport of powered parachuting. On the other hand, efficiency is more important in a wing used to generate and sustain lift, rather than just slow a descent to the ground.

That means that skydive parachute designers must take into account new design considerations before they can produce a good powered parachute wing. There are the dynamics of powered parachute flight, there are different styles of attaching chutes to airframes, and the gross weights are much higher. Because of the higher loads, the chute sizes become much bigger in powered parachute applications.

A parachute designer also must take into account the materials that the chute is to be made of. Since the wings are sewn out of fabric, there is an unavoidable tendency for the suspension lines and even the fabric wings themselves to stretch when loaded. Knowing how much a wing stretches when loaded is something a good parachute designer takes into account. Simply taking a great parachute that was designed for one fabric and copying it in a cheaper fabric will not produce great results.

Test flying is very important in parachute design. Many designs look good on paper, but they need to be tested thoroughly. Since this is a small market, there have been a lot of cases of parachutes that were touted as the next best thing. Sometimes they do work out in prototype. But without thorough test flying, it's difficult to predict how a new chute will behave once it hits production and once pilots get hold of it. That is, unless it has been tested completely.

Even established parachutes that are scaled larger or smaller do not always have the desired effect. A parachute design that works well as a 500 sq. ft. chute doesn't always become better just because it's made bigger. As size increases, so does drag. Therefore, the increased lift has to be much greater to overcome the increased drag and the larger engine required to match and overcome that drag.

Measurements of a Wing

When looking at parachute specifications, you'll see several measurement terms.

Area in Square Feet is the standard measurement for a wing. Depending on the manufacturer, this area is measured either as the 'actual' square footage or the 'projected' square footage.

- **Actual Area** refers to the size of the wing if you were to lay it flat on a table and measure the fabric. This measurement typically yields a larger number than the projected area..
- **Projected Area** accounts for the fact that parachutes are usually curved when inflated. The actual vertical lifting area is smaller than the 'actual' area. You can think of the projected size as the shadow a parachute would cast at noon when fully inflated.

Area in Square Meters is how wing area is measured in Europe and other regions. One square meter is roughly equivalent to 11 square feet.

Wingspan or Span is the length measured across the wing from tip to tip (or stabilizer to stabilizer).

Cord is the straight line length from the trailing edge of the parachute to the leading edge of the parachute,measured through the center of the inflated chute.

Aspect Ratio is calculated by dividing the wingspan by the chord length.

Square vs. Elliptical Wings

The most important design consideration a parachute designer can make is whether to design a square or an elliptical parachute. And it follows that one of the more important purchasing considerations you can make as a pilot is whether to purchase a square or an elliptical chute.

Square wings have their roots in the skydiving world. In contrast, elliptical parachutes evolved from the paragliding world.

Square chutes have always been designed to inflate and stay inflated. Remember, a square parachute is folded into a tiny pack that a skydiver carries with him as he boards and leaves the jump plane. When he leaves the plane, he needs to make sure that the tiny backpack will turn into a completely inflated wing. Square canopies do that very well.

On the other hand, elliptical chutes have been designed more for efficiency than stability. That's because in paragliding, the pilot needs as efficient a wing as possible to carry him upwards with thermals and updrafts. Ease of opening is sacrificed a little, but not dangerously. After all, a paraglider pilot is starting off on firm ground, kiting the chute, and then taking off.

Both types of wings have been adapted to powered parachuting, but there are advantages with each type of parachute.

Square Wings

Square canopies inflate faster and center quicker than elliptical chutes do. This is important when you have a limited takeoff field to work with. Square wings are less prone to 'surging' which is when a canopy tries to overfly the airframe on takeoff.

Square canopies are a lot more forgiving of pilot errors and overcontrol. New pilots normally take longer to learn to fly when flying an elliptical wing.

A square canopy has good directional stability due to the stabilizers on either side of the wing. A square canopy will not 'swim around' while flying in windy conditions. An elliptical parachute has no such stabilizers, which makes both the takeoff more exciting and can cause the swimming.

Square canopies fly relatively slower. This actually is a function of taste, but many people get into powered parachutes to enjoy the scenery and fly low and slow. Elliptical chutes are faster due to the physics of their design. They are an efficient airfoil, so less wing area is needed. (In fact too large a wing is dangerous.) With the smaller wing, they must move that much faster through the air to generate lift. Therefore, the set speed of the elliptical parachute is much faster.

Faster speeds mean that takeoff speeds are faster, power lines come up faster, landings are done with more energy, and everything is a lot less relaxed. Ultimately it's a matter of taste.

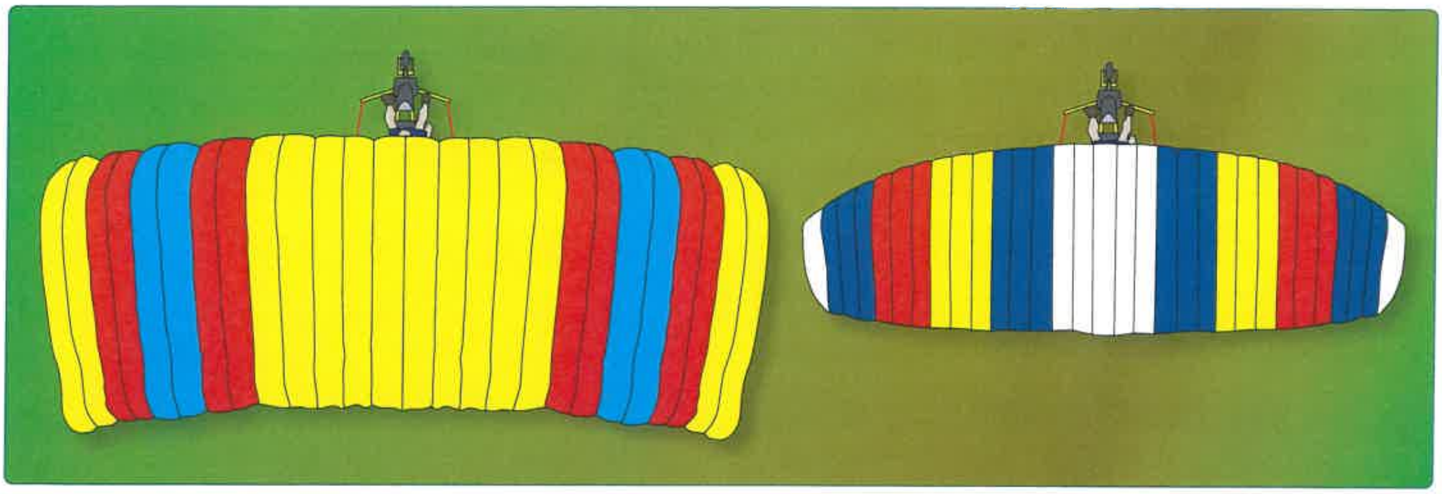
Square chutes are usually less bulky than elliptical chutes. That's because most ellipticals are foreign-made and use heavier, bulkier material. Besides that, their designs require more individual cells. Those additional cells mean more ribs, which increases the bulk even more.

Elliptical Wings

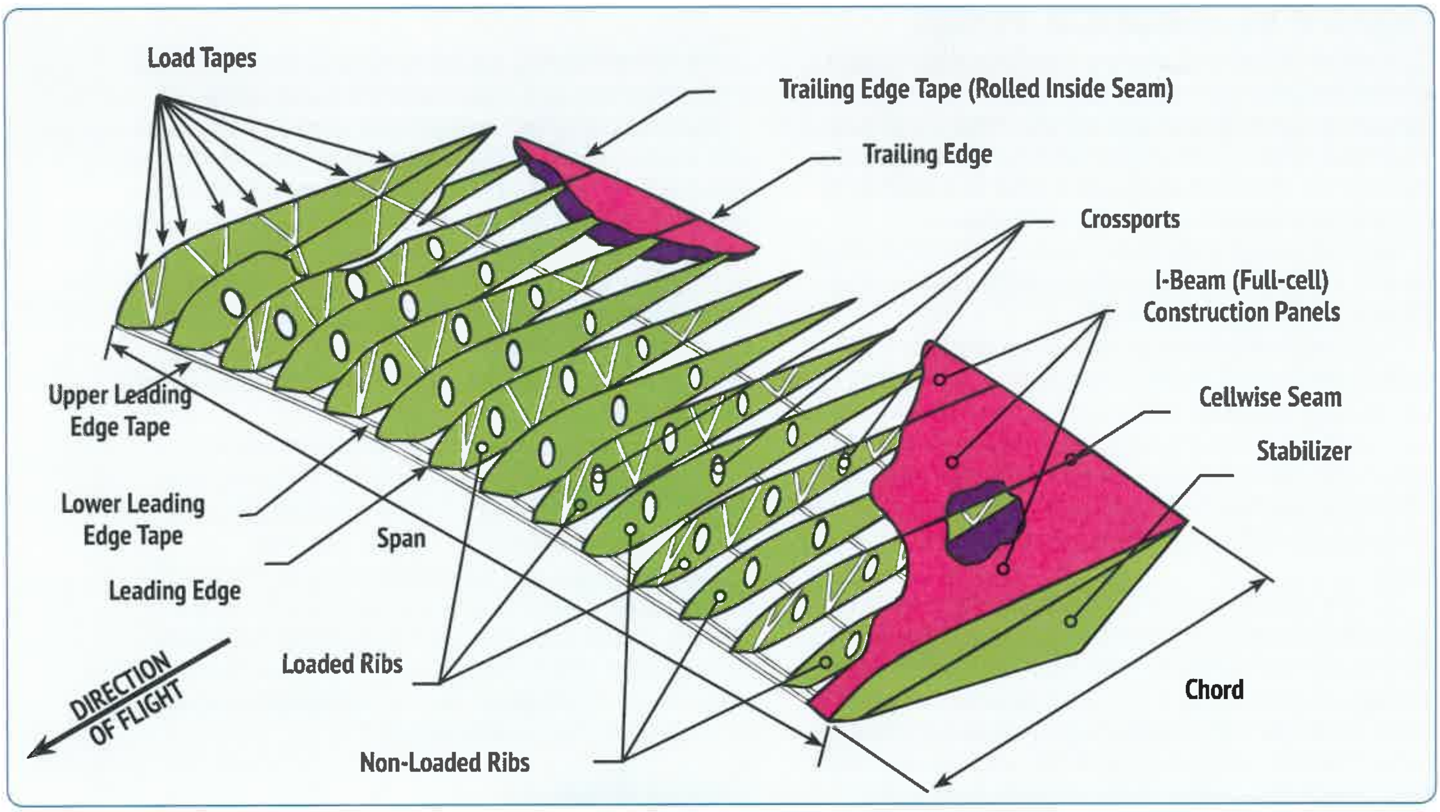
All that said, it doesn't mean that there aren't any advantages to elliptical chutes. For example, if speed is something you seek in a powered parachute, then an elliptical is a way to achieve that.

Ellipticals are also more efficient so that you are able to fly longer on a tank of fuel. Elliptical chutes have a better glide ratio than square chutes.

Elliptical and semi-elliptical wing designs constantly improve. Newer semi-elliptical wings inflate a lot better than older wings, now making them good wings for both beginners and advanced pilots. However, the lack of stabilization means that they still swim around during flight.



Difference in size and aspect ratios of square and elliptical wings.



Anatomy of a Wing

To understand a parachute, there are some terms that you need to understand. Some of these are basic airfoil terms that apply to all wings and some of these terms are specific to parachute airfoils.

Top Skin

The top skin forms the upper surface of the parachute wing. It's constructed in sections that are sewn together to create the complete upper surface.

Bottom Skin

Refers to the lower surface of the parachute wing. Like the top skin, it's also built in sections. In addition, the lower surface is where the suspension lines are attached to the chute.

Ribs

Ribs, more than any other part of the parachute, define the airfoil. They are the pieces of fabric that are sewn in between the top and bottom skins.

Each rib will typically have vent holes cut into it to allow air pressure to even out between the sections of the chute. This is one of the big differences between a parachute used for skydiving and one used for powered parachuting.

In skydiving, the vent holes are small because designers want the parachutes to open relatively slowly. That benefits the skydiver and the parachute alike. For powered parachuting, we want to see parachutes inflated quickly. Therefore the vent holes in a powered parachute canopy are bigger to allow air to pass easier and quicker between the sections of the chute. That makes chutes inflate quicker and helps prevent end cell closures.

Not all ribs in a canopy are alike. Ribs are considered loaded or non-loaded. Roughly half of the ribs are used to connect suspension lines to the canopy. Those loaded ribs have reinforcing tape sewn into them forming a truss structure to distribute the load from the lines. The reinforcing tape is a critical design element that transfers loads from the attach points throughout the rest of the loaded ribs.

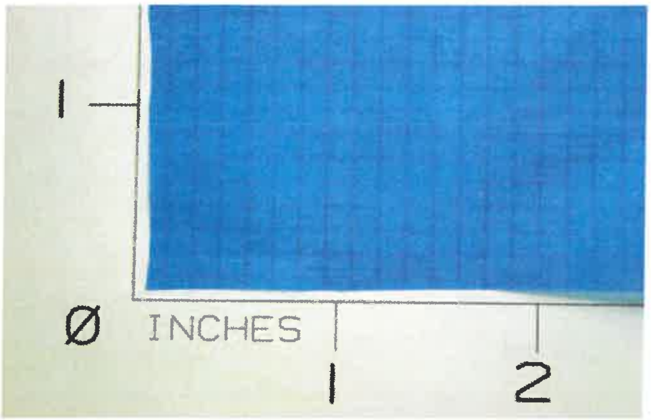
The remaining non-loaded ribs don't have the structural tape sewn onto them because there are no point loads that need to be transferred throughout the ribs.

Rib Stiffeners

Rib Stiffeners (or rib inserts) are small triangular pieces of stiff fabric sewn onto the ribs at the parachute openings. These help hold the leading edge open to catch air and in turn inflate the parachute faster.

Cells

Cells are defined by each section of the top and bottom skins. Those skins usually have one non-load-carrying rib sewn in the middle of them and have a load-bearing rib on either side. For example, a PD Sunriser 500 parachute has 13 cells, but there are 26 individual openings in the leading edge.



Zero Porosity, 1.13 oz., 0 CFM, silicone coated ripstop nylon. Trade names include Zero P3™ and Soar-Coat™. A boxlike pattern is apparent due to the ripstop weaving.

Stabilizers

Stabilizers can be found on the ends of many parachutes. As the name implies, they stabilize the wing. They do this much like a keel does in a boat. By providing a vertical surface on either end of the chute, they guide the wing through the air and help prevent rocking back and forth during flight.

Stabilizers can be as simple as a flap of fabric extending down on each side of the parachute or they can be inflatable stabilizers. Inflatable stabilizers are pressurized much like normal cells in a parachute. One difference is that they extend downward vertically. The other main difference is that they normally inflate exclusively through crossports with ribs connecting adjacent parachute cells instead of having their own openings in the leading edge of the wing.

Wing Fabrics

Parachute fabrics need to be strong, light, and have low-to-zero porosity. Just as important, fabrics have to be durable and maintain their strength and low porosity over time and use. Parachute fabrics need to have the following characteristics:

Strength is established by measuring the breaking force. The breaking force is the maximum force applied to a material before it ruptures.

Tear Strength measures a material's resistance to tearing forces. To determine tear strength, a notched sample of fabric is tested. The maximum load the notched sample can withstand is then measured, similar to how regular strength is tested.

Permeability: is measured as the rate of airflow through the fabric, expressed in cubic feet per minute (CFM) per square foot of fabric area. This is also known as the *Frazier number*. Zero porosity means that no air passes through the fabric when it is new.

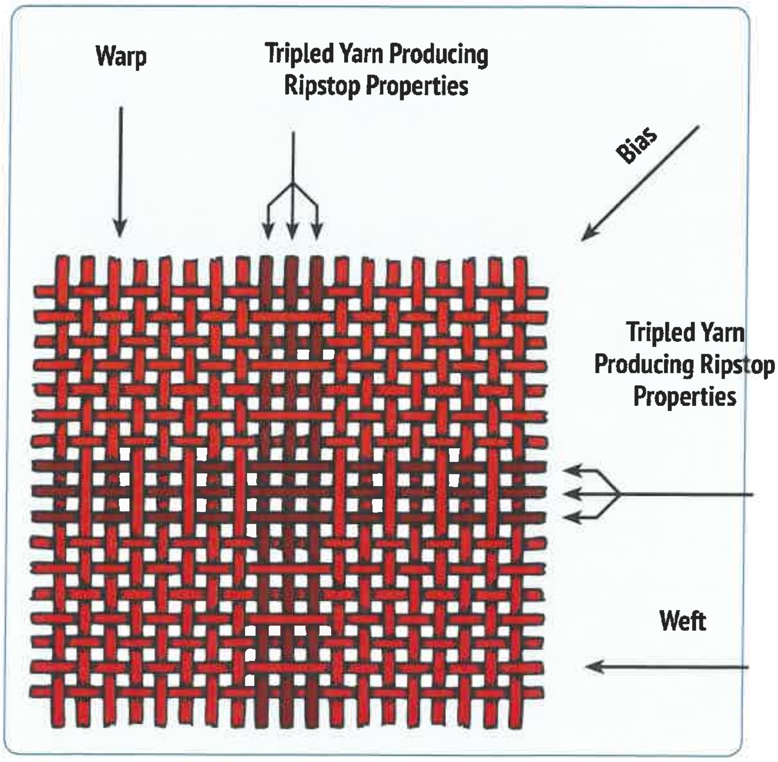
Attractiveness has to do with how a fabric is dyed, what colors are available, and how those colors resist fading over time and when exposed to UV light.

Weight is specified by weight per unit area, measured in ounces per square yard in the US and in grams per square meter in Europe

Ripstop Material

Fabric weaving has been practiced for millennia, but modern machines look quite different from those used centuries ago. Despite these changes, the goal remains the same: to interlace yarn and create fabric.

Ripstop material is produced through a unique weaving pattern. Instead of a simple alternating pattern of the weft passing over and under each warp thread, this pattern is interrupted at regular intervals. At these points, both the warp and weft threads are doubled or tripled, preventing tears from spreading and creating a distinctive box-like pattern in the fabric.



Weave Pattern of Ripstop Nylon

Manufacturing Processes Performed on Ripstop Nylon

Process	Description	Purpose
Washing	After weaving, fabric is wound onto a roll and that roll is washed and dried.	Removes residue from the weaving process.
Dyeing	Fabric is colored using UV resistant colors.	Special emphasis is on choosing colors that will not fade in the sun. Even 'white' fabric is dyed.
Calendaring	Colored cloth is passed between heated rollers at very high pressure.	Fabric made smoother and thinner and porosity is reduced. Helps 'fix' the dye and improves the durability and dimensional stability of the fabric by flattening and fusing the fibers.
Drying	Colored cloth is passed through an oven.	Further fixes the dye and prepares the material for further coatings.
Coatings	After the fabric is made, coatings are normally applied. Many coatings are normally only able to be done by the material manufacturer because they require special processes and/or solvents. Examples:	Provides the fabric with increased dimensional stability, strength, water resistance, UV resistance, and/or decreased porosity.
	• Solvent Based Silicone Rub (US-produced Soar-Coat® fabric)	Improves porosity and tear strength. Popular with skydive canopies and US-manufactured powered parachute wings.
	• Solvent Based Firm Coating (French-produced Skytex fabric)	Increases strength and reduces elongation of fabric. Used for ribs.
	• Solvent Based Medium Coating (French-produced Skytex fabric)	Good all-around fabric. Used for top and bottom surfaces as well as non-loaded ribs.
	• Solvent Based Water Repelling (French-produced Skytex fabric)	Like the 'Medium Coating' and adds water repellent feature.
	• Water Based Medium Mark 2 (French-produced Skytex fabric)	Improvements over 'Medium Coating' in degradation resistance. Also environmentally-friendly by being water-based.

Nylon

Nearly all parachute and paraglider fabrics are woven from a nylon yarn made by a company known as Invista. The specific nylon yarn used for parachute material is SolarMax®, a lightweight high-melt-point type 6,6 nylon fiber. SolarMax® brand nylon was originally introduced by DuPont, but it has been produced by Invista since 2003.

The SolarMax® family of nylon yarns was specifically designed to offer superior ultraviolet resistance, durability, and appearance for outdoor fabric applications. As a result, these materials are used not only in parachute canopies but also in fabrics for flags, banners, hot air balloons, life jackets, and tents. The inherent strength and built-in UV resistance of type 6,6 nylon deliver superior performance compared to type 6 nylons and polyesters with similar fabric constructions..

Another feature of the yarn is that it can be dyed in bright colors. Heat and light inhibitors help give the yarn superior heat and light resistance.

The entire SolarMax™ product line includes 200 and 400 denier bright and semi-dull lusters and 30 to 210 denier high tenacity yarns. Parachute fabric is made out of the lightest 30 denier yarn. 30 denier means that 9,000 meters of the yarn only weighs 30 grams. Or another way of looking at it is that one pound of the yarn will stretch almost 85 miles! Each thread is further made up of 10 filaments of the nylon fiber.

Processes After Weaving

The real differences in ripstop fabrics come after the material is woven. How the fabric is treated, dyed and coated after weaving does a lot to change the properties of the ripstop fabric. Properties include stiffness, porosity, and resistance to UV damage from sunlight. Many wings use more than one kind of fabric in their construction. Most skydiving wing designers seek lower pack sizes (the volume that a parachute takes up after it's folded) and use fabric that will optimize that. Paraglider wings use heavier fabric for ribs to help inflate the thinner, high-aspect-ratio airfoils. The table above shows a list of fabric processes and what they are meant to achieve. Not all ripstop nylons go through all of the processes.

If the fabric degrades and air is allowed to escape through pores of the cloth, the overall flight performance of the wing is greatly reduced. If your powered parachute wing should become too porous, more groundspeed may be needed to pressurize the wing, takeoff distance may increase, more RPM may be required to hold altitude, and fuel consumption may increase.

Tapes

Tapes are used in the construction of powered parachute wings. They're generally an inch or less in width and have a tensile strength that's less than 1,000 lbs. (Anything greater than that is considered 'webbing' by parachute riggers.) Tapes are sewn into the wing to distribute loads in the ribs, to protect edges from abrasion and to generally add strength where needed. Different types and sizes of tape are used for the purposes below.

Load Tapes: are also known as V-tapes because the tapes are arranged in a "V" pattern on loaded ribs. They're used to distribute the load from the line attachment tapes evenly into the canopy.

Rib Leading Edge Tapes: are found on the leading edge of each rib.

Leading Edge Tapes: are found on the leading edge of the top and bottom surfaces.

Trailing Edge Tape: is used on the trailing edge seam; usually rolled into the seam.

Line Attachment Tapes: are sewn to the bottom edge of the loaded ribs, aligned with the load tapes, and are used to transfer the load from the suspension lines to the load tapes. Some wings use line attachment tapes that continue onto the loaded rib, thus taking the place of the load tapes.

Cross Tapes: are reinforcing tapes that run spanwise on the top or bottom surface of the wing to distribute concentrated loads into the parachute

Parachute Lines

At first sight, the parachute lines on a powered parachute wing might appear like an unorganized wad of strings. On the contrary, each line has a distinct purpose, distinct properties and lengths.

Suspension Lines are the lines carrying the load of the airframe below the canopy. Suspension lines are attached uniformly across the bottom of the wing. Starting from the leading edge, the lines are attached over four rows that are often designated A through D. The front (or 'A') suspension lines are located at the leading edge. The suspension lines come together at a point where they connect with the risers on either side of the machine. Oftentimes A and B lines cascade together to form one line to reduce parasitic drag. This also happens with C and D lines.

Crossover Lines are suspension lines located on the center panels of a parachute. They cross from one side of the parachute to the quick link that attaches the suspension lines on the opposite side. Crossover lines help center the chute during inflation by pulling the center section over the airframe, ensuring the rest of the wing follows its center and reducing side-to-side oscillation during inflation.

Steering Lines are used for steering your parachute. Five or more upper steering lines connect across the rear left and right sides of the trailing edge of the parachute. The left set of upper steering lines comes together and is attached to one lower steering line. The same thing happens on the right side. Upper steering lines are made out of the same line material as the suspension lines. Lower steering lines are normally made out of a thicker cord that is easier to feed through and tie off to the steering mechanism on the airframe.

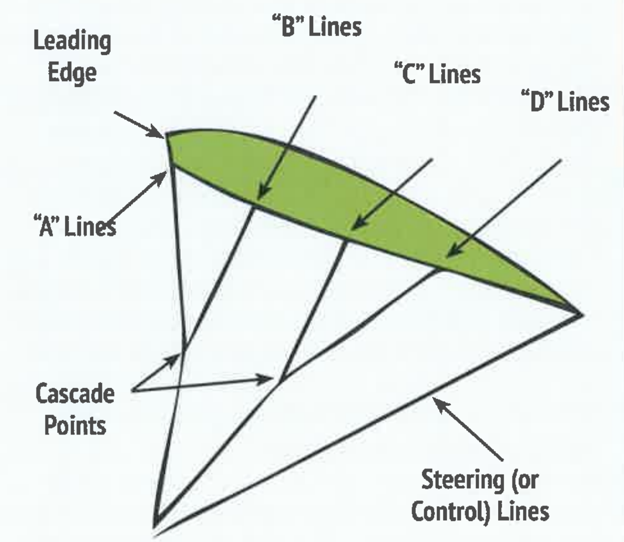
Left: 3/8" nylon tape with 200 lb. minimum breaking strength (MIL-T-5038) installed as rib reinforcing to distribute loads from suspension line attachment point.

Right: 3/4" nylon tape with 600 lb. minimum breaking strength (MIL-W-4088) installed as a suspension line attachment tape. Suspension line is shown attached.

Parachute Line Materials

Suspension lines must be constructed of very strong materials, yet remain very small in profile to reduce parasite drag. The most commonly used materials are polyaramid and polyethelene, which are both carbon-based. Upper steering lines and crossover lines will normally be made of the same materials used for the suspension lines.

Kevlar®, Technora®, and Twaron® are common high-performance polyaramid fibers used for suspension lines. Their properties render them extremely strong, as well as resistant to stretching or shrinking. They're also not susceptible to temperature changes. However, one critical drawback of polyaramids is that they tend to kink or knot when looped around. When polyaramids are used to construct suspension lines, they are encased in a skin of a Terylene product, like Dacron® (polyester) or a product with similar properties. That allows parachute builders to color-code the lines since Dacron® sheathed lines are offered in different colors.



Lines on a parachute wing.

Polyester lines made completely of Dacron® are possible to use although they do stretch and abrade with use.

Polyethelene materials, such as Spectra® or Dyneema®, are very strong as well as more flexible than polyaramids, which makes them more durable under hard use. A typical Spectra® suspension line will have a tensile strength of 825 pounds. Since polyethylenes are resistant to UV radiation, you will commonly find them unsheathed. The advantage to that is that they can be made into closing loops and cleaner cascade joints by feeding an open end into the center of the hollow braided material (known as finger-trapping). A sheathed line, on the other hand, cannot be finger-trapped and must be simply zigzag stitched together. That leaves a lot of ends that can catch on fellow lines. Many older parachutes are lined with Spectra® and with use the lines will stretch unevenly under load, putting the parachute out of trim.

Substance	Properties	Brand Name	Manufacturer
Aromatic Polyester	• Golden Fibers • Thermal Stability At High Temperatures • High Strength And Modulus • Low Creep • Good Chemical Stability • Moisture Resistant • Stable In Hostile Environments • Often Used In Combination With Polyester As A Coating Around A Vectran Core • High Uv Resistance	Vectran	Kuraray Co., Ltd
High Modulus Polyethylene	• High Strength • Low Weight (Floats on Water) • Low Stretch • Good UV Resistance • Good Fatigue Resistance • Good Chemical Resistance • Resists Bending Damage • White Color • RADAR Transparent	Dyneema	DSM High Performance Fibres
		Spectra	Honeywell Performance Fibers
Aromatic Polyamide/ Aramid	• Higher Strength (5X that of Steel) • Good Heat Resistance • Very Low Stretch • Heavier • Resistant to Organic Solvents • Sensitive to UV Radiation • Less Resistant to Fatigue • Less Resistant to Bending Damage • Difficult to Dye (Yellow-Brown Color	Technora	Teijin Ltd
		Twaron	
		Kevlar	DuPont

Materials Used For Parachute Suspension Lines

Vectran is a newer material used for powered parachute lines. Vectran is a high-performance synthetic fiber known for its exceptional strength, durability, and resistance to environmental factors. It is a liquid crystal polymer (LCP) that is strong, has good chemical resistance, is UV resistant, and has thermal stability. It's replacing Spectra as a preferred line for parachutes used in skydiving because of its dimensional stability.

Every line on a powered parachute wing is precisely measured and fitted to a specific location. This makes it essential to inspect the wing during preflight, as well as to have the wing and its lines periodically inspected by qualified technicians. The technician will perform strength tests and check for wear and compromised attachment points. Always refer to your wing manufacturer's specifications for inspection guidelines. Under no circumstances should powered parachute suspension lines be spliced or tied if severed! Each line's length and strength are precisely calibrated. Tying a knot in the line will alter the wing's engineered flight characteristics, making it unairworthy.

Other Materials

There are other specialty materials that may be used in parachute construction. For example, Mylar and Sailcloth have been used for ribs to make initial parachute inflation easier. Typically, these materials do not change the flying characteristics of the wing, but by their very nature they do increase the bulk of the parachute.

1. Kevlar Sheathed Spectra® suspension lines connected to quick links using zigzag stitched loops.

2. Unsheathed Spectra® suspension lines connected to quick links using finger-trapped loops.

3 Upper to lower interlocking loop steering line connections feature no sewn connection between upper and lower lines.

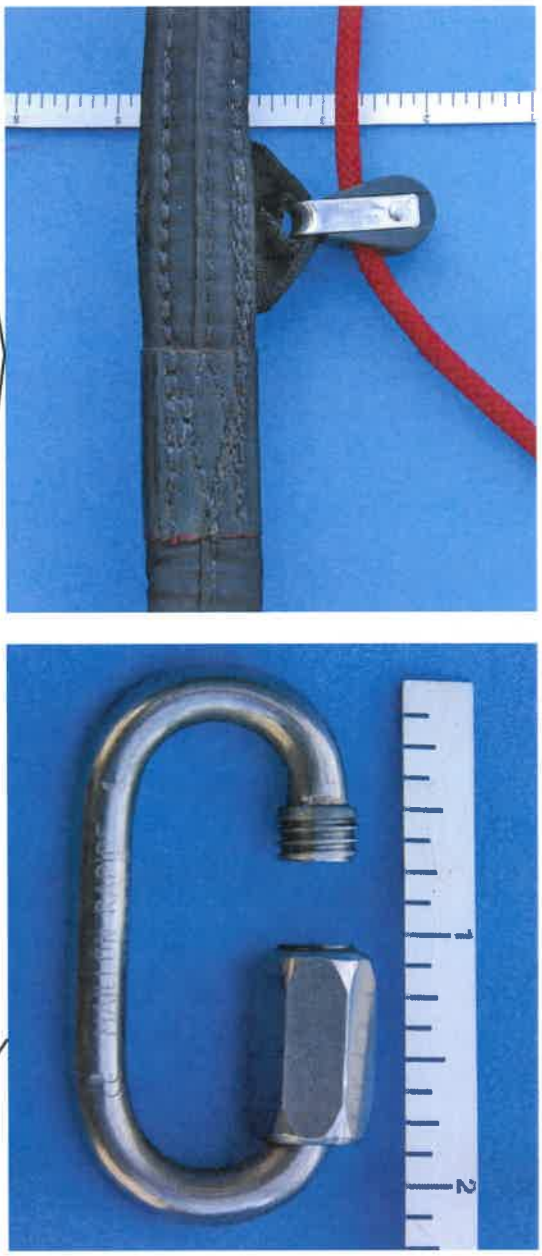
4. Finger-trapping used on a cascade joint on Spectra® suspension lines. The end of one line is pulled into the center of the other line where tension holds it in place. Stitching is used as an extra precaution to keep the line fixed in place.

Other Components

There are additional parts and components that are unique to parawing aircraft. Two of those components are used to attach the wing to the airframe.

Risers

Older equipment may use cables for risers, but most new equipment uses Kevlar® straps with a sheathing around them. The straps offer the advantages of being stronger than steel cables, absorbing inflation shocks better than cables, allowing the integration of pulleys and guides for steering lines, and are easier to obtain custom sizes to properly match a wing to an airframe.



Wings are typically built with standard suspension lines. However, the attachment points on airframes vary. Riser straps (also known as "*V-lines*") make it possible to use standard size parachutes on a variety of airframe geometries. Parachute quick links attach to the riser strap loops built into each riser.

Left and right risers are also regularly built at different lengths to compensate for engine torque and P-factor.

By decreasing the length of the riser on one side of the airframe, the wing is forced into a slight bank, just enough to cancel the effects of torque at cruise thrust settings. This design feature of risers makes it crucial to avoid mistakenly attaching the risers of different lengths to the wrong side of the airframe.

Powered parachutes with a counterclockwise rotating propeller require opposite adjustments than one with a clockwise turning prop. It's important to know which direction the propeller turns for your powered parachute to accurately counter turning tendencies.

Alternately, the wing could have the same length risers, and the airframe could have a higher attachment point for one riser. This is why each wing is designed for each airframe and should not be interchanged: the wing and the airframe are parts of a complete system.

Quick Links

The threaded connectors attaching the risers to the parachute on one end and the risers to airframe on the other are a critical part of the powered parachute. Only properly rated links should be used and those should be checked during preflight to make sure that they are installed properly, tightened, and undamaged.

The industry standard is the French-made Maillon Rapide, Stainless Steel link. They come in a variety of sizes, the most popular being the #6. The proper link will have Maillon Rapide stamped onto it. These links are the same ones used for mountain climbing, rescue work, skydiving, and other critical applications.

Fabric riser with detail of integrated steering line pulley and a quick link.

Chapter 9
Engines

Powerplant

The powered parachute's engine and propeller, often referred to as the powerplant, work together to generate thrust. In a traditional powered parachute, an internal combustion engine propels the aircraft and powers the electrical system. In an electric powerplant, stored battery power is used both to propel the parachute and to support the electrical systems. Most powered parachutes are equipped with piston-driven engines, offering the best balance of power, endurance, and cost.

The engine is a key component of a powered parachute and should be maintained according to the recommendations of both the engine and airframe manufacturers. Preflight information, maintenance schedules, and procedures can be found in the Pilot's Operating Handbook (POH) and maintenance references from the manufacturers.

The engine often has its own logbook to record inspections and maintenance procedures. It's a good idea to review this logbook, along with other maintenance records, before flying an unfamiliar powered parachute.

Reciprocating Engines

Most powered parachutes are equipped with reciprocating engines, named for the back-and-forth, or reciprocating, motion of the pistons. This motion generates the mechanical energy needed to perform work. Reciprocating engines are commonly classified by:

Number of piston strokes required to complete a cycle: two-stroke or four-stroke.
Cooling method: liquid-cooled or air-cooled.
Cylinder arrangement relative to the crankshaft: radial, in-line (e.g., Rotax 2-strokes), v-type, or opposed (e.g., the Rotax 9-series engines).

The main parts of a reciprocating engine include the cylinders, crankcase, and accessory housing. The spark plugs and pistons are in the cylinders. The crankshaft and connecting rods are in the crankcase.

The basic principle of reciprocating engines is to convert chemical energy, derived from fuel and surrounding air, into mechanical energy. This conversion takes place within the engine's cylinders through combustion.

Reciprocating engines cycle hundreds of times per minute, even at low speeds. The crankshaft's rotation is sustained by the precise timing of the engine, along with the coordinated operation of auxiliary systems, including the induction, ignition, fuel, oil, cooling, and exhaust systems.

Four-Stroke Engines

Four-stroke engines are very common in most categories of aircraft and they are now very common in newly produced powered parachutes. Four-stroke engines offer the advantages of:

- Reliability
- Fuel economy
- Longer engine life
- Higher horsepower ranges

These advantages are countered by a higher acquisition cost, lower power to weight ratios and a higher overall weight. Some of the weight and expense is a function of the complexity of a four-stroke engine. The engine has a cam shaft and valving system that closely controls the intake and exhaust into the engine's cylinders.

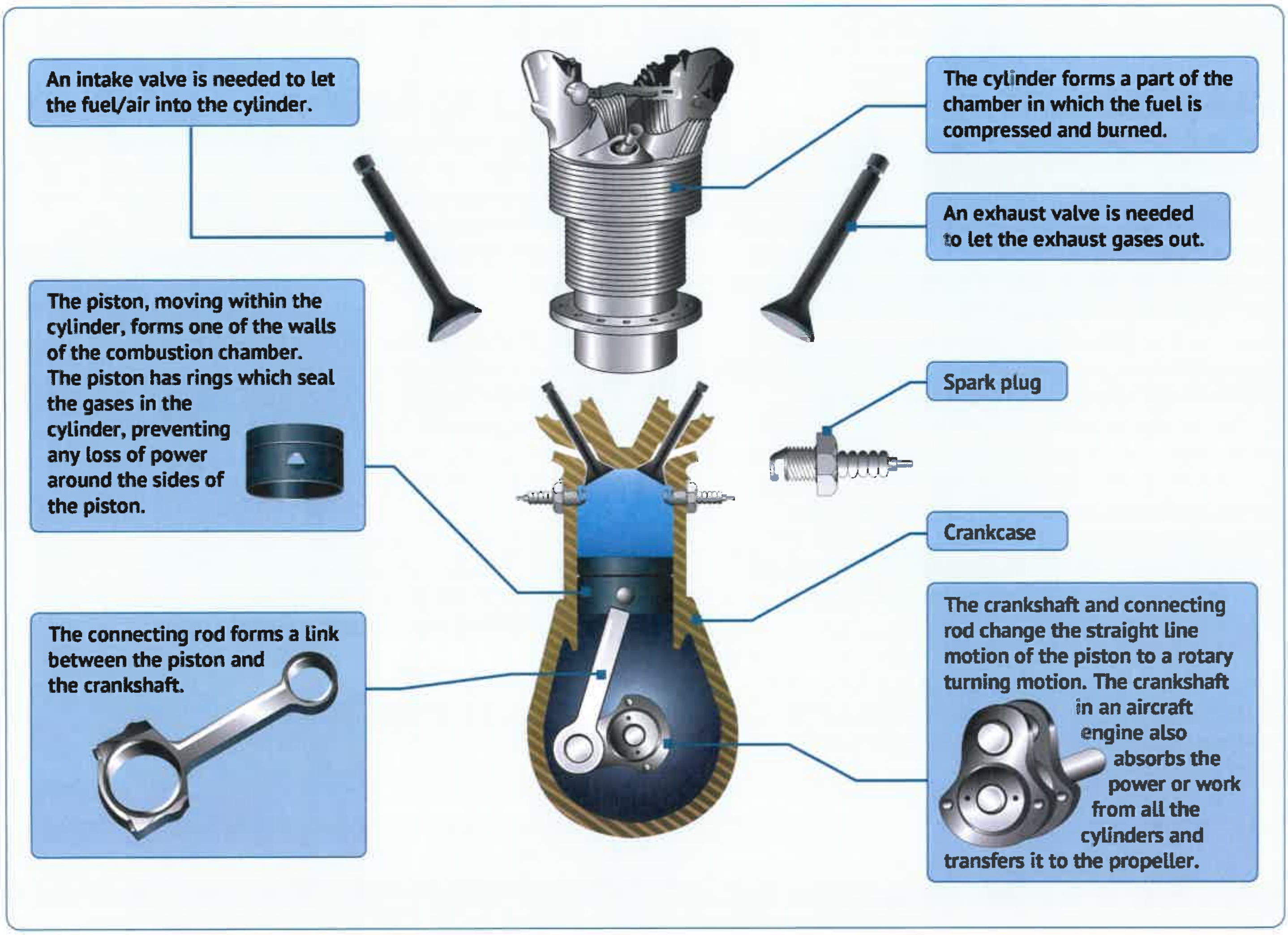
The four operations that need to be accomplished in a four-stroke engine are:

Intake: The intake stroke begins as the piston starts its downward travel. When this happens, the intake valve opens and the fuel-air mixture is drawn into the cylinder.

Compression: The compression stroke begins when the intake valve closes and the piston starts moving back to the top of the cylinder. This phase of the cycle is used to obtain a much greater power output from the fuel-air mixture once it is ignited.

Power: The power stroke begins when the fuel-air mixture is ignited. This causes a tremendous pressure increase in the cylinder, and forces the piston downward away from the cylinder head, creating the power that turns the crankshaft.

Exhaust: The exhaust stroke is used to purge the cylinder of burned gases. It begins when the exhaust valve opens and the piston starts to move toward the cylinder head once again.



Main components of a four-stroke, spark ignition, reciprocating engine.

Rotax 9-Series

The Rotax 9-series of engines is the most popular 4-stroke design in modern sport aviation.

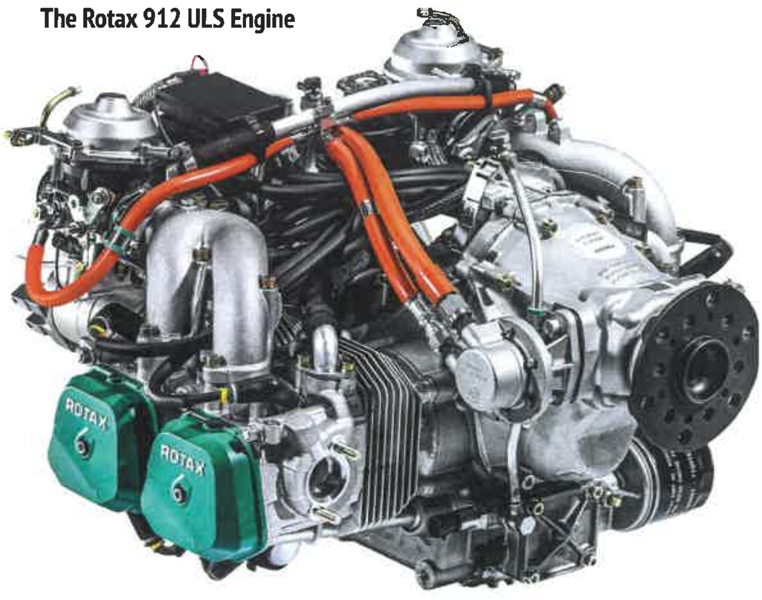
The Rotax 9-series is a line of horizontally-opposed, four-cylinder, four-stroke engines with air-cooled cylinders, liquid-cooled cylinder heads, and an oil-cooled crankcase and gearbox. Available in several variants, including the 912, 912 ULS, and 912 iS, these engines feature a range of power outputs and technological advancements to suit different aircraft requirements.

The 912-series has a very good power-to-weight ratio, with outputs ranging from 80 to 141 horsepower. The efficient design of the engine contributes to its economical fuel consumption, making it a popular choice for pilots seeking cost-effective operation.

The introduction of electronic fuel injection (912 iS) revolutionized the series, offering improved fuel efficiency, smoother operation, and enhanced reliability. Additionally, features such as redundant electronic engine control units (ECUs) and integrated engine monitoring systems provide pilots with greater peace of mind during flight. The compete range of 9-series engines as of this writing includes:

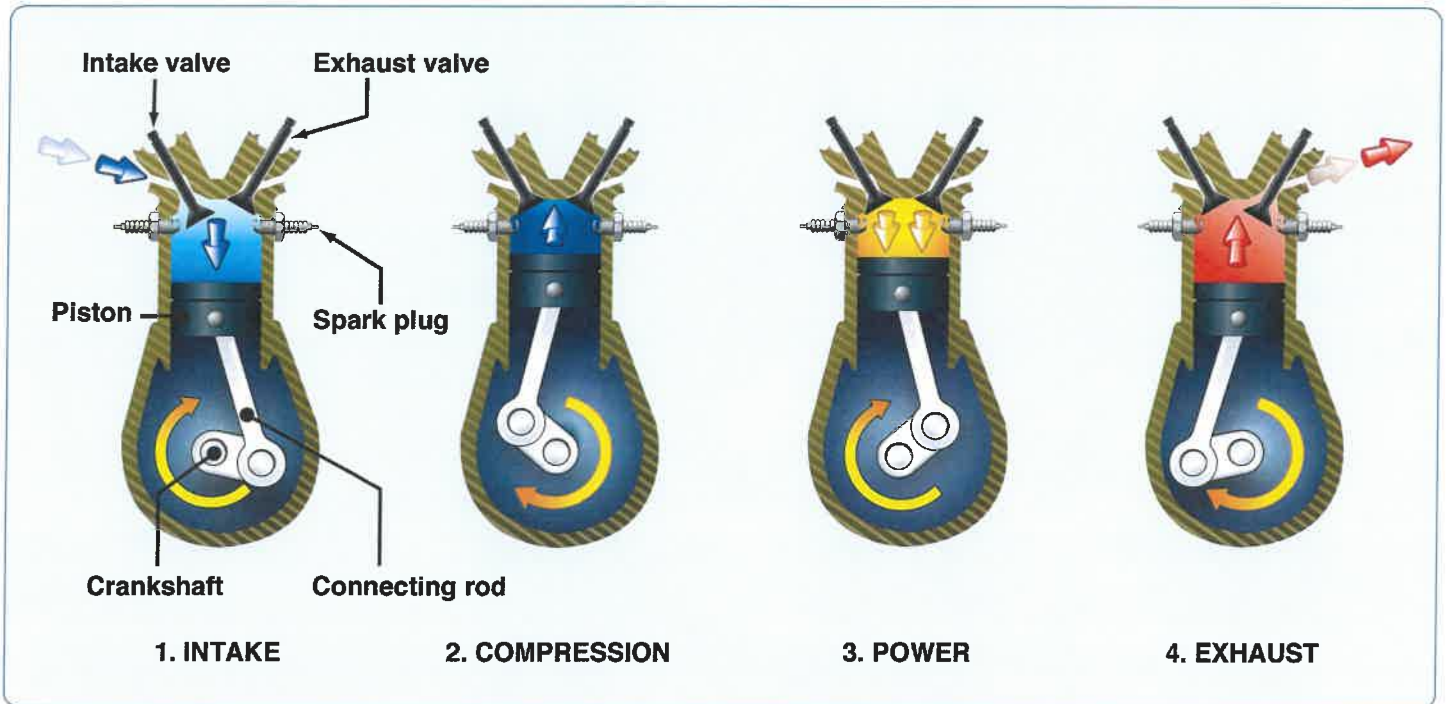
Engine	Power	Features
Rotax 912 UL	80 hp	Naturally Aspirated
Rotax 912 ULS	100 hp	Naturally Aspirated
Rotax 912 iS	100 hp	Fuel-Injected
Rotax 912 iS Sport	100 hp	Fuel-Injected with Enhanced Performance
Rotax 912 S	100 hp	Certified Version of 912 ULS
Rotax 914 UL	115 hp	Turbocharged
Rotax 915 iS	141 hp	Turbocharged, Fuel-Injected

The Rotax 912 ULS Engine



Key features of the Rotax 912 ULS Engine:

- 100hp @5800 RPM
- 4-cylinder
- 4-stroke liquid-/air-cooled engine with opposed cylinders
- Dry-sump forced lubrication with separate oil tank,
- Automatic adjustment by hydraulic valve tappet
- 2 carburetors
- Mechanical fuel pump
- Dual-electronic ignition
- Electric starter
- Propeller speed reduction gearbox
- Air intake system
- Time between overhaul (TBO) 2,000 hrs



The arrows in this illustration indicate the direction of motion of the crankshaft and piston during the four-stroke cycle.

Two-Stroke Engines

For many years, two-stroke engines were the most common choice for powered parachutes. These engines originally evolved from those used in snowmobiles and watercraft, benefiting from the technology developed for those sports. The key difference between a two-stroke snowmobile engine and a two-stroke aircraft engine is that the latter is optimized for reliability rather than high performance. The popularity of two-stroke engines is largely due to their high power-to-weight ratio, overall light weight, and the fact that they are inexpensive to manufacture in small quantities

The downsides of two-stroke engines are the high fuel consumption, the low time between overhauls, and the low horsepower ranges available. Two-stroke engines require that oil be mixed into the fuel instead of being held in a sump or a separate recirculating system.

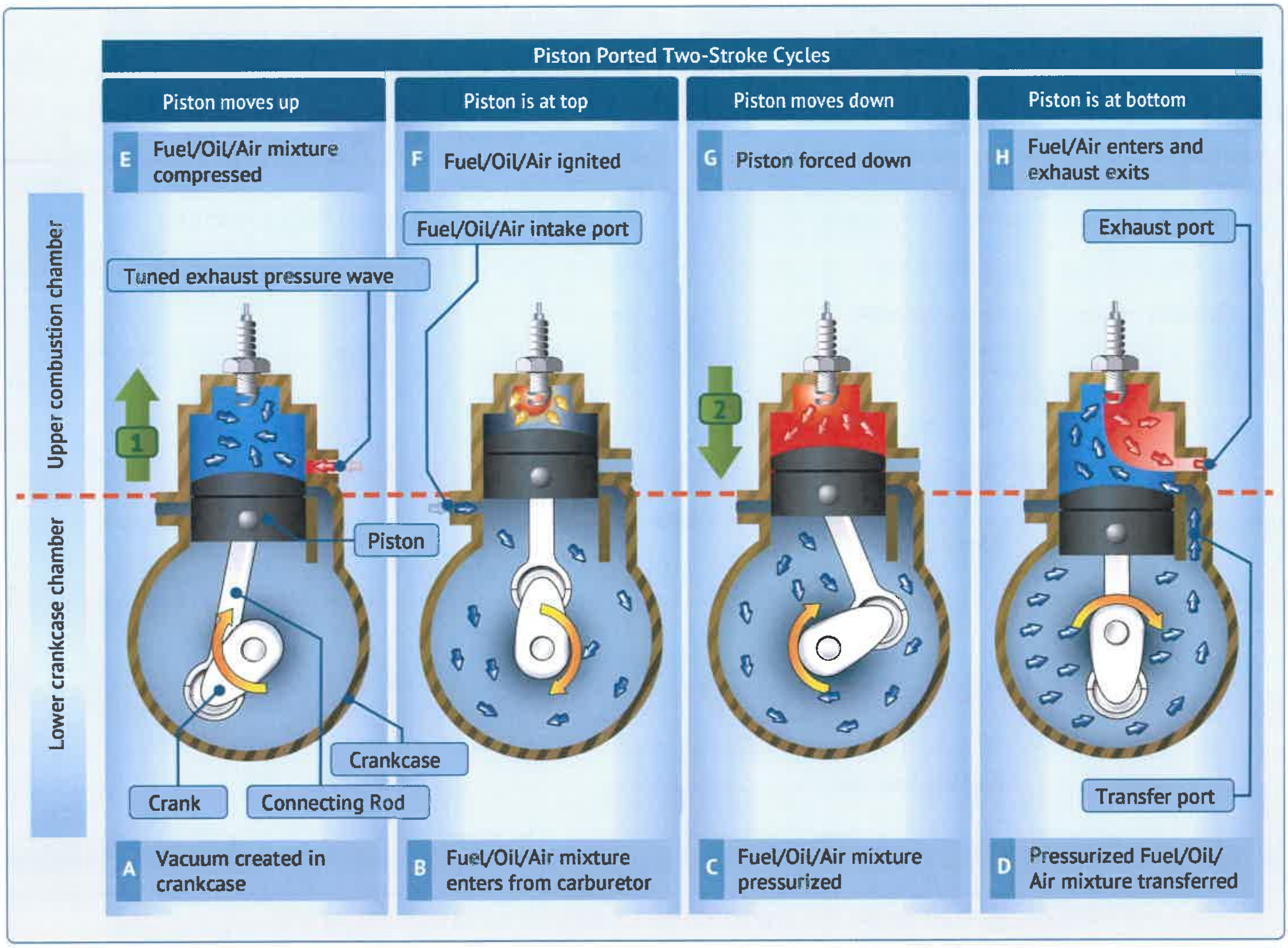
A two-stroke engine has fewer parts, making it lighter than a four-stroke engine. However, it experiences more wear because it cycles through twice as many engine strokes. In a four-stroke engine, the four operations are completed in one upstroke and one downstroke. In contrast, a two-stroke engine requires two upstrokes and two downstrokes of the piston to complete a single power stroke.

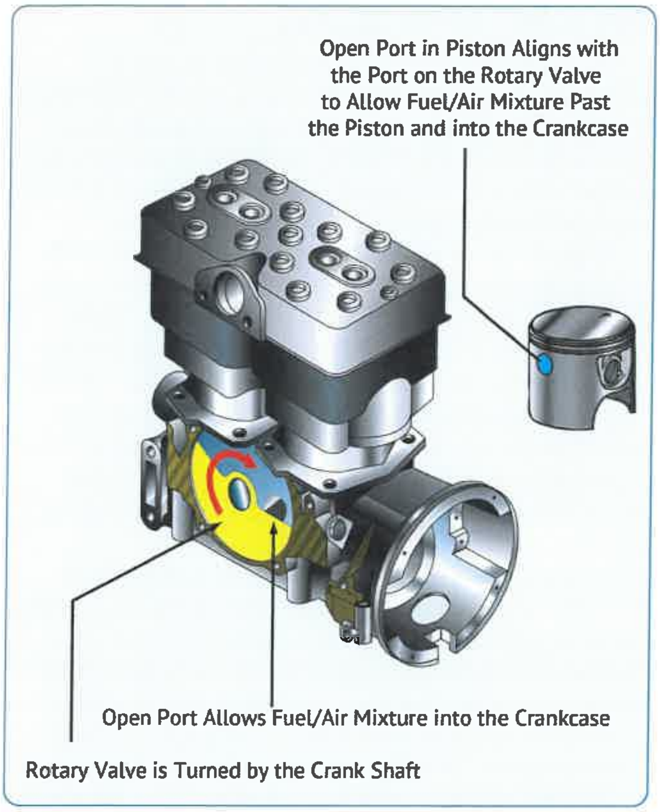
There is a lot going on in a two-stroke engine. There is more than one thing going on with each stroke.

Intake: The intake operation begins as the piston is moving up the cylinder. The piston forms a vacuum in the crank case as it moves up. The piston also uncovers the intake port on the carburetor side of the cylinder and allows a mixture of fuel and air to be sucked into the crankcase.

Compression: The compression operation begins as the piston continues to move up the cylinder. The cylinder compresses the fuel-air mixture that was previously pushed into the cylinder during the last down-stroke of the piston. The fuel-air mixture compresses efficiently after the piston has covered the exhaust port of the cylinder. As in a four-stroke, this phase of the cycle is used to obtain a much greater power output from the fuel-air mixture once it's ignited.

Power: The power operation begins when the piston is near the top dead center of the cylinder and the fuel-air mixture is ignited. This causes a tremendous pressure increase in the cylinder, and forces the piston downward away from the cylinder head, creating the power that turns the





Intake rotary valve for a Rotax 582 two-stroke engine.

crankshaft. The downward movement of the piston also pressurizes the fuel-air mixture in the crankcase.

Exhaust: The exhaust stroke is used to purge the cylinder of burned gases. It begins when the piston moves down near the bottom of the stroke. As the piston moves down, it reveals an exhaust port which allows the burned gases to escape. Revealed shortly afterward is a transfer port that allows fresh pressurized fuel-air mixture to move from the crankcase into the cylinder and help push out the remaining burned gases.

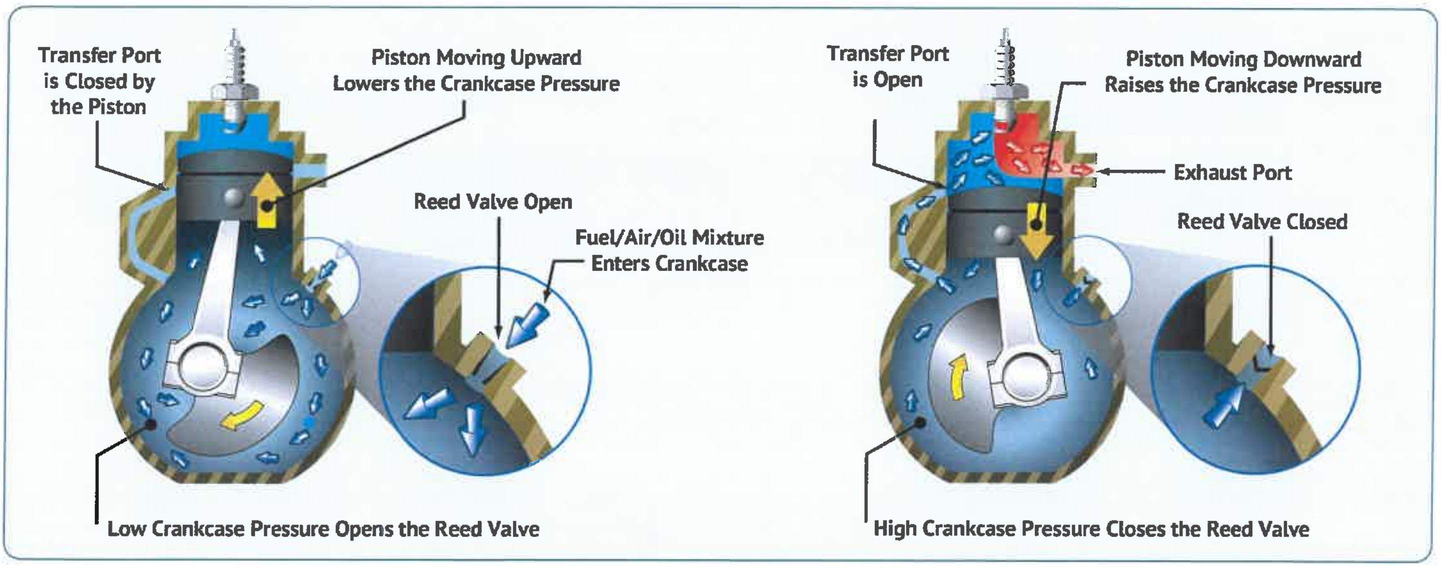
Two-Stroke 'Valves'

A wide range of valve systems are found on two-stroke engines for the purpose of opening and closing ports in the cylinder to let the fuel-air mixture in and the exhaust gas out at the proper times. This is similar to the intake and exhaust valves on a four-stroke engine. Three different intake designs are possible on two-stroke engines:

One-Way Pressure Valves: Spring, reed, or poppet valves open when the pressure inside the crankcase drops, drawing the fuel-air mixture from the carburetor into the crankcase. The reed petals allow the mixture to enter the engine and trap it there. By adjusting the tension of the reed petals—using different petals—you can enhance power at specific RPM ranges. Reed valves are commonly used on smaller two-stroke engines, such as those found on powered paragliders and lightweight powered parachutes that use paraglider engine/propeller systems. Engine brands include Cors-Air Motors' Black Devil series, the Simonimi 202, Cisco Motors' Snap 100, the Top80 and the Hirth F33. However, many of the larger Hirth engines also have reed valves.

Piston Porting: In this method, the pistons act as valves. The fuel inlet port is opened and closed by the position of the piston as it moves up and down in the cylinder. This process is known as a *"piston ported inlet"* and is used in the two-stroke process described with the image on the previous page. Popular engines with piston porting include the Solo 210 as well as the Rotax 447 and 503 models.

Mechanical Rotary Valves: These are disks with openings in them which are driven off the engine, rotate to provide an opening at the precise time, and can be on the intake and exhaust ports. A rotary valve engine has the best intake air control. A common powered parachute engine using a rotary valve is the Rotax 582, shown to the left.



Reed valve is open with low pressure and closes when the pressure increases in a two-stroke engine.

Exhaust Systems

Engine exhaust systems vent the burned combustion gases produced during the combustion process in the engine, reduce engine noise, and (in the case of two-stroke engines) help keep fresh fuel-air mixture in the cylinders. An exhaust system begins with the exhaust manifold, which collects and channels the hot gases from the engine's cylinders. These gases then flow through a series of pipes leading to a muffler.

The muffler is designed to minimize noise generated by the high-pressure exhaust gases. After the muffler, gases exit through the tailpipe, releasing them into the atmosphere.

The exhaust system is joined together with heavy duty springs. The spring joints allow the large, thin-walled structure to move and accommodate the vibration from the engine. If those joints are welded or formed from solid tubing, cracks in the system will form somewhere on the exhaust tubing, not always at the welded area. It's important to maintain your exhaust system by not allowing rust in the joints or at least cleaning it out on a regular basis. The rust may prevent movement in the joints and cause cracking somewhere else in the exhaust.

Overall, corrosion is the biggest problem with exhaust systems since they are subjected to high temperatures during the combustion process. Over time, the repeated heating and cooling cycles can make the metal more susceptible to corrosion. Normally the corrosion will begin on the outside and work its way in since the inside of the exhaust system is usually coated with a thin layer of residue from the exhaust. Stainless steel exhausts are superior to regular carbon steel exhausts for that reason.

A four-stroke engine exhaust system is pretty straightforward. However, there is a little bit more to a two-stroke exhaust system.

Two-Stroke Exhaust Systems

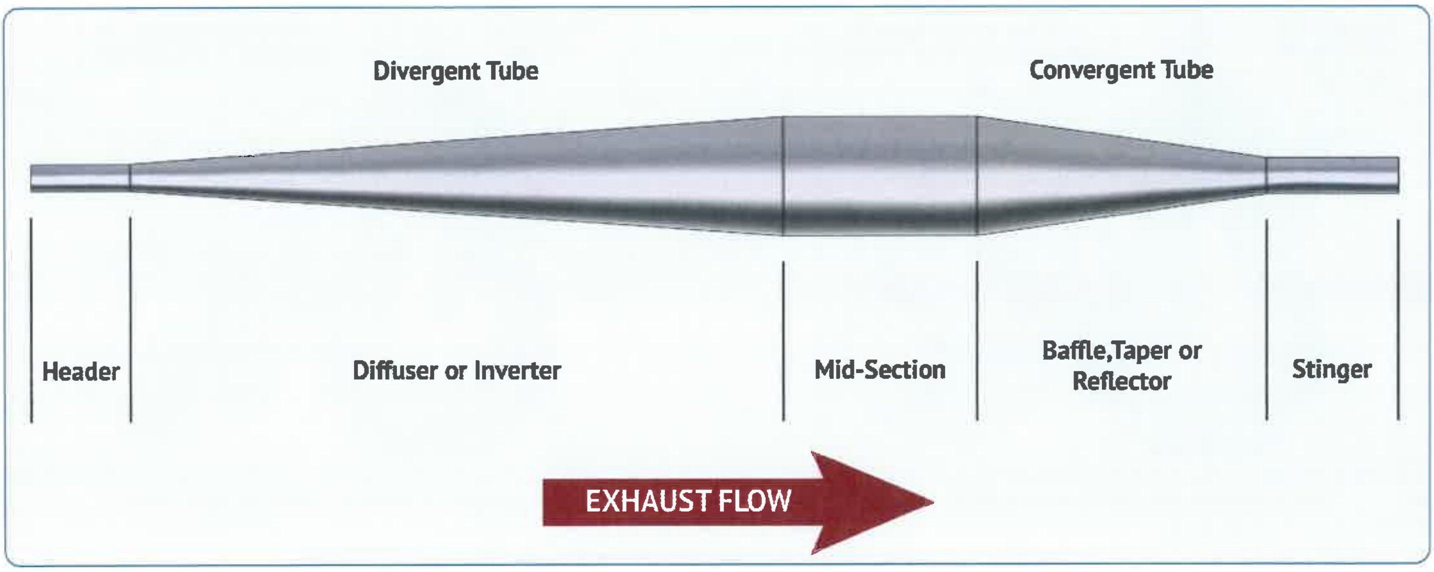
In two-stroke engines, the exhaust system enhances both fuel economy and power. The two-stroke exhaust system is an integral part of any two-stroke engine design, often controlling peak power output, the torque curve and even the RPM limit of the engine.

To produce power, expanding gases produced by the ignited fuel-air mixture push a two-stroke engine's piston down from the top of the cylinder. At the bottom of that same stroke, the piston uncovers the exhaust port on the cylinder, allowing those spent gases to leave the engine at the speed of sound. An 'exhaust port' is simply a hole in the side of the engine cylinder. The exhaust ports are what the exhaust manifold bolts up against.

In two-stroke engines, when hot spent gases are vented out of the exhaust port, they're moving fast enough to set up a high-pressure wave. The momentum of that wave down the exhaust pipe forms a vacuum behind it. That vacuum in turn generates a low-pressure wave behind the high pressure one. That low-pressure wave, if timed right, can be used to help suck out all the residual, hot, burnt gas from the power stroke and at the same time help pull a fresh fuel-air charge into the cylinder. This is called scavenging and is the most important thing a two-stroke exhaust can do.

Scavenging performs three key functions: it expels burned fuel, aids in drawing in a fresh fuel-air mixture, and helps cool the cylinder by replacing hot gases with cooler ones. Remarkably, this process happens quickly—at 6,500 RPM, the exhaust port remains open for less than 0.005 seconds, but this is sufficient because the gases move at the speed of sound.

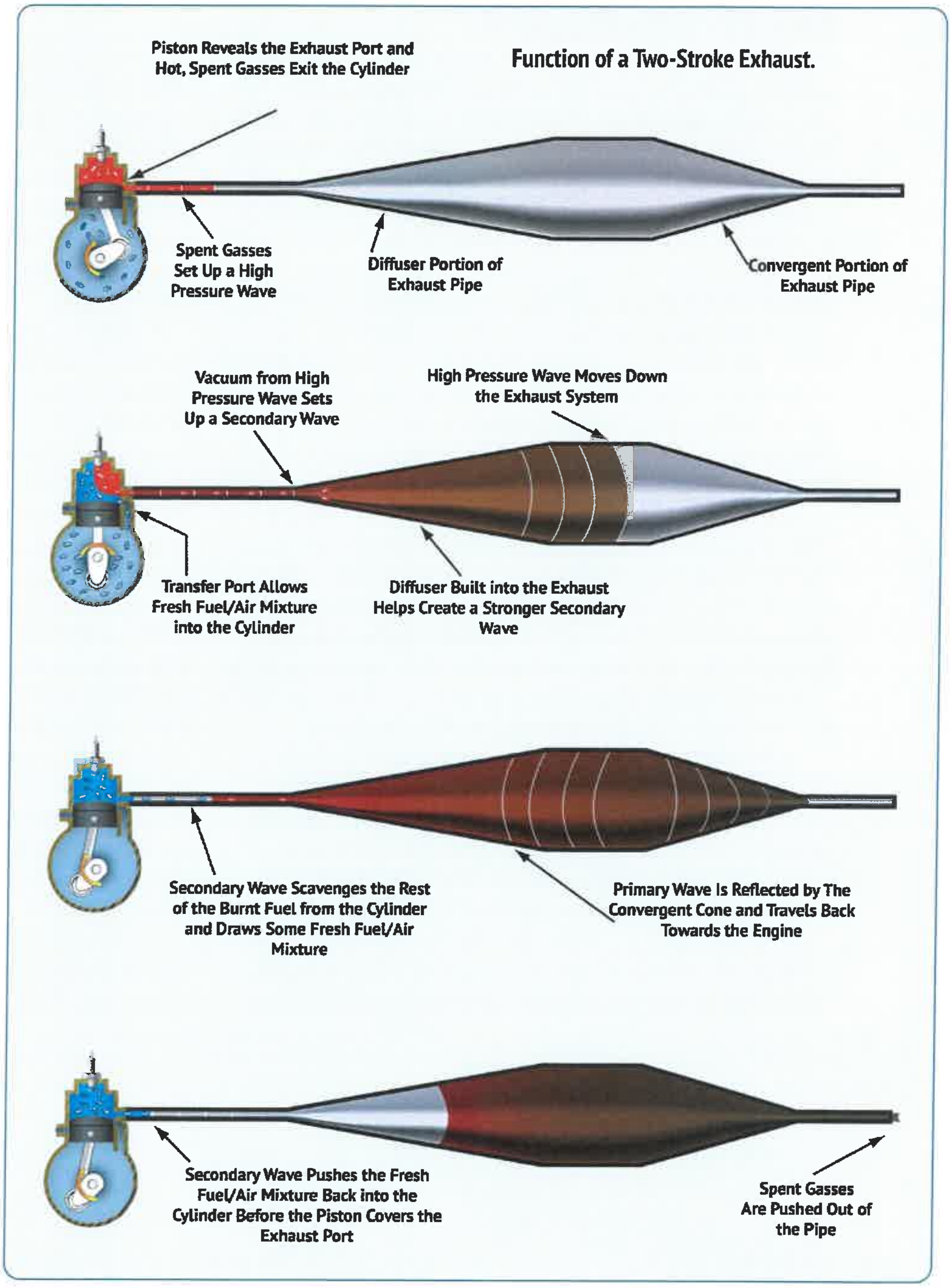
Parts of a Two-Stroke Exhaust.



History of Two-Stroke Exhaust Systems

When scavenging was first discovered, it was found that each engine RPM required a specific length of straight pipe for effective scavenging. If the engine was run higher than the resonance frequency of a particular length of tuned pipe, then the engine's piston would already have closed the exhaust port by the time the secondary low-pressure wave was generated, rendering that low-pressure wave ineffective. Conversely, at lower RPMs, the low-pressure wave would dissipate too quickly to be beneficial.

Engineers later found that gradually increasing the pipe diameter could produce a longer-lasting secondary wave. While not as intense as the wave from a straight pipe, this wave lasted longer and had a better chance of reaching the open exhaust port to assist in scavenging. A gently divergent cone helps organize the expansion of high-pressure gases, extending the duration of the wave front. This cone must be round, and its dimensions must account for the changing density, temperature, and pressure of the expanding gases. Various exhaust system designs use different shapes to achieve specific effects on engine performance.



A well-designed diffuser ensures effective scavenging. However, if scavenging occurs too early, it can also expel the fresh fuel-air mixture from the cylinder. To address this, a convergent cone is placed at the opposite end of the exhaust system to reflect a portion of the high-pressure wave back into the cylinder. This returning wave helps push the new fuel-air mixture back into the cylinder before the port closes, a process known as pulse-charging, which is nearly as important as scavenging.

Part of what makes pulse-charging effective it that the used, hot, burnt gases and the fresh, cool fuel-air charge have very different densities and do not mix very well. The returning pressure wave just pushes the fresh fuel-air charge back into the exhaust port before the cylinder closes off that port.

One of the problems with tuned exhausts is that they are generally tuned to a particular RPM range. The more an exhaust is optimized for a specific RPM range, the less efficiently it will perform at other RPMs. Vehicles like motorcycles work around this by using transmissions. Motorcycle pipe builders can optimize a certain RPM range and then the driver can shift gears to stay in that range. A powered parachute, with only a simple gear reduction, doesn't have that luxury.

For aircraft, the exhaust pipe must be designed to operate efficiently across a broad RPM range, from idle to full speed. Failure to do so can hinder the engine's ability to maintain consistent RPM. This is why simply installing a snowmobile engine on a powered parachute often doesn't work well—engine and exhaust system designs may not be suited for aviation applications.

Pulse-Tuned Exhaust Systems

Powered parachutes require an engine that will deliver power smoothly and predictably as the throttle is advanced. That basic requirement is difficult to meet with an exhaust system that is tuned to only a specific RPM range.

Pulse-tuned exhaust systems were developed to address the need for a broader RPM range in aircraft and other applications. The diagram below illustrates a typical cross-section of this exhaust type. In a pulse-tuned exhaust, the diffuser section has a divergence angle of only 3-4 degrees, compared to the 7-9 degree angles found in conventional exhaust systems. This smaller angle extends the duration of the secondary wave responsible for scavenging.

With a longer-lasting wave, it can start before the exhaust port opens and continue after it closes, ensuring the wave is present at the optimal moment. Although this wave is weaker than one produced by a larger diffuser angle, having a consistent wave is more beneficial for aviation purposes than a stronger wave that arrives too early or too late across different engine RPM ranges.

A diffuser alone will remove more than just the old, burnt fuel-air charge; it will also draw out some of the fresh charge. To prevent this, the second phase of scavenging generates a small reflected wave to stop the secondary wave from expelling the fresh fuel and air from the cylinder.

One issue with a conventionally tuned exhaust is that the reflected wave is generated by a fixed convergent cone installed downstream from the diffuser. The primary pressure wave hits this fixed wall, reflecting a portion of the wave back. The reflected wave then returns in time to push the fresh fuel-air charge back into the cylinder before the exhaust port closes. Since timing is crucial, a fixed convergent cone will send the reflected wave back at nearly the same time each cycle. This works well for a specific RPM range, but not for all RPM ranges.

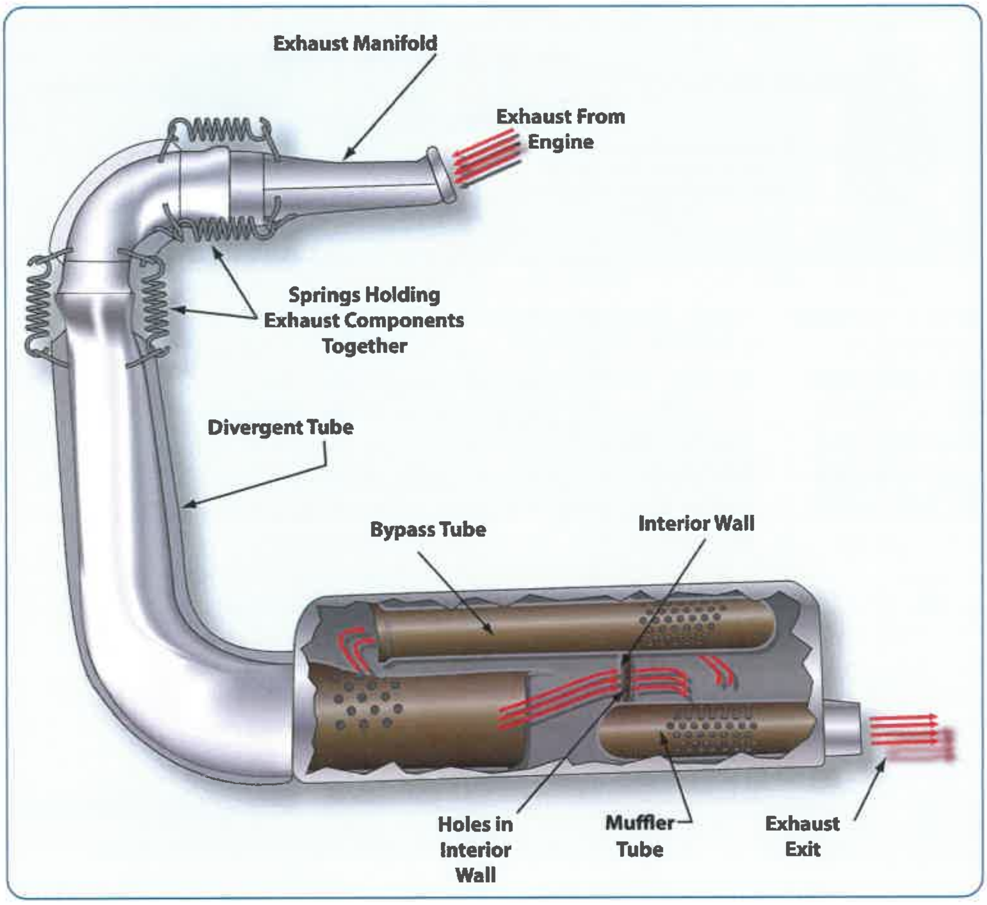
A pulse-tuned exhaust addresses this issue by eliminating the need for a convergent tube. Instead, it leverages the increasing density and pressure of exhaust gases as RPM increases. The magic happens inside the muffler, where an interior wall is welded slightly past the midway point. This wall reflects the wave needed to complete the scavenging process, while small holes in the wall allow exhaust gases to escape.

At low RPM, that wall is ideal for reflecting a wave at the right time. As RPM increases, so does the volume of exhaust, which builds up in front of the fixed metal wall, creating a barrier. This *"false wall"* reflects the exhaust wave sooner than the metal wall would. That works out well because the faster the engine runs, the sooner the reflected wave is needed at the exhaust port. As the pressure wall moves closer to the exhaust port with increasing RPM, it pushes the reflected wave back even faster.

At very high RPM, however, the small holes in the wall may not allow enough exhaust gases to escape. In such cases, a bypass tube comes into play. With a large opening near the muffler entrance, the bypass tube has holes that let excess gases escape, preventing the system from becoming overloaded and ensuring the reflected wave is properly timed.

The features of a two-stroke pulse-tuned muffler are:

- Noise deadening
- Reflect pulse wave for scavenging
- Back pressure changes pulse from long to short
- Broader torque band
- Good midrange torque
- Longer engine life
- Flat ramp torque curve
- Suitable for more power ranges
- Suits the harmonic resonance of the engine



The Rotax Pulse-Tuned Exhaust System.

Engine Warming

Warming up any aircraft engine is important and following manufacturer guidelines is best. If heat is applied gradually to an engine, all parts expand more evenly. Generally, most manufacturers recommend running the engine at a low RPM for a few minutes before increasing power. Warming the engine offers several benefits:

Cylinder Head Temperature: Gradually warming the engine helps prevent rapid temperature increases in the cylinders, which can cause uneven expansion and contraction of engine components.

Fuel Vaporization: Cold engines struggle to vaporize fuel efficiently. A warmed engine allows for better fuel vaporization, leading to improved combustion and overall engine performance.

System Checks: Warming up the engine gives you time to complete a preflight checklist, ensuring that all systems are functioning correctly before takeoff.

Oil Flow: An additional reason for warming up a four-stroke engine is to improve oil flow. When a four-stroke engine is cold, the lubricating oil is thicker and doesn't flow as easily. Warming up the engine allows the oil to reach its optimal operating temperature, reducing friction between moving parts and providing better lubrication.

High RPM: Warming up two-stroke engines is critical because they operate at high RPM, especially at full speed. Going to full power too early creates more stress on a two-stroke than on a four-stroke

Modern engines are manufactured with both steel and aluminum components. Since steel and aluminum expand at different rates when heated, the aluminum parts expand faster than the steel parts. This can create problems in two key areas of many engines. First, in the cylinders, where ferrous cylinder walls expand slowly while aluminum pistons expand quickly. If the engine is revved too quickly, excessive heat generated on the piston can cause it to expand rapidly and seize in the cylinder, abruptly stopping the engine.

The second area of concern is the lower part of the engine, around the crankshaft. In this region, heating too quickly can lead to components becoming too loose rather than seizing up. For example, many two-stroke engines have steel bearings that are designed to fit snugly within the aluminum engine case. The crankshaft spins within these steel bearings. If the engine heats up too quickly, the aluminum case expands faster than the steel bearings, allowing the crankshaft to force the bearings to spin along with it. If the bearings start spinning, they can damage the soft aluminum walls of the case, which is very expensive to replace.

Many engines are best warmed up by running at a set RPM for a specific duration. If no other instructions are provided in the Pilot's Operating Handbook (POH), here are some general guidelines:

Two-stroke engines: should be run at 2,000 RPM for two minutes. After the initial warm-up period, continue at 2,500 RPM until coolant temperature reaches 230 ° F.

Four-stroke engines: Let the engine idle at around 2,000 RPM for 2 minutes. This allows the engine to start warming up gradually and ensures that oil circulation is established. After the initial warm-up period, continue at 2,500 RPM, until oil temperature reaches 120 ° F.

You should consider the outside air temperature when determining the appropriate warm-up time for your engine. Colder temperatures require longer warm-ups.

It typically takes about five minutes for the engine crank and bearings to reach heat saturation. These components, located in the lower part of the engine, need to remain properly seated against the crankcase. The heavy steel parts require sufficient time to absorb enough heat to expand to their operating dimensions.

Even after you warm your engine up and take off, it's still possible for you to cool an engine down too much, especially in water-cooled, two-stroke engines. This typically occurs when the engine is idled for an extended period. While the engine continues to run, it generates less heat, and the cooling system may be over-efficiently dissipating heat into the atmosphere. As a result, the cylinders and can cool and contract. When you apply power to level off or climb, the sudden heat on the aluminum pistons can cause them to expand more quickly than the cylinder walls, leading to a cold seizure as if the engine had not been warmed up initially. To prevent this, gradually increase power well before you need it, allowing the cylinders to warm back up.

Finally, just as it takes time for the engine crank and bearings to warm up, these steel parts also take a while to cool down. If you land, refuel, and want to take off again quickly, you typically don't need to warm up the engine again for a full five minutes. The lower end of the engine can remain warm for up to 45 minutes after shutdown. However, during an engine restart, it's appropriate to warm up the engine until your gauges reach normal operating temperatures. This helps prevent piston seizure.

Gearboxes

Gearboxes on powered parachute engines convert the high RPM output of an internal combustion engine to a slower, more useful RPM for turning the propeller. That's because if the propeller turns too quickly, the tips can exceed the speed of sound, resulting in inefficiency.

Gearboxes come with various gear ratios depending on the engine's output speed and the desired propeller speed. For the Rotax 912-series engines, the gearbox is integrated with the engine and uses the engine oil for lubrication. That means that when you change your engine oil, you're also changing your gearbox oil.

In Rotax two-stroke engines, the gearbox is a simple unit that bolts directly to the engine, with the propeller attached to it. This gearbox is lubricated by its own built-in reservoir of heavy gearbox oil, which is part of the gearbox case. The gearbox oil needs to be changed periodically because gear meshing causes wear and generates steel filings in the oil. If the oil is not changed, these filings can be abrasive and cause further wear.

Induction Systems

The induction system draws air from the atmosphere, mixes it with fuel, and delivers the fuel-air mixture to the cylinder for combustion. Outside air enters the induction system through an air filter, which prevents dust, foreign objects, and sometimes moisture from entering. There are two common types of induction systems used in powered parachute engines:

Carburetor System, which mixes the fuel and air in the carburetor before this mixture enters the intake manifold.

Fuel Injection System, which mixes the fuel and air just before entry into each cylinder.

Carburetor Systems

Carburetors are classified as either float-type or pressure-type, with pressure carburetors being uncommon in powered parachutes. The main difference between the two is that pressure carburetors deliver fuel under pressure from a fuel pump, while float-type carburetors use a different mechanism.

In a float-type carburetor system, outside air first passes through an air filter, usually mounted directly on the carburetor. This filtered air then flows into the carburetor and through a venturi, a narrow section of the carburetor. As air moves through the venturi, it creates a low-pressure area that causes fuel to be drawn through a main fuel jet located at the throat of the venturi. The fuel mixes with the air in the airstream.

This fuel-air mixture is then drawn through the intake manifold and into the combustion chambers, where it's ignited. The float-type carburetor gets its name from the float (or floats) in the float chamber. This float is connected to a needle valve that opens and closes an opening at the bottom of the carburetor bowl. The float regulates the amount of fuel entering the carburetor based on its position, which is controlled by the fuel level in the float chamber. When the fuel level rises and lifts the float, the needle valve closes, shutting off the fuel flow. When the engine needs more fuel, the needle valve opens again.

The flow of the fuel-air mixture to the combustion chambers is controlled by the throttle valve, which is operated by the throttle in the flight deck. The carburetor features four circuits: three are controlled by the throttle, while the fourth is the starting circuit, commonly known as the choke.

Carburetion Theory

To the uninitiated, a carburetor may seem complicated, and indeed, it is a somewhat intricate and well-designed device. It includes various tubes, cables, adjustment screws, and moving parts of all sorts. This complexity becomes even more apparent when disassembling a carb to replace the elusive jets.

The carburetor's purpose is to deliver the perfect amount of fuel-air mixture to the engine across different throttle settings. It not only provides this mixture but also ensures that it's well-mixed for optimal ignition by the spark from the ignition system.

Since the carburetor works with both air and fuel, it's helpful to take a look at both of these ingredients. Our fuel of choice is gasoline, a hydrocarbon. Hydrocarbons include substances such as gasoline, butane, kerosene, oils, waxes, and polyethylene plastic. The term *"hydrocarbon"* combines *"hydro,"* referring to hydrogen, and *"carbon,"* which is the same thing charcoal briquettes are made of.

Air, the other ingredient the carburetor manages, consists of various gases. Nitrogen is the most prevalent, making up 78% of the atmosphere, followed by oxygen at 21%. The remaining 1% consists of other miscellaneous gases.

Between the fuel pump and the great outdoors, the carburetor has plenty of gasoline and air at its disposal. The question becomes, how much of each do we want to work with?

For ideal combustion, each carbon atom in the fuel needs to bond with two oxygen atoms, and each pair of hydrogen atoms must combine with one oxygen atom. Theoretical calculations suggest that one pound of fuel combines with approximately 14.8 pounds of air. This combination, along with a spark, creates an explosion in the engine cylinder, producing carbon dioxide and water vapor. Carbon dioxide is utilized by trees and plants, while water is absorbed by them, so our flying activity benefits the environment by dispersing these nurturing chemicals.

While the big chemical reaction is going on, the nitrogen doesn't just hang out in the engine cylinder looking invisible. It contributes by absorbing a lot of heat from the explosion and converting that heat into mechanical energy by expanding. That's what pushes your piston away from the spark plug and makes the crankshaft and the prop go round.

Before we move on, let's look at the air and fuel requirements in more practical terms. The theoretical ratio is one pound of fuel for 14.8 pounds of air. To put this into perspective, one gallon of fuel weighs approximately 6 pounds. Therefore, burning one gallon of fuel requires around 88.8 pounds of air. Since one cubic foot of air weighs about 0.075 pounds, this means that about 1,184 cubic feet of air—roughly the volume of a 12'x12' room with an eight-foot ceiling—is needed to burn one gallon of fuel. That's a substantial amount of air for just one gallon of fuel.

The theoretical 1:14.8 fuel-to-air ratio represents a 'perfect' mixture. However, in practice, this ideal mixture often generates too much heat for our engines. To achieve maximum power, it's better to run engines slightly richer than this theoretical optimum. A richer mixture means increasing the amount of fuel for a given amount of air, whereas a leaner mixture does the opposite.

Running a richer mixture lowers combustion temperatures and improves the combustion process by allowing more time to convert heat into mechanical energy. A mixture ratio of 1:13.1 is often found to produce the highest power. If the mixture is enriched beyond 1:12.5, power decreases due to the excessive cooling effect of the additional fuel, which reduces combustion efficiency.

Leaner mixtures have their place, particularly when you're trying to maximize fuel efficiency over long distances. To achieve this, carbs are designed to deliver a lean 1:16.4 to 1:18.2 mixture at cruising speeds. However, such a lean mixture isn't effective at low speeds because it can cause the engine to hesitate and not rev up smoothly. At high speeds above ¾ throttle, an excessively lean mixture can overheat and damage the pistons.

The graph on the next page illustrates the fuel demands of an engine. Starting the engine requires the richest fuel-air ratio, as seen on the left side of the chart. Even at idle, the engine remains inefficient and still needs a rich mixture. At cruising speeds, the engine operates at its optimum and uses the leanest mixture. At full throttle, a richer mixture is necessary to deliver maximum power and prevent the pistons from overheating.

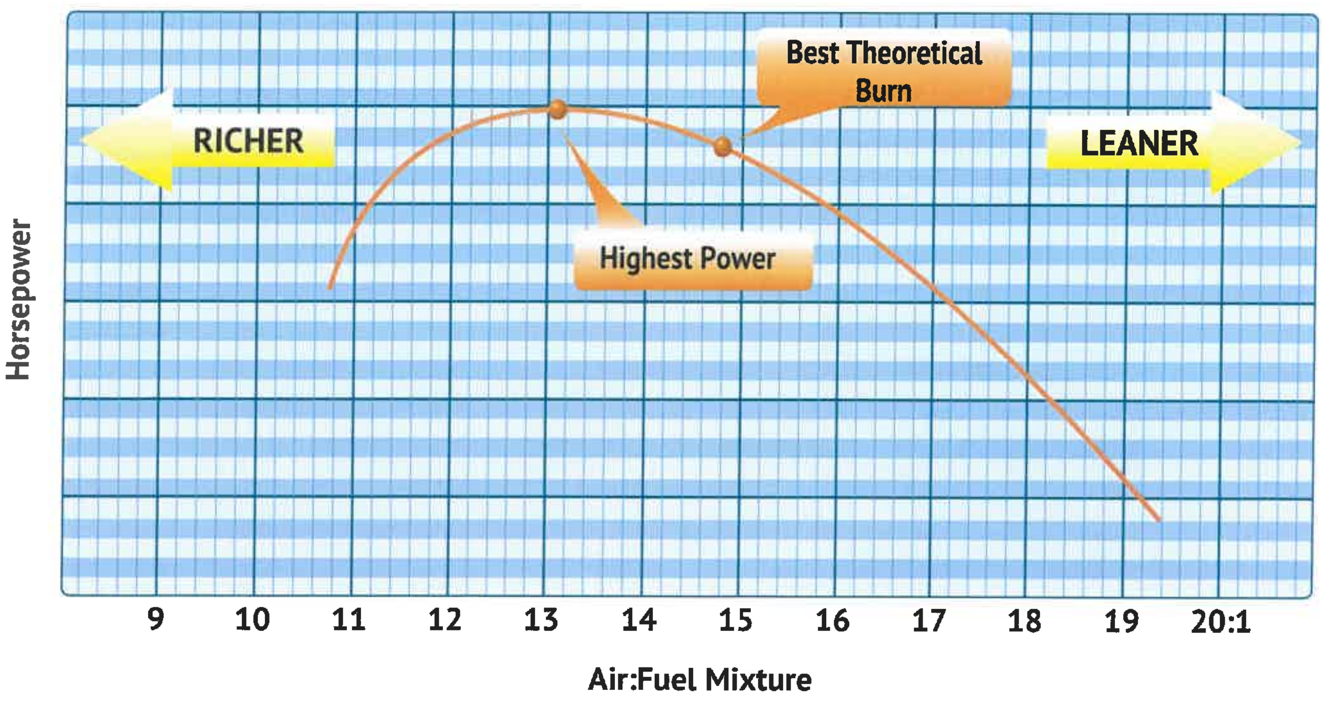
The carburetor manages these varying fuel demands through different circuits. These circuits exist to provide the appropriate fuel mixture at different throttle settings and because different types of valves are needed for low versus high volumes of fuel and air.

A carburetor 'circuit' refers to the fuel delivery system in use at a specific throttle or choke setting. The term 'mixture' refers to the ratio of fuel to air being delivered to the engine. Though the terms are related, they are not the same, but technical writers often use them interchangeably. The following terms correspond roughly with each other:

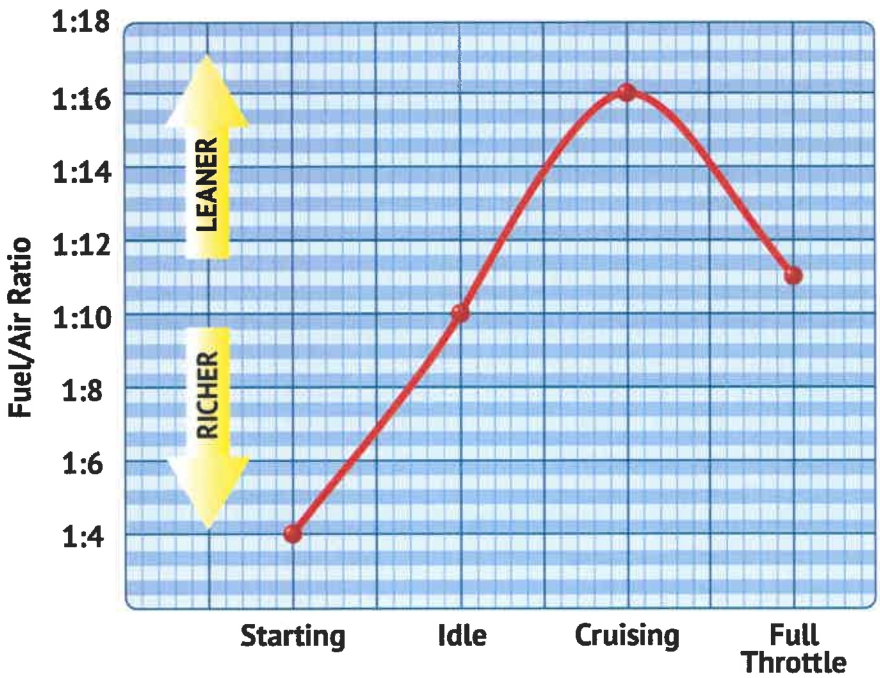
- Mid Range = Needle Jet Circuit = Part Throttle Mixture
- Pilot Circuit = Idle Speed Mixture
- Enrichment Circuit = Starting Mixture = Choke

Additionally, the carburetor includes various jets that are part of these circuits, such as the main jet, needle jet, jet needle, and pilot jet. Importantly, these jets don't simply switch off at certain points; instead, the influence of one jet gradually fades as the influence of the next jet increases.

Horsepower developed at different air to fuel ratios.



Fuel to air demands of an engine.



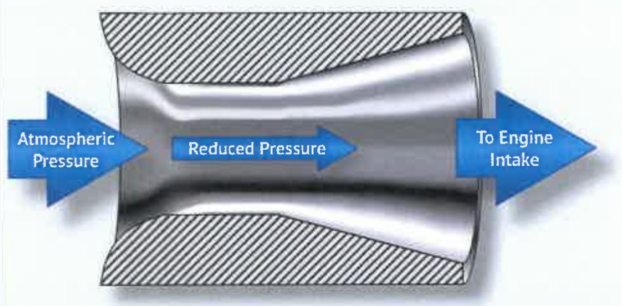
The Main Circuit

Bernoulli's Principle, which explains lift, also helps us understand how carburetors work. These carburetors are known as 'venturi-type' because they rely on the venturi effect, which is a practical application of Bernoulli's Principle.

In a two-stroke engine, as the engine's piston begins its upward movement toward the spark plug, a passageway opens between the engine intake and the lower engine case. This upward motion creates a vacuum in the engine case, which pulls air through the carburetor. In a four-stroke engine, air is drawn into the carburetor when the intake valve opens and the piston goes downward from the spark plug forming a vacuum.

However, the air doesn't go through the carburetor without doing a little work. As the air is drawn into the carburetor, it passes through the venturi, a constricted section of the air passageway. This constriction forces the air to speed up, causing a drop in air pressure at the venturi's narrowest point, thanks to Bernoulli's Principle.

This low pressure draws fuel from the carburetor bowl into the airflow. A tube extends from the fuel reservoir into the low-pressure area of the venturi, where the fuel is pulled up and mixed with the air before entering the engine's intake



Air passing through the throat of a venturi-type carburetor speeds up and its pressure is reduced.

manifold. At full throttle, the process is almost that simple.

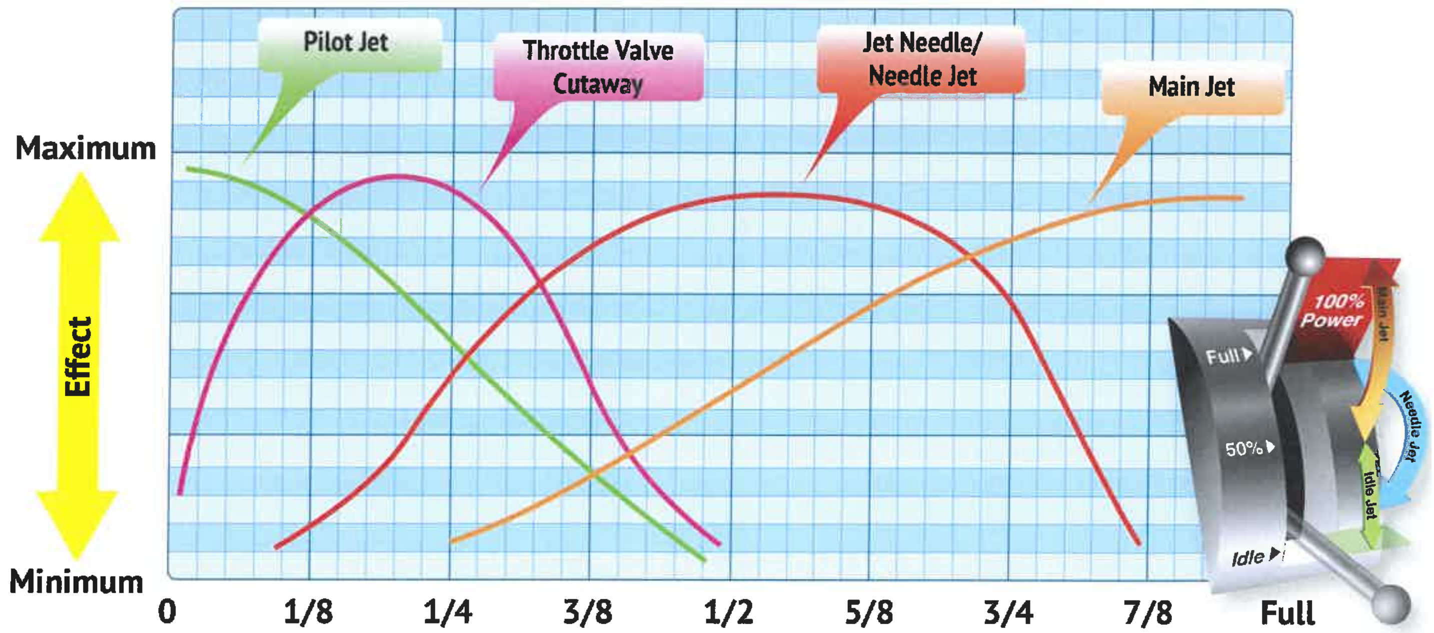
It's very important for the fuel reservoir to be open to the atmosphere because the fuel is drawn up due to the pressure difference between the atmosphere and the air moving in the venturi. If the reservoir is sealed off from the atmosphere, the system won't function properly.

There are other factors to consider with this straightforward method of fuel delivery. The fuel level in the reservoir must be consistent. If the level is too high, too much fuel will enter the airstream, causing the engine to run rich. If it's too low, insufficient fuel will be mixed with the air. There should be a consistent mix so that the engine can run evenly.

Additionally, the correct amount of fuel must be metered into the airstream. Larger engines pull more air than smaller ones, so carburetor manufacturers need to allow adjustments for different engine sizes. Pilots and mechanics also need to be able to fine-tune the fuel mixture.

The carburetor addresses these issues with various systems. The float system maintains a consistent fuel level. Fuel enters the reservoir (or float bowl) from the top. As the bowl fills, a float rises and pushes a needle valve into the fuel inlet, closing it off. When the venturi pulls fuel from the bowl and the level drops, the needle valve opens, allowing more fuel in. This cycle repeats continuously, similar to a toilet refilling after a flush. This float mechanism is one of the few parts of a carburetor that experiences significant wear.

Fuel metering is managed by a replaceable 'main jet.' The main jet is essentially a plug with a precisely drilled hole that controls how much fuel passes through. Larger engines require a jet with a bigger hole, while dual-carburetor engines need smaller jets for each carburetor compared to a single carburetor serving both cylinders.



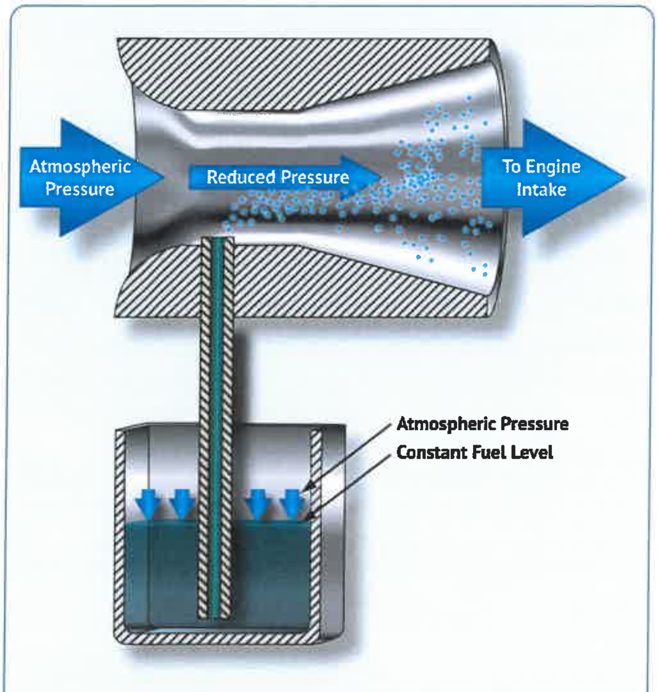
Jetting Effects of Different Throttle Positions

Changing Main Jets

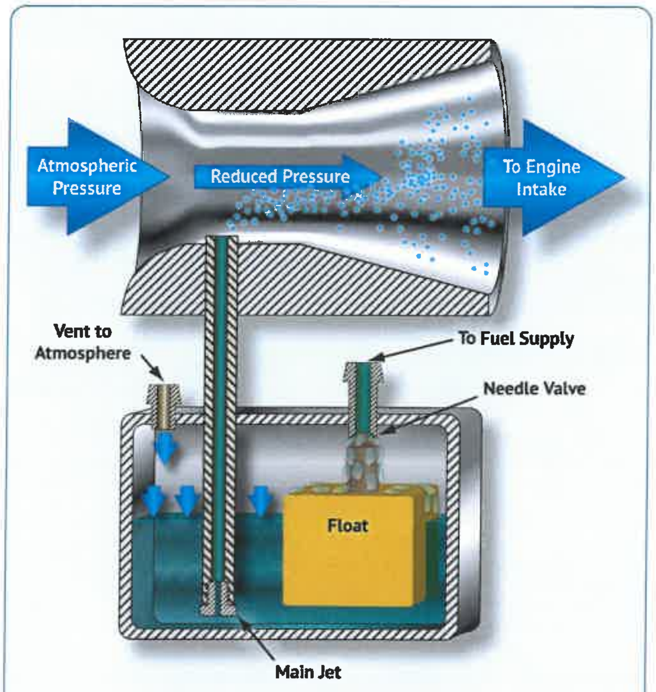
Carburetors are normally set at sea-level pressure, with jets and settings determined by the manufacturer. However, as altitude increases, the air entering the carburetor becomes less dense, while the fuel density remains the same. Carburetors used on two-stroke engines for powered parachutes do not automatically adjust for altitude changes (although the carburetors in four-stroke Rotax 9-series engines do). The carburetor is only affected by the pressure difference between the moving air in the venturi and the atmosphere, not by air density. So, if a carburetor is jetted for sea level—as they come out of the box—and you try to take off at 10,000 feet, you will be burning a rich fuel-air mixture.

This richer mixture can cause engine roughness and a noticeable loss of power. The roughness usually results from spark plug fouling due to excessive carbon buildup, which occurs because the rich mixture lowers the temperature inside the cylinder, preventing complete fuel combustion. This issue may arise at high-elevation airports or during climbs and cruise flights at high altitudes. To maintain the correct fuel-air mixture, you must change the main jets and adjust the midrange jets and settings. Leaning the mixture reduces fuel flow, compensating for the decreased air density at high altitudes.

In general, you shouldn't need to change your main jets unless you're switching your carburetor



The low pressure in the venturi pulls fuel from the float bowl.



The venturi carburetor main circuit.

to a different engine or flying at significantly different field altitudes. However, if you frequently fly out of high-altitude locations, main jet replacement may be something to consider.

While richer mixtures at high altitudes can reduce performance, there's a more dangerous situation: if your carburetor is perfectly jetted for high-altitude flying and you then operate at sea level, you could end up burning a dangerously lean mixture. This is where main jet correction charts come in handy. Jet numbers stamped on the main jets typically refer to the orifice area. Always consult your POH before operating a powered parachute at altitudes significantly different from your usual flying conditions. After changing jets, the best way to make sure that your carburetor is providing the proper mixture is by monitoring the engine's exhaust gas temperature gauge.

Again, this concern is unnecessary with the automatic altitude-compensating carburetors found on Rotax 9-series engines.

The Midrange Circuit

So far, we've learned how the carburetor pulls fuel from the float bowl, mixes it into the air stream, and delivers it to the engine's intake. However, this only explains how the carburetor functions at full throttle, where the main jet—essentially just a hole in a plug—regulates the perfect amount of fuel when the maximum air flows through the carburetor.

But engines need to operate at less than full throttle, and that's where the midrange circuit comes into play. Since the carburetor supplies both fuel and air to the engine, reducing engine speed requires a decrease in the delivery of these two ingredients.

The figure below illustrates how this is done. The throttle is shown wide open, and the carburetor piston or slide is pulled up into the carburetor housing, allowing maximum air to flow into the engine's intake.

On the opposing page, you'll see what happens when you reduce the throttle to idle. The slide springs into action, lowering into the venturi and reducing the airflow. Your throttle gives you full control: you can pull the slide up to increase engine speed to the maximum or lower it to reduce airflow to a trickle.

That's straightforward enough. However, if you reduce the airflow without reducing the fuel flow, your engine will run too rich. Therefore, fuel metering is also necessary.

In the midrange, fuel metering is handled by a system called the needle jet and the jet needle. The needle jet is a small tube with a precisely measured interior diameter, fitting into the bottom of the carburetor body and extending into the fuel in the float bowl.

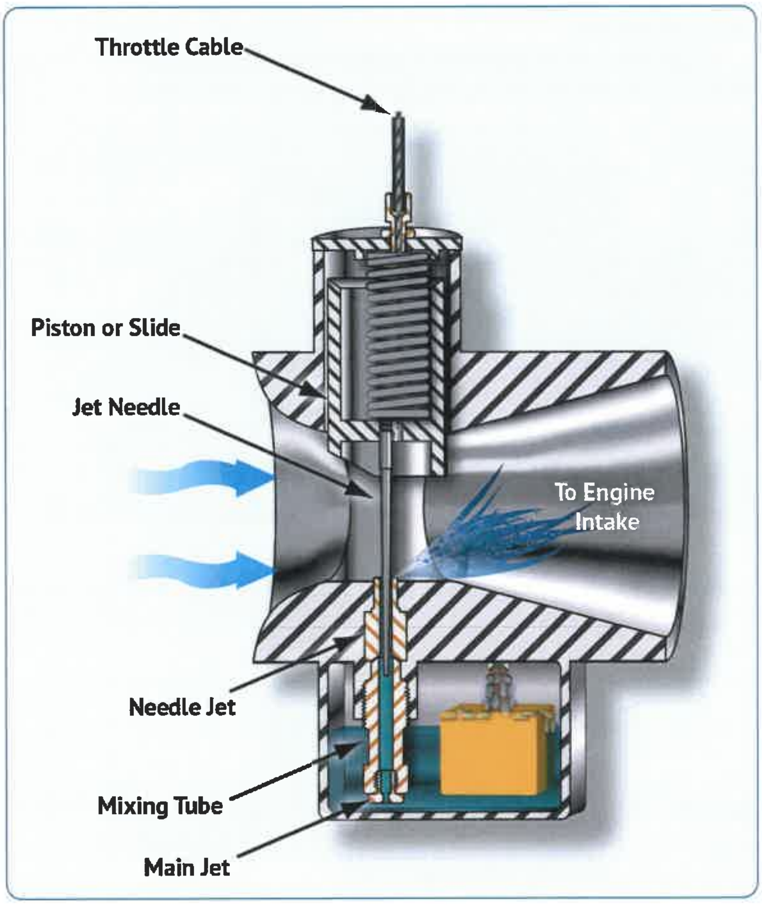
The jet needle, which is tapered and attached to the carburetor slide, controls the fuel flow. As the throttle cable pulls the slide up, the jet needle rises, 'unplugging' the needle jet and allowing more fuel to enter the air stream. This synchronized movement ensures that as more air enters the engine intake, more fuel does too.

Most midrange adjustments can be made by accessing the jet needle from the top of the carburetor.

Adjusting the Midrange Circuit

Unlike other jets in a slide-style carburetor, the jet needle is adjustable. While other jets have fixed sizes that meter a set amount of fuel, the jet needle offers flexibility with four different grooves for attaching the mounting clip. (See the opposing page.)

These grooves at the top of the jet needle allow you to fine-tune your midrange mixture. The position of the clip in a groove determines whether the midrange will run too lean, too rich, or just right. Moving the clip higher or lower on the jet needle effectively raises or lowers the needle relative to the carburetor slide. This adjustment is vital for matching the optimal fuel-to-air ratio. If your midrange mixture is too rich, you can correct it by lowering the jet needle slightly into the needle jet, which reduces fuel flow at that throttle setting. To do this, simply move the clip up a notch on the jet needle.



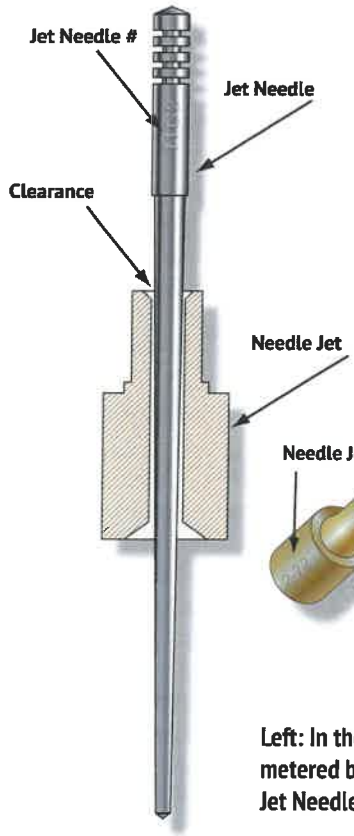
As the throttle pulls the slide open to allow more air into the intake, the jet needle lifts in order to allow more fuel past the needle jet.

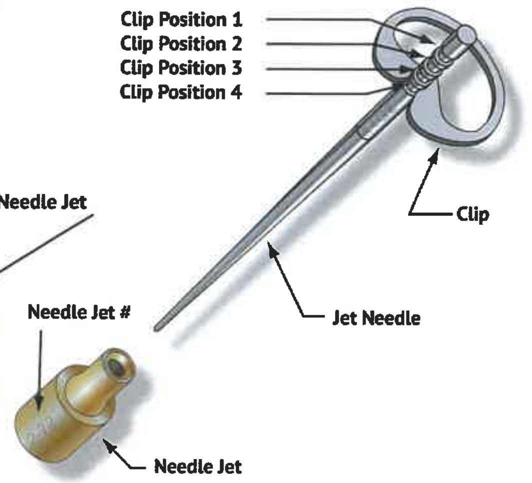
Each jet needle is marked with groove positions, starting with #1 at the top and numbered consecutively down the shaft. Some older jet needles may have only three grooves, which is important to note because factory specifications typically call out the correct clip position number. If you're experiencing carburetor issues, one of the first checks should be whether the clip is positioned in the groove specified by the engine manufacturer.

Major Jetting Changes

When moving your carburetor from one engine model to another or switching from a single carb to a dual carb setup, you'll need to adjust more than just the clip position on the jet needle. A change to the main jet is necessary, but you'll also need to replace the needle jet, jet needle, and find the appropriate clip position to match your new engine configuration.

All jets have identification numbers stamped on them, just like the main jet has its inside diameter marked. The needle jet also has its inside diameter stamped, though the number is larger to accommodate the jet needle. The jet needle itself doesn't have a hole to measure, and its diameter varies along its length, so the numbers on it are more of a code that distinguishes one jet needle from another.





Left: In the midrange circuit, fuel is metered by the clearance between the Jet Needle and the Needle Jet.

Above: The midrange circuit can be adjusted by moving the jet needle mounting clip to different positions on the jet needle.

The Idle Circuit

Below one-quarter throttle, the main fuel regulating system becomes less effective. When the engine is idling, the slide is nearly closed, reducing airflow so much that the venturi can't create enough vacuum to pull fuel through the main system from the float chamber. For that reason, there is an independent idle or pilot system.

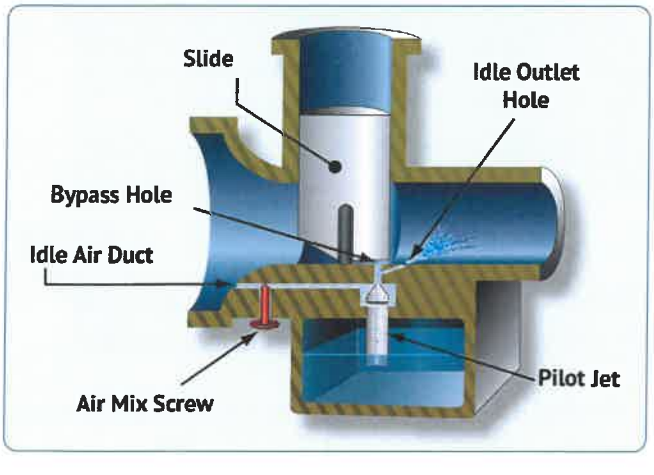
This system includes an idle jet and an idle air mix screw. Fuel is drawn through the idle jet, which is mounted on the bottom of the carburetor body within its own 'idle jet installation tube.' This tube dips into the fuel in the float bowl, similar to the main jet. Like the main jet, the idle jet has a fixed size, with a hole bored through its center that determines the amount of fuel allowed through.

Air for this system is supplied through additional ducting in the carburetor. On the air filter side of the carburetor is a small opening that allows air into the ducting, known as the 'idle air duct.' Another duct, located just below the slide, directs air to the idle jet and is known as the 'bypass hole.' The bypass hole functions when the slide is nearly closed, forcing air through it to mix with air from the idle air screw and fuel from the idle jet.

Since the idle jet is a fixed size, the amount of fuel allowed into the engine remains constant. The only way to adjust the fuel-air mixture is by regulating the amount of air entering the mix, which is done using the idle air mix screw. Unscrewing this valve allows more air into the ducting to mix with the fuel drawn through the idle jet.

The air mix screw has a tapered tip to provide a gradual increase in airflow as the screw is backed out. Typically, the screw is set by turning it all the way in until it is lightly seated, then backing it out by half to one full turn. This setting is specified for each particular engine, just like the jets themselves.

When we talk about air being forced through the carburetor, it's because low pressure is created at the engine's intake. The air drawn by the engine will typically be pulled through the venturi since it's the largest opening. But if that opening is closed off by the carb's piston, air will find its way into the engine through the smaller ducts of the idle system.



The idle circuit.

As the throttle opens and larger amounts of air are allowed through the main system, the idle system's role diminishes. The low-pressure area in the carburetor shifts from behind the slide, where the idle outlet bore is located, to the center of the carburetor, where the slide creates the venturi for the main circuit. By the time the throttle reaches half-open, the idle system no longer contributes a noticeable amount to the mixture.

Adjusting the Idle

Adjusting the idle involves setting the minimum engine speed and ensuring the engine receives the correct fuel-air mixture. Before making any adjustments to your idle system, first verify that the idle jet is the correct size and that the idle air mix screw is set to the recommended number of turns from fully closed. These factory specifications provide the best starting point.

Next, make sure that your engine is warmed up. Idle adjustments can only be accurate when the engine is at operating temperature to ensure proper fuel vaporization.

Finally, set your idle speed to the proper RPM. For most two-stroke Rotax engines, the minimum idle speed is 2000 RPM. Idling below this speed, especially with a load like a propeller, risks rough operation and potential damage to the crank and gearbox.

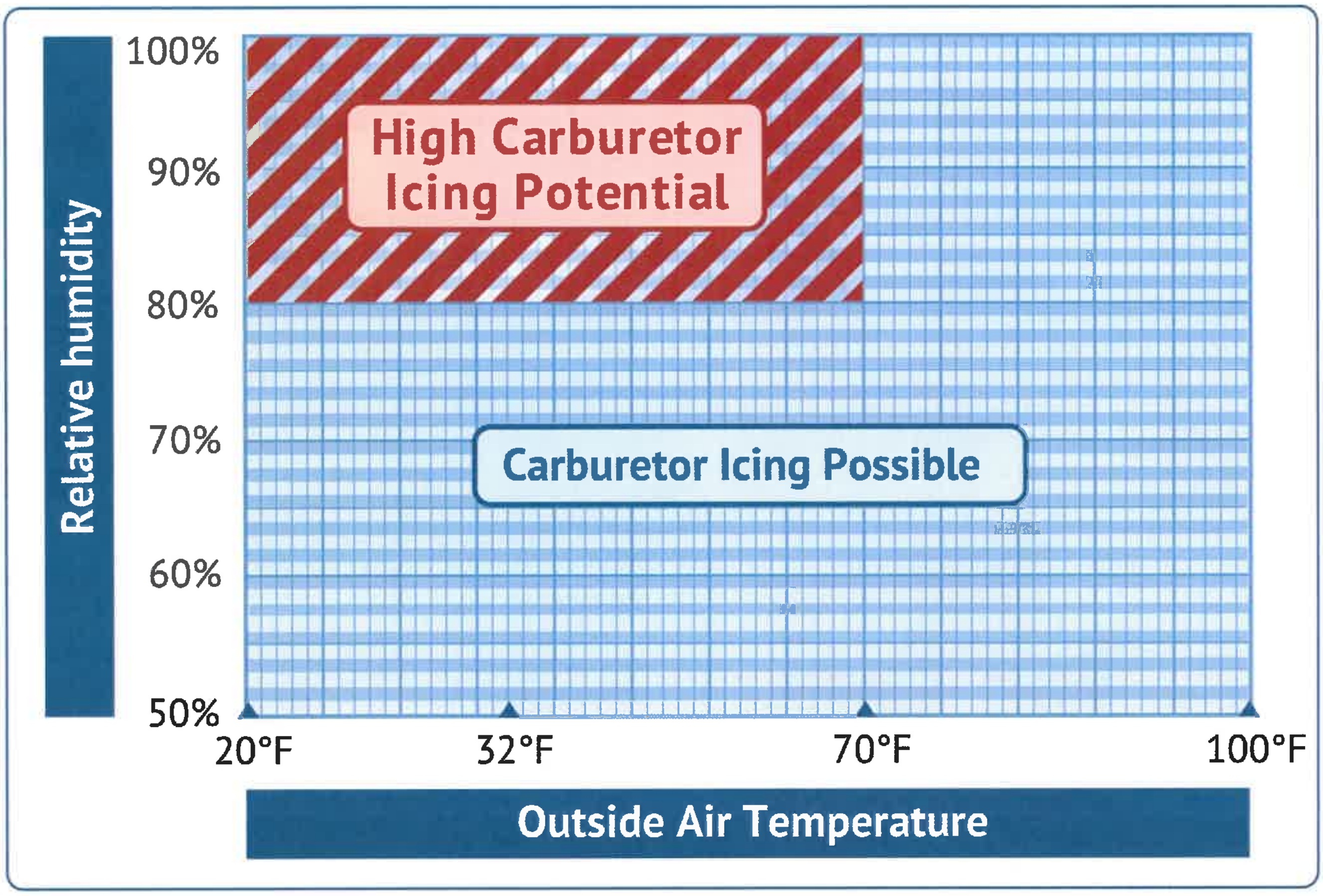
The engine's idle speed is adjusted using the idle speed adjustment screw, which acts as an adjustable stop to prevent the carburetor piston from dropping below a certain level. Inside the carburetor, the screw has a tapered tip that, when turned in, raises the slide higher in the carburetor body, increasing the idle speed.

If your engine has two carburetors, both idle speed adjustment screws must be set identically. If not, one cylinder will receive more fuel and air than the other, causing uneven operation and potential engine damage. If the idle jet and idle air mix screws are set to factory specifications, the engine is warmed up, and the idle speed is properly adjusted, the carburetors are likely set as well as they need to be. For any finer tuning, consult the engine or aircraft installation and maintenance manuals.

The Enrichment Circuit

When first starting an engine, low airflow and poor atomization in the idle circuit can create problems. Sometimes, extra raw fuel is needed, which is where the enrichment circuit, or choke, comes into play.

The choke system operates similarly to the idle system, using the low pressure on the intake side of the engine to pull raw fuel from the carburetor bowl. However, unlike the idle system, the choke can function at any RPM and is controlled by the



Although carburetor ice is most likely to form when the temperature and humidity are in ranges indicated by this chart, carburetor icing is possible under conditions not depicted

pilot. To activate the choke, a piston must be raised to allow fuel to flow through the emulsion tube, a third tube that dips into the carburetor bowl. The plunger can be operated remotely via a cable system or directly on the carburetor using a lever.

With the plunger raised and the throttle slide closed, air is forced through a porthole inside the carburetor inlet while fuel is pushed up through the emulsion tube, mixing with the air. This fuel-rich mixture is then ducted to the engine side of the carburetor and delivered to the engine intake.

Some manufacturers prefer a primer plunger system over a choke lever, which pumps raw fuel directly into the engine side of the carburetor.

Carburetor Icing

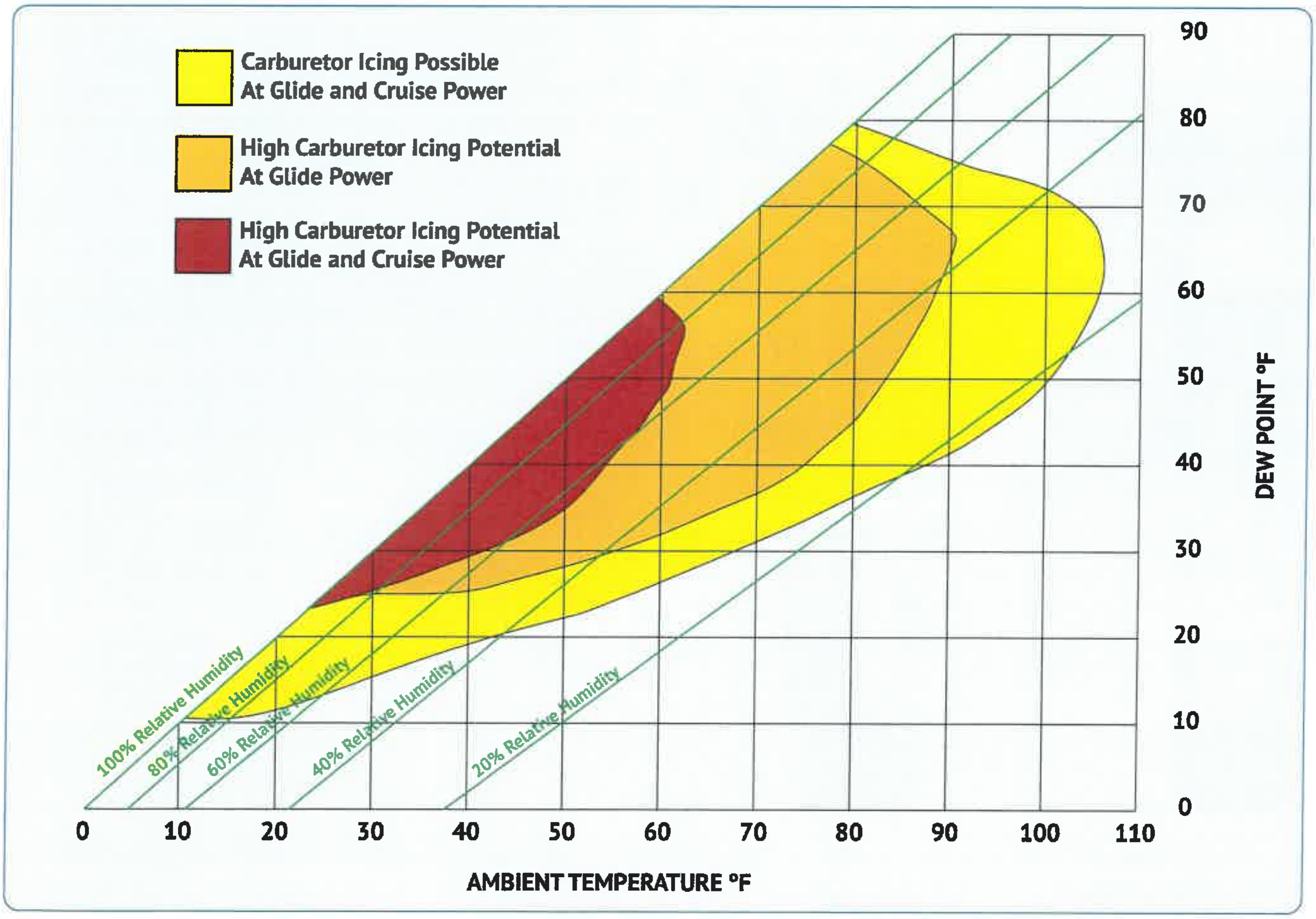
One disadvantage of the float-type carburetor is its tendency to ice. Carburetor ice forms due to the cooling effect of fuel vaporization and the decrease in air pressure in the venturi, which causes a sharp temperature drop within the carburetor. If water vapor in the air condenses when the carburetor temperature is at or below freezing, ice can form on internal surfaces, including the throttle valve.

The reduced air pressure and fuel vaporization both contribute to the temperature drop in the carburetor, with ice typically forming near the venturi throat. This ice buildup restricts the flow of the fuel-air mixture, reducing engine power. If enough ice accumulates, the engine may eventually quit. Carburetor icing is most likely to occur when temperatures are below 70°F (21°C) and the relative humidity is above 80 percent. However, due to the sudden cooling in the carburetor, icing can still occur at temperatures as high as 100°F (38°C) and humidity as low as 50 percent. The temperature drop within the carburetor can be as much as 60 to 70°F, meaning that at an outside air temperature of 100°F, the air temperature inside the carburetor could drop to 30°F.

The first sign of carburetor icing is a decrease in engine RPM, possibly followed by engine roughness. Although carburetor ice can form during any phase of flight, it's particularly dangerous during a descent when using reduced power. Under certain conditions, carburetor ice can build up unnoticed until you try to add power. To mitigate carburetor ice, ensure that the air filter is clean and well-oiled to prevent moisture penetration, and avoid flying in conditions that could cause carburetor icing. Always consult the aircraft's POH for information on carburetor ice probability and procedures specific to your installation.

Fuel Injection

An alternative to carburetors is fuel injection. You can learn more about them in *Chapter 10, "Aircraft Systems."*



Detailed Carburetor Icing Probability Chart

Combustion

During normal combustion, the fuel-air mixture burns in a very controlled and predictable manner. Although the process occurs in a fraction of a second, the mixture begins to burn at the point where it is ignited by the spark plugs, then burns away from the plugs until it is completely consumed. This type of combustion causes a smooth buildup of temperature and pressure and ensures that the expanding gases deliver the maximum force to the piston at exactly the right time in the power stroke.

Detonation

Detonation is an uncontrolled, explosive ignition of the fuel-air mixture within the cylinder's combustion chamber. It causes excessive temperatures and pressures which, if not corrected, can quickly lead to failure of the piston, cylinder, or valves. In less severe cases, detonation causes engine overheating, roughness, or loss of power.

Detonation is characterized by high cylinder head temperatures and is most likely to occur when operating at high power settings. Some common operational causes of detonation include:

- Using a lower fuel grade than that specified by the aircraft manufacturer.
- Operating the engine with old fuel. If fuel has been sitting for an extended period (normally longer than three weeks or as indicated by the POH) drain old fuel and replenish with fresh fuel.
- Operating the engine at high power settings with an excessively lean mixture.
- Extended ground operations.

Detonation may be avoided by following these basic guidelines during the various phases of ground and flight operations:

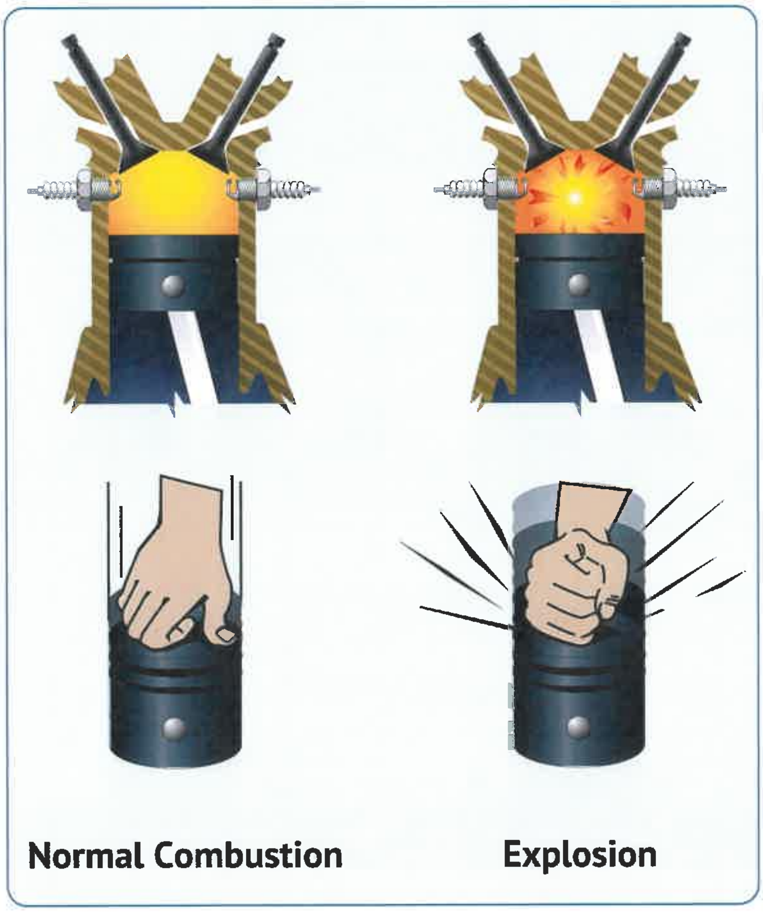
- Make sure the proper grade of fuel is being used and that it is fresh.
- Avoid extended, high power, steep climbs.
- Develop a habit of monitoring the engine instruments to verify proper operation according to procedures established by the manufacturer.

Pre-ignition

Pre-ignition occurs when the fuel-air mixture ignites prior to the engine's normal ignition event. Premature burning is usually caused by a residual hot spot in the combustion chamber, often created by a small carbon deposit on a spark plug, a cracked spark plug insulator, or other damage in the cylinder that causes a part to heat sufficiently to ignite the fuel-air charge. Pre-ignition causes the engine to lose power and produces high operating temperature. As with detonation, pre-ignition may also cause severe engine damage, because the expanding gases exert excessive pressure on the piston while still on its compression stroke.

The main difference between detonation and pre-ignition is that detonation happens after the spark plug fires and pre-ignition happens before the spark plug fires.

Detonation and pre-ignition often occur simultaneously and one may cause the other. Since either condition causes high engine temperature accompanied by a decrease in engine performance, it's often difficult to distinguish between the two. Using the recommended grade of fuel and operating the engine within its proper temperature and RPM ranges reduces the chance of detonation or pre-ignition.



Normal combustion and explosive combustion.

Chapter 10 Aircraft Systems

Powered parachutes can be looked at as a collection of systems, each performing a function that enables the aircraft to fly, navigate, monitor, or carry out other essential tasks. Some systems are critical for safe flight, while others enhance the overall experience. The systems found on a powered parachute, along with their discussions, are:

- Canopy/Riser and Control System (*Chapter 8, "Aircraft Structure"*)
- Flight Instruments and Engine Instruments (*Chapter 11, "Instruments"*)
- Landing Gear (This chapter)
- Engine (*Chapter 9, "Engines"*)
- Propeller (*Chapter 16, "Aerodynamics"*)
- Fuel, Oil, Electrical and Coolant System (This chapter)
- Avionics and Auxiliary Equipment (Varies by Manufacturer and Model and is discussed in each aircraft's Pilot's Operating Handbook (POH))

Landing Gear

One of the key features that distinguish a powered parachute from a foot-launched powered paraglider is its wheeled landing gear. This landing gear enables a powered parachute to take off and land at higher speeds than foot-launched equipment allows. Additionally, it allows takeoff from a wider variety of surfaces, reduces pilot fatigue, and provides mechanical shock absorption during taxi, takeoff, and landing operations. The primary parts of landing gear include:

- Wheel Assemblies
- Spring and Shock Absorbing Mechanisms
- Ground Steering System
- Braking Systems

Wheel Assemblies

Powered parachute airframes typically have either three or four wheels. Three-wheel systems are lighter and allow for simpler front-wheel steering assemblies. Four-wheel airframes are heavier but provide more ground stability and are less prone to rolling over during takeoff.

The rear and front wheels of a powered parachute consist of an assembly that includes a tire, rim, and both inner and outer wheel bearings. The wheel is secured on a spindle, held in place by a nut and cotter pin or a nylock nut, and each spindle is mounted on a suspension system.

Since powered parachute wheels don't need to roll for long periods on the ground, they are typically built lighter, with thinner treads, smaller diameters, and lighter-weight bearings. Certain features of wheels and tires are preferred for specific uses.

'Fat,' 'Turf,' or 'Tundra' Tires have the advantage of a wider footprint, allowing them to roll over softer surfaces like turf or sandy beaches, as well as rougher fields. They also look good. However, they are more expensive and increase the takeoff roll due to their rolling resistance.

Knobby Tires are generally impractical for most powered parachutes since most of the time the wheels are free-rolling and not engine-driven. In fact, knobby tires can catch suspension lines at the start of a takeoff roll. However, for powered parachutes designed to double as off-road vehicles, knobby tires make sense.

Taller Wheel Assemblies reduce rolling resistance and provide more clearance between the propeller guard and the ground. On some airframe designs, they are essential for achieving the necessary clearance.

Tires are often very lightweight and use inner tubes. If you plan to tow your powered parachute on the road, make sure the tires, wheels, and bearings can handle high speeds for extended periods. For those concerned about flats due to rough terrain, tire sealant or thorn guards are recommended over heavier ply tires.

Spring and Shock Absorbing Systems

Spring and shock absorbing systems are essential for smoothing out surface imperfections during taxiing or takeoff. They become even more critical during landing, where they absorb the energy of impact.

Since you'll likely be taking off from grass or dirt runways, your powered parachute will encounter bumps and depressions in these rougher surfaces. The energy from these impacts needs to be managed. Without a shock absorbing system, the forces are directly transmitted to the airframe and the passengers in the airframe. Springs and shocks help 'decouple' the wheel assembly from the rest of the airframe and its occupants.

The simplest shock absorbing systems use the hysteresis of a structural component within the suspension. Hysteresis is the property of a material to rebound with less force than it took to deform it. This is often achieved using fiberglass spring rods as part of the axle. These rods support the airframe while bending under force. The damping effectiveness of a spring rod depends on its ability to bend. If it's too rigid, it won't flex. For optimal performance, spring rods should be installed with minimal vertical angle, allowing them to bend rather than transfer forces directly to the airframe.

Heavier machines typically use hydraulic shock absorbers with built-in springs. The springs absorb the bumps, allowing the wheels to move up and down while keeping the airframe level. The hydraulic shocks dissipate the energy of this movement by channeling a viscous fluid through chambers within the shock.

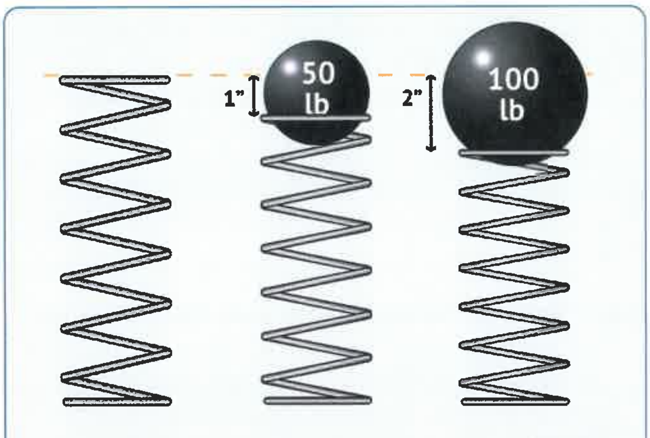
Springs

The capacity of springs is measured by their spring rate, which is the amount of force needed to compress the spring by a certain distance. For example, a spring with a rate of 50 pounds per inch will compress by one inch under a 50-pound load and by two inches under a 100-pound load. When selecting springs, designers aim for those that can support the machine's weight and the forces from taxiing and landing without fully compressing, or 'bottoming out.' When the coils compress so much that they touch each other, the spring is said to be 'binding.' Conversely, springs with too high a spring rate won't compress enough to absorb any impact.

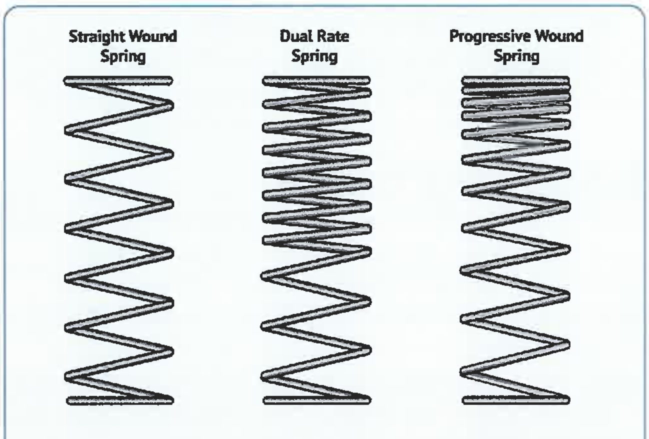
Springs typically come in three types:

Straight-Wound Springs compress uniformly and are inexpensive to manufacture, but they don't provide the best ride quality or absorb landing loads effectively.

Dual-Rate Springs: have two different spring rates. For example, a 40/60 dual-rate spring might compress one inch under a 40-pound load and another inch under a 60-pound load. The softer, closely wound coils absorb small bumps during taxiing. When landing, the closely wound coils bind and then the firmer coils handle the heavier loads. Some shocks have springs which are wound with two different spring rates and others have two separate springs with a collar holding them together.



Spring Rates



Types of springs.

Progressive-Wound Springs: gradually increase in stiffness as they compress. For example, a 40/80 progressive-rate spring might compress one inch under a 40-pound load, two inches under a 50-pound load, and so on, becoming firmer with each additional inch of compression. This design allows for a softer ride over small bumps while providing greater resistance for larger impacts, offering a smoother taxi ride and better absorption of landing forces.

Dampeners/Shock Absorbers

Springs alone do not dissipate the energy from a bump; they only absorb and then release it in the opposite direction. Well-designed landing gear not only absorbs the shocks from taxiing and landing but also dissipates the energy internally using dampeners or shock absorbers.

Damping is achieved by moving fluid through small openings in a piston inside the shock absorber. Most shock absorbers in powered parachute suspension systems consist of a cylinder filled with oil and a piston. As the piston moves up and down, the oil is forced through orifices from one side of the piston to the other.

The movement of the piston through the oil creates resistance; the faster the piston moves, the greater the resistance from the fluid. The resistance is determined by the size of the orifices in the piston and the viscosity (thickness) of the oil, which together slow down the piston. The absorbed energy is then transferred to the oil as heat. These damping assemblies are placed within the coil springs, working together to absorb the energy from bumps encountered by the landing gear.

Landing Loads on Shock Absorbers

Shock absorbers are typically designed to offer less resistance during compression (compression damping) and more during rebound (rebound damping). This allows the spring to absorb most of the impact when encountering a bump. After the spring absorbs the mechanical energy, the shock absorber works harder during the rebound, converting that energy into heat within the oil.

During landing, most of the mechanical energy is initially absorbed by the springs rather than the damping system. The shock absorbers primarily engage during the rebound phase. Therefore, the springs must be robust enough to handle the load from the powered parachute without fully compressing or binding.

Ground Steering Systems

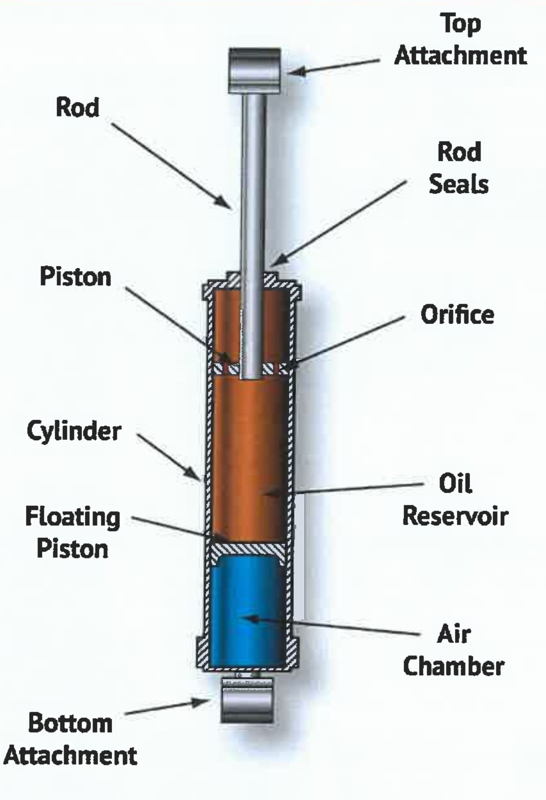
Powered parachutes typically have three wheels, which allows for a simple steering system. Steering a single front wheel is straightforward, using cables, push rods, and basic levers. You should inspect the ground steering system to ensure everything is secure and that the airframe tracks properly before takeoff. Additionally, when flying a new model of powered parachute, you should familiarize yourself with the steering and throttle systems beforehand. There is no standard design for these systems, and it's best to understand how they work before starting the engine.

Brakes

Brakes are an optional feature on powered parachutes because the large surface area of the parachute provides some aerodynamic braking during landing. However, this only works in a limited set of circumstances. If you plan to taxi on any hard surface, it's advisable to equip your powered parachute with a braking system. For airport operations, brakes help prevent runway incursions and enhance overall safety.

It's important to remember that your feet should never be used as brakes, as doing so could lead to injury. The only exception is when starting the engine at idle, and even then, ensure the throttle is set to idle and that the airframe is on level ground.

Braking systems can be either drum or disc style and are controlled either by cables or hydraulics. Typically, mechanically controlled brakes are used on single front-wheel brakes, while dual rear-wheel brakes are usually hydraulically actuated. Rear-wheel brakes are generally more effective than front-wheel brakes because the rear wheels bear more weight, reducing the risk of tire skidding when applying the brakes. Additionally, rear-wheel braking is more stable, similar to the braking dynamics of bicycles or cars.



Fluid friction dampener.

Fuel

While a few powered parachutes use alternative power sources like electricity, propane, or diesel, nearly all of them run on gasoline. It's important to understand which types of fuel are suitable for your engine, how to store it properly, when it might be necessary to change the fuel, and, in the case of some two-stroke engines, how to mix fuel with two-stroke oil.

Octane Rating

The octane rating is a key specification for gasoline, as it indicates the fuel's resistance to engine knocking or detonation. The higher the octane number, the more pressure the fuel can withstand before igniting prematurely. Engines with higher compression ratios require higher-octane fuels to avoid knocking, while lower compression engines can safely use lower-octane fuels. It's crucial to use the correct octane rating for your engine to ensure optimal performance and prevent damage. If the recommended octane rating isn't available, it's better to use a higher octane fuel as a substitute rather than a lower one, as using a lower grade can cause the cylinder head temperature to exceed safe levels, potentially leading to detonation.

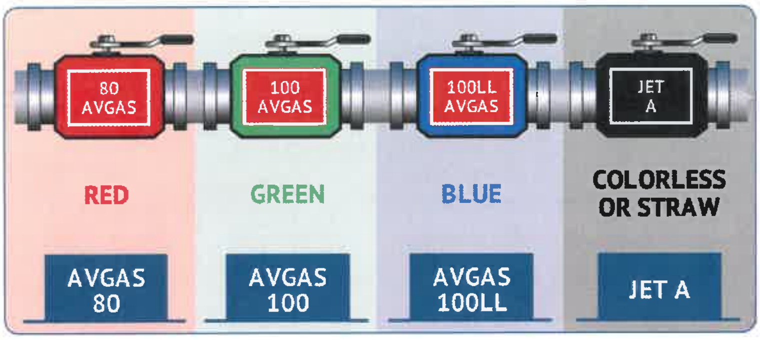
AVGAS

Aviation gasoline, or AVGAS, is specifically designed for aircraft and is identified by an octane or performance number (grade), which designates its antiknock value. The most commonly available AVGAS is 100LL, where *"LL"* stands for *"Low Lead."* However, despite the *"Low Lead"* designation, 100LL contains significant amounts of lead, which can cause various issues in engines commonly used in powered parachutes.

Manufacturers of engines installed on most powered parachutes generally do not recommend using AVGAS 100LL due to the lead content. Lead deposits can accumulate in the piston lands, spark plugs, and combustion chambers, leading to reduced engine performance and potential damage. In two-stroke engines, the cooler ignition system may lead to quicker spark plug failure due to lead deposits. In four-stroke Rotax 9-series engines, lead deposits can build up in the combustion chamber and valve seats, increasing wear and stress. Additionally, lead sediments can foul the oil system and gearbox.

If you must use AVGAS 100LL, Rotax recommends more frequent oil and oil filter changes—every 50 hours instead of the usual 100 hours—to help mitigate the buildup of lead residues and prevent operating problems.

Despite these drawbacks, AVGAS has some advantages. It has a longer shelf life than regular gasoline, lasting up to three months, and it remains consistent in quality across different regions and seasons. Additionally, AVGAS is readily available at most airports, making it a convenient choice for refueling.



Aviation Fuel Color Coding System

MOGAS

MOGAS, short for 'motor gasoline,' refers to automotive gasoline typically used as fuel for vehicles like cars, trucks, and motorcycles. It's the gasoline commonly available at gas stations. Some aircraft engines, including Rotax engines, are designed to operate on unleaded automotive gasoline or MOGAS.

MOGAS comes in various grades and formulations, with specific properties that can vary depending on regional regulations and fuel standards. It usually contains a blend of hydrocarbons and may include additives like detergents, antiknock agents, and stabilizers.

One concern with MOGAS is its inconsistency across different regions and seasons, particularly regarding the additives used. Many additives are included to meet emissions requirements rather than enhance engine performance. Fortunately, many of these additives are listed at the pump, so pilots can be aware of what they are purchasing.

Methanol is one additive to avoid, as it's corrosive, attracts water, and reduces engine performance. Engine builders recommend no more than 3% methanol in your fuel. Ethanol, though better than methanol, also attracts water and is less corrosive but provides poor fuel economy. Avoid using fuel with more than 10% ethanol.

To determine the alcohol content in your fuel, you can use a GA sump collector, which has graduated marks for measuring. Add water up to the indicated level, then fill the collector with a fuel sample up to the gas line mark. After covering and shaking it vigorously, let it settle. The increase in water level indicates the alcohol content, as the water pulls alcohol from the fuel. The graduated marks will show the exact percentage of alcohol present.

Another additive, Methyl Tertiary Butyl Ether (MTBE), is better for engines than methanol or ethanol but is banned in several states due to its carcinogenic properties and contamination of groundwater. MTBE doesn't attract water and is often found in higher-grade fuels, though it's expensive and doesn't boost octane as effectively as lead.

Fuel Contamination

Contaminated fuel can lead to power loss, malfunction, or even engine failure. There are two primary types of fuel contamination: water and particulate matter. Water can enter fuel through condensation in the tank, leaks, or improper handling, leading to engine stalling, corrosion, and microbial growth. Particulate matter, such as dirt, rust, and deteriorated fuel system components, can enter the system during fueling or storage, potentially causing blockages in fuel filters and damage to fuel system components.

Accidents attributed to powerplant failure from fuel contamination are often linked to:

- Inadequate preflight inspection by the pilot.
- Refueling with improperly filtered fuel from small tanks or drums.
- Storing aircraft with partially filled fuel tanks.
- Lack of proper maintenance.

During preflight, drain fuel from the tank sump (if equipped) into a transparent container and check for dirt and water. If contaminants are found in the first sample, continue draining until no trace remains. Water is the most common contaminant, often visible as suspended droplets causing a cloudy appearance in the fuel or as a clear separation once the water settles at the bottom of the tank.

To prevent moisture condensation, metal fuel tanks should be filled after each flight or at least after the last flight of the day. Additionally, avoid refueling from cans and drums, which can increase the risk of contamination.

If refueling from cans or drums is necessary, consider using a water-filtering funnel or a funnel with a chamois skin. However, be aware that a worn-out chamois, or one that is already wet or damp, will not effectively filter water. Most imitation chamois skins also do not filter water.

Bad Gas

Allowing MOGAS to sit unused for weeks can cause it to go bad. If gasoline smells off, it likely is and should not be used in a powered parachute. Even if the gas doesn't spoil completely, its octane level often decreases over time. This issue is even more pronounced for those who premix gasoline and two-stroke oil. Typically, gas and oil are mixed at a 50:1 ratio, but if the premixed fuel sits in a plastic container for a while, the gasoline may evaporate, leaving a richer oil mixture behind. It's best to use fresh fuel whenever possible.

Refueling Procedures

Always refuel outdoors. Never refuel in an enclosed area, as the fumes can be irritating and, if they reach the ideal fuel-air mixture, they can become explosive. Never smoke during refueling.

Exercise caution when refueling a just-landed aircraft, as there is a risk of spilling fuel onto hot engine components, particularly the exhaust system. Filling containers at a gas station or fueling your powered parachute directly from the pump at an airport also poses hazards. Static electricity can build up from the friction of air passing over the aircraft or from the flow of fuel through the hose and nozzle. Clothing made from materials like nylon, Dacron, or wool can further accumulate and discharge static electricity.

To prevent static electricity from igniting fuel fumes, always place fuel containers on the ground before filling them at a gas station. When fueling from a pump at an airport, attach a ground wire to the aircraft before removing the fuel cap. Ground the refueling nozzle by touching it to a metal part of the powered parachute before starting fueling.

Using a chamois filter can increase the risk of static electricity and sparks. Ensure the aircraft is properly grounded, and bond the nozzle, chamois filter, and funnel to the aircraft. If using a fuel can, connect it to either the grounding post or the funnel.

Fuel Storage Containers

You'll likely find yourself transporting and storing fuel for your powered parachute, as many airports only offer 100LL, assuming you're even flying from an airport. Always use safety-approved fuel containers for transporting, storing, and refueling, and clearly mark them with the type of fuel they contain to avoid confusion between premixed fuel and fuel without oil, which can have disastrous consequences.

When selecting fuel containers, you have a choice between metal and plastic, much like the decision manufacturers face when designing fuel tanks. Each material has its pros and cons.

Metal cans have the advantage of blocking the sun's ultraviolet rays, which can harm fuel. They also don't build up static charges like plastic containers might. However, metal cans are more prone to sweating when moving from cool to warm temperatures on humid days. To prevent condensation, metal cans and tanks are best kept either sealed or completely full to leave no room for moist air.

Plastic fuel containers seem to be the cans of choice for most people because they're easy to handle, inexpensive, widely available, and won't scratch the finish on airframes when fueling. They also don't sweat, so they don't need to be stored full. However, fuel can deteriorate slightly faster in plastic containers. Additionally, plastic containers can accumulate static electricity, especially when sliding around in a truck bed, particularly if the bed has a plastic liner. Many states now require that plastic fuel containers be placed on the ground before filling, as the rubber in truck tires insulates the truck bed from the ground.

Mixing Two-Stroke Oil and Fuel

Two-stroke engines require special two-stroke oil to be mixed with the fuel before it reaches the engine's cylinder. In many newer engines, a fuel injection pump delivers the precise amount of oil into the engine intake based on the throttle setting. This system is ideal because it eliminates the need for pilots to premix oil into the fuel. However, an important preflight check is ensuring that the two-stroke oil reservoir is properly filled.

If your two-stroke engine doesn't have an oil injection system, you must mix the oil into the fuel before filling the tank. Simply pouring oil directly into the fuel tank is not advisable, as it won't mix properly with the gasoline and makes it difficult to measure the correct amount of oil. To correctly mix two-stroke oil:

Mix oil and fuel outdoors. Never mix them in an enclosed area.

Use a clean, approved container. Start by pouring a small amount of gasoline into the container to pre-mix the two-stroke oil.

Add the two-stroke oil. Measure a known amount of oil, which should be approved for air-cooled engines at a 50:1 mixing ratio (always check the aircraft or engine POH to confirm the ratio). Use a measuring cup if needed. Shake the container slightly to mix the oil with the gasoline.

Add gasoline to reach the 50:1 ratio. If using a water-separating funnel, ensure it is grounded or in contact with the fuel container.

Shake the mixture thoroughly. After adding the fuel, secure the cap on the container and shake the gasoline and oil mixture thoroughly.

Fuel Systems

The fuel system is designed to provide an uninterrupted flow of clean fuel from the fuel tank to the engine. Fuel must be available to the engine under all conditions of engine power, altitude, attitude, and during all approved flight maneuvers.

Fuel Tank

In a powered parachute, the fuel tank is typically located under or behind the back seat and has a filler opening on top, covered by a filler cap. These tanks usually range in capacity from 5 to 20 gallons. While Light Sport Aircraft (LSA) powered parachutes have no fuel tank size limitations, ultralight powered parachutes are restricted to a maximum of five gallons. As with any aircraft, knowing your fuel tank's capacity is crucial for safe flight operations.

The fuel tank is generally positioned near the center of gravity to ensure that fuel burn does not significantly affect the aircraft's balance. Some fuel tanks are translucent, allowing for a visual inspection of the fuel level, while others are opaque or hidden. Opaque or hidden tanks usually feature a sight tube to help the pilot determine the fuel level.

As the engine consumes fuel, air must enter the tank to replace it; otherwise, a vacuum will form, preventing the fuel pump from drawing fuel. This is typically managed by a fuel venting system, which can be a vent in the fuel cap or a tube extending from the top of the tank. It's essential that the vent system remains free of debris to avoid fuel starvation during flight, particularly if the vent is a small hole in the fuel cap that can easily become clogged. Always check the fuel venting system during preflight inspections.

Fuel Lines

Fuel lines deliver fuel from the tank to the carburetors or fuel injection system and connect the various components of the fuel system. These lines can be made from different materials but must be flexible. The most common types are clear nylon fuel lines and rubber fuel lines. Clear fuel lines have the advantage of allowing you to see the fuel inside, but they don't last long and tend to harden and degrade within a year or two. Newer powered parachutes typically use rubber fuel lines, which are more durable.

Fuel Shut-Off Valve

A fuel shut-off valve may be located anywhere in the fuel line or on the fuel tank itself. It makes servicing a fuel system a little easier. If one is installed, you should make sure the fuel valve is open and stays open for normal operation.

Fuel Filters, Gascolators, Sumps, And Drains

We talked earlier about fuel contamination. Your last line of defense against contaminants includes the sump, drain system, fuel filter, or gascolator.

Contaminants, often heavier than fuel, may settle in a sump at the bottom of the fuel tank if one is present. A sump is a low point in the fuel system and/or tank where contaminants can accumulate. The fuel system may include sump and fuel tank drains, which are usually located together. Before each flight, check the fuel in the tank sump by draining a small amount. Visually inspect the fuel sample for water and contaminants. Water in the sump is hazardous because it can freeze in cold weather and block fuel lines or flow into the carburetor and stop the engine in warm weather. If water is present, continue draining the sump until no water is detected.

After leaving the fuel tank, the fuel passes through a filter or gascolator before entering the fuel pump. These components remove any remaining sediment. Fuel filters are often clear, making it easy to inspect them for solid contaminants.

A gascolator, short for 'gasoline strainer and collector,' is found on some powered parachutes. It removes water and other contaminants from the fuel before it reaches other components in the fuel system. A gascolator features:

Straining and Separation: As fuel passes through the gascolator, it moves through a fine mesh or screen that captures sediments in the bowl portion of the gascolator.

Water Collection: Unlike a fuel filter, a gascolator collects water in its bowl. You can drain this water from the system.

Drain Valve: The gascolator includes a drain valve in the bowl to facilitate the removal of collected water and contaminants.

Always ensure that all water and contaminants have been removed from the engine fuel system before takeoff. Familiarize yourself with your powered parachute's specific fuel system, as designs vary. Consult your powered parachute's POH for detailed instructions on how to perform these checks.

Fuel Pumps

Fuel pumps can be categorized into two types: mechanical fuel pumps supplied by the engine manufacturer and electric fuel pumps installed by aircraft manufacturers or owners. Under normal circumstances, the engine's mechanical fuel pump should be sufficient to supply fuel to the engine. If you experience a loss of fuel pressure, it's likely due to a failure of the mechanical fuel pump.

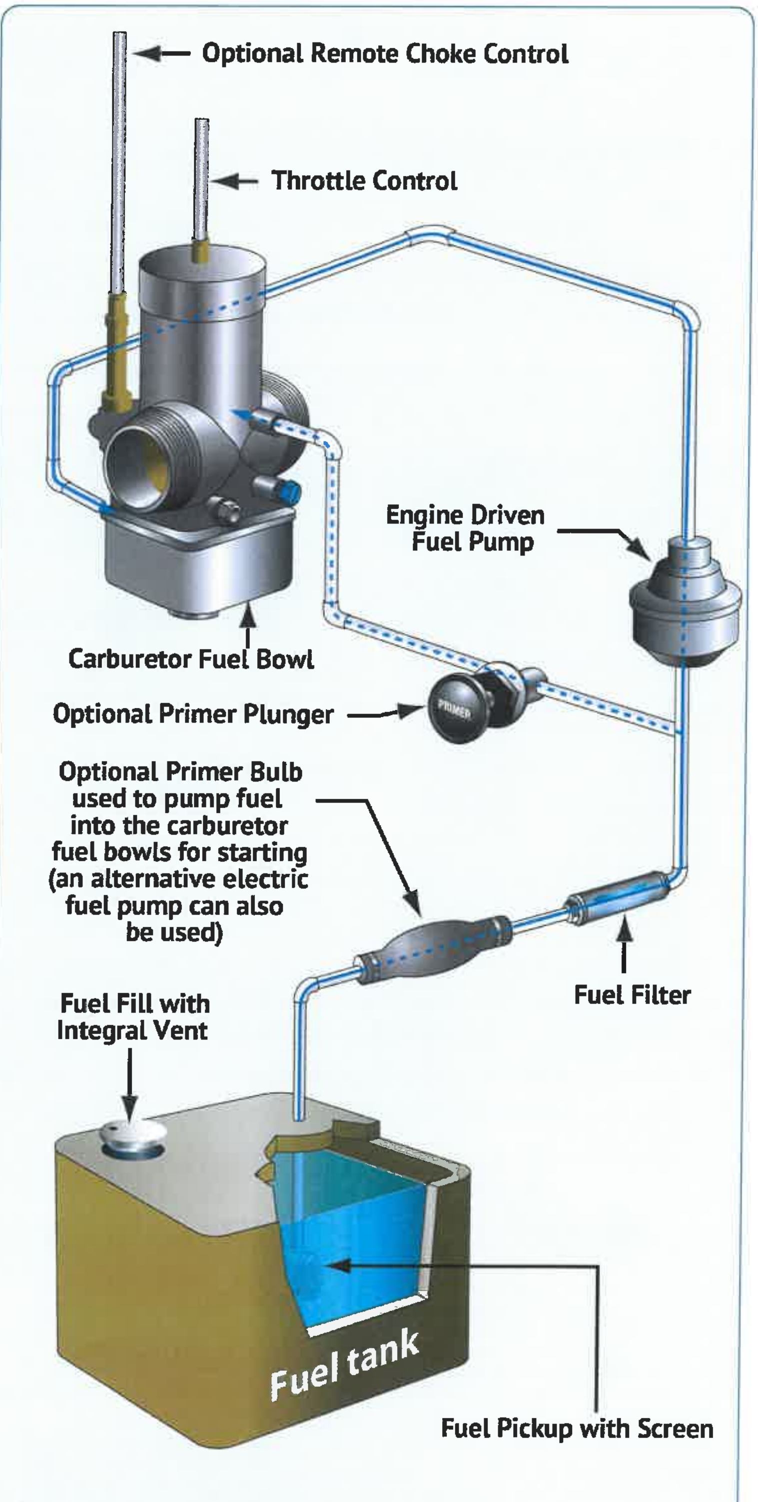
An electric fuel pump serves as an excellent backup and is useful in several situations: it can prime the fuel system before starting the engine, assist when the fuel tank is mounted significantly above the engine, and ensure adequate fuel supply in cases of vapor formation at high altitudes and temperatures.

Mechanical Fuel Pumps

Powered parachutes with carburetors use engine-driven fuel pump systems. These pumps are diaphragm-type pumps driven by the engine. For two-stroke engines, the fuel pump is activated by air pulses generated by the engine it's supplying. Its internal moving parts are made of high-tech plastic membranes. For four-stroke engines like the Rotax 9-series, the fuel pump uses a cam system and shaft to drive diaphragms made from advanced materials.

Two-stroke mechanical fuel pumps consist of four moving parts: two diaphragms and two check valves. These components are typically made from clear mylar, which is flexible and highly resistant to chemicals. The flexibility and the ability of mylar to return to its original shape are vital for its function in the pump. The pump is divided into six chambers: three filled with air and three with fuel, separated primarily by mylar diaphragms and valves.

The pumping cycle starts when the engine sends a pulse of air through the pulse line into the pump. The air is sealed in the pump and can only drive the main mylar diaphragm toward the center of the pump. On the opposite side of this diaphragm is the fuel. The movement of the diaphragm forces the fuel through a check valve, which is a thin mylar washer pinned to the pump body with a rubber stopper. This check valve allows fuel to flow only in one direction, into the fuel outlet chamber and towards the carburetors. Another



Typical Carburetor Fuel System.

mylar check valve prevents the pulse from pushing fuel back into the tank.

When the air pulse from the engine dissipates, the mylar diaphragm returns to its normal position, creating a suction effect on the fuel supply side. This causes the check valves to reverse roles: the check valve leading to the carburetor closes to prevent fuel from being drawn back into the pump, while the check valve leading to the fuel tank opens to draw in more fuel.

Often, there is an additional mylar diaphragm in the fuel pump that acts as a dampener on both the inlet and outlet sides. If the fuel entering the top chamber exceeds the needs of the carburetor, the secondary diaphragm absorbs some of the shock from the pulse of fuel entering the chamber, preventing excess pressure.

Electric Fuel Pumps

An electrically driven auxiliary pump, also known as a boost pump, is sometimes provided for use during engine starting and as a backup if the engine-driven pump fails. The boost pump enhances the reliability of the fuel system and is controlled by a switch on the control panel.

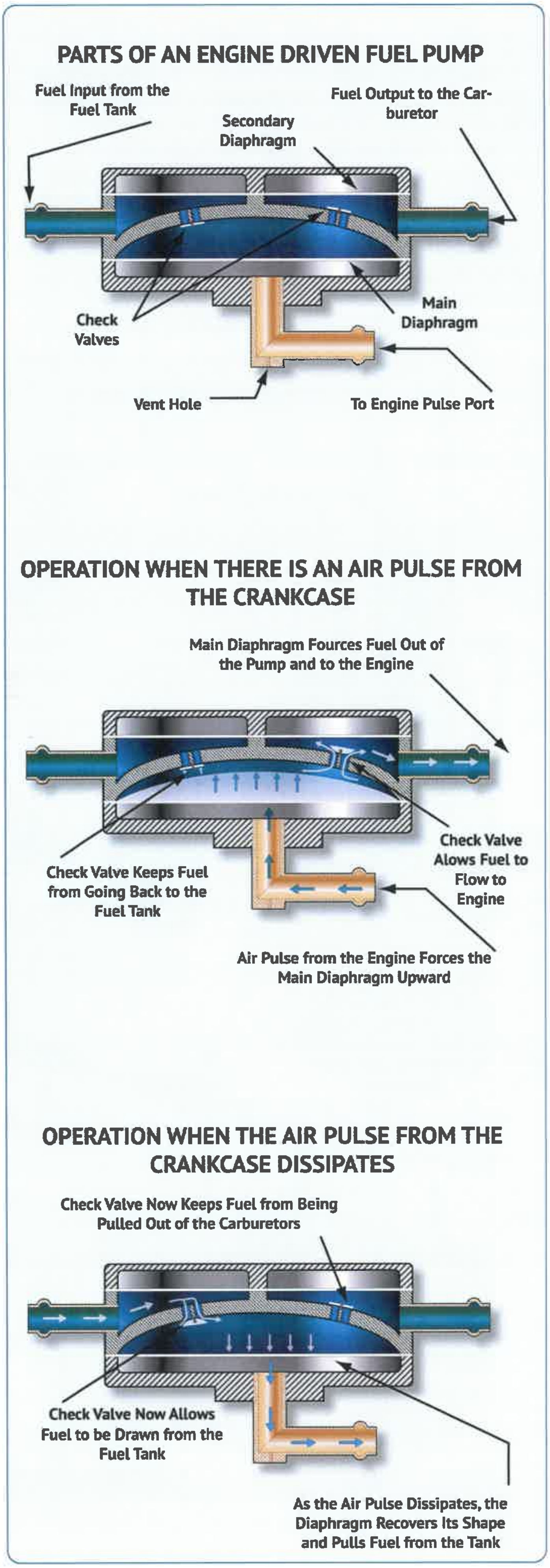
You should test the mechanical pump by turning off the boost pump to ensure that the engine is still receiving fuel. This can be done by observing the engine's performance or, preferably, by checking a fuel pressure gauge. However, it's worth noting that fuel pressure gauges are rarely installed by manufacturers.

It's important to verify that your mechanical fuel pump is functioning properly in case of a failure in the electric fuel pump or the entire electrical system. Unlike the electric pump, the mechanical fuel pump will continue to operate even if the electrical system fails.

Components Used for Starting

When your powered parachute has been idle for several hours, fuel may drain out of the fuel lines, making starting more difficult. Instead of running the electric starter (or worse, a pull starter) for an extended period to recharge the fuel system, powered parachutes are equipped with various components to assist with the first engine start of the day. These components may include:

- Choke or Enrichment Circuit on the carburetor (discussed in *Chapter 9, "Engines"*)
- Plunger Primer
- Bulb Primer
- Electric Fuel Pump (discussed above)



The operations of a mechanical impulse fuel pump.

Fuel Plunger Primer

The fuel plunger primer draws fuel from the fuel tank and delivers it to the engine's intake manifold, where it is vaporized to facilitate easier starting. This is especially helpful in cold weather when there isn't enough heat to vaporize the fuel in the carburetor. In some powered parachutes, the primer system is used instead of a choke. Once the engine starts and runs, the fuel pump takes over, pushing fuel to the carburetors and initiating normal fuel delivery. To avoid over-priming, follow the priming instructions specific to your powered parachute. This system is common on two-stroke engines.

Fuel Bulb Primer

A fuel bulb primer is used to draw fuel from the tank and charge the fuel lines and carburetor before starting the engine for the first time that day. Once the engine is running, the fuel pump handles the fuel delivery. Powered parachutes equipped with electric boost pumps typically do not have bulb primers.

Fuel Injection Systems

In a fuel injection system, the fuel is injected either directly into the cylinders, or just ahead of the intake valve. A fuel injection system usually incorporates these basic components—an engine-driven fuel pump, a fuel-air control unit, fuel manifold (fuel distributor), discharge nozzles, an auxiliary fuel pump, and fuel pressure/flow indicators.

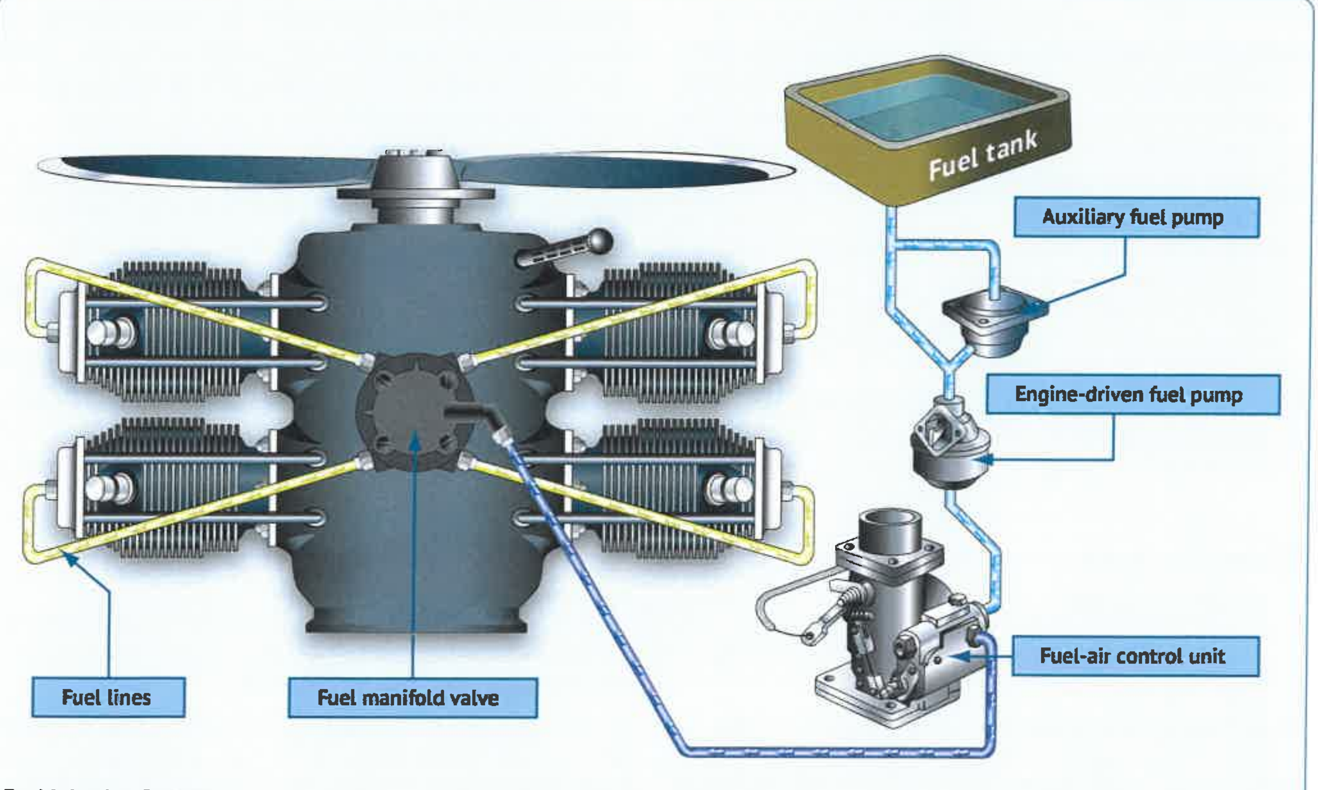
The auxiliary fuel pump provides fuel under pressure to the fuel-air control unit for engine starting and/or emergency use. After starting, the engine-driven fuel pump provides fuel under pressure from the fuel tank to the fuel-air control unit. This control unit, which essentially replaces the carburetor, meters fuel based on the mixture control setting, and sends it to the fuel manifold valve at a rate controlled by the throttle. After reaching the fuel manifold valve, the fuel is distributed to the individual fuel discharge nozzles. The discharge nozzles, which are located in each cylinder head, inject the fuel-air mixture directly into each cylinder intake port.

Some of the advantages of fuel injection are:

Precision Fuel Delivery: Fuel injection systems precisely control the amount of fuel delivered to each cylinder. This precision is achieved through electronic sensors and injectors, allowing for more accurate fuel-air mixture control compared to carburetors.

Improved Fuel Atomization: Fuel injectors atomize fuel into fine mist particles, ensuring a more homogeneous mixture with air. This enhances combustion efficiency and reduces the likelihood of fuel droplets condensing on engine surfaces, improving fuel economy and power output.

Better Cold Starts: Fuel injection systems are generally more effective at providing the right fuel-air mixture for cold starts. Electronic control allows for adjustments to the fuel-air ratio based on temperature, ensuring smoother starts in various conditions.



Fuel Injection System.

Adaptability to Engine Load and Speed: Fuel injection systems can quickly adjust to changes in engine load and speed, optimizing the fuel-air mixture for different operating conditions. This adaptability contributes to better overall engine performance.

Reduced Fuel Consumption: The precise control over fuel delivery enables fuel injection systems to operate more efficiently, leading to improved fuel economy compared to carburetors. This is especially noticeable during part-throttle and cruising conditions.

Emissions Control: Fuel injection allows for more accurate control over the fuel-air ratio, which, in turn, facilitates better control of emissions. This helps engines comply with increasingly stringent emission standards.

Improved Throttle Response: Fuel injection systems respond more quickly to changes in throttle position, providing better throttle response and acceleration compared to carbureted systems.

Consistent Performance at Different Altitudes: Unlike carburetors, which may require adjustment for changes in altitude, fuel injection systems automatically compensate for variations in air density. This ensures consistent performance across a wide range of altitudes.

Enhanced Reliability: Fuel injection systems are generally more reliable in delivering the right fuel-air mixture under varying conditions, reducing the likelihood of engine stumbling, flooding, or other issues associated with carburetion.

Disadvantages of fuel injection usually include:

Complexity and Cost: Fuel injection systems are more complex than carburetors, involving electronic components, sensors, and injectors. This complexity can result in higher manufacturing costs and increased complexity of troubleshooting and maintenance.

Technical Expertise: Diagnosing and repairing issues with fuel injection systems may require specialized knowledge and equipment, making repairs potentially more challenging for non-specialized mechanics.

Dependency on Electrical Systems: Fuel injection systems are dependent on the electrical system of the aircraft. If there are electrical issues, it can affect the functioning of the fuel injection system.

Sensor Dependency: Fuel injection systems rely on various sensors to provide data for fuel delivery adjustments. Sensor malfunctions or failures can lead to incorrect fuel mixture, affecting engine performance.

Vulnerability to Contaminants: Fuel injectors, as precision components, are sensitive to fuel contaminants. Impurities can cause clogging or malfunctions, affecting fuel delivery.

Maintenance and Repairs: While fuel injection systems are generally reliable, repairs and maintenance may be more complex than with carbureted systems. Replacement parts and specialized tools may be required.

Reduced Cold-Weather Tolerance: In extremely cold conditions, fuel injectors can be more susceptible to fuel-related issues, such as the formation of ice crystals, compared to carburetors.

Potential for Overheating: Some fuel injection components, such as fuel pumps and injectors, can be sensitive to overheating. High temperatures may affect their performance and reliability.

Engine Cooling Systems

The combustion of fuel within the engine's cylinders generates intense heat, much of which is expelled through the exhaust system. However, the remaining heat must be effectively dissipated to prevent engine overheating. Engine cooling systems are designed to maintain optimal operating temperatures, thereby ensuring the engine's longevity and efficiency. Powered parachute engines use various cooling systems, including air, liquid, and oil cooling.

Operating your engine at higher than its designed temperature can cause loss of power and detonation. It will also lead to serious permanent damage, such as scoring the cylinder walls and damaging the pistons and rings.

On the other hand, operating your engine at lower than its designed temperature range can cause piston seizure and scarring of the cylinder walls. This happens most often in liquid cooled powered parachutes in cold weather where large radiators designed for summer flying may need to be partially blocked off.

Air Cooling

Air-cooled engines dissipate heat by channeling air over metal cooling fins integrated into the engine's cylinders and heads. This air absorbs and carries away the engine's heat. Air cooling can be either passive or active.

Passive air cooling relies on external air being forced over the cooling fins, which is effective for lighter engines during flight or near a turning propeller's airstream. Active air cooling uses a fan to push air into the engine shroud, where baffles direct it over the cooling fins. The hot air is then expelled through one or more openings in the shroud.

If cylinder head temperatures rise excessively in an air-cooled engine with a fan, it could indicate lubrication issues, damage or wear in the cooling fan drive belt, or blockages in the cooling fins from debris like insect nests. While air cooling is simple and lightweight, it is generally only suitable for smaller engines.

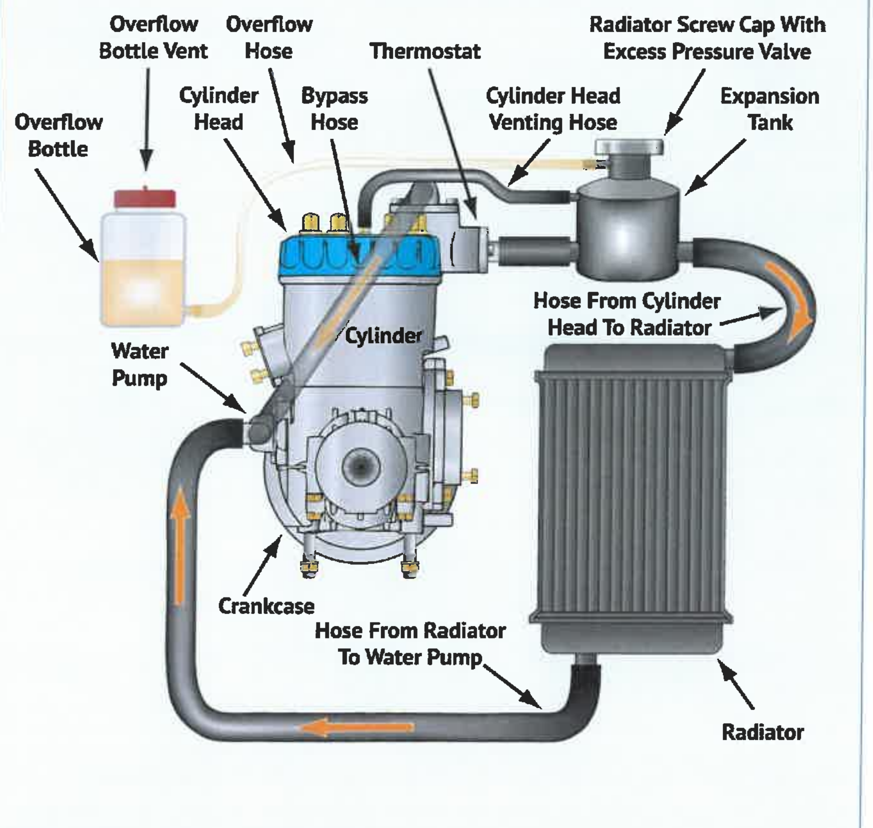
Liquid Cooling

As engines increase in size, they generate more heat, requiring a more efficient method of heat dissipation. Liquid cooling systems address this need by circulating a coolant—typically a mixture of water and antifreeze—through channels or water jackets surrounding the cylinders and/or cylinder head. The heated coolant is then pumped to a radiator, where it releases the heat into the air before returning, cooled, to the engine.

Liquid cooling is highly effective, sometimes even too effective. When an engine is warming up or idling, it's important to slow down the cooling process. This is automatically managed by a thermostat, a component in the cooling system that regulates coolant flow through the radiator based on the engine's temperature. The thermostat ensures the engine stays within an optimal temperature range for efficient and safe operation. Once the engine reaches the desired temperature, the thermostat opens, allowing the heated coolant to flow to the radiator and dissipate its heat into the atmosphere.

During cold weather, especially in winter, it may be necessary to block off a portion of the radiator to prevent over-cooling.

Despite its effectiveness, liquid-cooled engines can overheat if coolant levels are not properly maintained, if there is a leak, a water pump failure, or a blockage in the radiator. Blockages can occur internally from leftover manufacturing debris or externally from grass, dirt, or other materials that restrict airflow over the radiator.



Liquid Cooling System for a Rotax 582.

Oil Cooling

Oil cooling is a method of managing engine temperature by using engine oil as a coolant. Engine oil primarily functions as a lubricant, reducing friction between moving parts, but it can also play a role in absorbing and dissipating heat generated during engine operation.

In an oil cooling system, the engine oil circulates through various components, absorbing heat as it lubricates the engine. The heated oil is then routed to an oil cooler, a type of heat exchanger typically placed in the airflow. As the oil passes through the cooler, it transfers the absorbed heat to the surrounding air, before returning to the engine to repeat the process.

While oil cooling is effective at removing heat from specific engine components, it's generally not as efficient as liquid cooling when it comes to controlling the overall engine temperature. Liquid cooling systems, which use a dedicated coolant such as a water-antifreeze mixture, are better suited for managing the higher heat loads produced by larger or more powerful engines. For this reason, oil cooling is rarely used as a primary cooling system. Instead, it's often employed as a supplementary method, particularly in high-performance or air-cooled engines where additional cooling is necessary to protect critical components like the piston, crankshaft, and cylinder head.

Oil cooling has several advantages, especially in engines that operate under high-stress conditions or in environments where additional cooling is needed. It helps to maintain the oil's viscosity, ensuring consistent lubrication and preventing thermal breakdown, which can lead to engine wear or failure. Furthermore, oil coolers can be relatively compact and lightweight, making them suitable for applications where space and weight are limited.

However, oil cooling systems also have their limitations. They require careful maintenance to ensure the oil cooler and associated lines remain free of blockages. The oil itself must be monitored and replaced at regular intervals to maintain its effectiveness. Additionally, because oil cooling is less efficient at managing overall engine temperature, it is typically used in conjunction with other cooling methods, such as air or liquid cooling, to provide comprehensive temperature control.

The Rotax 9-series of engines uses a combination of air, liquid and oil cooling systems.

Oil Systems

Engines require oil to lubricate moving parts. Two-stroke engines mix oil with fuel before it enters the engine, while four-stroke engines use separate oil systems that recirculate the oil. In a four-stroke engine, the oil system serves several key functions:

- Lubricates moving parts
- Cools the engine by reducing friction
- Removes heat from the cylinders
- Seals between cylinder walls and pistons
- Carries away contaminants

Four-stroke engines use either a wet-sump or dry-sump oil system. In a wet-sump system, oil is stored in a sump integral to the engine and circulated by an oil pump. Some engines also use the rotating crankshaft to splash oil onto engine parts.

In a dry-sump system, oil is kept in a separate tank and circulated by pumps, with scavenge pumps returning the oil to the tank. Dry-sump systems are suitable for larger engines due to their ability to accommodate higher oil volumes.

The Rotax 9-series of engines features a dry-sump system with an external oil tank. This system includes a main oil pump with an integrated pressure regulator and oil pressure sensor. It enhances oil cooling, improves lubrication under various flight conditions, and reduces the risk of oil starvation during extreme maneuvers.

This is how the Rotax 9-series oil system works:

Oil Circulation: The oil pump draws oil from the tank, passes it through the oil cooler and filter, and then circulates it to lubricate engine components.

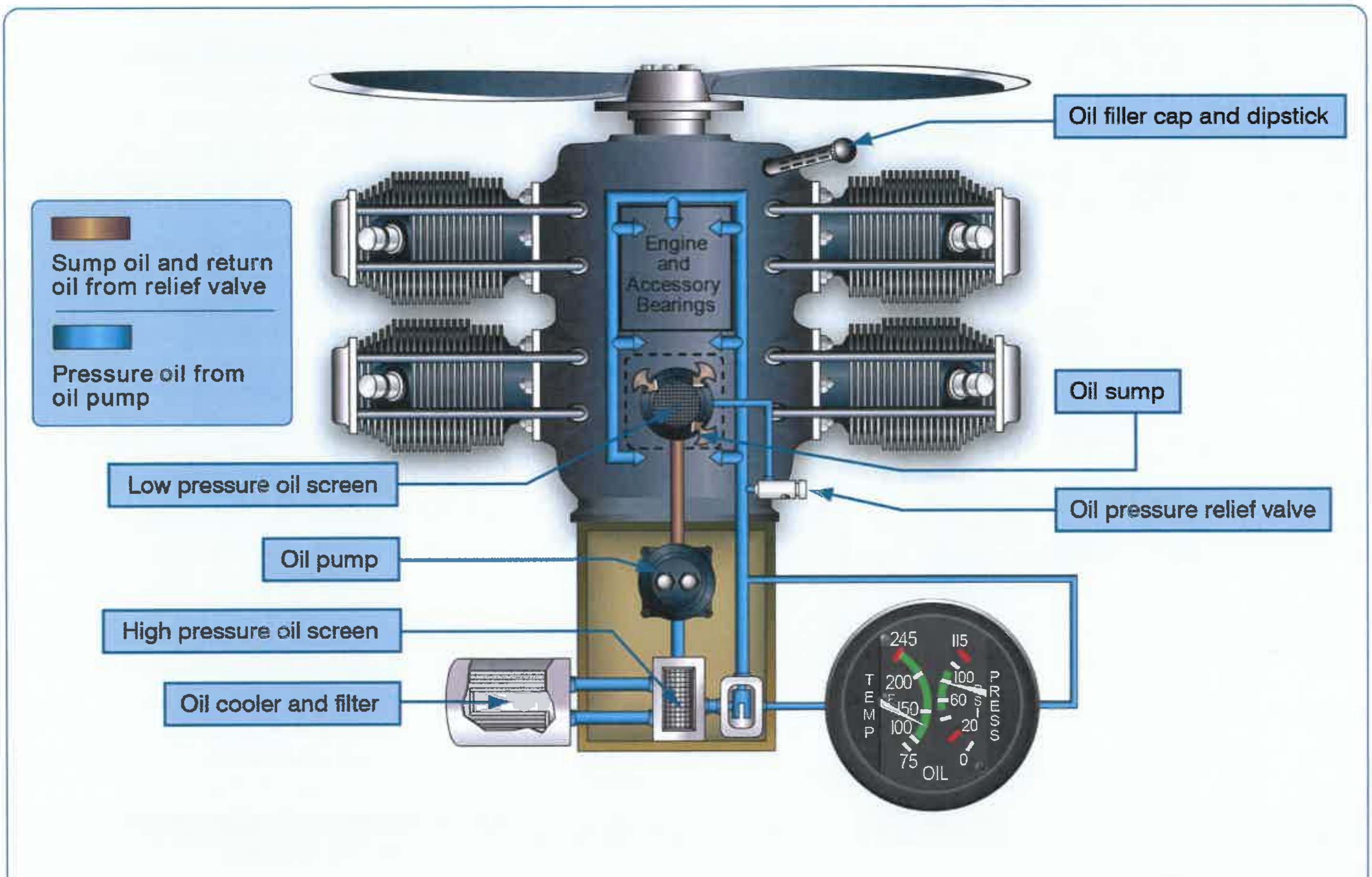
Return: Oil returning from lubrication points accumulates in the bottom of the crankcase and is then forced back to the oil tank by piston blow-by gases.

Pump Drive: The oil pumps are driven by the camshaft.

Ventilation: The oil circuit is vented through a vent in the external oil tank.

Temperature Monitoring: The oil temperature sensor, located on the oil pump housing, monitors the oil inlet temperature.

Regularly check the oil level with the dipstick and maintain the recommended oil quantity and type as specified in the POH or engine placards.



Wet-Sump Oil System.

Ignition System

The most popular engines used for powered parachutes, including the Rotax 582 two-stroke and the Rotax 9-series four-stroke engines are equipped with dual electronic ignition systems. These systems include:

- Charging Coils/Generators
- Electronic Modules
- Triggers
- High-Voltage Leads
- Spark Plugs
- Ignition Switches.

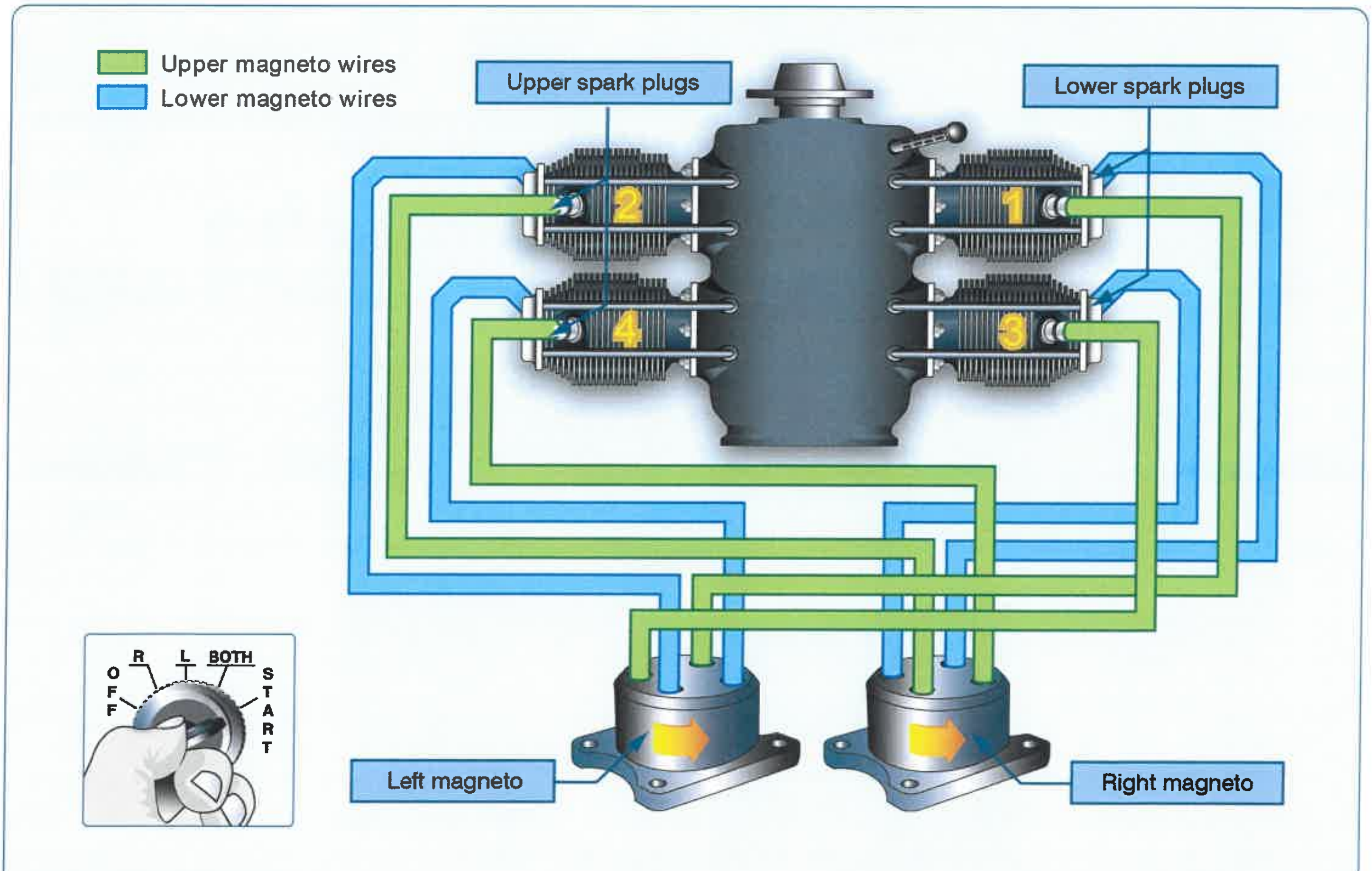
Each ignition system features two independent charging coils on the generator stator, providing power to separate ignition circuits. Energy is stored in capacitors within the electronic modules. At ignition, external trigger coils release this energy, creating a high voltage spark across the spark plug gap in each cylinder.

The system activates when you start the engine and continues to operate as long as the crankshaft is turning. Because the ignition system is independent of the airframe's electrical system, a dead battery or electrical failure doesn't affect it.

The dual, redundant ignition setup means each cylinder has two separate ignition circuits. If one fails, the other can keep the engine running, enhancing reliability. Typically, there are two ignition toggle switches or positions on the control.

Each ignition system independently fires one of the two spark plugs per cylinder. While the engine will continue to run if one ignition system fails, power may decrease slightly. A failed spark plug in a cylinder may cause engine vibration due to uneven power output among the cylinders. Ignition control is managed via separate switches in the flight deck.

Some powered parachutes use automobile engines with battery-powered ignition systems. In such cases, a battery failure will also stop the engine.



Ignition System Components

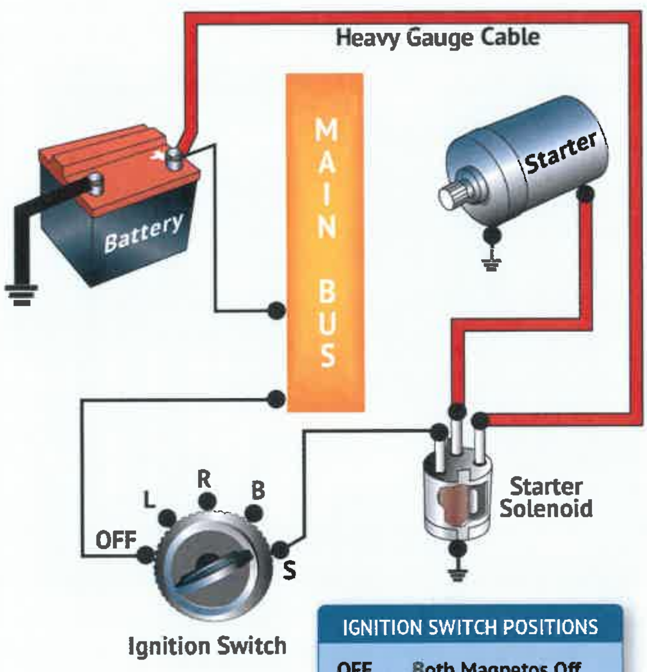
Electrical System

Powered parachutes are equipped with a 12-volt direct-current electrical system. A basic powered parachute electrical system consists of the following components:

- Generator/Alternator
- Battery
- Master/Battery Switch
- Voltage Regulator/Rectifier
- Electrical Wiring

The engine-driven alternator or generator supplies electrical power to the system and maintains the battery's charge. The battery stores electrical energy for starting the engine and provides backup power if the alternator or generator fails.

Generator vs. Alternator: A generator produces direct current (DC) and tends to generate insufficient electrical current at low engine speeds, requiring the system to draw from the battery at lower speeds, which can deplete the battery quickly. An alternator, on the other hand, produces alternating current (AC) that is converted to DC by a rectifier. Alternators are more efficient, especially at low engine speeds, as they can produce a higher output and are lighter and more compact than generators.



IGNITION SWITCH POSITIONS	
OFF	Both Magnetos Off
L	Left Magneto On
R	Right Magneto On
S	Engage Starter
B	Both Magnetos On

Typical Starting Circuit.

Rotax Engines and Alternators: Most modern Rotax engines, like those used in powered parachutes, use alternators rather than generators. The alternator's output is regulated by a voltage regulator/rectifier, which converts the AC output to the required 12-volt DC to charge the battery and power the electrical system. The voltage regulator typically maintains an output slightly higher than the battery voltage (about 13 to 14 volts) to keep the battery charged.

System Operation: The electrical system is controlled by a master switch, which, when turned on, supplies power to all electrical circuits except the ignition system. Commonly powered equipment includes:

- Position Lights
- Anticollision Lights
- Landing Lights
- Instrument Lights
- Radio Equipment
- Electronic Instrumentation
- Electric Fuel Pump
- Starting Motor

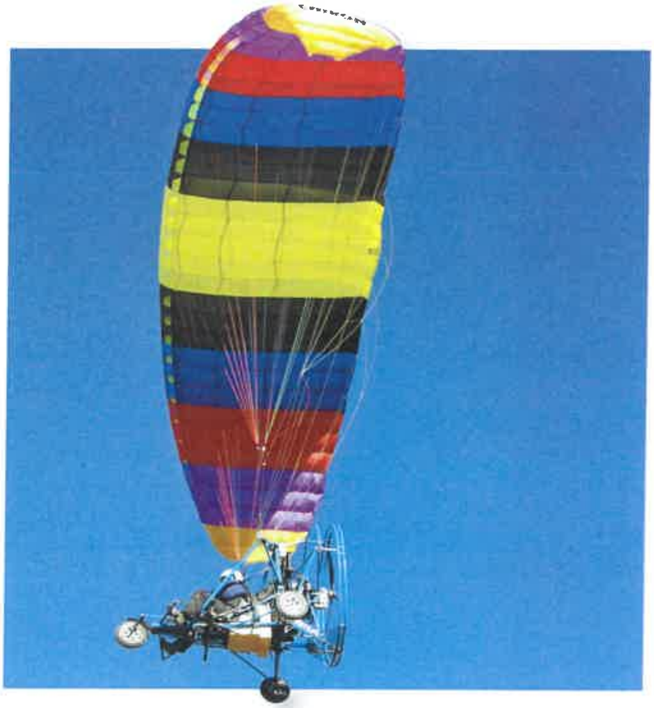
To protect against electrical overloads, the system uses fuses or circuit breakers. Fuses need to be replaced if blown, while circuit breakers can be manually reset. Placards identify each circuit and its amperage limit.

The voltage regulator/rectifier ensures that the electrical system operates efficiently by converting the alternator's AC output to DC and maintaining proper voltage levels to keep the battery charged and the system functioning.

Starting System

Most powered parachutes use a direct-cranking electric starter system, which includes a battery, wiring, switches, a solenoid, and a starter motor. This system engages the aircraft's flywheel or gearbox, rotating the engine to a speed that initiates and sustains operation.

Starting power is typically supplied by an onboard battery. When the battery switch is turned on, electricity flows to the main power bus. The starter switch draws current from the main bus. When the starter switch is turned to the 'start' position, it energizes the starting solenoid, which in turn directs current from the battery to the starter motor. The starter motor engages, cranking the engine. Once the engine starts, releasing the starter switch deactivates the solenoid, cutting power to the starter motor. A clutch in the starter drive prevents the engine from driving the starter motor once the engine surpasses the starter motor's speed.



Chapter 11 Instruments

Aircraft instruments can be classified in different ways: first by function, and then by form. Functionally, aircraft instruments are divided into two categories:

- Engine Instruments
- Flight Instruments

Engine gauges monitor the status of the engine and its support systems, such as fuel, cooling, and electrical. Flight instruments measure external factors like speed, altitude, position, and direction.

Regardless of what they measure, instruments display their output in one of two forms:

- Analog Gauges
- Digital or Electronic Gauges

Analog and digital gauges use different technologies to display and convey information.

Analog Gauges

Analog instruments, affectionately referred to by pilots as *"steam gauges,"* display data physically, typically using a moving needle or numbers on a wheel (as with an hour meter). The advantages of analog gauges include:

- Affordability
- Ease of reading at a glance, especially with red-line values clearly marked

However, analog gauges also have some disadvantages:

- They are relatively fragile in high-vibration, open flight deck environments, leading to common mechanical failures.
- They take up considerable space on compact instrument panels.
- Low accuracy
- Difficulty in reading detailed measurements

Digital Gauges

Digital gauges convert a physical measurement into a voltage, which is then electronically converted to a value displayed on a screen. As semiconductor prices have decreased, digital gauges have also become more affordable and increasingly common. With improved graphic capabilities, some digital instruments can now display data in formats that mimic analog gauges.

Advantages of digital gauges include:

- No moving parts to wear out
- A lot of information can be displayed on a single screen
- High accuracy
- The ability to easily read detailed measurements

Disadvantages of digital gauges include:

- Cost, although prices are steadily improving.
- They are not as easy to read at a glance compared to multiple analog needles. Sometimes, compact displays require scrolling through several screens to find a specific reading.

Most modern powered parachutes offer digital gauges exclusively, primarily due to their compact size and resistance to vibration. The biggest instrument-related decision when equipping your powered parachute is choosing the instrument package you want to invest in. Packages can include color displays, advanced navigation, and optional instruments.

Engine Instruments

Engine instruments provide vital information about the current condition of your powerplant and related systems. Key measurements include engine speed, flight time, total hours, engine temperatures, fuel level, fuel pressure, and more. These instruments not only display current readings but also tell you whether those readings are within acceptable limits. Regularly reviewing engine status should be a regular part of every flight.

Fuel Gauges

Fuel gauges are essential instruments for managing one of the most critical resources during flight—fuel. These gauges provide vital information about fuel quantity, pressure, and flow, enabling you to make informed decisions and ensure flight safety.

Fuel Level

The fuel level gauge indicates the amount of fuel in the tank, measured by a sensing unit, and displays it on the instrument panel. This sensing unit typically uses a float system within the fuel tank. As the fuel level changes, the float moves, and this movement is translated into a corresponding reading on the gauge.

However, don't rely solely on the accuracy of your fuel level gauge. Always visually check the fuel level in the tank during your preflight inspection, then compare it with the gauge's reading. Equally important is tracking in-flight fuel consumption. Your Pilot's Operating Handbook (POH) and prior experience can help you estimate fuel usage over a given period.

Fuel Pressure

The fuel pressure gauge measures the pressure within the aircraft's fuel system. If an electric fuel pump is installed, a fuel pressure gauge is sometimes included. As the pump operates, it pressurizes the fuel, and the gauge reflects this pressure in pounds per square inch (psi) or a similar unit.

Regardless of whether your engine is carbureted or fuel-injected, it requires a certain amount of fuel to operate efficiently. Both inadequate and excessive fuel pressures can lead to engine performance issues, indicating potential problems with the fuel system. Monitoring fuel pressure helps detect potential fuel system malfunctions early, preventing engine damage and ensuring a smooth, safe flight.

Fuel Flow Meter

The fuel flow meter measures the rate at which fuel is flowing from the aircraft's fuel system to the engine, usually based on a flow sensor that calculates the volume of fuel passing through the system per unit of time, such as gallons per hour.

Fuel flow information is particularly important during cross-country flights and for engine diagnostics. It's valuable data to monitor, especially over time and under different flying conditions.

Tachometer

Engine speed is measured using electrical pulses generated by the engine's ignition or electrical generating systems. These pulses are produced by the spinning crankshaft, which is connected to a trigger wheel.

The trigger wheel has evenly spaced ferrous teeth that create fluctuations in the magnetic field, generating electrical pulses. An electronic sensor mounted to the engine case counts these pulses. As the crankshaft turns faster, the pulse rate increases, allowing engine speed to be determined directly. The engine speed can be displayed on

Engine RPM indicated on an analog tachometer (left) and a tachometer gauge (right).

Engine	Idle Speed (minimum)	Max RPM (max 5 minutes)	Max RPM (Continuous)
Rotax 503 UL DCDI	2,000 rpm	6,800 rpm	6,500 rpm
Rotax 582 UL DCDI 40 (Silver Head)	2,000 rpm	6,400 rpm	6,000 rpm
Rotax 582 UL DCDI mod. 99 (Blue Head)	2,000 rpm	6,800 rpm	6,500 rpm
Rotax 912 series	1,400 rpm	5,800 rpm	5,500 rpm

Common engine RPMs

either an analog gauge or digital display.

For aircraft with a fixed-pitch propeller, the tach serves as the primary indicator of engine power. It's calibrated in hundreds of RPM and directly indicates both engine and propeller RPM. The RPM is regulated by the throttle, which controls the fuel-air mixture delivered to the engine. At a given altitude, higher tachometer readings correspond to higher engine power output.

In the example analog gauge depicted on the adjacent page, the engine RPM should never exceed 6800 RPM, a speed marked in red. The ideal operating range is between 2000 and 6500 RPM, marked in green. Speeds below 2000 RPM and between 6500-6800 RPM are cautionary zones, marked in yellow.

The digital gauge next to the analog gauge is not color-coded but displays *"6500 RPM MAX CON"* (continuous) and *"6800 MAX RPM,"* indicating the same critical values.

Hour Meter

An engine hour meter measures the total time the engine has been running by recording the duration from when the engine starts to when it stops.

Hour meters are calibrated in hours and tenths of an hour, providing you with valuable information on how long the engine has operated in total. This figure is crucial for determining when to perform scheduled maintenance on the engine and the rest of the aircraft.

Mechanical hour meters begin counting as soon as the engine power is on. Digital hour meters, however, only count time when the ignition system delivers a continuous series of electrical pulses to the meter. Some digital hour meters also function as tachometers. In these cases, the meter displays engine RPM while the engine is running and switches to show the total engine hours when the engine is shut down.

Engine Hours indicated on a mechanical gauge.

Engine Temperatures

Temperature indicators are used to determine:

- How efficiently the fuel-air mixture is being supplied to the engine by the carburetor.
- How well the cooling system is working.
- How well the lubrication system is working.

Most temperature gauges read either voltages from thermocouples or changes in resistance from thermistors, translating these measurements into temperature readings on a scale.

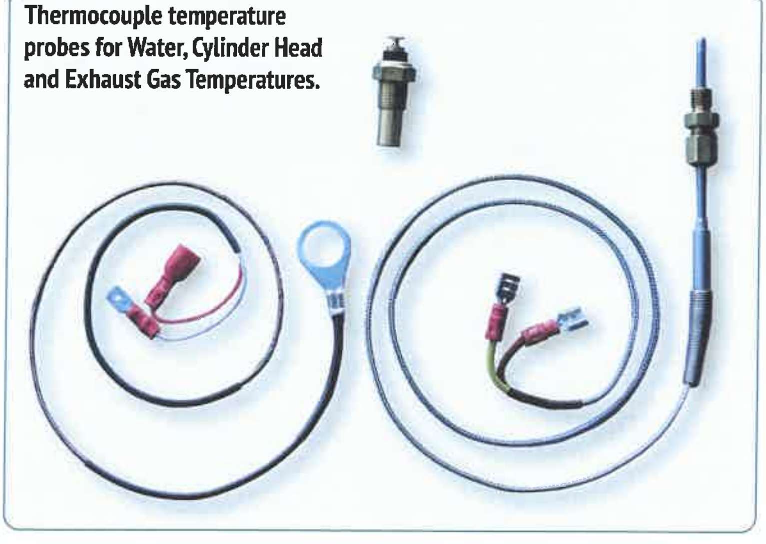
Thermocouples

Thermocouples are designed to accurately convert temperature into electrical voltage, which can then be displayed as a temperature reading on a gauge or display.

Thermocouples operate based on the *Seebeck Effect*, named after the German-Estonian physicist Thomas Johann Seebeck. In 1821, Seebeck discovered that any metal subjected to a temperature gradient generates a small electric voltage. The magnitude of the voltage generated depends on the size of the temperature gradient and the type of metal used.

While measuring the voltage difference between one end of a wire placed in a hot area and another in a cold area can be challenging, thermocouples overcome this by using two dissimilar metals welded together at a junction. When this

Thermocouple temperature probes for Water, Cylinder Head and Exhaust Gas Temperatures.



junction is placed in a hot area, each metal wire generates a different voltage at the cold ends. Measuring the voltage across these cold ends provides an accurate reading of the temperature difference between the hot and cold ends of the wires.

Thermocouples use specific pairs of metals, known as thermoelectric alloys, to ensure accurate temperature measurements. Common thermocouple alloys include:

Type K: Chromel-Alumel, Temperature range -454°F to 2,498°F
Type J: Iron-Constantan, Temperature range -346°F to 2,192°F
Type T: Copper-Constantan, Temperature range-454°F to 752°F

Due to their lack of moving parts, simplicity, low cost, and versatility, thermocouples are widely used. In aircraft engines, thermocouples take on different shapes depending on the specific engine component being measured.

Thermistors

Another technology used for measuring temperatures in engines is the thermistor. A thermistor is a type of temperature sensor that relies on the temperature-dependent resistance of certain semiconductor materials. That is, they change their resistance as the temperature changes, which can then be measured.

There are two main types of thermistors: Positive Temperature Coefficient (PTC) and Negative Temperature Coefficient (NTC). In engine applications, NTC thermistors are more commonly used. The resistance of NTC thermistors decreases as the temperature increases. Thermistors offer the following benefits.

Accuracy: Thermistors offer high accuracy in temperature measurement, allowing for precise monitoring of engine conditions.
Compact Size: Thermistors are generally small and lightweight, making them easy to integrate into various engine components without adding significant weight.
Rapid Response: Thermistors respond quickly to changes in temperature, providing near-instantaneous feedback to the engine management system.

Thermistors also have their downsides, which doesn't make them appropriate for all applications.

Non-linear: Thermistors have a predictable, but non-linear response to temperature increases. That makes them less suitable for analog gauges. However, their non-linear response can be calculated and translated accurately to a digital gauge.
Limited Temperature Range: Many NTC thermistors are suitable for moderate temperature ranges up to 300°F with some handling up to 600°F. That limits them from being used to measure exhaust gas temperatures (EGT) which can exceed 1200°F.

Exhaust Gas Temperature (EGT) Gauges

Some exhaust systems have an exhaust gas temperature probe made from a Type K thermocouple to measure the temperature of the hot exhaust gases coming out of the engine cylinders. This probe transmits the exhaust gas temperature (EGT) to an instrument in the flight deck. The probe is placed in the exhaust manifold where the gases are exiting the cylinder and are at their hottest.

This temperature varies with the ratio of fuel to air entering the cylinders and is often used as an indicator that the fuel-air mixture is within specifications. The EGT gauge is highly accurate in indicating the correct mixture setting. When there is a problem with carburetion, the EGT gauge is usually the first indicator for a pilot.

If the EGT readings are low, it indicates a rich fuel-air mixture, meaning there is too much fuel relative to the air passing through the carburetors. Conversely, high EGT readings suggest a lean mixture, with insufficient fuel being added. For a detailed discussion on carburetion and EGT readings, see *Chapter 9, "Engines."*

Excessively high EGT readings can indicate the risk of piston seizure or even a hole being blown in the piston. EGT readings that vary between cylinders may suggest that the carburetors have different settings, causing one cylinder to work harder than the other. High EGT in one cylinder compared to the other could also indicate an intake leak in the cylinder with the higher values.

Monitoring EGTs is especially important after any work or adjustments on the propeller or carburetor system, as this is when problems are most likely to arise. Most powered parachutes have dual EGT gauges, which are necessary only if there are two carburetors to monitor. If there's just one carburetor delivering fuel to one or two cylinders, a single EGT gauge will suffice.

Problems indicated by high EGTs include:

- Too rich a mixture
- Too lean a mixture
- Propeller pitched too high or too low
- Intake manifold leak
- Improper carburetor jets

- Unequal carburetor settings between cylinders
- Malfunctioning carburetors
- Fuel pump not delivering enough fuel
- Deteriorating fuel lines
- Partially blocked fuel filter

If EGT readings are erratic, it's often due to the failure of the temperature probe itself, which should be checked before making any other engine adjustments.

Cylinder Head Temperature (CHT) Gauges

CHT gauges measure the temperature of the cylinder head(s) in an engine using probes made from Type K thermocouples or thermistors. The cylinder head is one of the hottest parts of the engine and is often the first area to exceed temperature tolerances if the cooling system fails. Some engines use probes mounted directly into the cylinder head, while others use ring-shaped probes mounted under the spark plugs.

CHT gauges are critical for air-cooled engines since they are often the only indicator of cooling system issues. In other types of engines, CHT gauges work alongside water or oil temperature gauges to monitor overall engine temperature.

In both air-cooled and water-cooled two-stroke engines, CHT gauges will be the first indicator of problems related to the delivery of two-stroke oil. Issues may arise if the pilot forgets to mix oil into the fuel (for premix systems) or if the oil pump fails or the oil reservoir runs dry (for oil injection systems).

If only one CHT gauge is used, it should be placed on the 'hot' cylinder. In an air-cooled engine, this is typically the cylinder furthest from the cooling fan. In a water-cooled engine, there usually isn't a single hot cylinder.

Problems indicated by high CHTs include:

- Blocked radiator
- Low radiator coolant levels
- Failing water pump
- Failing cooling fan or cooling fan belt. (air-cooled engines)
- Blockage under engine cowling, such as insect nests (air-cooled engines)
- No two-stroke oil in fuel
- Two-stroke oil reservoir empty
- Two-stroke oil injector system failure

Water Temperature Gauges

In liquid-cooled engines, a water temperature sensor is placed in the engine head, extending into the water jacket. The water temperature gauge allows you to monitor whether the cooling system is functioning correctly and if the engine has properly warmed up before takeoff—both of which are critical functions. That's because engines can seize if they run too hot or if they aren't properly warmed up.

Problems indicated by high water temperature gauges include:

- Blocked radiator
- Failing water pump
- Low radiator fluid
- Leaking cooling system

Some liquid-cooled powered parachutes can't run for extended periods on the ground without showing high water temperature readings. That's because sufficient airflow over the radiator only occurs during flight, which is necessary to keep the engine cool. Keep this in mind during engine testing or when breaking in an engine.

Oil Temperature Gauges

For four-stroke engines, monitoring oil temperature becomes more critical than monitoring water temperature since the oil circulates through more of the engine.

The oil temperature gauge measures the temperature of the engine's lubricating oil. In the case of Rotax 9-series engines, the sensor used is an NTC thermistor.

Changes in oil temperature may occur gradually, especially after starting a cold engine, when it may take several minutes or longer for the gauge to show any increase.

The normal operating range for oil temperature in Rotax 9-series engines is 190°F to 230°F, with a minimum acceptable temperature of 120°F and a maximum of 285°F. Monitoring the oil temperature is crucial to prevent overheating, maintain proper viscosity, and ensure effective lubrication.

Check the oil temperature periodically during flight, particularly when operating in high or low ambient air temperatures.

Low oil temperature readings, especially during cold weather operations, may indicate improper oil viscosity.

High oil temperature readings may indicate:

- A plugged oil line
- Low oil quantity
- Blocked oil cooler
- Defective oil temperature gauge

Oil Pressure Gauges

The oil pressure gauge measures the pressure of the lubricating oil within the engine. It uses a pressure sensor, commonly an oil pressure transducer or sender, which is connected to the engine's oil system. As the engine operates, the oil pump pressurizes the lubrication system. The pressure sensor detects this pressure and sends a corresponding electrical signal to the gauge. The gauge then translates this signal into a pressure reading displayed on the instrument panel.

For Rotax 9-series engines, the oil pressure should fall within the specified range of 22-73 psi (pounds per square inch). The minimum pressure should only occur at idle, and the pressure should never exceed 102 psi. Monitoring oil pressure is crucial for ensuring proper lubrication, preventing engine wear, and detecting potential issues such as oil leaks.

Voltmeter

A voltmeter measures the condition of your battery and the performance of your electrical charging system. It can also indicate how much electrical power you're losing if you have too many accessories running.

When the engine isn't running, your voltage reading should be between 12.6 and 12.8 volts or higher. This range represents a fully charged battery. If the voltage is significantly below this range, it may indicate a discharged or faulty battery.

When the engine is running, the voltage reading should be between 13.8 and 14.2 volts. This range indicates that the alternator or generator is producing an adequate charging voltage, ensuring that the battery is properly charged and maintained. Consistently low voltage readings may signal an issue with the charging system.

Flight Instruments

Flight instruments enable you to operate a powered parachute with maximum performance and enhanced safety, especially when flying long distances. Manufacturers provide the necessary flight instruments, but to use them effectively, you need to understand how they operate.

Altimeter

An altimeter is a primary flight instrument that tells you how high you are flying. Due to its importance, *Chapter 14, "Altitude and Performance,"* provides an in-depth discussion on altimeters and their role in managing altitude and performance.

Vertical Speed Indicator

The vertical speed indicator (VSI), which is sometimes called a variometer or a vertical velocity indicator (VVI), indicates whether you are climbing, descending, or in level flight. The rate of climb or descent is indicated in feet per minute (fpm). If properly calibrated, the VSI indicates zero in level flight.

Like altimeters, VSIs measure pressure and convert it into useful data for you. And like altimeters, there are old school mechanical devices that measure pressure (or in the case of a VSI, changing pressure) and display that information on the face of a gauge.

Modern digital VSIs use advanced technology to provide pilots with accurate and precise information about the rate of climb or descent of an aircraft. Unlike traditional mechanical VSIs, digital versions employ electronic sensors and digital displays to convey vertical speed information. This is how digital VSIs work:

Pressure Sensors: Pressure sensors may be used to detect changes in static pressure associated with variations in altitude.

Accelerometers: Alternatively, an accelerometer may be used. An accelerometer, as the name implies, is a sensor that measures the acceleration of an object. Acceleration is the rate of change of velocity, and it can occur in various ways, including the linear acceleration an aircraft experiences when beginning to climb or descend.

Electronic Signal Processing: Pressure sensors generate electronic signals proportional to the rate of change in static pressure. Similarly, an accelerometer also generates electronic signals in the form of an electrical voltage or charge that represents the vertical acceleration. These signals are then processed electronically to determine the vertical speed of the aircraft.

Digital Display: The processed data is presented on your digital display. The digital display shows the rate of climb or descent in feet per minute (fpm) or meters per second (mps), depending on the unit selected.

Integration with Avionics: Modern digital VSIs are often integrated with the aircraft's avionics system. This integration allows for seamless communication with other instruments and avionic components.

Software Algorithms: Advanced software algorithms are used to filter and smooth out data, reducing the impact of short-term fluctuations in atmospheric conditions or turbulence. This enhances the accuracy and reliability of the vertical speed information.

Customization and Alerts: Some digital VSIs offer customization features, allowing pilots to set preferences for the display format, such as the rate of change in color or specific altitude thresholds. Additionally, they may provide audible or visual alerts when reaching predefined climb or descent rates.

To verify proper operation, make sure the VSI is indicating near zero prior to takeoff. After takeoff, it should indicate a positive rate of climb.

Airspeed Indicator

Powered parachutes generally don't have airspeed indicators (ASIs) because their airspeeds are fairly constant and cannot be easily controlled by the pilot. However, there are two reasons a powered parachute might be equipped with an airspeed indicator. The first is if the powered parachute is flown at night, as regulations may require an airspeed indicator for night operations. The second reason is if the powered parachute has a mechanism for changing airspeed in flight.

There are two types of airspeed indicators: the 'Hall' airspeed indicator, a simple device originally designed for hang gliders and ultralights, and the conventional airspeed indicator used in general aviation aircraft.

Hall Airspeed Indicator

The Hall airspeed indicator was invented to provide a simple, rugged solution for hang glider pilots. It functions by allowing air to enter through a hole at the bottom of a clear plastic cylinder. Inside the cylinder, a small, lightweight disk is lifted as air flows through the tube and exits at the top. The position of the disk indicates the airspeed.

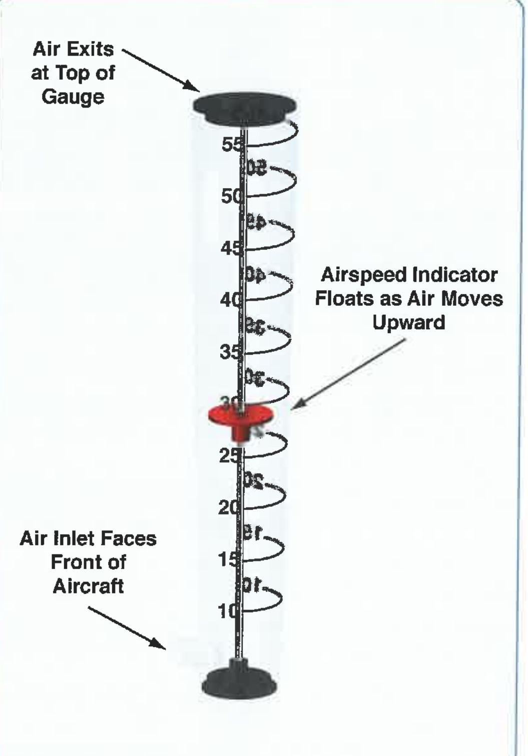
The Hall airspeed indicator is mounted on one of the structural tubes of the powered parachute, with the front facing the direction of travel.

Standard Airspeed Indicator

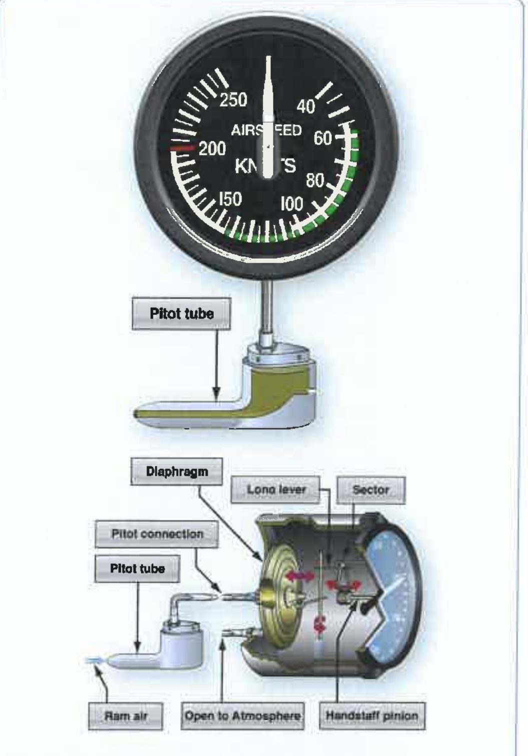
A standard airspeed indicator measures pressure instead of actual speed. It's a sensitive, differential pressure gauge which measures and shows promptly the difference between pitot or impact pressure, and static pressure, the undisturbed atmospheric pressure at level flight. These two pressures will be equal when the powered parachute is parked on the ground in calm air. When the powered parachute moves through the air, the pressure on the pitot line becomes greater than the pressure in the static lines. This difference in pressure is registered by the airspeed pointer on the face of the instrument, which is calibrated in miles per hour or knots instead of units of pressure.

There are both mechanical and electronic versions of this instrument, but both require a pitot tube. A pitot tube is a probe in the front of the aircraft to measure the impact pressure of the oncoming air. If this probe is blocked, then the instrument won't indicate any speed.

Electronic Airspeed Indicators (EASIs) are favored by powered parachute pilots. EASIs offer several advantages over traditional mechanical ASIs, including increased accuracy, reliability, and integration capabilities with other avionics systems. Sharing a digital display with other instruments reduces the space required for a separate instrument on size-limited powered parachute instrument panels.



Hall airspeed indicator.



Standard mechanical airspeed indicator.

Here's how electronic airspeed indicators work:

Pressure Sensors: Solid-state sensors or transducers are used to measure the dynamic pressure of the air and the static pressure of the air. Dynamic pressure is obtained by a probe extending forward from the powered parachute while static pressure is obtained by a sensor normally mounted out of the wind in the instrument pod.

Microprocessor: The output from the pressure sensors is an electronic signal, typically in the form of voltage or current, which is processed by the electronic circuitry within the instrument. Electronic airspeed indicators incorporate microprocessors or digital signal processors (DSPs) to process the incoming signals. These processors analyze the data and convert it into a digital format for further calculations.

Calibration and Correction: The microprocessor applies calibration and correction algorithms to the data, compensating for factors such as instrument error, mounting error for the pitot system, and temperature variations. This ensures that the displayed airspeed is accurate and reliable.

Digital Display: The processed airspeed information is then presented on a digital display.

Integration with Avionics: Electronic airspeed indicators are often integrated with the aircraft's avionics suite. This integration allows for data sharing between different instruments.

Prior to takeoff, the ASI should read zero. However, if there is a strong wind blowing directly into the pitot tube, the ASI may read higher than zero. When beginning the takeoff, make sure the airspeed is increasing at an appropriate rate.

Compass Systems

The Earth acts as a giant magnet, spinning in space and surrounded by a magnetic field made up of invisible lines of flux. These lines emerge from the surface at the magnetic north pole and reenter at the magnetic south pole.

Magnetic flux lines have two important characteristics: any freely rotating magnet will align with them, and an electrical current is induced in any conductor that intersects them. Most direction indicators installed in aircraft take advantage of one of these two principles.

However, powered parachutes rarely come equipped with compasses. Instead, pilots typically use true course headings obtained from onboard navigation tools, smartphones, or tablets. However, understanding how a compass works and how to account for errors introduced by the region and specific aircraft is beneficial.

Magnetic Compass

One of the oldest and simplest instruments for indicating direction is the magnetic compass.

A magnet is a material, usually a metal containing iron, that attracts and holds lines of magnetic flux. Every magnet has two poles: north and south. When one magnet is placed in the field of another, unlike poles attract each other, while like poles repel.

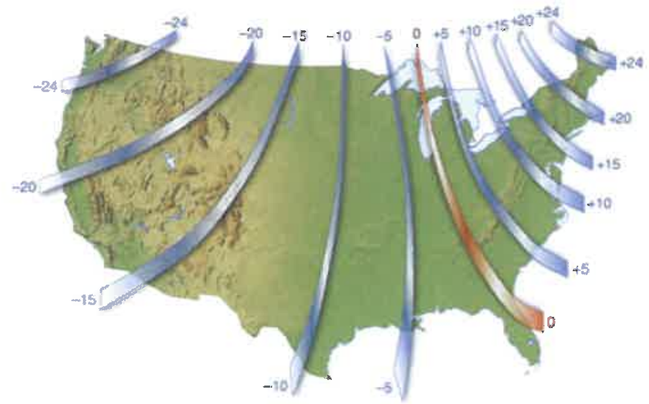
An aircraft magnetic compass consists of two small magnets attached to a metal float, sealed inside a bowl of clear compass fluid, similar to kerosene. A graduated scale, called a card, wraps around the float and is viewed through a glass window with a lubber line across it. The card is marked with letters representing the cardinal directions (north, east, south, and west) and numbers for each 30° interval between these letters. The final "0" is sometimes omitted from these directions. For example, 3 represents 30°, 6 represents 60°, and 33 represents 330°. Long graduation marks represent 10°, and short marks represent 5°.

The float and card assembly has a hardened steel pivot at its center, which rides inside a special, spring-loaded, hard glass jewel cup. The float's buoyancy takes most of the weight off the pivot, and the fluid dampens the oscillation of the float and card. This jewel-and-pivot mounting allows the float to rotate and tilt up to approximately 18° of bank. At steeper bank angles, compass indications become erratic and unpredictable.

The compass housing is filled entirely with compass fluid. To prevent damage or leakage due to fluid expansion and contraction with temperature changes, the rear of the compass case is sealed with a flexible diaphragm or, in some compasses, with a metal bellows.

The magnets align with the Earth's magnetic field, and the pilot reads the direction on the scale opposite the lubber line. Note that the pilot views the compass card from its backside. When the compass shows north, east is to the pilot's right. On the card, "33," which represents 330° (west of north), is to the right of north. This apparent backward graduation occurs because the card remains stationary while the compass housing and pilot rotate around it, always viewing the card from its backside.

The magnetic compass is the simplest instrument on the panel but is subject to two errors that must be considered.



Isogonic lines are lines of equal variation.

Variation

The Earth rotates about its geographic axis, determining the geographic north and south poles. Maps and charts are drawn using meridians of longitude that pass through these poles. Directions measured from the geographic poles are called true directions. The magnetic North Pole, to which the magnetic compass points, is not aligned with the geographic North Pole but is approximately 1,300 miles away. Directions measured from the magnetic poles are called magnetic directions. In aerial navigation, the difference between true and magnetic directions is called variation. This same angular difference in surveying and land navigation is known as declination.

The graphic above shows the isogonic lines that identify the number of degrees of variation in their area. The line that passes near Chicago is called the agonic line. Along this line, the magnetic North Pole is aligned with the geographic North Pole, resulting in no variation. East of this line, the magnetic North Pole is to the west of the geographic North Pole and a correction must be applied to a compass indication to get a true direction.

Flying in the Washington, D.C., area, for example, the variation is 11° west. If a pilot wants to fly a true course of south (180°), the variation must be added to this, resulting in a magnetic course of 191° to fly. Flying in the Los Angeles, California, area, the variation is 12° east. To fly a true course of 180° there, the pilot would have to subtract the variation and fly a magnetic course of 168°. The variation error does not change with the heading of the aircraft; it's the same anywhere along the isogonic line.

FOR	000	030	060	090	120	150
STEER						
RDO. ON	001	032	062	095	123	155
RDO. OFF	002	031	064	094	125	157

FOR	180	210	240	270	300	330
STEER						
RDO. ON	176	210	243	271	296	325
RDO. OFF	174	210	240	273	298	327

A compass correction card shows the deviation correction for any heading.

Deviation

The magnets in a compass align with any magnetic field. Local magnetic fields in an aircraft caused by electrical current flowing in the structure, in nearby wiring or any magnetized part of the structure, conflict with the Earth's magnetic field and cause a compass error called deviation. Deviation, unlike variation, is different on each heading, but it's not affected by the geographic location.

Many airports have a compass rose, which is a series of lines marked out on a ramp or maintenance runup area where there is no nearby magnetic interference. Lines, oriented to magnetic north, are painted every 30°.

The mechanic aligns the aircraft on each magnetic heading and records the error on a compass correction card, like the one below, and places it in a cardholder near the compass. The pilot can taxi the aircraft to the compass rose and maneuver the aircraft to the headings and complete the compass correction card for an experimental aircraft. In this example, if the pilot wants to fly a magnetic heading of 120° and the aircraft is operating with the radios on, the pilot should fly a compass heading of 123°.

Calculating Corrections

The corrections for variation and deviation must be applied in the correct sequence and are shown below.

Step 1: Determine the True Heading (THdg)

You get THdg from measuring the course line on your sectional to obtain the True Course (TCrs) and then applying the effects of wind. In this example we'll use a THdg of 180°

Step 2: Determine the Magnetic Heading (MHdg)

You also obtain the Variation (Var) from your sectional. Variation lines are marked with dashed magenta lines.

True Heading (180°) ± Variation (+10°) = Magnetic Heading (190°)

The magnetic heading (190°) is steered if there is no deviation error to be applied. The compass card must now be considered for the magnetic heading of 190°.

Step 3: Determine the Compass Heading (CHdg)

Magnetic Heading (190°, from Step 2) ± Deviation (−2°, from correction card) = Compass Course (188°)

NOTE: Intermediate magnetic courses between those listed on the compass card need to be interpreted. Therefore, to steer a true course of 180°, the pilot would follow a compass course of 188°.

Electronic Flight Displays

As mentioned earlier in this chapter, electronic instrumentation ranges from basic engine monitoring to advanced glass panel displays. While such sophisticated systems might be overkill for powered parachutes, they can still be fun to own and use.

Electronic instrumentation can vary greatly in complexity. It may include simple digital readouts or more advanced features such as real-time weather radar and ADS-B In data received via satellite systems.

Engine Gauges

Engine temperature and RPM measurement systems are typically electrically operated, making them easily adaptable to digital formats. Common instruments found in a basic electronic gauge system include:

- Tachometer (RPM)
- Cylinder Head Temperature
- Water Temperature
- Oil Temperature (4 stroke)
- Oil Pressure (4 stroke)
- Exhaust Gas Temperature
- Hour meter
- Voltmeter

Flight Instruments

With sensors available, basic flight instruments can be integrated into the electronic instrument. Almost universally available are:

- Altimeter
- Vertical Speed Indicator

Additional instruments or capability can be added either for an additional price or by adding additional sensors on auxiliary circuits.

Possible additions include:

- Outside Air Temperature
- Fuel Gauge
- Airspeed Indicator
- GPS
- Fuel Flow

EIS

The most common system found on powered parachutes is the EIS engine monitor by GRT Avionics. If you choose a more advanced system, your flight instructor or aircraft dealer should explain how to operate it. More complex systems require more time to learn.

The initial screen of the EIS displays various values, which can be accessed by pressing the 'Display' button momentarily. This button allows additional data to be shown on the screen, serving as a 'cheat sheet' of values.

The gauge displays a range of information in a compact format. You can access different data formats by pressing the 'Next' or 'Previous' buttons, which scroll through various windows. Some formats include labels, while others require pressing the 'Display' button again to identify the information.

The computer within the gauge can be programmed with limits for temperatures, RPM, and a user-defined auxiliary gauge. When these limits are exceeded, a red light flashes, and the screen automatically scrolls to show the out-of-tolerance value.

In this electronic engine display, finding out what all the values mean is as simple as pressing the display button on the right. This screen features the high CHT and EGT cylinders.

In this screen, the CHT and EGT temperatures for both cylinders are shown.

Chapter 12
Weather Theory

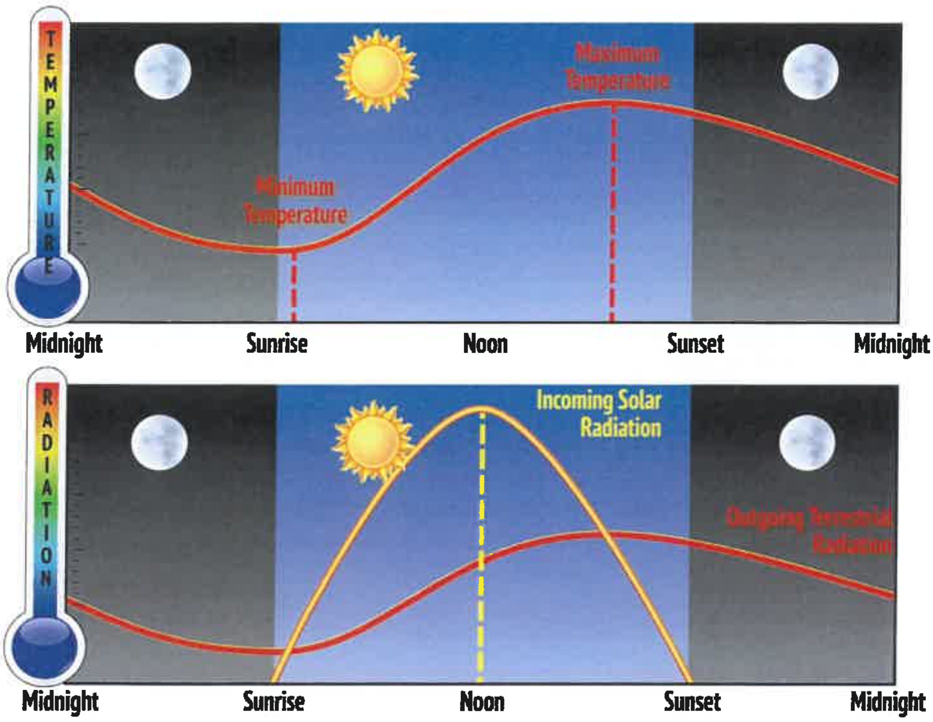
Understanding weather is important because it makes you a safer pilot. Weather is far more important to flying than it is to almost any other kind of transportation or outdoor activity. In fact, the topic is important enough that I've included four chapters on the subject. We start with this chapter on general weather theory. Then there is a specific chapter on winds, which are particularly important for powered parachute pilots, then density altitude, which affects aircraft performance, and we wrap things up with a chapter on weather reports and forecasts.

The Sun

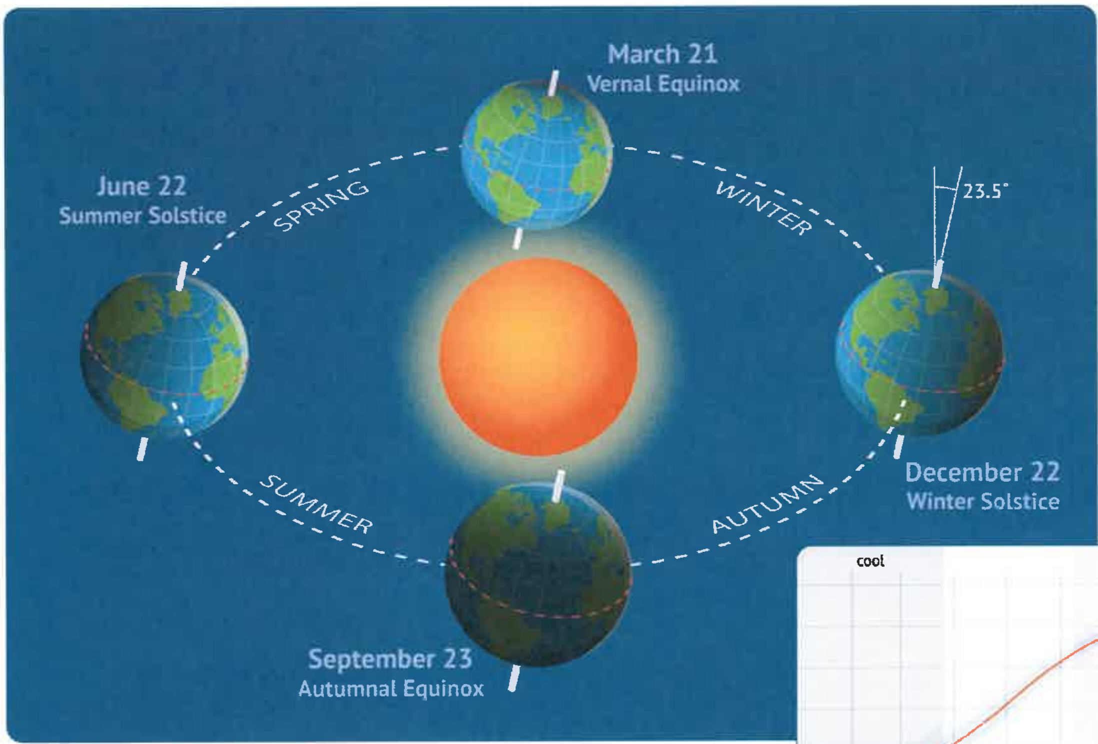
Weather results from interactions among the Earth, the Earth's atmosphere, and the Big Light in the Sky. The Sun provides light and solar radiation. Solar radiation heats the earth, but unevenly. There are three big reasons for that uneven heating.

Spinning

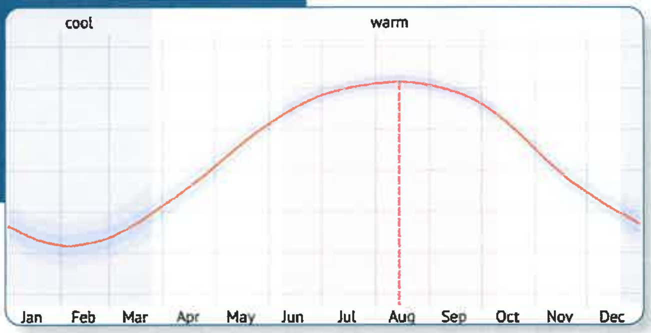
The Earth spins in space, which gives us day, night, and uneven solar heating. The technical term is *Diurnal Temperature Variation*. The Sun begins heating the surface of the Earth at sunrise, gets to a peak around noon, and then the heating lessens and finally goes away at sunset. Meanwhile, the Earth also gives off heat both day and night. Again, there is a technical term, *Outgoing Terrestrial Radiation*. The outgoing heat also changes with the time of day but has much less variation than the incoming heat.



Typical diurnal temperature and radiation variations over land when the sky is clear.



The seasons in the Northern Hemisphere are driven by variations in the Solar Zenith Angle.



The warmest days of the year occur after the summer solstice.

The extent of daily temperature fluctuations is primarily determined by various factors, including the type of surface, latitude, sky conditions (such as cloud cover or pollutants), moisture content in the air, and wind speed. Generally, temperature variations are most pronounced over land, particularly at lower latitudes, when the sky is clear, the air is dry, and there is light wind. On the other hand, temperature variations are minimized over water, especially at higher latitudes, when the sky is cloudy, the air is moist, and there is a strong wind.

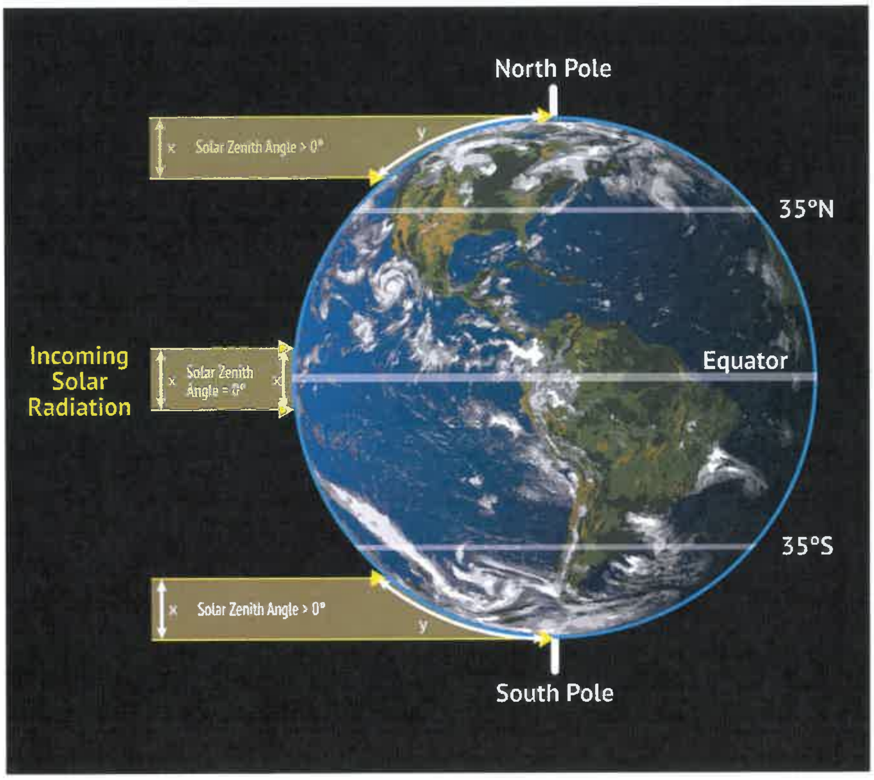
Seasons

All that Earth spinning happens on a rotational axis that is tilted relative to the Earth's orbital path around the Sun. The Earth's rotational axis is tilted 23 ½° from the perpendicular drawn to the plane of the Earth's orbit about the Sun and points the same direction in space all year long.

The North Pole is tilted most directly toward the Sun during the summer solstice. That means that in the Northern Hemisphere, the longest day of the year occurs on the summer solstice. The shortest day of the year occurs on the winter solstice. On the vernal equinox and the autumnal equinox, day and night are an equal 12 hours long worldwide.

Latitude Imbalance

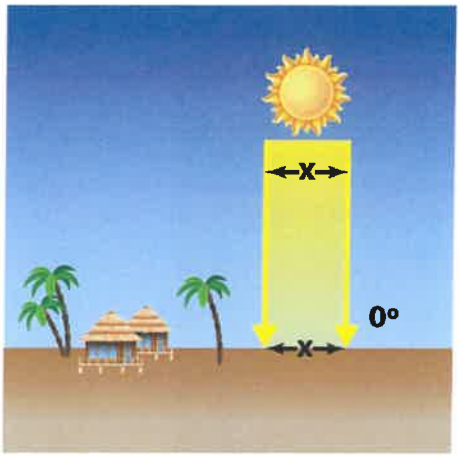
Spinning and the seasons both affect the solar zenith. But the solar zenith also differs on different places on the globe. On the equator, the Sun's radiation is the strongest because the Sun is more direct. As you move closer to either the north or south poles, the Sun's rays are gradually spread out over a wider area. Intuitively, it's easy to understand that when the Sun is overhead, everything warms up a lot better than when the Sun is closer to the horizon.

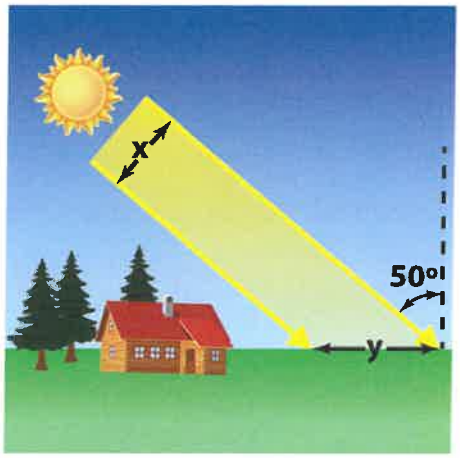


The Solar Zenith Angle increases with latitude.

When the solar zenith angle is 0°, the Sun is directly overhead and the sun is the warmest.

As you go north, the solar zenith angle increases and the radiation from the Sun is spread over an increasingly larger surface area (y is greater than x) and becomes less intense.





Atmospheric Circulation

The amount of solar radiation that heats the Earth depends upon the time of day, time of year, and the latitude of the specific region. The most solar radiation is over the equator at noon.

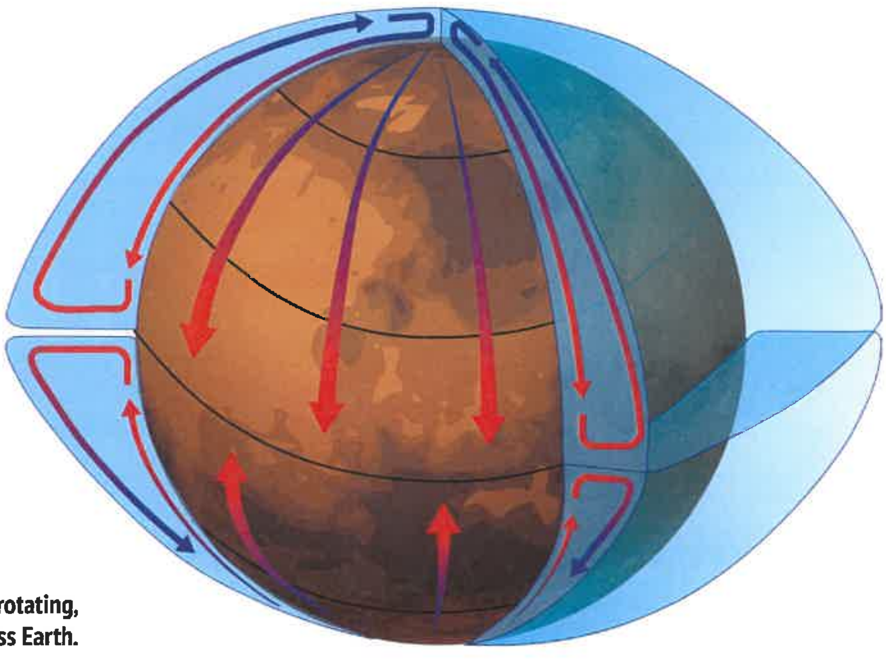
This uneven heating of the Earth's surface upsets the equilibrium of the atmosphere. It moves the air and changes the atmospheric pressure.

The differences in temperature create areas of low pressure over equatorial regions and areas of high pressure over polar regions. Solar heating causes air to become *less dense* and rise in equatorial areas. "*Less dense air*" means that there is lower pressure near the equator. Denser, high-pressure air at the poles then flows along the planet's surface toward the equator. At altitude, warm air from the equatorial regions flows towards the poles where it cools, becomes denser, and sinks back towards the Earth's surface. This pattern of air circulation is correct in theory and is the way things would work for a non-rotating, non-tilted, waterless Earth. Happily, things just aren't that simple. I mean, who wants to live on a waterless planet with no sunrise or sunset?

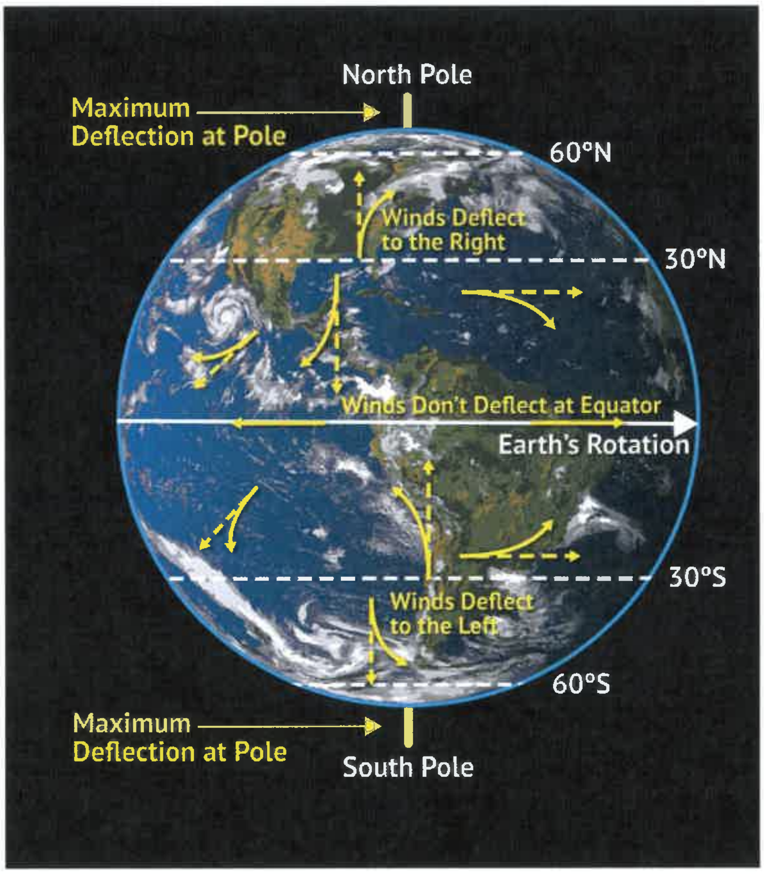
The circulation of the air in our atmosphere is modified by several factors, all contributing to fluctuating weather.

- The Earth rotates.
- The Earth's axis of rotation is tilted.
- There's a lot of water on the Earth's surface.
- There's more land mass in the Northern Hemisphere than in the Southern Hemisphere.
- Land masses aren't smooth and level.

The rotation of the Earth creates Coriolis force. This force is not perceptible to us as we walk around because we move so slowly and travel relatively short distances compared to the size and rate of rotation of the Earth. However, it does significantly affect bodies that move over great distances, such as a mass of air or a body of water. Coriolis force deflects air to the right in the Northern Hemisphere, causing it to follow a curved path instead of a straight line. The amount of deflection differs depending on the latitude and the speed of the moving air.



Atmospheric Circulation on a non-rotating, non-tilted, waterless Earth.

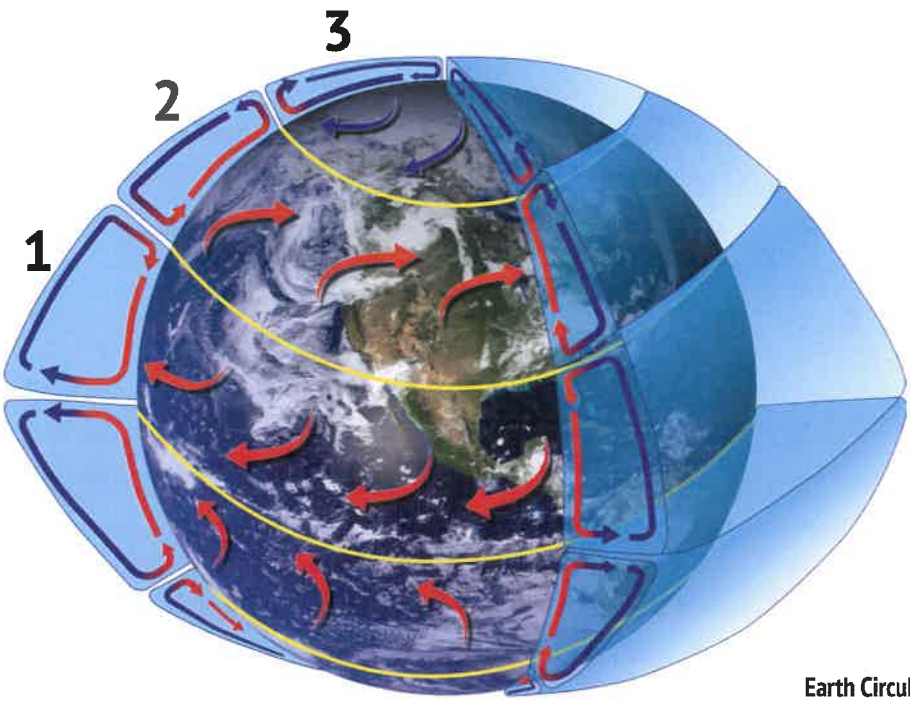


Coriolis Force variations across the Earth

The deflection is greatest at the pivot axis of the poles and diminishes to zero at the equator. In the Northern Hemisphere, the rotation of the Earth deflects moving air to the right. The magnitude of Coriolis force becomes greater when the mass of air is moving faster.

The speed of the Earth's rotation also causes the general flow of air to break up into three distinct cells in each hemisphere. In the Northern Hemisphere, the warm air at the equator rises upward from the surface, travels northward, and is deflected eastward by the rotation of the Earth. By the time it has traveled one-third of the distance from the equator to the North Pole, it's no longer moving northward, but eastward. This air cools and sinks in a belt-like area at about 30° latitude, creating an area of high pressure as it sinks towards the surface. Then it flows southward along the surface back towards the equator. Coriolis force bends the flow to the right, thus creating the northeasterly trade winds that prevail from 30° latitude to the equator. Similar forces create circulation cells that encircle the Earth between 30° and 60° latitude, and between 60° and the poles. The contiguous United States are located mostly between 30º North and 60º North. That means that the big takeaway for us is that the middle circulation pattern results in prevailing westerly winds, meaning that winds generally move from the west to the east.

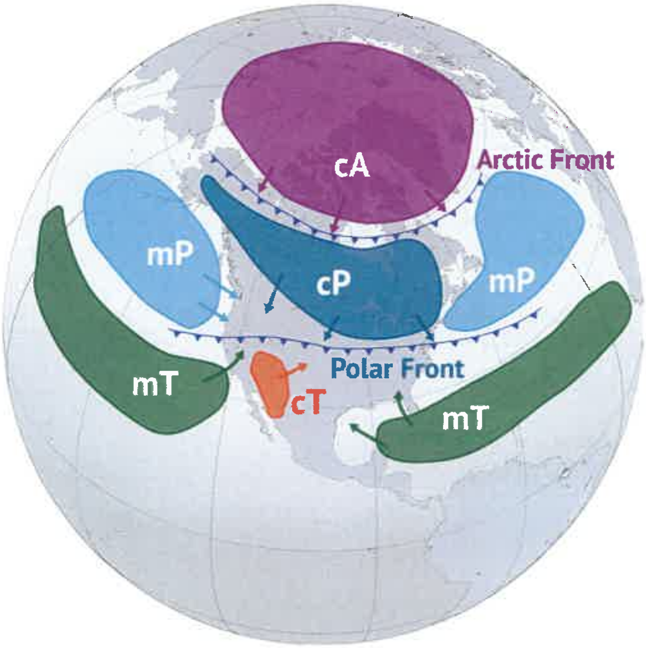
Other factors complicate circulation patterns. The Earth's tilted axis of rotation creates seasonal changes. Another big factor is that within 2,000 feet of the ground, friction between the surface and the atmosphere slows the moving air. The wind is diverted from its path because that frictional force reduces the Coriolis force. And because of that friction, the wind direction near the surface varies somewhat from the wind direction just a few thousand feet above the Earth.



Earth Circulation System

Air Mass Classification

Source Region	Continental (c)	Maritime (m)
Arctic (A)	Continental Arctic (cA) Cold & Dry	Not Applicable
Polar (P)	Continental Polar (cP) Cold & Dry	Maritime Polar (mP) Cold & Moist
Tropical (T)	Continental Tropical (cT) Hot & Dry	Maritime Tropical (mT) Warm & Moist



Air Masses

Atmospheric circulation moves masses of air over the surface of the Earth. An air mass is a large body of air that takes on the characteristics of the surrounding area, or source region. A source region is an area where a mass of air remains relatively stagnant for a period of days or longer. During this stagnant period, the air mass takes on the temperature and moisture characteristics of the source region. Areas of stagnation can be found in polar regions, tropical oceans, and dry deserts. Air masses are classified based on their properties, which they get from different regions. The first three of these properties describe temperature and the last two describe moisture.

Arctic (A) is an extremely deep, cold air mass that develops mostly in winter over arctic surfaces of ice and snow.
Polar (P) is a relatively shallow, cool to cold air mass that develops over high latitudes.
Tropical (T) is a warm to hot air mass that develops over low latitudes.
Continental (c) is a dry air mass that develops over land.
Maritime (m) is a moist air mass that develops over water.

These five properties are used to describe five kinds of air masses.

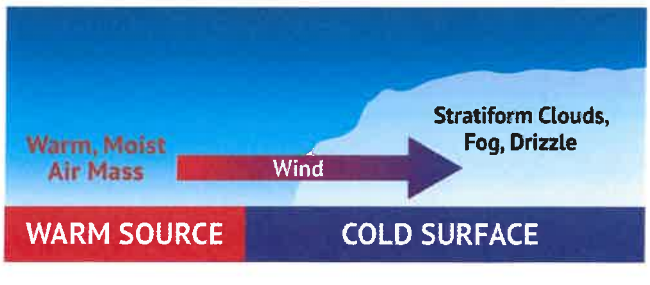
Continental Arctic (cA): Frigid and dry
Continental Polar (cP): Cold and dry
Continental Tropical (cT): Hot and dry
Maritime Polar (mP): Cool and moist
Maritime Tropical (mT): Warm and moist

A continental polar air mass forms over a polar region and brings cool, dry air with it. Maritime tropical air masses form over warm tropical waters like the Caribbean Sea and bring warm, moist air. As the air mass moves from its source region and passes over land or water, the air mass is subjected to the varying conditions of the land or water, and these modify the nature of the air mass.

As air masses move around the Earth, they commonly acquire attributes from the new surfaces they travel over. For example, in the winter, an arctic (cA) air mass can move over the ocean, picking up some warmth and moisture from the warmer ocean and become a maritime polar (mP) air mass—one that's still cold but now contains moisture. If that same air mass instead moves south from Canada into the southern United States, it will pick up some of the warmth of the ground, but due to lack of moisture, it will remain very dry. Then it will instead become a continental polar (cP) air mass.

There are other common trends. A maritime tropical (mT) air mass is air from the tropics that has moved north over cooler water. Gulf Coast states and the eastern third of the country commonly experience a maritime tropical (mT) air mass in the summer. Continental tropical (cT) air is dry air pumped north, from Mexico.

During the summer, a moist air mass can pass over a warmer surface and will be warmed from below, causing the air to rise. This creates an unstable air mass with good surface visibility. This moist, unstable air causes cumulus clouds, showers, and turbulence to form. Conversely, a warm air mass passing over a colder surface creates a stable air mass with poor surface visibility. The poor surface visibility is brought about by smoke, dust, and other particles that are trapped near the surface and can't rise out of the air mass. A stable air mass can also produce low stratus clouds and fog.



A warm, moist air mass moving over a cold surface produces stable air associated with stratiform clouds, fog, and drizzle.

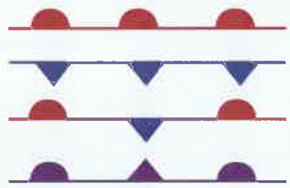
Fronts

An air mass can control the weather for a period ranging from days to months. As air masses move across the Earth, they eventually encounter other air masses with different characteristics. The boundary layer between two distinct air masses is known as a front. The approach of a front signals imminent weather changes.

There are four types of fronts, named according to the temperature of the advancing air mass compared to the air it's replacing:

- Warm Front
- Cold Front
- Stationary Front
- Occluded Front

Symbols for surface fronts and other significant lines shown on the surface analysis chart



* Note: Fronts may be black and white or color, depending on their source. Also, fronts shown in color code will not necessarily show frontal symbols.

Fronts can be detected at ground level in several ways:

Significant temperature gradients exist along fronts, especially on the cold air side.
Winds usually converge, or come together, at fronts.
Pressure typically decreases as a front approaches and increases after it passes.

Fronts have a vertical structure, beginning at the surface of the Earth and extending upward, where the warm air mass slopes over the colder, denser air mass.

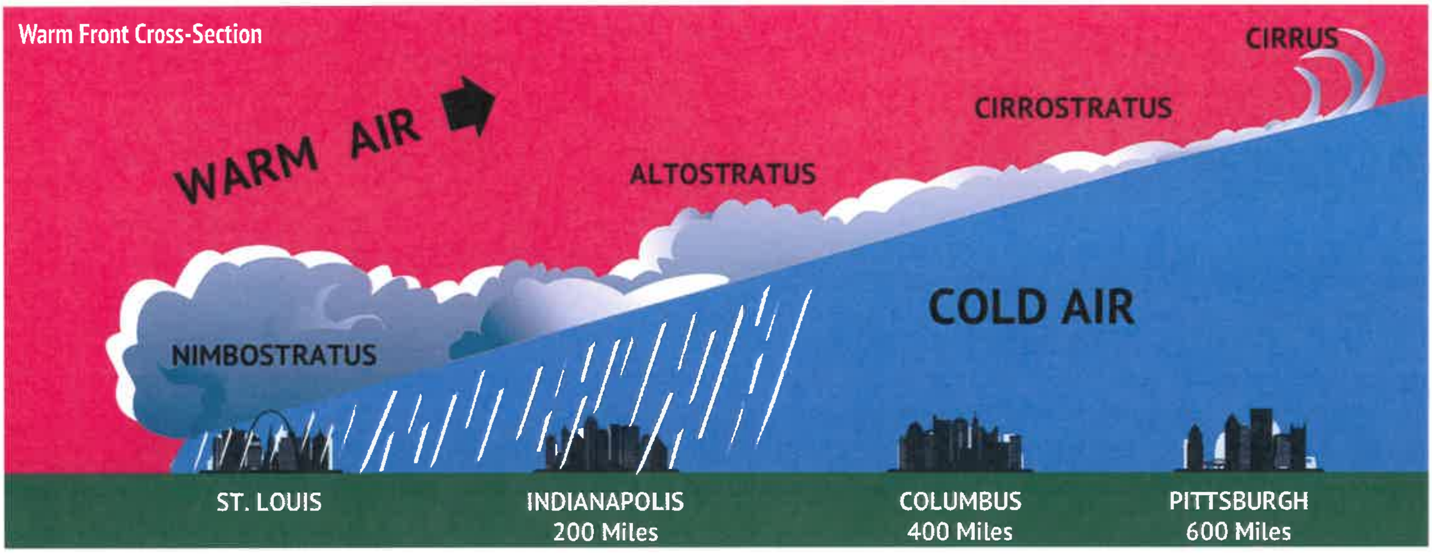
Warm Front

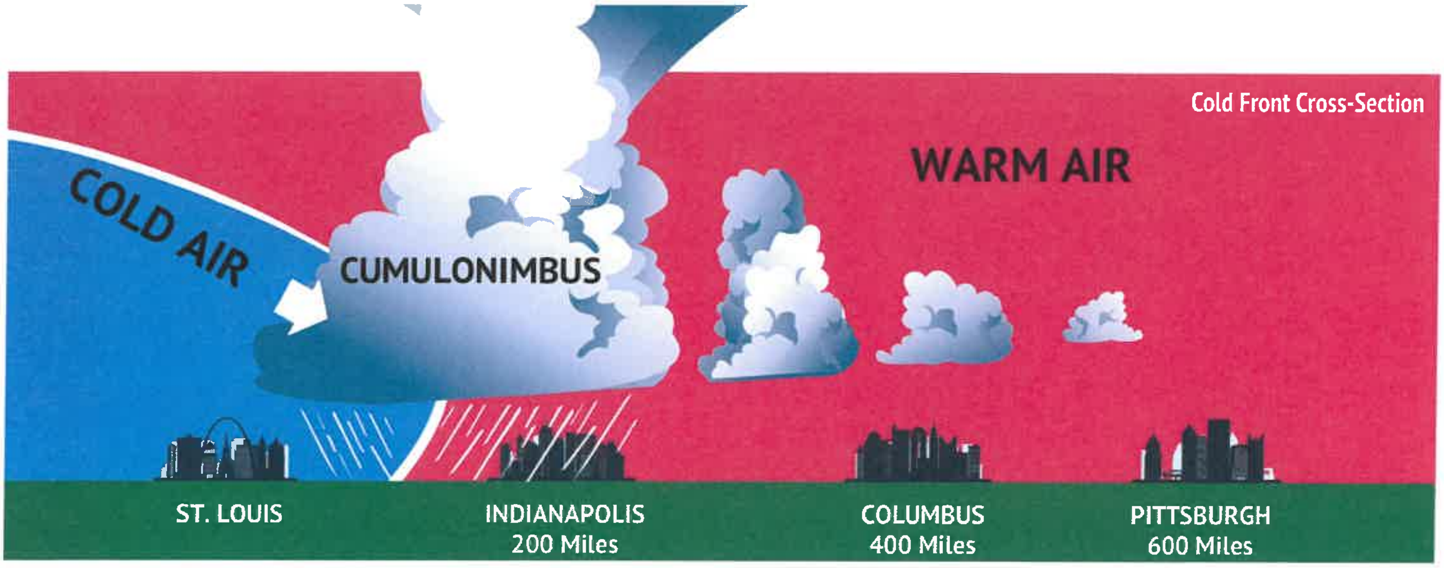
A warm front occurs when a warm air mass replaces a body of colder air. Warm fronts move slowly, typically at speeds of 10 to 25 mph, and often contain a significant amount of humidity. The advancing warm air slides over the cooler air, gradually pushing it out of the area. Warm fronts typically have a gentle slope, which causes the warm air to rise gradually along the frontal surface. This gradual rise favors the development of widespread layered cloudiness and precipitation along and ahead of the front, especially if the warm rising air is stable. These layered clouds can include cirriform or stratiform clouds, along with fog. During the summer months, cumulonimbus clouds (thunderstorms) are likely to develop.

As a warm front approaches, you can expect light to moderate precipitation, often in the form of rain, sleet, snow, or drizzle, which can lead to poor visibility. Winds typically blow from the south-southeast, with cool or cold temperatures and an increasing dew point. The barometric pressure will continue to fall until the front passes completely.

During the passage of a warm front, stratiform clouds are visible, and drizzle may be present. Visibility is generally poor but improves with variable winds. The temperature rises steadily due to the inflow of relatively warmer air. For the most part, the dew point remains steady, and the pressure levels off.

After the passage of a warm front, stratocumulus clouds are common, and rain showers are possible. Visibility eventually improves, although hazy conditions may persist for a short period. Winds shift to blow from the south-southwest. With rising temperatures, the dew point also increases before leveling off. Typically, there is a slight rise in barometric pressure, followed by a decrease.





Cold Front

A cold front occurs when a mass of cold, dense, and stable air advances and replaces a body of warmer air. Due to its higher density, the cold air stays close to the ground and acts like a snowplow, sliding under the warmer air and forcing it aloft. Cold fronts have a steep slope, causing the warm air to rise abruptly. If the rising warm air is unstable, a cold front may generate a narrow band of showers and thunderstorms along, or just ahead of, the front. Cold fronts move at a rate of 25 to 30 mph, much faster than warm fronts, and extreme cold fronts can reach speeds of up to 60 mph.

The rapidly ascending warm air cools suddenly, creating clouds. The type of clouds that develop depends on the stability of the warm air mass. In the Northern Hemisphere, a cold front is typically oriented from northeast to southwest and can extend several hundred miles.

Before a typical cold front passes, cirriform or towering cumulus clouds often appear, and cumulonimbus clouds may develop, potentially causing rain showers. A high dew point and falling barometric pressure are also signs of an imminent cold front.

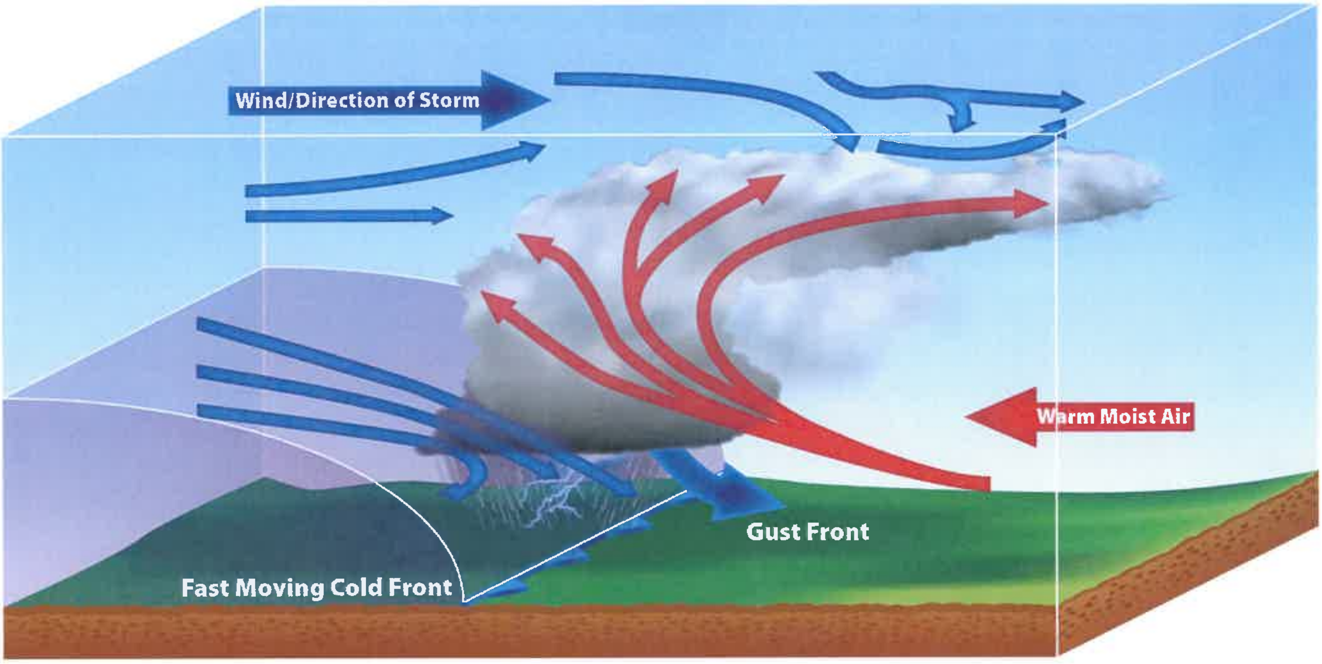
As the cold front passes, towering cumulus or cumulonimbus clouds dominate the sky. Depending on the front's intensity, heavy rain showers may form, often accompanied by lightning, thunder, and/or hail. Severe cold fronts can also produce tornadoes. During the passage, visibility is poor, winds are variable and gusty, and both temperature and dew point drop rapidly. Barometric pressure falls quickly, reaching its lowest point during the frontal passage before beginning a gradual rise. After the cold front passes, the towering clouds dissipate into cumulus clouds, precipitation decreases, and good visibility prevails. Winds shift to the west-northwest, temperatures remain cooler, and barometric pressure continues to rise.

Fast-Moving Cold Front

Fast-moving cold fronts are driven by intense pressure systems located far behind the actual front. The friction between the ground and the cold front slows its movement and creates a steeper frontal surface. This results in a narrow band of concentrated weather along the front's leading edge. If the warm air being overtaken by the cold front is relatively stable, overcast skies and rain may occur for some distance behind the front. If the warm air is unstable, scattered thunderstorms and rain showers may develop. A continuous line of thunderstorms, or a squall line, may form along or ahead of the front. Squall lines present a serious hazard to pilots, as squall-type thunderstorms are intense and fast-moving. After a fast-moving cold front passes, skies usually clear rapidly, leaving behind gusty, turbulent winds and colder temperatures.

Comparison of Cold and Warm Fronts

Warm fronts, cold fronts, and their associated hazards differ significantly in nature. These fronts vary in speed, composition, weather phenomena, and predictability. Cold fronts, which move at 20 to 35 mph, are much faster than warm fronts, which move at only 10 to 25 mph. Cold fronts also have a steeper frontal slope. Violent weather activity is typically associated with cold fronts, with weather usually occurring along the frontal boundary, not ahead of it. However, during the summer months, squall lines can form as far as 200 miles ahead of a severe cold front. While warm fronts bring low ceilings, poor visibility, and rain, cold fronts bring sudden storms, gusty winds, turbulence, and sometimes hail or tornadoes. Cold fronts approach quickly, often with little or no warning, and can cause a complete weather change in just a few hours. After a cold front passes, the weather clears rapidly, and drier air with unlimited visibility prevails. In contrast, warm fronts provide advance warning of their approach and may take days to pass through a region.



Flying can change from mild and fun to dangerous in the matter of a few minutes when a fast-moving cold front is involved. This cross-section shows warm, moist winds flowing towards the front and a gust front pushing out forward of the front.

Wind Shifts

Wind around a high-pressure system rotates clockwise, while winds around a low-pressure system rotate counterclockwise. When two high-pressure systems are adjacent, their winds can oppose each other at the point where they meet. Fronts, which are the boundaries between two pressure areas, are zones where wind shifts frequently occur. These shifts in wind direction are most pronounced in the presence of cold fronts.

Stationary Front

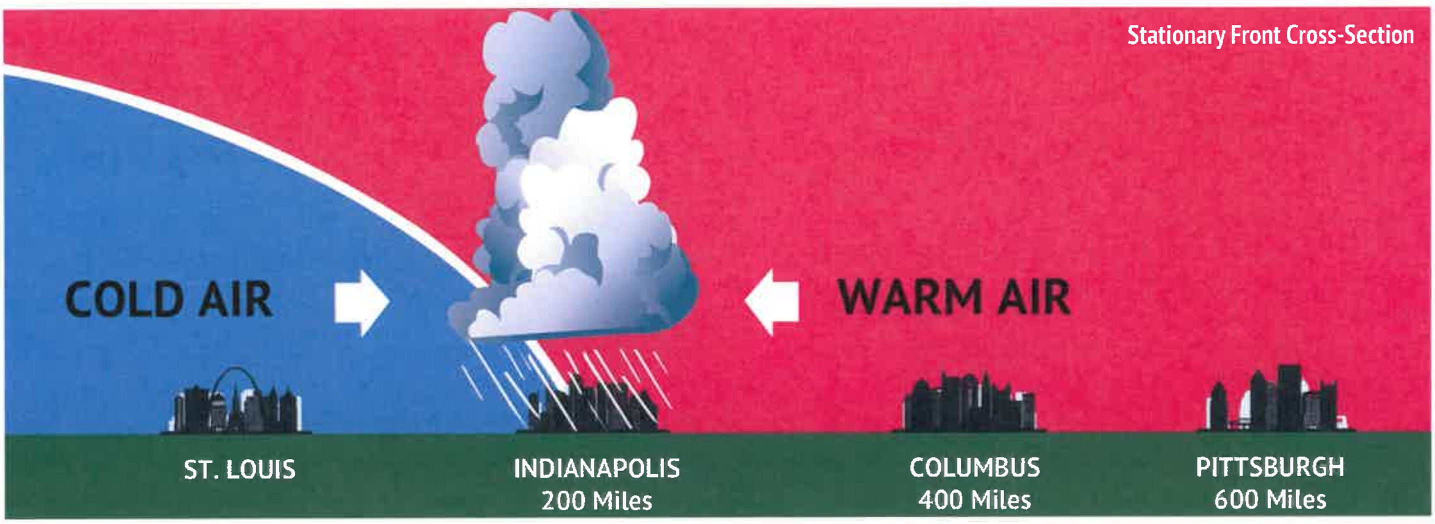
When two air masses have relatively equal forces, the boundary between them remains stationary, leading to a stationary front. This front can influence the local weather for several days. The weather associated with a stationary front often includes a mix of conditions found in both warm and cold fronts, such as extended periods of cloudiness and precipitation.

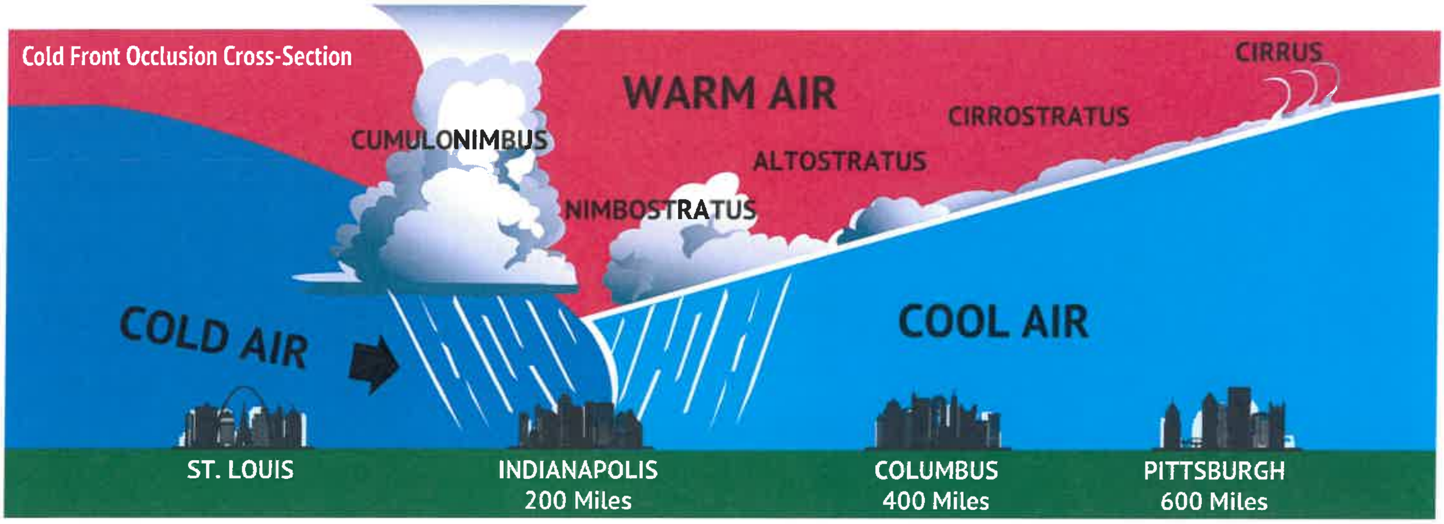
Occluded Front

Cold fronts generally move faster than warm fronts, so over time they can overtake warm fronts, forming an occluded front. When this occurs, the faster-moving cold front undercuts the cooler air mass associated with the warm front, causing the warm air to be lifted even further aloft. Clouds and precipitation can occur in areas of frontal lift, including along, ahead of, and behind the surface position of the occluded front. As the occluded front approaches, the weather typically transitions from warm front conditions to cold front conditions.

There are two types of occluded fronts, defined by the relative temperatures of the colliding air masses and the resulting weather patterns:

Cold Front Occlusion: This occurs when a fast-moving cold front is colder than the air ahead of a slower-moving warm front. In this





scenario, the cold air replaces the cooler air, lifting the warm air mass further aloft. This type of occlusion usually creates a mixture of weather conditions associated with both warm and cold fronts, provided the air is relatively stable.

Warm Front Occlusion: This occurs when the cold air ahead of the warm front is colder than the air associated with the advancing cold front. In this case, the cool air from the advancing cold front rides up and over the cold air in front of the warm front. If the warm air forced aloft by a warm front occlusion is unstable, the resulting weather is often more severe than that found with a cold front occlusion, potentially including thunderstorms, rain, and fog.

Atmospheric Stability

Atmospheric stability can be a difficult thing to wrap your mind around. We could go through a lot of numbers and talk about parcels of air, but that may confuse the issue more than help it. Let's keep it as simple as we can!

Atmospheric stability depends on its ability to resist vertical movement. A stable atmosphere makes vertical air movement difficult and dampens small disturbances, causing them to dissipate. On the other hand, in an unstable atmosphere, small vertical movements can grow, leading to turbulent airflow and convective activity. Instability can result in significant turbulence, extensive vertical clouds, and severe weather.

Rising air expands and cools due to decreasing pressure with altitude, a process known as adiabatic cooling. Conversely, descending air is compressed and warms up, known as adiabatic heating. The adiabatic process occurs in both upward and downward moving air. As air rises into an area of lower pressure, it expands and cools. When air descends, it compresses and warms. The rate of temperature decrease with altitude is called the lapse rate. Typically, the average lapse rate is 2°C (3.6°F) per 1,000 feet.

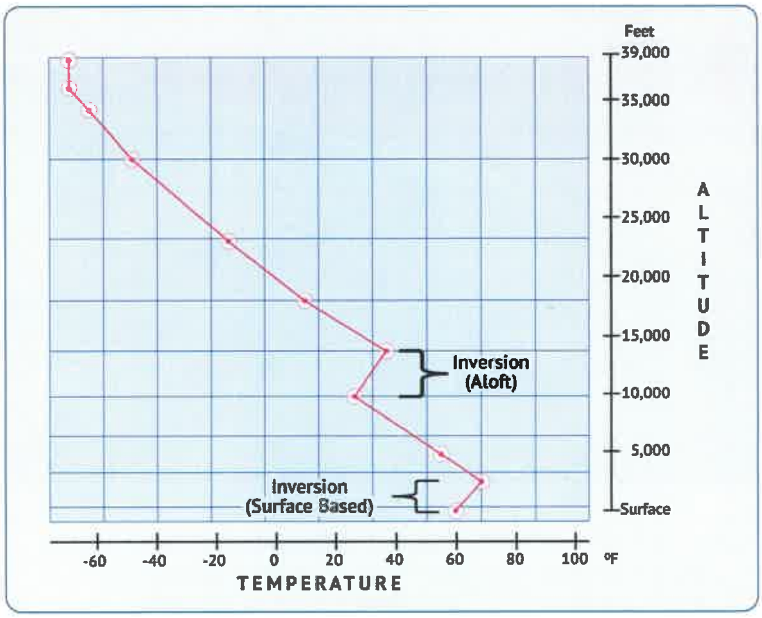
Since water vapor is less dense than dry air, moist air is lighter and rises more easily. Conversely, dry air is denser and tends to sink. Moist air cools at a slower rate than dry air, making it generally less stable. A parcel of moist air must rise higher to reach the temperature of the surrounding air. The dry adiabatic lapse rate (for unsaturated air) is 3°C (5.4°F) per 1,000 feet, while the moist adiabatic lapse rate ranges from 1.1°C to 2.8°C (2°F to 5°F) per 1,000 feet.

The combination of moisture and temperature determines atmospheric stability and the resulting weather. Cool, dry air is very stable and resists vertical movement, generally leading to clear weather. The greatest instability occurs when the air is moist and warm, such as in tropical regions during the summer, which is why these areas experience frequent thunderstorms.

Inversions

As air rises and expands in the atmosphere, the temperature normally decreases. However, sometimes the temperature increases with altitude, which is called a temperature inversion. Inversion layers are commonly shallow layers of smooth, stable air close to the ground. The temperature continues to increase with altitude up to a certain point, known as the top of the inversion. The air at the top of this layer acts as a lid, trapping weather

Stable Air	Unstable Air
Defined by decrease or slow increase of temperature with altitude	Defined by rapid decrease of temperature with altitude
Caused by surface cooling or lack of surface warming	Caused by surface warming
Suppression of rising air	Enhances rising air
May cause sinking air	Hot surface heats the air just above it and causes it to rise.
Smooth Air	Rough Air
Stratiform Clouds or Fog	Cumuliform Clouds
Continuous Precipitation	Storms or Showery Precipitation
Poor Visibility, Haze	Good visibility



Temperature Inversions: Temperature normally decreases with altitude. This graph shows examples of two kinds of temperature inversions where the temperatures increase with altitude.

and pollutants below. If the relative humidity is high, this can lead to the formation of clouds, fog, haze, or prevent smoke from rising, which diminishes visibility within the inversion layer.

Surface-based temperature inversions occur on clear, cool nights when the air close to the ground is cooled by the lowering temperature of the ground. The air within a few hundred feet of the surface becomes cooler than the air above it. This is something that you may often notice while flying a powered parachute early in the morning. It's often cooler near the ground than it is just a couple of hundred feet higher. As you climb or descend through an inversion layer, you will notice both a change in temperature and perhaps some light turbulence.

Frontal inversions occur when warm air spreads over a layer of cooler air, or cooler air is forced under a layer of warmer air.

Moisture and Temperature

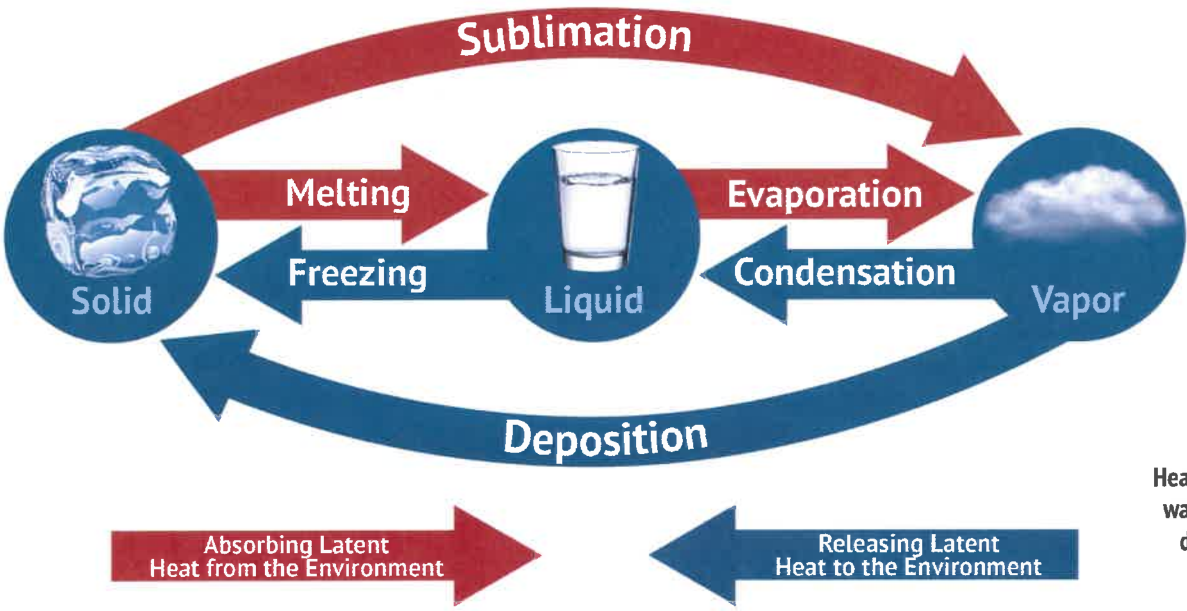
The atmosphere contains moisture in the form of water vapor. The maximum amount of water vapor the atmosphere can hold depends on the air temperature. Every 20°F increase in temperature doubles the amount of moisture the air can hold, while a 20°F decrease cuts the capacity in half.

Water is present in the atmosphere in three states: liquid, solid, and gas. All three forms can readily change to another, and all are present in the atmosphere. Changes in state occur through evaporation, sublimation, condensation, deposition, melting, or freezing. Whenever a change in state occurs, there is an exchange of heat. Water vapor is added to the atmosphere only through evaporation and sublimation.

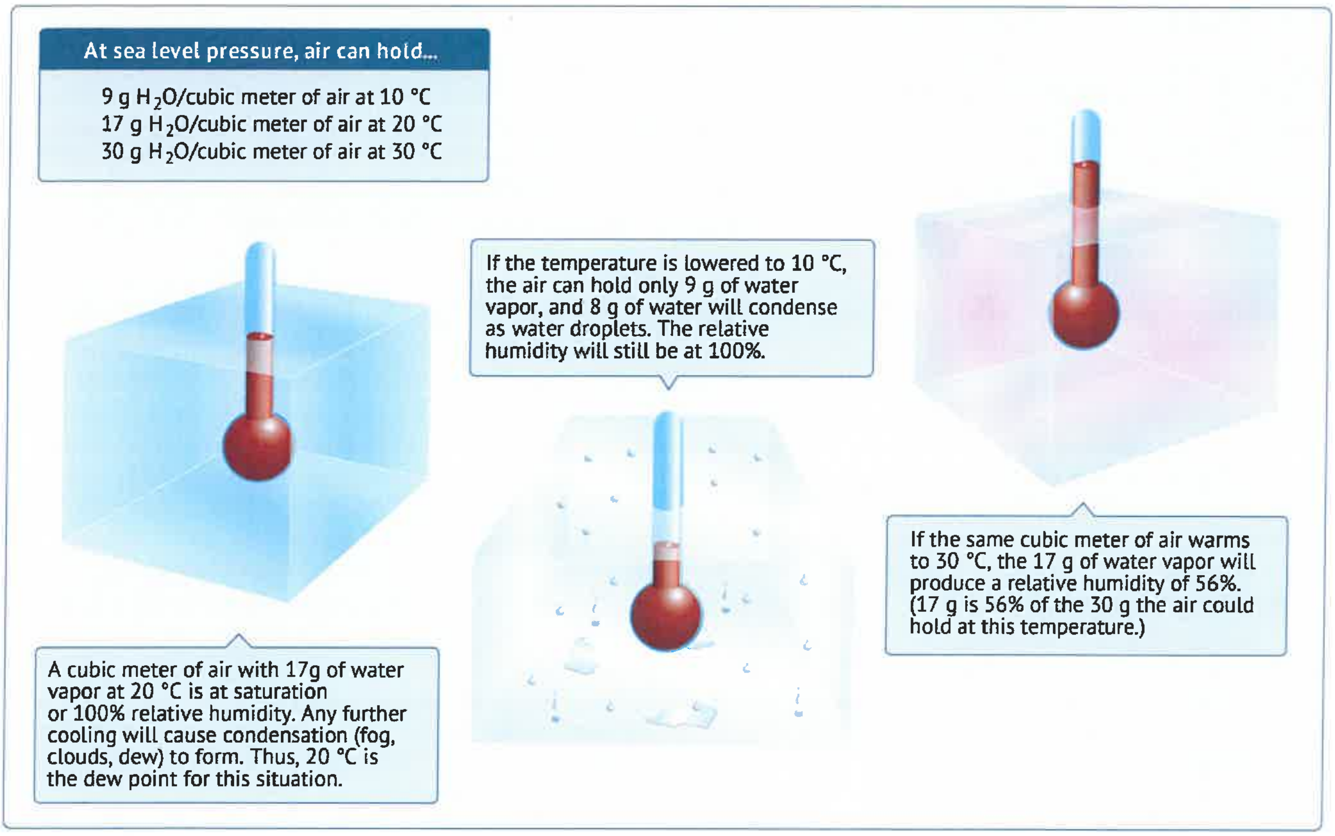
Evaporation is the process of changing liquid water into water vapor. As water vapor forms, it absorbs heat from the nearest available source. This heat exchange is known as the latent heat of evaporation. For example, when the body's perspiration evaporates, it creates a cooling sensation as heat is extracted from the body. Similarly, sublimation is the process of changing ice directly into water vapor, bypassing the liquid stage entirely. Although dry ice is made of carbon dioxide, not water, it still demonstrates sublimation as it turns directly from a solid into vapor.

Relative Humidity

Humidity refers to the amount of water vapor present in the atmosphere. Relative humidity is the actual amount of moisture in the air compared to the total amount of moisture the air could hold at that temperature. For example, if the relative humidity is 65 percent, the air is holding 65 percent of the moisture it could hold at that temperature. While much of the western United States rarely experiences high humidity, relative humidity readings of 75 to 90 percent are not uncommon in the southeastern United States during warmer months.



Heat is exchanged between water and its environment during phase transitions.



The Relationship Between Relative Humidity, Temperature, and Dew point

Temperature/Dew Point Relationship

The relationship between dew point and temperature defines the concept of relative humidity. The dew point, given in degrees, is the temperature at which the air can hold no more moisture. When the temperature of the air is reduced to the dew point, the air is completely saturated and moisture begins to condense out of the air in the form of fog, dew, frost, clouds, rain, hail, or snow.

As moist, unstable air rises, clouds often form at the altitude where temperature and dew point reach the same value. When lifted, unsaturated air cools at a rate of 5.4°F per 1,000 feet and the dew point temperature decreases at a rate of 1°F per 1,000 feet. This results in a convergence of temperature and dew point at a rate of 4.4°F per 1,000 feet. You can apply the convergence rate to the reported temperature and dew point to determine the height of the cloud base.

For example, if the temperature is 85° F and the dew point is 71°F, the calculations for the cloud base would be:

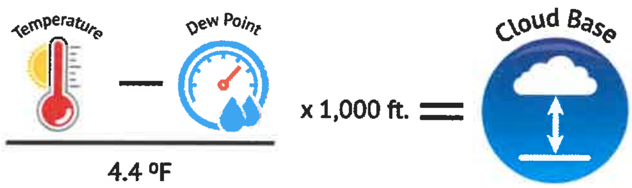
Temperature/dew point spread is

TDS = Temperature - Dew Point

The convergence rate is CR = 4.4 °F

Given: Temperature (T) = 85°F

Given: Dew point (DP) = 71°F



TDS = 85°F - 71°F = 14 °F

Cloud Base = TDS ÷ CR x 1,000 ft
Cloud Base = 14°F ÷4.4°F x 1,000 ft
Cloud Base = 3.18 x 1,000 ft
Cloud Base = 3,180 ft above ground level.

Explanation: With an outside air temperature (OAT) of 85°F at the surface, and dew point at the surface of 71°F, the spread is 14°. Divide the temperature dew point spread by the convergence rate of 4.4°F, and multiply by 1,000 feet to determine the approximate height of the cloud base.

Air Saturation Methods

The formula for cloud base also shows that if the dew point and temperature are equal, the cloud base is at ground level. Clouds at ground level are known as fog. When the temperature and dew point are close together and the air reaches saturation, it's highly likely that fog, low clouds, and precipitation will form. There are four methods by which air can reach complete saturation:

- Warm air moving over a cold surface, causing the air's temperature to drop.
- The mixing of cold and warm air.
- Air cooling at night through contact with the cooler ground.
- Air being lifted or forced upward in the atmosphere.

As air rises, it uses heat energy to expand, leading to rapid cooling. Unsaturated air loses heat at a rate of 3.0°C (5.4°F) for every 1,000 feet of altitude gain. Regardless of the cause, saturated air leads to clouds, rain, and other significant weather events for pilots.

Dew and Frost

On cool, calm nights, the temperature of the ground and objects on the surface can cause the surrounding air to drop below the dew point. When this happens, moisture in the air condenses and deposits itself on the ground, buildings, and objects like cars and aircraft. This moisture is known as dew and is often visible on grass in the morning. If the temperature is below freezing, the moisture will be deposited as frost. While dew and frost pose no threat to your powered parachute, dew will dampen the wing after you lay it out. However, it should dry off shortly after takeoff.

Fog

Fog is a cloud that begins within 50 feet of the surface. When the temperature of air near the ground is cooled to the air's dew point, water vapor in the air condenses and becomes visible in the form of fog. Fog is classified according to how it's formed and is dependent upon the current temperature and the amount of water vapor in the air.

Radiation Fog

On clear nights with little to no wind, radiation fog may develop. This type of fog occurs when the ground cools rapidly at night, causing the surrounding air temperature to reach its dew point. As the sun rises and the temperature increases, radiation fog will lift and eventually dissipate, or "*burn off.*" Any increase in wind will also speed up the dissipation of radiation fog. When radiation fog is less than 20 feet thick, it's known as ground fog.

Radiation fog is relatively shallow but may be dense enough to obscure the entire sky. Factors favoring the formation of radiation fog include:

- A shallow surface layer of moist air beneath a dry layer.
- Clear skies.
- Light surface winds.

Terrestrial radiation cools the ground, which in turn cools the air in contact with it. When the air is cooled to its dew point, fog forms. After rain soaks the ground, followed by clearing skies, radiation fog is common the following morning.

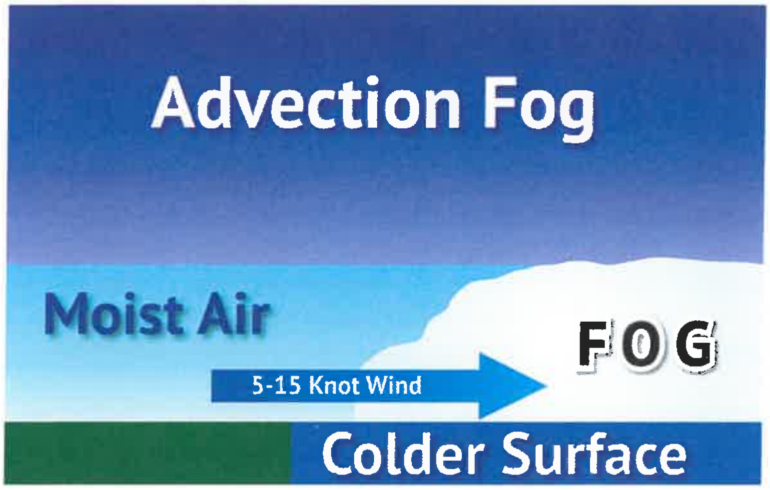
Radiation fog is limited to land because water surfaces cool little from nighttime radiation. Radiation fog remains shallow with calm winds. Winds up to about 5 knots mix the air slightly, deepening the fog by spreading the cooling through a deeper layer. Stronger winds disperse the fog or mix the air through a deeper layer, with stratus clouds forming at the top of the mixing layer.

Ground fog usually burns off quickly after sunrise, while other radiation fog generally clears before noon unless clouds move in. It can be challenging to differentiate between radiation fog and other types, especially since nighttime cooling intensifies all fogs.

Radiation fog occurs when the ground cools rapidly at night and the surrounding air temperature reaches its dew point.

Advection Fog

Advection fog forms when moist air moves over a colder surface and is cooled to below its dew point. It's most common along coastal areas but often moves deep into continental regions. At sea, it's called sea fog. Advection fog deepens as wind speed increases up to about 15 knots.



Advection fog is common in coastal areas where sea breezes can blow the air over cooler landmasses.

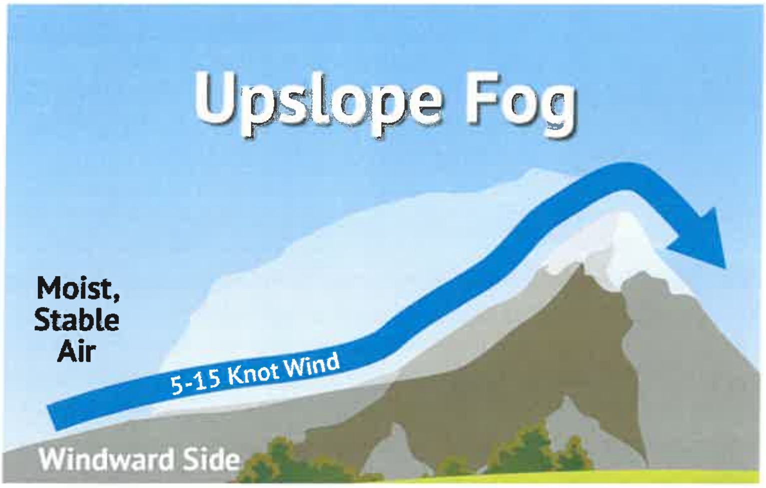
Winds much stronger than 15 knots lift the fog into a layer of low stratus or stratocumulus clouds.

The west coast of the United States is particularly vulnerable to advection fog. This fog frequently forms offshore over cold water and is then carried inland by the wind. It can remain over the water for weeks, advancing over the land during the night and retreating over the water the next morning.

During winter, advection fog over the central and eastern United States occurs when moist air from the Gulf of Mexico spreads northward over cold ground. The fog may extend as far north as the Great Lakes.

Water areas in northern latitudes often experience dense sea fog in the summer due to warm, moist, tropical air flowing northward over colder Arctic waters.

Advection fog is usually more extensive and much more persistent than radiation fog, often lingering in an area for days. It can also move in rapidly, regardless of the time of day or night.

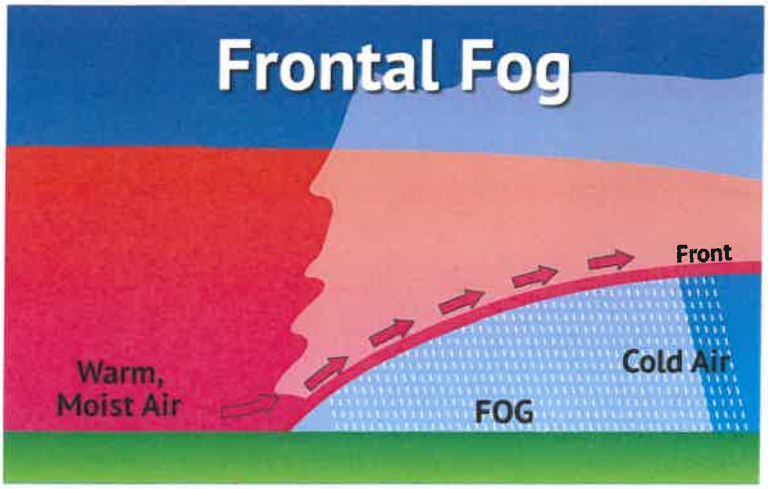


Upslope fog occurs when wind forces moist, stable air up sloping land features like a mountain range.

Upslope Fog

Upslope fog forms when moist, stable air is cooled to or below its dew point as it moves up sloping terrain. Wind speeds of 5-15 knots are most favorable, as stronger winds may lift the fog into a layer of low stratus clouds. Unlike radiation fog, it can form under cloudy skies. Upslope fog is common along the eastern slopes of the Rocky Mountains and, to a lesser extent, east of the Appalachian Mountains. This type of fog is often quite dense and can extend to high altitudes.

Upslope fog may not dissipate with the morning sun but can instead persist for days. It also often extends to greater heights than radiation fog. Wind is required both for its formation and continued existence.



Frontal fog is most associated with warm fronts but can occur with other fronts as well.

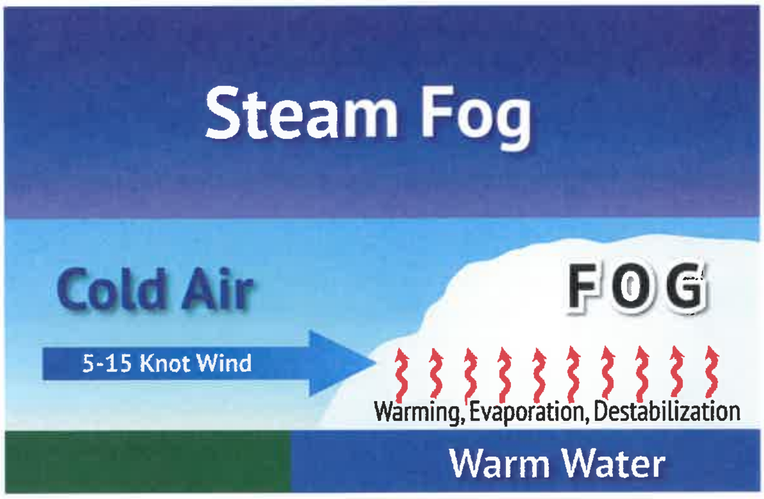
Frontal Fog

When warm, moist air is lifted over a front, clouds and precipitation may form. If the cold air below is near its dew point, evaporation (or sublimation) from the precipitation can saturate the cold air and form fog. This type of fog is called frontal or precipitation-induced fog. The result is a continuous zone of condensed water droplets extending from the ground up through the clouds. Frontal fog can become quite dense and persist for an extended period, potentially covering large areas and completely suspending air operations.

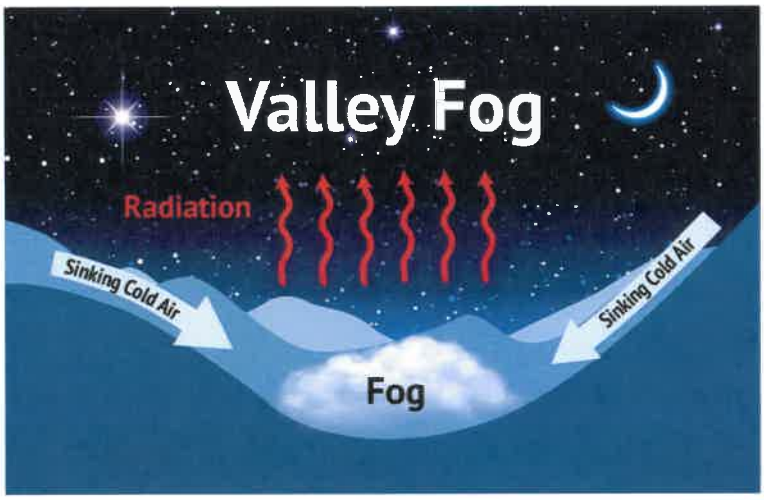
Steam Fog

When cold, dry air moves across relatively warm water, enough moisture may evaporate from the water surface to produce saturation. As the rising water vapor meets the cold air, it immediately recondenses and rises with the air that is being warmed from below. Because the air is destabilized, fog appears as rising filaments or streamers resembling steam. This phenomenon is commonly observed over lakes and streams on cold autumn mornings, and over the ocean during winter when cold air masses move off continents and ice shelves. Steam fog is often very shallow, as the steam rises and re-evaporates into the unsaturated air above. However, it can be dense and extend over large areas.

Steam fog is associated with a shallow layer of unstable air. On occasion, columns of condensed vapor rise from the fog layer, forming whirling steam devils, which resemble the dust devils seen on land.



Steam fog, or sea smoke, forms when cold, dry air moves over warm water.



Mountain/Valley Fog forms when denser, cooler air on mountaintops sinks into valleys overnight.

Mountain/Valley Fog

Mountain/valley fog occurs in areas of variable terrain. It forms overnight as heat is released into the air near ground level, causing the ground to cool. The denser, cooler air on mountaintops sinks into valleys and collects there. Overnight, the valley fills with cold layers of air, a phenomenon known as *"cold air drainage."* This cooler air lowers the surrounding air temperature closer to the dew point, leading to saturation. If there is sufficient moisture in the air, fog will begin to form in these valleys as the night progresses. This type of fog is most commonly observed in the autumn and spring months and is densest around sunrise when surface temperatures are often the lowest.

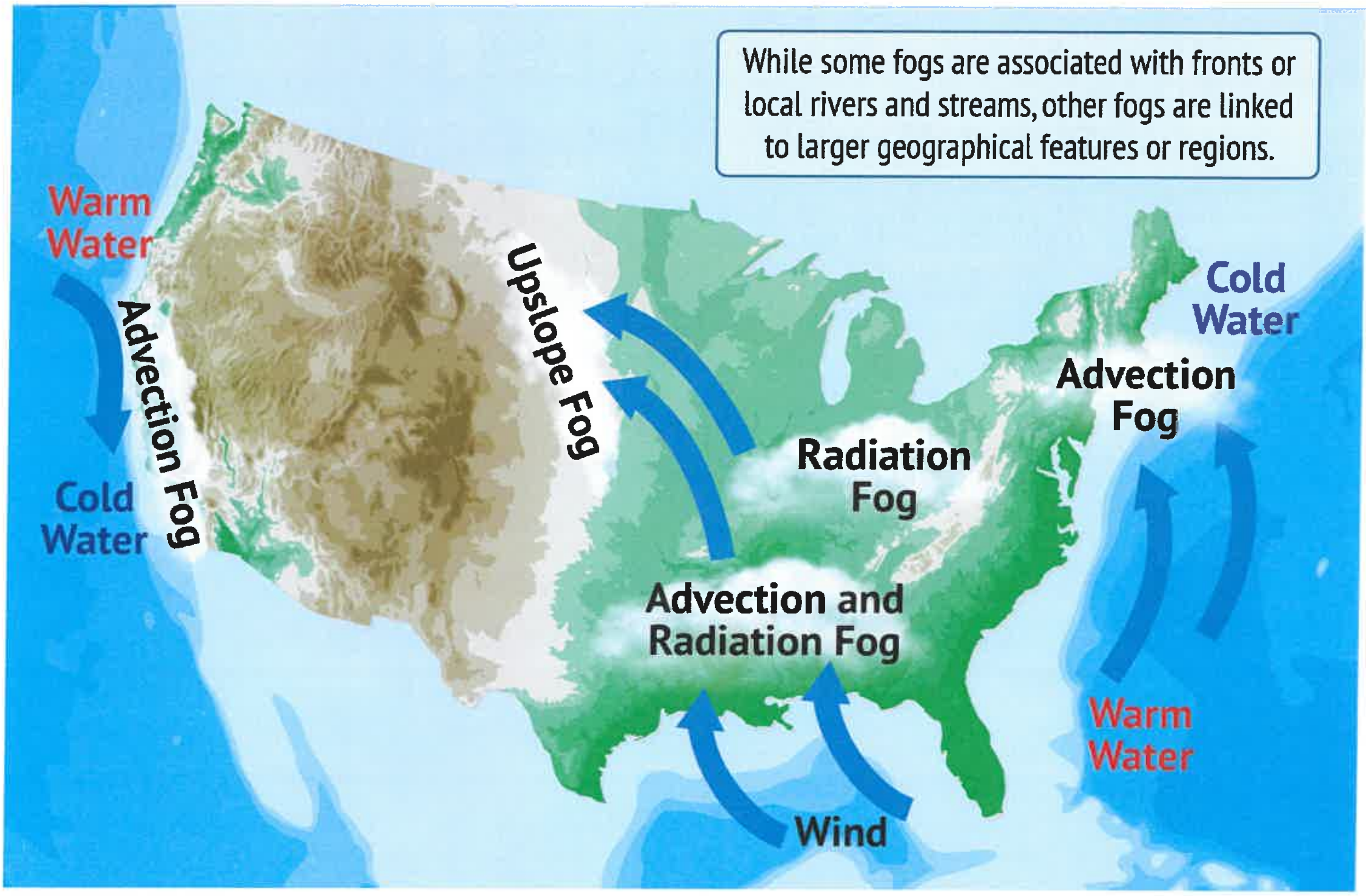
Freezing Fog

Freezing fog occurs when the temperature falls to 32°F (0°C) or below. Tiny supercooled liquid water droplets in the fog can freeze instantly on exposed surfaces when surface temperatures are at or below freezing. These droplets may freeze on surfaces such as tree branches, stairs and rails, sidewalks, roads, and vehicles, creating a layer of ice.

This phenomenon is distinct from *"frost,"* which forms through direct deposition of water vapor onto surfaces when temperatures are below freezing

Ice Fog

Ice fog occurs in extremely cold weather when the temperature is well below freezing, causing water vapor to form directly into ice crystals. The conditions favorable for its formation are similar to those for radiation fog, with the key difference being the cold temperature, usually −25°F or colder. Ice fog is most common in arctic regions, but it can also occur in middle latitudes during the cold season.



Geographical Patterns for Fog

There is a clear geographical pattern to the formation of different types of fog. Radiation fog is widespread across much of the country since it doesn't require specific landscape features like mountains or oceans to develop. Advection fog commonly forms along coastlines, where air that originates over warm water travels over cooler water or land surfaces. Upslope fog is prevalent in the western Great Plains and along the eastern slopes of the Rocky Mountains, where warm, moist air, often from the Gulf of Mexico, moves toward higher elevations.

Haze

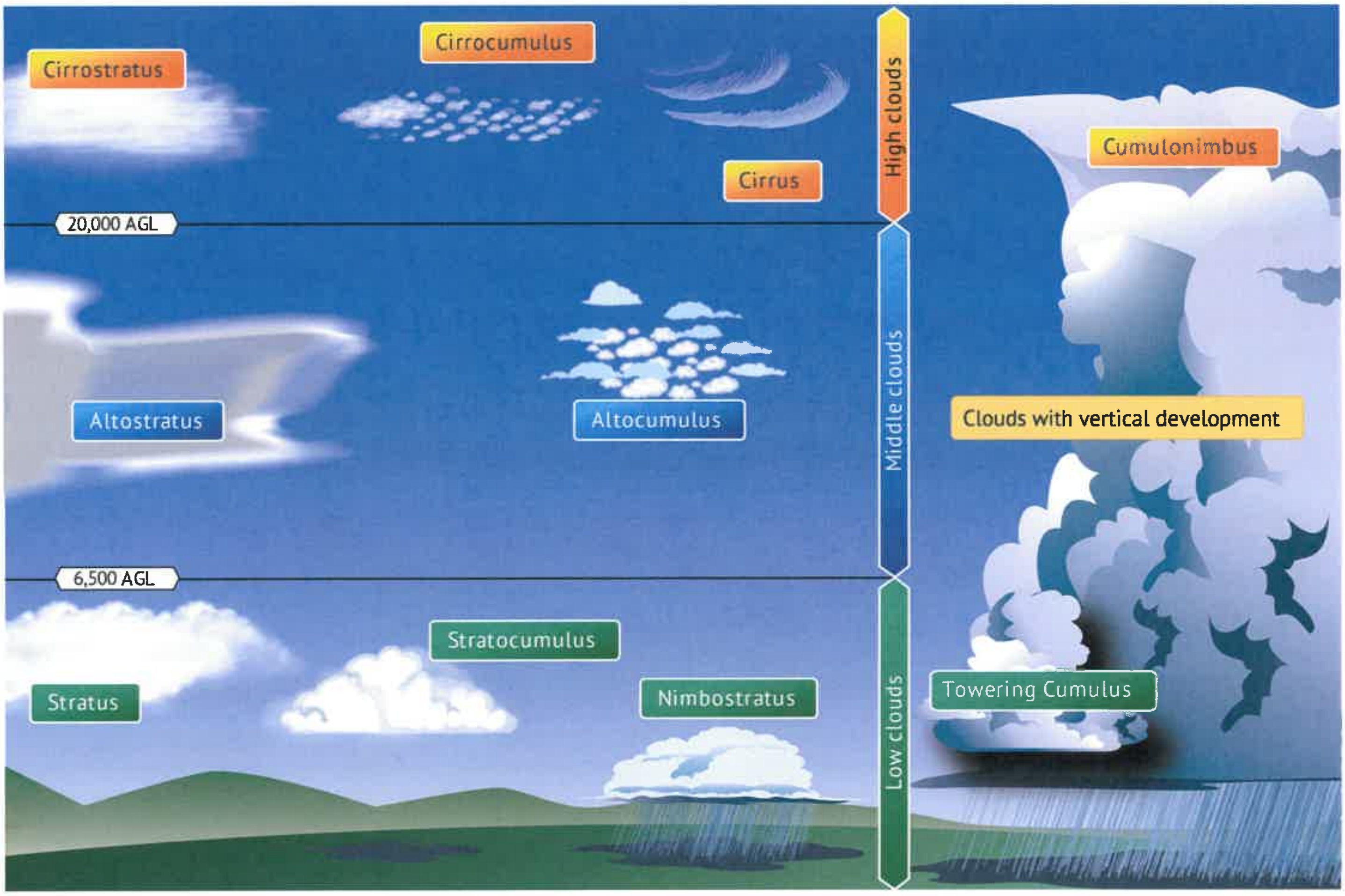
Haze is a suspension of extremely small particles in the air, invisible to the naked eye, yet numerous enough to give the air a blue or yellow tint. It reduces visibility by scattering the shorter wavelengths of light. Haze appears bluish when viewed against a dark background and yellowish when viewed against a light background, distinguishing it from mist, which produces only a gray obscuration. Some haze particles increase in size as relative humidity rises, further decreasing visibility. While visibility measures how far one can see, including the ability to discern textures and colors, haze reduces the clarity of the scene.

Haze occurs in stable air and is usually only a few thousand feet thick, but it may extend upwards to 15,000 feet. A haze layer has a definite ceiling, above which in-flight (air-to-air) visibility is unrestricted. At or below this level, air-to-ground visibility is poor. You will find that the same layer of haze can affect your visibility differently, depending on whether you're facing into or away from the Sun.

Mist

Mist is a visible aggregate of minute water droplets or ice crystals suspended in the atmosphere, reducing visibility to between 5/8 and 7 statute miles. It forms a thin grayish veil over the landscape, similar to fog but less obstructive to visibility.

Mist may be considered an intermediate between fog and haze, with a relative humidity of 95 to 99 percent. However, the distinction between fog, mist, and haze is not always clear-cut.



Clouds

Clouds provide insight into current and future weather conditions, indicating factors such as wind, turbulence, updrafts, and potential rain. For clouds to form, there must be adequate water vapor, condensation nuclei (tiny particles in the air), and a method by which the air can be cooled. When the air cools to its saturation point, invisible water vapor condenses or sublimates onto the condensation nuclei, which are tiny particles like dust, salt, and smoke. The nuclei are important because they provide a means for the moisture to change state from gas into a liquid or solid.

Cloud types are determined by height, shape, and behavior. They are classified by the height of their bases as low, middle, or high clouds, as well as clouds with vertical development.

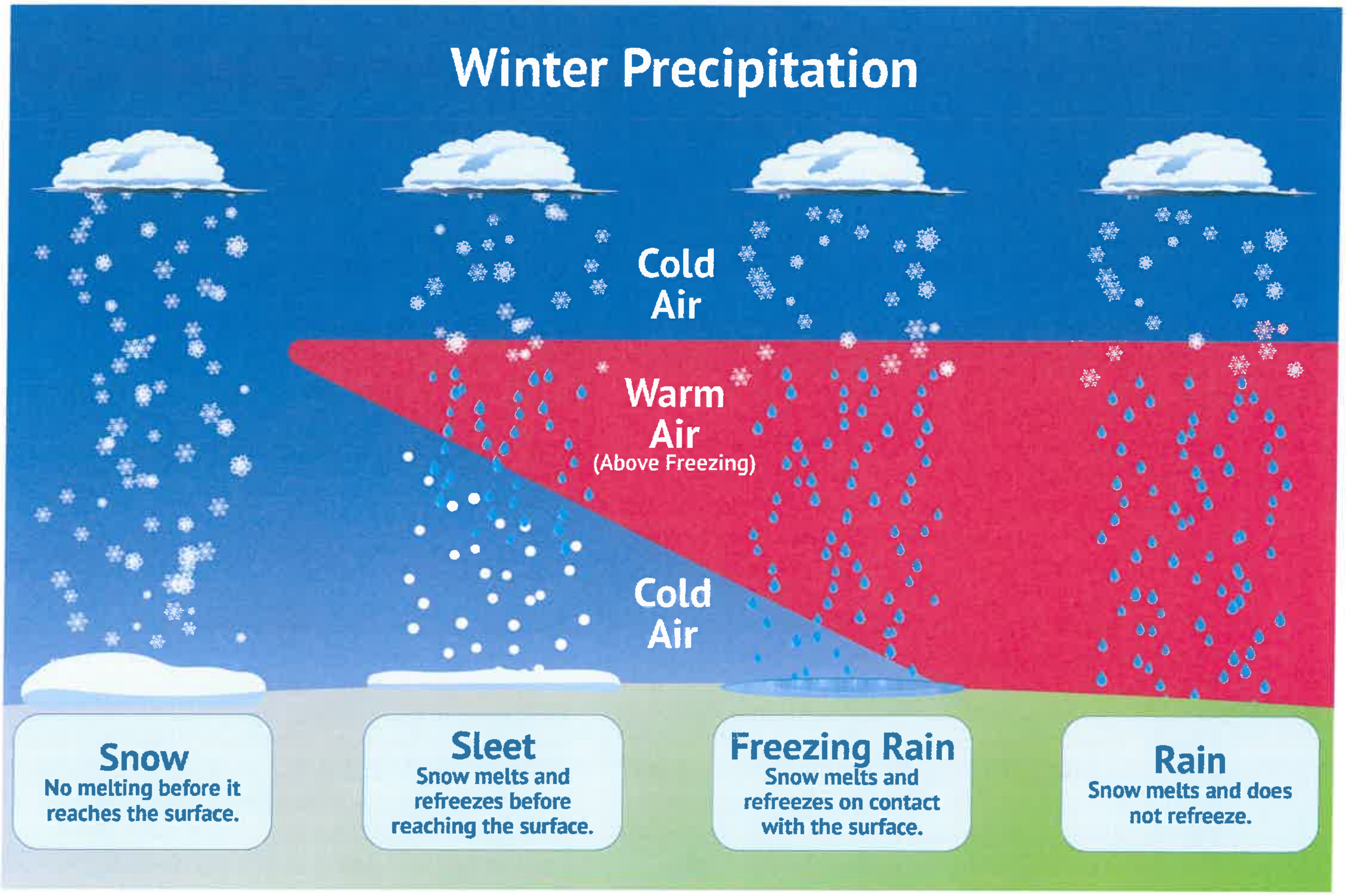
Low Clouds form near the Earth's surface and extend up to 6,500 feet AGL. They're primarily composed of water droplets. Typical low clouds include stratus, stratocumulus, and nimbostratus. Fog is also considered a type of low cloud formation. These clouds create low ceilings, hinder visibility, and can change rapidly, affecting flight planning and potentially making VFR flight impossible.

Middle Clouds form around 6,500 feet AGL and extend up to 20,000 feet AGL. They consist of water, ice crystals, and supercooled water droplets. Common middle-level clouds are altostratus and altocumulus. Altostratus clouds form as a result of extensive lifting of air, often ahead of a warm front or other weather systems, and can bring light, continuous precipitation, such as drizzle or snow. Altocumulus clouds can sometimes produce light turbulence and may contain some icing.

High clouds form above 20,000 feet AGL, typically in stable air, and are composed of ice crystals. Cirrus, cirrostratus, and cirrocumulus are common high-level clouds.

Clouds with Vertical Development start as cumulus clouds and can develop into towering cumulus or cumulonimbus clouds. Their bases form in the low to middle cloud regions, but they can extend into high-altitude cloud levels.

Towering Cumulus Clouds indicate atmospheric instability and the air around and inside them is turbulent. These clouds contain large amounts of moisture and unstable air and can evolve into cumulonimbus clouds, leading to thunderstorms, which can produce hazardous weather phenomena such as lightning, hail, tornadoes, gusty winds, and wind shear. When these clouds are obscured by other formations, they are known as being embedded.



Cumulonimbus Clouds are the most dangerous cloud type for flying and can appear individually, in groups, or as part of a squall line. These clouds, formed by rising air currents, are extremely turbulent and can produce severe weather conditions, including updrafts and downdrafts exceeding 3,000 feet per minute, large hailstones, lightning, tornadoes, heavy rainfall, and freezing conditions.

Cloud classification can be further broken down by appearance and composition. Knowing these terms can help identify visible clouds.

Cumulus: Heaped or piled clouds.
Stratus: Layered clouds.
Cirrus: Fibrous clouds, typically high-level clouds above 20,000 feet.
Castellanus: Clouds with a common base and separate vertical development, resembling castles.
Lenticularis: Lens-shaped clouds formed over mountains in strong winds.
Nimbus: Rain-bearing clouds.
Fractus: Ragged or broken clouds.
Alto: Middle-level clouds existing at 5,000 to 20,000 feet, though the term *"alto"* also means high.

Precipitation

Precipitation refers to any type of water particles that form in the atmosphere and fall to the ground. Depending on its form, precipitation can reduce visibility, create icing conditions, and affect the landing and takeoff performance of an aircraft.

Precipitation occurs when water or ice particles in clouds grow until the atmosphere can no longer support them. As it falls toward the Earth, precipitation can take various forms, including drizzle, rain, ice pellets, hail, snow, and ice.

Drizzle consists of very small water droplets, smaller than 0.02 inches in diameter, often accompanying fog or low stratus clouds.
Rain consists of water droplets larger than 0.02 inches in diameter. Rain that evaporates before reaching the ground is known as virga, and the air below virga can be very turbulent.
Freezing Rain and Freezing Drizzle occur when surface temperatures are below freezing, causing the rain to freeze on contact with the cooler surface.
Ice Pellets may form when rain falls through a temperature inversion and freezes as it passes through the underlying cold air. Ice pellets are an indication of a temperature inversion and that freezing rain exists at a higher altitude.

Hail forms when freezing water droplets are carried up and down by drafts inside cumulonimbus clouds, growing larger as they encounter more moisture. Once the updrafts can no longer support the freezing water, hail falls to the ground. Hail can range in size from peas to over five inches in diameter, larger than a softball.

Snow is precipitation in the form of ice crystals, varying in size from small grains to large flakes. Snow grains are the equivalent of drizzle in size.

Precipitation in any form poses a threat to your safety. It's often accompanied by low ceilings and reduced visibility. Ice, snow, or frost can form on an air filter, preventing air from entering the engine. Rain can also lead to water contamination in fuel tanks and create hazards on the runway, making takeoffs and landings challenging.

Powered parachute pilots have flown in light rain. However, rain stings your bare skin since the droplets could be hitting you at over 30 mph. Rain also affects the parachute both during and after a flight. Water can enter the leading edge of the parachute, pool in the tail of the wing, and contribute to a metastable stall. After flying in the rain, you must dry out the wing within a couple of days to prevent mildew, especially if the parachute is stored in warm conditions.

Thunderstorms

A thunderstorm progresses through three distinct stages before dissipating. It begins with the **cumulus stage**, where lifting action of the air occurs. If enough moisture and instability are present, the clouds increase in height, and strong updrafts prevent moisture from falling. Within about 15 minutes, the storm reaches the **mature stage**, the most violent phase. At this point, moisture, whether in the form of rain or ice, becomes too heavy for the cloud to support and falls as precipitation, creating a downward airflow known as a downdraft. In this stage, warm, rising air (updrafts) and cool, precipitation-induced downdrafts coexist, producing violent turbulence within and near the cloud. Below the cloud, the downrushing air increases surface winds and lowers the temperature. As the vertical motion near the cloud top slows, the cloud spreads out into an anvil shape, marking the transition to the **dissipating stage**, where downdrafts dominate and replace the updrafts that sustained the storm.

Thunderstorms are classified based on how they form and their weather patterns.

Air Mass Thunderstorms develop due to surface heating. As the ground warms, the heated air rises, causing localized convection that can trigger thunderstorms. Air mass thunderstorms often occur randomly in unstable air, typically lasting for an hour or two. They are generally characterized by moderate wind gusts and rainfall.

Orographic Thunderstorms form when air is forced upward by the slopes of mountains or high terrain. The rising air cools as it ascends, leading to condensation and cloud formation. These thunderstorms are common in mountainous regions and are triggered primarily by the topography of the land.

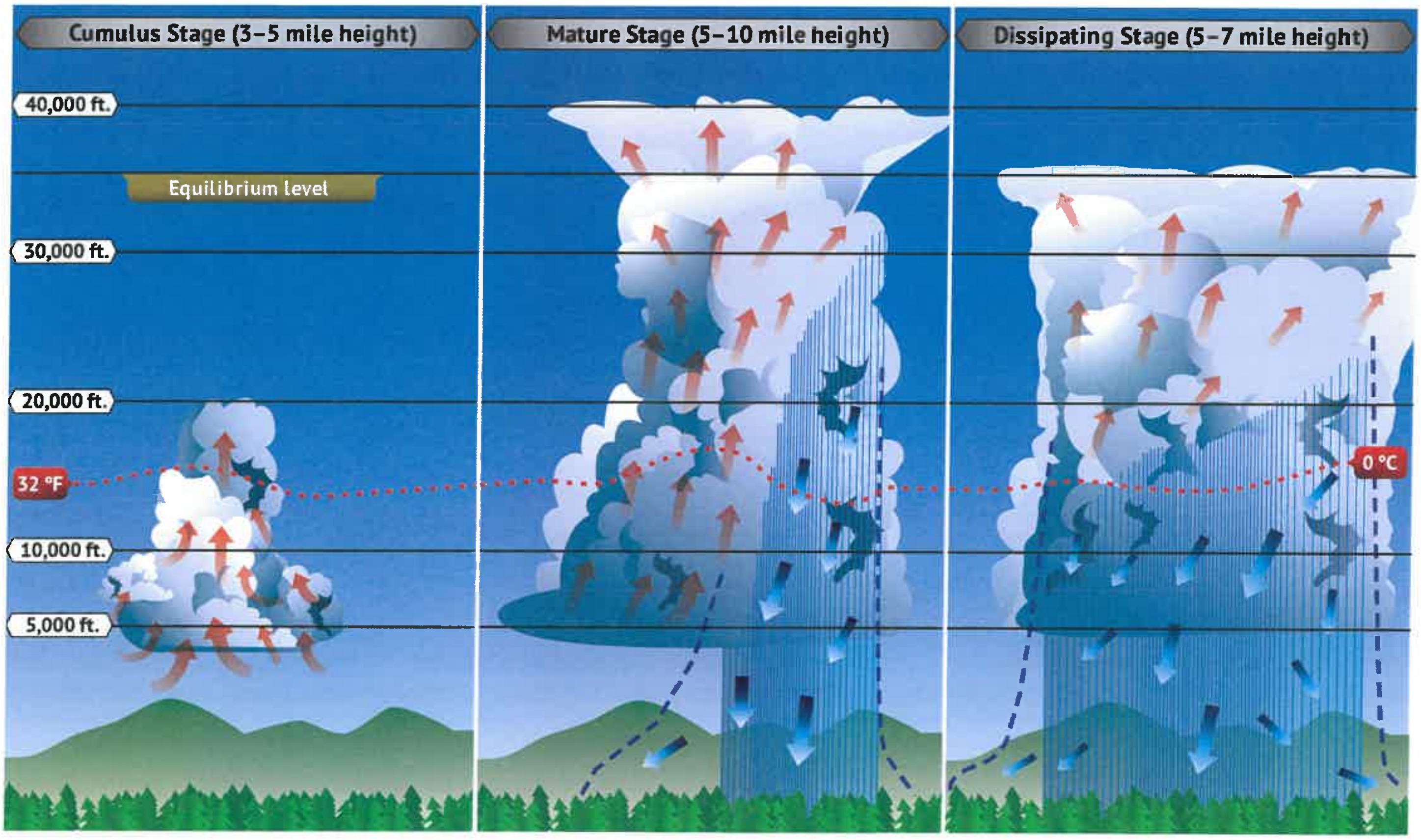
Squall Lines are narrow, continuous bands of active thunderstorms, often forming along or ahead of cold fronts in moist, unstable air. However, they can also develop far from any front in similarly unstable conditions. These lines of cumulonimbus clouds can stretch for hundreds of miles, producing severe weather, including heavy rainfall, hail, violent winds, and intense turbulence. Squall lines are typically too long to detour around and too wide and severe to penetrate safely.

Squall lines often contain steady-state thunderstorms, making them one of the most intense weather hazards for aircraft. They tend to form rapidly and reach peak intensity in the late afternoon or early evening. You may face strong wind gusts, wind shear, and dangerous turbulence when encountering squall lines, making them particularly hazardous for flight operations.

Steady-State Thunderstorms are associated with weather systems such as fronts and converging winds, these storms feature more sustained updrafts than air mass storms and often last longer. They frequently form squall lines and can be much more severe due to their organization and longevity.

Supercell Thunderstorms: are the most dangerous type of thunderstorm, supercells are characterized by a rotating updraft that allows them to persist for hours. Supercells are well-organized and capable of producing severe weather, including large hail, damaging winds, and tornadoes. Updraft speeds can reach up to 9,000 feet per minute (100 knots), which significantly amplifies their destructive power. About 25 percent of supercells result in tornadoes, making them particularly hazardous for pilots.

For a thunderstorm to form, three conditions must exist: sufficient water vapor, an unstable lapse rate, and an initial lifting force to start the storm process. Knowledge of these different types of thunderstorms and their associated hazards is essential for flight safety.



The life cycle of a thunderstorm includes the Cumulus, Mature, and Dissipating stages.

Thunderstorm Hazards

Flying over thunderstorms in a powered parachute is impossible, as severe storms can reach altitudes of 50,000 to 60,000 feet, depending on the latitude. Flying beneath a thunderstorm is equally dangerous, as it exposes you to intense weather phenomena such as heavy rain, large hail, damaging lightning, and violent turbulence. A general rule for safety is to avoid flying within 20 nautical miles of severe thunderstorms or those showing extreme radar echoes, as hail may fall miles from the storm core. When thunderstorms are nearby, it's safest to land and remain grounded until the storm has passed.

All thunderstorms present significant hazards to aviation. The turbulent air currents within cumulonimbus clouds make them especially dangerous. If your powered parachute is caught in a thunderstorm, you could encounter violent updrafts and downdrafts exceeding 3,000 feet per minute. Additionally, you may be exposed to large hailstones, damaging lightning, tornadoes, and freezing conditions. These hazards often occur in various combinations, and it's impossible to visually identify which specific threats a thunderstorm contains. Gust fronts, often forming miles ahead of the storm, can also cause sudden, severe turbulence, catching you off-guard.

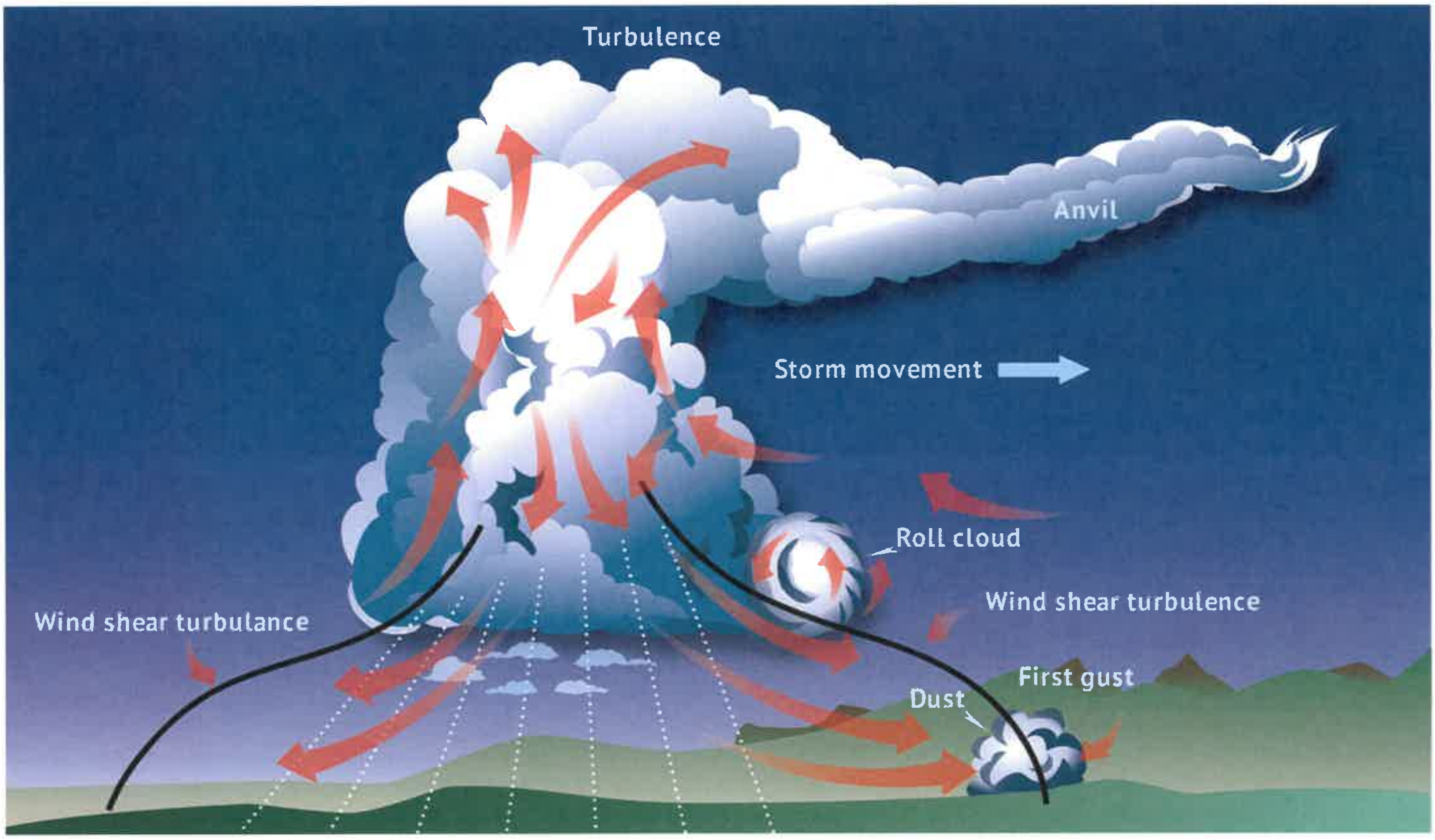
Given the unpredictability and intensity of these conditions, avoiding thunderstorms altogether is essential for flight safety. It's crucial to stay grounded until the storm has completely passed.

Tornadoes

The most violent thunderstorms aggressively draw air into their cloud bases. If the incoming air has any rotational motion, it can form a highly concentrated vortex that extends from the surface well into the cloud. Meteorologists estimate that wind speeds within such a vortex can exceed 200 knots, and the pressure inside the vortex is significantly low. The strong winds collect dust and debris, while the low pressure forms a funnel-shaped cloud descending from the cumulonimbus base. If the funnel cloud does not reach the surface, it remains a funnel cloud; if it touches land, it becomes a tornado; and if it touches water, it's called a waterspout.

Tornadoes can occur with both isolated thunderstorms and squall lines. However, over 80 percent of all tornadoes in the United States are produced by supercell thunderstorms. Any reports or forecasts of tornadoes indicate that atmospheric conditions are favorable for violent turbulence. An aircraft encountering a tornado vortex is almost certain to experience loss of control and severe structural damage.

Tornadoes may also form in *"families"* as appendages of the main cloud, extending several miles outward from areas of lightning and precipitation. As a result, any cloud associated with a severe thunderstorm carries the potential for violent weather.



Movement and turbulence of a maturing thunderstorm.

Turbulence

Potentially hazardous turbulence is present in all thunderstorms, and severe thunderstorms can destroy an aircraft. The strongest turbulence within the cloud occurs where wind shear exists between updrafts and downdrafts. Turbulence has also been encountered several thousand feet above and up to 20 miles laterally from severe storms. Near the surface, a low-level turbulent zone forms in the shear area of the gust front. A *"roll cloud"* often marks the top of this turbulent zone and signals extreme turbulence. Gust fronts may move up to 15 miles ahead of a storm's precipitation, causing rapid and sometimes drastic changes in surface wind.

Icing

Thunderstorm updrafts carry abundant liquid water, often in large droplets, above the freezing level. As temperatures cool to around −5°F, much of the water vapor sublimates into ice crystals. At lower temperatures, the amount of supercooled water decreases. Supercooled water freezes on impact, and in an open-cockpit aircraft like a powered parachute, icing poses a serious hazard, as paraglider pilots caught in thunderstorms have found to their peril.

Hail

Hail competes with turbulence as one of the greatest thunderstorm hazards to aircraft. Supercooled water droplets freeze as they are carried upward, with additional droplets attaching and freezing to form hailstones, sometimes growing into massive ice balls. Large hailstones occur in severe thunderstorms with strong updrafts. Hail can fall miles from the storm core and may even be encountered in clear air. Hailstones larger than half an inch in diameter can cause significant damage to an aircraft.

Ceiling and Visibility

Visibility within a thunderstorm cloud is typically near zero. Precipitation and dust between the cloud base and the ground further reduce ceiling and visibility. These reductions create the same problems as other low visibility situations, but they are far more dangerous when combined with the turbulence, hail, and lightning typical of thunderstorms.

Lightning

A lightning strike can puncture the skin of an airplane. If you're flying a powered parachute, you have more sensitive concerns. Although lightning has been suspected of igniting fuel vapors and causing an explosion, serious accidents due to lightning strikes are rare. Nearby lightning can blind you, rendering you momentarily unable to navigate either by instrument or by visual reference. Lightning discharges, even distant ones, can disrupt radio communications on low and medium frequencies. Though lightning intensity and frequency have no simple relationship to other storm parameters, severe storms, as a rule, have a high frequency of lightning.

Chapter 13
Wind and Turbulence

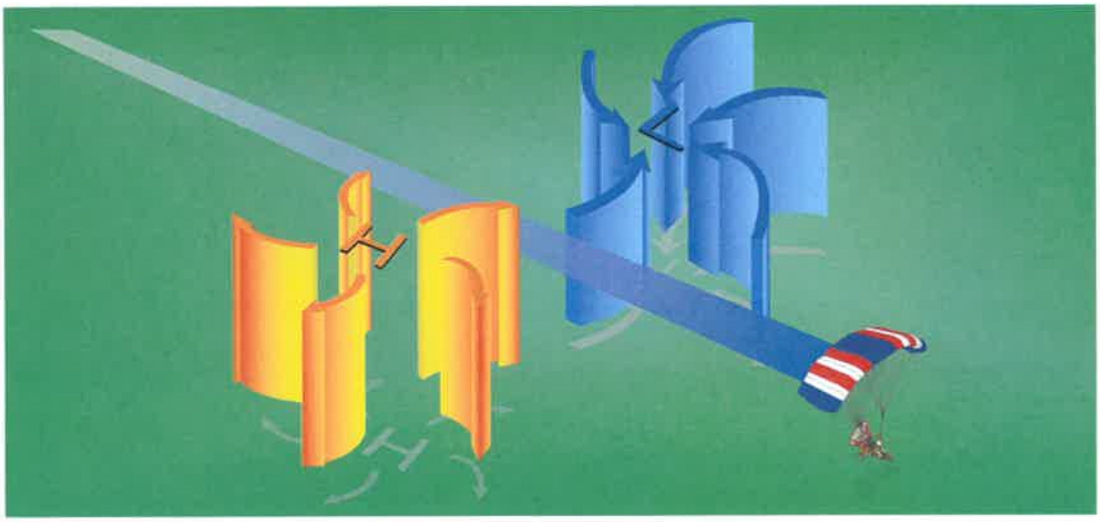
As powered parachute pilots, we generally aren't that concerned about atmospheric circulation, certainly not on the grand global scale. It's good to know that as the Big Light in the Sky heats the earth up unevenly, it produces pressure and temperature changes around our planet and those changes produce two kinds of motion in the atmosphere—vertical movement of ascending and descending currents, and horizontal movement in the form of wind. On a planetary scale, wind is what pushes masses of air around and causes weather. On a personal scale, wind will push you around in the sky, sometimes unmercifully. That personal scale is what the FAA calls *"local winds"* and that's what we're going to focus on most in this chapter.

In fact, while the theory of circulation and wind patterns is mostly accurate for large-scale atmospheric circulation; it doesn't consider changes to the circulation on a local scale. Local conditions, geological features, and other anomalies can change the wind direction and speed close to the Earth's surface where we do most of our flying.

Wind Patterns

Air flows from areas of high pressure into areas of low pressure because air always seeks out lower pressure. In the Northern Hemisphere, this flow of air from areas of high to low pressure is deflected to the right, producing a clockwise circulation around an area of high pressure. This is also known as anti-cyclonic circulation. The opposite is true of low-pressure areas; the air flows towards a low and is deflected to create a counterclockwise or cyclonic circulation. A lot goes into why this happens and if you want to learn more, the FAA's Aviation Weather Handbook is a good place to go.

Circulation/Wind patterns around areas of high and low pressure.



Favorable winds near a high-pressure system.

Sensitivity to Wind

Powered parachutes are affected by winds more than any other powered aircraft. This is both directly and indirectly related to the speed of the aircraft. A powered parachute has a far slower speed than most powered aircraft, while at the same time having a wing area as great as three times larger than a Cessna 172. That means that a powered parachute's wing loading is also very low, 1.9 lbs per ft² vs. the Cessna's 14.1 lbs per ft². That makes a powered parachute's wing loading less than 1/7th of one of the most common light airplanes built.

Airspeed and wing loading translate directly to a sensitivity to winds. A wind of 11 mph is not a big deal to an airplane pilot, but it is one third of the forward speed of a powered parachute. And with the lighter wing loading, a parawing is far more 'floaty,' which means that in turbulence, a powered parachute wing is going to move around more than a conventional airplane wing.

Unseen Danger

Winds are generally an unseen danger since air is invisible to us most of the time. Turbulence is the violent or unsteady movement of that unseen air. If the air movement becomes too violent or unsteady, there isn't enough pilot control to smooth out a flight or a landing approach.

Powered parachutes fly at low speeds and often close to the ground. Both the light wing loading and the closeness to the ground makes them particularly susceptible to turbulence. Fortunately, in a powered parachute, pendulum stability keeps the wheel side pointed down towards the ground. But even with that, there's plenty of rocking, rolling, and swaying to turn things into a handful.

The FAA defines aircraft turbulence as an irregular motion of an aircraft in flight, especially when characterized by a rapid up-and-down motion caused by a rapid variation of atmospheric wind velocities. The rest of us would probably define it as bumpy air.

Turbulence can vary from annoying bumpiness to severe jolts that can cause structural damage to an aircraft and even injury to those in the aircraft.

Turbulence is caused by one of four things:

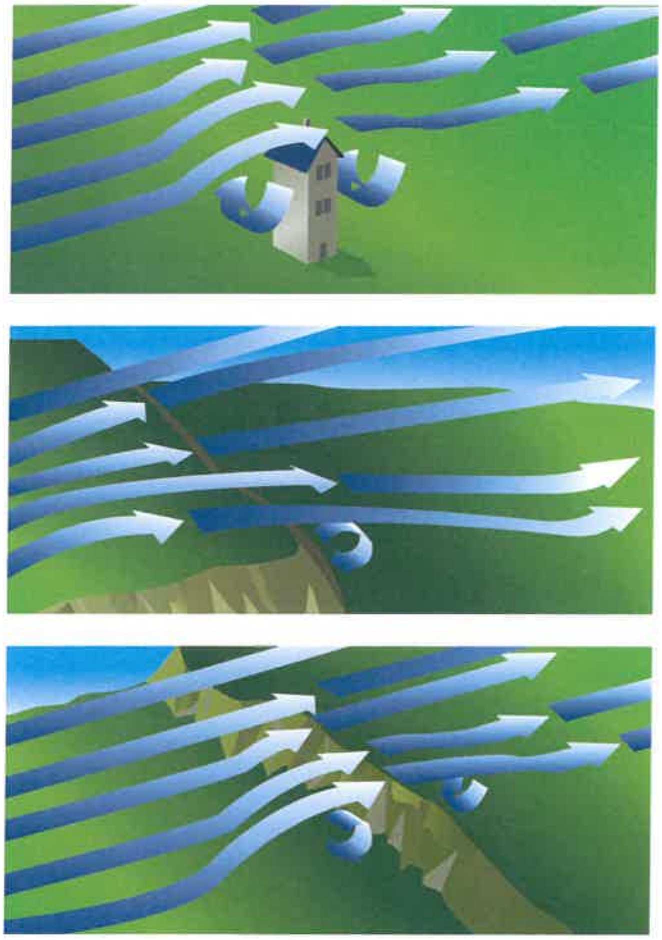
- Obstructions in the wind flow
- Wind shear
- Convective currents
- Wingtip vortices

Mechanical Turbulence

Ground topography and large buildings can break up the flow of the wind and create wind gusts that change rapidly in direction and speed. These obstructions range from man-made structures like hangars to large natural obstructions, such as mountains, bluffs, or canyons. It's especially important to be vigilant when flying in or out of airports that have large buildings or natural obstructions located near the runway.

The intensity of the turbulence associated with ground obstructions depends on the size of the obstacle, the primary speed of the wind, and the direction the wind is coming from. This can affect the takeoff and landing performance of any aircraft and can present a very serious hazard. If you don't clear obstacles fast enough during takeoff or stay high enough above them on approach, you could end up flying into those obstacles.

You will notice this even more when flying in mountainous regions. While the wind flows smoothly up the windward side of the mountain



Surface obstructions cause eddies and other irregular air movements.

Left: Mechanical turbulence as winds pass over a building, over a cliff, and into the face of a cliff.

Above, mechanical turbulence created by buildings near a private, residential runway.

and the upward currents help to carry a powered parachute over the peak of the mountain, the wind on the leeward side does not act in a similar manner. As the air flows down the leeward side of the mountain, the air follows the contour of the terrain and is increasingly turbulent. This tends to push an aircraft into the side of a mountain. The stronger the wind, the greater the downward pressure and turbulence become.

Wind and terrain can combine to cause severe downdrafts in valleys and canyons. Before you fly in mountainous terrain, seek out an instructor or at least a local powered parachute pilot to find out where the more dangerous areas are.

A parawing's low airspeed also plays an indirect role in exposing a powered parachute to winds disturbed by obstructions. Slow forward speeds make flying 'low and slow' very enjoyable and far safer than in faster aircraft. It's one of the big features of flying a powered parachute! However, low is where the obstructions are and so it is also where some 'textured' wind can be found.

Mechanical turbulence can make for a very uncomfortable ride. Even more risky is the loss of control experienced by pilots attempting to fly low or land in turbulent conditions. The worst case is a 'drop in' during an approach. That's when the wind you are landing into stalls, or you get a wind from behind, or you get into a rotor (which we will talk about soon). The parawing reacts by going into an immediate and temporary dive to recover airspeed. That dive is completely natural and will normally sort itself out. But if you are too close to the ground, you may find yourself unexpectedly diving into the dirt.

Fortunately, there are indicators you can look for to see what is going on with the wind and what it might be doing to create hazards.

Airports often have some of the larger buildings in town in the form of hangars. Those buildings can create a lot of mechanical turbulence if the winds are 'right'.

Objects Affect the Flow of Wind

Objects of any size can affect the flow of wind. Wind must go around objects and if the wind has any speed, it doesn't do this smoothly. The larger the object and the faster the wind, the greater the effect.

It helps to compare air to water and wind to a moving stream. If you're canoeing in a lake, there is no real water flow and so large rocks and logs are simply things to avoid bumping into. That's how to think of objects when flying on a calm day.

However, say you take those same rocks and logs out of a lake and put them into a moving stream. Immediately downstream of those objects, you will see white water. How turbulent the water is depends on the size and shape of the object and how fast the water is moving. Lazy, slow-moving streams become hazardous when flooded with fast-moving water.

So, what kinds of objects are we talking about when it comes to the wind? Going generally from smaller to larger, we have:

Individual Trees standing in a field are tempting things to fly around. Just be aware that during windy days, the downwind side of that tree will be turbulent.

Buildings come in many sizes and shapes. Worse, they're often inconveniently placed close to runways, creating their own turbulence.

Wooded Areas add their own texture to the ground and change with the seasons. As trees leaf up in the spring, they form a more solid barrier to the wind.

Topography is the surface of the ground such as hills, rivers, and other surface features. Of course, they can range from the flat to the very mountainous. Turbulence is the worst in mountainous regions, but valleys and canyons can also funnel the wind, creating faster winds and more turbulence within them.

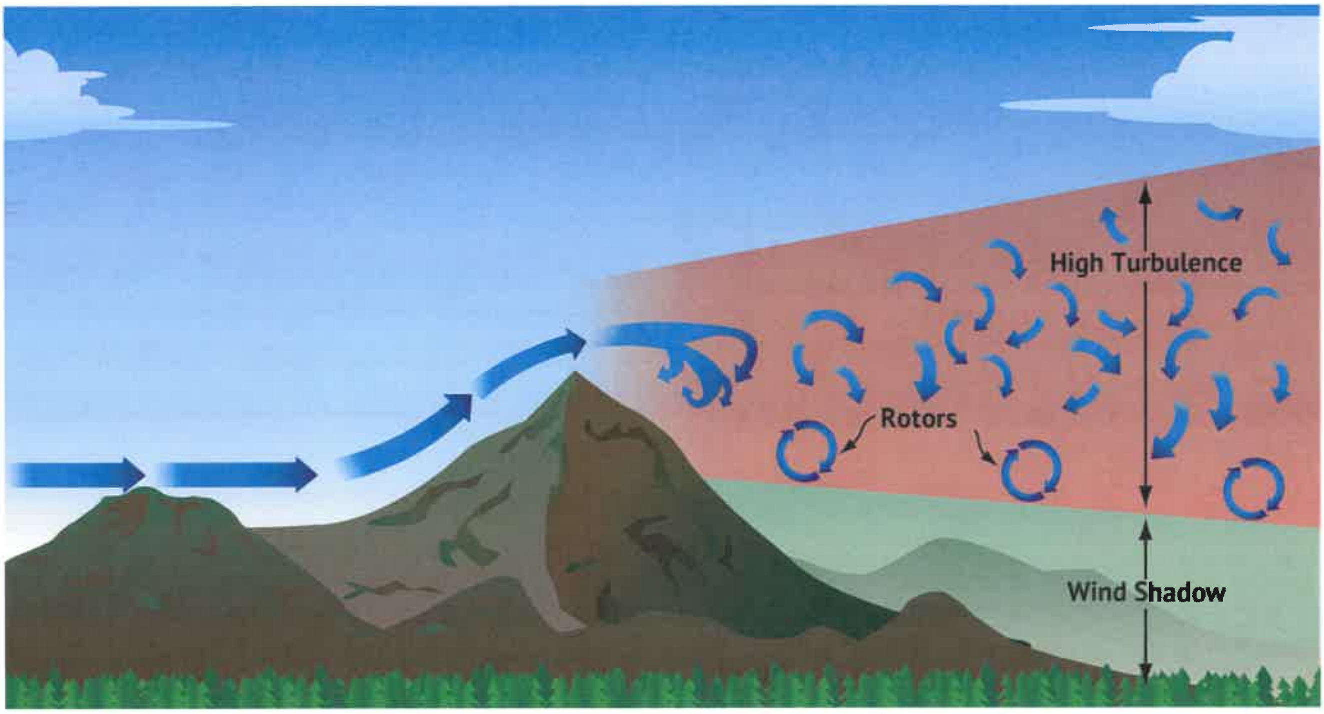
Rotors

Normally winds are simply disrupted by objects and become turbulent. However, a special situation happens when there is a ridgeline, a row of buildings or even a line of trees. In cases like these, it's like having a log laying across the stream bed. In the case of the streambed, the turbulence is more 'organized,' stronger, and lasts further downstream. In fact, a submerged log can create a lot of white water quite a distance above it.

Like water flowing into a submerged log, the wind may stall right in front of a ridgeline or a line of trees, but behind the obstruction there will be a significant amount of turbulence, with even a possibility of rotors. Rotors are pockets of spinning wind, lying on their sides. Being more organized than regular turbulence, they are more powerful and can travel further downwind from the obstruction than you might expect.

Wind Shadow

Downwind of obstructions is usually a very dangerous place to be while flying. However, there are occasions when those areas can be of benefit. For instance, there are valleys, normally running perpendicular to prevailing winds, where winds are calm as long as you stay relatively close to the surface. However, venturing higher can get you into some trouble.



A ridge line can form some impressive turbulence, especially when winds are significant. But for those of us flying low and slow, shelter from those winds and turbulence can be found in the wind shadow low and close to the obstruction.

The wind shadow formed by a building or a line of trees can also be used to inspect a parachute or dry it out from an earlier flight.

A wind shadow can also be deceptive. Sometimes conditions look good for flying when they actually are not. For example, towns and urban areas create wind shadows. It often feels like there's no breeze on the surface in town, but simply looking up at the branches moving on the tops of trees will dispel that notion.

Wind Gradient

Most powered parachutes fly well over 90% of the time in the boundary layer. The boundary layer is the layer of air that begins at the Earth's surface and is directly influenced by its contact with the surface. Within the boundary layer, air movement is turbulent, and characteristics like temperature, humidity, and wind speed are significantly affected by surface conditions, such as terrain, vegetation, and buildings.

The altitude of the boundary layer varies depending on factors like weather conditions, time of day, and location, typically ranging from a few hundred feet to about 2,000 to 6,500 feet AGL. Part of this *"directly influenced by its contact with the surface"* involves the slowing of winds due to friction and mechanical turbulence created by surface features. These features disrupt the wind's straight, speedy flow, contributing to the turbulence observed within the boundary layer.

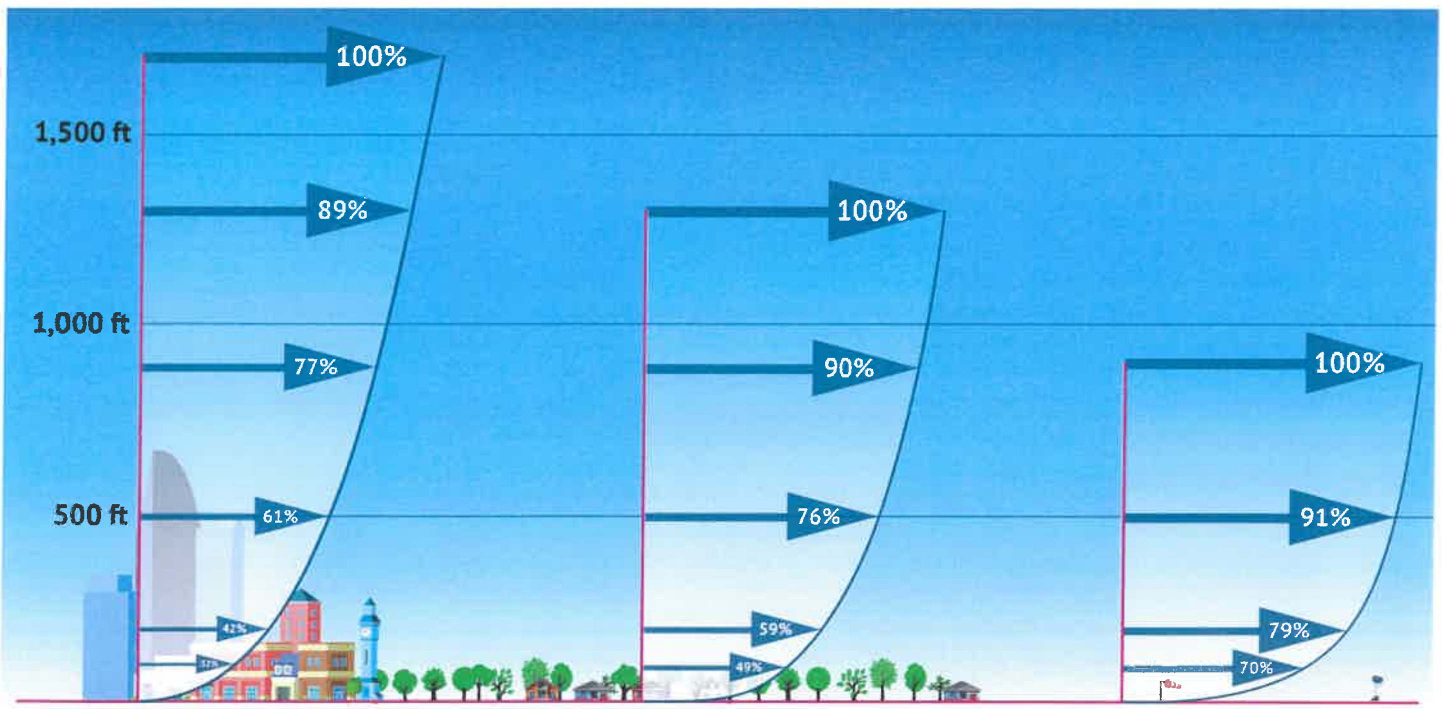
The influence is greatest at the very surface of the Earth. In fact, if you were an insect spending your life in the grass, you might not ever experience wind since by the time the wind gets to below grass-blade-top level, the wind speed would be near 0 mph with all the friction from the turf!

However, just above the turf, the wind increases dramatically. Surface winds are officially measured in clear areas, 10 meters (32.8 feet) above ground level. That makes it even more remarkable that winds often almost double in speed at 100 feet AGL. Winds 1,500 to 3,000 feet above the terrain are normally no longer affected by the terrain.

It isn't just the speed of the wind that changes in the boundary layer; the direction changes, too! Due to the Coriolis Effect, winds in the northern hemisphere come more out of the right as altitude increases. That can make winds a little different from what you are expecting when just observing the surface winds.

Wind gradient has huge implications for powered parachute pilots. First, knowing that the wind doubles in speed in as little as 100 feet can help you decide whether or not the fresh breeze you're feeling on the ground is going to be a little too fresh with you after takeoff. Second, it's good to know that you have different speeds and directions of wind to work with for cross-country flights. When doing a downwind leg of a cross-country, increasing altitude will often get you there that much faster. When going upwind, lower altitudes may allow you more progress on your ground track.

Just remember, all of the benefits of wind gradient come with its ugly sister, mechanical turbulence! This is especially true when flying in mountainous regions. If possible, always seek advice from pilots already flying in a mountainous region you are visiting so that you don't become introduced to the ugly sister and she does immoral things to you.

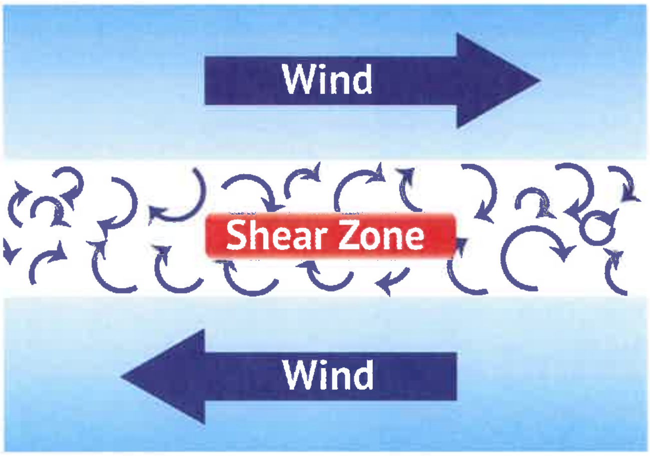


Full wind speed (100%) at altitude gradually decreases closer to the surface, illustrating the effects of friction and terrain on wind velocity.

Wind Shear

Wind shear is a sudden, drastic change in wind speed and/or direction over a very small area. Wind shear almost always includes turbulence between two different wind currents. Wind shear can subject you to violent updrafts and downdrafts as well as abrupt changes to the horizontal movement of your powered parachute. While wind shear can occur at any altitude, low-level wind shear is especially hazardous due to the proximity of an aircraft to the ground. Low-level wind shear involves rapid changes in wind direction and speed, with direction shifts of up to 180° and speed changes of 50 knots or more. This phenomenon is commonly associated with passing frontal systems, thunderstorms, and temperature inversions accompanied by strong upper-level winds exceeding 25 knots.

Wind shear is dangerous for several reasons. The rapid changes in wind direction and velocity changes the wind's relation to the aircraft disrupting the normal flight attitude and performance. The effects of wind shear can be subtle or very dramatic depending on the wind's speed and direction change. For example, a tailwind that quickly changes to a headwind will increase a powered parachute's angle and rate of climb. Conversely, when a headwind changes to a tailwind, your powered parachute will quickly descend. In either case, you must be prepared to react immediately to the changes to maintain control of your powered parachute when close to the ground.

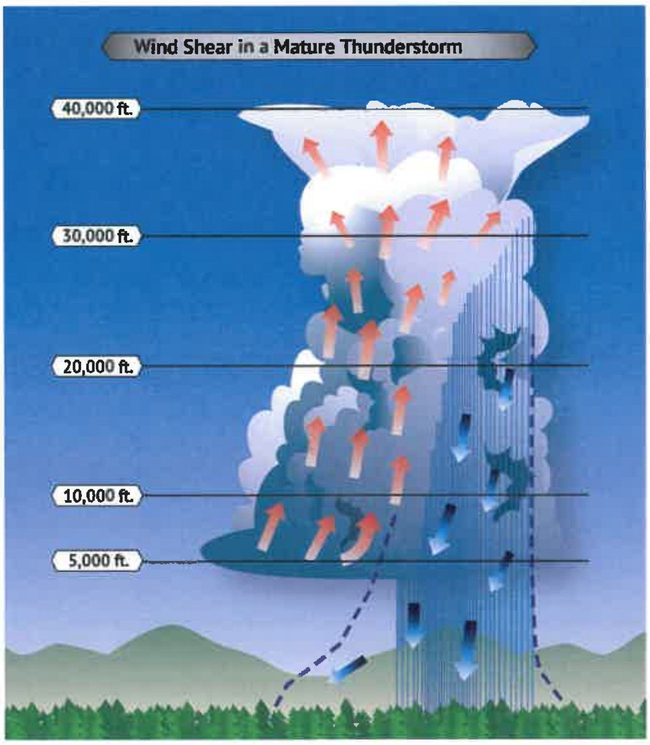


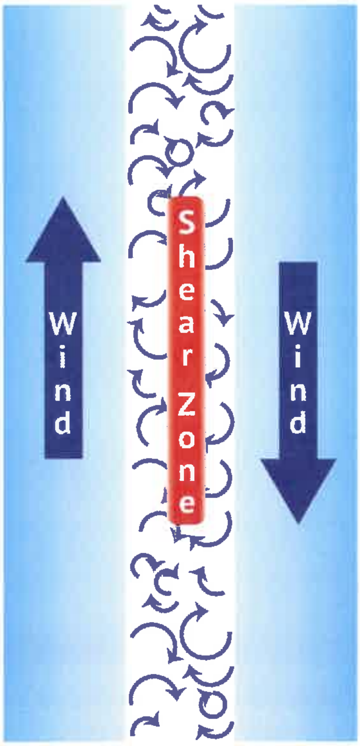
Simple depiction of wind shear and the turbulence associated with it.

Wind Shear Turbulence

Wind shear involves a change in wind direction (wind shift) or wind speed gradient and can be horizontal or vertical. It can occur at any level in the atmosphere, but our primary concern is with wind shear at lower altitudes.

While wind shear can be reported, it often goes undetected, making it a silent danger to aviation. Therefore, you should remain vigilant for the possibility of wind shear, especially when flying near thunderstorms and frontal systems. The most severe low-level wind shear is typically associated with convective precipitation or rain from thunderstorms. Thunderstorms generate powerful updrafts and downdrafts, creating substantial wind shears between these vertical air currents—a serious hazard for any aircraft.

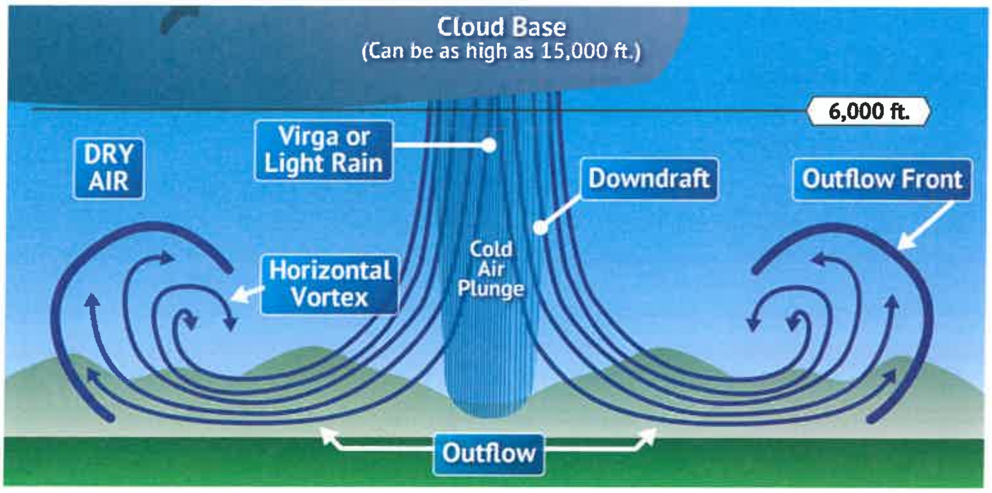


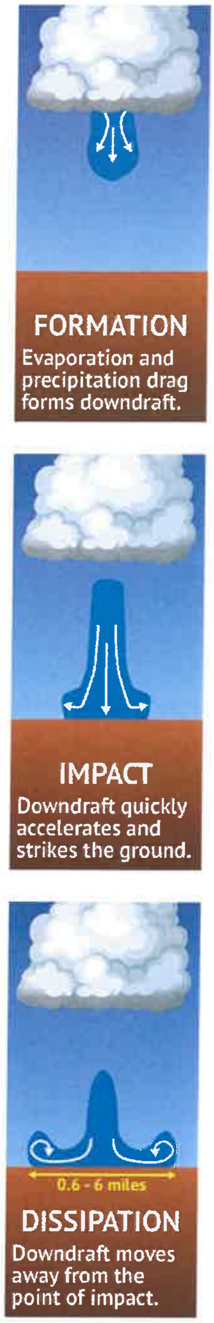


Left: Thunderstorm showing strong updrafts and downdrafts

Right: Vertical wind shear

A symmetric microburst occurs when there is no wind or light winds.





The Downburst Life Cycle

Downbursts and Microbursts

Convective clouds, shower cells, and thunderstorm cells can sometimes produce intense downdrafts known as downbursts, which generate strong, often damaging winds and wind shear. Downbursts pose significant hazards for pilots and have been responsible for many low level wind shear (LLWS) accidents. Smaller, shorter-lived downbursts are called microbursts.

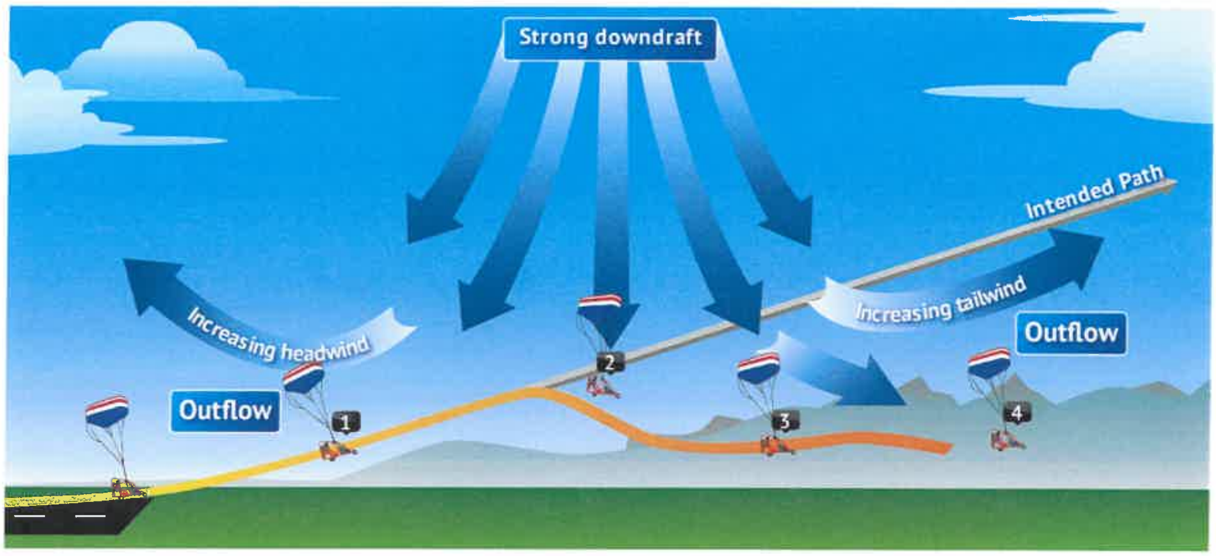
Despite the innocent-sounding name, a microburst is the most severe type of low-level wind shear. A microburst is a small-scale, intense downdraft that, upon reaching the surface, spreads outward in all directions from its center. Microburst activity might be indicated by an intense rain shaft at the surface, but sometimes the only visible clues are virga (precipitation streaks that don't reach the ground) at the cloud base or a ring of blowing dust.

A typical microburst has a horizontal diameter of less than 2.5 miles and a nominal depth of about 1,000 feet. The lifespan of a microburst is short, typically 5 to 15 minutes, but during this time, it can produce downdrafts of up to 6,000 feet per minute (FPM). This can result in sudden headwind gains and losses of 30 to 90 knots, severely degrading aircraft performance. Microbursts can also generate strong turbulence and hazardous wind direction changes.

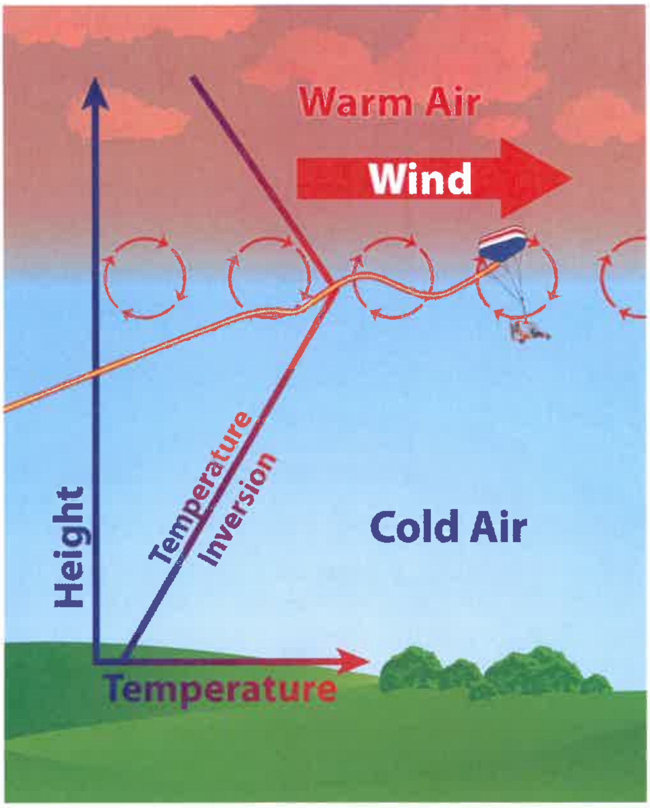
During an inadvertent encounter with a microburst, a powered parachute may experience:

1. An initial climb due to an increasing headwind.
2. A sharp descent caused by intense downdrafts.
3. A rapid shift to a tailwind.
4. The tailwind can then potentially result in an impact with the ground.

If you encounter a microburst, maintain flight and wait for the event to pass, which typically lasts 5 to 15 minutes. If you suspect a microburst during landing, execute a go-around and consider leaving the area altogether. Be aware that multiple microbursts can occur within the same weather system, so remain vigilant if one has already been observed or encountered.



Flight into a microburst.



Wind shear associated with a temperature inversion. Cold air is settled near the ground and the temperature increases with altitude.

Temperature Inversion

A temperature inversion occurs when a layer of the atmosphere experiences an increase in temperature with altitude, rather than the usual decrease. Inversions commonly form within the lowest few thousand feet above ground, often due to nighttime radiational cooling, along frontal zones, or when cold air becomes trapped in a valley.

Strong wind shears frequently develop across temperature inversion layers, which can lead to turbulence. Pilots of powered parachutes may experience mild turbulence caused by a temperature inversion, particularly early in the morning. This turbulence can be expected when the air near the ground is cooler, and temperatures just a few hundred feet above are warmer. Flying through these layers, from cooler to warmer air (and vice versa), often results in some bumpiness. To avoid this turbulence, you can either climb above the inversion layer or stay below it.

Convective Turbulence

Generally, powered parachutes are best flown when the winds are low and either before or after the heat of the day. That's because as the sun heats up the surface of the earth, the warm ground heats the air immediately above it. That warm air eventually rises. But it usually doesn't rise smoothly. Instead of smooth updrafts of air, bubbles of warmer air break free of the surface of the earth, kind of like bubbles churning up in a pot of boiling water.

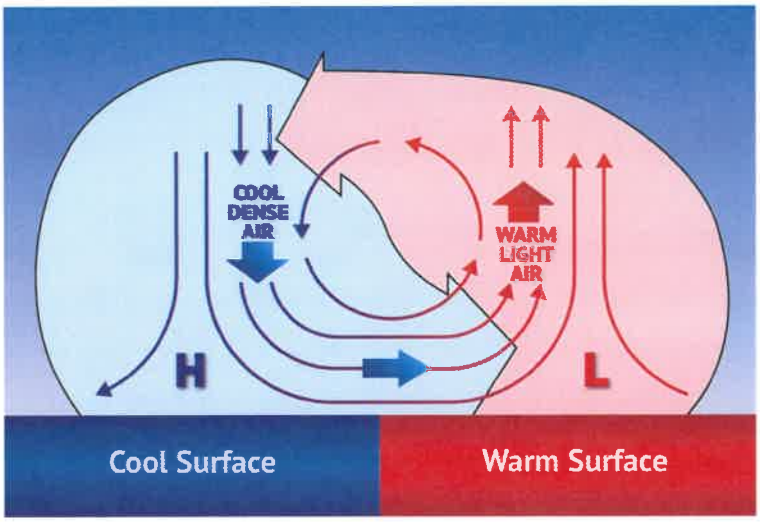
This unevenly rising air is called convective turbulence. Along with the rising of warmer air, an equal amount of cooler air descends from higher altitudes. After all, it makes sense that the air that rises from near the ground must be replaced with air from somewhere. The resulting uneven heating of the air creates small areas of local circulation called convective currents.

The difference between the rising air and the descending air is that the upward moving air is more concentrated and faster moving. The downward currents of air are slower and descend over larger areas of the ground. Nevertheless, flying over an area with the boiling upward-moving air to an area with cooler descending air can result in both turbulence and a change in flight path. This is very noticeable when you're flying an approach to landing or trying to fly really close to the ground. In fact, low altitude flying should be avoided during thermally days. Flying fifty feet above the ground can turn into flying into the ground if one isn't careful.

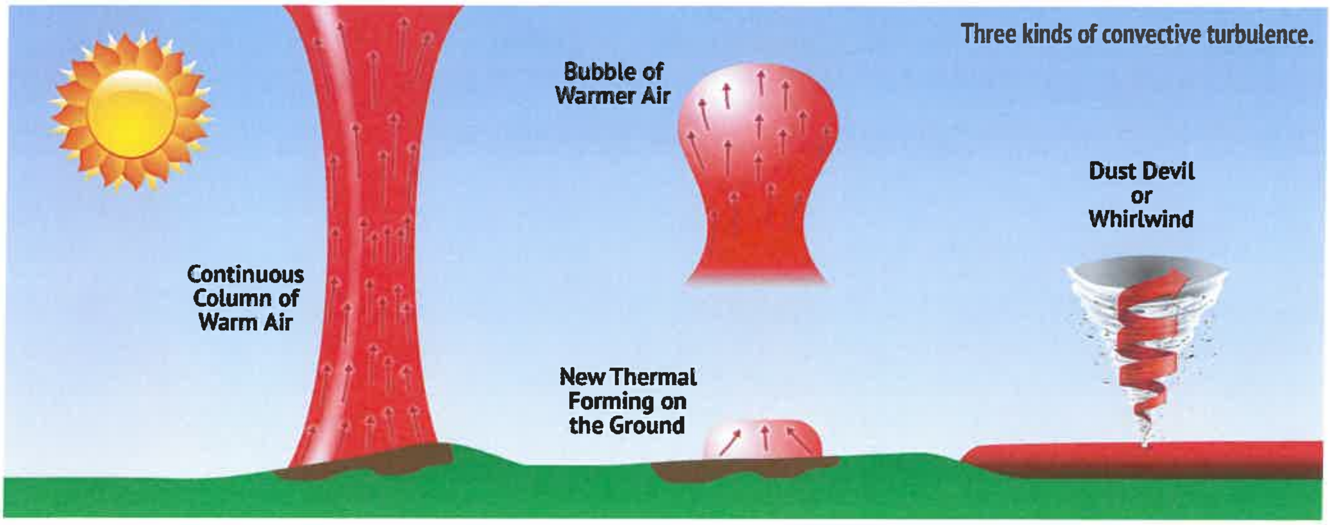
These convective currents are most active on clear-sky-days as the sun gets higher in the sky. They're even more pronounced when winds are light. You know, the kind of winds when we like to fly powered parachutes.

The sun heats surfaces on the ground, which in turn warm the air immediately above them. This heated air creates a shallow, absolutely unstable layer near the surface. The thickness of this layer depends on the wind conditions. If there is little to no wind, the warm, unstable layer can become thicker, as the lack of wind allows it to remain undisturbed. This warm layer is the source of rising air bubbles that rise upward.

Certain surfaces will create thermals faster than others, and other surfaces create no thermals at



Local wind circulation caused by convective currents.



Three kinds of convective turbulence.

all. Where thermals aren't being created is normally where cooler air descends to the ground. The surfaces that create thermals are areas that would be warmer (or even hot) if you would walk across them barefoot. Examples are:

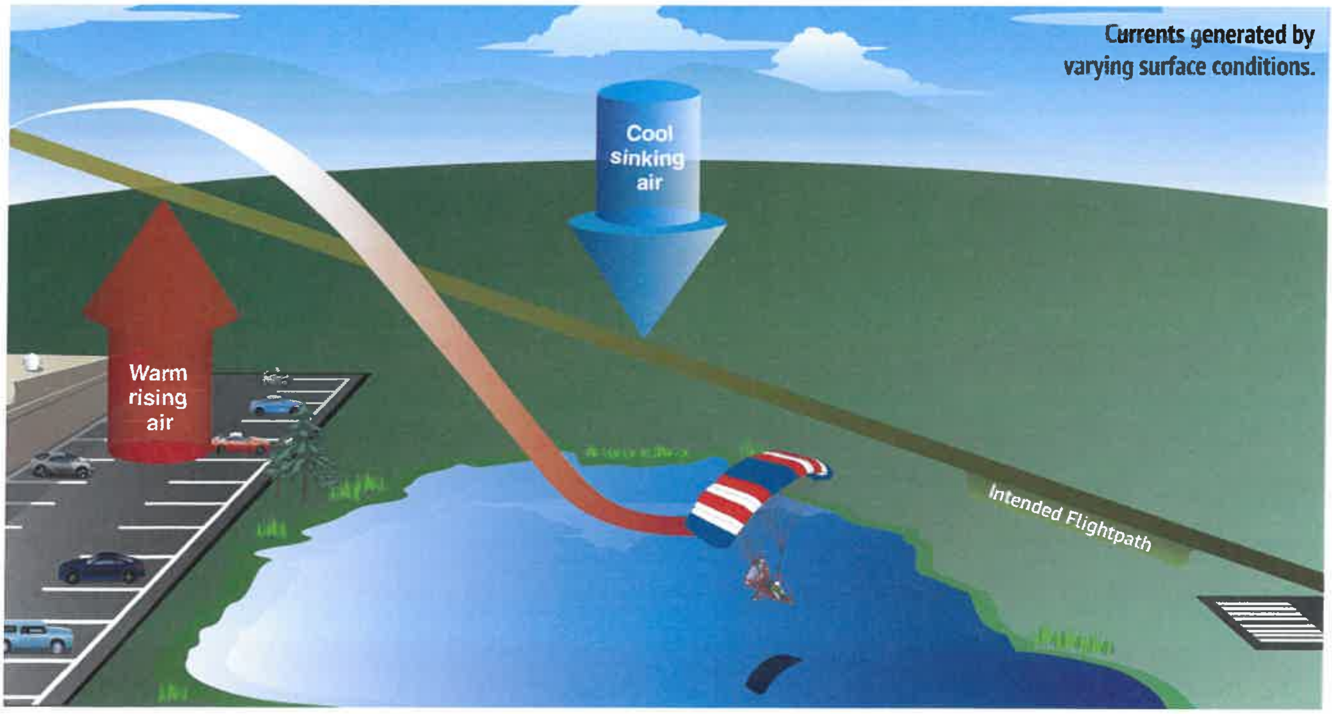
- Barren surfaces
- Sandy areas
- Rocky areas
- Plowed fields with no vegetation
- Parking lots
- Concrete or asphalt runways
- Airport ramp areas and taxiways
- Highways
- Dark, dry surfaces in general

Cooler surfaces are those that absorb the heat or use the heat to evaporate water instead of heating the air. You won't generally feel updrafts over those. Instead, you will feel downdrafts. Mostly those areas are covered by either water, vegetation, or both. Examples are:

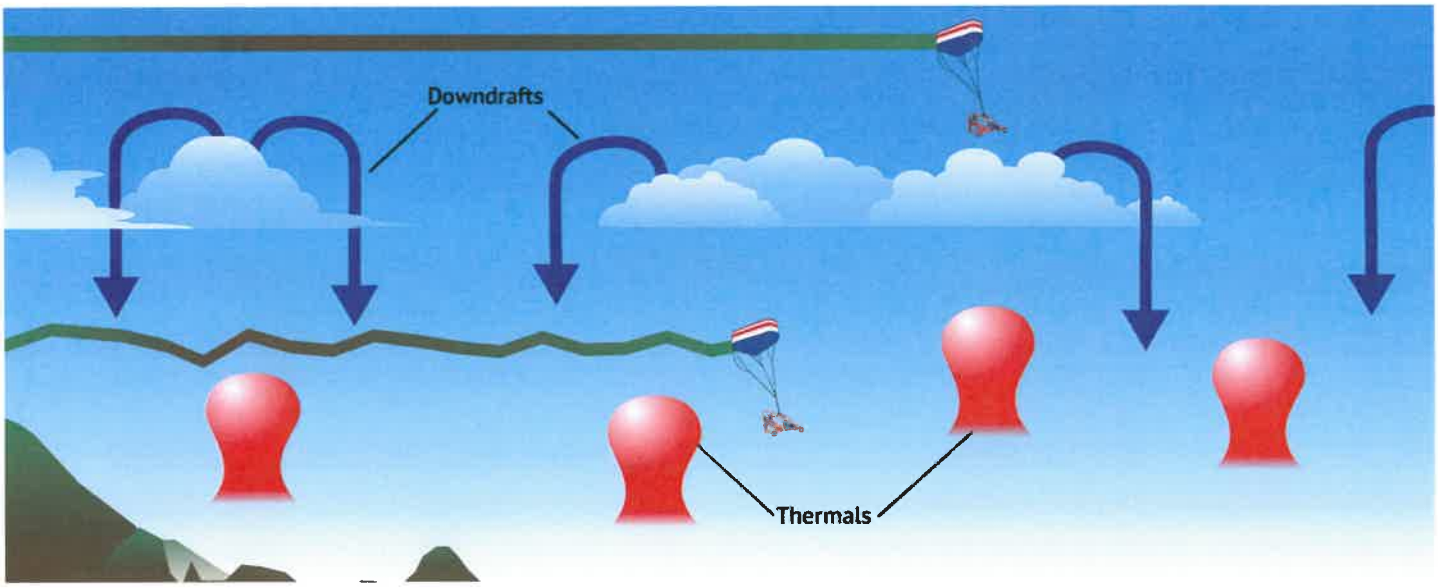
- Lakes, ponds, wide rivers
- Wooded areas
- Mature crops
- Swampy areas
- Thick, green, grassy areas
- Irrigated areas
- Snow or ice covered areas

Convection currents close to the ground can affect your ability to control your aircraft. On final approach, for example, the rising air from terrain devoid of vegetation sometimes produces a ballooning effect that can cause you to overshoot your intended landing spot. On the other hand, an approach over a large body of water or an area of thick vegetation tends to create a sinking effect that can cause you to land short of your intended landing spot.

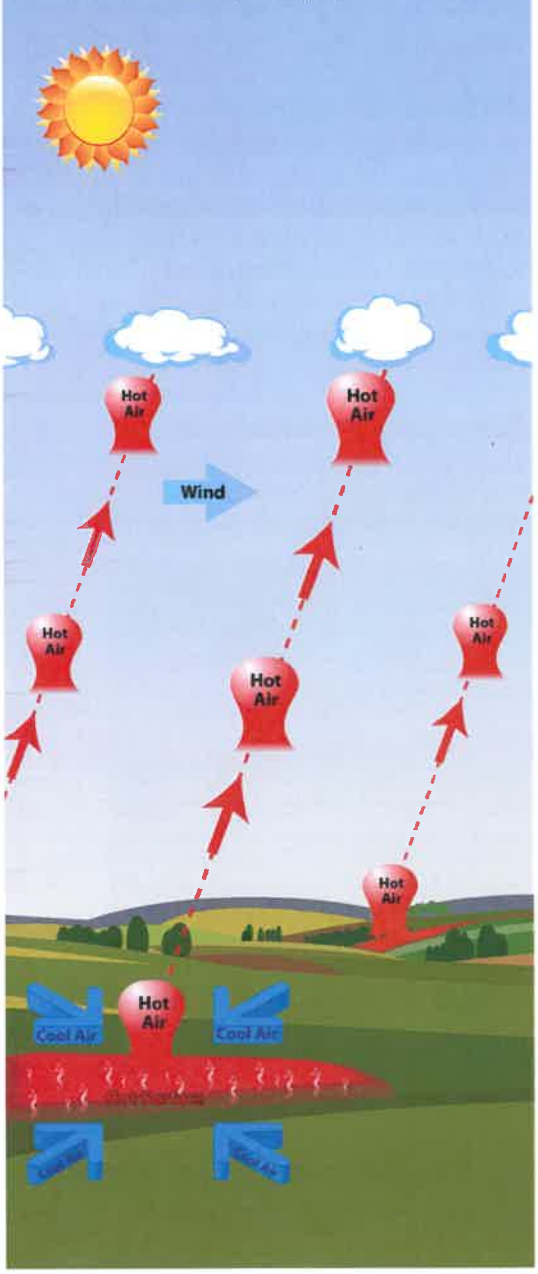
As warm air rises, it cools due to expansion, with an average temperature decrease of about 3.5°F per 1,000 feet of altitude. This convective current continues upward until the rising air cools



Currents generated by varying surface conditions.



You can avoid thermals by flying above the clouds, although that is higher than most powered parachute pilots want to fly



Thermals form over barren surfaces on either flat land or on hillsides facing the sun. Wind then causes 'thermal drift.'

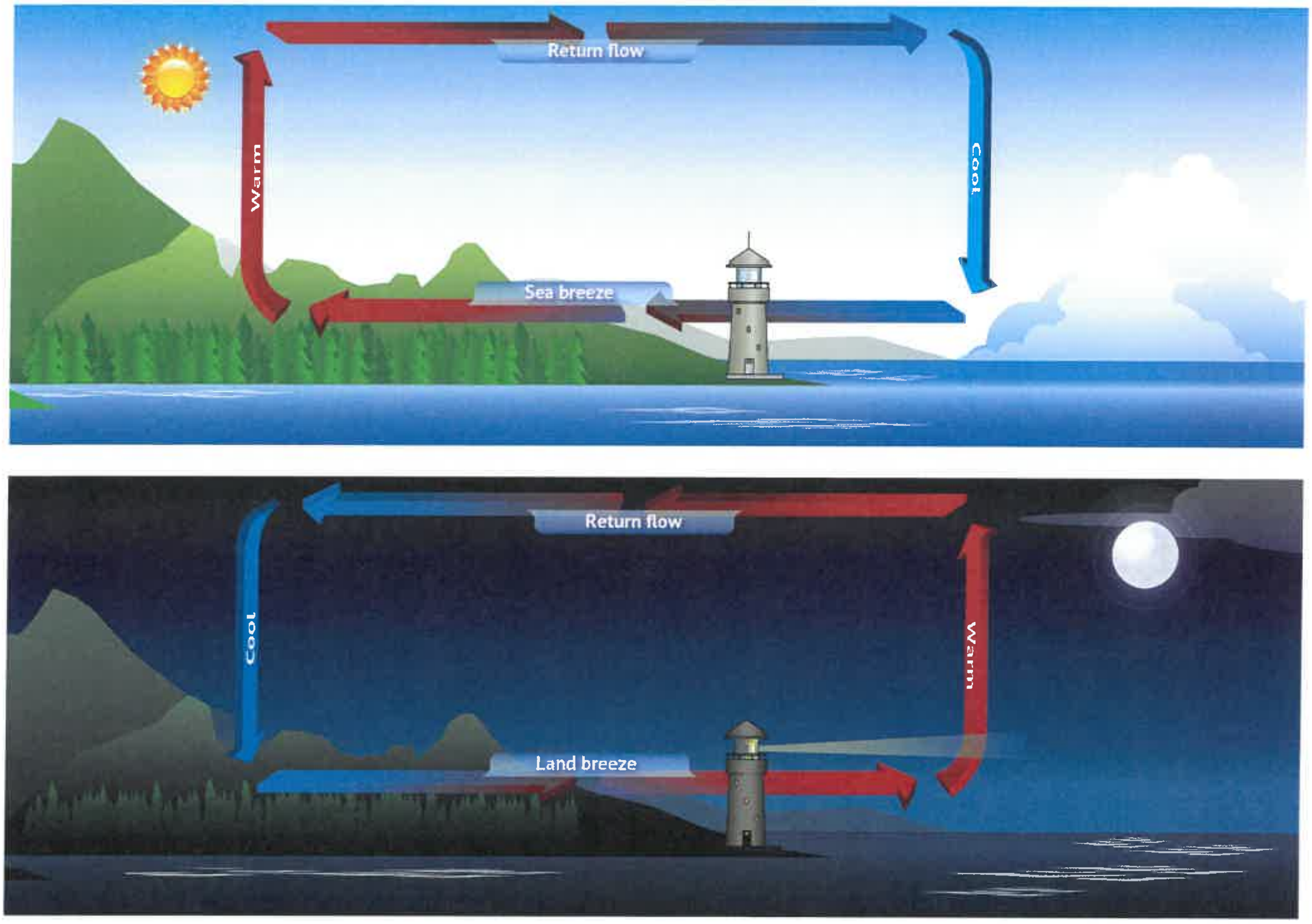
to the temperature of the surrounding air. Because moisture is often carried along with the rising air, it condenses to form cumuliform clouds once the air reaches a certain altitude, known as the condensation altitude. This is why cumulus clouds usually have uniform base altitudes, while their tops vary depending on the amount and strength of the rising warm air.

These billowy cumuliform clouds, often seen over land on sunny afternoons, act as signposts in the sky, indicating areas of convective turbulence. The cloud tops generally mark the upper limit of the convective current, and turbulence can be expected beneath or within the clouds. Above the clouds, the air is generally smooth. When convection extends to great heights, it can develop into larger towering cumulus clouds or cumulonimbus clouds with anvil-like tops, which serve as visual warnings of severe convective turbulence.

Convective currents cause the bumpy, turbulent air often experienced when flying at lower altitudes during warmer weather. On a low-altitude flight over varying surfaces, updrafts are likely over pavement or barren areas, while downdrafts are common over water or areas with dense vegetation, such as forests. Typically, these turbulent conditions can be avoided by flying at higher altitudes, even above cumulus cloud layers. However, flying at those altitudes is often impractical and sometimes illegal.

Winds and Convective Turbulence

When predicting where convective turbulence might occur, it's usually easy to identify large sources of warm air, such as a brown, plowed field surrounded by woods or growing crops. However, the upward currents of warm air, or thermals, are influenced by horizontal winds. This means that thermals originating from the flat, brown field upwind of you may cause turbulence before you even fly over the field. By the time you reach the source of the turbulence, the thermal may have already moved downwind, and the turbulence might be gone.



Sea breeze and land breeze wind circulation patterns.

Land and Sea Breezes

Convective currents are particularly noticeable in areas with a landmass directly adjacent to a large body of water, such as an ocean, large lake, or other appreciable area of water. During the day, land heats faster than water, so the air over the land becomes warmer and less dense. It rises and is replaced by cooler, denser air flowing in from over the water. This causes an onshore wind, called a sea breeze. Conversely, at night land cools faster than water, as does the corresponding air. In this case, the warmer air over the water rises and is replaced by the cooler, denser air from the land, creating an offshore wind called a land breeze. This reverses the local wind circulation pattern. Convective currents can occur anywhere there is an uneven heating of the Earth's surface.

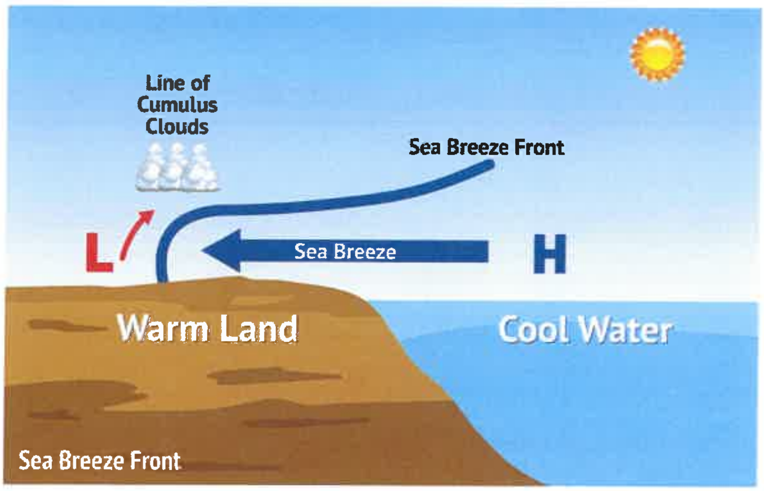
Sea Breeze Front

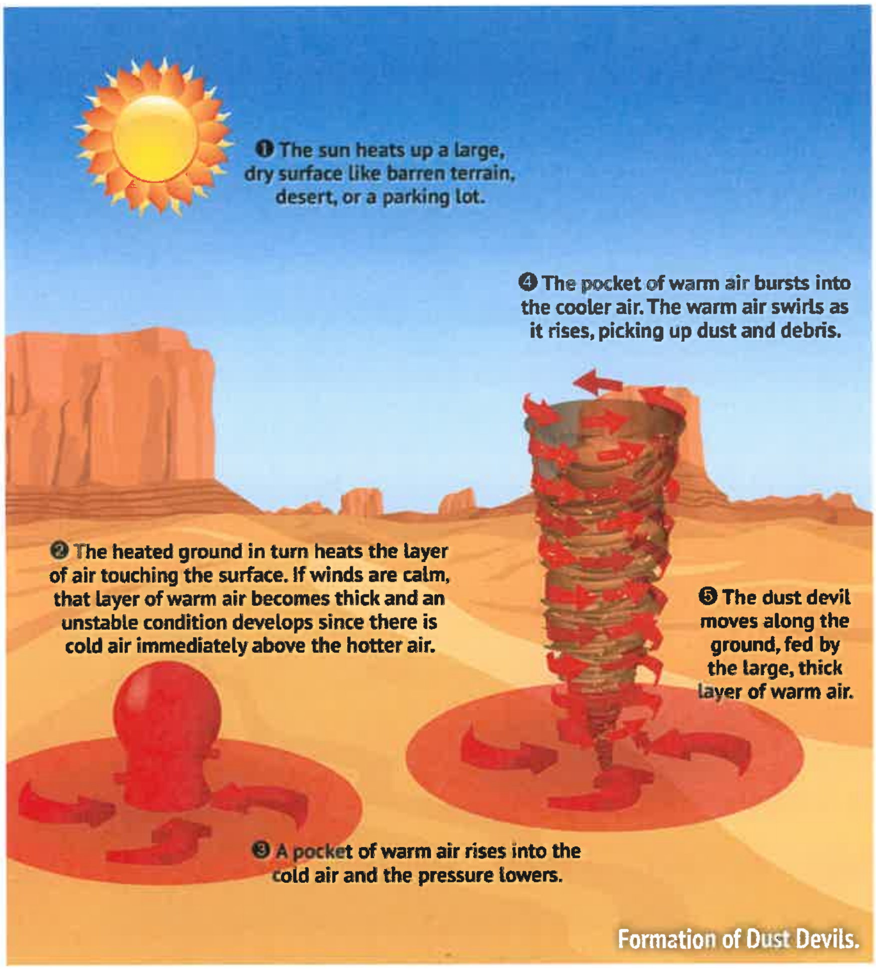
As cooler moist air moves from the sea onto the land, it can form its own miniature front. A sea breeze front is the leading edge of the intrusion of the cooler, moister marine air associated with a sea breeze. It often produces a wind shift and enhanced cumulus clouds along its leading edge. Cumuliform clouds may be absent if the air mass being lifted over land is dry or stable.

A sea breeze front's position and movement are influenced by coastline shape, low-level winds and the temperature difference between land and sea. This temperature difference can be affected by the presence of cloud cover over land and the time of day. The depth of convection is usually too shallow for precipitation to develop. However, sea breeze fronts can be a lifting mechanism for shower and thunderstorm development.

This explains both the cooler temperatures near most coasts during the day and regular afternoon showers on some coasts.

There is a similar effect near the Great Lakes called *lake breeze*. The strength of lake breeze circulation is affected by a lake's depth. Shallow lakes like Lake Erie and Lake St. Clair warm up rapidly and are less effective as sources of a lake breeze in the summer than the other, deeper Great Lakes.





Formation of Dust Devils.

Dust Devils

So far, we've talked about how air near the ground is heated by the sun and then bubbles of warmed air burst through the unstable layer to form thermals. But sometimes that air doesn't just go straight up. Sometimes the warmed air develops a twist to it on its trip upward. If that happens in particularly calm conditions, that single disruption through the unstable layer could become an escape for more and more warm air. And then that disruption could begin moving, something like a vacuum cleaner, sucking up more and more of the hot air near the surface of the ground. Finally, if that column of twisted air is over a dusty area like a dry, plowed field or the desert floor, debris can be sucked up along with the warm air, causing a dust devil.

A dust devil is a relatively small phenomenon, normally only 5-10 feet wide and maybe 30 feet tall. They can be seen sometimes in gravel parking lots during the summer. But if the conditions are right, they can reach diameters of 50 feet and reach 3,000 feet into the air! Dust devils of that size are certainly to be avoided.

But here is the interesting thing. The ingredient that makes a dust devil a dust devil is, well, dust. If there is no dust available to be sucked into the sky, that doesn't mean that the whirlwinds don't exist. It just means that instead of them being a visible danger, they become an invisible danger.

Dust devils can form in a wide variety of locations, and the whirlwinds that cause them are more common than you might think. A striking example occurred after the 1980 eruption of Mt. St. Helens in Washington state. The eruption deposited ash in areas where dust devils were typically unheard of. However, on sunny days following the eruption, hundreds of *"ash devils"* could be seen swirling across the landscape.

The point is, that even if you live in a state that isn't desert-like, be careful about whirlwinds forming if the following conditions are right:

Flat barren terrain, desert or tarmac: Flat conditions increase the likelihood of the hot-air 'fuel' being a near constant. If dust or sand is available, it can become caught up in the vortex, making the dust devil easily visible.

Clear skies or lightly cloudy conditions: The surface needs to absorb significant amounts of solar energy to heat the air near the surface and create ideal dust devil conditions.

Calm or light winds with a cool atmospheric temperature: The underlying factor for sustainability of a dust devil is the extreme difference in temperature between the near-surface air and the atmosphere. Windy conditions will destabilize the spinning effect of a dust devil.

Unusual Convective Turbulence

What we've talked about so far is natural convective turbulence that you can feel on a normal, sunny day. However, there is also man-made turbulence that can be even more violent. Fires, even small fires, can produce significant upward thermals that will disrupt a nice straight-and-level flight on a smooth evening. If you're based at an airport, a jet- or turbine-powered aircraft starting up on the ramp can really rock your world. If you're flying over the ramp and get a whiff of burning kerosene, you will probably soon feel a lot of significant bump.

Flying over factories and electrical powerplants comes with its own risk of bumpiness since they are big heat generators. And you aren't safe in the country, either. Fly over a grain bin in the Midwest in the fall with its natural gas grain driers fired up or over a hot poultry house in Arkansas and you will also feel some significant bump.

All thermal-like updrafts end when the source of heat dissipates. When the sun gets low in the sky, fires die, or the unstable layer of warm air above the ground is expended, thermal activity dies down. That's why late afternoon flights can be the wonderful, stable flights they are.

Wake Turbulence

Every aircraft in flight creates wake turbulence, a disturbance caused by swirling air currents, known as vortices, trailing from its wingtips. For powered parachute pilots, it's crucial to be aware of these vortices from larger planes, as they can induce uncontrollable rolling or even damage your wing if you get too close. To stay safe, always be mindful of where these vortex wakes are and adjust your flight path accordingly.

When you're on the ground or taking off, be aware of jet engine blast, also known as thrust stream turbulence. This powerful air can cause serious issues if you get too close. Always consider the effects of jet-engine blast and maintain a safe distance.

Even the propeller blast from another powered parachute or light aircraft can twist your wing while you're setting up to fly. Be cautious when laying out your wing near other powered parachutes to avoid setting up too close behind another pilot. Likewise, ensure you're not creating problems for others by setting up directly in front of them.

It's all about staying cautious and maintaining the right separation to ensure a smooth and safe flight.

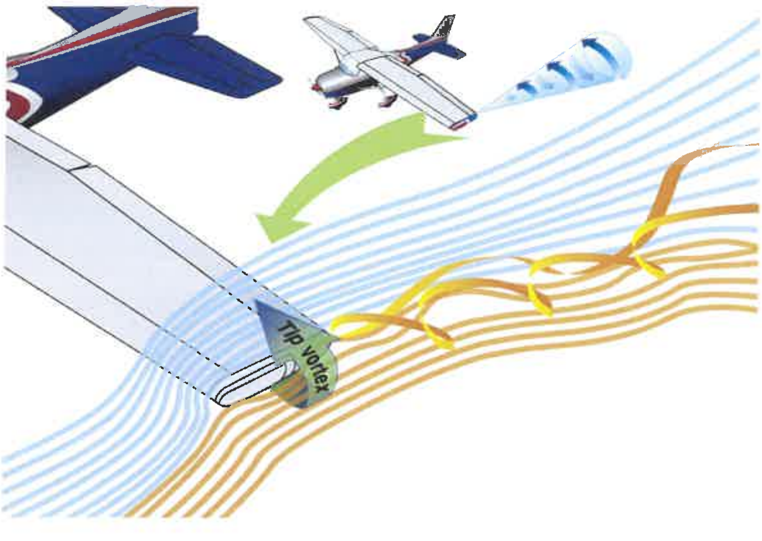
Formation of Wingtip Vortices

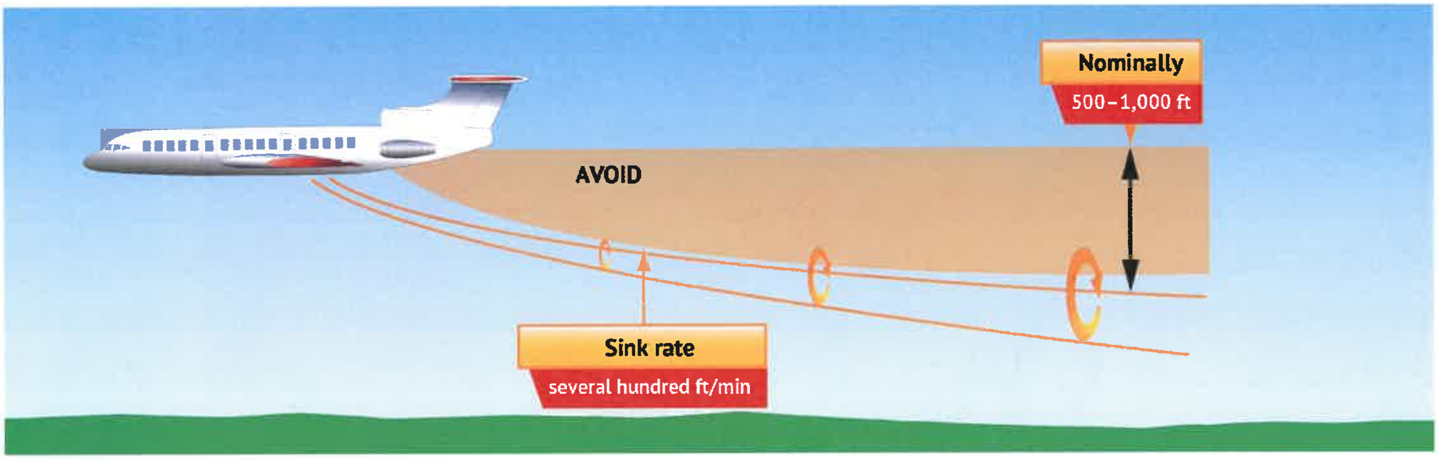
The action of an airfoil that generates lift also results in induced drag. When an airfoil is flown at a positive angle of attack (AOA), a pressure differential is created between the upper and lower surfaces of the airfoil. The pressure above the wing is less than atmospheric pressure, while the pressure below the wing is equal to or greater than atmospheric pressure. Since air naturally moves from areas of high pressure to low pressure, and the easiest path is towards the wing tips, this causes air to move spanwise from the bottom of the airfoil outward from the fuselage and around the tips. This movement results in air spilling over the tips, creating a whirlpool effect known as a *vortex*.

As air curls upward around the wingtip, it merges with the downwash to form a fast-spinning trailing vortex. Each side of the wing produces two counter-rotating cylindrical vortices. These vortices contribute to induced drag due to the energy expended in creating the turbulence. Whenever an airfoil generates lift, induced drag is present, and wingtip vortices are formed.

When the wing's AOA increases, both lift and induced drag also increase. The increased AOA amplifies the pressure difference between the top and bottom of the airfoil, leading to a greater lateral flow of air, which in turn results in more intense vortices.

The most concentrated energy is found within a few feet of the vortex center, but pilots should avoid flying within approximately 100 feet of the vortex core. The intensity of these vortices is directly proportional to the weight of the aircraft and inversely proportional to the wingspan and speed.





Vortices are most intense when the generating aircraft is heavy, clean, and slow:

Heavy: A heavier aircraft requires more lift, leading to stronger vortices.
Clean: An aircraft without extended flaps or landing gear generates stronger vortices.
Slow: At lower airspeeds, an aircraft must maintain a higher AOA to sustain lift, which results in stronger vortices.

These conditions—heavy, clean, and slow—mean that vortices are most powerful during the takeoff, climb, and landing phases of flight, which are also when aircraft are typically near airports.

All aircraft, including airplanes, helicopters, and powered parachutes, produce wingtip vortices. For powered parachutes, as with other aircraft, the intensity of these vortices is directly proportional to the weight and inversely proportional to the wingspan and speed. The heavier and slower the powered parachute, the greater the AOA and the stronger the wingtip vortices.

While it's important to understand how powered parachutes generate turbulence, it's even more critical to recognize that all powered aircraft create turbulence. Knowing where this turbulence exists, how long it lasts, and how to avoid it is essential for safe flight.

Vortex Behavior

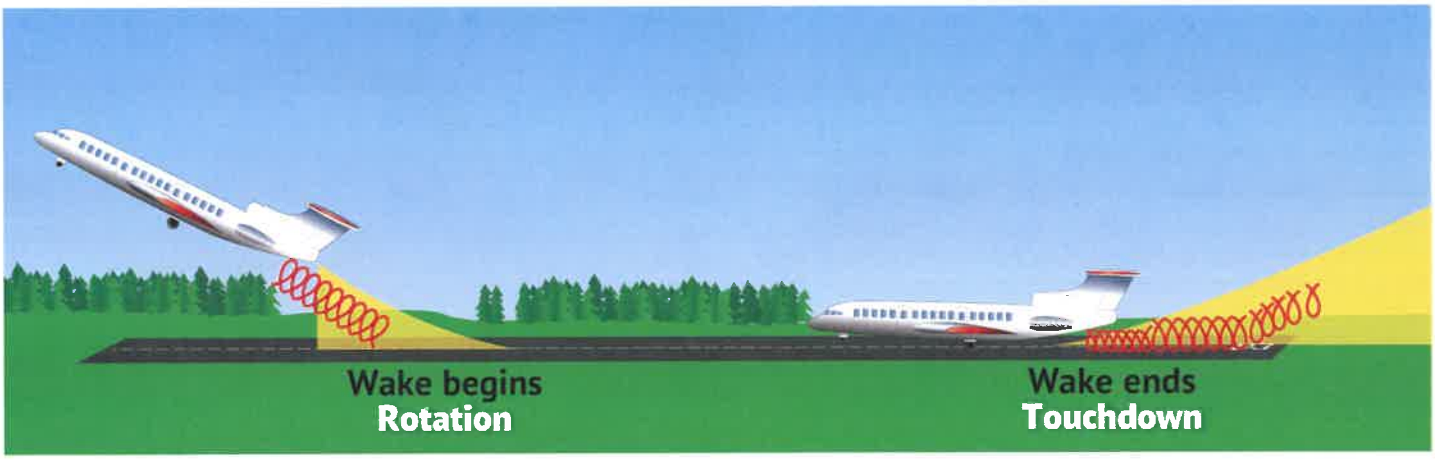
Trailing vortices behave in a way that can help you visualize their locations and avoid them.

Trailing vortices are generated from the moment an aircraft lifts off until it lands, as they are a byproduct of wing lift. These vortices circulate outward, upward, and around the wingtips, whether viewed from the front or behind the aircraft.

Tests have shown that vortices remain about a wingspan apart and drift with the wind at altitudes greater than a wingspan above the ground. When the vortices of larger aircraft sink close to the ground (within 100 to 200 feet), they tend to move laterally at speeds of 2–3 knots.

A crosswind can decrease the lateral movement of the upwind vortex and increase the movement of the downwind vortex. A tailwind can push vortices forward into the touchdown zone.

Vortices sink at a rate of several hundred feet per minute, gradually slowing their descent and diminishing in strength with time and distance from the generating aircraft.



Avoiding Wake Turbulence

Wingtip vortices are strongest when the generating airplane is *"heavy, clean, and slow,"* which is commonly during approaches or departures due to the higher angle of attack required for lift. To minimize the risk of encountering wake turbulence:

General Guidelines

Avoid flying through another aircraft's flight path: Maintain sufficient distance from another aircraft's flight path to avoid wake turbulence.

Maintain altitude separation: Avoid following another aircraft on a similar flight path at an altitude within 1,000 feet.

Taking Off

Behind another aircraft: If taking off behind another aircraft, take off before the preceding aircraft's rotation point.

Intersection takeoffs on the same runway: Be cautious of larger aircraft operations, especially upwind of your runway. Avoid crossing below a larger aircraft's flight path.

After a large aircraft's low approach: Wait at least two minutes before taking off after a large aircraft executes a low approach, missed approach, or touch-and-go landing.

Landing

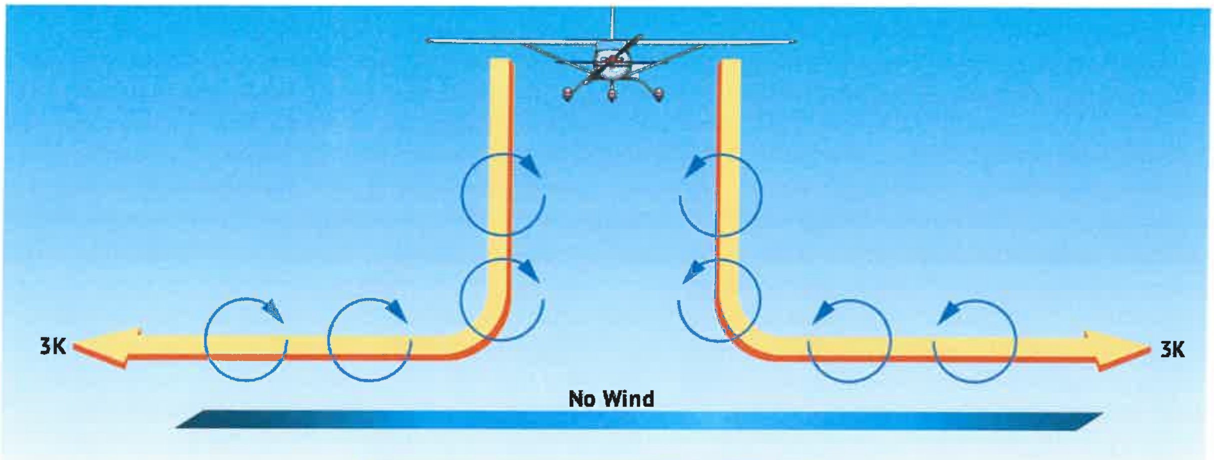
Behind a larger aircraft on the same runway: Stay at or above the larger aircraft's approach flight path and land beyond its touchdown point.

On a parallel runway: If landing behind a larger aircraft on a parallel runway closer than 2,500 feet, consider drift and stay at or above its final approach path.

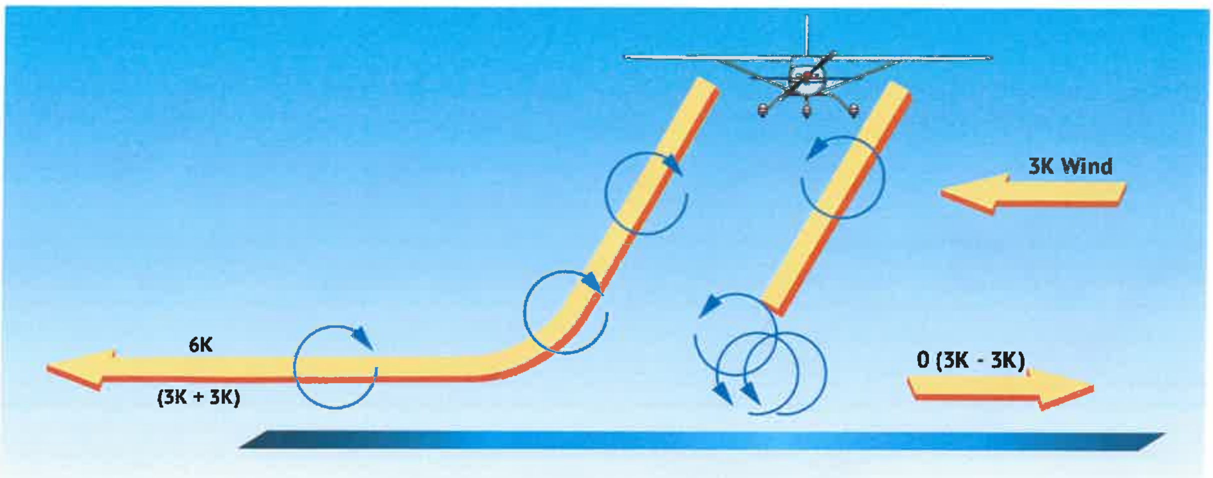
On a Crossing Runway: Cross above the larger aircraft's flight path.

Landing behind a departing aircraft: Land before the departing aircraft's rotation point if on the same runway. If landing on a crossing runway, land before the intersection. Avoid descending below the larger aircraft's flight path and consider abandoning the approach if landing cannot be ensured before reaching the intersection.

After a large aircraft's low approach: Wait at least two minutes to land after a large aircraft executes a low approach, missed approach, or touch-and-go landing on your intended runway.

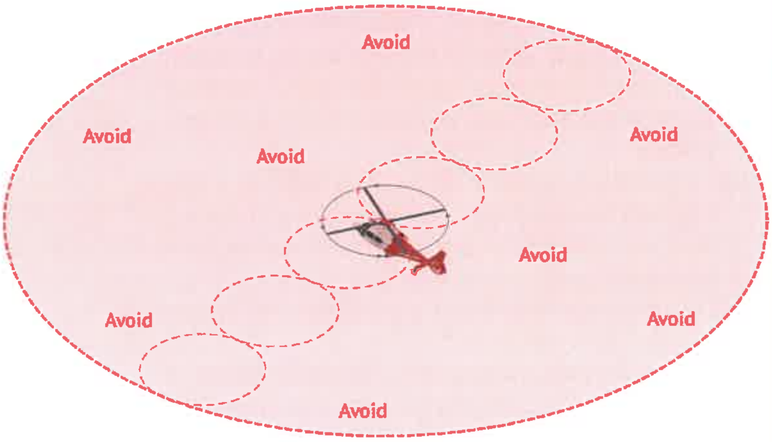


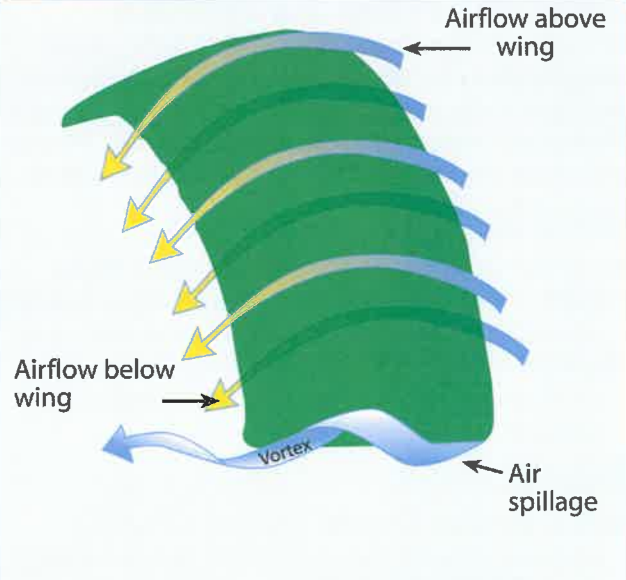
Vortex Movement Near Ground - No Wind



Vortex Movement Near Ground - with Cross Winds

Stay at a distance of at least 3 times the rotor diameter from a helicopter in a slow hover taxi or a stationary hover.





Parachutes also generate vortices when developing lift.

Turbulence from Helicopters

A hovering helicopter generates a down wash from its main rotor(s) similar to the vortices of an airplane. Powered parachute pilots should avoid a hovering helicopter by at least three rotor disc diameters to avoid the effects of this downwash. In forward flight this energy is transformed into a pair of strong, high-speed trailing vortices similar to wing-tip vortices of larger fixed-wing aircraft. Helicopter vortices should be avoided because helicopter airspeeds are often very slow and can generate exceptionally strong wake turbulence.

Wind Considerations

Wind is an important factor in avoiding wake turbulence because wingtip vortices drift with the wind at the speed of the wind. For example, a wind speed of 10 knots causes the vortices to drift at about 1,000 feet per minute in the wind direction. When following another aircraft, you should consider wind speed and direction when selecting an intended takeoff or landing point. If you are unsure of the other aircraft's takeoff or landing point, approximately two minutes provides a margin of safety that allows wake turbulence dissipation.

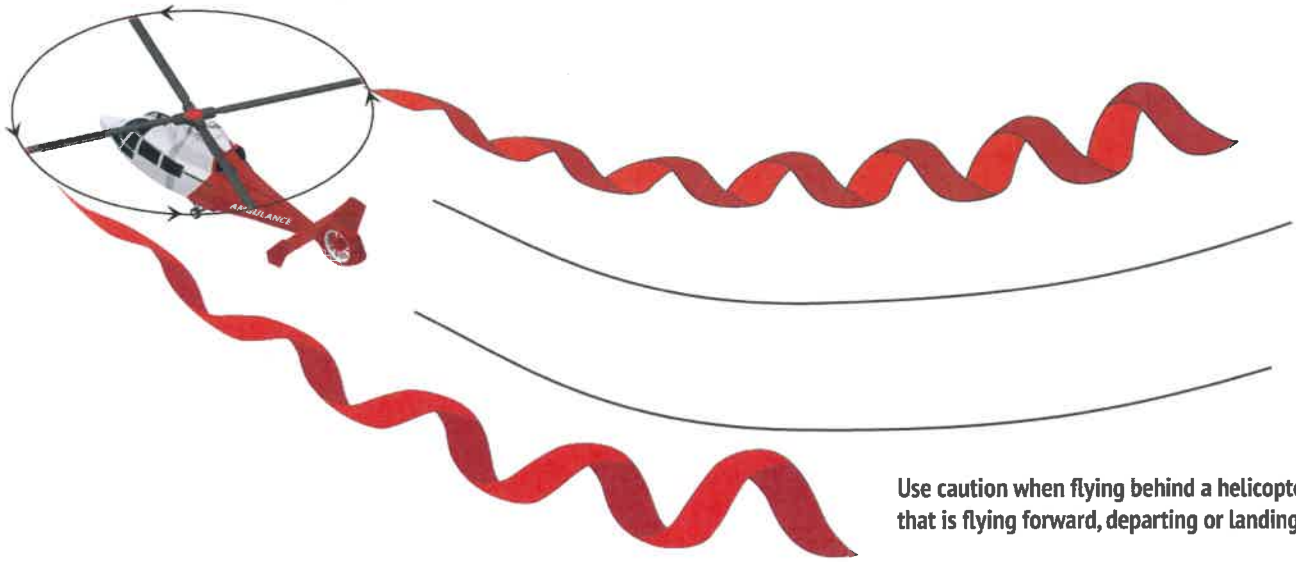
Flying With Other Powered Parachutes

When flying with other powered parachutes, remember that they also create wingtip vortices. In a sense, those vortices may be even more dangerous since you may not consider them while flying with friends. If it's calm, as it often is when flying powered parachutes, the vortices will be less prone to dissipate. In addition, you will be tempted to fly a lot closer to another powered parachute than you would any other kind of aircraft. When flying with other powered parachutes, keep these safety tips in mind:

Maintain Distance: Avoid flying directly behind and below another powered parachute.

Pattern Safety: Keep a safe distance when flying in a pattern with other powered parachutes.

Communicate and Coordinate: Ensure communication with other pilots when taking off as a group. Take off one at a time and allow time between launches for turbulence to settle.



Use caution when flying behind a helicopter that is flying forward, departing or landing.

Chapter 14 Altitude and Performance

We fly in air. Yes, I know that makes me Captain Obvious, but we're going to talk about the performance of powered parachutes and that performance is directly related the air we fly in. Air is a substance, it has mass, and it is what our parachutes use to create lift and what our props use to create thrust. Importantly, air is not consistent. It changes with the weather and with the altitude we're flying at. As the air changes, so does the capability of our aircraft.

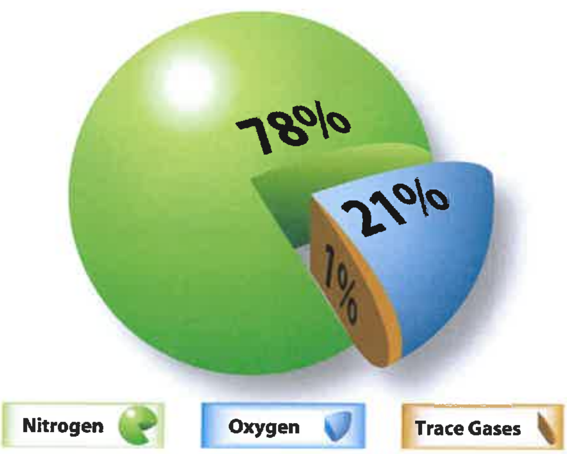
The thinner the air becomes, the harder it becomes to create lift, thrust, and for our engines to perform well. In general, the first thing we want to keep in mind is that the higher we go in altitude, the less air we must work with. In fact, all aircraft have a service ceiling. Generally speaking, a service ceiling is an altitude where an aircraft stops climbing, even at full power. Service ceilings are just one of the reasons you will never accidentally find yourself flying your powered parachute in outer space.

The ever-changing air that we fly in is just one of the things that affect powered parachute performance. This chapter will also cover the effects of weight, runway surfaces, and the fundamental physical laws governing the forces acting on a powered parachute.

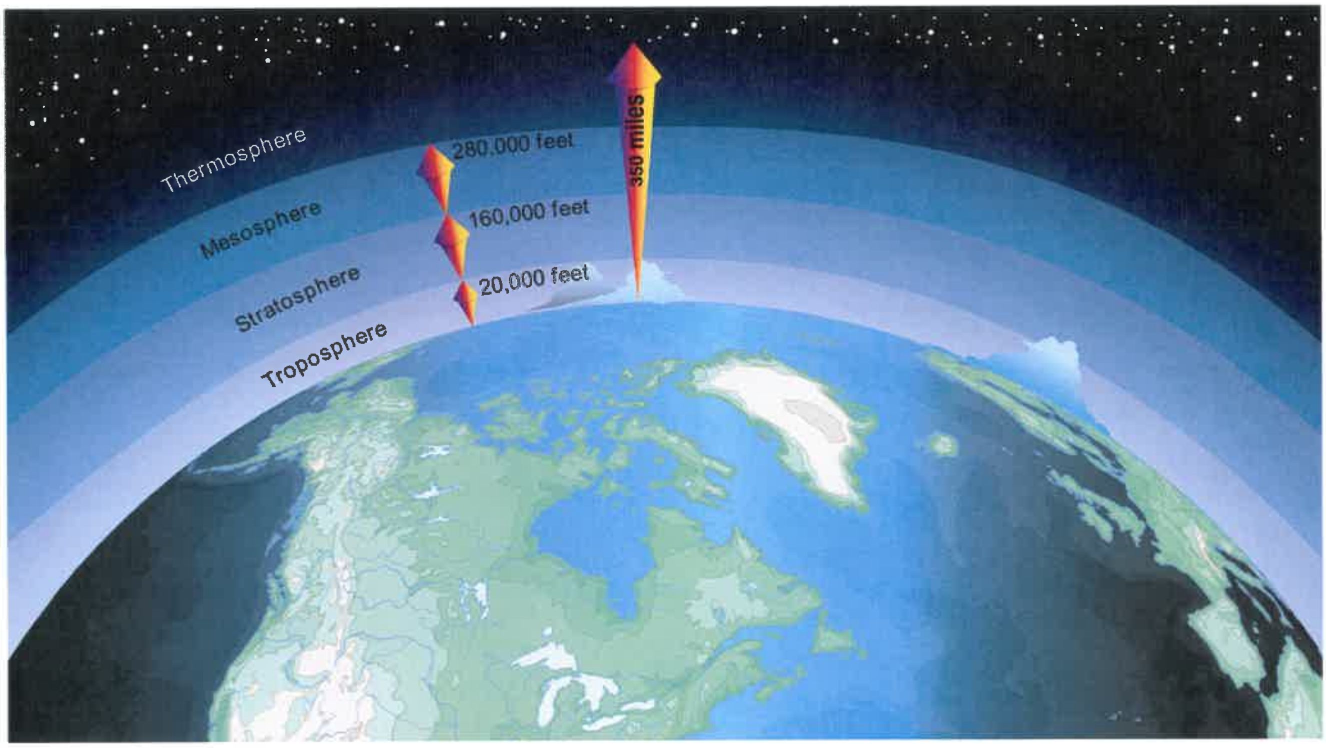
Nature of the Atmosphere

The atmosphere is a mixture of gases that surround the Earth. *"Mixture of Gases"* doesn't sound as sexy as *"air"* so we'll just call it air. Air has mass, weight, and indefinite shape. Air can flow and change shape when subjected to even minute pressures because it lacks strong molecular cohesion. For example, air completely fills any container into which it's placed, expanding or contracting to adjust its shape to the limits of the container.

The atmosphere is composed of 78 percent nitrogen, 21 percent oxygen, and 1 percent other gases, such as argon or helium. Some of these elements are heavier than others. The heavier elements, such as oxygen, settle to the surface of the Earth, while the lighter elements are lifted up to higher altitudes. Most of the atmosphere's oxygen is located below 35,000 feet.



Composition of the atmosphere.



Layers of the atmosphere.

There are several recognizable layers of the atmosphere that are defined not only by altitude, but also by the specific characteristics of that level.

The troposphere is the first layer of the atmosphere. It extends from sea level up to 20,000 feet over the northern and southern poles and up to 48,000 feet over the equatorial regions. Most of the weather, clouds, storms, temperature variances, and powered parachute flying occurs within this first layer of the atmosphere. Inside the troposphere, the temperature decreases at a rate of about 2° Celsius every 1,000 feet of altitude gain, and the pressure decreases at a rate of about 1 inch of mercury per 1,000 feet of altitude gain.

The other layers of the atmosphere are important but are beyond what you need to know as a powered parachute pilot.

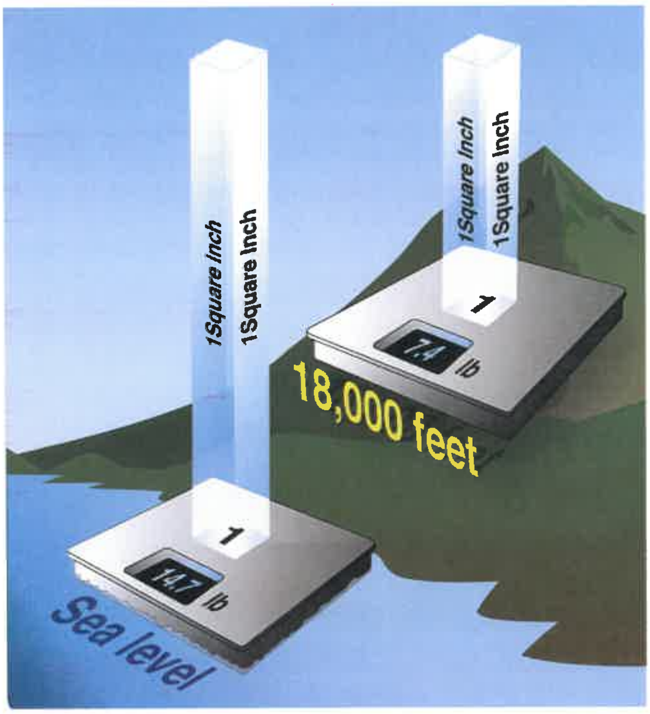
Atmospheric Pressure

Although there are various kinds of pressure, pilots are mainly concerned with atmospheric pressure. It's one of the basic factors in weather changes, it helps to lift an aircraft, and it actuates important flight instruments like your altimeter and rate of climb indicator.

Air is very light, but it has mass and is affected by the attraction of gravity. Therefore, like any other substance, it has weight, and because of its weight, it has force. Since it's a fluid substance, this force is exerted equally in all directions, and its effect on bodies within the air is called pressure.

Under standard conditions at sea level, the average pressure exerted by the weight of the atmosphere is approximately 14.70 pounds per square inch (psi) of surface, or 1,013.2 millibars (mb). This means a column of air 1-inch square, extending from the surface up to the upper atmospheric limit, weighs about 14.7 pounds. A person standing at sea level also experiences the pressure of the atmosphere; however, the pressure is not a downward force, but rather a force of pressure over the entire surface of the skin.

The atmosphere's thickness is limited. The higher the altitude, the less air there is above that level. For this reason, the weight of the atmosphere at 18,000 feet is one-half what it is at sea level.



One square inch of atmosphere weighs approximately 14.7 pounds at sea level. It weighs less as you go higher.

Standard Pressure and Temperature

The pressure of the atmosphere varies with time and location. Due to the changing atmospheric pressure, a standard reference was developed. The standard atmosphere at sea level is a surface temperature of 59 °F or 15 °C and a surface pressure of 29.92 inches of mercury ("Hg), or 1,013.2 mb.

Lapse rate is the rate that the temperature falls with increasing altitude. A standard temperature lapse rate is approximately 3.5 °F or 2 °C per thousand feet up to 36,000 feet which is approximately -65 °F or -55 °C.

A standard pressure lapse rate is one in which pressure decreases at a rate of approximately 1 inch Hg per 1,000 feet of altitude gain to 10,000 feet. Any temperature or pressure that differs from the standard lapse rates is considered non-standard temperature and pressure.

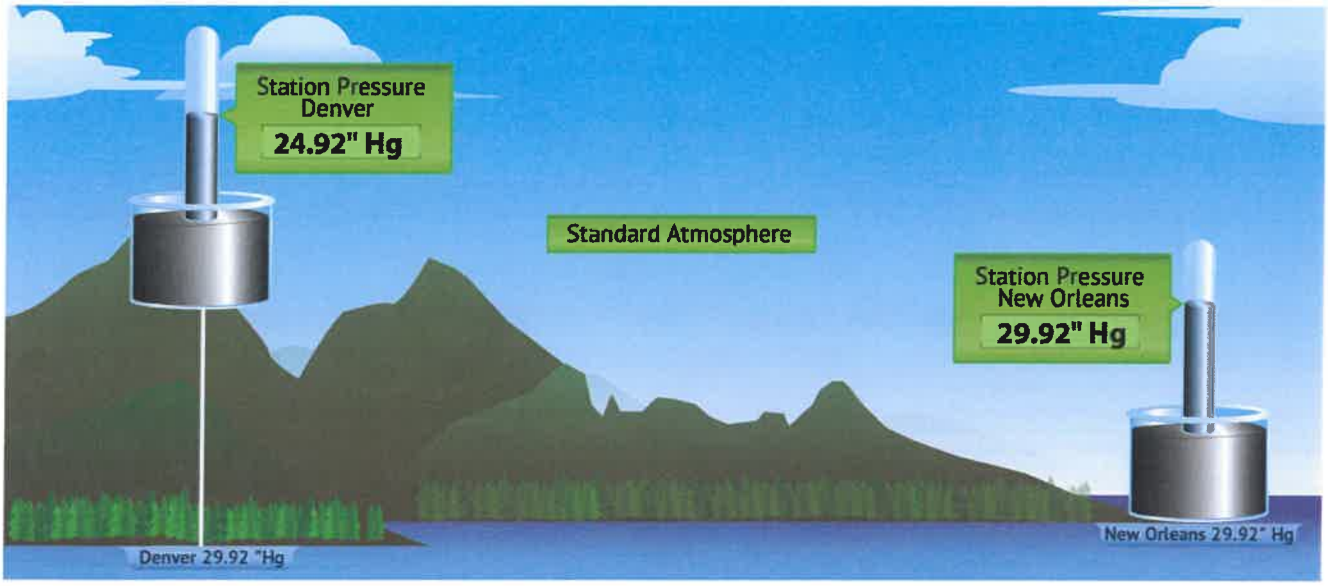
Although mercurial barometers are no longer used in the U.S., they are still a good historical reference for where the altimeter setting came from (inches of mercury).

Measuring Atmospheric Pressure

Atmospheric pressure can be measured in inches of mercury (in. Hg.) by a mercurial barometer. The barometer measures the height of a column of mercury inside a glass tube. A section of the mercury is exposed to the pressure of the atmosphere, which exerts a force on the mercury. An increase in pressure forces the mercury to rise inside the tube. Then when there is a decrease in pressure, mercury drains out of the tube, decreasing the height of the column. This type of barometer is typically used in a lab or weather observation station, is not easily transported, and is a bit difficult to read.

Since weather stations are located around the globe, all local barometric pressure readings are converted to a sea level pressure to provide a standard for records and reports. To achieve this, each station converts its barometric pressure by adding approximately 1 inch of mercury for every 1,000 feet of elevation gain. For example, a station at 5,000 feet above sea level, with a reading of 24.92 inches of mercury, reports a sea level pressure reading of 29.92 inches. Using common sea level pressure readings helps ensure aircraft altimeters are set correctly, based on the current pressure readings.

Station pressure is converted to and reported in sea level pressure.



Altitude (ft)	Pressure ("Hg)	Temperature	
		(°C)	(°F)
0	29.92	15.0	59.0
1,000	28.86	13.0	55.4
2,000	27.82	11.0	51.9
3,000	26.82	9.1	48.3
4,000	25.84	7.1	44.7
5,000	24.89	5.1	41.2
6,000	23.98	3.1	37.6
7,000	23.09	1.1	34.0
8,000	22.22	-0.9	30.5
9,000	21.38	-2.8	26.9
10,000	20.57	-4.8	23.3
11,000	19.79	-6.8	19.8
12,000	19.02	-8.8	16.2
13,000	18.29	-10.8	12.6
14,000	17.57	-12.7	9.1
15,000	16.88	-14.7	5.5
16,000	16.21	-16.7	1.9
17,000	15.56	-18.7	-1.6
18,000	14.94	-20.7	-5.2
19,000	14.33	-22.6	-8.8
20,000	13.74	-24.6	-12.3

Properties of a standard atmosphere showing lapse rates.

Pilots aren't the only ones concerned with the pressure of the air they're flying in. Weather forecasters can more accurately predict movement of pressure systems and the associated weather by tracking barometric pressure trends across a large area. For example, if you notice a pattern of rising pressure at a single weather station, you can anticipate the approach of fair weather. On the other hand, decreasing or rapidly falling pressure usually indicates approaching bad weather and possibly severe storms.

Altimeters

It isn't very useful for pilots to schlep around buckets of mercury to try to determine altitude. Fortunately, altimeters have been designed to measure altitude compactly and accurately by measuring atmospheric pressure.

Your altimeter measures the height of your powered parachute above a given pressure level. But an altimeter doesn't really measure distance at all. What an altimeter measures is air pressure. Even then it doesn't measure air pressure, but rather a difference in air pressure between a constant value in the instrument and what is going on in the atmosphere.

That makes an altimeter one of the most vital instruments in a powered parachute. To use the altimeter effectively, its operation and how atmospheric pressure and temperature affect it must be thoroughly understood.

In most powered parachutes, electronic pressure measuring equipment is used to measure altitude. Barometric pressure sensors are small and inexpensive. The sensors are most often integrated into instruments that digitally display a variety of engine and flight data. This is how they work:

The Barometric Pressure Sensor measures atmospheric pressure. The sensor is calibrated to provide accurate readings based on standard atmospheric conditions. It continuously measures atmospheric pressure.

A Baseline Pressure is necessary for calculating altitude. Most instruments in powered parachutes establish a baseline above ground level (AGL) altitude of 0 feet AGL when they are first turned on. In that case, all altitudes are calculated relative to the elevation of the field you depart from. Other instruments can be manually set to the current mean sea level (MSL) altitude. Yet others determine their baseline pressure through Global Positioning System (GPS) integration.

Altitude Calculation is accomplished by taking the readings of atmospheric pressure from the pressure sensor and comparing them to the calibrated baseline pressure. By analyzing the difference between the current atmospheric pressure and the known pressure at the reference altitude, the instrument calculates the altitude above or below the reference point.

Altitude Presentation is on a screen, providing real-time altitude readings.

Some aviation digital altimeters use GPS technology to enhance their accuracy. A GPS receiver in the avionics system determines the precise three-dimensional position of the aircraft using signals from multiple satellites. The instrument combines GPS altitude data with the barometric pressure readings to refine and cross-check the calculated altitude.

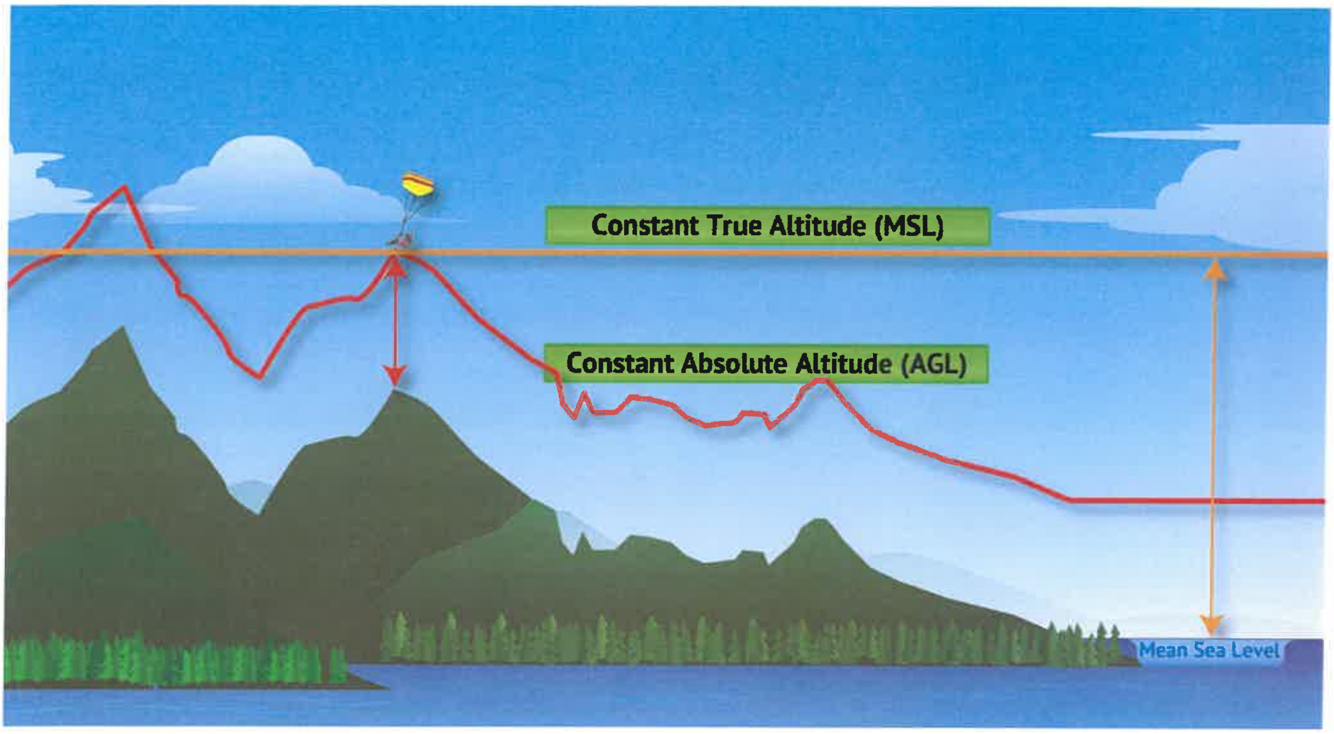
The accuracy of altitude measurements depends on various factors, including instrument calibration, sensor quality, whether it integrates GPS altitude data, and environmental conditions. Whenever possible, you should cross-check altitude readings from multiple sources.

Altitude

We pay close attention to altitude because it affects every aspect of flight from aircraft performance to human performance.

As altitude increases, air pressure decreases due to the diminishing weight of the air column above the aircraft. This decrease in air pressure has a pronounced effect on aircraft performance. As air pressure is reduced, it reduces:

- Power because the engine takes in less air,
- Thrust because the propeller is less efficient in thin air, and
- Lift because the thin air exerts less force on the wing.



True Altitude vs. Absolute Altitude.

High altitude results in:

- Increased takeoff distances
- Increased landing distances
- Decreased climb rates
- Lower payloads

Since our performance is linked to pressure and pressure is linked to altitude, we need to discuss altitude and how to measure it beyond just reading an altimeter. At first, this may seem like a pretty simple concept.

Altitude can be simply expressed as *"How high up are you?"* But it gets a little more complicated when you ask follow-on questions like *"How high up from what?"*, *"How are you doing the measuring?"*, and finally, the strangest and most important question, *"How high up does your powered parachute think it is?"*

Absolute Altitude

Absolute Altitude (or the distance Above Ground Level or AGL) would seem to be the best definition at first glance. Absolute altitude measures how high you are above the surface of the ground. That seems like a pretty handy way to look at things, right? If you're standing on top of a 30-foot tower, you're 30 feet above ground level. If you're flying at 400 feet above the surface, you're flying at 400 feet AGL. What could be simpler or more relevant?

And for navigation, absolute altitude makes a lot of sense if you are looking for an obstacle, normally something like a tower. A 200-foot-tall tower is remarkably different looking from a 1,000-foot-tall tower and those differences are best visualized as how far up from the ground the tops happen to be.

But what if you're standing on the top of Pike's Peak? What altitude are you at then? Well, you're at 0 feet AGL. But try doing a few push-ups there. Your body will tell you that you're higher up than that! Since terrain varies, the ground turns out to not always be a great place to measure altitude from. That's why we have...

True Altitude

True altitude (or the vertical distance above Mean Sea Level or MSL) is what the FAA considers the actual altitude. In fact, sectionals (the aviation maps that we'll learn more about later) are all drawn with altitudes expressed in MSL, which might be confusing for those flying a powered parachute in the flatlands. You might wonder what the point is.

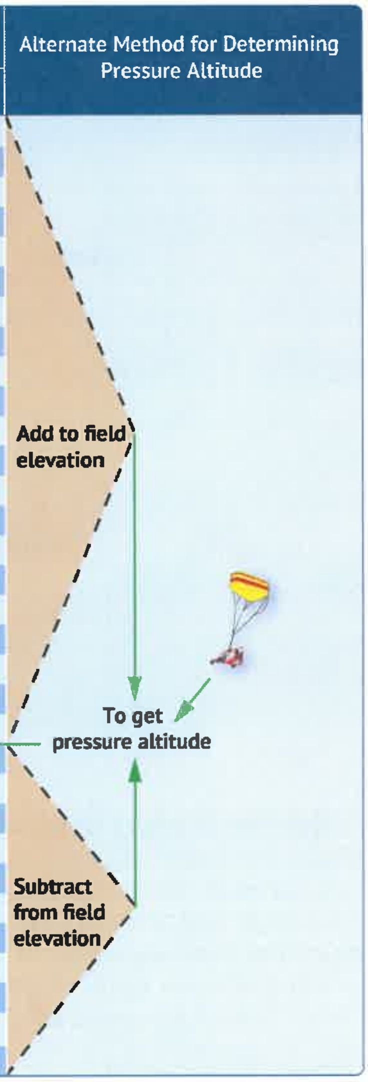
Well, for one, if someone tried to fly at AGL as the ground rises and falls, it would take some effort to hold a course, especially since there is no low-cost way to measure absolute altitude in most aircraft. Since MSL is referenced from the flat oceans (well, flat on a big ball, but you know what I mean), that means that a constant altitude course in MSL is nice, level flying.

Also, mountain peaks are measured in MSL. So if you find yourself on Pike's Peak again, you will be at 0 feet AGL, but at the same time all the way up to 14,115 feet MSL. After a few push-ups, your lungs will believe the MSL number more than the AGL number!

So how do pilots measure altitude in MSL? Tape measures to the ground are unrealistic enough, tape measures to the ocean are completely unreasonable. That's why we have...

Method for Determining Pressure Altitude		
Altimeter setting		Altitude correction
28.0		1,824
28.1		1,727
28.2		1,630
28.3		1,533
28.4		1,436
28.5		1,340
28.6		1,244
28.7		1,148
28.8		1,053
28.9		957
29.0	Add	863
29.1		768
29.2		673
29.3		579
29.4		485
29.5		392
29.6		298
29.7		205
29.8		112
29.9		20
29.92		0
30.0		-73
30.1		-165
30.2		-257
30.3		-348
30.4		-440
30.5	Subtract	-531
30.6		-622
30.7		-712
30.8		-803
30.9		-893
31.0		-983

Field elevation is sea level



Field elevation versus pressure. The aircraft is located on a field that happens to be at sea level. Set the altimeter to the current altimeter setting (29.7). The difference of 205 feet is added to the elevation or a PA of 205 feet.

Indicated Altitude

Absolute Altitude and True Altitude are *"real altitudes."* Indicated altitude is what we read from our altimeters. Now we're talking about an instrument reading instead of a real distance value.

The official definition of indicated altitude is *"the altitude read directly from an altimeter when it is set to the current altimeter setting."* The definition is an artifact of older aneroid altimeters that required manual setting before takeoff and periodic resetting on longer cross-country flights.

That definition doesn't hold a lot of meaning to powered parachute pilots since we use digital altimeters that often automatically set to 0' AGL when they're first switched on. That altitude is known as *"feet above origin."* Many of those altimeters can also be manually set to the field elevation which converts the readings to MSL.

If you're using a GPS-based altimeter, such as an application on a smartphone, the altitude will be displayed in feet MSL. Some apps also display the feet above origin if you start them while you're still on the ground.

For most of aviation, indicated altitude implies readings in MSL. In reality, there is another step called corrected altitude. It isn't necessary to know that for powered parachute operations.

Altitude as a Performance Measure

So far, we've discussed altitude in terms of how far away we are from the planet, both real numbers and ways to measure altitude using an altimeter. But there is a whole different kind of altitude out there that is certainly linked to how high an aircraft is from the planet, but has more to do with the performance of an aircraft than navigation. Calling these values 'altitude' is a little misleading because they aren't real altitude numbers. They are what I consider pretend altitude numbers. They are values that will give you important information, but only for aircraft performance.

Pressure Altitude

Pressure altitude is the vertical distance above or below the standard pressure level. The standard pressure level is that theoretical location where the temperature is 59 degrees Fahrenheit and the pressure equals 29.92 inches of mercury.

So why is this important? Pressure altitude helps us predict how well an aircraft is going to perform. We know that performance increases as pressure increases and performance decreases as pressure decreases. But what is it increasing or decreasing from and how can we visualize it?

That's what pressure altitude does for us. Most aircraft have performance specifications determined for standard conditions. So this is a way to place a number on how far away we may be operating from a standard pressure. It works because pilots think in altitude, not in pressure readings.

Pressure altitude is also used to compute density altitude and other performance data.

There are ways to determine pressure altitudes at any *"real"* altitude, but we're mostly concerned with surface level conditions. And that's handy because many public airports report altimeter settings, which we can use to calculate pressure altitude. All we need is the field elevation of the airport and the handy table on this page.

For instance, if the local altimeter setting is 30.1 inches of mercury (inHg) we can look at the table and see that the correction altitude is -165 feet. Then the formula is pretty easy.

Pressure Altitude (PA) = Field Altitude + Correction Altitude

In this example, since the altimeter setting is higher than the standard 29.92 in-Hg, the air pressure at that location is higher and denser than what would be expected at that true altitude. This indicates that the air at that location resembles the compressed air found at a lower altitude. Consequently, the pressure altitude is lower than the actual height above mean sea level.

Air Density and Density Altitude

The unseen truth is that wings, props, and carbureted engines all perform better in denser air. It makes sense since all those things use air to do their jobs. More concentrated air means they can do a better job.

First, we'll talk about air density and its effects. Then we'll talk about how we measure air density in a way that describes those effects for us. That measurement is called *density altitude*.

Air Density

Air density refers to the mass or number of air molecules within a given volume. Air can be compressed or expanded, affecting its density. When air is compressed, it occupies less space and contains a greater amount of air for a given volume. When the pressure on air is reduced, it expands and a given volume contains a smaller mass of air, leading to a decrease in density. Density and pressure are directly proportional, meaning that if pressure is doubled, so is density, and vice versa.

The biggest factor for air density is altitude. As you increase in altitude, the atmospheric pressure decreases, causing air to expand and become less dense. As altitude increases, air density decreases due to the lower number of air molecules at those increased altitudes.

It makes sense that higher altitudes and elevations would result in less dense air. But there are other factors that may be less obvious. So, let's talk about those.

Effect of High- and Low-Pressure Systems

Weather systems such as high or low-pressure areas influence atmospheric pressure, which, in turn, affects air density. High-pressure systems are characterized by a concentration of air molecules that result in relatively higher atmospheric pressure compared to the surrounding areas. Low-pressure systems have relatively lower atmospheric pressure compared to the surrounding areas. High-pressure systems have denser air while low-pressure systems have less dense air.

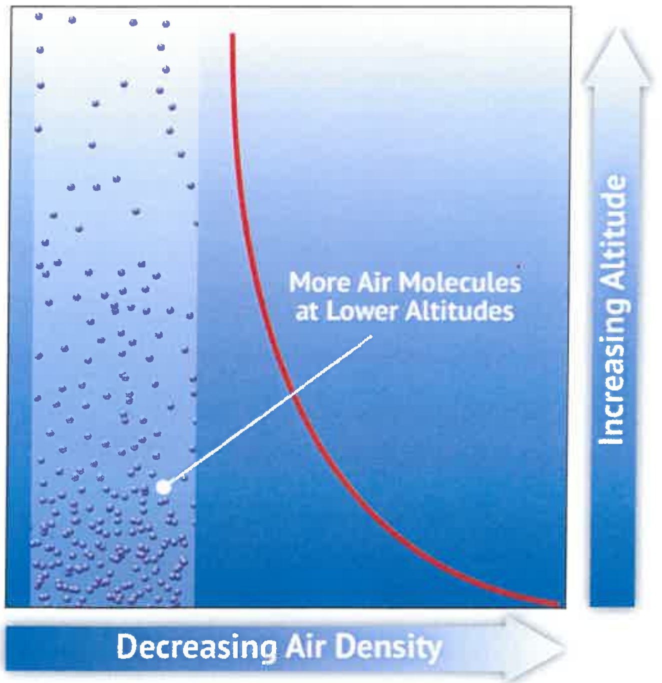
High- and low-pressures are used to calculate *pressure altitude*, which was discussed earlier in the chapter.

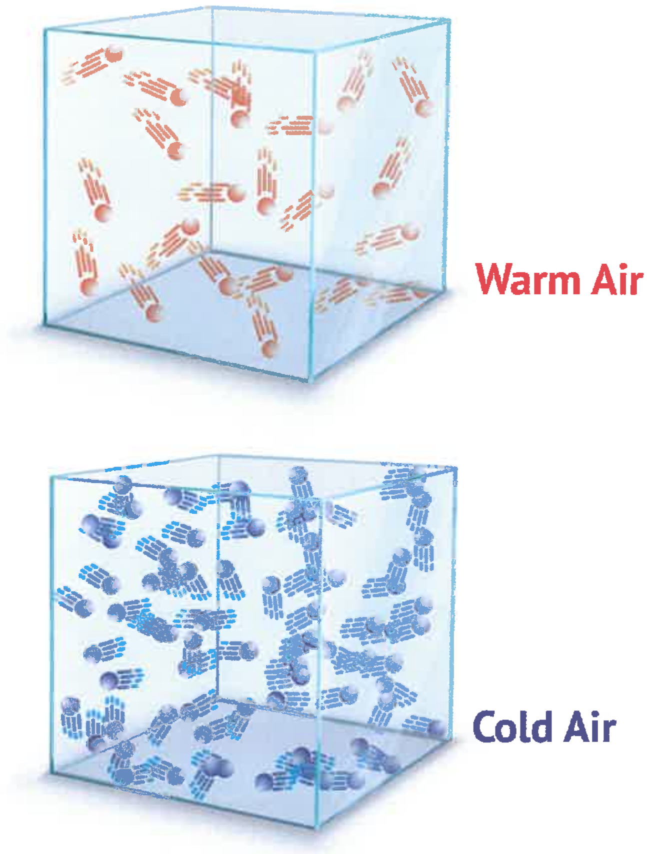
Effect of Temperature

Increasing temperature reduces air density by making air molecules more energetic and spread out. The opposite occurs when temperature is decreased.

(For the record, both temperature and pressure decrease with altitude in the atmosphere, but the more rapid drop in pressure typically has a greater effect on air density. That's why ultimately air density decreases as altitude increases.)

Temperature effects on density are combined with *pressure altitude* to calculate *density altitude*, which we're going to get to soon.





Above: Air density decreases as you go up in altitude.

Right: Warmer molecules move faster and take up more volume than cooler molecules

Effect of Humidity (Moisture)

Humidity also plays a role on the density of air, although not as significant as pressure or temperature. The higher the humidity, the less dense the air becomes since water vapor (H2O) is lighter than the nitrogen (N2) and oxygen (O2) molecules that it displaces.

Water vapor is lighter than air, making moist air lighter than dry air. As the water content of the air increases, it becomes less dense, which decreases powered parachute performance. Humidity is expressed as relative humidity, a percentage of the maximum amount of water vapor that air can hold at a given temperature. Warm air can hold more water vapor than cold air, and humid conditions contribute to decreased performance in a powered parachute.

When comparing two separate air masses, the first one warm and moist (both qualities tending to lighten the air) and the second one cold and dry (both qualities making it heavier), the first air mass must be less dense than the second. Pressure, temperature, and humidity all have a significant impact on powered parachute performance due to their effect on density.

Humidity alone is not typically calculated into performance figures even though it does contribute.

Weight vs. Volume comparison of naturally occurring Nitrogen,Oxygen, and Water in the atmosphere shows that water vapor is lighter than most 'air'.

So it turns out that there are a total of four things that determine how dense a given volume of air is.

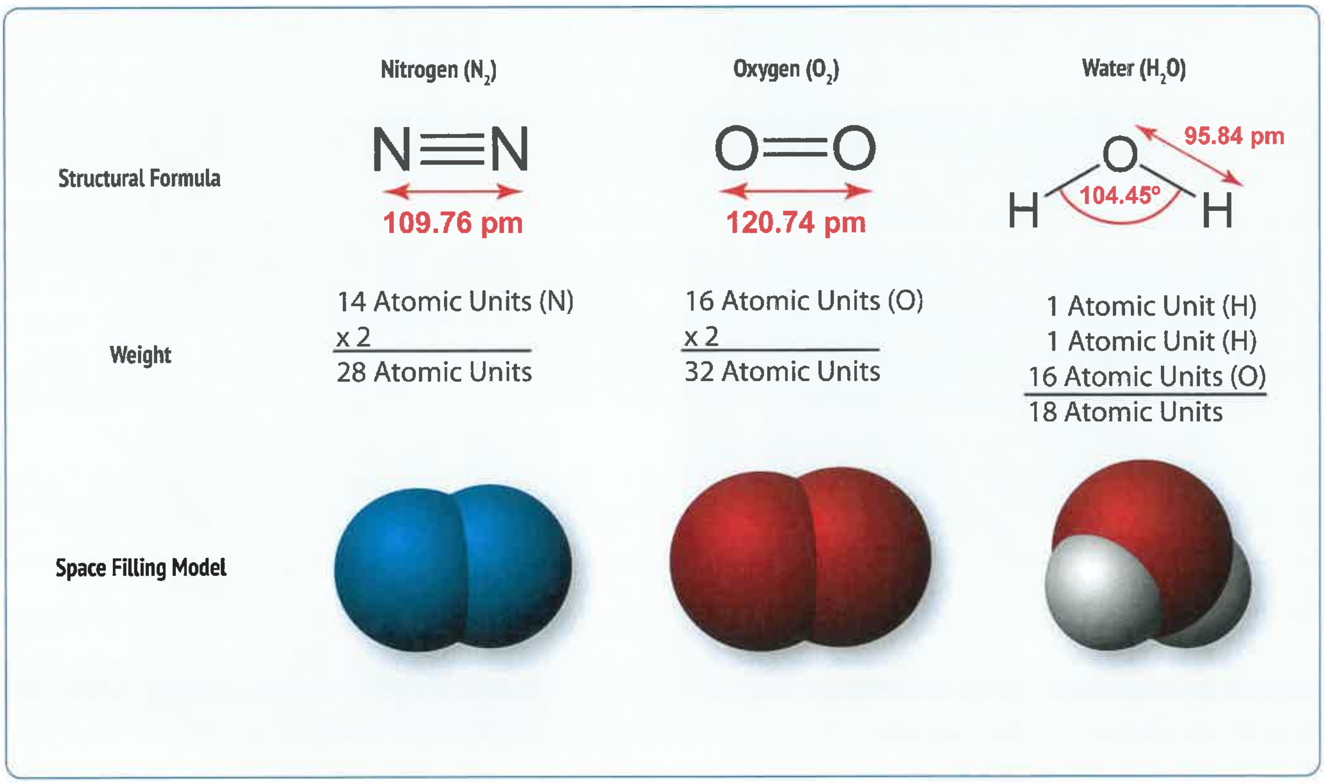
- Altitude (Which is accounted for in Pressure Altitude)
- Atmospheric pressure (Which is accounted for in Pressure Altitude)
- Temperature (Which is accounted for in Density Altitude)
- Humidity (Which is not included in calculations, but still has an effect)

Effects of Air Density on Lift and Control

Air density directly affects lift generation. As air density decreases, your wing encounters fewer air molecules, resulting in reduced lift forces. To get the same amount of air over your airfoil in order to climb, your powered parachute will have to move faster to climb as fast in less dense air as it would in denser air. That increase in speed isn't something you control, it's just what happens aerodynamically when you add throttle to climb.

The opposite also happens. Denser air enhances lift because your wing has more air molecules to work with. That means improved takeoff performance, quicker climb rates, and increased maneuverability.

Weight vs. Volume Comparison of naturally occurring Nitrogen, Oxygen, and Water in the atmosphere shows that water vapor is lighter than 'air'.



Effects of Air Density on Engine and Propeller Performance:

Air density significantly influences engine and propeller performance. As air density decreases, your engine's ability to intake air decreases, leading to reduced engine power.

Propeller performance is also affected by air density. In thinner air, propellers are less efficient and do not generate as much thrust as they do in denser air. This also results in decreased overall performance and reduced rate of climb.

Combined Effects

The effects of less dense air combine to reduce aircraft performance. That's because less dense air reduces:

Power because the engine takes in less air
Thrust because the propeller is less efficient
Lift because thin air exerts less force on the wing

Together, the effects of less dense air decreases aircraft performance in many ways. Here's a list:

- Increases takeoff roll
- Increases landing roll-out
- Decreases rate of climb
- Decreases angle of climb
- Decreases payload

All these performance hits are similar to those you get when increasing the takeoff weight of your powered parachute—like taking along a passenger! And of course, all of these factors become that much more important when you have a short field, obstacles to clear, or are taking that passenger along with you for a flight.

Density Altitude

Now that we've established the importance of air density, let's work on measuring it. That measurement is called *density altitude*.

Density altitude is important because it's the best predictor of how well your powered parachute will perform in the sky. To calculate density altitude, you take pressure altitude and correct it for temperature.

In fact, the textbook definition of density altitude *"is the Pressure Altitude corrected for variations from standard temperature."*

To recap, we addressed altitude and atmospheric pressure in a previous section when we discussed pressure altitude. There we talked about how air density is decreased by reduced air pressure, which is what you get when you fly at higher altitudes. The weather also changes air density when a high- or low-pressure system comes through. The field altitude and pressure are used to calculate pressure altitude.

And we now know that air density is also decreased by higher air temperatures.

Wrapping Your Mind Around Density Altitude

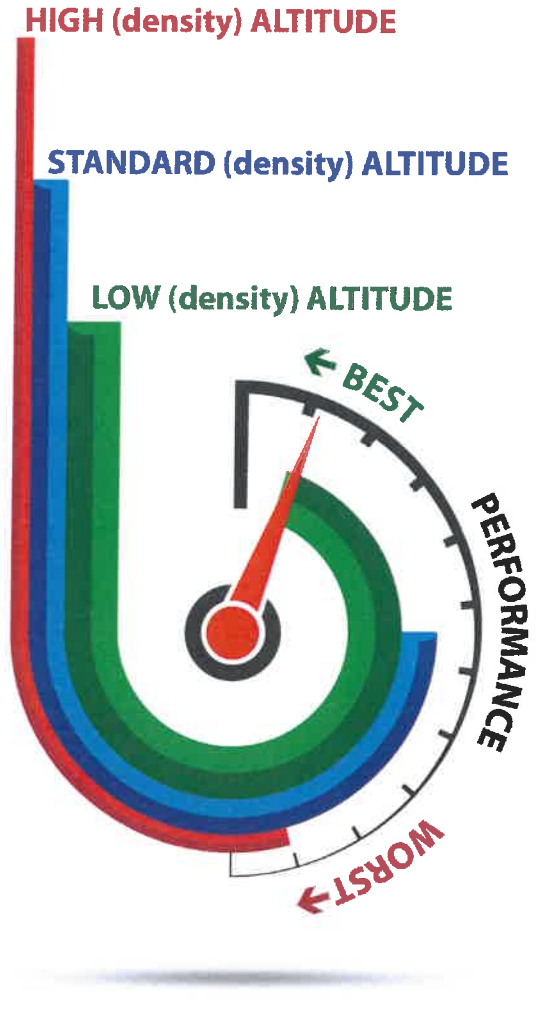
Now there's a problem here and a huge source of confusion. Air density is difficult to describe by itself. Aviation needed something pilots could wrap their minds around. The elegant way that was invented to easily describe how the three factors of altitude, pressure and temperature combine to affect air density and aircraft performance is called *density altitude*. It probably should have been called something different like *adjusted altitude*, but nobody asked me.

It turns out that the problem with the term density altitude is the word *density*. When words like 'high' or 'low' get put in front of it, it seems like we're talking about high density or low density air.

But we aren't. We're actually talking about how aircraft are performing. They perform poorer in high altitude and better at low altitude. Slipping the word *density* in just makes it confusing.

So when thinking about density altitude, think about it as High (density) Altitude and Low (density) Altitude. Just kind of ignore the idea of (density). Because remember, high altitude equals poorer performance, and low altitude means better performance. The denseness (or lack of denseness) of the air is just how we describe that feature of the air.

As we mentioned while talking about pressure altitude, the Standard Datum Plane is a theoretical starting point to measure pressure altitude from.



But the atmosphere is very rarely 'standard.' So, we use density altitude to describe the vertical distance above (or below) sea level in that standard atmosphere where the real atmosphere matches up, performance-wise. This measure of altitude becomes important because air density (at whatever the 'real' altitude may be) has significant effects on your powered parachute's performance.

Density altitude values are based on how air behaves compared to standard conditions. For example, as temperature increases and pressure decreases, the air behaves more like it would at higher altitudes on a 'standard' day.

Calculating Density Altitude

Density altitude is determined by first finding pressure altitude, and then correcting this altitude for nonstandard temperature variations. Calculating density altitude can be a handful and should be left to electronic calculators, web sites, phone apps, or (worst case) the not-so-handy chart I'm providing for you here. The nice thing about the chart is that it allows you to visually understand density altitude values and how they are related to pressure altitude and temperature if you take a little time to study it.

The graph shows that for standard temperature conditions, the pressure altitude and density altitude are equal. As the temperature increases, so does the density altitude.

If you're preparing for an FAA knowledge test, I recommend getting an ASA CX-3 flight computer or a similar tool. This is a menu-driven calculator that not only calculates pressure altitude and density altitude, but it also performs a lot of other aviation-related mathematical functions. Best of all, the FAA allows you to take the CX-3 calculator in with you when you take your knowledge test. They won't let you do that with your smart phone.

For just everyday use, this is a great on-line density altitude calculator.

http://www.pilotfriend.com/pilot_resources/density.htm

Several apps exist for both iPhone and Android smart phones. I saw at least one Apple App (Density Altitude+) that uses onboard iPhone sensors to calculate density altitude for you. Talk about easy! Some calculators (both online and apps) also take into account humidity.

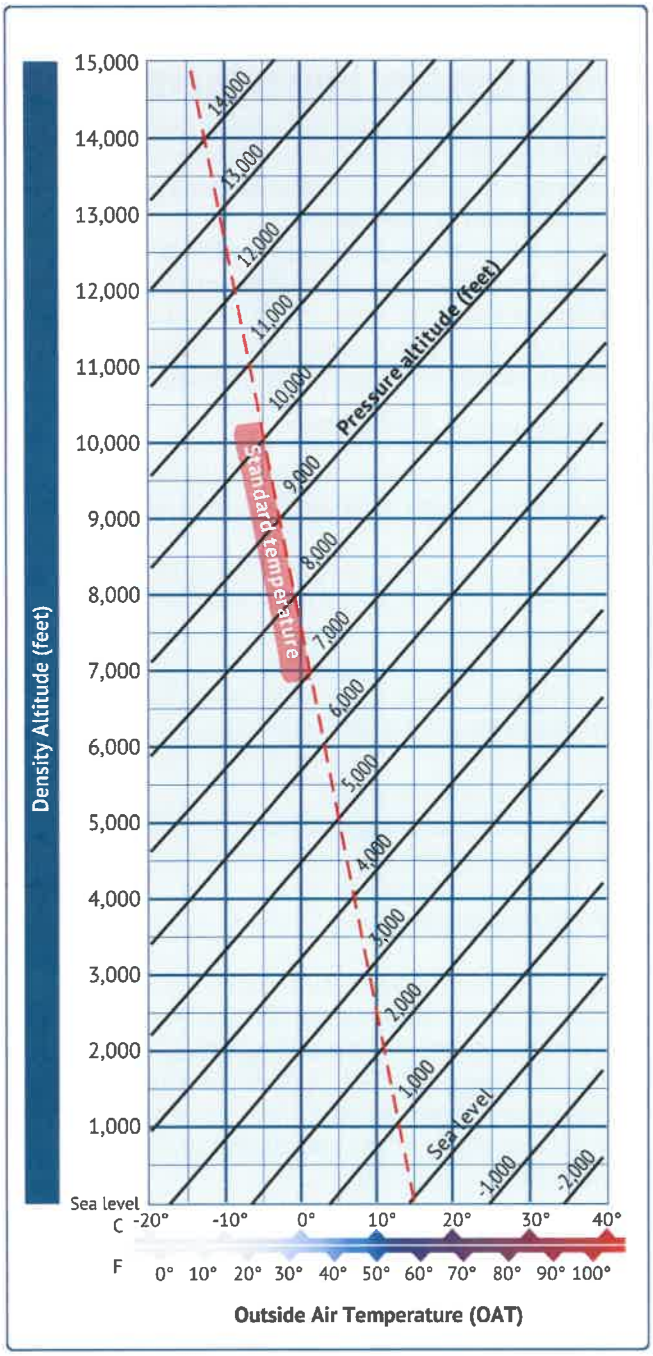
If you want to do a deep dive into the formulas behind density altitude, you should visit:

https://wahiduddin.net/calc/density_altitude.htm

Your brain may hurt a little bit when you're done, but you'll be smarter for it!

Tying It All Together

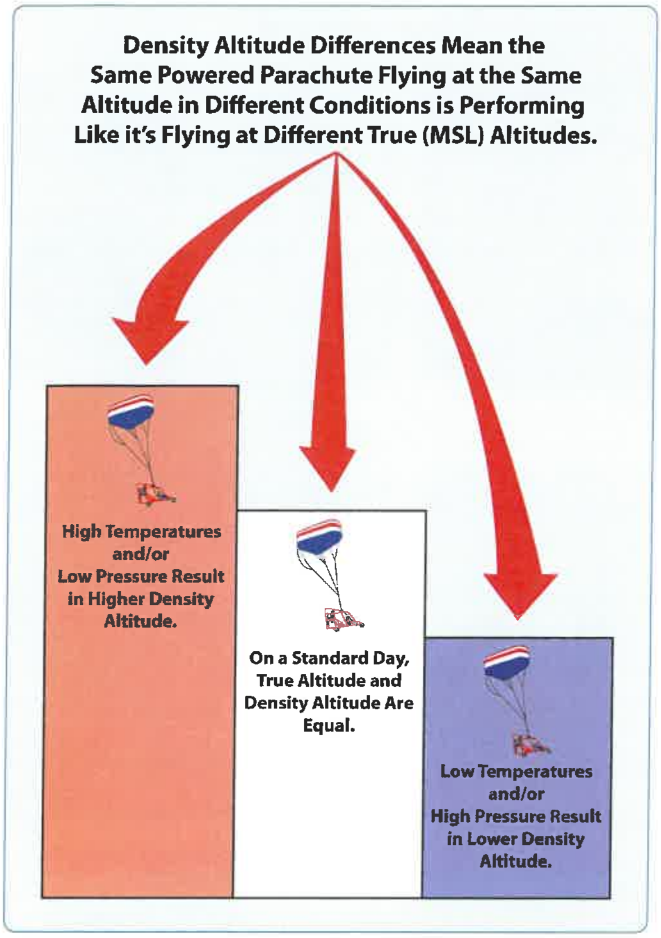
As altitude increases, atmospheric pressure decreases, leading to a reduction in air density. This decrease in air density affects aircraft performance, as it reduces the power, thrust, and lift generated by the engine, propeller, and wing.

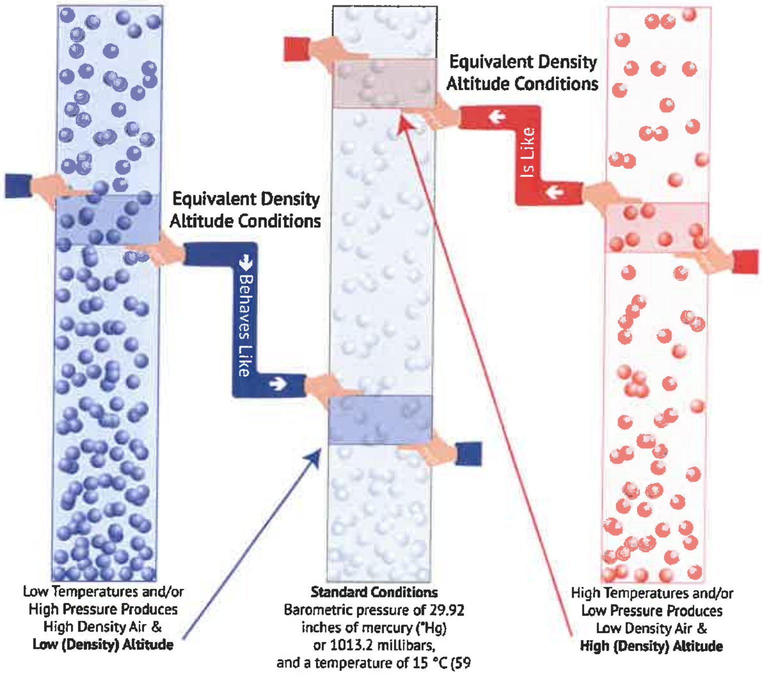


Density altitude chart.

This results in increased takeoff and landing distances, reduced climb rates, and a lower ceiling you can climb to. If your powered parachute requires a certain distance to take off at sea level, it will require a longer ground run at a higher altitude and will need more room to clear an obstacle once in the air.

Since the air is less dense at altitude, your powered parachute will also fly faster. That's because you need a certain amount of air to flow over your wing to develop lift. At altitude, the powered parachute needs to go faster to expose the airfoil to the same amount of air that is easily obtained at slower speeds at sea level. This isn't something you control, it just naturally happens. That effect isn't free, though. It also means that you have to use more fuel and a higher throttle setting.





Two ways to visualize density altitude.

Density altitude is the best kind of altitude measure to use when comparing performance. High density altitude refers to thin air (the kind of air you find at high altitudes), while low density altitude refers to dense air (the kind of air you find at low altitudes). The conditions that contribute to high density altitude are:

- High elevations
- Low atmospheric pressures
- High temperatures

The conditions contributing to low density altitudes are:

- Lower elevations
- High atmospheric pressure
- Low temperatures

Performance Data

When flying a powered parachute, it's important to have performance data for your make and model under different environmental and operating conditions. That data should factor in density altitude and different flight weights and includes data on runway lengths required, rate of climb, fuel range, endurance, descent, and landing roll-outs.

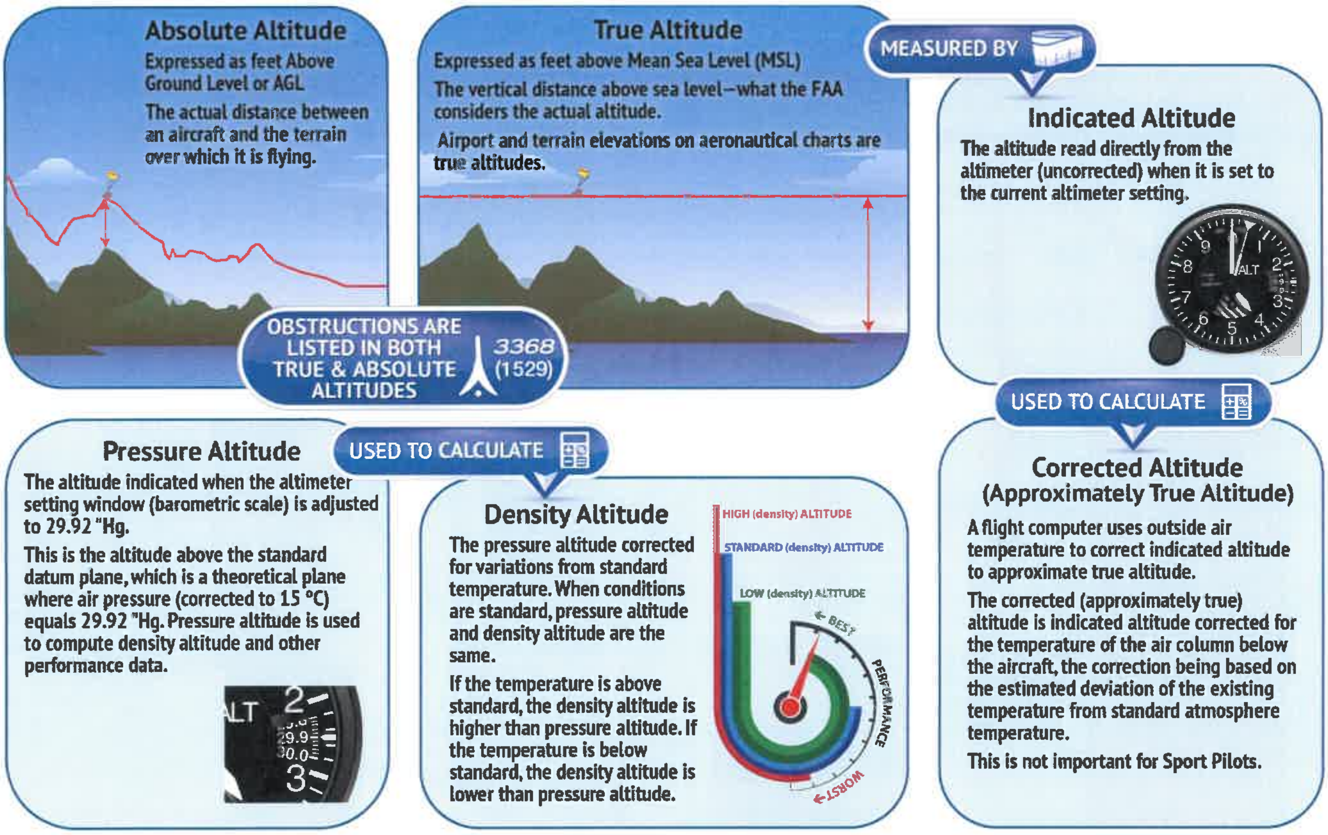
You can find that information in the *Performance* section of the *Aircraft Operating Instructions* (AOI) for Special Light Sport Aircraft (SLSA) and most late model Experimental Light Sport Aircraft (ELSA) powered parachutes. Familiarize yourself with the manufacturer's information and data, but keep in mind it may be incomplete or inaccurate. It's a great starting point to get to know your powered parachute.

The data may not keep up with changes in powered parachute design or with the specific options you have on your aircraft. The changes or options that could change performance from what you find in the AOI include:

- Different engine
- Different parachute
- Different landing gear
- Different empty weight due to the weight of options
- Options like a windshield that change the aerodynamic profile of your powered parachute

Performance

The term *performance* refers to the capabilities of a powered parachute that make it suitable for specific purposes. For instance, the capacity of a powered parachute to take off and land within a very limited distance is a crucial consideration for pilots who frequently operate from small, unimproved fields surrounded by obstacles. On the other hand, other pilots require performance features like the ability to transport heavy payloads, fly at high elevations, or travel long distances.



The chief elements of performance are:

- Takeoff distance
- Landing distance
- Rate of climb
- Ceiling (the maximum altitude at which the powered parachute can operate efficiently and effectively)
- Payload
- Range
- Speed
- Maneuverability
- Stability
- Fuel economy

Some of these factors are often directly opposed: for example, speed versus shortness of landing distance; long range versus great payload; high rate of climb versus fuel economy; and maneuverability versus stability.

Powered parachute performance depends on the combined characteristics of the airframe, powerplant, parachute, and rigging. The aerodynamic features of the parachute determine the power and thrust demands at different flight conditions, while the powerplant and propeller determine the power and thrust available. Manufacturers match the airframe and powerplant with the parachute to achieve optimal performance features, such as endurance, range, climb, and cost. You can further optimize rigging for the weight and performance desired.

Straight-and-Level Flight

Straight-and-level flight seems like it would be easy to obtain in a powered parachute but can be elusive. On the other hand, level flight is easy to obtain since that only requires an appropriate throttle setting.

Whether or not the flight path is straight or not at level flight depends on how the powered parachute is rigged. If a powered parachute isn't rigged properly for straight flight, then performance will degrade since straight flight will require a constant turning input, either using the steering bars or trim locks. Both methods result in a wing that is creating more drag on one side than the other, decreasing performance.

In-flight trimming for speed is challenging in powered parachutes, as most are unable to adjust trim for different speeds once in flight. The technology exists for in-flight trim, but it's rarely available for most models. In-flight trim is possible by either adjusting rigging in-flight or by shifting the center of gravity of the airframe.

Note your engine RPM at level flight on a given day and aircraft loading. Throttle settings above that level flight RPM is considered reserve power.

Takeoff Performance

If a powered parachute of given weight and configuration is operated at greater heights above standard sea level, the powered parachute will still require the same dynamic pressure to become airborne.

An increase in density altitude can produce a fourfold effect on takeoff performance:

- A need for greater takeoff speed
- Decreased thrust and reduced net accelerating force from the engine
- Reduced rate of climb
- Increased runway required

Climb Performance

The ability to climb is reliant on the amount of reserve power or thrust available. Reserve power refers to the excess power beyond what is needed to maintain level flight. For example, if a powered parachute's engine generates a total of 65 horsepower and only 48 horsepower is needed for level flight, then the remaining 17 horsepower can be used for climbing.

Our engine gauges don't have a horsepower indicator. However, they do have a tachometer which measures engine RPM. That number can be used to estimate how much excess power and (even more indirectly) how much excess thrust you have available for climb.

Let's talk about the difference between the terms *power* and *thrust*, which are sometimes used interchangeably but are not synonymous. Mechanical power is measured in horsepower. One horsepower is equivalent to lifting 550 pounds a vertical distance of one foot in one second. Power refers to the rate of work over time and is a function of the speed at which a force is developed.

On the other hand, thrust is the force that imparts a change in the velocity of a mass and is measured in pounds without any element of time or rate. It's similar to the forces of weight and lift. During a steady climb, the rate of climb depends on excess thrust, or push from the propeller.

Showing the "Why" of Excess Power

During steady level flight, whether level or with a slight rate of climb, the vertical component of lift in a powered parachute is almost equivalent to the total lift generated. As a result, the lift will be approximately equal to the weight of the powered parachute. For the sake of simplicity, we'll ignore the influence of the net thrust of the powerplant, which is often at an angle relative to the flight path of a powered parachute. (Most powered parachutes are designed with the thrust going straight back, however, we fly with a small nose-up attitude.) In addition, we can acknowledge that since the weight of the powered parachute is acting vertically, a portion of it will also act rearward along the flight path.

Stay with me here. If we assume that the powered parachute is in a steady climb with essentially a small inclination of the flight path, the summation of forces along the flight path resolves to:

Forces forward = Forces aft

So while this basic relationship doesn't fully consider important factors that can impact climb performance, such as the inclination of thrust from the flight path, lift not being equal to weight, and an increase in induced drag from the parachute, it remains the fundamental factor governing climb performance. Essentially, this relationship states that the rate of climb for a powered parachute depends on the excess thrust, or the difference between thrust and drag, given a certain weight. If excess thrust is zero, then the powered parachute will remain in steady, level flight. A greater amount of excess thrust will result in an increased rate of climb, whereas insufficient thrust will cause the powered parachute to descend.

Why Climb Performance Matters

The primary concern with climb performance is the ability to clear obstacles, particularly when taking off from short or restricted fields. The greatest rate of climb is achieved when the thrust available exceeds the thrust required by the largest margin.

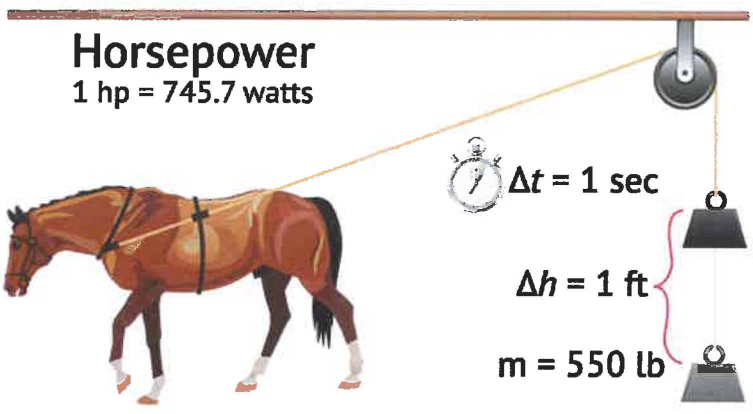
The maximum rate of climb for a powered parachute occurs when there is the greatest difference between the available power and the power required. This relationship implies that, for a given weight of the powered parachute, the rate of climb depends on the excess power, or the difference between available power and required power. If the excess power is zero, the rate of climb is also zero, and the parachute remains in steady, level flight. A greater excess power results in a higher rate of climb.

The climb performance of a powered parachute is influenced by several variables, such as high gross weight, high altitude, and powerplant malfunction.

Effect of Weight on Climb Performance

The impact of weight on powered parachute performance is significant. When weight is added, a powered parachute must create more lift to stay at the same altitude. That's done by maintaining a higher power setting. That increases thrust, which increases the speed of the powered parachute so that more air can flow over the wing. But that increase in lift comes with an increase of induced drag from the parachute. That's where the increased thrust is used up. As a result, less reserve thrust is available for climbing.

An increase in weight lowers the maximum rate of climb, but the powered parachute will fly faster.



Effect of Altitude on Climb Performance

As altitude increases, the air thins and a powered parachute has to go faster to generate sufficient lift from the wing. That requires more power. At the same time, the power available from an engine and propeller decreases with altitude. This results in a reduction of climb performance until the absolute ceiling is reached. At the absolute ceiling, no excess power is available and full throttle will only maintain steady, level flight.

The service ceiling, on the other hand, is the altitude at which the powered parachute can no longer climb at a rate greater than 100 feet per minute.

Power Loading and Wing Loading

When discussing performance, two useful terms are *power loading* and *wing loading*. Power loading is calculated by dividing the powered parachute's weight by its engine power and is expressed in pounds per horsepower. A higher power loading represents a greater power-to-weight ratio, indicating the ability to generate more thrust for lift and climb.

Wing loading, on the other hand, is calculated by dividing the powered parachute's weight by the parachute wing area and is expressed in pounds per square foot. A higher wing loading indicates that each square foot of the wing supports more weight. Higher wing loadings come from either smaller parachutes or higher aircraft gross weights. Either way, the result is faster powered parachute forward speeds.

Endurance and Range Performance

Endurance of a powered parachute refers to the maximum length of time that it can spend in straight-and-level flight. Efficient fuel consumption is a crucial aspect of powered parachute performance as it determines how long a powered parachute can fly using a specific amount of fuel. Gross weight also plays a big part in endurance since a powered parachute carrying a heavier load will require more power and more fuel to generate that power. And finally, the capacity of the fuel tank also limits the endurance of a powered parachute.

While endurance is measured in time, range is measured in distance. Range is the maximum distance a powered parachute can fly between takeoff and landing. Range for a powered parachute can be divided into two parts:

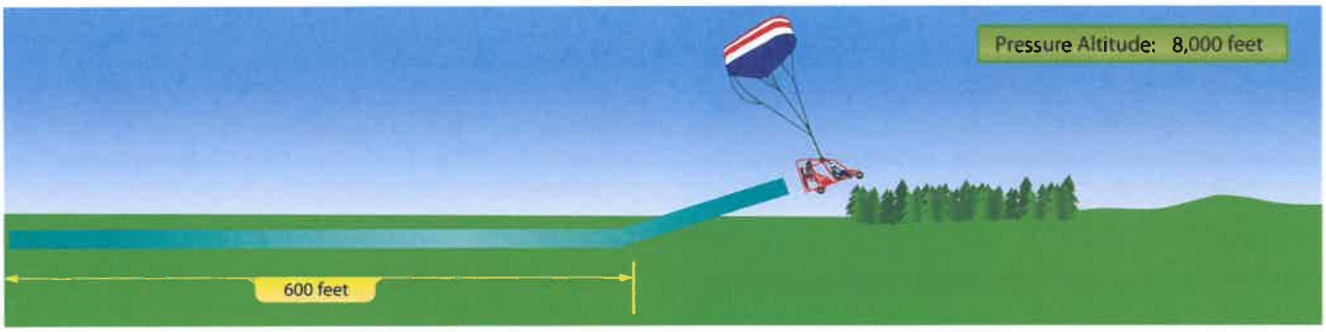
Endurance, how long a powered parachute can stay aloft on a given amount of fuel.

Prevailing winds since powered parachutes have such slow forward speeds. A powered parachute will go much further downwind than it will upwind in the same amount of time and using the same amount of fuel.

Wings

Powered parachutes can change their performance by changing out their parachute wings for different models. In addition, wings can become porous with age or mistreatment. That makes wings important to consider when looking at powered parachute performance.

Takeoff distance increases with increased altitude.



Models of Wings

Like most technology, there is always a newer, better thing and happily powered parachute technology continues to progress. In the case of wings, from the early days of the 1980's, designs, fabrics, and lines have all improved. But unfortunately, you can rarely get everything you want in one wing. For example, you may want a wing that has higher performance. A wing that optimizes for performance may have a problem with suspension lines that stretch with use making it more expensive to maintain.

Another issue is that some performance features are deemphasized when a parachute design emphasizes another performance feature. So you need to define what performance means to you. Performance in a wing includes:

Easy to Kite: This performance factor helps more than any other when taking off from short fields. Spending time and runway kiting and centering a parachute can use up more runway than the rest of the takeoff roll. Smaller wings generally kite easier than larger wings.

Speed: There are speed differences between makes and models of wings. And smaller wings of the same model are faster than larger models. Faster wings in the sky also require more runway on the ground to get up to takeoff speeds.

Payload: Powered parachute airframes and pilots both seem to be getting heavier by the decade. That puts an additional demand on wings to carry that extra weight. Generally, larger wings can carry more weight than smaller wings. But the design of the wing matters, too.

Turning: A powered parachute that turns quickly is a lot of fun. And like other performance features, turning capability has a lot to do with the design and size of the wing with smaller wings normally outperforming larger wings in turning.

Flare Authority: Flare authority is closely related to turning ability. This is the ability of the parachute to flare on landing without having to pull excess steering line. How the wing is rigged to the airframe also affects flare.

Effects of Wing Age on Performance

Age by itself doesn't affect a parachute's performance as much as a lot of people believe. However, use and how a parachute is treated and stored can have a huge impact on performance. Parachutes experience wear in fabric strength, fabric porosity, suspension line strength, and suspension line stretching.

Here are some of the areas to be concerned about:

UV Degradation: Prolonged exposure to sunlight can lead to ultraviolet (UV) degradation of parachute fabrics. UV rays can break down the molecular structure of the fabric, leading to a loss of strength and the creation of microscopic openings in the fabric, making it porous. This degradation is more pronounced in materials that aren't specifically treated or coated to resist UV damage. Sunlight exposure can also cause the colors of parachute fabric to fade over time. This is particularly true for fabrics that are not UV-resistant or those with vibrant colors. Color fading may be cosmetic and doesn't necessarily impact the structural integrity of the fabric. However, faded colors do indicate how much a parachute has been exposed to the sun.

Aging: Over time, the materials used in parachute fabric can naturally degrade and lose their integrity. Aging is a gradual process, and as the fabric breaks down, it may develop pores or small openings that compromise its original impermeability.

Abrasion: Friction and abrasion during kiting, landing, and stowing can cause physical damage to the fabric. Small tears, punctures, or abrasions can create openings in the material, allowing air to pass through and making the parachute porous.

Moisture and Mildew: Exposure to moisture, especially if the parachute is not properly dried and stored, can lead to the growth of mildew or mold. These organisms can contribute to the breakdown of the fabric, creating porous areas.

Chemical Exposure: Contact with harsh chemicals or contaminants can adversely affect the structure of the parachute fabric. Chemical exposure may weaken the fibers and make the material more prone to becoming porous. Battery acid from a non-sealed starter battery, fertilizers and chemicals on the grass, and even insect repellent can be detrimental to parachute fabric.

Insects: Insects can be swept into a parachute, particularly while it's on the ground and being stowed. Some insects will chew through fabric and once they die, the acid from their decomposing bodies can deteriorate a parachute further.

Mammals: Mice and other rodents can nest in a stowed parachute and render in unusable. They chew through fabric and their urine is highly acidic. A parachute stowed for an extended period should be placed in some kind of hard, plastic container.

Line Stretching: Different parachute lines have different resistances to stretching. Some are very prone to stretching with the loads placed on them during normal flight. Suspension line lengths should be checked periodically to see if they are still within manufacturer specifications.

Improper Maintenance: Lack of proper care and maintenance, such as failing to follow manufacturer recommendations for cleaning, storage, and usage, can contribute to premature degradation of parachute fabric.

Runway Surface and Gradient

The condition of the runway can significantly affect the performance of a powered parachute during takeoff and landing.

The surface of a runway can be made of concrete, asphalt, gravel, dirt, or grass, with information about the surface type provided in the Chart Supplement U.S. In general, it's preferable to use a grass or dirt runway for takeoff over a concrete or asphalt runway for several reasons. First, grass runways are more forgiving when dealing with crosswinds. If the wing pulls to one side during takeoff on a grass runway, the tires can slide, while on asphalt, the tires will grab, increasing the likelihood of tipping over. Additionally, grass runways typically don't have landing lights on both sides, which can serve as obstacles if the wing dips to one side during kiting. Finally, occupying an asphalt runway for an extended period during parachute setup or recovery could be an inconvenience to other pilots waiting to use the runway.

Runway surfaces that are not hard and smooth can increase the ground roll during takeoff. Tires sinking into soft or muddy terrain reduce the powered parachute's acceleration. Obstructions like snow, tall grass and standing water can also reduce acceleration during takeoff. Poor tire movement along the runway can result from holes or ruts in the pavement or field. Soft or wide tires make many of these hindrances even worse since they increase resistance themselves. If you run into an obstacle that stops you entirely while accelerating, it's possible for your parachute to drift down into a spinning prop, damaging the prop, the parachute and possibly even the engine.

The gradient or slope of the runway is expressed as a percentage and represents the amount of change in height over the length of the runway. For example, a three percent gradient means that for every 100 feet of runway length, the runway height changes by three feet. A positive gradient means the runway height increases, while a negative gradient means the runway decreases in height. An upsloping runway impedes acceleration during takeoff, leading to longer ground runs, but typically reduces the landing roll. Conversely, a downsloping runway assists acceleration during takeoff, resulting in shorter takeoff distances, but increases landing distances.

Water on the Runway and Dynamic Hydroplaning

When water is present on the runway, it decreases the friction between the tires and the ground, which can cause issues with takeoff and landing. If the runway is wet, dynamic hydroplaning can occur, which is when the powered parachute's tires ride on a layer of water instead of the runway's surface. This can significantly reduce directional control, making it difficult to maneuver. To maximize directional control on wet runways or frozen lakes, it's recommended to land into the wind and avoid abrupt control inputs. When dealing with wet or icy runways, it's important to be prepared for potential sliding and understand that normal braking distances may be more than doubled.

Takeoff and Landing Performance

Most powered parachute accidents happen during takeoff and landing. Therefore, you must know all the factors that affect takeoff and landing performance and follow professional procedures during those phases of flight. During takeoff, your powered parachute goes from zero to the speed needed to kite your wing and then to takeoff speed to become airborne. During landing, the powered parachute decelerates from landing speed to zero. Important factors include the speed, rate of acceleration and deceleration, and the distance needed to takeoff or land.

Takeoff Performance

A big concern for most powered parachute pilots is the minimum takeoff distance, which determines the necessary runway length. The minimum takeoff distance is the length of runway that allows sufficient margin to inflate the parachute and then satisfactory room to initiate a liftoff and climb. Takeoff performance is partly a condition of accelerated motion. For instance, during takeoff, the powered parachute starts at zero speed and accelerates to inflate the parachute, then to takeoff speed, and then finally becomes airborne. The important factors of takeoff performance are:

Ease of kiting the parachute since that takes up distance on the runway.
The takeoff speed, which will generally be close to the actual flying speed.
The rate of acceleration during the takeoff roll.

Quick kiting of the wing followed by full throttle is crucial to achieving minimum takeoff distance, and the wing's kiting and lifting characteristics both play a significant role. The most important variable to affect your takeoff performance is how fast you can get the parachute wing overhead, centered, and ready to take the load of the airframe. Often, most of the runway used by a pilot will be for the deployment of the wing. It's always best to practice that skill at a longer field where you can make mistakes and correct them before taking off.

After kiting the wing and making sure that it's overhead, you get into the sky quickly by going to full power. Lift and drag are present from the beginning of kiting, with drag initially exceeding lift. Drag is produced as soon as the powered parachute moves forward. The drag of the parachute decreases as it rotates into position over the airframe. Then lift and drag become functions of the forward speed and the angle of attack of the parachute.

In addition to the important factors of proper procedures, other variables affect the takeoff performance of a powered parachute. Any item that alters the takeoff speed or acceleration rate during the takeoff roll will affect the takeoff distance.

Takeoff performance is most critically affected by a combination of factors including:

- Altitude
- Temperature
- Runway slope
- Runway conditions like snow, ice, or tall grass.
- High gross weight
- Wind

We talked about the effects of altitude and temperature when we discussed density altitude earlier in the chapter. To review, an increase in density altitude can produce a twofold effect on takeoff performance:

- Greater takeoff speed required and
- Decreased thrust and reduced net accelerating force

We also talked about runway conditions above. Let's round that out with a discussion on the last two factors of weight and wind.

Effect of Gross Weight on Takeoff

If the gross weight increases, you need more speed to produce the greater lift necessary to get your powered parachute airborne. Increased gross weight has a significant impact on takeoff performance, resulting in a threefold effect:

- Higher liftoff speed
- Greater mass to accelerate
- Increased drag and ground friction, which requires even more engine power to generate the necessary speed for takeoff.

A change in gross weight will change the net accelerating force required for takeoff. If the powered parachute has a relatively high thrust-to-weight ratio, the change in the net accelerating force is slight and the principal effect on acceleration is due to the change in mass.

The takeoff distance will vary at least as the square of the gross weight. For example, a 10 percent increase in takeoff gross weight would cause:

- A 5 percent increase in takeoff velocity
- At least a 9 percent decrease in the rate of acceleration, and
- At least a 21 percent increase in takeoff distance.

For a powered parachute with a high thrust-to-weight ratio, the increase in takeoff distance might be approximately 21 to 22 percent. But for a powered parachute with a relatively low thrust-to-weight ratio, the increase in takeoff distance could be 25 to 30 percent or more. Such a powerful effect requires proper consideration of gross weight in predicting takeoff distance.

Normally, when you take a passenger, the gross weight increases by more than 10 percent. For example, a 21 percent increase in takeoff weight will require a 10 percent increase in liftoff speed to support the greater weight.

Even more realistically, adding a 200-pound passenger to a machine that already weighs 400 pounds and with a pilot weighing 200 pounds will increase the gross weight by 33 percent. That increase of one passenger will degrade the performance of the powered parachute dramatically. The 33 percent increase in takeoff gross weight would cause:

- At least a 25 percent decrease in rate of acceleration,
- At least a 76 percent increase in takeoff distance.

For a powered parachute with a high thrust-to-weight ratio (for example a Rotax 912 ULS with 100hp) the increase in takeoff distance might be approximately 76 percent. But for a powered parachute with a relatively low thrust-to-weight ratio (such as a Rotax 582 with 65hp) the increase in takeoff distance would be more. Shorter runways that work just fine for solo flying may not be suitable for taking passengers.

Effect of Wind on Takeoff

The effect of wind on takeoff distance is greater on powered parachutes than it is for almost any other kind of flying. The effect of a headwind is to allow the wing to kite faster and for the powered parachute to reach the liftoff speed at a lower groundspeed. On the other hand, the effect of a tailwind is to make the wing harder to kite (if kiting is possible at all!) and then achieve a greater groundspeed to attain the liftoff speed.

Even a slight headwind will have a dramatic effect on takeoff distances for powered parachutes because a wind helps inflate a wing much faster than can be done on a calm day. Another thing that helps is the fact that even light winds can be a large percentage of the flying speed of a powered parachute.

A powered parachute that flies at 35 MPH taking off into a headwind of only 3.5 MPH is working with a 10 percent headwind.

Setting aside the time and runway required for kiting the wing, a headwind equivalent to 10 percent of the takeoff airspeed can reduce the takeoff distance by around 19 percent. Conversely, a tailwind that's 10 percent of the takeoff airspeed will increase the takeoff distance by approximately 21 percent after the wing is kited. And if the headwind speed is equal to 50 percent of the takeoff speed (a brisk 17.5 MPH), the takeoff distance would be around 25 percent of the zero-wind takeoff distance, which is a reduction of 75 percent.

And the good news is that kiting distances are vastly reduced with a headwind, sometimes almost becoming almost instantaneous. That reduces the overall amount of runway required even more dramatically. There are possible problems with kiting in a headwind, though.

- Everything moves a lot faster, including blown launches.
- With headwinds, there are often gusts, which complicate a takeoff and a flight.
- You should be launching as directly into the wind as possible, which often doesn't work with an available runway.

When takeoff distances are crucial, the significance of appropriate takeoff speed cannot be overstated. If you attempt to take off with less than full throttle after your parachute is kited and centered, your powered parachute's initial rate of climb may be exceedingly low.

Landing Performance

Landing performance is most critically affected by a combination of factors including:

- Altitude
- Temperature
- Runway slope
- Runway conditions like snow, ice, or tall grass.
- High gross weight
- Wind

This should look familiar since it mirrors the factors affecting takeoff performance. For example, as density altitude rises, the landing speed will also increase. At an altitude of 5,000 feet, the minimum landing distance would be roughly 16 percent greater than at sea level. For every 1,000 feet of altitude, there is an approximate 3 1/2 percent increase in landing distance.

Runway conditions are also important. To achieve the minimum landing distance, the runway must be long enough to accommodate landing at power, with the ability to stop before reaching any obstructions, and with the capability for a go-around.

Effect of Gross Weight on Landing

The landing distance is largely determined by the gross weight of the vehicle. An increase in gross weight will result in a higher landing speed which is required to create enough lift to support the vehicle's weight just before touchdown. For example, a 21 percent increase in landing weight will necessitate a 10 percent increase in landing speed.

The minimum landing distance will directly correlate with the gross weight of the vehicle. For instance, a 10 percent increase in gross weight during landing would result in a 5 percent increase in landing velocity and a 10 percent increase in landing distance.

Effect of Wind on Landing

Wind can have a significant impact on landing distance. While a powered parachute will land at the same airspeed regardless of the wind, the primary effect of wind on landing distance is the difference in the groundspeed at which the vehicle touches down. The effect of wind on deceleration during landing is equivalent to its effect on acceleration during takeoff. A headwind that is 10 percent of the landing airspeed (3-4 MPH) will reduce the landing distance by roughly 19 percent. On the other hand, a tailwind that is 10 percent of the landing speed will increase the landing distance by approximately 21 percent.

Headwinds dramatically reduce takeoff distance because a headwind facilitates wing kiting. Headwinds also dramatically decrease landing distance because the parachute's aerodynamic braking is more effective when facing the wind than mechanical brakes or rolling resistance.

To achieve a minimum landing distance, the forces acting on the powered parachute must provide maximum deceleration during the landing roll. Typically, when decelerating a powered parachute, the most efficient method is through aerodynamic drag. Aerodynamic drag is achieved by pulling in the steering lines in as much as possible after the engine is shut down and while the airframe is rolling out. That turns the parachute into something like a drogue chute. This is very efficient when landing upwind.

But if the landing is downwind, trying to use the wing as an aerodynamic brake isn't effective, and you'll need to rely on rolling friction and mechanical brakes on the wheels. That's why it's always advisable to land in the direction of the wind and pull in the steering lines to slow down the vehicle.

Chapter 15
Weather Information

There are two kinds of weather information we're going to review in this chapter. The first is the kind of weather information that you're going to be responsible for understanding when you take your FAA Knowledge Test for Powered Parachutes. That weather information is frankly going to feel a little clunky. That's because the FAA style of delivering weather information goes back to the 1940s when weather reports were transmitted over teletype and radiotelegraph in many confusing styles and formats. Eventually, these reports were standardized into a handful of worldwide confusing styles and formats. It doesn't help to complain. Just study the information and be ready for the test. Some FAA sample questions are included in this chapter to give you a flavor of what the FAA is looking for. The good news is that most powered parachute examiners won't quiz you further on the codes.

The second kind of weather information you will learn about in this chapter is far more useful. This weather information comes to you in the form of web sites and apps. The information is far more intuitive and is critical when trying to figure out when a good time to fly might be. That weather information is as solid as the government weather information. That's because it's essentially the same information. Private companies take the government information that's made available as a digital package and present it in a variety of ways on their own web sites and apps. They may have their own algorithms that they run the raw data through, but mostly it's just packaging.

The National Weather Service (NWS), Federal Aviation Administration (FAA), Department of Defense (DoD), independent weather observers, and commercial weather information providers work to provide weather services for pilots. Weather forecasts are rarely 100% accurate, but meteorologists can predict weather patterns, trends, and characteristics with increasing accuracy thanks to careful scientific study and computer modeling. The vast knowledge base provided by these agencies helps us make informed decisions about weather and flight safety before and during a flight.

FAA Weather Briefings

The Flight Service Station (FSS) is your main government source of preflight weather information, and you can obtain a preflight weather briefing by calling 1-800-WX-BRIEF, available 24/7 throughout the United States and Puerto Rico. Before every flight, you should gather all necessary information vital to the nature of the flight, including an appropriate weather briefing from an FSS specialist.

Briefers will ask about the flight's nature. They want to know things like:

- Whether it's visual flight rules (VFR) or instrument flight rules (IFR) (You will always be VFR in a powered parachute!)
- Aircraft identification
- Aircraft type
- Departure point
- Estimated time of departure (ETD)
- Flight altitude
- Route of flight
- Destination
- Estimated time en route (ETE).

This information is recorded in the flight plan system. It can be used later to file or amend a flight plan and if an aircraft is overdue or reported missing. However, you aren't required to file a flight plan. If you simply identify yourself as a powered parachute pilot flying locally, you can avoid a lot of the extraneous information gathering and get right to the weather briefing.

There are three kinds of briefings

Standard Briefing

You obtain a complete weather picture by getting a standard briefing, which is recommended before any flight and is used for flight planning. The briefing covers adverse conditions, a synopsis of the larger weather picture, current conditions, en route and destination forecasts, forecast winds and temperatures aloft, Notices to Air Missions (NOTAM), known ATC delays, and other information such as radio frequencies.

Abbreviated Briefing

If you want to quickly update or supplement a previously obtained weather briefing, you can request an abbreviated briefing which is a shorter version of the standard briefing. An abbreviated briefing is appropriate when a flight departure is delayed or when new weather information is needed. To ensure that you don't miss any information, you should inform the weather specialist of the time and source of your previous briefing.

Outlook Briefing

You should request an outlook briefing when your planned departure is 6 hours or more away. This type of briefing provides initial forecast information, but it's limited in scope due to the time frame of the planned flight. It can help you make a go/no-go decision early in the flight planning process. You should still request a follow-up briefing prior to departure since an outlook briefing generally only contains information based on local weather trends. A standard briefing near the time of departure ensures that you have the latest information available prior to your flight.

Sample FAA Questions

Q: To best determine general forecast weather conditions covering a flight information region, the pilot should refer to what?

A: Graphical Forecasts for Aviation (GFA).

Q: When telephoning a weather briefing facility for preflight weather information, pilots should state whether they intend to fly under which kinds of rules?

A: IFR or VFR only.

Elements Of A Standard Weather Briefing	
Adverse Conditions	This includes information about adverse conditions that may influence a decision to cancel or alter the route of flight. Adverse conditions includes significant weather, such as thunderstorms or aircraft icing, or other important items such as airport closings.
VFR Flight NOT RECOMMENDED	If the weather for the route of flight is below VFR minimums, or if it is doubtful the flight could be made under VFR conditions due to the forecast weather, the briefer may state that VFR is not recommended. It is the pilot's decision whether or not to continue the flight under VFR, but this advisory should be weighed carefully.
Synopsis	The synopsis is an overview of the larger weather picture. Fronts and major weather systems that affect the general area are provided.
Current Conditions	This portion of the briefing contains the current ceilings, visibility, winds, and temperatures. If the departure time is more than two hours away, current conditions will not be included in the briefing.
En Route Forecast	The en route forecast is a summary of the weather forecast for the proposed route of flight.
Destination Forecast	The destination forecast is a summary of the expected weather for the destination airport at the estimated time of arrival (ETA).
Winds and Temperatures Aloft	Winds and temperatures aloft is a report of the winds at specific altitudes for the route of flight. However, the temperature information is provided only on request.
Notices to Airmen	This portion supplies NOTAM information pertinent to the route of flight which has not been published in the Notice to Airmen publication. Published NOTAM information is provided during the briefing only when requested.
ATC Delays	This is an advisory of any known air traffic control (ATC) delays that may affect the flight.
Other Information	At the end of the standard briefing, the FSS specialist will provide the radio frequencies needed to open a flight plan and to contact en route flight advisory service (EFAS). Any additional information requested is also provided at this time.

Q: Which type weather briefing should a pilot request, when departing within the hour, if no preliminary weather information has been received?
A: Standard briefing

Q: Which type weather briefing should a pilot request to supplement mass disseminated data?
A: Abbreviated briefing

Q: To update a previous weather briefing, a pilot should request...
A: an abbreviated briefing

Q: A weather briefing that is provided when the information requested is 6 or more hours in advance of the proposed departure time is...
A: an outlook briefing.

Q: When requesting weather information for the following morning, a pilot should request...
A: an outlook briefing.

Q: When telephoning a weather briefing facility for preflight weather information, pilots should state the aircraft identification or the pilot's name.
A: True

Q: When speaking to a Flight Service weather briefer, you should state whether the flight is...
A: VFR or IFR.

Observations

Weather forecasts, advisories, and briefings rely on data collected from surface and upper altitude observations. There are four types of weather observations: surface, upper air, radar, and satellite.

Surface Aviation Weather Observations

Surface aviation weather observations (METARs) are current weather reports from ground stations across the US. The network includes government and privately contracted facilities, as well as automated weather sources like AWOS and ASOS. These observations provide local weather conditions for specific airports, including wind, visibility, weather phenomena, temperature/dew point, and more. You can use this information to get a good picture of the weather in a wider area by looking at many reporting stations together. AWOS and ASOS stations are normally found at airports.

AWOS (Automated Weather Observing System) is an automated system that continuously collects and disseminates weather data. It provides information such as wind speed and direction, temperature, humidity, visibility, cloud cover, and altimeter setting. AWOS units are usually installed at airports, and since they are automated, that ensures the timely and accurate reporting of current weather conditions. There are many kinds of AWOS systems including:

AWOS-A: Reports the altimeter setting only
AWOS-AV: Reports altimeter and visibility
AWOS-1: Reports altimeter setting, wind data, temperature, dew point, and density altitude
AWOS-2: Reports the information provided by AWOS-1, plus visibility
AWOS-3: Reports the information provided by AWOS-2, plus cloud/ceiling data
AWOS-3T: Reports the same as the AWOS-3 system and includes a thunderstorm/lightning reporting capability
AWOS-3P: Reports the same as the AWOS-3 system, plus a precipitation identification sensor
AWOS-3PT: AWOS-3PT reports the same as the AWOS-3P system, plus thunderstorm/lightning reporting capability.
AWOS-4: Reports the same as the AWOS-3 system, plus precipitation occurrence, type and accumulation, freezing rain, thunderstorm, and runway surface sensors

ASOS (Automated Surface Observing System) is a more advanced and comprehensive version of AWOS and can provide minute-by-minute updates on weather conditions. It includes additional sensors to measure weather parameters including:

- Cloud height
- Visibility
- Precipitation identification
- Freezing rain
- Pressure
- Ambient temperature/dew point temperature
- Anemometer (wind direction and speed)
- Rainfall accumulation
- Lightning detection and reporting

You should save local AWOS and ASOS phone numbers on your phone so that you can easily get up to the minute weather data for surrounding airports. You can find the numbers for those automated systems in the Chart Supplement U.S. You can also find them online at web sites like **airnav.com**, **skyvector.com** and **faa.gov**.

Upper Air Observations

The government uses several methods to observe upper air weather, such as radiosonde observations, pilot weather reports (PIREPs), Aircraft Meteorological Data Relay (AMDAR) and the Meteorological Data Collection and Reporting System (MDCRS). Radiosondes are small instrumentation packages that are attached to balloons and rise at a rate of approximately 1,000 feet per minute, gathering various pieces of data such as air temperature, moisture, pressure, wind speed and direction, and relaying the information to ground stations via a radio transmitter. Airplane pilots also provide vital information regarding upper air weather observations, such as turbulence, icing, and cloud heights. However, powered parachutes rarely need this upper air weather information.

Radar Observations

There are four types of radar that provide information on precipitation and wind. Three of the four are designed mostly for airline traffic either airborne or at large airports. For powered parachuting, we are only concerned with one type, WSR-88D NEXRAD Radar. You're probably already familiar with this type of radar and know it as Doppler radar. NEXRAD radar provides detailed information about upcoming weather conditions to both pilots and nearby communities. It has two modes of operation: clear air and precipitation. In clear air mode, the radar is very sensitive and scans the atmosphere for longer periods with a slow antenna rotation. Images are updated every 10 minutes in this mode. In precipitation mode, the radar is set to a faster antenna rotation as precipitation provides stronger signals. Images are updated about every 4 to 6 minutes in this mode. The intensity of the weather is measured in decibels of Z (dBZ) and displayed on the radar image with different colors. You can get radar information from **windy.com**, **ventusky.com**, **weather.com** and other websites. If you're using your phone, the free app MyRadar is a great resource among others.

Satellite Observations

Satellite weather observations provide information on global weather patterns, including storm movements and atmospheric conditions. The observations rely on various satellite technologies, such as geostationary and polar-orbiting satellites, to gather data about atmospheric parameters such as temperature and moisture. The information collected from satellite weather observations is used for generating weather forecasts, monitoring storms, and tracking long-term climate trends.

Aviation Weather Reports

Aviation weather reports are created to provide you with accurate depictions of current weather conditions. Each report offers you current information that is updated at different times. Some typical reports you might encounter are METARs and PIREPs.

Terms Used in Weather Reports

An important aspect of weather reports is the use of specific terms to describe weather. For example, *visibility* refers to how far you can see, while *ceiling* refers to the height of the lowest clouds. Other terms used in weather reports include *wind direction and speed*, *temperature*, *dew point*, *pressure*, *precipitation*, and *turbulence*. Most of these terms have been described in earlier chapters. Here we'll describe those that are particular to weather reporting.

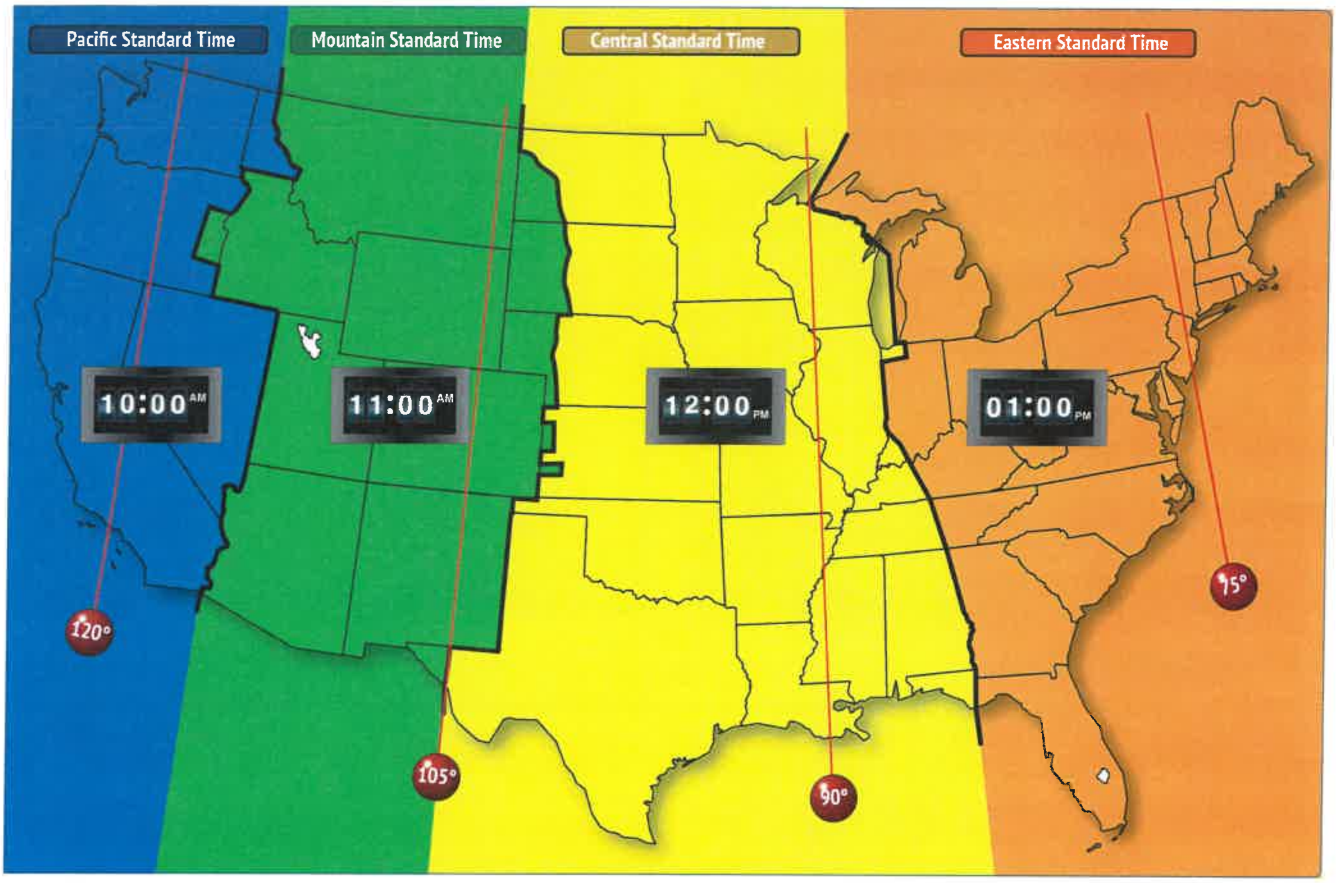
Date and Time

Weather reports and forecasts don't mean too much without time. Weather reports from last week don't really help with this week. A forecast that tells you that it's going to be windy without telling you when it's going to be windy has very little value. Therefore it's critical that you know how to tell time the way the FAA tells time.

The FAA uses a standard worldwide clock and a concise format to report on dates and times. It's called *Zulu Time* or sometimes *Coordinated Universal Time (UTC)*. It's a time standard used in the aviation and military for coordinating activities across different time zones. It's denoted by the letter "Z" and is based on the 24-hour clock. Since Zulu time is so important in FAA weather reporting, you should understand some things about it:

Time Zone	Convert to UTC from Standard Time	Example Standard Time	Coordinated Universal Time (UTC)	Convert to UTC from Daylight Saving Time	Example Time (Daylight Saving Time)	Coordinated Universal Time (UTC)
Eastern	Add 5 hours	1:00 PM	16:00 Zulu	Add 4 hours	1:00 PM	15:00 Zulu
Central	Add 6 hours	12:00 PM	16:00 Zulu	Add 5 hours	12:00 PM	15:00 Zulu
Mountain	Add 7 hours	11:00 AM	16:00 Zulu	Add 6 hours	11:00 AM	15:00 Zulu
Pacific	Add 8 hours	10:00 AM	16:00 Zulu	Add 7 hours	10:00 AM	15:00 Zulu

Converting to Zulu Time from Standard Time and Daylight Saving Time.



Time zones in the conterminous United States.

Universal Reference: Zulu Time is considered a universal reference time, providing a common point of reference for people and organizations operating in different time zones. It eliminates the confusion that can arise when dealing with local time variations.

24-Hour Clock: Zulu Time uses a 24-hour clock format, where the day is divided into 24 hours, starting at midnight (00:00) and ending at the next midnight. Each hour is numbered from 00 to 23.

Greenwich, England: Zulu Time is based on the Prime Meridian, which is tied to navigation. The Prime Meridian (or 0º Longitude) runs through Greenwich, England.

Aviation and Military Usage: Zulu Time is commonly used in aviation and military operations to ensure precise coordination between different locations and time zones. This is crucial for flight schedules, international operations, mission planning, and of course weather reporting.

No Daylight Saving Time: Unlike many local time zones, Zulu Time does not observe daylight saving time. It remains constant throughout the year, making it a stable reference point for global coordination.

Letter Z: Zulu corresponds to the zero meridian, or Prime Meridian.

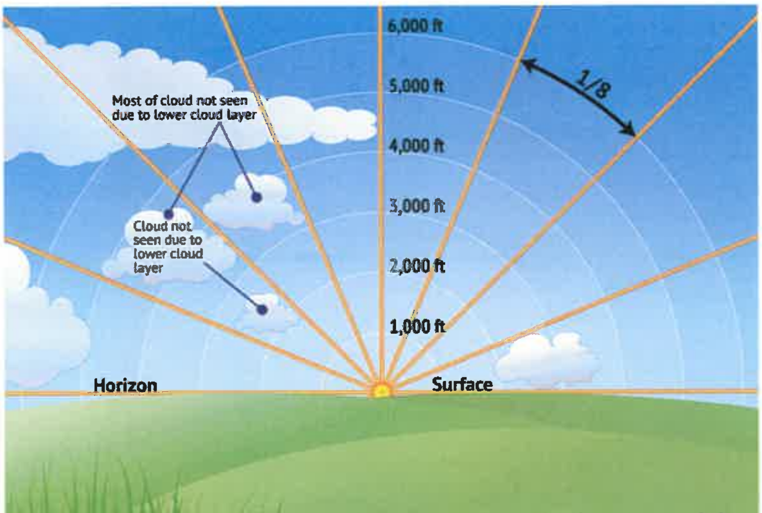
FAA weather reports are given in Zulu time along with the day of the month. That makes it a six-number code with the first two numbers being the date and the last four numbers being the time. 1720 Zulu on the 12th day of the month is represented as 121720Z.

Visibility

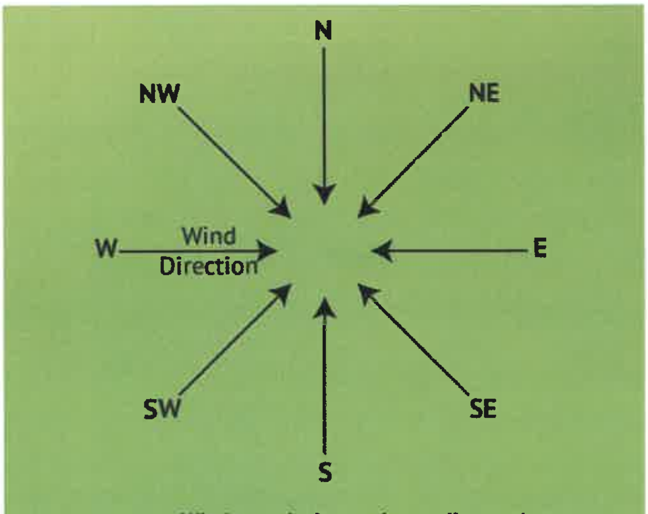
Visibility describes the maximum horizontal distance at which significant objects can be seen with the naked eye. You can find current visibility information in various aviation weather reports like METAR and automated weather stations. Additionally, meteorologists predict visibility information that is available during preflight weather briefings.

Sky Cover and Ceilings

Sky Cover is a description of the appearance of the sky. This information includes cloud cover, vertical visibility, or clear skies. The term *ceiling* specifically refers to the lowest layer of clouds reported as being broken or overcast, or the vertical visibility into an obscuration like fog or haze. A cloud layer is considered *broken* when five-eighths to seven-eighths of the sky is covered with clouds, while *overcast* means the entire sky is covered with clouds. You can find current ceiling information in aviation routine weather reports (METAR) and automated weather stations of various types.



The sky divided into eighths, for the purpose of determining sky cover and ceiling.



Winds are designated according to the compass heading from which the wind comes. A west wind comes from the west, but the air is moving eastward.

Wind Direction and Speed

A wind is named according to the direction from which it is blowing. For instance, a wind coming from the west to the east is called a west wind. There are 36 specific azimuth degrees which are expressed in 10-degree intervals. In aviation, it's typical to use the points of the compass to represent the direction from which the wind is blowing. For instance, winds blowing from the north are represented by 360º, winds blowing from the east are represented by 90º, winds blowing from the south are represented by 180º, and winds blowing from the west are represented by 270º.

Wind speed is often given in knots, which are about 15% faster than miles per hour. For wind speeds we're normally concerned with, the difference isn't great enough to worry too much about.

Aviation Routine Weather Report (METAR)

A METAR is a standard international format used for reporting current surface weather observations.

METAR reports are issued at regular intervals, but if there are significant weather changes, a special report called SPECI can be issued at any time between routine METAR reports.

Let's walk through a sample METAR report and decode it. First, it's handy to know that typical METAR reports contain information in the same sequential order. So walking through this example will help a lot when you try to figure out other METAR reports. Here's the cryptic report with the translation following:

METAR KGGG 161753Z AUTO 14021G26KT 3/4SM +TSRA BR BKN008 OVC012CB 18/17 A2970 RMK PRESFR

Type of report (METAR)– There are two types of METAR reports: routine and SPECI. This example is a routine METAR report.

Station identifier (KGGG)– A station identifier is a unique four-letter code established by the International Civil Aviation Organization (ICAO). In the 48 contiguous states, a three-letter identifier is used, preceded by the letter "K." For example, Gregg County Airport in Longview, Texas is identified by "KGGG," where "K" is the country designation and "GGG" is the airport identifier.

Date and time of the report (161753Z)– The first two numbers are the date of the month. The last four digits are the time. The Z emphasizes that the time is in Zulu time, otherwise known as coordinated universal time (UTC).

Modifier (AUTO)– "AUTO" means that the report came from an automated source. Another possible modifier is "COR" which would mean that the METAR is a corrected report.

Wind (14021G26KT)– Wind is normally reported with five digits (14021KT). The first three digits indicate the direction the true wind is blowing from in tens of degrees. If the wind is variable, it is reported as "VRB." The last two digits indicate the speed of the wind in knots. If the winds are gusting, the letter "G" follows the wind speed (G26KT). After the letter "G," the peak gust recorded is provided.

Visibility (¾ SM) – The prevailing visibility is reported in statute miles as denoted by the letters "SM." It's reported in both miles and fractions of miles.

Weather (+TSRA BR)– The codes for weather can be broken down into two different categories: qualifiers and weather phenomenon. First are the qualifiers of intensity, then proximity, and finally the descriptor of the weather are given. The intensity may be light (–), moderate ( ), or heavy (+). Proximity only depicts weather phenomena that are in the airport vicinity. The notation "VC" indicates a specific weather phenomenon is in the vicinity of five to ten miles from the airport. Descriptors are used to describe certain types of precipitation and obscurations. Weather phenomena may be reported as being precipitation, obscurations, squalls, funnel clouds, etc.

Sky condition (BKN008 OVC012CB)– Clouds are always reported in the sequence of amount, height, and type. If it's an indefinite ceiling or height (known as vertical visibility and denoted for example as VV003). The heights of the cloud bases are reported with a three-digit number in hundreds of feet AGL. Clouds above 12,000 feet are not detected or reported by an automated station. The types of clouds, specifically towering cumulus (TCU) or cumulonimbus (CB) clouds, are reported with their height. Contractions are used to describe the amount of cloud coverage and obscuring phenomena. The amount of sky coverage is reported in eighths of the sky from horizon to horizon.

Altimeter setting (A2970)– is always expressed as a four-digit number group in inches of mercury preceded by the letter "A." In addition, the "*Remarks*" sections may indicate increasing or decreasing pressure as "*PRESRR*" or "*PRESFR*," respectively.

Remarks (RMK PRESFR)– The "*RMK*" always initiates the remarks section in the METAR, which may or may not contain comments. The remarks section provides data on wind, variable visibility, start and end times of specific weather events, pressure data, and other relevant information. For instance, a remark that doesn't belong to any other category could be: "*OCNL LTGICCG*," indicating sporadic lightning occurring in the clouds and from cloud to ground.

Sky Cover	Contraction
Less than ⅛ (Sky Clear, Clear)	SKC, CLR
⅛–²⁄₈ (Few Clouds)	FEW
⅜–⁴⁄₈ (Scattered)	SCT
⅝–⅞ (Broken)	BKN
⁸⁄₈ or (Overcast)	OVC

Reportable contractions for sky condition.

METAR Practice

Fortunately, you will only be responsible for translating at the very most, five METAR/SPECI reports on your knowledge test. Even better news is that I can tell you which ones they are. Here they are, straight from the 2018 edition of the FAA's Airman Knowledge Testing Supplement for Sport Pilot, along with the translations:

METAR KINK 121845Z 11012G18KT 15SM SKC 25/17 A3000

- METAR Report
- Station: KINK (Winkler County Airport, located in Wink, Texas)
- Date and Time: 121845Z (12th day of the month at 18:45 UTC time)
- Wind: 110 degrees, 12 knots, with gusts up to 18 knots (11012G18KT)
- Visibility: 15 statute miles (15SM)
- Sky conditions: clear skies (SKC)
- Temperature and Dew point: 25°C and 17°C respectively (25/17)
- Altimeter setting: 30.00 inches of mercury (A3000)

Qualifier		Weather Phenomena		
Intensity or Proximity 1	**Descriptor 2**	**Precipitation 3**	**Obscuration 4**	**Other 5**
- Light	MI Shallow	DZ Drizzle	BR Mist	PO Dust/sand whirls
Moderate (no qualifier)	BC Patches	RA Rain	FG Fog	SQ Squalls
+ Heavy	DR Low drifting	SN Snow	FU Smoke	FC Funnel cloud
VC in the vicinity	BL Blowing	SG Snow grains	DU Dust	+FC Tornado or waterspout
	SH Showers	IC Ice crystals (diamond dust)	SA Sand	SS Sandstorm
	TS Thunderstorms	PL Ice pellets	HZ Haze	DS Dust storm
	FZ Freezing	GR Hail	PY Spray	
	PR Partial	GS Small hail or snow pellets	VA Volcanic ash	
		UP *Unknown precipitation		

The weather groups are constructed by considering columns 1–5 in this table in sequence:
Intensity, followed by descriptor, followed by weather phenomena. (For example, heavy rain showers(s) is coded as +SHRA.)
* Automated stations only

Descriptors and weather phenomena used in a typical METAR.

METAR KINK 121845Z 11012G18KT 15SM SKC 25/17 A3000
METAR KBOI 121854Z 13004KT 30SM SCT150 17/6 A3015
METAR KLAX 121852Z 25004KT 6SM BR SCT007 SCT250 16/15 A2991
SPECI KMDW 121856Z 32005KT 1 1/2SM RA OVC007 17/16 A2980 RMK RAB35
SPECI KJFK 121853Z 18004KT 1/2SM FG R04/2200 OVC005 20/18 A3006

The 5 METAR reports you may see on your knowledge test.

METAR KBOI 121854Z 13004KT 30SM SCT150 17/6 A3015

- METAR Report
- Station: KBOI (Boise Airport)
- Date and Time: 121854Z (12th day of the month at 18:54 UTC time)
- Wind: 130 degrees, 4 knots (13004KT)
- Visibility: 30 statute miles (30SM)
- Sky conditions: scattered clouds at 15000 feet (SCT150)
- Temperature and Dew point: 17°C and 6°C respectively (17/6)
- Altimeter setting: 30.15 inches of mercury (A3015)

METAR KLAX 121852Z 25004KT 6SM BR SCT007 SCT250 16/15 A2991

- METAR Report
- Station: KLAX (Los Angeles International Airport)
- Date and Time: 121852Z (12th day of the month at 18:52 UTC time)
- Wind: 250 degrees, 4 knots (25004KT)
- Visibility: 6 statute miles (6SM)
- Weather: mist (BR)
- Sky conditions: scattered clouds at 700 feet and scattered clouds at 25000 feet (SCT007 SCT250)
- Temperature and Dew point: 16°C and 15°C respectively (16/15)
- Altimeter setting: 29.91 inches of mercury (A2991)

SPECI KMDW 121856Z 32005KT 1 1/2SM RA OVC007 17/16 A2980 RMK RAB35

- Special METAR Report
- Station: KMDW (Chicago Midway International Airport)
- Date and Time: 121856Z (12th day of the month at 18:56 UTC time)
- Wind: 320 degrees, 5 knots (32005KT)
- Visibility: 1 1/2 statute miles (1 1/2SM)
- Weather: rain (RA)
- Sky conditions: overcast clouds at 700 feet (OVC007)
- Temperature and Dew point: 17°C and 16°C respectively (17/16)
- Altimeter setting: 29.80 inches of mercury (A2980)
- Remarks: Rain began 35 minutes past the hour (RMK RAB35)

SPECI KJFK 121853Z 18004KT 1/2SM FG R04/2200 OVC005 20/18 A3006

- Special METAR Report
- Station: KJFK (John F. Kennedy International Airport)
- Date and Time: 121853Z (12th day of the month at 18:53 UTC time)
- Wind: 180 degrees, 4 knots (18004KT)
- Visibility: 1/2 statute miles (1/2SM)
- Weather: fog (FG)
- Runway visual range: Runway 04 visual range is 2200 feet (R04/2200)
- Sky conditions: overcast clouds at 500 feet (OVC005)
- Temperature and Dew point: 20°C and 18°C respectively (20/18)
- Altimeter setting: 30.06 inches of mercury (A3006)

Typical questions you may see on the test include:

Q: Which of the reporting stations have VFR weather?
A: KINK, KBOI, KLAX (The other two airports only have less than 3 miles visibility and ceilings less than 1,000 feet AGL.)

Q: What are the wind conditions at Wink, Texas (KINK)?
A: 110º at 12 knots, gusts 18 knots.

Q: The remarks section for KMDW has RAB35 listed. What does that mean?
A: This entry means rain began at 1835Z.

Q: Which airport is reporting the conditions of sky 700 feet overcast, visibility 1-1/2 SM, rain?
A: Chicago Midway Airport (KMDW)

TAF

KMEM 121720Z 1218/1324 20012KT 5SM HZ BKN030 PROB40 1220/1222 1SM TSRA OVC008CB
FM122200 33015G20KT P6SM BKN015 OVC025 PROB40 1220/1222 3SM SHRA
FM120200 35012KT OVC008 PROB40 1202/1205 2SM-RASN BECMG 1306/1308 02008KT BKN012
BECMG 1310/1312 00000KT 3SM BR SKC TEMPO 1212/1214 1/2SM FG
FM131600 VRB06KT P6SM SKC=

KOKC 051130Z 0512/0618 14008KT 5SM BR BKN030 TEMPO 0513/0516 1 1/2SM BR
FM051600 18010KT P6SM SKC BECMG 0522/0524 20013G20KT 4SM SHRA OVC020
PROB40 0600/0606 2SM TSRA OVC008CB BECMG 0606/0608 21015KT P6SM SCT040=

The 2 TAFs you may get questions about on your knowledge test.

Aviation Forecasts

Multiple forecast products are created specifically by the FAA for use during preflight planning. Here I'm going to acquaint you with a few FAA forecasts, including the terminal aerodrome forecast (TAF), inflight weather advisories (SIGMET, AIRMET), and winds and temperatures aloft forecast (FB). The most useful one for powered parachute pilots is the TAF since that provides near term surface forecasts for a local airport. The others you may still see referred to on a knowledge test and perhaps a check ride, but they don't have that much extra value for us.

Terminal Aerodrome Forecasts (TAF)

If you are flying near an airport, you should take advantage of its Terminal Aerodrome Forecast (TAF) report. These reports are typically issued for larger airports and cover a five-statute mile radius around the airport. Each TAF report is valid for a 24 or 30-hour period and is updated four times daily at 0000Z, 0600Z, 1200Z, and 1800Z. The TAF utilizes the same descriptors and abbreviations as used in the METAR report.

First, it's handy to know that like METAR reports, typical TAF reports contain information in a predictable, sequential order. Unlike METAR reports, TAF reports use several lines to describe forecasts beginning and ending at different times. Let's walk through an example to explain what is going on. This is an example you might see on your knowledge test:

TAF KMEM 121720Z 1218/1324 20012KT 5SM HZ BKN030 PROB40 1220/1222 1SM TSRA OVC008CB FM122200 33015G20KT P6SM BKN015 OVC025 PROB40 1220/1222 3SM SHRA FM120200 35012KT OVC008 PROB40 1202/1205 2SM RASN BECMG 1306/1308 02008KT BKN012 BECMG 1310/1312 00000KT 3SM BR SKC TEMPO 1212/1214 1/2SM FG FM131600 VRB06KT P6SM SKC=

Type of report (TAF)—a TAF can be either a routine forecast (TAF) or an amended forecast (TAF AMD).

ICAO station identifier (KMEM)— is the same as that used in a METAR. In this example, KMEM is the identifier for the Memphis International Airport

Date and time of origin (121720Z)— is given in a six-number code with the first two numbers being the date and the last four being the time. Time is always given in UTC as denoted by the Z following the time block. In this example, on the 12th day of the month, at 1720Z.

Valid period dates and times (1218/1324)— follows the date/time of forecast origin group. The first two digits (12) are the day of the month for the start of the TAF. The next two digits (18) are the starting hour in UTC. 13 is the day of the month for the end of the TAF, and the last two digits (24) are the ending hour (UTC) of the valid period. A forecast period that begins at midnight UTC is annotated as 00. If the end time of a valid period is at midnight UTC, it is annotated as 24. In this example, the TAF is valid from 1800Z on the 12th to 2400Z on the 13th.

Forecast wind (20012KT)—The wind direction and speed forecast are coded in a five-digit number group. The first three digits indicate the direction of the wind in reference to true north. The last two digits state the wind speed in knots appended with "KT."

Forecast visibility (5SM)— is given in statute miles and may be in whole numbers or fractions. If the forecast is greater than six miles, it is coded as "P6SM."

Forecast significant weather (HZ)— The weather phenomena are coded in the TAF reports in the same format as the METAR. Only cumulonimbus (CB) clouds are forecast in this portion of the TAF report.

Forecast sky condition (BKN030)— given in the same format as the METAR.

Forecast change group (FM, BECMG, TEMPO and PROB40)— for any significant weather change forecast to occur during the TAF time period, the expected conditions and time period are included in this group. "FM" is used when a rapid and significant change, usually within an hour, is expected. *"BECMG"* is used for gradual changes in the weather. *"TEMPO"* is used for temporary fluctuations of weather, expected to last less than 1 hour. *"PROB"* is a given percentage that describes the probability of thunderstorms and precipitation occurring in the coming hours.

When interpreting a TAF, it's useful to break the forecast into its change groups. Here's the complete translation of the rest of the example TAF:

PROB40 1220/1222 1SM TSRA OVC008CB

- Probability Forecast: 40% chance of weather event between Day:12; 20:00 and Day:12; 22:00 UTC
- Forecast visibility: 1 SM.
- Forecast significant weather: Thunderstorm (TS) Rain (RA)
- Forecast sky condition: Clouds Overcast (OVC) 800ft AGL Cumulonimbus

FM122200 33015G20KT P6SM BKN015 OVC025

- From Group: Weather forecast for after Day: 12; 22:00 UTC
- Wind Direction: 330
- Wind Speed: 15KT, Gusts: 20KT
- Visibility (P): More than 6 SM.
- Broken (BKN) 1,500ft AGL
- Clouds Overcast (OVC) 2,500ft AGL

PROB40 1220/1222 3SM SHRA

- Probability Forecast
- 40% chance of weather event between Day: 12; 20:00 and Day: 12; 22:00 UTC
- Visibility: 3 SM.
- Showers (SH) Rain (RA)

FM120200 35012KT OVC008 From Group

- Weather Forecast for after Day: 12; 02:00 UTC
- Wind Direction: 350
- Wind Speed: 12KT
- Overcast (OVC) 800ft AGL

PROB40 1202/1205 2SM-RASN

- Probability Forecast
- 40% chance of weather event between Day :12; 02:00 and Day: 12; 05:00 UTC
- Visibility: 2 SM.
- Rain (RA) Snow (SN)

BECMG 1306/1308 02008KT BKN012

- Becoming Group
- Conditions are expected to change gradually between Day: 13; 06:00 and Day: 13; 08:00 UTC
- Wind Direction: 020
- Wind Speed: 08KT
- Clouds Broken (BKN) 1,200ft AGL

BECMG 1310/1312 00000KT 3SM BR SKC

- Becoming Group
- Conditions are expected to change gradually between Day: 13; 10:00 and Day: 13; 12:00 UTC
- Wind Direction: 000
- Wind Speed: 00KT
- Visibility: 3 SM
- Mist (BR)
- Sky clear (SKC)

TEMPO 1212/1214 1/2SM FG

- Temporary Group
- Conditions are expected to change temporarily between Day: 12; 12:00 and Day: 12; 14:00 UTC
- Visibility: 0.5 SM
- Fog (FG)
- FM131600 VRB06KT P6SM SKC=

From Group

- Weather Forecast for after Day:13; 16:00 UTC
- Wind Direction: Variable (VRB)
- Wind Speed: 06KT
- Visibility(P): More than 6 SM
- Sky clear (SKC)

TAF Practice

Fortunately, you'll only be responsible for translating one of two TAF reports on your knowledge test. Even better news is that I can tell you which ones they are. They're on the previous page straight from the 2018 edition of the FAA's Airman Knowledge Testing Supplement for Sport Pilot.

The first one should look familiar since that's the one we used for the example. Just to be thorough, let's go ahead and interpret the second one:

KOKC 051130Z 0512/0618 14008KT 5SM BR BKN030

- Header Group
- Station ID: KOKC–Will Rogers World Airport, Oklahoma City
- Date and Time of Origin: Day: 05; Time: 11:30 UTC
- Valid Time Period: Starts at Day: 05; 12:00 UTC, Ends at Day: 06; 18:00 UTC
- Wind Direction: 140
- Wind Speed: 08KT
- Visibility: 5 SM.
- Mist (BR)
- Clouds Broken (BKN) 3,000ft AGL

TEMPO 0513/0516 1 1/2SM BR

- Temporary Group
- Conditions are expected to change temporarily between Day: 05; 13:00 and Day: 05; 16:00 UTC
- Visibility: 1.5 SM
- Mist (BR)

- FM051600 18010KT P6SM SKC From Group
- Weather forecast for after Day: 05; 16:00 UTC
- Wind Direction: 180
- Speed: 10KT
- Visibility: More than 6 SM (P)
- Sky clear (SKC)

BECMG 0522/0524 20013G20KT 4SM SHRA OVC020

- Becoming Group
- Conditions are expected to change gradually between Day: 05; 22:00 and Day: 05; 24:00 UTC
- Wind Direction: 200
- Speed: 13KT, Gusts: 20KT
- Visibility: 4 SM
- Showers (SH) Rain (RA)
- Clouds: Overcast (OVC) 2,000ft AGL

PROB40 0600/0606 2SM TSRA OVC008CB

- Probability Forecast
- 40% chance of weather event between Day: 06; 00:00 and Day: 06; 06:00 UTC
- Visibility: 2 SM
- Thunderstorm (TS) Rain (RA)
- Clouds: Overcast (OVC) 800ft AGL Cumulonimbus

BECMG 0606/0608 21015KT P6SM SCT040

- Becoming Group
- Conditions are expected to change gradually between Day: 06; 06:00 and Day: 06; 08:00 UTC
- Wind Direction: 210
- Speed: 15KT
- Visibility: More than 6 SM (P)
- Clouds: Scattered (SCT) 4,000ft AGL

Typical TAF questions you may see on the test include:

Q: What is the valid period for the TAF for KMEM?
A: 12th 1800Z to 13th 2400Z.

Q: Between 1000Z and 1200Z the visibility at KMEM is forecast to be what?
A: 3 statute miles.

Q: What is the forecast wind for KMEM from 1600Z until the end of the forecast?
A: Variable in direction at 6 knots.

Q: During the time period from 0600Z to 0800Z, what visibility is forecast for KOKC?
A: Greater than 6 statute miles.

Q: What is the only cloud type forecast in TAF reports?
A: Cumulonimbus.

In-Flight Weather Advisories

Inflight weather advisories, which are provided to en route aircraft, are forecasts that detail potentially hazardous weather. These forecasts are issued in the form of AIRMETs, SIGMETs, or convective SIGMETs. Additionally, you can also access these advisories before your departure for flight planning purposes.

You can receive these weather advisories via various means, including through air traffic control, in-flight weather briefing services, or by accessing them through your aircraft's communication and navigation systems.

You can also get them by contacting 1-800-WX-BRIEF or online or through various apps.

Airman's Meteorological Information (AIRMET)

AIRMETs (WAs) are an important type of inflight weather advisory. AIRMETs are issued every 6 hours for a particular area forecast region, with additional updates issued as needed.

AIRMETs provide operational information for all types of aircraft, but the weather section specifically highlights phenomena that could be potentially hazardous to light aircraft or aircraft with limited operational capabilities. Examples of such phenomena include moderate icing, moderate turbulence, sustained surface winds of 30 knots or greater, widespread areas of ceilings less than 1,000 feet, and/or visibilities less than three miles, and extensive mountain obscurement. Definitely not powered parachute weather.

Significant Meteorological Information (SIGMET)

SIGMETs (WSs) are another important type of inflight weather advisory that warn pilots of weather even worse than AIRMETs. SIGMETs are forecasts that report non-convective weather that could be potentially hazardous to all types of aircraft. They're issued when there is severe weather that could impact flight safety.

SIGMETs provide information on weather forecasts that include severe icing not associated with thunderstorms, severe or extreme turbulence or clear air turbulence (CAT) not associated with thunderstorms, dust storms or sandstorms that lower surface or inflight visibilities to below three miles, and volcanic ash.

Unlike AIRMETs, SIGMETs are unscheduled and are valid for 4 hours unless they relate to a hurricane, in which case they are valid for 6 hours.

Convective Significant Meteorological Information (WST)

Convective SIGMETs (WSTs) are a kind of inflight weather advisory that is specifically issued for hazardous convective weather.

Convective SIGMETs are issued when there are severe thunderstorms with surface winds greater than 50 knots, hail at the surface greater than or equal to ¾ inch in diameter, or tornadoes. They're also issued to advise pilots of embedded thunderstorms, lines of thunderstorms, or thunderstorms with heavy or greater precipitation that affect 40 percent or more of a 3,000 square mile or greater region.

Convective SIGMETs are issued for each area of the contiguous 48 states (excluding Alaska and Hawaii) and are categorized into eastern (E), western (W), and central (C) regions. Each report is issued at 55 minutes past the hour, and each forecast is valid for 2 hours. Special Convective SIGMETs can also be issued during the interim for any reason.

Sample FAA Weather Advisory Questions

Q: SIGMETs are issued as a warning of weather conditions hazardous to which aircraft?
A: All aircraft

Q: AIRMETs are advisories of significant weather phenomena but of lower intensities than SIGMETs and are intended for dissemination to...
A: All pilots.

Winds and Temperature Aloft Forecast (FD)

Winds and Temperatures Aloft Forecasts (FB) provide wind and temperature forecasts for specific locations throughout the United States, including network locations in Hawaii and Alaska.

These forecasts are made twice a day based on the radiosonde upper air observations taken at 0000Z and 1200Z. Altitudes through 12,000 feet are classified as true altitudes, while altitudes 18,000 feet and above are classified as flight levels. Wind direction is always in reference to true north, and wind speed is given in knots, and temperature is given in degrees Celsius.

If a given level is within 1,500 feet of the station elevation, no winds are forecasted. Similarly, temperatures are not forecasted for any station within 2,500 feet of the station elevation.

When the forecast wind speed is calm, or less than 5 knots, the data group is coded "9900," which means light and variable.

Let's work through the FB that you may need to interpret for your knowledge test. It's in the figure below.

The heading indicates that this FB was transmitted on the 15th of the month at 1745Z and is based on the 1200Z upper air data. The valid time is 1600Z on the same day and should be used for the period between 1800Z and 0300Z. The heading also indicates that the temperatures above FL240 are negative. Therefore, the minus sign will be omitted for all forecast temperatures above FL240.

A four-digit data group shows the wind direction in reference to true north and the wind speed in knots. The elevation at Amarillo, Texas (AMA) is 3,605 feet, so the lowest reportable altitude is 6,000 feet for the forecast winds. In this case, "2714" means the wind is forecast to be from 270° at a speed of 14 knots. A six-digit group includes the forecast temperature aloft.

The elevation at Denver (DEN) is 5,431 feet, so the lowest reportable altitude is 9,000 feet for the winds and temperature forecast. In this case, "2321-04" indicates the wind is forecast to be from 230° at a speed of 21 knots with a temperature of –4 °C.

FB Practice

You may be asked questions that require you to refer to the graphic below during your knowledge test. Here are a few sample questions.

Q: What wind is forecast for STL at 9,000 feet?
A: 230º true at 32 knots.

FB WBC 151745
DATA BASED ON 151200Z
VALID 1600Z FOR USE 1800-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
ALS			2420	2635-08	2535-18	2444-30	245945	246755	246862
AMA		2714	2725+00	2625-04	2531-15	2542-27	265842	256352	256762
DEN			2321-04	2532-08	2434-19	2441-31	235347	236056	236262
HLC		1707-01	2113-03	2219-07	2330-17	2435-30	244145	244854	245561
MKC	0507	2006+03	2215-01	2322-06	2338-17	2348-29	236143	237252	238160
STL	2113	2325+07	2332+02	2339-04	2356-16	2373-27	239440	730649	731960

Winds and Temperatures Aloft Forecast.

Q: What wind is forecast for STL at 12,000 feet?
A: 230º true at 39 knots.

Q: Determine the wind and temperature aloft forecast for DEN at 9,000 feet.
A: 230º true at 21 knots, temperature -4ºC

Q: Determine the wind and temperature aloft forecast for MKC at 6,000 feet.
A: 200º true at 6 knots, temperature +3ºC

Other questions related to winds aloft forecasts are:

Q: What values are used for Winds Aloft Forecast?
A: True direction and knots.

Q: What does the term *"light and variable"* mean when is used in a Winds Aloft Forecast?
A: The forecast windspeed is less than 5 knots.

Practical Weather Tools

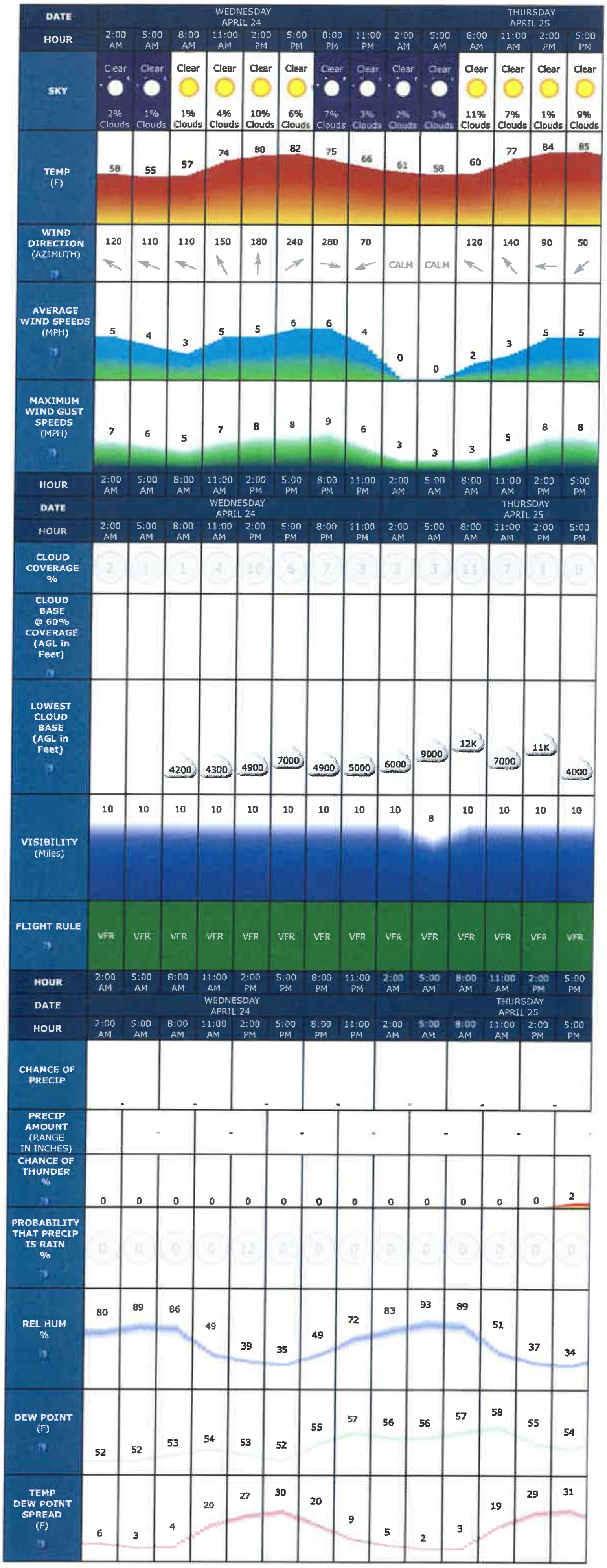
The material in this chapter up to now is testable during your FAA knowledge test. And there was a time when those government weather resources were the gold standard, especially 1-800-WX-BRIEF. And while you can still get great, personalized service from the flight briefers at 1-800-WX-BRIEF, there are a lot of other resources that present virtually the same information on your laptop or smartphone.

It's impossible to list and review all the available weather apps available now. But I have, over time, gathered a pretty good list of web sites and apps that I use on a regular basis. Some of these items I check every day. Others I use every time I get ready to fly. These are all free resources although you can subscribe to a few paid versions that will block ads or offer a little more capability.

USAIRNET.COM

This is a web site that I use nearly every day because it does a pretty good job of telling me what the weather will be like for the next three days. It's a little clunky to use, but after you navigate to the nearest airport that the National Weather Service (NWS) has a forecast for, you will be treated to a very detailed graphical representation of weather for three days.

The website is riddled with ads, but I don't begrudge that since everyone has to pay the bills somehow. It uses open-source government National Oceanic & Atmospheric Administration (NOAA) data. It just has a superior way of presenting that data.



Screenshot of a USAIRNET.com Forecast. Full forecast is for three days.

RyanCarlton.com

I like this website because of its focus on winds at low altitudes. RyanCarlton gets granular on winds, both by the hour and by altitude. In the old days, when the only good weather source was 1-800-WX-BRIEF, you could request a *"Balloon Forecast"* from the briefer. You still can. But RyanCarlton takes that digital data package from the NOAA and puts it up on a website.

The accuracy of the data on RyanCarlton varies with the season, location, and the algorithm that drives the creation of the data for the NOAA. The best thing about the website is that it warns you about winds aloft that could be trouble. If it forecasts a brisk wind at 100-400 feet above the surface, you know that you may be in for a bumpy ride, no matter what it feels like on the ground.

Like all wind forecasts, RyanCarlton has limitations. Three things that the current NOAA model doesn't appear to take into account are thermal activity, sea and land breezes, and frontal activity.

Thermal Activity

The sun's heating of the Earth's surface causes the air to rise and form thermals. These updrafts, in turn, create advective winds. While wind forecasts aim to predict these patterns, they may not always account for rapidly changing thermal conditions, particularly in areas with uneven heating, such as mountainous regions, deserts, or areas with rapidly changing cloud cover.

You should be cautious when relying on wind forecasts during periods of intense heating, as the wind conditions may vary from the predicted values due to the influence of thermals. For powered parachutes, heating intense enough to consider wrapping it up occurs about 2-3 hours after sunrise and lasts until 1-2 hours before sunset.

Sea and Land Breezes

Sea and land breezes are local wind patterns that result from differential heating between the land and sea. During the day, warmer air over the land rises, drawing in cooler air from the sea, creating an onshore breeze. At night, the process reverses, resulting in an offshore breeze.

Wind forecasts may not always capture the nuances of these sea and land breezes, especially in areas with complex coastlines. Pilots flying near coastal regions should be aware of the potential for these localized wind effects, which can vary depending on the time of day and geographical features.

Frontal Activity

Frontal boundaries are notorious for causing rapid and often unpredictable changes in weather, including wind patterns. Wind forecasts may provide some indication of frontal passages, but they might not capture the full extent of the turbulence, gusty winds, and shifting directions associated with these boundaries.

Windy.com

This is both a website and an app for iOS and Android. I don't use it as consistently as the two sites above, although I should. It graphically depicts surface winds over as wide an area as you would like to look at. And the depictions are attractive. The nice thing about looking at the winds over a wide area is that it builds confidence in the forecast for the place you're focused on.

Two things about Windy that set it apart from other products in the list is that first it is both a website and an app that you can download for both Apple and Android devices. Second is that if you upgrade your subscription to a low-cost annual fee, you get the added feature of hourly forecasts, instead of the normal three-hour forecasts. Since flying windows are small for powered parachutes, this feature seems very handy.

A web site that has a similar look and feel to **Windy.com** is **Ventusky.com**. However, there is no free version of the Ventusky app.

MyRadar

This is one of the very first apps I downloaded after I bought my first iPhone. The magic of having live radar displayed on a portable screen was amazing. And it still is. And it's free!

It's available for both Apple and Android devices. It's great for finding and tracking summer storms when you're trying to figure out if it's safe to get into the sky. Before I used MyRadar, if the sky was overcast, I would call 1-800-WX-BRIEF to see if there were embedded thunderstorms. Now, I just glance at my phone instead.

You can upgrade the app from the free version. The paid version offers hurricane tracking (not much use in a lot of the country) and a sectional maps feature. The sectional maps layer turns the app into an inexpensive moving map display, suitable for the short hops we do in powered parachutes.

NavMonster.com

NavMonster is available as a free app for iOS and Android, as well as a website. I downloaded the iOS app a few years ago and it's the first app I look at when I wake up on a flying morning. NavMonster is also the last app I look at before going to bed. Here's why:

The key feature I enjoy about NavMonster is that it translates the Morse code of METARs and TAFs that we waded through earlier in the chapter into plain English. There's a lot of important data in those reports and forecasts and having a way of reading them in plain English is very valuable. NavMonster also displays winds aloft forecasts in 3,000 foot increments, Aviation Forecast Discussions (AFDs), Notice to Air Missions (NOTAMs), Temporary Flight Restrictions (TFRs), as well as important airport information like radio frequencies and runways.

WeatherSpark.com

If you want to travel to a region to fly, WeatherSpark can provide you with a history of weather conditions for the city or state. That's handy if you are trying to figure out if an area is generally warm or cold, windy or calm, even how many hours of daylight there are at a given time of the year. The information is presented in graphs so you can see how the averages vary over a day, a month, a season or a full year.

Just as fun (or depressing) is the comparison feature that lets you compare the weather from two to six different localities. I say depressing because if you live in Detroit, it probably isn't a morale builder to compare your January weather with Honolulu.

Nav Clock

Here is a very simple, specialized app that provides me with changing information that I always have trouble with. It provides current weather with temperature in both °C and °F right next to each other. A small problem with NavMonster is that everything is in Celsius, and I don't think in Celsius. It also provides the local time in both 'real' time and Zulu time. Again, on the same screen, which is handy because I don't think in Zulu, either. Sunrise, sunset, ceiling altitude, density altitude and more are also part of this one-page free app.

WorldWeatherOnline.com

This is a nice weather site that offers hourly forecasts. Of course, a few other websites do that, too. However, this has hourly forecasts for winds and gusts, which are very important for powered parachute pilots.

Bottom Line: Weather To Pay Attention To

So after four chapters, thousands of words, graphics, FAA reports, FAA forecasts and internet resources, what does it all come down to? Is there a basic cheat sheet to make good, quick weather decisions? Well, this is a practical list of weather conditions I like to look at before I take off.

Surface Winds

Far and away, surface winds are the thing I look at most. Surface winds are critical because they are going to determine how clean your wing kite-up and takeoff will be. Everyone has their own limitations based on their skill set, their equipment, their terrain, and their comfort level.

The basics I look at are wind speed, direction and directional consistency. With powered parachutes, the lower the wind speed, the better. A general rule is that if it is so windy that you're having a difficult time laying out your wing, then it's definitely too windy to fly. My comfort level goes down a lot after 5-7 knots of wind. Even more important, passenger and student comfort levels go down a lot faster. That's because I like to fly at lower altitudes and the mechanical turbulence created by brisker winds going over trees, buildings, and such can make for a rowdy ride.

Wind direction is important because you always want to begin your takeoff by kiting your parachute into the wind. If you can't do that, the risk of a rollover is real–and can be embarrassing. For a similar reason, a wind that is changing direction can offer a lot of challenge. If it's changing quickly, fly another day. If it's changing in a predictable manner and you're watching a windsock upwind while you're getting ready to fly, you may be able to take off at just the right moment. Can be tricky, but can be done.

Winds Aloft

As soon as you get into the sky, you're beginning to deal with 'winds aloft.' In general aviation terms they worry about winds at 3,000 then 6,000 etc. For us, we're concerned with winds at treetop level to perhaps a couple of thousand feet.

The one thing that's almost guaranteed is that whatever winds you're dealing with on the ground will be increased once you begin flying. The best you can expect is for the winds to gradually increase with altitude. You certainly don't want them to double at a hundred feet if you're taking off in a five-knot wind, though!

There are three ways to check for winds aloft.

1. A forecasting tool like **RyanCarlton.com** is my favorite. It provides the hot air balloon forecast and probably provides it for an airport near you. It forecasts surface winds, then about 100 feet AGL, then around 250 feet, then 500 and so on. The altitudes seem a little arbitrary at times, but the information is good.
2. Another great way to check the winds aloft is to simply watch the sky. Treetops, chimneys, smoke stacks, and the movement of low clouds are all useful. Hint: When watching clouds, look at them compared to something you can site against like the roof of a hanger. You can really note cloud movement when you use a reference point.
3. Finally, for the enthusiastic, you can launch a low-budget weather balloon. Party balloon kits, with helium, are available at retail outlets. Inflate one and launch it. If it goes (relatively) straight up, you're good to go. If it darts off near horizontal at some low altitude, perhaps you should wait to fly.

Sunny vs. Overcast

As the sun begins to rise, it heats the ground and that causes thermals. Thermals are vertical wind, but not in a nice, organized way. Thermals are bumpy, and with the big wings and low speeds that we fly, that bump can become uncomfortable. Again, this is something that normally bothers your passenger more than it should bother you. But if a nice, smooth flight is something you want, a nice, sunny day is going to ruin that for you.

So that of course means that you can enjoy a lot more flying during an overcast day, everything else being equal. Overcast conditions mean the sun never really gets to heat up the ground and cause those uncomfortable thermals.

Temperature

Flying is an outdoor activity. And happily, even the warmest days get comfortable once you take off, get the wind in your face, and climb to cooler altitudes. But to get there you still need to take time on the ground to set up your wing. Laying out or packing your wing isn't that stressful under normal conditions, but it can become a handful under a hot, summer sun.

But worse, higher temperatures make your aircraft perform poorer. Which leads us to...

Density Altitude

Density altitude is the combination of altitude and temperature that can really degrade the performance of most any aircraft. The higher the altitude, the thinner the air. And the higher the temperature, the thinner the air. The combination of the two effects is called density altitude, or the altitude that your aircraft believes it is flying at.

The higher the (density) altitude, the poorer your wing, propeller, and engine perform. That translates into longer takeoff rolls, slower climbs, faster descents, and lower possible payloads. While summer flying is often the most fun because you can fly in short pants and a T-shirt, it also is the kind of weather that works your equipment the hardest.

Temperature/Dew point

Dew point is the temperature (varying according to pressure and humidity) below which water droplets begin to condense and dew can form. You don't even have to know how dew point is figured out, but you do need to know that the closer the actual temperature gets to the dew point, the higher the chances are of fog forming. A temperature/dew point spread of 0ºF means that fog is very likely, although oddly not guaranteed.

Visibility

The sport pilot rules say that we need at least three miles of visibility to fly. Oddly, ultralight pilots and private pilots only need one mile of visibility to fly in a lot of that same airspace. However, even though sometimes I fly ultralights and I do have private pilot credentials for powered parachutes, I always wait for three miles of visibility before I commit to the sky. That's because very often, the one mile of visibility can turn into a quarter mile of visibility just as easily as it can turn into three miles of visibility. That's because the conditions that bring us one mile of visibility are actually a little unstable. If the temperature goes down just a degree, the conditions get ripe for even more reduced visibility.

In other words, a small hole in the fog is nothing but a sucker hole. Don't get suckered into it.

Clouds

Clouds tell us a lot about the sky. They tell us about thermal activity, possible thunderstorms, winds aloft, and other weather. They are well worth paying attention to and continuing to pay attention to after you take off. This is especially true late in the afternoon when a particularly enthusiastic cumulus cloud can turn into a cumulonimbus cloud and bring with it all the delights of a thunderstorm, including high winds, heavy rain, lightning, and other goodies.

Rain

Rain hurts at 30 mph. I just thought I would say that up front. But more importantly, rain makes your parachute heavier and water collecting in the chute after long exposure to precipitation can make the wing tail-heavy and a little closer to stall.

If you get caught in a little bit of rain while you're flying, it's not a disaster. Just recognize that you will need to spend some time drying out your parachute once you are on the ground. Packing a parachute away wet and leaving it that way for any length of time sets it up for mildew damage.

However, heavy rain is to be avoided. It's not only uncomfortable, but it also has a habit of coming with things like lightning and wind. If you see something close on the radar, stay on the ground. If you're in the sky and see rainclouds heading your way, get on the ground. Even flying under virga, the kind of rain that evaporates before it gets close to the ground, can be a turbulent ride.

Fronts

Weather fronts could easily have gone to the front of this list rather than the back. The movement of weather fronts are something that get cooked into all the weather forecast models that you will normally access. The big, color weather maps you see on the local news with moving weather fronts actually are a big deal. They can indicate what kind of weather changes are coming and approximately when you can expect them. Sometimes clouds come with those fronts, but it is possible that the only thing you will notice on the ground is a gust front, a high wind out of 'nowhere.' And remember, wind IS the item that's on the top of the list!

Chapter 16 Aerodynamics

Achieving flight in a powered parachute involves overcoming a few challenges. The biggest challenge is gravity, the force pulling things down. Another challenge is drag, which is the air's resistance to movement. Drag is overcome by thrust, but where does that come from? To fly, we need to generate lift, an upward force created by the wing moving through the air. This lift needs to be stronger than gravity pulling the aircraft down. Creating lift involves following some important principles, like Newton's laws of motion and Bernoulli's principle of pressure differences. These principles help us defy gravity and keep our powered parachutes in the sky.

Newton's Laws of Motion

The fundamental physical laws governing the forces acting upon an aircraft in flight were adopted from postulated theories developed before any human successfully flew an aircraft. These physical laws emerged from the Scientific Revolution, which began in Europe in the 1600s. Driven by the belief that the universe operated in a predictable manner open to human understanding, many philosophers, mathematicians, natural scientists, and inventors dedicated their lives to unlocking the secrets of the universe. One of the best-known figures was Sir Isaac Newton, who not only formulated the law of universal gravitation but also described the three basic laws of motion.

Newton's First Law: *"Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it."*

This means that nothing starts or stops moving until some outside force causes it to do so. An aircraft at rest on the ramp remains at rest unless a force strong enough to overcome its inertia is applied. Once it is moving, its inertia keeps it moving, subject to the various other forces acting on it. These forces may add to its motion, slow it down, or change its direction.

Newton's Second Law: *"Force is equal to the change in momentum per change in time. For a constant mass, force equals mass time acceleration."*

When a body is acted upon by a constant force, its resulting acceleration is inversely proportional to the mass of the body and directly proportional to the applied force. This law addresses the factors involved in overcoming Newton's First Law. It covers both changes in direction and speed, including starting up from rest (positive acceleration) and coming to a stop (negative acceleration or deceleration). It's why heavier aircraft need more powerful engines to get airborne than lighter aircraft.

Newton's Third Law: *"For every action, there is an equal and opposite reaction."*

In a powered parachute, the propeller moves and pushes back the air; consequently, the air pushes the propeller (and thus the powered parachute) in the opposite direction—forward.

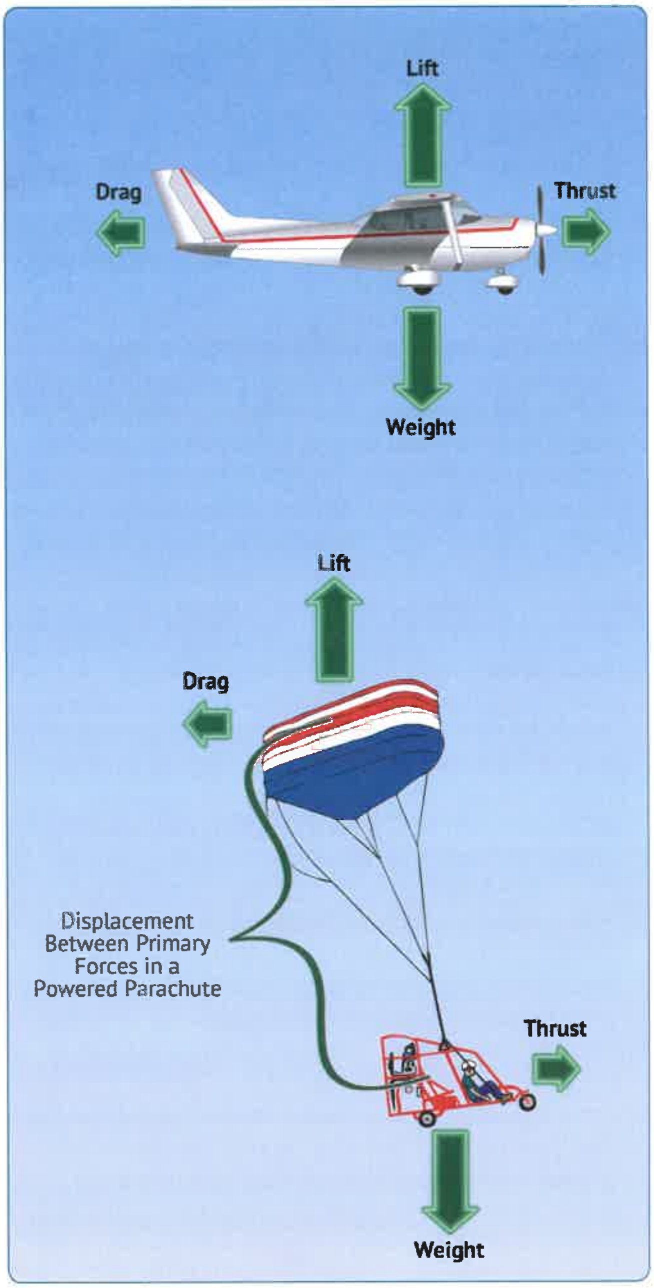
Forces Acting on the Powered Parachute

A force is a push or a pull that influences the motion of an aircraft. Forces such as lift and thrust work together to overcome opposing forces like gravity and drag, allowing the aircraft to move and stay in the air.

Like an airplane, powered parachutes have the four forces of lift, drag, thrust, and weight. And also like with an airplane, those forces must balance out in steady-state flight.

However, these forces are applied in different places on a powered parachute than they are on an airplane. On top of that, a typical powered parachute has a wing that is flexibly attached to the rest of the airframe. That means that the angle of incidence of the wing changes with thrust, which is something that doesn't happen with an airplane.

Your performance in flight depends on your ability to plan and coordinate the use of power and flight controls to manage thrust, drag, lift, and weight. The better you understand these forces and how to control them, the greater your skill in flying.



The following defines these forces in relation to straight-and-level, unaccelerated flight.

Thrust is the forward force produced by the powerplant and propeller. It opposes or overcomes the force of drag. While it's generally said to act parallel to the longitudinal axis, this is not always the case, as will be explained later.

Drag is a rearward, retarding force caused by the disruption of airflow by the wing, parachute suspension lines, airframe, and other protruding objects. Drag opposes thrust and acts rearward parallel to the relative wind.

Weight is the combined load of the powered parachute itself, the crew, the fuel, and anything else on board. Weight pulls the powered parachute downward because of the force of gravity. It opposes lift and acts vertically downward through the powered parachute's center of gravity.

Lift opposes the downward force of weight and is produced by the dynamic effect of the air acting on the wing. Lift acts perpendicular to the flight path through the wing's center of lift.

In steady flight, the sum of these opposing forces is equal to zero. According to Newton's Third Law of Motion, *"For every action, there is an equal and opposite reaction."* This means that if a plane is flying with no acceleration or deceleration, all the forces must balance out. There can be no unbalanced forces in steady, straight flight, whether the flight is level, climbing, or descending.

This is not the same thing as saying that the four forces are all equal. It simply means that the opposing forces are equal to and cancel the effects of each other. To be precise about it:

The sum of all upward forces (not just lift) equals the sum of all downward forces (not just weight).

The sum of all forward forces (not just thrust) equals the sum of all backward forces (not just drag).

Displacement of Forces

Unlike most other aircraft, there's a significant displacement of forces in a powered parachute. In the illustration showing the force vectors of thrust, drag, lift, and weight to the left, there's a major difference between a powered parachute and an airplane. With an airplane, the forces appear to pass through nearly the same place near the center of the aircraft. In a powered parachute, lift and drag are created mostly by the wing, and the weight and thrust are centered on the airframe portion of the powered parachute. This displacement of forces, combined with the flexible attachment of the parachute to the rest of the aircraft, makes the aerodynamics of a powered parachute vastly different from those of any other aircraft.

Balance of Forces During Climb

In a climb, the forces acting on a powered parachute are more complex than in level flight. While the classic formula—thrust equals drag and lift equals weight—applies to straight-and-level, unaccelerated flight, it needs refinement when an aircraft is climbing. During a climb:

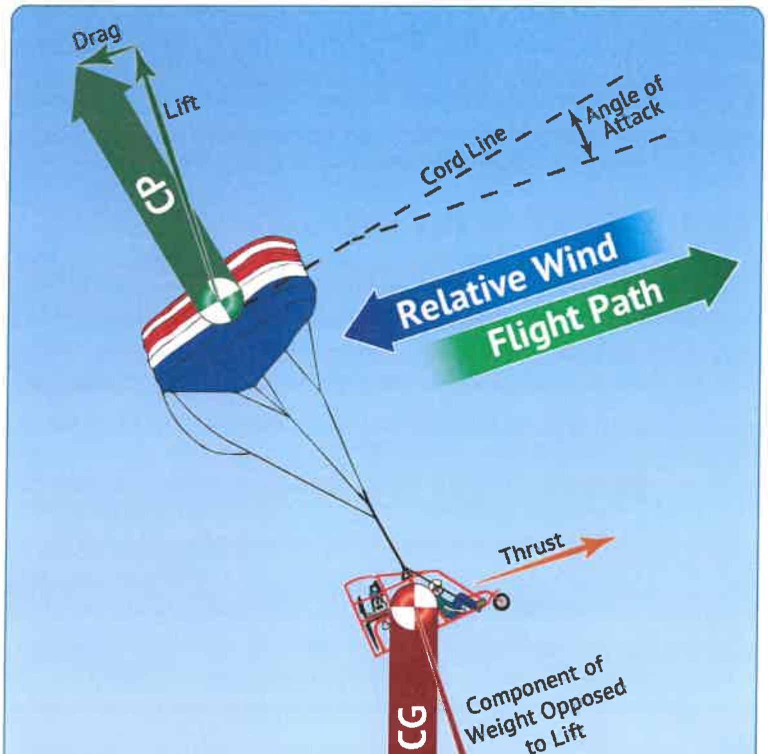
Thrust is not only providing forward motion but also contributes to overcoming a portion of the aircraft's weight. Since thrust is angled slightly upward relative to the horizontal, part of the thrust acts in the vertical direction, effectively adding to the lift force.

Weight is no longer acting purely downward relative to the aircraft's motion. A component of the weight acts backward, opposing the forward motion, similar to drag. This backward component of weight must be overcome by thrust in addition to the traditional aerodynamic drag.

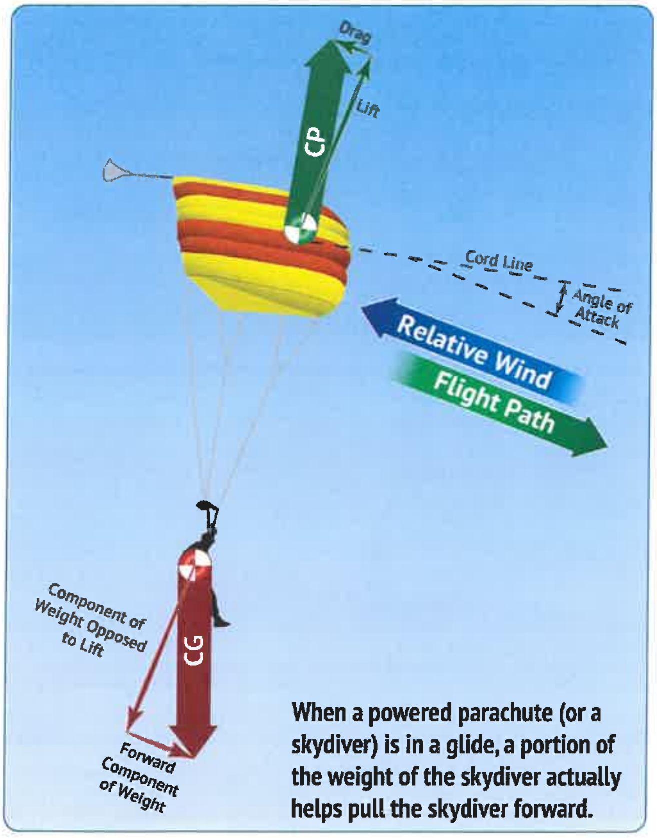
Thus, in a climb, the forces are redistributed:

- The vertical component of thrust assists lift in countering the aircraft's weight.
- The backward component of weight effectively adds to the drag, requiring more thrust to maintain or increase the climb rate.

This means that during a climb, some thrust is *"borrowed"* to assist lift, and some weight contributes to drag. This redistribution of forces explains why climbing requires more power and why the relationship between thrust, drag, lift, and weight isn't as straightforward as in level flight.



When a powered parachute is climbing, part of the weight is holding back its flight into the relative wind. A normally rigged wing will allow the thrust to point directly into the relative wind.



When a powered parachute (or a skydiver) is in a glide, a portion of the weight of the skydiver actually helps pull the skydiver forward.

Balance of Forces During Glide

When discussing the forces acting on a powered parachute during a glide, the relationship between thrust, drag, lift, and weight also becomes more complex, similar to a climb. However, we can simplify this. If the aircraft is gliding, we can assume the engine is either idle or off, so thrust is essentially zero, and the aircraft is descending under the influence of gravity. During a Glide:

Weight: In a glide, weight plays a dual role. It acts vertically downward, as always, but because the aircraft is descending at an angle, a portion of the weight acts in the direction of the glide path, essentially driving the aircraft forward through the air.

Lift: Lift continues to act perpendicular to the flight path, but since the flight path is no longer horizontal, the lift is slightly tilted relative to the Earth's surface. In a glide, lift is less than weight because the aircraft is descending.

Drag: Drag still acts parallel and opposite to the flight path, opposing the forward motion of the aircraft. Since there is no thrust to counteract drag, the forward motion is maintained by a portion of the weight component, which acts along the glide path.

Thus, in a glide, the forces are redistributed:

Weight Components: In a glide, weight is resolved into two components:

- One component acts perpendicular to the glide path and is opposed by lift.
- The other component acts along the glide path, effectively contributing to the forward motion and opposing drag.

Lift vs. Weight: Lift is less than weight during a glide because it only needs to balance the vertical component of weight, not the entire weight. This is why the aircraft descends rather than maintains level flight.

Drag vs. Thrust: With no engine power, thrust is absent, so the forward motion comes entirely from the component of weight along the glide path. Drag acts to slow this forward motion, and the balance between the component of weight along the glide path and drag determines the glide angle. A steeper glide angle results in higher airspeed and less drag, but also a faster descent.

In a glide, gravity acts as the aircraft's primary *"engine,"* with weight driving forward motion while also requiring lift to counterbalance it. Whenever the flight path isn't horizontal, the vectors for lift, weight, thrust, and drag must be broken down into components.

You can also think in terms of the direction the aircraft is flying. In straight-and-level flight, the relative wind and flight path are parallel to the earth, which is straightforward. However, in a descent, the flight path angles downward, with the relative wind pointing upward.

Understanding relative wind helps clarify the forces acting on a powered parachute in non-level flight. It's often a matter of terminology. For instance, it's commonly believed that a powered parachute climbs due to excess lift or a significant increase in the angle of attack. But climbs aren't simply about increasing lift. But if by increased lift" we're referring to the sum of all upward forces, then we're closer to the truth.

Weight

Weight is the simplest of the four forces to understand, as it's the force of gravity pulling all objects toward the Earth's center. Still, there's a way to visualize weight that may be new to you. That's called the *center of gravity* (CG). You will see this term a lot in aviation. This is the point where the entire weight of an object can be considered to act, like a theoretical balance point. For symmetrical objects like a ball or a cube, the CG is at the geometric center. For irregularly shaped objects, the CG is harder to determine. For a powered parachute, it's located within the airframe.

The CG is crucial for stability and control in flight. If a powered parachute were supported exactly at its CG, it would balance in any position. But it isn't that simple. The CG can change depending on the weight of the pilot, the weight of the passenger, the fuel load, and anything else that has mass. To allow for that, powered parachute designers design aircraft with a CG range, allowing for adjustments to ensure stability.

Weight interacts directly with lift, just as thrust interacts with drag. Lift is the upward force on the wing that counters the powered parachute's weight, which acts downward through the CG. In level flight, when lift equals weight, the powered parachute is in equilibrium and maintains altitude. If lift is less than weight, the parachute descends; if lift exceeds weight, it ascends.

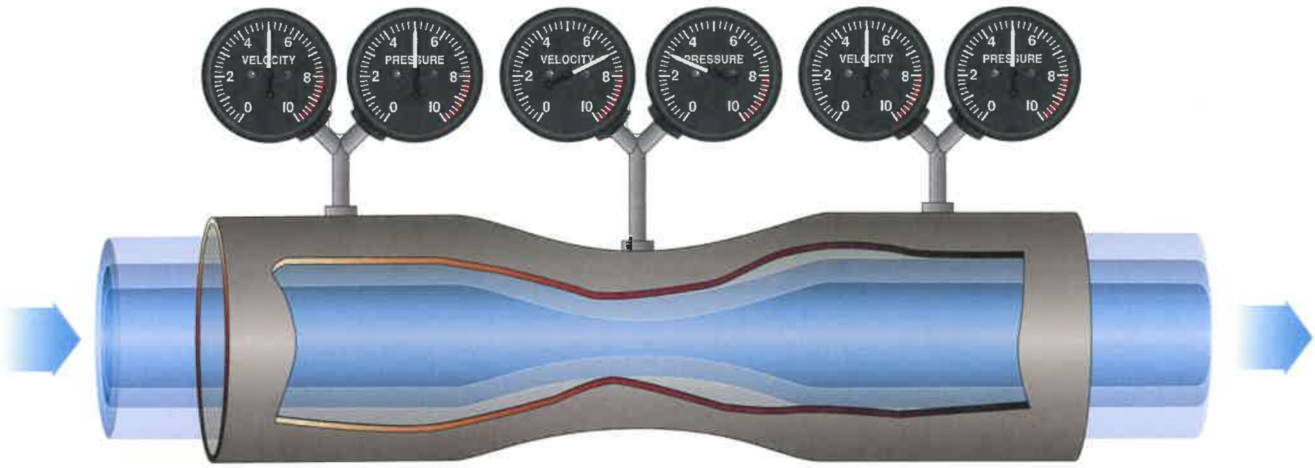
Lift

Lift is what makes a powered parachute go up and stay up. The creation of lift is what makes a powered parachute very different from a car or any other vehicle that's stuck to the ground.

Theories in the Production of Lift

The formulation of lift has evolved over centuries, rooted in basic physical laws. While these laws broadly apply to lift, they don't fully explain how lift is generated. This becomes evident when considering symmetrical airfoils, which, despite their shape, still produce significant lift.

Air pressure decreases in a venturi tube.



Bernoulli's Principle of Differential Pressure

A half-century after Newton formulated his laws, Swiss mathematician Daniel Bernoulli explained how the pressure of a moving fluid varies with its speed. Bernoulli's Principle states that as the velocity of a moving fluid (liquid or gas) increases, the pressure within the fluid decreases. This principle explains what happens to air passing over the curved top of the parachute wing.

A practical application of Bernoulli's Principle is seen in a venturi tube, which has an air inlet that narrows to a throat (a constricted point) before widening again at the outlet. As air flows through the venturi tube, it speeds up at the throat, causing a decrease in pressure, and then slows down at the outlet, where the pressure increases again.

Applying this to a wing: as the wing moves through the air, the airflow over its curved top surface speeds up, creating a low-pressure area that pulls the wing upward, generating lift.

Lift Explained by Newton's Third Law

Newton's third law of motion states that for every action, there's an equal and opposite reaction. In the context of powered parachutes, this law explains how lift is generated as the wing moves through the air. As the wing interacts with the surrounding air molecules, it creates a downward flow known as downwash. This downwash is the result of the wing deflecting air molecules downward—this is the action. According to Newton's third law, the reaction to this downwash is an upward force on the wing, which we recognize as lift.

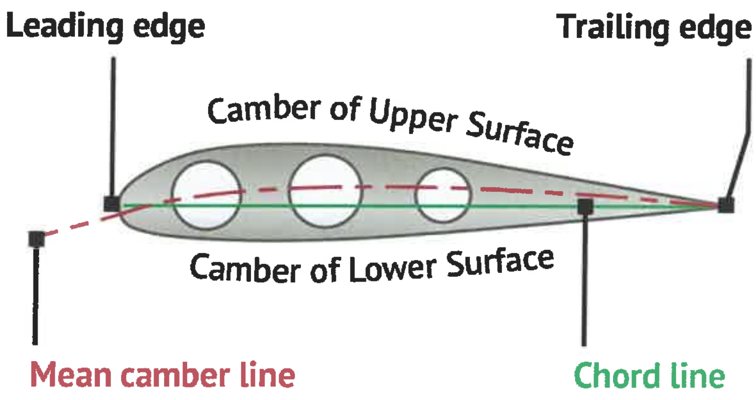
In aviation, there are two main schools of thought: one that attributes lift primarily to Bernoulli's principle and another that emphasizes Newton's third law. The reality is that both principles play important roles in explaining lift. Bernoulli's principle describes how the pressure difference between the upper and lower surfaces of the wing contributes to lift, while Newton's third law accounts for the reaction force created as the wing moves through the air. Together, these principles offer a more complete understanding of the aerodynamics of lift.

Although Newton, Bernoulli, and other early scientists lacked the advanced technology available today, their work laid the foundation for our modern understanding of how lift is created.

Airfoil Design

An airfoil is a specially shaped structure engineered to interact with air as it moves through it, harnessing principles such as Bernoulli's principle and Newton's laws of motion to generate lift.

A typical airfoil profile features distinct characteristics. The upper and lower surfaces have different curvatures, known as cambers. The upper surface usually has a more pronounced camber compared to the flatter lower surface. The airfoil also has two notable edges: the leading

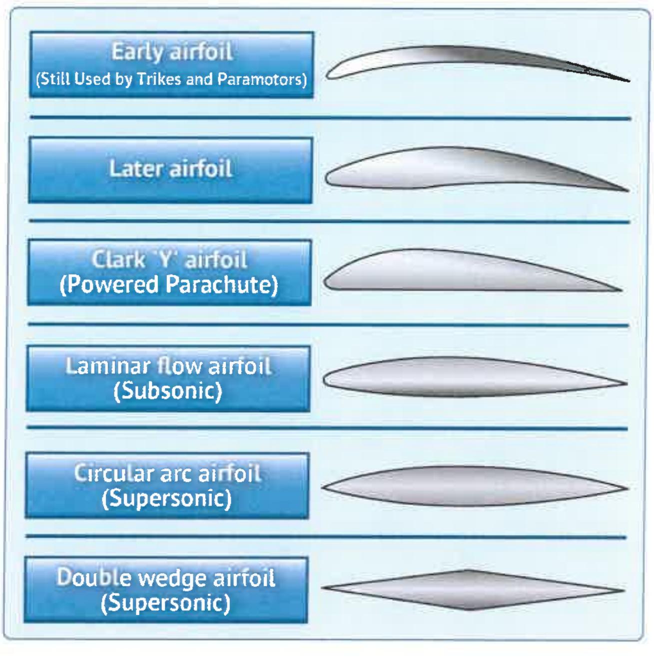


edge, which is rounded and faces forward during flight, and the trailing edge, which is narrow and tapered. In a powered parachute wing, however, there is no firm, rounded leading edge. Instead, the leading edge is formed by air pressure stagnated inside the wing and forward of the cell openings.

The chord line is a straight reference line drawn from the leading edge to the trailing edge of the airfoil. The distance from this chord line to the upper and lower surfaces indicates the camber at any point. The mean camber line, another reference line, is drawn from the leading edge to the trailing edge and instead of a straight line, is equidistant from the upper and lower surfaces at all points.

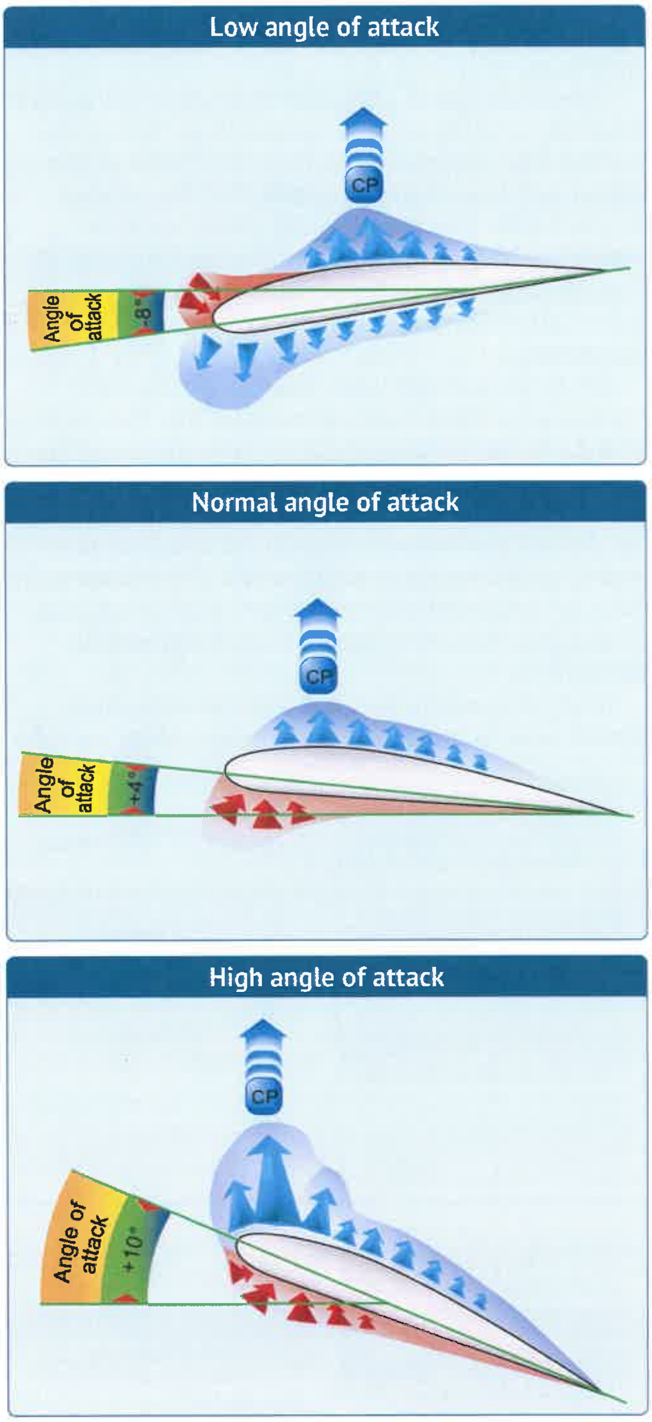
An airfoil's shape takes advantage the air's response to physical laws to create lift. This design results in two primary actions: positive pressure lift from the air below the airfoil and negative pressure lift from the reduced pressure above. As air strikes the lower surface, it rebounds downward, contributing to positive lift. Simultaneously, the upper curved section deflects the air upward. These forces work to push and pull the airfoil upward.

If lift were solely derived from air deflection by the lower surface, a flat wing like a kite would



suffice. However, the critical lift comes from the airflow above the wing. It's not practical to assign fixed percentages to lift generated by the upper versus the lower surface, as these values vary with flight conditions and wing designs.

Airfoils come in many shapes, each suited to different flight characteristics. While thousands of airfoils have been tested, no single design meets all needs. The specific shape of an airfoil depends on the aircraft's weight, speed, and purpose. For example, efficient airfoils for maximum lift often feature a concave or *"scooped out"* lower surface, but such designs may limit speed. Therefore, aircraft airfoils strike a balance between design extremes, tailored to the aircraft's requirements.



Pressure distribution on an airfoil and Center of Pressure (CP) changes with Angle of Attack (AOA.)

Low Pressure Above

In flight, an airfoil is a streamlined shape moving through air. Imagine an airfoil as a teardrop. If you slice it lengthwise, you get a basic airfoil profile. When this profile is inclined at an angle of attack (AOA), the air over the top surface travels faster than the air below, creating a pressure difference.

According to Bernoulli's Principle, the increased speed of air over the top surface leads to lower pressure above the airfoil. This pressure drop contributes to lift. However, the total lift force is not solely due to this pressure difference.

As air moves over the top surface of the airfoil, it creates a downward flow known as downwash. This downwash interacts with the airflow from the bottom surface at the trailing edge. According to Newton's Third Law, the reaction to this downward flow generates an upward and forward force on the airfoil, contributing further to lift.

High Pressure Below

As a wing moves through the air, it generates lift partly from the pressure beneath the airfoil. At higher angles of attack, this pressure is particularly significant.

Here's how it works: Air moving underneath the airfoil slows down near the leading edge, almost comes to a stop as it reaches a stagnation point, and then speeds up as it approaches the trailing edge. By Bernoulli's Principle, this slowdown results in increased pressure beneath the airfoil. This higher pressure contributes to lift, complementing the lower pressure above the airfoil.

So Bernoulli's Principle and Newton's Laws combine to describe how an airfoil generates lift. Bernoulli's Principle accounts for pressure differences, while Newton's Laws describe the resulting forces, together describing the upward force necessary for flight.

Pressure Distribution

When air flows over a wing, it creates areas of varying pressure: low pressure (negative) on the upper surface and high pressure (positive) on the lower surface. Typically, the upper surface experiences more pronounced low pressure, resulting in a stronger lifting force compared to the positive pressure below.

Wings have a key point called the center of pressure (CP), which represents the average of all pressure variations at a given angle of attack. This is the point where the aerodynamic force is effectively concentrated. At higher angles of attack, the CP moves forward, while at lower angles, it shifts backward.

Understanding the movement of the CP is vital in wing design. It influences how aerodynamic forces act on the wing, impacting performance at various flight angles. This principle is fundamental in the design and rigging of parachute wings, guiding how they are constructed to ensure optimal flight characteristics.

Airfoil Behavior

Lift generation is a complex process influenced by various principles, and it's not solely about the pressure difference between an airfoil's upper and lower surfaces. Some airfoils, like symmetrical ones used in high-speed aircraft or helicopters, don't have a longer upper surface yet still produce lift.

Consider a paper airplane, which is essentially a flat plate with identical top and bottom surfaces. Despite this, it can generate lift due to a phenomenon known as *flow turning*.

When an airfoil moves through the air at an angle, it causes the airflow to change. Imagine sticking your hand out of a car window at high speed. If you tilt your hand in one direction or another, it moves either up or down. This deflection of air results in swirling and changes in velocity around the airfoil, creating lift. Flow turning is essential in understanding how airfoils generate lift as they interact with the airstream.

Rotating Flow

So far, we've focused on how air flows over the upper and lower surfaces of an airfoil to produce lift. However, the tip of the airfoil also plays a crucial role. At the wingtip, high-pressure air from below the airfoil moves around to the low-pressure area above, creating a rotating flow known as a *tip vortex*. This vortex generates a downwash that extends back to the airfoil's trailing edge, which can reduce the overall lift on the affected portion of the airfoil.

To mitigate this effect, designers employ various strategies. Side stabilizers can be added to the ends of the wing or parachute to act as barriers that prevent vortex formation. Alternatively, airfoil tips can be tapered to reduce the pressure differential and smooth the airflow, a technique favored by paraglider designers.

Managing Lift

Lift is a major aerodynamic factor from the powered parachute pilot's viewpoint because it can be controlled readily and accurately by varying power and thrust. For instance, in straight-and level flight, altitude is maintained by adjusting lift to match the weight.

There are many ways you can control the lift on a powered parachute. Some of the control comes by installing different sizes or models of wings. Other forms of control come from flight controls. Methods include:

- Changing the overall weight of the powered parachute
- Changing to a larger or smaller wing
- Changing the model of wing
- Changing the trim of the wing
- Increasing or decreasing throttle
- Adding flare

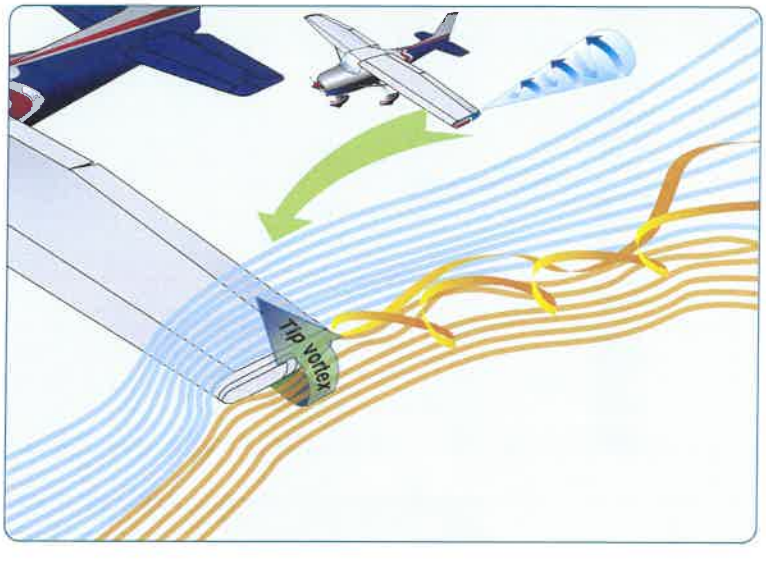
We can start with the easiest way to increase lift and that is to increase the overall weight of the powered parachute. If you increase the weight of a powered parachute and you're flying it straight-and-level, the forces balance out with Lift equaling Weight. That extra lift doesn't appear magically, though. Something else has to change to make it happen. The things that may change can be found in the lift equation.

$$L = \frac{C_L \cdot \rho \cdot V^2 \cdot S}{2}$$

The lift equation describes the relationship between Lift (L), air density (ρ), airfoil velocity (V), wing surface area (S), and the coefficient of lift (C_L) for a specific airfoil. That means that since Weight (W) = Lift (L) then weight is also equal to the same equation. So if weight and lift are both increased, there has to be an increase in one of the following things from the equation:

- Airfoil Velocity (V)
- Air Density (ρ)
- Wing Surface Area (S)
- The Coefficient of Lift (C_L)

Everything above is normally a constant on a given day except for the airfoil velocity. So that's what naturally increases when you increase weight. To get that increase in velocity, you'll have to increase



Wing Tip Vortex on an airplane wing. Parachute wings create vortices in a similar fashion.

the throttle setting. That said, let's explore how each variable in the lift equation affects lift.

Velocity (V) In a powered parachute, lift is directly proportional to the square of the velocity. This means that as the velocity increases, lift increases exponentially. It also means that if nothing else changes, an increase in weight will require a modest increase in forward speed to maintain straight-and-level flight.

Air Density (ρ) significantly impacts lift. It's influenced by pressure, temperature, and humidity. At higher altitudes or in warmer, moister air, air density decreases. For example, at 18,000 feet, air density is half that at sea level. To compensate for reduced air density and maintain the necessary lift, pilots typically increase airspeed or adjust the coefficient of lift (often by increasing the angle of attack). This adjustment is usually achieved by increasing power.

Wing Surface Area (S) also affects lift. A larger wing generates more lift at the same power setting compared to a smaller wing. For instance, a wing with a 500-square-foot area can lift approximately twice as much as a wing with a 250-square-foot area, provided the wing shape and airfoil section are the same. Smaller wings require higher speeds to generate the same amount of lift due to their reduced surface area.

Coefficient of Lift (CL) We've saved this for last since there is more going on with this coefficient than with the other parts of the lift equation. The coefficient of lift is a dimensionless number that represents the lift generated by an airfoil, in this case, a parachute.

The coefficient of lift depends on two things:

1. **Airfoil Design:** The specific airfoil design and aspect ratio significantly influence the coefficient of lift. Different wing designs have distinct aerodynamic characteristics that affect their lift capabilities.
2. **Angle of Attack:** The coefficient of lift also varies with the angle of attack. Generally, as the angle of attack increases, the coefficient of lift increases. However, once the wing reaches its stall angle of attack, the coefficient of lift drops sharply.

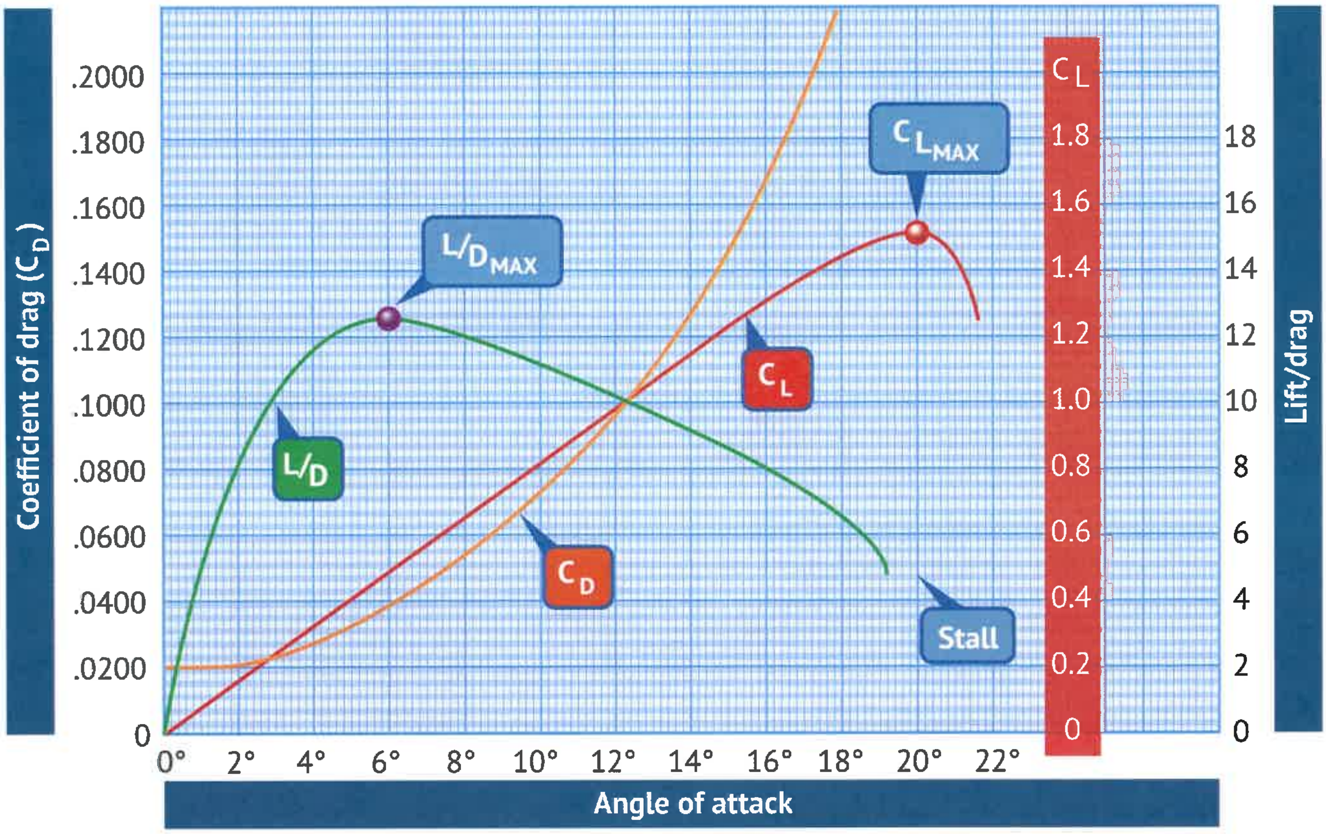
Angle of Attack

The wing design is set when it's built. The only thing that can be modified is the angle of attack. There are three ways that the angle of attack changes for a powered parachute.

1. Adjusting the trim of the wing
2. Automatic changes that occur in flight
3. Adding flare while flying.

The wing is trimmed for its optimum angle of attack at the factory by installing parachute lines at specific lengths. However, that trim can be modified in the field. Increasing the angle of attack can be accomplished by increasing the length of the front suspension lines of the parachute relative to the rear suspension lines. To decrease the angle of attack, the rear suspension lines need to be increased relative to the front suspension lines.

That's done as a ground adjustment by adding quick links to either the front or rear sets of



canopy lines. The quick link lengthens all the lines in that line set and changes the angle of attack for that wing. You should be cautious about doing that if you don't have technical help describing what the practical limits and risks are. Experiments by even experienced pilots have gone tragically awry.

It's possible for a powered parachute to have that kind of AOA control in flight from the flight deck, but most powered parachutes don't have that capability. It's something that has been accomplished in tests, prototypes and in at least one production model of powered parachute.

In flight, a powered parachute will automatically increase its angle of attack when you increase the throttle. As the angle of attack increases, lift increases (all other factors being equal). This is different from airplanes because of the way that the wing is attached to the airframe. Changes in thrust change the angle of attack of the wing in a powered parachute since the wing and the thrust are displaced by several feet, connected flexibly with fabric lines, and have a pivot point where the risers attach to the airframe.

As power is increased, the airframe moves forward of the parachute until the drag of the parachute balances the thrust of the engine. That movement of the airframe forward of the parachute results in an increased AOA and contributes to the lift and climb of the powered parachute. Conversely, when power is reduced, the parachute rotates forward relative to the airframe and the AOA is reduced. That results in a slightly slower forward airspeed when power is increased and a faster forward speed when power is reduced.

All other factors being constant, for every AOA there is a corresponding airspeed required to maintain altitude in steady, unaccelerated level flight. The changes in speed for a powered parachute are not radical. Speed differences probably range perhaps 5-10% from steady state descent to steady state climb.

And finally there's flare. Flare is a critical technique when it comes to landing because it increases lift right at landing and softens your touchdown. Flare is when you push both steering bars forward at the same time and deflect the trailing edge of the parachute downward. When you do that, you increase drag on the parachute, which pulls it further behind the airframe in flight. That increases the AOA of attack, and in turn increases lift.

There's a hazard in increasing the angle of attack (AOA) too much. When an airfoil reaches its critical AOA, also known as CL_{MAX}, lift no longer increases and instead begins to diminish rapidly. This point is where the airfoil stalls, resulting in a significant loss of lift. The graph on the previous page shows how the coefficient of lift (C_L) increases until the critical AOA is reached, then decreases rapidly with any further increase in the AOA.

The hazard is that many powered parachute wings are factory trimmed to fly close to the *critical*, or stalling, AOA in order to get the most lift out of them. There's a margin of safety built into them so that gusty wind and flaring won't normally stall the wings. However, changing the trim in the field by adding quick links or deeply flaring a parachute at altitude while flying risks stalling the wing.

Except for flaring, the angle of attack (AOA) and, therefore, the coefficient of lift generally remain within a stable range during normal flight. This stability is crucial because an airfoil always stalls at the same critical AOA, which you want to avoid exceeding. However, when the overall weight of a powered parachute increases, additional lift is required to maintain level flight. Since the AOA and coefficient of lift are already optimized, the only way to generate more lift is by increasing velocity. Fortunately, this adjustment happens automatically as the powered parachute compensates for the added weight.

Drag

Drag is one of the four basic forces acting on an aircraft and it's probably the least useful. (At least weight will bring you back to the ground.) Drag is the force that resists movement of an aircraft through the air. There are two general types: parasite drag and induced drag. The first is called parasite because all it does is slow you down, while the second, induced drag, is a result of an airfoil developing lift. Neither one is particularly helpful, but is the cost of doing business.

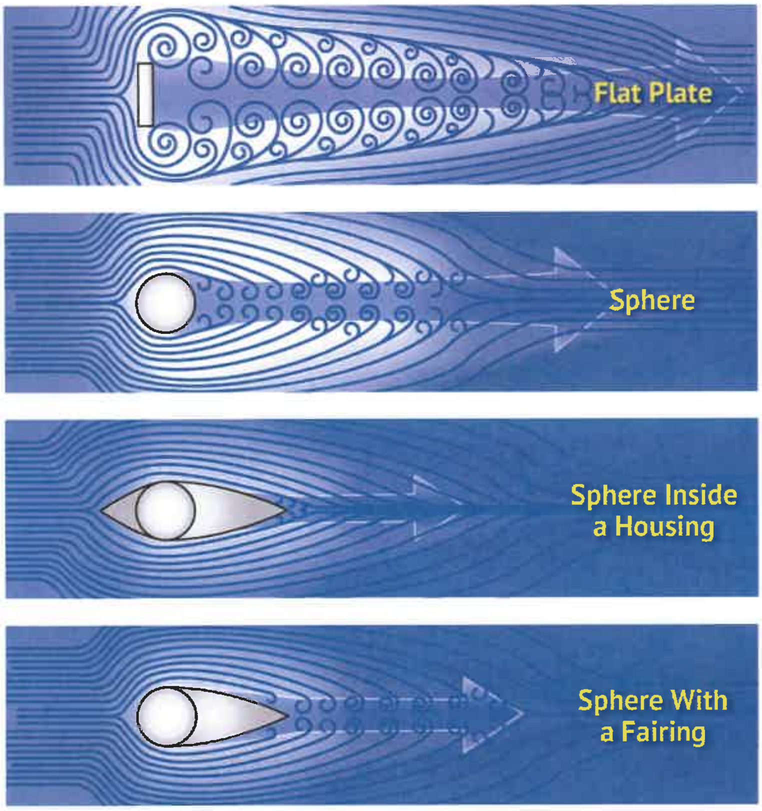
Parasite Drag

Parasite drag is a collective term encompassing forces that act to slow down an aircraft's forward motion. Unlike lift-induced drag, parasite drag is unrelated to the generation of lift and includes factors such as air displacement, turbulence, and hindrance of airflow over the aircraft's surfaces. There are three types of parasite drag: form drag, interference drag, and skin friction.

Form Drag: Form drag arises due to the shape of the aircraft and how air flows around it. Components like parachute suspension lines, risers, structural tubes, tires, antennas, and even passengers disrupt the smooth flow of air, creating resistance. Streamlining these components (but maybe not your passenger) is a key strategy to minimize form drag.

Interference Drag: Interference drag results from the collision of airstreams, creating eddies, turbulence, or disruptions in smooth airflow. Areas like the wing-fuselage intersection in an airplane can induce significant interference drag. The use of fairings and maintaining distance between surfaces helps mitigate this drag.

Skin Friction Drag: Skin friction drag occurs due to the aerodynamic resistance resulting from the contact of moving air with the surface of the aircraft or parachute wing. Even



Form drag for different shapes

seemingly smooth surfaces exhibit a microscopically rugged structure. As air molecules near the surface slow down, a boundary layer is formed. This is not normally a problem for powered parachutes since the speeds are so slow. The exception is your propeller. Keeping your propeller clean and waxed aids in reducing this kind of drag on your fast-moving propeller blades.

The shape of an object significantly influences parasite drag, but airspeed is equally critical in determining its impact. For a streamlined object held in a fixed position relative to the airflow, profile drag increases approximately with the square of the velocity. This means that doubling the airspeed results in four times the drag, while tripling the airspeed increases drag ninefold. Given the low speeds at which powered parachutes operate, parasite drag—particularly from the airframe—is less significant compared to induced drag.

Powered parachutes are built in ways that are notoriously non-aerodynamic. For example bigger tires have more form drag than smaller tires, but we like them anyway. Mounting mirrors and tablets in the airstream also increases form drag. Realize that there is a parasite drag cost for everything we put in the airstream, even though we aren't flying high-speed aircraft.

Induced Drag

The second primary category of drag is induced drag. Think of it as the unavoidable companion to lift creation – a consequence of the physics involved in keeping your aircraft aloft. No mechanical system is 100 percent efficient and parachutes are notoriously inefficient wings. As your wing generates lift, energy is inevitably lost as induced drag.

As lift is produced, the higher pressure beneath the wing and lower pressure above it cause air to flow from the bottom to the top near the wingtips, creating vortices. These vortices rotate counterclockwise around the right wingtip and clockwise around the left. This circulation induces an upward flow beyond the tip and a downwash behind the wing's trailing edge. Unlike the beneficial downwash that contributes to lift, this additional downwash alters the lift vector, making it tilt backward and causing induced drag.

The more pronounced the downwash, the greater the induced drag, especially at higher angles of attack (AOA). As airspeed decreases, a higher AOA is needed to maintain lift, which in turn increases induced drag. And powered parachutes are pretty much stuck on slow. Given their high angles of attack and slow speeds, powered parachute wings experience significant induced drag, a force that inversely varies with the square of airspeed.

The math describing induced drag looks a lot like the math describing lift.

$$D = \frac{C_D \cdot \rho \cdot V^2 \cdot S}{2}$$

Where:

- D is the drag force.
- C_D is the coefficient of drag.
- ρ is the air density.
- V is the velocity of the object relative to the air.
- S is the reference area of the object.

This equation mirrors the lift equation, with the key difference being the use of the coefficient of drag (C_D) instead of the coefficient of lift. The coefficient of drag, a dimensionless value, quantifies the drag experienced by an airfoil and is determined through wind tunnel tests or simulations. Changes in the airfoil's shape and AOA alter the C_D, impacting overall drag.

At low AOAs, changes in AOA result in minor shifts in the coefficient of drag, but at high AOAs, even small adjustments cause significant increases in drag. While parasite drag increases with the square of the airspeed, induced drag varies inversely with the square of the airspeed. Given the low speeds of powered parachutes, induced drag from the wing is the dominant form of drag.

Lift/Drag Ratio

Understanding the lift-to-drag ratio (L/D) is crucial for evaluating the efficiency of your wing. The L/D ratio compares the lift generated by the wing to its drag. Higher L/D ratios signify greater efficiency.

The L/D ratio is determined by dividing the C_L by the C_D, which is the same as dividing the lift equation by the drag equation. All terms except coefficients cancel out.

The graph on page 224 illustrates how the coefficient of lift curve reaches its maximum at 20° AOA, known as the critical angle of attack. On the same graph, the coefficient of drag curve increases rapidly from 14° AOA, overcoming the lift curve at 21° AOA. The lift/drag ratio peaks at 6° AOA, representing the point where you get the most lift for the least amount of drag.

Generally, operating an aircraft at the angle of attack corresponding to the maximum lift/drag ratio ensures the total induced drag is at a minimum. Any deviation from this optimal AOA increases the total induced drag for a given lift, impacting the efficiency of an aircraft. The figure below provides a visual representation of the L/D ratio's impact on total drag, emphasizing the importance of finding and maintaining the optimal angle of attack for peak efficiency.

For powered parachutes, the L/D ratio is set by the wing shape and the angle of attack. With higher power engines, it's possible to get closer to the L/D_{MAX} by changing the parachute rigging to reduce the AOA.

Thrust

To get your powered parachute airborne, you need thrust to be stronger than drag. After you get to altitude and level off, thrust and drag balance out. To stay aloft, thrust and drag must stay equal, just like lift and weight need to be balanced for a constant altitude.

Thrust and drag must remain equal even though the canopy is flexibly attached to the airframe. If the engine power is reduced in level flight, the thrust is lessened, and the powered parachute descends. Likewise, if the engine power is increased, thrust becomes greater and the parachute rotates to increase its angle of attack. The push upwards of the thrust combined with the aerodynamic lift of the parachute causes the powered parachute to climb. The greater the increase in thrust, the greater the rate of climb.

Since most powered parachutes don't have a way to trim a wing in flight to adjust the angle of attack (AOA), excess thrust mostly results in a greater rate of climb. However, the balance of forces means that an increase in thrust will also result in an increase in drag.

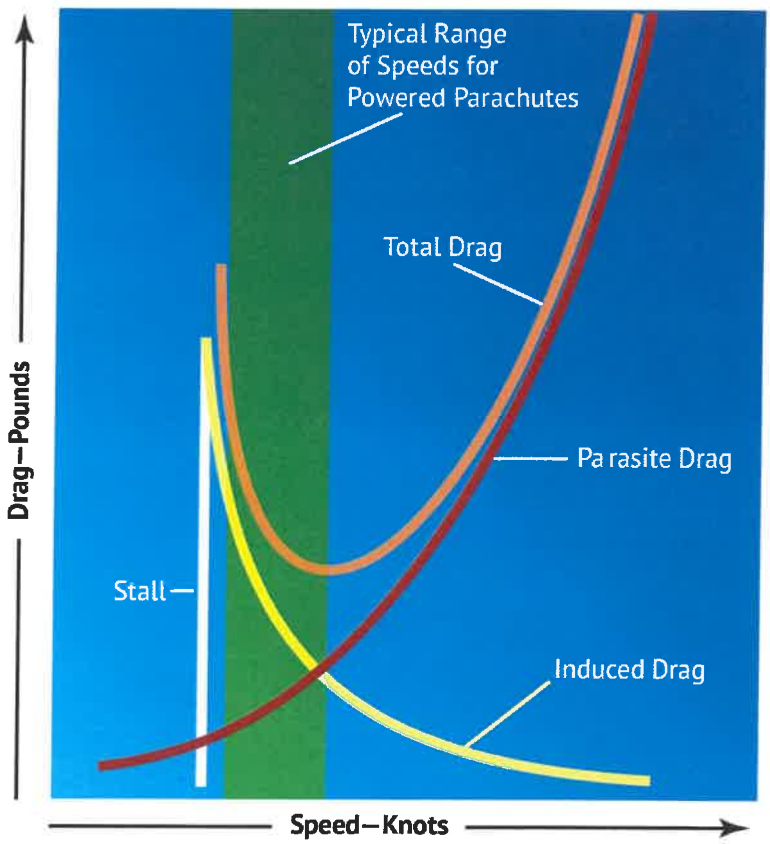
Much of this increase in drag can be accounted for by the rearward pull of the weight of the airframe. However, the displacement of forces shown in the diagram on page 219 implies that something else may also be going on.

With the airframe pushing forward due to thrust, the wing pulling rearward with drag, and a hinge where the parachute riser attaches to the airframe, it makes sense that an increase in the AOA will also result from the increase in throttle. An increase in AOA will measurably slow down the forward speed of a powered parachute.

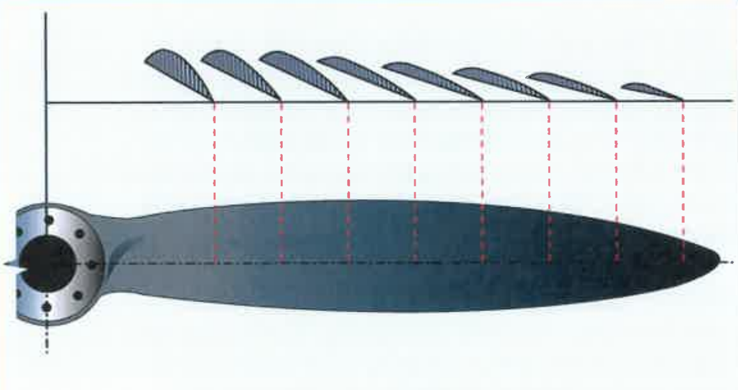
The reverse is also true. When the throttle is reduced, the AOA decreases and the powered parachute perceptively speeds up. These changes in speed are not great, usually only resulting in a 10% speed difference from straight-and-level flight. However, 10% is significantly more than the common belief of there being absolutely no change in speed during climb and descent.

There's another interesting effect that comes from thrust in a powered parachute. Pilots can actually increase their payloads by adjusting the center of gravity of their powered parachutes. By adjusting the center of gravity so that the nose of the airframe is pitched higher, part of the thrust from the engine is forced downward instead of just to the rear of the airframe. That contributes to the upward forces on the powered parachute and helps the powered parachute lift even more weight.

There are downsides to that kind of arrangement, though. The first is a reduction in forward speed. Aerodynamic lift is created by air moving over the wing. If the thrust is providing lift, then the wing doesn't have to work as hard. And in order to balance the forces, the wing absolutely won't work as hard. That means the whole powered



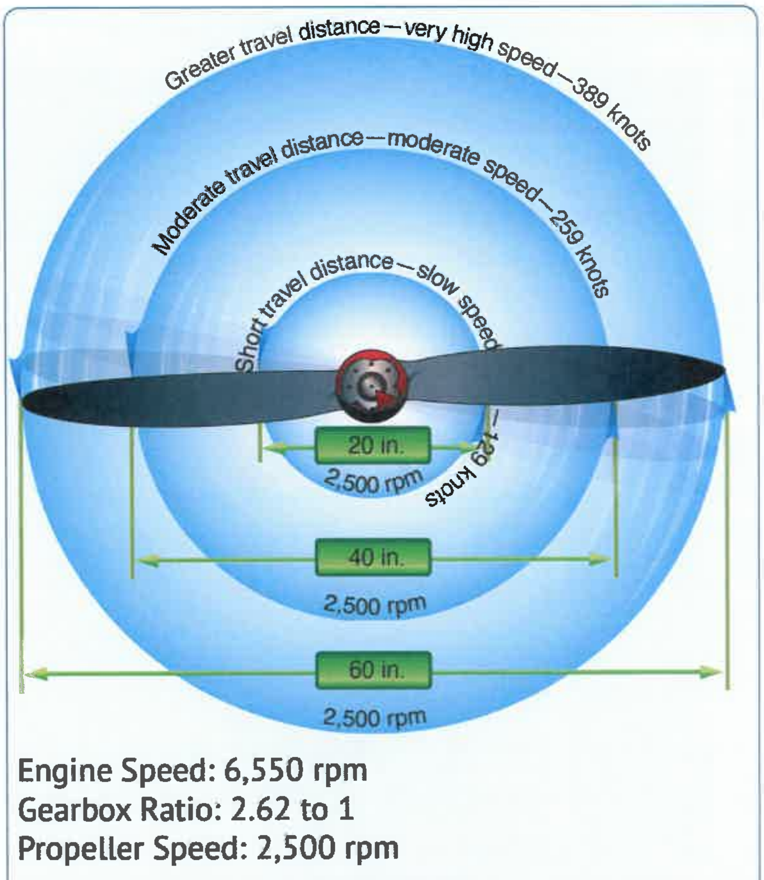
Drag vs. Speed


Airfoil sections of a propeller blade.

parachute will slow down.

But there is more to it than that. As thrust is used to push the airframe into the sky, it's partially unloading the wing. This isn't an issue if there's already a heavy payload. But it can be hazardous if someone adjusts the center of gravity so that the nose is very high in order to carry a heavy passenger and then forgets to reset it for solo flight. This can help contribute to a metastable stall.

Then of course there's the problem of what to do if power quits entirely. If you're depending on surplus power directed downwards to maintain level flight with a heavier payload, you will have that much more of a handful if the engine fails.



Propeller tips travel faster than the hub.

Propeller

A propeller is a rotating airfoil that provides the necessary thrust to propel a powered parachute through the air. Just like a wing, it's subject to aerodynamic principles such as induced drag and stalls. The engine powers the rotation of the propeller, which in turn generates thrust by creating a pressure difference between the front and back surfaces of the blades. This thrust is what drives the powered parachute forward.

Basic Propeller Principles

A powered parachute propeller consists of two or more blades attached to a central hub. Each blade acts like a rotating wing, generating thrust as it spins. A cross-section of a propeller blade resembles an airfoil, comparable to a wing's cross-section. The blade has a curved surface similar to the upper surface of a wing, and a flat surface similar to the bottom of a wing.

Understanding how a propeller works involves considering both its rotational and forward motion. As each section of a blade moves through the air, it creates an angle of attack, generating thrust by creating a pressure difference across the blade. This thrust depends on the mass of air moved by the propeller, and propeller efficiency can range from 50 to 87 percent, depending on conditions.

The efficiency of a fixed-pitch propeller varies with airspeed and RPM. At low speeds the efficiency is lower because the blades cannot reach their optimal angle of attack. Propeller efficiency is influenced by factors like geometric pitch, effective pitch, and slip. The efficiency of the thrust depends on factors such as the shape of the airfoil, the angle of attack of the blades, and the engine's revolutions per minute.

The angle between the chord of the blade and the plane of rotation is known as the blade angle, typically measured in degrees. While pitch and blade angle are related, pitch is usually designated in inches and represents the theoretical distance the propeller would advance in one revolution with no slippage. When mechanics talk about *pitching* a ground adjustable prop, they're normally talking about changing blade angles on the propeller blades.

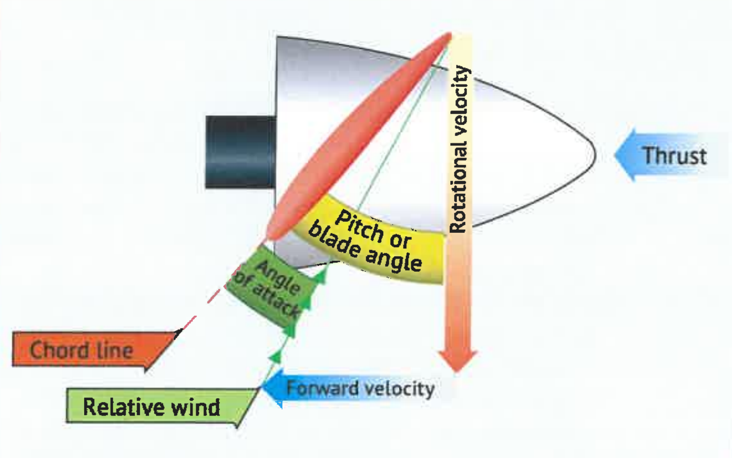
Propeller blades are normally twisted along their length, with the greatest angle of incidence (or pitch) near the hub and the smallest near the tip. This twist ensures consistent lift across the blade during flight, compensating for the difference in speed between the hub and the tip as they rotate. The propeller tip travels faster than the section near the hub because it covers a greater distance in the same amount of time.

Powered parachutes generally use either fixed-pitch or ground-adjustable pitch propellers. Given a powered parachute's relatively constant speed during flight, there's little benefit to using an in-flight adjustable propeller.

Fixed-Pitch Propeller

A fixed-pitch propeller has blade angles that are set by the manufacturer and cannot be adjusted. This design offers simplicity and cost-effectiveness but operates with optimal efficiency only at specific combinations of airspeed and RPM. Because of this, performance can be compromised in both climb and cruise phases of flight. For powered parachutes, fixed-pitch propellers are often made from laminated wood or composites, providing durability and lightweight characteristics.

There are two main subtypes of fixed-pitch propellers: climb and cruise. The choice between them typically depends on the intended use of the aircraft, but for powered parachutes, which are low-speed aircraft, the difference is minimal.

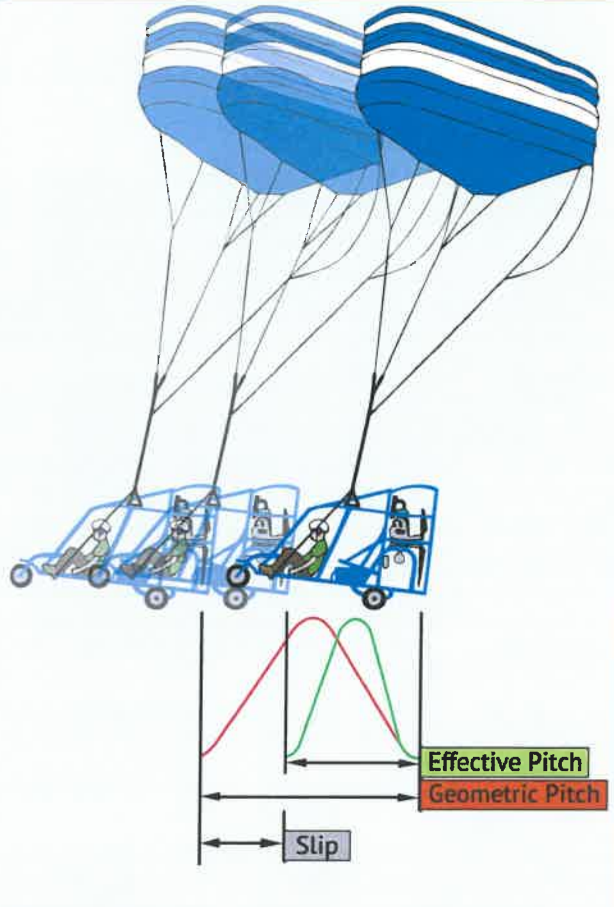


Propeller blade angle.

Climb Propeller: Features a lower pitch and less drag, allowing the engine to achieve higher RPM and produce more horsepower. This configuration enhances performance during takeoffs and climbs but reduces efficiency during cruising.

Cruise Propeller: Has a higher pitch and more drag, leading to lower RPM and less horsepower. While this setup decreases performance during takeoffs and climbs, it improves efficiency during cruising flight.

In a fixed-pitch propeller, the propeller is typically mounted on a shaft, which can be either an extension of the engine crankshaft or a shaft geared to it. The tachometer, calibrated in hundreds of RPM, serves as the primary indicator of engine power by showing engine and propeller RPM directly.



Propeller slippage.

RPM is controlled by the throttle, which regulates the fuel-air mixture flowing into the engine. At a given altitude, higher RPM readings on the tachometer indicate increased engine power output. However, at higher altitudes, reduced air density can affect the accuracy of the tachometer as an indicator of power output. As density altitude rises, the throttle must be opened further to maintain the same RPM, compensating for the thinner air.

For many aircraft, a fixed-pitch propeller is a compromise, as it can only be efficient at a specific combination of airspeed and RPM. However, because powered parachutes fly at relatively constant airspeeds, a fixed-pitch propeller is well-suited to their operational needs.

Adjustable-Pitch Propeller

Adjustable-pitch propellers for powered parachutes are designed to be adjusted on the ground using hand tools. This type of propeller is advantageous for powered parachutes because these aircraft typically fly at a constant speed. The propeller's pitch can be set to optimize engine performance and ensure that the engine operates within its recommended RPM range

Adjustable-pitch propellers can be fine-tuned to allow the engine to reach its maximum RPM without over-revving. If the engine is over-revving, increasing the pitch of the propeller can reduce RPM. Conversely, if the engine is not reaching the recommended RPM, decreasing the pitch can help achieve the desired performance.

Like fixed-pitch propellers, the tachometer indicates engine power. It helps in adjusting the propeller pitch to ensure that the engine operates efficiently.

Things to consider when adjusting an adjustable-pitch propeller:

Blade Angle Consistency: When adjusting the pitch, ensure that all propeller blades are set to the same angle. Uneven blade angles can cause imbalanced loading on the propeller, leading to vibration and potential damage to the gearbox and engine.

Static vs. In-Flight RPM: During ground testing, set the propeller pitch so that the engine doesn't exceed a 200 RPM below its maximum RPM. In flight, RPM naturally increases, so setting the propeller for maximum static RPM may cause the engine to exceed its safe RPM limits while airborne. Test fly the powered parachute to make sure that the propeller is pitched properly.

3-Blade Props vs. 2-Blade Props

When comparing 3-blade and 2-blade propellers, several factors come into play, including disk size, efficiency, and noise, each of which affects the performance and characteristics of the aircraft.

Disk Size: Disk size is different from prop diameter. The disk size refers to the area covered by the rotating propeller blades. In general, 2-blade propellers have a larger disk size compared to 3-blade propellers of the same diameter. This is because each blade of a 2-blade propeller covers a larger portion of the disk area. With fewer blades, each blade has a greater share of the disk, thus covering a larger area as it rotates. This larger disk size allows a 2-blade propeller to move more air with each rotation, which can be advantageous for producing thrust, particularly at lower speeds.

On the other hand, 3-blade propellers have a smaller disk size but offer more surface area in contact with the air at any given time. This additional blade improves the propeller's grip on the air, providing smoother power delivery and potentially better performance at higher speeds or in more demanding flight conditions.

Efficiency: Efficiency in propellers is largely about converting engine power into thrust with minimal loss. In ideal conditions, 2-blade propellers are generally more efficient than 3-blade propellers. This efficiency is due to less drag created by the blades, allowing the engine's power to be used more effectively to generate thrust.

However, 3-blade propellers can outperform 2-blade props in certain situations, particularly at higher speeds or when dealing with more significant aerodynamic loads. The additional blade helps distribute the load more evenly across the propeller, reducing stress on the individual blades and the engine. This can result in a more consistent performance, especially in conditions where the aircraft requires more thrust or when flying at speeds where a 2-blade prop might struggle to maintain efficiency.

Noise: 2-blade propellers, with their larger disk size and fewer blades, tend to produce more noise due to the larger sections of air they displace with each rotation. This noise can be more noticeable, especially at lower frequencies.

3-blade propellers, by contrast, tend to generate less noise. The smaller disk size and the increased number of blades mean that each blade displaces less air, resulting in a smoother, quieter operation. The noise produced by a 3-blade propeller is often at a higher frequency, which is less intrusive.

The choice between a 2-blade and a 3-blade propeller involves trade-offs. A 2-blade propeller may offer greater efficiency and a larger disk size, making it ideal for lower-speed, high-thrust situations. Conversely, a 3-blade propeller may provide better performance at higher speeds, smoother operation, and reduced noise levels, which can be beneficial in various flight conditions. The decision ultimately depends on the specific needs of the aircraft and the preferences of the pilot.

Torque and P-Factor

Torque is the left or right turning tendency of a powered parachute. It's made up of three elements which cause or produce a twisting or rotating motion around at least one of the powered parachute's three axes. These three elements are:

1. Torque Reaction from Engine and Propeller.
2. Gyroscopic Action of the Propeller.
3. Asymmetric Loading of the Propeller (P-Factor).

Torque Reaction

Torque reaction is explained by Newton's Third Law of Physics—every action has an equal and opposite reaction. For powered parachutes, this means that as the internal engine parts and propeller are revolving in one direction, an equal force is trying to rotate the powered parachute airframe in the opposite direction.

When a powered parachute is airborne, this force is acting as an additional load on one of the risers while simultaneously unloading the opposite riser. What this means to you is that the engine torque is trying to roll (turn) the powered parachute to the side with the extra loading.

There are two primary engine/gearbox combinations used on powered parachutes. As viewed from behind the aircraft:

Rotax two-cycle engines try to turn the airframe to the left.

Rotax 9-series engines try to rotate the airframe to the right.

There are several ways that powered parachute designers and pilots deal with torque reaction and those methods are discussed in *Chapter 18, "Flight*

Controls and Trimming."

You should rig your powered parachute so that it can compensate for this force at level flight since you will spend most of your time flying at that engine RPM. Since powered parachutes are light-weight aircraft, pilot and passenger weights can greatly impact torque reaction. What pilots normally do is trim their powered parachutes for how they fly most of the time. That means either with the load of a passenger on board or not, or perhaps somewhere in the middle.

After the machine is trimmed, you will often find yourself flying at different engine speeds. There are tools available to you to compensate for varying torque reaction like steering line trim tabs and weight shifting.

In flight, the magnitude of torque reaction depends on:

- Horsepower of the engine.
- Size of the propeller.
- Engine speed
- Gross weight of the powered parachute.
- Airframe design

During a takeoff roll with the wheels still on the ground, torque reaction induces an additional turning moment around the vertical axis. As torque forces one side of the airframe down, more weight on that side's landing gear leads to increased friction on that tire, causing an additional turning moment. Pilots correct this yawing moment during takeoff by steering away from the pull to the other side.

The magnitude of torque reaction on the ground is dependent on some of the same things that affect the magnitude of torque reaction in flight, with some differences.

- Horsepower of the engine.
- Size of the propeller.
- Engine speed
- Gross weight of the powered parachute.
- Airframe design
- Main landing gear track width (see illustration on the right.)
- Tricycle or quad landing gear.
- Condition of the ground surface.

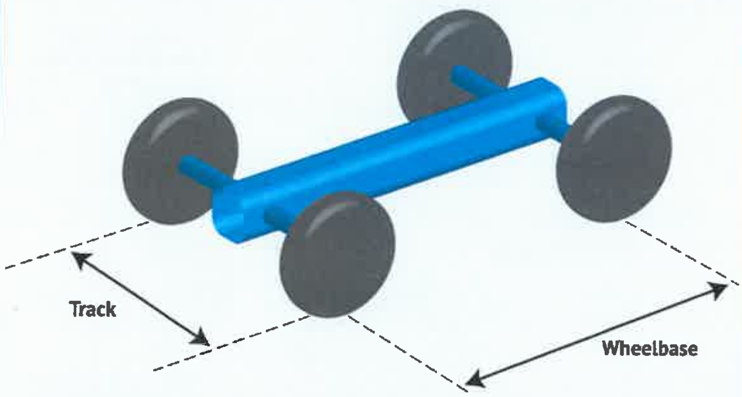
You should be aware of the possibility of takeoff torque reaction and be ready to compensate with ground steering.

Gyroscopic Action

To comprehend the gyroscopic effects of the propeller, it's essential to grasp the fundamental principle of a gyroscope, relying on two key properties: rigidity in space and precession. What's important for us here is precession.

Precession is the deflection of a spinning rotor (like a propeller) when a force is applied to its rim. The resulting force occurs 90° ahead of the point

Torque reaction.



Airframe track vs. wheelbase.

Gyroscopic precession

of application in the direction of rotation. Since the rotating propeller of a powered parachute functions similarly to a gyroscope, it exhibits these gyroscopic properties. When a force deflects the propeller from its plane of rotation, the resulting force induces a pitching, yawing, or combined moment, depending on where the force is applied. The magnitude of this effect depends on the abruptness of the applied force.

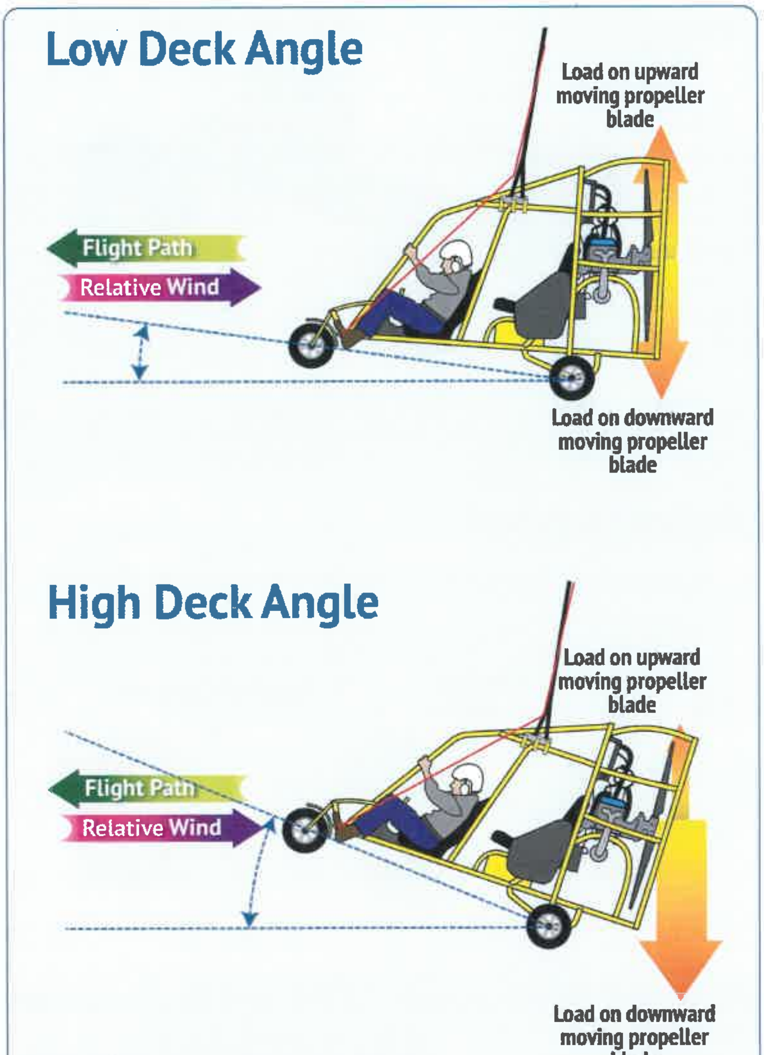
In a powered parachute, gyroscopic precession is most noticeable when the nose is raised quickly, either by a sudden increase in power or by flaring. Abruptly raising the nose mimics a force applied to the top of the propeller's rotation plane, leading to a yawing moment around the vertical axis.

Right-Turning Propeller (Clockwise): For a right-turning propeller, such as those on Rotax 2-stroke engines, the resultant force tends to turn the airframe to the right.

Left-Turning Propeller (Counterclockwise): For a left-turning propeller, like those on Rotax 9-series engines, gyroscopic precession tends to turn the airframe to the left.

This gyroscopic effect can initially help balance the torque reaction during takeoff. However, during landing, particularly in a properly rigged powered parachute, abrupt flaring reduces the torque reaction, causing the airframe to compensate more for gyroscopic action. This compensation can result in the powered parachute abruptly turning to the right or left, depending on the propeller's rotation direction.

In turbulent conditions, the gyroscopic action can contribute to a more pronounced pitching moment from yawing and a yawing moment from pitching, adding to the challenges and excitement of flying.



Asymmetrical loading of propeller (P-factor).

Asymmetric Loading (P-Factor)

When a powered parachute's airframe is tilted nose-high, the propeller blades experience uneven loading, known as asymmetric loading or P-factor. This occurs because the downward-moving propeller blade takes a "*bigger bite*" of air than the upward-moving blade, causing the center of thrust to shift toward the side of the downward-moving blade. This shift induces a yawing moment, turning the aircraft in the opposite direction around its vertical axis.

The root of this phenomenon lies in the *resultant velocity*, which is a combination of the propeller blade's rotational velocity and the horizontal velocity of the air passing through the propeller disc. At positive deck angles, the downward-moving blade experiences a higher resultant velocity than the upward-moving blade. Since the propeller blades function as airfoils, the higher velocity on the downward-moving blade generates more lift, leading to a yawing effect that pulls the aircraft's nose to the opposite side.

To visualize this, imagine the propeller shaft perpendicular to the ground, similar to a helicopter. Without external air movement, each propeller blade section would experience the same airspeed. However, when horizontal air movement is introduced, the blade advancing into the airflow achieves higher airspeed, generating more lift or thrust and shifting the center of thrust toward that blade. As the propeller shaft angle becomes shallower relative to the moving air, resembling a traditional aircraft configuration, this unbalanced thrust diminishes until it reaches zero when the propeller shaft is horizontal to the airflow.

In powered parachutes, asymmetric loading tends to turn the aircraft in the same direction as torque effect. Therefore, extreme deck angles amplify the torque effect, causing the powered parachute to turn more noticeably.

The impact of asymmetric loading varies across different flight phases, with some elements being more prominent at certain times. The extent of these effects depends on factors like the airframe, engine, and propeller combinations. To maintain control in varying flight conditions, pilots must skillfully apply flight controls to compensate for these changing torque effects.

Chapter 17 Stability and Stalls

An aircraft needs a certain amount of stability to even be flyable. That stability can come from the design of the aircraft itself or from advanced controls that create easy-to-fly aircraft.

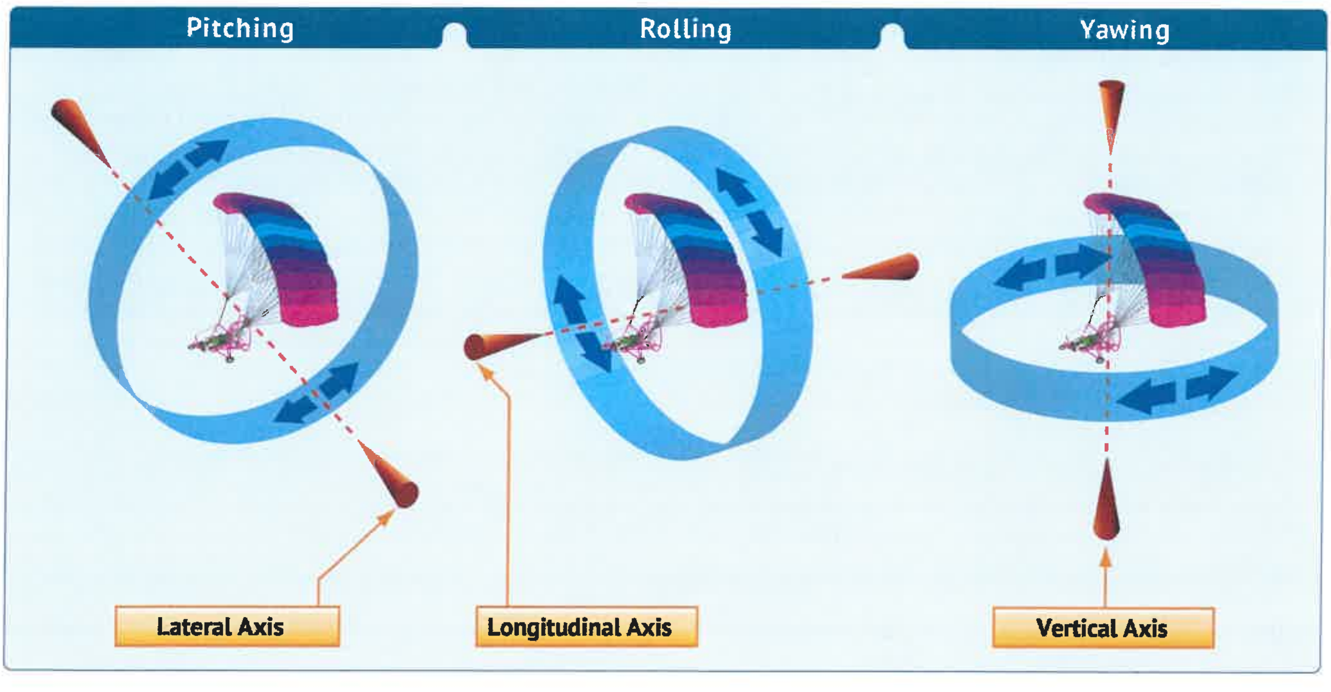
A powered parachute is inherently stable, just by its design. In fact, powered parachutes are some of the most statically and dynamically stable aircraft ever designed.

Linked to stability is stalling. Powered parachutes were once marketed as *"stall proof."* However, pilots pushing the envelope of powered parachuting have proven that all airfoils stall. For powered parachutes, it's a matter of how well the aircraft recovers from stalls and what techniques you use to recover from a stall.

Axes of a Powered Parachute

The axes of your powered parachute are like imaginary axles passing through its center of gravity (CG), and they play a crucial role in how your aircraft moves. There are three axes, each meeting at 90° angles in relationship to each other. The longitudinal axis runs from front to back of the airframe and the lateral axis extends from side to side of the airframe. The vertical axis is perpendicular to the other two and extends from top to bottom of the airframe.

Whenever your powered parachute changes its attitude or position, it rotates about one or more of these axes. Imagine it's like the roll of a ship when it moves from side to side. The three motions your aircraft experiences are roll, pitch, and yaw. Roll is



the side-to-side motion, pitch is the up-and-down motion, and yaw is the left-and-right movement of the aircraft's nose.

The three motions of the powered parachute (roll, pitch, and yaw) are controlled by the pilot. Pitch is controlled by the throttle and (to a lesser degree) by the steering bars while roll and yaw are controlled primarily by the steering bars. The use of these controls is explained in *Chapter 18, "Flight Controls and Trimming."*

Design Characteristics

As you become familiar with various powered parachutes, you'll notice that each one has distinct handling characteristics. The way an aircraft responds to control inputs can differ markedly from one model to another.

Different combinations of airframes, wings, and trim settings shape the characteristics of a powered parachute. These configurations determine whether the powered parachute is effortlessly controllable, highly maneuverable, capable of lifting larger weights safely, or designed for optimal efficiency in flight. The two kinds of designers in the powered parachute world are airframe designers and wing designers. They work together to build aircraft that meet the needs of pilots.

The goal of this section is to understand what goes into a powered parachute's stability, maneuverability, and controllability and how those features influence each other. Let's start with what those three things really are.

Stability refers to the inherent ability of a powered parachute to correct itself when faced with conditions that might disrupt its balance, enabling it to return to or maintain its original flight path. This characteristic is primarily determined by the design of the powered parachute. While all powered parachutes possess this quality to some extent, the degree of stability can be intentionally incorporated into the machine through design choices.

Maneuverability, on the other hand, is the powered parachute's capability to be easily maneuvered and endure the stresses induced by various maneuvers. It's influenced by factors such as weight, inertia, parachute design, parachute attachment point, structural strength, and the powerplant. Similar to stability, maneuverability is an inherent design characteristic of powered parachutes.

Controllability is the powered parachute's ability to respond to the pilot's control inputs, particularly concerning changes in flight path and attitude. It represents how well the powered parachute reacts to the pilot's control applications during maneuvers, irrespective of its stability characteristics.

Stability in an aircraft significantly influences maneuverability and controllability.

Basic Concepts of Stability

Stability is an inherent quality of an aircraft, allowing it to correct for disturbances that may affect its balance and return to or maintain its original flight path. This characteristic is primarily a result of the aircraft's design. The aerodynamic features, propulsion system, and structural strength of a powered parachute (mostly the wing) set limits on the flight paths and attitudes it can achieve. These limitations define the maximum performance and maneuverability of the aircraft.

For an aircraft to be as useful as possible, it must be safely controllable within these limits, without surpassing the pilot's physical strength or demanding exceptional flying skills. To ensure an aircraft can fly steadily along any chosen flight path, the forces acting on it must be in static equilibrium. Stability, in this context, refers to the reaction of a body when its equilibrium is disrupted. There are two general types of stability, static and dynamic, and we will cover both.

Static Stability

Static stability concerns the initial response or direction of movement back to equilibrium in aviation. Specifically, in powered parachuting, it refers to the initial reaction of the aircraft when disturbed from its designated flight path and attitude.

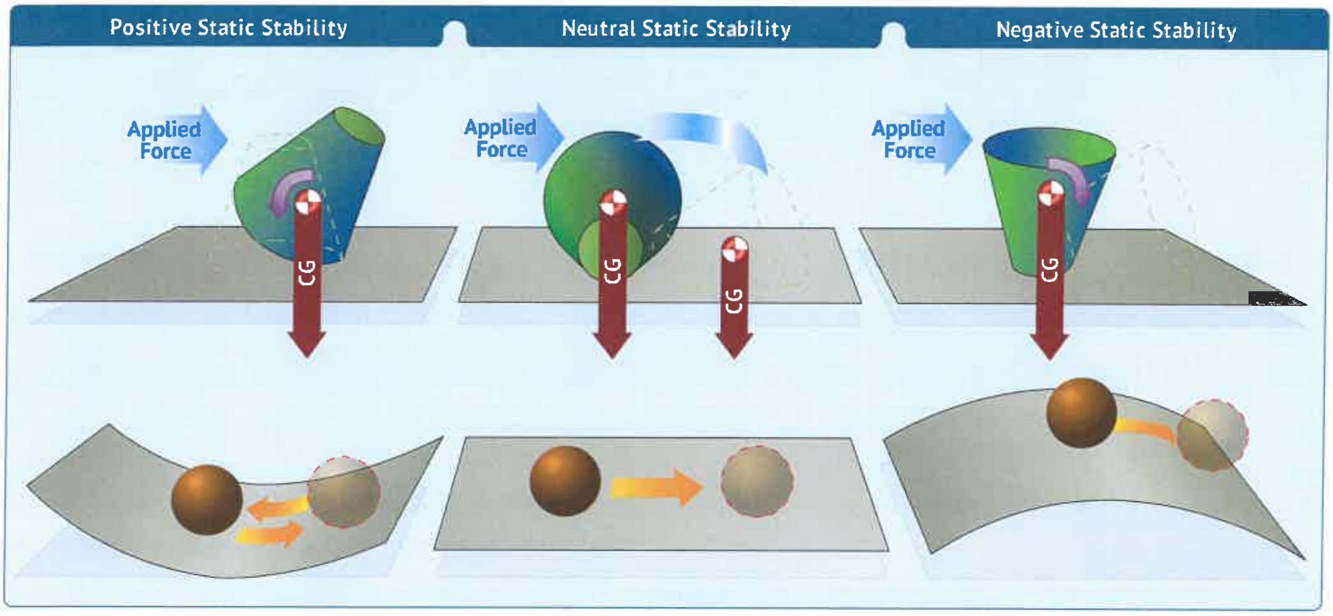
A powered parachute is free to move in various directions and must be controllable in pitch, roll, and direction. This introduces a design challenge where engineers need to find a balance between stability, maneuverability, and controllability. Excessive stability can hinder maneuverability and climb performance, while insufficient stability is detrimental to controllability. Therefore, the key in designing powered parachutes lies in striking the right compromise between these factors.

Static stability can be categorized as follows:

Positive Static Stability: The initial tendency of the powered parachute to return to the original state of equilibrium after being disturbed.

Neutral Static Stability: The initial tendency of the powered parachute to remain in a new condition after its equilibrium has been disturbed.

Negative Static Stability: The initial tendency of the powered parachute to continue away from the original state of equilibrium after being disturbed.



Types of static stability..

Pendulum Stability

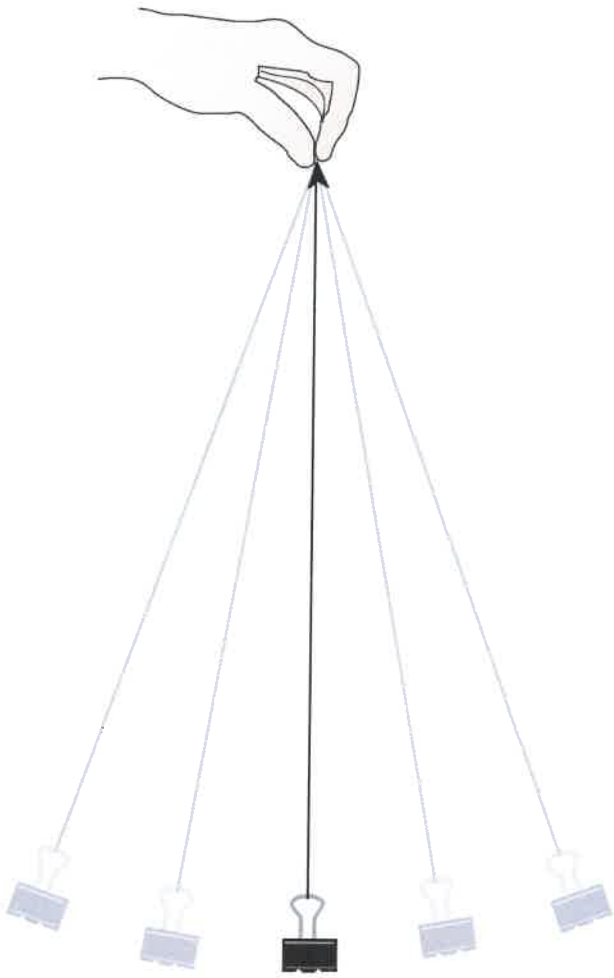
More than any other powered aircraft, a powered parachute has great static stability, primarily due to the displacement between the upward force of lift from the parachute and the downward force of gravity on the airframe. This displacement of forces is known as pendulum stability.

To grasp the pendulum effect, imagine attaching a small weight (such as a pencil or paper clip) to a string. Notice how the weight naturally wants to hang directly beneath where you hold it. If you move the weight to the side while holding the string still, the weight swings and stabilizes directly under your hand. This phenomenon, where gravity pulls down on the weight to stabilize it beneath its hanging point, illustrates pendulum stability.

In flight, pendulum stability manifests as an automatic correction of the flight attitude after disturbances caused by pilot inputs or wind. For instance, when a wind gusts from the side, the lighter, higher surface area wing is affected first and moves to the side. Then the heavier airframe swings back under the wing. Although there might be a slight rocking motion initially, the pendulum effect dampens out, and the powered parachute returns to straight-and-level flight.

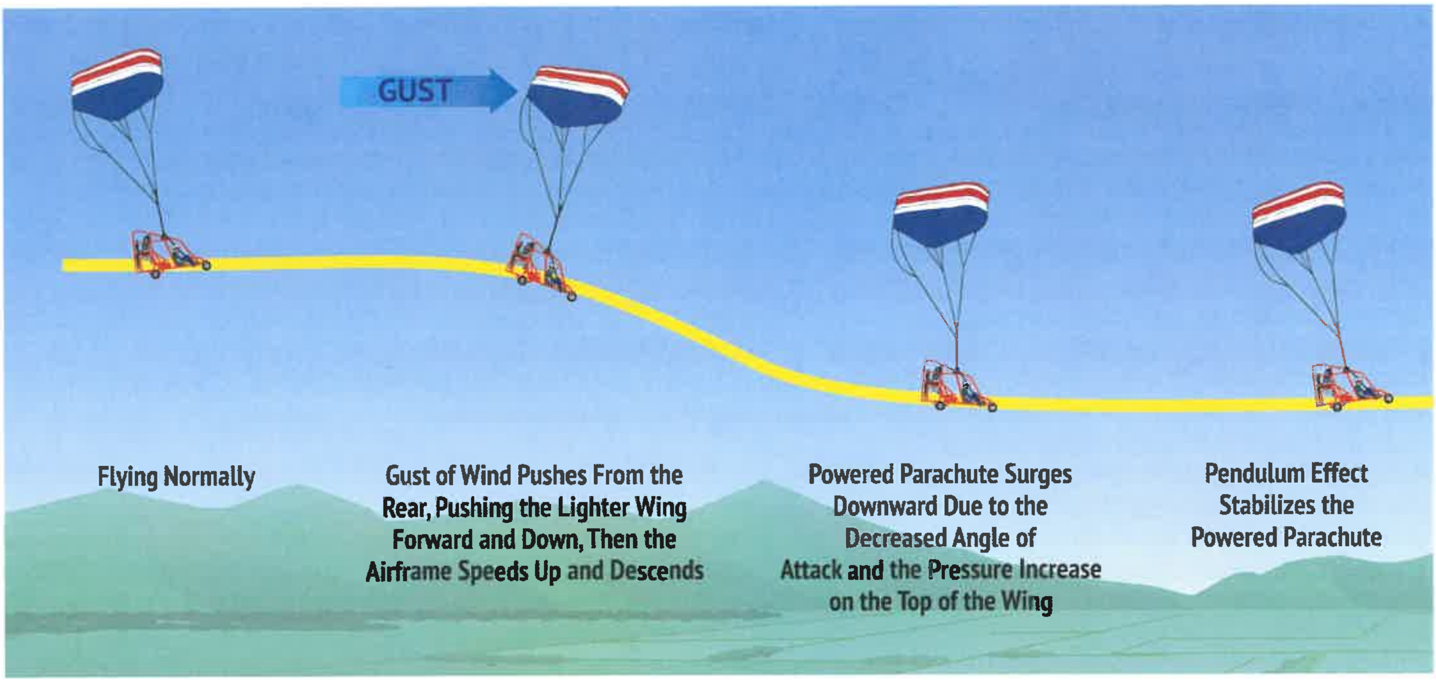
When there's a gust of wind from behind, the top of the wing is the largest area exposed to the wind. The wind pushes the wing forward and downward, reducing the angle of attack and causing the aircraft to descend. Pendulum stability eventually settles the aircraft into straight flight at its new, lower altitude.

Conversely, if a gust of wind comes from the front, the bottom of the wing is the most exposed area. This leads to increased pressure on the bottom of the wing and a rearward forcing of the wing, increasing its angle of attack. These factors result in a temporary increase in the rate of climb. Once again, pendulum stability brings the machine back into straight flight, but this time at a slightly higher altitude.

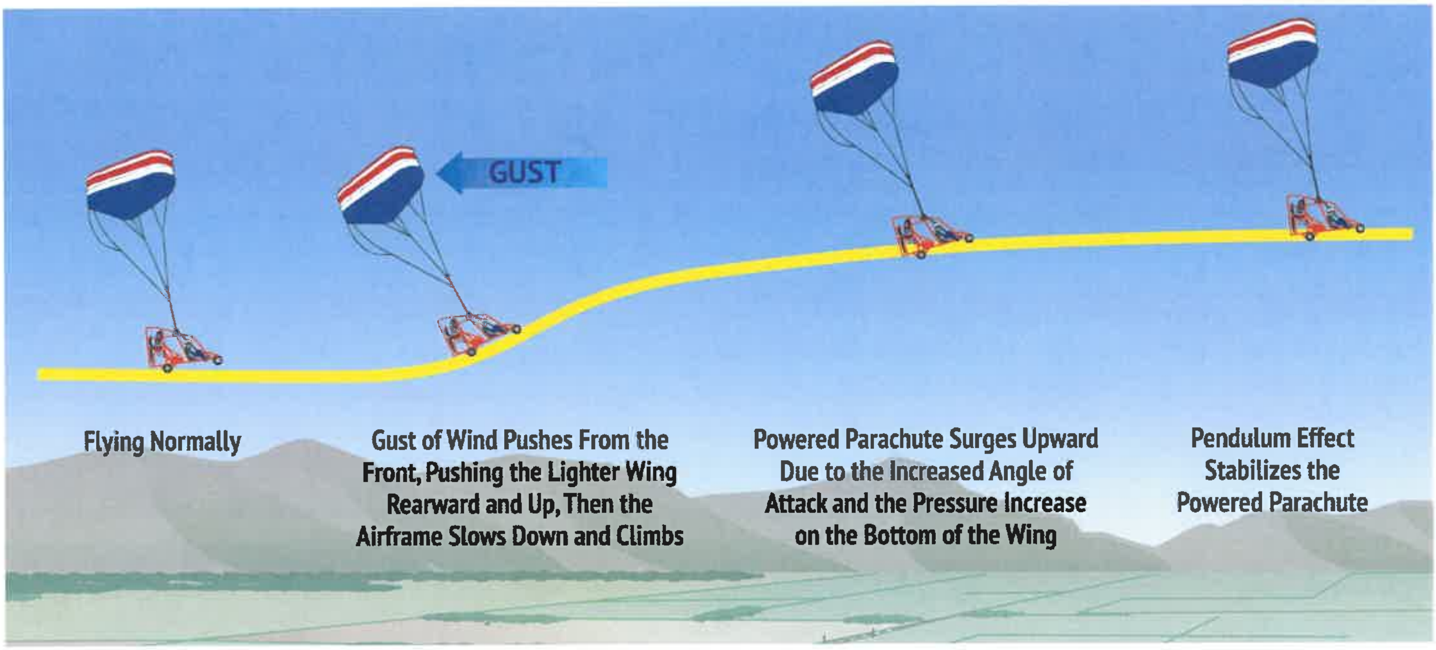


A pendulum swings but dampens and stabilizes over time. How fast it swings depends on how heavy the weight is and the length of the string. Heavier weights and longer strings slow the rate of oscillation.

Pendulum effect after a gust of wind from the side.



Pendulum effect after a gust of wind from the rear.



Pendulum effect after a gust of wind from the front.

Dynamic Stability

Static stability is the initial tendency of an aircraft to return to its equilibrium state after being disturbed from its trimmed condition. It isn't connected to time, it just indicates a trend towards positive, neutral, or negative equilibrium.

When we talked about pendulum stability, we talked about how a powered parachute would return to equilibrium. Part of that process was an oscillation (or pendulum swinging) that eventually would dampen out. The oscillation is over time. That's where dynamic stability comes in.

Dynamic stability refers to how an aircraft responds over time when disturbed from a given pitch, yaw, or bank. There are three subtypes of dynamic stability:

Positive Dynamic Stability: Over time, the motion of the displaced object decreases in amplitude, and because it's positive, the object returns toward the equilibrium state. That describes pendulum stability in a powered parachute.

Neutral Dynamic Stability: Once displaced, the object neither decreases nor increases in amplitude. A worn automobile shock absorber exhibits this tendency because the suspension is just riding on the springs.

Negative Dynamic Stability: Over time, the motion of the displaced object increases and becomes more divergent. This is a dangerous state.

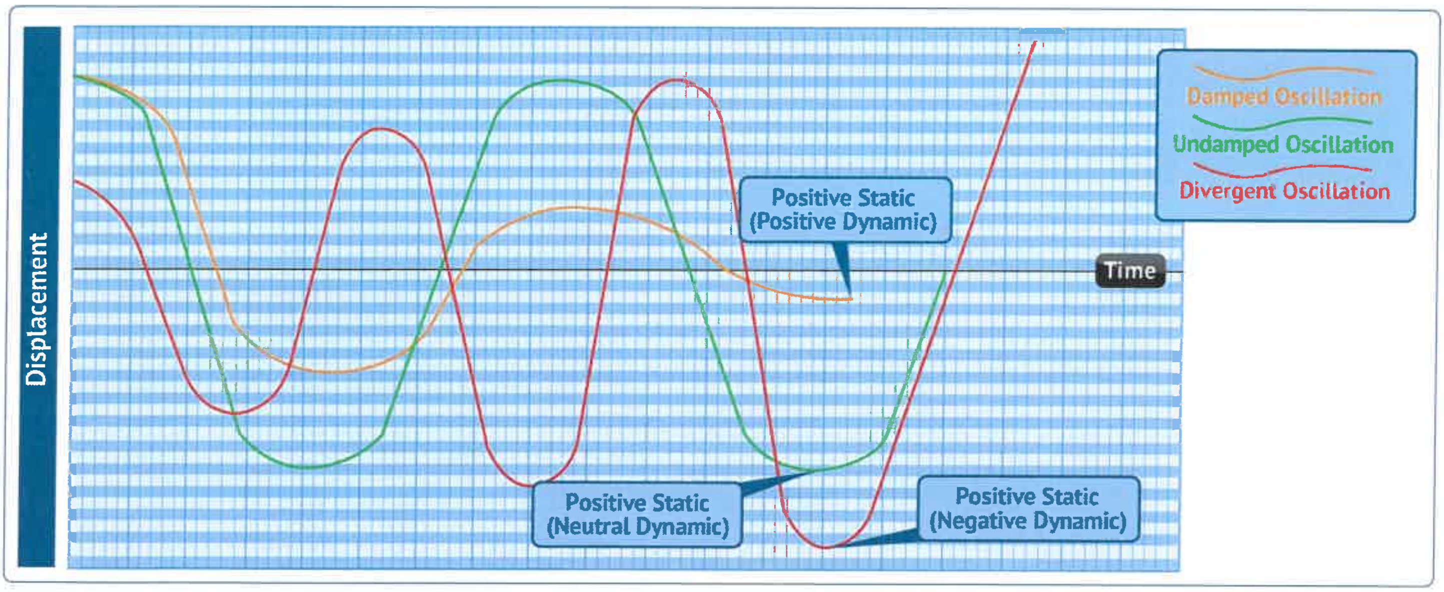
The curves in the figure below illustrate the variation of controlled functions over time. The unit of time proves to be crucial, distinguishing between oscillations of different durations. When the time unit for one cycle or oscillation exceeds 10 seconds, it's termed a *long-period oscillation* (phugoid), which is generally easily controlled. In a longitudinal phugoid oscillation, the angle of attack remains constant as airspeed fluctuates. While a convergent phugoid is somewhat desirable, it's not mandatory.

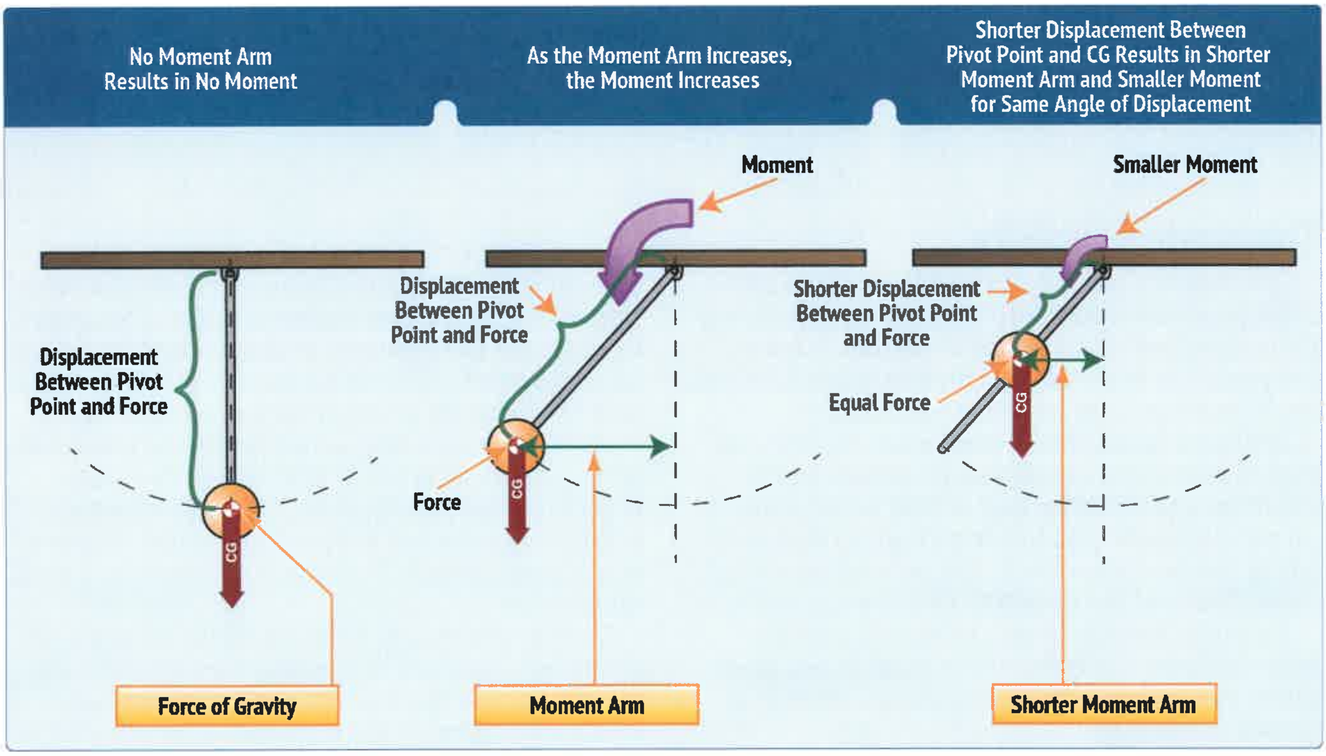
On the other hand, if the time unit for one cycle or oscillation is less than one or two seconds, it's referred to as a *short-period oscillation*, typically very challenging, if not impossible, for the pilot to control. Instead, pilots can easily synchronize with and reinforce this type of oscillation. That makes things even worse.

A neutral or divergent short-period oscillation is perilous, as it often leads to structural failure if not promptly damped. Fortunately, such occurrences are extremely rare in professionally designed and produced powered parachute airframes and wings.

Oscillations manifest as *porpoising* or side-to-side *swinging* in a powered parachute and can be initiated by either the pilot or wind conditions.

Damped versus undamped stability.





Relationship between moment arms and moments.

Moment and Moment Arm

A freely rotating body will consistently turn around its center of gravity (CG). In aerodynamics, the measure of an aircraft's inclination to rotate around its CG is termed a *moment*. This moment is essentially the product of the applied force and the distance at which the force is applied. The distance from the center of gravity to the applied force is known as the *moment arm*.

While flying, you don't have direct control over the position of forces acting on the powered parachute except for influencing the center of lift by adjusting the angle of attack (AOA) of the wing through flare. You can adjust force magnitudes like increasing throttle but doing that immediately triggers changes in other forces. When external forces like turbulence or gusts act upon the aircraft, you can respond by applying counteractive control forces to counteract the displacement.

For powered parachutes, forces are applied at four places and two of them are adjustable by the pilot. Thrust is applied by the engine at a fixed location. Lift and most of drag are applied to the two adjustable points on the airframe where the wing's risers are attached. The center of gravity doesn't change for a particular pilot and additional loading (like passengers and fuel) are collocated with the CG.

The mathematical value of a moment is the product of the force times the moment arm. The moment arm is the perpendicular distance between the point where the force is applied and the pivot point. The mathematical formula for that is:

Moment = Force x Moment Arm

Moments are measured in ft-lbs, inch-lbs, or Newton-meters.

With a pure pendulum, the force of gravity remains constant, and the moment arm changes as the pendulum moves. When the weight of a pendulum is hanging directly below its suspension point, there is no moment arm. (See the figure above.) As the pendulum is moved further away from directly below the suspension point, the moment arm increases as does the moment's attempt to bring the pendulum back to the position directly below the suspension point. With a powered parachute, the pivot point is the place where the airframe attaches to the risers or parachute lines. The wing is allowed to float above the pivot point just as the airframe is allowed to swing below that same pivot point. That means that there are moments affecting the wing which are similar to those affecting the airframe. The moments affecting the wing result from lift rather than gravity.

Wing Moments

Wings typically try to pitch nose down or roll forward, following the curvature of the airfoil. Unlike airplanes that rely on tails to counteract these tendencies, a powered parachute operates without a tail. This is possible because the airfoil is kept in a specific position relative to the airframe through a combination of the lift force pulling the wing upward, the force of gravity pulling the airframe downward, and the moment arm created by the suspension lines. These elements work together to consistently push the airfoil into its correct position, even if it's displaced by wind or pilot inputs.

Any pitching moment encountered by the wing is countered by the pendulum effect, primarily attributed to the weight of the airframe hanging beneath the center of lift. The swinging motion of the weight generates stabilizing moments, and the wing itself aids in damping the swinging. This pendulum effect is unique to powered parachutes because the airframe can rotate around the powered parachute's pendulum axis of rotation, in addition to its rotation about the CG.

The moment arm between the weight of the airframe and the lift of the airfoil forms the fundamental basis of pendulum stability in a powered parachute.

Wing Attachment to Airframe

The wing should be attached to a point on the airframe over the center of gravity of the airframe when the pilot is on board. This has more of an effect on the orientation of the airframe than it does on the wing. That's because the airframe acts as a pendulum below the attachment point mating the risers to the airframe. The pitching stability of the airframe increases with the length of the moment arm between the attachment point of the airframe to the risers and the center of gravity of the airframe.

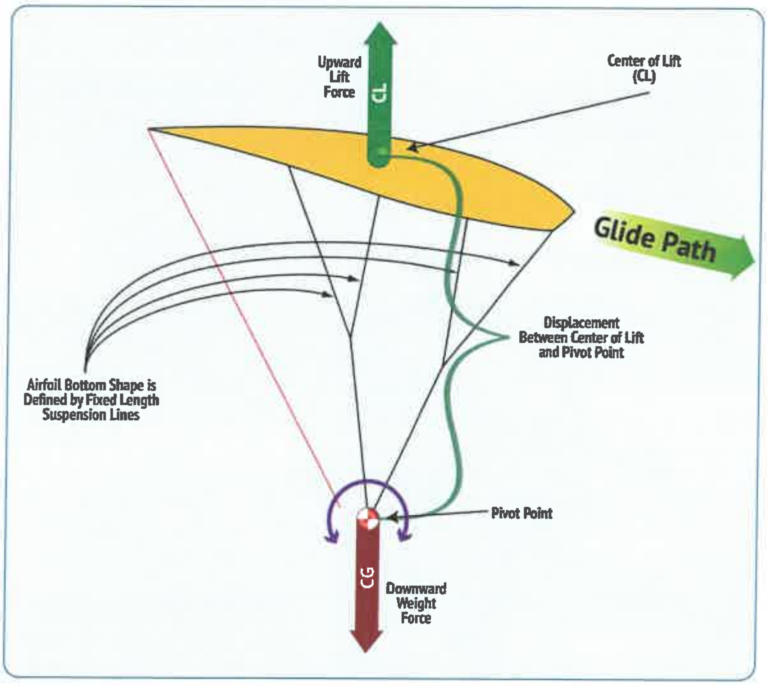
If flying straight-and-level over a perfectly flat landing strip with the rear wheels one inch above the runway, the nosewheel should be 6-12" above the surface. The Pilots Operating Handbook (POH) normally specifies the parachute riser fore and aft attachment points to the airframe based on pilot weight. Incorrectly attaching the wing to the airframe on a position too far forward would cause the nosewheel to be higher than it should. Attaching the wing too far back would place the nosewheel too low, where it would touch down before the main landing gear.

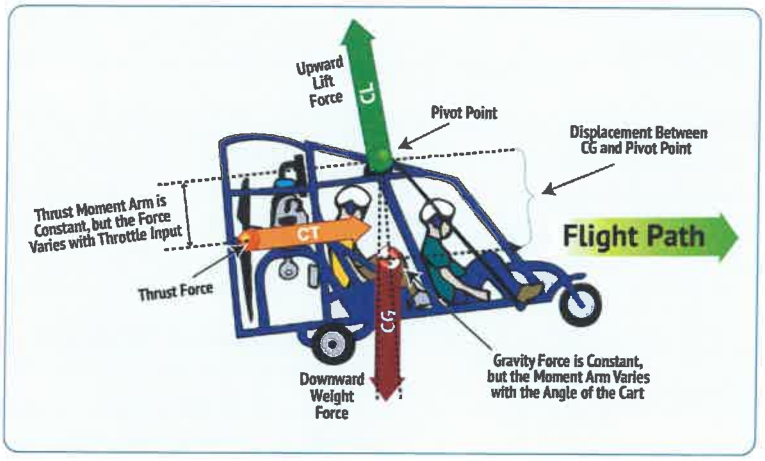
Properly balancing the airframe according to the POH is essential to ensure that the airframe hangs correctly under the wing and that thrust aligns as intended by the manufacturer. If the nosewheel is too low, it results in increased wing loads and airspeed, as thrust is pushing the airframe both downward and forward. Conversely, if the nosewheel is too high, there's a risk of reduced rearward thrust, unwanted P-factor, and an unloading of the wing.

Airframe Moments

Similar to how the parachute pivots above the riser attachment points, the airframe has the freedom to pivot below these same attachment points. However, the airframe experiences three conflicting forces.

The first force originates from the lifting action of the wing. Despite the airframe's ability to pivot below the riser attachment points, remember that the parachute is also free to pivot above those same points. Consequently, the lift and drag forces generated by the airfoil, while generally directed upwards, exhibit some rearward components when the powered parachute is under power.





Top: Powered parachute airfoil is kept in position by its lift, which centers the airfoil above the pivot point where the lines are attached.

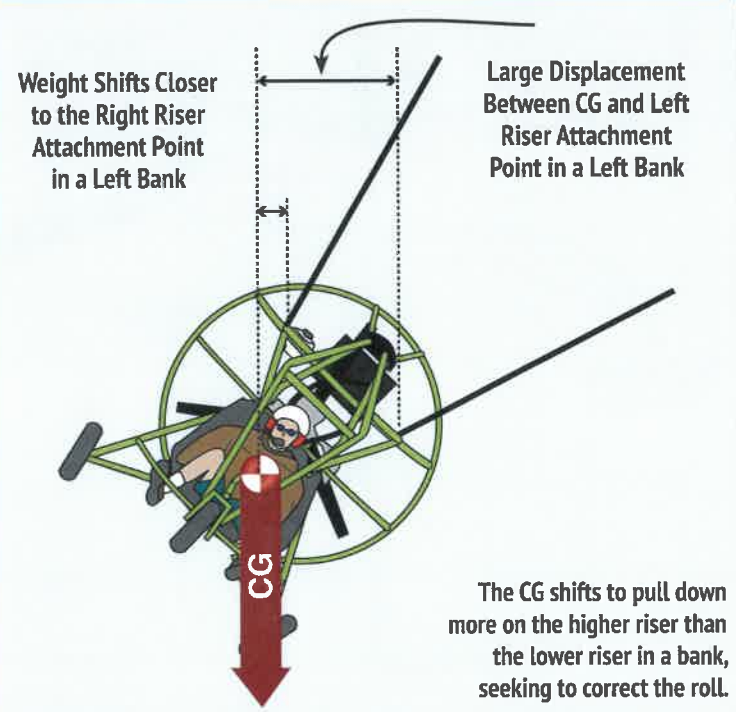
Bottom: Forces and moments acting on a powered parachute airframe.

These forces tend to be more vertically oriented when the aircraft is gliding, although gusts of wind can cause the wing's position to fluctuate.

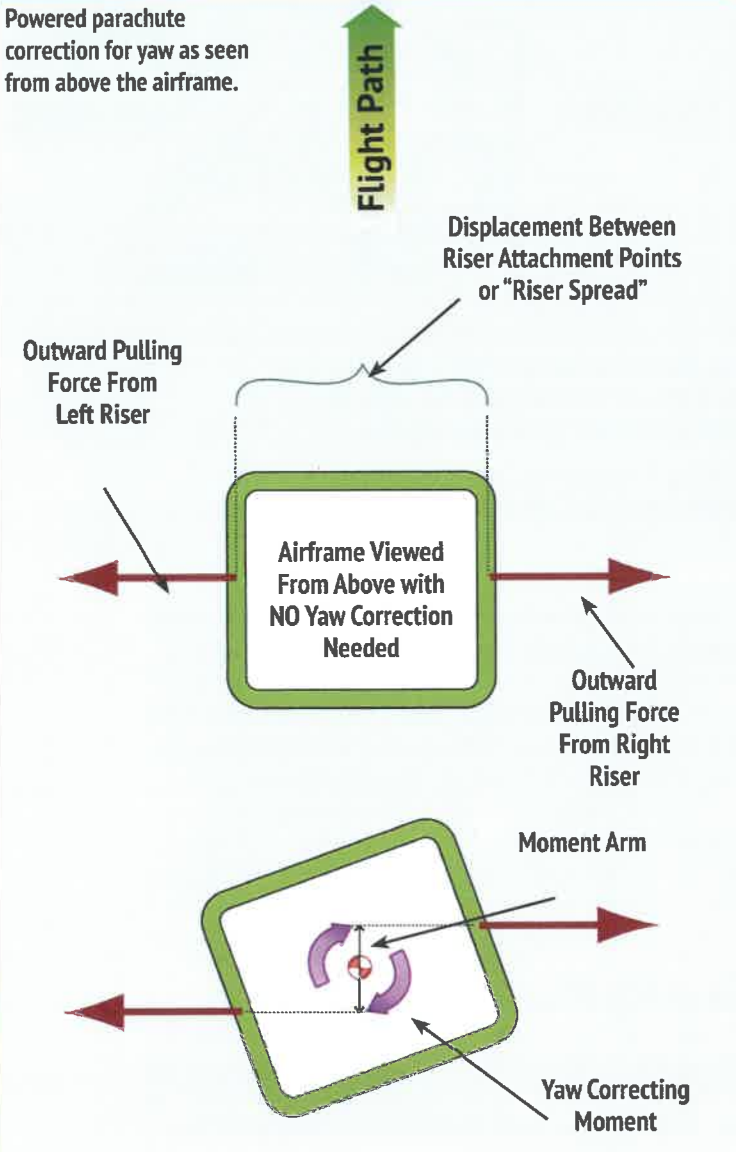
The forces exerted by the wing travel directly through the risers, influencing the airframe in the direction dictated by the movement of the wing and risers. This creates moments around the center of gravity of the airframe, and these moments are counteracted by gravity moments. Thrust moments can increase pitching instability, although effective design can mitigate this effect.

Gravity Moment

A moment arm stretches from the CG of the airframe to the attachment point of the wing to the airframe. The airframe's pitch stability improves as the distance from the CG to the wing attachment point increases.



Roll Stability



Powered parachute correction for yaw as seen from above the airframe.

The other two forces acting on the airframe—the combined force of lift and drag at the parachute attachment point and the thrust—contribute to instability during turbulent conditions. Turbulence affects the wing the most, and its pull on the airframe heightens instability. This, in turn, induces a rocking motion in the airframe, altering the direction of thrust and potentially amplifying the instability.

During flight, a high attachment point provides the advantage of minimizing the swinging motion of the airframe under the wing and reducing airframe pitch-up when throttle is applied for climbing.

Thrust Line Moment

Increased power or thrust can lead to a destabilizing effect, causing the nose to rise. To counteract this, the aircraft designer can establish a thrust line that passes at or above the CG. With this configuration, as power or thrust is increased, there won't be a tendency for the airframe to rotate around the center of gravity and cause the nose to pitch up. It also helps in turbulent conditions.

Longitudinal Stability (Pitching)

When designing powered parachutes and their wings, considerable effort is dedicated to achieving the desired level of stability across all three axes. However, longitudinal stability about the lateral axis is particularly impacted by variables in different flight conditions.

Longitudinal stability, which concerns the pitching motion of the aircraft's nose in flight, is crucial for a stable flight. An aircraft lacking longitudinal stability tends to progressively dive or climb into a steep and sometimes dangerous trajectory. When a powered parachute airframe goes to an extreme nose-up attitude, it's essentially *flying into the wing* and unloading it. That makes it possible to bring the wing closer to a stall. Thus, a powered parachute with longitudinal instability becomes difficult and sometimes dangerous to fly.

Static longitudinal stability or instability in a powered parachute is dependent upon three factors:

1. Location of the wing attach points with respect to the CG.
2. Location of the thrust line with respect to the CG.
3. Location of the thrust line with respect to the attach points of the wing or risers.

Power or thrust, if increased, may destabilize a powered parachute by making the nose rise. Designers can counteract this by establishing a *high thrust line*, ensuring the line of thrust passes above the CG.

When examining stability, it's essential to remember that a powered parachute usually possesses a pivot point where the parachute risers connect to the rest of the airframe. This pivot point contributes to one of the three moments critical in determining the stability of a powered parachute. As the attachment points for the wing are lowered, stability decreases. However, if these attachment points are positioned too high, it can lead to a reduction in maneuverability and controllability.

Lateral Stability (Rolling)

Stability about the aircraft's longitudinal axis, which extends from the nose of the aircraft to its tail, is called lateral stability. This helps to stabilize the lateral or 'rolling effect' when the wing is pushed by a gust of wind to one side of the airframe or another. One of the features of the pendulum effect is to create lateral stability in a powered parachute. In the case of a roll, the weight shifts to exert more force on the riser on the high side of the bank. That increased force on the high riser, combined with a corresponding lesser force on the lower riser, seeks to return the powered parachute to straight-and-level flight after a wind gust or after a turn has been completed.

Lateral stability can be enhanced by wing and airframe design. Wings with a less pronounced arch to them generally seem to have less roll. However, the less the arch to the wing, the less maneuverable the wing may also be. Airframe designs with wider attach points (as measured from left to right on the airframe) also have more lateral stability since they accentuate the correcting weight-shift differences to the risers.

Vertical Stability (Yawing)

Stability about an aircraft's vertical axis (the sideways moment) is called yawing or directional stability. Yawing or directional stability is accomplished the same way lateral stability is achieved in a powered parachute. By separating the left and right attachment points for the wing, there is a greater tendency for the powered parachute to correct for twisting in flight.

This again has to do with moment arms, but this time one has to look straight down on the powered parachute airframe from above. As one can see from how the parachute risers appear in flight, those risers do not just pull upwards towards the parachute, they also pull outwards respectively from the left and right side of the airframe. That outward force is what corrects for yaw in a powered parachute. The greater the lateral distance between the attaching points of the risers, the larger the moment arm that appears when a twist occurs between the airframe and the parachute and therefore the greater the correcting torque. The displacement between the riser attachment points is commonly known as *"riser spread."*

Aerodynamic Forces in Flight Maneuvers

Understanding the forces at play during flight maneuvers is important for safe and effective piloting. Turning, climbing, and descending all introduce specific aerodynamic forces that affect the aircraft's performance and stability. In this section, we'll explore the forces involved in turns, the impact of load factors, and the dynamics of climbing and descending.

Forces In Turns

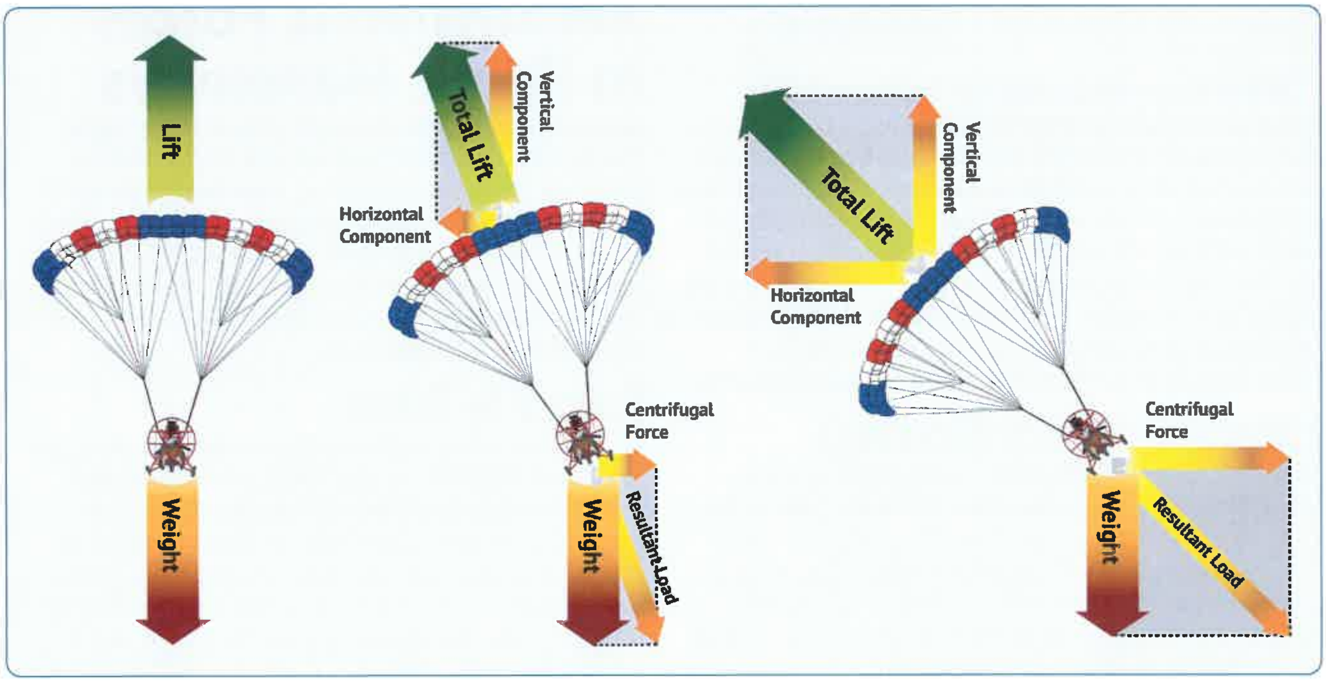
When observing a powered parachute in straight-and-level flight from the front, two prominent forces become apparent: lift and weight. In a banked position, it becomes evident that lift no longer acts directly opposite to weight; instead, it operates in the direction of the bank. A fundamental principle regarding turns is that, during a bank, lift acts inward toward the center of the turn, perpendicular to the lateral axis and upward.

Newton's First Law of Motion, the Law of Inertia, states that *"Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it."* For a powered parachute to turn, a sideward force is necessary, supplied by banking the wing so that lift is exerted inward and upward during a normal turn. This lift force during a turn is divided into two components: the *vertical component of lift*, acting vertically and opposing gravity, and the *horizontal component of lift* or centripetal force, acting horizontally toward the center of the turn. The horizontal component of lift is responsible for pulling the aircraft from a straight flight path to initiate the turn. Centrifugal force is the powered parachute's equal and opposite reaction to the change in direction, countering the horizontal component of lift.

Unlike steering a boat or an automobile, a powered parachute turns by being banked. Without banking, there's no force to cause the aircraft to deviate from a straight flight path.

Simply banking the powered parachute into a turn doesn't change the total lift developed. Since lift during a bank is divided into vertical and horizontal components, the lift opposing gravity and supporting the powered parachute's weight is reduced. Consequently, the aircraft loses altitude unless additional lift is created. This is done by increasing the power, which in this case increases the airspeed, until the vertical component of lift is again equal to the weight.

Since the vertical component of lift decreases as the bank angle increases, the power must be progressively increased to produce sufficient vertical lift to support the powered parachute's weight. The fact that the vertical component of lift must be equal to the weight to maintain altitude is an important fact to remember when making constant altitude turns.



Forces during turns.

The rate at which a powered parachute turns depends on the magnitude of the horizontal component of lift. This horizontal component is proportional to the angle of bank, increasing or decreasing as the angle of bank changes. As the angle of bank increases, the horizontal component of lift increases, subsequently elevating the rate of turn.

For a level turn to maintain altitude, an increase in power is necessary to provide a sufficient vertical component of lift. The additional thrust results in greater airspeed, which is needed to develop the necessary additional lift. Remember, airfoils develop lift by deflecting air molecules. An increase in speed increases the airflow over the wing and generates that additional lift.

Powered parachutes naturally execute coordinated turns. That is, turns without either slipping or skidding, which is something airplane pilots need to be concerned about. The pendulum effect results in having the horizontal component of lift being exactly equal and opposite to the centrifugal force.

Load Factors

While talking about forces in turns, we should talk about a related concept, load factors. Any force applied to a powered parachute to deflect its flight from a straight line produces a stress on the structure of both the airframe and the wing; the amount of this force is termed *load factor*. A load factor is the ratio of the total air load acting on the powered parachute to the gross weight of the powered parachute. For example, a load factor of 3 means that the total load on a powered parachute's structure is three times its gross weight. Load factors are usually expressed in terms of G—that is, a load factor of 3 is referred to as 3 G's, or a load factor of 4 as 4 G's.

If you enter a 2 G turn in a powered parachute you will be pressed down into the seat with a force equal to two times your weight. Thus, an idea of the magnitude of the load factor obtained in any maneuver can be determined by considering the degree to which you are pressed down into the seat. The structures of powered parachutes, and particularly powered parachute wings, are designed to withstand only a certain amount of overload.

Load Factors in Powered Parachute Design

Determining the optimal strength for a powered parachute hinges largely on features you want built into the wing, itself. Parachutes have fabric placards sewn onto them that announce the maximum load for that wing. Those placards often reflect the tested strength, but sometimes also include judgments about how much weight the wings could slowly descend with if the engine failed.

Wings are required to do a lot of things and those things need to be put into balance. For example, more parachute lines and larger wings make for stronger parachutes because stresses are spread out over more components and wing area. However, larger wings are often more expensive to build, more difficult to launch, and fly slower. Early powered parachute wings had about twice the number of suspension lines as modern parachutes and the cost and drag that came with those lines was considered unnecessary.

The issue of load factors in powered parachute design boils down to identifying the highest load factors anticipated during normal operation in various scenarios. These are termed *limit load factors*. For safety reasons, it's imperative that the powered parachute is engineered to withstand these load factors without sustaining structural damage. Most powered parachutes are designed to be at least half again as strong as needed and placarded. This 1.5 value is referred to as the *factor of safety*, serving as a reserve for strength against loads higher than those expected in routine operation. You shouldn't abuse this strength reserve, as it's designed for your protection during unexpected conditions.

These considerations are applicable to all loading conditions, whether they arise from gusts, maneuvers, or landings.

Load Factors in Steep Turns

In any powered parachute executing a constant altitude turn, the load factor is determined by two forces: centrifugal force and gravity.

The chart on the following page highlight a crucial aspect of turns—the load factor experiences a rapid increase once the bank exceeds 45°. In a 60° bank, the load factor for a powered parachute is 2 G's, escalating to 5.76 G's in an 80° bank. The wing must generate lift equivalent to these load factors to maintain altitude.

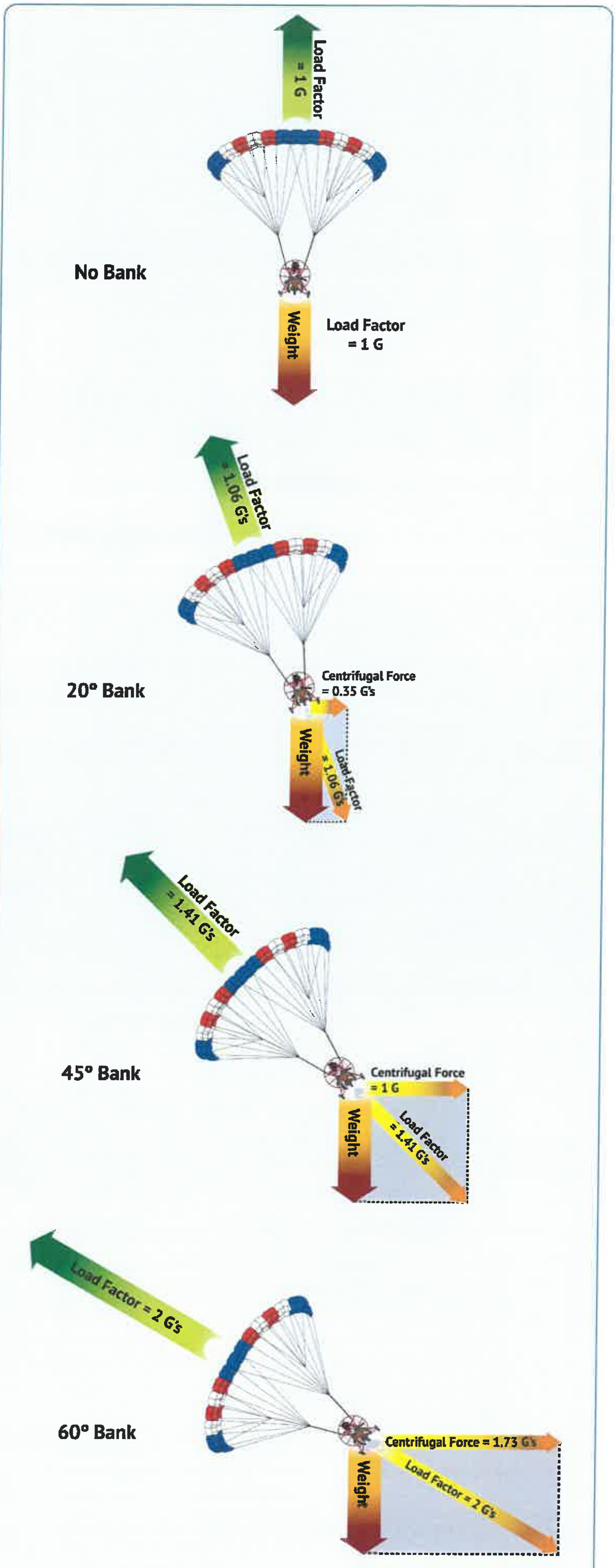
It's noteworthy how swiftly the load factor curve increases as it approaches the 90° bank line. Achieving a 90° banked, constant altitude turn is mathematically implausible. While a powered parachute may momentarily be banked to 90°, it cannot sustain that angle without going into a spiraling dive.

For a constant altitude turn, the typical maximum bank for a powered parachute is around 60°. This bank, along with its associated required power setting, approaches the limit for this type of powered parachute. Adding an extra 10° bank increases the load factor by approximately 1 G, bringing it close to the yield point set for these powered parachutes. More importantly, the powered parachute will probably break into a dive past a 60° bank.

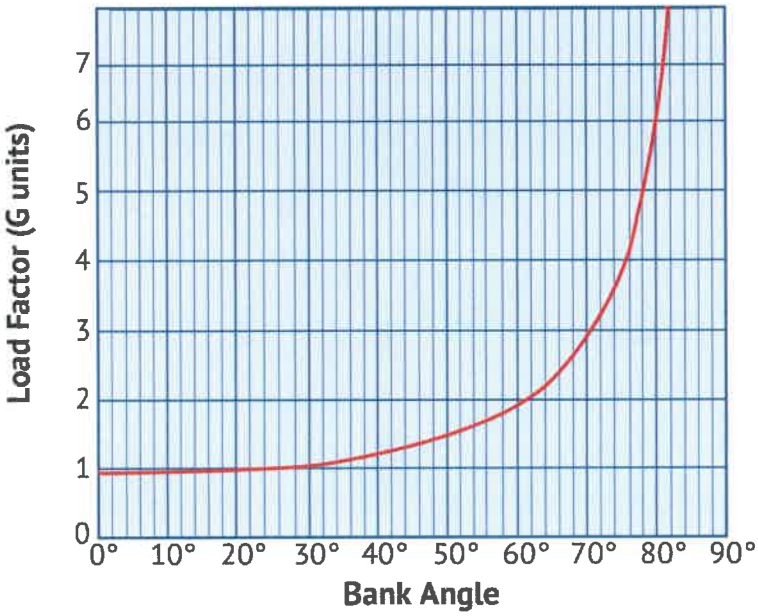
Forces in Climbs

For all practical purposes, the wing's lift in a steady state normal climb is the same as it is in a steady level flight. However, the airspeed of the powered parachute is about 10% less (a barely measurable 3-5 mph less) and the lift is maintained through a slight increase in the angle of attack. This follows from Newton's Third Law of Motion, the Law of Reciprocal Actions. When thrust is initially increased to begin a climb, the parachute increases its drag as an equal and opposite reaction. As the airframe pushes forward with thrust, the parachute pivots slightly backwards to increase drag. That slight pivot rearwards is a change in angle of attack of the airfoil.

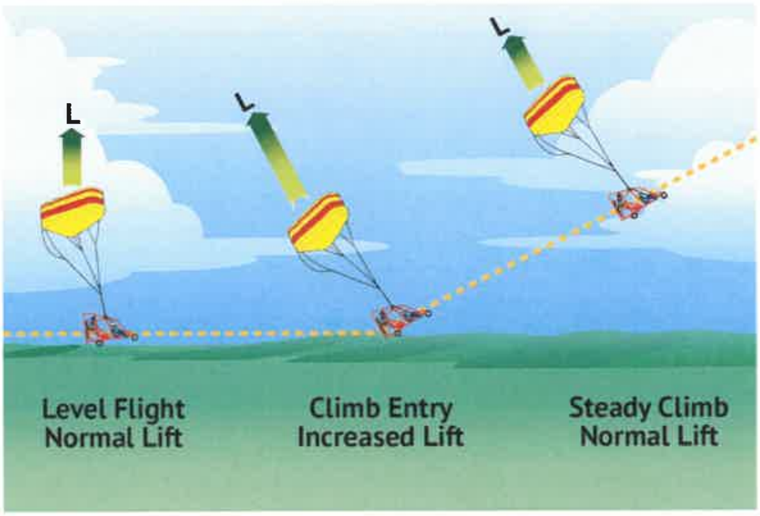
At the beginning of the climb, when both thrust and drag are increased initially, the powered parachute is traveling at its straight-and-level flight airspeed. When power is added, there's a momentary increase in lift resulting from the higher cruising airspeed and the higher angle of attack



Angle of Bank vs. Load Factor



Forces Causing G-load Factors In Turns.



Changes in Lift During Lift Entry.

as shown on the graphic above. That transitional increase is only momentary, however. Afterwards, the parachute settles into its new flight path with a slightly slower airspeed and slightly higher angle of attack.

As the flight path inclines, a component of the powered parachute's weight adds to the total drag, increasing total effective drag. In a climb, the powered parachute's weight, acting downward and rearward with drag, necessitates additional power to sustain the climb. The power required depends on the climb angle, and climb performance relies on the available reserve power. The climb angle is determined by the *excess thrust* to overcome a portion of the weight. While aircraft can climb with excess thrust, once depleted, they reach their *absolute ceiling*, unable to climb any further.

Thrust lines don't always line up with the flight path. Sometimes this is due to manufacturer design, sometimes it's the way that the owner has adjusted the center of gravity on the powered parachute, or of course a combination of the two.

For example, if a powered parachute is designed with a thrust line that pushes the airframe upwards, some of the thrust will be contributing to lift. This is often done in underpowered machines intentionally, or in other machines without understanding the ramifications. If engine thrust is pushing upwards, that means that it's taking some of the load off the parachute. That leads to slower speeds and less stable conditions.

On the other hand, if a powered parachute is designed with a very high attachment point for the airframe, it's possible that the airframe will tend to fly closer to level, whether or not it is climbing, flying at level flight, or descending. In that case, the thrust line is pointing below the flight path in a climb and contributing to a small downward force, acting as more weight on the powered parachute. This means that the rate of climb will be slower for the same amount of thrust than it could be with a higher *nose up* attitude.

Forces in Descents

In descents, powered parachute forces undergo changes from straight-and-level flight. In this scenario, the powered parachute descends at reduced power from level flight. Initiating the descent with reduced power decreases the AOA. The powered parachute, influenced by momentum, briefly follows the existing flight path. During this moment, reduced AOA leads to decreased lift, causing the powered parachute to descend as weight exceeds lift. The flight path shifts from level to a descent. The reduced AOA means that the powered parachute's airspeed will increase slightly.

Stalls

An aircraft stall occurs when lift rapidly decreases due to the separation of airflow from the wing's surface, triggered by exceeding the wing's critical angle of attack (AOA). A stall can happen at any pitch attitude or airspeed, though it's often misunderstood as a complete loss of lift. In reality, the wing still produces some lift, but not enough to sustain level flight.

This concept is illustrated by the graphic on the next page. The critical AOA, or $C_{L\text{-}MAX}$, marks the peak lift before a decline. Stalling doesn't halt lift completely and recovery involves reducing the AOA to restore adequate lift.

For a powered parachute, flight continues as long as the wing generates enough lift to counteract the load imposed on it. When lift drops significantly, the powered parachute stalls. It's important to remember that every stall results from an excessive angle of attack. While various flight conditions may increase the angle of attack, a stall only occurs when this angle becomes too high.

The stalling speed of a powered parachute is not a fixed value across all flight conditions. Instead, a wing always stalls at the same angle of attack, regardless of airspeed, weight, load factor, or density altitude. This critical angle of attack, where airflow separation from the upper wing surface causes the stall, typically ranges between 16° and 20°, depending on the wing's design.

Stall Considerations for Powered Parachutes

Powered parachutes were once believed to be *stall-proof*. It's now widely acknowledged that powered parachutes are, in fact, *stall-resistant*. Still, this term doesn't precisely capture the aerodynamic reality. As mentioned earlier, all airfoils stall for the same reason: exceeding the critical angle of attack. The distinctive feature of powered parachutes is that their pendulum stability makes it easier to stay below this critical angle of attack. Even if the wing stalls, a powered parachute typically corrects it automatically, often without the pilot being fully aware of the situation.

There are additional considerations for powered parachutes due to the flexible attachment of the parachute to the airframe. Aircraft designers and pilots must be aware of these unique characteristics of powered parachutes to develop safe aircraft and competent pilots.

Conventional Stalls

Student pilots typically don't undergo specific *stall recovery* training because a powered parachute normally manages this automatically. If an aircraft is configured with a large wing, a high-powered engine, or is lightly loaded, it may experience regular stalls during climbs at full power. While not a safety concern, you should be aware of this phenomenon, which occurs due to the pendulum stability inherent in powered parachutes.

Remember, the rate of climb is determined by excess thrust. In a high-power climb, as thrust increases, there needs to be a growing force countering that thrust once the aircraft achieves a steady-state climb. Much of this countering force is the weight of the airframe and passengers on board. But if the airframe's gross weight is low or the engine thrust is high, there may be excess thrust force that the weight of the airframe cannot balance. In such a scenario, the airframe tends to push further ahead of the wing, increasing its angle of attack and, consequently, its drag. If excessive thrust is applied, the wing may exceed the critical angle of attack, leading to a stall.

When a stall occurs in this situation, it corrects automatically. The wing stops lifting, and the airframe starts descending, correcting the angle of attack. The wing then resumes climbing. This process may repeat multiple times in a high-power climb, creating a *stair-stepping* appearance—climbing, leveling off, and climbing again. See the image on the next page.

Metastable Stalls

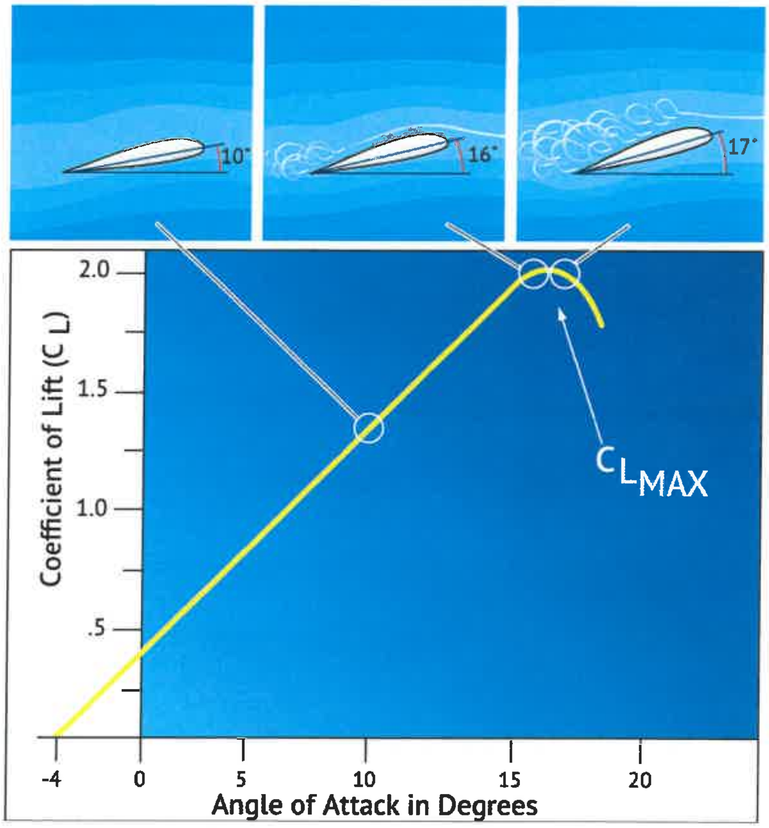
The combination of a pivoting attachment point and a substantial moment arm between the wing and the airframe introduces the possibility of a unique stall not found in other aircraft—known as the *metastable stall*.

A metastable stall occurs when the wing's angle of attack has far exceeded its critical angle of attack and the wing locks into position due to excess drag. All wings can stall and powered parachutes can recover from mild stalls without pilot input. That happens when the aircraft is properly designed, properly trimmed out and the pilot isn't performing extreme maneuvers.

However, during a metastable stall, the wing is forced well behind the top of the airframe, and the drag from the parachute prevents it from returning to its normal flight position. Increasing engine power is futile because the stalled wing matches any increase in engine thrust with increased drag, perpetuating the stall.

Metastable stalls can occur both during take off and in flight. During a takeoff roll while still on the ground, if the wing doesn't rotate promptly over the airframe, it might stall behind the airframe at an angle around 45 degrees. While the airframe can still roll forward, the wing won't generate enough lift for takeoff. This situation is generally not considered dangerous because the aircraft remains on the ground. Strategies for handling takeoff metastable stalls are discussed in *Chapter 20, "Departures and Climbs."*

In flight, a metastable stall poses a significant risk if not promptly recognized and addressed



Critical angle of attack and stall.

because the wing is no longer creating enough lift to stay flying. This leads to a dangerously rapid descent. (That's being gentle. It feels more like *"falling out of the sky"*) The stall occurs when the wing is pushed well behind the airframe and beyond the critical angle of attack. Increasing power doesn't help, thrust instead keeps the wing locked in the stall due to increased drag.

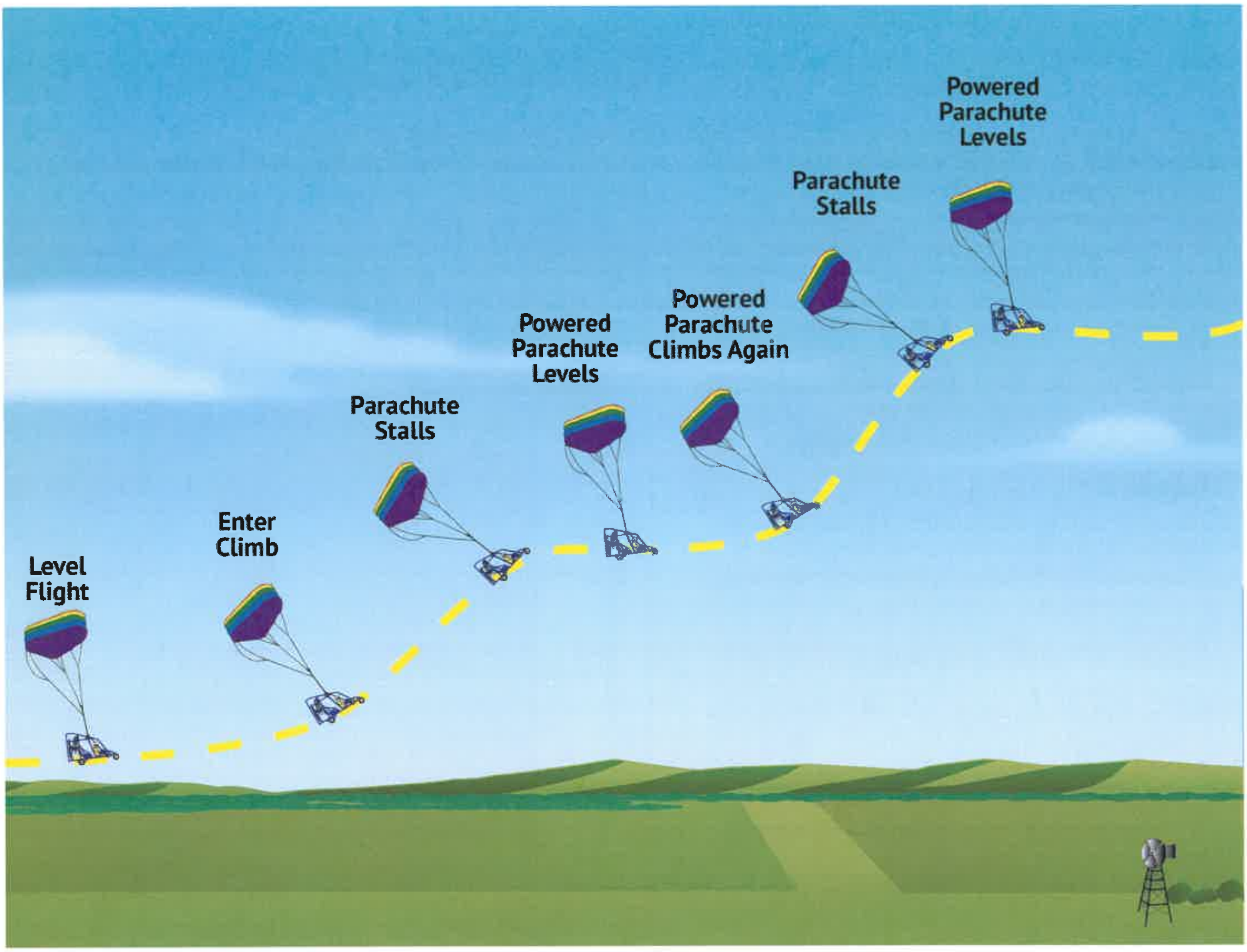
Metastable stalls are uncommon, and most pilots never encounter them. There needs to be a combination of two or more of the following conditions at work at the same time to create a metastable stall.

1. Parachute steering lines trimmed too tightly.
2. Excessive flare at altitude.
3. Excessive power or a very rapid increase in power.
4. A wind gust from the front of the powered parachute.

The four conditions above will either push the wing too far behind the airframe or the airframe too far in front of the wing. If more than one of the conditions are at work at the same time, a metastable stall can occur.

While in flight you will recognize a metastable stall when you stop feeling the wind in your face. Instead, the wind will begin blowing from below the airframe. That's because the powered parachute is falling. The parachute is still inflated, but is no longer acting as a flying wing. The parachute is now acting as a drag device, only serving to slow your descent somewhat. In that sense the wing has gone *parachutal*. However, unlike the big round parachutes the military uses to drop payloads, our wings are very small and don't develop enough drag to slow the descent enough to safely land.

To exit a metastable stall, reduce power to idle and eliminate all flare and turning inputs. That reduces the rearward drag on the parachute, allowing it to rotate back into position over the airframe. The parachute may briefly overfly the airframe, inducing a dive. It's then safe to modestly increase power and return to level flight.



Self-correcting stalls during high power and low weight climbs.

Chapter 18 Flight Controls and Trimming

Flight controls and powered parachute trimming are closely related subjects. Flight controls are the tools you use to make the powered parachute go where you want it to go during a normal flight. Trimming a powered parachute properly is important because when you let go of the controls in steady-state flight, you want it to fly straight and predictably. A lot of the concepts overlap, but there are distinctive differences. For example, you will use flight controls during every flight. On the other hand, you probably will only have to trim your powered parachute once or twice a year, and certainly never while in flight.

Flight Controls

Flight control systems are the tools available to you to control the forces of flight while you're flying, and therefore the powered parachute's direction and attitude. Flight control systems and characteristics can vary greatly from powered parachute to powered parachute. Since there's no real standard for flight or even ground handling controls, you need to pay special attention when transitioning from aircraft to aircraft. Especially important is the movement of the throttle, since even that can be reversed from airframe to airframe and can differ from what pilots may be used to in other categories of aircraft.

Aircraft flight control systems are classified as primary and secondary. The primary control systems consist of those that are required to safely control an aircraft during flight. These include the left and right steering bars and engine power. Secondary control systems improve the performance characteristics of the powered parachute or relieve you of excessive or persistent control forces. Examples of secondary control systems are weight shifting, trim tabs and even rudders.

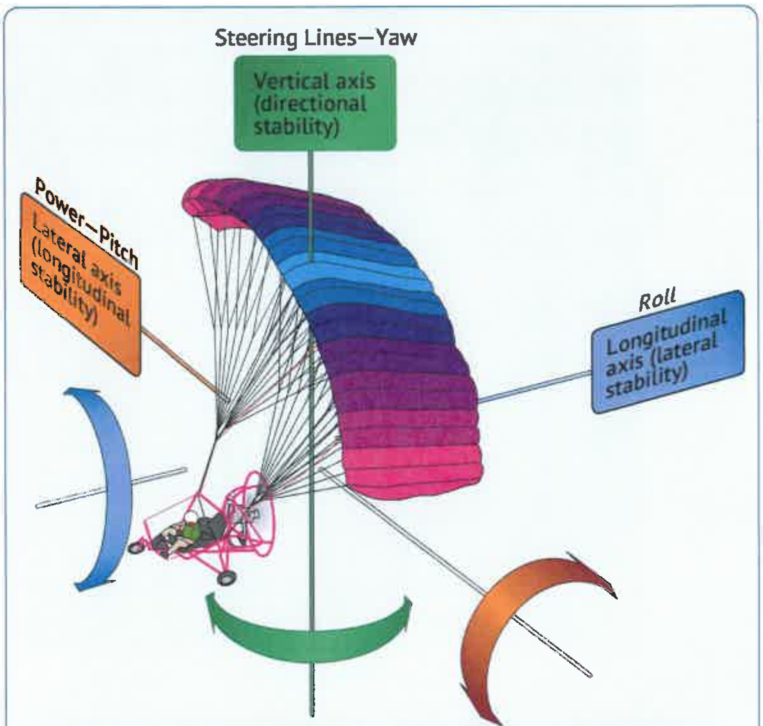
Primary Flight Controls

Powered parachute control systems are designed to provide a natural feel and to allow adequate responsiveness to control inputs. During takeoff, parachute steering bars usually feel soft and sluggish, and the powered parachute responds slowly to control applications. Once you get off the ground, the controls feel firm and the response is more rapid.

Movement of primary flight controls changes the airflow and pressure distribution over and around the airfoil. These changes affect the lift and drag produced by the airfoil and allow you to control the powered parachute about its three axes of rotation.

Design features limit the amount of deflection of flight control surfaces. For example, control-stop mechanisms are normally incorporated into the steering bars and the throttle. The purpose of these design limits is to prevent you from inadvertently overcontrolling your powered parachute during normal maneuvers or harming the mechanisms themselves.

A properly designed powered parachute should be stable and easily controlled during maneuvering. Control inputs cause movement about the three axes of rotation. These are the same three axes of rotation we use to describe stability.



Primary Control	Powered Parachute Movement	Axes of Rotation	Type of Stability
None*	Roll	Longitudinal	Lateral
Power	Pitch	Lateral	Longitudinal
Steering Lines	Yaw	Vertical	Directional

*Centrifugal Force Determines Roll in a Powered Parachute

Powered parachute controls, movement, axes of rotation, and type of stability.

Steering Lines

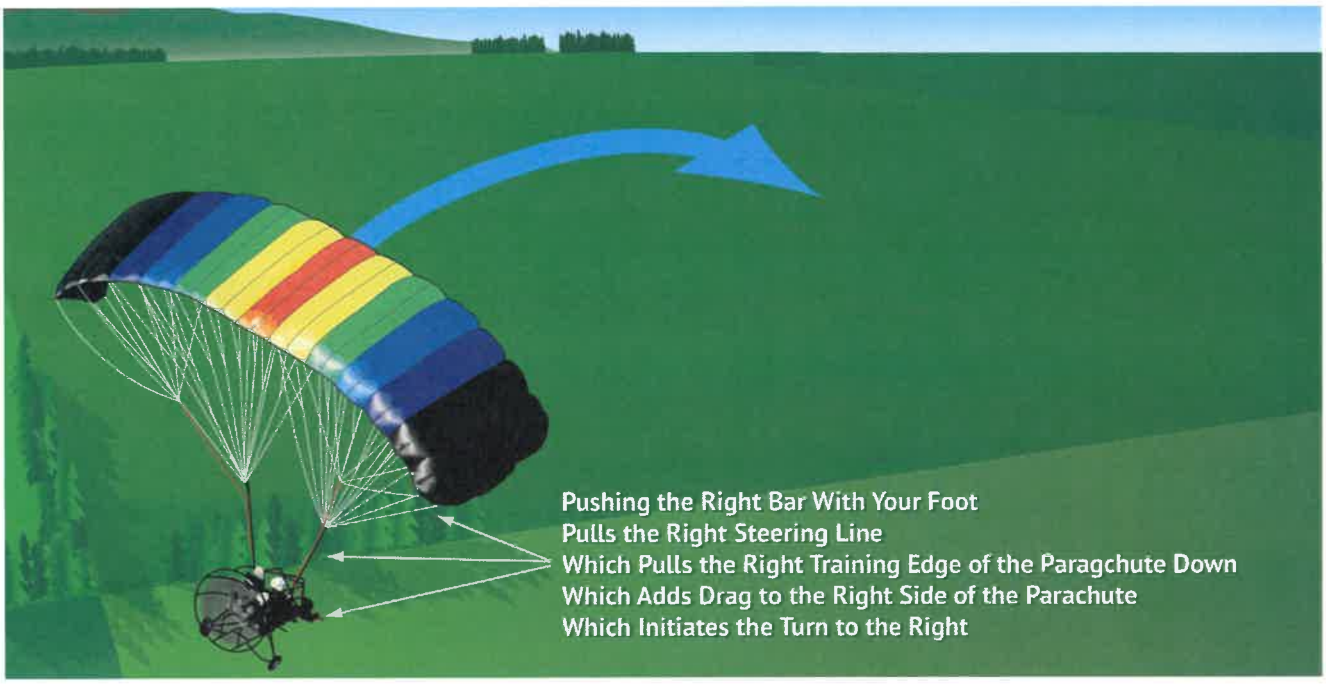
The steering lines control yaw about the vertical axis. The steering lines are attached to the outboard trailing edge on each side of the wing and deflect the trailing edge of the parachute downwards when pulled. Steering lines can be connected straight to toggles for a hand-steered powered parachute just like a skydiver or paraglider pilot. Steering lines can also be fed through a series of pulleys to steering bars, foot pedals, or hand toggles to allow for different styles of foot or hand steering.

Pushing the left steering bar or pulling on the left toggle causes the left side of the wing to deflect downward while not affecting the other side of the wing. The downward deflection of the left side of the wing increases the camber resulting in increased drag on the left wing. Thus, the increased drag on the left wing causes the powered parachute to yaw to the left.

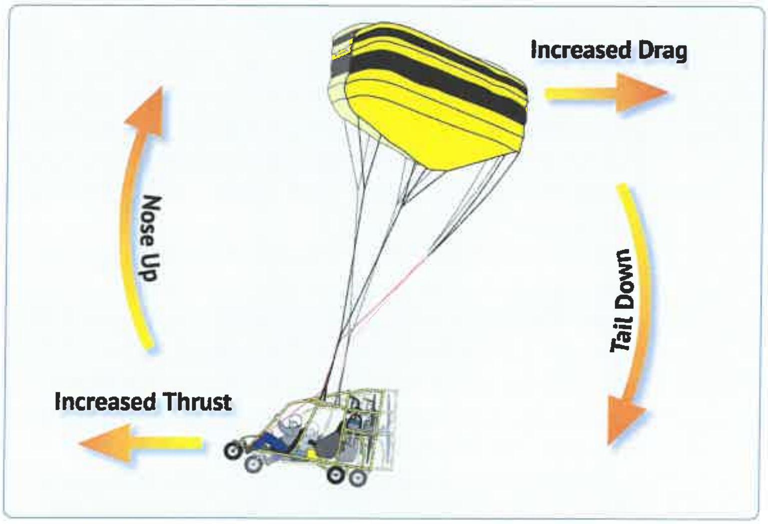
Adverse Roll

When the downward deflected trailing edge produces more drag, it also produces more lift. This added lift attempts to raise the left side of the wing and roll the powered parachute to the right. This is called adverse roll. Adverse roll is most noticeable when there is a gradual and light amount of steering applied to one side of a slower moving aircraft like a powered parachute. However, adverse roll is normally only a transient effect that is quickly countered by the drag and the centrifugal force of the airframe swinging out to the opposite side of the turn. As the airframe swings out, it induces a bank to the inboard side of the turn which continues the turn and makes it even more aggressive.

Apply steering input to one side of the trailing edge to turn.



Power is the primary control for changing the pitch attitude of a powered parachute.



Despite adverse roll and the ultimate banks achieved by a powered parachute in a turn, there's no need for you to do anything to *coordinate* a turn. A properly designed powered parachute will use the lift, drag, weight, and centrifugal forces to automatically create a coordinated turn. One of the benefits of pendulum stability is that if you deflect one side of the parachute in flight, then you will get a properly coordinated turn to that side.

Unlike other aircraft, once the desired rate of turn has been established, the turn must be held by continuing to deflect the trailing edge of the parachute wing. As soon as you relax the turn input, your powered parachute will seek to end the turn and fly straight once again. That makes turns in a powered parachute very intuitive for the beginning pilot.

Power

Engine thrust controls the pitch about the lateral axis. Since the risers or parachute lines are always attached on the airframe somewhere above the center of gravity of the airframe, there's always a force pulling upwards and somewhat rearward. As engine power is increased, the airframe is pushed forward and pivots the nose upwards. Along with the nose pivoting upwards, the entire powered parachute seeks to fly upward. When power is reduced, the powered parachute's pitch decreases. This is referred to as *power pitch* control.

Throttle controls vary quite a bit on powered parachutes. There are conventional throttle quadrants, reverse throttles (where pushing forward on the throttle reduces power), foot throttles, thumb throttles (like on an ATV), lever throttles (like those used with powered paragliders) and more. There was once even a mouth throttle that was used on a particular brand of powered paraglider. You bit down to increase power and concentrated hard to not get too excited.

You must become thoroughly familiar with the throttle control on the powered parachute you are preparing to fly. You need to do that before you ever start it up for the first time. Pilots have injured themselves while transitioning from conventional throttle set-ups (like those used in most aircraft) to reverse throttle set-ups during what should have been simple first-time taxis or takeoffs. Starting an unfamiliar aircraft at full throttle when you're expecting it to be at idle can be disastrous.

Secondary Flight Controls

Secondary flight control systems consist of wing flare and weight shifting but may also include trimming devices and rudders.

Flare

You flare a powered parachute by pulling both steering lines at the same time. However, it's far different from using the steering lines for steering. Flaring is used as a high-lift technique, normally during landings and sometimes during takeoff. It increases the airfoil camber, resulting in a significant increase in the coefficient of lift (C_L). At the same time, it greatly increases drag as well as the angle of attack (AOA) of the wing.

The increase in AOA is what can make flaring a high-risk maneuver if executed at the wrong altitude or at the wrong time. Powered parachute wings are typically trimmed at the factory with relatively high AOAs to allow powered parachutes to achieve reasonable climb rates under load even with low-power engines. Flaring increases the already high AOA of a wing and brings it closer to the its stalling AOA. This can be detrimental when combined with wind gusts, improperly rigged machines, and/or excessive power.

That said, flare is very useful during both the takeoff and landing phases of flying and should be mastered by the powered parachute pilot. For detailed guidance, refer to *Chapter 20, "Departures and Climbs,"* and *Chapter 21, "Approaches and Landings."*

Weight Shift

Many powered parachute pilots don't realize how useful weight shifting can be while flying. All aircraft have a weight shift component to them, which is what makes determining where the Center of Gravity is and adjusting properly for it so important.

Inherent turns in a powered parachute can be corrected for in several ways and those will be covered in later in the chapter. However, even a well-adjusted powered parachute for solo flight will be slightly out of adjustment as soon as a passenger is taken along for a flight. That's because the loading has changed, higher power is needed for straight-and-level flight, and torque has increased.

Those changes can be corrected for simply by moving your own weight in the seat to the left or right. If more correction is needed, the passenger should be asked to shift his/her weight also. This is by far the easiest, least expensive, and aerodynamically the best way to make small adjustments and trim for straight flight.

If you're carrying cargo on your powered parachute, it's good to balance the load forward and back as well as left and right. If you know that you have a left-turning tendency in flight, then load your heavier stuff on the right side of the airframe and the lighter stuff on the left side.

Trim Locks

Trim locks are devices used to hold a steering line in place to relieve a pilot of the constant stress of having to keep a foot bar depressed on a powered parachute. Trim locks are used to correct for a powered parachute's left or right turning tendency.

Trim locks are not the best solution for trimming for straight flight because while they do increase the drag on one side of the parachute, they are also increasing the lift on the same side. That means that the parachute wing is being somewhat cross-controlled with drag wanting to turn the parachute to the side being corrected to and lift wanting to roll the parachute into a bank going the other direction. For that reason, a lot of control input has to be used to remove a turning tendency of a powered parachute when using only the steering lines and trim locks. Drag will eventually win out, but it takes a lot of control input.

The amount of trim needed to correct for a turning tendency creates other problems. First, it puts one half of the parachute into a higher AOA and closer to its critical AOA. That makes the wing less stable in higher winds. Also, the higher AOA will increase power requirements and slow the powered parachute. The issue is even worse if the powered parachute isn't trimmed properly for straight flight in the first place and trim locks are used as the sole source of adjustment. Those adjustments are even coarser than those used to fine-tune turns when passengers are on board and can make all of the problems mentioned above worse.

Rudder

Some models of powered parachutes mount a rudder behind the propeller of the airframe. The rudder is then used to guide the thrust of the propeller in one direction or the other to give more steering authority in yaw.

Trimming

Trimming your powered parachute involves adjusting wing attachment positions and steering bars to achieve a balanced and stable flight. Proper trimming lets your powered parachute fly hands-free in a specific configuration, like straight-and-level flight with a particular loading. This not only improves fuel efficiency but also provides relief from constantly using primary controls during straight-and-level flight, enhancing overall flight safety and comfort.

Balance, Stability, and Center of Gravity

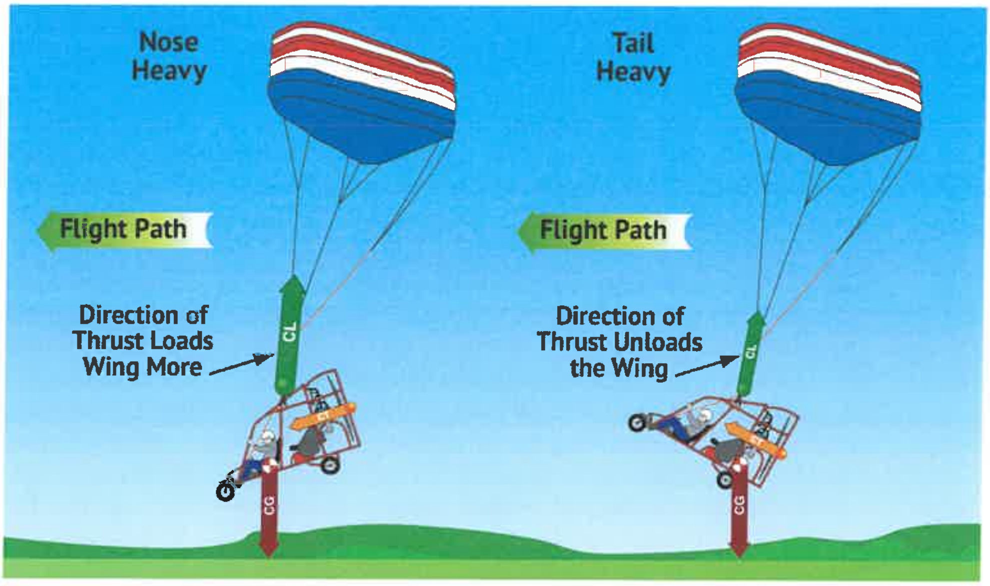
Weight and balance control should be a matter of concern to all pilots. You have control over the balance point of the powered parachute you're preparing to fly. Before any flight, you should determine the weight and balance condition of the powered parachute. Simple procedures have been devised by aircraft manufacturers to help you determine the balance point. You must use these procedures and exercise good judgment.

Balance refers to the location of the center of gravity (CG) of a powered parachute and is important to powered parachute stability and safety in flight. The CG is a point at which a powered parachute would balance if it were suspended at that point. And, in fact, is very close to where it should be suspended in flight.

The CG is not necessarily a fixed point; its location depends on the distribution of weight in the powered parachute. It depends on variables such as pilot and passenger weights and fuel.

The prime concern of powered parachute balancing is the fore and aft location of the CG along the longitudinal axis. As variable load items are shifted or expended, there is a resultant shift in

The Paraski was a Canadian design that integrated a significant rudder into their design.



Longitudinal unbalance with the center of gravity too far forward of the center of lift and with the center of gravity behind the center of lift.

CG location and you should make sure that the powered parachute is rigged properly for CG before flight. However, it's also important to balance forces side to side on the lateral axis. Lateral forces are more complicated since they change with more than the CG-loading. Lateral forces also change with power settings on the engine and the resultant torque from the engine and propeller.

The powered parachute owner or operator should make certain that up-to-date information is available in the powered parachute for the pilot's use and should ensure that appropriate entries are made in the powered parachute records when repairs or modifications have been accomplished. Weight changes must be accounted for, and the proper notations made in weight and balance records. Without such information, the pilot has no foundation upon which to base the necessary decisions when adjusting the aircraft.

Flying a powered parachute that's out of balance can be unsafe, inefficient, and tiring. When trimming a powered parachute, you need to trim for both longitudinal (front and back) CG and lateral (side-to-side) forces.

Effects of Adverse Longitudinal Balance

Adverse longitudinal balance mostly affects the direction of thrust of the powered parachute. In extreme cases, it can also affect the control of a powered parachute and lead to airframe damage.

Most powered parachutes have a single point on either side of the airframe where the riser for that side of the wing is attached. Those two attachment points act like a fulcrum for the entire airframe, much like an old-fashioned balancing scale. For simplicity's sake, it's easy to visualize the parachute attachment point as balancing the two heaviest things fore and aft of the attachment point. Those are the engine in the back of the airframe and the pilot in the front of the powered parachute. Risers are holding the whole scale up.

The engine on any particular model of powered parachute is a constant weight, but pilots come in many sizes. So, what if a powered parachute only had one fixed attachment point for the wing and it was set for the *average* American male pilot weighing 200 lbs.?

That would be great for any pilot weighing at or near 200 lbs. But if a pilot who's lighter than 200 lbs sits in the front seat, the engine weight will tip the scale to the engine side. Then the thrust from the engine and propeller will angle downward. On the other hand, if a pilot heavier than 200 lbs. sits in the front seat, then the front of the powered parachute would go down and the thrust will be directed upwards. Why is this important?

In the case of the lighter pilot, the powered parachute is considered tail-heavy. It has a serious effect on longitudinal stability because the thrust directed somewhat downward unloads the wing. That's because part of the thrust is pushing in the same direction of lift and is doing the work that should be done by the wing. In less extreme cases, this isn't necessarily a bad thing. It may help increase the payload of the powered parachute overall. But as the nose-up attitude increases, what follows is more instability, lower airspeed, and an increased susceptibility to turbulence. It also leads to an overly sensitive throttle response where small inputs have oversized effects on climb, level flight, and descent. The worst case is that a tail-heavy powered parachute can lead to a metastable stall.

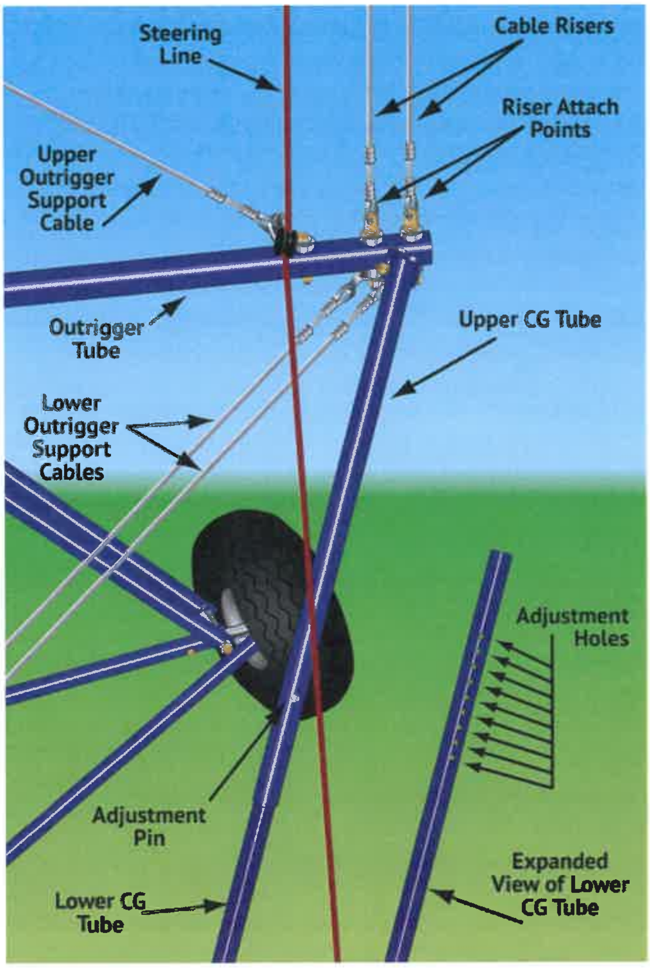
For some powered parachute designs, a high nose-up attitude can also damage the propeller prop guard and even the propeller. That's because as the powered parachute is taking off, when the nose rotates, the prop guard is forced down and drags on the ground. Upon landing, especially with flare, the prop guard may be the part of the airframe that touches the ground first, instead of the landing gear. After the prop guard hits the ground, it bounces the nose down, forcing the nose gear to slap the ground and perhaps damage it.

If the prop guard hits too hard, it may be pushed into the propeller arc. That can lead to damage to the airframe, the propeller, the engine, and the gearbox.

When the CG is too far forward, the thrust is directed somewhat upward and increases the load on the wing. A forward-loaded powered parachute tends to fly nose-down and behaves as if it is heavier due to the direction of the thrust. This setup places a greater load on the wing compared to the same model with a properly adjusted center of gravity. As a result, the overall payload and rate of climb are reduced, and the powered parachute behaves as if it is heavier than its actual weight.

A decision to forward-load a powered parachute is primarily driven by stability considerations. A thrust angle that brings the nose down increases the speed of the powered parachute and improves its resistance to turbulence.

In the extreme, a powered parachute taking off with a heavier pilot may take off with the rear wheels leaving the ground first. That means that the front wheel will be tracking on the ground like a wheelbarrow, which is a very unnatural and uncomfortable deck angle. Worse, upon landing, the front wheel will touch first and nose gear wheels typically don't have suspension systems. That leads to a harder landing and the initial touchdown will force the nose up and bounce the main gear down harder.



Telescoping CG Tube Balancing System.

Trimming for Center of Gravity

Powered parachutes aren't built to accommodate just one size of pilot, which makes loading difficult to control on a powered parachute. Instead of trying to control the loading, powered parachute designers arrange for pilots to be able to adjust the balance point of the airframe.

To accommodate different sized pilots, manufactures have come up with a couple of ways to adjust where the wing risers attach to the airframe. By having a way to move the attach points of the wing fore and aft, the powered parachute can accommodate nearly any weight of pilot.

First you need to understand the difference between *Center of Gravity* and *Center of Gravity Setting*. The former pertains to the actual position of the load and is influenced by airframe weight, pilot weight, fuel quantity, presence of a passenger, and overall weight distribution. On the other hand, the Center of Gravity Setting refers to the attachment points on the airframe for the risers or parachute, which are typically adjustable.

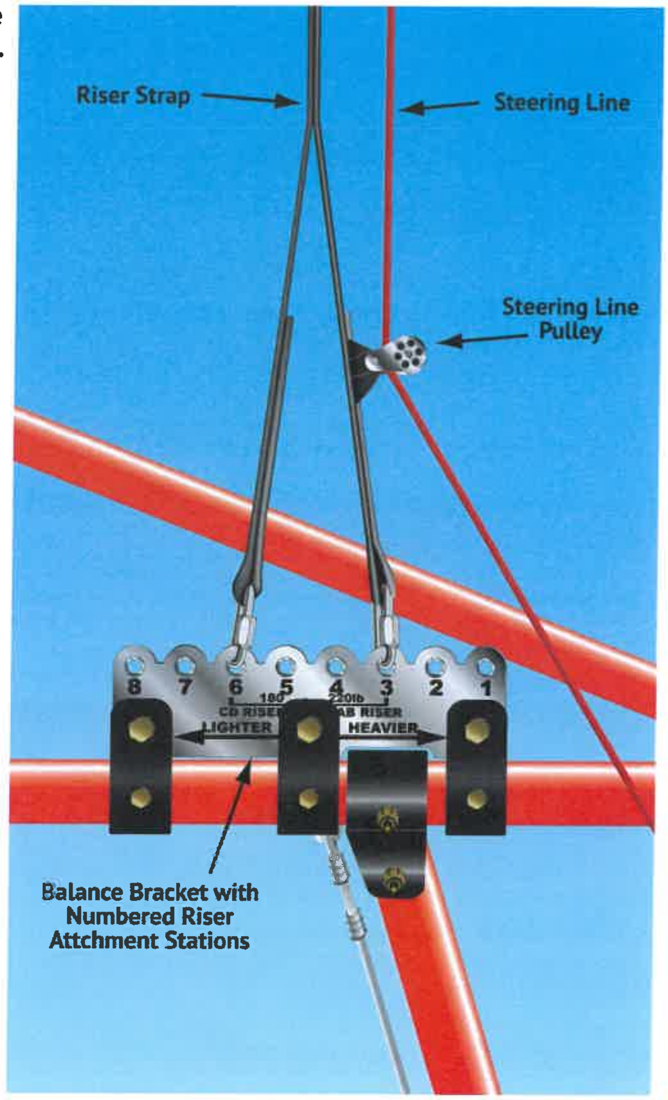
There are at least three different approaches to setting the center of gravity on a powered parachute:

No Adjustment Needed. It's possible to design an airframe that doesn't need center of gravity adjustment. This method is used on simple single-seat airframes, or on airframes that have extremely high wing attach points. For high attach point single-seat machines, the pilot sits close enough to the center of gravity that adjustment for different pilot weights isn't necessary.

Some two seat machine designs relied on incredibly high wing attachment points. The old Canadian-designed Paraski had a cradle system where a riser cable attached to the very front of the machine and a riser cable attached to the very rear of the machine. The two cables came together and formed a fixed point several feet above the airframe that increased the envelope that the CG could fall within. That stability came at a cost in performance and maneuverability. The high balance point forced the airframe to stay level with the ground, even on climbs and descents. That reduced the climb performance drastically since the airframe would never match the relative wind of the wing during climb and the engine thrust would end up loading the parachute.

Telescoping CG Tubes. In other machines, the airframe itself can be adjusted to change the balance point. Telescoping *CG tubes* are integrated into the airframe. The overall length of the CG tube assembly is changed by extending or contracting the two tubes and then pinning them in place with a bolt or similar fastener. As the

Riser Bracket Balancing System. For heavier pilots, the quick links are attached to the more forward holes.



CG tube assembly is made shorter, it brings the balance point of the powered parachute forward for heavier pilots. As it's extended, it pushes the balance point of the powered parachute rearward. This method results in riser attachment points that are relatively low, making the airframe less pitch stable.

Riser Attach Brackets. Riser brackets are plates with a series of holes where the risers attach to the airframe with quick links. Different holes are used as attachment points for different CG settings. The system is less complicated and allows designers to easily place the balance point higher on the airframe. This optimum position over the heads of pilots provides stability without a huge sacrifice in climb performance. This is by far the preferred method of designers of modern powered parachutes.

The bracket settings and CG tube assembly lengths for different loadings are established by the manufacturer. These settings are usually listed by pilot weight since the passenger and the fuel cell are positioned very close to the balance point and have little effect on the CG. These settings are published for each powered parachute in the weight and balance sheet (for many experimentally certificated powered parachutes) and in the powered parachute Pilot's Operating Handbook (POH). If you weigh more or less than the last pilot flying a particular powered parachute, you must make sure to adjust the CG tubes or the attachment of the risers to the balance bracket before flying.

Effects Of Adverse Lateral Balance

When forces don't balance laterally (side-to-side) on a powered parachute, the aircraft is going to turn to one side or another until those forces balance. Total lateral forces on a powered parachute change often during a single flight because torque forces from the engine and propeller change with each throttle change.

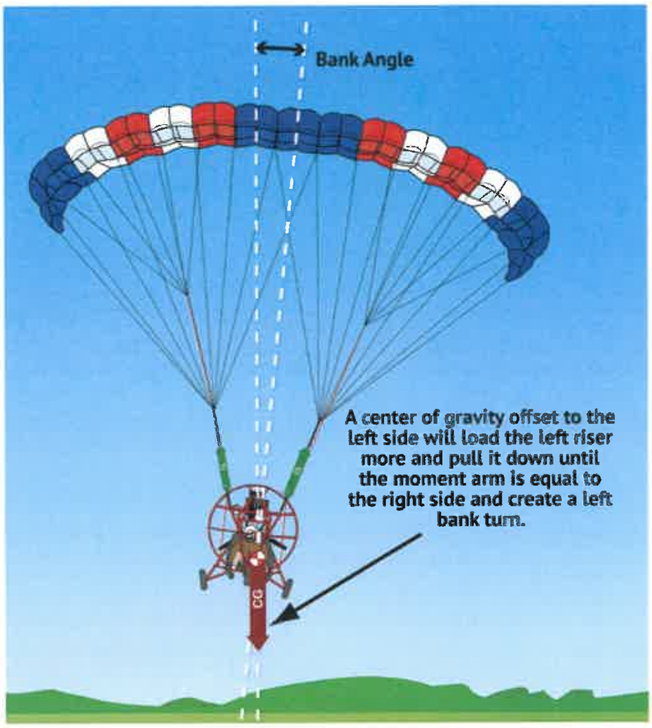
Effects of Center of Gravity on Lateral Balance

A starting point for lateral balance is CG balance. Let's look at a powered parachute gliding with the engine off and see how a displaced CG affects flight. Lateral imbalance will occur if the load is positioned to one side or if the parachute attach points are positioned improperly.

Despite the off-balance loading, each of the risers is going to have an equal force pulling towards the parachute. For the force vectors to balance, the airframe will tip towards the side where the center of gravity is located. How much it tips depends on how off-balance the CG is between the riser attachment points and how far it is located below the attachment points. The airframe will bank until the vertical component of lift times the moment arm on one side of the airframe equals the vertical component of lift times the horizontal moment arm on the other side of the airframe. By turning into a bank to the side with the shorter moment arm, the vertical load is then shared evenly by the risers.

As you can see in the figure on the next page, the vertical forces for the risers become unequal as the airframe tips. The riser (and therefore the forces) on the side away from the center of gravity become more vertical while the riser closer to the center of gravity angles toward the horizontal. That horizontal component of the forces is what pulls the powered parachute into a bank to that side of the airframe.

So, a CG imbalance will cause a powered parachute to tip to the side of imbalance and that will cause the powered parachute to turn. You can even experience that effect by leaning way over to one side while flying. Moving your body over will move the entire CG of the airframe over and will cause a turn to the side you are leaning into.



Effects of Propeller Torque on Lateral Balance

But unlike longitudinal balance, there are more forces affecting lateral balance than just the location of the center of gravity of the airframe. The biggest additional lateral force comes from the engine when it's running. The spinning prop creates torque which the airframe reacts to by torquing in the opposite direction.

When the powered parachute has its engine running in flight, the torque from the engine is going to attempt to increase the load on one of the risers and unload the other riser. The exact amount of the load change will equal the amount of torque that the engine is producing divided by the moment arm from the center of the prop to the riser attach point. The other side of the airframe will see an unloading of the riser that is calculated the same way, by dividing the amount of torque created by the engine by the distance between the center of the prop and that riser attachment point.

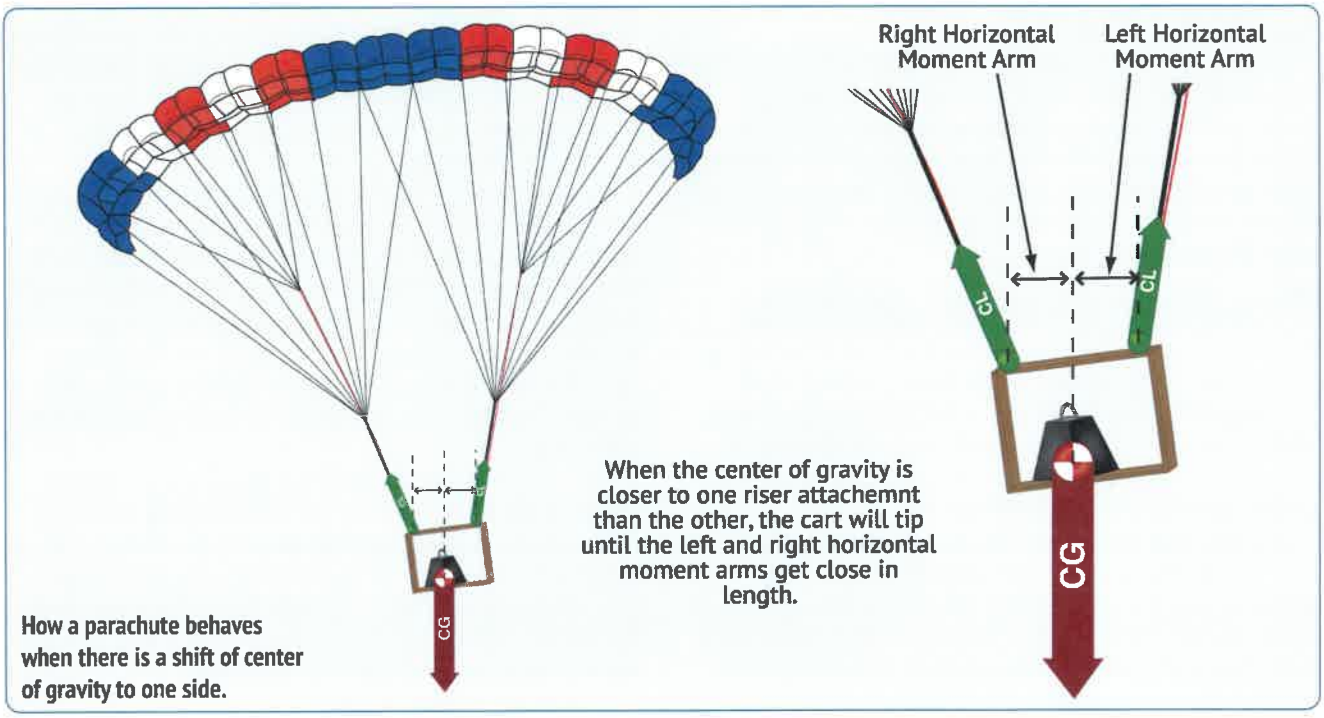
The introduction of torque loads to the risers and parachute doesn't mean that one riser is going to ultimately be loaded more than the other. Instead, what it does mean is that the airframe will behave like the center of gravity has shifted to the side that has the increased torque load. The airframe will tilt until the total loads on both risers balance. In other words, the effects of the torque load and the CG must be considered together to make sure that there's lateral balance.

The rate of turn can be a little or a lot, it depends on the imbalance of forces at that point of the flight. This can be seen in the nearby illustrations.

Which riser is loaded and which riser is unloaded is determined by the direction the propeller turns. If the propeller turns clockwise when looking at it from behind the airframe (Rotax 503 or 582 engines), the opposing turning reaction will turn the airframe counter-clockwise and the left riser will be loaded more by torque. The powered parachute will then have a left-turning tendency.

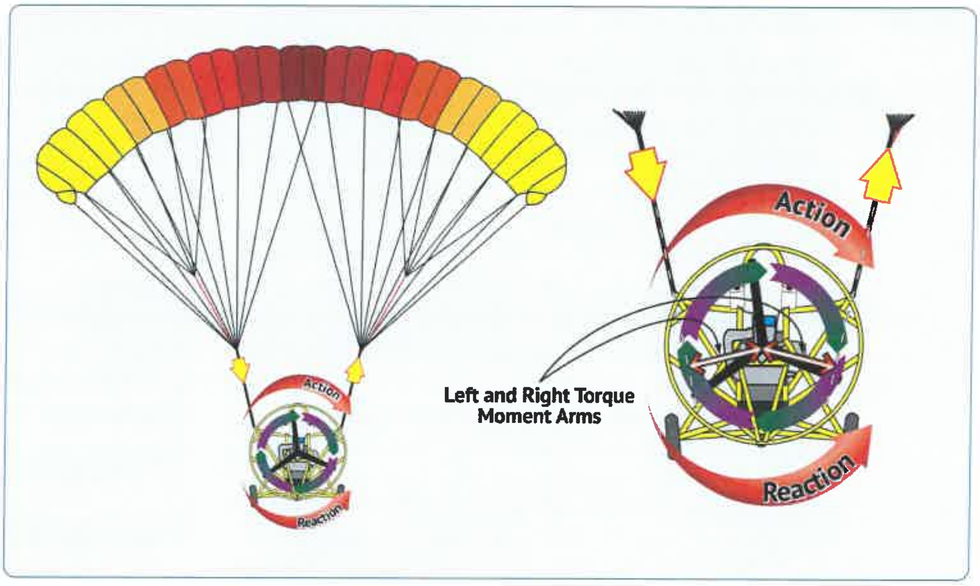
If the propeller turns counter-clockwise (Rotax 9-series engines), the reacting force will increase the load on the right riser and decrease in on the left riser. That will give the powered parachute a right-turning tendency.

The torque loads produced by the powerplant change with the engine RPMs. That means that as the total gross weight of the powered parachute changes, the torque of the engine also changes because the RPMs required to maintain level flight



How a parachute behaves when there is a shift of center of gravity to one side.

Forces created by clockwise-turning propeller torque.



will change. Worse, as the throttle increases or decreases for climb and descent, the torque values will change, too. That means (for example) that a powered parachute powered by a Rotax 9-series engine will have a right-turning tendency in climb and a left-turning tendency during descent if the powered parachute is balanced properly for straight-and-level flight. The best that you can do when setting the lateral weight and balance is to set it for level flight for whatever gross weight you expect to fly.

The normal pilot response is to steer into the opposite direction by pulling down on the opposite steering line. This is OK for short periods such as during climb or descent, but is not a long term solution because it places the powered parachute controls in an out-of-streamline condition, increases drag, and results in decreased operating efficiency. It also puts the wing closer to a stall since one half of the chute may need a lot of steering control for the powered parachute to fly straight.

Trimming for Lateral Balance

It's very important to adjust and trim a powered parachute's center of gravity not only for fore and aft settings, but also for left-to-right settings. That includes adjusting for lateral forces like the torque created by the engine as well as the center of gravity. But since lateral forces change with throttle settings, you can never get the adjustment perfect. The best you can do is to adjust the aircraft for straight-and-level flight and then use steering inputs to compensate for the different amounts of torque during climbs and descents.

There are a few ways to compensate for lateral balance. Which one you use depends on the design of your powered parachute.

Counter-Rotating Propellers. This technique was used by ParaPlane for the first commercially produced powered parachute. It relies on having two engines, each spinning its own propeller on the same axis. The trick is that the propellers spin in opposite directions, eliminating propeller torque. No matter what throttle setting you adjust to, the lateral forces balance out. The system worked but was inefficient. Besides requiring another engine, the inline counter-rotating propellers created turbulence for each other and that reduced the overall thrust. No one has used such a system since then on a powered parachute because of those inefficiencies. Also, many of the innovations on the ParaPlane were patented when it was introduced and that discouraged other designers from incorporating that idea.

Offset Airframe. This method is available to designers, but not to owners. That's because it involves designing the airframe slightly asymmetrical to compensate for the torque forces for the chosen powerplant. Some aircraft manufacturers offset the mounting of the engine. For powered parachutes, you can also offset the attach points for the parachute, but that is normally an airframe issue.

Telescoping CG Tubes. One of the benefits of telescoping CG tubes is that they move the parachute attachment point in three dimensions when they are extended or retracted. When extended they move the riser attachment point to the rear of the powered parachute, but also outward and upward. Getting the proper location for CG tubes while adjusting them for both longitudinal and lateral forces can be a challenge, but it's possible to do in many cases.

Differing Riser Lengths. Many manufacturers make one parachute riser a little longer than the other. That works by introducing a small bank in the parachute on the shorter riser side. This works well, but isn't always exact. To fine tune the adjustment, additional quick links may be added to one riser or another. This compensates for airframe and wing manufacturing inconsistencies. It can also compensate for some parachute line stretching with time. This method works in combination with any of the methods above and nearly all powered parachute designs.

Shortening One Steering Line. This is probably the worst way to compensate for lateral imbalance. You should not attempt to correct for lateral imbalance by pulling in a parachute steering line and tying it off shorter than recommended. Some pilots shorten the steering line on the opposite side of a turn to correct for a poorly balanced machine. Others use trim tabs and leave them permanently set, which has the same effect.

Pulling one steering line in and making it shorter than the other steering line adds flare to one half of the parachute. If you do that, you are making your parachute less efficient and bringing at least half of your wing closer to stall. When you try to put an additional steering input into that side to turn normally, then the parachute is in an even more dangerous state.

Effect of Improper Line Trimming

Steering lines are the primary control for steering and it's your responsibility to make sure they're properly set before you fly. Steering lines are the two ropes that are fixed to the left and right sides of the airframe, are rigged through pulleys to the steering bars and then upward parallel to the risers. Above the risers, each rope is tied off to five or more small lines. Those small lines are attached to points across the trailing edge on each side of the wing.

The steering can be too loose or too tight, according to how tight the steering line is tied off. If the ropes are tied off too loose, then the steering becomes sloppy and ineffectual. If tied too tight, the steering pulls the trailing edge of the parachute wing down too far and changes the airfoil, bringing it closer to stall. Tying off the steering lines too tight is one of the things that can lead to a metastable stall.

Trimming Steering Lines

Trimming the steering lines just means choosing the best point on each steering rope to tie to the airframe. Even if a steering rope is tied off properly, it may need to be reset at some point. That will be necessary if the wing is removed for maintenance, inspection or storage. It will also be necessary if you change the position of the steering bars on the airframe.

In a car, the gas pedal and brake are fixed and the seat adjusts so that people with different leg lengths can comfortably reach the pedals. In a powered parachute, the seat is often fixed and the steering bars are repositioned for different size pilots. If the steering bars are moved, then the steering lines also need to be adjusted.

When initially routing a steering line through the pulleys, you should be very careful to make sure that the lines are being routed properly. If the lines are not installed properly, they can bind when you want to steer. That can easily lead to an accident.

Steering lines normally have an index line either permanently installed or clip on, depending on the manufacturer preference. These index lines should be used to initially set up the steering line lengths. Those lines are only an estimation since geometries change from airframe to airframe and the parachute manufacturer can only go by averages. Only through test flying can you be certain that the steering line is tied off at the right place.

Trimming a Powered Parachute: Step-by-Step

Trimming a powered parachute for flight is a multistep process that includes setting the balance point of the airframe and sometimes adjusting the lengths of the risers themselves. The complete solution is more complicated than just simply hanging the airframe and determining its lateral balance point. What may seem like a perfectly balanced powered parachute when hung by its risers on the ground will have different characteristics in flight. These changes are caused by both the thrust and torque of the engine.

Additionally, there may be imperfections in the airframe, wing, or risers. It's very normal to have two identical powered parachutes, equipped and trimmed identically, which will have different flight characteristics. An experienced pilot can tune the wing to the airframe so that it flies very close to true, with little or no pilot input needed to maintain straight-and-level flight.

Step One: Initial Balance Point Settings

Longitudinal balance is where we start. This involves getting the airframe to hang slightly nose-up in flight by setting the balance point properly fore and aft. These are settings that are normally provided by the documentation for the specific make and model of powered parachute and are either in the Pilot's Operating Handbook (POH) or on the weight and balance sheet that should be carried with the aircraft. If that documentation isn't available, then you must create it.

If the risers aren't installed, you'll have to first install them. Left and right risers are often different lengths. You should make sure that you have the correct risers for your model of powered parachute and then make sure that you install them on the proper sides. Risers are normally marked for the left and right sides. If they aren't marked, you need to consult other documentation or the manufacturer.

The best way to begin to create a weight and balance document is to suspend the powered parachute slightly off the floor by its risers with the pilot in the front seat. The bottom of the front wheel should rise only an inch or two off the floor before the rear tires lift up. There are three reasons for that.

1. In powered flight, the thrust of the engine and propeller will normally push the airframe forward and increase its deck angle.
2. Should the engine quit in flight, you will want to flare the parachute aggressively just before landing. That will again bring the nosewheel up and increase the deck angle, sometimes so much that the prop guard ring may get damaged by hitting the ground first.
3. In normal flight, a flatter deck angle will keep the thrust of the powered parachute directed to the back of the airframe. That results in a more stable flight with greater airspeed. If the thrust is directed downward, it will work to unload the wing, slowing it down, and make it less stable.

You make adjustments in the balance point by moving the attach points of the risers to different places on the riser bracket, if equipped. If you have CG tubes, you may need to unpin them, telescope them in or out to new positions, drill holes in the new positions, and then pin them into place.

Finally, the exception to rigging with a flatter deck angle may be with underpowered equipment. There, it may be necessary to have the thrust directed somewhat downward to augment lift and get additional payload off of the ground.

Step Two: Rigging the Parachute

Learning to attach and rig a wing to a powered parachute requires some training and you shouldn't attempt it without the advice and help of an experienced powered parachute pilot or instructor.

The wing's A-B riser sets should be attached to the forward-facing cables or riser strap loops and the C-D riser sets should be attached to the rear-facing cables or riser strap loops.

The less-than-straightforward part of the process is attaching the steering lines. The steering lines must be routed as per the airframe and riser manufacturer instructions. Then the steering lines must be tied off at the right locations and at the right length. Some wings have built-in index lines for setting steering line lengths. Others are shipped with separate index lines and yet others require that you use a tape measure to set them. It's important that you set the steering lines as per manufacturer instructions and that the left and right steering lines are equal in length.

If the steering lines are not equal in length, one half of the trailing edge will be pulled down lower than the other which will have the following effects:

- The airfoil will be less efficient.
- It will force the airfoil to operate unlike the manufacturer designed.
- The parachute will be harder to kite.
- It will possibly bring at least one half of the wing dangerously close to a stalling angle of attack in flight.

Finally, inspect your work. It's easy for things to get twisted as you're installing the wing. Make sure everything is orderly, straight, and that you have tightened each of the attaching quick links.

Step Three: The Test Flight

After you've adjusted the powered parachute for balance longitudinally and the wing is installed, it's time to take the powered parachute for a test flight. Test flights should take place in wide, open fields. Even if you normally fly from a home field, you should do your test flight at an airport or another place with a long, wide runway where you have a chance to kite, have a long ground roll to inspect your wing, and slowly take off. If you have problems during any phase of flight, you should have a place where you can land or shut down.

When you take your test flight, don't assume success. At the minimum, you should bring along a wrench, flat blade screwdriver, and extra quick links (two short and two long ones) in case you need to make an adjustment in the field.

Longitudinal Balance

During the test flight, the goal is to first make sure that the longitudinal balance settings are correct. Having someone on the ground to observe the flight and specifically the deck angle of the airframe during straight-and-level flight is helpful. A video or even still pictures are even more helpful. If you don't have anyone to help, the best way to determine lateral balance is to fly the machine a few feet off the runway. The perspective there will help you determine how high the nosewheel is relative to the rear main wheels. Another test is to go to altitude and reduce the throttle to idle. When the power is reduced, the front wheel should not be lower than the rear wheels. If any longitudinal balance adjustments are required, you should land the powered parachute and make necessary adjustments for center of gravity.

- If the powered parachute is flying nose-low, then the balance point (where the risers are attached to the airframe) needs to be brought forward.
- If the powered parachute is flying nose-high, then the balance point needs to be adjusted rearward.

Steering Lines

During your first test flight, you should also check to see if your steering lines are set properly. First observe the steering ropes to make sure that they are routed properly through the pulleys and rigging. If they aren't rigged properly, you should land immediately and correct the problem.

Then look at your wing overhead. If the steering lines are too loose, you will notice softness in the controls as well as being able to observe the steering lines billowing out behind the trailing edge of your wing. If your parachute has a permanently installed index line, it will be tight and the steering rope visibly looser. While still in flight, you can tighten the steering ropes by using trim locks. You want to tighten the steering lines enough that the index line just begins to billow. That indicates that the steering lines are just starting to engage.

Your steering lines may instead be too tight. As you're looking up at your wing overhead, check to see if there's a crease in the bottom skin of the wing parallel to the trailing edge. That indicates that the trailing edge is being pulled down. There normally isn't anything you can do about that in flight except note it so you can make an adjustment on the ground.

Once on the ground, retie your steering ropes to the airframe, if needed. Loose steering ropes can be set by tying them just tight enough so that you don't need to use your trim locks. If your steering ropes are too tight, you'll have to estimate how much to loosen them.

It's far safer and easier to begin test flights with steering lines a little too loose rather than too tight. Normally, initially rigging your wing according to the index lines will make them a little loose, giving you the ability to tighten things just enough during your first test flight.

Lateral Balance

After longitudinal balance is confirmed and your steering lines are set properly, then it's time to work on lateral balance. Fortunately, you don't need to understand all the science and engineering about lateral balance in order to correct for it. All you really need to know is what to do if your powered parachute has a left or right turning tendency.

Lateral balance is determined by first making sure that the parachute is rigged properly as per Step 2 above. If the steering lines are not set properly, then it will be more difficult for you to truly determine if there is an unbalance or how bad it is. It's also important that longitudinal balance is set before worrying too much about lateral balance.

After you have confirmed that the steering lines and CG are set properly, you merely have to fly the powered parachute at level cruise and observe whether the powered parachute is flying to the left, right, or straight ahead. Of course, if the powered parachute is flying straight (or relatively straight) then no further adjustment is needed. If the powered parachute is flying either to the left or right, then you will need to adjust either the CG tubes or the risers themselves.

Adjusting Riser Lengths

Adjusting the overall riser lengths by adding additional quick links where necessary is by far the easiest and most straightforward way to make a lateral balance adjustment. The general rule is that you want to increase the length of the riser on the side to which you are turning when in level flight. That is, if you're turning right in level flight, you want to lengthen the right riser by replacing the short quick links with longer quick links on both the front and back ends of that riser where they attach to the airframe. By using longer links, you're putting the parachute into a slight bank angle to the opposite side, which balances out the forces trying to turn the powered parachute. If longer quick links don't work, then replace each long quick link with two short links.

Both standard and longer quick links are available for fine tuning adjustments to riser lengths. It's always best to use the same brand and gauge recommended by the manufacturer.

Adjusting CG Tubes

Older powered parachutes can be adjusted for turning tendency by adding quick links, just like newer powered parachutes with CG brackets. However, the CG tubes allow for finer adjustments without extra hardware.

As CG tubes are extended, they move in three dimensions. Forward and back is the primary adjustment for longitudinal balance. However, as the tubes are extended they also move up and down as well as inward and outward from the center of gravity. Those other dimensions can be used to do lateral adjustments.

As the attach point for the riser moves outward, that increases the moment arm away from the center of gravity. Additionally, as the arm moves outward, it moves upward. Both of those changes help correct for turning tendency.

The rule of thumb is that for a left-turning correction, you want to extend the left tube outward and/or shorten the right tube inward.

Generally, it's best to do both, by one-inch increments per side. For example, if your powered parachute is flying to the left, you would want to begin by extending the left CG tube one inch. Then test fly again and see if there has been an improvement. If you still need to correct more for a left turn tendency, then you would want to shorten the right CG tube by one inch and then test fly. Moving back and forth incrementally on the left and right CG tubes helps preserve your longitudinal balance.

It may take a little more work and thinking to solve center of gravity problems properly, but the effort will make your flying safer and more fun.

Chapter 19 Parachute Layout and Stowing

Powered parachutes are unique in that they are aircraft where pilots must 'build their wings' out of piles of fabric and strings on the ground before taking off into the sky. How well and how safely a powered parachute takes off depends largely on how well you lay out the wing on the ground. How efficiently you're able to lay out that wing in turn relies partly on how well you stowed or packed the wing after its last flight. And if there were problems with stowing, you need to be able to quickly recognize and correct line twists and other problems.

There's more than one way to lay out and stow a wing. The best way for you to lay out and stow a wing depends on what you fly, where you fly, and other factors. This is something that's best for you to work on with your flight instructor. He or she has ways of doing things and will have reasons for doing them.

However, this book wouldn't be complete if I didn't explain at least one way to deploy and recover a wing. The particular method I will be talking about here will not include folding the wing. The way I'm offering in this chapter is one that works for me and a lot of other pilots.

This isn't the way I did things when I started flying. To put even a finer point on it, when I started flying, we didn't even have line socks. Parachute lines were daisy-chained for stowing the way many powered paraglider pilots still do things today. And yes, we liked it that way...

The goals with my methods are safety, consistency, and efficiency. Every powered parachute flight instructor I know teaches safety and consistency. Not everyone emphasizes efficiency. Efficiency means that there's as little wasted motion as possible and that things move along as quickly as possible. With practice, laying out a wing should take very little time. With practice, stowing a wing should take even less time.

Use of Checklists

You may find that a wing layout checklist can be an important training aid while learning to fly powered parachutes. Some methods of laying out the wing depend on being able to consistently do things the same way each time.

After you become proficient in laying out and stowing a wing, you may find it better to use an abbreviated checklist focusing on outcomes rather than the process itself. After all, it's important to know that everything is in place before the engine is started either for takeoff or for the taxi back to the hangar.

Wing Layout

Wing layout is part of the equipment staging process. Before beginning to lay out your wing, you should make sure that the airframe is positioned on an appropriate runway that is:

- Into the wind.
- Has a place to set up that's clear of other traffic.
- Clear of debris or holes in the direction of takeoff.
- Long enough to kite the wing and take off.

Even after beginning the process, you may need to move the airframe if the wind changes. There's more about positioning a powered parachute in *Chapter 20, "Departures and Climbs."*

There are several different styles for laying out wings and for stowing them. But things break down into two major layout methods, the inverted method and the stacked method.

Inverted Method

The inverted method of laying out a wing involves spreading your chute out upside down like a blanket on the beach. The trailing edge is positioned close to the propeller prop guard and the leading edge is pulled out further behind the machine.

The method allows for a clear inspection of the bottom of the wing. It also allows the propeller blast from many airframes to go over the wing, keeping it from inflating too early. The main advantage to the inverted method is that when the airframe rolls forward on the takeoff roll, it pulls the leading edge (A-lines) before it pulls the other suspension lines. This allows for a quick inflation of the wing.

One downside to the inverted method is that it keeps the suspension lines very slack. That allows for a higher chance for pressure knots in the lines as those lines tighten up on takeoff. It also puts a lot of loose lines close to the propeller arc. Some pilots solve that problem by looping the steering line around those suspension lines to keep them organized. That's a technique that you should learn from an instructor. Too many loops (or an unequal number of loops on the left and right sides) and you may introduce yet another problem on inflation.

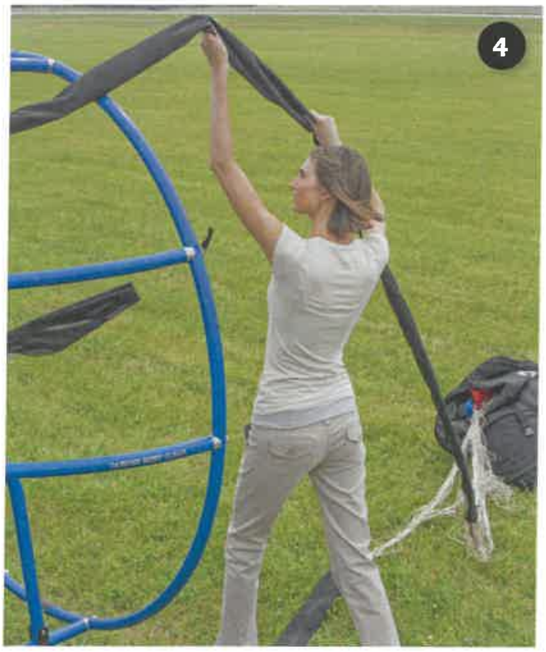
Another concern is that a wing laid out using the inverted method can be prone to lofting when the wind is blowing. The wind can get under one of the corners of the wing and blow it up and back before the you're ready to take off. That's solved by some pilots by placing small sandbags on the trailing edge corners of the wing.

Stacked (or Accordion) Method

The stacked method of laying out a wing involves piling the wing up like an accordion with all of the suspension lines stretched out as far as possible to the rear of the airframe. This method makes it easy for you to inspect all the suspension lines and can be easily modified for use during both calm and windy days. This is the style we will illustrate in this chapter.

With your wing spread out, you push your airframe forward to tighten all the suspension lines. That will naturally begin the stacking process. When the lines are tight, it's easy to inspect them for damage, twists, knots, and debris. Then you go to the back of the parachute and finish the process by grabbing the leading edge of the wing and tucking it under the rest of the chute.

The downside to this method is that if a powered parachute has a thrust line directed downward, it can blow the wing up before you're ready to fly. This problem is even greater for wings made from less flexible paraglider fabric.



Unpacking the Wing

How you get the wing from the airframe to the rear of your powered parachute can determine how successful you are in laying out your wing without line twists. Another big determining factor is how you put it away the last time you flew.

First you want to undo the zipper about halfway on the wing bag. ❶ This is to allow the line socks to freely deploy as you move the bag into position behind the airframe. You do this first because your hands will soon be busy handling the wing bag and line socks. (You'll find that I recommend that when you stow a wing, that you arrange both of the line socks to come out of the same side of the bag. It makes everything easier to deploy and reduces the risk of line twists.)

Next you want to unbuckle all the straps securing the suspension lines and the wing bag. ❷ Normally, that should only be the two straps that are sewn to the bag. If you're using additional straps or bungees that are separate from the wing bag, you should stow them right away or place them well to the side or rear of the powered parachute. Once the wing is out of the bag, it can accidentally cover up or get tangled up in things you lay on the ground. It's better to kite and take off leaving things behind and out of the way than to it is to take off with something tangled in your wing.

Suspension lines are normally the last things to go into the bag when the wing is stowed and should be the first to deploy. They should be able to just spool out naturally as you move the wing bag into position behind the airframe. ❸ Be careful that you don't pull the bag over the line socks or (worse) move the bag over just one of the line socks. Crossing the wing bag over a line sock is a way to introduce a twist into your lines that you won't discover until after the wing is laid out.

Place the wing bag behind the airframe and place the line socks so that they lead directly from

the wing bag to the attach points on the airframe. That will mean lifting one line sock over the airframe. ❹ If the line socks are twisted around each other, spin the wing bag to undo the twists. ❺

Now you can open the wing bag completely and dump the bag forward to spill the wing out of the bag. ❻ Stow the bag. Then remove the line socks and stow those. ❼

At this point you should only have the wing to work with. Your wing bag, line socks, and whatever strapping you may have used should be stowed. This is a great time to make sure those items are stowed because your wing isn't going to billow up in the wind very easily while it's still in a pile. It's best to put away any loose items before they get tangled into the wing or suspension lines or are forgotten.

With the wing lying there in a pile, you're ready to spread it out.

Inspecting the Wing

Grab the left side of the wing and pull it out to the left. ❶ You should then do the same thing with the right side. ❷ Now that the wing is spread out, this is a great time to inspect it.

Inspections can vary from rudimentary to detailed. Some of the factors that go into how detailed your inspection should be include:

Terrain. If you take off from dessert terrain or where there is very little clean turf, then you probably want to do a more thorough inspection. The further south you go, the greater the chances of nettles or even cactus being in undeveloped fields. Those can snag the threads used to sew the panels together and even damage the fabric itself.

Last Inspection. If you inspected the wing thoroughly within the last few flights, then you can be more confident that the wing is OK.

Last flight. If you took off from rough terrain on your last flight, if your wing landed on top of your engine area or if anything else unusual happened then that may warrant a closer look.

Your inspection should include checking for tears in the fabric, torn or loose stitching, abrasions, and deterioration of the fabric from ultraviolet rays. The sun is one of the powered parachute wing's worst enemies, next to the prop! Certain colors, like red and orange, deteriorate faster than others when exposed to ultraviolet rays from the sun. When the wing is not being used, you should always return it to its bag.

Also take this opportunity to check the wing cells for debris, such as stones, sticks, and bugs; lifting the wing by the trailing edge and gently shaking it will allow most captured debris to fall out of the ram-air openings on the leading edge of the wing.

There are three primary areas you want to inspect.

Top Skin. The wing should be spread out so that you see the entire top of the parachute. You're looking for wear on the material, particularly near the trailing edge of the wing. That's because as a wing kites and rotates upward, the top of the wing drags across whatever surface you have laid it out on. This is a particular problem for those who use the inverted layout method. The stitching holding the panels together should also be inspected. Double stitching is the industry standard and you should make sure that both stitches are unbroken.

Bottom Skin. Flip the wing over and look over the bottom of the wing. You are again looking at the fabric and the stitching. However, now you're also able to see where all of the suspension lines attach to the wing.

Suspension Lines. You want to check for breaks, fraying and hard spots. Hard spots are where the suspension lines have landed on a hot surface like a muffler or exhaust manifold. Those hard spots mean that the fibers have melted and are now very weak. If you find any hard spots in the suspension lines, you should definitely not fly the wing until it's repaired. Hard spots can be located easiest by running your finger and thumb along a suspension line. You will feel a hard spot faster than you will see it.

Initial Layout

With your wing spread out, stand behind it and see if it's centered on the prop. ❸ If it isn't, pick up the center of the wing and drag it into position. ❹ Then you go to the end of the side that you bunched up, pick up that side of the wing, and pull out the slack in the fabric. ❺ Now you have a wing that's centered behind your airframe.

The next step is to straighten out the cells. This is done by gathering the A, B, C, D and steering line tabs attached to each outboard side of the wing and using them to pull that side of the wing away from the center of the wing. ❻ That tugs all the cells into alignment on either side of the wing, organizes the suspension lines most likely to cause a line-over, and puts those lines where you can see them. Those outside suspension lines are the most at risk because they are on the end and it's easier for them to find their way onto the top of the wing during inflation and kiting, causing a line-over.

Inspecting Steering Lines and Risers

Next you want to focus on the steering lines and risers. It's best to adjust and inspect the steering lines and riser (or risers) on one side of the airframe before you go to the other side.

Start at the front of the airframe and inspect the steering line. Begin your inspection from the place where the steering line is tied off on the airframe and trace it through the rigging to make sure everything is routed properly. Trace the line back to the point where the riser is attached to the airframe, making sure that the steering line flows freely through all guides and pulleys and that the pulleys spin freely. You also want to eliminate any slack. Pull the steering bar back to the most rearward position and pull out any slack in the steering line. You should clear everything up to the point where the steering line joins the riser.

At the riser attach point on the airframe, make sure that both quick links attaching the riser to the airframe are secure. They should be finger-tight plus one-quarter turn. You shouldn't be able to turn them with your fingers.

Working your way further back, you want to make sure that the riser is lying flat and straight towards the rear of the airframe, where you want to make sure that it's placed in the hanger on the propeller guard. ❶ Then check the steering line and riser on the other side of the aircraft.

Making sure the steering lines and risers are clear and straight does two things. First it makes it easier to determine later in the layout process if you really have a line twist in your wing or not. If you skip this step, what may look like a line twist when you're working behind the airframe could just be a twist in the risers between the riser attaching points on the airframe and the propeller guard.

The second thing straightening out the risers and how they're attached to the airframe does is to prevent the risers and quick links from becoming damaged when you inflate and load the wing on takeoff. There are a lot of forces acting on those points during kiting and those forces can be damaging. This is especially a problem for older style cable risers. The thimbles in the cable loops attaching the risers to the airframe can be easily torn free when the cables are loaded improperly.

Inspecting Parachute Suspension Lines

After both sets of steering lines and risers are inspected, it's time to push or pull the airframe forward. Doing that adds a little tension to the suspension lines and they will pull apart from each other and fan out. That little bit of tension also pulls the lines away from the propeller. One of your final checks is to make sure that there aren't any slack lines by the soon-to-be spinning prop.

How far you push the airframe forward depends on the model of airframe and how much slack you have. Generally, it's good to pull the airframe forward far enough so that all the lines are tight, including the steering lines. That prepares them for flight and makes them easier to inspect.

Now it's time to start checking your parachute lines. ❷ At first glance it looks as if it would be very difficult to sort out all the lines from the riser to the wing. But there is some good news. There are never really any knots in the lines unless you disconnect the lines from the riser and reinstall them improperly. The bad news is that lines can still get pretty tangled, especially when laying out the wing for your first flight of the day after it's been stowed.

Inspecting for Line Twists

If you put your wing away correctly and took it out as described, it shouldn't have any line twists in it. However, you still want to check to make sure that's the case.

With the lines straight, you then want to pick up the set of lines that go to the leading edge of the parachute. Those lines are called 'A' and 'B' lines because they attach to the parachute on the leading edge and the position right behind the leading edge. *See Parachute Lines on page 101.*

Each A-B line set is sewn together about halfway towards the risers and all of the individual lines are brought together on either side of the canopy to a stainless steel quick link. By grabbing that quick link and holding it up, you should see all the A and B line sets hang free of the other lines left on the ground. ❸ If that happens, you don't have a line twist and you can begin more detailed work.

If on the other hand, you have a big twist or the lines seem really tangled, then you may have a line twist or a line-over. Those problems will be covered later in this chapter. A good thing to keep in mind is that if the wing hasn't been disconnected from the airframe, you can solve problems without any tools.

Clearing Lines

Begin clearing your parachute lines by making sure that you don't have any debris caught in them. Small twigs, stems from weeds, and other debris can get caught in the parachute lines and form pressure knots. Pressure knots are insidious because they are only knots when there is tension on the lines. That means they are only a problem when your chute is inflated and a stick is caught and wrapped by a couple of lines. That deforms the wing and can cause a steep turn to the side where the debris is lodged. Then, as soon as you land, the stick often shakes free and the knot disappears. As much as possible, you want to make sure there is nothing around to catch into your line sets. A nice open grassy field really does end up being the best place to take off a powered parachute.

After you have cleared out any debris in the lines, you must make sure that individual lines are clear of each other. Again, you want to work on one side of your wing, finish your checks, and then do the other side. Stand near the prop guard and begin by focusing on lines in the A-B line set. Inspect each line from the quick link attaching them to the riser. Each line should be clear of other lines, but one or two lines may seem to be wrapped over each other. Gently tugging on one of the wrapped lines will often allow the wrap to clear. If you notice that there is still debris in the lines, you will probably have to walk over to it to clear it out.

After you're sure that your A-B leading edge lines are clear and straight, it's time to make sure that the other lines are also not twisted. Lift the quick link attaching the A-B lines up so that you can inspect the C-D lines. Inspect and clear the C-D lines the same way you just did on the A-B lines. Finally, lift both sets of lines at their attachment points to the riser. That will allow you to inspect the steering line, which cascades out to several points on the trailing edge of the chute. You want to make sure that the individual lines are clear and untwisted.

The more organized the suspension lines are laid out during this preflight check, the more likely that your wing will kite evenly and without mishap.

Tucking the Wing

With the wing in place and the suspension lines straightened out, it's time to finish preparing the wing for takeoff. By now you may have noticed that the steps are iterative. We began by pulling the line socks out of the bag. Then we unpacked the wing. Then we uncovered the line socks. We moved to laying out the wing. Next we spent more time on the suspension lines. Now we're back to the wing. We finish preparing the powered parachute for flight by tucking the leading edge of the wing under the body of the wing.

You want to do this so that the wind and prop blast don't kite the wing before you're ready to fly. Tucking the wing allows the wind to move over it without filling the openings in the leading edge.

Before you begin this last step, make sure that your steering and suspension lines don't have any slack in them. You tightened them earlier by pushing the airframe forward. Depending on how much work you had to do clearing the suspension lines after that, you may find yourself needing to push the airframe forward one more time just enough to retighten the lines. Then it's time to tuck the leading edge of the wing.

The leading edge is picked up section by section and pulled to the rear of the wing and tucked under the rest of the wing. ❶ The result is that the A-lines and a portion of the bottom of the wing are rolled over on top of the wing. ❷ This prevents the wind and propeller blast from inflating the wing until the airframe rolls forward on takeoff, pulls the A-lines, and then exposes the cell openings to the prop blast. That controls when the wing will kite.

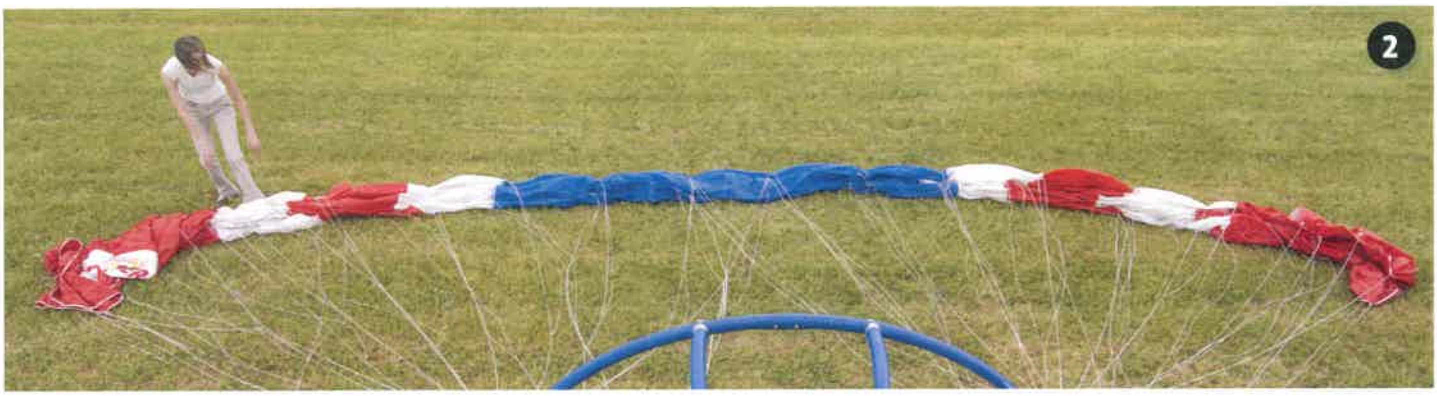
It's important to tuck the center of the wing where the propeller blast will hit it. It's just as important to stop tucking the leading edge about one cell from either end of wing. First, it isn't necessary since the propeller blast doesn't reach out that far to the side. But more important, you don't want to cause a line-over with one of those end lines by twisting it over the edge of the wing.

Walk Around

After you've finished tucking the wing, it's time to do one more walk around. An effective way to do this is to *point and say*. Walk around the entire powered parachute pointing to individual rigging items and describe their condition. Describing them out loud is optimum, but pointing and going over the items in your mind can be effective, too.

After that, it's time to get your passenger into the passenger seat and strapped in. Be careful while doing that because you don't want to roll the airframe either forwards or backwards. Either way may create slack in the lines which may in turn cause those lines to find their way into the propeller when you start up the engine.

The more effort you put into setting up your wing before flight, the better the wing will kite and the cleaner you'll be able to take off. If you don't do things well, it may take a great deal of runway to get all the cells open during the inflation of the wing. It may also lead to aborting a takeoff because of a poorly inflating wing. Aborting the takeoff to lay out the wing again and re-kite is always an option, but it's not desirable.



Tangles, Line Twists and Line-Overs

Line tangles and twists can be incredibly frustrating if you don't understand how to solve them. That's especially true if you're trying to grab a few minutes of flight late in the afternoon and the sun is setting fast. The good news is that suspension line problems are simple to understand, few in type, and easy to solve. They break down into tangles, twists, and line-overs.

Many people look at all the lines leading from the risers to the wing and wonder how anyone can sort out such a mess. Anyone who has worked with fishing line, extension cords, or Christmas lights knows how frustrating a bunch of lines or cords can be. With over 100 little strings going every which way, the uninformed may wonder how anyone ever gets things sorted out enough to fly.

Fortunately, unlike Christmas lights, suspension lines have two very important things going for them. First, both ends are tied to either the riser or the wing itself. That means there are no loose ends to get twisted in and around each other and that all the loops are open loops. Those loops readily just pull out if tugged a little bit. The other helpful thing to know is that the lines don't have anything mounted in them to readily catch another line like the lights on a string of Christmas tree lights.

These words are little comfort when you're staring at a wing that just isn't right, or worse, is obviously wrong. We'll talk about the problems here.

Tangles

Tangles are just what they sound like. Imagine fishing line or yarn all tangled up. Occasionally the lines on powered parachute wings will look that way. Properly stowing the wing using line socks prevents a lot of tangles. However sometimes tangles just happen. Possibilities are when the wing lands over the top of the airframe, during the process of undoing a line twist or sometimes just when unpacking the wing.

The key to working through a tangle is patience. First make sure that there isn't a line-over. Then just work on one line at a time. The lines are only looped through each other and by focusing on one line and freeing it from the others, a big part of the tangle will be worked out.

If the line you choose to work on first seems impossibly tangled, just abandon it and pick another line to work on that isn't so tangled. By working around the fringes of a major tangle and clearing individual lines, you'll eventually clear everything.

Line Twists

A line twist is when all the suspension lines on both sides of the wing are spiraled together. Sometimes it will look like all the lines on one side are twisted around the steering line. Trying to fly with a line twist is unwise because steering is more difficult and the steering line can abrade the suspension lines. With some wings, a line twist can warp the wing itself. Instead of attempting to fly, you should consider a wing with line twists to be unairworthy until the twists are resolved.

Line twists most often occur because the pilot inadvertently flips, or turns, the wing over while stowing or unpacking it. It's particularly common with pilots who separate their line socks in the wing bag rather than having them come out together on one side. Regardless of how you stow your equipment, preventing line twists is achieved largely by stowing your wing and unpacking it the same way every time.

Far less common, the suspension lines can also get twisted if the wing flies over the airframe after landing, or if the wing settles to one side of the airframe after an aborted takeoff or upon landing. The line twist occurs if you move the wing back into position incorrectly.

Unless someone has mistakenly twisted a single set of suspension lines while rigging the canopy to the airframe at the attachment points, a line twist will happen to both sets of lines on both sides of the powered parachute at the same time. This stands to reason if you think of the entire configuration of airframe and attached wing as a continuous structure.

To correct a line twist, you don't have to pack the wing back into the wing bag and flip the whole bag in reverse, although that's an option. You can also flip the wing while it's out of the bag. In fact it's better to do it that way since it takes far less time and it's easier to see what you're doing.

Before you try to undo a line twist, you need to confirm that you actually have a line twist. Then you must determine which way the lines are twisted so that you can reverse the twist. If you don't take the time to make these important checks, you can make the situation worse, not better.

Start by making sure you have a twist. Go to the front of the airframe and check the rigging from front to back. If a riser is flipped over, then it will appear that there is a line twist. If you straighten the riser, the false line twist will disappear.

If you determine that you still have a twist, you need to figure out which way the twist is going. There are only two possibilities. The lines can only spiral one way or the other between the riser and the wing. With some experience, you will be able to immediately determine which way the lines are twisting. Before you get that experience, there's an easy way to figure out what's going on.

With the wing laid out behind the airframe, go to one side of the wing and find the leading edge suspension line (A-line) attached to the wing tip. Then walk back to the airframe while tracing that line to the riser. 1 You'll be able to easily see which way the lines are twisted. The line you're tracing will either go under the rest of the lines or it will go over the rest of the lines. 2 or 12 And that's the way the wing tip must go in order to undo the line twist.

Go back to the wing tip. 3 Grab that wing tip and throw it over or under the entire line set on that side, following the twist of the suspension lines. 4 or 13 Grab the wing tip with your other hand 5 & 6 and pull it completely clear of the lines by walking back behind the airframe. 7 & 8 If the wing fabric bunches up, then walk towards the middle of the wing while clearing the leading edge of the wing by going hand-over-hand. 10 & 11 The key is to go from what you know should be right (the wing tip you passed around the line set) to the unknown (the rest of the leading edge on that side of the wing.) Then you can check your work on that side of the wing.

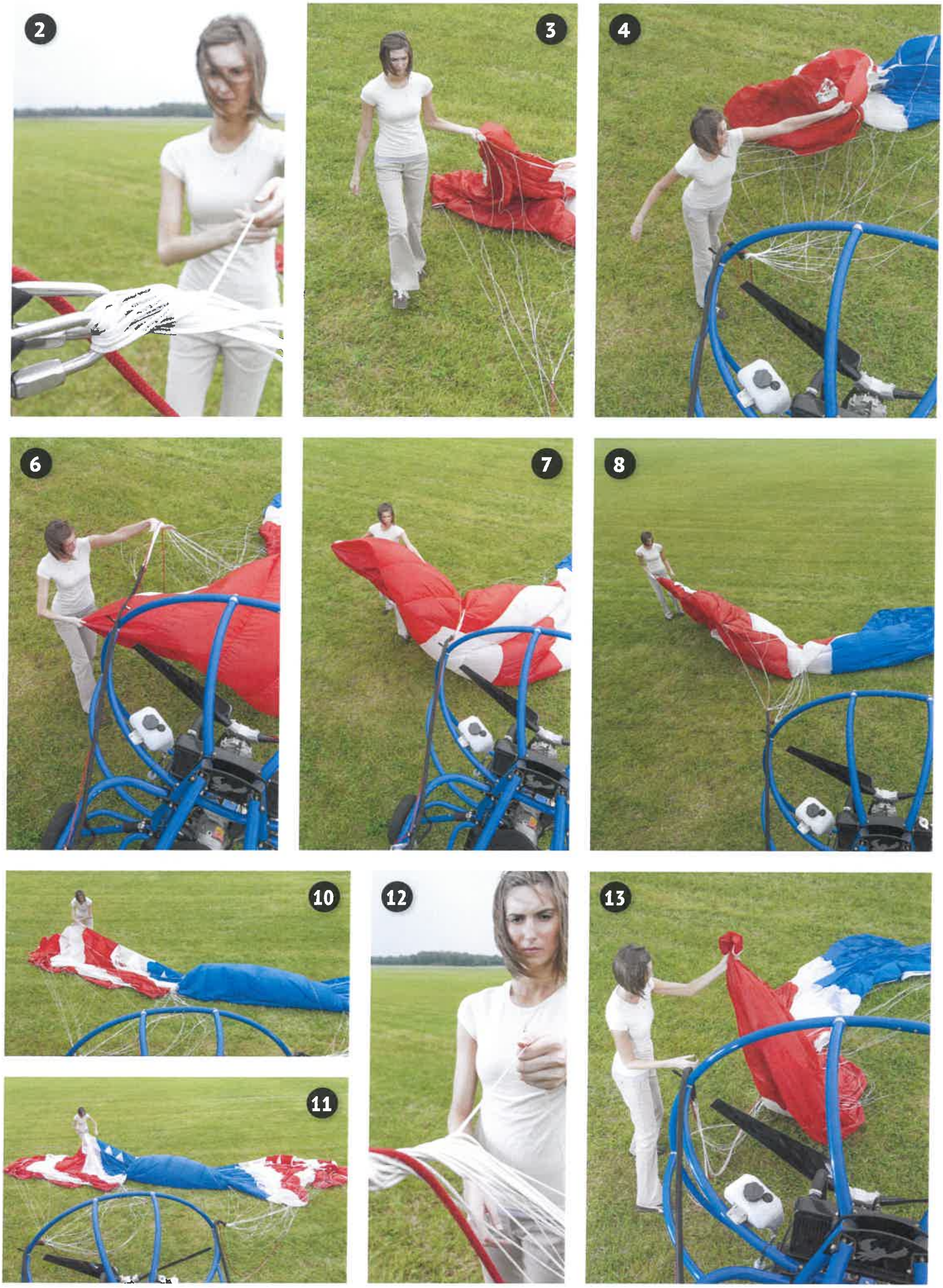
Lay out the half of the wing you just worked on and check the lines. If that side looks good and there are no twists, it means you can do the same thing to the other side of the wing. Perform the same sequence of checking for twist direction, grabbing the wing tip, 9 throwing it over (or under) the line set, and pulling it through. 10 & 11 It stands to reason that the twist will be in the opposite direction of the twist on the first set of lines you just cleared.

There's a possibility that the first side you worked on won't look good when you check it. It may look bad because the wing and lines are bunched up or you created a line-over. If that's the case, you need to spend time clearing them. If you're able to lay out the wing after clearing all tangles and it still doesn't look good, then it probably looks twice as bad as when you started. That's because you flipped that side of the wing the wrong way.

If that happens, take that same wing tip and pull it over or under the lines in the opposite direction to the one you first tried. That should get you back to where you started. Now you just need to do that one more time and that side of the wing will be OK when you pull it out. Then work on the wing tip and lines on the other side of the wing.

Disconnecting the wing from the risers or the wing from the airframe is not a safe practice for solving a line twist. You can introduce more mistakes by doing it that way.

This may sound confusing and it's best explained on a powered parachute by an instructor where you can practice the technique. The good news is that there are only two types of line twists, over and under, and with a little practice you'll be able to recognize a twist quickly and be able to correct it without wasting flying time.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Line-Overs

The line-over is one of the most dangerous things that can happen to your wing. It doesn't happen a lot, but if it does and you try to take off with a line-over, you risk very serious injury or death. It has happened before. I'm guessing I have your attention now!

A line-over is exactly what it sounds like. Instead of a wing's suspension line going straight from the riser system to the wing, it takes a trip over the top of the wing first. That means that when the wing inflates, the suspension line over the top of the wing will pinch the wing together and ruin the airfoil.

So how can you recognize a line-over before you take off? What you want to look for is a line that is twisted in with other lines on one or both sides of the wing. If you see that, your next step should be to inspect the leading edge and top of the wing closely. If you see a line wrapped over the top of the wing, you have found your problem. 1

You may think that after you find the line-over that you want to move the line over to the side of the parachute. The easier solution is to pull the parachute through the loop made by the line-over. 2 It may seem like a mess as you're doing it –actually a lot of these procedures look that way– but you'll find things sorting out after you get the errant line moved over to the side. 3 4 5

That raises the question, *"How do I know which side to pull the noncompliant suspension line to?"* The answer is to trace the line to its home line group (left or right riser) before you start pulling things around. Sometimes the side will be easy to determine because the line-over is either close to the left or right wingtip. When it's not, tracing the line is the best way to discover which way to pull the fabric.

Stowing the Wing

Packing the wing back into the wing bag at the end of your flight is a necessary task.

There are several methods used to stow a wing. Pilots with a skydiving background seem to gravitate towards folding their wing. It looks nice, but honestly there's very little value added in the process. Folding a parachute is critical for skydivers since they must put it into a container which they strap on for their next flight. They *"take off"* when they exit an airplane at 3,000 feet AGL or higher. The wing must deploy quickly, precisely and without any handling by the skydiver.

Powered parachute wings are deployed far differently. The wing is dumped onto the ground and spread out. Whether the wing is folded or stuffed matters very little in that deployment. The process of folding the wing takes time on the runway. At best, the pilot is working in either increasing darkness or increasing wind, depending on whether it was an evening or morning flight. Either way, extra time spent folding a wing on an active runway in dim light conditions isn't as safe as someone quickly stowing the wing and taxiing off the field.

Wing Stowing Process

Stowing a wing after flight is the reverse of the steps you take to deploy a wing for flight. First, reposition the wing behind the airframe if it hasn't already landed there. Next pull the steering lines towards the wing. The goal is to tighten them up and remove all the slack in them from the flaring process. You don't want to leave steering lines loose at the front of the airframe where they can drag on the ground or get in your way while taxiing.

Next, gather the suspension lines on one side by grasping where they attach to the riser and walk towards the center of the wing. 6 Then do that on the other side of the powered parachute. 7 Once you gather the lines, it'll be easy to place the line socks on the risers and suspension lines. The line socks are usually long enough that you can clip them onto the base of the riser strap at the airframe. 8 Then it's just a matter of zipping up the sock with the lines inside.

It's best to zip while keeping one finger below the zipper to make sure that a suspension line doesn't accidentally get caught and damaged in the zipper. 1

From there, pull the leading edges of the parachute towards the prop, leaving the trailing edge further back. This lines up the cell openings so that air will be forced out of them as you stuff the wing into its bag. 2

Get your wing bag and move to the trailing edge of the wing. From there, pull the wing evenly into the bag. 3 The wing will come to you as you stuff it, so you don't have to move forward until the end of the process. Also, the air in the wing will be forced out of the openings in the leading edge. 4 If you find yourself fighting air bubbles in the wing, that means that you haven't pulled it evenly into the bag.

Once the wing is in the bag, stand it up and move it a couple of feet closer to the rear of the airframe. 5 From there you can stuff any suspension lines that remain exposed and begin putting the line socks into the bag. 6 7 Before you get too close to the airframe, you'll need to flip one riser set over the airframe. 8

Then you move to one side of the airframe to stow the wing bag. Move a few feet, pause, and put the loose line socks into the bag. 9 Repeat that process until you're close enough to place the bag in the rear seat or suspend it from a bar on the airframe. 10


2


3


5


6


9


10

The wing bag is typically hung from the airframe or placed on the rear seat. Check with your manufacturer for the recommended stowing area.

Now begin zipping the bag. You should begin zipping the bag while it's on the ground and with both line socks coming out of the side of the bag which remains unzipped. Next you can place the bag in the seat or use the straps to hang it on the airframe. 1 Finish putting the line socks into the bag and use one of the bag's straps to secure the line socks against a frame member. This is so that the line socks won't come out of the wing bag during taxi or during a trip on an open air trailer. 2

If you use other straps or bungee cords to strap down the wing and/or line socks, place them on now. When finished, you're ready for your taxi back to the hangar or trailer.

Chapter 20 Departures and Climbs

Most incidents in powered parachuting seem to occur during the takeoff. This is because unlike most other types of aviation, a powered parachute needs to take a pile of fabric and strings and turn it into an airfoil before flight can be attempted. That process can be organized or chaotic, depending on several factors, many which you can control as a pilot.

The Pilot's Operating Handbook (POH) for a specific make and model of powered parachute provides essential procedures and details, including weight and balance settings, wing layout, and other important information for takeoffs and departure climbs. If the information in this chapter differs from the manufacturer's recommendations in the POH, always follow the manufacturer's guidance, as it takes precedence.

Whatever procedure you use, it's very useful to document it in a checklist. On powered parachutes, pre-takeoff checklists can be found as stickers on the airframe, contained in a phone or tablet application, or be a document you take along on a kneeboard. However the information is displayed, it's important that you refer to it before you commit to takeoff.

Terms and Definitions

Although much of the takeoff and climb is one continuous maneuver, it will be divided into five separate steps for purposes of explanation:

Staging—the portion of the takeoff procedure during which you position the powered parachute and set it up for takeoff.

Kiting— the portion of the takeoff procedure when you advance the throttle and initially inflate the wing.

Takeoff Roll (ground roll)—the portion of the takeoff procedure during which the powered parachute is accelerated from a standstill to an airspeed that provides sufficient lift for it to become airborne.

Liftoff (rotation)—the act of becoming airborne as a result of the wing lifting the powered parachute off the ground.

Initial Climb—begins when the powered parachute leaves the ground and you establish a rate of climb to move the powered parachute away from the takeoff area.

Normally, the process is considered complete when the powered parachute has reached a safe maneuvering altitude, or an en route climb has been established.

Staging

Before taxiing to the runway, you should ensure that the engine is operating properly and that the center of gravity is set in accordance with the powered parachute's weight and balance document. Even though you will perform the final checks in the staging area, it's normally a lot easier to make corrections at the hangar or trailer before you taxi away from your tools.

Make sure you understand the control systems for both the throttle and the ground steering before you start the engine. There's no convention for throttles. Some throttles are similar to airplane throttles, where you add power by pushing the throttle open. Others are completely opposite. Some steering control mechanisms are such that when you push the steering control lever left, the nosewheel steers left. Others look the same but operate completely opposite. Yet other machines use a steering lever located to the side of the pilot which needs to be pushed forward to steer right and back to steer left. And yes, others may be completely opposite.

Not thoroughly understanding the throttle and ground steering controls on a powered parachute before starting the engine can result in disaster if a you push the throttle while open while believing it's in the idle position.

When first beginning to taxi a powered parachute airframe equipped with brakes, test them for proper operation as soon as you begin rolling. Apply power to start the powered parachute moving forward slowly, and then retard the throttle and simultaneously apply pressure smoothly to the brakes.

§ 91.107 Use of safety belts, shoulder harnesses, and child restraint systems.

(a) Unless otherwise authorized by the Administrator—

(1) No pilot may take off a U.S.-registered civil aircraft (except a free balloon that incorporates a basket or gondola, or an airship type certificated before November 2, 1987) unless the pilot in command of that aircraft ensures that each person on board is briefed on how to fasten and unfasten that person's safety belt and, if installed, shoulder harness.

(2) No pilot may cause to be moved on the surface, take off, or land a U.S.-registered civil aircraft (except a free balloon that incorporates a basket or gondola, or an airship type certificated before November 2, 1987) unless the pilot in command of that aircraft ensures that each person on board has been notified to fasten his or her safety belt and, if installed, his or her shoulder harness.

(3) Except as provided in this paragraph, each person on board a U.S.-registered civil aircraft (except a free balloon that incorporates a basket or gondola or an airship type certificated before November 2, 1987) must occupy an approved seat or berth with a safety belt and, if installed, shoulder harness, properly secured about him or her during movement on the surface, takeoff, and landing. For seaplane and float equipped rotorcraft operations during movement on the surface, the person pushing off the seaplane or rotorcraft from the dock and the person mooring the seaplane or rotorcraft at the dock are excepted from the preceding seating and safety belt requirements. Notwithstanding the preceding requirements of this paragraph, a person may:

(i) Be held by an adult who is occupying an approved seat or berth, provided that the person being held has not reached his or her second birthday and does not occupy or use any restraining device;

(ii) Use the floor of the aircraft as a seat, provided that the person is on board for the purpose of engaging in sport parachuting; or...

Taxiing

Taxiing begins as soon as the pilot and passenger are seated in the powered parachute and the aircraft begins controlled movement under its own power. Before starting the engine, you should make sure that you and your passenger have your seat belts and shoulder harnesses fastened. There are two reasons to do this.

1. §91.107(a)(3) requires it.
2. It just makes good common sense. Powered parachutes are lightweight, high-powered machines. There have been cases when the aircraft got away from the pilot because of malfunctions or other reasons. It's far safer to be strapped into the airframe than to be thrown from the airframe and risk being struck by the propeller, the ground, or part of the airframe itself.

You taxi the aircraft to move it from one place to another. You can taxi with the wing stowed or with the wing inflated above you. If the wing is inflated, it's called *kiting* or *taxiing with the chute up*. During all ground operations it's important to keep your hand on the throttle and your feet on the steering bars. Don't dangle your feet. If you do, you risk your feet getting caught under the airframe and that could easily lead to broken ankles, feet, or legs. For the same reason, don't use your feet to slow or stop a moving powered parachute, even from low speeds.

Wind is not a factor when taxiing with the wing stowed. But if your wing is inflated or kited, follow the procedures for initial takeoff if taxiing in any wind.

While on the ground, the throttle directly controls your groundspeed. Don't taxi too fast. It's not a race and if you're moving too quickly you will make other pilots nervous, particularly airplane pilots who have limited visibility compared to you.

What may seem like a safe and natural speed for you, may be distracting to pilots of other aircraft that are used to slower taxi speeds.

It's difficult to set any rule for a single, safe taxiing speed. What's reasonable and prudent under some conditions may be hazardous or imprudent under others. While going too fast on turf fields, you may encounter holes or ditches that could damage the suspension. Limit your speed depending on the smoothness of the turf field. But while taxiing quickly on turf is bumpier, the aircraft will slow down quickly when you reduce power.

Taxiing quickly on hard surfaces is smooth, but that smoothness means that when you're ready to slow down or stop you will be relying more on your brakes. Many powered parachute braking systems are lightweight, which makes them easy to overheat. That means that you normally want to keep engine power low to avoid overheating the brakes.

Rather than continuously riding the brakes to control speed, it's better to apply brakes only occasionally. The throttle should be at idle before the brakes are applied. It's a common error to taxi with a power setting that requires controlling taxi speed with the brakes. This is the aeronautical equivalent of driving an automobile with both the accelerator and brake pedals depressed at the same time. Stop the powered parachute with the nosewheel straight ahead to relieve any side load on the nosewheel and to make it easier to start moving ahead when you are ready to go again.

When taxiing, it's best to slow down before attempting a turn. Sharp, high-speed turns place undesirable side loads on the landing gear and may result in an uncontrollable swerve or a rollover. Your powered parachute airframe may look like a high-performance go-kart and it does have a lot more power and a higher power to weight ratio than most ground vehicles. But it also has a higher center of gravity along with ground steering, wheels, and braking systems that aren't designed for high speeds. This combination can create dangerous situations at high speed.

Be courteous and keep track of your prop blast. You don't want to accidentally direct it into hangars, onto airplanes, or at the deployed wings of other powered parachutes.

Taxiing to the Staging Area

Take care when taxiing to your staging area. Begin by proceeding at a cautious speed on congested or busy ramps. After you leave the ramp area, you may need to cross active runways or taxiways to get to the area designated for powered parachute operations. That means understanding radio communications and keeping your eyes and ears open. Remember that you probably have far more visibility than a pilot in a typical airplane. Be aware of the entire area around your powered parachute to make sure that you will clear all obstructions and other aircraft. A common mistake is to forget how wide the back end of a powered parachute is and risk running into things like taxiway or runway lights. If at any time there's doubt about the clearance from an object, you should stop your powered parachute and verify clearance.

At uncontrolled airports, you should announce your intentions on the common traffic advisory frequency (CTAF) assigned to that airport. When operating from an airport with an operating control tower, you must instead contact the tower operator and receive a clearance before taxiing to the active runway.

Staying aware of other aircraft during takeoff, landing, or taxiing is essential for safety. When taxiing, keep a lookout in all directions, including above, to spot aircraft approaching the runway. Be mindful of your entire surroundings to ensure your powered parachute clears all obstructions and other aircraft. Follow yellow taxiway centerline stripes when available, unless you need to avoid obstacles or other airplanes.

The key requirements for safe taxiing are maintaining positive control, recognizing potential hazards early enough to avoid them, and being able to stop or turn as needed without over-relying on the brakes. You should be that much more cautious if your powered parachute doesn't have a braking system.

Choosing the Departure Position

The ideal departure area for a powered parachute is an open grassy area clear of debris and obstacles with a groomed, even surface. You should avoid concrete and asphalt surfaces, as well as lit runways. Concrete and asphalt abrade the wing as it's being kited. The wear on the wing shows up on the top panels in the area near the trailing edge. That wear is especially bad if you use an inverted wing layout since it drags the top of the wing on the surface as you kite. Runway light fixtures can pose a hazard if your powered parachute veers off to the side while kiting the wing. Striking one of these fixtures can cause damage to both the aircraft and the light.

Powered parachutes normally don't take off where the rest of the airport traffic takes off. This is to help both powered parachute pilots and the pilots of other aircraft. It's not considered polite or safe to tie up an active runway and a powered parachute requires some time to set up and depart. If you're sharing a runway with airplanes, it's best to stage at the edge of a grass runway or on an undeveloped area next to a paved runway. As much as possible, you want to stay well away from the centerline of an active runway.

Another reason powered parachute pilots typically don't use standard runways is that you want as much as possible to set up into the wind to avoid a crosswind takeoff. While crosswind takeoffs are possible, they're usually unnecessary due to the short-field capabilities of a powered parachute. You should do your best to point the aircraft into the wind before you lay out the wing.

While selecting a takeoff position, make certain the approach and takeoff paths are clear of other aircraft, or will be clear by the time you set up. Fences, power lines, trees, buildings, and other obstacles shouldn't be in your immediate flight path unless you're certain you will be able to safely take off and clear them well before you reach them.

Normal Takeoff

A normal takeoff involves positioning the powered parachute into a light to moderate wind. The takeoff surface is firm, free of debris, and long enough to allow for a quick acceleration to liftoff and climb-out speed. Additionally, the takeoff path is clear of obstructions to ensure a safe ascent.

There are four key reasons for taking off as nearly into the wind as possible.

1. The headwind helps inflate the wing.
2. There's less chance of your wing blowing over to the side while kiting.
3. The ground speed of the powered parachute is significantly lower compared to a downwind takeoff, which makes the aircraft easier to control during the takeoff roll.
4. A headwind reduces the ground roll, allowing the powered parachute to achieve the necessary lift with less runway. Since powered parachutes rely on airspeed to fly, the headwind contributes to that airspeed by flowing over the kited wing, even if the powered parachute itself is not yet moving much.

Positioning the Aircraft

It can't be emphasized enough that proper positioning of your powered parachute before you do anything else is key to success in taking off without incident. Once you select a departure area, you should position the aircraft into the wind at the furthest position downwind on the field in order to allow for as much room as possible for takeoff. Confirming that you're pointed directly into the wind can be done by throwing a bit of grass or debris into the air and observing which way the wind takes it. If possible, pick a position where you'll be able to see some sort of wind indicator (preferably a windsock) from the seat of your powered parachute. Otherwise, you can't tell which way the wind is blowing after you start your engine.

Once you've positioned your airframe, you can lay out your wing (see *Chapter 19, "Parachute Layout and Stowing"*). Since this process can take some time, especially at the beginning of your training, keep an eye on potential wind changes. A significant shift in wind direction might require you to adjust the airframe's orientation or taxi to a new position on the field.

Kiting

After you lay out your wing, you should get back into the powered parachute, buckle in, perform any preflight checks you need to make, announce your takeoff over the radio and finally start the engine. You'll want to be holding onto the wheel brakes or brace the airframe with your feet before starting the engine. That's so you don't roll forward early and prematurely inflate the wing.

If you took a while to lay out the wing on a cold day, you may need to bring the engine back up to operating temperature. If you suspect that the engine needs additional warming up, you should wait until the engine is warm before announcing your intent to take off. Instead, use that warm-up

Photo sequence showing a normal takeoff.

Positioning the powered parachute for takeoff should take into consideration the direction of the wind, obstacles, and the ability to see man-made or natural wind indicators.

time to listen to the radio, straighten the nose-wheel, make any other appropriate last-minute checks and then finally announce your intent to take off. However, you should be ready to fly if the wing begins to kite prematurely. If the wing begins inflating, it's time to either start your takeoff roll or shut down and start over, depending on engine temperature.

Before releasing the brakes (or raising your feet off the ground), you should make a final check to make sure that the airframe is still pointed into the wind and that nothing has moved into your intended takeoff path. After that, you should look over your shoulder so that you can observe the wing inflation. Then release the brake and advance the throttle smoothly and firmly to about one half to two thirds takeoff power.

Too abrupt an application of power may cause the airframe to yank the wing too roughly forward. This can damage the riser system and shorten wing life. This is more of a problem with higher-horsepower engines than in lower-powered aircraft. As the airframe starts to roll forward, you should put your feet on the steering bars in order to be ready to steer the wing right away.

You may notice that one side of the wing inflates and kites before the other side. There are two strategies for dealing with that. One is to adjust your engine speed. If you're running too high of a throttle, then the lift from the off-center wing may tip you over. If your throttle setting is too slow, that may be causing the wing to slip down on one side. An ideal throttle setting will provide enough airspeed over the wing to allow it to straighten itself up and center over the airframe.

If you're at the correct throttle setting and the parachute is still pulling to one side, the rudder tube for the higher side should be pushed in order

to steer the wing overhead. If you don't make the correction early, the wing will tend to want to fly over to the slower inflating side. This may create wing oscillations, especially if combined with too slow a takeoff speed. While it's important to not overcontrol while kiting the wing, remember that steering controls during kiting are sluggish and more control inputs are needed than during flight.

Now's the most critical point during takeoff and possibly during the entire flight. While the wing is inflating, most of the powered parachute's weight is still being carried by the wheels and the suspension system. The goal is to get the wing overhead and then transition the load from the wheeled suspension to the wing.

During the takeoff roll, you need to divide your attention between the direction the airframe is going and the wing. This is when a procedure called the *rolling preflight* is performed. You need to quickly inspect the wing to make sure that it's fully inflated and that there are no line-overs, end cell closures, pressure knots, or huge oscillations before adding full power for takeoff. This all must be done quickly.

Items to Check During Kiting and Rolling Preflight

While the list of things to monitor during takeoff may seem extensive, it's important to remember that anything appearing abnormal or different from a properly inflated wing is a signal to either extend the takeoff roll, allowing time for the issue to resolve, or to abort the takeoff entirely. Some launching problems cannot work themselves out. In cases where the problem may be able to work itself out, you may not have enough runway left to allow that to happen. Aborting a takeoff is frustrating, but is sometimes the best course of action.

Things you should watch for while kiting your wing include:

- Lines Caught Under a Wheel
- Wing Lockout
- Rolling Metastable Stall
- Restricted Lines
- Line-Overs
- Pressure Knots
- End Cell Closures
- Wing not Centered
- Wing Oscillations

Lines Caught Under a Wheel

It's important when laying out the wing to make sure that the risers, steering lines, and suspension lines are all clear of the rear wheels. If they aren't, the wheels may roll over them at the beginning of the takeoff roll. If this happens, immediately shut the powered parachute down and lay out the wing again. This is not a problem that can solve itself after it happens. In fact it may drag parts of the wing into the spinning propeller, causing expensive damage to the lines, propeller and possibly the airframe.

Wing Lockout or Wall

A wing lockout occurs when the wing initially inflates but the trailing edge remains on the ground. The term *wall* refers to the wing taking on a wall-like appearance behind the airframe. The trailing edge of the wing remains on the ground, while the leading edge forms the top of the wall.

Although some pilots may attempt to *pop* the wing out of the lockout, the safest approach is to immediately abort the takeoff and re-layout the wing. Trying to force the wing out of the lockout through abrupt throttle movements increases the risk of lines getting entangled in the propeller. That in turn can lead to damaged lines and propeller blades.

That's because when the wing's trailing edge seals with the ground, any increase in throttle results in the increased thrust being immediately absorbed by the wing. Since the thrust is pushing straight into the inflated wing, the airframe cannot roll forward. The powered parachute has reached an equilibrium with the wing pulling rearward as much as the propeller is pushing forward.

Parachute lockout occurs when the trailing edge of the parachute seals with the ground.

Metastable stall occurs when the parachute locks in a 45° angle from the horizontal.

If the trailing edge of the wing does break free of the surface while the engine is at a high throttle setting, that could create problems of its own. The wing will likely surge upward and forward. That may allow it to overfly the airframe (which will take longer to get rolling) or fly to the side. That may result in at best an uncontrolled situation and at worst a rollover.

By shutting down and setting up the wing again, you'll avoid the expenses associated with repairs.

Rolling Metastable Stall

A rolling metastable stall occurs when the initial forward momentum is insufficient to move the wing through the prop-wash and up and above your airframe. During this phenomenon, the inflated wing will hang at about a 45° angle behind the airframe while the airframe rolls forward. This is a *metastable stall* while the aircraft is still on the ground. Usually, regardless of how much the throttle is increased, the wing will stay in a metastable stall behind the airframe because the force of the induced drag of the wing in that 45° angle of attack changes to match the thrust of the engine.

There are two techniques that you can use to correct a metastable stall while the aircraft is still on the ground. These techniques can be used separately or together:

1. Lower your throttle until the wing begins to fall behind your airframe. Then before the wing touches the ground, smoothly and firmly increase the throttle to increase the groundspeed and rotate *(slingshot)* the wing up and above the airframe.
2. Maintain a moderate throttle setting and flare the wing by pushing both foot steering bars. Hold your flare until the increased drag on the tail of the wing pulls the wing back down—about a 60° angle— and then smoothly release the flare. The release of the flare will again slingshot the wing up and above the airframe.

Consult your instructor to determine the most suitable technique for your powered parachute. Understanding the different characteristics of powered parachute wings is essential in best addressing a rolling metastable stall effectively.

Just as important, you should check your steering line rigging if rolling metastable stalls happen on a regular basis. Regular rolling metastable stalls are an indication that the steering lines are rigged too tight. That could lead to other problems in flight, including an in-flight metastable stall.

Restricted Lines

Risers and steering lines can become caught on an outrigger tube, in a pulley, or on anything that's in their immediate area. Restricted lines can be hard to discover because they may be out of sight from where you're sitting in the flight deck. Your only indication may be that a steering bar isn't working properly.

If this happens while still on the ground, it's often possible to correct while still rolling forward. You should correct it while traveling well below takeoff power, but still fast enough to keep the wing flying overhead. Then you can reach out and push the steering line off the obstructing object. If you can't correct the restricted line, you should shut down and lay out the wing again.

If you take off with restricted lines, your powered parachute may go into a steep bank to the side that's restricted. It's very important to check and double-check your wing layout and steering lines before you attempt a takeoff.

Line-Overs

Line-overs are caused by one or more of the suspension lines crossing over the top of the wing instead of going straight down to the riser or airframe. Line-overs are very easy to detect because the wing will be obviously deformed. The wing will look like it's pinched wherever the line-over occurs. If you see a line-over, there is no real cure for that without shutting down and setting up again. Attempting to take off with a line-over is extremely dangerous and results in an uncontrolled high-banking turn to the side of the line-over. Attempting flight with a line-over has resulted in serious injuries and even fatalities.

Pressure Knots

While suspension lines are loose on the ground, they occasionally get some debris caught in them. When the lines tighten up during kiting, the effective length of the lines are shortened because of being twisted in the debris. Some styles of suspension lines are abrasive and may get twisted in with neighboring lines, also resulting in a pressure knot when the wing kites and the lines tighten up.

Taking off with a pressure knot will result in the powered parachute turning very sharply to the side of the pressure knot. It may be nearly impossible to correct for that turn without nearly stalling the wing with input on the other side. The engine will have to be kept at a very high setting just to maintain what little altitude is gained.

Pressure knots are difficult to see during a rolling preflight. It's hard to see what's going on with the lines themselves, so you should look for deformations on the bottom surface of the wing caused by a tangled line puckering the wing fabric downward compared to its neighboring lines. If you see wing deformations like that, shut the aircraft down and lay out the wing again. After the lines relax, the debris may fall out of the lines, but they should be inspected closely anyway.

Wing Not Centered Overhead

You shouldn't attempt a takeoff before your wing is centered above the airframe. If the wing is not centered above you, then you should:

- Keep steering into the wind, and
- Remain below takeoff speed.

One of the most important things you're doing during the takeoff preflight roll is verifying that the wing is positioned correctly overhead. Wings are designed with features like crossed center suspension lines to help wings seek their proper position. Wings also naturally want to weathervane into the wind. If you don't rush the takeoff roll and give the wing the time and speed it needs to adjust and settle overhead, the takeoff will be fine. The wing wants to be centered over the airframe and pointing into the wind, making it best to steer into the wind during the entire takeoff roll.

You can adjust the wing's position during your takeoff roll once the wing is up and rotated past the 45° position. When the wing is down on one side, apply steering input to the opposite side. For example, if the wing is hanging down on the left side of the airframe, push on the right steering bar. The additional drag and lift created on the right side will begin to pull the right side of the wing over to a more centered position, and along with it, the rest of the wing.

Once the wing begins to come up from the side and center, it will generate some inertia which can lead to it oscillating to the other side of the airframe. To compensate for the inertia of the wing's movement as it's traveling upward, reduce the initial steering bar pressure, just before (not when) the wing is centered overhead. Then slowly add slight opposite steering bar pressure to compensate for possible over-correction of the wing to the other side.

That said, you don't normally need to steer the wing to center it over the airframe. The design of the wing and its attachment points create the tendency for the wing to position itself properly. You need only to steer the airframe into the wind, allow the time needed for the wing to self-correct, and provide the proper groundspeed to achieve proper wing position prior to takeoff.

End Cell Closures

End cell closures are usually self-correcting, given time. Most modern powered parachute wings have large cross-venting ports in the ribs to allow the whole wing to pressurize evenly. Generally, the wing will pressurize in the middle first. As the pressure evens out across the wing, sometimes the wingtips don't inflate right away. If they aren't inflated immediately, taxi a little longer to give the entire wing a chance to pressurize.

It's critical that the end cells are inflated before taking off. Some wing manufacturers recommend that the rudder tubes be *pumped* to help open the end cells. You do that by pushing and releasing the rudder tubes quickly.

Parachute line-over.

Wing Oscillations

A wing oscillation refers to a back-and-forth motion of the wing, moving from left to right and back over the airframe. Wing oscillations occur for several reasons. There may not have been enough power added initially to kite the wing, or the pilot may have waited too long to correct for a wing that was flying to one side. Perhaps the pilot overcorrected for a wing flying to one side.

Small oscillations are OK and will merely lift one side of the airframe into the air before the other. Big oscillations will change the lift from a straight upward vector to an upward and side-pulling force. If too much power is added when the wing is off to the side of the aircraft, it can result in the wing pulling the airframe over.

Oscillations are easier to prevent by using good inflation techniques than they are to correct. But if a wing is oscillating, it's possible to correct using steering control by steering opposite to the side that the wing is oscillating towards. As soon as the wing begins moving to the other side, opposite correction is needed to arrest that movement. Arresting a wing's oscillations requires some skill because the wrong inputs can make the problem worse rather than better. If the oscillations become too severe, it's best to abort the takeoff and set things up again.

Takeoff Roll

Once you make a commitment to take off, it takes a minimum airspeed to keep the wing inflated. Inflating the wing, then cutting the power, will usually result in the wing deflating and falling from the sky. That can be difficult to recover from and should only be done if you wish to abort the takeoff.

Otherwise, as the speed of the takeoff roll increases, more and more pressure will be felt on the rudder control tubes. It's important during this time to keep the wing moving in the same direction as the airframe. That sometimes means using the ground and flight controls to keep the airframe and the wing coordinated.

Eventually the nose of the airframe will rise from the ground making nosewheel steering ineffective. That means that even though the back wheels of the airframe are still on the ground, you will only be able to steer the airframe by steering the wing. Nowhere during this process should you attempt any kind of tight radius turn.

Liftoff

Once the wing is overhead and enough power is added, the powered parachute will lift off the ground. There are no special controls or procedures needed at this point since the aircraft flies at a set airspeed and manages its angle of attack and flight angle automatically depending on the amount of power added.

Normal climbs will use just extra power to lift off the ground and climb.

Initial Climb

Once the powered parachute is off the ground, it's important to maintain at least the same throttle setting that got the powered parachute flying in the first place. When the powered parachute is free of the drag of the ground acting on the landing gear, it will begin to climb.

Once the airframe is off the ground, prop torque will become very noticeable. It will want to pull the aircraft to one side or the other, depending on which way the prop spins. During initial climb, it's important to keep the takeoff path aligned with the runway to avoid drifting into obstructions or the path of another aircraft taking off from a parallel runway. Using proper scanning techniques enhances safety by helping maintain direction and ensuring collision avoidance in the busy airport environment.

When you first solo a powered parachute, its takeoff performance will be much different without the weight of an instructor on board. Due to decreased load, the powered parachute will become airborne sooner and will climb more rapidly. The pitch attitude that you learned to associate with initial climb will also change, and the flight controls may seem more sensitive. You want to be prepared for that so that it doesn't add to the tension of your first solo. You don't want to think that something is wrong with the powered parachute or that the takeoff was somehow abnormal.

Parachute oscillations.

Takeoff Errors

Common errors during normal takeoffs and departure climbs are:

- Failure to adequately clear the area prior to taxiing to the staging position.
- Poor selection of a staging position. (Not allowing for enough takeoff area).
- Failure to set up into the wind.
- Abrupt use of the throttle.
- Not using enough power to kite the wing.
- Failure to observe the wing during inflation.
- Failure to perform a rolling preflight.
- Failure to anticipate the powered parachute's turning tendency on initial climb.
- Over correcting or under correcting for turning tendency.

Crosswind Takeoff

Powered parachutes have very limited crosswind capability. So much so that it's always advisable to take off directly into the wind. If the wind is slowly changing direction and the powered parachute is positioned to take off into a crosswind, it's better to wait and see if the winds will change back to headwinds before committing to a takeoff. If winds are changing direction very quickly, the flight should be canceled. If the winds change quickly during a takeoff roll, things could get hazardous.

Sometimes there's only one runway, and the winds are blowing cross to it. It's still possible to take off, but it will still involve positioning the powered parachute so that the initial inflation and roll will be into the wind. If you fly at a field that has only one main runway, you must be familiar with these principles and techniques involved in crosswind takeoffs or not fly when there is a crosswind.

Positioning the Aircraft

In all but the lightest of crosswinds, it's still a good idea to position the powered parachute into the wind. Once the parachute is inflated and kited, it will be possible to steer both the airframe and the parachute down the designated runway area. Several feet should be allowed for the initial parachute kiting and turn. The wing should be laid out as it would for a normal takeoff.

Kiting

The initial inflation and kiting when the wind is blowing across the runway should be done as it would be for a normal takeoff. The main difference is that as soon as the wing is overhead and flying, it should be steered along with the airframe into the direction desired for takeoff. This procedure is one that requires some practice because it requires coordinated controls for the ground steering and the wing. Also, the wing needs to be stabilized and producing some lift before the turn is attempted. That may mean a more aggressive than normal kiting if the area is tight.

Takeoff Roll

The technique used during the initial takeoff roll with a crosswind is generally the same as used in a normal takeoff, except that some steering bar control must be held to the side from which the crosswind is blowing. This will help keep the wing from pulling the airframe to the other side or away from the centerline of the runway. It's important that there's sufficient airspeed over the wing to create lift. Otherwise, the wing will tend to fall towards the downwind side of the airframe. That exposes the powered parachute to a rollover since the wind will be blowing into the bottom of the wing that is now acting as a sail.

Things will usually be happening very fast during a crosswind takeoff, but it's still important to do a rolling preflight.

Liftoff

As the nosewheel lifts off the runway, the steering control for the powered parachute is transferred fully to the flight controls.

If a significant crosswind exists, it will take longer for the powered parachute to take off because of the steering control added to one half of the wing. This may be naturally compensated for by the headwind component of the wind as well as the tendency for the deflected side of the parachute to act as a flared wing.

As both main wheels leave the runway and ground friction no longer resists drifting, the powered parachute will be carried sideways with the wind unless you maintain adequate drift correction. Therefore, you should establish and maintain the proper amount of crosswind correction prior to liftoff by continuing to apply rudder pressure as needed to prevent weathervaning.

Initial Climb

If you're properly correcting for crosswind, the airframe will rotate so that it's lined up with the wing as soon as you're airborne. You should continue to use the steering bar to correct for the crosswind and keep the powered parachute moving straight down the intended takeoff path.

The force of a crosswind may vary markedly within a few hundred feet of the ground. You should make frequent checks of actual ground track and correct for the changing wind as necessary. The remainder of the climb technique is the same used for normal takeoffs and climbs.

Crosswind Takeoff Errors

Common errors during crosswind takeoffs are:

- Failure to adequately clear the area prior to taxiing into the staging position.
- Poor selection of a staging position.
- Not allowing for enough takeoff area.
- Not allowing for enough area to kite the wing and turn to the intended takeoff path.
- Failure to set up into the wind.

- Not using enough power to kite the wing.
- Failure to observe the wing during inflation.
- Failure to perform a rolling preflight.
- Failure to attain enough airspeed to load the wing properly before turning and aligning with the intended takeoff path.

Short-Field Takeoff

Takeoffs and climbs from fields where the takeoff area is short, or the available takeoff area is restricted by obstructions, is not optimum. The first recommendation is to seek a more appropriate field because a short-field takeoff requires you to operate your aircraft at the limit of both your capabilities and the powered parachute's takeoff performance capabilities. By its very nature, you're reducing safety by flying from a short field.

To depart from such an area safely, you must be able to kite the wing quickly so that runway length isn't used up unnecessarily.

Positioning the Aircraft

Taking off from a short field requires the takeoff to be started from the very beginning of the takeoff area. You need to align the powered parachute with the intended takeoff path. Lay out your wing like you would for a normal takeoff.

Kiting

Your initial kiting should be more aggressive than it would be for a normal takeoff. Before the engine is even started for takeoff, you should establish an abort line. If the wing isn't kited and ready to fly by the time you reach that line, you should abort the takeoff attempt.

There's an alternative if a your taxiing skills are up to the task, winds are low, and the field is wide. Then you can kite the wing normally, but then turn around and return to the starting point with the wing kited and ready to fly. That way more of the takeoff area can be used for the actual takeoff roll.

Takeoff Roll

If there's adequate room for takeoff after the wing is kited, then you should increase to full power. You should have another abort line where if the powered parachute isn't in the air by the time it crosses that line, then you should abort the takeoff. The position of the abort line should be determined using information provided in the Pilot's Operating Handbook, if available. The line is measured from the obstacle and is based on the powered parachute, the gross weight, the density altitude, the quality of the field, and the height of the obstacle you need to avoid.

Liftoff

You can use a little flare to break free from the ground earlier than would otherwise happen. It's important to have adequate forward speed before you attempt the technique. Just as important, you shouldn't release the flare quickly after the powered parachute has left the ground, otherwise the airframe may quickly settle back onto the runway. Instead, you should slowly release the flare while maintaining full power.

Initial Climb

On short-field takeoffs, it's important to maintain full power until the powered parachute is clear of obstacles. Remember that a powered parachute normally turns to one side during climb due to torque. Rather than trying to correct for that turn, it's often best to allow the powered parachute to turn. That's especially true if the turn will help you clear the obstacle.

If the inherent turn from torque won't help you clear the obstacle, it's sometimes better to add even more turn control to clear the obstacle rather than to cross-control the aircraft by trying to turn opposite to the torque. The bottom line is that the more turning input you add to the wing in either direction, the more you potentially decrease the rate of climb.

Taking off with a crosswind.

Short-Field Takeoff Errors

Common errors during short-field takeoffs and maximum performance climbs are:

- Failure to adequately clear the area.
- Failure to consider all available runway/takeoff areas.
- Taking too long to kite the wing.
- Attempting to flare the wing before building up enough speed.
- Target fixation on an obstacle resulting in steering right towards it.

Soft or Rough Field Takeoff

Takeoffs and climbs from soft fields demand specific techniques to get a powered parachute airborne quickly, reducing drag from tall grass, soft sand, mud, or snow. These takeoffs may or may not involve clearing an obstacle. The technique involves careful use of flare and requires a keen feel for your powered parachute along with precise control. These techniques are also valuable on rough fields, where getting a powered parachute off the ground promptly helps prevent damage to the landing gear.

Soft surfaces or long, wet grass can significantly slow a powered parachute's acceleration during takeoff, making it difficult to reach adequate takeoff speed with normal techniques. This issue is further amplified when a powered parachute is equipped with wide or soft tires, which increase resistance and reduce acceleration even more.

The correct takeoff procedure for soft fields differs significantly from that for short fields with firm, smooth surfaces. On soft or rough fields, the primary goal is to transfer the powered parachute's weight from the wheels to the wing as quickly as possible to minimize the drag and hazards associated with these surfaces. You do this by using appropriate flare.

Takeoff Roll

With your powered parachute aligned with the takeoff path, you apply takeoff power smoothly and as rapidly as the powerplant will accept it without faltering. The extra power is needed to overcome the resistance of the surface. As you accelerate the airframe, the wing should be kited as quickly as possible.

After you've accelerated to about 80-90% of the normal takeoff speed, you can add a touch of flare to increase the angle attack of the wing. If done properly, this adds enough lift to help break free from the ground. This technique works even better if you use the terrain to the highest advantage. If your takeoff roll takes you over a small rise in the terrain, the ideal place to add the flare is right at the top of the rise.

Liftoff

After you become airborne, you should gently release the flare. The release of flare will decrease both the lift and the drag on the wing. Exercise extreme care while releasing the flare immediately after you become airborne and while accelerating, to avoid settling back onto the surface.

Releasing the flare too soon or too quickly will result in the aircraft settling back onto the ground. Preventing that requires a feel for the powered parachute, and a very fine control touch, to avoid overcontrolling the flare.

Initial Climb

After you establish a positive rate of climb, you should take care to avoid obstacles in the path of flight. Some of the same techniques used during a short-field takeoff may be appropriate.

Soft or Rough Field Takeoff Errors

Common errors during soft/rough field takeoffs and climbs are:

- Failure to adequately clear the area.
- Insufficient forward speed before attempting to use flare to break free of the runway.
- Flaring too much or not enough.
- Not taking advantage of the terrain.
- Releasing flare too early, allowing the powered parachute to *mush* or settle, resulting in an inadvertent touchdown on the soft surface after liftoff.

Takeoff Emergencies

Rejected takeoffs and engine failures during takeoff and climb are considered emergencies and are covered in *Chapter 27, "Emergency Procedures."*

Takeoff Performance

The most critical takeoff conditions arise from a combination of factors such as high gross weight, altitude, temperature, and unfavorable wind. These elements can significantly reduce the performance of the powered parachute, making it more difficult to achieve liftoff and climb safely. High gross weight increases the amount of lift needed, while high altitude and temperature reduce air density, decreasing engine performance and lift. Unfavorable winds, especially tailwinds, further hinder acceleration and lift generation.

Specific factors are:

- Density altitude.
- Gross weight.
- Wind.
- Runway slope and condition.
- Parachute model and condition.

Takeoff performance is covered in detail in *Chapter 14, "Altitude and Performance."*

Chapter 21 Approaches and Landings

Landings are your chance to shine. Landings are obviously important from a practical point. Every flight needs one. However, the way you end a flight when you have a passenger leaves a lasting impression on them. Honestly, most passengers don't expect too much and many pilots meet those low expectations. But if you can learn to nail your landings by landing where you want to be and softly, you will cap a great passenger experience. Passengers remember takeoffs and landings the most and you want to give them the best.

Not to mention that great landings are easier on your aircraft and on your own back. They're worth spending time to perfect and a good instructor will spend a lot of time coaching you through them. Yes, we keep gravity on, and you will always come down. But knowing how to set up a landing and mastering the all-important flare takes time, practice, and feedback from your instructor. Great landings can become one of the most fun and satisfying parts of flying for you.

The manufacturer's recommended procedures, including center of gravity, rigging, and other information specific to approaches and landings for a particular make and model of powered parachute, can be found in the Pilot's Operating Handbook (POH). If any details in this chapter differ from the manufacturer's guidelines, the manufacturer's recommendations should always take precedence

Normal Approach and Landing

A normal approach and landing involve following standard procedures under typical conditions. This includes having engine power, light winds or headwinds on final approach, a clear path with no obstacles, and a firm, level landing surface that provides enough distance to bring the powered parachute to a gradual stop. Ideally, the landing point should be just beyond the runway's approach threshold but within the first one-third of the landing area to ensure a safe and controlled landing

Procedures for a normal approach and landing also have applications to the other-than-normal approaches and landings. The last part of the approach pattern and the actual landing can be divided into five phases:

1. Base Leg
2. Final Approach
3. Roundout
4. Touchdown
5. After-Landing Roll and Wing Grounding

Base leg and final approach.

Base Leg

Deciding where to fly your base leg is a key judgment in any landing approach. You must accurately assess the altitude and distance needed for a gradual descent to reach your intended landing spot. This distance depends on both the altitude of your base leg and wind conditions. In strong winds, you'll need to turn onto the base leg closer to the approach end of the runway than in lighter winds.

You need to correct for drift to maintain a ground track perpendicular to the runway's extended centerline. Since the final approach and landing are typically made into the wind, the base leg often involves a crosswind. To prevent drifting away from your landing target, steer the powered parachute into the wind as necessary.

Continue the base leg until you can make a medium to shallow-banked turn to align with the runway centerline. Make this descending turn at a safe altitude, factoring in the terrain and any obstructions. Ensure the turn to final approach is made high enough to allow for an accurate estimate of the touchdown point, with enough room for a controlled descent. Careful planning is essential regarding when to begin the turn and the radius required.

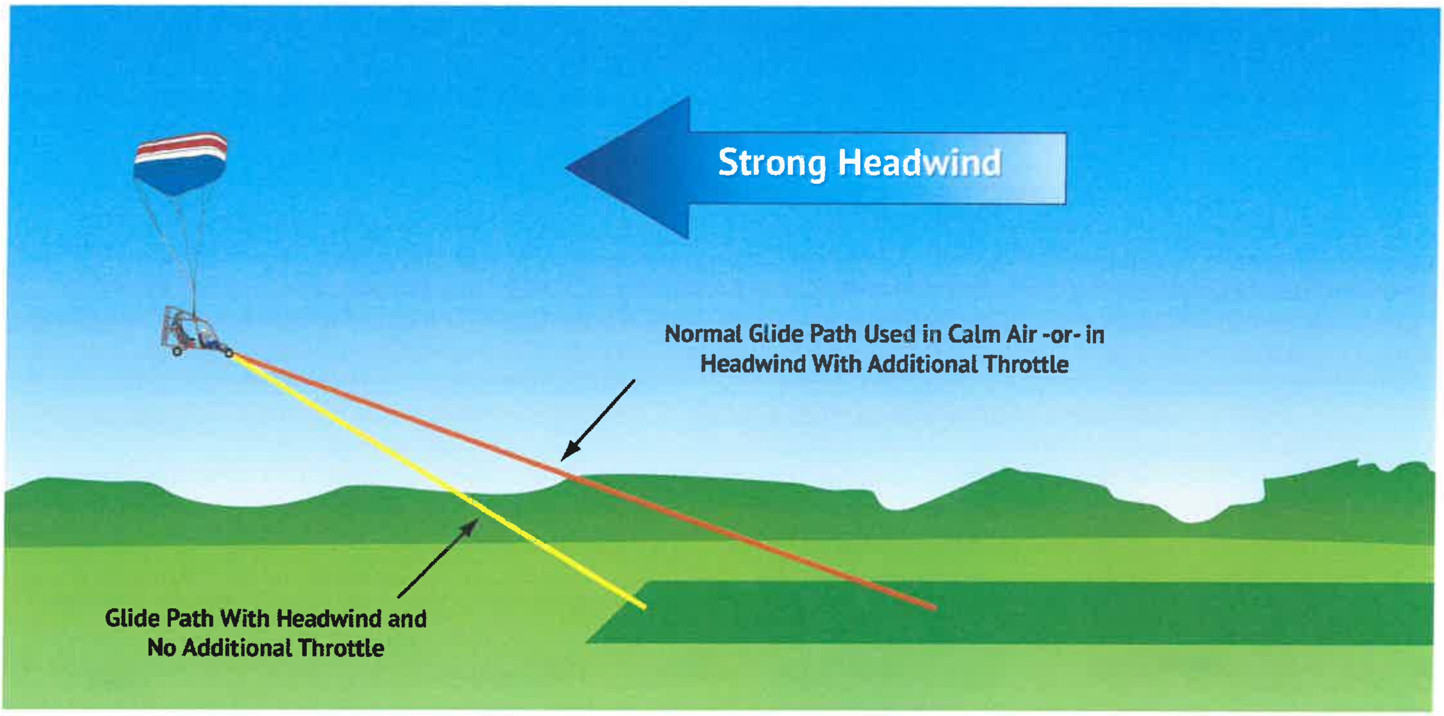
Avoid exceeding a medium bank angle, as steeper banks cause faster descents. Given the relatively low altitude of the base-to-final turn, avoid making abrupt or radical movements. If a steep bank is necessary to avoid overshooting the final approach, it's safer to go around and try again. On the next attempt, plan to start the turn earlier to avoid overshooting

Final Approach

After completing the base-to-final turn, you should be aligned with the runway or landing surface centerline. From this point, you can check for any drift. On a normal approach, with no wind drift, the aircraft's longitudinal axis should remain aligned with the centerline throughout the approach and landing.

Once aligned with the landing area, you may need to make slight power adjustments to maintain a proper descent. Your goal is to control the descent angle so that you touch down within the center of the first third of the runway. The descent angle is influenced by the four fundamental forces acting on the powered parachute: lift, drag, thrust, and weight. If these forces remain constant and there's no wind, the descent angle will also remain constant. You can control lift by adjusting power, and wind will affect your gliding distance over the ground, requiring throttle adjustments to compensate.

The objective of a good final approach is to descend at an angle that allows the you to reach the desired touchdown point. Adjust power as needed to control your descent or achieve the desired altitude along the approach path. If your approach is too high, reduce power; if too low, add power



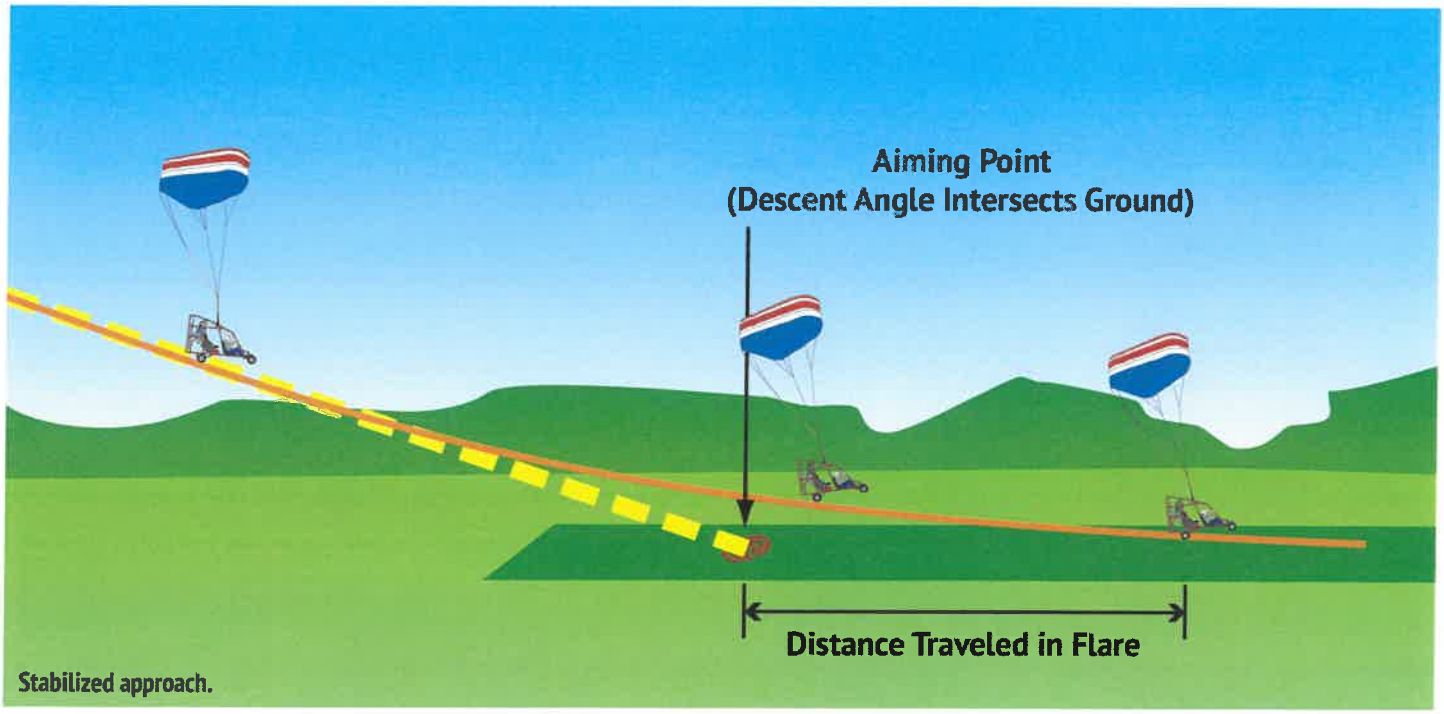
Effect of headwind on final approach.

Stabilized Approach

A stabilized approach is one where you establish and maintain a constant glide path toward a predetermined point on the runway. This requires good judgment, relying on visual cues and making only minimal throttle adjustments. A powered parachute descending at a constant rate on final approach will appear to head toward a fixed spot on the ground, called the *aiming point*. This point, however, is not where you will land, as you'll float when you round out and flare. Where you will actually land is considered the *touchdown point*.

The aiming point is the spot on the ground where, if you don't flare, the powered parachute would make contact with the ground. It can be distinguished because it remains stationary in your field of vision, while objects in front of or beyond it appear to move in opposite directions as you close the distance.

One of the most important skills you need to learn is how to use visual cues to accurately determine the true aiming point from any distance on final approach. From this, you can assess whether



Stabilized approach.

your glide path will result in an undershoot or overshoot, and taking into account the float during roundout, predict the touchdown point within just a few feet.

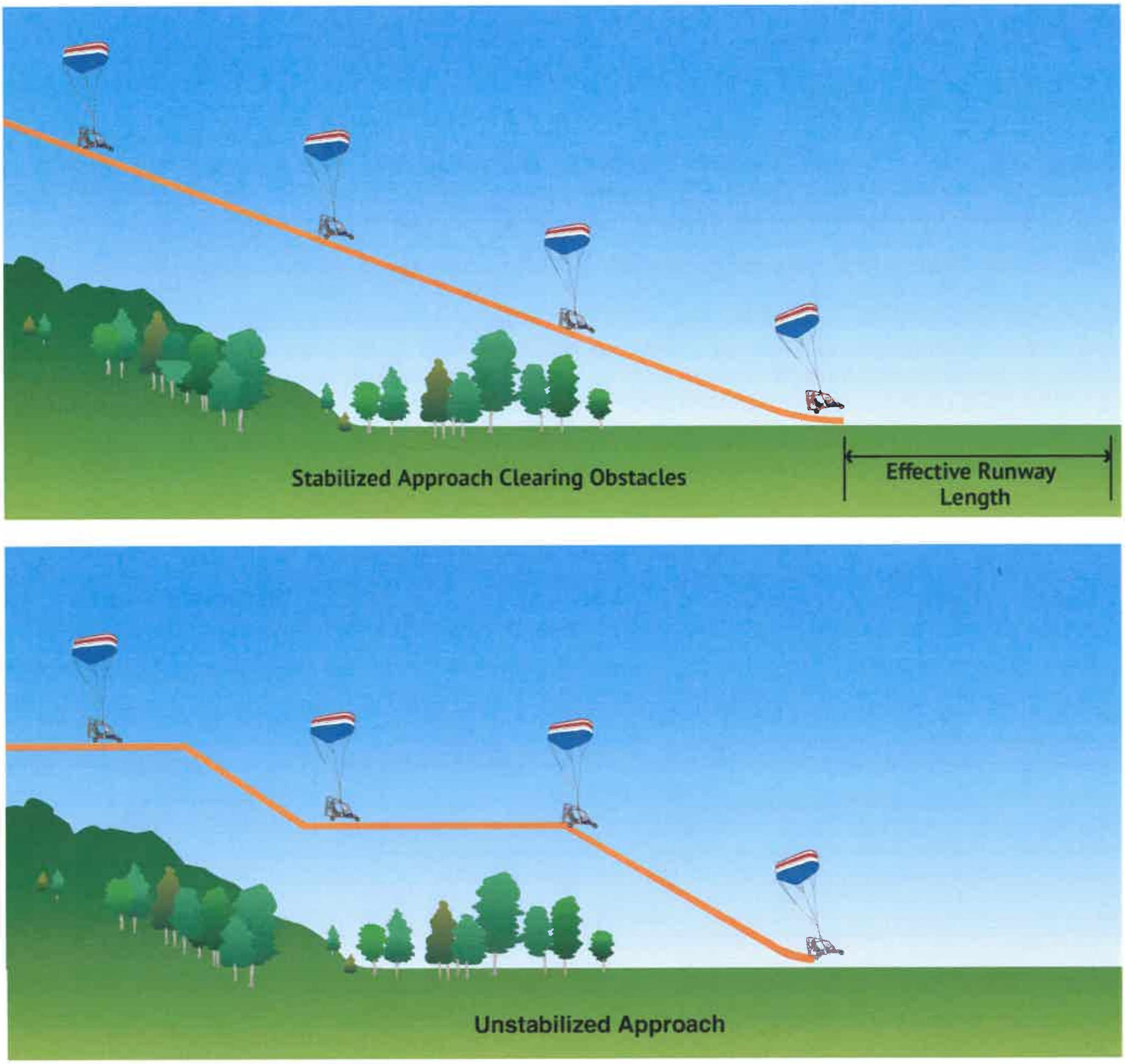
For a constant glide path, the distance between the horizon and the aiming point will remain the same. If the aiming point moves down and away from the horizon, the touchdown point is farther down the runway. If the aiming point moves up toward the horizon, the touchdown point is closer than you want.

After establishing a final approach, the shape of the runway and surrounding objects will also give clues about your approach. Your goal is to select a touchdown point and adjust the glide path so that the aiming point and the touchdown point coincide. Once you roll out on final approach, adjust the power so that you're descending directly toward the aiming point. Doing so will allow you to focus on outside references—scanning from the aiming point to the horizon, then to objects along the runway, and back to the aiming point. This scanning will help you perceive any deviations from your glide path and correct as necessary.

If the aiming point isn't where you want it, adjust your glide path to move it. For example, if the aiming point is short of your desired touchdown, increase power to shallow the glide path and move the aiming point farther down the runway. If the aiming point is too far down the runway, decrease power to steepen the glide and bring the aiming point closer.

Keep in mind, the closer you get to the runway before establishing a stabilized approach, the larger and more frequent the corrections will need to be. This can lead to an unstabilized approach, so it's best to set up your approach early to ensure a smooth and safe landing

Stabilized vs. unstabilized approach.



Roundout

The powered roundout is a smooth transition from a normal approach descent to a landing descent, gradually leveling the flight path until it is parallel to and just a few inches above the runway. When you reach an altitude of about 10 to 20 feet above the ground during a normal descent, you should begin the roundout, continuing until the main rear tires of your powered parachute touch down.

As you approach the ground and reach the point where you can smoothly transition to a landing descent, gradually apply power to slow the rate of descent. The speed of the roundout depends on your height above the ground and your rate of descent. If you begin your roundout too high, it must be executed more slowly than one started from a lower altitude to avoid floating down the runway and landing farther than intended. The roundout should match the closure rate with the ground—if your descent is slow, you may not need to increase power.

Visual cues are crucial for performing the roundout at the proper altitude and keeping the wheels just above the surface until touchdown. These cues rely on the angle at which your central vision intersects the ground or runway ahead, slightly to the side. Depth perception plays a significant role, but the most useful visual cues are changes in the runway or terrain perspective and the size of familiar objects near the landing area, like fences, trees, buildings, or runway texture. As you begin the roundout, focus your vision downward at a shallow angle of 10° to 15° toward the runway.

Keeping the same viewing angle allows the visual point of interception with the runway to shift progressively rearward as the powered parachute descends. This is a key cue for judging altitude loss. If the point moves forward, indicating an altitude increase, power may have been applied too quickly, leading to floating. In many powered parachutes, you can use the front wheel as a visual reference for how far the main wheels are above the runway.

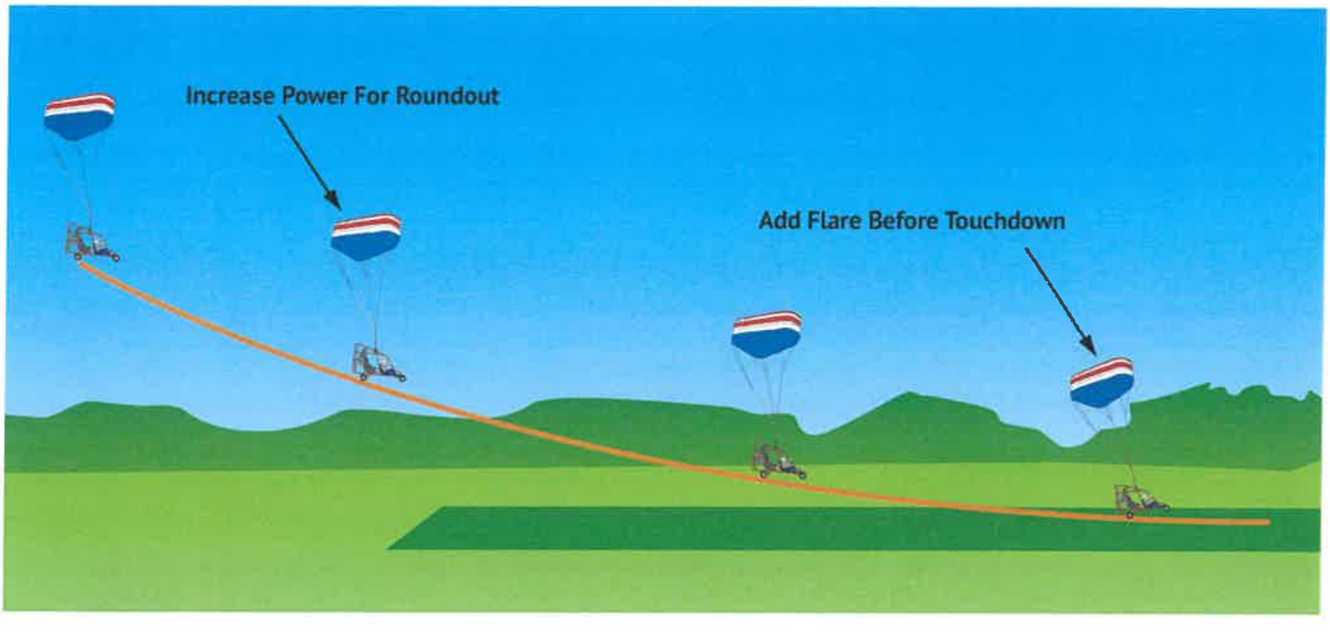
Use of Power

In some cases, you may need to slightly advance the throttle to avoid an excessive sink rate, which could result in a hard, drop-in landing. Power can be used during the approach and roundout to correct errors in judgment by adding lift and slowing your descent to a manageable rate. It's important to develop the habit of keeping one hand on the throttle throughout the approach and landing. This allows you to respond immediately to sudden hazards or unexpected wind gusts with a quick application of power.

However, you should avoid constantly adjusting the throttle. The goal is to achieve a smooth descent, not one where the throttle is being frequently manipulated. A general rule is that once you've established your approach, it's acceptable to advance the throttle during the approach and roundout, but you should avoid reducing it unless you're at risk of landing short of the runway. Any reductions in throttle should be made at least 100 feet above the surface.

Maintain power all the way to touchdown. A common mistake made by transitioning airplane pilots is anticipating ground effect, expecting the aircraft to float down the runway. In a powered parachute, there is no ground effect since the wing is so high above the airframe and the aircraft moves at a relatively slow speed. Cutting the throttle a few feet above the surface leads to a hard, drop-in landing.

Increasing power for roundout and flare.



Touchdown

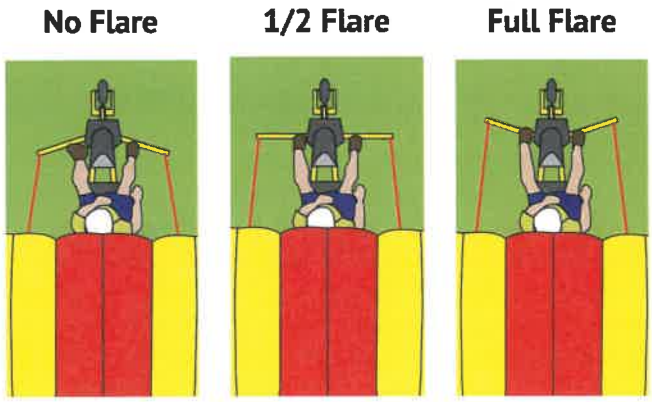
The touchdown is the gentle settling of the powered parachute onto the landing surface. You should make the roundout and touchdown with the engine at slightly below the level flight power setting. You flare the wing to smooth out the landing as the airframe settles onto the surface.

You shouldn't *fall in love* with a particular spot on the runway. Trying to hit an arbitrary spot on the runway often leads to a hard landing.

It's paradoxical that the way to make an ideal landing is to try to hold the powered parachute's wheels a few inches off the ground as long as possible. However, in many cases, when the main wheels are within a foot or less of the ground, the powered parachute may still be descending too quickly for a smooth touchdown. When that happens, you need to slow the rate of descent during those final moments of flying by using flare.

Flare is accomplished by pushing both steering bars simultaneously. That pulls the entire trailing edge of the wing down. That increases drag, lowers the forward speed, and most importantly for landing, increases the lift of the wing. The amount of flare needed depends on the rate of descent right before landing. If the rate of descent is very gradual, very little flare is needed. Conversely, in an engine-out situation a lot of flare is required. Accurately determining how much flare is needed for a given situation is developed with practice. A general rule is to begin your flare one second before you would otherwise touch the ground.

Flare is used rather than engine power because the wing is much more responsive than engine power. When a pilot adds flare, the drag on the wing increases and the wing quickly responds by rotating backwards and increasing its angle of attack. To achieve the same effect with engine power, a pilot adds power, the propeller speeds up, and the thrust pushes the airframe forward of the wing. Newtonian physics explains that it's easier to change the inertia and positioning of a 25 pound wing than it is for a 500+ pound airframe-engine-pilot-fuel assembly.

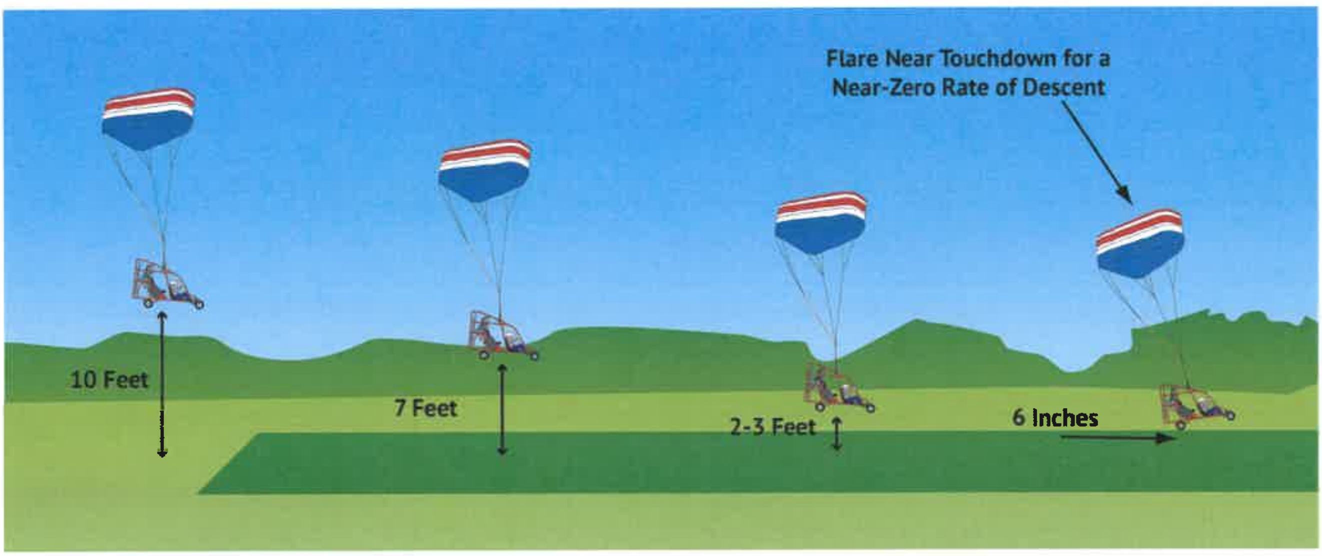


Flaring the wing.

It's extremely important that your touchdown occurs with your powered parachute's longitudinal axis exactly parallel to the direction in which the airframe is moving along the surface. If you don't do that, you get severe side loads on the landing gear. To avoid these side stresses, you shouldn't allow your powered parachute to touch down while drifting.

After-Landing Roll

You should never consider the landing process complete until after you've come to a complete stop, you've shut the engine down, and you've collapsed the wing and it's on the ground. Many incidents have occurred because of pilots abandoning their vigilance and positive control after touching down. Some have damaged their wings by failing to stop the engine before the wing fell into the moving propeller. Other incidents have been recorded where the wind has caught a still inflated wing and rolled the aircraft over.



Flaring on touchdown.

Collapsing and grounding the parachute after landing

Normally, as soon as you land, you should do these four things in this order:

Release any flare that was used during landing. Once you release the flare, the wing will rotate forward relative to the airframe. That decreases both the angle of attack and lift that you generated with your landing flare. That will bring the front landing gear down and load it, which in turn makes the airframe easier to ground handle.

Close the throttle, unless you intend to taxi the powered parachute with the wing inflated.

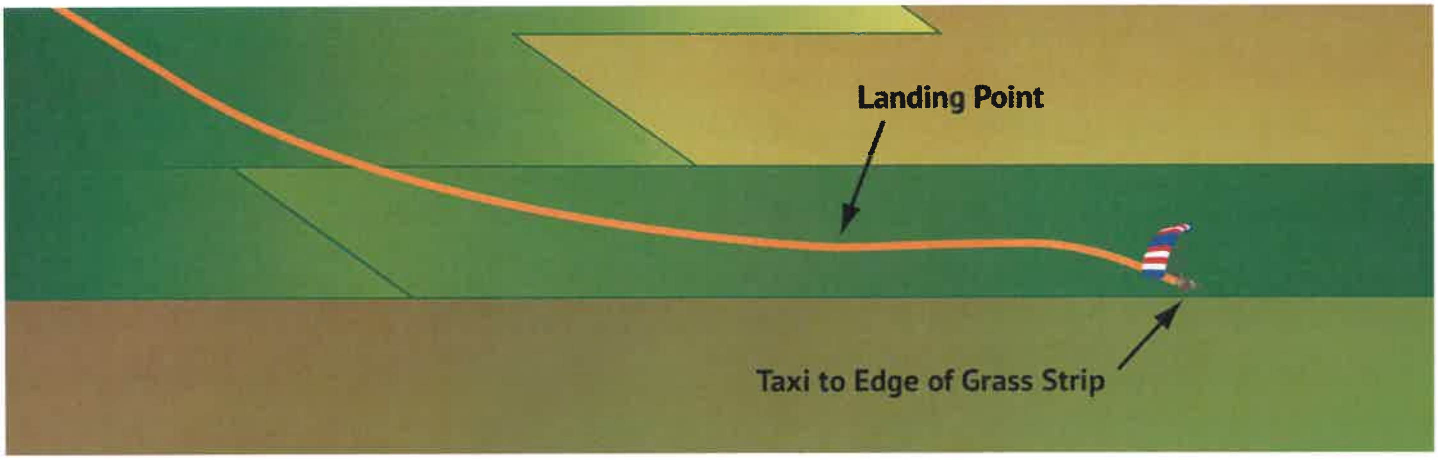
Shut the ignition system down. Normally powered parachutes have two ignition switches that are toggle switches. Both toggle switches must be turned off to shut the engine down. If the engine doesn't shut down, you should immediately double check to make sure that both switches are off. If for some reason both switches are in the off position and the engine is still running, you should immediately initiate emergency shut down procedures. See *Chapter 27 "Emergency Procedures"*. That's because the wing (which is still overhead) could drift down into the prop arc and cause damage to the wing, the propeller, the engine and even the structure of the airframe itself.

Collapse and ground the wing. This is done by tugging on the steering lines of the wing. One long pull will generally not be adequate. Three or four quick tugs will normally be enough. If the wing is allowed to *float* down on its own, a small gust of wind can force the suspension lines onto hot exhaust surfaces which can melt the lines. An airborne wing can also be pushed over by the wind and cause the airframe to roll over. Properly collapsing the wing behind the airframe will help it act as a brake for the powered parachute, much like a drogue chute is used to help stop a drag racer.

Normal Landing Errors

Common errors during normal approaches and landings are:

- Inadequate wind drift correction on the base leg.
- Overshooting or undershooting the turn onto final approach, resulting in too steep or too shallow a turn onto final approach.
- Unstabilized approach.
- Rounding out too high.
- Rounding out too low.
- Touching down prior to attaining a stabilized approach.
- Flaring the wing too early before touchdown.
- Flaring either too much or too high before touchdown.
- Failure to release the flare after touchdown.
- Slowing down too much while clearing the runway, allowing the wing to fall and touch the ground.
- Failure to shut off the engine and collapse the wing after landing and rolling out.



Taxiing to the edge of the runway allows a powered parachute pilot time to stow the parachute without closing the runway to other traffic for long periods.

Clearing the Runway

Powered parachutes don't normally take off or land where the rest of the airport traffic takes off and lands. This is to help both the powered parachutist and the pilots of other aircraft. It's not considered polite or safe to tie up an active runway for the time needed to stow the wing after landing. Ways to avoid tying up a runway is to land or taxi to the edge of a wide runway or to an undeveloped area next to the active runway where you can stow the wing well away from other landing aircraft.

Clearing the runway normally involves taxiing with the wing kited. The primary requirements for safe taxiing are positive control of the aircraft at all times, the ability to recognize potential hazards in time to avoid them, and the ability to stop or turn where and when desired.

Taxiing With the Wing Kited

If you land a powered parachute on the center of a runway, it's considered good practice to taxi to the edge of or even off the runway before collapsing and stowing the wing. When doing this, you need to keep your powered parachute moving after landing in order keep the wing inflated and overhead. The safest and easiest method is to keep taxiing straight into the wind until you clear the runway and can collapse the wing out of the way of other aircraft. If the winds are too strong or gusty to taxi off an active runway, you should consider an alternate landing area, if possible.

When taxiing with an inflated wing (kiting), the ram air wing will try to weathervane and drift downwind. The wing is designed to be self-centering; its strongest desire is to point into the wind. If the wing is inflated, you will probably have to steer the powered parachute using both wing and ground controls.

You can continue to steer the wing with steering bar controls. Depending on the model of aircraft and the speed you're taxiing, you may even find that steering the entire aircraft with the wing is more effective than wheel steering. The faster you taxi, the less contact your front wheel has with the runway surface. That means that at certain speeds you may not be able to steer with the front wheel at all.

If the airframe and wing are not going in the same direction, you must prevent the wing from gaining enough lift to pull the airframe over on its side. Taxiing with the wing inflated requires you to coordinate movements between the rolling airframe on the ground and the flying wing in the air. Cross-controlling by steering the airframe one way while failing to steer the wing in the same direction creates a dangerous situation that may end in the airframe being pulled over.

Taxi Errors

Common errors while taxiing with the wing inflated are:

- Failing to maintain enough forward speed to keep the wing inflated and flying overhead.
- Maintaining too much speed over the ground and thereby lifting the nosewheel off the ground, preventing the nosewheel from being able to control the direction of the airframe.
- Not steering the wing along with the airframe.
- Attempting to turn the airframe too tight and not being able to match the turning radius with the wing.
- Failing to take wind into account.
- Attempting to taxi when winds are too high, change in direction, or are gusty.

Parking

You should select a location to park which gets you out of the way of other aircraft. This also prevents the propeller blast from other aircraft from striking the your wing before you have time to stow it.

After exiting the powered parachute, you should immediately pull the trailing edge of the wing forward toward the airframe and roll the leading edge and cell openings under the rest of the wing. This will prevent gusts of air from grabbing the wing and pulling the airframe backward. If it's windy or if you plan to step out of reach of the airframe, you should pull the steering line in on one side and tie it to the airframe. Tie off a long length of steering line because a shorter length might not do the job. Tying off a longer length of steering line also completely disables a wing. That prevents you or someone else from trying to fly the aircraft with the steering line only partially pulled in. After the wing is totally disabled from becoming airborne, you can assist your passenger in disembarking.

Your passenger may attempt to help you stow your wing. If a passenger tries to help, warn your guest that engine surfaces are still extremely hot. Those surfaces can burn passengers and suspension lines alike. You also want to warn passengers not to step on parts of your wing or the suspension lines. Both can be damaged by grinding them into the surface of the runway. Never assume a bystander will know how to behave around a powered parachute.

Estimating Height and Movement

Vision is especially crucial during the approach, roundout, and touchdown. Your head should be in a natural, straight-ahead position, allowing for a wide field of vision and good judgment of height and movement. Your visual focus should not be fixed on any one point or area but should shift gradually from just over the airframe's nosewheel to the desired touchdown zone and back again. Simultaneously, it's important to maintain awareness of the distance to either side of the runway using your peripheral vision. Estimating distance accurately, besides being a matter of practice, depends on how clearly objects are seen, which requires proper focus to ensure key reference points are distinct.

Speed affects visual perception, as nearby objects blur, while those farther away remain clearer, similar to driving a fast-moving vehicle. In flight, your eyes automatically adjust to focus far enough ahead to see distinctly. However, focusing on references that are too close or directly below can cause them to blur, leading to abrupt or delayed reactions. This often results in overcontrolling, rounding out too high, or making drop-in landings due to mistiming the flare. Conversely, focusing too far ahead reduces the accuracy of judging the ground's proximity, delaying necessary actions, and risking a landing without a proper flare, causing you to fly into the ground.

Turbulent Air Approach and Landing

If you find yourself landing in turbulent air, you'll want to use a steeper approach than normal. This provides for better wing loading, a lower angle of attack for the wing, and better stability for the powered parachute when you experience strong horizontal wind gusts, or up-and-down drafts. But with a steeper approach, you should be ready to add throttle for a more aggressive round out or, if a particular approach isn't good, a go-around.

Another issue with a steep approach is that you will drift a lot more to the side since there will be less engine torque. A properly rigged powered parachute will fly straight during level flight. That means that it will drift more to the side when power is reduced.

The more turbulent the air, the steeper your approach should be. In extreme cases and with some equipment, it may be appropriate to make the approach without any power at all. That way damage to the propeller and engine can be avoided. Of course, in that situation, there's very little room to react if a sudden downdraft occurs. Experience in reading the winds and turbulence becomes very important.

Go-Arounds (Rejected Landings)

Whenever landing conditions are unsatisfactory, you should go-around should. There are many situations where a go-around may be necessary, including:

- Unexpected hazards on the runway
- Overtaking another powered parachute
- Wind shear
- Wake turbulence
- Mechanical failure
- An unstabilized approach
- Directive from air traffic control.

It's a common misconception that an aborted landing is always the result of a poor approach due to a lack of skill or experience. In reality, the go-around is not strictly an emergency procedure; it's a normal maneuver that can be used in any situation requiring an alternative to landing. Like any other maneuver, the go-around must be practiced regularly.

While the need to discontinue a landing can arise at any point, the most critical moment for a go-around is when the aircraft is close to the ground. The sooner you recognize the need for a go-around, the safer the maneuver will be. Go-arounds only become dangerous when delayed or improperly executed.

Delays in initiating a go-around typically result from two factors:

Landing expectancy – the assumption that conditions are not as threatening as they appear and that a safe landing will still occur.
Pride – the mistaken belief that initiating a go-around is a sign of failure in making the approach.

Improper execution of the go-around maneuver often results from a lack of familiarity with its three cardinal principles: power, power, and more power. The primary objective is to gain altitude as quickly as possible. That makes power your first concern during a go-around. As soon as you decide to abort the landing, you must apply full power smoothly and without hesitation, maintaining it until you've climbed back to pattern altitude. Partial power is not sufficient in this situation.

There is a degree of inertia that must be overcome before a powered parachute, which is descending toward the ground, can safely turn or climb. Power must be applied smoothly yet firmly. Abrupt throttle movement can cause the engine to falter in some powered parachutes.

Rejected Landing Errors

Common errors during go-arounds (rejected landings) are:

- Failing to recognize when a go-around is necessary.
- Indecision or hesitation.
- Delaying the initiation of the maneuver.
- Not applying maximum allowable power promptly.
- Applying power too abruptly.
- Failing to adequately compensate for torque or P-factor.
- Adding unnecessary flare or maintaining flare during the go-around.

Crosswind Approach and Landing

You should be prepared for landings where the wind blows across, rather than parallel to, the runway or landing direction. While the basic principles of a normal approach and landing still apply, additional procedures are needed to correct for wind drift during a crosswind landing.

The method of approaching the ground in a crosswind is called *crabbing*. The crab method requires a high degree of judgment and timing in removing the crab immediately prior to touchdown.

Crosswind Final Approach

To crab in a crosswind, establish a heading toward the wind to keep your ground track aligned with the center or upwind side of the landing area. This is done by applying pressure to the steering bar on the side from which the wind is blowing. Lining up on the upwind side of the runway allows for drift correction after releasing the crab.

Maintain the crab angle until just before touchdown. At that point, release the pressure on the steering bar to land straight down the runway and execute a normal flare for landing. Timing is crucial when transitioning from the crab to the roundout and flare.

When reducing power, consider the resulting drift due to decreased engine torque. For example, if you have a left-turning propeller (like on a Rotax 9-series engine), the powered parachute will tend to drift left after reducing power. If the crosswind is from the left, these forces will cancel each other out. However, if the wind is from the right, the combined effects will cause a more aggressive left drift.

Conversely, with clockwise-turning props (like on Rotax 2-stroke engines), the powered parachute will drift right when power is reduced. In a left crosswind, this drift will be enhanced, so positioning on the left side of the runway will help center you after releasing the crab.

Crosswind Roundout

Generally, the powered roundout should be made like a normal landing approach. The key is to keep your powered parachute lined up with the runway. You should hold your crab as you begin your roundout and be ready to release it just before touchdown. If you end your crab too early, it will allow the powered parachute to begin drifting. If you end your crab too late, you won't be able to flare properly.

Crosswind Touchdown

One of the reasons you want to release your turning input before flaring is that you want to have full authority when you flare. In a crosswind, your flare may be asymmetrical. That is, you may need to push one pedal more than the other in order to keep the airframe and wheels lined up with the runway.

During gusty or high wind conditions, prompt adjustments must be made to make sure that the airframe is lined up with the runway. You should be ready to execute a go-around if an approach looks particularly bad. If conditions don't improve, an alternate field should be sought out that does not require the extra crosswind maneuvering.

Touchdown in a Drift or Crab

When you touch down while drifting to the side or crabbing, the airframe will contact the ground while moving sideways. This can impose extreme side loads on the landing gear, and if severe enough, may cause structural failure or a rollover.

There are three factors that will cause the longitudinal axis and the direction of motion to be misaligned during touchdown: drifting, crabbing, or a combination of both.

If your powered parachute drifts during a landing, the main wheels' tire tread resists the powered parachute's sideways movement in respect to the ground. This resistance varies by surface. Resistance is the worst on a hard surface like asphalt. Grass is more forgiving and will allow the tires to slide somewhat sideways on touchdown.

Either way, any sideways velocity of the airframe is abruptly decelerated. Meanwhile, the wing will continue to drift downwind to the side since it's flexibly attached to the airframe. This creates a moment around the main wheel when it contacts the ground, tending to overturn or tip the airframe.

This is an important reason for you to avoid landing with strong crosswinds.

Crosswind After-Landing Roll

When landing in windy or gusty conditions, you should give special attention to collapsing the wing quicker than you normally would. That's done by concentrating your efforts on only one of the steering lines rather than trying to tug on both steering lines at the same time. By picking one steering line and reeling it in hand-over-hand, the wing will quickly collapse and not be able to roll the airframe over.

When a powered parachute is airborne, it moves with the surrounding air mass, regardless of its heading or speed. However, when the airframe is on the ground, it can't move freely with the air mass (crosswind) due to the friction between the wheels and the ground.

A crosswind acting on a powered parachute during or after landing is influenced by two factors: the natural wind, which moves in the direction of the air mass, and the movement of the powered parachute itself, which creates a force parallel to its direction of travel. This results in two wind components: a headwind acting along the powered parachute's ground track and a crosswind acting 90° to it. The combined force, or relative wind, falls somewhere between these two components.

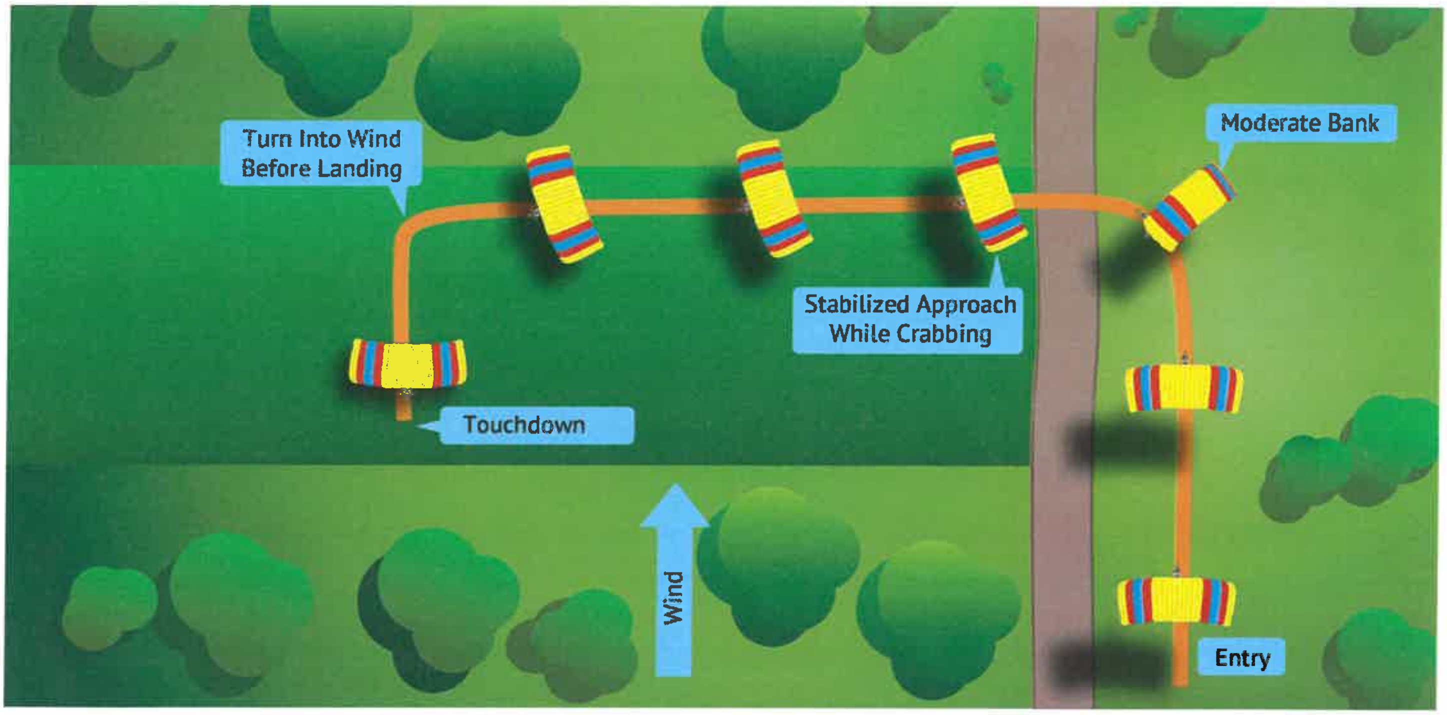
As your forward speed decreases during the landing roll, the headwind component diminishes, and the relative wind shifts, becoming more dominated by the crosswind component. The stronger this crosswind component becomes, the more challenging it is to keep the wing stable and prevent it from collapsing to one side, which could lead to the airframe rolling over.

It's important to quickly collapse your wing after landing when there is any amount of wind. During crosswind, gusty, or high wind conditions, it becomes critical. You shouldn't try to taxi with the wing inflated in those conditions.

Wing Blowing Over After Touchdown

When landing in a crosswind, your wing may blow downwind and to the side of the airframe during the after-landing roll.

Whenever a powered parachute is rolling on the ground in a crosswind, the upwind side of the wing experiences a force that pushes it downwind, toward the opposite side of the airframe. This creates a lift differential, where the upwind side of the



Crosswind approach and landing when winds are strong across the runway.

airframe is lifted as the wing is pushed toward the downwind side.

If the effects of these forces become strong enough, the upwind side of the wing may rise, even while maintaining directional control. Without corrective action, the upwind side could lift to the point where the downwind side of the wing strikes the ground. If the wind or forward motion of the powered parachute is strong enough, this could lead to a rollover. To prevent this, it's essential to steer both the airframe and the wing in unison while on the ground. It's important to pull the wing to the ground immediately after landing and taxiing to where you want end your taxi.

Maximum Crosswind Velocities

It can be inadvisable or even dangerous to land in certain crosswind conditions. You shouldn't try to land on a runway with a high crosswind unless you are trying to land perpendicular to it as illustrated on the previous page. Crosswind landings are something that you learn to do over time. You should work to be aware of your and your equipment's limitations.

Crosswind Landing Errors

Common errors during crosswind approaches and landings are:

- Attempting to land in crosswinds that exceed the powered parachute's maximum demonstrated crosswind component.
- Inadequate compensation for wind drift during the turn from base leg to final approach, leading to undershooting or overshooting.
- Insufficient compensation for wind drift on final approach.
- Performing an unstabilized approach or powered roundout.
- Failure to release steering inputs before touchdown flare.
- Flaring too early.
- Not collapsing the wing after landing.
- Failure to go around when necessary.

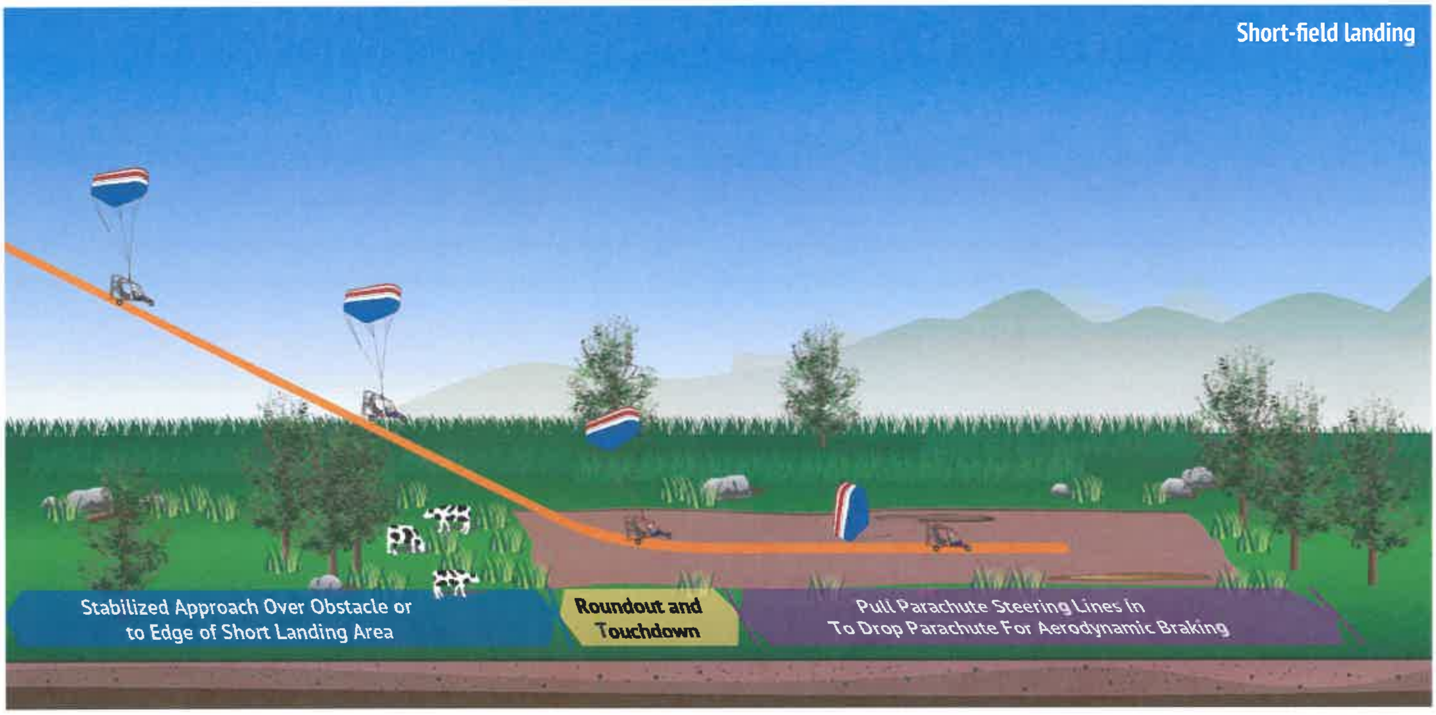
Short-Field Approach and Landing

You use short-field approach and landing procedures at fields with a relatively short landing area or where an approach is made over obstacles that limit the available landing area. It's one of the most critical of the maximum performance operations. It requires you to fly close to the ground and often over obstacles in order to safely land within confined areas.

To land within a short-field or a confined area, you must have precise, positive control of the rate of descent to produce an approach that will clear any obstacles, result in little or no floating during the roundout, and permit the powered parachute to be stopped in the shortest possible distance.

A stabilized approach is essential for a safe landing. Typically, the final approach begins from an altitude of at least 400 feet above the touchdown area. Using a wider-than-normal flight pattern allows you to better assess the landing conditions and make necessary adjustments.

After turning onto final, adjust the power to establish and maintain the proper descent angle, which will be steeper than that for a normal landing. When done correctly, only minimal changes to the power setting will be necessary to correct the descent angle.



The short-field approach is essentially an accuracy approach aimed at a specific landing spot. Follow the procedures outlined in the stabilized approaches section. If it appears that obstacle clearance is excessive and your touchdown will occur well beyond the desired spot, reduce power to steepen your descent path and increase your rate of descent. Conversely, if the descent angle won't ensure safe clearance of obstacles, increase power to shallow your descent path and decrease your rate of descent.

Due to the steep approach angle over obstacles, accurately judging when to begin your powered roundout is crucial to avoid descending too quickly.

You should touch down while carrying less throttle power than normal and with more wing flare. You should close the throttle immediately after touchdown but not before touchdown because closing the throttle early may result in an immediate drop in altitude and a hard landing.

After you touch down, you should collapse the wing by tugging on both steering lines. Dropping the wing behind the airframe will provide aerodynamic braking to assist in deceleration.

Short-Field Landing Errors

Common errors during short-field approaches and landings are:

- Failure to allow enough room on final to set up the approach, necessitating an overly steep approach and high sink rate.
- Unstabilized approach.
- Delays in initiating glide path corrections.
- Not rounding out with enough power.
- Prematurely reducing power after roundout resulting in a hard landing.
- Touching down without flare.
- Not shutting the engine down after touchdown.
- Collapsing the wing too slowly after touchdown.

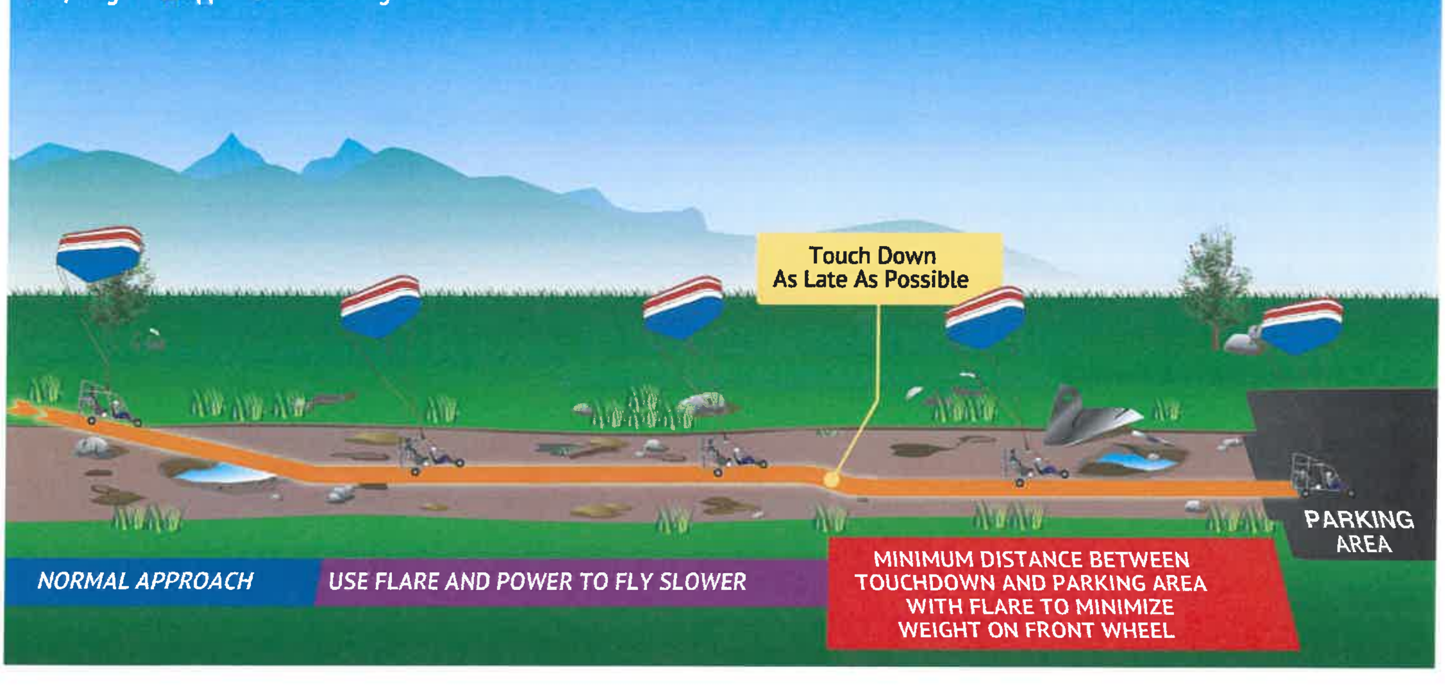
Soft-Field Approach and Landing

There are procedures for when you land on fields that are rough or have soft surfaces, such as snow, sand, mud, or tall grass. When landing on such surfaces, the objective is to touch down as smoothly as possible, and at the slowest possible landing speed. You must control the powered parachute so that the wing supports the weight of the airframe as long as possible. That minimizes drag and stresses imposed on the landing gear by the rough or soft surface when you finally touch down.

The approach for a soft-field landing is like a normal approach used for landing on long, firm runways. The major difference between the two is that during a soft-field landing, you hold the powered parachute one to two feet off the surface while increasing wing flare and engine power. This allows for a more gradual reduction in forward speed, enabling the wheels to touch down gently at the minimum possible speed. You should use power throughout the level-off and touchdown to ensure that you touch down at the slowest possible airspeed. You should fly the powered parachute onto the ground with the weight fully supported by the wing.

You can use the same final approach descent for soft-field landings that you use for short-field landings. If you use a higher descent rate, you will need more flare on landing in order to slow your forward speed. However, there's no reason for a

Soft/rough field approach and landing.



steep angle of descent unless obstacles are present in your approach path.

You should make your touchdown on a soft or rough field at the lowest possible airspeed with the powered parachute in a nose-high pitch attitude. You do that by using both a high power setting and a lot of flare.

If field conditions are particularly poor, you may want to keep flying the powered parachute with only the main wheels touching the ground, while the weight of the airframe remains supported by the wing, until you find a firmer surface to fully land. During this transition phase—before the weight is fully on the wheels and the nosewheel touches the surface—you should be able to apply full power and safely take off again (provided obstacle clearance and field length allow) if you decide to abort the landing. Once fully committed to landing, gently lower the nosewheel onto the surface. A slight reduction in wing flare will usually help ease the nosewheel down.

You want to avoid using wheel brakes on a soft field. Brakes aren't needed. The soft or rough surface itself will provide sufficient reduction in the aircraft's forward speed. On very soft fields, you may often need to increase power after landing to keep the powered parachute moving and prevent it from getting stuck in the soft surface. It's always best to taxi with the wing kited until you find a dry surface. But if you get bogged down in a wet field, it's best to shut the engine down rather than risk slowing down so much that the wing drops out of the sky and into the spinning propeller.

Soft Field Landing Errors

Common errors during soft-field approaches and landings are:

- Excessive descent rate on final approach without flaring the wing.
- Unstabilized approach.
- Roundout too high above the runway surface.
- Poor power management during roundout and touchdown.
- Hard touchdown.
- Inadequate control of the airframe weight transfer from the wing to the wheels after touchdown.
- Allowing the nosewheel to 'fall' to the runway after touchdown rather than controlling its descent.

Power-Off Accuracy Approaches

Power-off accuracy approaches are approaches and landings made by gliding with the engine idling, through a specific pattern to a touchdown beyond and still within 25 feet of a designated line or mark on the runway. This is an advanced maneuver that's worth practicing so that you can develop the skills needed to accurately fly a powered parachute, without power, to a safe landing.

Your ability to estimate the distance a powered parachute will glide to a landing is the real basis of all power-off accuracy approaches and landings. This will largely determine the amount of maneuvering that you can do from a given altitude.

With experience and practice, you should be able to estimate altitudes up to about 1,000 feet with reasonable accuracy. At lower altitudes, large trees—typically 80-100 feet tall—can serve as useful reference points for judging height. However, above 1,000 feet, features on the ground begin to blend, making it difficult to judge altitude by sight alone. At higher altitudes, it's best to rely on your altimeter while also observing the general appearance of the terrain below.

Your judgment of altitude in feet, hundreds of feet, or thousands of feet isn't as important as the ability to estimate gliding angle and its resultant distance. After you learn to judge the normal glide angle of your powered parachute, you can estimate with reasonable accuracy the approximate spot along a given ground path at which you'll land, regardless of altitude. If you can both judge your glide and accurately estimate altitude, you can in turn judge how much maneuvering is possible during the glide, which is important if you need to choose a landing area in an actual emergency.

You want to give yourself enough altitude before starting your final approach to permit the powered parachute to reach the desired landing area.

Unlike a normal approach where you can adjust the power, a power-off approach has the throttle set to idle, so your gliding distance is determined by your altitude and the wind. For this reason, it's better to aim for a landing spot that's closer rather than farther away.

Uniform approach patterns, such as the 90°, 180°, or 360° power-off approaches, are explained further in this chapter. Practicing these approaches will help you develop judgment in gauging gliding distance and planning your approach.

The basic procedure involves reducing the throttle to idle at a set altitude and gliding toward a key position. However, don't focus too much on reaching this key position; it's simply a reference point in the air to help you assess whether you can glide safely to your chosen landing spot. The key position should be selected based on the available altitude and wind conditions, and you must constantly evaluate the situation from there.

While accurate spot touchdowns are important, safety and proper execution of approaches and landings should always take priority over hitting the exact landing spot.

Flaring the Wing on Power-Off Approaches

As you reduce power for landings, the descent rate of the powered parachute increases. With a lot of modern equipment, you can land a powered parachute at power-off without needing any special skill to prevent hurting you and your passenger. However, the landing forces without flare are great enough to damage the airframe and still possibly hurt you. Flaring prevents that damage by trading airspeed for lift by changing the shape of the airfoil and angle of attack at the right time.

A normal flare is executed about one second before the powered parachute would otherwise touch down. With a normal power-on approach, that one second translates to as little as inches above the surface. Also, with a power-on approach, very little flare authority is needed because little extra lift is needed to make the landing soft.

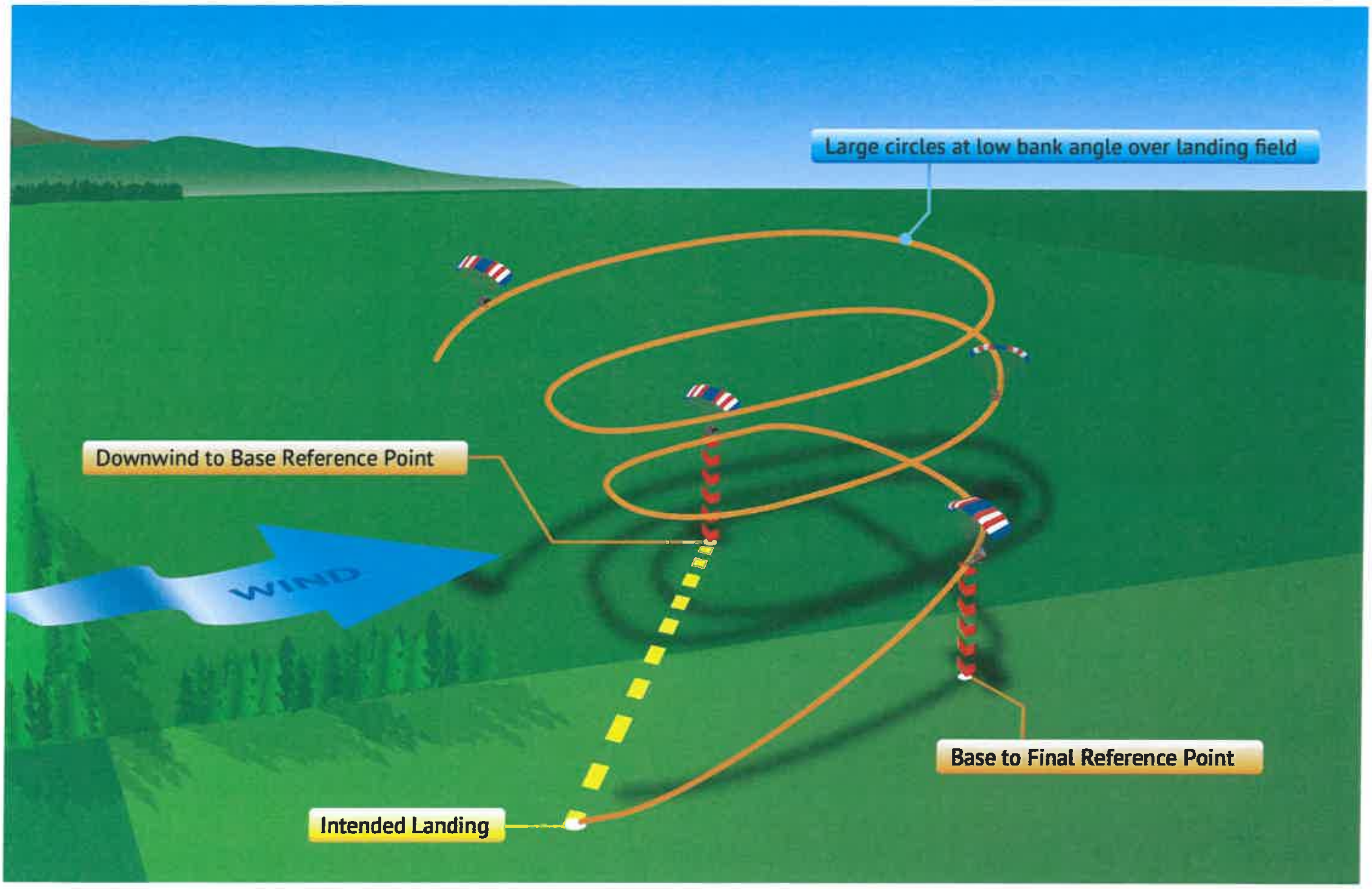
That changes in power-off situations. With descent rates of 10+ feet/second with no power, the flare needs to be started 10 feet or higher above the surface. Not only that, but the flare also needs to be greater. Instead of pushing both steering bars lightly to initiate the flare, both tubes need to be pushed to full extension and it may still be necessary for you to grab the steering lines with both hands and pull the lines across your chest.

This significantly turns down the trailing edge of the wing, increases the drag of the airfoil, rotates the wing backwards from the airframe, and increases both angle of incidence and the angle of attack of the wing. The increase in angle of attack creates the lift needed to slow down the descent rate of the powered parachute just before landing. It slows the descent by trading the energy of the inertia of the forward motion of the powered parachute for lift.

It's important not to flare too early. If you flare too early, you trade all of your forward speed for lift too far above the ground. If you do that, your powered parachute is left with neither lift nor forward inertia. That will cause the powered parachute to go into a dive to regain the proper amount of forward speed for the wing to fly normally. A dive close to the ground can be more damaging to equipment and occupants than a power-off landing without flare.

That's why it's important to transition slowly to power-off landings. The first attempt at a power-off landing should be at a power setting that is 90% of that needed for level flight. After you've mastered landing softly at that power setting, begin making approaches at 80% of the power needed for level flight and so on. You'll find that more and more flare is needed with every reduction in power and will learn the timing needed to execute the flare to safely land your powered parachute.

After you touch down, you need to either take off again or remember to shut the engine down.



If you're high enough over your intended landing area, remain over the intended landing area with large low-banked circles to establish reference points for landing.

Reduced Power Landing Errors

Common mistakes made during reduced power landings are:

- Reducing power settings too much on initial attempts at flaring.
- Flaring too early.
- Not flaring enough for a particular power setting.
- Flaring too much for a particular power setting.
- Failing to release the flare and add power for takeoff fast enough after landing or alternatively failing to shut the engine off.
- Undershooting the landing area.
- Overshooting the landing area.

Flaring with Heavy Loads

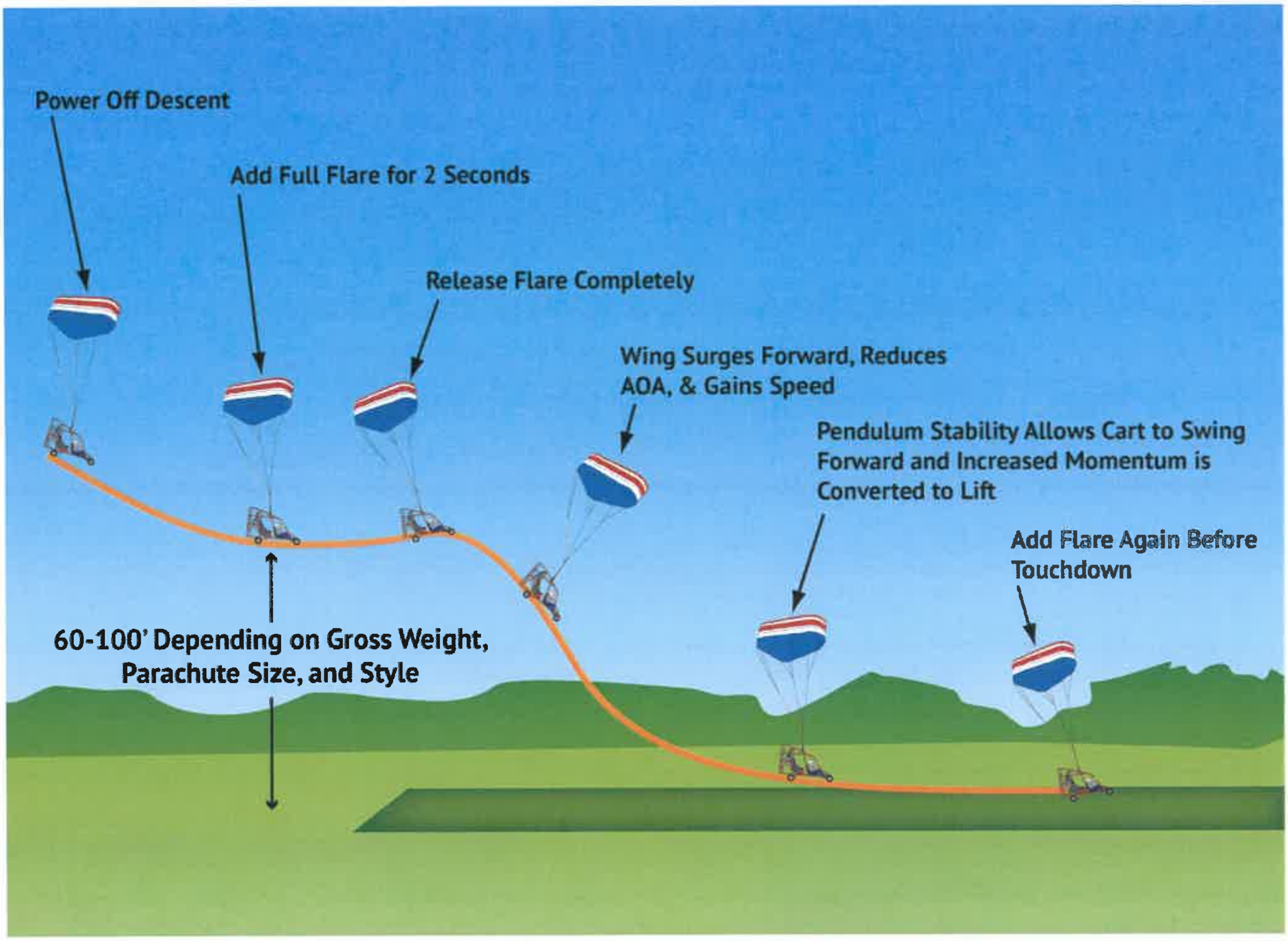
The normal power-off flaring technique isn't adequate in engine-out situations with heavy airframes or heavy loads. That's when you may find it necessary to do a *double flare*. A double flare gives you greater flare authority by using a *preflare* to help build airspeed before the normal flare and touchdown.

This is an advanced technique and shouldn't be attempted without instructor coaching. Timing is critical and if you mistime this technique, you could damage your powered parachute and injure yourself and your passenger.

Normally powered parachutes are constant-speed aircraft. To increase their speed temporarily, something abnormal must be done like a banked turn or a dive. Achieving increased speed is handy for something like an engine-out landing where you can translate the energy of inertia into lift right before touchdown.

You can temporary dive a powered parachute for landing by flaring it sixty feet or more above the surface. The flare trades the current speed for lift and slows the aircraft down while at the same time putting the wing further behind the airframe. After you release the flare, the wing rotates forward and the entire powered parachute flies to the ground at an increased speed. You can then flare the wing one second before touchdown and achieve a very soft landing. Some pilots can time the maneuver well enough that they don't even have to do the second flare since the wing is catching the bottom of the swoop right at ground level.

The double flare method for no-power landings



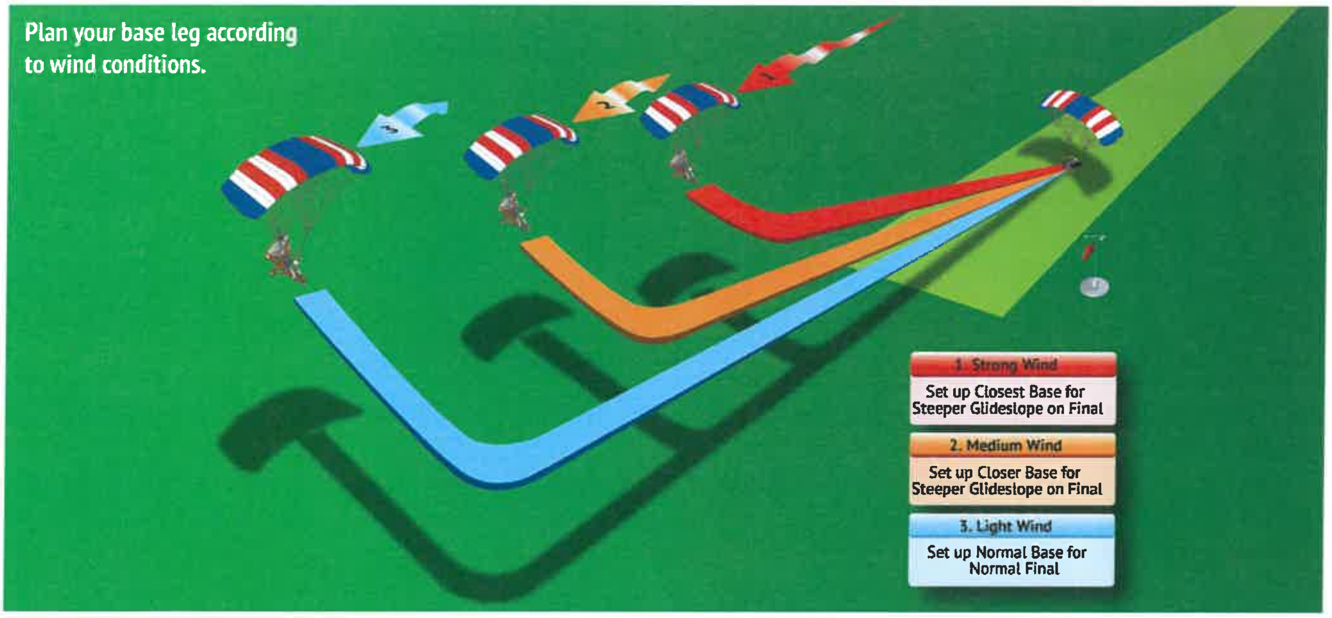
90° Power-Off Approach

The 90° power-off approach begins from the base leg and requires only a 90° turn onto the final approach. You can adjust the path by positioning the base leg closer to or farther from the runway, depending on wind conditions.

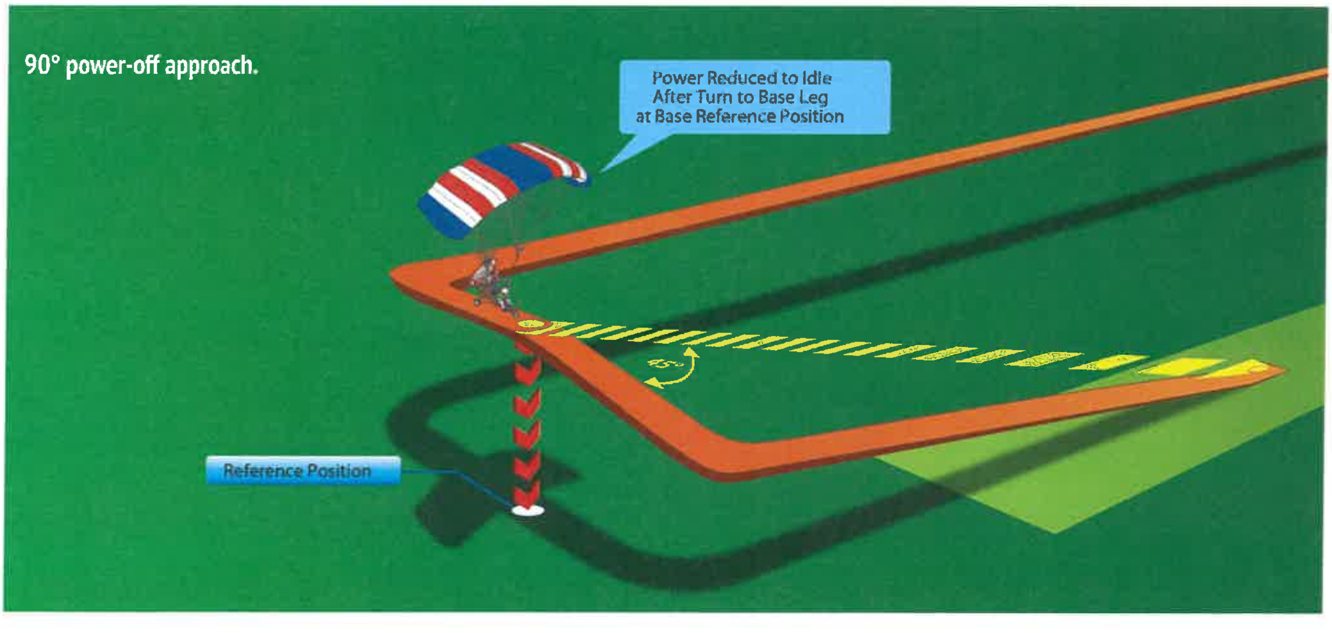
The glide from the key position on the base leg through the 90° turn onto final is a crucial part of all accuracy landings. Typically, the 90° power-off approach begins from a rectangular traffic pattern at about 500 feet above the ground or the standard powered parachute pattern altitude. You should fly a normal downwind leg at the same distance from the landing surface as in a standard traffic pattern.

Once on the base leg, complete a medium-banked turn and slightly reduce the throttle. Maintain wind drift correction and altitude until reaching the 45° key position, where your intended landing spot appears at a 45° angle from the powered parachute's nose. You can assess wind strength and direction by the amount of crab needed to hold the ground track on the base leg, which helps plan the final turn.

At the 45° key position, close the throttle completely and plan the base-to-final turn so that you roll out aligned with the runway centerline. You can make the final approach with or without further turns. Once the final glide is established, focus on executing a smooth, safe landing rather than fixating on a precise touchdown spot. It's better to land safely 200 feet from the spot than to force a poor landing on target.



Plan your base leg according to wind conditions.



90° power-off approach.

180° Power-Off Approach

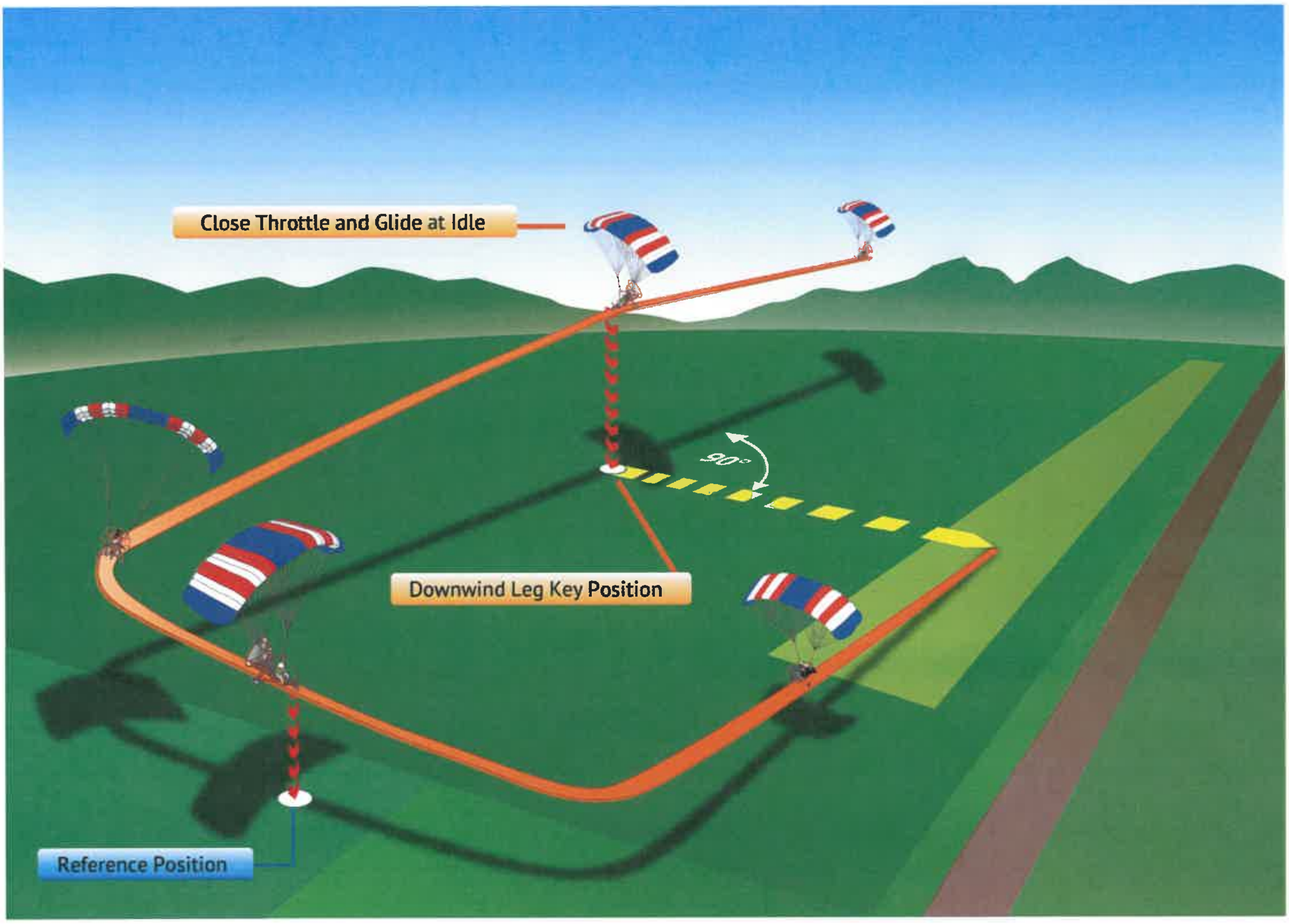
The 180° power-off approach involves gliding from a downwind leg, with power off, to a preselected landing spot. It builds on the principles of the 90° power-off approach and helps develop your ability to judge distances and glide ratios. The approach starts at a higher altitude, requiring you to glide through a 90° turn to reach the base leg at the right altitude for executing the 90° approach.

This maneuver demands more planning and judgment than the 90° approach. During the 180° power-off approach, you fly downwind, parallel to the landing runway. The altitude at which you initiate the approach depends on your powered parachute, wing, and loading, but generally, it shouldn't exceed 1,000 feet AGL.

Close your throttle when you're directly opposite or just past your landing spot, marking the downwind key position. You should begin your turn from downwind to base with a medium or slightly steeper bank, depending on the glide angle and wind speed. Adjust the base leg to conserve or lose altitude as needed to reach your landing spot.

Make the base-to-final turn at a height that allows you to glide smoothly to the base key position of a 90° power-off approach. While the key position is important, it shouldn't be treated as a rigid point on the ground. Many inexperienced pilots mistakenly fixate on landmarks like trees or roads, which can cause confusion when those references aren't available at a different runway. After reaching the base key position, the rest of the approach mirrors that of the 90° power-off approach.

180° power-off approach.



360° Power-Off Approach

The 360° power-off approach involves gliding through a full 360° turn to a preselected landing spot. While the ideal pattern is circular, the turn can be adjusted—shallowed, steepened, or even discontinued—to fine-tune your approach path.

You typically start the 360° approach from a position over or slightly off to the side of the approach end of the landing runway, facing the intended landing direction. The maneuver is usually initiated at an altitude between 1,000 and 1,500 feet AGL, where wind conditions may differ significantly from those closer to the ground. You'll need to account for this when planning to transition into a 90° or 180° power-off approach.

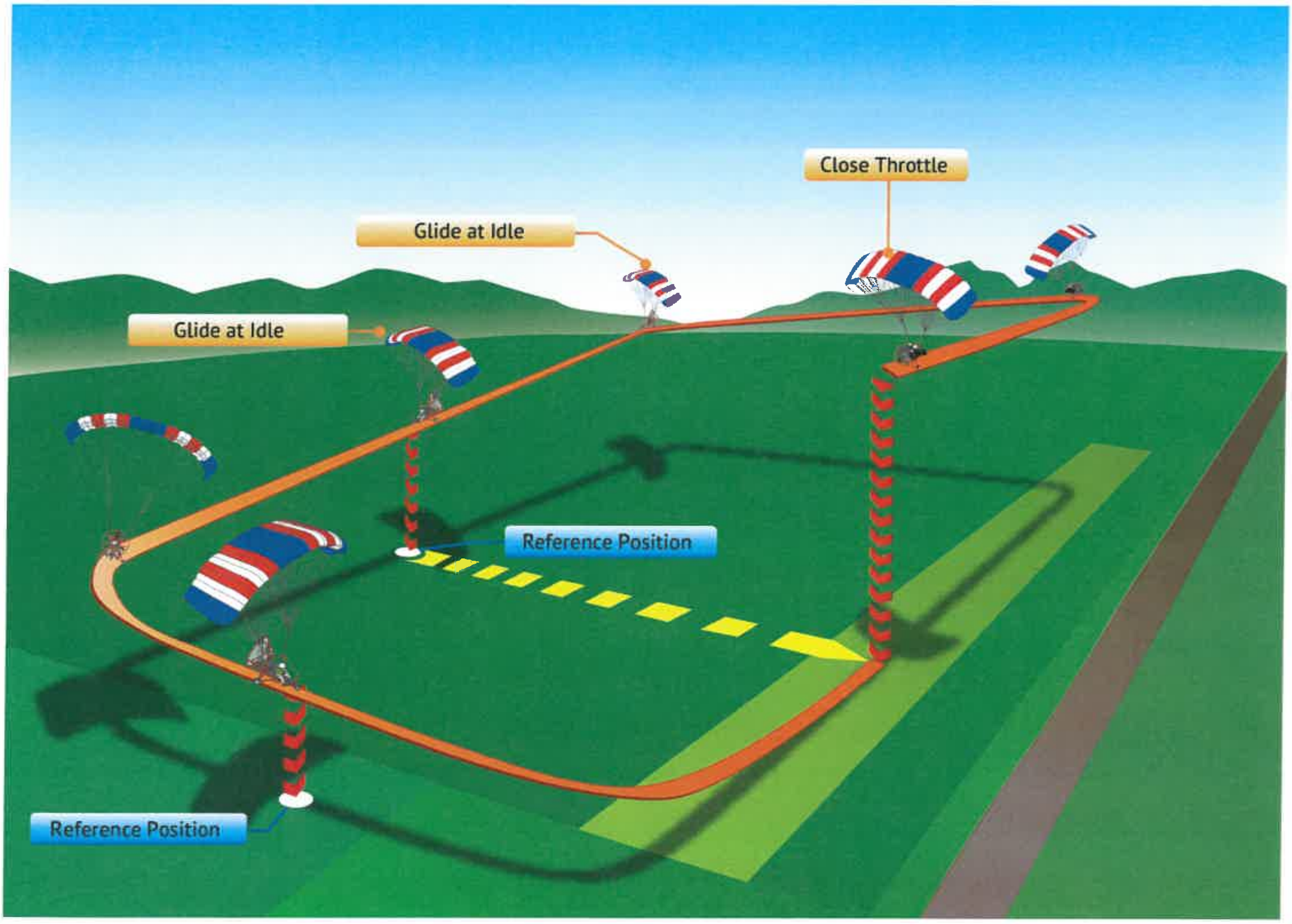
After closing the throttle over your intended landing spot, begin a medium-banked turn to reach the downwind key position, opposite the landing spot, at an altitude of 700 to 1,000 feet AGL. Continue the turn, aiming to arrive at the base-leg key position about 500 feet above the terrain. The final turn should be completed at a minimum altitude of 200 to 300 feet above the ground.

Power-Off Approach Errors

Common errors during power-off accuracy approaches are:

- Downwind leg too far from the runway/landing area.
- Overextension of downwind leg resulting from tailwind.
- Inadequate compensation for wind drift on base leg.
- Attempting to *stretch* the glide by flaring during an undershoot.
- Forcing the powered parachute onto the runway to avoid overshooting the designated landing spot.
- Failing to add power and going around if necessary.

360° power-off approach.



Emergency Approaches and Landings (Simulated)

From time to time on dual flights, your instructor will probably give you simulated emergency landings by closing the throttle and calling *simulated emergency landing*. The objective of these simulated emergency landings is to develop your accuracy, judgment, planning, procedures, and confidence when little or no power is available.

A simulated emergency landing can be initiated at any time. When your instructor calls for one, immediately assess your gliding distance and select a landing spot. Factors like altitude, obstacles, wind direction, landing surface, gradient, and the landing distance required for your powered parachute will influence your approach and pattern.

Based on your chosen landing area, you'll need to use a mix of gliding maneuvers—from straight-and-level to steep turns—to reach the key position at a normal traffic pattern altitude. From there, continue with a standard power-off approach as closely as possible..

The first time you face a simulated emergency landing, you will probably be a little surprised at how quickly you descend. You'll quickly learn that you need to stay high enough over wooded and developed areas to make it to a suitable landing area if your engine fails you.

When you're flying higher above the surface, you'll have more choices for landing areas when power is cut. But you need to commit to one of those choices promptly. As you quickly descend, options will vanish. And what may look like an appealing choice at first may turn out to be unattainable because of the wind and your glide angle.

Wind speed and direction are critical, especially since you're flying such a low-speed aircraft. You should learn to determine the wind direction and estimate its speed from the windsock at the airport, smoke from factories or houses, dust, brush fires, and windmills.

Once you select a landing area, your instructor will want to know which one it is. Normally, you'll be required to plan and fly a pattern for landing on the field first selected until your instructor terminates the simulated emergency landing. This will give your instructor an opportunity to explain and correct any errors and it will give you an opportunity to see the results of the errors.

If you realize during your approach that you selected a poor landing area —one that would obviously result in disaster if you continue—and there is a more advantageous field within gliding distance, change to that better field. However, there are hazards involved in these last-minute decisions, such as excessive maneuvering at very low altitude or not being able to glide to the new choice.

You only get one chance to make your approach and land during a real emergency. The way you correct for misjudging altitude, wind, or glide angle is by using turns, varying the position of your base leg, and varying the turn onto final approach.

PARTIAL OR COMPLETE POWER LOSS DURING FLIGHT:

- Maintain control of the aircraft.
- Look for a suitable landing area considering wind, obstacles and terrain.
- Determine best approach considering wind, obstacles and terrain.
- Only after the aircraft is under control and a suitable landing area is established should you try to restart the engine if you have enough altitude and time. Again, always maintain control of the aircraft.
- Check fuel and position of ignition switches.

You want to keep your engine warm and cleared during all simulated emergency landings. If you're flying with an instructor, that instructor will probably retain control of the throttle. In any case, there should be no doubt as to who has the throttle since many near-accidents have occurred from such misunderstandings.

Every simulated emergency landing approach should be terminated as soon as it can be determined whether a safe landing could have been made. In no case should it be continued to a point where it creates an undue hazard or an annoyance to persons or property on the ground.

There are emergency flight deck procedures you should work on in addition to flying the powered parachute from the point of simulated engine failure to where a reasonable safe landing could be made. Mostly, you're interested in getting the engine running again. You want to be able to combine the two operations, accomplishing emergency procedures and planning and flying the approach during emergency landings. That adds an additional layer of difficulty, but it's an important thing to master.

You need to check critical items like the position of the ignition switches. Many actual emergency landings could have been prevented if the pilots had developed the habit of checking these critical items while practicing emergency approaches.

Your instructor may cover other emergency procedures while training. Other emergencies associated with powered parachutes should be explained, demonstrated, and practiced if possible. These emergencies include things like fire in flight, electrical system malfunctions, unexpected severe weather conditions, engine overheating, and imminent fuel exhaustion.

Faulty Approaches and Landings

Landing requires precise, timely control inputs. Small errors, when corrected early, often go unnoticed. However, if left uncorrected, they can lead to an undesirable situation. This section addresses several common landing imperfections and corrective actions.

Low Final Approach

If your base leg is too low, or if you're using insufficient power or if you misjudged the wind, you may lose too much altitude on final approach. That will cause you to be well below the proper final approach path. If that happens, you will have to apply considerable power to fly the powered parachute (at an excessively low altitude) up to the runway threshold. That can be a problem if you're flying over water, congested or wooded areas.

If you realize you won't reach the runway, apply power immediately to increase lift and slow or stop your descent. When the proper approach path has been intercepted, you should reduce the power and reestablish a stabilized approach. If you have any doubt about completing the approach safely, it's advisable to **execute a go-around immediately**.

Hard Landing

When a powered parachute contacts the ground during landings, the airframe's vertical speed is instantly reduced to zero. Unless provisions are made to slow the vertical speed and cushion the impact of touchdown, the force of contact with the ground may be so great it could cause structural damage to the airframe.

Pneumatic tires, shock-absorbing landing gear, and other devices cushion impact by increasing the time it takes to stop the airframe's vertical descent. To illustrate, a 6-inch free fall on landing is roughly equivalent to a 340-foot-per-minute descent. In just a fraction of a second, the powered parachute must decelerate from this rate to zero without damage. Depending on the severity of the landing, the load at touchdown can be three to four times the weight of the aircraft.

During this time, the landing gear together with some aid from the lift of the wing must supply whatever force is needed to counteract the force of the powered parachute's inertia and weight. However, when the descent stops for the airframe, the wing will continue downward and the suspension lines will slacken. That means that the lift will quickly be reduced to zero, leaving the landing gear alone to carry the powered parachute's weight and inertia force.

Bouncing During Touchdown

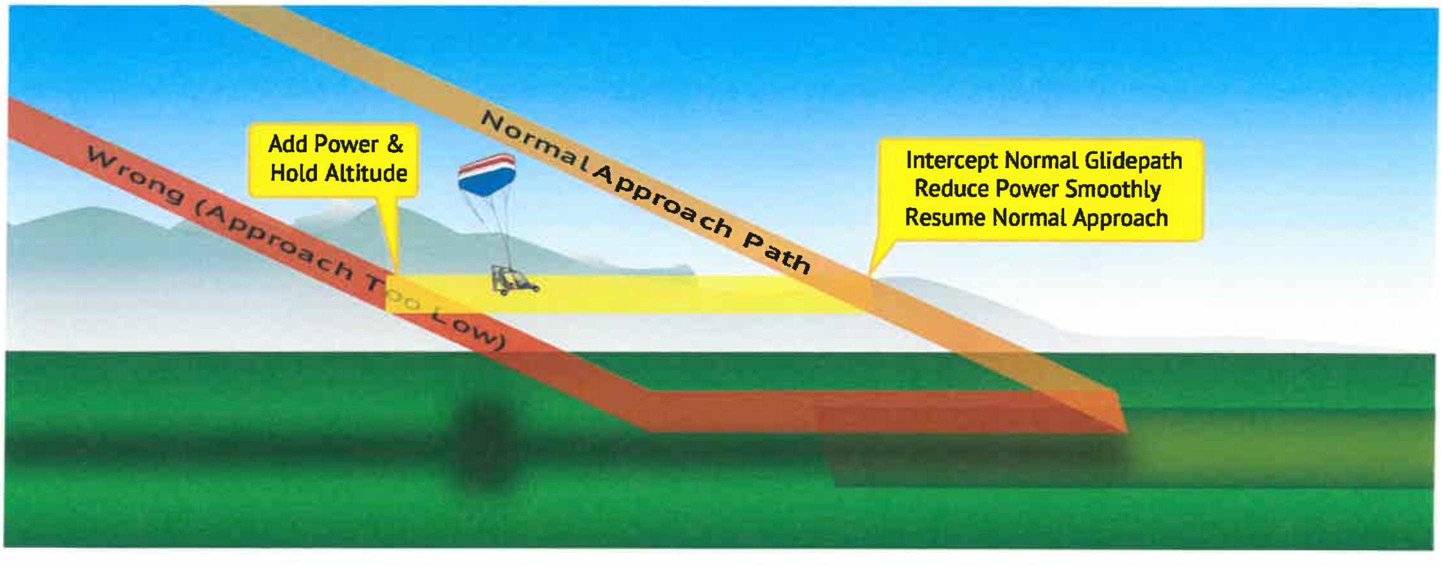
When a powered parachute makes contact with the ground after an excessive rate of sink, it can bounce back into the air due to the sharp impact. The tires and shock struts provide springing action which is often combined with a new pilot's instinctive reflex to add power at the last moment to slow the descent just as the touchdown occurs. The power normally doesn't arrive in time to slow the descent, but it does temporarily force the powered parachute into flight after the bounce.

The corrective action for a light bounce is to make a follow-up landing by applying sufficient power and wing flare to cushion the subsequent touchdown.

The corrective action for a severe bounce is to **execute a go-around immediately**. Don't attempt to salvage the landing. The go-around procedure should be continued even though the powered parachute may descend and another bounce may be encountered. You don't want to attempt a landing after a severe bounce because the skill set that got you to the bounce is probably not up to the task of salvaging that bad landing.

One bounce can also easily end up being multiple bounces. It's best to execute a go-around after that first bounce to prevent further possible damage to the airframe.

Right and wrong methods of correction for low final approach. Correcting at altitude is safer than waiting too long to correct.



High Final Approach

If your final approach is too high, reduce power as needed—ideally as soon as you notice the issue. Bring the power to idle or near idle, and once you're back on the correct approach path, adjust power to maintain a stabilized descent. Be cautious not to steepen the approach to the point where your descent rate becomes too high close to the ground. A high sink rate near the surface can make it difficult to stabilize the approach before landing.

Alternating Turns

If your final approach altitude is too high for throttle reduction alone to bring you back onto a normal approach path, consider making alternating turns to lose altitude. These turns can help you descend until reducing the throttle is enough to intercept the proper path. However, avoid making these turns below 400 feet AGL. Ensure that the turns are evenly spaced from the runway centerline to maintain your position. The bank angle and direction of the turns should be adjusted based on how much altitude needs to be lost for a smooth interception of the normal approach.

High Roundout

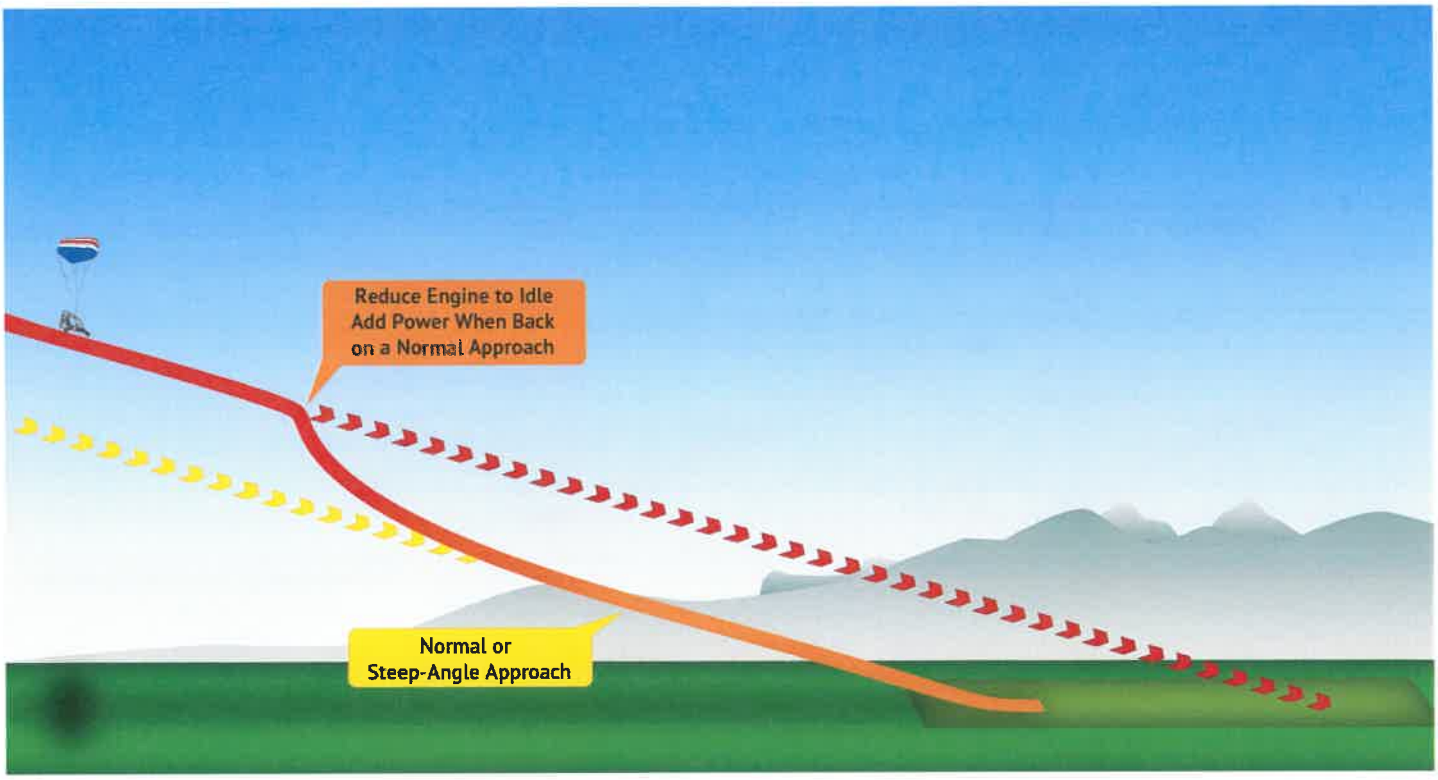
Sometimes a powered parachute appears to temporarily stop descending. That happens when you make your powered roundout too rapidly and your aircraft is flying level, too high above the runway. It may also happen when you experience a momentary wind gust.

If this happens, the first thing to do is figure out why it happened. If it happened because of a gust, you need to determine whether you can rescue the landing or if you need to go around.

If the high roundout is because you advanced the power too much or too early, you should reduce the power very slightly in order to land further down the runway. Some students try to correct this situation by reducing the throttle a lot to land closer to their chosen landing point. This most often results in a hard landing because lift has been dramatically reduced.

You should **go around** any time it appears that there may not be enough runway to safely land or if the landing is in any other way uncertain.

Change in glide path and increase in descent for high final approach.



Gust-Induced Oscillations

Gusty headwinds can induce pitch oscillations as the large, lightweight wing responds faster and more easily to a wind gust than the airframe. That will feel like porpoising. It can fully turn into porpoising if you try to correct for the gusts.

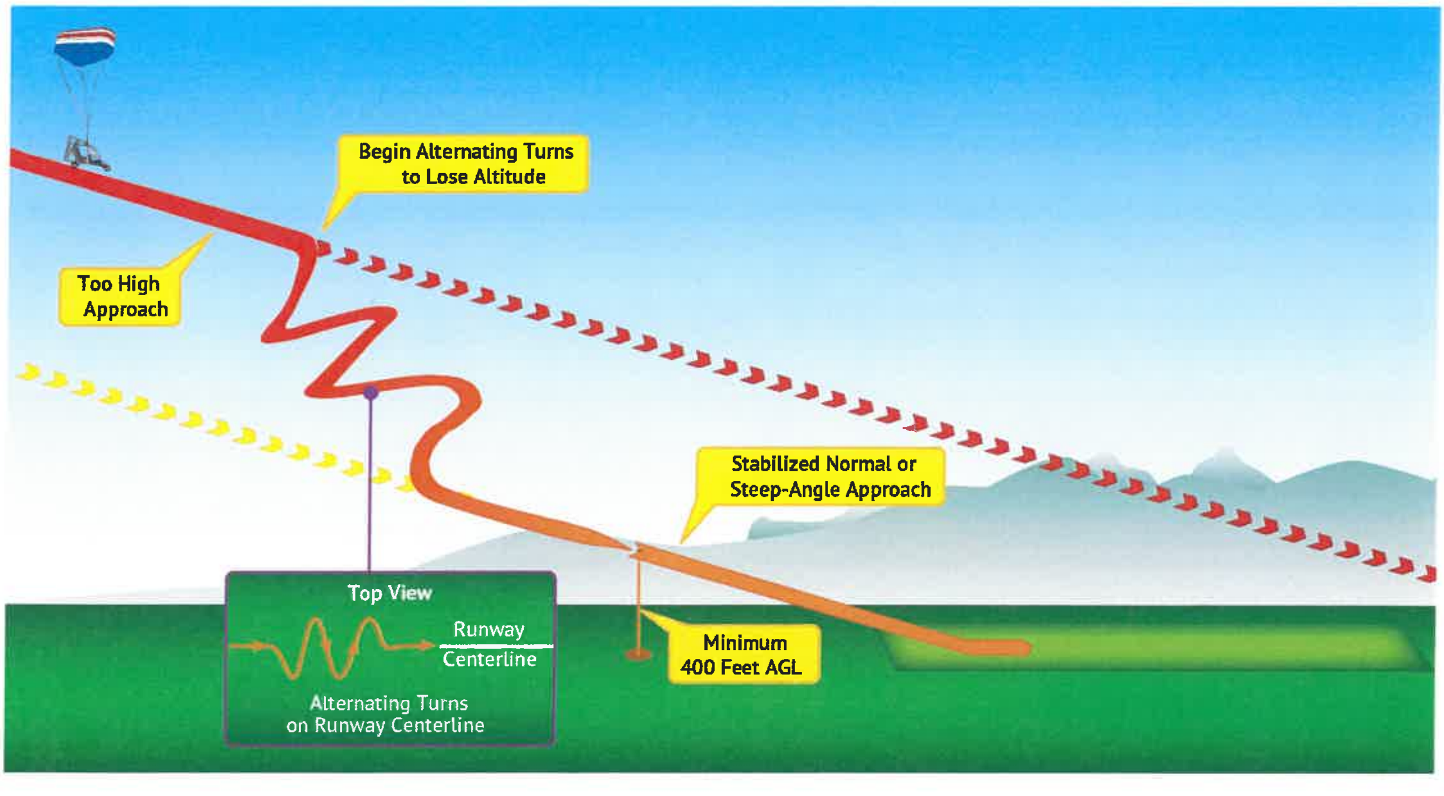
Crosswinds can induce side-to-side swing oscillations. A crosswind from the right, for instance, tends to push the wing to the left. The pendulum effect will force the wing back to the right while the airframe moves left. This rocking will normally settle down by itself unless you try to oversteer the wing.

Pilot-induced side-to-side swinging can occur if the pilot overcontrols steering. This usually occurs with new pilots during the landing phase, and typically begins after a side gust of wind impacts the powered parachute during the approach. The wing is pushed to one side and the airframe begins to swing under the wing while the wing swings back towards the airframe. The student perceives the movement of the airframe to the side and tries to steer the aircraft back to the center of the runway even while the wing is already moving back due to the pendulum effect. That produces an overcorrection. Then the student pilot pushes on the other bar to correct that and only increases the oscillations since the pendulum effect is once again already trying to make a correction.

The solution for gust-induced porpoising and side-to-side oscillations is to stop adding too many controls to the throttle and relax your steering control pressures. Realize that a powered parachute wants to be centered (side to side, as well as fore and aft). You should adjust your throttle setting for a stabilized approach and hold it there. Ease the pressure on the steering bars, and only steer on one side, usually the upwind side. Your focus should be on aligning the airframe with the runway, not with correcting the oscillations.

Local terrain can have a considerable effect on the wind. Wind blowing over and around obstacles can be gusty and chaotic. Nearby obstacles, such as buildings, trees, cliffs, and mountains can create mechanical turbulence, particularly on the downwind side of the obstruction. In general, the effect of an upwind obstacle is the creation of additional turbulence. These conditions are usually found from the surface to a height 10 times above the obstacle.

Using alternate turns to quickly lose altitude.



Porpoising

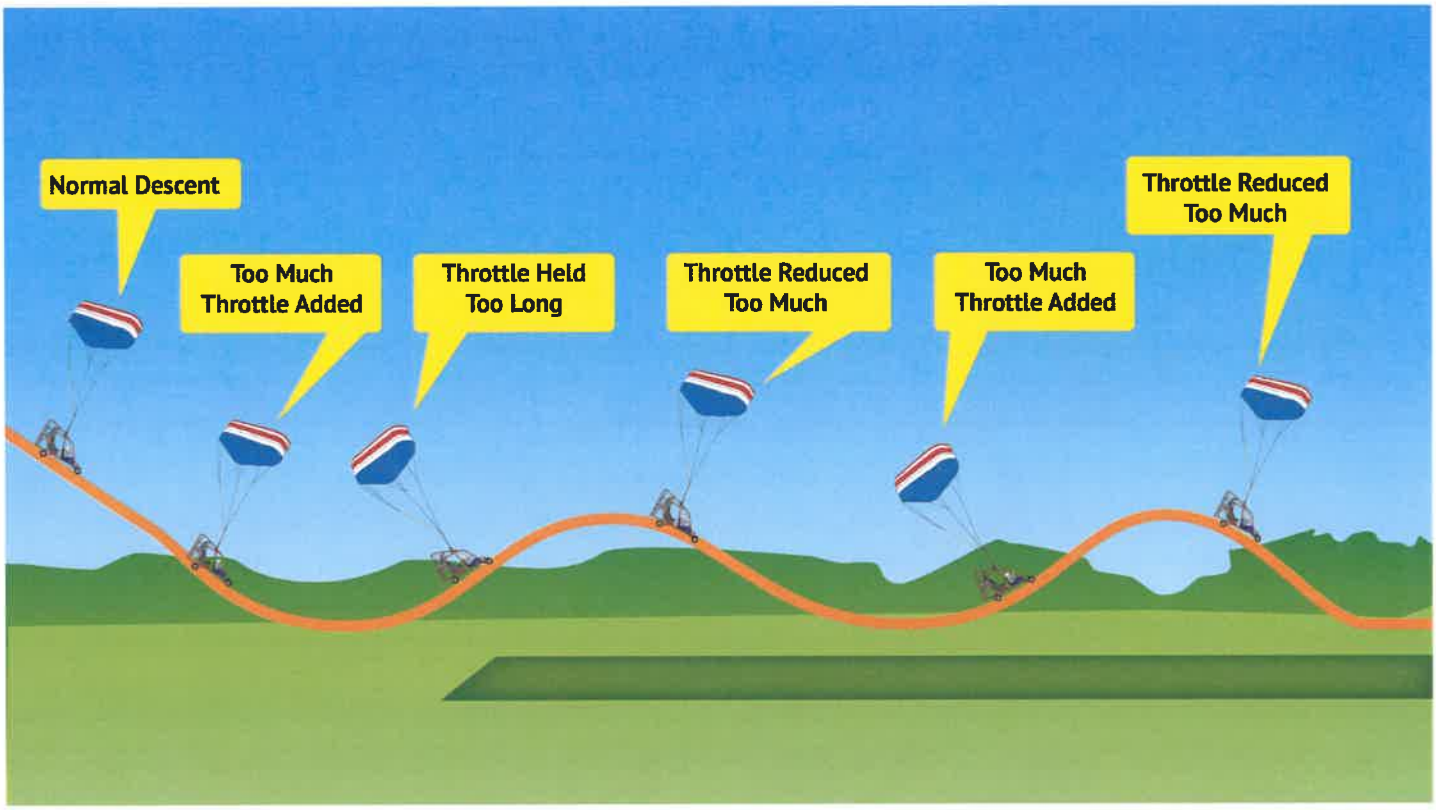
Sometimes a student pilot makes far too many and too severe of throttle adjustments during final approach or roundout. These over-corrections set off a series of motions that imitate the jumps and dives of a porpoise — hence the name. The problem is that the student doesn't yet understand the lag time between a throttle adjustment and its effect on the climb or descent rate of a powered parachute.

When throttle is increased, it takes a finite amount of time for it to add more fuel-air mixture into the engine, for the engine and propeller to increase speed, and for the propeller's thrust to push the airframe far enough forward of the wing to initiate a climb. During that lag time, a student will add even more throttle because of what is imagined to be a lack of response from the first throttle increase. So by the time the powered parachute is climbing, it's *really* climbing. Then the cycle begins in reverse with the student reducing power a little at first and then a lot.

Sometimes this sets up something of a panic in a student where the throttle adjustments become faster and faster. Things can become worse when the throttle adjustments become almost opposite of, but in sync with, the porpoising of the powered parachute.

When a porpoise is severe, the safest procedure is to **execute a go-around immediately**. In a severe porpoise, the powered parachute's pitch oscillations can become progressively worse, until the aircraft strikes the runway nose first with sufficient force to damage the nose gear. Pilot attempts to correct a severe porpoise with power inputs will most likely be untimely, out of sequence with the oscillations, and make the situation worse. You should not attempt to salvage the landing, instead apply full power. On the next turn to final, relax and work with a slow, smooth throttle action.

Porpoising during a landing approach.



Chapter 22 Maneuvers

Flying isn't quite like driving a car. Car drivers often have a narrow field of view and are focused on the road right in front of them. When you begin flying, you might find yourself doing the same thing in the air. But unlike a car, a powered parachute not only moves forward but also rotates in bank, pitch, and yaw while making horizontal, vertical, and lateral movements.

To become a proficient pilot, you begin with mastering the fundamentals. Straight-and-level flight, turns, climbs, and descents lay the groundwork for everything you'll do in the sky.

Flight Controls

A powered parachute has two primary flight controls:

1. **Throttle:** is used to adjust the vertical speed to climb or descend
2. **Steering bars:** are used to turn right or left

Most powered parachutes employ steering systems with either foot pedals or foot steering bars. However, some designs incorporate hand steering controls. These are particularly popular with foreign built powered parachutes and those evolved from powered paraglider designs. In addition to the mechanical hand or foot steering controls, the steering line itself can be pulled directly or in combination with the mechanical controls. For simplicity, flight steering controls here will be addressed as foot controls.

Speed

Notice that your throttle doesn't directly control your speed. Powered parachutes are considered constant-speed aircraft, with speed being determined by a variety of other factors including:

- Wing Design
- Wing Size
- Wing Trim
- Gross Weight of the powered parachute
- Thrust angle of the powered parachute
- Whether the powered parachute is climbing, descending, flying straight-and-level or turning.

Most of these factors remain constant for a particular flight of a powered parachute. Those that do change, do not change the speed of a powered parachute more than 10% from straight-and-level flight. The change in speed is because the angle of incidence between the airframe and the wing will change as the powered parachute climbs, flies straight-and-level, and descends. The angle of incidence can change because wing risers can pivot forward and rearward on the riser attachment points to the airframe.

A wing's angle of trim is determined by the suspension lines and set at the factory that manufactured the wing. A knowledgeable pilot can reduce wing trim angle by adding quick links to the rear suspension line sets (the C-D line sets), which will lower the angle of attack and speed up the powered parachute. This is rarely recommended. Moreover, pilots should never put additional quick links in the front suspension line sets (the A-B line sets) since that can brings the wing closer to a stall.

Throttle

While flying, your throttle provides thrust and therefore controls altitude; you use it to maintain altitude, climb and descend. Increasing your throttle increases your rate of climb while decreasing throttle allows you to descend.

As you descend with reduced throttle, the nose of the airframe is pointed more towards the ground while the wing is overhead. As you climb, the nose of the airframe is pointed more towards the sky, and the wing appears to be rotated behind you. These can be large pitch changes. A common misunderstanding is that changes in the wing's angle of attack are completely responsible for these pitch changes, which can be as much as 40 degrees. This is not the case. While the wing's angle of attack does change, the pitch angle of the entire aircraft is what changes dramatically.

A common, inappropriate use of the throttle is abruptly reducing or increasing engine power. Abrupt throttle changes create immediate drops or climbs that can startle you or your passenger. Pilots often instinctively overcorrect that descent or climb by abruptly changing the throttle again. That results in porpoising. Gradually change the throttle to avoid porpoising.

Throttle changes will slightly change the speed of a powered parachute, but that change is counterintuitive. With an increase in throttle, a powered parachute actually slows down because of the increased drag from the increasing angle of attack of the wing rotating rearward. Decreases in throttle allow the aircraft to speed up because the wing can rotate forward relative to the airframe.

Steering Bars

Steering lines run from the controls, through a series of pulleys parallel to the risers and suspension lines, then cascade out to several smaller lines that are attached to the trailing edge on the corresponding sides of the wing. The right steering line is attached to the right steering control at the flight deck (either foot or hand control), and the other end of the cascaded steering lines are attached to the wing's right trailing edge.

When you push a steering bar, you pull on a steering line and pull down the trailing edge of the corresponding side of the wing, which creates drag on that side of the wing. Drag from the pulled-down trailing edge slows down that side of the wing. The opposite side of the wing continues at normal speed and pivots around the vertical axis in a coordinated turn. Centrifugal force moves the weight of the airframe outward on the radius of the turn and creates a bank that increases the rate of the turn and *coordinates* the turn. This is explained further in *Chapter 17, "Stability and Stalls."*

While airborne, you'll turn in the same direction of the foot steering bar that you push: push the right steering bar—go right; push the left steering bar—go left.

Feel of the Powered Parachute

When flying, the ability to sense flight conditions without relying on instruments is often referred to as *feeling the aircraft*. This sensation encompasses various elements, such as the sound of air flowing around you, vibrations, and the physical sensations that accompany different movements during flight.

This ability is developed through two main sensory processes: *kinesthesia* (the sense of body movement) and *proprioception* (the unconscious awareness of your body's position and movement in space). These sensations are detected by nerves in the body and the semicircular canals in the inner ear. Developing this intuitive sense takes time and comes with practice in various flight conditions. Some examples of that feel are:

Engine sounds: The engine sounds different in climb, cruise and descent.

Engine vibrations: A subtle change in vibrations can alert you to engine performance issues or adjustments needed in throttle settings.

Banking awareness: In a turn, you feel pushed into your seat due to the load factor.

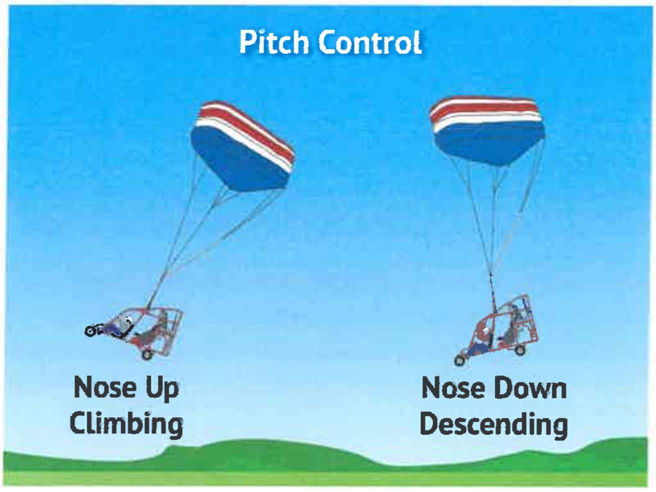
Updrafts and downdrafts: When encountering thermal updrafts and downdrafts you'll feel yourself either pushed down or lighter in your seat, respectively.

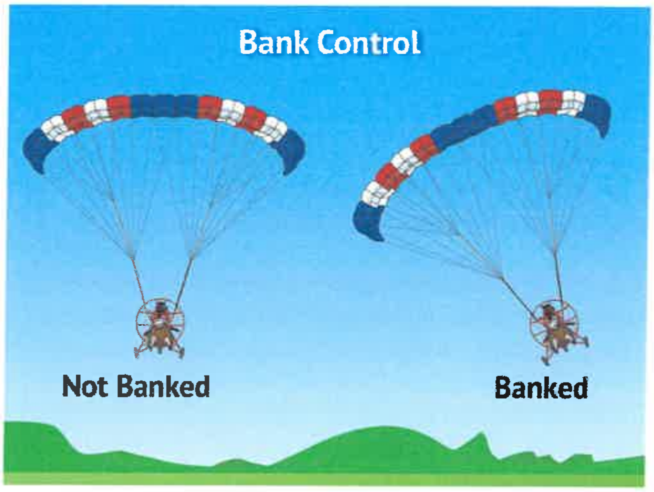
Gusts: You can feel crosswind gusts and anticipate the pendulum effect. In a descent, you feel the lift and drops from slight gusts as you get close to the ground.

Temperature: While climbing and descending, you'll feel temperature differences while passing through temperature inversions.

This actual *feel* in flight is the result of acceleration, which describes how velocity changes over time. Acceleration imparts forces on both the aircraft and you, which you can sense through pressure changes and movements in your seat. Even small accelerations are detectable by skilled pilots and provide valuable feedback about the aircraft's state.

Your flight instructor will guide you in distinguishing between simply noticing these sensations and effectively responding to them. Understanding this distinction is essential to developing a true *feel* for the powered parachute. Developing this sense early in your flight training makes advanced maneuvers and techniques feel more intuitive and smoother as you progress.





Attitude Flying

In a powered parachute, flying by attitude means visually establishing the aircraft's attitude with reference to the natural horizon. Attitude is the angular difference measured between an aircraft's axis and the line of the Earth's horizon. *Pitch attitude* is the angle formed by the longitudinal axis of the aircraft and the horizon. *Bank attitude* is the angle formed by the lateral axis with the horizon.

In attitude flying, you control two components: pitch and bank.

Pitch control is the control of the aircraft about the lateral axis by using the throttle to raise and lower the nose in relation to the horizon.

Bank control is control of the powered parachute about the longitudinal axis by use of the steering bars to attain a desired bank angle in relation to the horizon.

Trim is used to relieve control pressures after a desired altitude and direction have been attained.

Straight-and-Level Flight

When learning to fly, it's crucial to establish correct habits for maintaining straight-and-level flight. This fundamental skill serves as the basis for all other flight maneuvers. Achieving perfection in straight-and-level flight requires practice and attention. Sometimes, pilots fall short of expected standards because they struggle with this basic skill.

Straight-and-level flight means keeping a constant heading and altitude. To do this, you make immediate corrections for any unintentional turns, descents, or climbs. Initially, keeping level flight involves paying attention to your altimeter and vertical speed indicator. They are your best references to whether you're flying level at altitudes above 100 feet AGL.

If you want to maintain a specific direction, consider the wind component. Unlike driving a car, flying a powered parachute straight requires selecting a reference point on your airframe that compensates for the wind. This point is often left or right of center of the aircraft because it's rare for the wind to align perfectly with your direction of travel. As a result, the aircraft's ground track is offset due to wind drift, requiring corrections to maintain your desired flight path or landing approach. That means that you'll feel like you're flying a little sideways because you're pointed at an angle into the wind. However, your ground track should be straight.

When controlling the aircraft in level flight, use gentle control movements. Associate the apparent movements with the forces causing them. For maintaining a constant altitude, focus on the ground below and the RPMs of the engine, cross-checking occasionally with the altimeter. Use throttle adjustments to control altitude.

You want to avoid constantly staring forward for heading alignment. Spend more time scanning for air traffic to broaden your field of vision and prevent fixating on the direction you're going.

Straight-and-level flight usually requires minimal control pressures if the aircraft is properly trimmed. Some powered parachutes have wing steering line trim controls, while others may rely on weight shifting for minor adjustments. That's done by shifting your and your passenger's weight to the side opposite of the direction the aircraft is flying off-course. By shifting in your seat even slightly to one side of the airframe, you can make changes in direction without putting steering inputs into the wing and adding drag.

Avoid forming the habit of unnecessary control movements. Recognize when corrections are needed and respond measuredly. Tolerances for the practical test are ±10 degrees heading and ±100 feet altitude. You should initiate a correction before the tolerances are exceeded, such as starting a correction when you find yourself ±5 degrees off heading and ±50 feet from your chosen altitude.

Flying close to the ground requires a different technique since sometimes you may want to control your altitude within only a few feet of the ground and sometimes within only inches. In flying a low approach, think of the throttle as the coarse and slow responding altitude control. On the other hand, think of flare as the fine and immediate adjustment for altitude. The throttle in a powered parachute has a slight delay between when you apply it and when you notice an increase in altitude. Flare increases altitude relatively quickly but can only hold altitude small changes temporarily.

While trying to maintain a constant altitude when close to the ground, you can fly with about one third flare. By holding a small flare, if you encounter downdrafts, you can immediately add even more flare to maintain your altitude. If you begin to climb, then you can reduce the amount of flare to return to the desired level above the ground. If the throttle is set well initially, flare control can be used to respond to small differences in wind and thermals on a low pass. If there's a major change in wind or thermals, then additional flare can be applied to make an immediate correction while you adjust your throttle for longer term effect.

Straight-and-Level Flight Errors

Common errors while flying straight-and-level are:

- Failing to regularly scan the altimeter at higher altitudes.
- Attempting to establish or correct aircraft altitude at low levels using the altimeter rather than outside visual references.
- Overcontrol and lack of feel.
- Improper scanning and/or devoting insufficient time to outside visual references.
- Fixation on the nose.
- Unnecessary or inappropriate control inputs.
- Failure to make timely and measured control inputs when deviations from straight-and-level flight are detected.
- Inadequate attention to sensory inputs in developing a feel for the powered parachute.

Level Turns

A turn is made by banking the wing in the direction of the desired turn. You select the angle of bank, you apply control pressure to the steering bar to achieve the desired bank angle, and you maintain that pressure once you establish the desired bank.

All powered parachutes have unique flying characteristics, but generally, the more stable rectangular wings will dampen quicker than higher performance elliptical wings, which means they will rock less from side to side after a turn. On the other hand, elliptical wings typically have better turning performance than rectangular wings and can make smaller radius turns.

You use both primary controls in close coordination when making level turns. Their functions are as follows:

Steering Bars: Pulling the steering line yaws the wing and determines the rate of turn. (Keeping in mind that centrifugal force swings the airframe out and automatically adjusts the bank.)

Throttle: To maintain altitude the throttle must be increased during a turn. The greater the degree of turn, the greater the throttle/thrust required to remain level.

For purposes of this discussion, turns are divided into three types: shallow, medium, and steep.

Shallow turns are those in which the bank is less than approximately 20°.

Medium turns are those resulting from approximately 20° to 45° of bank.

Steep turns are those resulting from 45° or more of bank. Steep turns are generally not recommended in a powered parachute. Going beyond the specified limitations in regulations or the Pilot's Operating Handbook (POH) is considered aerobatics and is not allowed.

In a powered parachute, you measure bank angle by checking the angle between the horizon and any level or vertical part on the airframe, like the instrument panel or steering bars. Each design has its unique reference point.

To start a turn, you push the steering bar to create drag on one side of the wing, slowing it down. The side without drag flies faster, causing the powered parachute to yaw around the vertical axis. Then centrifugal forces pull the airframe out from the wing and that in turn puts the aircraft into a bank.

A shallow bank gives a noticeable turn without a significant increase in load or airspeed. You need constant pressure on the steering bar to maintain the turn. Releasing the pressure brings the aircraft back to straight flight due to the minor pendulum effect.

A medium bank turn requires more effort and comes with higher G-loading and airspeed. Again, you must maintain pressure on the steering bar to keep the bank. Abruptly releasing pressure in this case can lead to overcorrection, causing oscillations until returning to straight flight. Smoothly releasing the input reduces the bank angle evenly.

Comparison of Pitch Controls on a Powered Parachute

	Throttle	Flare
How it works	By increasing the throttle, you add more fuel to the engine, which speeds up the prop and pushes the cart forward in relation to the wing. That initiates a climb.	By increasing flare, you warp the wing and increase its angle of attack. It immediately slows the wing down in relation to the airframe. The increase in angle of attack increases lift and drag on the wing.
Response	Relatively sluggish because the propeller has to push the relatively heavy cart forward relative to the wing. There's a lot of inertia to overcome.	Relatively quick because it is easy to slow down the light wing relative to the airframe. The airframe continues to move forward due to inertia and helps increase the flare.
How long it lasts	Long term. As long as you keep the throttle advanced, the engine will maintain speed and therefore the climb.	Very short term. Flare takes advantage of the forward inertia of the airframe to increase lift, but as soon as the airframe slows down, the effect is over.
When used	At any altitude, but rarely as landing.	Normally only within a few feet of the surface. Most landings have some flare added on touchdown to slow both the descent and the forward speed of the powered parachute.

To stay level during a turn, coordinate steering input with a throttle increase due to the loss in vertical lift from the banked wing. A shallow turn needs modest steering and throttle increase. The steeper the turn, the more throttle is required. Increased skill is needed to prevent swaying when coming out of the turn.

To end the turn and return to straight flight, smoothly release the steering bar. The powered parachute's pendulum stability will guide it back to a straight path. Always manipulate controls smoothly to avoid pilot-induced oscillation, whether you're adjusting throttle or steering.

The rate of the turn in a powered parachute is linked to the steering input. More input means a quicker turn. Using full steering without enough throttle can significantly reduce lift, leading to a rapid descent during the turn.

Level Turn Errors

Common errors during level turns are:

- Failure to adequately clear the area before beginning the turn.
- Attempting to sit up straight, in relation to the ground, during a turn, rather than maintaining posture with the airframe.
- Insufficient feel for the powered parachute.
- Gaining proficiency in turning in only one direction; not practicing turns in both directions.
- Failure to coordinate the throttle with the steering bars.
- Altitude gain/loss during the turn.
- Too great of a bank angle.

Climbs and Climbing Turns, Descents and Descending Turns

To go up, increase throttle. To descend, decrease throttle. When your powered parachute starts climbing, it shifts from flying level or descending to ascending with an incline.

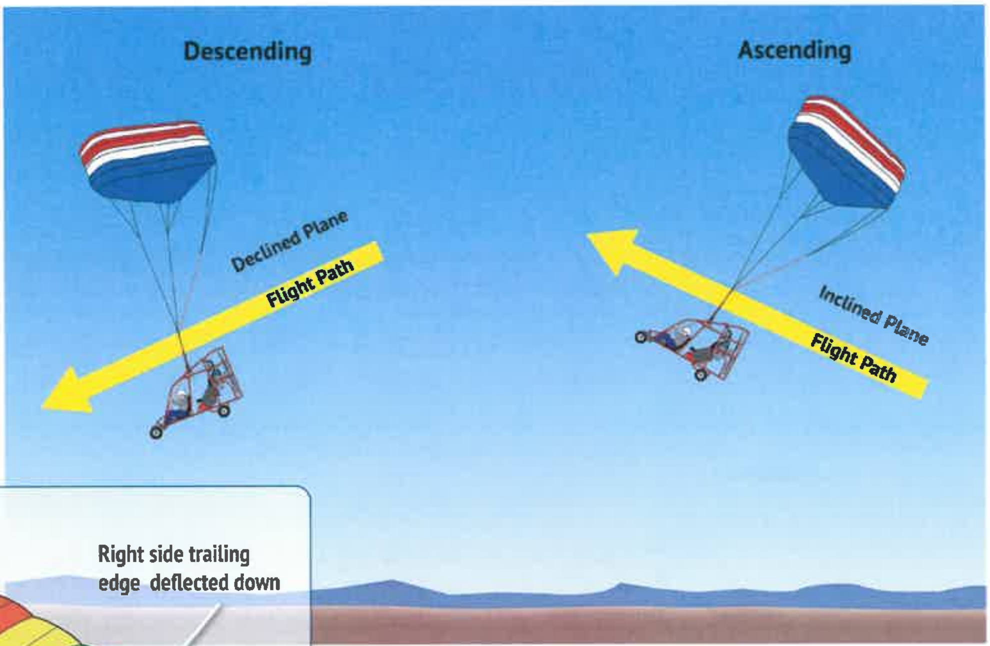
If you want a straight climb, just increase the throttle above the level flight power setting while keeping a straight heading. You will probably have to use some steering input to compensate for torque.

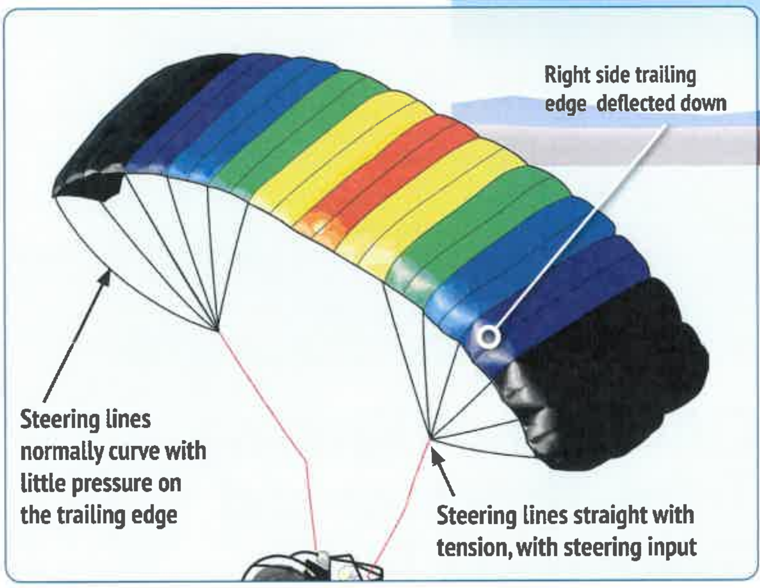
Climbing turns need more throttle than straight climbs. Torque may help or hinder your turn, depending on whether you want to turn to the same side that the torque is pulling you to or not. When flying low and trying to climb to avoid an obstacle, it's good to know which way your powered parachute wants to turn because of torque. That way you can use the torque to help you turn away from the obstacle.

Before descending, make sure to check the area below and to the side you want to turn towards.

To come down, decrease the throttle below the straight-and-level RPM, whether you're flying straight or turning. The descent rate is determined by how much you reduce the throttle. Banking the aircraft will also speed up your descent. The steeper the bank, the faster you descend. On a properly trimmed powered parachute, descents will pull you to the opposite side that climbs pull you toward.

Right: When a powered parachute stabilizes in a climb or descent, the flight path is a declined or inclined plane.





Left: The right trailing edge is shown pulled down to correct for a left-turning tendency in climb for a clockwise turning prop or descent for a counter-clockwise-turning prop..

Gliding

In a glide, your powered parachute descends in a controlled manner with little or no engine power. The glide ratio measures how far the aircraft moves forward compared to the altitude it loses. For example, if you travel 4,000 feet forward while descending 1,000 feet, your glide ratio is 4 to 1.

Wind significantly influences gliding distance. With a tailwind, you'll glide farther. For the example above, your glide may increase to a 6 to 1 ratio, due to higher groundspeed. Conversely, you won't glide as far with a headwind or crosswind, maybe a 2 to 1 ratio, because of the slower groundspeed.

Powered parachutes are designed to fly at a high angle of attack, extracting more lift from their somewhat inefficient airfoil. Adding flare at altitude will decrease your speed by increasing drag and angle of attack, reducing your glide ratio. Avoid trying to *stretch* a glide by applying flare. This tends to increase the descent rate and angle after the initial benefits of flare quickly wear off.

A stabilized power-off descent is a normal glide. The only steering control needed is to compensate for any turning tendency and to maintain your intended direction. Pay attention to the feel of the powered parachute during the glide.

Trimming

Most powered parachutes can be adjusted to fly straight without pressure on the steering bars for a specific weight loading. When the forces of weight and torque are balanced, a powered parachute flies straight-and-level. Changes in loading or torque, such as increased engine torque during climbing or changes in loading during descent, can take a powered parachute out of trim.

If your powered parachute is flying temporarily out-of-balance, like during a climb or descent, you can use a steering bar to bring it back to straight flight. For long-term imbalances, such as taking on a passenger when the aircraft is adjusted for solo flight, two techniques can be used. The first and preferred method is to shift your weight to the opposite side of the turning direction. This simple weight shift accounts for torque changes without altering the airfoil's shape.

The second method involves using the steering controls. Pulling down one steering line and locking it in place with a trim lock can relieve the constant need for steering input. While this method is effective, it's not ideal due to inefficiency from increased drag. Using weight shifting, if your powered parachute allows it, is a better way to adjust for minor loading changes. Without trim locks or the ability to shift weight, an improperly trimmed powered parachute can lead to pilot fatigue, requiring constant pressure on the steering bars.

Trimming is covered in detail in *Chapter 18, "Flight Controls and Trimming."*

Performance Maneuvers

Performance maneuvers are generally used to develop a high degree of pilot skill. Happily for powered parachute pilots, there's only one performance maneuver, and it isn't terribly difficult to master. However, it's still important to understand and perform it according to FAA standards on your practical test. It begins with a clearing turn and continues with specific tolerances from the FAA.

Clearing Turns

Before starting any maneuver or turn, it's crucial for you to perform a clearing turn. Effective collision avoidance relies on proper clearing procedures and visual scanning techniques. The primary goal of a clearing turn is to ensure that your next maneuver won't intersect with another aircraft's flight path. Clearing turns are covered in *Chapter 2, "Flight Safety."*

Steep Turns

The only FAA-required performance maneuver for pilot testing is steep turns. The goal is to develop smoothness, coordination, orientation, attention division, and control techniques for executing maximum performance turns near the powered parachute's limits. Key features are smooth control use, coordination, and execution accuracy. This maneuver involves turning in either direction with a bank angle between 45° to 60°, causing an overbanking tendency for maximum turning performance and high load factors. The check ride demands that you execute a steep turn until completing a full 360° turn.

A powered parachute's maximum turning performance is determined by engine power, parachute strength, and aerodynamics. The load on a powered parachute increases significantly as the bank angle exceeds 45°. A 70° bank angle can impose a load factor of about 3 Gs on the wing and airframe, stressing the wing more than most general aviation airplanes. High wing loadings are generally manageable, but there's limited practical experience on the impact of repeated high loading and unloading on a wing's life.

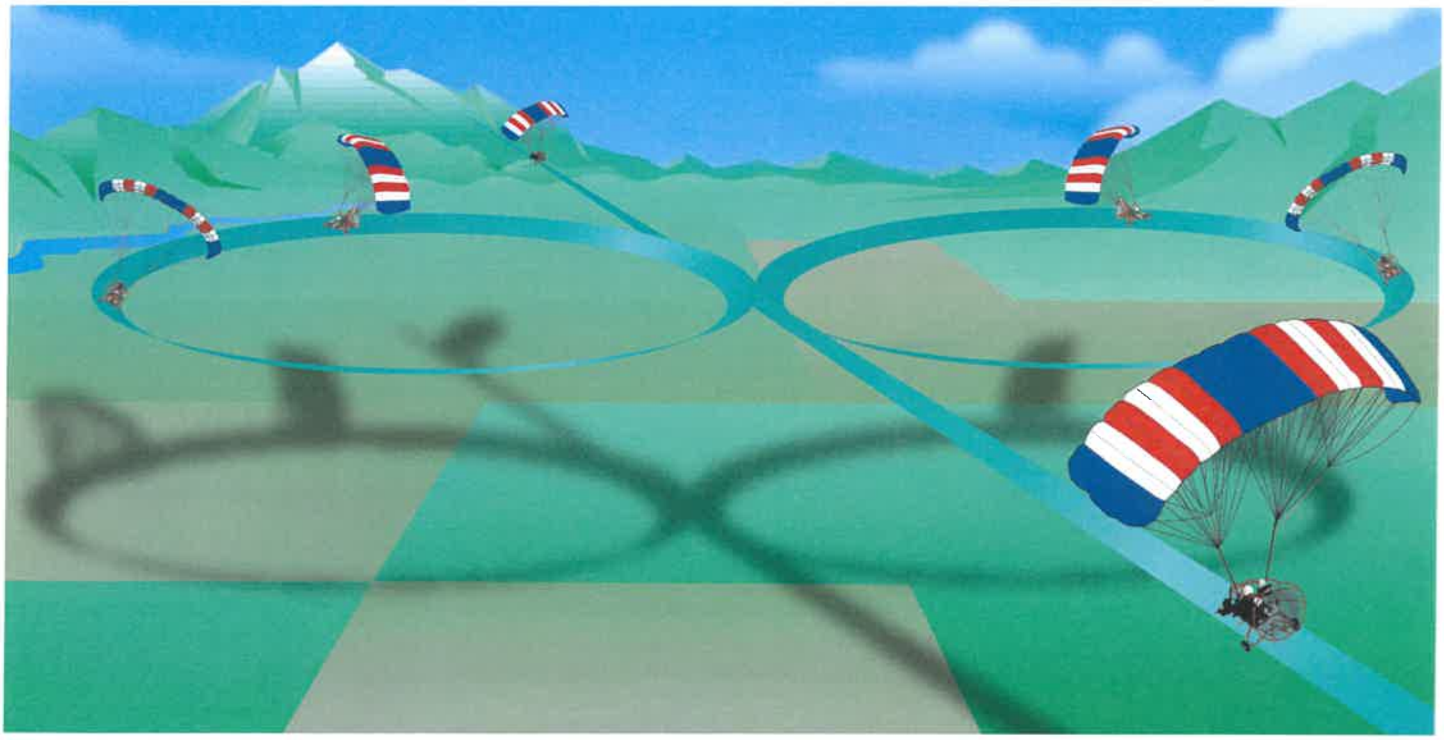
A given angle of bank in a turn, during which altitude is maintained, will always produce the same load factor.

To perform the maneuver, first perform a clearing turn. Then smoothly roll into a 45° to 60° bank. Increase the throttle during the turn to maintain entry your altitude, compensating for the decreasing vertical lift from the banked wing. You will need to hold considerable force on the steering control as the load factor increases with bank angle.

Avoid staring at a single object in front of you. Instead, maintain awareness of the nose, horizon, bank, and altitude. Increase the throttle as needed to prevent altitude changes.

Time the rollout from the maneuver so that you reach level flight on your original heading. Do that by smoothly reducing steering inputs while reducing power during recovery as necessary to prevent climbing.

In powered parachuting, too high of a turn rate will eventually transition to a *spiral dive*. That occurs when the inboard side of the wing (the side with the steering line being deflected) has stalled. The other side of the wing overflies the stalled side and the wing begins flying toward the ground in a spiral. You recover from a spiral by smoothly releasing the steering control.



Steep turns, or Constant Altitude Turns as the practical test standard refers to them, can be made either to the left or right.

Steep Turn Errors

Common errors during steep turns are:

- Failure to adequately clear the area.
- Failure to stop the turn on a precise heading.
- Inadequate power management.
- Gaining or losing altitude.
- Failure to maintain constant bank angle.
- Disorientation.
- Failure to scan for other traffic during the maneuver.
- Attempting to start recovery prematurely.
- Recovering too late.

Ground Reference Maneuvers

Ground reference maneuvers are important for honing your pilot skills. While you may not perform these maneuvers in everyday flying, the elements and principles involved apply to standard pilot operations. They help you understand the impact of wind and other forces on your powered parachute, developing precise control and the division of attention needed for safe and accurate maneuvering.

In the early stages of training, the focus is on mastering technique, understanding maneuvers, and developing the feel for handling the powered parachute. Your primary attention is on the aircraft's handling and the effects of control inputs.

As you progress, it's important not to become fixated solely on the aircraft. Once you demonstrate proficiency in basic maneuvers, you'll be introduced to those requiring attention beyond the flight deck.

During ground reference maneuvers, you should maintain the fundamental flying techniques you've learned. Your instructor should ensure that previous standards aren't relaxed just because new elements are introduced. Consistency is key as each new maneuver builds on the principles of the last, ensuring orderly progress.

Maneuvering by Reference to Ground Objects

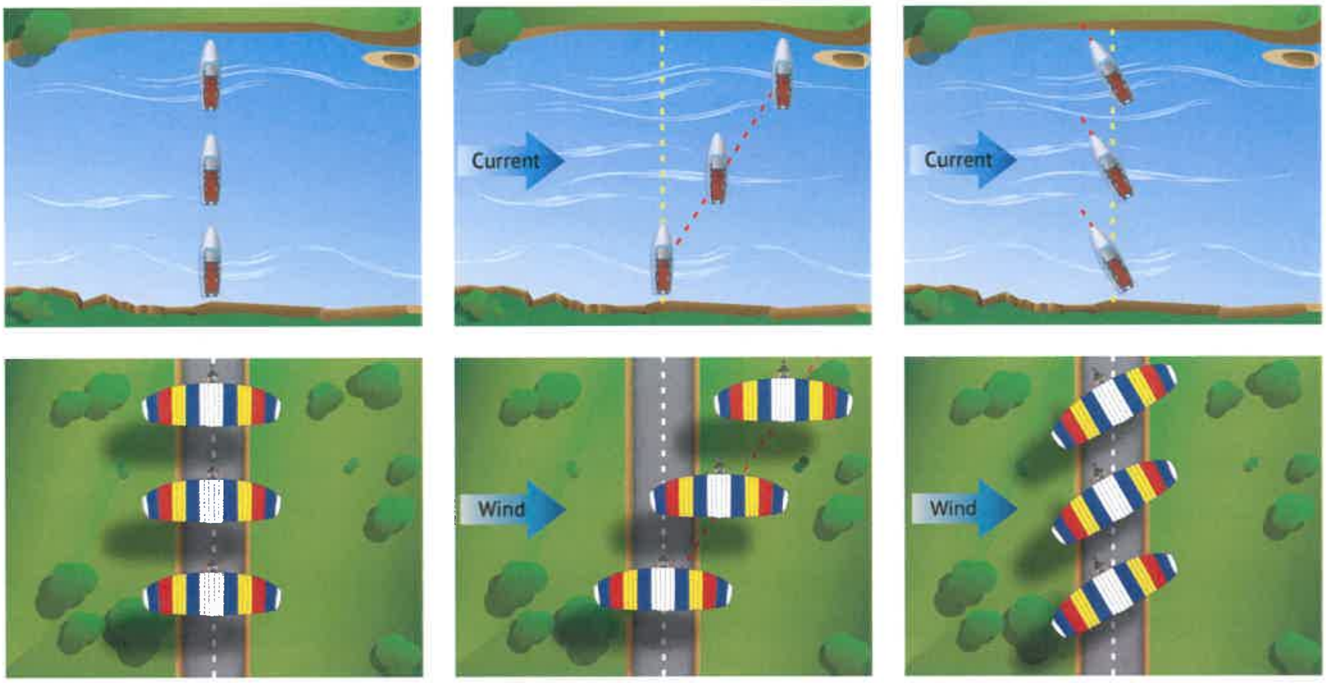
Ground track or ground reference maneuvers are performed at a relatively low altitude while correcting for wind drift as needed to stay on a predetermined path over the ground. They develop your ability to control your powered parachute, correcting for wind effects while managing various tasks. The maneuvers require you to plan ahead, maintain orientation to ground objects, follow appropriate headings, and be aware of nearby air traffic.

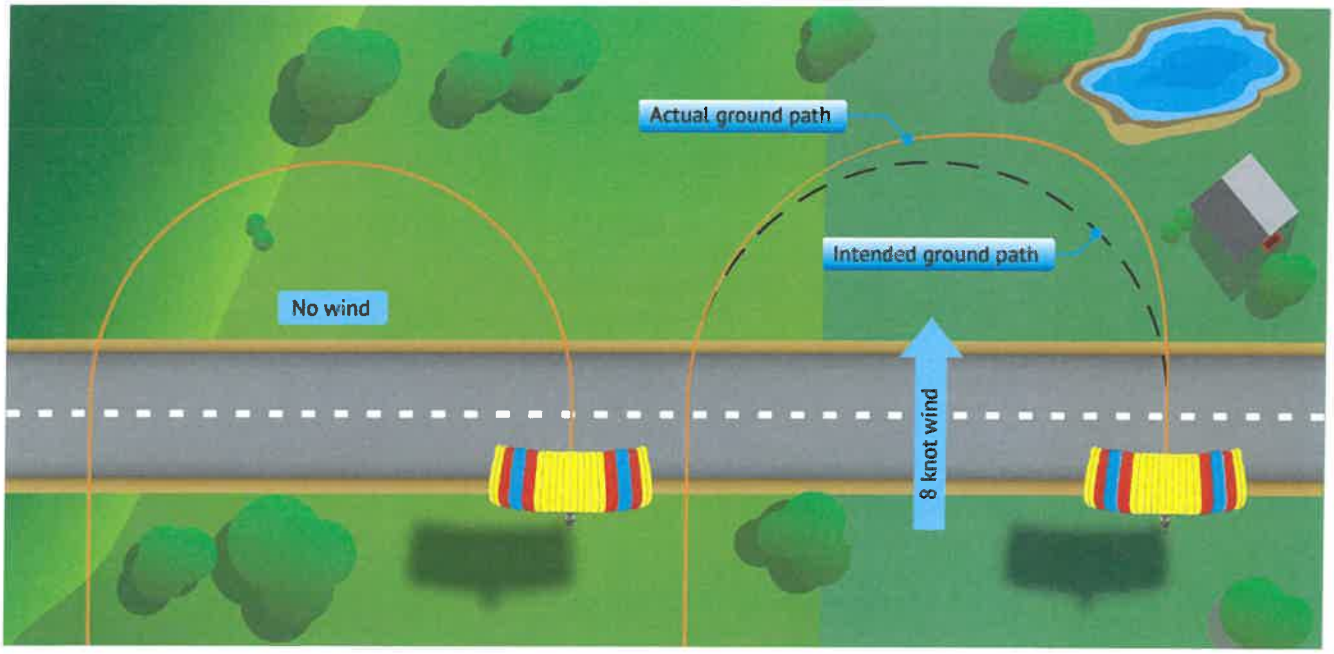
Two of the three standard maneuvers require you to conduct clearing turns before starting to ensure that you won't interfere with another aircraft's path. Proper clearing procedures, combined with effective visual scanning, are key for collision avoidance while performing ground reference maneuvers.

Keep ground reference maneuvers above 300 feet AGL and stay a safe distance of at least 500 feet from people, vessels, vehicles, or structures during the maneuvers. Pay attention to the radius of your turns and your powered parachute's path over the ground, making adjustments as needed.

When you're introduced to these maneuvers, your instructor will make sure that the winds you're flying in will create drift that be noticeable but manageable for you when making corrections. You'll be guided to maintain an altitude low enough to perceive any changes but never closer

Wind drift and wind correction angle (crab angle).





Effect of wind during turns.

than 500 feet to the highest obstruction or lower than 300 feet above the ground.

Stay alert for suitable forced-landing fields during these maneuvers. Choose areas away from communities, livestock, or groups of people to avoid hazards. Due to the low altitudes involved, be prepared to quickly identify a suitable landing field if needed.

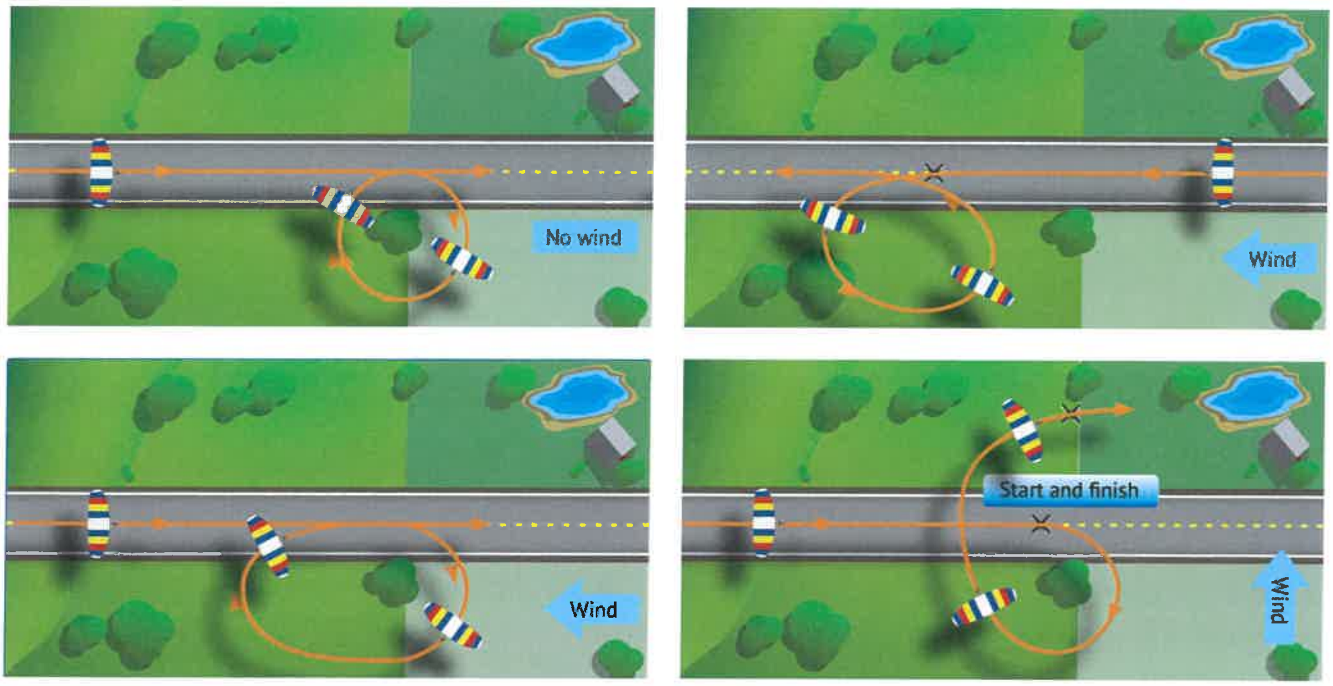
Drift and Ground Track Control

When an object is free from the ground, it moves according to the surrounding medium. For instance, a powerboat crossing a river adjusts its heading to counteract the river's current. Similarly, once a powered parachute is airborne, it moves with the air mass, not necessarily along the exact direction it's pointed. To correct for wind drift, you must angle your powered parachute into the wind to counteract sideways movement.

When flying straight-and-level and following a selected ground track, align your powered parachute into the wind to nullify drift. Depending on the wind velocity, this may require a large wind correction angle or one of only a few degrees. When the drift has been neutralized, the powered parachute will follow the desired ground track.

During turns, the wind will be acting on your powered parachute from constantly changing angles. That means you'll have to constantly adjust the wind correction angle. Groundspeed affects the rate of turn, with steeper banks on the downwind portion and shallower banks on the upwind part.

Effect of wind during turns.



Wind can distort a constant-radius turn. Without wind, you could easily complete a constant-radius 360° turn with a constant steering input. However, wind causes drift, necessitating steering adjustments during the turn. If you try to fly a circular path over a straight line like a road, parallel to the wind, you'll quickly see the need to control the ground track by adjusting your steering for wind.

Conducting a 360° turn directly into the wind results in a distorted ground track, requiring straight flight for realignment. A similar turn directly downwind causes drift, also impacting the ground track.

If you select different reference lines and repeat the process, you'll see the impact of wind drift and the necessity of adjusting the angle of bank and rate of turn. These principles and techniques can be practiced through ground reference maneuvers for better understanding and application.

Rectangular Course

The rectangular course is usually the first ground reference maneuver you'll learn. It involves maintaining a consistent distance from all sides of a selected rectangular area on the ground while also maintaining a constant altitude.

The rectangular course is beneficial for refining several skills:

- Practical application of turns.
- Division of attention among flight path, ground objects, and powered parachute handling.
- Timing the start and recovery of turns to establish a definite ground track.
- Establishing a ground track and determining the appropriate *crab* angle.

The goal is to improve your ability to divide your attention between the flight path, ground references, controlling the powered parachute, and remaining alert for other aircraft. It also helps you recognize drift toward or away from a line parallel to your intended ground track, a valuable skill while flying in airport traffic patterns.

To practice, select a square or rectangular field away from air traffic and fly parallel to its boundaries. For best results, position your flight path just outside the field, especially if the area is small. Avoid flying directly over the edges so you can clearly see reference points for turns. Maintain a consistent distance from the boundaries, regardless of the direction you're flying.

Begin your turns when you're abeam the field's corners, particularly when heading downwind, which is where the maneuver typically starts. Use the turning points to help establish the correct distance for executing the maneuver

Downwind

Although you can enter the rectangular course from any direction, this discussion assumes you are entering on a downwind. On the downwind leg, the wind is a tailwind which results in an increased groundspeed. Consequently, the turn onto the next leg is entered with a fairly fast rate of turn. As the turn progresses, you should reduce the turn gradually because the tailwind component is diminishing, resulting in a decreasing groundspeed.

Base Leg

During and after the turn onto this leg (the equivalent of the base leg in a traffic pattern), the wind will tend to drift you away from the field boundary. To compensate for the drift, you will have to turn more than 90°. You should finish the turn pointed slightly inward towards the field and into the wind to correct for drift. You should again be the same distance from the field boundary, and at the same altitude, as on other legs. Continue the base leg until you approach the upwind leg boundary.

Upwind Leg

You should again anticipate drift and turning radius. Since you kept drift correction on the base leg, turning less than 90° will align you parallel to the upwind leg boundary. You should start this turn with a medium bank angle and gradually reduce the turning input as the turn progresses. The rollout should be timed to assure paralleling the boundary of the field.

Since the wind is a headwind on this leg, it's reducing your groundspeed. While you're on the upwind leg, observe the next field boundary, so you can plan your turn onto the crosswind leg.

Crosswind Leg

During your turn onto the crosswind leg, the wind will try to drift you toward the field. To counteract this effect, your turn must be slow and the bank relatively shallow. As your turn progresses, the headwind component decreases, allowing your groundspeed to increase. To ensure that the crosswind ground track remains equidistant from the field edge, it's important keep the nose of the aircraft pointed away from the field and into the wind.

This requires that the turn be less than a 90° change in heading. If you make the turn properly, you should be the same distance from the field boundary, and at the same altitude, as on other legs. While on the crosswind leg, the wind correction angle should be adjusted as necessary to maintain a uniform distance from the field boundary. As you approach the next field boundary, you should plan your turn back onto the downwind leg.

Downwind Leg (Again)

Since you previously held a wind correction angle into the wind and away from the field on the crosswind leg, this next turn will need to be more aggressive, exceeding 90°. As the crosswind becomes a tailwind during the turn, your groundspeed will increase, requiring you to begin with a medium bank and progressively steepen it as the turn continues. Time your rollout so that you complete the turn when the powered parachute's longitudinal axis is once again parallel to the field boundary, aligning with the crosswind corner. The distance from the field boundary should be consistent across all sides of the course.

While you typically won't encounter drift on the upwind or downwind legs, it's rare to have wind perfectly aligned with the field boundaries. In most cases, you'll need to apply a slight wind correction angle on all legs. Anticipate the turns to account for changes in groundspeed, drift, and turning radius. When flying with a tailwind, the turn should be faster and steeper; with a headwind, slower and shallower turns are necessary.

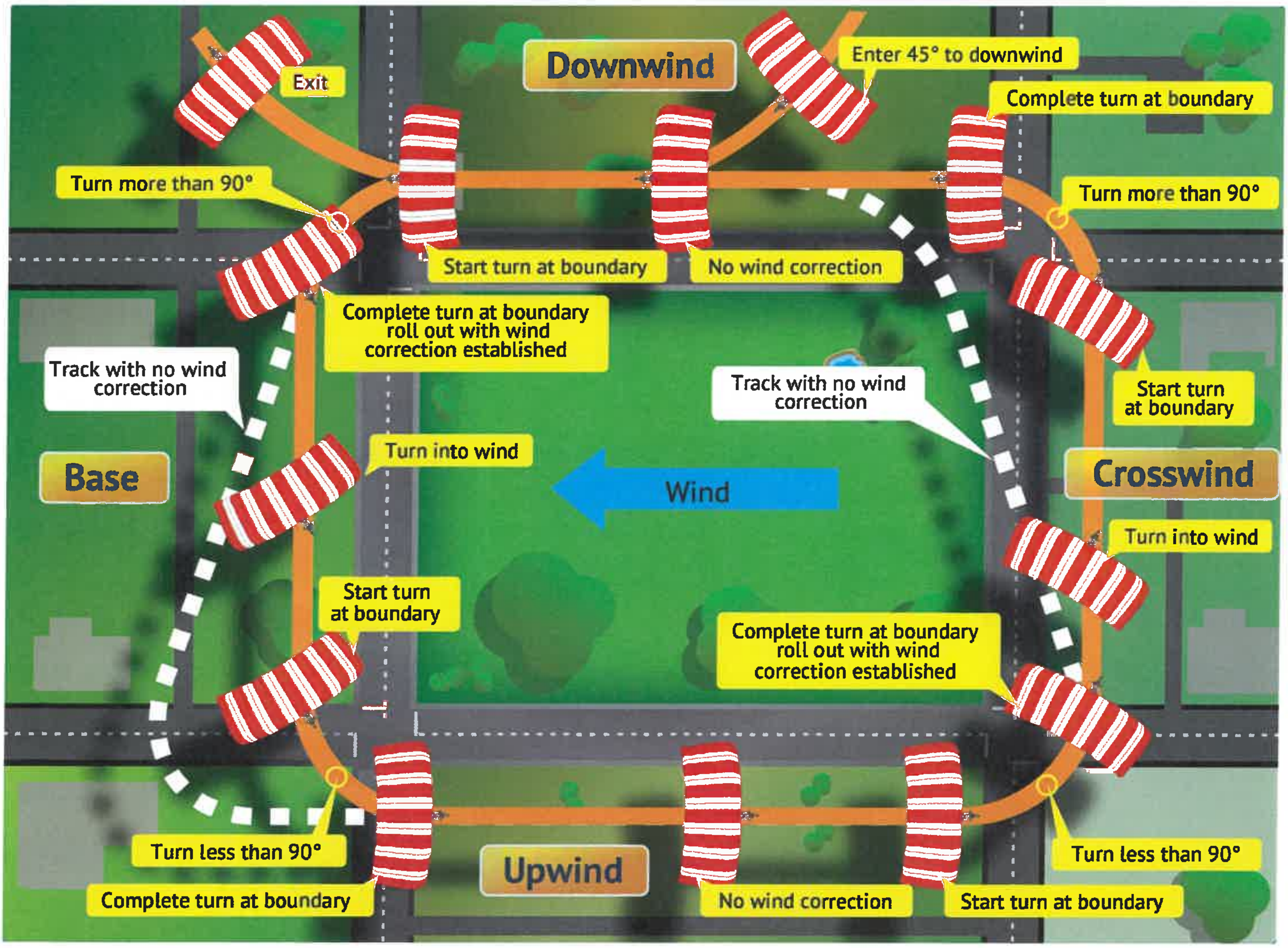
These techniques are important for mastering the rectangular course and for flying airport traffic patterns.

Rectangular Course Errors

Common errors while flying rectangular courses are:

- Failure to adequately clear the area. (You don't specifically need a clearing turn, but you should still check for other aircraft.)
- Failure to establish proper altitude prior to entry. (Typically, pilots make the mistake of entering the maneuver while descending.)
- Failure to establish appropriate wind correction angle resulting in drift.
- Gaining or losing altitude.
- Abrupt control usage.
- Inability to adequately divide attention between powered parachute control, maintaining ground track, and maintaining altitude.
- Improper timing in beginning and recovering from turns.
- Inadequate lookout for other aircraft.

Rectangular course.



S-Turns Across a Road

S-turns across a road is a training maneuver where the ground track follows a series of semicircles of equal radius on either side of a straight reference line, like a road or fence. This exercise develops your ability to compensate for wind drift during turns while maintaining a constant altitude. You should select a straight line perpendicular to the wind and long enough for a series of turns, maintaining an altitude of at least 300 feet throughout the maneuver.

S-turns are introduced after practicing the rectangular course. The goals include improving your ability to:

- Compensate for wind drift during turns.
- Use ground references to orient the flight path.
- Follow an assigned ground track.
- Reach specific points on assigned headings.
- Divide attention between tasks.

To perform this maneuver, you start by crossing the road at a 90° angle and immediately begin a 180° turn in one direction, followed by a 180° turn in the opposite direction. You cross the road perpendicularly each time you complete a turn.

To maintain a constant-radius ground track, you must adjust your rate of turn based on changing groundspeed. The steepest turn occurs at the beginning of the downwind side of the turn, and the bank gradually shallows as you transition from downwind to upwind. Conversely, on the upwind side, you start with a shallow bank and increase it as you turn toward the downwind.

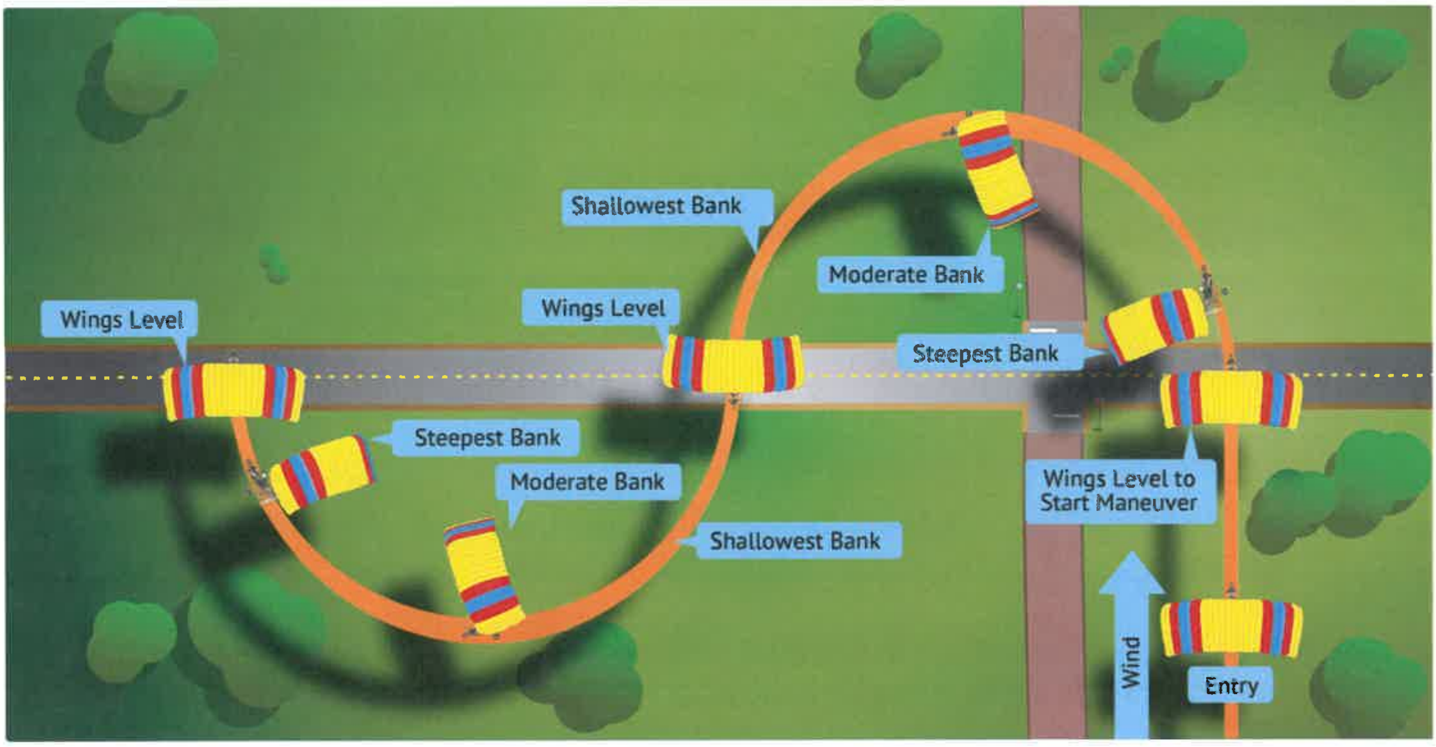
Begin by selecting a straight line perpendicular to the wind, check for obstructions, and perform a clearing turn to ensure no other aircraft are nearby. Approach the road from the upwind side at your selected altitude, flying on a downwind heading. Start the first turn as soon as you reach the road.

When heading downwind, your groundspeed will be at its maximum, causing a rapid departure from the road. You must enter the turn swiftly to establish the correct wind correction angle. This prevents the ground track from becoming too wide. As you turn past the initial 90°, transitioning from a downwind to a crosswind heading, the groundspeed decreases, slowing your departure from the road. The wind correction angle will be greatest when the powered parachute is directly crosswind.

As you turn to an upwind heading, your groundspeed will decrease further, slowing your closure rate with the road. If you maintain a constant, steep bank, you may turn too quickly, causing premature alignment with the road. To prevent this, gradually reduce the bank angle in the final 90° of the turn, ensuring that the wing levels out and the 180° turn completes just as you reach the road.

Once you cross the road again, initiate the turn in the opposite direction. Since you're still flying into the wind, start with a shallow bank to avoid turning too rapidly and overcorrecting for the wind. Adjust the bank angle as needed to maintain a ground track of the same radius as on the downwind side.

S-Turns Across a Road



As you turn from upwind to downwind, your groundspeed will increase, and after turning 90°, the rate of closure with the road will accelerate. Progressively steepen the bank and increase the rate of turn to complete the 180° turn by the time you reach the road. Roll out so that you're straight and level, flying directly over the road at a 90° angle.

Maintain a constant altitude throughout the maneuver, continuously adjusting the bank angle to create accurate semicircular ground tracks.

A common mistake is to increase the bank angle too rapidly during the upwind turn, preventing the completion of the full semicircle before crossing the road again. This often results in crossing the road at an angle rather than perpendicularly. To avoid this, visualize the half-circle ground track and adjust the bank early in the turn. As you approach the road, assess the closure rate and adjust the bank as necessary to cross the road perpendicularly at the end of the turn.

S-Turn Errors

Common errors while flying S-turns across a road are:

- Failure to adequately clear the area.
- Gaining or losing altitude.
- Inability to visualize the half circle ground track.
- Poor timing in beginning and recovering from turns.
- Faulty correction for drift.
- Inadequate visual lookout for other aircraft.

Turns Around a Point

Turns around a point is a training maneuver that builds on the concepts practiced in S-turns across a road. Its primary purposes are to

- Refine turning technique.
- Improve your ability to control the powered parachute while dividing your attention between the flight path and ground references.
- Heighten altitude awareness.
- Teach how the turn radius is influenced by the degree of bank.
- Help perfect wind drift correction during turns.

During this exercise, you fly a continuous, uniform circle around a prominent ground reference point while maintaining a consistent distance (or radius) from it and holding a constant altitude of no less than 300 feet. The maneuver requires continuous adjustments to both the bank angle and wind correction, as changes in groundspeed throughout the circle will influence the turn dynamics. Wind plays a significant role in this, as you will need to apply varying degrees of bank and wind correction depending on whether you're flying upwind or downwind.

To begin the maneuver, choose a distinct, easy-to-recognize ground reference point that is compact enough to serve as an accurate target for maintaining a constant radius. Isolated trees, intersections, or other small landmarks are good choices. Before starting the turn, conduct a clearing turn to check the area for other aircraft.

When you initiate the maneuver, approach the chosen point on a downwind heading, flying parallel to it at a distance equal to your desired turning radius. This downwind entry is important because it allows you to establish the steepest bank early in the turn, where your groundspeed is highest. As you start the turn, the high groundspeed downwind means you need a steeper bank to maintain the proper turn radius. The rate of turn must be quicker on the downwind side to counteract the increased groundspeed, ensuring you don't drift too far from the reference point.

As you transition from the downwind side to the crosswind, you'll notice the groundspeed decreasing. The turn becomes less aggressive, and you can gradually reduce the bank angle to maintain the same radius. By the time you reach the upwind portion of the circle where your groundspeed is at its slowest, your bank angle should be at its shallowest. However, it's still necessary to maintain some wind correction to prevent being pushed inside the turn.

As the maneuver progresses back toward the downwind side, you'll need to increase the bank again as your groundspeed picks up, making the turn steeper. The transition through each part of the turn—downwind, crosswind, and upwind—should be smooth, with continuous and precise adjustments to the bank and wind correction to maintain a uniform distance from the reference point.

A critical aspect of turns around a point is the awareness of wind drift. On the downwind side, you'll need to point the powered parachute slightly inward toward the center of the turn to compensate for the increased groundspeed and prevent drifting away from the circle. Conversely, on the upwind side, the reduced groundspeed requires pointing the nose slightly outward to keep the powered parachute from drifting inside the turn. The downwind half of the maneuver mirrors the challenges faced during the downwind portion of S-turns across a road, while the upwind half resembles the upwind portion of that same maneuver.

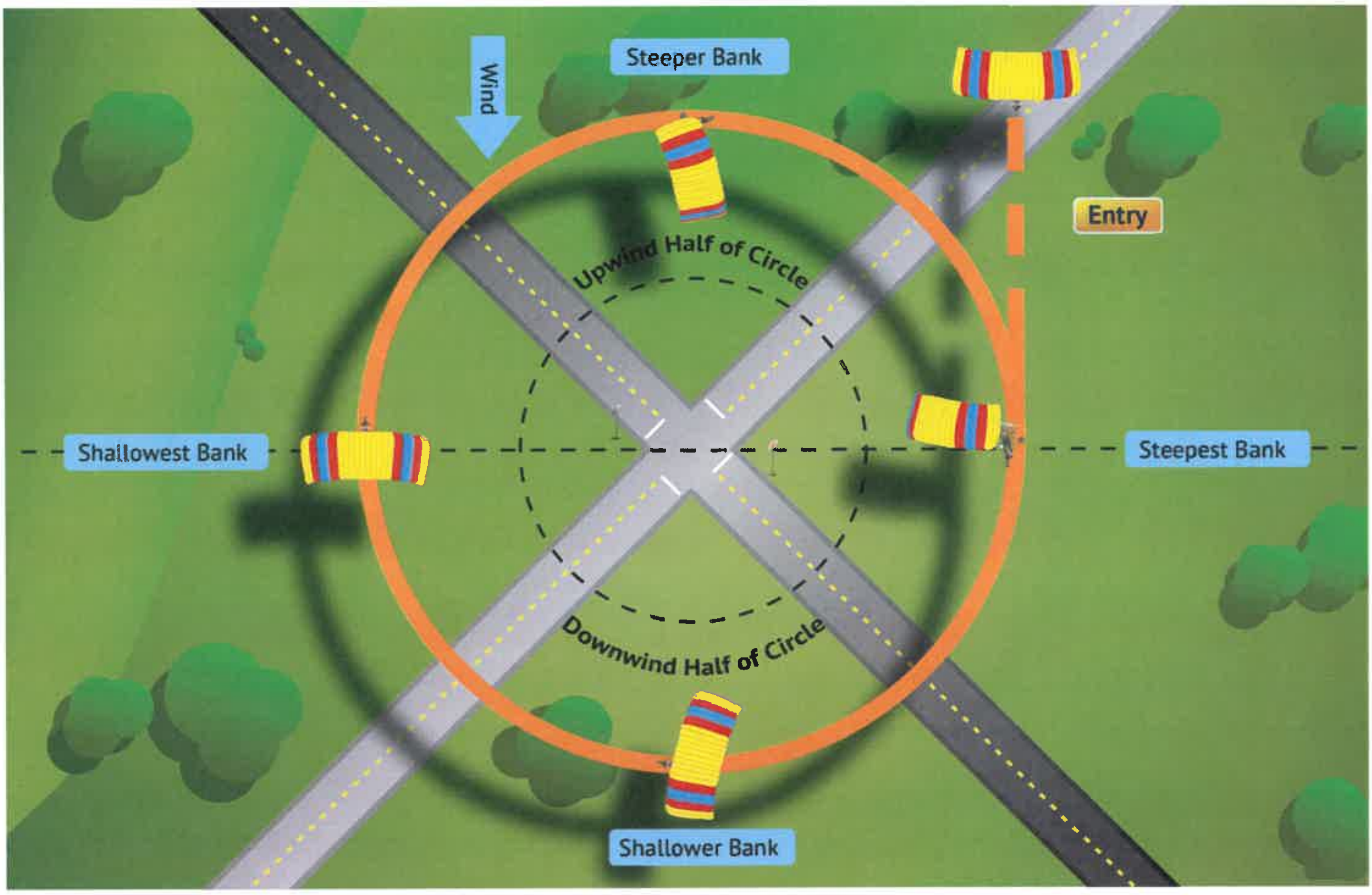
As you gain experience and become more proficient at compensating for wind drift, adjusting the bank, and maintaining a constant radius, you'll be able to enter the maneuver from any point—not just the downwind side. However, starting the maneuver downwind is advisable during initial practice because it allows for a quicker understanding of how bank and groundspeed interact. Your flight instructor will emphasize the importance of establishing the correct bank from the beginning. If you fail to adjust the bank appropriately early on, it can result in deviations from the intended ground track, requiring more drastic corrections later in the turn.

Turns Around a Point Errors

Common errors while flying turns around a point include:

- Failing to adequately clear the area before starting the maneuver.
- Not entering the maneuver from the downwind side.
- Failing to establish the appropriate bank angle on entry.
- Not recognizing or correcting for wind drift.
- Using excessive bank and/or insufficient wind correction angle on the downwind side, causing drift toward the reference point.
- Applying insufficient bank and/or too much wind correction angle on the upwind side, leading to drift away from the reference point.
- Gaining or losing altitude during the maneuver.
- Neglecting to perform an adequate visual lookout for other aircraft.
- Struggling to divide attention between controlling the powered parachute and monitoring the ground reference and surrounding environment.

Turns around a point



Chapter 23
Preflight

You, and you alone, are responsible as the pilot-in-command to prepare for your flight. Many people believe that *preflight* is just an inspection of the aircraft before flight. It's actually a lot more. Your preflight preparations should include evaluating the airworthiness of the:

Pilot: experience, sleep, food and water, drugs/medications, stress, illness
Aircraft: fuel, weight (does not exceed maximum), density altitude, takeoff and landing requirements, equipment
enVironment: weather conditions and forecast, airports and fields
External pressures: schedules, available alternatives, purpose of flight

Often remembered as PAVE, it's important for you to consider each of these factors and establish your own personal minimums for flying. One of the most important concepts you should understand is the difference between what is *legal* in terms of the regulations, and what is *smart* or *safe* in terms of your pilot experience and proficiency.

PILOT
AIRCRAFT
ENVIRONMENT
EXTERNAL PRESSURES

This chapter is kind of a putting-it-all-together chapter. Many of the preflight items mentioned here are considered in detail in other chapters. In this chapter, we're looking at a lot of those items and adding some practical information to tie things together and help you make your flying safer.

You must become familiar with all available information concerning your flight, to include runway lengths at airport of intended use, takeoff and landing distance while accounting for airport elevation and runway slope, aircraft gross weight, wind, and temperature. For a flight not in the vicinity of a conventional airport, this information must include weather reports and forecasts, fuel requirements, and alternatives available if the planned flight cannot be completed.

§ 91.103(b)(2) Preflight action.
Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include for any flight, runway lengths at airports of intended use, and the following takeoff and landing distance information and other reliable information appropriate to the aircraft, relating to aircraft performance under expected values of airport elevation and runway slope, aircraft gross weight, and wind and temperature.

The Preflight Checklist

Use a written checklist during preflight and ground operations. The checklist is an aid to your memory and helps to ensure that critical items necessary for the safe operation of the aircraft are not overlooked or forgotten.

Pilot

You're a key risk factor in any flight, so it's critical to ask yourself, *"Am I ready for this flight?"* Consider your experience, recency, currency, physical, and emotional condition. While *Chapter 6, "Aeromedical Factors,"* covers these aspects in detail, the most important part of your preflight routine is assessing yourself to ensure you're fully prepared.

But don't worry if you have a little nervousness about a flight, that's healthy. This is especially true if you've only been flying a short time or if it's been awhile since you've flown last. Use that nervousness to fuel your preparation for flight.

Aircraft

Preparing your powered parachute for flight is critical. A lot of the preparation can be done weeks in advance, but some things you must do the day of the flight.

Trailering

Many use a trailer to transport and store their powered parachute. If you're using a trailer to *transport* your powered parachute, your preparation includes looking over your trailer and how you have your powered parachute stowed. It also includes making sure that you have the other equipment that you need to have a successful flight like helmets and radio. You should have a whole checklist just for this.

Your powered parachute and the other equipment you need for your flight should fit snugly without being forced, be guarded against chafing, and be well-secured within the trailer. You should also plan how you load your trailer so that you avoid towing with too much or too little tongue weight. An improperly loaded trailer may fishtail at certain speeds and become uncontrollable.

Before taking the trailer on the road, perform the following checks:

- Inspect the tires for proper inflation and adequate tread.
- Verify that all lights are functioning correctly.
- Ensure the hitch is free-moving and properly lubricated.
- Confirm the vehicle attachment is rated for the trailer's weight.
- Check the vehicle and trailer brake operation.

After you're finished loading, begin the trip to your field. But stop again a few miles down the road and check your equipment after it has been exposed to the vibration of the road. Make sure your tie-down straps are still tight, nothing is rubbing against the powered parachute or the walls of the trailer, and that loads haven't shifted.

When you arrive, be careful when unloading your powered parachute to avoid damaging it or the trailer. Your preflight inspection on your powered parachute needs to be especially thorough if you trailer it to your field. Road vibration can be worse on an aircraft than flying it and you should inspect it accordingly.

Certificates and Documents

The airworthiness of the powered parachute is determined, in part, by the following certificates and documents, which must be on board the aircraft when operated:

- **A**irworthiness certificate.
- **R**egistration certificate.
- **O**perating limitations, which may be in the form of an FAA-approved Aircraft Flight Manual and/or Pilot's Operating Handbook (AFM/POH), placards, instrument markings, or any combination thereof.
- **W**eight and balance.

AROW is the acronym commonly used to remember these items. The pilot in command is responsible for making sure the proper documentation is on board. Aircraft logbooks are not required to be on board the powered parachute.

You must carry a valid U.S. driver's license, or a valid medical certificate accompanied by a photo identification and pilot certificate. Unless you're flying solo as a student, pilot logbooks are not required to be on board for a flight.

Weight and Loading

Before each flight, you need to consider weight and loading. Don't go beyond the maximum gross weight outlined in the POH. It's crucial to adhere to the performance limitations detailed in the POH.

Check the balance of the pilot, passenger, fuel, and baggage against the specified limitations. Additionally, ensure the wing attachment to the airframe is within the limits as stated in the POH. Proper balance of the airframe is essential; otherwise, an unsafe airframe configuration, either nose-high or nose-low, could occur.

Visual Inspection

Embarking on a safe flight begins with a visual inspection. Your routine preflight inspection serves a dual purpose: ensuring the powered parachute is legally airworthy and in a condition fit for safe flight. To assess the powered parachute's airworthiness, conduct a thorough preflight inspection according to the printed checklist provided by the manufacturer for your specific make and model.

As you approach the aircraft, start your preflight inspection by visually checking for any signs of damage, especially if the powered parachute was transported by trailer. This is a good opportunity to inspect the airframe for any damage that may have occurred during transit. Powered parachutes can be vulnerable to damage during transport.

Take note of the overall appearance of the aircraft, checking for noticeable issues like low tire pressure, structural distortion, wear points, airframe damage, and any signs of fuel, oil, or coolant leaks. Remove all tie-downs, control locks, and chocks during the unloading process.

Ensure that you're well-acquainted with the locations and functions of the aircraft systems, switches, and controls before commencing the actual preflight inspection. Use this time as an orientation, especially when operating a new make/model for the first time.

Before diving into the inspection, take care of items that are consumable. Confirm that fuel tanks and oil reservoirs are full, and batteries in radios or electronic devices are fresh. This avoids interruptions during the preflight inspection, keeping you focused on the task at hand.

The *walk around* is a tried-and-true style of preflight inspection used across all aircraft types. Apply the same detailed approach each time you prepare to fly. Try to minimize distractions. One of the worst things that can happen during a preflight is to lose your place and then miss something because someone comes up to ask you questions or otherwise draw your attention away from your inspection. The walk around encompasses four main areas:

1. Fuel and oil
2. Airframe inspection
3. Powerplant inspection
4. Equipment check

While each powered parachute should have a specific preflight inspection checklist, the following is a general guideline.

Fuel and Oil

When it comes to fuel, pay close attention to quantity, type, grade, and quality. Always verify the fuel quantity indicated on the gauge by visually checking the fuel tank.

Follow the engine manufacturer's recommendation for the type of fuel your engine should use. Most recommend premium grade ethanol-free recreational fuel, but on occasion, it's acceptable to use 100LL AVGAS. Keep in mind that recreational fuel is not normally available at airports, or even in entire regions of the country.

After each refueling, ensure the fuel cap is securely replaced. Many powered parachutes have an inline fuel filter; inspect it for contaminants.

Include the fuel tank vent in your preflight checks. Look out for any signs of damage or blockage in the vent tubing. You can perform a simple functional check by opening the fuel cap after a flight. If there's a rush of air, it might indicate a serious problem with the vent system.

Check the oil level during each preflight and after refueling. If oil consumption increases or changes suddenly, have qualified maintenance personnel investigate. After checking or adding oil, make sure the cap is securely replaced. Two-stroke engines without an oil injection system require oil to be premixed with the fuel, so ensure the mixture ratio is correct, as explained in the fuel section of *Chapter 10, "Aircraft Systems."* Also, check the venting of the oil reservoir on a two-stroke engine to prevent oil starvation to the engine.

Airframe Inspection

Nosewheel: Check the front nosewheel for proper play, tire inflation, and secure axle bolt. Inspect and test the ground steering mechanism and ensure there's smooth steering range of motion. Check for secure connections between the front fork, connecting spindle, and gooseneck.

Brakes: Check all brake systems for corrosion, loose fasteners, alignment, and brake pad wear. Front wheel brakes are common. They're normally drum or disk style operated by a cable. Inspect the cable ends for damage and security. Hydraulic disk brake systems should be checked for hydraulic fluid leakage as well as hydraulic line security and abrasion.

Seats: Check seats and seat belts for wear, cracks, and serviceability. A few manufacturers offer adjustable front seats where a lever moves a pin in and out of the seat rail holes and the seat then moves forward and back along one or two rails. The seat rail holes should be checked for wear; they should be round and not oval so there's no play in the fixed position of the pilot seat. Inspect the seat lock pins and seat rail grips for wear and serviceability.

Systems: Battery and ignition switches need to be in the OFF position at the beginning of the preflight inspection. Turn the master switch on and then turn system switches on and off to check each system. Check all aircraft lighting. Check the remote primer or primer bulb, if the aircraft is so equipped. You should feel resistance from the remote primer when exercised. Primer bulbs should not be hard or cracked.

Instruments: Turn the engine instrument system on to make sure electronic instruments are functioning. Note the fuel quantity and compare the reading with a visual inspection of the fuel tank during the exterior inspection. Set the altimeter to the field elevation or set the barometric pressure, if equipped.

Throttle: Move the engine throttle and choke controls through their full range of motion to check for binding or stiffness. On two-stroke engines with oil injection, check that the oil injection mechanism is also moving freely. Inspect any visible bare control cables for fraying.

Airframe: Inspect for any signs of deterioration, distortion, and for loose or missing fasteners. Gently shake the airframe to determine if objects and airframe parts are loose and need to be tightened. Treat the and its components with respect and care while conducting a preflight. Your powered parachute doesn't need to be *over-handled* to perform an adequate preflight inspection. Check that all structural cables are free of kinks, frays, abrasions and broken strands. Check each end of each cable for fastener security and check that the thimbles aren't twisted or elongated.

Steering: Check the steering bars to make sure they're securely attached, for freedom of movement, and for proper steering line attachments.

Main wheels: Inspect the rear wheel and axle assemblies. Check the tires for proper inflation, as well as cuts, bruises, wear, bulges, deterioration, and embedded foreign objects. Tires with cords showing and those with cracked sidewalls are not airworthy. Check wheel axles and hardware. Roll the aircraft forward and back a few feet to make sure the wheels rotate properly and that you hear no grinding from wheel bearings.

Powerplant Inspection

Foreign Objects: Powered parachute engines are set up in a pusher configuration, so check the engine area for loose items to ensure nothing is blown through the propeller, possibly injuring the propeller, aircraft, observers, or property.

Carburetor(s) Each carburetor must be checked to make sure it's secure; check air filters for condition and secure fit. Check the rubber intake sockets for cracks and security.

Spark Plugs: Make sure all spark plug caps are secure.

Oil: Check the oil. On some two-stroke engines, there's a reservoir that contains the lubricant for the rotary valve which also needs to be checked.

Leaks and Fluid levels: Check gear reduction boxes for leaking seals. Look for signs of fuel leaks and deterioration of fuel lines. Check for oil leaks, deterioration of oil lines, and make certain that the oil cap, filter, cooler and drain plug are all secure.

Exhaust System: Check the exhaust system for white stains caused by exhaust leaks at the cylinder head. Check exhaust components for freedom of movement, cracks and excessive corrosion. Check exhaust springs and safety wire.

Liquid-Cooled Engines: Check the radiator fluid level and fill as necessary. Check for cooling system leaks and worn or hard hoses.

Wires: Check all visible wires and cables for security and condition. Pay special attention to connections to the main battery where terminals may loosen with vibration.

Propeller: Check the propeller for large nicks in the leading edge, cracks, pitting, corrosion, and security. All propeller tape should be securely attached to the propeller surface. Propeller tape is used primarily for protection on the leading edge of the propeller as well as a supplemental balancing device. Check the propeller hub for security, secure attachment to the gearbox, and general condition.

Equipment Check

You need more than a powered parachute to have a successful flight. There are normally accessories that are either required or will make your flight more enjoyable. Some of these items have their own battery power so you may need to make sure that they're on chargers the night before a flight. Here's a list of the kinds of things that you may want to bring along for your flight:

- Handheld Aviation Band Radio
- Headsets and Helmets
- Smart Phone or Tablet with Navigation Software
- Camera or Video Camera
- Flashlight
- Proper Clothing

Having these items handy and ready to go before you fly will speed the entire preflight process.

Engine Starting

If it's wintertime, you should follow the engine manufacturer's recommendations for engine preheating. This may take awhile and is something you normally plan for the night before. A blanket over the engine and a heat source (like a 100 watt incandescent light bulb) below the engine will often do the trick.

You probably have two sources of engine starting procedures for your powered parachute and ideally they say the same thing. One is the Pilot's Operating Handbook and the other is the Engine Operating Handbook. Follow the procedures in either one.

Generally, the engine start-up will follow these steps:

- Walk-around inspection is complete.
- Safety check to include: wheels properly braced, engine and propeller area clear of loose and foreign objects, area behind the airframe is clear of debris, steering and suspension lines are clear of the propeller.
- Turn on the master power switch.
- Prime the fuel system or start the electric fuel pump and activate the choke.

- Activate the strobe light if its switch is independent of the master switch.
- Shout *"CLEAR PROP"* and wait for a *"CLEAR"* response from bystanders.
- Turn the magnetos on.
- Confirm the throttle is at idle.
- Start the engine.
- Turn on the electronic engine gauges.
- Ease the choke to the closed position.

Beyond that, certain precautions apply to all powered parachutes. Don't start the engine with the propeller facing an open hangar door, parked vehicles, aircraft, or a group of bystanders. This is not only discourteous but may result in personal injury and damage to the property of others as your propeller blast is surprisingly powerful.

When ready to start the engine, look in all directions to be sure nothing is or is moving into the vicinity of the propeller. This includes nearby people and aircraft that could be hit by the propeller blast or the debris it might pick up from the ground. Turn on the anticollision strobe prior to engine start, even during daylight operations.

After visually checking to make sure the area is clear of people shout *"CLEAR PROP."* Wait for a response from people who may be nearby before activating the starter. Other pilots will typically look behind your aircraft for you and shout, *"CLEAR"* if no one is in danger.

While activating the starter with one hand, keep the other hand on the throttle. This readiness allows you to act swiftly if the engine falters or if the RPM becomes excessive. It's recommended to keep the RPM low immediately after starting the engine to prevent damage. Avoid high RPMs, as the engine won't have sufficient lubrication until the oil pressure rises. In freezing temperatures, the engine can be stressed until it warms up and reaches normal operating clearances. Your hand activating the starter should be ready to turn off the ignition switches in case the engine races immediately after starting and the throttle has no effect.

As soon as a four-stroke engine is operating smoothly, check the oil pressure. If it doesn't rise to the manufacturer's specified value, the engine may not be receiving proper lubrication and should be shut down immediately to prevent serious damage.

Starters are small electric motors designed to draw large amounts of current for short periods of cranking. Should the engine fail to start readily, avoid continuous starter operation for periods longer than 30 seconds without a cool-down period of at least 30 seconds to a minute (some POHs specify even longer). Starter service life is drastically shortened from high heat through overuse. Although quite rare, the starter motor may remain on and engaged after the engine starts. You will probably hear this and it can be confirmed by seeing a continuous very high current draw on the ammeter. The engine should be shut down immediately should this occur.

If the engine fails to start at all, it may be necessary to charge the battery or use an external power source. Hand propping is not typically done on powered parachutes. Always follow the manufacturers' recommendations while troubleshooting.

First Engine Warm-Up

Engine warm-up, or run-up, not only brings the engine up to proper operating temperatures, but also allows you to make sure that the engine and its components are operating properly.

The warm-up procedure should never be skipped, as the result can be costly in engine repairs and could lead to in-flight engine failure. Pilots should know their engine temperature parameters from the markings on the instrument panel, built into the electronic instruments, and the POH limitations. Once again, refer to manufacturer manuals for recommended procedures and parameters.

Warming up normally takes at least five minutes. That's a long time to sit idle when you're ready to fly! You can use that time to slowly taxi around your takeoff area to make sure that there aren't any holes or debris in your way. You may discover that your selected takeoff area isn't that select after all!

Two-Stroke Engines

The first warm-up for two-stroke engines is often done independent of any engine temperature gauges. The reason that engine gauges aren't used for this warm-up is because their sensors are located at parts of the engine that heat up quickly and don't accurately measure the temperature of core engine parts. For example, they can't directly tell you how warm the crankshaft is.

Instead, this first warm-up for a two-stroke is done best by time and engine RPM, normally five minutes just above idle. The purpose is to warm up the large portions of the engine such as the engine case, crank, and bearings. This is particularly important with two-stroke engines which use a built up crank and large steel bearings installed in an aluminum engine case. A high throttle setting will apply too much heat, too quickly to an engine.

Excess heat will quickly expand aluminum parts like the engine case and pistons. The denser steel parts require a longer time to become heat saturated and expand slower than the aluminum engine case. If the steel parts aren't allowed to become heat saturated, bearing surfaces that aren't supposed to move may begin spinning and tear up the mating surfaces in the engine case.

All of this is bad and can cause expensive repairs. It's very important to follow engine manufacturer recommendations and not rev the engine too high during that first warm-up period.

Four-Stroke Engines

Four-stroke engines are warmed up according to oil temperature. Monitoring oil temperature is the most reliable way to ensure a proper warm-up for four-strokes because oil temperature is a more accurate indicator of the engine's internal readiness for operation. As the engine warms, the oil reaches an optimal viscosity, which allows for proper lubrication of internal components. This lubrication is critical, especially in cold conditions where oil may thicken, increasing friction and causing excessive wear if the engine is prematurely throttled up too high. By monitoring oil temperature, you can ensure the engine's lubrication system is functioning effectively, reducing the risk of damage.

Additionally, the oil temperature directly correlates with overall engine temperature and the expansion of critical engine components. When the oil reaches the manufacturer's recommended operating temperature, it signifies that the internal components have expanded to their normal operating clearances, ensuring optimal performance and minimizing mechanical stress. Over-revving an engine before the oil reaches the correct temperature can lead to insufficient lubrication, thermal shock, and premature engine wear. Therefore, focusing on oil temperature ensures that the engine is warmed up evenly and safely, reducing the risk of mechanical issues and extending the engine's lifespan.

Monitoring the Engine During Warm-Up

Continually monitor all the engine's temperature gauges and know the engine's operational minimum, normal, and maximum temperature ranges. The engine manual will also specify *difference* temperatures between cylinders. Excessive split differences between cylinders should not be overlooked, even if both temperature readings are within the acceptable ranges for the engine. Don't fly your powered parachute if the temperature readings aren't normal! Figure out what the problem is before it results in a dangerous situation or costly engine repair.

To test a dual ignition system, turn off one ignition switch while observing the RPM, then repeat with the other switch to ensure both circuits are working correctly. A small RPM drop, typically around 400 RPM for a two-stroke engine (check the POH for specifics), is normal. However, if the engine stops or the RPM drop exceeds the allowable limit, don't fly until the issue is fixed, as it may be caused by fouled plugs or faulty wiring. Additionally, no RPM drop during the test is abnormal, and the aircraft should not be flown until the problem is resolved.

You risk long term damage to the engine if you don't start and warm up the engine according to the POH and the gauges.

Wing Inspection

After inspecting the airframe, warming the engine up, and taxiing into position, you're almost ready to fly. However, one crucial step remains: the parachute layout and inspection. This process is so important that there is an entire chapter dedicated to it—*Chapter 19, "Parachute Layout and Stowing."*

Second Engine Warm-Up

Powered parachutes are unusual in that there is a short run-up period, where the engine is warmed and the aircraft taxied to the runway. Then the engine is shut down while the wing is deployed.

After you have set up your wing, have your passenger seatbelted in, and are ready to go yourself, you may find that your engine has cooled. It's important to warm the engine up again, at least long enough to heat it back up to operating temperatures.

Critical temperatures will be indicated by your engine temperature gauges. The crank and case area of the engine stay warm for a half hour or more, but the cylinders, head, and pistons cool quickly. After you start up your engine for takeoff, you want to make sure that all your engine temperatures get a chance to climb back to their operating values. This is particularly important with liquid-cooled engines.

If you don't pay attention to the second warm-up period, you risk a cold seizure when you take off. That's when a piston (normally aluminum) expands with the excessive heat and seizes on the cooler and non-expanded interior steel walls of the engine cylinder.

Environment

The facility you use for your flight operations and the day's weather both impact your flying. Both must be right on the day and time you want to fly.

Where to Fly

Powered parachutes are incredibly versatile since they can take off from and land in very short fields. But still, not all airports are suitable and friendly to powered parachutes.

Powered parachutes can be transported by trailer from one flying field to the next. For as many benefits as this provides, transporting your powered parachute into unfamiliar territory also includes some safety and operational issues.

Check the Chart Supplement U.S. for information about the airport you want to visit including traffic patterns, no-fly zones surrounding the airport, special accommodations, and contact information for the airport. Contact airport management to inquire about any special arrangements that you should make prior to visiting an unfamiliar airport. Find out if there are already some powered parachute procedures for the airport, preferred runway areas, and how to arrange access to the airport through a security gate if they have one.

You should avoid the flow of faster aircraft traffic when piloting your powered parachute. It's also helpful, when possible, to talk with general aviation pilots at the field. Let them know what you're doing and why you're doing it. A lot of things about powered parachute operations are foreign to many GA pilots. Where you take off from, the time it takes to set up, and the low and slow aspects of your actual flying are very different from how they fly. The more information that other category pilots have about powered parachute flight characteristics, the more they will understand what you're doing while sharing the same airspace.

Extend consideration to any landowner who owns a runway or flight park. You need permission to use private property as an airstrip.

Locate your intended flight area on a sectional chart to check for possible airspace violations or unusual hazards that could arise by not knowing the terrain or location. Check for temporary flight restrictions (TFRs). Learn where residential structures and animal enclosures are so that you can avoid flying over them.

The precise location you choose for takeoff at the airport is crucial. There's an entire section in *Chapter 20, "Departures and Climbs,"* dedicated to this topic. Before you taxi to any departure area, you need to coordinate with airport management.

Inspect the entire length of your intended takeoff and landing area prior to departure. Look for holes, muddy spots, rocks, dips in the terrain, high grass, and other objects that can cause the aircraft to be damaged or the wing to snag during takeoff and landing. If you can, physically mark areas of concern with paint, flags, or cones; a pothole may not look like a pothole from above.

Weather

Checking current and forecast weather is a big part of the preflight process. Before taking off, make sure to get a comprehensive weather briefing. This includes checking current conditions and forecasts for the time you plan to stay in the air. You don't want unexpected bad weather to ruin a cross-country trip.

Numerous resources, like **www.nws.noaa.gov**, 1-800-WX-BRIEF, and commercial websites can provide this information. Be familiar with wind conditions, temperature, dew point spread, sky condition, and visibility. For detailed insights into weather reports and forecasts, refer to *Chapter 15, "Weather Information."*

Powered parachutes perform best in calmer air. Always check the wind forecast and current conditions to determine if safe flight is possible. Surface winds should be less than 10 MPH and even that may be excessive since high winds indicate even stronger winds at altitude. Follow the recommendations from your aircraft's manufacturer, especially regarding wind speed. Steady winds without gusts are preferable, ensuring more predictable wing inflation and overall performance. For instance, a 5 MPH wind with no gusts is better than a 1 MPH wind gusting to 5 MPH. Different wings respond uniquely to specific wind conditions, so understand your wing and your abilities.

Avoid pure crosswind takeoffs as they are dangerous. If the runway configuration doesn't allow for a headwind takeoff, consider canceling or postponing the flight. Meanwhile, crosswind landings are possible and aren't the concern that crosswind takeoffs are.

Pressure, temperature and humidity directly impact a powered parachute's wing and engine performance. Understanding density altitude is crucial, since it serious affects takeoff and climb capability. Conditions that were favorable in the morning might change in the afternoon, so always reassess your aircraft's performance.

Learn about different cloud formations and the effects they can have on ground and sky conditions. Maintain proper cloud clearance and visibility based on your planned operations. Knowing when and where thermals and turbulence might occur is essential.

Never fly when visibility falls below the minimums for your pilot certificate and the airspace class you're operating in. Pay close attention when air and dew point temperatures are close because of the risk of fog and reduced visibility.

Beyond following regulations and manufacturer recommendations, establish your own personal minimums. These will evolve with experience and can change based on your recency and currency in powered parachutes.

External Pressures

External pressures are the influences from outside the flight environment that can make you feel compelled to fly, sometimes at the expense of safety. Part of your preflight process should be thinking through whether you should fly at all on a given day. Try to objectively look at external pressures. These pressures might include:

- A passenger you don't want to let down.
- The urge to showcase your pilot skill.
- The desire to impress someone. (Beware of the tempting phrase, *"Watch this!"*)
- The need to fulfill a specific personal goal (*"let's-go-itis"*).
- Your general drive to accomplish goals.

There's also emotional pressure tied to admitting that your skill and experience levels may not be as high as you'd like them to be. Pride can be a significant external factor!

Managing these external pressures is crucial for effective risk management because they can lead you to overlook other risk factors. External pressures often create time-related stress for pilots and contribute to a significant number of accidents.

One approach to handling external pressures is to develop and follow personal standard operating procedures (SOPs). The aim is to provide a safety valve for the external pressures of a flight. Consider these practices as part of your SOP:

Establish personal limits such as maximum wind, minimum visibility, and how close rains are.

Manage passenger expectations. Make sure your passenger understands that flying on a set day may not be possible and that the flight may have to be done another day.

The key to handling external pressure is to be prepared for and accept the possibility that you can't fly on a given day. Your goal as a pilot is to manage risks, not create unnecessary hazards.

Briefing the Passenger

Before taxiing onto the runway, your passenger should be briefed on basic safety procedures. You need to tell your passenger how to operate the safety belt or restraint system, what to expect during the flight, and what to do in case of an emergency. If your aircraft is certified as *'Experimental'* you also need to let your passenger know that before flight.

Many people have never been in a powered parachute before, so it will be a foreign environment. Explain what the flight will feel like, what your passenger should do, and where your passenger can put things like hands and feet. Explain the communication system as necessary. If your passenger wants to use items like cameras, video recorders, or phones, those items should be secured so they don't inadvertently depart the aircraft during flight.

Your passenger should be aware that an aborted takeoff is always a possibility and not uncommon.

§ 91.107 Use of safety belts, shoulder harnesses, and child restraint systems.

(a) Unless otherwise authorized by the Administrator -

(1) No pilot may take off a U.S.-registered civil aircraft ... unless the pilot in command of that aircraft ensures that each person on board is briefed on how to fasten and unfasten that person's safety belt and, if installed, shoulder harness.

(2) No pilot may cause to be moved on the surface, take off, or land a U.S.-registered civil aircraft ... unless the pilot in command of that aircraft ensures that each person on board has been notified to fasten his or her safety belt and, if installed, his or her shoulder harness.

(3) Except as provided in this paragraph, each person on board a U.S.-registered civil aircraft ... must occupy an approved seat or berth with a safety belt and, if installed, shoulder harness, properly secured about him or her during movement on the surface, takeoff, and landing...

Your passenger should know that everything depends upon the wing. If the wing doesn't kite properly or doesn't kite in time to take off and clear an obstacle, the engine will be shut down.

Finally, emergency procedures should be discussed. At a minimum, explain that if the airframe tips over, your passenger should keep arms and legs inside the protected areas of the airframe. In case of an accident, your passenger should not be holding onto a part of the structure that could hit the ground or an obstacle and hurt their hand or any other part of their body.

Seat Belts

The FAA has a lot to say about seat belts and shoulder harnesses. They require you to wear them. However, you don't have to wear them all the time. Not that anybody normally wants to take off their seat belt and move about the cabin in a powered parachute, but it's allowed. In fact, there was at least one man who got out of his seat, climbed to the top of the airframe and *"wing-walked"* a powered parachute! The pertinent regulation on safety belts is shown below.

Helmets

People have varying opinions on helmets. Some like them, some won't wear them at all. The FAA is quiet on the subject of helmets. However, powered parachuting can be considered a motorsport and most motorsports encourage participants to wear helmets. I personally don't fly a powered parachute without a helmet.

Powered parachutes are more prone to tipping over than other aircraft. The risk for injury isn't from hitting your head on the ground. Instead, your risk of injury comes from hitting your head on the metal structure of the airframe itself.

If you do use helmets, make sure that your passenger's helmet fits and that the chin strap is fastened before takeoff. Treat helmets the same way you do safety belts.

Postflight

A flight is never complete until the engine is shut down and the aircraft is secure. You should consider this an essential part of any flight.

After shutting down the engine, always leave the ignition switches in the OFF position. Even with the battery and master switches OFF, the engine can still fire if an ignition switch is left ON and the propeller moves, as magnetos don't require external power. This can lead to serious injury.

After you shut the engine down and your passenger exits the aircraft, you should do a postflight inspection. This includes checking the general condition of the aircraft with special attention on the propeller and anything that you suspect may be damaged. For additional flights, check the oil and add fuel if required. If you won't be flying again for more than a few minutes, put the wing properly back in the bag to keep it out of the sun.

Chapter 24
Airport Operations

Every flight begins and ends at an airport. An airport, as defined by the Federal Aviation Regulations, is an area of land or water that is used or intended to be used for the landing and takeoff of aircraft. That definition of an airport includes the very large airports supporting commercial traffic all the way down to a pasture you may choose to fly from on a given day. This is an important consideration since you want the training you may receive at someone's home field to count towards your required aeronautical experience for a sport pilot or higher rating.

The larger the airport, the more complicated the procedures needed for aircraft operations. Luckily, few -if any- of these procedures are conflicting. That is, there aren't separate rules for smaller airports and a completely different set of rules for larger airports. For the most part, the rules are very consistent, with the difference being that at the larger airports, additional procedures are needed for the increase in activity.

As a powered parachute pilot, you may have the opportunity or requirement to fly from airports that have control towers. That makes it important for you to learn the traffic rules, procedures, and patterns that are in use at various airports. These rules and procedures are not only based on logic and common sense, but also on courtesy. The objective is to keep air traffic moving with maximum safety and efficiency.

The use of any traffic pattern, service, or procedure does not alter the responsibility for you to see and avoid other aircraft. You remain responsible for your, your passenger's and other people's safety at airports.

Types of Airports

There are two types of airports—towered and non-towered. These types can be further subdivided to:

Civil Airports—airports that are open to the general public.
Military/Federal Government Airports—airports operated by the military, National Aeronautics and Space Administration (NASA), or other agencies of the Federal Government.
Private Airports—airports designated for private or restricted use only. They are not open to the general public.

Towered (Controlled) Airport

A towered airport has an operating control tower. Air traffic control (ATC) is responsible for providing the safe, orderly, and expeditious flow of air traffic at airports where the types of operations or volume of traffic requires such a service.

When you operate from a towered airport, you are required to maintain two-way radio communication with air traffic controllers, and to acknowledge and comply with their instructions. You must advise ATC if you cannot comply with the instructions issued and request amended instructions. You may deviate from an air traffic instruction in an emergency, but must advise ATC of the deviation as soon as possible.

Non-towered Airport

A non-towered airport doesn't have an operating control tower. Two-way radio communications are not required, although it's a good operating practice for you to transmit your intentions on the specified frequency for the benefit of other traffic in the area.

Sources For Airport Data

When you fly at or into a different airport, it's important to review the current data for that airport. This data provides you with information, such as communication frequencies, services available, closed runways, and airport construction. Three common sources of information are:

- Aeronautical Charts
- Chart Supplements US
- Notices to Air Missions (NOTAMs)

Aeronautical Charts

Aeronautical charts provide specific information on airports. *Chapter 26, "Navigation,"* provides more information about aeronautical charts and chart legends, offering guidance on how to interpret the information they contain.

Chart Supplements US

Chart Supplements are the FAA's best source for information on airports that are open to the public. Only so much information can be printed on an aeronautical chart and the Chart Supplement fills in the missing information like airport hours of operation, facility layout, manager contact information, types of fuel available, and runway data.

In addition to airport information, each Chart Supplement U.S. contains a lot of other information. Information that you may be interested in includes Federal Aviation Administration (FAA) and National Weather Service (NWS) telephone numbers, airport diagrams for selected towered airports, parachute jumping areas, and facility telephone numbers.

The Chart Supplement U.S. is published in seven books, which are organized by regions and revised every 56 days. You can buy just the book that applies to your region from pilot shops or download one or all of them for free at **www.faa.gov/air_traffic/flight_info/aeronav.**

Notice to Air Missions (NOTAM)

NOTAMs provide the most current information available. They provide time-critical information on airports and changes that affect the national airspace system (NAS). There are many kinds of NOTAMs, but we are primarily concerned with two of them.

NOTAM-D (NOTAM-Distant):

NOTAM-Ds are informational notices that provide a wide range of non-regulatory information essential for flight planning. These NOTAMs are more focused on specific airports and facilities. They note things like changes in procedures, runway closures, navigational aid status, and other noteworthy information that you should be aware of.

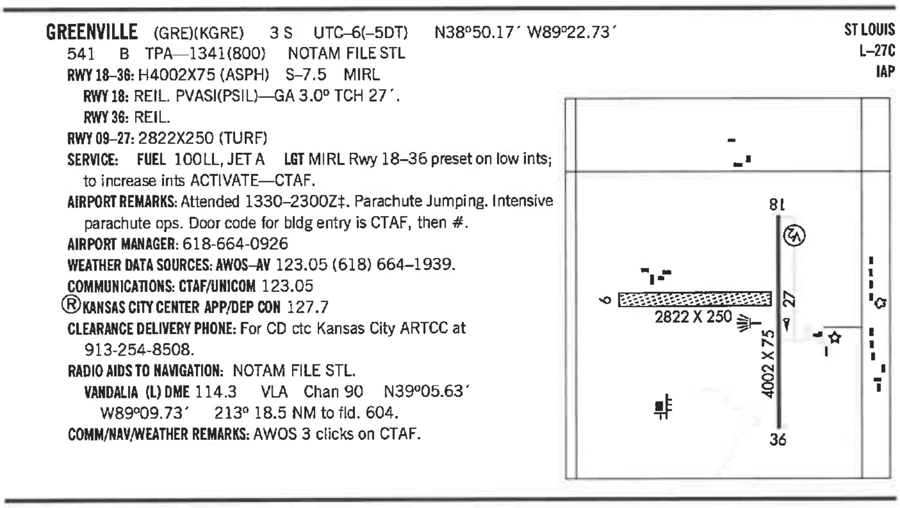
For example, if there's construction taking place at an airport, a NOTAM-D would provide details about the affected runways or taxiways and the duration of the construction. Similarly, changes in radio frequencies, lighting systems, or other operational aspects are communicated through NOTAM-Ds.

For more information on NOTAM-Ds, refer to *Chapter 2, "Flight Safety."*

FDC NOTAM (Flight Data Center NOTAM):

FDC NOTAMs are a specialized category that primarily deals with changes in flight procedures, rules, and airspace restrictions. Issued by the FAA's Flight Data Center, these NOTAMs are regulatory in nature and demand strict compliance. FDC NOTAMs cover a lot of things that powered parachute pilots aren't concerned with. The things that we *are* concerned about are temporary flight restrictions (TFRs).

For more information on FDC NOTAMs, refer to *Chapter 25, "Airspace."*


GREENVILLE (GRE)(KGRE) 3 S UTC–6(–5DT) N38°50.17′ W89°22.73′ — ST LOUIS L–27C IAP
541 B TPA—1341(800) NOTAM FILE STL
RWY 18–36: H4002X75 (ASPH) S–7.5 MIRL
RWY 18: REIL. PVASI(PSIL)—GA 3.0° TCH 27′.
RWY 36: REIL.
RWY 09–27: 2822X250 (TURF)
SERVICE: **FUEL** 100LL, JET A **LGT** MIRL Rwy 18–36 preset on low ints; to increase ints ACTIVATE—CTAF.
AIRPORT REMARKS: Attended 1330–2300Z‡. Parachute Jumping. Intensive parachute ops. Door code for bldg entry is CTAF, then #.
AIRPORT MANAGER: 618-664-0926
WEATHER DATA SOURCES: AWOS–AV 123.05 (618) 664–1939.
COMMUNICATIONS: CTAF/UNICOM 123.05
®**KANSAS CITY CENTER APP/DEP CON** 127.7
CLEARANCE DELIVERY PHONE: For CD ctc Kansas City ARTCC at 913-254-8508.
RADIO AIDS TO NAVIGATION: NOTAM FILE STL.
VANDALIA (L) DME 114.3 VLA Chan 90 N39°05.63′ W89°09.73′ 213° 18.5 NM to fld. 604.
COMM/NAV/WEATHER REMARKS: AWOS 3 clicks on CTAF.

Cover and excerpt from Chart Supplement US

Airport Markings and Signs

Airports are busy places. It's easy to get disoriented on even small airports. That's why airport markings and signs are so important. Understanding airport markings and signs helps you navigate airports, pass the knowledge test, and be the most informed guy in the family when flying commercially.

Runway Markings

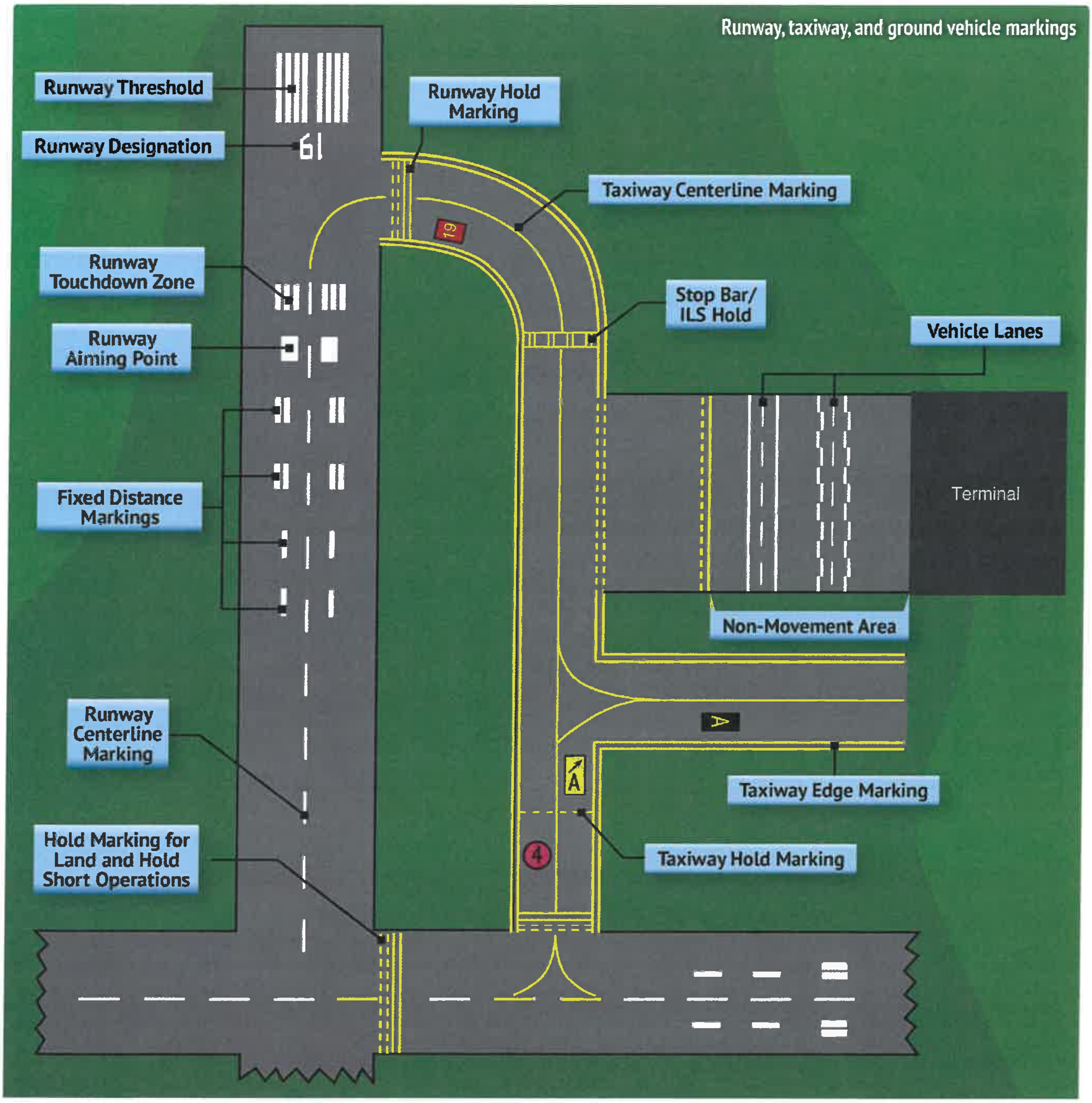
Runway markings vary depending on the type of operations conducted at the airport. Grass strips have no markings, and a basic VFR runway may only have centerline markings and runway numbers. The figure below is for a more complicated airport. It shows a runway that's approved as a precision instrument approach runway and includes some other common markings.

Runway Numbers

Since aircraft are affected by the wind during takeoffs and landings, runways are laid out according to the local prevailing winds. Runway numbers are in reference to magnetic north. Certain airports have two or even three runways laid out in the same direction. These are referred to as parallel runways and are distinguished by a letter added to the runway number. Examples are runway 36L (left), 36C (center), and 36R (right).

Relocated Runway Threshold

When part of a runway is closed for construction or maintenance, the starting point of the runway, known as the threshold, is moved to a new location. This relocated threshold is often marked with a ten-foot-wide white bar across the runway width.



When the threshold is relocated, that specific part of the runway can't be used for aircraft takeoffs or landings, but it remains open for taxiing. It's important to note that relocating the threshold not only closes a section of the approach end of the runway but also reduces the usable length of the runway in the opposite direction. To signal the relocated threshold, yellow arrowheads are placed across the width of the runway just before the threshold bar.

Displaced Threshold

A displaced threshold is positioned further down the runway, rather than at its usual starting point, typically due to an obstruction near the runway's end. This adjustment reduces the available runway length for landing. However, the section of the runway before the displaced threshold remains usable for takeoffs in either direction and for landings from the opposite direction.

The displaced threshold is marked by a ten-foot-wide white bar, with white arrows along the centerline leading up to it. Just before the threshold bar, white arrowheads span the width of the runway. These markings help pilots easily identify the shifted threshold from altitude.

Permanently Closed Runways and Taxiways

For permanently closed runways and taxiways, the lighting circuits are disconnected to prevent use. The runway threshold, runway designation, and touchdown markings are removed or covered. Large yellow "X" markings are placed at each end of the runway and at 1,000-foot intervals along its length, signaling its closure to pilots.

Taxiway Markings

Aircraft use taxiways to transition between parking areas and the runway. Taxiways are easily distinguishable from runways by their yellow centerlines, whereas runways have white centerlines. Taxiways are marked by a continuous yellow centerline stripe and may also have edge markings to indicate the edge of the usable surface. If the edge marking is solid, the paved shoulder is not intended for aircraft use. If dashed, aircraft may use that area.

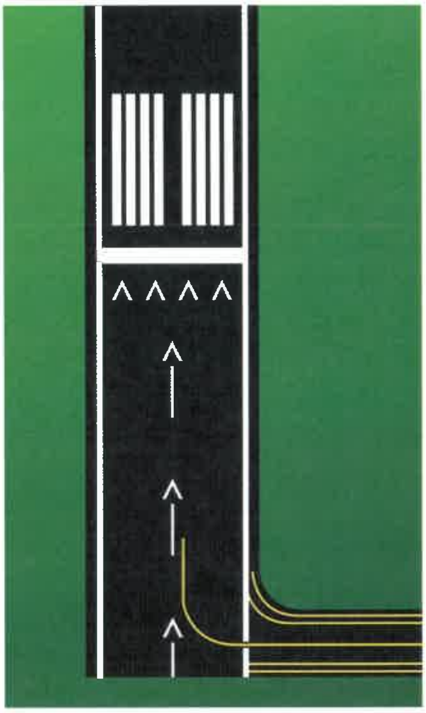
Where a taxiway meets a runway, you'll often find a holding position marker, consisting of two solid and two dashed yellow lines. Aircraft hold at the solid lines before entering the runway. Some towered airports may also place holding position markings on runways, especially at intersections, where instructions like *"cleared to land—hold short of runway 36"* are given.

Vehicle Roadway Markings

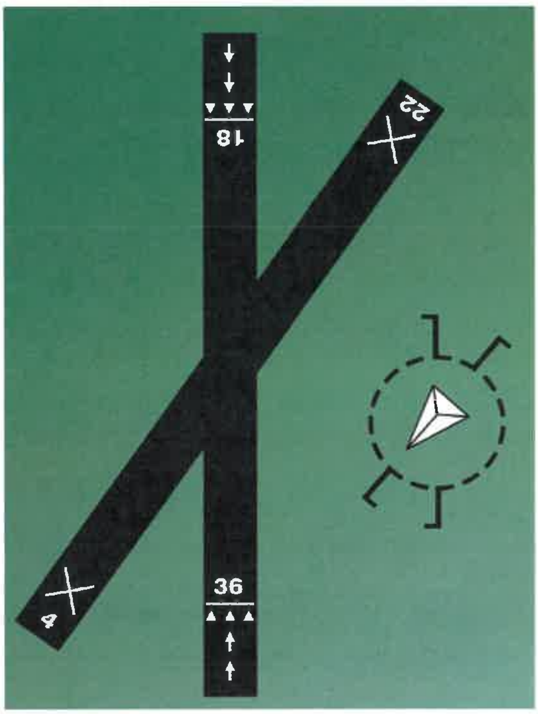
Vehicle roadway markings are used to define pathways where vehicles and aircraft share crossing areas. These markings typically consist of solid white lines along each edge of the roadway, with dashed lines separating lanes within the roadway. Alternatively, zipper markings may be used to outline the edges of the vehicle roadway instead of solid lines. These markings ensure clear separation between vehicle and aircraft movement areas.

Relocated runway threshold

Displaced runway threshold



Runways 18 and 36 have displaced thresholds. Runways 4 and 22 are closed. The preferred usable runway is runway 18 according to the wind indicator.



Airport Signs

There are six types of signs found at airports, each serving a specific purpose to help pilots navigate while taxiing:

1. **Mandatory Instruction Signs** have a red background with white inscriptions, indicating entrances to runways, critical areas, and prohibited areas.
2. **Location Signs** are black with yellow inscriptions and borders. They identify taxiway or runway locations, boundaries of the runway, and instrument landing system (ILS) critical areas.
3. **Runway Distance Remaining Signs** have a black background with white numbers. The numbers indicate the distance of the remaining runway in thousands of feet.
4. **Information Signs** have a yellow background with black inscriptions. They provide information like unseen areas from the tower, radio frequencies, and noise abatement procedures. Their size, location, and necessity are determined by the airport operator.
5. **Direction Signs** have a yellow background with black inscriptions and arrows. They identify intersecting taxiway(s) leading out of an intersection.
6. **Destination Signs** have a yellow background with black inscriptions and arrows. These signs include arrows that point to locations such as runways, terminals, cargo areas, or civil aviation areas.

Airport Lighting

Most airports have some type of lighting for night operations. The type and extent of lighting used depends on the airport's operational complexity and traffic volume. Airport lighting is standardized across all facilities, ensuring consistency in the use of light colors for runways and taxiways.

Airport Beacons

Airport beacons help pilots identify airports at night, often making them easier to spot than during the day. Beacons operate from dusk until dawn, and in some cases, they're activated when the ceiling is less than 1,000 feet or visibility is below three statute miles (VFR minimums), though this is not a requirement. Pilots must still determine if the weather meets VFR conditions.

From a distance, airport beacons appear to flash, created either by an omnidirectional capacitor-discharge device or a rotating light. The color combinations indicate the type of airport:

Civilian Land Airports: Flashing white and green
Water Airports: Flashing white and yellow
Heliports: Flashing white, yellow, and green
Military Airports: Two quick white flashes followed by a green flash

Airport Sign Systems

Type of Sign	Action or Purpose	Type of Sign	Action or Purpose
4-22	**Taxiway/Runway Hold Position:** Hold short of runway on taxiway		**Runway Safety Area/Obstacle Free Zone Boundary:** Exit boundary of runway protected areas
26-8	**Runway/Runway Hold Position:** Hold short of intersecting runway		**ILS Critical Area Boundary:** Exit boundary of ILS critical area
8-APCH	**Runway Approach Hold Position:** Hold short of aircraft on approach	J →	**Taxiway Direction:** Defines direction & designation of intersecting taxiway(s)
ILS	**ILS Critical Area Hold Position:** Hold short of ILS approach critical area	↙ L	**Runway Exit:** Defines direction & designation of exit taxiway from runway
⊖	**No Entry:** Identifies paved areas where aircraft entry is prohibited	22 ↑	**Outbound Destination:** Defines directions to takeoff runways
B	**Taxiway Location:** Identifies taxiway on which aircraft is located	↖ MIL	**Inbound Destination:** Defines directions for arriving aircraft
22	**Runway Location:** Identifies runway on which aircraft is located		**Taxiway Ending Marker:** Indicates taxiway does not continue
4	**Runway Distance Remaining:** Provides remaining runway length in 1,000 feet increments	↙A G L →	**Direction Sign Array:** Identifies location in conjunction with multiple intersecting taxiways

Rotating beacons for civilian land and water airports. Don't get them confused!

Approach Light Systems

Not all runways have approach light systems. However, if a runway has an instrument approach, it will include an approach light system to help pilots transition from instrument flight in low-level clouds to visual flight for landing. These lights can also assist airplane pilots flying under VFR at night.

For powered parachute pilots, it's important to avoid airplane traffic. If you find that you're maneuvering in the glide slope area for airplanes, it's best to stay clear by flying well above, below or away from that glide path to maintain safety.

Visual Glide Slope Indicators

An ideal glide path for landing allows an airplane to clear obstacles and touch down near the runway's beginning. Visual glide slope indicators assist pilots with maintaining the correct glide path, ensuring safe obstacle clearance and proper runway touchdown. There are several kinds of glide slope indicators.

Visual Approach Slope Indicator (VASI) systems are the most common systems used to provide pilots with glide path information during approaches. They ensure obstruction clearance within 10° of the extended runway centerline and up to four nautical miles from the runway threshold.

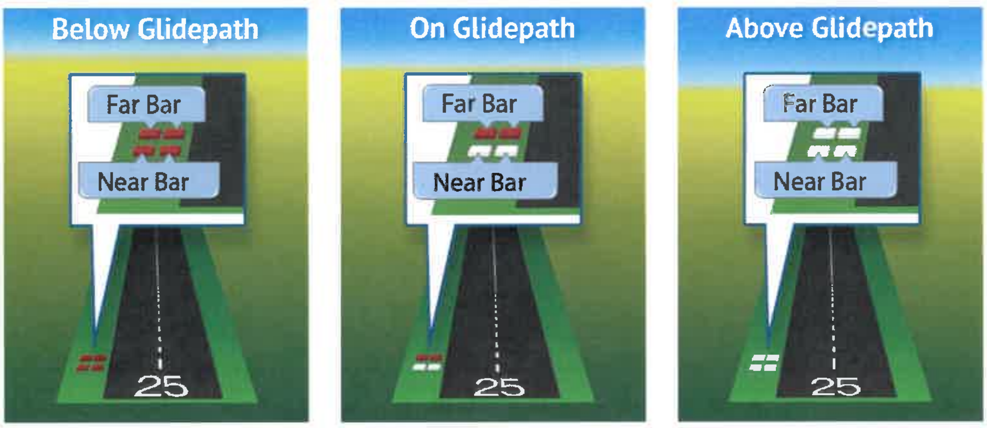
The VASI is composed of light units arranged in either two or three bars. A 2-bar VASI features near and far light bars, providing a single visual glide path typically set at 3°. In contrast, a 3-bar VASI includes near, middle, and far light bars, offering two glide paths: a lower glide path at 3° and an upper glide path at 3.25°.

The system operates on the principle of color differentiation between red and white. Each light unit emits a beam containing a white segment at the top and a red segment at the bottom. This arrangement allows pilots to interpret their position relative to the glide path based on the combination of colors they see, indicating whether they are below, on, or above the desired glide path.

Precision Approach Path Indicator (PAPI) systems use lights similar to the VASI system except they're installed in a single row, normally on the left side of the runway.

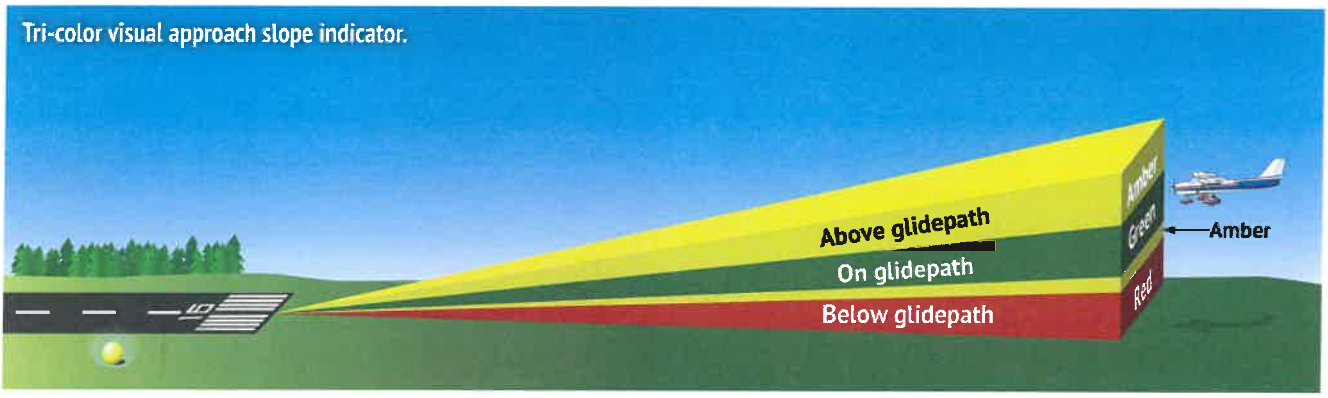
Tri-Color systems consists of a single light unit projecting a three-color visual approach path. Below the glide path is indicated by red, on the glide path is indicated by green, and above the glide path is indicated by amber. When descending below the glide path, there's a small area of dark amber.

Pulsating Visual Approach Slope Indicators consist of a single light unit projecting a two-color visual approach path. The on-glide path indication is a steady white light. The slightly below glide path indication is a steady red light. If the airplane descends further below the glide path, the red light starts to pulsate. The above glide path indication is a pulsating white light. The pulsating rate increases as the airplane gets further above or below the desired glide slope. The useful range of the system is about four miles during the day and up to ten miles at night.

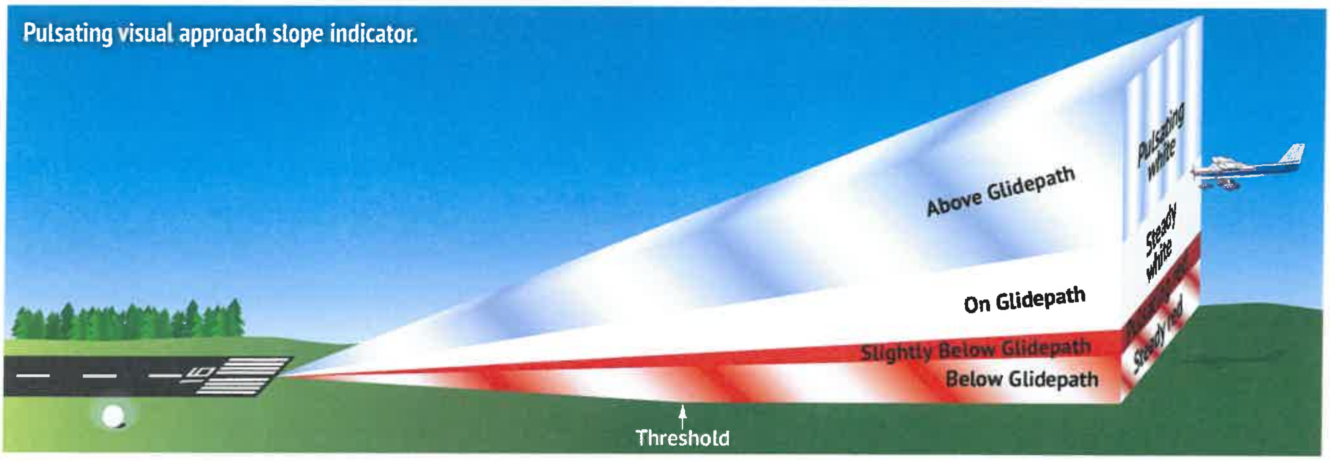


Two-bar VASI system.

Precision approach path indicator.



Tri-color visual approach slope indicator.



Pulsating visual approach slope indicator.

Runway Lighting

There are various lights that identify parts of the runway complex, assisting pilots in safely taking off or landing at night. Lighting systems include:

Runway End Identifier Lights (REIL)

REILs are installed on the approach end of some runways. The system consists of synchronized flashing lights located laterally on each side of the runway threshold to help pilots rapidly identify the approach end. REILs may be either omnidirectional or unidirectional facing the approach area.

Runway Edge Lights

Runway edge lights are used to outline the edges of runways at night or during low visibility conditions. These lights are classified according to the intensity they are capable of producing:

- High Intensity Runway Lights (HIRL)
- Medium Intensity Runway Lights (MIRL)
- Low Intensity Runway Lights (LIRL)

HIRL and MIRL have variable intensity settings. The lights are white, except on instrument runways where amber lights are used on the last 2,000 feet or half the length of the runway, whichever is less. Red edge lights mark the ends of the runway.

Control of Airport Lighting

Airport lighting is controlled by air traffic controllers at towered airports. You may request various light systems be turned on or off and also request a specified intensity, if available, from ATC personnel.

At non-towered airports the lights are probably on a timer or a dusk-to-dawn system. You're able to control the lighting by radio at some non-towered airports. You do this by selecting a specified frequency (often the UNICOM) and clicking the radio microphone a specified number of times. You can find information on pilot-controlled lighting at a specific airport in the Chart Supplement U.S.

Taxiway Lights

Blue, omnidirectional taxiway lights outline the edges of the taxiway.

At many towered airports, these edge lights have variable intensity settings that may be adjusted by an air traffic controller when deemed necessary or when requested by the pilot. At non-towered airports, you may be able to control taxiway lights the same way runway lighting is adjusted by clicking on the radio microphone.

Key Mike	Function
7 times within 5 seconds	Highest intensity available
5 times within 5 seconds	Medium or lower intensity (Lower REIL or REIL off)
3 times within 5 seconds	Lowest intensity available (Lower REIL or REIL off)

Radio controlled runway lighting

Obstruction Lights

Obstructions are marked or lighted to warn pilots of their presence during daytime and nighttime conditions. Obstruction lighting can be found both on and off an airport to identify obstructions like towers. In fact, obstruction lighting can help you identify waypoints during cross country flights. Obstructions may be marked or lighted in any of the following conditions.

Red Obstruction Lights either flash or emit a steady red color during nighttime operations, and the obstructions are painted orange and white for daytime operations.

High Intensity White Obstruction Lights flash high intensity white lights during the daytime with the intensity reduced for nighttime. They're used to mark some supporting structures of overhead transmission lines that stretch across rivers, chasms, and gorges. These high-intensity lights are also used to identify tall structures, such as chimneys and towers.

Dual Lighting is a combination of flashing red beacons and steady red lights for nighttime operation along with high intensity white lights for daytime operations.

Wind Direction Indicators

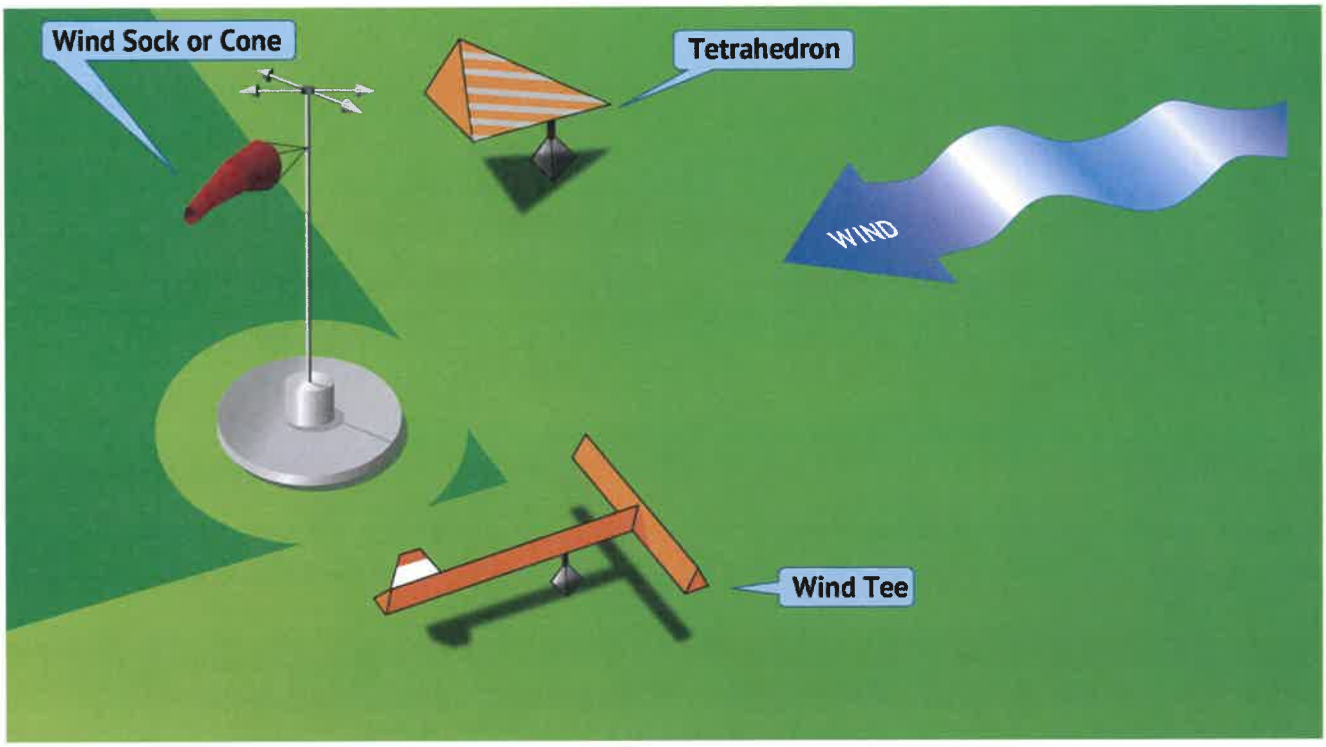
You should always know the direction of the wind, how hard it's blowing, and whether it's gusting or not. At towered airports, this information is provided by ATC. At non-towered airports, you can get it from an AWOS system or by contacting airport management on the common traffic advisory frequency (CTAF).

If these services aren't available, check visual wind indicators like windsocks, tetrahedrons, or wind tees, which are usually near the runway, often in the center of a segmented circle. Even with CTAF information, verify with these indicators, as they may be more accurate.

Windsocks are the most useful, showing both wind direction and strength. They straighten in strong winds and sway when gusty. Wind tees and tetrahedrons also align with the wind, but may be manually set to show the runway in use, so check the windsock if available.

Additionally, observe unofficial wind indicators like flags, pennants, or smoke from nearby fires for wind cues.

Wind direction indicators.



Traffic Patterns

Traffic patterns and traffic control procedures exist at airports to improve safety. Airport owners and operators, in coordination with the FAA, are responsible for establishing traffic patterns. Traffic patterns provide routes for takeoffs, departures, arrivals, and landings. The exact nature of each airport traffic pattern is dependent on the runway in use, wind conditions, obstructions, and other factors.

You're not expected to have extensive knowledge of all traffic patterns at all airports, but if you're familiar with the basic rectangular pattern, it'll be easy to make proper approaches and departures from most airports, regardless of whether they have control towers.

Standard Airport Traffic Patterns

To ensure orderly air traffic flow at an airport, a traffic pattern is established based on local conditions. This pattern dictates the direction of turns, altitude to be flown, and procedures for entering and exiting the pattern. At most airports, unless otherwise indicated by visual markings, fixed-wing pilots will make all turns to the left while flying in the pattern.

Exceptions to this standard left-turn pattern are listed in the Chart Supplement U.S. and, in some cases, are also shown on sectional charts. For non-towered airports, a right-traffic pattern is indicated by "*RP*" in the airport information section of the VFR sectional chart. The runways requiring the right-hand pattern will be listed next to the "*RP*." If no "*RP*" is listed, it is assumed that the standard left-traffic pattern applies.

Towered Airports

When operating at an airport with an active control tower, pilots receive radio clearance for both approach and departure, as well as instructions about the traffic pattern. The tower operator may direct pilots to enter the traffic pattern at any point or allow a straight-in approach, bypassing the usual rectangular pattern. Flexibility in the pattern is common as the tower and pilots work together to manage smooth traffic flow.

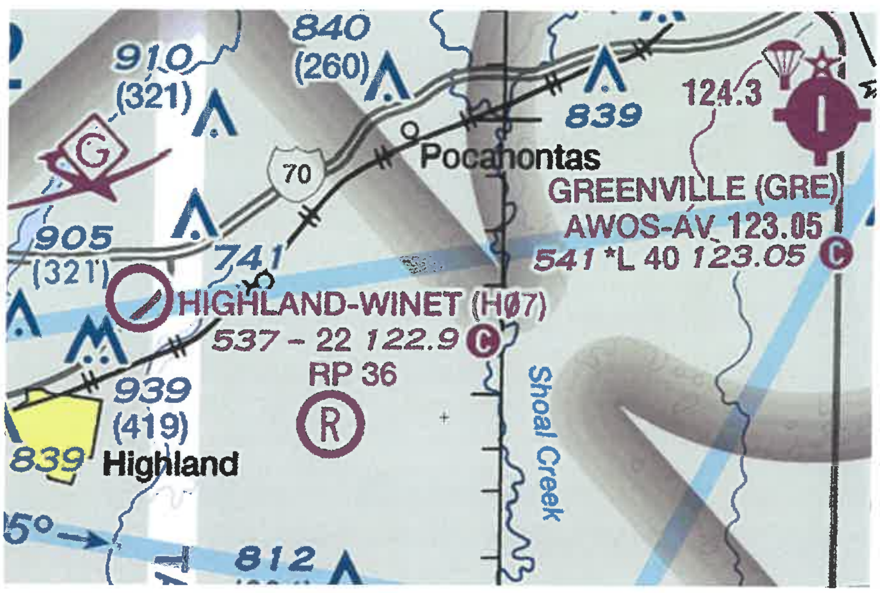
Larger jets or heavy aircraft often fly wider or higher patterns compared to smaller general aviation (GA) aircraft, and they may opt for a straight-in approach. The standard GA traffic pattern is a rectangular layout, with pattern altitude typically at 1,000 feet above ground level. Specific traffic pattern altitudes vary by airport and can be found in the Chart Supplement U.S

Uncontrolled Airports

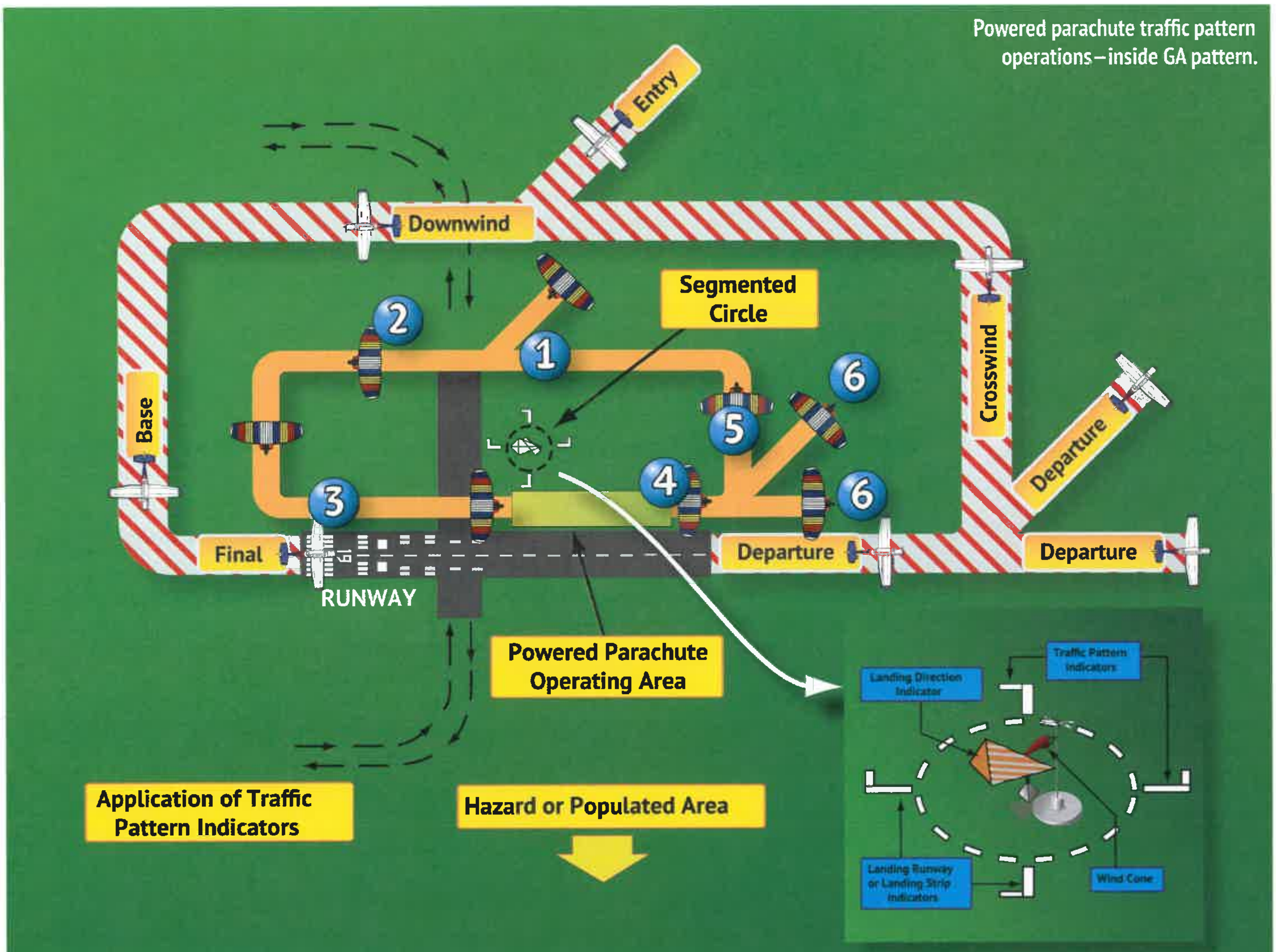
At airports without a control tower, pilots are responsible for determining the traffic pattern, following appropriate rules, and practicing common courtesy toward other pilots. The common traffic advisory frequency (CTAF) is useful for listening to airport traffic, and if available, the automatic terminal information service (ATIS) provides additional information.

When entering the traffic pattern at an uncontrolled airport, pilots are expected to observe aircraft already in the pattern and conform to the established traffic flow. If no aircraft are present, pilots rely on ground traffic indicators and wind direction indicators to choose the appropriate runway and traffic pattern.

A segmented circle visual indicator system provides traffic pattern information at uncontrolled airports. This system, typically placed in a highly visible location, includes wind direction indicators, landing direction indicators, landing strip indicators, and traffic pattern indicators. A tetrahedron, often found at the center of a segmented circle, indicates the direction of landings and takeoffs and may be lighted for night operations. The small end of the tetrahedron points in the landing direction. At tower-controlled airports, the tetrahedron is only referenced when the tower is not in operation, as tower instructions take precedence.



The Highland-Winet gliderport has a grass north-south runway. There are a lot of homes to the east of the gliderport so the gliderport established a right traffic pattern when flying Runway 36 to keep aircraft from flying over the homes. That's noted as "RP 36" on the sectional. Runway 18 has a normal left traffic pattern since it isn't noted.



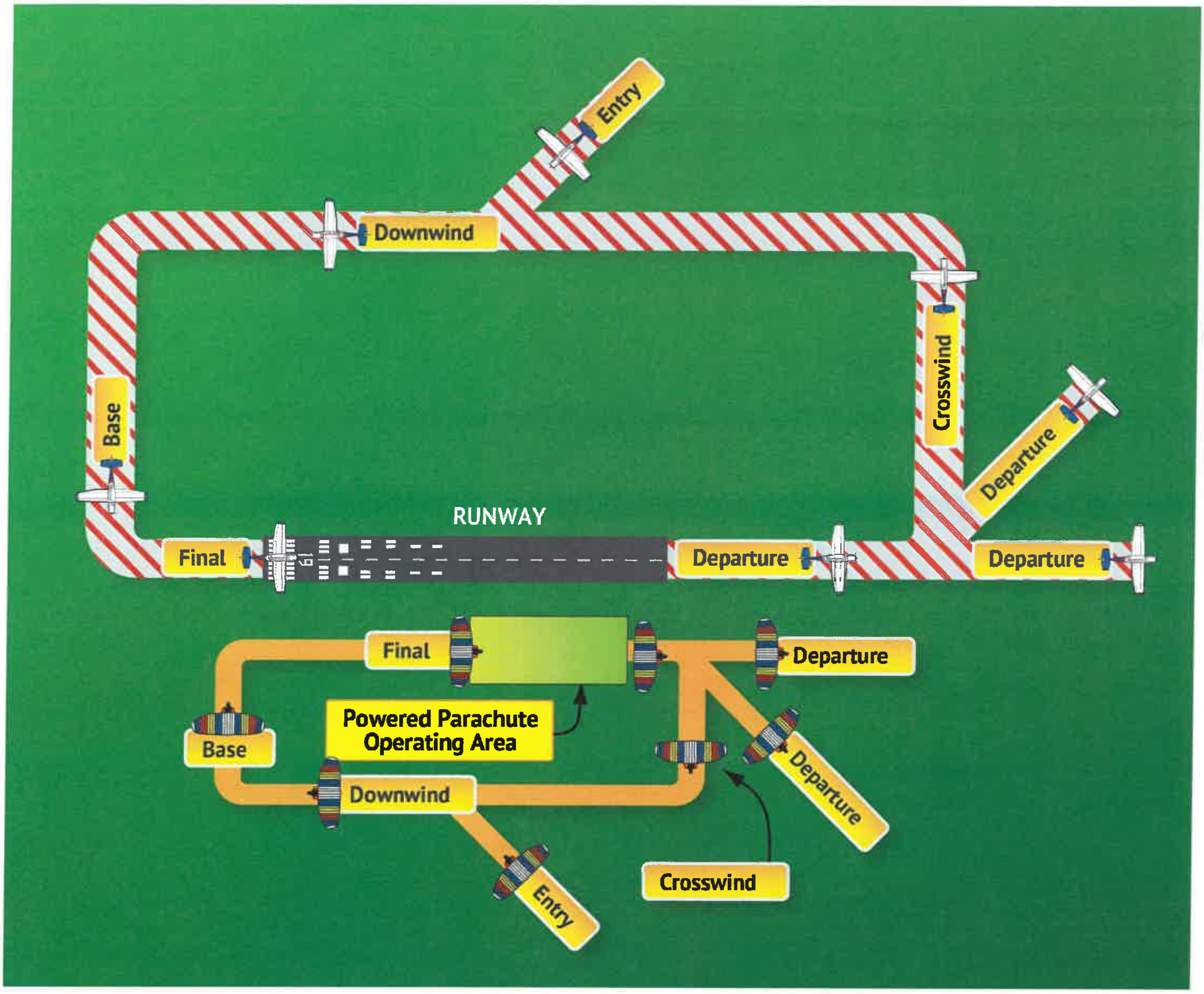
LEGEND

Airplane Recommended Standard Left-Hand Traffic Pattern

Powered Parachute Recommended Inside Left-Hand Traffic Pattern

(Standard right-hand traffic patterns would be mirror images)

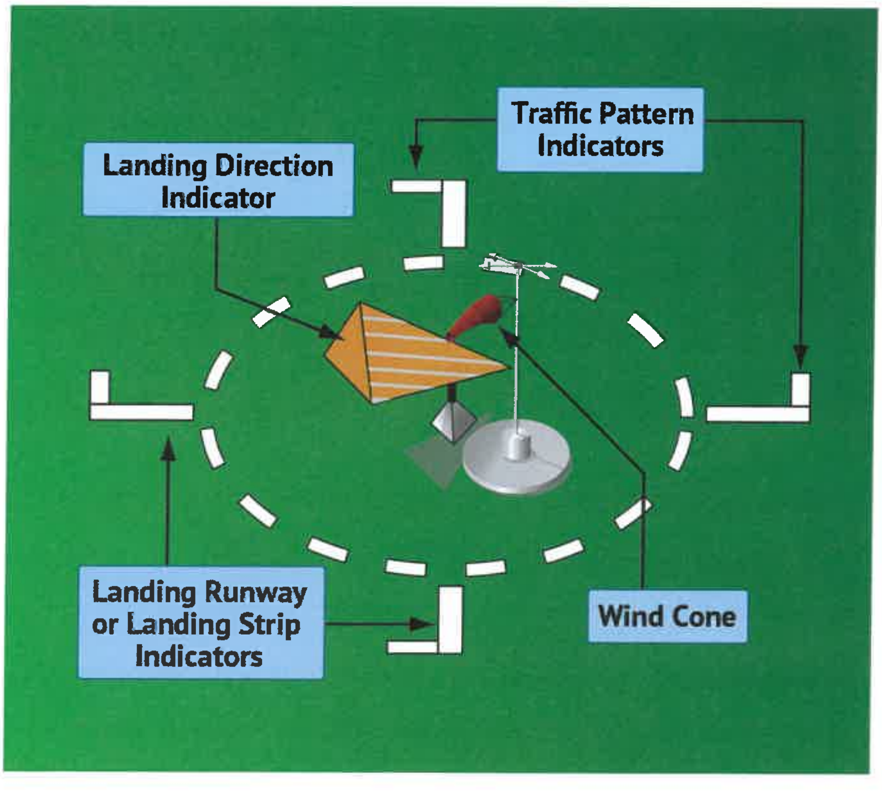
1. Enter pattern in level flight, abeam the midpoint of the runway, at pattern altitude. (500' AGL) is recommended pattern altitude unless established otherwise.)
2. Maintain pattern altitude until abeam approach end of the landing runway on downwind leg.
3. Complete turn to final at least past the main runway threshold. Do not overshoot final or continue on a track which penetrates the final approach of the airplane traffic.
4. Continue straight ahead until beyond departure end of runway.
5. If remaining in the traffic pattern, commence turn to crosswind leg beyond the departure end of the runway within 150 feet of pattern altitude.
6. If departing the traffic pattern, continue straight out, or exit with a 45° turn (to the left when in a left-hand traffic pattern; to the right when in a right-hand traffic pattern) beyond the departure end of the runway, after reaching pattern altitude. Do not fly at an altitude which penetrates the crosswind or departure paths of the airplane traffic.



Powered parachute flying a right traffic pattern to avoid interrupting the GA pattern.

Landing strip indicators align with airport runways, while traffic pattern indicators show the direction of turns in the pattern. Pilots should check these indicators from a distance, well away from any active pattern or at a safe altitude above pattern levels. Once the proper traffic pattern direction is determined, the pilot maneuvers to a point clear of the pattern before descending to pattern altitude.

Traffic pattern altitudes for propeller-driven aircraft usually range from 600 to 1,500 feet above ground level (AGL), with 1,000 feet AGL being the standard. Nonstandard altitudes are listed in the Chart Supplement U.S.



An airport's segmented circle offers a lot of clues about pattern direction and winds for a flight.

Powered Parachute Operations at Airports

Non-towered airport operators establish local procedures for rotorcraft, glider, ultralight, lighter-than-air aircraft, skydive, and powered parachute operations as needed. Those procedures may be listed in the Chart Supplement U.S. However, most often you'll have to talk to airport management to learn what those local procedures may be. If you're the first powered parachute pilot to fly at that airport, lucky you. You get to work with the manager to establish those procedures.

The largest factor in determining the proper traffic pattern is airspeed. Slow aircraft and fast aircraft don't mix well, and powered parachutes are among the slowest aircraft typically found at most airports. That means that powered parachute operations are often segregated from other airport traffic. In fact, the regulations require that powered parachutes avoid the flow of airplane traffic at uncontrolled airports.

To avoid airplanes, you should fly at a pattern altitude at least 500 feet below the GA pattern altitude. Even after an airplane has slowed to traffic pattern speed, it's still two to three times faster than a powered parachute.

A powered parachute pattern with its own dedicated landing area will typically have a pattern parallel to the standard pattern with turns in the opposite direction. An airport may instead designate a smaller pattern for powered parachutes, referred to as a *tight pattern* or *inside pattern*, and it might be in the same direction or opposite to the other traffic. This smaller pattern, combined with a pattern altitude of one-half the standard airplane traffic pattern, helps ensure separation from aircraft flying much faster. The pattern used depends on local requirements and winds. However, it's advisable that the powered parachute pattern should not cross over the airplane active runway or any leg of the airplane traffic pattern.

Powered parachutes also operate best from a grass surface, which causes less wear and tear on the parachute and allows you both the needed amount of time to set up the wing as well as the ability to set the aircraft up directly into the wind. That often works best for everyone involved and helps separate powered parachute operations from airplane traffic. If an off-runway area is used for powered parachute operations, examine the area for surface condition, holes, standing water, rocks, tall vegetation, moguls, fences, wires and other hazards before setting up.

At some airports, off-runway operations may disrupt normal airport operations or may not be safe for powered parachutes due to poor surface conditions. In that case, you may have to set up on the runway threshold. If you elect to use the airport runway, take into consideration any crosswind that may be present. The airport runway may not be aligned close enough into the wind for your flying skills or may exceed aircraft limitations.

Regardless of the traffic pattern flown, you must always stay aware of your position in relation to other aircraft in the airport area.

Flying the Pattern

Most powered parachute pilots fly in Class G Airspace, which means airports without Air Traffic Control (ATC). However, the absence of ATC doesn't mean the absence of rules.

When you enter a traffic pattern without a control tower, you must observe other aircraft (particularly other powered parachutes) and conform to the traffic pattern in use. If there aren't any other aircraft present, then check traffic indicators on the ground and wind indicators to determine which runway and traffic pattern to use.

Approaching the Pattern: When approaching an airport for landing, enter the traffic pattern at a 45° angle to the downwind leg, aiming for a point abeam the runway's midpoint. Ensure you reach the correct traffic pattern altitude before entering and stay clear of the traffic flow until established on the entry leg. Avoid descending while entering the pattern, as this can create collision risks.

Entry Leg: Your entry leg should be long enough to provide a clear view of the entire traffic pattern and allow you adequate time for planning your intended path in the pattern and landing approach.

Downwind Leg: The downwind leg is a course flown parallel to the landing runway, but in a direction opposite to the intended landing

§ 91.126 Operating on or in the vicinity of an airport in Class G airspace.

(a) General. Unless otherwise authorized or required, each person operating an aircraft on or in the vicinity of an airport in a Class G airspace area must comply with the requirements of this section.

(b) Direction of turns. When approaching to land at an airport without an operating control tower in Class G airspace -

(1) Each pilot of an airplane must make all turns of that airplane to the left unless the airport displays approved light signals or visual markings indicating that turns should be made to the right, in which case the pilot must make all turns to the right; and

(2) Each pilot of a helicopter or a powered parachute must avoid the flow of fixed-wing aircraft.

(c) ...

direction. You fly this leg at one-half the specified airplane traffic pattern altitude to alleviate conflicts with faster aircraft. You normally want to be at 300-500 feet AGL. Maintain pattern altitude until abeam the approach end of the landing runway. Depending on winds, that's usually a good place to reduce power and begin a descent. The downwind leg continues past a point abeam the approach end of the runway to a point approximately 45° from the approach end of the runway, and a medium bank turn is made onto the base leg.

Base Leg: The base leg is the transitional part of the traffic pattern between the downwind leg and the final approach leg. Depending on the wind, you should establish it at a sufficient distance from the approach end of the landing runway to permit a gradual descent to your intended touchdown point. Your ground track while on the base leg should be perpendicular to the extended centerline of the landing runway. If there's wind, your powered parachute may not be aligned with the ground track because you'll have to turn into the wind to counteract drift. While on your base leg and before you turn onto your final approach, make sure that there's no danger of colliding with another aircraft that may already be on their final approach.

Final: The final approach leg is a descending flight path starting from the completion of the base-to-final turn and extending to the point of touchdown. This is probably the most important leg of the entire pattern, because here is where your judgment, procedures, and skill must be the sharpest to accurately control the descent angle while approaching the intended touchdown point.

§91.113 says that aircraft while on final approach to land or while landing have the right-of-way over other aircraft in flight or operating on the surface. When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way. Don't take advantage of this rule to cut in front of another aircraft that's on final approach to land, or to overtake another powered parachute.

Upwind Leg: The upwind leg is a course flown parallel to and in the same direction as the landing runway. The upwind leg continues past a point abeam the departure end of the runway where a medium bank 90° turn is made onto the crosswind leg.

The upwind leg is another transitional part of the traffic pattern. It includes the final approach, when a go-around is initiated, and while climbing after liftoff. You should commence a shallow bank turn to the crosswind leg of the airport after you reach a safe altitude. If you're going around because another aircraft is on the runway, it's best if you fly to the side of the runway so that the departing aircraft can better see that the runway is clear.

Departure Leg: The departure leg of the rectangular pattern is a straight course aligned with, and leading from, the takeoff runway. This leg begins at the point you leave the ground and continues until you start your 90° turn onto the crosswind leg.

On the departure leg after takeoff, continue climbing straight ahead. If you're remaining in the traffic pattern, begin your turn to the crosswind leg. Begin your turn to crosswind after you establish a positive rate of climb and you're climbing high enough to allow clearance from ground obstructions.

If you're departing the traffic pattern from the upwind leg, continue straight out or exit with a 45° turn. Either way, make sure that you have established a positive rate of climb and you are high enough to clear ground obstructions.

§ 91.123 Compliance with ATC clearances and instructions.

(a) When an ATC clearance has been obtained, no pilot in command may deviate from that clearance unless an amended clearance is obtained, an emergency exists, or the deviation is in response to a traffic alert and collision avoidance system resolution advisory. ... When a pilot is uncertain of an ATC clearance, that pilot shall immediately request clarification from ATC.

(b) Except in an emergency, no person may operate an aircraft contrary to an ATC instruction in an area in which air traffic control is exercised.

(c) Each pilot in command who, in an emergency, or in response to a traffic alert and collision avoidance system resolution advisory, deviates from an ATC clearance or instruction shall notify ATC of that deviation as soon as possible.

(d) Each pilot in command who (though not deviating from a rule of this subpart) is given priority by ATC in an emergency, shall submit a detailed report of that emergency within 48 hours to the manager of that ATC facility, if requested by ATC.

(e) Unless otherwise authorized by ATC, no person operating an aircraft may operate that aircraft according to any clearance or instruction that has been issued to the pilot of another aircraft for radar air traffic control purposes.

If parallel operations are in place (i.e., airplanes on the hard surface, powered parachutes on the grass), fly a pattern that stays within the pattern of the airplane traffic and does not cross the airplanes' active runway. In all cases, you shouldn't make any turns until you're certain you won't obstruct any aircraft operating in either pattern.

Crosswind Leg: The crosswind leg is the part of the rectangular pattern that's horizontally perpendicular to the extended centerline of the takeoff runway and is entered by making approximately a 90° turn from the upwind leg. From the crosswind leg, you're heading to the downwind leg position.

Since takeoffs are typically into the wind, the wind will now be roughly perpendicular to your flight path on the crosswind leg. To maintain a ground track perpendicular to the runway centerline extension, you'll need to adjust by turning slightly into the wind.

Remember that traffic pattern altitudes for military turbojet aircraft sometimes extend up to 2,500 feet AGL. You want to be constantly on the alert for other aircraft in the traffic pattern and avoid these areas and altitudes whenever possible.

Additional information on airport traffic pattern operations can be found in Advisory Circular 90-66C, *"Non-Towered Airport Flight Operations."* You can find traffic pattern information and restrictions such as noise abatement in the Chart Supplement U.S.

Air Traffic Control (ATC)

Most powered parachute pilots will never enter airspace where they have to deal with ATC. At our altitudes and flying VFR, that means Class B, C, and D airspace. If you do want to fly into towered airspace, you need to make sure that your powered parachute is properly equipped for such a foray and that you have the proper training and endorsements for the trip. See *Chapter 25, "Airspace,"* for more information.

Radio Communications

An aviation band radio is a safety device. While *"optional"* in Class G and E airspace, including around uncontrolled airports, a radio allows you to let others know what you're doing. More importantly, it allows you to know what's going on in the pattern. Flying at an airport without a radio is like going to a party and not being able to hear what anyone is saying, only possibly more dangerous.

Proper communication is not optional at towered airports. If you're operating in and out of a towered airport, you must have a two-way radio and know how to use it.

Radio Equipment

In general aviation, the most common types of radios are VHF. VHF radios are limited to *line-of-sight* transmissions. That means that aircraft at higher altitudes are able to transmit and receive at greater distances.

Aviation band radio equipment varies in output and effectiveness. Generally, panel mount radios transmit better than handheld radios. But even a handheld radio can be improved by replacing the rubber duck antenna with a remote antenna and a ground plane.

There is no station license requirement for handheld aviation band radios or for the radios installed in most general aviation aircraft operating in the United States.

Radio Procedures

A lot of student pilots fear using the radio more than they fear anything else about flying. The language is different and when you first start using it during training, you'll feel a little bit like you're performing on stage for all the other pilots at the airport. That's OK and pretty natural. Public speaking is often a little scary. But not to worry, most all pilots remember when they were students and are happy to see others trying. And besides, your instructor is there to help you out as you begin.

The key is to practice on the ground. A lot of students rehearse radio communications while on the ground so that they're ready when they begin flying. Even when flying, it's best to mentally rehearse what you're going to say before you mash the push-to-talk button and begin your transmission.

Here are some general tips on radio communication.

- Before speaking on the radio, always listen first. If someone is already transmitting, your message won't go through, and you may disrupt their communication, forcing them to repeat themselves. When switching frequencies, pause briefly to ensure the channel is clear before transmitting.

Traffic advisories.

Someone looking at radar can't tell which way you are facing, they can only tell which way you are moving. Traffic information would be issued to the pilot of aircraft "A" as 12 o'clock. The actual position of the traffic as seen by the pilot of aircraft "A" would be 2 o'clock. Traffic information issued to aircraft "B" would also be given as 12 o'clock, but in this case, the pilot of "B" would see traffic at 10 'clock.

The International Civil Aviation Organization (ICAO) phonetic alphabet is used to clearly transmit numbers and letters over the radio.

Character	Morse Code	Telephony	Phonic Pronunciation
A	•—	Alfa	(AL-FAH)
B	—•••	Bravo	(BRAH-VOH)
C	—•—•	Charlie	(CHAR-LEE) or (SHAR-LEE)
D	—••	Delta	(DELL-TAH)
E	•	Echo	(ECK-OH)
F	••—•	Foxtrot	(FOKS-TROT)
G	——•	Golf	(GOLF)
H	••••	Hotel	(HOH-TEL)
I	••	India	(IN-DEE-AH)
J	•———	Juliett	(JEW-LEE-ETT)
K	—•—	Kilo	(KEY-LOH)
L	•—••	Lima	(LEE-MAH)
M	——	Mike	(MIKE)
N	—•	November	(NO-VEM-BER)
O	———	Oscar	(OSS-CAH)
P	•——•	Papa	(PAH-PAH)
Q	——•—	Quebec	(KEH-BECK)
R	•—•	Romeo	(ROW-ME-OH)
S	•••	Sierra	(SEE-AIR-RAH)
T	—	Tango	(TANG-GO)
U	••—	Uniform	(YOU-NEE-FORM) or (OO-NEE-FORM)
V	•••—	Victor	(VIK-TAH)
W	•——	Whiskey	(WISS-KEY)
X	—••—	Xray	(ECKS-RAY)
Y	—•——	Yankee	(YANG-KEY)
Z	——••	Zulu	(ZOO-LOO)
1	•————	One	(WUN)
2	••———	Two	(TOO)
3	•••——	Three	(TREE)
4	••••—	Four	(FOW-ER)
5	•••••	Five	(FIFE)
6	—••••	Six	(SIX)
7	——•••	Seven	(SEV-EN)
8	———••	Eight	(AIT)
9	————•	Nine	(NIN-ER)
0	—————	Zero	(ZEE-RO)

- Think before transmitting. Plan out what you want to say, and practice it mentally to ensure clarity.
- Hold the microphone close to your lips. After pressing the *push-to-talk* button, pause briefly to ensure your first word is transmitted, then speak in a normal, conversational tone.
- Monitor the sounds, or lack thereof, from your radio. Check the volume, verify your frequency, inspect your headset, and ensure your push-to-talk button isn't stuck in transmit mode. Unintentional transmitter operation can block the frequency for a long time, causing interference known as a *stuck mic*.
- Make sure your radio equipment operates within its specified range. Remember that higher altitudes can extend the range of VHF line-of-sight communications.
- Use the ICAO phonetic alphabet when identifying your aircraft on the radio to improve communication clarity.

Communicating with a Control Tower

Most powered parachute pilots will never have a need to communicate with an air traffic control tower. If you want to learn how to do that, a lot of the radio procedures you learn while flying in uncontrolled airspace will apply. The big differences while talking in controlled airspace are:

- You're talking to the tower and not directly to other pilots.
- You're not making your own decisions about where you're flying. That's why they call it controlled.
- It's a busier environment and brevity on the radio is valued.

Using proper radio phraseology and procedures will help you operate safely and efficiently in the airspace system. You should review the Airman's Information Manual (AIM) for specific radio procedures for talking with ATC. You can also study the Pilot/Controller Glossary, which is also in the AIM, to learn standard terminology.

Communicating in Uncontrolled Airspace

Most aviation accidents occur within a few miles of an airport. That's where congestion is heaviest and pilots are the busiest. That makes *see and avoid* critical for safe operations. Radio communication is also important at non-tower-controlled airports and flying fields, as it helps you stay informed about the activities of other aircraft and allows you to communicate your position and intentions to fellow pilots. It's another layer of safety over and above see and avoid.

The first thing you need to do when using your radio at an uncontrolled airport is find the correct Common Traffic Advisory Frequency (CTAF). That's the frequency pilots use at the airport to communicate with each other. The CTAF is identified on sectionals and in the Flight Supplement U.S. and may be a:

- Universal Communications (UNICOM) Frequency
- MULTICOM Frequency
- Tower Frequency

UNICOM is the frequency used for non-government radio communication stations that provide airport information at public-use airports. At uncontrolled airports, these systems typically offer various features that can be accessed through microphone clicks. Upon pilot request, UNICOM stations may provide essential information, including weather updates, wind direction, the recommended runway, and other pertinent details. If the UNICOM frequency serves as the CTAF, it will be clearly identified on both sectional charts and in the Chart Supplement U.S.

MULTICOM is a specific frequency (122.9) designated for pilot use and serves as the CTAF when no other radio frequency is assigned to an airport. If an airport's information on a sectional chart does not list a specific frequency, pilots should use the MULTICOM frequency for communication.

The Tower Frequency is exactly that, the frequency designated for a control tower. If a Class D airport tower closes, that tower frequency becomes the CTAF and the airspace is uncontrolled.

Fortunately, radio transmissions aren't that complicated and can be learned and practiced on the ground. Most radio calls have five basic parts. They are:

Who You're Talking To: Since CTAFs can overlap between neighboring airports, it's crucial to clearly state which airport you're communicating with. This helps others at different airports disregard your transmission while ensuring that those who need to hear it can focus on your message. Typically, at a non-towered airport, you will only need to communicate with one of three entities.

UNICOM: Contact the airport office (UNICOM) for information about weather, fuel availability, preferred runways, and other essential details.

Right: Talking on the radio in uncontrolled airspace is fairly basic. This flow chart can help you make flawless transmissions if you just use your aircraft N-number and the airport you are operating from, and the appropriate runway designations.

Other Traffic: Keep other pilots informed of your position and intentions within the airport area. This communication is vital for maintaining safety and situational awareness.

Specific Aircraft: Communicate with specific aircraft for courtesy and to coordinate runway or taxiway usage. When addressing other aircraft, refer to them by type and/or N-number for clarity.

Who You Are: Clearly identify yourself as a powered parachute, including your N-number for easy recognition.

Where You Are: Provide your location to inform other traffic whether you're on the ground, in the air, on a specific taxiway, or in the traffic pattern (downwind, base, or final). This helps maintain situational awareness.

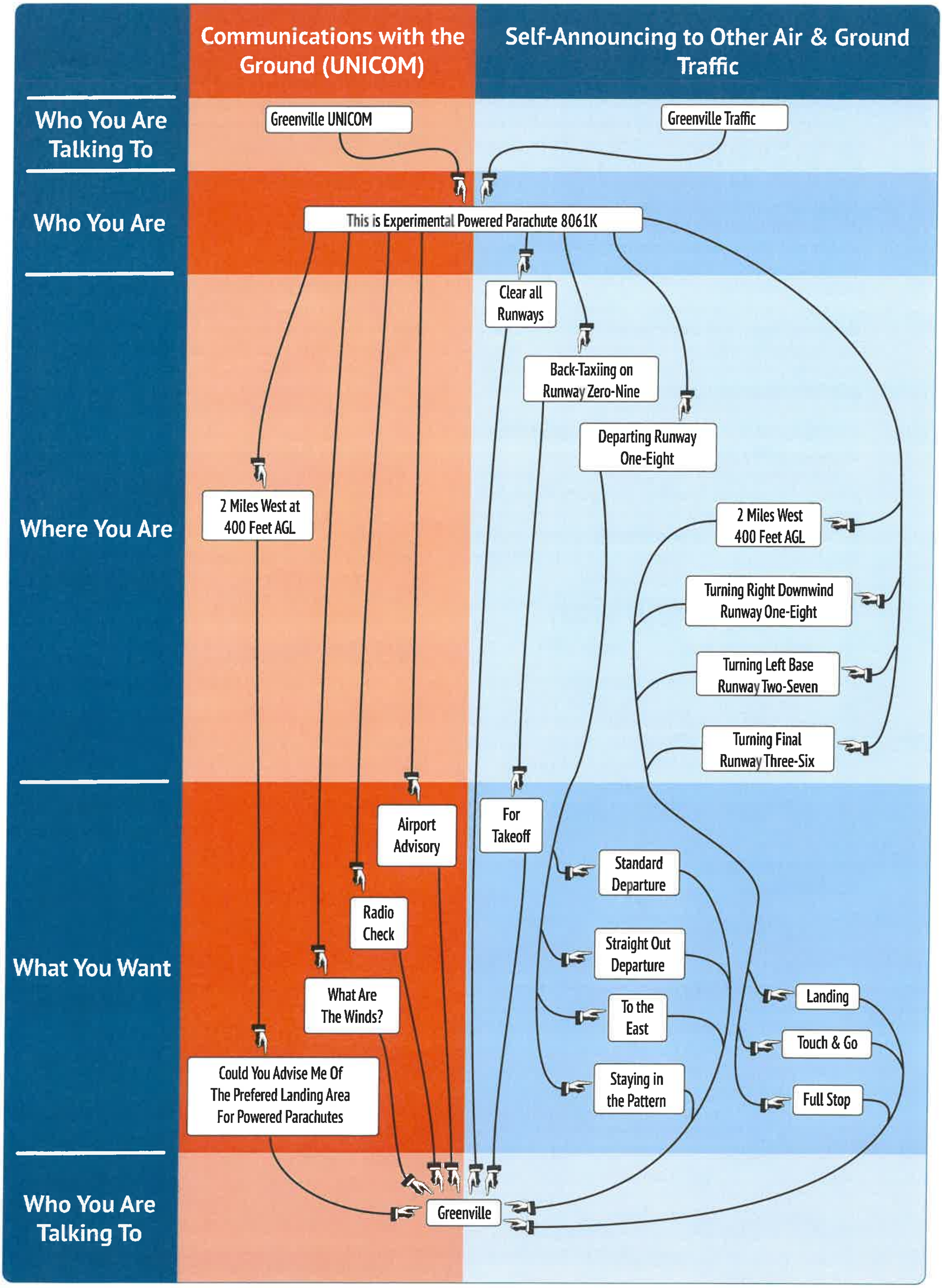
What You Want: State your intentions or requests, whether you're announcing your position in the pattern or asking UNICOM for wind speed and direction. Given the unique traffic patterns for powered parachutes, specify whether you're flying a left or right pattern.

Who You're Talking To: To ensure clarity, repeat the entity you're addressing at the end of your transmission. This helps those who may have missed the initial part of your message understand which airport or traffic you're communicating with.

The graphic on the next page has examples of the kinds of radio calls that you will hear and need to make at non-towered airports. The figure shows that not only do all transmissions follow a certain pattern, but they also include very similar information.

Color and Type of Signal	Movement of Vehicles, Equipment and Personnel	Aircraft on the Ground	Aircraft in Flight
Steady green	Cleared to cross, proceed or go	Cleared for takeoff	Cleared to land
Flashing green	Not applicable	Cleared for taxi	Return for landing (to be followed by steady green at the proper time)
Steady red	Stop	Stop	Give way to other aircraft and continue circling
Flashing red	Clear the taxiway/runway	Taxi clear of the runway in use	Airport unsafe, do not land
Flashing white	Return to starting point on airport	Return to starting point on airport	Not applicable
Alternating red and green	Exercise extreme caution!!!!	Exercise extreme caution!!!!	Exercise extreme caution!!!!

Light gun signals.


Communications with the Ground (UNICOM)
Self-Announcing to Other Air & Ground Traffic
Who You Are Talking To
Greenville UNICOM
Greenville Traffic
Who You Are
This is Experimental Powered Parachute 8061K
Where You Are
Clear all Runways
Back-Taxiing on Runway Zero-Nine
Departing Runway One-Eight
2 Miles West at 400 Feet AGL
2 Miles West 400 Feet AGL
Turning Right Downwind Runway One-Eight
Turning Left Base Runway Two-Seven
Turning Final Runway Three-Six
What You Want
Airport Advisory
For Takeoff
Radio Check
What Are The Winds?
Could You Advise Me Of The Prefered Landing Area For Powered Parachutes
Standard Departure
Straight Out Departure
To the East
Staying in the Pattern
Landing
Touch & Go
Full Stop
Who You Are Talking To
Greenville

Lost Communications at Airports with an ATC

In the event of a radio malfunction, such as the failure of the transmitter, receiver, or both, specific procedures should be followed when operating near a towered airport.

If the *receiver* fails and you need to land at a towered airport, remain outside or above Class D airspace until you determine the traffic flow. Then, inform the tower of your aircraft type, position, altitude, and intention to land. Continue by entering the traffic pattern, reporting your position, and watching for light signals from the tower. The meanings of light signal colors can be found in the table on page 348.

If the *transmitter* becomes inoperative, follow the same steps, but monitor the ATC frequency. During daylight hours, acknowledge ATC transmissions by rocking your wing, and at night, by blinking the landing light.

If *both the receiver and transmitter* are inoperative, remain outside Class D airspace, observe the flow of traffic, and rely on light signals.

Should your radio malfunction occur prior to departure, it's best to repair the issue if possible. If repairs can't be made, contact the tower to request authorization for departure without two-way radio communications. If authorized, monitor the frequency and watch for light signals.

Runway Incursion Avoidance

A runway incursion is any occurrence on an airport runway involving an aircraft, vehicle, person, or object that creates a collision hazard or compromises the required separation between an aircraft taking off, landing, or intending to do either. Paying attention during surface operations is just as crucial as in other phases of flight, and careful planning is key to avoiding runway incursions and potential ground collisions.

Three main factors contributing to runway incursions are:

1. Communication issues
2. Lack of airport knowledge
3. Inadequate flight deck procedures for maintaining orientation

Many flight activities take place at non-tower-controlled airports and powered parachutes are just part of the mix. These airports often host multiple operations like skydiving, ultralights, gliders, helicopters, and airplanes, all sharing the same facility at the same time.

Powered parachutes are unique since pilots must step out of the aircraft to set up the wing immediately before flight. This adds an extra layer of responsibility to ensure that not only is the taxi operation performed safely, but also that the take-off area is chosen to avoid interference with other airport activities.

You need to stay aware of your aircraft's position on the ground and keep track of other aircraft and vehicle movements. At towered airports, operations can be complex, and taxi instructions may be difficult to remember. In such cases, writing down taxi instructions is highly recommended.

The following are some practices to help prevent runway incursions at a towered airport:

- Always read back runway crossing and hold instructions.
- Review the airport layout during preflight planning, before descent, and while taxiing if necessary.
- Know airport signage.
- Check NOTAMs for runway and taxiway closures or construction updates.
- Request progressive taxi instructions from ATC when unsure of your taxi route.
- Look for traffic before crossing any Runway Hold Line or entering a taxiway.
- Turn on aircraft lights while taxiing.
- After landing, promptly clear the active runway, and wait for taxi instructions before moving further.
- Study and use correct phraseology to ensure clear communication with ground control.
- Write down complex taxi instructions, especially at unfamiliar airports.

Noise Abatement

Aircraft noise has become a significant concern at many airports across the country. Local communities have pressured airports to implement operational procedures to reduce noise over surrounding areas. In response, the FAA, airport managers, pilots, aircraft operators, and special interest groups have collaborated for years to mitigate noise in sensitive areas. This effort has led to the creation of noise abatement procedures at many airports, incorporating standardized profiles and operational techniques to minimize noise impact on nearby communities.

Standard noise abatement procedures don't necessarily apply to powered parachutes, but similar issues exist. Since powered parachutes fly at lower altitudes and fly tighter patterns, the possibility exists for you to become frustrating to airport neighbors. Compounding that is the fact that powered parachutes fly early in the morning and late in the evening. Powered parachute pilots should actively work with airport management to determine takeoff areas, patterns, and procedures that emphasize both safety and good neighborhood relations.

Chapter 25 Airspace

Airspace refers to the governmental sectioning up of the sky for air traffic, security, and safety purposes. For example, you probably don't want to be flying your powered parachute into the same airspace that jet airliners are flying or where the Army is practicing firing their howitzers. By understanding airspace and how it's depicted on aviation maps (called Sectionals), you can keep yourself safe and legal while flying.

This whole thing may seem rather complicated, but the categories and types of airspace do have purposes behind them. The categories and types are dictated by the:

- Complexity or density of aircraft movements
- Nature of the operations conducted within the airspace
- Level of safety required
- National and public interest

Categories and Types of Airspace

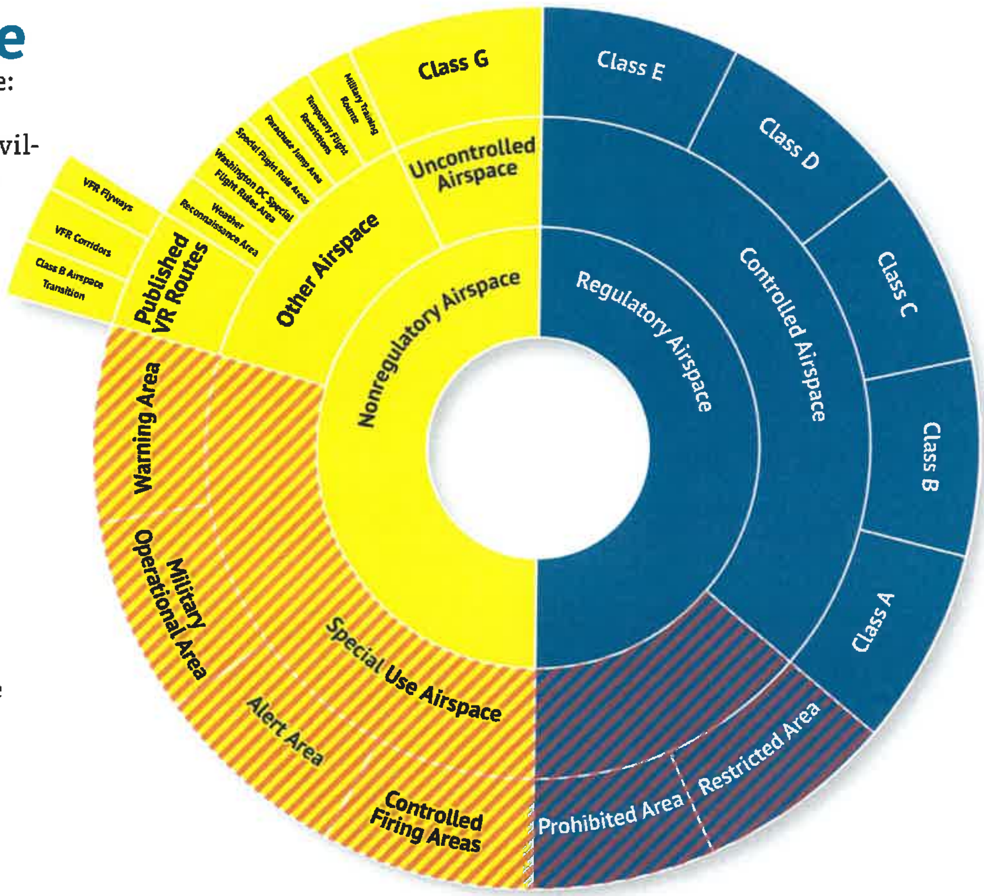
There are two categories of airspace:

Regulatory. This includes all the civilian controlled classes of airspace (Class A, B, C, D, and E airspace areas) as well as military controlled airspace (Restricted and Prohibited Areas). See CFR Title 14, Parts 71 and 73.

Nonregulatory. This includes areas that are set up to notify you that a higher level of operations may be afoot. These nonregulatory areas include Military Operations Areas (MOAs), Warning Areas, Alert Areas, Controlled Firing Areas and National Security Areas.

Within the two categories, there are four types of airspace:

- Uncontrolled
- Controlled
- Special Use
- Other airspace (Of course!)



Classes of Airspace

Classes of airspace refer to the A through G lettering system for airspace. Each class of airspace has its own rules regarding operations in it.

A, B, C, D and E airspace is controlled airspace. Controlled airspace is the airspace where air traffic control services are provided and sometimes mandated. Only Class G airspace is uncontrolled, yet even it has rules for operating in it. The rules for airspace pertain to:

- Visibility Requirements
- Distance from Clouds
- Permission Required to Fly in the Airspace
- Who Grants Permission
- Aircraft Equipment Requirements
- Minimum Pilot Certification

How Airspace Is Depicted on Sectionals

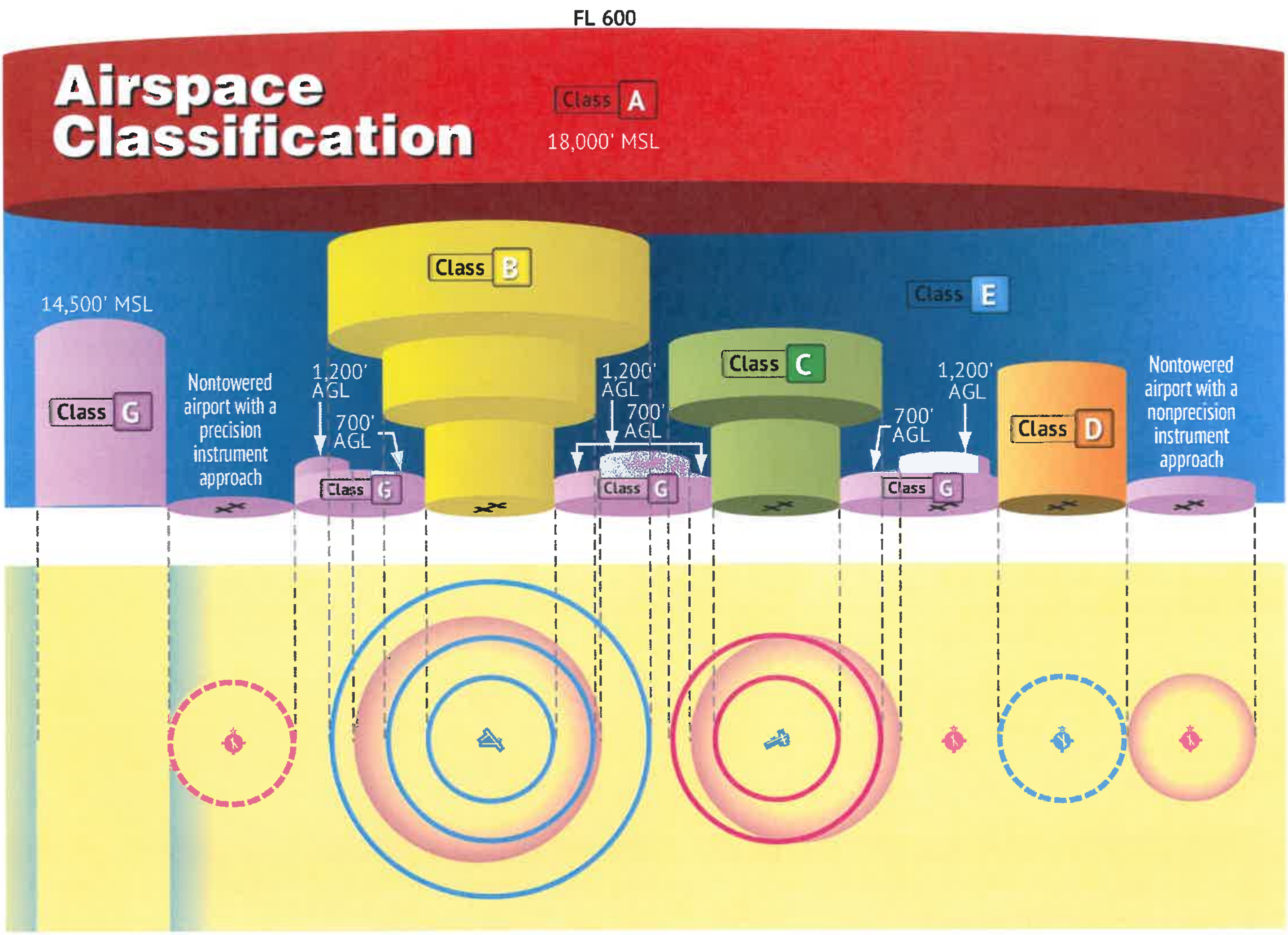
As we get started into the A-B-C's of airspace, it's important to realize that any given piece of ground in the US is going to have a least two classes of airspace over it. More often, there are at least three classes of airspace in the most common and simplest areas. The problem for the mapmakers was how to designate the three-dimensionality of airspace on a two-dimensional map. The solution was to develop some marking standards that make things clearer for everyone involved.

The first problem was to describe the most common kinds of airspace. As it turns out, there are two vertical boundaries for three layers of airspace that don't have to be marked because they are the most common airspaces. Repeatedly marking standardized items would only make sectionals more cluttered. Those standard airspaces and their transition altitudes are:

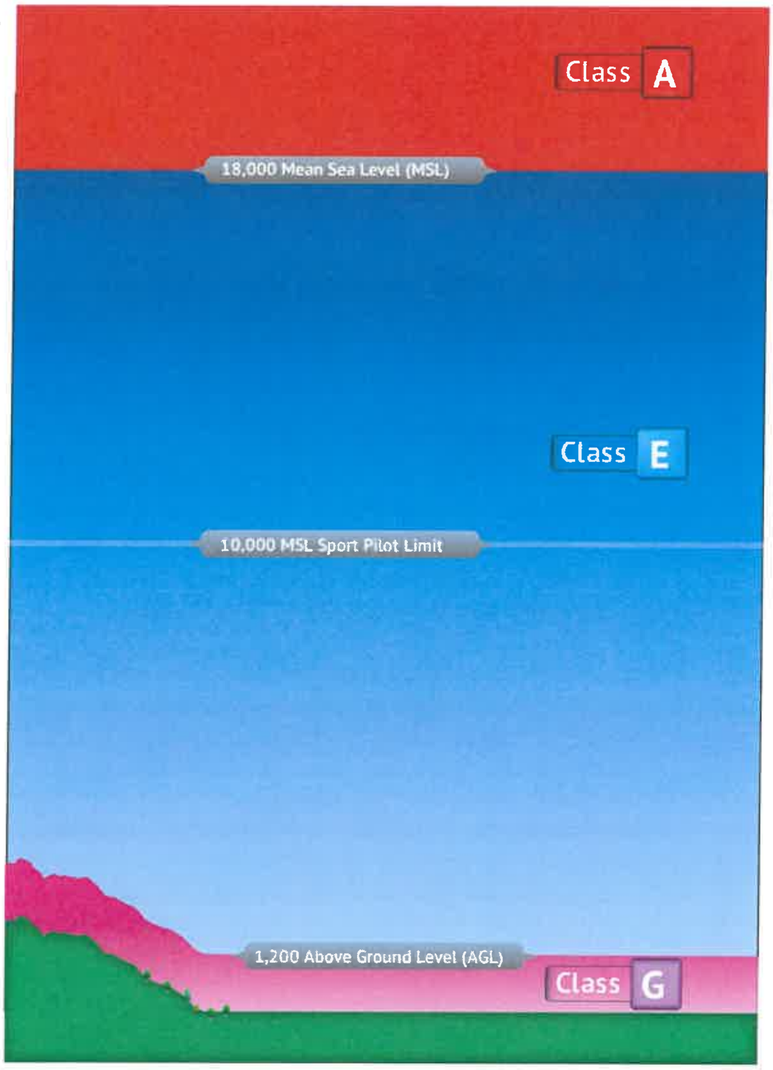
Class G Airspace *Normally* begins at ground level and ends just before 1,200 feet above ground level (AGL). If Class G airspace doesn't begin at ground level, there will always be some kind of marking noting the difference.

Class A Airspace *Always* begins at 18,000 feet MSL. No reason to mark that on any sectionals either.

Class E Airspace *Normally* fills up the areas between other marked and unmarked areas of airspace and is defined by the outside boundaries of other classes of airspace. (Except of course for Classes A and G airspace as described above.)



Airspace boundaries and limits not depicted on a sectional.



That means the only thing that must be marked is the airspace that deviates from those most common airspaces and altitudes.

Next, the FAA needed to come up with some simple colors and lines to mark airspace boundaries on sectionals. Each border between different types of airspace has its own combination of color and type of line depicting it. The two colors the FAA decided to use are blue and magenta. Those colors are used in solid, shaded, dashed, and cross-hatched lines to designate airspace boundaries.

The third problem was to make a simple rule for what kind of airspace takes precedence over any areas that may overlap vertically on the sectional. That was solved by making the operating rules for the more restrictive airspace apply to any areas that may appear to overlap.

So which type of airspace is more restrictive than the next? This is very simple to remember. Class A airspace is the most restrictive, followed by Class B, Class C, Class D, Class E and (what will quickly become your favorite) Class G airspace.

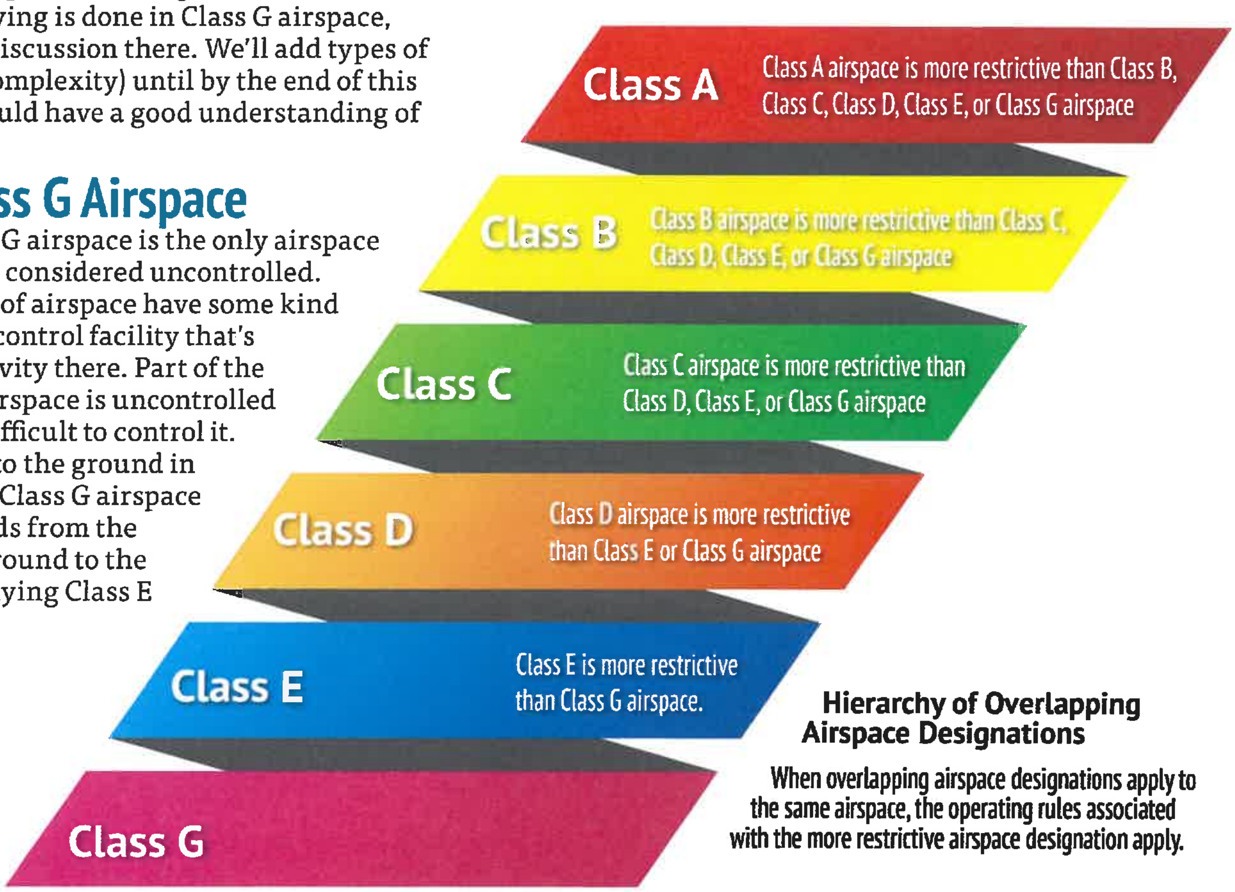
Classes A, B, C, D, E, and G

Most powered parachute flying is done in Class G airspace. On the other hand, only a very few people have ever flown powered parachutes into Class A airspace. Those flights into Class A airspace were done for the purpose of setting aviation records.

Since most flying is done in Class G airspace, we'll start our discussion there. We'll add types of airspace (and complexity) until by the end of this section you should have a good understanding of the concept.

G Class G Airspace

Class G airspace is the only airspace that's considered uncontrolled. All other forms of airspace have some kind of an air traffic control facility that's monitoring activity there. Part of the reason that G airspace is uncontrolled is because it's difficult to control it. Class G is close to the ground in airplane terms. Class G airspace normally extends from the surface of the ground to the base of the overlying Class E airspace.



Hierarchy of Overlapping Airspace Designations

When overlapping airspace designations apply to the same airspace, the operating rules associated with the more restrictive airspace designation apply.

In practical terms, Class G airspace is a good place to be for powered parachutes because other civilian aircraft normally try to stay out of it unless they're taking off or landing.

Most of the time Class G airspace starts at ground level and ends at 1,200 feet AGL. If you look at a sectional and you don't see any other airspace markings near the point you're focusing on, the Class G airspace goes from the surface to 1,200 AGL. That probably covers most of the ground in the USA. But it doesn't cover the airspace surrounding airports with instrument approaches.

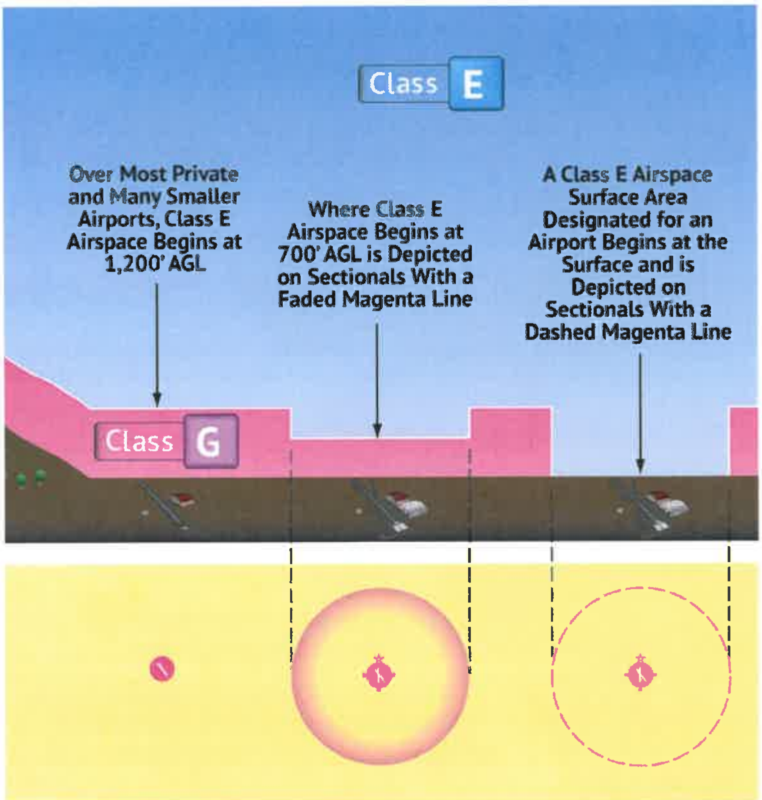
Class G Airspace Around Airports

The ceiling for Class G airspace is lower around many airports and ultimately disappears around some airports. As you get closer to those airports, there's an increase in air traffic control to help aircraft get closer to the ground and land.

There's a very common marking that designates the lowering of the ceiling of Class G airspace. That marking is a *magenta vignette*, otherwise known as the *faded magenta line*. Where you see a magenta vignette on a sectional, the Class G airspace past the dark edge is the normal ground-to-1,200 AGL. On the faded side of the line, the Class G airspace ceiling drops to 700 feet AGL.

Other controlled airspace markings completely eliminate any Class G since the controlled airspace they represent begins at the surface.

Weather Minimums. When flying in Class G airspace as a sport pilot below 1,200 feet AGL, you need to have 3 miles of visibility and stay clear of clouds. There are different rules for private pilots and for flying at night.



Transitions between Class G and Class E Airspace and their depictions on sectionals.

Equipment Requirements. When flying in Class G airspace, you don't need any particular equipment, including radios. Of course operating a radio is a very good safety practice, particularly when flying close to airports.

Controlled Airspace

Controlled airspace refers to the airspace in which air traffic control services are provided by the FAA to ensure the safety and efficiency of air traffic flow. In the United States, controlled airspace is designated as Class A, B, C, D, or E airspace. Each class of airspace has its own requirements and restrictions for pilots as well as equipment requirements for aircraft.

E Class E Airspace

Class E airspace is a default type of controlled airspace that covers the airspace not classified as Class A, B, C, or D. It encompasses a significant amount of airspace above the United States and provides adequate space for the safe control and separation of aircraft during instrument flight rules (IFR) operations.

The default base of Class E airspace is 1,200 feet AGL, with exceptions mainly around airports. Near airports, it may start either at the surface or 700 feet AGL. Typically, Class E airspace extends up to, but not including, 18,000 feet MSL (the lower boundary of Class A airspace). All airspace above FL 600 (60,000 feet MSL) reverts to Class E.

The basic requirements to fly in Class E airspace are:

Pilot Certification. You don't need a pilot license to enter Class E airspace. Even ultralights may regularly fly in Class E.

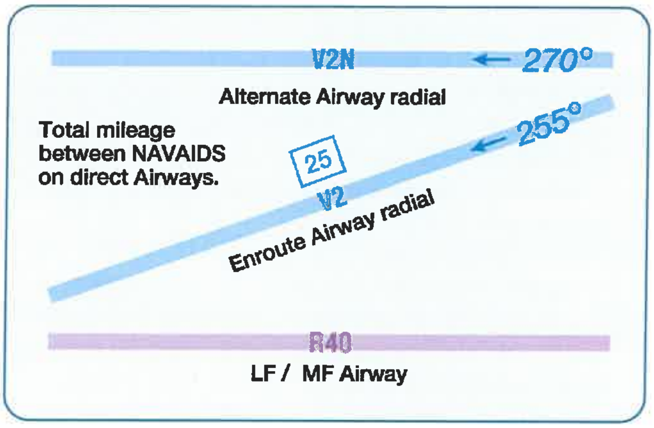
Weather Minimums. When flying in Class E airspace below 10,000 feet MSL, you need to have 3 miles of visibility. You must also maintain 500 feet below, 1,000 feet above, and 2,000 feet horizontal distance from clouds.

Equipment Requirements. There are no specific equipment requirements for flying in Class E airspace below 10,000 ft MSL, which is the altitude limit for sport pilots.

Operating in Class E Airspace

Class E is the least restrictive of controlled airspace. There are no specific pilot license or equipment requirements, and no special procedures for arrivals or transiting through the airspace.

Federal Airways are Class E airspace areas and, unless otherwise specified, extend upward from 1,200 feet to, but not including, 18,000 feet MSL. They have little effect on powered parachute operations, but it's good to know what the chart markings mean.



Surface Class E Airspace

Surface Class E airspace is a controlled airspace that begins at the ground level, typically surrounding airports that require support for instrument flight operations but don't have a control tower. This type of airspace ensures safe separation for aircraft conducting instrument approaches or departures, providing a structured environment while still allowing VFR operations without communication or clearance requirements for VFR pilots. The boundaries of surface Class E airspace are depicted on sectional charts with a *dashed magenta line*, indicating where the controlled airspace begins at the surface. The airspace extends upward to protect aircraft flying IFR.

In many cases, surface Class E airspace is used to contain standard instrument approaches while reducing the regulatory burden on VFR pilots, such as powered parachute operators. Unlike Class D or higher airspace, which imposes communication and equipment requirements, surface Class E airspace allows VFR pilots to operate freely while maintaining the benefits of controlled airspace for instrument flight rules (IFR) traffic. This configuration helps airports without control towers maintain safe operations for both IFR and VFR pilots.

Airspace Used for Transition

A Class E transition area is designated for aircraft transitioning to or from an airport, particularly those flying under IFR. Common around airports with approved instrument procedures, these areas typically start at 700 feet AGL and are depicted by a magenta vignette on sectional charts. The 700-foot AGL transition areas are always active, regardless of the airport's operating hours or surface area status.

Operational Differences Between Class E and Class G Airspace

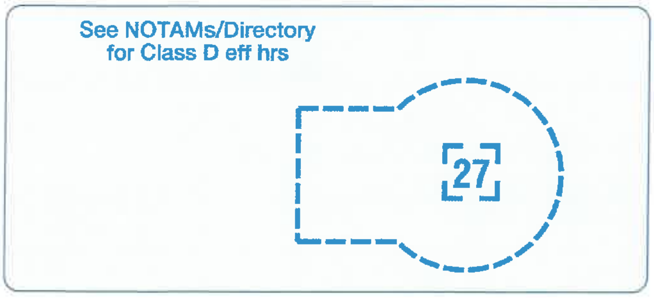
At this point, you may be wondering, *"What's the difference between Class E and Class G for powered parachutes?"* As a sport pilot, all you need to remember is that while operating in Class G airspace you must remain clear of clouds. That just means no flying through clouds. On the other hand, in Class E airspace, you need to remain at least 500' below a cloud, 1,000' above a cloud, and 2,000' off to the side of a cloud. That's because pilots in Class E airspace may be legally flying IFR directly through those same clouds.

Somebody flying IFR can safely fly directly through the clouds. They have instruments on board that allow them to fly straight-and-level and they have radar support from ATC. ATC is watching IFR aircraft on radar, guiding them to their destinations, and keeping them from bumping into each other. ATC may not see you in your powered parachute because you don't have much of a radar signature, you're going slow, and you probably aren't using ADS-B Out. You are invisible to both the airplane in the clouds and the FAA. And at the same time, you can't see into the clouds to know what dangers may be popping out at any moment. The cloud clearances in Class E airspace give you and IFR pilots a chance to react in case there is a head-on collision in the making.

D Class D Airspace

Class D airspace normally extends from the surface to 2,500 feet above the airport elevation surrounding those airports that have an operational control tower. The configuration of Class D airspace will be tailored to meet the operational needs of the area. The top of Class D airspace is always charted in MSL, which is usually the field altitude plus the 2,500 feet.

Class D airspace surrounds the least busy towered airports, so not all airports with Class D airspace are busy enough to operate 24 hours a day. You'll find the operating hours of the tower on the appropriate sectional charts and in the Chart Supplement U.S. During the hours the tower isn't in operation, the airspace will convert to Class E or Class G airspace. The Chart Supplement U.S. will have specific details for the airport.



Class D airspace areas are depicted on Sectional and Terminal charts with blue segmented lines.

Basic requirements to fly in Class D airspace are:

Pilot Certification. You don't need a specific pilot license to enter Class D airspace, but if you're a Student Pilot or Sport Pilot, you'll need appropriate training and an endorsement by a CFI before you can enter it.

Weather Minimums. When flying VFR in Class D airspace, you need to have 3 miles of visibility. You must also maintain at least 500 feet below, 1,000 feet above, and 2,000 feet horizontal distance from clouds.

Equipment Requirements. An operable two-way radio is required to enter Class D airspace. ATC can authorize flight without a two-way radio. That will take some coordination with the tower, probably by telephone.

Operating in Class D Airspace

You must call the tower managing the Class D airspace before you enter it and maintain communications while in their Class D airspace. If arriving, you should contact the control tower on the publicized frequency and give your position, altitude, destination, and any requests. Make your initial radio contact far enough from the Class D airspace boundary to give controllers time to establish two-way radio communications with you before you enter the airspace.

If the controller responds to your radio call with:

"[aircraft callsign] standby,"

...then radio communications have been established and you can enter the Class D airspace.

If workload or traffic conditions prevent immediate entry into Class D airspace, the controller will inform you to remain outside the Class D airspace until conditions permit entry. Then the controller transmission may sound like:

"N1234 remain outside the Class Delta airspace and standby."

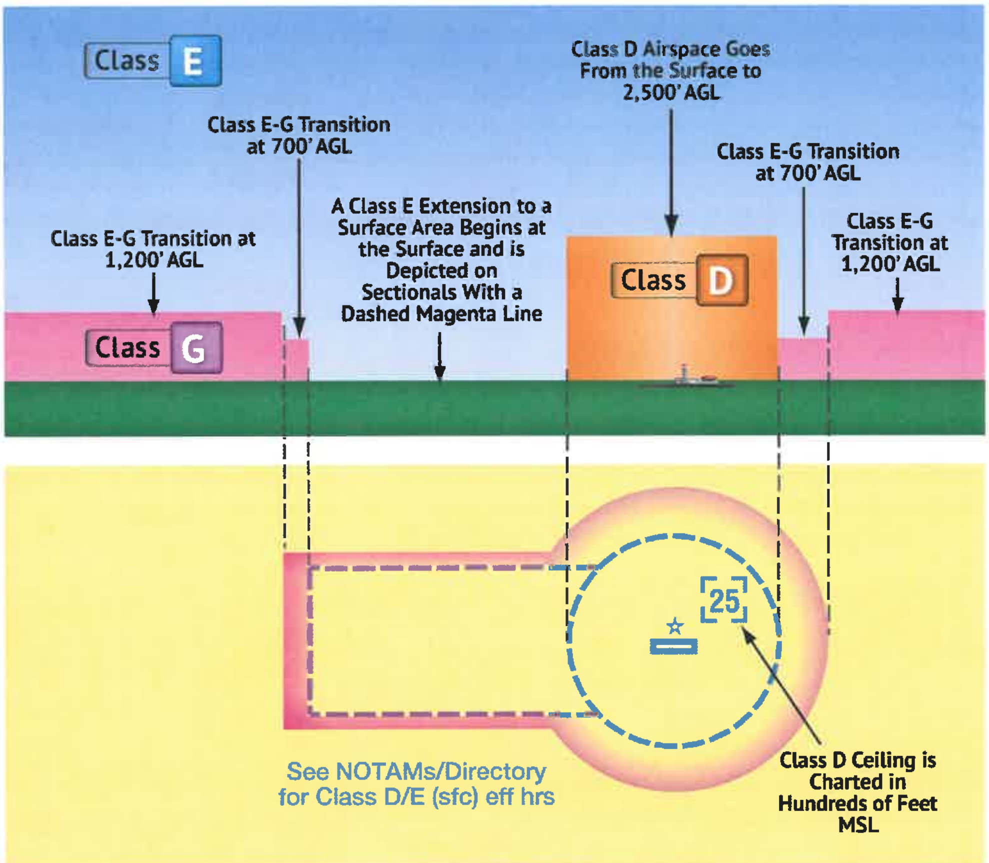
It's important to understand that if the controller responds to the initial radio call without using your aircraft callsign, radio communications have not been established and you may not enter the Class D airspace. In that case, a controller transmission may sound like:

"Aircraft calling Ocala tower standby."

If your aircraft radio fails in flight under VFR, you may fly and land if weather conditions are at or above basic VFR weather minimums, visual contact with the tower is maintained, and a clearance to land is received.

When departing from an airport with an active control tower, you must establish and maintain two-way radio communication with the tower. Continue this communication as instructed by ATC while operating in Class D airspace.

If departing from a satellite airport (within Class D airspace) without an operating control tower, you must establish two-way radio communication with the ATC facility that controls the Class D airspace. Do this as soon as practicable after takeoff.



Class D airspace with a Class E extension to a surface area.

C Class C Airspace

Class C airspace is the next step up from Class D airspace. Class C generally extends from the surface to 4,000 feet above the airport elevation surrounding an airport that:

- Has an operational control tower.
- Is serviced by a radar approach control.
- Has a lot of IFR traffic or scheduled passenger services.

Like Class D airspace, Class C airspace is charted in feet MSL. Each Class C airspace is uniquely configured, but it typically consists of a core surface area with a 5 NM radius, extending from the surface up to 4,000 feet above the airport elevation. Surrounding this core is a shelf area with a 10 NM radius that extends from 1,200 feet to 4,000 feet above the airport elevation. Both of these areas are charted in feet MSL. Additionally, there is an outer area with a 20 NM radius that extends from the surface to 4,000 feet above the primary airport, which may encompass one or more satellite airports, but this area is not charted on sectional charts. Class C airspace is represented on Sectional and Terminal charts by solid magenta lines.

Basic requirements for operating in Class C airspace are:

Pilot Certification. You don't need a specific pilot license to enter Class C airspace, but if you're a Student Pilot or Sport Pilot, you'll need appropriate training and an endorsement by a CFI before you can enter it.

Weather Minimums. When flying VFR in Class C airspace, you need to have 3 miles of visibility. You must also maintain at least 500 feet below, 1,000 feet above, and 2,000 feet horizontal distance from clouds.

Equipment Requirements. To enter or operate in Class C airspace, you must have an operational two-way radio, a radar beacon transponder with altitude reporting capabilities, and ADS-B Out. ATC can grant permission to fly without this equipment, but it will require prior coordination with the tower, likely by phone. A Mode C transponder and ADS-B Out are mandatory within and above all Class C airspace, extending up to 10,000 feet MSL.

§ 91.129 Operations in Class D airspace.

(a) General. .... For the purpose of this section, the primary airport is the airport for which the Class D airspace area is designated. A satellite airport is any other airport within the Class D airspace area.

(b) Deviations. An operator may deviate from any provision of this section under the provisions of an ATC authorization issued by the ATC facility having jurisdiction over the airspace concerned. ATC may authorize a deviation on a continuing basis or for an individual flight, as appropriate.

(c) Communications. Each person operating an aircraft in Class D airspace must meet the following two-way radio communications requirements:

(1) Arrival or through flight. Each person must establish two-way radio communications with the ATC facility ... providing air traffic services prior to entering that airspace and thereafter maintain those communications while within that airspace.

(2) Departing flight. Each person -

(i) From the primary airport or satellite airport with an operating control tower must establish and maintain two-way radio communications with the control tower, and thereafter as instructed by ATC while operating in the Class D airspace area; or

(ii) From a satellite airport without an operating control tower, must establish and maintain two-way radio communications with the ATC facility having jurisdiction over the Class D airspace area as soon as practicable after departing.

(d) Communications failure. Each person who operates an aircraft in a Class D airspace area must maintain two-way radio communications with the ATC facility having jurisdiction over that area.

(1) ...

(2) If the aircraft radio fails in flight under VFR, the pilot in command may operate that aircraft and land if -

(i) Weather conditions are at or above basic VFR weather minimums;

(ii) Visual contact with the tower is maintained; and

(iii) A clearance to land is received.

(e) ...

(f) Approaches. Except when conducting a circling approach under part 97 of this chapter or unless otherwise required by ATC, each pilot must -

(1) Circle the airport to the left, if operating an airplane; or

(2) Avoid the flow of fixed-wing aircraft, if operating a helicopter.

(g) Departures. No person may operate an aircraft departing from an airport except in compliance with the following:

(1) Each pilot must comply with any departure procedures established for that airport by the FAA.

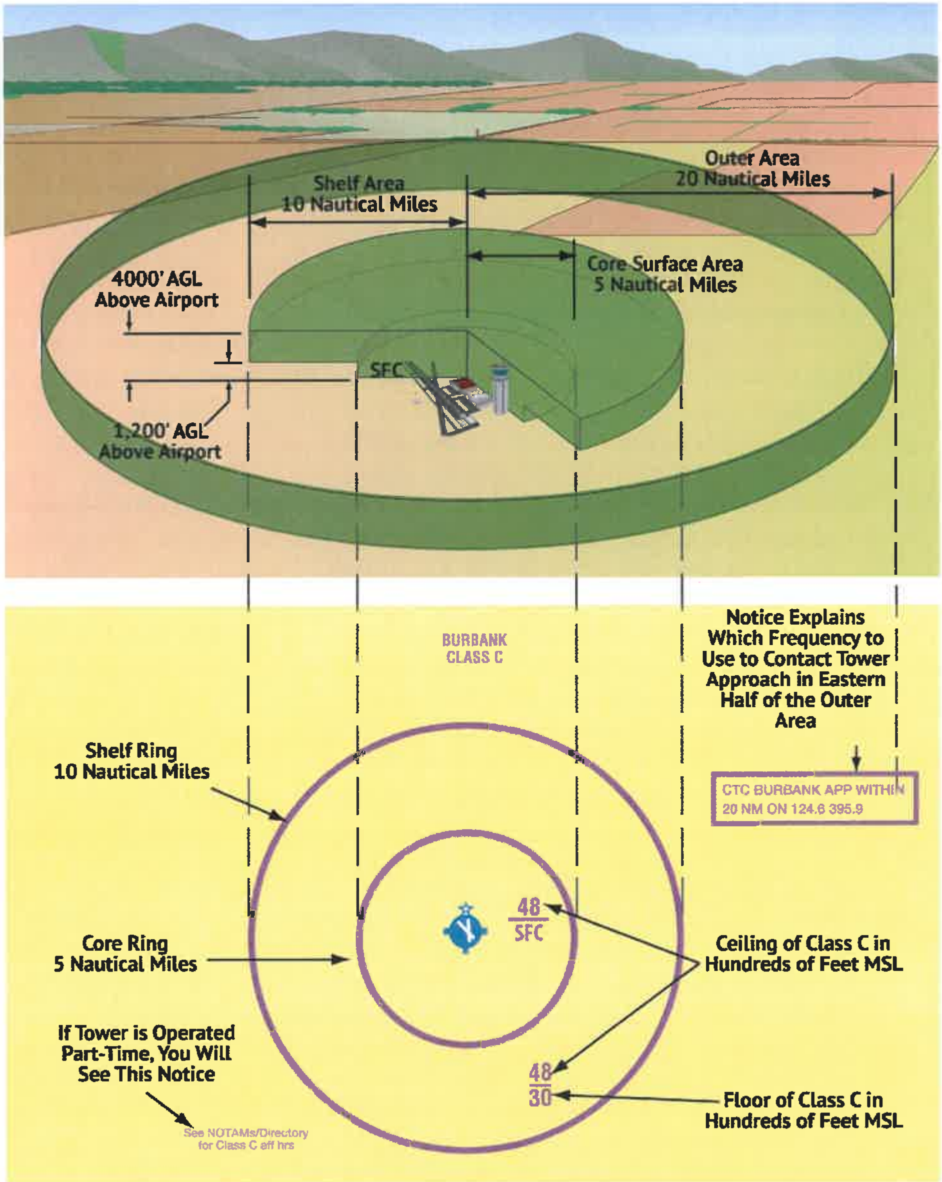
(2) ...

(h) ...

(i) Takeoff, landing, taxi clearance. No person may, at any airport with an operating control tower, operate an aircraft on a runway or taxiway, or take off or land an aircraft, unless an appropriate clearance is received from ATC.

Operating in Class C Airspace

You must call the tower managing the Class C airspace before you enter it and maintain communications while in their Class C airspace. Radio procedures are the same as for operating in Class D airspace.



Class C airspace is depicted on Sectional and Terminal charts with solid magenta lines.

§ 91.130 Operations in Class C airspace.

(a) General. ... For the purpose of this section, the primary airport is the airport for which the Class C airspace area is designated. A satellite airport is any other airport within the Class C airspace area.

(b) Traffic patterns. No person may take off or land an aircraft at a satellite airport within a Class C airspace area except in compliance with FAA arrival and departure traffic patterns.

(c) Communications. Each person operating an aircraft in Class C airspace must meet the following two-way radio communications requirements:

(1) Arrival or through flight. Each person must establish two-way radio communications with the ATC facility ... providing air traffic services prior to entering that airspace and thereafter maintain those communications while within that airspace.

(2) Departing flight. Each person -

(i) From the primary airport or satellite airport with an operating control tower must establish and maintain two-way radio communications with the control tower, and thereafter as instructed by ATC while operating in the Class C airspace area; or

(ii) From a satellite airport without an operating control tower, must establish and maintain two-way radio communications with the ATC facility having jurisdiction over the Class C airspace area as soon as practicable after departing.

(d) Equipment requirements. Unless otherwise authorized by the ATC having jurisdiction over the Class C airspace area, no person may operate an aircraft within a Class C airspace area designated for an airport unless that aircraft is equipped with the applicable equipment specified in ... § 91.225.

(e) Deviations. An operator may deviate from any provision of this section under the provisions of an ATC authorization issued by the ATC facility having jurisdiction over the airspace concerned. ATC may authorize a deviation on a continuing basis or for an individual flight, as appropriate.

Class B Airspace

Class B airspace surrounds the busiest airports in the country in terms of operations. Similar to Class C airspace, Class B is charted in feet MSL. Each Class B airspace is uniquely configured, typically featuring a core surface area with a 5 NM radius that extends from the surface to altitudes between 8,000 and 10,000 feet MSL. Surrounding this core are several shelf areas that start at progressively higher altitudes as they move away from the airport, all extending to the same altitude as the core area. Each ring of airspace is charted, with altitudes displayed in a fraction format, where the top number indicates the ceiling and the bottom number represents the floor of the airspace. Additionally, the airspace within 30 nautical miles of most Class B airports, from the surface up to 10,000 feet MSL, is designated as the Mode C Veil, shown as a thin magenta line on charts.

Basic requirements for operating in Class B Airspace are:

Pilot Certification. You don't need a specific pilot license to enter Class B airspace, but if you're a Student Pilot or Sport Pilot, you will need appropriate training and an endorsement by a CFI before you can enter it. While you may fly in the airspace, you probably won't be able to land at the primary airport. There are twelve Class B airports that specifically don't allow Student Pilots or Sport Pilots to land there. The other 27 Class B airports probably won't roll out the red carpet for a powered parachute, either.

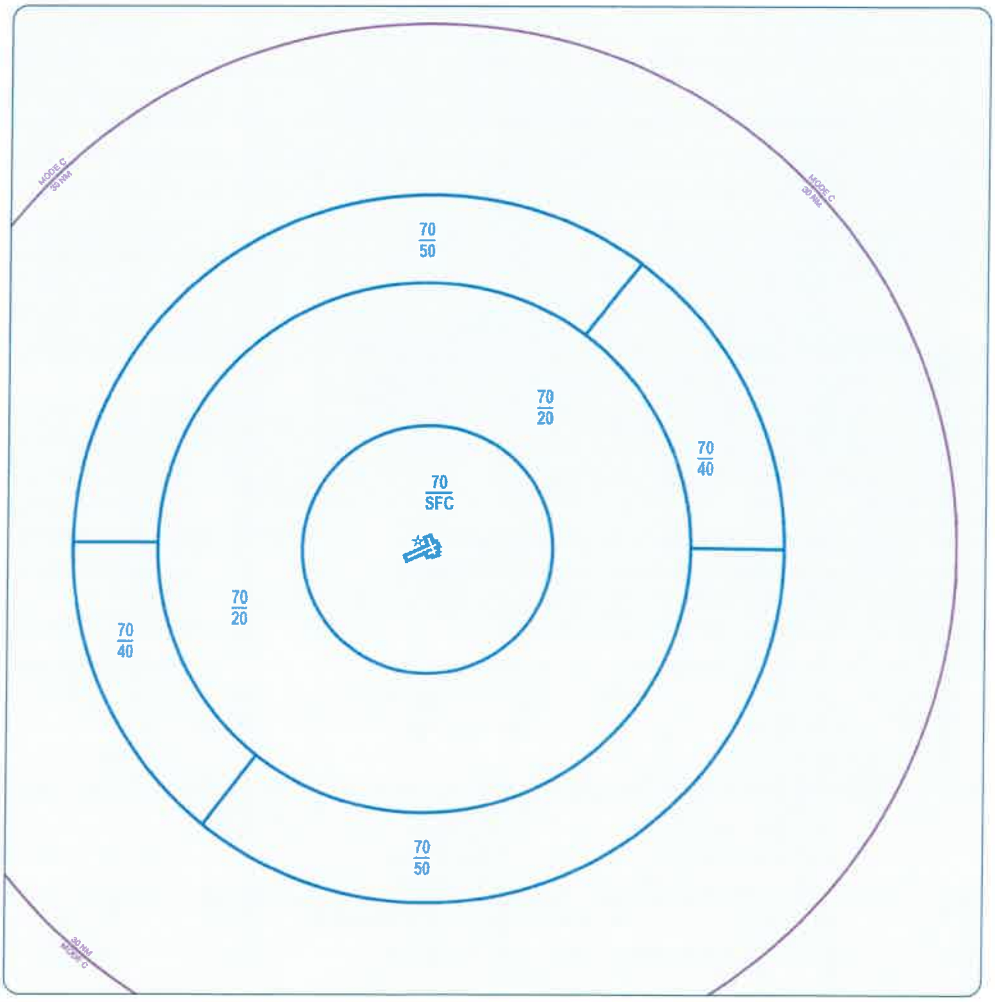
Weather Minimums. When flying VFR in Class B airspace, you need to have 3 miles of visibility and remain clear of clouds.

Equipment Requirements. An operable two-way radio is required to enter or fly in Class B airspace. A Mode C transponder and ADS-B Out is required in the Mode C Veil surrounding Class B airspace, up to 10,000 feet MSL. ATC can authorize flight without that equipment. That will take some coordination with the tower, probably by telephone.

A powered parachute that lacks an engine-driven electrical system, and was not certified with one, can operate within a Mode C Veil as long as it remains outside Class A, B, or C airspace, and stays below the ceiling of Class B or Class C airspace or 10,000 feet MSL, whichever is lower. This allowance is part of the regulations that accommodate certain light and sport aircraft operations.

Operating in Class B Airspace

All aircraft require ATC clearance to operate in this airspace. The procedures are similar to operating in Class D and Class C airspace.



Class B airspace and Mode C Veil as depicted on Sectional and Terminal charts.

§ 91.131 Operations in Class B airspace.

(a) Operating rules. No person may operate an aircraft within a Class B airspace area except in compliance with § 91.129 and the following rules:
  (1) The operator must receive an ATC clearance from the ATC facility having jurisdiction for that area before operating an aircraft in that area.
  (2) ....
  (3) Any person conducting pilot training operations at an airport within a Class B airspace area must comply with any procedures established by ATC for such operations in that area.

(b) Pilot requirements.
  (1) No person may take off or land a civil aircraft at an airport within a Class B airspace area or operate a civil aircraft within a Class B airspace area unless -
    (i) The pilot in command holds at least a private pilot certificate;
    (ii) ...
    (iii) The pilot in command holds a sport pilot certificate and has met -
      (A) The requirements of § 61.325 of this chapter; or
      (B) The requirements for a student pilot seeking a recreational pilot certificate in § 61.94 of this chapter; or
    (iv) The aircraft is operated by a student pilot who has met the requirements of § 61.94 or § 61.95 of this chapter, as applicable.
  (2) Notwithstanding the provisions of paragraphs (b)(1)(ii), (b)(1)(iii) and (b)(1)(iv) of this section, no person may take off or land a civil aircraft at those airports listed in section 4 of appendix D to this part unless the pilot in command holds at least a private pilot certificate.

(c) Communications and navigation equipment requirements. Unless otherwise authorized by ATC, no person may operate an aircraft within a Class B airspace area unless that aircraft is equipped with -
  (1) ...
  (2) For all operations. An operable two-way radio capable of communications with ATC on appropriate frequencies for that Class B airspace area.

(d) Other equipment requirements. No person may operate an aircraft in a Class B airspace area unless the aircraft is equipped with -
  (1) The applicable operating transponder and automatic altitude reporting equipment specified in § 91.215 (a), except as provided in § 91.215 (e), and
  (2) After January 1, 2020, the applicable Automatic Dependent Surveillance-Broadcast Out equipment specified in § 91.225.

A Class A Airspace

Class A airspace extends from 18,000 feet MSL to Flight Level (FL) 600 (60,000 feet MSL), including the airspace over waters within 12 nautical miles of the U.S. coastlines in the 48 contiguous states and Alaska.

You are unlikely to fly a powered parachute into this airspace for several reasons: it's frighteningly high, extremely cold, dominated by fast aircraft, and requires IFR operations unless otherwise authorized.

As mentioned earlier, Class A airspace is not charted since it is everywhere overhead.

Weather Minimums. There aren't any since everyone is flying under IFR and talking to ATC.

Equipment Requirements. An operable two-way radio, an operable radar beacon transponder with automatic altitude reporting equipment, and ADS-B Out is required to enter or fly in Class A airspace. ATC can authorize flight without that equipment.

Operating in Class A Airspace

To fly in Class A airspace, you must operate under IFR and obtain an ATC clearance before entering.

Weather Minimums

Most powered parachute pilots will spend their time flying in either Class G or Class E airspace. It's important to know which of these airspaces you're in to determine the applicable minimum weather requirements. As a sport pilot, you need at least 3 statute miles of flight visibility to operate in both Class G and Class E, as per the rating limitations. If you hold a private pilot certificate with a third-class or higher medical certificate, you must follow the weather minimums outlined in § 91.155, Basic VFR weather minimums.

However, the key difference for sport pilots lies in the cloud clearance requirements between Class G and Class E airspace.

Class G: Clear of Clouds

Class E: You must maintain a minimum of 500 feet below, 1,000 feet above, and 2,000 feet horizontal distance from clouds.

All airspace: You can't fly above a layer of clouds and lose visual reference with the surface.

§ 61.315 What are the privileges and limits of my sport pilot certificate?

...

(c) You may not act as pilot in command of a light-sport aircraft:

...

(12) When the flight or surface visibility is less than 3 statute miles.

(13) Without visual reference to the surface.

...

§ 91.155 Basic VFR weather minimums.

(a) Except as provided in paragraph (b) of this section and § 91.157, no person may operate an aircraft under VFR when the flight visibility is less, or at a distance from clouds that is less, than that prescribed for the corresponding altitude and class of airspace in the following table:

Basic VFR Weather Minimums for Private Pilots

Airspace			Flight Visibility	Distance from Clouds
Class A			Not applicable	Not applicable
Class B			3 statute miles	Clear of clouds
Class C			3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class D			3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class E	At or above 10,000 feet MSL		5 statute miles	1,000 feet above 1,000 feet below 1 statute mile horizontal
Class E	Less than 10,000 feet MSL		3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class G	1,200 feet or less above the surface (regardless of MSL altitude).	Day, except as provided in section 91.155(b)	1 statute mile	Clear of clouds
Class G	1,200 feet or less above the surface (regardless of MSL altitude).	Night, except as provided in section 91.155(b)	3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class G	More than 1,200 feet above the surface but less than 10,000 feet MSL.	Day	1 statute mile	1,000 feet above 500 feet below 2,000 feet horizontal
Class G	More than 1,200 feet above the surface but less than 10,000 feet MSL.	Night	3 statute miles	1,000 feet above 500 feet below 2,000 feet horizontal
Class G	More than 1,200 feet above the surface and at or above 10,000 feet MSL.		5 statute miles	1,000 feet above 1,000 feet below 1 statute mile horizontal

(b) Class G Airspace. Notwithstanding the provisions of paragraph (a) of this section, the following operations may be conducted in Class G airspace below 1,200 feet above the surface:

...

(2) Airplane, powered parachute, or weight-shift-control aircraft. If the visibility is less than 3 statute miles but not less than 1 statute mile during night hours and you are operating in an airport traffic pattern within 1/2 mile of the runway, you may operate an airplane, powered parachute, or weight-shift-control aircraft clear of clouds.

(c) Except as provided in § 91.157, no person may operate an aircraft beneath the ceiling under VFR within the lateral boundaries of controlled airspace designated to the surface for an airport when the ceiling is less than 1,000 feet.

(d) Except as provided in § 91.157 of this part, no person may take off or land an aircraft, or enter the traffic pattern of an airport, under VFR, within the lateral boundaries of the surface areas of Class B, Class C, Class D, or Class E airspace designated for an airport -

(1) Unless ground visibility at that airport is at least 3 statute miles; or

(2) If ground visibility is not reported at that airport, unless flight visibility during landing or takeoff, or while operating in the traffic pattern is at least 3 statute miles.

(e) For the purpose of this section, an aircraft operating at the base altitude of a Class E airspace area is considered to be within the airspace directly below that area.

Ultralight Vehicles in Controlled Airspace

The rules are a little more restrictive for ultralight powered parachutes. No person may operate an ultralight vehicle within Class A, Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport unless that person has prior authorization from the Air Traffic Control (ATC) facility having jurisdiction over that airspace. That covers all airspace depicted by dashed or solid blue or magenta markings. Ultralights may fly in airspace depicted by faded magenta lines or with no markings at all.

Special Use Airspace (SUA)

Special use airspace exists where activities must be confined because of their nature. In special use airspace, limitations may be placed on aircraft that are not a part of the activities. Special use airspace usually consists of:

- Prohibited Areas
- Restricted Areas
- Warning Areas
- Military Operation Areas (MOAs)
- Alert Areas
- Controlled Firing Areas (CFAs)
- National Security Areas (NSAs)

Except for controlled firing areas, all permanent special use airspace areas are depicted on aeronautical charts. A table on each sectional lists the hours of operation, altitudes, controlling agency and contact information (if applicable) for each charted special use airspace.

Prohibited Areas

Prohibited areas are established to protect national security or other vital interests of the country. These areas cover specific airspace with clearly defined boundaries, where aircraft operations are strictly prohibited by federal law. While there are relatively few prohibited areas, it's crucial to ensure your flight path doesn't bring you near one—unless you want a close encounter with Black Hawk helicopters. Prohibited areas are marked on aeronautical charts with a blue crosshatched border and identified by a code starting with the letter 'P'. Additional details, such as the ceiling of the area, can be found in the chart's margin data. Though all prohibited areas extend from the surface upward, their ceilings vary significantly. Here's a complete list:

P-40 – Camp David, Maryland (Up to 5,000' MSL)
P-47 – Pantex Nuclear Assembly Plant, Amarillo, Texas (Up to 4,800' MSL)
P-49 – Bush Ranch near Crawford, Texas (Up to 2,000' MSL)
P-50 – Naval Submarine Base Kings Bay, Georgia (Up to 3,000'MSL)
P-51 – Naval Base Kitsap, Washington (Up to 2,500' MSL)
P-56 – Washington, D.C., U.S. Capitol, White House, and Naval Observatory (Up to 18,000'MSL)
P-67 – Bush compound near Kennebunkport, Maine (Up to 1,000' MSL)
P-73 – Mount Vernon, Virginia, home of George Washington (Up to 1,500' MSL)
P-204, P-205, and P-206–Boundary Waters Canoe Wilderness Area on the Minnesota-Canada border (Up to 4,000' MSL)

Class Airspace	Entry Requirements	Equipment	Minimum Pilot Certificate
Class A	ATC clearance	IFR equipped	Instrument Rating
Class B	ATC clearance	Two-way radio, transponder with altitude reporting capability, ADS-B Out	Private–(However, a student or recreational pilot may operate at other than the primary airport if seeking private pilot certification and if regulatory requirements are met.)
Class C	Two-way radio communications prior to entry	Two-way radio, transponder with altitude reporting capability, ADS-B Out	No specific requirement
Class D	Two-way radio communications prior to entry	Two-way radio	No specific requirement
Class E	None for VFR	No specific requirement	No specific requirement
Class G	None	No specific requirement	No specific requirement

Requirements for airspace operations.

Restricted Areas

Restricted areas are designated airspace where activities or operations could be potentially hazardous to nonparticipating aircraft. Restricted areas denote the existence of unusual, often invisible hazards to aircraft such as:

- Weapons Testing
- Artillery Firing
- Aerial Gunnery
- Guided Missiles
- Rocket Launches
- Tethered Balloons that Extend on Cables up to 60,000'

Permanent restricted areas are depicted on aeronautical charts using a blue crosshatched border. They're identified with a code beginning with the letter 'R.'

You aren't necessarily prohibited from flying in Restricted Areas, but you are subject to restrictions. Whether you might be allowed in depends on whether the Restricted Area is labeled as *joint-use* or *nonjoint-use*. Joint-use means that an aircraft may enter the restricted area if the pilot has obtained permission from the *controlling agency* (the FAA), and then only if the restricted area is not active and has been released to the controlling agency by the *using agency* (probably a branch of the military). For all nonjoint-use restricted areas, unless otherwise requested by the using agency, the phrase "*NO A/G*" (No Air to Ground) is shown. In other words, don't even come a knocking, there's no one to talk to about it.

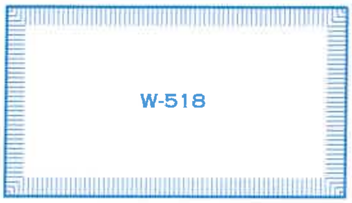
Penetration of restricted areas without authorization from the using or controlling agency may be extremely hazardous to the aircraft and its occupants.

§ 91.133 Restricted and prohibited areas.

(a) No person may operate an aircraft within a restricted area ... contrary to the restrictions imposed, or within a prohibited area, unless that person has the permission of the using or controlling agency, as appropriate.

(b) Each person conducting, within a restricted area, an aircraft operation (approved by the using agency) that creates the same hazards as the operations for which the restricted area was designated may deviate from the rules of this subpart that are not compatible with the operation of the aircraft.

Warning Areas



You will probably never have to worry about a warning area as a powered parachute pilot since they don't even begin until 3 NM offshore from the United States. Warning areas are similar in nature to restricted areas, except that they're over water instead of over land. A warning area contains activity that may be hazardous to nonparticipating aircraft. The purpose of such areas is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both.

The airspace is depicted on aeronautical charts using a blue crosshatched border. Warning areas are identified with a code beginning with the letter 'W.' Like Prohibited and Restricted areas, you can learn more about each one in the margin areas of the Sectional.

Military Operation Areas

A military operation area (MOA) is airspace established to separate certain military flight training activities from IFR traffic. Examples of activities conducted in MOAs include, but are not limited to:

- Air Combat Tactics
- Air Intercepts
- Aerobatics
- Formation Training
- Low-Altitude Tactics
- Flying Faster than 250 Knots Below 10,000 Feet MSL.

There's no restriction against flying a powered parachute in these areas since your flying would be done under visual flight rules (VFR). However, you should exercise extreme caution while flying within an MOA when military activity is being conducted. Before flying, you can contact any FSS within 100 miles of the area to obtain accurate real-time information concerning the MOA hours of operation. Even then, the activity status (active/inactive) of MOAs are known to change frequently. You should contact the controlling agency for traffic advisories prior to flying in an active MOA.

MOAs are depicted on aeronautical charts with magenta crosshatched borders and are named rather than simply assigned numbers. The altitudes normally begin well above surface level, so you may be able to stay under an MOA without much worry. To find the altitudes of an MOA, you should refer to the margin area of the appropriate sectional.

SPECIAL USE AIRSPACE ON JACKSONVILLE SECTIONAL CHART

Unless otherwise noted altitudes are MSL and in feet. Time is local.
"TO" an altitude means "To and including."
FL – Flight Level
NO A/G – No air to ground communications.
Contact Flight Service for information.

† Other times by NOTAM.
NOTAM – Use of this term in Restricted Areas indicates FAA and DoD NOTAM systems. Use of this term in all other Special Use areas indicates the DoD NOTAM system.

U.S. P–PROHIBITED, R–RESTRICTED, W–WARNING, A–ALERT, MOA–MILITARY OPERATIONS AREA

NUMBER	ALTITUDE	TIME OF USE	CONTROLLING AGENCY/ CONTACT FACILITY	FREQUENCIES
P-50	TO BUT NOT INCL 3000	CONTINUOUS	NO A/G	
R-2903 A	TO BUT NOT INCL 23,000	INTERMITTENT 0700-1900 TUE-SUN †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-2903 C	TO 7000	INTERMITTENT 0700-1900 TUE-SUN †24 HRS IN ADVANCE	JACKSONVILLE TRACON	
R-2903 D	TO 5000	INTERMITTENT 0700-1900 TUE-SUN †24 HRS IN ADVANCE	JACKSONVILLE TRACON	
R-2904 A	TO BUT NOT INCL 1800	0800-1700 (APR-AUG) 0800-1700 SAT-SUN (SEP–MAR) †24 HRS IN ADVANCE	JACKSONVILLE TRACON	
R-2906	TO 14,000	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE TRACON	121.3
R-2907 A	TO FL 230	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE CNTR	134.0
R-2907 B	2000 TO FL 230	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE CNTR	134.0
R-2907 C	500 TO BUT NOT INCL 2000	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE TRACON	121.3
R-2910 A	TO FL 230	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE CNTR	134.0
R-2910 B, C	TO 6000	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	CENTRAL FLORIDA TRACON	119.525
R-2910 D	2000 TO FL 230	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE CNTR	134.0
R-2910 E	500 TO BUT NOT INCL 2000	INTERMITTENT 0800-2400 †6 HRS IN ADVANCE	JACKSONVILLE TRACON	118.6
R-2932	TO BUT NOT INCL 5000	CONTINUOUS	MIAMI CNTR	
R-2933	5000 TO UNLIMITED	INTERMITTENT BY NOTAM NORMALLY 24 HRS IN ADVANCE	MIAMI CNTR	
R-2934	UNLIMITED	INTERMITTENT BY NOTAM NORMALLY 24 HRS IN ADVANCE	MIAMI CNTR	
R-2935	11,000 TO UNLIMITED	INTERMITTENT BY NOTAM NORMALLY 24 HRS IN ADVANCE	MIAMI CNTR	
R-3005 A, B, D, E	TO 29,000	0600-2400 †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-3005 C	TO 29,000	0600-0300 †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-3007 A	TO BUT NOT INCL 13,000	0700-2200 MON-FRI †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-3007 B	1200 AGL TO BUT NOT INCL 13,000	0700-2200 MON-FRI †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-3007 C, E	100 AGL TO BUT NOT INCL 13,000	0700-2200 MON-FRI †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-3007 D	13,000 TO FL 250	0700-2200 MON-FRI †24 HRS IN ADVANCE	JACKSONVILLE CNTR	
R-3008 A	TO 10,000	0800-0130 MON-THU 0800-2200 FRI †6 HRS IN ADVANCE	USAF VALDOSTA APP	
R-3008 B	100 AGL TO 10,000	0800-0130 MON-THU 0800-2200 FRI †6 HRS IN ADVANCE	USAF VALDOSTA APP	
R-3008 C	500 AGL TO 10,000	0800-0130 MON-THU 0800-2200 FRI †6 HRS IN ADVANCE	USAF VALDOSTA APP	
R-3008 D	10,000 TO BUT NOT INCL FL 230	0800-0130 MON-THU 0800-2200 FRI †6 HRS IN ADVANCE	USAF VALDOSTA APP	
W-74	TO 10,000	INTERMITTENT BY NOTAM	JACKSONVILLE CNTR	
W-135	TO 1200	INTERMITTENT BY NOTAM	JACKSONVILLE TRACON	
W-136 B, C, E, F	UNLIMITED	CONTINUOUS	JACKSONVILLE CNTR	
W-137 A, B, C, D, E, F, L	UNLIMITED	CONTINUOUS	JACKSONVILLE CNTR	
W-137 G	TO 13,000	CONTINUOUS	JACKSONVILLE CNTR	
W-138 A, B, C, D, E, L	UNLIMITED	CONTINUOUS	JACKSONVILLE CNTR	
A-211	TO 5000	0600-2200 MON-FRI	NO A/G	
A-293	TO 4000	0600-2400	DAYTONA BEACH INTL	122.85
A-294	TO 4000	0600-2400	DAYTONA BEACH INTL	123.5

Alert Areas do not extend into Class A, B, C and D airspace, or Class E airport surface areas.

MOA NAME	ALTITUDE*	TIME OF USE†	CONTROLLING AGENCY/ CONTACT FACILITY	FREQUENCIES
BEAUFORT 1	100 AGL TO 10,000	INTERMITTENT, BY NOTAM	JACKSONVILLE CNTR	
COASTAL 1 EAST, COASTAL 1 WEST, COASTAL 2	300 AGL	INTERMITTENT 0700-2200 MON-FRI INTERMITTENT 0700-2200 BY NOTAM SAT-SUN	JACKSONVILLE CNTR	
COASTAL 4	14,000	INTERMITTENT 0700-2200 MON-FRI INTERMITTENT 0700-2200 BY NOTAM SAT-SUN	JACKSONVILLE CNTR	
COASTAL 5	300 AGL	INTERMITTENT 0700-2200 MON-FRI INTERMITTENT 0700-2200 BY NOTAM SAT-SUN	JACKSONVILLE CNTR	
COASTAL 6, 7	10,001	INTERMITTENT 0700-2200 MON-FRI INTERMITTENT 0700-2200 BY NOTAM SAT-SUN	JACKSONVILLE CNTR	
COASTAL 8	11,000	INTERMITTENT 0700-2200 MON-FRI INTERMITTENT 0700-2200 BY NOTAM SAT-SUN	JACKSONVILLE CNTR	
CORSAIR NORTH, CORSAIR SOUTH	8000	0700-0200 MON-FRI	JACKSONVILLE CNTR	
FORT STEWART B1	500 AGL TO 4999	INTERMITTENT 0600-2200 MON-FRI	JACKSONVILLE CNTR	
FORT STEWART B2	5000 TO 10,000	BY NOTAM	JACKSONVILLE CNTR	
FORT STEWART C1	500 AGL TO 2999	INTERMITTENT 0600-2200 MON-FRI	JACKSONVILLE CNTR	
FORT STEWART C2	3000 TO 10,000	BY NOTAM	JACKSONVILLE CNTR	
MUSTANG	8000	0700-0200 MON-FRI	JACKSONVILLE CNTR	
PALATKA 1, 2	3000	INTERMITTENT 0800-2400	JACKSONVILLE CNTR	
SABRE	8000	0700-0200 MON-FRI	JACKSONVILLE CNTR	
THUD	8000	0700-0200 MON-FRI	JACKSONVILLE CNTR	
TYNDALL C, D	300 AGL TO 6000	INTERMITTENT SR-SS MON-FRI	TYNDALL APP	
TYNDALL E, F	300 AGL	INTERMITTENT SR-SS MON-FRI	TYNDALL APP	
TYNDALL G	1000 AGL	INTERMITTENT SR-SS MON-FRI	TYNDALL APP	
TYNDALL H	9000	INTERMITTENT SR-SS MON-FRI	TYNDALL APP	
TYNDALL I, J	5000	0600-0030	JACKSONVILLE CNTR	118.275 342.1
WARHAWK	8000	0700-0200 MON-FRI	JACKSONVILLE CNTR	

*Altitudes indicate floor of MOA. All MOAs extend to but do not include FL 180 unless otherwise indicated in tabulation or on chart.
†Other times by DoD NOTAM.

Sectional table giving details on special use airspace. A similar table is found on every sectional and provides information on the specific special use areas found on that sectional. It lists those areas by name and provides altitude, time of use information and more.

Alert Areas

Alert areas exist to advise you that a high volume of pilot training or unusual aerial activity is taking place so that you can be particularly alert. The activity is usually military in nature, but is conducted in accordance with FAA regulations. Pilots of participating aircraft as well as pilots transiting the area are equally responsible for collision avoidance.

Alert areas are depicted on aeronautical charts using a magenta crosshatched border. They're identified with a code beginning with the letter 'A.'

Controlled Firing Areas (CFAs)

CFAs are established temporarily for operations that could be hazardous to uninvolved aircraft. Unlike other types of special use airspace, you don't need to worry about avoiding CFAs. Operations within a CFA are halted as soon as an approaching aircraft is detected by a spotter aircraft, radar, or ground lookout, which makes charting them unnecessary. Nonparticipating aircraft can maintain their flight paths without deviation. Only ground-based activities that can be immediately stopped when a nonparticipating aircraft approaches are suitable for a CFA. Examples include:

- Ordnance Disposal.
- Blasting.
- Static Testing of Large Rocket Motors.

National Security Areas (NSAs)

NSAs (National Security Areas) are established around locations where ground facilities require enhanced safety and security. The overflight altitudes are specified in notices near the airspace, and temporary flight restrictions under 14 CFR Part 99 may be imposed. These restrictions are communicated via NOTAMs. While not always mandatory, the FAA strongly recommends that pilots voluntarily avoid flying through NSAs.

National Security Areas are depicted on aeronautical charts using a heavy magenta dashed line border. There's a notation next to the border indicating how high it extends vertically.

Other Airspace Areas

Other airspace areas is a general term referring to the majority of the remaining airspace. Some of it's very important, so much so that you'll be tested by the FAA on it during both your knowledge test and your practical test. Other airspace is very specialized and has little to no impact on your flying.

- Airport Advisory/Information Services
  - Local Airport Advisory (LAA)
  - Remote Airport Information Service (RAIS)
- Military Training Route (MTR)
- Temporary Flight Restriction (TFR)
- Parachute Jump Aircraft Operations
- Published VFR Routes
  - VFR Flyways
  - VFR Corridors
  - Class B Airspace VFR Transition Routes
- Terminal Radar Service Area (TRSA)
- Special Air Traffic Rules (SATR) and Special Flight Rules Area (SFRA)
- Washington DC Air Defense Identification Zone (ADIZ) and Flight Restricted Zone (FRZ)
- Wildlife Areas/Wilderness Areas/National Parks
- NOAA Regulated Overflight Zones

Airport Advisory/ Information Services

A select few airports have the following services available.

Local Airport Advisory (LAA) service is available only in Alaska and is operated within 10 statute miles of an airport where a control tower is not operating but where a Flight Service Station (FSS) is located on the airport. At such locations, the FSS provides a complete local airport advisory service to arriving and departing aircraft.

Remote Airport Information Service (RAIS) is provided in support of short term special events like small to medium fly-ins. The service is advertised by NOTAM D only. The FSS will not have access to a continuous readout of the current winds and altimeter. However, known traffic, special event instructions, and all other services are provided.

Military Training Routes

Military Training Routes (MTRs) are essential for maintaining the readiness of our airborne military forces, which rely on extensive training in various combat tactics. Some of this training involves low-level, high-speed maneuvers that can make visual flight (VFR) more challenging, requiring heightened vigilance. To enhance safety, the MTR program was developed as a collaborative effort between the FAA and the Department of Defense (DoD).

MTRs are designed for low-altitude, high-speed military training. Routes above 1,500 feet AGL are typically flown under IFR, while those below 1,500 feet AGL are generally flown under VFR. MTRs are usually established below 10,000 feet MSL for speeds exceeding 250 knots, though some segments may extend higher to accommodate climbs, descents, or mountainous terrain. Since powered parachutes operate at lower altitudes, it's crucial to be aware of nearby MTRs. Although not prohibited, extreme caution is needed when flying near these routes. To obtain current information on MTR activity, contact 1-800-WX-BRIEF. They can provide details on scheduled times, altitudes, and the width of active routes, which may extend several miles on either side of the charted centerline. Always inform the FSS specialist of your intended flight area to ensure relevant information is provided.

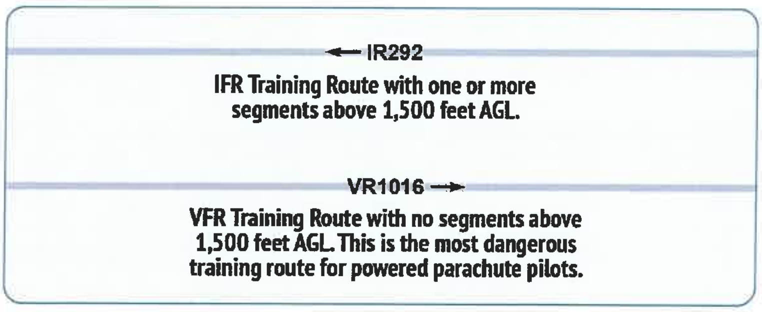
Military training routes are identified on sectional charts as follows:

IFR Routes Are Labeled IR. Operations on these routes are conducted in accordance with IFR regardless of weather conditions.

VFR Routes Are Marked VR. Operations on these routes are conducted in accordance with VFR except flight visibility shall be five miles or more; and flights shall not be conducted below a ceiling of less than 3,000 feet AGL.

MTRs With No Segment Above 1,500 Feet AGL are identified by four number characters; e.g., IR1206, VR1207. These are the routes powered parachute pilots should be most concerned about.

MTRs That Include One or More Segments Above 1,500 Feet AGL are identified by three number characters; e.g., IR206, VR207.



Military Training Routes

Temporary Flight Restrictions

Temporary Flight Restrictions (TFRs) temporarily prohibit most general aviation flights within designated areas. Because (with notable exceptions) they're short-term, TFRs aren't depicted on sectional charts. Instead, they're published in Notices to Air Missions (NOTAMs).

Notice to Air Mission (NOTAM)

NOTAMs provide time-sensitive information on airports and changes that impact the national airspace system. Flight Data Center (FDC) NOTAMs, issued by the National Flight Data Center, include regulatory details such as TFRs, which are among the most critical NOTAMs.

A NOTAM for a TFR follows a specific format. It begins with "*FLIGHT RESTRICTIONS*" and includes:

- The location of the restricted area
- The effective time period
- The area defined in statute miles
- The affected altitudes
- The FAA coordination facility and its contact number
- The reason for the TFR
- The agency managing any relief activities and its contact number
- Any additional relevant information from the issuing authority.

Some of the purposes for establishing a TFR are:

Protect persons and property from existing or imminent hazards posed by incidents on the surface when low-flying aircraft could worsen the situation. Examples include:
- Toxic gas leaks, spills, or flammable agents, where rotor or propeller wash could spread the hazard or endanger aircraft in flight.
- Imminent volcanic eruptions that pose risks to airborne aircraft and their occupants.
- Nuclear accidents or incidents.
- Hijackings.

Ensure the safety of public figures such as the President or Vice President.

Provide a safe environment for disaster relief aircraft during operations such as:
- Forest fires, where aircraft release fire retardants.
- Disaster relief efforts following hurricanes, earthquakes, floods, etc.

Prevent unsafe congestion of sightseeing aircraft above high-interest incidents or events. Examples include:
- Sporting events.
- Airshows.
- Public celebrations.

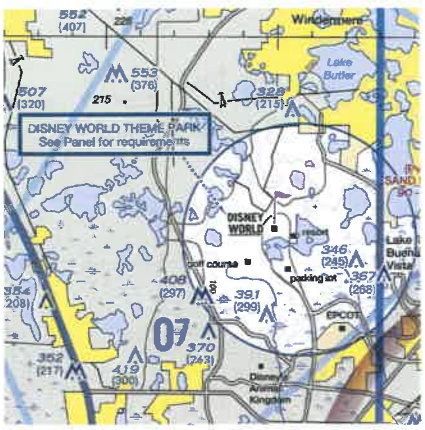
Provide a safe environment for space agency operations.

The airspace required to protect persons, property, or ensure a safe environment for rescue and relief operations is typically limited to 2,000 feet above the surface and within a three nautical mile radius. In cases where incidents occur within Class B, C, or D airspace, they're generally managed through existing procedures without the need for a TFR NOTAM.

TFRs are a key reason why you must always review NOTAMs during flight planning. Numerous incidents of aircraft violating TFRs have led to security investigations and certificate suspensions. It's your responsibility to be fully aware of any TFRs in your intended flight area.

Notable Permanent and Regular TFRs

- Disney World and Disneyland theme parks, Permanent, SFC-3,000' AGL
- Kennedy Space Center, Merritt Island, Normally Restricted Airspace
- Several areas near or surrounding military bases.
- Surrounding the Camp David Prohibited Airspace.



Oxymorons: The permanent temporary flight restrictions above the Disney World and Disneyland theme parks.

Published VFR Routes

Published VFR routes help pilots navigate around, under, or through complex airspace, like Class B. Terms such as *VFR Flyway, VFR Corridor*, and *Class B Airspace VFR Transition Route* refer to different types of routes. Here's a breakdown:

VFR Flyways: General flight paths for planning around Class B airspace. No ATC clearance is needed. Depicted on the reverse of some VFR Terminal Area Charts (TACs), flyways guide pilots to avoid major controlled traffic flows. However, these routes can still be congested, so pilots must follow VFR rules and maintain communication with control towers when under Class B airspace.

VFR Corridors: Airspace through Class B with defined boundaries, allowing passage without ATC clearance. They're like *"holes"* through Class B airspace, surrounded on all sides. Caution is crucial due to heavy VFR traffic.

Class B Airspace VFR Transition Routes: Specific flight courses through Class B airspace, depicted on TACs, requiring an ATC clearance and assigned altitudes. Pilots must stay clear of Class B until cleared by ATC and must follow the route and ATC instructions after clearance.

These routes are over areas where you wouldn't normally fly a powered parachute and you probably won't be asked about them during any test.

§ 91.137 Temporary flight restrictions in the vicinity of disaster/hazard areas.

(a) The Administrator will issue a Notice to Airmen (NOTAM) designating an area within which temporary flight restrictions apply and specifying the hazard or condition requiring their imposition, whenever he determines it is necessary in order to -
- (1) Protect persons and property on the surface or in the air from a hazard associated with an incident on the surface;
- (2) Provide a safe environment for the operation of disaster relief aircraft; or
- (3) Prevent an unsafe congestion of sightseeing and other aircraft above an incident or event which may generate a high degree of public interest.

The Notice to Airmen will specify the hazard or condition that requires the imposition of temporary flight restrictions...

§ 91.141 Flight restrictions in the proximity of the Presidential and other parties.

No person may operate an aircraft over or in the vicinity of any area to be visited or traveled by the President, the Vice President, or other public figures contrary to the restrictions established by the Administrator and published in a Notice to Airmen (NOTAM).

§ 91.143 Flight limitation in the proximity of space flight operations.

When a Notice to Airmen (NOTAM) is issued in accordance with this section, no person may operate any aircraft of U.S. registry, or pilot any aircraft under the authority of an airman certificate issued by the Federal Aviation Administration, within areas designated in a NOTAM for space flight operation except when authorized by ATC.

§ 91.145 Management of aircraft operations in the vicinity of aerial demonstrations and major sporting events.

(a) The FAA will issue a Notice to Airmen (NOTAM) designating an area of airspace in which a temporary flight restriction applies when it determines that a temporary flight restriction is necessary to protect persons or property on the surface or in the air, to maintain air safety and efficiency, or to prevent the unsafe congestion of aircraft in the vicinity of an aerial demonstration or major sporting event. These demonstrations and events may include:
- (1) United States Naval Flight Demonstration Team (Blue Angels);
- (2) United States Air Force Air Demonstration Squadron (Thunderbirds);
- (3) United States Army Parachute Team (Golden Knights);
- (4) Summer/Winter Olympic Games;
- (5) Annual Tournament of Roses Football Game;
- (6) World Cup Soccer;
- (7) Major League Baseball All-Star Game;
- (8) World Series;
- (9) Kodak Albuquerque International Balloon Fiesta;
- (10) Sandia Classic Hang Gliding Competition;
- (11) Indianapolis 500 Mile Race;
- (12) Any other aerial demonstration or sporting event the FAA determines to need a temporary flight restriction in accordance with paragraph (b) of this section.

(b) In deciding whether a temporary flight restriction is necessary for an aerial demonstration or major sporting event not listed in paragraph (a) of this section, the FAA considers the following factors:...

Parachute Jump Areas

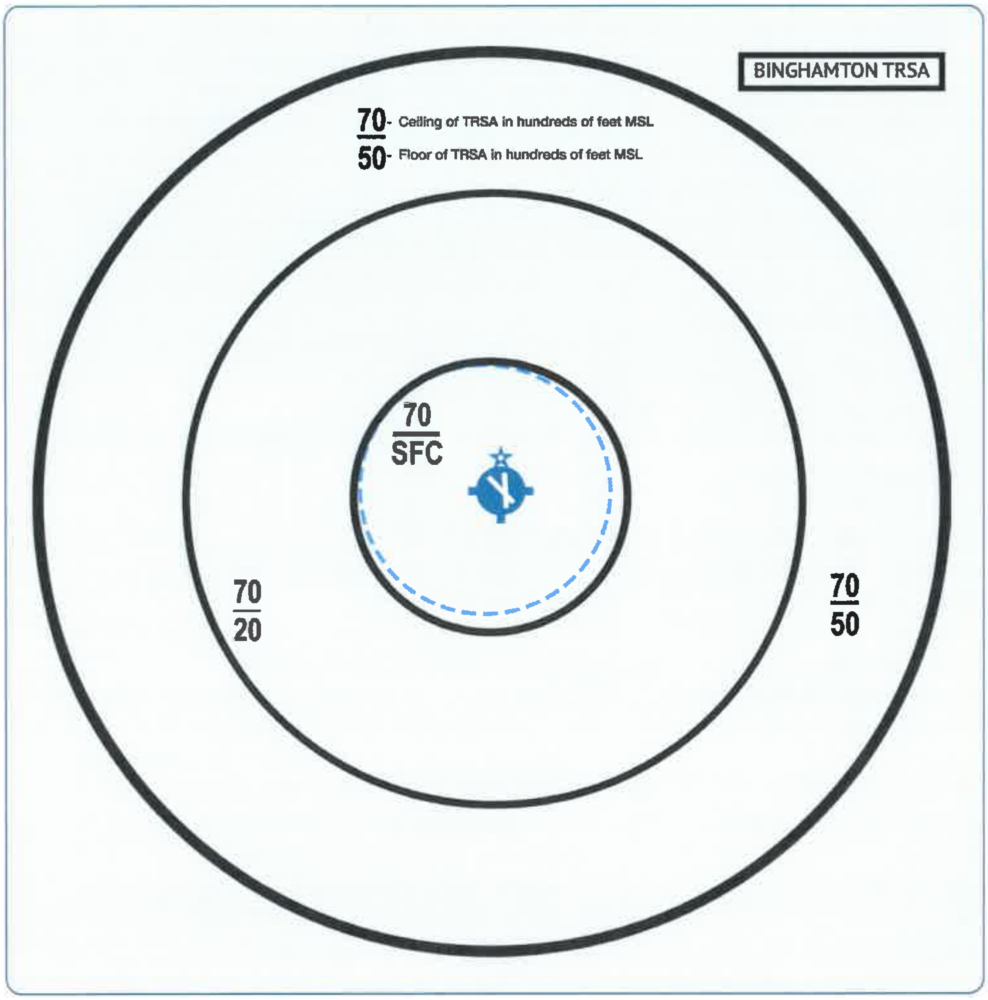
Parachute jump operations are listed in the Chart Supplement U.S., and airports frequently used for skydiving are marked on sectional charts. Most skydive operations are based at uncontrolled airports so you should continuously monitor and broadcast on the designated CTAF. Before initiating a jump, the jump pilot typically announces the aircraft's altitude, position relative to the airport, and the approximate time the jump will start and finish. This ensures other pilots in the vicinity are aware of the activity and can adjust accordingly to maintain safety. Normally skydive operations work *around* general aviation traffic, but you don't want to assume anything.

Terminal Radar Service Areas

TRSAs provide additional radar services to pilots who choose to participate, helping maintain safe separation between IFR traffic and participating VFR aircraft. The primary airport within a TRSA operates as Class D airspace, while the surrounding area typically falls under Class E. TRSAs are depicted on VFR sectional and terminal area charts with a solid black line and altitude information for each segment. Class D airspace within the TRSA is marked with a blue segmented line. Participation in TRSA services is voluntary for VFR pilots.

Special Air Traffic Rules (SATR) and Special Flight Rules Area (SFRA)

14 CFR Part 93 outlines special air traffic rules for aircraft operating within specific designated airspace. These areas, marked on VFR sectional and terminal area charts, vary in procedures, operations, size, and traffic density, as detailed in the regulation. Pilots flying to, from, or within SATR (Special Air Traffic Rules) or SFRA (Special Flight Rules Areas) must comply with the rules set in 14 CFR Part 93 unless ATC provides alternate instructions or authorizations.



TRSA with Class D airspace.

Washington DC Air Defense Identification Zone (ADIZ) and Flight Restricted Zone (FRZ)

The airspace around Washington, D.C. is more restricted than any other airspace in the country. Rules put in place after the 9/11 attacks establish *national defense airspace* over the area and limit aircraft operations to those with an FAA and Transportation Security Administration (TSA) authorization. Violators face stiff fines and criminal penalties.

The larger airspace area is a Special Flight Rules Area (SFRA) and includes an area within a 30 nautical mile radius of Ronald Reagan Washington National Airport. That's almost 4,000 square statute miles of terrain that they don't want you flying over without special permission. And for a lot of it, you probably can't get special permission.

The specific rules for the area can be found in 14 CFR Part 93, Subpart V. If you want to give the SFRA a go, here are the requirements.

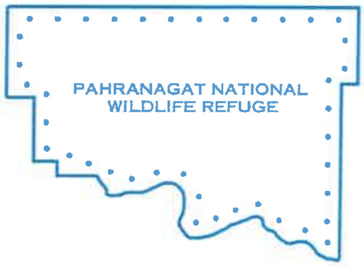
- Pilots must obtain an advanced clearance from FAA air traffic control to fly within, into, or out of the SFRA.
- Aircraft flying within the SFRA must have an altitude-encoding transponder and it must be operating.
- FAA air traffic control must assign a four-digit number that identifies the aircraft by callsign or registration number when it gives a pilot clearance to fly in the SFRA.
- While flying within the SFRA, the pilot must be in direct contact with air traffic control unless cleared to the local airport traffic advisory frequency.

And be careful, that only gets you into the outer ring! The inner ring has a 15 NM radius and includes sensitive areas like the White House, Congress, and the Pentagon. That area is called the Flight Restricted Zone (FRZ) and the only non-governmental flights allowed within the FRZ without a waiver are scheduled commercial flights into and out of Ronald Reagan Washington National Airport.

"*Waiver?*" you ask. Yes, certain general aviation flights may be authorized to fly within the FRZ. Pilots who have been vetted by the TSA are allowed to fly in and out of the three Maryland general aviation airports in the area.

And realize that there are Prohibited Areas within the FRZ that you can't fly over at all unless you would like to fly formation with a couple of Black Hawk helicopters.

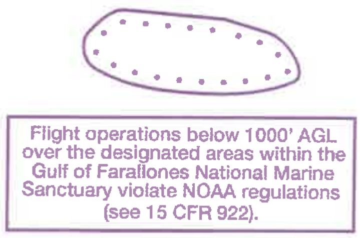
Flight Over Charted U.S. Wildlife Refuges, Parks, and Forest Service Areas



Pilots are requested to maintain a minimum altitude of 2,000 feet above the surface of the following: national parks, monuments, seashores, lakeshores, recreation areas, and scenic riverways administered by the National Park Service, National Wildlife Refuges, Big Game Refuges, Game Ranges, and Wildlife Ranges administered by the U.S. Fish and Wildlife Service and wilderness and primitive areas administered by the U.S. Forest Service.

The landing of aircraft is prohibited on lands or waters administered by the National Park Service, U.S. Fish and Wildlife Service, or U.S. Forest Service without authorization from the respective agency. Exceptions include:

- When forced to land due to an emergency beyond the control of the operator.
- At officially designated landing sites.
- On approved official business of the Federal Government.



Flight Over NOAA Regulated National Marine Sanctuary Designated Areas

National Oceanic and Atmospheric Administration (NOAA) regulated overflight zones (NROZs) are *designated areas* within four West Coast national marine sanctuaries where motorized flight below minimum altitude limits is presumed to disturb wildlife, violating federal wildlife protection regulations enforced by NOAA. These zones are marked on aeronautical charts with solid magenta lines and magenta dots near coastlines and islands. Text boxes adjacent to the zone markings identify them as sanctuary areas where NOAA regulations apply

Special Use Airspace at a Glance

Type Airspace	Symbol	Purpose	Normal Altitudes
Prohibited Area	P-56	Pilots stay out because of security or other reasons associated with the national welfare.	Surface Up
Restricted Area	R-6401	Pilots stay out when active because of the existence of unusual, often invisible hazards to aircraft such as artillery firing, aerial gunnery, and guided missiles.	Surface Up
Warning Area	W-518	Warn nonparticipating aircraft about activities which may be much the same as those in a restricted area.	Surface Up
Miltary Operations Area	VANCE 2 MOA	Separating certain military training activity from IFR traffic. Pilots can fly there.	Altitudes Vary
Alert Area	ALERT AREA A-631 CONCENTRATED STUDENT HELICOPTER TRAINING	Advise pilots that a high volume of pilot training or unusual aerial activity is taking place so that the pilots can be particularly alert. Pilots can fly there.	Surface Up
Controlled Firing Area	None	Contain activities, which, if not conducted in a controlled environment, could be hazardous to nonparticipating aircraft. Pilots can fly there.	Surface Up
Military Training Routes	IR292 VR1016	Used by the military for the purpose of conducting low-altitude, high-speed training. Pilots can fly there but stay alert.	Below 10,000
Temporary Flight Restrictions	None	Prohibit most general aviation flight into specified areas during set periods of time for specific reasons.	Surface Up
Parachute Jump Area	122.9	Denoting a high volume of parachute jumping activity. Pilots should be wary.	Surface Up
Terminal Radar Service Area	PALM SPRINGS TRSA 80 - Ceiling of TRSA in hundreds of feet MSL 40 - Floor of TRSA in hundreds of feet MSL	Participating pilots can receive additional radar services. No restrictions on flight.	Surface Up
National Security Area		Pilots are requested to voluntarily avoid flying through these depicted areas. Pilots should avoid.	Surface Up
Wildlife Refuge	PAHRANAGAT NATIONAL WILDLIFE REFUGE	Pilots are requested to voluntarily avoid flying through these depicted areas. Pilots should fly higher than 2,000 AGL.	Surface to 2,000 feet AGL
Marine Sanctuary	Flight operations below 1000' AGL over the designated areas within the Gulf of Farallones National Marine Sanctuary violate NOAA regulations (see 15 CFR 922).	Motorized flight below minimum altitude limits are presumed to disturb wildlife in violation of federal wildlife protection regulations enforced by NOAA.	Surface to 1,000 feet AGL

Chapter 26
Navigation

Some powered parachute pilots are satisfied flying locally, while others like to stretch their legs and fly to other airports. And there are yet other pilots who load their machines into trailers and travel to new locations to enjoy flying. This chapter covers cross-country flying under visual flight rules (VFR), providing an introduction to the fundamentals of planning and executing cross-country flights in a powered parachute.

Air navigation involves piloting an aircraft from one geographic location to another while continuously monitoring position throughout the flight. It begins with flight planning, which entails plotting the course on an aeronautical chart, selecting checkpoints, measuring distances, gathering relevant weather data, and calculating flight time, headings, and fuel needs. This chapter covers three methods: *pilotage*—navigating using visible landmarks; *dead reckoning*—calculating direction and distance from a known position; and *utilizing a global positioning system (GPS)*.

Aeronautical Charts

An aeronautical chart serves as a road map for pilots flying under VFR, offering essential information to help track their position and enhance safety. Powered parachute pilots primarily use two types of aeronautical charts:

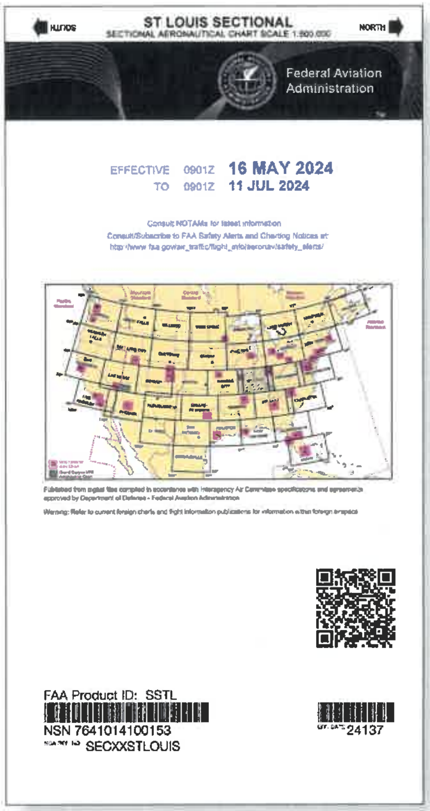
- Sectional Charts
- VFR Terminal Area Charts

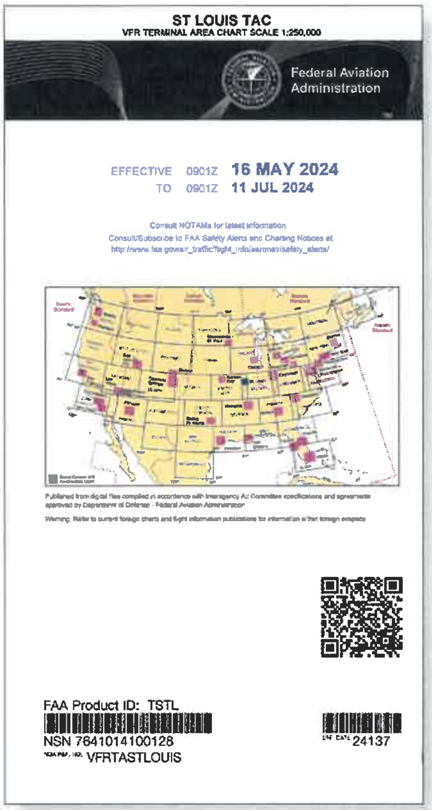
You can purchase physical maps from several online retailers as well as at some airports. You can also view them online for free at websites like **SkyVector.com**.

When you first inspect an aeronautical chart, you may feel overwhelmed by the foreign look of it. However, there are only so many different kinds of items on it and the terrain, symbols, and markings all follow logical patterns that repeat. That makes learning how to read an aeronautical chart easier than it may first appear.

Sectional Charts

Sectional Aeronautical Charts are the primary navigation tool for VFR pilots, especially for powered parachute pilots, who rely on them more than any other chart. Designed for slow to medium speed aircraft, these charts have a scale of 1:500,000 (1 inch = roughly 8 statute miles). They provide essential topographic details, including relief, visual checkpoints such as towns, drainage patterns, roads, railroads, and other landmarks used for visual navigation. Aeronautical information includes navigation aids, airports, controlled airspace, restricted areas, obstructions, and more. These charts are updated every 56 days since airport data changes and there are always new obstructions being built. You can interpret most of the information on the chart by referring to the chart legend, which includes data on airports, airspace, and topography. Tables also provide details on control towers and special use airspace.





Left: St. Louis Sectional chart covering airspace over portions of six states.

Right: St. Louis Terminal Area chart covering the Class B airspace over the St. Louis area.

VFR Terminal Area Charts

Terminal Area Charts (TACs) offer a detailed view of selected metropolitan areas to meet pilotage and local control needs. With a scale of 1:250,000 (1 inch = approximately 4 statute miles), TACs provide more detail than Sectional Charts and depict Class B airspace. These charts are designed for pilots operating from airfields within or near Class B and Class C airspace. Updated every 56 days, TACs are essential for navigating in complex airspace environments, offering greater precision due to their larger scale.

Pilotage

Pilotage is navigation by using landmarks or checkpoints. It can be applied on any route with visible checkpoints but is often combined with dead reckoning and GPS navigation. Begin by selecting an aeronautical chart, typically a Sectional, although some pilots prefer more detailed maps like county maps. Whichever map you choose, determine your direction and pick checkpoints along the route to stay on course.

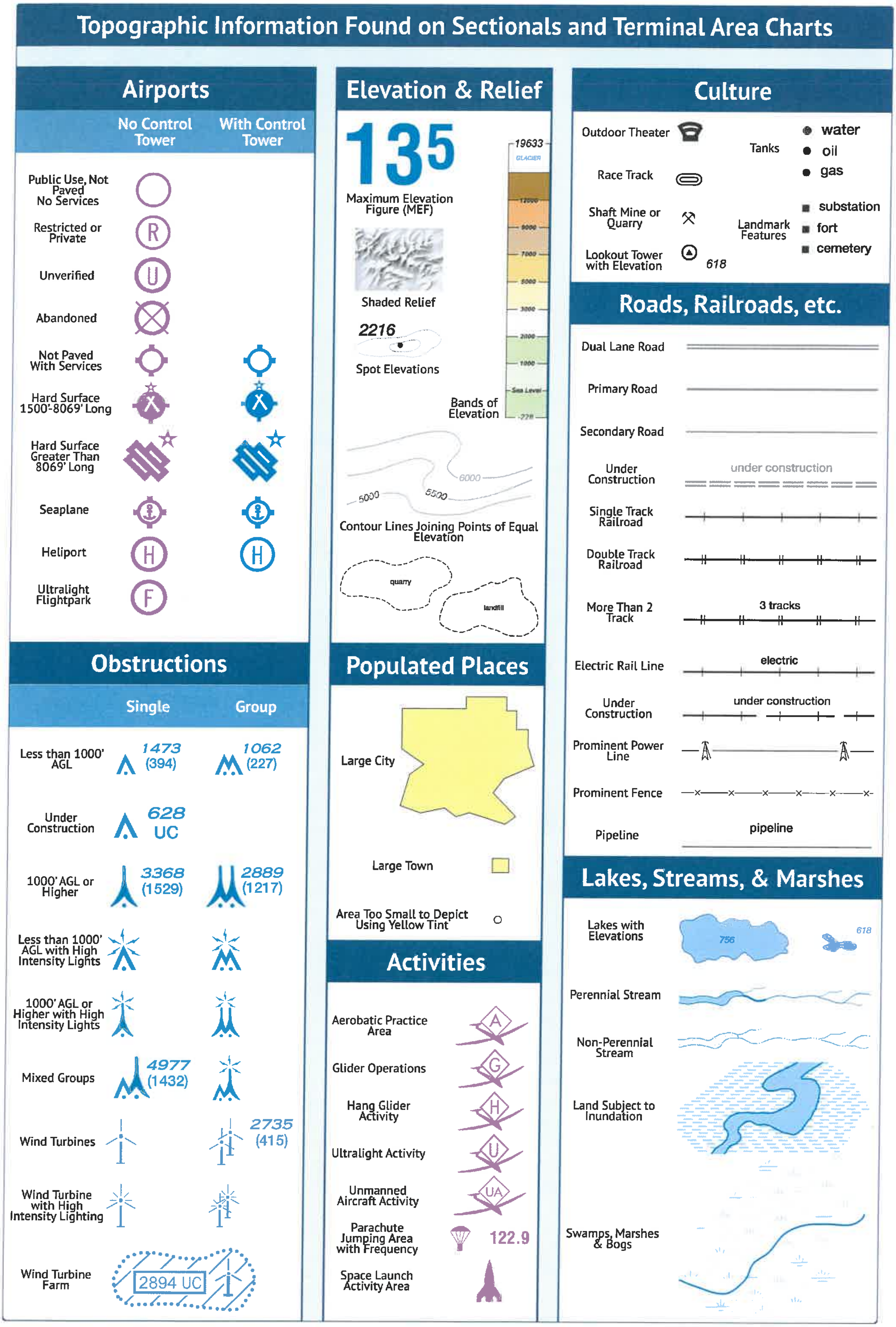
Checkpoints should be prominent and easily distinguishable, such as roads, rivers, lakes, or power lines. For example, a tower is a great checkpoint, but it's best if you can tell the difference between that tower and the other towers in the area. Whenever possible, select natural or man-made features like highways, rivers, or railroads that can act as boundaries or brackets to prevent drifting off course.

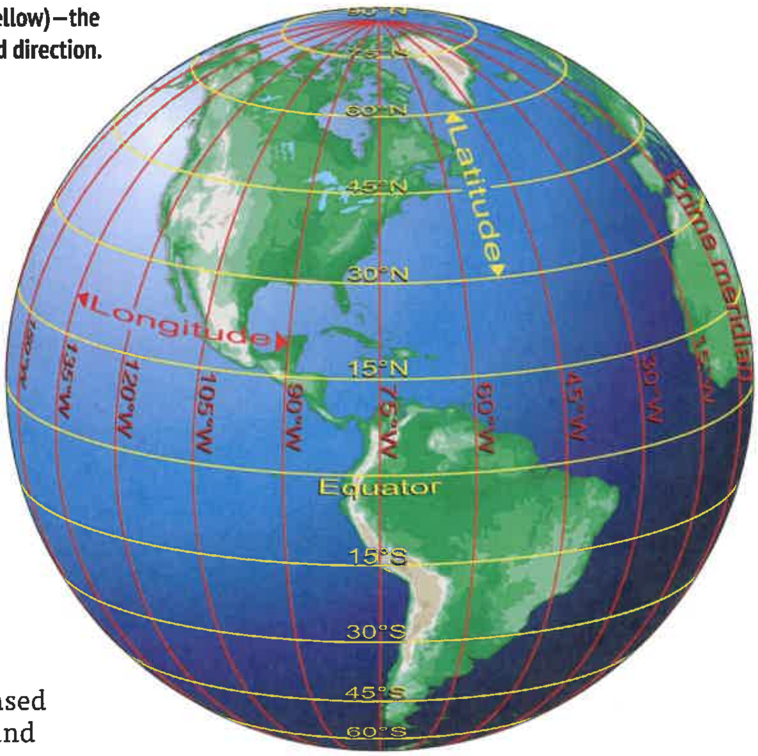
Avoid relying solely on a single checkpoint; instead, choose multiple so that if one is missed, you can rely on the next while maintaining your heading. Keep in mind that on a Sectional chart, 1 inch equals 8 statute miles (or 6.86 nautical miles). For instance, a checkpoint half an inch from the course line on the chart is roughly 4 statute miles or 3.43 nautical miles from the course on the ground.

In congested areas, some smaller landmarks may not be depicted on the Sectional, and if unsure, it's best to maintain your heading rather than making unnecessary turns, which can lead to getting lost. Roads shown on Sectionals are typically the most prominent, but new roads and structures may not appear until the chart is updated.

Some obstacles, like antennas, may be hard to spot. TV antennas are often grouped near towns, supported by nearly invisible guy wires. Always remain at least 500 feet above the tallest structure in an antenna field. While many tall structures are marked with strobe lights, certain weather conditions or background lighting can make them difficult to see.

Aeronautical charts reflect the best available information at the time of printing, but always remain alert for new structures or changes since the chart's publication. Understanding chart symbols is crucial, and the most common symbols can be found in the legend on the chart. Those symbols and others can also be found in the figure on the next page.


Topographic Information Found on Sectionals and Terminal Area Charts
Airports
No Control Tower
With Control Tower
Public Use, Not Paved No Services
Restricted or Private
R
Unverified
U
Abandoned
Not Paved With Services
Hard Surface 1500'-8069' Long
Hard Surface Greater Than 8069' Long
Seaplane
Heliport
H
Ultralight Flightpark
F
Obstructions
Single
Group
Less than 1000' AGL
1473 (394)
1062 (227)
Under Construction
628 UC
1000' AGL or Higher
3368 (1529)
2889 (1217)
Less than 1000' AGL with High Intensity Lights
1000' AGL or Higher with High Intensity Lights
Mixed Groups
4977 (1432)
Wind Turbines
2735 (415)
Wind Turbine with High Intensity Lighting
Wind Turbine Farm
2894 UC
Elevation & Relief
135
Maximum Elevation Figure (MEF)
19633
GLACIER
Shaded Relief
2216
Spot Elevations
Bands of Elevation
6000
5000
5500
Contour Lines Joining Points of Equal Elevation
quarry
landfill
Populated Places
Large City
Large Town
Area Too Small to Depict Using Yellow Tint
Activities
Aerobatic Practice Area
A
Glider Operations
G
Hang Glider Activity
H
Ultralight Activity
U
Unmanned Aircraft Activity
UA
Parachute Jumping Area with Frequency
122.9
Space Launch Activity Area
Culture
Outdoor Theater
Tanks
water
oil
gas
Race Track
Shaft Mine or Quarry
Landmark Features
substation
fort
cemetery
Lookout Tower with Elevation
618
Roads, Railroads, etc.
Dual Lane Road
Primary Road
Secondary Road
Under Construction
under construction
Single Track Railroad
Double Track Railroad
More Than 2 Track
3 tracks
Electric Rail Line
electric
Under Construction
under construction
Prominent Power Line
Prominent Fence
Pipeline
pipeline
Lakes, Streams, & Marshes
Lakes with Elevations
756
618
Perennial Stream
Non-Perennial Stream
Land Subject to Inundation
Swamps, Marshes & Bogs



Meridians (red) and parallels (yellow)—the basis of measuring time, distance, and direction.

Dead Reckoning

Dead reckoning is a method of navigation based on calculations of time, airspeed, distance, and direction. When these factors are adjusted for wind speed and direction, they determine the heading and groundspeed. The calculated heading keeps you on course, while the groundspeed helps estimate your arrival time at each checkpoint and your final destination. Except over water, dead reckoning is typically combined with pilotage in cross-country flying. The calculated heading and groundspeed should be continuously monitored and corrected using visual checkpoints. Most of the rest of this chapter is dedicated to the calculations you need to perform dead reckoning.

Latitude and Longitude (Meridians and Parallels)

Latitude and longitude are geographical coordinates used to specify locations on the Earth's surface.

Latitude

- Latitude lines run east-west and measure the distance north or south of the equator.
- Lines of latitude are parallel to each other.
- The equator is the starting point for measuring latitude and is 0 degrees latitude.
- As you move north from the equator, the latitude increases up to a maximum of 90 degrees at the North Pole.
- Moving south from the equator, the latitude also increases, reaching a maximum of 90 degrees at the South Pole.
- The 48 contiguous states of the United States are located between 25° and 49° N latitude, reflecting that they are north of the equator.

Longitude

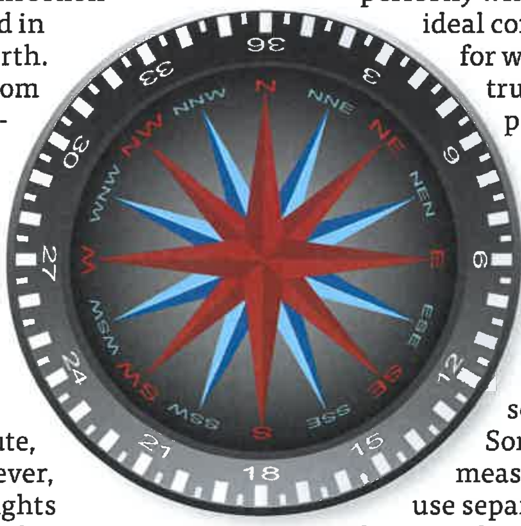
- Longitude lines run north-south and measure the distance east or west of the Prime Meridian.
- Lines of longitude converge at the north and south poles.
- The Prime Meridian is the starting point for measuring longitude and is 0 degrees longitude. It passes through the Royal Observatory in Greenwich, London, United Kingdom.
- Longitude ranges from 0 to 180 degrees eastward and 0 to 180 degrees westward from the Prime Meridian.
- The International Date Line, opposite the Prime Meridian, is at 180 degrees longitude.
- The 48 contiguous states of the United States are between 67° and 125° W longitude indicating that they are all west of Greenwich, England.

Together, latitude and longitude provide a precise way to identify any point on the Earth's surface, helping in navigation, mapping, and locating places accurately on a global scale. Any specific geographical point can be located by its latitude and longitude. For example, Washington, D.C. is located at approximately 39° N latitude, 77° W longitude, and Chicago is located at approximately 42° N latitude, 88° W longitude.

The thing most people have problems with in remembering latitude and longitude is trying to remember which one is which. Here's how I do it. Latitude affects my attitude. In the winter, I want to go south, not east or west. So a decrease in latitude (getting closer to the equator) improves my attitude.

Measurement of Direction (True Course, TCrs)

Using meridians of longitude, direction between two points is measured in degrees clockwise from true north. To chart a course, draw a line from the departure point to the destination and measure the angle this line forms with a meridian. This angle, or direction, is expressed in degrees, as shown by the compass rose here.



Since meridians converge toward the poles, the course should be measured at a meridian near the midpoint of the route, especially for long flights. However, in powered parachutes, short flights often cover only one meridian or less, so it may be necessary to extend the course line beyond the departure and destination points so that it crosses at least one meridian so that you can accurately measure the course with a plotter.

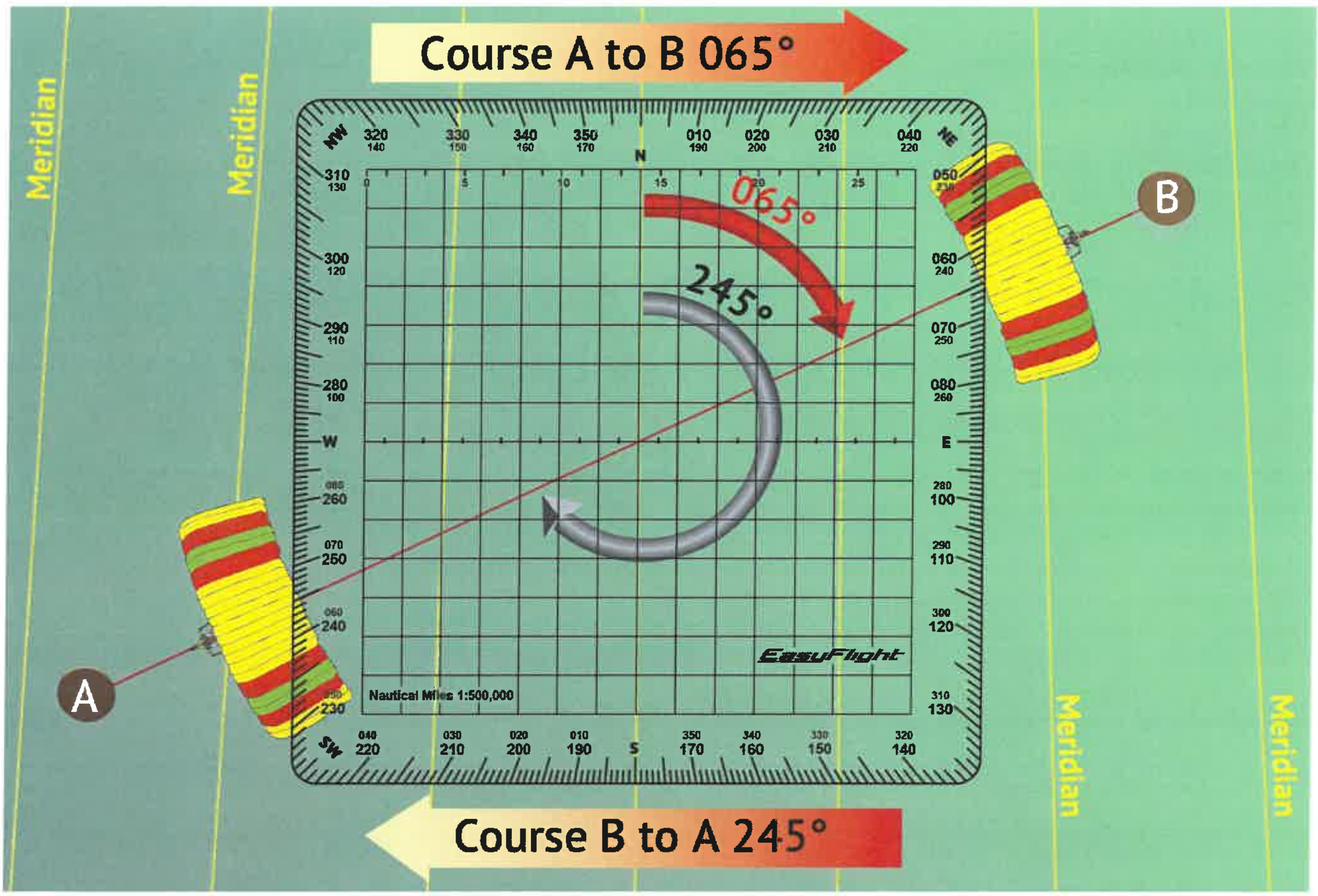
The resulting measurement is known as the true course, which is the intended flight direction in degrees clockwise from true north. In the example below, the direction from point A to point B is 065°, with the reciprocal direction, or return trip, being 245°.

This true course is the direction to follow in a windless environment or when the wind aligns perfectly with the flight path. However, such ideal conditions are rare, so adjusting for wind is necessary, making the true course merely a starting point for navigation.

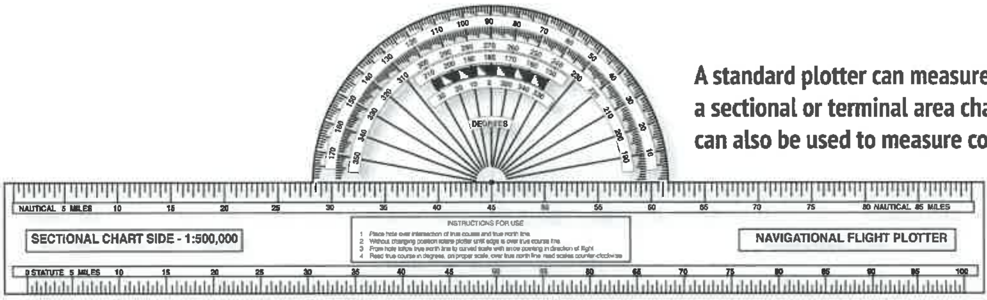
Plotter

A plotter is a navigation tool, much like a protractor, used to measure your true course on an aeronautical chart. Though there are different types of plotters, they all serve the same basic function. Some combine a ruler for distance measurement, but it's often easier to use separate tools for each task to avoid clutter and confusion.

To measure your true course, one commonly used option is the ASA Square Plotter (CP-P5). Start by aligning the center point of the plotter where your course line intersects a meridian on the sectional chart. Next, ensure the vertical lines on the plotter are parallel with the meridian. Once aligned, read the true course directly from the degree markings on the plotter's edges. This method provides an accurate course heading, which forms the basis for your navigation.



Courses are determined by reference to meridians on aeronautical charts.



A standard plotter can measure distance directly from a sectional or terminal area chart. This kind of plotter can also be used to measure course headings.

Measurement of Distance (Dist)

Another important piece of information you need to get from your sectional is the distance from your point of departure to your destination. You could use a regular ruler and convert the inches to miles or nautical miles, but there's a far easier way.

Inexpensive rulers are produced which are already scaled for your sectional. The problem is that many of them also have scales for Terminal Area Charts and World Air Charts. On top of that, many rulers have scales for miles, nautical miles and even kilometers. You must be careful when using the ruler to make sure that you're using the scale for the proper chart with the right units. So many variations can make it easy to make a mistake.

So should you use miles, nautical miles or kilometers? Honestly, it doesn't really matter, but you must be consistent. Later, you'll be taking into account wind speeds and the speed of your powered parachute in your calculations. If your wind speed information is in knots, you might want to work in nautical miles. Or perhaps you'll later want to convert your wind speeds to mph. Again, it doesn't matter which you use as long as you're consistent.

True Airspeed (TAS)

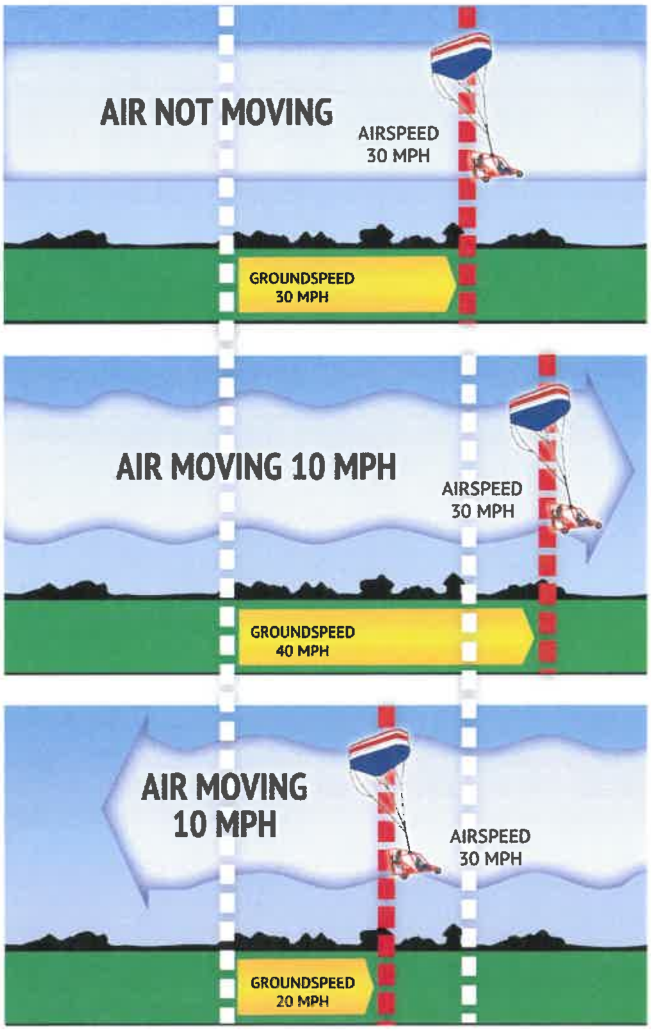
In navigation, it's not just important to know which way you're going and how far you need to go. You also want to know how long it's going to take you to get there. Much of that depends on the airspeed of your powered parachute.

Airspeed is just the rate of progress of an aircraft through the air. Of course, this being aviation, you know that there's going to be more than one kind of airspeed.

Indicated Airspeed (IAS) is the airspeed displayed on the aircraft's airspeed indicator. This instrument measures the dynamic pressure of the air, converting it into a speed reading.

Calibrated Airspeed (CAS) is the speed at which the aircraft is moving through the air, found by correcting IAS for instrument and position errors. To determine calibrated airspeed, pilots consider factors such as instrument error and installation effects. Corrections are applied to the indicated airspeed, as provided in the aircraft's Pilot's Operating Handbook (POH) or other performance documentation.

True Airspeed (TAS) is the actual speed of the aircraft through the air. True airspeed is calculated by correcting calibrated airspeed for altitude and temperature variations, providing a more accurate measure for navigation purposes. Pilots use indicated or calibrated airspeed as a starting point for calculating true airspeed. Atmospheric conditions, specifically altitude and temperature, are factored in to adjust for variations. This is often done using an airspeed correction chart or a flight computer.



If the air isn't moving, true airspeed (TAS) is equal to the groundspeed indicated on your GPS. However, you can determine your TAS by averaging your groundspeed while flying upwind with your groundspeed while flying downwind

Powered parachutes are low performance aircraft that fly at a fairly steady airspeed. Speeds probably vary within 10%, depending on the wing rigging, pilot weight, passenger weight, and whether the powered parachute is climbing, descending or flying straight-and-level. Moreover, most powered parachutes aren't even equipped with airspeed indicators, so IAS and CAS really aren't available, meaning that TAS calculations based on them is impossible.

Determining True Airspeed

Powered parachute pilots need an alternative way to determine TAS. You can get that speed or a usable approximation from aircraft documentation. Alternatively, you can determine a more accurate number for your powered parachute by experimentation. All you need is a GPS, which is available on most smart phones.

To calculate the TAS for your powered parachute, you need to take off, establish straight-and-level flight and fly directly into the wind. Determine your speed from your GPS, (which will be your groundspeed in that direction.) Then turn around and fly straight-and-level at the same altitude directly with the wind. Note the speed your GPS indicates. It should be a faster speed than your upwind measurement. The average of those two speeds will be your TAS for your powered parachute with that loading. By averaging those two speeds, you'll be eliminating the effects of wind and get an accurate TAS number for your powered parachute. For those of you who like math, this is what that looks like...

$$\text{TAS} = \frac{\text{GS Upwind} + \text{GS Downwind}}{2}$$

$$\text{TAS} = \frac{(\text{TAS} - \text{Wind Speed}) + (\text{TAS} + \text{Wind Speed})}{2}$$

$$\text{TAS} = \frac{\text{TAS} + \text{TAS}}{2}$$

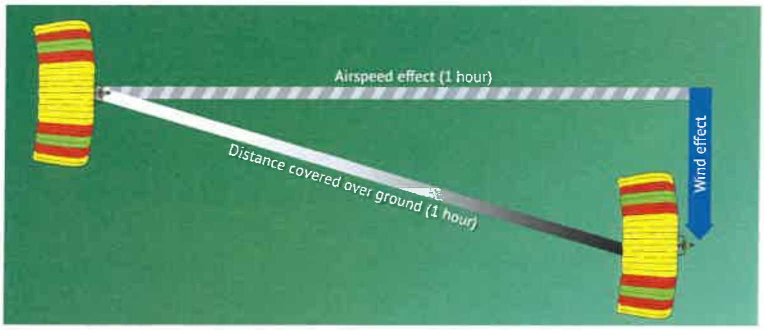
A benefit of the formula is that you don't need to be exactly into the wind to do it. The formula works as long as you go 180° in opposite directions. Following a straight road for the experiment works just fine. The benefit of going directly into the wind is that you don't have to hold a steering input to maintain a straight course.

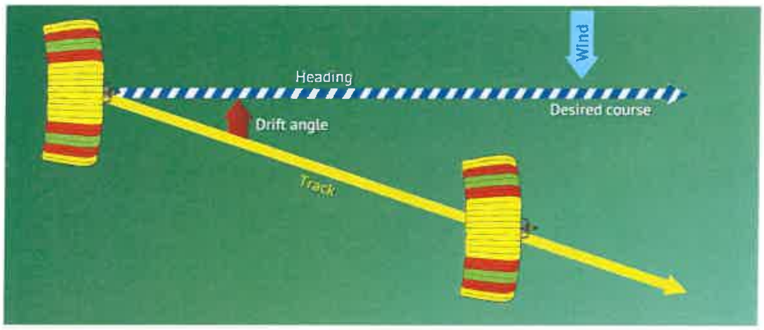
Effect of Wind

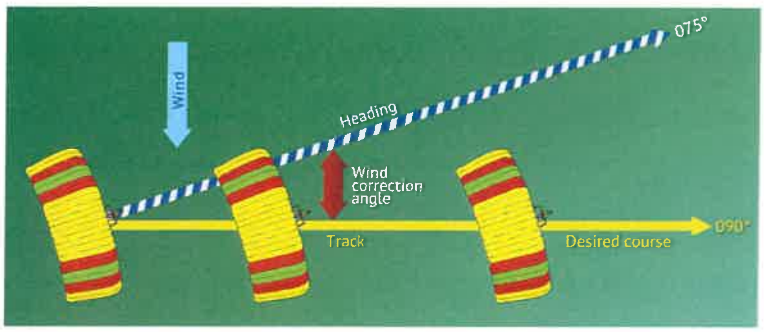
After we measure the True Course (TCrs) and Distance (Dist) on a sectional and know our True Airspeed (TAS), it's time to consider the effects of wind on our planned trip. As discussed in the study of the atmosphere, wind is a mass of air moving over the surface of the Earth in a definite direction. When the wind is blowing from the north at 10 mph, it simply means that air is moving southward over the Earth's surface at the rate of 10 miles in one hour.

Under these conditions, any inert object free from contact with the Earth (like clouds or balloons) will be carried 10 miles southward in one hour. A powered parachute flying within the moving mass of air will be similarly affected. Even though the powered parachute does not float freely with the wind, it moves through the air at the same time the air is moving over the ground, so it's affected by wind. Consequently, at the end of one hour of flight, the powered parachute will be in a position which results from a combination of these two motions:

1. The movement of the air mass in reference to the ground, and
2. The forward movement of the powered parachute through the air mass.







Top: Powered parachute flight path resulting from its airspeed and direction, and the wind speed and direction.

Middle: Effects of wind drift on maintaining desired course.

Bottom: Establishing a wind correction angle that will counteract wind drift and maintain the desired course.

These two motions are independent. So far as the powered parachute's flight through the air is concerned, it makes no difference whether the mass of air through which the powered parachute is flying is moving or is stationary. A pilot flying in a 70-knot gale would be totally unaware of any wind (except for possible turbulence) unless the ground were observed. In reference to the ground, however, the powered parachute would appear to fly faster with a tailwind or slower with a headwind, or to drift right or left with a crosswind.

Groundspeed (GS)

As shown in the figure on a previous page, a powered parachute flying eastward at an airspeed of 30 miles per hour in still air, will have a groundspeed exactly the same—30 MPH. If the mass of air is moving eastward at 10 MPH, the airspeed of the powered parachute will not be affected, but the progress of the powered parachute over the ground will be 30 plus 10, or a groundspeed of 40 MPH. On the other hand, if the mass of air is moving westward at 10 MPH, the airspeed of the powered parachute still remains the same, but groundspeed becomes 30 minus 10 or 20 MPH.

Assuming no correction is made for wind effect, if the powered parachute is heading eastward at 30 MPH, and the air mass is moving southward at 5 MPH, the powered parachute at the end of one hour will be almost 30 miles east of its point of departure because of its progress through the air. It will be 5 miles south because of the motion of the air. Under these circumstances, the airspeed remains 30 MPH, but the groundspeed is determined by combining the movement of the powered parachute with that of the air mass. Groundspeed can be measured as the distance from the point of departure to the position of the powered parachute at the end of one hour. The groundspeed can be computed by the time required to fly between two points a known distance apart. It also can be determined before flight by constructing a wind triangle, which will be explained later in this chapter.

Heading (Hdg)

The direction in which an aircraft is pointing as it flies is called the *heading*. Its actual path over the ground, which is a combination of the motion of the powered parachute and the motion of the air, is called a *track*. The angle between the heading and the track is the *drift angle*. If the powered parachute's heading coincides with the true course and the wind is blowing from the left, the track will not coincide with the true course. The wind will drift the powered parachute to the right, so the track will fall to the right of the desired course or true course.

By determining the amount of drift, you can counteract the effect of the wind and make the track of the powered parachute coincide with the desired course. If the mass of air is moving across the course from the left, the powered parachute will drift to the right, and a correction must be made by heading the powered parachute sufficiently to the left to offset this drift. To state in another way, if the wind is from the left, the correction will be made by pointing the powered parachute to the left a certain number of degrees, therefore correcting for wind drift. This is wind correction angle and is expressed in terms of degrees right or left of the true course.

To Summarize So Far:

True Course (TCrs) is the intended path of a powered parachute over the ground; or the direction of a course line drawn on a chart representing the intended powered parachute path, expressed as the angle measured from true (geographic) north clockwise from 0° through 360° to the course line.

True Heading (THdg) is the direction of the aircraft in relation to true north. It's the direction in which the nose of the powered parachute points during flight relative to true north. Usually, it's necessary to head the powered parachute in a direction slightly different from the true course to offset the effect of wind. Consequently, the numerical value of the true heading may not correspond with that of the true course.

Track is the actual path made over the ground in flight. (If proper correction has been made for the wind, track and course will be identical.)

Drift Angle is the angle between heading and track.

Wind Correction Angle (WCA) is correction applied to the course to establish a heading so that track will coincide with course.

True Airspeed (TAS) is the rate of the powered parachute's progress through the air.

Groundspeed (GS) is the rate of the powered parachute's in-flight progress over the ground.

Wind Triangle or Vector Analysis

This section is included so that you can understand the theory behind dead reckoning calculations. Don't become too worried if some of this is too confusing. Your knowledge test won't require you to create a wind triangle. At most, you'll be required to identify the parts of an existing wind triangle, which only includes six different items. And for practical flying, there are calculators, apps, and websites that can all do the calculations for you. But try to understand the principles. The best way to crosscheck something you get out of a calculator is to understand roughly what the calculator is supposed to be doing for you.

If there's no wind, the powered parachute's ground track will be the same as the heading and the groundspeed will be the same as the true airspeed. This condition rarely exists. The wind triangle, the pilot's version of vector analysis, is the basis of dead reckoning.

The wind triangle is a graphic explanation of the effect of wind upon flight. Groundspeed, heading, and time for any flight can be determined by using the wind triangle.

If a flight is to be made on a course to the east, with a wind blowing from northeast, the powered parachute must be headed somewhat to the north of east to counteract drift. This can be represented by a diagram as shown on the top right. Each line represents direction and speed. The long, blue and white line shows the direction the aircraft is heading, and its length represents the airspeed for one hour. The short, sold blue line at the right shows the wind direction, and its length represents the wind velocity for one hour. The solid yellow line shows the direction of the track, or the path of the powered parachute as measured over the Earth, and its length represents the distance traveled in one hour, or the groundspeed.

In practice, the triangle shown on the top right isn't drawn; instead, construct a similar triangle as shown by the blue and black lines in the bottom right image, which is explained in the following example.

Suppose a flight is to be flown from E to P. Draw a line on the aeronautical chart connecting these two points then measure its direction with a protractor, or plotter, in reference to a meridian. This is your true course, which in this example is assumed to be 090° (east). From a weather briefing, you find that the wind at the altitude of the intended flight is 10 knots from the northeast (045°). Since you received the wind speed in knots, if the true airspeed of your powered parachute is 30 knots, there's no need to convert speeds from knots to miles per hour or vice versa.

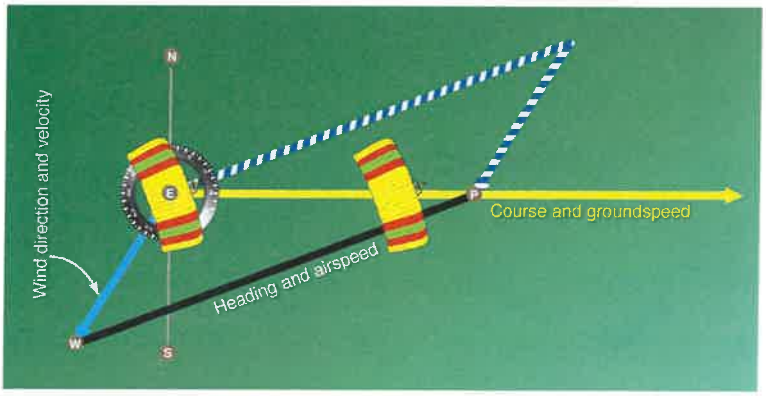
Now on a plain sheet of paper draw a vertical line representing north and south. (And see image on the next page.)

Step 1: Place the protractor with the base resting on the vertical line and the curved edge facing east. At the center point of the base, make a dot labeled *E* (point of departure), and at the curved edge, make a dot at 90° (indicating the direction of the true course) and another at 45° (indicating wind direction).

Step 2: With the ruler, draw the true course line from E, extending it somewhat beyond the dot by 90°, and labeling it *TCrs 090°*.

Step 3: Next, align the ruler with E and the dot at 45°, and draw the wind arrow from E, not toward 045°, but downwind in the direction the wind is blowing, making it 10 units long, to correspond with the wind velocity of 10 knots. Identify this line as the wind line by placing the letters *WDir* at the end to show the wind direction.

Step 4: Finally, measure 30 units on the ruler to represent the airspeed, making a dot on the ruler at this point. The units used may be of any convenient scale or value (such as 1/4 inch = 2 knots), but once selected, the same scale must be used for each of the linear movements involved. Then place the ruler so that the end is on the arrowhead (W) and the 120-knot dot intercepts the true course line. Draw the line and label it *AS 30*. The point *P* placed at the intersection represents the position of the powered parachute at the end of one hour. The diagram is now complete.



Top: Principles of the wind Triangle.

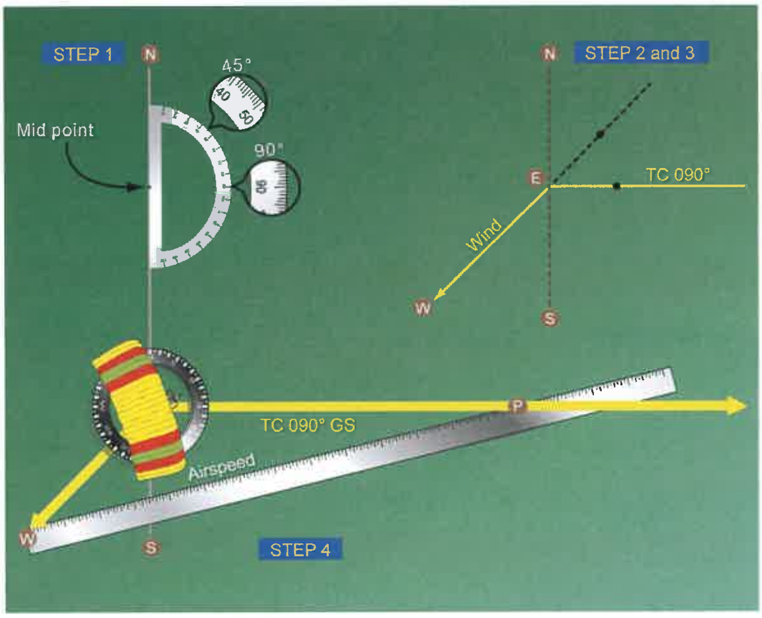
Bottom: The wind triangle as is drawn in navigation practice.

The distance flown in one hour (groundspeed) is measured as the numbers of units on the true course line (22 nautical miles per hour or 22 knots).

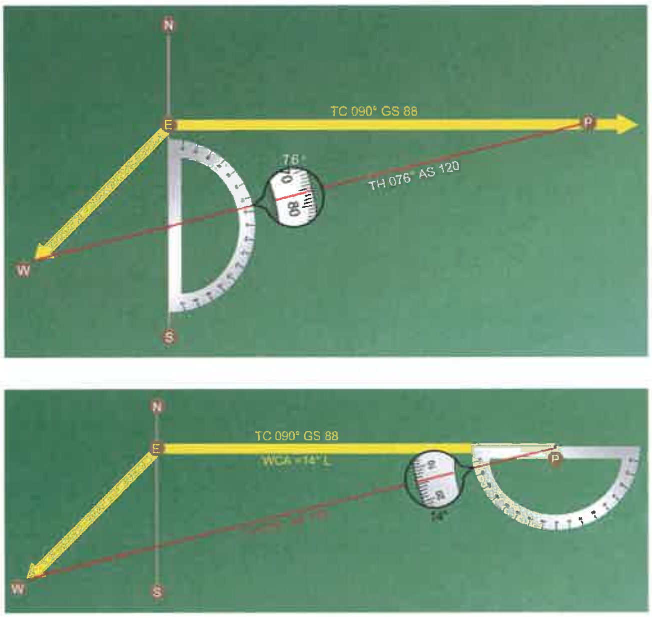
The true heading necessary to offset drift is indicated by the direction of the airspeed line, which can be determined in one of two ways:

By placing the straight side of the protractor along the north-south line, with its center point at the intersection of the airspeed line and north-south line, read the True Heading (THdg) directly in degrees (076°).

By placing the straight side of the protractor along the true course line, with its center at P, read the angle between the true course and the airspeed line. This is the wind correction angle (WCA) which must be applied to the True Course to obtain the True Heading. If the wind blows from the right of true course, the angle will be added; if from the left, it will be subtracted. In the example given, the WCA is 14° and the wind is from the left; therefore, subtract 14° from True Course of 090°, making the True Heading 076°.



Steps in drawing the wind triangle.

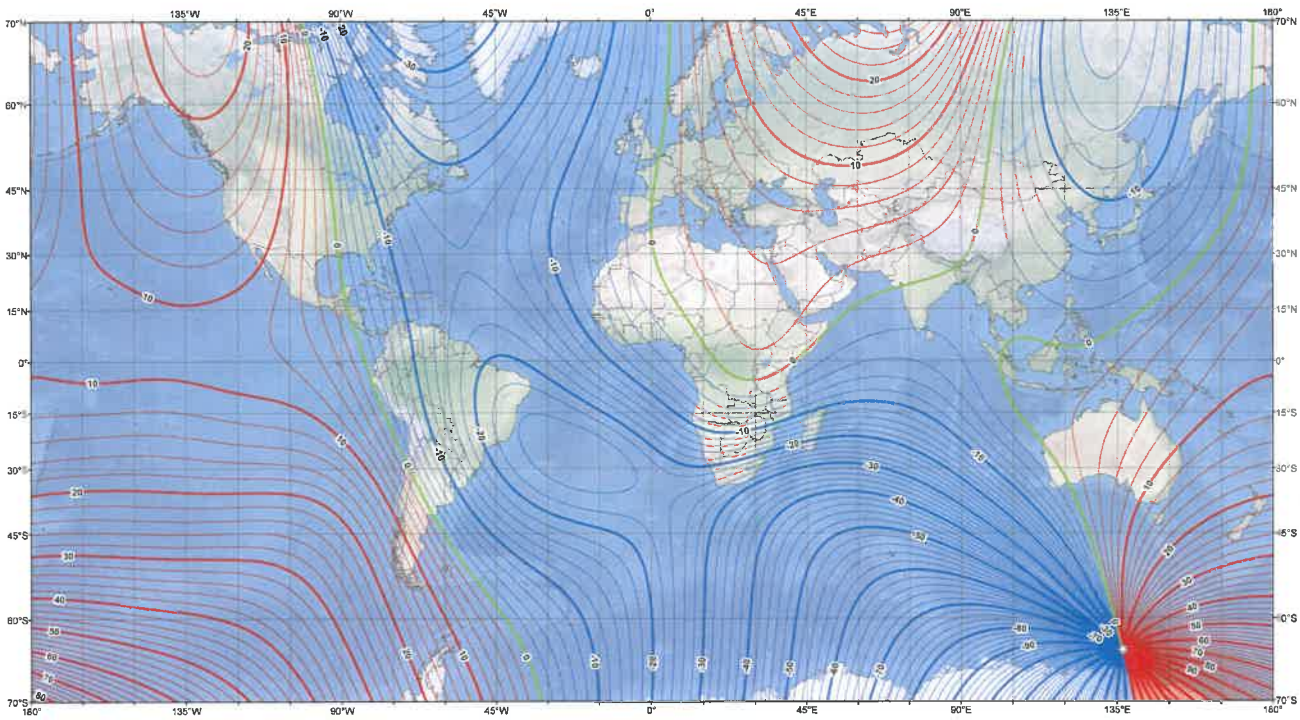


Top: Finding true heading by the wind correction angle.
Bottom: Finding true heading by direct measurement.

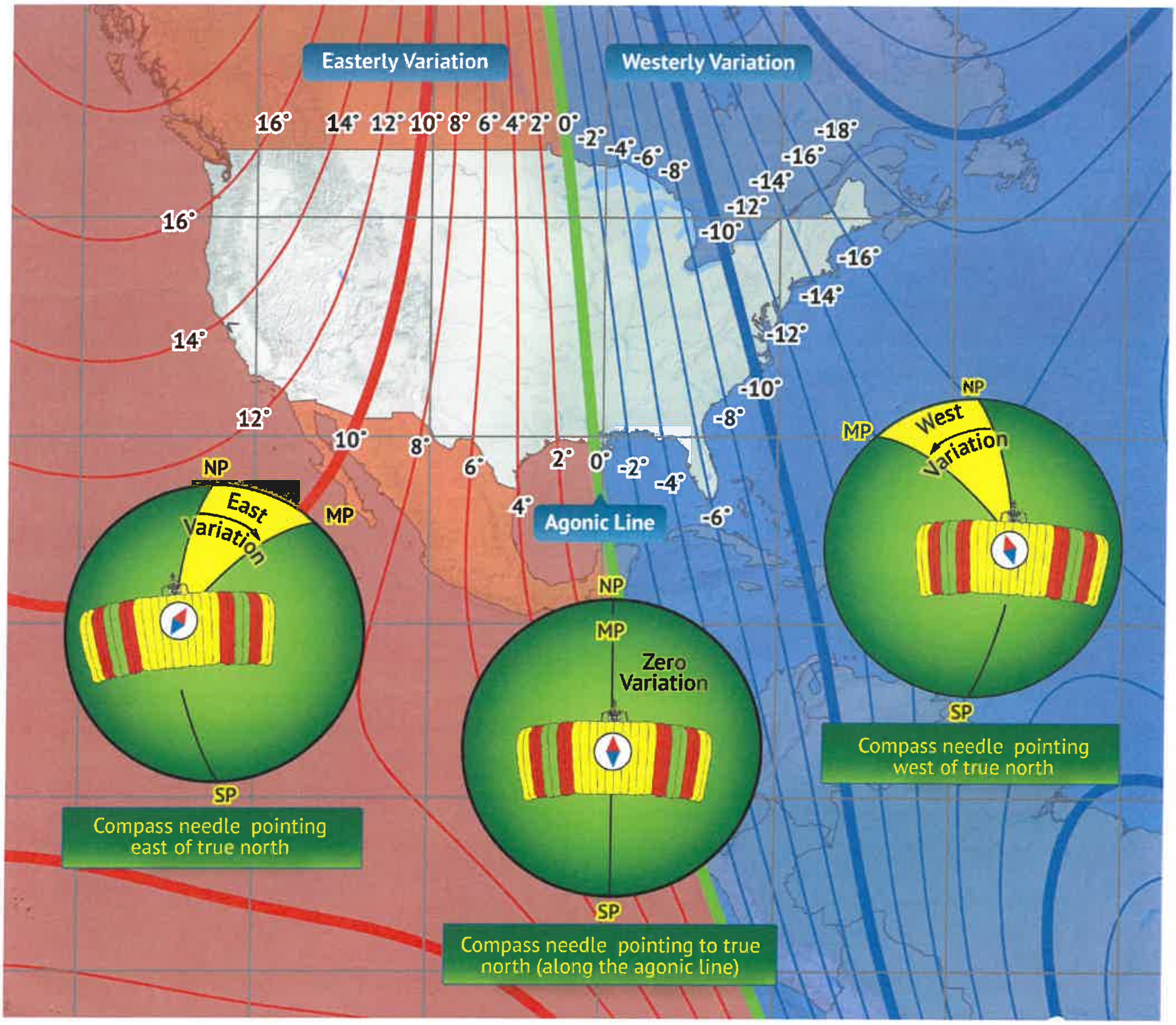
Variation

When navigating with a GPS, your calculations are based on True Heading. However, if you're using a magnetic compass, there are a few additional steps needed to determine the correct heading. The next factor to account for is Magnetic Variation—the difference between true north (TN) and magnetic north (MN). Variation is expressed as either east or west, depending on whether MN is located east or west of TN.

The north magnetic pole is near 71° North latitude and 96° West longitude, about 1,300 miles from the true north pole. If the Earth's magnetism were uniform, the compass needle would always point directly to MN, allowing us to calculate variation consistently at any meridian intersection. However, the Earth's magnetism varies, so the compass needle points slightly differently depending on your location.



Magnetic meridians are in red and blue while the lines of longitude and latitude are in black. From these lines of variation (magnetic meridians), one can determine the effect of local magnetic variations on a magnetic compass. The agonic line is green and that's where magnetic compasses read true.



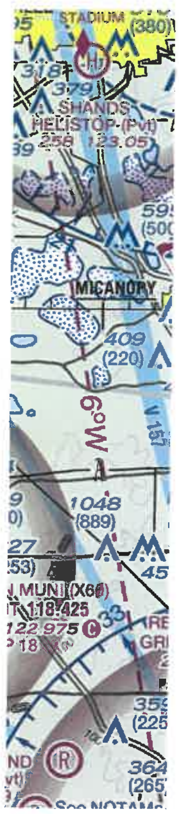
Effect of variation on the compass.

In the U.S., the variation can be several degrees. To account for this, aeronautical charts show *isogonic lines*—broken magenta lines connecting points of equal variation. The *agonic line*, where there is no variation between true and magnetic north, currently runs west of Chicago and through New Orleans. The isogonic lines may bend due to geological factors affecting magnetic fields.

On the west coast of the U.S., MN is east of TN, while on the east coast, MN is west of TN. Courses are measured in reference to geographical meridians (true north), but since the compass aligns with magnetic meridians (magnetic north), you must adjust the true course to get the correct magnetic heading. This is done by adding or subtracting the variation indicated by the nearest isogonic line.

For example, with a 9°E variation, you subtract 9° from a true heading of 360°, yielding a magnetic heading of 351°. Similarly, to fly east, subtract 9° from 090°, giving you a magnetic heading of 081°. To fly west, subtracting 9° from 270° results in 261°.

To convert a true heading to a magnetic heading, remember: if the variation is east, subtract; if it's west, add. An easy way to recall this is the phrase: *"east is least (subtract), and west is best (add)."*



Straight, dashed, magenta lines indicate lines of variation. This line indicates 6° West.

FOR (MAGNETIC)..........	N	30	60	E	120	150
STEER (COMPASS).......	0	28	57	86	117	148
FOR (MAGNETIC)..........	S	210	240	W	300	330
STEER (COMPASS).......	180	212	243	274	303	332

Compass deviation card.

Deviation

Using variation to determine the magnetic heading is a key intermediate step in finding the correct compass heading for a flight. However, you must also account for *deviation*—a deflection caused by magnetic influences inside the aircraft, such as:

- Electrical Circuits
- Radios
- Lights
- Magnetized Parts

Deviation varies between aircraft and even across different headings in the same aircraft. For example, if the engine's magnetism pulls the north end of the compass, the reading may be accurate on a northerly heading but incorrect on easterly or westerly headings.

To reduce this error, adjustments (called *compensation*) can be made by a skilled technician, but some residual deviation will remain and must be corrected by the pilot. Since magnetic forces in the aircraft can change over time—due to vibrations, mechanical work, or equipment changes—pilots should periodically check the compass deviation, a process known as *swinging the compass*.

Swinging the compass involves placing the aircraft on a *magnetic compass rose* (usually found on the ramp at airports). With the engine running and electrical devices turned on, the aircraft is aligned with magnetic north, and the compass reading is recorded. The aircraft is then aligned at 30° intervals, and each reading is noted. If flying at night, the lights are switched on to check for any further deviations. These readings are listed on a *deviation card* mounted near the compass, showing corrections (additions or subtractions) needed for different headings.

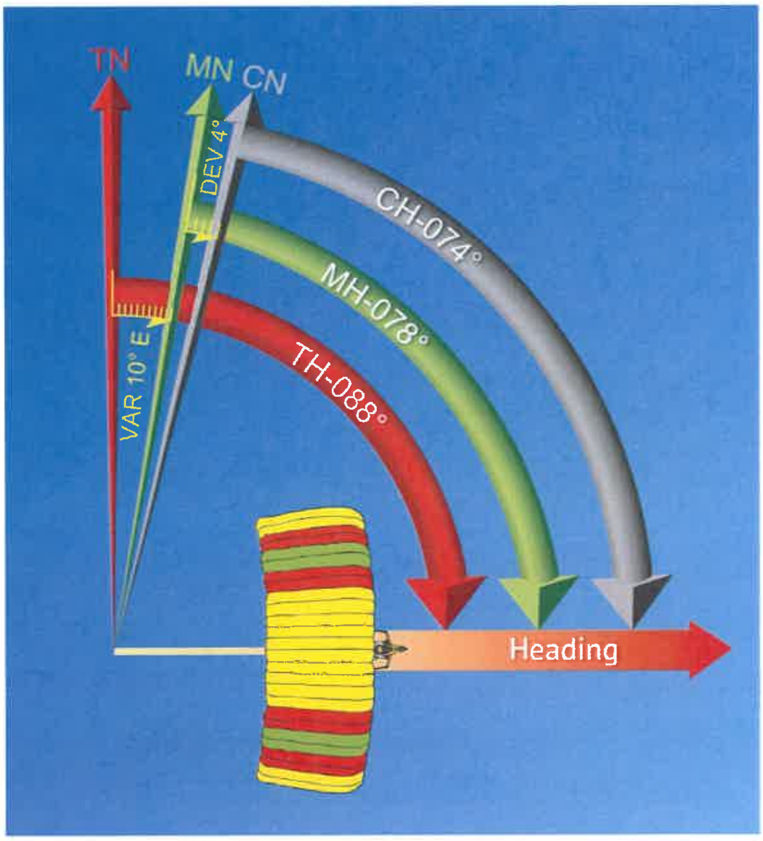
A pilot can also check compass accuracy by comparing it to known runway headings. For intermediate headings not listed on the deviation card, a pilot can mentally interpolate. For example, if the correction for 180° is 0° and for 210° is +2°, the correction for 195° would be approximately +1°.

The corrected heading, after factoring in deviation, is known as the *compass heading*. Pilots often follow this sequence to find it:

True Heading (TH) ± Variation (V) =
Magnetic Heading (MH) ± Deviation (D) =
Compass Heading (CH)

After applying both the variation and deviation corrections, the compass heading can be used to navigate to your destination via dead reckoning.

This is valuable information for passing the knowledge test. However, most powered parachutes aren't equipped with magnetic compasses. Most of the time powered parachute pilots navigate using GPS instead of compasses. That will be covered at the end of the chapter.



Relationship between true, magnetic, and compass headings for a particular instance.

Other Calculations

Determining your heading before a cross country flight is the most difficult part of the planning process. After that's completed, then other basic calculations can be made for your journey. You need to be able to make calculations for time, speed, distance, and the amount of fuel required.

Converting Minutes to Equivalent Hours

When solving speed, time, and distance problems, it's often necessary to convert minutes into hours. To do this, divide the number of minutes by 60, since there are 60 minutes in an hour. For example, 30 minutes is equivalent to 30/60 = 0.5 hours. Conversely, to convert hours to minutes, multiply by 60. For instance, 0.75 hours is equal to 0.75 x 60 = 45 minutes.

Estimated Time En Route (ETE), Distance (Dist), and Groundspeed (GS) are closely related. If you know any two of these variables, calculating the third is straightforward. Typically, you'll know both the groundspeed and the distance.

Estimated Time En Route (ETE) = Dist/GS To estimate the time (T) it will take you to make a flight, divide the distance (Dist) by the groundspeed (GS). The time to fly 45 nautical miles at a groundspeed of 30 knots is 45 divided by 30, or 1.5 hours. (The 0.5 hour multiplied by 60 minutes equals 30 minutes.) Answer: 1:30.

Distance Dist = GS x T To find the distance flown in a given time, multiply groundspeed by time. The distance flown in 1 hour 45 minutes at a groundspeed of 30 knots is 30 x 1.75, or 52.5 nautical miles.

Groundspeed GS = Dist/T To find the groundspeed, divide the distance flown by the time required. If a powered parachute flies 60 nautical miles in three hours, the groundspeed is 60 divided by 3 = 20 knots.

Converting Knots to Miles per Hour

Another important conversion is between knots and miles per hour. While aviation primarily uses knots, powered parachute pilots often use miles per hour. Many GPS units in powered parachutes are calibrated in miles per hour, though aviation models display both. You need to understand how to convert between the two since calculations need to stay consistent, either using miles and mph or nautical miles and knots.

A knot is one nautical mile per hour. Since a nautical mile is 6,076.1 feet and a statute mile is 5,280 feet, the conversion factor from knots to miles per hour is 1.15. Therefore, to convert knots to miles per hour, simply multiply by 1.15. For instance, a wind speed of 20 knots is equivalent to 23 miles per hour.

Most flight computers or calculators include a conversion function, and another quick method is using the nautical and statute mile scales found at the bottom of aeronautical charts.

Fuel Consumption

Fuel considerations are an important part of flight planning. After you determine the course and how long it will take you to fly the course, you need to make sure that you have enough fuel (and fuel capacity!) to complete the flight. And you should take along more fuel than just the amount it takes you to get to your destination. It's hard to predict things like increasing headwinds and it's just as difficult to pull over and gas up if your engine starts sputtering mid-flight.

The fuel burn rate (Rate) of a powered parachute is calculated in gallons per hour (GPH). To determine the fuel needed for a flight, you must first calculate the estimated time en route (ETE). Multiply the ETE by the fuel burn rate to get the total fuel required. For example, if you're flying 36 nautical miles at a groundspeed of 24 knots, the flight will take 1.5 hours. If your engine consumes 5 gallons per hour, the total fuel consumption will be 1.5 x 5, or 7.5 gallons.

The fuel burn rate of a powered parachute is influenced by several factors: engine condition, propeller pitch, RPM, fuel mixture richness, and the percentage of horsepower used during cruise. You can estimate the consumption rate using cruise performance charts or personal experience. In addition to the fuel needed for your planned flight, always carry enough for a reserve.

Unlike airplanes or helicopter pilots, you have no legal minimum amount of fuel you're required to carry on a cross-country flight. However, the minimums required for an airplane flight seem reasonable. Plan enough fuel to complete the flight and then give yourself at least another half-hour's worth of fuel in case things don't go according to your plan.

§ 91.151 Fuel requirements for flight in VFR conditions.

(a) No person may begin a flight in an airplane under VFR conditions unless (considering wind and forecast weather conditions) there is enough fuel to fly to the first point of intended landing and, assuming normal cruising speed -

(1) During the day, to fly after that for at least 30 minutes; or

(2) At night, to fly after that for at least 45 minutes.

(b)...

Flight Computers

So far, we've focused on geometric methods and formulas to calculate true heading, estimated time en route, groundspeed, and fuel consumption. However, for practical flight planning, an electronic flight computer is much more efficient. These devices handle a wide range of calculations needed for flight planning and navigation. While some pilots may be familiar with the mechanical E6B flight computer, it's not useful for powered parachute pilots due to its inability to calculate heading and ground speed problems for aircraft with our low flight speeds. An electronic flight computer, though more expensive, is far more versatile and easier to use.

You may not even need to buy one—there are phone apps and flight planning software that offer the same functionality. However, phone apps can't be used during the knowledge test, so you might consider purchasing an electronic flight computer or borrowing one from your instructor or a friend for that purpose.

Flight Planning

Flight planning isn't just a good idea, it's cooked into the regulations. It's a part of your preflight process. If you're leaving the airport, then your planning must include information on available current weather reports and forecasts, fuel requirements, and alternatives available if your planned flight cannot be completed.

Assembling Your Material

You should collect the necessary material well before the flight.

- Appropriate and Current Sectional Chart
- Chart Supplement U.S.
- Electronic Calculator
- Plotter
- Fuel
- Appropriate Clothing for You and Your Passenger
- Emergency Supplies

Weather Check

Before you commit too much time and energy to planning a particular flight, you should check weather forecasts. You want to know if the flight is feasible. *Chapter 15, "Weather Information,"* discusses how to obtain a weather briefing.

Chart Supplement U.S.

Before landing at any airport, it's important to study all relevant information, including NOTAMs and the Chart Supplement U.S. This review should cover key details like location, elevation, runway and lighting facilities, available services, aeronautical advisory frequencies (UNICOM), fuel types, control tower and ground control frequencies, traffic patterns, and any other pertinent information. Airport NOTAMs, which are updated every 28 days, provide critical updates on hazardous conditions or changes that may have occurred since the last Airport/Facility Directory was published.

Additionally, check the sectional chart bulletin for significant changes since the last publication of each sectional chart being used. Sectional charts are valid for 56 days, and their effective date is shown at the top of the front page. In case of discrepancies between the Chart Supplement U.S. and the back of the chart, always rely on the Chart Supplement for the most up-to-date information.

Each airport listing in the Chart Supplement U.S. typically includes a contact number for the airport manager. If you're unfamiliar with the airport, it's a good idea to call the manager in advance. This gives you the chance to::

- Confirm if there are any established powered parachute operations at the airport.
- Learn about local procedures for powered parachutes.
- Identify the best runways or turf areas for powered parachute operations.
- Establish rapport with the airport manager and/or tower personnel.

§ 91.103 Preflight action.

Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include:

(a) For ... a flight not in the vicinity of an airport, weather reports and forecasts, fuel requirements, alternatives available if the planned flight cannot be completed, and any known traffic delays of which the pilot in command has been advised by ATC;

(b) For any flight, runway lengths at airports of intended use, and the following takeoff and landing distance information:

(1) ...

(2) For civil aircraft ... reliable information appropriate to the aircraft, relating to aircraft performance under expected values of airport elevation and runway slope, aircraft gross weight, and wind and temperature.

Aircraft Flight Manual or Pilot's Operating Handbook

Check the Powered Parachute Aircraft Flight Manual (AFM) or Pilot's Operating Handbook (POH) to verify proper loading, including weight and balance data. Remember, usable fuel contributes to the total gross weight. Also, account for the weight of your passenger, cargo, and the empty weight of your powered parachute to ensure you don't exceed the maximum allowable weight. Always use the latest weight and balance figures for that powered parachute to get accurate empty weight and center of gravity details.

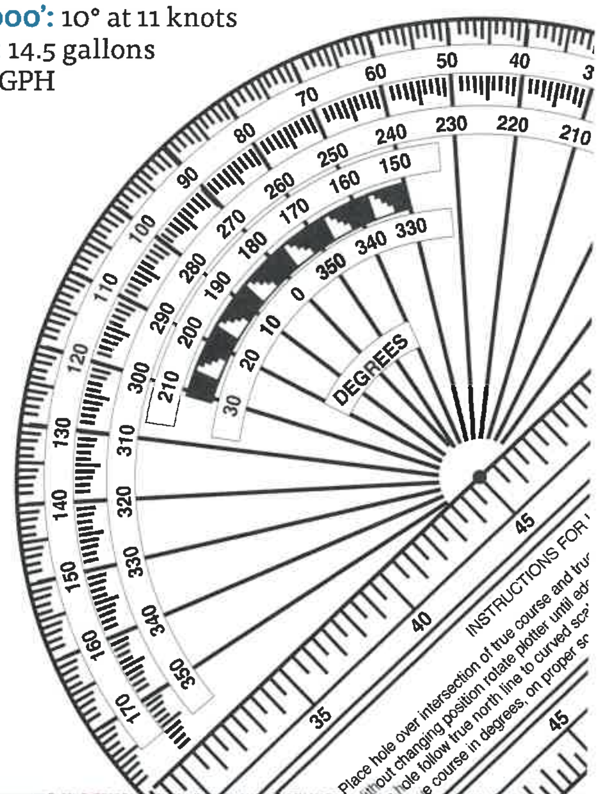
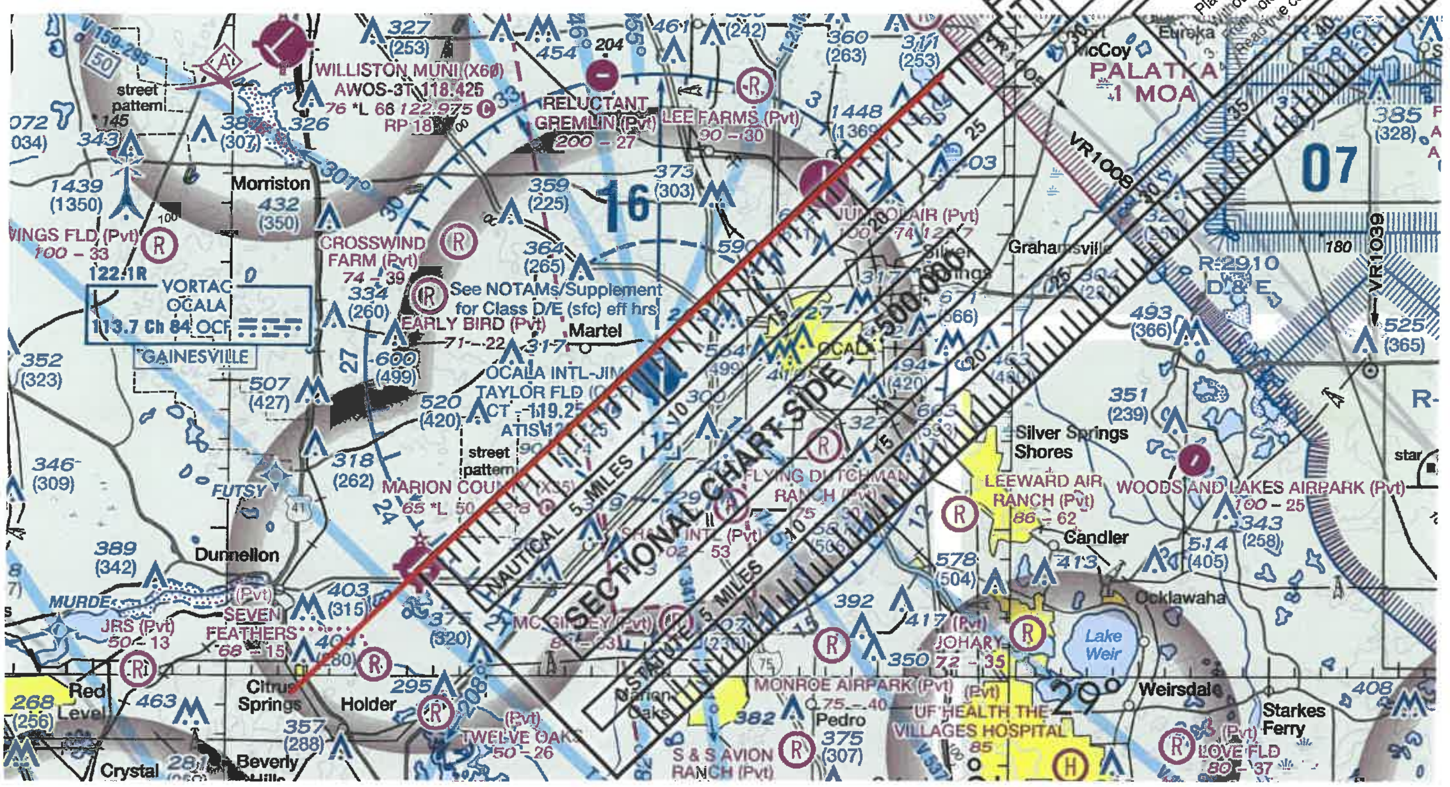
Consult the appropriate charts to determine takeoff and landing distances, factoring in load, airport elevation, and temperature. Heavier loads, higher elevations, and increased temperature or humidity will lengthen the takeoff and landing rolls and reduce climb performance. Ensure the runway is sufficient for safe operation under these conditions.

Review engine documentation for fuel consumption rates at your expected altitude and power settings. Calculate fuel consumption and compare it to your estimated flight time, planning refueling stops if necessary. Always consider weather conditions and any unexpected delays to avoid fuel shortages.

Sample Flight Planning

After checking the weather and completing preliminary planning, it's time to plan your flight. The next sections outline a logical sequence for charting the course, filling out a flight planning sheet, and filing a flight plan. The example uses the data below and the sectional chart excerpt.

Route of Flight: Marion County Airport (X35) direct to Jumbolair Airport (Pvt) and return
True Airspeed (TAS): 26 knots
Surface Winds: 340° at 5 knots
Winds at 500': 360° at 10 knots
Winds at 2,000': 10° at 11 knots
Usable Fuel: 14.5 gallons
Fuel Rate: 5 GPH

Steps in Charting the Course

This is how you can plan a cross country flight. As you obtain information for the flight, you should copy that information onto a flight planning sheet. I use a simplified planning sheet developed for powered parachute flying that can be folded and put on a kneeboard. The data you gather is what you need to input into the electronic flight planning calculator to determine groundspeed, wind correction angle, time of the flight, fuel required and more. The results from your calculations also have a place on the flight planning sheet.

Course Line

First draw a line from Marion County Airport (point A) directly to Jumbolair Airport (point B). The course line should begin at the center of the airport of departure and end at the center of the destination airport. If the route is direct, the course line will consist of a single straight line. If the route is not direct, it will consist of two or more straight line segments. You do this if there's something you don't want to fly over like controlled airspace or a hazard like a large body of water. In this case, we'll plan our flight directly over the top of Class D airspace and Ocala International Jim Taylor Field (OCF). Since we're flying under sport pilot rules with no endorsement for flying into controlled airspace, we'll need to stay clear of the Class D airspace. That airspace ends at 1,500 feet MSL, so we'll want to fly at about 2,000 feet over the field.

From the course line we get two important pieces of information using our plotters:

True Course: 52°
Distance: 19 NM

If you were planning a flight near open water, you would either want to go around the body of water or go over it at an altitude high enough that you could glide to a shore if the engine failed. Glide ratios vary for powered parachutes and you should know your glide ratio in case of engine failure. So as an example, say you wanted to fly over a two-mile-wide lake and the powered parachute had a glide ratio of 4:1, meaning that with the engine turned off, it glides four feet forward for every foot it drops. The worst case for an engine out would be if the engine failed over the middle of the lake meaning that you would have to glide over a mile of water to safety. With the 4:1 glide ratio, you would want to be at least ¼ of mile above the surface of the lake, or 1,320 feet AGL. Personally, I would want at least a few hundred feet more altitude to make sure that I could make it safely to shore.

§ 91.153 VFR flight plan: Information required.

(a) Information required. Unless otherwise authorized by ATC, each person filing a VFR flight plan shall include in it the following information:
- (1) The aircraft identification number and, if necessary, its radio call sign.
- (2) The type of the aircraft or, in the case of a formation flight, the type of each aircraft and the number of aircraft in the formation.
- (3) The full name and address of the pilot in command or, in the case of a formation flight, the formation commander.
- (4) The point and proposed time of departure.
- (5) The proposed route, cruising altitude (or flight level), and true airspeed at that altitude.
- (6) The point of first intended landing and the estimated elapsed time until over that point.
- (7) The amount of fuel on board (in hours).
- (8) The number of persons in the aircraft, except where that information is otherwise readily available to the FAA.
- (9) Any other information the pilot in command or ATC believes is necessary for ATC purposes.

(b) Cancellation. When a flight plan has been activated, the pilot in command, upon canceling or completing the flight under the flight plan, shall notify an FAA Flight Service Station or ATC facility.

Variation

The magnetic variation for this flight can be pulled directly from the sectional. It is 6°W.

Establish Checkpoints

Appropriate checkpoints should be selected along the route and noted in some way. These should be easy-to-locate points, such as large towns, large lakes and rivers, or combinations of recognizable points, such as towns with an airport, towns with a network of highways, and railroads entering and departing.

Normally, choose only towns indicated by splashes of yellow on the chart. Don't choose towns represented by a small circle—these may turn out to be only a half-dozen houses. (In isolated areas, however, towns represented by a small circle can be prominent checkpoints.) For this trip, four checkpoints have been selected. Checkpoint 1 consists of a pair of towers located southeast of the course and can be further identified by the road they're on, which parallels the course at this point. Checkpoint 2 is the Ocala International Airport, which you will be flying directly over. Checkpoints 3 and 4 are groups of towers, which you will again fly directly over.

Review the Course

You should check the course and areas on either side of the planned route to determine if there's any type of airspace with which you should be concerned or which has special operational requirements. For this trip, the course passes over the Class D airspace surrounding the Ocala International Airport. That means that you'll want to have the control tower frequency handy in order to talk to them while near their facility.

Minimum Safe Altitudes

Study the terrain and obstructions along the route. This is necessary to determine the highest and lowest elevations, as well as the highest obstruction to be encountered so an appropriate altitude that conforms to 14 CFR part 91 regulations can be selected.

One of the enjoyable aspects of flying a powered parachute is the ability to fly low and slow, although slow really isn't that much of an option. Low ends up being the option. Low altitudes allow you to see the world in detail, wave at people, and get caught in power lines. Indeed, there are downsides to flying too low, especially on a cross-country when you're away from your home field and flying over unfamiliar territory.

There are regulatory minimums and we'll get to those. But maybe more important, there are also minimums that are a function of safety. When choosing an area to fly low over, you should first be familiar with it. You need to ask questions like:

- Is this area safe to fly low over?
- Is this area legal to fly low over?
- Am I going to be rude or upsetting to people on the ground?

Power lines seem to be the hazards that powered parachute pilots get caught in the most. Power lines become almost invisible in certain light conditions. If there's any wind, mechanical turbulence also must be considered. Fly too low and you can get caught in winds that will put you on the ground or worse.

Check your route for particularly rugged terrain so it can be avoided. Areas where a takeoff or landing will be made should be carefully checked for tall obstructions. Television transmitting towers may extend to altitudes over 1,500 feet above the surrounding terrain. You must be aware of their presence and location. For the trip we're planning to Jumbolair, notice that the tallest obstruction is an antenna directly to the east of the Jumbolair Airport which is 1,369' tall.

Flying low also may not be welcome to those on the ground. Normally the first time someone sees a powered parachute from the ground, it's kind of exciting and fun. After the fiftieth time overflying the same house, you may be inadvertently making an enemy out of someone you don't even know.

If your flight will be at an altitude more than 3,000 feet above the terrain, you must follow specific cruising altitudes based on your direction of flight. These altitudes help maintain safe separation between aircraft traveling in opposite directions. Following these rules is required to ensure safe and organized air traffic flow.

Legal Minimums for Light Sport Aircraft Powered Parachutes

For § 91.119, the FAA divides the world into *congested* and *other than congested* areas. Unfortunately, they don't have a hard and fast rule about which one is which. If you're over town, that's obviously *congested*. If you're flying over a cornfield, that's obviously *other than congested*. Anything in between is subject to interpretation by the FAA and ultimately a judge, so it's good to err on the side of caution. Besides, overflying people and homes at low altitudes lacks courtesy, especially if done regularly.

Powered parachutes flying under the sport pilot rules can fly over congested areas (even cities) if they can land safely if the power quits. That usually means flying pretty high. But there are other rules that are found in § 91.119.

§ 91.119 Minimum safe altitudes: General.

Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

(a) Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

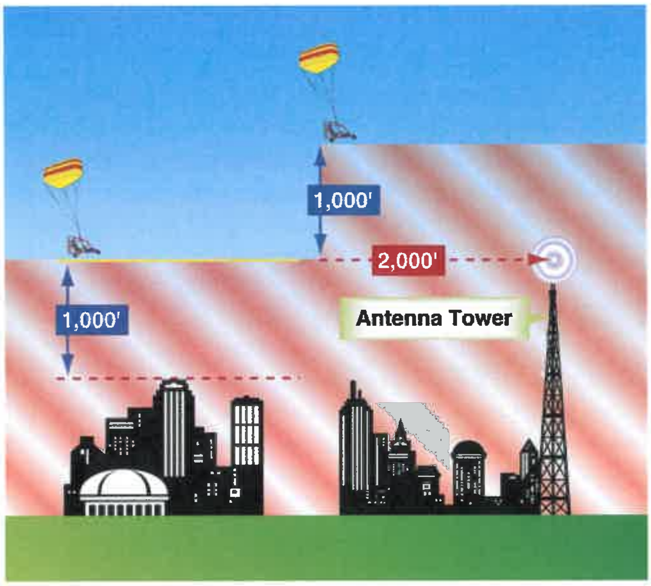
(b) Over congested areas. Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

(c) Over other than congested areas. An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.

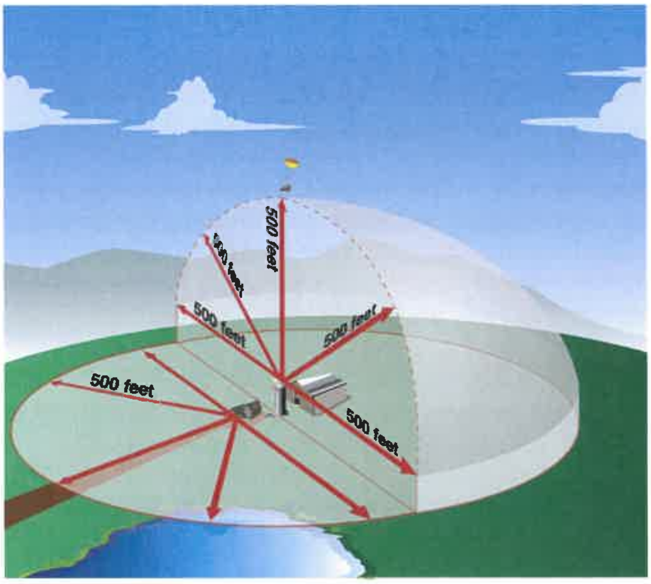
(d) Helicopters, powered parachutes, and weight-shift-control aircraft. If the operation is conducted without hazard to persons or property on the surface -

(1)...

(2) A powered parachute or weight-shift-control aircraft may be operated at less than the minimums prescribed in paragraph (c) of this section.



Minimum altitudes for light sport aircraft over congested areas. Ultralights can't fly over congested areas at all.



Recommended minimum altitude over non-congested areas.

For powered parachutes, this condenses down to:

Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

Over congested areas. Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

Over other than congested areas. If the operation is conducted without hazard to persons or property on the surface, a powered parachute or weight-shift-control aircraft may be operated at less than 500 feet above the surface and less than 500 feet away from any person, vessel, vehicle, or structure over open water or sparsely populated areas.

(This sounds confusing until you realize that this was written in such a way that prevents airplanes, gliders, and gyroplanes from flying this close to people or property on the ground. That's a privilege we get because of our lower speed. But it isn't anything you want to abuse because regulations can be changed if there are enough complaints!)

§ 103.15 Operations over congested areas. No person may operate an ultralight vehicle over any congested area of a city, town, or settlement, or over any open air assembly of persons.

Legal Minimums for Ultralight Pilots

Ultralight powered parachutes must be vigilant when planning cross country trips to avoid flying over congested areas. The rule pertaining to ultralights is § 103.15, Operations over congested areas. It says, *"No person may operate an ultralight vehicle over any congested area of a city, town, or settlement, or over any open air assembly of persons."*

Cities seem pretty easy to define, but what is an *"open air assembly of persons?"* Is it 100 people? A dozen? Two? Truth is, that's defined by the FAA themselves and the civil courts. A few years ago an ultralight pilot was fined for flying over an interstate. I'm not sure whether it was considered congested or an open air assembly of cars.

Prevailing Winds

For powered parachutes, wind is almost always an issue. When flying upwind, it's usually best to fly at low altitudes in order to take advantage of the generally lighter winds found at lower altitudes. When traveling downwind, a higher altitude is actually some help since higher winds will help push you along. In any case, make sure to stay above legal minimum altitudes.

Time for the Calculator

After you've gathered the aircraft data, wind data, and course data, you're ready to do some calculations. The latest flight calculator on the market is the CX-3 Flight Computer and it's programmed with a separate menu item called, *"Plan a Leg"*. The more information you provide the calculator, the more information you'll get from it. That means that if you don't provide the value for variation (as an example), the flight computer cannot calculate a magnetic heading.

PILOT'S PLANNING SHEET

Pilot: Jack Daniels
Date and Time of Flight: Later Today
True Air Speed (TAS): 30 mph / 26 knots

Winds

Altitude	Direction (WDir)	Speed (WSpd)
Surface	340°	5 knots
500' AGL	0°	10 knots
2,000' AGL	10°	11 knots

Variation (Var): 6° West
Magnetic Deviation (Dev): N/A
Fuel Rate: 5 GPH

FIRST LEG

Destination & CTAF: Jumbolair / 122.7
Overall Distance (Dist): 19 NM
True Course (TCrs): 52°
Ground Speed (GS): 16.76 knots
Course Heading (CH): N/A
Magnetic Heading (MH): 42°
True Heading (TH): 36°
Wind Correction Angle (WCA): -16°
Fuel Required (Fuel): 5.67 US Gallons

Checkpoints

Checkpoint	Distance	Elapsed Time (ETE)
1. Ocala International	11 NM	39 minutes
2.		
3.		
4. Jumbolair / 122.7	19 NM	1 hour, 8 min.

SECOND LEG

Destination & CTAF: ______
Overall Distance (Dist): ______
True Course (TCrs): ______
Ground Speed (GS): ______
Course Heading (CH): ______
Magnetic Heading (MH): ______
True Heading (TH): ______
Wind Correction Angle (WCA): ______
Fuel Required (Fuel): ______

Checkpoints

Checkpoint	Distance	Elapsed Time (ETE)
1.		
2.		
3.		
4.		

THIRD LEG

Destination & CTAF: ______
Overall Distance (Dist): ______
True Course (TCrs): ______
Ground Speed (GS): ______
Course Heading (CH): ______
Magnetic Heading (MH): ______
True Heading (TH): ______
Wind Correction Angle (WCA): ______
Fuel Required (Fuel): ______

Checkpoints

Checkpoint	Distance	Elapsed Time (ETE)
1.		
2.		
3.		
4.		

Total Elapsed Time (ETE): ______
Total Fuel Required (Fuel): ______

Following is the information that you want to input into the calculator:

Distance (Dist)—Obtained by measuring the length of the TC line on the chart using your plotter or the scale at the bottom of the chart.

True Course (TCrs)—Direction of the line connecting two desired points, drawn on the chart and measured clockwise in degrees from true north on the mid-meridian.

True Airspeed (TAS)—Obtained from the POH.

Wind Direction (WDir)—Obtained from a weather forecast for the altitude you plan to fly.

Wind Speed (WSpd)—Obtained from a weather forecast for the altitude you plan to fly.

Variation (Var)—Obtained from the nearest isogonic line on the chart. (Added to TH if west; subtract if east.)

Deviation (Dev)—Obtained from the deviation card on the powered parachute. (Normally not available.)

Fuel Burn Rate (Rate)—Obtained from the POH.

Departure Time (Dep)—Normally an approximation.

This is the information that the calculator will probably provide for you:

Groundspeed (GS)

Compass Heading (CH or CHdg)—The reading on the compass, obtained by applying deviation to MH. (Normally not calculated.)

Magnetic Heading (MH or MHdg)—Obtained by applying variation to true heading.

True Heading (TH or THdg)—The direction, in degrees clockwise from true north, that the aircraft's nose must point to stay on course.

Wind Correction Angle (WCA)—Added to TC if the wind is from the right and subtracted if wind is from the left.

Fuel Burned (Fuel)—The amount of fuel required.

Estimated Time En Route (ETE)—Total distance divided by groundspeed. You calculate this for the entire flight, but also for each leg and each checkpoint by changing the Dist input for each checkpoint.

Estimated Time of Arrival (ETA)—Based on your departure time and the ETE.

Record the information from the calculator onto your planning sheet and carry it with you on the flight. As your trip progresses, you can note headings and times and make adjustments in heading, favorable altitudes and winds, and your ETA.

FLIGHT PLAN

1. TYPE	2. AIRCRAFT IDENTIFICATION	3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT	4. TRUE AIRSPEED	5. DEPARTURE POINT	6. DEPARTURE TIME PROPOSED (Z)	6. DEPARTURE TIME ACTUAL (Z)	7. CRUISING ALTITUDE
X VFR / IFR / DVFR	N8061K	PPC/X	26 KTS	Marion County X35	2300Z		2,000

8. ROUTE OF FLIGHT: Marion County Airport Direct to Jumbolair

9. DESTINATION (Name of airport and city)	10. EST. TIME ENROUTE HOURS	10. EST. TIME ENROUTE MINUTES	11. REMARKS
Jumbolair Airport, Ocala FL	1	02	

12. FUEL ON BOARD HOURS	12. FUEL ON BOARD MINUTES	13. ALTERNATE AIRPORT(S)	14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE	15. NUMBER ABOARD
1	8	Ocala (Emergency only)	Jack Daniels 280 Lynchburg Hwy. Lynchburg, TN 37352	2

16. COLOR OF AIRCRAFT	
Red, White, & Blue	CLOSE VFR FLIGHT PLAN WITH 1-800-WX-BRIEF FSS ON ARRIVAL

Explanation Of Visual Flight Rules (VFR) Flight Plan Items

Block	Description
1	Check the type flight plan. For all powered parachute operations, VFR should be checked.
2	Enter your complete aircraft "N" number.
3	Enter the designator for your aircraft. "PARA" is the designation for powered parachutes. We are also supposed to list special equipment here. The probable codes for powered parachutes are: • PARA/X (Powered Parachute with no transponder) • PARA/B1 (Powered Parachute with B1 ADS-B with dedicated 1090 MHz ADS-B "out" capability) • PARA/B2 (Powered Parachute with ADS-B with dedicated 1090 MHz ADS-B "out" and "in" capability)
4	Enter your true airspeed (TAS).
5	Enter the departure airport identifier code, or if unknown, the name of the airport.
6	Enter the proposed departure time in Coordinated Universal Time (UTC) (Z).
7	Enter the your VFR altitude (to assist the briefer in providing weather and wind information). But "VFR" can also be entered in this block, since the pilot will choose a cruising altitude to conform to FAA regulations.
8	Define the route of flight. If the flight is to be direct, enter the word "direct;" if not, enter the actual route to be followed such as via certain towns.
9	Enter the destination airport identifier code, or if unknown, the airport name. It may also be helpful to include the city name (or even the state name) if needed for clarity.
10	Enter your estimated time en route in hours and minutes. You can add a few minutes to the total time to allow for the climb.
11	Enter only those remarks pertinent to ATC or to the clarification of other flight plan information, such as the appropriate radiotelephony (call sign) associated with the designator filed in Block 2. Items of a personal nature are not accepted.
12	Specify the fuel on board in hours and minutes. This is determined by dividing the total usable fuel aboard in gallons by the estimated rate of fuel consumption in gallons.
13	Specify an alternate airport if desired.
14	Enter your complete name, address, and telephone number. Enter sufficient information to identify home base, airport, or operator. This information is essential in the event of search and rescue operations.
15	Enter total number of persons on board (POB) including pilot and passenger.
16	Enter the predominant parachute colors since that is what would be seen both in flight and on the ground in rescue operations.
17	Record the FSS name for closing the flight plan. If the flight plan is closed with a different FSS or facility, state the recorded FSS name that would normally have closed your flight plan. You will probably dial 1-800-WX-BRIEF to close the flight plan.
Optional	Record a destination telephone number to assist search and rescue contact should you fail to report or cancel your flight plan within 1/2 hour after your estimated time of arrival (ETA).

Filing a Visual Flight Rules (VFR) Flight Plan

Filing a flight plan isn't required by regulations, but it's a good practice. The information can assist in search and rescue in the event of an emergency.

You have at least three different ways that you can file a flight plan.

Phone: You can contact the Flight Service Station (FSS) at 1-800-WX-BRIEF and get your weather briefing, ask about temporary flight restrictions along your path and file your flight plan.

Apps: There are several flight planning apps that also include the ability to file your flight plan. This is probably the easiest if you subscribe to the right app.

Online: Flight service has an online service with a familiar-sounding domain: **1800wxbrief.com**.

When a VFR flight plan is filed, it will be held by the FSS until one hour after the proposed departure time and then canceled unless:

- The actual departure time is received.
- A revised proposed departure time is received.
- At the time of filing, the FSS is informed that the proposed departure time will be met, but actual time cannot be given because of inadequate communication.

In order to use your flight plan, you need to activate it. The best time is right before takeoff. Contact the Flight Service Station (1-800-WX-BRIEF) by cell phone and give them the takeoff time so your flight plan can be activated. Many apps also have this feature. Radio is the last possibility, but not recommended. Our radios are low power and usually don't transmit far enough to activate flight plans.

The top of the previous page shows the form you can use to file a flight plan with the Flight Service Station. When filing a flight plan by telephone, give the information in the order of the numbered spaces on the form. This enables the FSS specialist to copy the information more efficiently. Most of the spaces are either self-explanatory or not applicable to a VFR flight plan. The table below the sample flight plan details each item.

Remember, there's an advantage in filing a flight plan; but don't forget to close the flight plan on arrival. Do this by telephone by calling 1-800-WX-BRIEF.

Alternate Flight Plan

In powered parachuting, we're normally flying very short cross countries. Most pilots don't file flight plans with the FAA. Instead, they give the same information to a trusted family member or friend. You should let someone know that you're out there flying in case you run into trouble and can't make it back to the airport.

But just like a *"real"* flight plan, you want to *close it* by letting your family member or friend know when you've landed so they don't worry.

Radio Navigation

Advances in aircraft radio receivers, aeronautical charts that show the locations and frequencies of ground transmitting stations, and improved flight instruments now allow precise navigation to almost any point. While this equipment provides accuracy, you should first use it to supplement visual navigation (pilotage) to ensure you're prepared in case of equipment failure and potential disorientation.

There are three radio navigation systems available for use for VFR navigation. They are:

- VHF Omnidirectional Range (VOR)
- Nondirectional Radio Beacon (NDB)
- Global Positioning System (GPS)

GPS is the most commonly used system due to its ease, portability, affordability, and accuracy. Powered parachutes often lack even a compass, but they frequently include GPS receivers.

The GPS constellation arrangement. GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km (12,550 miles). Each satellite circles the Earth twice a day.

Global Positioning System

The global positioning system (GPS) is a satellite-based radio navigation system providing worldwide area navigation (RNAV) guidance. Both portable and permanently installed GPS units are commonly used in powered parachutes. Permanently mounted aviation GPS receivers often come with extensive navigation databases. However, many pilots opt to use GPS apps on their phones or tablets, ranging from basic to advanced functionalities.

GPS was developed and is operated by the U.S. Department of Defense (DoD), with civilian access and system status information provided by the U.S. Coast Guard.

The GPS system is composed of three major elements:

1. **The Space Segment** is composed of a baseline constellation of 24 satellites orbiting approximately 12,500 miles above the Earth. The operational satellites are often referred to as the GPS constellation. The satellites are not geosynchronous, but instead orbit the Earth in periods of 11 hours and 58 minutes. Each satellite is equipped with highly stable atomic clocks and transmits a unique code and navigation message. Transmitting in the UHF range means that the signals are virtually unaffected by weather although they are subject to line-of-sight limitations. The satellites must be above the horizon (as seen by the receiver's antenna) to be usable for navigation.
2. **The Control Segment** consists of a master control station at Falcon AFB, Colorado Springs, Colorado, five monitor stations, and three ground antennas. The monitor stations and ground antennas are distributed around the Earth to allow continual monitoring and communications with the satellites. Updates and corrections to the navigational message broadcast by each satellite are uplinked to the satellites as they pass over the ground antennas.
3. **The User Segment** consists of all components associated with the GPS receiver, ranging from smart phones to receivers permanently installed in transport aircraft. The receiver matches the satellite's coded signal by shifting its own identical code in a matching process to precisely measure the time of arrival. Knowing the speed the signal traveled (approximately 186,000 miles per second) and the exact broadcast time, the distance traveled by the signal can be inferred from its arrival time.

To solve for its location, the GPS receiver utilizes the signals of at least four of the best-positioned satellites to yield a three-dimensional fix (latitude, longitude, and altitude). A two-dimensional fix (latitude and longitude only) can be determined with as few as three satellites. GPS receivers have extensive databases. Databases are provided initially by the receiver manufacturer and are updated by the manufacturer or a designated data agency.

Initialization of the receiving unit will take some time and should be accomplished prior to flight. If the unit has not been operated for several months or if it has been moved to a significantly different location (by several hundred miles) while off, this may require several additional minutes. During initialization, the unit will make internal integrity checks, acquire satellite signals, and display the database revision date. While the unit will operate with an expired database, the database should be current, or verified to be correct, prior to relying on it for navigation.

VFR navigation with GPS can be as simple as selecting a destination, normally an airport or a waypoint, and placing the unit in the navigation mode. Course guidance provided will be the shortest distance to the destination. Advanced units and apps provide advisory information about special use airspace and minimum safe altitudes, along with extensive airport data, ATC services and frequencies.

When using any sophisticated and highly capable navigation system, such as GPS, there is a strong temptation to rely almost exclusively on that unit, to the detriment of using other techniques of position keeping. The prudent pilot will never rely on one means of navigation when others are available for cross-check and backup.

Tips for Using GPS for VFR Operations

Using a GPS for VFR operations can greatly enhance navigation, but it's essential to use the system properly and understand its limitations. While GPS technology provides accuracy and convenience, it should always be treated as a supplement to visual navigation and thorough preflight planning. The following tips will help you get the most out of your GPS while ensuring a safe and enjoyable flight.

Verify Database Currency: Ensure your GPS database is up to date. If the database is expired and cannot be updated, avoid using the moving map display for critical navigation decisions.

Be Prepared for Signal Loss: Hand-held GPS receivers offer great navigation capabilities, but you should be prepared for sudden signal loss, sometimes without warning. If installing a GPS in an SLSA powered parachute, comply with 14 CFR Part 43. Experimental and ultralight aircraft have no such restrictions.

Plan Ahead: Thoroughly plan your flights before takeoff. Enter user-defined waypoints ahead of time, not during flight, and verify your route against current sectional charts. Avoid using waypoints created by others without verification to prevent navigation errors.

Minimize Head-Down Time: Reduce the time spent looking at your GPS during flight. Stay alert for traffic, terrain, and obstacles. Proper preparation on the ground reduces distractions in the air.

Learn Your GPS: Familiarize yourself with your GPS receiver's functions. Many receivers aren't intuitive, so take time to learn the necessary operations before flight. Some manufacturers provide tutorials or simulations—use them to master your unit.

Don't Over-Rely on GPS: While GPS is a powerful tool, don't rely entirely on it for VFR navigation. Unless it's an IFR-certified unit, GPS accuracy and integrity aren't guaranteed. Ultimately, the pilot is responsible for navigating the aircraft.

Lost Procedures

Getting lost in a powered parachute is a potentially dangerous situation, especially when low on fuel or the weather is changing. If you become lost, there are some good commonsense procedures to follow.

Stay Calm: Remain calm and composed so you can think clearly and avoid panic.

Aviate, Navigate, Communicate: You must first control your aircraft, then determine your position, and finally communicate your situation if appropriate.

Navigation Systems: Remember the tools you have on board, such as a sectional, a GPS or a smart phone, to ascertain your position and chart a course to a known location. If equipped, use these systems to navigate back to a recognized point or toward a suitable airport.

Maintain an Appropriate Heading and Climb if Necessary: To prevent further disorientation, you should maintain a straight course. If you can't see a town or city, the first thing to do is climb, being mindful of traffic and weather conditions. Depending on the situation, climbing can help increase visibility and provide you with a better chance of spotting recognizable landmarks. An increase in altitude also increases your radio range.

Reversing Course: If possible, you may choose to reverse your flight path and return to a known point, such as the departure airport.

Identify Prominent Landmarks: If visibility permits, pilots should scan the terrain for prominent landmarks, such as major roads, rivers, cities, or geographical features. Water towers normally have the name of the town painted on them. Finding a *rail*, that is a landmark of some length like a road, river, railroad, coastline or high tension power lines, is very useful if you can follow it to a known point.

Flight Diversion

A flight diversion is something you do when you need to alter your planned route during a cross-country to an alternative destination due to factors like unexpected weather, system malfunctions, airspace restrictions, or emergencies. At some point, you may be unable to reach your intended destination, so it's crucial to be prepared to divert safely and efficiently.

Before embarking on a cross-country flight, review charts for nearby airports or suitable landing areas along your route. If a diversion becomes necessary, you'll need to compute course, time, speed, and distance—similar to preflight planning but in a more constrained environment. Given the limited space in the flight deck, wind conditions, and the need to monitor other aircraft while flying, use shortcuts and rule-of-thumb calculations whenever possible.

In-flight, plotting a full course on a sectional chart with checkpoints is usually impractical. Instead, select the most appropriate alternate destination and approximate your course using the chart. If possible, begin your diversion over a prominent ground feature for better reference. In emergencies, head toward your alternate immediately without delay.

Once you're on course, note the time and use the nearest winds aloft data to calculate your heading and groundspeed. Based on this, estimate your new arrival time and fuel consumption. Throughout the diversion, prioritize flying the powered parachute while balancing navigation and planning. When choosing an altitude, consider factors like cloud heights, wind conditions, terrain, and radio reception.

And don't forget, sometimes the best alternative is to turn around and return to the airport you started from.

Lost? Look for a water tower. Most towns have them and they normally come labeled with the towns' names for your convenience! Another thing to look for is a major road like an interstate.

Chapter 27 Emergency Procedures

Flight involves the potential for unexpected challenges, both in the air and on the ground. This chapter is dedicated to preparing you for the unforeseen—covering both in-flight emergencies and survival strategies in case you find yourself landing away from an airport.

By mastering emergency procedures, you'll boost your confidence and ability to handle unexpected situations with composure. Preparation is crucial for overcoming unforeseen challenges. While it may seem overly cautious, many pilots anticipate potential issues by considering what could go wrong during a flight. They prepare by studying these scenarios on the ground, mentally rehearsing their responses, creating a list of situations to avoid, and, in some cases, investing in equipment to survive emergencies they hope never to face. This proactive approach helps prepare them for the unexpected.

Preparing for Emergencies

Flying, while generally safe, requires a thorough understanding of emergency procedures to ensure your safety and that of your passenger. Whether it's an engine failure, avionics malfunction, or adverse weather conditions, knowing how to respond promptly and effectively is paramount.

Reviewing Your Aircraft's POH for Emergency Preparedness

Successfully managing an emergency or preventing it from becoming a true emergency requires a thorough understanding of and adherence to the procedures outlined by the aircraft manufacturer. Guidelines in this book are by necessity generic and you shouldn't substitute them for the manufacturer's recommended procedures. Instead, this chapter aims to supplement your general knowledge in emergency operations.

The Pilot's Operating Handbook (POH) should have information specific to your powered parachute. Familiarize yourself with the necessary pilot actions required for various system and equipment malfunctions. The POH can help you be prepared to analyze and act if you experience any of the following malfunctions:

Engine/Oil and Fuel Issues: Understand the procedures to address engine, oil, or fuel-related problems.

Electrical Malfunctions: Learn the steps to manage electrical system malfunctions effectively. Some ignition systems rely on a charging system while others do not.

Carburetor or Induction Icing: Be aware of protocols for handling carburetor or induction icing situations.

Smoke and Fire Incidents: Know the correct responses to manage smoke or fire emergencies.

Flight Control and Flight Trim Problems: Understand how to handle issues related to flight control and trim systems.

Flight Instruments: Familiarize yourself with procedures for malfunctions affecting flight instruments.

Propeller Challenges: Learn the steps to take in the event of a propeller-related malfunction.

Ballistic Recovery System Malfunction (if applicable): If your powered parachute is equipped, know the procedures for dealing with any issues related to the ballistic recovery system.

Other Unique Emergencies: Be aware of any emergency situations unique to the specific powered parachute you are flying.

By reviewing and internalizing these procedures from your POH, you enhance your ability to respond effectively to diverse emergency scenarios. Stay informed and be prepared for any challenge you might encounter during your flights.

Reviewing Other Chapters

Some emergencies are covered in this book, but in other chapters. For example, lost procedures and flight diversion techniques are covered in *Chapter 26, "Navigation."* For a quick review:

Lost Procedures: In case you find yourself disoriented, it's essential to act decisively. Maintain an appropriate heading and climb if needed. Identify prominent landmarks to re-establish your bearings. Use your sectional or GPS and, if appropriate, ask your passenger to help locate landmarks.

Flight Diversion: Being able to select an alternate airport or landing area is a skill you must master. Assess the fuel available for a safe flight to the alternate destination. Turn to and establish a course to the selected alternate, ensuring you maintain the appropriate altitude and heading throughout.

Blown takeoffs are discussed in *Chapter 20, "Departures and Climbs."* Additionally, *Chapter 12, "Weather Theory,"* and *Chapter 13, "Wind and Turbulence,"* address factors that could potentially lead to emergencies. Carburetor icing is covered in *Chapter 9, "Engines."*

Accidents

Statistics show that about 85 percent of accidents occur during takeoff, 10 percent during landing, and 5 percent in flight. Surprisingly, complacency plays a significant role in many of these incidents. The simplicity of flying a powered parachute can create a false sense of security, causing pilots to become too relaxed. If you find yourself becoming complacent, it's important to shift your focus back to situational awareness and minimize distractions.

The ease of flying a powered parachute has many advantages, but these same benefits can sometimes lead to a more casual approach to flying:

Delayed Reactions: The nature of a powered parachute doesn't demand rapid responses, potentially leading to a sense of complacency.

Comparatively Slow Speeds: When compared to other Light-Sport Aircraft (LSA), a powered parachute tends to fly at slower speeds, which may contribute to a relaxed mindset.

Limited Direct Control Axes: With only two direct control axes (lateral-pitch and vertical-yaw), controlling a powered parachute is straightforward.

Intuitive Controls: Powered parachute controls are intuitive – push right to go right, left to go left, increase throttle to ascend, and decrease throttle to descend.

Pendulum Stability: The aircraft seeks to fly straight-and-level which reduces the workload and can increase complacency.

Maintaining a high level of situational awareness is crucial during flight to prevent distractions from impacting your focus. Here's how you can mitigate the risk of in-flight accidents:

Obstruction Awareness: You may inadvertently overlook power lines and tower cables, leading to potential accidents. Stay vigilant and actively scan your surroundings to identify any obstacles.

Weather Anticipation: Failure to anticipate weather-related turbulence can have adverse effects on your aircraft. Be proactive in assessing weather conditions to avoid wind rotors or mechanical turbulence.

Landing Safety: Landing accidents often result from factors like porpoising (quick throttle movements), thermals, or challenging field terrain. Exercise caution during landings to prevent mishaps.

Takeoff Precautions: Takeoff issues can arise from neglecting essential steps, such as ensuring that the wing is properly kited before applying power and taking off into the wind.

Ground Emergencies

Emergencies can arise before you even start flying. Or they can arise after you believe you've safely landed. There are two main types of emergencies, the out-of-control wing and an engine that won't shut down.

Wing Caught in the Wind

When stationary on the ground, winds can unexpectedly lift the wing of an unsecured powered parachute. The *out-of-control* wing can roll the aircraft roll over or even carry it away, especially if the aircraft is unmanned or the engine is running. This can be dangerous to others on the runway, damaging to the aircraft, and can hurt you if you grab hold of the wrong part of the aircraft while attempting to prevent it from getting away.

Prevention

By taking preventative measures to secure your powered parachute in challenging wind conditions, you can keep an emergency from developing. Here's what you can do immediately after landing to secure your powered parachute's wing, minimize exposure and prevent it from being damaged:

Swiftly Secure the Wing: Right after landing, take immediate steps to secure the wing. Whether you plan to refuel or have other tasks, minimize the time the wing is exposed to the elements. The most basic way to secure a wing is to tie at least one of the steering lines to the airframe. Don't go halfway, tie a generous amount of steering line to the airframe.

Fold and Protect: Condense the wing by folding it on top of itself. Place something on top of the folded wing to secure it. Better, you can stow the wing in its bag to keep it out of the sun while also preventing the wind from inflating it.

Act Even for Short Breaks: Even for short breaks, it's highly recommended to reduce the wing's exposure to the elements. Harmful sun rays and unexpected wind gusts can impact your powered parachute, so act promptly.

Don't Walk Away: Don't leave your powered parachute without securing it. The wind can grab a wing quickly and without notice. Leaving a powered parachute unsecured and unattended is asking for trouble.

Emergency Actions

A wing kiting while you're on the ground is potentially dangerous. Suspension lines can cut your fingers if you grab them since the lines are small diameter and are where the wing's force is focused. Grabbing the airframe is normally ineffective if the wing is inflating. You can be dragged along with the airframe if there's a strong wind gust inflating the wing.

To regain control of a powered parachute with a semi-inflated wing, follow these steps:

Focus on the Steering Lines: In the event of an out-of-control wing, don't attempt to control the airframe or the suspension lines. Instead, grab a steering line or the fabric of the wing itself, whichever is closer. When you pull a steering line, it collapses the wing on that side, pushing air out of the wing.

Pull Forward of the Airframe: Hold the steering line and pull it toward the front of the airframe. This pulls the trailing edge of the wing down and dumps the air already inflating it, helping you maintain control.

Secure the Line: Tie the steering line off to any structural part of the airframe. This prevents the wing from reinflating, keeping it in a controlled state.

Manage the Situation Solo: If you find yourself alone in high winds, focus on securing one steering line initially. While it's ideal to secure both lines, getting one line secured is usually enough to prevent further issues.

Engine Fails to Quit

If you can't shut down your engine after landing, it can get very expensive. Moving propellers and wings don't mix well. Typically, both are harmed if a wing drifts into a moving prop. The abrupt stop can tear the wing, break suspension lines, and damage prop blades. Even the gear box and the engine itself can be damaged.

The first step is preventative. If you consistently land into the wind and promptly collapse the wing by tugging on the steering lines, then the wing has a better chance of landing behind the airframe and away from the propeller.

An engine that you can't stop is dangerous. Understand what may have happened and be ready to shut the engine down using emergency procedures.

What has probably happened is that the ignition switch became corroded, an ignition wire broke, or a connection became loose. Most of the engines are shut off by grounding out the ignition system. That means that the ignition switch closes a circuit to do the grounding. Electricity takes the path of least resistance and goes to ground rather than fighting its way through the ignition coil system and across a spark plug gap. This is the opposite to something like a light switch where the circuit is opened to turn it off.

The first step is to try to get the ignition switch(s) to do the job by turning it (or them) on and off repeatedly. If the switch is corroded, then the repeated switching may dislodge the corrosion.

The next step is to flood the engine. Keep the engine at idle and add as much choke as possible. If you have a plunger primer, keep pumping and flooding the carburetors until the engine dies.

Kiting Issues

The minute or two that it takes to launch a powered parachute is your busiest time during a flight. A lot of things are happening in the process and your attention must be divided between the direction you're going on the runway and kiting the wing. This is also a time when many things can go wrong. Many problems can be avoided by setting the wing up properly before trying to take off. That's covered in *Chapter 19, "Parachute Layout and Stowing."*

Even when you do everything right, sometimes a launch is just no good and should be aborted. Recognizing problems early and either correcting them (if possible) or shutting down completely prevents a blown launch from turning into something more destructive.

Things you're watching for while kiting your wing include:

- Lines Caught Under a Wheel
- Parachute Lockout
- Rolling Metastable Stall
- Restricted Lines
- Line-Overs
- Pressure Knots
- End Cell Closures
- Parachute Oscillations

All these topics are covered in *Chapter 20, "Departures and Climbs,"* under the section titled *"Items to Check During Kiting and Rolling Preflight."*

Rejected Takeoff

Emergency or abnormal situations can occur during a takeoff that will require you to reject the takeoff while still on the runway. Many of the kiting issues listed above can't be resolved on a takeoff roll. But there are other reasons for rejecting a takeoff such as a malfunctioning powerplant, inadequate acceleration, runway incursion, or air traffic conflict.

Prior to takeoff, you should have in mind a point along the runway at which you should be airborne. If that point is reached and you aren't airborne, immediate action should be taken to discontinue the takeoff. Properly planned and executed, chances are excellent that you can stop your powered parachute on the remaining runway without using extraordinary measures, such as excessive braking or trying to stop by using your feet as brakes, that may result in you damaging your equipment or becoming injured.

In the event of a rejected takeoff, reduce the throttle to idle and shut the engine down. Immediately collapse and ground the wing. The quicker you collapse the wing, the more likely it will be able to help slow the aircraft down by acting somewhat as a *drogue parachute*.

Rollover

A rollover refers to an incident where the powered parachute airframe tips over or turns upside down on the ground. This can happen during taxiing, takeoff, or landing. They occur when the wing is flying, and the wheels are on the ground. It can result from various factors such as steering errors, wind conditions, or uneven terrain.

Steering Errors: If the pilot fails to coordinate the steering of the wing and the airframe correctly during taxiing or takeoff, it can lead to the wing pulling the airframe over.

Crosswind Takeoffs: Crosswind takeoffs increase the chances of the wing blowing to one side and rolling the aircraft over.

Crosswind Taxiing: Attempting to taxi in crosswind conditions beyond the limits of the powered parachute or the pilot's skill level may force the wing to the side, leading to a rollover.

Uneven Terrain: Taking off, landing or taxiing on uneven or rough terrain increases the risk the of wheels catching on obstacles or irregularities.

Incorrect Takeoff Procedure: Applying too much or too little throttle when kiting and taking off.

It's crucial to prevent the wing from gaining enough horizontal lift to tip the airframe over. This occurs when an off-centered wing is moving fast enough through the air to generate enough lift to match the weight of the airframe. A strong crosswind can also pull an inflated wing hard enough to the side to force a rollover with little forward speed.

While kiting your wing for takeoff, make sure that the wing is centered, the wing's cells are all open and that the suspension and steering lines are unobstructed before you add throttle to create lift. If you can't confirm those things, slow down until you can confirm a proper wing kiting.

While kiting a ram air wing, it naturally tends to drift downwind in a crosswind. As you kite your wing, you want to steer the airframe into the wind to help center the wing. If you encounter an unexpected side gust of wind or attempt to take off before centering the wing, the airframe might be in a position where the horizontal lift of the wing could tip it over on its side. In a potential rollover scenario, you may find yourself in one of two situations:

1. Your airframe is lifting on one side, but there's still time for recovery.
2. Your airframe is up on one wheel, beyond the point of recovery, and starting to tip over.

In the first scenario, you may be able to recover by either reducing the lifting force of the wing by decreasing throttle and groundspeed to allow the aircraft to settle. The riskier alternative is to try to take off while the wing is partly off-center. That can turn into very ugly takeoff or uglier rollover.

In the second and more challenging situation where you can't prevent the rollover:

1. Immediately turn the magneto switches OFF to stop the engine and propeller.
2. Avoid attempting to prevent the rollover by bracing with your legs. Instead, pull your arms and legs up into a tuck position to protect your limbs. Once the aircraft comes to a stop, promptly unstrap and exit the aircraft.
3. If the situation does not conflict with 49 CFR 830, reposition the airframe back into an upright position to prevent fuel and oil from spilling out.
4. If the aircraft appears to be undamaged, perform a full inspection on it before attempting to fly it again. If you couldn't shut the engine down in time to prevent a prop strike, you may need to tear down the engine and gearbox for inspection.

While taxiing a powered parachute with the wing kited, you must steer both the wing and the airframe. As you taxi, keep in mind that at low speeds the friction between the wheels and the ground determines the primary direction of travel. Wheels roll forward and not to the side. If the wing is in the air and pulling the airframe to the side, opposing forces come into play. Rollovers can occur when you attempt a crosswind taxi beyond the aircraft's limitations or your current skill level.

Keep in mind that a rollover should never be a normal or periodic occurrence. In fact, since training has improved, they have become rare. Rollovers are usually benign since they typically happen at lower speeds. Nevertheless, these accidents can result in death, serious injuries, and damage to your aircraft.

With proper training and experience taking off, you can easily prevent rollovers during takeoff by following these steps:

1. Keep the airframe headed into the wind.
2. Stay calm, relaxed, and don't rush your takeoff roll.
3. Realize that airspeed is giving the wing lift, so slow down if you feel one side of the aircraft lifting excessively.
4. Let the airframe settle back on all wheels while maintaining your heading into the wind.
5. Allow the wing to settle overhead, and ensure all cells fully inflate.
6. Re-check suspension lines to make sure they are free and unrestricted.
7. Verify that there is no pinch in the bottom of the wing fabric or a friction knot in the lines.
8. Get your wing centered before taking off or, if needed, abort the takeoff and begin again.

Emergency Landings

There are three different kinds of emergency landings:

1. **Forced Landing:** You must make an immediate landing, whether on or off an airport, due to the inability to continue further flight. An example of this situation is when your powered parachute is forced down by engine failure.
2. **Precautionary Landing:** In situations where further flight is possible but inadvisable, you should make a premeditated landing, either on or off an airport. Examples of conditions that may require a precautionary landing include deteriorating weather, being lost, experiencing a fuel shortage, or facing gradually developing engine trouble.
3. **Ditching:** A forced or precautionary landing on water.

A precautionary landing is generally less hazardous than a forced landing because you have more time for terrain selection and planning the approach. You can use power to compensate for errors in judgment or technique. It's crucial to be aware that many situations calling for a precautionary landing are allowed to develop into immediate forced landings when you rely on wishful thinking instead of reason, especially in self-inflicted predicaments. For example, a pilot trapped by weather or a pilot facing imminent fuel exhaustion who doesn't consider the feasibility of a precautionary landing is accepting an extremely hazardous alternative.

Psychological Hazards

Several factors may interfere with your ability to act promptly and properly when faced with an emergency. Here are some of the factors:

1. **Reluctance to accept the emergency** situation can severely handicap you in handling the situation effectively. Allowing your mind to become paralyzed at the thought of the imminent landing may lead to errors such as delaying the selection of the most suitable landing area within reach and overall indecision.
2. **Undue concern about getting hurt** is understandable, as fear is a crucial part of the self-preservation mechanism. However, when fear leads to panic, it can invite the very outcome we want to avoid. The records show that pilots who maintain composure and apply well-established concepts and procedures tend to have better survival outcomes. Keep in mind that the success of an emergency landing is not only a matter of skills but also a state of mind.
3. **The urge to save the aircraft** often affects pilots, especially if they've been trained to locate safe landing areas during simulated forced landings. This instinct might lead to actions that defy basic airmanship principles.

For instance, you might find yourself attempting a risky 180° turn back to the runway without enough altitude or accepting a risky approach just to avoid damage to your aircraft. While it's natural to want to protect your powered parachute, there are times when it's crucial to prioritize the safety of you and your passenger, even if it means making the tough decision to sacrifice the aircraft for a safe outcome.

Terrain Selection

You should constantly be on the lookout for emergency landing fields. Your decision on where to make an emergency landing should be influenced by a few key factors:

Preflight Planning: The route you choose during preflight planning sets the initial options.
En Route Choices: Sometimes it's more appropriate to fly around a hazard you see coming up than to fly straight over it.
Altitude When Emergency Occurs: The height above the ground when an emergency happens plays a crucial role. Generally, the more hazardous the terrain, the higher you should fly.

Your options are most limited during the low phase of takeoff. Even then, making a slight change in heading can significantly impact the outcome. If you're beyond gliding distance from a suitable open area, assess the available terrain for a smooth landing.

When the emergency occurs at a considerable height, focus on selecting a general area rather than a specific spot. Terrain features can be deceiving from altitude, and delaying the decision might result in significant altitude loss. Don't hesitate to discard the original plan for a better one. However, changing your mind more than once is generally not recommended. A well-executed crash landing in poor terrain can be safer than an uncontrolled touchdown on an established field.

Engine Failures

If you drive a car, motorcycle, boat, or most anything else on the surface of the planet, engine failures are an annoyance, but not always an emergency in and of themselves. Of course, being stranded somewhere may develop into an emergency, but there are few times when an engine stopping is going to put a person into immediate danger. That isn't true with powered aviation.

Power loss or engine failure after liftoff is always marked by a sense of urgency. In many cases, you have only a few seconds to decide on a course of action and execute it. If you're not prepared in advance to make the right decision, the likelihood of making a poor choice—or worse, freezing and making no decision at all—is high, allowing the situation to spiral out of control.

In powered aviation, you kind of need power. That said, aircraft don't just fall out of the sky if they lose power. Proper procedures will help you safely return to the ground, where you were eventually heading anyway. Of course after landing, the engine problems should be addressed.

Signs of Engine Failure

Engine failures can occur due to a variety of reasons, and being able to recognize, troubleshoot, and respond to these issues is crucial for ensuring the safety of the flight. Here are some of the engine problems that may occur:

Loss of Power: A sudden and noticeable decrease in RPM or a complete loss of power.–**Possible Causes:** Fuel system malfunction, fuel exhaustion, ignition system failure, carb icing, or mechanical issues within the engine.
Abnormal Vibrations or Noises: Unusual vibrations, knocking sounds, or any abnormal noises coming from the engine.–**Possible Causes:** Internal engine components failure, loose parts, or propeller issues.
Increased Engine Temperatures: Rapid rise in engine temperatures, indicated by elevated cylinder head or oil temperatures.–**Possible Causes:** Cooling system failure, insufficient oil, or improper engine management.
Smoke or Fluid Leaks: Visible smoke or fluid leaks, such as oil or coolant.–**Possible Causes:** Oil or coolant system failure, damaged seals, or cracked engine components.

Causes of Engine Failure

Here's a list of engine failures and their possible causes:

Fuel System Issues: Fuel exhaustion, fuel contamination, carburetor or fuel injector problems, improper fuel mixture, or fuel pump failure.
Ignition System Failure: Malfunctioning spark plugs, ignition switch issues, or problems with the magneto. Automobile engines or other non-aircraft engines may be used on powered parachutes where the ignition system runs off a generator and battery rather than a magneto system. In this case if the battery system fails, the engine ignition system will fail and the engine will stop.
Mechanical Failures: Bearing failures, connecting rod failures, crankshaft issues, or other failed internal components.
Oil System Problems: Low oil levels, oil pump failure, or oil contamination. In two-stroke engines, oil exhaustion is a possible problem.
Cooling System Failures: Radiator or coolant system malfunction, coolant leakage, or overheating.

Responding to Engine Failure

There are general things that you should always do when your engine fails. Do those things in the order presented. If there isn't time to get to the things at the end of the list, don't worry. That's why they're at the end of the list.

Calm Down: Panicking won't help the situation. This is something you can handle.

Immediate Action: Maintain control of the aircraft.–Aviate, navigate, and communicate–prioritize flying the aircraft.

Emergency Landing: Select a suitable landing site and prepare for an emergency landing.

Troubleshoot: Check for any fuel system issues. Check to see if you accidentally turned off the engine mag switches. Verify the ignition system, turn on emergency fuel pumps and attempt to restart the engine.

Emergency Communications: If you're flying with others or are near the airport, let them know that you're making an emergency landing so they can look for you. Your radio will transmit further in the air than it will after you land.

Engine Failure on Climbout

During an initial climbout after takeoff, a powered parachute is at a high pitch angle with the airframe well in front of the wing. If the engine fails, the airframe will rock back under the wing and the wing will surge forward, relative to the airframe. That will cause the powered parachute to go into a temporary and possibly dangerous dive. After the powered parachute goes into a dive it will naturally want to round out after diving 20-30 feet.

The diving and rounding out you can expect upon engine failure is a result of pendulum stability. While in a climb, the airframe is pushed forward of the wing because of high thrust. When the thrust suddenly stops, the airframe wants to rock back under the wing. At the same time, the balancing drag on the wing is released and the wing wants to surge forward. There are usually only one or two oscillations of the powered parachute when an engine failure occurs, and the key is to expect the oscillations and be prepared to dampen or use those oscillations to achieve a soft engine-out landing. Here's what you can expect if your engine quits, you don't make any adjustments, and you have enough altitude for the powered parachute to go through all the movements.

Engine Fails while at high RPM and high thrust. The powered parachute is flying at a high pitch angle.

Initial Dive begins because thrust disappeared. The airframe rocks backward because of lack of thrust and the wing surges forward because the balancing drag was dramatically reduced.

Roundout occurs after a drop of 20-30 feet, depending on the powered parachute. Pendulum stability causes the wing to rock backwards and further behind its normal position behind the airframe. That causes the powered parachute to slow both its forward speed and its downward speed.

Overcorrection happens after roundout. The powered parachute levels off or enters a slight climb due to the wing remaining behind the airframe. The powered parachute continues to slow its forward speed.

Hang describes what happens after the overcorrection phase. The powered parachute has slowed down by this point and has little forward speed and isn't climbing or descending. This is a somewhat dangerous place to be if you're close to the ground. Flare is ineffective here because you have limited forward speed.

Secondary Dive is very mild compared to the initial dive after the engine fails. It's a slight climb, or at least a reduced descent due to the aircraft settling out due to pendulum stability. Nevertheless, you're in a greater than normal descent towards the ground but you normally won't have enough forward speed established to perform a significant flare.

Conventional Descent is when all the transients from the pendulum effect have settled down and the aircraft is descending normally.

The altitude available and the phase that the airframe is in after the engine fails are the controlling factors in how you should perform an emergency landing. The engine out could happen below 20 feet, between 20 feet and 50 feet, or above 50 feet. These altitudes are only approximate, and the procedure you need to use will vary with the wing, the weight of the airframe and occupants, and the wind.

Engine Failure Below 20 Feet

If the engine fails below 20 feet, and the wing starts to surge out in front of the airframe, the best thing to do is immediately flare. By flaring you can stop the wing from surging forward and causing the whole aircraft to go into a dive.

Engine Failure Between 20 and 50 Feet

Above 20', you don't want to flare immediately because you can take advantage of the initial dive to perform a soft landing. Ideally the wing could round out perfectly, or it could be on a trajectory to round out too low, leading to an impact with the ground. In case the round out is too low, you want to be ready to flare.

The initial dive is increasing the airspeed of the powered parachute and that gives you even more flare authority than normal. Steering controls are stiffer, but flares should be timed normally, that is, within a couple of seconds of touchdown. Flaring may need to begin higher above the surface than normal since the closure rate with the ground may be higher.

If the engine fails high enough up that the wing goes into an initial dive and rounds out above the surface, that means that it will have reached a low airspeed and you may not have enough airspeed to land gently. If that's the case, it's a good idea to try to correct the initial dive immediately with flare. That flare should be very temporary and released completely after a second or two. That way you're delaying the wing from surging forward.

Engine Failure Above 50 Feet

If the engine fails above 50 feet, you need to quickly determine whether your powered parachute will settle into a normal glide before getting too close to the ground. If possible, that's the best situation because you can then execute a normal engine-out landing.

If the engine fails just after takeoff and before reaching a safe maneuvering altitude, attempting to turn back to the departure field may not be the safest option. Instead, you should choose a landing area directly ahead or slightly to either side of the takeoff path. Execute the landing following the guidelines outlined in the next section.

Engine Failure in Flight

Always avoid flying over areas where you cannot safely land, considering your altitude and glide slope. Stay vigilant and aware of the surrounding terrain, identifying potential landing zones. Adhering to these guidelines helps prevent an in-flight engine failure from resulting in an accident or incident. In the event of an engine failure, maintain control of the aircraft and execute a glide away from obstacles, heading toward the safest available landing area.

Identify the safest landing zone based on your altitude and situation. If you have sufficient altitude, aim for the center of the airport or flight park. However, if you're below 100 feet, focus on landing straight ahead. While landing into the wind is ideal, safety comes first in an engine-out situation. Prioritize suitable terrain over wind direction. If possible, land into the wind, but if not, a downwind landing may be necessary. Crosswind is the least favorable direction for landing.

As you approach about one second from touchdown, initiate a full flare. Perform a 1-2-3 rhythmic timing motion: push both foot steering bars entirely forward and maintain this position as the rear wheels contact the ground. While you can increase the flare before landing, remember that it cannot be released when you are close to the ground and without power. Upon landing smoothly, release the flare and pull down the wing, considering the engine is already off.

Double Flare Method

The engine out landing method above is considered *textbook* and is the answer that an examiner is looking for during a checkride. However, there are other methods:

1. Quickly turning from a downwind approach to an upwind final right before touchdown.
2. The double flare method.

Both methods allow a skilled pilot to make very soft landings without the engine running. They both require timing and practice. It's best to practice these methods with partial power and reduce engine power during each practice approach or session.

Turning from downwind to upwind is only mentioned because it exists as a technique. However, low turns close to the ground are rarely recommended and performing them during an emergency requires room to set up, a better-than-average awareness of wind direction, wind to work with, and a higher skill set. I recommend the double-flare method as easier, more dependable, and better during an actual emergency.

The double flare method involves placing your powered parachute into a dive to increase airspeed. That increased airspeed can be used to flare more aggressively for a soft landing.

You do this by flaring your engine out aircraft about 100' above the surface, holding the flare and releasing it at about 50'. These altitudes are only approximate since the actual altitude depends on vehicle weight and the model of powered parachute.

After you release the flare on the wing, the aircraft will go into a dive, because the wing will surge from well behind the airframe to a little bit in front of the airframe. The dive increases your airspeed and that gives you more flare authority.

Remember that this is a technique that you should practice before you need it. If you do the initial flare too early and don't correct for it, you could round out several feet above the ground with no forward speed. That means your wing will be hardly flying and you will possibly land very hard. It's best to time your roundout late rather than early because you can always flare using the extra airspeed from the in-progress dive.

This is definitely something to practice and perfect with your instructor!

Engine Failure Over Water

Ditching is a forced or precautionary landing on water. Having your engine fail while you're flying over water is particularly dangerous if you don't have enough altitude to safely glide back to land. Make sure that you and your passenger are wearing life vests when you fly low over water or over large bodies of water. You should also consider attaching an automatic inflatable raft or flotation device to your powered parachute if you plan regular flights over water. Practice emergency procedures to be well-prepared and brief your passengers on evacuation procedures before any over-water flight.

If you must ditch your powered parachute, you're going to have two immediate hazards that you may have to cut yourself out of. Your seat belts may be impossible to unbuckle. Also, your wing may land on you, and you could get tangled in the suspension lines. A seat belt cutter is lightweight tool that you can mount in hands-reach on the airframe. After all, if you're upside-down in the water, you don't have a lot of time to fumble around in your pockets or in a saddle bag that you probably can't reach.

If you find yourself over water with an engine failure and too far away to glide to shore, remain in the aircraft and fly it down to the water's surface. Flare a second or two over the surface of the water like you would for a landing on a hard surface. The airframe may flip over when you hit the water and disorient you. Also be prepared to become entangled in the wing and suspension lines as they descend upon the airframe.

While your airframe may remain afloat for a few minutes, it will inevitably sink. The duration before sinking depends on factors such as the remaining fuel, the condition of the seals on your tubing ends, the air in your tires, and the depth of the water.

Once you realize that ditching is unavoidable, follow these steps.

Stay Calm: Maintain your composure and focus on executing the emergency procedures.

Maneuver: Align your powered parachute into the wind if feasible and maneuver as close to the shore as possible.

Attempt a Restart: Make sure that your mags are on, your fuel pump is on and try to restart the engine.

Communicate with Your Passenger: Inform your passenger about the situation and instruct the passenger to remain calm and follow your directions.

Declare Emergency: If possible, let friends you're flying with and the local airport know that you're having to ditch your aircraft and where.

Stay Seated: Don't attempt to dive out of the airframe before it hits the water.

Keep Your Helmet On: Ditching your powered parachute can throw your head up against a structure member of the powered parachute. The last thing you want is to be rendered unconscious after impact.

Remove Objects: Remove anything that will delay your evacuation prior to impact (i.e., communication cords, camera straps, etc.).

Discard: You want to get rid of anything, such as cameras, that can penetrate your skin or anchor you down upon impact.

Buckle Up: Tighten your seat belt and shoulder harness.

Prepare for Impact: At approximately two seconds (about 25 feet) above the water, bring your head, neck, and legs in as close to your body as possible. Place your arms along the side of your head, with your hands over the lower back of your head.

Full Flare: If you have experience, you can perform a full flare to reduce both your forward and downward speeds, executing a landing like one over land. However, keep in mind that landing on water differs from landing on land. The lack of surrounding ground features may create the illusion of a higher altitude, potentially leading to a mistimed flare.

Evacuation After Landing: Once the aircraft is in the water, exit promptly. Unbuckle your seatbelt and assist your passenger.

Move to a Safe Location: Move yourself to a safe distance from the aircraft. In the event of sinking, be cautious not to get entangled with any components of the aircraft, particularly the wing. Resist the urge to retrieve items or salvage the aircraft. Upon resurfacing, steer clear of the wing and swim towards the side of the powered parachute. If entangled with the canopy lines, use the seat best cutter to free yourself and swim to the edge of the wing.

Activate Emergency Signaling Devices: Use emergency signaling devices such as a personal locator beacon (PLB), life jacket lights, or any other available signaling equipment to attract attention.

Stay Together: If possible, stay with your passenger to enhance visibility and increase the chances of rescue. If the water is shallow, the wing will remain afloat for awhile and be visible to rescuers.

Swim: Try to make it to shore, particularly if no one knows that you're out flying and have ditched.

A seat belt cutter is useful for cutting both seat belts and suspension lines in a ditching.

Engine Failure Over a Forest

Landing a powered parachute in a wooded area is a challenging and potentially hazardous situation. Here are some guidelines to enhance survivability if faced with a tree landing:

Stay Calm: Maintain your composure and stay calm. Panic can exacerbate the situation and hinder your ability to make rational decisions.

Control the Descent: If possible, steer away from dense tree areas and opt for areas with more open spaces between branches.

Prepare for Impact: Adopt a landing position with your legs raised and flexed to absorb impact forces. Brace for contact with the tree branches, keeping your body as compact as possible to minimize the risk of entanglement. Pull your legs in from the steering bars. The bars aren't strong enough to protect your feet and legs from injury.

Avoid Direct Contact with Trunks: If you cannot steer clear of tree trunks, aim for areas with thinner branches rather than direct contact with solid trunks.

Choose Wisely: Opt for trees with shorter heights and thicker foliage, as they may provide a softer landing compared to tall, spindly trees.

Stay Strapped In: Remain securely strapped into your seat. This provides protection and prevents you from being ejected during impact.

Avoid Power Lines: If possible, steer clear of power lines or any other obstacles within the tree canopy that could pose additional dangers.

Seek Professional Help: More people have been injured from falling out of trees they landed in than any kind of injury from impact. Contact emergency services before you consider unstrapping from your airframe.

Evaluate the Surroundings: Assess the surroundings for the safest way to descend after impact with the tree, but only if you're in a remote area or low in a tree. You want to avoid falling from great heights.

Evacuation After Landing: Once on the ground, carefully assess your situation. Avoid sudden movements, especially if lines are entangled in branches.

In-Flight Fire

A fire in-flight demands immediate and decisive action, especially considering the flammability of a ram air wing. If you encounter an in-flight fire—especially one involving the engine or fuel—it is among the most serious of emergencies. At any sign of fire near the engine, fuel tank, or fuel lines, take every possible action to reduce the chances of the fire spreading and land as soon as possible.

Here are the necessary procedures you should follow:

- Reduce the throttle to idle.
- Turn off any electric fuel pumps.
- If possible, shut off fuel valves.
- Shut off magnetos.
- Shut off all electronics.
- Land immediately and stop as quickly as possible.
- Evacuate the aircraft immediately.

After landing, make sure to get far away. The primary danger post-evacuation is the potential ignition and explosion of fuel, which can pose a risk to people at considerable distances.

An electrical fire in the front of the airframe is unlikely to cause more than an engine failure; refer to "*Engine Failures*" above for this specific emergency.

Propeller Emergencies

Many worry about the prospect of colliding with a bird while flying a powered parachute and the potential issues it might cause. The likelihood of such an encounter is quite low, given that birds are more agile, even if they aren't faster than a powered parachute. The most likely scenario for a bird strike is when you're flying low over a field and you startle a nesting bird.

A more realistic scenario involves items on board inadvertently entering your propeller. Lightweight items like hats, gloves, sectionals, parachute bags, and line socks can easily be lifted from the front of the airframe and end up in the propeller.

If this occurs, you'll likely hear a distinctive sound when the object contacts the propeller. In such a situation, you should land as soon as possible and inspect the propeller for any damage.

Another potential scenario is direct impact damage to the propeller from an object. If the propeller fails, you'll immediately feel intense vibrations due to the imbalance. If you experience such vibrations, you should shut down the engine for an engine-off landing. Severe vibrations could lead to the propeller causing further damage, potentially tearing the engine off its mounting and posing additional risks of injury.

Cross-Country Emergency Preparations

Being prepared for an emergency during a cross-country flight is crucial. Always carry your wing bag and line sleeves if possible. In case of unexpected weather or another emergency, you can land and safely stow your wing. Choose a suitable landing site, ideally near a road for easy access, and avoid private property or crops. Once on the ground, pack your wing and secure the wing bag to the airframe. Then you can wait out the weather, seek shelter, taxi, or walk to find help.

Taxiing out may not be an option. Some places can be flown over in 10 minutes but may take days to walk out from, especially if you're injured after a forced landing.

Before departing from an unfamiliar location, it's wise to circle the area and note key landmarks. Always inform someone of your flight plan, including your expected return, and close it out by letting them know when you've landed safely.

Survival

In the unlikely event that you find yourself needing to make an unplanned landing away from an airport, your survival skills may become crucial. This could involve scenarios like off-field landings or navigating through unfamiliar terrain. It's essential to understand how to assess your surroundings, secure your aircraft, and access necessary resources for your well-being until help arrives. This section will provide you with essential survival strategies, covering topics such as shelter, communication, and basic survival tools. After an emergency landing or ditching in a remote location, you'll be faced with the challenge of surviving until rescue arrives.

Psychological Aspects

While the likelihood of encountering a multi-day survival situation is low, it's important to recognize that it can happen. Are you mentally prepared to face such a scenario? This section highlights the mental challenges of survival and strategies for overcoming them.

The first step is to acknowledge the possibility of a survival situation. Once you accept this, begin preparing both mentally and physically, which greatly improves your chances of making it through. A strong mindset and productive thinking are essential, and knowing how to use your gear and improvise helps build confidence.

Maintaining a positive mental attitude during a survival ordeal can be the key to success. You'll be tested by factors like stress, isolation, and the will to survive, so be prepared to manage these challenges with resilience and determination

Post-Crash Shock: Being suddenly introduced to a threatening environment can be a very traumatic experience. After evacuating and treating injuries, take a moment to objectively assess the situation. Drinking water can help with shock.

Managing Injuries: Injuries affecting the mind and body should be promptly treated. Pain is the body's way of signaling a problem, so address it to maintain a positive mental attitude. Wounds will be very prone to infection which will in turn cause fever. Fever makes it very hard to think through survival challenges.

Thirst and Hunger: Stay hydrated to combat thirst; dehydration can impair mental skills. While you can survive without food for an extended period, being mindful of your eating schedule can help manage hunger expectations.

Coping with Cold or Heat: Seek shelter or build one out of your wing to address cold or heat-related challenges.

Managing Fatigue: Physical and mental fatigue are interlinked; prevent physical fatigue by pacing yourself and address mental fatigue by taking breaks. Adequate rest is crucial for maintaining overall well-being.

Dealing with Depression: Stay busy with productive thoughts, such as signaling or improving your shelter, to counteract negative feelings.

Controlling Emotions: Fear, anxiety, panic, boredom, and helplessness are common emotions in survival situations. Recognizing and controlling these emotions is crucial for your chances of survival.

- **Fear and Anxiety:** Learn to recognize symptoms and control fear consciously.
- **Panic:** Uncontrolled irrational behavior may follow panic; take positive steps to control fear promptly.

Combating Boredom and Hopelessness: Stay mentally focused with positive tasks. Splitting responsibilities between you and your passenger can keep minds occupied and contribute to a sense of purpose.

The will to survive is perhaps the most important psychological factor in any survival situation. Without it, survival is impossible. You need something in your life that outweighs your fears—a powerful motivator. For many, family is a strong driving force. The love of life or even the fear of death can push a person to overcome seemingly impossible odds.

While most people are born with an inherent will to survive, modern conveniences and reliance on technology can weaken it. However, you can't buy the will to survive—you must cultivate and reinforce it. One effective way to do this is by packing a personal survival kit and carrying it on every flight. This kit contains the essentials for survival and, more importantly, strengthens your mindset. By preparing this kit, you acknowledge the possibility of a survival situation and start mentally confronting your fears about what might happen after an emergency landing. This simple act helps you develop resilience and readiness for any challenge.

Search and Rescue

There is a distinction between the terms search and rescue. In the event rescuers are unaware of your location, it constitutes a search; however, if they know where you are, it transforms into a rescue mission. Responsibilities are twofold: when rescuers lack knowledge of your location, it becomes your duty to communicate through tools like flight plans, radio calls, Emergency Locator Beacon (ELB), and ground-to-air signals. Once rescuers are aware of your location, collaboration with them is essential to facilitate your safe return.

The average time from Last Known Position (LKP) to rescue is approximately 27.3 hours. Even before entering the aircraft, filing a flight plan serves as invaluable insurance, and may significantly impact survival time.

In the activation of the National Search and Rescue Plan, any instance of an overdue, missing, or distress call triggers the involvement of the federal government. For inland search and rescue, the U.S. Air Force assumes responsibility, with the Civil Air Patrol executing over 85% of federal inland missions.

It's also possible that local authorities will take the lead on a search and rescue mission, particularly if you haven't filed a flight plan and the local authorities are notified first. When someone goes missing in a wilderness area, the responsibility often falls on local law enforcement, fire departments, or volunteer search and rescue organizations to conduct the search and rescue mission.

The process begins when someone reports a another as missing. Authorities gather information about the missing person, including the last known location, the intended route, and any relevant details about the individual's experience and equipment. This information is critical for planning an effective search operation.

Survival Gear

When packing a personal survival kit, there are several categories of equipment that should be included, such as:

First Aid Kit which should include at least:

- 2 compress bandages (4"x 4")
- 2 compress bandages (2" x 6 yards)
- 1 roll athletic tape
- 1 small bottle of Methiolate
- 5 adhesive bandages
- Personal medications

Shelter The primary shelter that you take with you on the aircraft is your clothing. Try not to dress for the flight environment, but for the potential survival environment. Footwear is a major consideration. If you're flying over rough terrain, you may want to wear boots instead of sandals or tennis shoes. Other shelter to consider would be something to further insulate the clothing you already have. A garden trash bag works very well to insulate your clothing from the wind and wet.

And don't forget your wing. Your wing is made out of zero porosity fabric which will help keep you dry, conserve body heat, and provide relief from excessive sunlight if needed.

Water Purification: Water purification tablets will make it easy for you to purify water. Boiling water for five minutes will also purify water.

Fire Starting: Fire is a survivor's best friend. It will give you a source of light, heat, protection, and signaling, and will sanitize food and water. Starting a fire in the wilderness requires a great deal of skill. This skill must be nurtured through practice and not from just reading a book. There are several fire-starting devices that may be purchased for your kit. But none are as easy and effective as just simple matches; take precautions to keep them waterproof.

Food: Food has a low priority in survival. The average person can survive over three weeks without food. If food is placed in the kit, ensure that it is the type that won't spoil.

Survival Tools: Simple tools can make your survival experience a lot easier.

Knife: The best tool for survival is a good knife. There are several types on the market to choose from. Make sure that the knife is sharpened before using it. Also, check out some of the multi-tools on the market. These tools will give you a variety of functions in a small package.

Dental floss or fishing line with a weight: If you are stuck in a tree, it can be lowered to help rescuers get a larger rope up to you.

Tire repair can with sealer and air pressure.

Tape to repair small canopy tears: The manufacturer's POH typically has specifications for repairs but as a guideline, a tear less than 2" can be repaired with common duct tape. However, cut lines will ground you and force you to drive the airframe back or walk.

Signaling: A signaling device that should be included in all kits is a signal mirror. Considered to be the best all-around signaling device, mirror flashes have been spotted over 20 miles away. Other items you may want are a cellphone and a flashlight.

Remember too, that your wing can be employed to lay out a prominent marker to aid recognition from the air by other aircraft.

Pack Tight: Try to keep your survival kit as compact as possible. It's also best to keep the kit in close proximity at all times. After an emergency landing, you may need to evacuate the powered parachute as quickly as possible. If your survival kit isn't handy, you may not have a chance to get it out of the airframe. If you'll be flying over big water, keeping everything in plastic bags will keep important items dry and unspoiled.

Emergency Equipment
Equipment should be kept stowed handy, packed tight, and waterproof, especially over bodies of water. Of course seat belt knives and flotation devices should be easily accessible.

	Mild Conditions	Mountainous Terrain	Desert Conditions	Extreme Temperature Changes	Large Bodies of Water
ESCAPE					
Seat Belt Knife	✔	✔	✔	✔	✔
Dental Floss or Paracord	✔	✔			
Parachute Tape		✔	✔	✔	
Flotation Devices					✔
FIRST AID					
Insect Repellent	✔	✔		✔	
Prescriptions		✔	✔	✔	✔
Anti-Diarrhea Medication		✔	✔	✔	✔
Bandanna		✔	✔	✔	✔
CLOTHING					
Zip-Off Pants		✔	✔	✔	
Long Sleeve Shirt		✔		✔	
Long Underwear				✔	
Boots, Wool Hiking Socks	✔	✔	✔	✔	
Fleece				✔	
Hat				✔	
Gloves				✔	
Poncho		✔		✔	
Wetsuit (For over cold water)					✔
SHELTER					
Tarp (Or use your wing)		✔	✔	✔	
FIRE STARTING					
Lighter or Matches		✔	✔	✔	✔
Waterproof Storage		✔			✔
WATER & PURIFICATION					
Water Bottles or Canteen	✔	✔	✔	✔	✔
Water Filter/Purification Tablets		✔		✔	✔
FOOD					
Protein Bars, Dried Fruit, Trail Mix		✔	✔	✔	✔
TOOLS					
Multi-Tool and/or Survival Knife	✔	✔	✔	✔	✔
Rope, Duct Tape, Parachute Tape	✔	✔	✔	✔	
Survival Guide		✔	✔	✔	✔
LIGHTING					
LED Flashlight	✔	✔	✔	✔	✔
Glowsticks		✔	✔	✔	✔
SIGNALING					
Aviation Radio tuned to 121.5	✔	✔	✔	✔	✔
Cell phone	✔	✔	✔	✔	✔
Signal Mirror		✔	✔	✔	✔
Emergency Whistle		✔	✔	✔	✔
NAVIGATION					
Compass or GPS	✔	✔	✔	✔	✔
Local Map	✔	✔	✔	✔	

General Survival Tips

As you're flying along, look below and ask yourself, *"What would I do if I had to make an emergency landing at this very moment?"*

If you find yourself in a survival situation, look at your basic needs. And then devise a plan to meet those needs. A checklist would be outstanding for this situation. A checklist will put all your tasks in black and white. It'll give you a basic idea on how to survive. But, probably most important of all, it will allow you to start to think and plan everything logically. This will go a long way in the fight against fear, anxiety, and panic.

Here is a simple checklist that you can use in any survival environment:

Stay Near the Aircraft: Try to remain close to the aircraft. Search and rescue efforts are directed towards the crash site. Staying near the airframe increases visibility for rescue parties.

Seek Other Shelter in Extreme Temperatures: When faced with extreme temperatures, such as intense heat or cold, assess the suitability of the immediate area for shelter. If conditions are extreme, look for alternative shelter options, like shade or creating an overhead shelter.

Light A Fire: Lighting a fire serves multiple positive purposes for a survivor. However, caution is essential, as a fire can also pose risks. Carefully manage and monitor the fire to maximize its benefits while minimizing potential hazards.

Procure Water: Water is crucial for survival, and life expectancy without it can be very short under extreme conditions. Procure water proactively, ensuring hydration before reaching a critical point. Additionally, purify all water sources before consumption.

Ready Signaling Devices: Have signaling devices, such as mirrors, flares, or radios readily available. Immediate use of these devices enhances the chances of attracting attention. Familiarize yourself with their operation, especially radios and flares, before needing to use them.

Rest: Avoid pushing yourself to exhaustion, as it diminishes your effectiveness for yourself and potential rescue efforts. Take regular rest breaks to maintain both mental and physical well-being during a survival situation.

If You Need to Walk Out

It's often best to stay near your powered parachute and wait for rescue. But there are situations where hiking out of the wilderness is the best option. For example, perhaps you know exactly where you are and you know that it's a short hike. Maybe no one knows you're missing and you haven't been able to signal anyone.

As you travel, remember that search and rescue teams are particularly tuned to signals of threes. Hence, three fires arranged in a triangle, three bangs against a log, or three flashes of a mirror—all of these will initiate a rapid response by search and rescue. Your aviation radio can be tuned to broadcast and receive on the emergency frequency 121.5 MHz or any other usable frequency that will elicit a response.

If you decide to walk out, keep these tips in mind.

Stay Calm and Orient Yourself: Take a moment to calm yourself and assess your surroundings. Determine your current location and the direction you need to travel.

Use Landmarks: Identify prominent landmarks or natural features that can serve as reference points during your journey. This will help you maintain a sense of direction.

Follow Water Sources: If possible, follow rivers, streams, or other water sources. They can lead to civilization and provide a consistent path to follow.

Travel During Daylight: Walk during daylight hours to maximize visibility and reduce the risk of getting lost. Plan your journey to use available daylight effectively.

Prioritize Safety: Be cautious of wildlife and potential hazards. Prioritize safety, and avoid risky routes or terrains.

Create a Trail: Leave markers or create a trail using natural materials to help search and rescue teams follow your path. This can include items of three or arrows made of stones, broken branches, or other noticeable signs.

Signal for Help: If you have signaling devices, use them periodically to attract attention. Your aviation radio, signal mirrors, whistles, or brightly colored clothing can make you more visible.

Stay Hydrated and Conserve Energy: Conserve energy by taking breaks when needed. Stay hydrated by rationing your water supply, and avoid overexertion.

Make Noise: Make periodic loud noises, especially in open areas, to increase the chances of being heard by rescuers or nearby people.

Navigate Using the Sun: Use the sun's position to determine cardinal directions. The sun rises in the east and sets in the west, providing a natural compass.

Stay Positive and Persistent: Maintain a positive mindset, and stay persistent. Walking out of the wilderness may take time, but determination is crucial for survival.

Know When to Stop: If you're unsure of your location or encounter difficulties, consider staying in one place. It increases the chances of being found.

Try to remember to use every tool at your disposal. And if you plan on flying over harsh terrain, some survival knowledge would be good to get ahead of time.

Chapter 28
Night Operations

Flying a powered parachute at night requires a private pilot license for powered parachutes, at least a third class medical, and a properly equipped powered parachute. While all of this seems to be a tall order, it isn't as bad as it seems. A private pilot license for powered parachutes requires the same total amount of dual instruction as a sport pilot rating, although it adds in specific requirements night flying instruction and a longer dual cross-country. The knowledge tests and practical tests are also very similar to the sport pilot tests. The lighting and equipment requirements aren't too extensive, either. The main differences between the requirements for sport pilot and private pilot ratings are shown on the table here.

The difficulties come from finding instructors who can train for the private pilot rating and examiners to provide the practical testing. As this book is being published, only five examiners exist in the country who can perform that practical test.

The benefits of the rating are nice. It allows for a safety margin in case you stay out a little late after sundown or if you want to get an early start in the morning. Winds are great after sunset. City lights are awesome from above, even if your city is a small town. And on the 4th of July, you can watch multiple fireworks displays at the same time!

Flying at night offers several benefits, but you should recognize that the risks associated with night flying are higher than flying day VFR. By being cautious and gaining knowledge about night-flying techniques, you can effectively reduce these risks and develop comfort and proficiency in the night sky.

Comparison of Requirements Between Sport Pilot and Private Pilot

Requirement	Sport Pilot	Private Pilot
Reference	§ 61.313(g)	§ 61.109(i)
Total Flight Time	12 Hours	25 Hours
Total Takeoffs and Landings to a Full Stop	20	30*
Dual Training Time	10 Hours	10 Hours
Solo Flight Time	2 Hours	3 Hours
Dual Cross-Country Training	1 Hour/15 NM**	1 Hour/25 NM
Solo Cross-Country	10 NM	25 NM
Night Training	0 Hours	3 Hours
Night Takeoffs and Landings	0	10
Solo Takeoffs and Landings to a Full Stop	10	20
Takeoffs and Landings at an Airport with a Control Tower	0	3
Hours of Training within 2 Calendar Months of a Practical Test	1	3

**Technically there is no requirement for dual landings to a full stop for private pilot.*
***The length of the cross-country time is defined in §61.1(b).*

Vision in Flight

Your safety during flight relies heavily on your vision. Most of the information you gather while flying comes from what you see or is strongly influenced by your vision. Despite its significance, vision has limitations like illusions and blind spots. The more you comprehend about your eyes and their functioning, the better equipped you are to use your vision efficiently and compensate for its limitations.

Your eye operates like a camera. It comprises an aperture, a lens, a focusing mechanism, and a surface for capturing images. Light enters through the cornea at the front of your eyeball, passes through the lens, and reaches the retina. The retina houses light-sensitive cells that transform light energy into electrical impulses, which then travel through nerves to your brain. Your brain interprets these electrical signals to create images. In your eyes, there are two types of light-sensitive cells: *rods* and *cones*.

Your ability to see and appreciate colors, from a beautiful sunset to the subtle shades in a fine painting, is thanks to the cones in your eyes. These cones are distributed across the entire retina but are most concentrated in the central area at the back of your retina, known as the *fovea*. The fovea is a small pit where almost all the light-sensing cells are cones. It's the primary spot for *looking*, situated at the center of your visual field, offering the highest level of detail, color sensitivity, and resolution.

While cones and their associated nerves excel at detecting fine detail and color in bright light, rods are more adept at detecting movement and providing vision in low light conditions. Rods lack the ability to perceive color but are highly sensitive in low-light settings. The challenge with rods is that they can be overwhelmed by a significant amount of light, and it takes them longer to *reset* and adapt to darkness again.

In the fovea, the central area of your visual field where there are numerous cones, there are virtually no rods. Consequently, in low-light situations, the middle of your visual field lacks sensitivity. However, as you move farther from the fovea, rods become more abundant, playing a significant role in providing most of your night vision.

The area where the optic nerve enters the eyeball has no rods or cones, leaving a blind spot in its field of vision. Normally, each eye compensates for the other's blind spot.

Vision Types

There are three types of vision: *photopic*, *mesopic*, and *scotopic*. Each type functions under different ambient light conditions.

Photopic Vision

In good lighting conditions, you experience photopic vision, which allows you to see colors and discern fine details (achieving 20/20 vision or better). This type of vision is active during daylight or when there's ample artificial illumination.

The cones, mainly located in the *fovea centralis* of your eye, play a key role in bright light vision. Due to the high light levels, *rhodopsin*, a biological pigment in the retina responsible for forming *photoreceptor* cells and initiating the initial stages of light perception, gets bleached out. This bleaching process affects the rod cells, making them less effective during such well-lit conditions.

§ 61.109 Aeronautical experience. (Private Pilot)

(i) For a powered parachute rating. A person who applies for a private pilot certificate with a powered parachute category rating must log at least 25 hours of flight time in a powered parachute that includes at least 10 hours of flight training with an authorized instructor, including 30 takeoffs and landings, and 10 hours of solo flight training in the areas of operation listed in § 61.107 (b)(9) and the training must include at least—

(1) One hour of cross-country flight training in a powered parachute that includes a 1-hour cross-country flight with a landing at an airport at least 25 nautical miles from the airport of departure;

(2) Except as provided in § 61.110, 3 hours of night flight training in a powered parachute that includes 10 takeoffs and landings (with each landing involving a flight in the traffic pattern) at an airport;

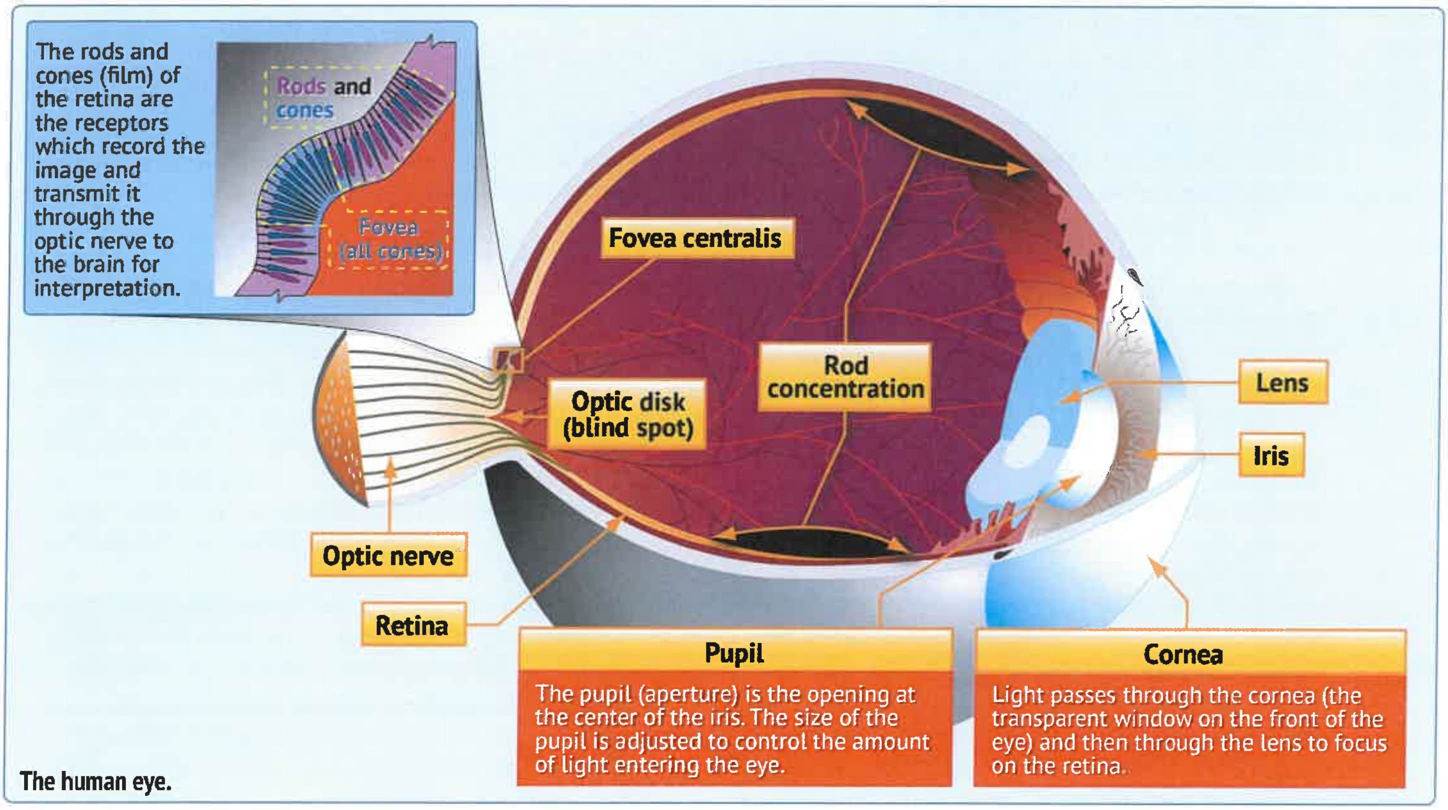
(3) Three hours of flight training with an authorized instructor in a powered parachute in preparation for the practical test, which must have been performed within the preceding 2 calendar months from the month of the test;

(4) Three hours of solo flight time in a powered parachute, consisting of at least—

(i) One solo cross-country flight with a landing at an airport at least 25 nautical miles from the departure airport; and

(ii) Twenty solo takeoffs and landings to a full stop (with each landing involving a flight in a traffic pattern) at an airport; and

(5) Three takeoffs and landings (with each landing involving a flight in the traffic pattern) in an aircraft at an airport with an operating control tower.



The human eye.

Mesopic Vision

You experience mesopic vision during dawn, dusk, and full moonlight, thanks to a combination of rods and cones. As the available light decreases during this time, visual acuity gradually diminishes, and color perception changes because the cones become less effective. The mesopic viewing period is considered the most perilous for viewing.

As cone sensitivity decreases, it's crucial for you as a pilot to rely on off-center vision and employ proper scanning techniques to detect objects during low-light levels.

Scotopic Vision

Under low-light conditions, you experience scotopic vision where the cones become ineffective, leading to poor resolution of details. Your visual acuity decreases to 20/200 or less, allowing you to see only objects the size of or larger than the big "E" on visual acuity testing charts from 20 feet away. In other words, you must stand at 20 feet to see what you can normally see from 200 feet away under daylight conditions.

When relying on scotopic vision, color perception is lost, and there's a night-blind spot in your central field of view at low light levels when you lose cone-cell sensitivity.

Central Blind Spot

In the back of each of your eyes, where the optic nerve connects to the retina, there's a region known as the *optic disk*. This area lacks both cones and rods, making each eye completely blind in this spot. This is commonly referred to as the blind spot that everyone has in each eye.

Under normal conditions of using both eyes together, this isn't an issue because an object can't be in the blind spot of both eyes simultaneously. However, in situations where the field of vision of one of your eyes is blocked by an object (like a structural member of your powered parachute), a visual target might end up in the blind spot of the other eye and go unnoticed.

A search on the internet will give you ways to observe this phenomenon in your own eyes.

Types of Vision

Types of vision used	Light level	Technique of viewing	Color perception	Receptors used	Acuity best	Blind spot
Photopic	High	Central	Good	Cones	20/20	Day
Mesopic	Medium/Low	Both	Some	Cones/Rods	Varies	Day/Night
Scotopic	Low	Scanning	None	Rods	20/200	Day/Night

Empty-Field Myopia

You shouldn't ever experience empty-field myopia since you shouldn't be flying in the conditions where that becomes an issue. Empty-field myopia is a condition that usually occurs when flying at night above the clouds or in a haze layer that provides nothing specific to focus on outside the aircraft. This causes your eyes to relax and seek a comfortable focal distance that may range from 10 to 30 feet. This means looking without seeing, which is dangerous. You should search out and focus on distant light sources, no matter how dim, to help prevent the onset of empty-field myopia.

Night Vision

Most people aren't well-informed about night vision, but understanding how to use your eyes correctly and recognizing their limitations can significantly improve your night vision. Several reasons support training to use your eyes correctly. Your mind and eyes work as a team for you to see well, and you need to use both effectively. Your eyes are constructed in a way that sees differently at night than during the day. You need to understand your eye's construction and how darkness affects it.

To review, at the back of your eyes or retina, there are numerous light-sensitive nerves called cones and rods, forming the layer on which all images are focused. Cones, located in the center of the retina, detect color, details, and distant objects. Rods, concentrated in a ring around the cones, function when something is seen in your peripheral vision but don't provide detail or color—only shades of gray. Both cones and rods contribute to vision during daylight.

Although the division of function isn't entirely clear-cut, rods play a vital role in night vision. While both rods and cones function in daylight and moonlight, the absence of normal light places the process of night vision almost entirely on the rods.

Since rods are distributed in a band around the cones and not directly behind the pupils, off-center viewing (looking to one side of an object) becomes crucial during night flight. Unlike daylight, where looking directly at an object is most effective, a scanning procedure for off-center viewing is more effective at night. Therefore, you should consciously practice this scanning procedure to improve your night vision.

Dark Adaptation

Adaptation to darkness is another key aspect of night vision. When entering a dark room, your pupils first enlarge to receive as much available light as possible. After about five to ten minutes, the cones adjust to dim light, making your eyes 100 times more sensitive to light. Rods take about 30 minutes to adjust and become about 100,000 times more sensitive. Once this adaptation process is complete, you can see much more, especially if you use your eyes correctly.

After adapting to the dark, the process reverses when entering a lit room. Your eyes are initially dazzled by brightness but become adjusted in seconds, losing their adaptation to the dark. Therefore, before and during night flight, consider the adaptation process of your eyes. Allow them to adapt to low light, and once adapted, avoid exposing them to bright white light to prevent temporary blindness and potential serious consequences.

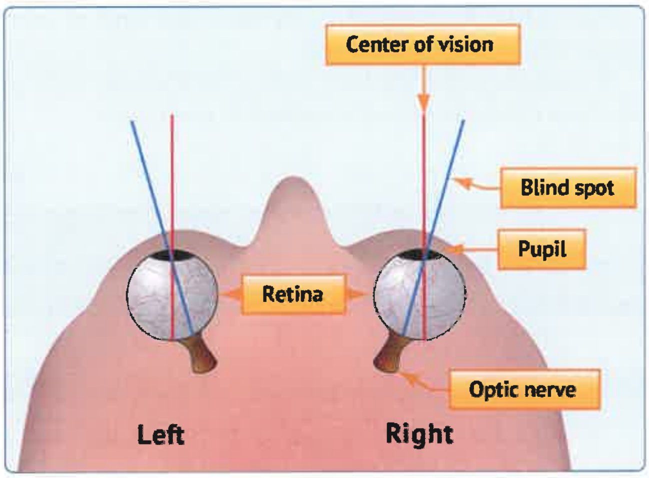
Protecting Your Night Vision

Unusually bright lights causing temporary blindness may result in illusions or after-images until your eyes recover. Recognizing that the brain and eyes can play tricks is the best protection for flying at night. Good eyesight depends on your physical condition, and factors like fatigue, colds, vitamin deficiency, alcohol, stimulants, smoking, or medication can seriously impair your vision. Being aware of these factors and taking precautions is crucial for safeguarding night vision.

Avoiding bright lights before and during the flight is an obvious safeguard. For 30 *minutes* before a night flight, steer clear of bright light sources like headlights, landing lights, strobe lights, or flashlights. If exposed to a bright light, close one eye to maintain light sensitivity, allowing the use of that eye once the light is gone.

Diet and general physical health also impact how well you can see in the dark. Deficiencies in vitamins A and C, as well as factors like carbon monoxide poisoning, smoking, alcohol, certain drugs, and lack of oxygen, can significantly decrease night vision.

To increase night vision effectiveness, adapt your eyes to darkness before flight and keep them adapted. Close one eye when exposed to bright light to avoid the blinding effect. Move your eyes more slowly than in daylight, blink them if they become blurred, concentrate on seeing objects, and force your eyes to view off-center.



Central blind spot.

Aircraft Lighting

A lot of powered parachute lighting is poorly designed. Strobes and landing lights are commonly positioned in a manner that leads to reflections from structural members and your instrument panel. You may find it necessary to turn off some lighting to be able to see beyond the flight deck.

Sunglasses

You should avoid wearing sunglasses after sunset. However, if you're planning a night flight, you should wear neutral density (N-15) sunglasses or equivalent filter lenses when exposed to bright sunlight. This increases the rate of dark adaptation at night and improves night visual sensitivity.

Night Blind Spot

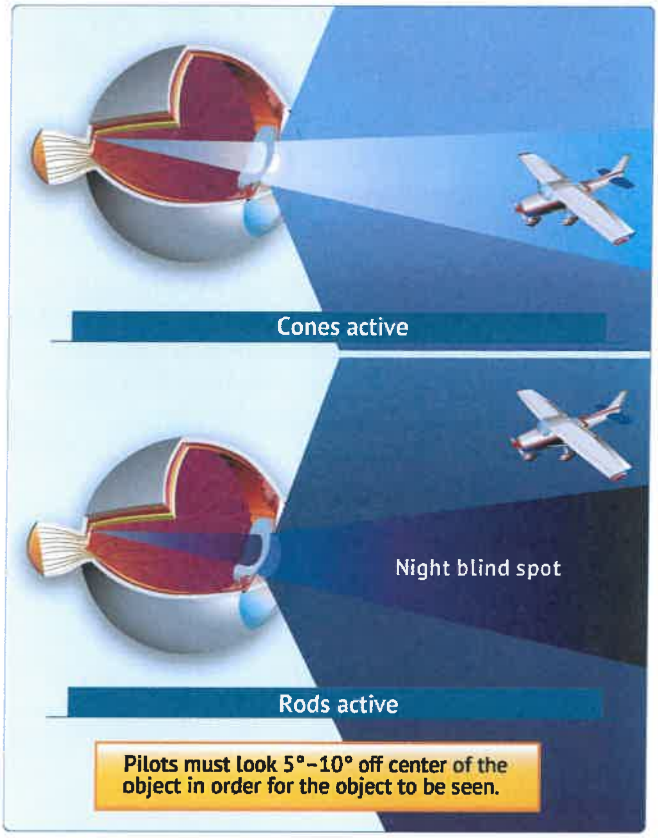
Once you're fully adapted to darkness, it's estimated that the rods in your eyes become 10,000 times more sensitive to light than the cones, making them the primary receptors for night vision. Since the cones are mainly concentrated near the fovea, the rods also play a significant role in your peripheral vision. However, the concentration of cones in the fovea can create a *night blind spot* at the center of your field of vision.

The night blind spot emerges under low ambient illumination conditions because of the absence of rods in the fovea, affecting the central 5 to 10 degrees of your visual field. When viewing an object directly at night, it might go unnoticed or fade away after initial detection. This blind spot can conceal larger objects as the distance between you and the object increases.

To see an object clearly at night, especially in the center of your vision, you need to expose the rods to the image. Try looking 5° to 10° off-center from the object. You can experiment with this in a dimly lit room. When looking directly at the light, it may dim or disappear, but when you shift your gaze slightly off-center, the image becomes clearer and brighter.

When you focus directly on an object, the image is primarily on the fovea, where details are best seen. However, at night, the ability to see an object in the center of your visual field is reduced as the cones lose sensitivity and the rods become more sensitive. Looking off-center can help compensate for this night blind spot. Along with the loss of sharpness (acuity) and color at night, there may be challenges with depth perception and judging size.

There is a dramatic way to find your blind spot at night when there's a full moon. Cover your left eye, looking at the full moon with your right eye. Gradually move your right eye to the left (and maybe slightly up or down). Before long, all you will be able to see is the large halo around the full moon; the entire moon itself will seem to have disappeared.



Night blind spot.

Night Scanning Techniques

There are specific scanning techniques that you use at night to identify objects. You should look from right to left or left to right. Start scanning at the farthest distance where an object can be perceived and move inward toward the position of your aircraft. Each stop in your scan should cover an area approximately 30° wide. The duration of each stop depends on the level of detail needed, but no stop should last longer than 2 to 3 seconds. When transitioning from one viewing point to the next, make sure to overlap the previous field of view by 10°.

Another useful scanning technique for night flying is off-center viewing. This involves looking at an object by directing your gaze 10° above, below, or to either side of the object. This technique allows your peripheral vision to maintain contact with the object.

However, with off-center vision, the images of an object viewed for more than 2 to 3 seconds may disappear. This happens because the rods reach a photochemical equilibrium that prevents further response until the scene changes, creating a potentially unsafe condition. To overcome this limitation of night vision, be aware of this phenomenon and avoid looking at an object for more than 2 or 3 seconds. Shifting your eyes from one off-center point to another will allow your peripheral field of vision to continue picking up the object.

Stress of Flying at Night

Night flights can be more fatiguing and stressful compared to day flights, and many stressors are self-imposed that can limit your night vision. You can manage this kind of stress by understanding the factors that contribute to self-imposed stressors. Here are some of those factors.

Drugs: Medications can significantly reduce your visual acuity, both during the day and especially at night. Consult with an aviation medical examiner (AME) to determine which drugs are suitable for you to take while flying.

Exhaustion: If you become fatigued during a night flight, you won't be mentally alert, and your response to situations requiring immediate action will slow down. Exhaustion may lead you to focus on one aspect of a situation, neglecting the overall requirements. Your performance could become a safety hazard, depending on the degree of fatigue. Instead of using proper scanning techniques, you might get fixated on the instruments or stare off rather than multitasking.

Poor Physical Conditioning: When you're physically fit, you'll experience less fatigue during flight and enhance your night scanning efficiency. A regular exercise program will improve your physical conditioning. Be cautious, though, as too much exercise in a single day may leave you too fatigued for night flying.

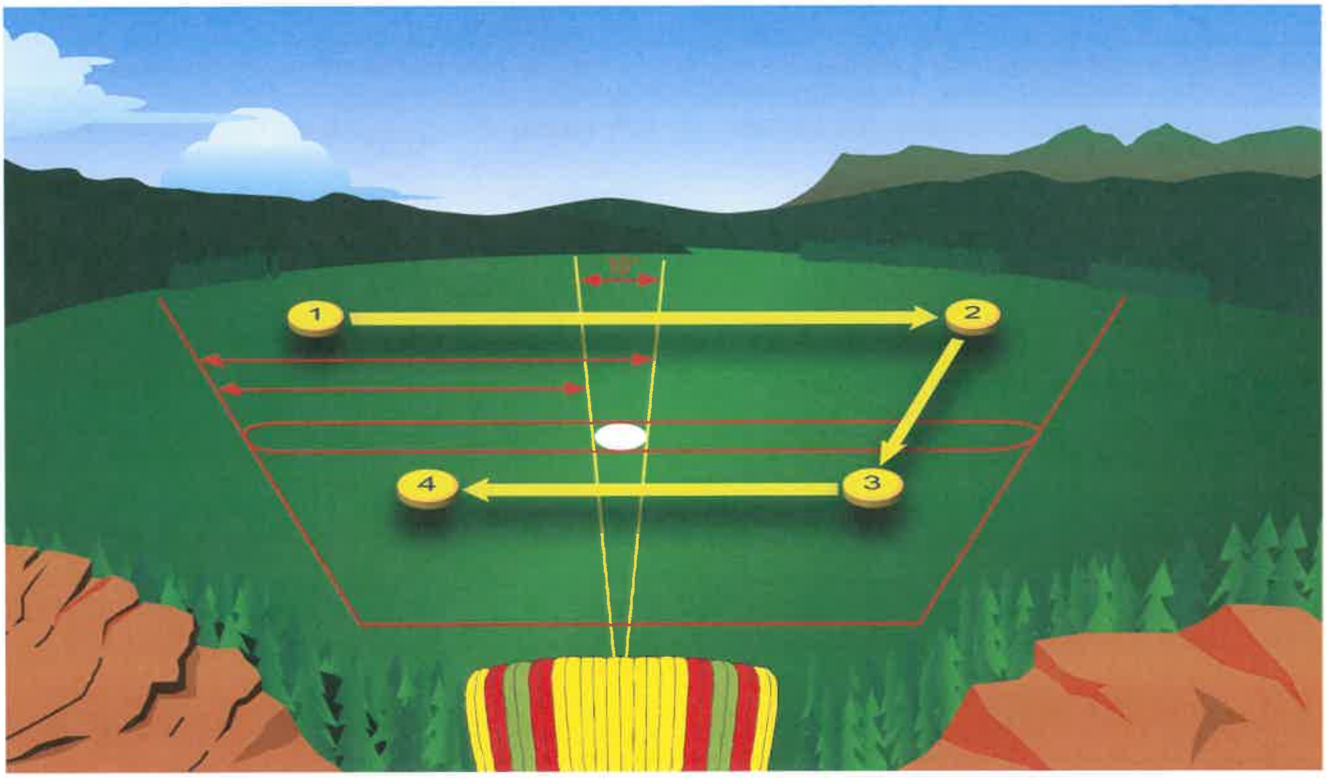
Alcohol: Alcohol impairs your coordination and judgment since it's a sedative. If you're impaired by alcohol, you're likely to neglect proper night vision techniques, staring at objects and overlooking scanning techniques. The effects of alcohol are long-lasting and the extent to which your night vision is affected depends on the amount of alcohol consumed.

Tobacco: Cigarette smoking decreases your visual sensitivity at night. When you smoke, the amount of carbon monoxide carried by hemoglobin in your red blood cells significantly increases. This reduces your blood's capacity to combine with oxygen, resulting in less oxygen being carried in your blood. The hypoxia caused by carbon monoxide poisoning affects your peripheral vision and dark adaptation, with outcomes like hypoxia caused by high altitude.

If you smoke 3 cigarettes in rapid succession or 20 to 30 cigarettes within a 24-hour period, you may saturate 8 to 10 percent of the capacity of hemoglobin. As a result, smokers lose 20 percent of their night vision capability at sea level, which is equivalent to a physiological altitude of 5,000 feet.

Hypoglycemia: Low blood sugar from missing or postponing meals impairs your performance during night flights. Low blood sugar levels may lead to stomach contractions, distraction, breakdown in habit patterns, and a shortened attention span.

Vitamin A Deficiency: You need vitamin A to maintain your night vision. Include foods rich in vitamin A in your diet, such as eggs, butter, cheese, liver, apricots, peaches, carrots, squash, spinach, peas, and various greens. While high quantities of vitamin A don't boost night vision, a deficiency in vitamin A certainly impairs it.



Scanning techniques

Distance Estimation and Depth Perception

Understanding the mechanisms and cues that influence distance estimation and depth perception will help you accurately judge distances at night. These cues can be either *monocular* or *binocular*. Monocular cues that play a role in distance estimation and depth perception include *motion parallax, geometric perspective, retinal image size,* and *aerial perspective*.

Motion Parallax: Motion parallax refers to the apparent motion of stationary objects as you move across the landscape. When you look outside a car window towards the side of the road, near objects appear to move backward, past, or opposite your path of motion, while far objects seem to move with you or remain fixed. The rate of this apparent movement depends on your distance from the object.

Geometric Perspective: Objects can appear to have different shapes when viewed at varying distances and angles.

Linear Perspective: As the distance from the observer increases, parallel lines like runway lights, power lines, and railroad tracks tend to converge.

Apparent Foreshortening: is the visual phenomenon where objects appear shorter along their length when viewed from an angle. When an object is not viewed straight on, its apparent length is compressed, making it look shorter than its actual size. You can experience apparent foreshortening when observing objects at an angle, affecting your perception of distance and size. Knowing this can help you accurately judge the spacing and dimensions of objects in the surrounding environment, particularly when you are assessing the distance to runways, obstacles, or other elements during flight.

Vertical Position in the Field: refers to how objects appear higher or lower in the visual field, providing cues for depth perception and distance estimation. When looking at objects vertically, those higher in your field of view may be perceived as farther away, while objects lower in your field of view may be perceived as closer. This geometric perspective helps you judge the altitude and distance of objects in relation to you.

Aerial Perspective: As you observe objects, your brain uses the clarity of the object and the shadow it casts as cues to estimate distance. When you're close to an object, subtle color or shade variations are clearer. However, as you increase your distance, these distinctions become blurry. The same goes for the details or texture of an object. As you move farther away, the discrete details become less apparent.

An important point to remember during night flights is that every object casts a shadow from a light source. The direction of the shadow depends on the position of the light source. If the shadow of an object is cast toward you, it means the object is closer than the light source is to you.

Binocular Cues: When you observe an object, the binocular cues rely on the slightly different viewing angles of each of your eyes. However, these binocular cues become useful only when the object is close enough to create a noticeable difference in the viewing angle of both your eyes. That's normally within 30 feet. When flying, the distances outside the flight deck are often so vast that binocular cues provide little value until landing. Binocular cues operate on a more subconscious level than monocular cues and are performed automatically.

Geometric Perspective:
Linear Perspective

Geometric Perspective:
Apparent Foreshortening

Geometric Perspective:
Vertical Position in the Field

Optical Illusions

Optical illusions exist both in the day and night. In normal daylight conditions, many of these illusions won't have a huge impact on your flying. But as you lose light after sunset, these illusions can affect you more.

For safe flight, your vision is the most crucial sense. Yet, optical illusions can arise due to different terrain features and atmospheric conditions, especially during landing. Here are descriptions of major illusions that can lead to landing errors:

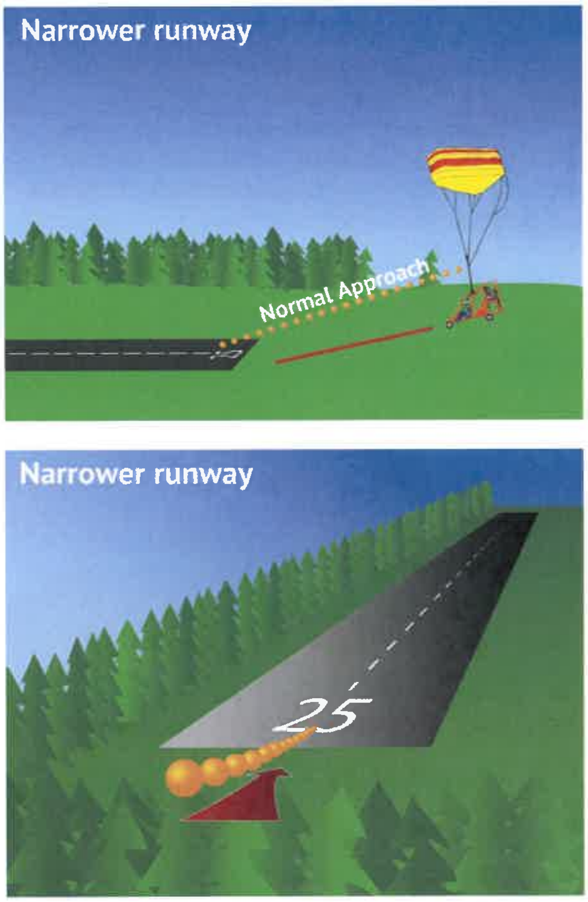
Runway Width Illusion: When you encounter a narrower-than-usual runway, it may create an illusion that you're at a higher altitude than you really are, especially if the runway length-to-width relationships are comparable. Failing to recognize this illusion might lead you to fly a lower approach, putting you at risk of striking objects along your approach path or landing short. On the other hand, a wider-than-usual runway can have the opposite effect, potentially causing you to level out high and land hard or overshoot the runway entirely.

Slopes Illusion: If you encounter an upsloping runway, an upsloping terrain, or both, it may create an illusion that your aircraft is at a higher altitude than it really is. Failing to recognize this illusion could lead you to fly a lower approach. On the other hand, downsloping runways and downsloping approach terrain can have the opposite effect.

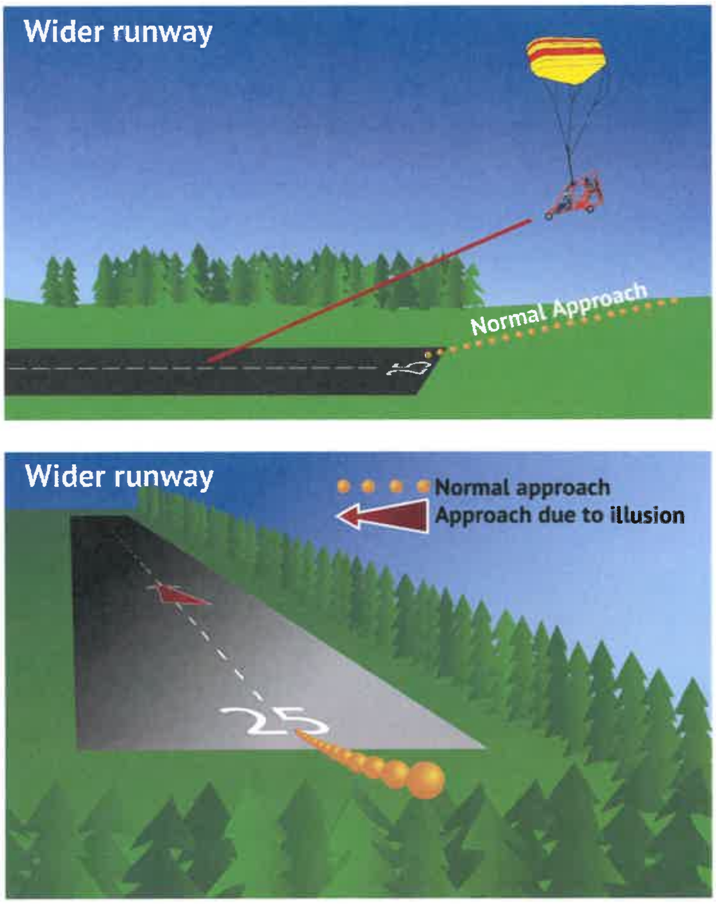
Featureless Terrain Illusion: When you experience an absence of surrounding ground features, such as during an over-water approach over darkened areas or terrain made featureless by snow, it can create an illusion that you're at a higher altitude than you really are. This phenomenon, commonly known as the *black hole approach*, may lead you to unintentionally fly a lower approach than desired.

Haze: When you encounter atmospheric haze, it can create the illusion of objects being further away than they really are. It can also create the illusion of being at a greater distance and height from the runway. Consequently, you will tend to be low on the approach. On the flip side, in extremely clear air, like the clear bright conditions at a high-altitude airport, you may get the illusion of being closer than you actually are. This can lead to a high approach, increasing the risk of overshooting or necessitating a go-around.

Illusions rank among the most common factors cited as contributing to fatal aviation accidents. To avoid these illusions and their potential hazards, follow these guidelines:



A narrower-than-usual runway can create an illusion that the aircraft is higher than it actually is, leading to a lower approach.



A wider-than-usual runway can create an illusion that the aircraft is lower than it actually is, leading to a higher approach.

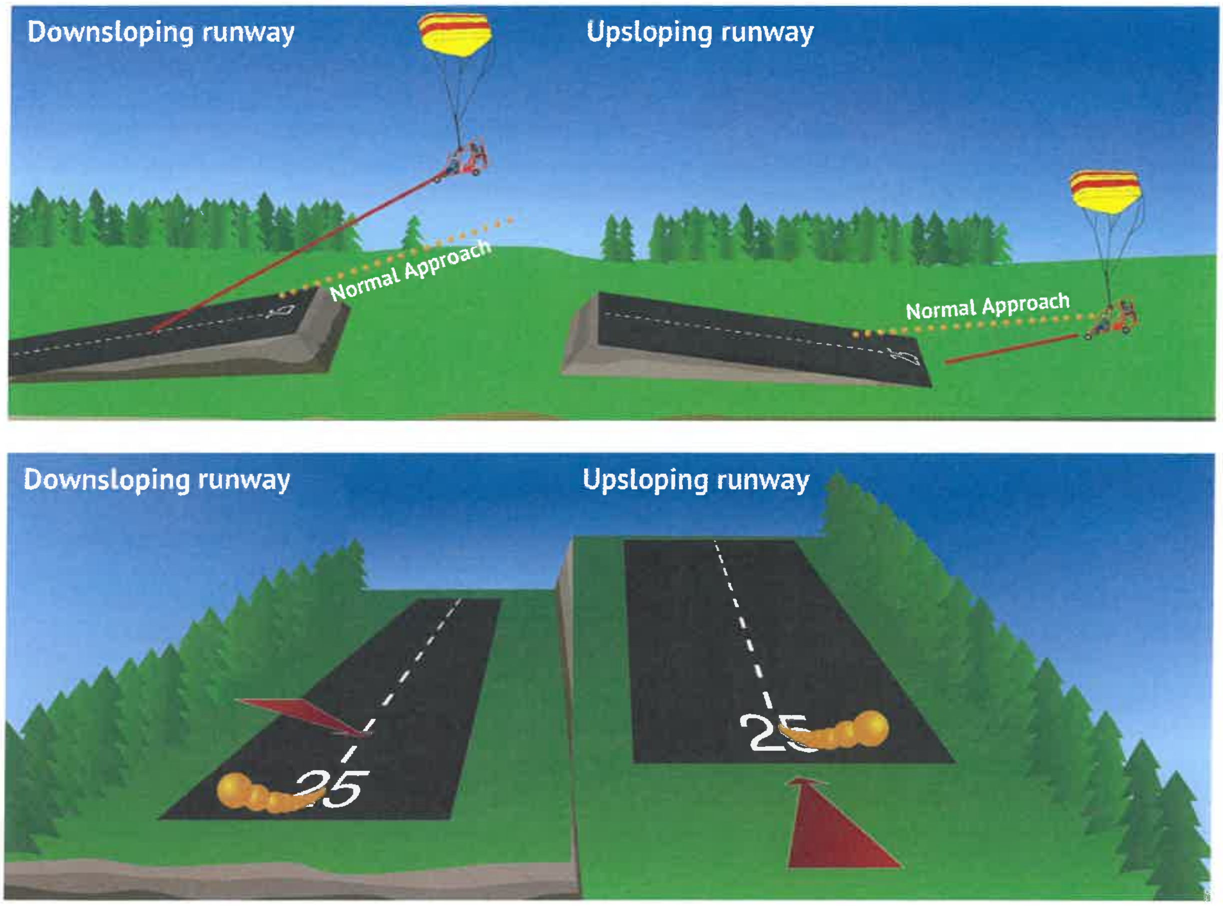
- Be aware of the possibility of visual illusions during approaches to unfamiliar airports, especially at night or in adverse weather conditions.
- Refer to the altimeter regularly, particularly during all approaches, whether it's day or night.
- If feasible, perform an aerial visual inspection of unfamiliar airports before attempting to land.
- Acknowledge that the likelihood of being involved in an approach accident increases when emergencies or other activities distract you from usual procedures.
- Keep your proficiency in landing procedures at its best.

Night Illusions

You rely on your eyes for accurate information, and visual illusions pose a significant hazard, especially in darkness or low visibility conditions that heighten susceptibility to errors. Even worse, some visual illusions are exclusive to night flying. The best approach to avoid these illusions is to know they exist and to anticipate them.

Autokinesis: If you stare at a single point of light against a dark background for more than a few seconds, you may experience autokinesis, where the light appears to move on its own after a while. The apparent movement typically starts around 8 to 10 seconds. To prevent this illusion, focus your eyes on objects at varying distances and avoid fixating on one light source. Visual scanning is crucial to eliminating or reducing this illusion. Ensure you don't stare at a light or lights for more than 10 seconds. Additionally, you can consider increasing the number of lights or varying the light intensity as alternative solutions. Stay mindful of these practices to avoid autokinesis.

False Horizon: A false horizon can occur when the natural horizon is obscured or not readily apparent. Flying at night under clear skies with ground lights below can result in situations where it's difficult to distinguish the ground lights from the stars. You can also experience it while flying toward the shore of an ocean or a large lake. Because of the relative darkness of the water, the lights along the shoreline can be mistaken for stars in the sky. An Aurora Borealis display at night or a visible sloping cloud formation can also affect your sense of the horizon. A similar problem is encountered during certain daylight operations over large bodies of water. Atmospheric and water conditions can create a visual scene without a discernible horizon.



A downsloping runway creates the illusion that the aircraft is lower than it actually is, leading to a higher approach.

An upsloping runway can create the illusion that the aircraft is higher than it actually is, leading to a lower approach.

Reversible Perspective Illusion: At night, an aircraft may appear to be moving away from you when it is, in fact, approaching you. This illusion often occurs when you're flying parallel to another aircraft. To determine the direction of flight, observe aircraft lights and their relative position to the horizon. If the intensity of the lights increases, the aircraft is approaching; if the lights dim, the aircraft is moving away.

Size-Distance Illusion: This illusion results from viewing a source of light that is increasing or decreasing in brightness. You might interpret the light as approaching or retreating when in reality fog or a cloud may be obscuring the light.

Fixation: The *fascination illusion* is where you might ignore orientation cues and focus solely on a goal or object. This happens to student pilots when they concentrate intensely on aircraft instruments or landing procedures. You don't want to risk becoming fixated on one task, neglecting awareness of the surrounding environment. This tendency is particularly risky at night since it's already difficult to determine ground-closure rates in the dark. There may be limited time to correct the situation if you fall into the trap of fixation.

Flicker Vertigo: For some people, flashing lights at certain frequencies can trigger vertigo, dizziness, grogginess, headaches, confusion, seizures, nausea, or vomiting. On rare occasions, convulsions and unconsciousness are also possible. Flickering lights at a rate between 4 and 20 cycles per second can come from lights in the flight deck, anticollision lights, strobe lights, or other aircraft lights. Reflections of strobe lights can be particularly distracting near or after sunset. These symptoms are rare but be aware of the possibility. You should try to eliminate any light source causing blinking or flickering problems in the flight deck. If you can't do that, proper scanning techniques at night can help prevent you from getting flicker vertigo.

Night Landing Illusions

Landing illusions occur in many forms. Prior to flying at night, you should learn the challenges of the area you plan to be flying in. Study the area and know how to navigate your way through areas that may pose a problem at night. Here are some of the things to look out for:

Featureless Terrain Illusion: Above featureless terrain at night, there's a natural tendency to fly a lower-than-normal approach. Elements that cause any type of visual obscuration, such as rain, haze, or a dark runway environment can also cause low approaches.

Ground Light Illusions: Bright lights, steep surrounding terrain, and a wide runway can produce the illusion of being too low, with a tendency to fly a higher-than-normal approach. It works the other way, too. When flying over terrain with only a few lights, it will make the runway appear farther away. With this situation, the tendency is common to fly a lower-than-normal approach. If the runway has a city in the distance on higher terrain, the tendency will be to fly a lower-than-normal approach. Often a set of regularly spaced lights along a road or highway can appear to be runway lights. Pilots have even mistaken the lights on moving trains as runway or approach lights. Bright runway or approach lighting systems can create the illusion that you're closer to the runway, especially where few lights illuminate the surrounding terrain. If you fail to recognize this illusion, you may end up flying a higher approach.

Black Hole Approach: A black-hole approach occurs when the landing is made from over water or non-lighted terrain where the runway lights are the only source of light. Without peripheral visual cues to help, you can have trouble orienting yourself relative to Earth. The runway can seem out of position (downsloping or upsloping) and in the worst case, results in landing short of the runway. If at any time you are unsure of your position or altitude, you should go-around.

Pilot Equipment

Before beginning a night flight, make sure that you have a reliable flashlight, aeronautical charts, pertinent flight data, and the checklists you'll need. If you haven't yet transitioned to using your phone or tablet to store and display your sectional and other data, flying at night is a good reason to make that transition.

You should carry at least one reliable flashlight on all night flights. Opt for an incandescent or LED dimmable flashlight capable of producing white and red light. Your flashlight should be easy to locate and it's a good idea to have a spare set of batteries. Use white light for your preflight inspection and setting up your wing. Use red light while flying since it's non-glare and won't impair your night vision. Adjust the brightness of your phone or tablet so that it won't impair your night vision either.

Consider having two flashlights— one with white light for preflight and wing layout and another, a penlight type, with red light for in-flight use. Your hands are full while you're laying out your wing so you may want to use a wearable headlamp instead of a handheld light. You may also want to wear your red penlight. Wear it on a string around your neck for easy access. Keep in mind that red light distorts color perception on charts.

Regardless of the equipment used, organize your flight deck before taxiing to ease the burden and enhance safety. Place equipment and charts within easy reach.

Powered Parachute Equipment and Lighting

§ 91.205(c) lists essential equipment required for VFR night flight for standard category aircraft.

Anti-Collision Lights are mandated by § 91.205(c) and normally consist of flashing beacons. However, the pilot-in-command, as per § 91.209(b), has the discretion to turn off anticollision lights for safety reasons.

Position Lights on aircraft are placed like those on boats and ships, including a red light on the left side of the airframe, a green light on the right side, and a white light facing rearward. This arrangement provides a means to determine the general direction of movement of other aircraft in flight. If you see both the red and green light of another aircraft, and the red is on the right and green on the left, the other aircraft may be on a collision course.

Landing Lights serve not only during taxi, takeoff, and landing but also enhance visibility to other pilots at night. You should keep your landing lights on day and night to promote visibility.

See and be Seen. Turning on aircraft lights aligns with the second half of the *"see and be seen"* principle. The other half of the principle requires that you stay on the lookout for other aircraft. Aircraft lights may blend with stars or city lights, requiring a conscious effort to distinguish them from other sources.

Optional Lighting. Not required by regulation are lights to the rear and above to illuminate your wing as it inflates when there is no sunlight.

§ 91.205 Powered civil aircraft with standard category U.S. airworthiness certificates: Instrument and equipment requirements.

(a) General. Except as provided in paragraphs (c)(3) and (e) of this section, no person may operate a powered civil aircraft with a standard category U.S. airworthiness certificate in any operation described in paragraphs (b) through (f) of this section unless that aircraft contains the instruments and equipment specified in those paragraphs (or FAA-approved equivalents) for that type of operation, and those instruments and items of equipment are in operable condition.

(b) Visual-flight rules (day). For VFR flight during the day, the following instruments and equipment are required:

(1) Airspeed indicator.
(2) Altimeter.
(3) Magnetic direction indicator.
(4) Tachometer for each engine.
(5) Oil pressure gauge for each engine using pressure system.
(6) Temperature gauge for each liquid-cooled engine.
(7) Oil temperature gauge for each air-cooled engine.
(8) Manifold pressure gauge for each altitude engine.
(9) Fuel gauge indicating the quantity of fuel in each tank.
(10) Landing gear position indicator, if the aircraft has a retractable landing gear.
(11) For small civil airplanes certificated after March 11, 1996, in accordance with part 23 of this chapter, an approved aviation red or aviation white anticollision light system. In the event of failure of any light of the anticollision light system, operation of the aircraft may continue to a location where repairs or replacement can be made.
(12) If the aircraft is operated for hire over water and beyond power-off gliding distance from shore, approved flotation gear readily available to each occupant and, unless the aircraft is operating under part 121 of this subchapter, at least one pyrotechnic signaling device. As used in this section, "shore" means that area of the land adjacent to the water which is above the high water mark and excludes land areas which are intermittently under water.
(13) An approved safety belt with an approved metal-to-metal latching device, or other approved restraint system for each occupant 2 years of age or older.
(14) For small civil airplanes manufactured after July 18, 1978, an approved shoulder harness or restraint system for each front seat. For small civil airplanes manufactured after December 12, 1986, an approved shoulder harness or restraint system for all seats. Shoulder harnesses installed at flightcrew stations must permit the flightcrew member, when seated and with the safety belt and shoulder harness fastened, to perform all functions necessary for flight operations. For purposes of this paragraph—
(i) The date of manufacture of an airplane is the date the inspection acceptance records reflect that the airplane is complete and meets the FAA-approved type design data; and
(ii) A front seat is a seat located at a flightcrew member station or any seat located alongside such a seat.
(15) An emergency locator transmitter, if required by § 91.207.
(16) [Reserved]
(17) For rotorcraft manufactured after September 16, 1992...

(c) Visual flight rules (night). For VFR flight at night, the following instruments and equipment are required:

(1) Instruments and equipment specified in paragraph (b) of this section.
(2) Approved position lights.
(3) An approved aviation red or aviation white anticollision light system on all U.S.-registered civil aircraft. Anticollision light systems initially installed after August 11, 1971, on aircraft for which a type certificate was issued or applied for before August 11, 1971, must at least meet the anticollision light standards of part 23, 25, 27, or 29 of this chapter, as applicable, that were in effect on August 10, 1971, except that the color may be either aviation red or aviation white. In the event of failure of any light of the anticollision light system, operations with the aircraft may be continued to a stop where repairs or replacement can be made.
(4) If the aircraft is operated for hire, one electric landing light.
(5) An adequate source of electrical energy for all installed electrical and radio equipment.
(6) One spare set of fuses, or three spare fuses of each kind required, that are accessible to the pilot in flight.

Training for Night Flight

Learning to fly safely at night takes time and experience. You should practice various maneuvers, such as straight-and-level flight, climbs and descents, level turns, climbing and descending turns, and steep turns. It's important to note that practicing anything unusual like engine out landings for the first time should only be done with a flight instructor.

During your practice sessions, consider turning off all flight deck lights to simulate an electrical or instrument light failure – a technique known as *blackout training*.

There isn't a specific night cross country dual requirement for the private pilot powered parachute rating. That means that your first cross country at night could be a challenge because you may be flying it without a flight instructor. When conducting night cross-country flights, planning is crucial. Despite having fewer references or checkpoints, these flights don't pose significant problems if you consistently monitor your position, time estimates, and fuel consumption, just as you would during the day.

Preparation and Preflight

Night flying requires that you are aware of and operate within your abilities and limitations. You need to plan carefully for a night flight and you should pay extra attention to preflight preparation and planning details.

Prepare for a night flight by thoroughly reviewing available weather reports and forecasts, paying particular attention to the temperature/dew point spread, as a narrow spread indicates the possibility of ground fog. Also, focus on wind direction and speed, as their effects are less easily detected at night. Many of the wind indicators you probably rely on during the day –like smoke and waving flags– can't be seen at night.

For night cross-country flights, choose and use an appropriate aeronautical chart, drawing course lines in black for better visibility in low-light conditions. Use visual checkpoints such as rotating beacons at airports, lighted obstructions, city or town lights, and headlights from traffic on major highways. When relying on a global positioning system (GPS), smartphone, or tablet, make sure the battery is fully charged. Also make sure that you know how to use your navigation system in the dark, load necessary waypoints before the flight, and make sure the database is up to date.

Before takeoff, check all personal equipment to ensure proper functioning. During the preflight inspection, briefly turn on all aircraft lights to confirm their operation. All personal equipment should be checked prior to starting your engine to ensure proper functioning. You don't want to find out at the worst possible time in flight that your flashlight has dead batteries.

§ 91.209 Aircraft lights.

No person may:

(a) During the period from sunset to sunrise (or, in Alaska, during the period a prominent unlighted object cannot be seen from a distance of 3 statute miles or the sun is more than 6 degrees below the horizon)–

- (1) Operate an aircraft unless it has lighted position lights;
- (2) Park or move an aircraft in, or in dangerous proximity to, a night flight operations area of an airport unless the aircraft–
  - (i) Is clearly illuminated;
  - (ii) Has lighted position lights; or
  - (iii) is in an area that is marked by obstruction lights;
- (3) Anchor an aircraft unless the aircraft–
  - (i) Has lighted anchor lights; or
  - (ii) Is in an area where anchor lights are not required on vessels; or

(b) Operate an aircraft that is equipped with an anticollision light system, unless it has lighted anticollision lights. However, the anticollision lights need not be lighted when the pilot-in-command determines that, because of operating conditions, it would be in the interest of safety to turn the lights off.

Night Flight Operations

If you use a lighted airport runway for night flight, you will be challenged in ways that airplane pilots aren't. Laying out your wing on a runway (and especially in the dark) can tie up a runway for a considerable amount of time. You will be difficult to see by landing aircraft, which could create a hazard. You should keep a handheld radio on so that you can listen to airport traffic and warn incoming aircraft of your presence on the runway. That way they can either land long or use another runway.

The runway lighting itself and the hard surface may be challenges you aren't familiar with. You don't want to hit any of the runway lights while taking off. Harder surfaces are less forgiving and it's easier to roll an airframe over on paved runways than it is on grass runways.

Airport and Navigation Lighting Aids

The lighting systems used for airports, runways, obstructions, and other visual aids at night are important aspects of night flying. Before flying at night, you should review the section on airport lighting in *Chapter 24, "Airport Operations."* You should also check the availability and status of lighting systems at your destination airport prior to a night flight, and particularly a cross-country night flight. This information can be found on aeronautical charts and in the Chart Supplements. You can learn the up-to-date status of each facility by reviewing pertinent Notices to Air Missions (NOTAMs).

Starting, Taxiing, Run-Up, and Parachute Layout

Once you're seated and before starting the engine, organize and arrange all items and materials you'll need during the flight. Particularly at night, take extra care to clear the propeller area. Turning on your strobe and flashing your position lights will alert nearby individuals to stay clear. Still, systematically scan the area around the airframe.

After starting the engine and preparing to taxi, turn on the landing light. In some powered parachutes, continuous use of the landing light while taxiing at low engine speeds may place an excessive drain the electrical system. Use the landing light only if necessary, being considerate to not blind other pilots. Taxi slowly, especially in congested areas, and follow painted taxi lines on the ramp or taxiway for a proper path. Make sure your instruments are working while taxiing to ensure proper operation before takeoff.

Ensure that your intended takeoff area is well-lit to avoid hazards.

Make sure that you warm up your engine properly, especially since it's usually colder at night. When using the checklist for run-up checks at night, be attentive to the possibility of the airframe creeping forward unnoticed. Hold or lock the brakes during the run-up and stay alert for any forward movement.

Before you lay your wing out, walk forward of your airframe and inspect the ground thoroughly, especially if you're taking off from a grass runway or undeveloped field. Use your flashlight to inspect the runway for potential obstacles, chuckholes, mounds, debris and other items that may pose a challenge for kiting and takeoff.

Setting up on a runway and laying out your wing in the dark could tie up a designated runway area for a considerable amount of time. Make sure that you have a spare handheld radio on so that you can monitor traffic at the airport.

Wing layout is particularly critical in night operations because it's harder to identify kiting problems at night. Use your flashlight to carefully inspect your suspension lines to make sure that there's no debris caught in them. Lay out your wing using a flashlight, even if your powered parachute is equipped with rear lighting. A direct light will help identify problems that might be missed in the shadows.

Takeoff and Climb

If you plan to fly a powered parachute at night, make sure you have enough illumination for takeoff. Illuminate the wing to ensure all cells are open, the wing is centered, and the lines are untangled.

Be careful when entering your powered parachute in the dark. With no light, it's hard to notice when the airframe might roll slightly backwards. You want to avoid this because risers and lines could slacken and drop into the propeller arc, which would be disastrous.

When you're settled back into the flight deck, make your radio announcement for takeoff. Then start your engine, increase power, and kite the wing. It's best if there is rear and top lighting to help watch what the wing is doing during the kiting process. Not being able to see the wing well makes taking off the most dangerous part of flying at night.

The most noticeable difference between daylight and nighttime flying is the limited availability of outside visual references at night. Therefore, use flight instruments more during night takeoffs and climbs. Adjust instrument lighting to a minimum brightness setting that allows you to read instruments but won't hinder outside vision.

Stay conscious of engine torque during takeoff. In the day, it's easy to see the aircraft veering to one side due to engine torque. At night, you need to remember to be aware of torque and compensate with rudder tube inputs to climb out straight.

After ensuring the final approach and runway are clear, the FAA would like you to turn on the landing lights if they aren't already on. You may find that using your landing lights are helpful during the takeoff, especially from an undeveloped runway. But landing lights are ineffective after you have climbed to an altitude where the light beam no longer extends to the surface.

Landing lights can be a distraction, however. The light can reflect back from parts of the airframe and can also cause distortion when reflected by haze, smoke, or fog that might exist in the climb. Therefore, when the landing light is used for the takeoff, it may be turned off after the climb is well established provided other traffic in the area doesn't require it for collision avoidance.

In the dark, it's difficult to judge how close you are to the surface and whether you're climbing or descending. Check your altimeter and VSI for a positive climb. Avoid turns until reaching a safe altitude.

Orientation and Navigation

During your night flights, especially on dark nights or under an overcast sky, spotting clouds and visibility restrictions can be challenging. Steer clear of clouds and fog. If you notice lights on the ground gradually disappearing or surrounded by a halo, be cautious, as it may indicate ground fog. If you're flying a cross country, you should probably not continue in that direction.

When descending through smoke or haze, keep in mind that horizontal visibility is significantly reduced compared to a straight-down perspective. Avoid embarking on a VFR night flight if you expect conditions below VFR minimums.

When crossing large bodies of water at night in a powered parachute, be aware of the potential hazard of ditching in case of an engine failure. Additionally, the limited or absent lighting over water can make it challenging to distinguish the horizon or the surface of the water, especially during poor visibility conditions.

Keep in mind that lighted runways, buildings, or objects can create illusions at different altitudes. Lights seen individually at 2,000 feet might appear as a solid mass at 5,000 feet or higher. Watch for these illusions, especially during altitude changes, as they could pose challenges when approaching lighted runways.

Approaches and Landings

When approaching an airport for landing at night, it's important to identify the runway lights and other airport lighting early on. If the airport layout is unfamiliar, you might find it challenging to spot the runway until you're very close due to the other lights in the area. The best method is to identify and fly toward the rotating beacon until the lights outlining the runway become distinguishable. To navigate a proper traffic pattern, positively identify the runway threshold and runway-edge lights. Once the airport lights are visible, keep them in sight throughout the approach.

Distance perception can be tricky at night due to limited lighting, causing a lack of ground references. Depend more on flight instruments, particularly the altimeter, to avoid flying too low for the distance from the airport.

Execute your approach and landing like you would during the daytime. However, avoid a low, shallow approach during night operations. Cross-check the altimeter and VSI against your position along the base leg and final approach. Night is the time when a visual approach slope indicator (VASI) can be valuable for establishing and maintaining a proper glide path in a powered parachute.

After turning onto the final approach and aligning midway between the two rows of runway-edge lights, note and correct for any wind drift. Use power judiciously for a stabilized approach. Turn on the landing light around halfway through the final approach but be aware of its limitations. It won't reach the ground from higher altitudes and may even be reflected back into your eyes by any existing haze, smoke, or fog. Despite that, the FAA prefers that you leave the landing light on as part of their *"Operation Lights ON"* program.

The round out and touchdown process is like day landings. Judging height and sink rate is challenging due to the limited observable objects in the landing area. The runway usually comes up quicker than expected and your first few landings at night will probably be harder because you will mistime your flare. Harder landings can be avoided by making more gradual approaches. You should include blackout landings as part of your night flying training and practice.

Optical Illusions During Landing

To avoid potential hazards caused by visual illusions during approaches to unfamiliar airports, especially at night, follow these guidelines:

- Anticipate the possibility of visual illusions and stay alert.
- Refer to airport diagrams and Chart Supplements for information on runway slope, terrain, and lighting.
- Keep a close eye on the altimeter during all approaches, whether it's day or night.
- If feasible, conduct an aerial visual inspection of unfamiliar airports before attempting to land.
- Use Visual Approach Slope Indicator (VASI) or Precision Approach Path Indicator (PAPI) systems for visual references.
- Be aware that distractions, emergencies, or other activities can increase the risk of approach accidents.
- Practice landings regularly to enhance overall safety during approaches.

Night Emergencies

When flying a powered parachute at night, one of the main concerns is the potential for a complete engine failure and the need for an emergency landing. To address this concern, here are important procedures to follow in case of an engine failure at night:

Maintain Control: Keep positive control of the powered parachute. Turn the aircraft towards an airport or away from congested areas.

Select an Emergency Landing Area: If the nearby terrain is known and suitable for a forced landing, turn towards an unlighted portion and plan for an emergency forced landing in that area.

Consider Public Access: Choose an emergency landing area close to public access if possible. This may aid in rescue or assistance if needed.

Identify the Malfunction: Check for the cause of the engine malfunction, such as the position of the magneto switch, or electric fuel pump switch. If possible, correct the issue immediately and attempt to restart the engine.

Manage Wind Orientation: Maintain orientation into the wind to avoid a downwind landing.

Prepare for Landing: Check the landing lights for operation at altitude. Turn them on in sufficient time to illuminate the terrain or obstacles along the flight path. If landing lights are unusable and outside visual references are unavailable, maintain a straight flight path until contact with the ground.

Post-Landing: After landing, turn off all switches and evacuate the airframe quickly.

Appendix A: Sport Pilot Powered Parachute Practical Test Standards

The Sport Pilot Practical Test Standards, or PTS as it's lovingly called by flight instructors and students, is the guide designated pilot examiners use to perform practical tests for pilot applicants. It's also the guide that CFIs use to test existing pilots who want to add powered parachute sport pilot privileges to their existing pilot certificate.

For powered parachute applicants, there are three different sport pilot standards:

- Sport Pilot Powered Parachute
- Sport Pilot Flight Instructor Powered Parachute
- Private Pilot Powered Parachute

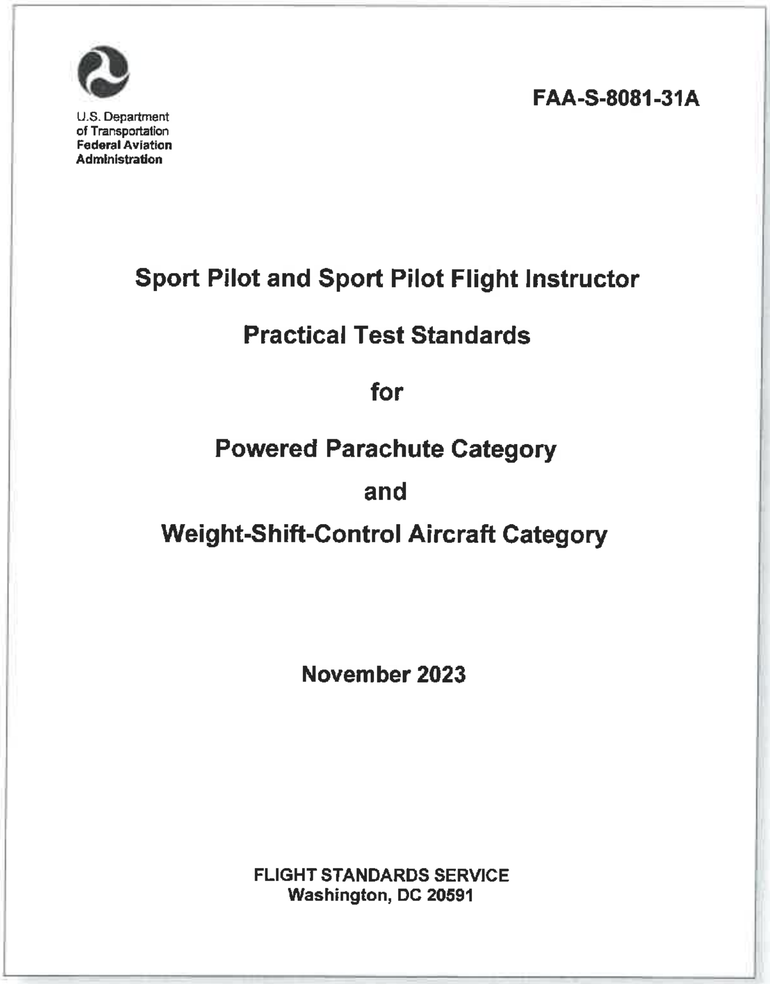
Within the Sport Pilot and Private Pilot standards there are also the options to apply for a land or sea designation.

Passing Your Practical Test

This appendix is dedicated to the majority of pilots who are working to obtain sport pilot privileges for powered parachute land.

With that in mind, the practical test standard we will be focusing on is the one for Sport Pilot Powered Parachute. Even that standard will be abridged to focus on just the land rating. The standards for Private Pilot Powered Parachute are very similar and this appendix will be very helpful for that rating. Sea ratings are not currently very popular and flight instructor training is beyond the scope of this book.

Besides just reading the text of the PTS, you will find cross-references back to parts of the book that pertain to the area being tested. That can help you both during test preparations and during the test itself. That's because you can bring along any reference materials you want to the practical test, including this book!



U.S. Department of Transportation
Federal Aviation Administration

FAA-S-8081-31A

Sport Pilot and Sport Pilot Flight Instructor

Practical Test Standards

for

Powered Parachute Category

and

Weight-Shift-Control Aircraft Category

November 2023

FLIGHT STANDARDS SERVICE
Washington, DC 20591

Foreword

FAA-S-8081-31A, Sport Pilot and Sport Pilot Flight Instructor Practical Test Standards for Powered Parachute Category and Weight-Shift-Control Aircraft Category is published by the FAA to establish the standards for sport pilot practical tests and proficiency checks for the weight-shift-control, powered parachute, and flight instructor. FAA inspectors and designated evaluators shall conduct practical tests in compliance with these standards. Instructors and applicants should find these standards helpful in practical test preparation.

FAA-S-8081-31A supersedes FAA-S-8081-31, Sport Pilot Practical Test Standards for Weight Shift Control, Powered Parachute, and Flight Instructor with changes 1, 2, 3, and 4 dated December 2004.

Introduction

General Information

This PTS has been published by the FAA to establish the standards for the knowledge and skills necessary for the issuance of a Sport Pilot Certificate, Flight Instructor Certificate with a Sport Pilot Rating, Sport Pilot additional privileges to operate an additional category or class of light-sport aircraft and Flight Instructor additional privileges seeking to provide training in an additional category or class of light-sport aircraft at the sport pilot level.

FAA inspectors and designated pilot examiners, and flight instructors shall conduct proficiency checks and practical tests in compliance with these standards. Flight instructors and applicants should find these standards helpful during training and when preparing for the practical test or proficiency check.

The FAA has developed this PTS as the standard that shall be used by FAA inspectors, SAEs, and DPEs when conducting sport pilot and flight instructor with a sport pilot rating practical tests and by authorized instructors when conducting proficiency checks.

Throughout this PTS the following titles will be referred to as an evaluator: ASI, pilot examiner (other than administrative pilot examiners), TCE, chief instructor, assistant chief instructor, check instructor of a pilot school holding examining authority, or authorized instructor. A proficiency check is an evaluation of aeronautical knowledge and flight proficiency in accordance with 14 CFR part 61, sections 61.321 or 61.419. A proficiency check must be administered using the appropriate PTS for the category of aircraft when a pilot or a flight instructor adds new category/class privileges. Upon successful completion of the proficiency check the authorized instructor will endorse the applicant's logbook indicating the added category/class of equipment that the applicant is authorized to operate. When an evaluator conducts a proficiency check, they are acting in the capacity of an authorized instructor. DPEs and SAEs must have designation authority to conduct sport pilot initial evaluations SPE and flight instructors with a sport pilot rating initial evaluations SFIE per FAA Order 8000.95, Designee Management Policy. Information considered directive in nature is described in this PTS in terms such as *"shall"* and *"must"* indicating the actions are mandatory. Guidance information is described in terms such as *"should"* and *"may"* indicating the actions are desirable or permissive, but not mandatory. This PTS is available for download, in PDF format, from **www.faa.gov**. Comments regarding this PTS may be emailed to **acsptsinquiries@faa.gov**.

PTS Concept

14 CFR part 61 specifies the subject areas in which knowledge and skill must be demonstrated by the applicant before the issuance of a certificate. The practical test standards contain the Areas of Operation and specific Tasks in which competency shall be demonstrated. The FAA will revise this PTS whenever it is determined that changes are needed in the interest of safety. Per 14 CFR part 61, section 61.43, adherence to the practical test standards is mandatory.

PTS Description

This PTS contains the following:

Section 1— Sport Pilot Weight-Shift-Control
Section 2— Sport Pilot Powered Parachute
Section 3— Sport Pilot Flight Instructor (The flight instructor section contains a separate introduction in section 3.)

The PTS includes the AREAS OF OPERATION and TASKs for the issuance of an initial Sport Pilot Certificate and for the addition of sport pilot category/class privileges. It also contains information on how to obtain an initial Flight Instructor Certificate with a sport pilot rating and for the addition of flight instructor category/class privileges.

AREAS OF OPERATION are phases of the practical test or proficiency check arranged in a logical sequence within each standard. They begin with Preflight Preparation and end with Postflight Procedures. The evaluator may conduct the practical test or proficiency check in any sequence that will result in a complete and efficient test. An authorized instructor may conduct a proficiency check in any sequence that will result in a complete and efficient test; **however, the ground portion of the practical test or proficiency check must be accomplished before the flight portion.**

TASKs are specific knowledge areas, flight procedures, or maneuvers appropriate to an AREA OF OPERATION. The abbreviation(s) within parentheses immediately following a TASK refer to the appropriate class of aircraft. The meaning of each class abbreviation is as follows:

WSCL—Weight-Shift-Control—Land
WSCS—Weight-Shift-Control—Sea
PPCL—Powered Parachute—Land
PPCS—Powered Parachute—Sea

When administering a test using section 1, 2, or 3 of this PTS, the TASKs appropriate to the class aircraft (WSCL, WSCS, PPCL, and PPCS) used for the test must be included in the plan of action. The absence of a class indicates the TASK is for all classes.

NOTE is used to emphasize special considerations required in the AREA OF OPERATION or TASK.

REFERENCE identifies the publication(s) that describe(s) the TASK. Descriptions of TASKs are not included in these standards because this information can be found in the current issue of the listed reference. Publications other than those listed may be used for reference if their content conveys substantially the same meaning as the referenced publications.

These practical test standards are based on the following references.

14 CFR part 43 Maintenance, Preventive Maintenance, Rebuilding, and Alteration
14 CFR part 61 Certification: Pilots, Flight Instructors, and Ground Instructors
14 CFR part 67 Medical Standards and Certification
14 CFR part 68 Requirements for Operating Certain Small Aircraft without a Medical Certificate
14 CFR part 71 Designation of class A, B, C, D, and E Airspace; Air Traffic Service Routes; and Reporting Points
14 CFR part 91 General Operating and Flight Rules
AC 60-22 Aeronautical Decision Making
AC 60-28 FAA English Language Skill Standard for an FAA Certificate Issued Under 14 CFR Parts 61, 63, 65, and 107
AC 61-65 Certification: Pilot and Flight and Ground Instructors
AC 61-67 Stall and Spin Awareness Training
AC 61-134 General Aviation Controlled Flight Into Terrain Awareness
AC 90-23 Aircraft Wake Turbulence
AC 90-48 Pilots' Role in Collision Avoidance
AC 90-66 Non-Towered Airport Flight Operations
AC 91-69 Seaplane Safety for FAR Part 91 Operations Crew
AC 120-51 Crew Resource Management Training
FAA-H-8083-1 Aircraft Weight and Balance Handbook
FAA-H-8083-2 Risk Management Handbook
FAA-H-8083-3 Airplane Flying Handbook
FAA-H-8083-5 Weight-Shift Control Aircraft Flying Handbook
FAA-H-8083-9 Aviation Instructor's Handbook
FAA-H-8083-13 Glider Flying Handbook
FAA-H-8083-15 Instrument Flying Handbook
FAA-H-8083-21 Helicopter Flying Handbook
FAA-H-8083-23 Seaplane, Skiplane, and Float/Ski Equipped
FAA-H-8083-25 Pilot's Handbook of Aeronautical Knowledge
FAA-H-8083-28 Aviation Weather Handbook
FAA-H-8083-29 Powered Parachute Flying Handbook
AIM Aeronautical Information Manual
AFM Aircraft Flight Manual
NOTAM Notice to Air Missions
Other Pilot Operating Handbook/FAA-Approved Flight Manual
Aeronautical Navigation Charts
Seaplane Supplement
Chart Supplements

NOTE: Users should reference the current edition of the reference documents listed above. The current edition of all FAA publications can be found at: **www.faa.gov**.

The Objective lists the important elements that must be satisfactorily performed to demonstrate competency in a TASK. The Objective includes:

1. specifically what the applicant must be able to do;
2. conditions under which the TASK is to be performed;
3. acceptable performance standards; and
4. safety considerations, when applicable.

Abbreviations/Acronyms

14 CFR	Title 14 of the Code of Federal Regulations
AC	Advisory Circular
ADM	Aeronautical Decision Making
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AKTR	Airman Knowledge Test Report
ATC	Air Traffic Control
CFIT	Controlled Flight into Terrain
CRM	Crew Resource Management
DPE	Designated Pilot Examiner
FAA	Federal Aviation Administration
GFA	Graphical Forecasts for Aviation
IACRA	Integrated Airman Certification and Rating Application
ID	Identification
IMC	Instrument Meteorological Conditions
NOTAM	Notice to Air Missions
NTSB	National Transportation Safety Board
PDF	Portable Document Format
POH	Pilot Operating Handbook
PPC	Powered Parachute

PPCL	Powered Parachute—Land
PPCS	Powered Parachute—Sea
PTS	Practical Test Standards
SAE	Specialty Aircraft Examiner
SFIE	Sport Flight Instructor Examiner
SOP	Standard Operating Procedures
SRM	Single-Pilot Resource Management
SS	Single-Seat
SUA	Special Use Airspace
TCE	Training Center Evaluator
TFR	Temporary Flight Restrictions
U.S.	United States
USCG	United States Coast Guard
VFR	Visual Flight Rules
WSC	Weight-Shift Control
WSCL	Weight-Shift Control—Land
WSCS	Weight-Shift Control—Sea

Use of the PTS

The FAA requires that all sport pilot and sport pilot flight instructor practical tests and proficiency checks are conducted in accordance with the appropriate sport pilot practical test standards. Applicants must be evaluated in **ALL** TASKs included in each AREA OF OPERATION of the appropriate practical test standard, unless otherwise noted.

In preparation for each practical test or proficiency check, the evaluator or authorized instructor shall develop a written *"plan of action."* The *"plan of action"* shall include all TASKs in each AREA OF OPERATION, unless noted otherwise. If the elements in one TASK have already been evaluated in another TASK, they need not be repeated.

For example, the *"plan of action"* need not include evaluating the applicant on complying with markings at the end of the flight, if that element was sufficiently observed at the beginning of the flight. **Any TASK selected for evaluation during a practical test or proficiency check shall be evaluated in its entirety.** Exception: the examiner or ASI (practical test); or Authorized Instructor (proficiency check) evaluating single-seat applicants from the ground shall evaluate only those TASK **elements** that can be accurately assessed from the ground.

The evaluator or authorized instructor is not required to follow the precise order in which the AREAS OF OPERATION and TASKs appear in this PTS. The evaluator or authorized instructor may change the sequence or combine TASKs with similar Objectives to have an orderly and efficient flow of the practical test or proficiency check events.

The evaluator's or authorized instructor's *"plan of action"* shall include the order and combination of TASKs to be demonstrated by the applicant in a manner that will result in an efficient and valid test.

The evaluator or authorized instructor is expected to use good judgment in the performance of simulated emergency procedures. The use of the safest means for simulation is expected. Consideration must be given to local conditions, both meteorological and topographical, at the time of the test, as well as the applicant's workload, and the condition of the aircraft used during the practical test or proficiency check. If the procedure being evaluated would jeopardize safety, it is expected that the applicant will simulate that portion of the maneuver.

Special Emphasis Areas

Evaluators and authorized instructors must place special emphasis upon areas of aircraft operations considered critical to flight safety. Among these are:

1. positive aircraft control;
2. procedures for positive exchange of flight controls;
3. stall and spin awareness (if appropriate);
4. collision avoidance;
5. wake turbulence and low level wind shear avoidance;
6. runway incursion avoidance;
7. CFIT;
8. ADM and risk management;
9. SRM and CRM;
10. wire strike avoidance;
11. checklist usage;
12. spatial disorientation;
13. TFR;
14. SUA;
15. aviation security; and
16. other areas deemed appropriate to any phase of the practical test or proficiency check.

Although these areas may not be specifically addressed under each TASK, they are essential to flight safety and will be evaluated during the practical test or proficiency check. In all instances, the applicant's actions will be relate to the complete situation.

Sport Pilot—Practical Test Prerequisites (Initial)

14 CFR part 61, section 61.39 and subpart J, provides practical test and certification prerequisites.

Sport Pilot—Additional Privileges

If you hold a Sport Pilot Certificate or higher and seek to operate an additional category or class of light-sport aircraft you must comply with 14 CFR part 61, section **61.321.If** you hold a Flight Instructor Certificate with a Sport Pilot Rating or higher and seek to operating an additional category or class of light-sport aircraft you must comply with 14 CFR part 61, section 61.419.

Aircraft and Equipment Required for the Practical Test/Proficiency Check

14 CFR part 61, section 61.45 provides requirements for aircraft and equipment for the practical test. The aircraft utilized for sport pilot and sport pilot flight instructor practical tests and proficiency checks must be a light-sport aircraft as defined in 14 CFR part 1.

Single-Seat Aircraft Practical Test

Applicants for a Sport Pilot Certificate may elect to take their test in a single-seat aircraft. The FAA established in 14 CFR part 61, section 61.45(f) specific requirements to allow a practical test for a Sport Pilot Certificate ONLY. This provision does not allow a practical test for a Flight Instructor Certificate or Recreation Pilot Certificate or higher to be conducted in a light-sport aircraft that has a single-pilot seat.

With certain limitations, the practical test for a Sport Pilot Certificate may be conducted from the ground by an examiner or ASI. The examiner or ASI must agree to conduct the practical test in a single-seat aircraft and must ensure that the practical test is conducted in accordance with the sport pilot practical test standards for single-seat aircraft. **Knowledge of all TASKs applicable to their category/class of aircraft will be evaluated orally.** Single-seat sport pilots shall demonstrate competency in those specific TASKs identified by a NOTE in the AREA OF OPERATION for a single-seat practical test and any other TASKs selected by the examiner or ASI. Examiners or ASIs evaluating single-seat applicants from the ground shall evaluate only those TASK **elements** that can be accurately assessed from the ground.

The examiner and ASI **must maintain radio contact** with the applicant and be in a position to observe the operation of the aircraft while evaluating the proficiency of the applicant from the ground.

Upon successful completion of the practical test, the pilot certificate will be issued with a limitation *"No passenger carriage and flight in a single-seat light-sport aircraft only."* Only an examiner or ASI is authorized to remove this limitation when the sport pilot takes a complete practical test in a two-place light-sport aircraft. This practical test may be conducted in the same or additional category of aircraft.

Single-Seat Aircraft Proficiency Check

Sport pilot proficiency checks may be performed for an additional category or privilege in accordance with 14 CFR part 61, section 61.321, to be added to a Sport Pilot Certificate or higher using a single-seat light-sport aircraft, providing the authorized instructor is an examiner. When an examiner conducts a proficiency check, they are acting in the capacity of an authorized instructor.

The authorized instructor must agree to conduct the practical test in a single seat light-sport aircraft and must ensure that the proficiency check is conducted in accordance with the sport pilot practical test standards for single-seat aircraft. Knowledge of all TASKs applicable to the category or class of aircraft will be evaluated orally. Those pilots seeking sport pilot privileges in a single-seat light-sport aircraft must demonstrate competency in those specific TASKs identified by a NOTE in the AREA OF OPERATION for a single-seat proficiency check and any other TASKs selected by the authorized instructor. Authorized instructors evaluating single-seat applicants from the ground must evaluate only those TASK elements that can be accurately assessed from the ground.

The authorized instructor must have radio contact and be in a position to observe the operation of the light-sport aircraft and evaluate the proficiency of the applicant from the ground.

On successful completion of a proficiency check, the authorized instructor will issue an endorsement with the following limitation *"No passenger carriage and flight in a single-pilot seat aircraft only (add category/class/make and model)"* limiting their operations to a single-seat aircraft in this category, class, make, and model. The authorized instructor must sign this endorsement with their flight instructor and examiner number.

This limitation can be removed by successfully completing a complete proficiency check; in a two-place light-sport aircraft in that specific category and class, in accordance with 14 CFR part 61, section 61.321. This proficiency check must be conducted in the same category and class of light-sport aircraft. Upon successful completion of the proficiency check, the applicant will be given an endorsement for the aircraft privilege sought.

Evaluator Responsibility

The evaluator conducting the practical test or authorized instructor conducting the proficiency check is responsible for determining that the applicant meets the acceptable standards of knowledge and skill of each TASK within each appropriate AREA OF OPERATION. Since there is no formal division between the *"oral"* and *"skill"* portions of the practical test or proficiency check, this oral portion becomes an ongoing process throughout the test. Oral questioning, to determine the applicant's knowledge of TASKs and related safety factors, should be used judiciously at all times, especially during the flight portion of the practical test or proficiency check. Evaluators and authorized instructors shall test to the greatest extent practicable the applicant's correlative abilities rather than mere rote enumeration of facts throughout the practical test or proficiency check.

If the evaluator or authorized instructor determines that a TASK is incomplete, or the outcome uncertain, the evaluator may require the applicant to repeat that TASK, or portions of that TASK. This provision has been made in the interest of fairness and does not mean that instruction, practice, or the repeating of an unsatisfactory TASK is permitted during the certification process. When practical, the remaining TASKs of the practical test or proficiency check phase should be completed before repeating the questionable TASK.

The evaluator or authorized instructor shall use scenarios when applicable to determine that the applicant can use good risk management procedures in making aeronautical decisions. Examples of TASKs where scenarios would be advantageous are weather analysis, performance planning, and runway/landing area selection.

Throughout the flight portion of the practical test or proficiency check, the evaluator or authorized instructor shall evaluate the applicant's knowledge and practical incorporation of special emphasis areas.

Flight Instructor Responsibility

An appropriately rated authorized flight instructor is responsible for training the sport pilot applicant to acceptable standards in all subject matter areas, procedures, and maneuvers included in the Tasks within the appropriate PTS.

Because of the impact of their teaching activities in developing safe, proficient pilots, flight instructors should exhibit a high level of knowledge, skill, and the ability to impart that knowledge and skill to students. Additionally, the flight instructor must certify that the applicant is able to perform safely as a sport pilot and is competent to pass the required practical test.

Throughout the applicant's training, the flight instructor is responsible for emphasizing the performance of effective visual scanning, collision avoidance, and runway incursion avoidance procedures. These areas are covered, in part, in AC 90-48, Pilots' Role in Collision Avoidance; FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge; and the Aeronautical Information Manual.

Practical Test—Sport Pilot-Satisfactory Performance

14 CFR part 61, section 61.43(a), describes the satisfactory completion of the practical test for a certificate or rating.

Practical Test—Sport Pilot—Unsatisfactory Performance

If, in the judgment of the evaluator, the applicant does not meet the standards of performance of any Task performed, the associated Area of Operation is considered unsatisfactory and, therefore, the practical test is failed. 14 CFR part 61, section 61.43(c)-(f) provides additional unsatisfactory performance requirements and parameters.

Typical areas of unsatisfactory performance and grounds for disqualification are:

1. Any action or lack of action by the applicant that requires corrective intervention by the evaluator to maintain safe flight.
2. Failure to use proper and effective visual scanning techniques to clear the area before and while performing maneuvers.
3. Consistently exceeding tolerances stated in the Objectives.
4. Failure to take prompt corrective action when tolerances are exceeded.

When a disapproval notice is issued, the evaluator will record the applicant's unsatisfactory performance in terms of Area of Operations and specific Task(s) not meeting the standard appropriate to the practical test conducted. The Area(s) of Operation/Task(s) not tested and the number of practical test failures must be recorded. If the applicant fails the practical test because of a special emphasis area, the Notice of Disapproval must indicate the associated TASK.

Proficiency Check—Sport Pilot—Satisfactory Performance When Adding an Additional Category/Class

Satisfactory performance of TASKs to add category/class privileges is based on the applicant's ability to safely:

1. perform the TASKs specified in the AREAS OF OPERATION for the certificate or privileges sought within the approved standards;
2. demonstrate mastery of the aircraft with the successful outcome of each TASK performed never seriously in doubt;
3. demonstrate satisfactory proficiency and competency within the approved standards;
4. demonstrate sound judgment in aeronautical decision making/ risk management; and
5. demonstrate single-pilot competence.

When an applicant is adding a category/class privileges to their Pilot Certificate, the authorized instructor, upon satisfactory completion of the proficiency check, shall endorse the applicant's logbook indicating that the applicant is qualified to operate the additional sport pilot category/class of aircraft. The authorized instructor shall forward FAA Form 8710-11, Airman Certificate and/or Rating Application to Civil Aviation Registry within 10 days or submit the application through IACRA.

Proficiency Check—Sport Pilot—Unsatisfactory Performance When Adding an Additional Category/Class

When the applicant's performance does not meet the standards in the PTS, the evaluator or authorized instructor conducting the proficiency check shall annotate the unsatisfactory performance on the FAA Form 8710-11, Airman Certificate and/or Rating Application and forward it to Civil Aviation Registry within 10 days or submit the application through IACRA. A Notice of Disapproval will **NOT** be issued in this instance; rather, the applicant should be provided with a list of the AREAS OF OPERATION and the specific TASKs not meeting the standard, so that the applicant may receive additional training.

When the applicant receives the additional training in the AREAS OF OPERATION and the specific TASK(s) found deficient during the proficiency check, the recommending instructor shall endorse the applicant's logbook indicating that the applicant has received additional instruction and has been found competent to pass the proficiency check. The applicant shall complete a new FAA Form 8710-11, Airman Certificate and/or Rating Application and the recommending instructor shall endorse the application. The authorized instructor, other than the one who provided the additional training, shall evaluate the applicant on all TASKS applicable to the additional light-sport aircraft privilege sought. When the applicant successfully accomplishes a complete proficiency check, the authorized instructor, shall forward the FAA Form 8710-11, Airman Certificate and/or Rating Application to Civil Aviation Registry within 10 days, or submit the application through IACRA, and endorse the applicant's logbook indicating the airman's additional category/class privileges.

ADM, Risk Management, CRM, and SRM

Throughout the practical test, the evaluator must assess the applicant's ability to use sound aeronautical decision-making procedures in order to identify hazards and mitigate risk. The evaluator must accomplish this requirement by developing scenarios that incorporate and combine Tasks appropriate to assessing the applicant's risk management in making safe aeronautical decisions. For example, the evaluator may develop a scenario that incorporates weather decisions and performance planning.

In assessing the applicant's performance, the evaluator should take note of the applicant's use of CRM and, if appropriate, SRM. CRM/SRM is the set of competencies that includes situational awareness, communication skills, teamwork, task allocation, and decision-making within a comprehensive framework of SOP. SRM specifically refers to the management of all resources onboard the aircraft, as well as outside resources available to the single pilot.

If an applicant fails to use ADM, including CRM/SRM, as applicable in any Task, the evaluator will note that Task as failed.

Applicant's Use of Checklists

Throughout the practical test or proficiency check, the applicant is evaluated on the use of an appropriate checklist. Proper use is dependent on the specific Task being evaluated. The situation may be such that the use of the checklist while accomplishing the elements of the Objective would be either unsafe or impractical, especially in a single-pilot operation. In this case, a review of the checklist after the elements have been accomplished, would be appropriate. Division of attention and proper visual scanning would be considered when using a checklist.

Use of Distractions During Practical Tests or Proficiency Checks

Numerous studies indicate that many accidents have occurred when the pilot has been distracted during critical phases of flight. To evaluate the pilot's ability to utilize proper control technique while dividing attention both inside and outside the flight deck, the evaluator should simulate a realistic distraction during the flight portion of the practical test or proficiency check to evaluate the applicant's ability to divide attention while maintaining safe flight.

Positive Exchange of Flight Controls

During flight, there must always be a clear understanding between pilots of who has control of the aircraft. Prior to flight, a briefing should be conducted that includes the procedure for the exchange of flight controls. A positive three-step process, subsequently described, in the exchange of flight controls between pilots is a proven procedure and one that is strongly recommended.

When one pilot wishes to give the other pilot control of the aircraft, they will say, *"You have the flight controls."* The other pilot acknowledges immediately by saying, *"I have the flight controls."* The first pilot again says, *"You have the flight controls."* When control is returned to the first pilot, follow the same procedure. A visual check is recommended to verify that the exchange has occurred. There should never be any doubt as to who is flying the aircraft.

Letter of Discontinuance

When a practical test is discontinued for reasons other than unsatisfactory performance (e.g., equipment failure, weather, or illness) FAA Form 8710-11, Airman Certificate and/or Rating Application, and, if applicable, the Airman Knowledge Test Report, is to be returned to the applicant. The evaluator at that time prepares, signs, and issues a Letter of Discontinuance to the applicant. The Letter of Discontinuance should identify the Areas of Operation and their associated Tasks of the practical test that were successfully completed. The applicant should be advised that the Letter of Discontinuance must be presented to the evaluator when the practical test is resumed, and made part of the certification file.

Applicant's Practical Test Checklist

Appointment with Evaluator

Evaluator's Name________________________________

Location ________________________________

Date/Time ________________________________

ACCEPTABLE AIRCRAFT

- ☐ Aircraft Documents: Airworthiness Certificate, Registration Certificate, and Operating Limitations
- ☐ Aircraft Maintenance Records: Logbook Record of Airworthiness Inspections/Safety Directives
- ☐ Pilot's Operating Handbook or FAA-Approved Flight Manual or Manufacturer's Operating Instructions

PERSONAL EQUIPMENT

- ☐ Current Aeronautical Chart
- ☐ Flight Logs
- ☐ Current Chart Supplements and Appropriate Publications

PERSONAL RECORDS

- ☐ Identification—Photo/Signature ID
- ☐ Pilot Certificate
- ☐ Medical Certificate, Driver's License, or show compliance with 14 CFR part 68
- ☐ Completed FAA Form 8710-11, Application for an Airman Certificate and/or Rating—Sport Pilot
- ☐ AKTR
- ☐ Logbook with Instructor's Endorsement
- ☐ FAA Form 8060-5, Notice of Disapproval Application (if applicable)
- ☐ Evaluator 's Fee (if applicable)

Sport Pilot Powered Parachute Areas of Operations and Tasks

References to chapters in this book are in highlighted text.

I. Area of Operation: Preflight Preparation

A. Task: Certificates and Documents (PPCL and PPCS)

REFERENCES: 14 CFR parts 43, 61, 91; FAA-H-8083-25, FAA-H-8083-29; Aircraft Flight Manual/POH/FAA Operating Limitations.
Chapter 5, "Pilot Certifications and Documentation"
Chapter 7, "Aircraft Certificates and Documents"
Objective: To determine that the applicant exhibits its knowledge of the elements related to certificates and documents by:

1. Explaining—
   a. certificate privileges, limitations, and currency experience requirements.
   b. medical eligibility.
   c. pilot logbook or flight records.
2. Locating and explaining—
   a. airworthiness and registration certificates.
   b. operating limitations, placards, instrument markings, and flight training supplement.
   c. weight and balance data and/or equipment list, as applicable.

B. Task: Airworthiness Requirements (PPCL and PPCS)

REFERENCES: 14 CFR part 91; FAA-H-8083-25, FAA-H-8083-29; Aircraft Operating Limitations.
Chapter 7, "Aircraft Certificates and Documents"
Objective: To determine that the applicant exhibits its knowledge of the elements related to airworthiness requirements by:

1. Explaining—
   a. required instruments and equipment for sport pilot privileges (as required by the operating limitations).
   b. procedures and limitations for determining if the aircraft, with inoperative instruments and/or equipment, is airworthy or in a condition for safe operation.
2. Explaining—
   a. safety directives (as applicable to the aircraft brought for flight test).
   b. maintenance/inspection requirements and appropriate record keeping.

C. Task: Weather Information (PPCL and PPCS)

REFERENCES: 14 CFR part 91; AC 61-134; FAA-H-8083-25, FAA-H-8083-28, FAA-H-8083-29; AIM.
Chapter 15, "Weather Information"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to real time weather information appropriate to the specific category/class aircraft by consulting weather reports, charts and forecasts from aeronautical weather reporting sources.
2. Makes a competent "go/no-go" decision based on available weather information.
3. Describes the importance of avoiding adverse weather and inadvertent entry into IMC.
4. Explains courses of action to safely exit from an inadvertent IMC encounter.

D. Task: Cross-Country Flight Planning (PPCL and PPCS)

REFERENCES: 14 CFR part 91; FAA-H-8083-25, FAA-H-8083-29; Navigation Charts; Chart Supplements; AIM.
Chapter 26, "Navigation"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to cross-country flight planning appropriate to the category/class aircraft.
2. Uses appropriate and current aeronautical charts.
3. Properly identifies airspace, obstructions, and terrain features.
4. Selects easily identifiable en route checkpoints, as appropriate.
5. Selects most favorable altitudes considering weather conditions and equipment capabilities.
6. Determines headings, flight time, and fuel requirements.
7. Selects appropriate navigation system/facilities and communication frequencies, if so equipped.
8. Applies pertinent information from NOTAMs, Chart Supplements, and other flight publications.
9. Completes a navigation plan and simulates filing a VFR flight plan.

E. Task: National Airspace System (PPCL and PPCS)

REFERENCES: 14 CFR parts 71, 91; Navigation Charts; FAA-H-8083-29; AIM.
Chapter 25, "Airspace"
Objective: To determine that the applicant exhibits knowledge of the elements related to the National Airspace System by explaining:

1. Sport pilot privileges applicable to the following classes of airspace:
   a. Class B.
   b. Class C.
   c. Class D.
   d. Class E.
   e. Class G.
2. Special use and other airspace areas.
3. TFRs.

F. Task: Operation of Systems (PPCL and PPCS)

REFERENCES: FAA-H-8083-25, FAA-H-8038-29; Aircraft Flight Manual/POH.
Chapter 8, "Aircraft Structure"
Chapter 9, "Engines"
Chapter 11, "Instruments"
Objective: To determine that the applicant exhibits its knowledge of the elements related to the operation of systems on the light-sport aircraft provided for the flight test by explaining at least three (3) of the following systems, if applicable:

1. Canopy/riser and control system.
2. Flight instruments and engine instruments.
3. Landing gear.
4. Engine and propeller.
5. Fuel, oil, electrical and coolant system (if liquid cooled).
6. Avionics and auxiliary equipment, as installed..

G. Task: Aeromedical Factors (PPCL and PPCS)

REFERENCES: FAA-H-8083-25, FAA-H-8083-29; AIM.
Chapter 6, "Aeromedical Factors"
Objective: To determine that the applicant exhibits its knowledge of the elements related to aeromedical factors by explaining:

1. The effects of alcohol, drugs, and over-the-counter medications.
2. The symptoms, causes, effects, and corrective actions of at least three (3) of the following—
   a. hypoxia.
   b. hyperventilation.
   c. middle ear and sinus problems.
   d. spatial disorientation.
   e. motion sickness.
   f. stress and fatigue.
   g. dehydration.
   h. hypothermia

H. Task: Water and Powered Parachute—Sea Characteristics (PPCS)...

I. Task: Seaplane Bases, Maritime Rules, and Aids to Marine Navigation (PPCS)...

J. Task: Performance and Limitations (PPCL and PPCS)

REFERENCES: FAA-H-8083-1, FAA-H-8083-23, FAA-H-8083-25, FAA-H-8032-29.
Chapter 14, "Altitude and Performance"
Objective: To determine the applicant:

1. Exhibits knowledge of the elements related to performance and limitations by explaining the effects of temperature, altitude, humidity, and wind.
2. Determines if weight and center of gravity is within limits.
3. Describes the effects of atmospheric conditions on the PPC's performance and limitations.
4. Explains the effects and hazards of high winds, referencing the ground speed, high rates of turn, and power requirements on making downwind turns in close proximity to the ground.)

K. Task: Principles of Flight (PPCL and PPCS)

REFERENCES: FAA-H-8083-1, FAA-H-8083-25, FAA-H-8083-29.
Chapter 16, "Aerodynamics"
Chapter 17, "Stability and Stalls"
Chapter 18, "Flight Controls and Trimming"
Objective: To determine the applicant exhibits knowledge of at least three (3) of the following aerodynamic principles:

1. Aerodynamics with respect to steering.
2. Propeller/Engine Torque Compensation.
3. Pendulum effect in PPCs.
4. Load factor effects in level flight and turns.
5. Wing flaring characteristics.
6. Explain the characteristics of improper chute rigging.

II. Area of Operation: Preflight Procedures

Note: For single-seat applicants, the examiner shall select at least TASKS A, B, C, E, and for PPCS, TASK F.

A. Task: Preflight Inspection (PPCL and PPCS)

REFERENCES: FAA-H-8038-29; Aircraft Flight Manual/POH.
Chapter 23, "Preflight"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to preflight inspection. This shall include which items must be inspected, the reasons for checking each item, and how to detect possible defects.
2. Inspects the powered parachute with reference to an appropriate checklist, or procedure.
3. Ensures that risers are properly attached and the chute is properly trimmed.
4. Verifies the powered parachute is in condition for safe flight.

B. Task: Canopy Layout (PPCL and PPCS)

REFERENCES: FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 19, "Parachute Layout and Stowing"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements of canopy layout.
2. Explains how to identify a line-over and demonstrates how to remove a line-over.
3. Verifies that canopy and riser system is laid out properly and in condition for inflation.
4. Demonstrates the ability to untwist twisted canopy suspension/ steering lines.
5. Verifies suspension and steering lines are not tangled or twisted.

C. Task: Engine Warm Up/ Starting (PPCL and PPCS)

REFERENCES: FAA-H-8083-25, FAA-H-8083-29; Aircraft Flight Manual/POH..\
Chapter 23, "Preflight"
Chapter 20, "Departures and Climbs"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to recommended engine starting/warm up procedures.
2. Positions the powered parachute properly considering structures, surface conditions, other aircraft, and the safety of nearby persons and property

D. Task: Cockpit Management (PPCL and PPCS)

REFERENCES: FAA-H-8083-25, FAA-H-8083-29; Aircraft Flight Manual/ POH.
Chapter 2, "Flight Safety"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to flight deck management procedures.
2. Ensures all loose items in the flight deck are secured.
3. Organizes material and equipment in an efficient manner so they are readily available.
4. Briefs occupant on the use of safety belts, shoulder harnesses, methods of egress, and other emergency procedures.

E. Task: Taxiing (Canopy Inflated) (PPCL and PPCS)

REFERENCES: FAA-H-8083-25, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 21, "Approaches and Landings"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements of taxiing with canopy inflated.
2. Positions PPC properly for existing wind conditions.
3. Monitors position and shape of canopy/riser system during taxi.
4. Centers the chute using power and steering as required.
5. Avoids other aircraft and ground hazards.
6. Controls direction and speed for 100 feet of forward movement.
7. Completes proper engine shutdown and canopy deflation procedure)

F. Task: Taxiing And Sailing (PPCS)...

G. Task: Before Takeoff Check (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/ POH.
Chapter 23, "Preflight"
Chapter 20, "Departures and Climbs"
Chapter 24, "Airport Operations"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to the before takeoff check. This shall include the reasons for checking each item and how to detect malfunctions.
2. Reviews takeoff performance, takeoff distances, departure, and emergency procedures.
3. Positions the powered parachute properly considering wind, other aircraft, and surface conditions.
4. Ensures that engine temperature is suitable for run-up and takeoff.
5. Ensures the powered parachute is in safe operating condition.
6. Avoids runway incursions and/or ensures no conflict with traffic.

III. Area of Operation: Airport and Seaplane Base Operations

A. Task: Radio Communications (PPCL and PPCS)

NOTE: If the aircraft is not radio equipped, this TASK shall be tested orally for procedures ONLY.
REFERENCES: 14 CFR part 91; FAA-H-8083-25, FAA-H-8083-29; AIM.
Chapter 24, "Airport Operations"
Objective: To determine that the applicant.

1. Exhibits knowledge of the elements related to radio communications at airports without operating control towers.
2. Selects appropriate frequencies.
3. Transmits using recommended phraseology.
4. Receives, acknowledges and complies with radio communications and complies with instructions.

B. Task: Traffic Patterns (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-25, FAA-H-8083-29; AC 90-66; AIM.
Chapter 24, "Airport Operations"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to traffic patterns and shall include procedures at airports with and without operating control towers, prevention of runway incursions, collision avoidance, wake turbulence avoidance, and wind shear.
2. Complies with proper local traffic pattern procedures.
3. Maintains proper spacing from other aircraft.
4. Corrects for wind drift to maintain the proper ground track.
5. Maintains orientation with the runway/landing area in use.
6. Maintains traffic pattern altitude, ±100 feet.

C. Task: Airport Runway Markings and Lighting (PPCL and PPCS)

REFERENCES: FAA-H-8083-23, FAA-H-8083-25, FAA-H-8083-29; AIM.
Chapter 24, "Airport Operations"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to airport/seaplane base, markings and lighting with emphasis on runway incursion avoidance.
2. Properly identifies and interprets airport/ seaplane base markings and lighting.

IV. Area of Operation: Takeoffs, Landings, and Go-Arounds

Note: For single-seat applicants, the examiner shall select all TASKS.

A. Task: Normal Takeoff And Climb (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 20, "Departures and Climbs"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to normal takeoff and climb operations and rejected takeoff procedures.
2. Clears the area.
3. Divides attention inside and outside the flight deck/airframe.
4. Makes smooth and appropriate throttle applications as the canopy transitions from ground pickup through maximum drag to taxi position.
5. Checks canopy, ensuring that all end cells are fully inflated and canopy is centered, lines are free and unobstructed and in condition for takeoff.
6. (PPCS)
7. (PPCS)
8. Maintains takeoff power to a safe maneuvering altitude.
9. Maintains directional control and proper wind-drift correction throughout the takeoff and climb.
10. Complies with noise abatement procedures

B. Task: Normal Approach and Landing (PPCL and PPCS)

NOTE: The applicant's knowledge of minimizing crosswind elements shall be evaluated through oral testing.
REFERENCES: FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 21, "Approaches and Landings"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to a normal approach and landing.
2. (PPCS)
3. Considers the wind conditions, landing surface, obstructions, and selects a suitable touchdown point.
4. Establishes the recommended approach and landing configuration and adjusts power as required.
5. Maintains a stabilized approach.
6. Makes smooth, timely, and correct control application during the flare and touchdown.
7. (PPCS)
8. (PPCS)
9. Maintains directional control throughout the approach and landing sequence and touchdown.
10. Completes proper engine shutdown and canopy deflation procedure.

C. Task: Glassy Water Takeoff and Climb (PPCS)...

D. Task: Glassy Water Approach And Landing (PPCS)...

E. Task: Rough Water Takeoff and Climb (PPCS)...

F. Task: Rough Water Approach and Landing (PPCS)...

G. Task: Go-Around/Rejected Landing (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 21, "Approaches and Landings"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to a go-around/ rejected landing.
2. Makes a timely decision to discontinue the approach to landing.
3. Applies takeoff power immediately.
4. Retracts the water rudders as appropriate, after a positive rate of climb is established. (PPCS)
5. Maneuvers to the side of the runway/ landing area to clear and avoid conflicting traffic, if appropriate.
6. Maintains appropriate power to a safe maneuvering altitude.
7. Maintains directional control and proper wind-drift correction throughout the climb.

V. Area Of Operation: Performance Maneuver

A. Task: Constant Altitude Turns (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 22, "Maneuvers"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to constant altitude turns.
2. Plans the maneuver no lower than 200 feet AGL.
3. Rolls into a constant bank 360° turn.
4. Performs the task in the opposite direction, as specified by the evaluator.
5. Divides attention between powered parachute control and orientation.
6. Maintains altitude, ±100 feet, and rolls out on the entry heading ±10°.

VI. Area of Operation: Ground Reference Maneuvers

NOTE: The evaluator shall select at least one ground reference maneuver.
NOTE: For single-seat applicants, the evaluator shall select at least one ground reference maneuver.

A. Task: Rectangular Course (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-29.
Chapter 22, "Maneuvers"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to a rectangular course.
2. Selects a suitable reference area, considering all obstacles.
3. Plans the maneuver so as to not descend below 200 feet above ground level at an appropriate distance from the selected reference area, 45° to the downwind leg.
4. Applies adequate wind-drift correction during straight-and- turning flight to maintain a constant ground track around the rectangular reference area.
5. Divides attention between powered parachute control and the ground track while maintaining coordinated flight.
6. Maintains altitude, ±100 feet.

B. Task: S-Turns (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-29.
Chapter 22, 'Maneuvers'
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to S-turns.
2. Selects a suitable ground reference line, considering all obstacles.
3. Plans the maneuver so as to not descend below 200 feet above the ground.
4. Applies adequate wind-drift correction to track a constant radius turn on each side of the selected reference line.
5. Reverses the direction of turn directly over the selected reference line.
6. Divides attention between powered parachute control and the ground track while maintaining coordinated flight.
7. Maintains altitude, ±100 feet.

C. Task: Turns Around a Point (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-29.
Chapter 22, "Maneuvers"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to turns around a point.
2. Selects a suitable ground reference point, considering all obstacles.
3. Plans the maneuver so as to not descend below 200 feet above the ground, at an appropriate distance from the reference point.
4. Applies adequate wind-drift correction to track a constant radius turn around the selected reference point.
5. Divides attention between powered parachute control and the ground track while maintaining coordinated flight.
6. Maintains altitude, ±100 feet.

VII. Area of Operation: Navigation

A. Task: Pilotage And Dead Reckoning

REFERENCE: FAA-H-8083-25, FAA-H-8083-29.
Chapter 26, "Navigation"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to pilotage and dead reckoning, as appropriate.
2. Follows the preplanned course by reference to landmarks.
3. Identifies landmarks by relating surface features to chart symbols.
4. Verifies the aircraft's position within 3 nautical miles of the flight-planned route.
5. Determines there is sufficient fuel to complete the planned flight, if not, has an alternate plan.
6. Maintains the appropriate altitude, ±200 feet and heading, ±15.

B. Task: Diversion

REFERENCES: FAA-H-8083-25, FAA-H-8083-29; AIM.
Chapter 26, "Navigation"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to diversion.
2. Selects an appropriate alternate airport or landing area and route.
3. Determines there is sufficient fuel to fly to the alternate airport or landing area.
4. Turns to and establishes a course to the selected alternate destination.
5. Maintains the appropriate altitude, ±200 feet, and heading, ±15°.

C. Task: Lost Procedures

REFERENCES: FAA-H-8083-25, FAA-H-8083-29; AIM.
Chapter 26, "Navigation"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to lost procedures.
2. Selects an appropriate course of action.
3. Maintains an appropriate heading and climbs if necessary.
4. Identifies prominent landmarks.
5. Uses navigation systems/facilities and or contacts an ATC facility for assistance, as appropriate.

VIII. Area of Operation: Emergency Operations

Note: For single-seat applicants, the examiner shall select TASK A.

A. Task: Emergency Approach And Landing (Simulated) (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 27, "Emergency Procedures"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to emergency approach and landing procedures.
2. Analyzes the situation and selects an appropriate course of action.
3. Plans and follows a flight pattern to the selected landing area considering altitude, wind, terrain, and obstructions.
4. Prepares for landing or go-around, as specified by the evaluator.

B. Task: Systems And Equipment Malfunctions (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 27, "Emergency Procedures"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to causes, indications, and pilot actions for various systems and equipment malfunctions.
2. Analyzes the situation and takes action, appropriate to the aircraft used for the practical test, in at least three (3) of the following areas, if applicable—
   a. engine/oil and fuel.
   b. electrical.
   c. carburetor or induction icing.
   d. smoke and/or fire.
   e. flight control/trim.
   f. propeller.
   g. any other emergency unique to the powered parachute flown.

C. Task: Emergency Equipment And Survival Gear (PPCL and PPCS)

REFERENCES: AC 91-69; FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/POH; AIM.
Chapter 27, "Emergency Procedures"
Objective: To determine that the applicant exhibits knowledge of the elements related to emergency equipment appropriate to the following environmental conditions:

1. Mountainous terrain.
2. Large bodies of water.
3. Desert conditions.
4. Extreme temperature changes.

IX. Area of Operation: Postflight Procedures

Note: For single-seat applicants, the examiner shall select TASK A and all other TASKS as applicable.

A. Task: After Landing, Parking, And Securing (PPCL and PPCS)

REFERENCES: FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-29; Aircraft Flight Manual/POH.
Chapter 19, "Parachute Layout and Stowing"
Objective: To determine that the applicant:

1. Exhibits knowledge of the elements related to after landing, parking, and securing procedures.
2. Observes runway hold lines and other surface control markings and lighting.
3. Parks in an appropriate area, considering the safety of nearby persons and property.
4. Follows the appropriate procedure for engine shutdown.
5. Protects canopy/riser system from the hot engine while stowing/ securing.)

B. Task: Anchoring (PPCS)...

C. Task: Docking And Mooring (PPCS)...

D. Task: Ramping/ Beaching (PPCS)...

Appendix B: List of Federal Aviation Regulations

Regulation Overview

US Aviation Law is primarily contained in Title 14 of the Code of Federal Regulations (CFR). Regulations come from two different sources. One is through Federal Law. That is, bills passed by congress and signed into law by the President.

Other regulations are created administratively. That means they are written by the FAA itself. Those rules are proposed and then published as a Notice of Proposed Rule Making (NPRM). After the public is given an opportunity to comment on the proposed rules, the FAA reviews the comments and then publishes the rule as proposed, in a modified form, or does not publish it at all.

Regulations cover nearly all aspects of aviation and are organized into "*Parts*." The Parts that are of concern to powered parachutists are:

Part 1: Definitions and Abbreviations
Part 11: General Rulemaking Procedures
Part 21: Certification Procedures for Products and Parts
Part 39: Airworthiness Directives
Part 43: Maintenance, Preventive Maintenance, **Rebuilding, and Alteration**
Part 45: Identification and Registration Marking
Part 61: Certification, Pilots and Instructors
Part 65: Certification: Airmen Other Than Flight Crew Members
Part 67: Medical Standards and Certification
Part 71: Designation of Class A, B, C, D, and E Airspace Areas; Air Traffic Service Routes; and Reporting Points
Part 73: Special Use Airspace
Part 103: Ultralight Vehicles
Part 91: General Operating and Flight Rules
49 CFR(National Transportation Safety Board)
Part 830: Notification and Reporting of Aircraft Accidents or Incidents And Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records

How to Use This Appendix

This appendix was designed to give you an overview of the regulations that apply to powered parachute pilots. The list of regulations is far longer, but these are the ones that you should at least be aware of.

You can find the details of these regulations in a recent copy of a FAR/AIM book online at **www.faa.gov**.

Some entire regulations are already integrated into other parts of this book. For example, the relevant definitions found in Part 1 of the FARs are included in the glossary of this book. Other regulations are shown in red sidebars. Page numbers to those regulations are listed in this appendix.

Part 11 General Rulemaking Procedures

Part 21 Certification Procedures For Products And Parts

Part 39 Airworthiness Directives

Part 43 Maintenance, Preventive Maintenance, Rebuilding, And Alteration

Part 45 Identification And Registration Marking

Part 47 Aircraft Registration

Part 61 Certification: Pilots, Flight Instructors, And Ground Instructors

Part 65 Certification: Airmen Other Than Flight Crewmembers

Part 91 General Operating And Flight Rules

Part 103 Ultralight Vehicles

Title 49: Transportation
Part 830—Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records

Glossary

1-800-WX-BRIEF
Phone number for reaching an FAA Flight Service Station 24 hours a day almost anywhere in the United States.

14 CFR (Title 14 of The Code Of Federal Regulations)
Federal regulations pertaining to aviation activity. Previously known as Federal Aviation Regulations.

100-Hour Inspection
An inspection required by 14 CFR 91.409 for FAA-certificated aircraft that are operated for hire, or are used for flight instruction for hire. A 100-hour inspection is similar in content to an annual inspection, but it can be conducted by an aircraft mechanic who holds an Airframe and Powerplant rating, but does not have an Inspection Authorization. A list of the items that must be included in an annual or 100-hour inspection is included in 14 CFR Part 43, Appendix D.

Aborted Takeoff
To terminate a preplanned takeoff when it's determined that some condition exists which makes takeoff or further flight dangerous.

Absolute Altitude
The vertical distance of an airplane above the terrain, or above ground level (AGL).

Absolute Pressure
Pressure measured from the reference of zero pressure, or a vacuum.

A.C.
Alternating current.

Acceleration
Force involved in overcoming inertia, and which may be defined as a change in velocity per unit of time.

Accordion Layout
A method of laying out the wing with the canopy lines extended and the canopy fabric stacked at the end of the lines.

Adiabatic Cooling
A process of cooling the air through expansion. For example, as air moves up a slope it expands with the reduction of atmospheric pressure and cools as it expands.

Adiabatic Heating
A process of heating dry air through compression. For example, as air moves down a slope it is compressed, which results in an increase in temperature.

Adjustable-Pitch Propeller
A propeller with blades whose pitch can be adjusted on the ground with the engine not running, but which cannot be adjusted in flight. Also referred to as a ground adjustable propeller. Sometimes also used to refer to constant-speed propellers that are adjustable in flight.

ADM
See AERONAUTICAL DECISION MAKING.

ADS-B
See AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST.

Administrator
Refers to the Federal Aviation Administrator or any person to whom he has delegated his authority in the matter concerned. While you will probably never meet the administrator, you will probably meet one of his or her many loyal representatives in the FAA.

Advection Fog
Fog resulting from the movement of warm, humid air over a cold surface.

Adverse Yaw
A condition of flight in which the nose of an airplane tends to yaw toward the outside of the turn. This is caused by the higher induced drag on the outside wing, which is also producing more lift. Induced drag is a by-product of the lift associated with the outside wing.

Aerodynamics
The science of the action of air on an object, and with the motion of air on other gases. Aerodynamics deals with the production of lift by the aircraft, the relative wind, and the atmosphere.

Aeronautical Chart
A map used in air navigation containing all or part of the following: topographic features, hazards and obstructions, navigation aids, navigation routes, designated airspace, and airports.

Aeronautical Decision Making (ADM)
A systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances.

Aeronautical Experience
Pilot time obtained in an aircraft, flight simulator, or flight training device for meeting the appropriate training and flight time requirements for an airman certificate, rating, flight review, or recency of flight experience requirements.

A/FD
See FLIGHT SUPPLEMENT U.S.

AFM
See AIRCRAFT FLIGHT MANUAL.

AGL
Above Ground Level, a measurement of an aircraft's altitude above the surface.

Agonic Line
An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are in alignment, and along which there is no magnetic variation.

Aiming Point
A specific spot on the runway that pilots aim to touch down or land their aircraft during a landing approach.

Aircraft
A device that is used, or intended to be used, for flight in the air.

Aircraft Accident
An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. (NTSB 830.2)

Aircraft Altitude
The actual height above sea level at which the aircraft is flying.

Aircraft Categories
(1) As used with respect to the certification, ratings, privileges, and limitations of airmen, means a broad classification of aircraft. Examples include: powered parachute, airplane, rotorcraft, glider, lighter-than-air, and weight-shift control.
(2) As used with respect to the certification of aircraft, means a grouping of aircraft based upon intended use or operating limitations. Examples include: transport, normal, utility, acrobatic, limited, restricted, and provisional.

Aircraft Flight Manual (AFM)
A document developed by the aircraft manufacturer and approved by the Federal Aviation Administration (FAA). It is specific to a particular make and model aircraft by serial number and it contains operating procedures and limitations.

Aircraft Operating Instructions
A document developed by the aircraft manufacturer and accepted by the Federal Aviation Administration (FAA). It is specific to a particular make and model powered parachute by serial number and it contains operating procedures and limitations.

Aircraft Owner/ Information Manual
A document developed by the aircraft manufacturer containing general information about the make and model of an aircraft. The aircraft owner's manual is not FAA approved and is not specific to a particular serial-numbered airplane. This manual is not kept current, and therefore cannot be substituted for the AFM/POH.

Airfoil
An airfoil is any surface, such as a wing or propeller, which provides aerodynamic force when it interacts with a moving stream of air.

Airframe
The engine and seats, attached by a structure to wheels; sometimes referred to as the fuselage, flight deck, chaise, or airframe.

Air Mass
An extensive body of air having fairly uniform properties of temperature and moisture.

AIRMET
In-flight weather advisory concerning moderate icing, moderate turbulence, sustained winds of 30 knots or more at the surface, and widespread areas of ceilings less than 1,000 feet and/or visibility less than three miles.

Airplane
An engine-driven, fixed-wing aircraft heavier than air that is supported in flight by the dynamic reaction of air against its wings.

Airport
An area of land or water that is used or intended to be used for the landing and takeoff of aircraft, and includes its buildings and facilities, if any.

Airport Advisory Area
An area within 10 statute miles (SM) of an airport where a control tower is not operating, but where a flight service station (FSS) is located. At these locations, the FSS provides advisory service to arriving and departing aircraft.

Airport/Facility Directory (A/FD).
See CHART SUPPLEMENT U.S.

Airspace
See CLASS A, CLASS B, CLASS C, CLASS D, CLASS E, or CLASS G AIRSPACE.

Airspeed
Rate of the aircraft's progress through the air.

Air Traffic
The aircraft operating in the air or on an airport surface, exclusive of loading ramps and parking areas.

Air Traffic Control
A service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic.

Airspeed Indicator
A differential pressure gauge that measures the dynamic pressure of the air through which the aircraft is flying. Displays the craft's airspeed, typically in knots, to the pilot.

Airway
An airway is based on a centerline that extends from one navigation aid or intersection to another navigation aid (or through several navigation aids or intersections); used to establish a known route for en route procedures between terminal areas.

Airworthiness
A state in which an aircraft or component meets the conditions of its type design and is in a condition for safe operation.

Airworthiness Certificate
A certificate issued by the FAA to aircraft that have been proven to meet the minimum standards set down by the Code of Federal Regulations.

Airworthiness Directive
A regulatory notice sent out by the FAA to the registered owner of an aircraft informing the owner of a condition that prevents the aircraft from continuing to meet its conditions for airworthiness. Airworthiness Directives (AD notes) are to be complied with within the required time limit, and the fact of compliance, the date of compliance, and the method of compliance are recorded in the aircraft's maintenance records. Does not apply to ELSA or SLSA aircraft. Instead, Safety Directives issued by the aircraft manufacturer are used.

Alert Area
An area depicted on an aeronautical chart to advise pilots that a high volume of pilot training or unusual aerial activity is taking place.

Almanac Data
Information the global positioning system (GPS) receiver can obtain from one satellite which describes the approximate orbital positioning of all satellites in the constellation. This information is necessary for the GPS receiver to know what satellites to look for in the sky at a given time.

Altimeter
A flight instrument that indicates altitude by sensing pressure changes.

Ambient Pressure
The pressure in the area immediately surrounding the aircraft.

Ambient Temperature
The temperature in the area immediately surrounding the aircraft.

AME
See AVIATION MEDICAL EXAMINER.

Ammeter
An instrument installed in series with an electrical load used to measure the amount of current flowing through the load.

Aneroid
The sensitive component in an altimeter or barometer that measures the absolute pressure of the air. It is a sealed, flat capsule made of thin disks of corrugated metal soldered together and evacuated by pumping all of the air out of it.

Aneroid Barometer
An instrument that measures the absolute pressure of the atmosphere by balancing the weight of the air above it against the spring action of the aneroid.

Angle of Attack (AOA)
The angle of attack is the angle at which relative wind meets an airfoil. It is the angle that is formed by the chord of the airfoil and the direction of the relative wind or between the chord line and the flight path. The angle of attack changes during a flight as the pilot changes the direction of the aircraft and is related to the amount of lift being produced.

Angle of Incidence
The angle formed by the chord line of the wing and a line parallel to the longitudinal axis of the airframe.

Annual Inspection
A complete inspection of an aircraft and engine, required by the Code of Federal Regulations, to be accomplished every 12 calendar months on all certificated aircraft. Only an A&P technician holding an Inspection Authorization can conduct an annual inspection for GA aircraft. A Light Sport Aircraft Repairman with a Maintenance Rating can conduct annual inspections on Special and Experimental Light Sport Aircraft (SLSA and ELSA).

AOA
See ANGLE OF ATTACK.

Area Forecast (FA)
A report that gives a picture of clouds, general weather conditions, and visual meteorological conditions (VMC) expected over a large area encompassing several states.

Arm
The horizontal distance in inches from the reference datum line to the center of gravity of an item. Used in weight and loading calculations.

Armed Forces
The Army, Navy, Air Force, Marine Corps, and Coast Guard, including their regular and reserve components and members serving without component status.

AROW
The mnemonic aid to remember the certificates and documents required to be onboard an

aircraft to determine airworthiness: Airworthiness certificate, Registration certificate, Operating limitations, Weight and balance data.

ASOS
See AUTOMATED SURFACE OBSERVING SYSTEM.

Aspect Ratio
Span of a wing divided by its average chord.

Asymmetrical Airfoil
An airfoil section that is not the same on both sides of the chord line.

Asymmetric Thrust
Also known as P-factor. A tendency for an aircraft to yaw to the left due to the descending propeller blade on the right producing more thrust than the ascending blade on the left. This occurs when the aircraft's longitudinal axis is in a climbing attitude in relation to the relative wind. The P-factor would be to the right if the aircraft had a counterclockwise rotating propeller.

ATC
See AIR TRAFFIC CONTROL.

ATIS
See AUTOMATIC TERMINAL INFORMATION SERVICE.

Attitude
A personal motivational predisposition to respond to persons, situations, or events in a given manner that can, nevertheless, be changed or modified through training as sort of a mental shortcut to decision-making.

Attitude Management
The ability to recognize hazardous attitudes in oneself and the willingness to modify them as necessary through the application of an appropriate antidote thought.

Authorized Instructor
(1) A person who holds a valid ground instructor certificate issued under Part 61 or Part 143 when conducting ground training in accordance with the privileges and limitations of his or her ground instructor certificate;
(2) A person who holds a current flight instructor certificate issued under Part 61 when conducting ground training or flight training in accordance with the privileges and limitations of his or her flight instructor certificate.

Autofeathering
A feature in some aircraft propeller systems that automatically adjusts the propeller blades to a feathered position (parallel to the airflow) when the engine is shut down or fails, minimizing drag and allowing for better performance and control of the aircraft.

Autokinesis
Nighttime visual illusion that a stationary light is moving, which becomes apparent after several seconds of staring at the light.

Automated Surface Observing System (ASOS)
Weather reporting system which provides surface observations every minute via digitized voice broadcasts and printed reports.

Automated Weather Observing System (AWOS)
Automated weather reporting system consisting of various sensors, a processor, a computer-generated voice subsystem, and a transmitter to broadcast weather data.

Automatic Dependent Surveillance–Broadcast (ADS-B).
A function on an aircraft or vehicle that periodically broadcasts its state vector (i.e., horizontal and vertical position, horizontal and vertical velocity) and other information.

Automatic Terminal Information Service (ATIS)
The continuous broadcast of recorded non-control information in selected terminal areas. Its purpose is to improve controller effectiveness and to relieve frequency congestion by automating the repetitive transmission of essential but routine information.

Aviation Medical Examiner (AME)
A medical doctor authorized to perform aviation medical exams for aviators.

Aviation Routine Weather Report (METAR)
Observation of current surface weather reported in a standard international format.

AWOS
See AUTOMATED WEATHER OBSERVING SYSTEM.

Axes of an Aircraft
Three imaginary lines that pass through an aircraft's center of gravity. The axes can be considered as imaginary axles around which the aircraft rotates. The three axes pass through the center of gravity at 90° angles to each other. The axis from nose to tail is the longitudinal axis (pitch), the axis that passes from wingtip to wingtip is the lateral axis (roll), and the axis that passes vertically through the center of gravity is the vertical axis (yaw).

Bank Attitude
The angle of the lateral axis relative to the horizon.

Base Leg
A flight path at right angles to the landing runway off its approach end. The base leg normally extends from the downwind leg to the intersection of the extended runway centerline.

Bernoulli's Principle
A principle that explains how the pressure of a moving fluid varies with its speed of motion. An increase in the speed of movement causes a decrease in the fluid's pressure.

Brake
Applying brake means deflecting one or both sides of the trailing edge of the parachute wing in order to turn or flare the chute.

Brake Horsepower
The power delivered at the propeller shaft of an aircraft engine.

Camber
The curvature of an airfoil when looking at a cross-section. A wing has upper camber on its top surface and lower camber on its bottom surface. The upper camber is more pronounced, while the lower camber is comparatively flat. This causes the velocity of the airflow immediately above the wing to be much higher than that below the wing.

Canopy
The fabric part of the parachute. The canopy is the primary component of the parachute system, designed to provide lift.

Carburetor Ice
Ice that forms inside the carburetor due to the temperature drop caused by the vaporization of the fuel. Induction system icing is an operational hazard because it can cut off the flow of the fuel-air charge or vary the fuel-air ratio.

Airframe
See AIRFRAME.

Category
(1) As used with respect to the certification, ratings, privileges, and limitations of airmen, means a broad classification of aircraft. Examples include: airplane; rotorcraft; glider; and lighter-than-air; and
(2) As used with respect to the certification of aircraft, means a grouping of aircraft based upon intended use or operating limitations. Examples include: transport, normal, utility, acrobatic, limited, restricted, and provisional.

Cavitation
A condition that exists in a fluid pump when there is not enough pressure in the reservoir to force fluid to the inlet of the pump. The pump picks up air instead of fluid.

Ceiling
The height above the earth's surface of the lowest layer of clouds, which is reported as broken or overcast, or the vertical visibility into an obscuration.

Cell
A portion of a canopy including the portions of the upper and bottom surfaces and a non-load rib between two loaded ribs. Wings are often described by the number of cells they have as well as the square footage of the overall canopy.

Center of Gravity (CG)
The point at which an aircraft would balance if it were possible to suspend it at that point. It is the mass center of the aircraft, or the theoretical point at which the entire weight of the powered parachute is assumed to be concentrated. It may be expressed in inches from the reference datum, or in percent of mean aerodynamic chord (MAC). The location depends on the distribution of weight in the aircraft.

Center of Lift
The location along the chord line of an airfoil at which all the lift forces produced by the airfoil are considered to be concentrated.

Center of Pressure (CP)
A point along the wing chord line where lift is considered to be concentrated. For this reason, the center of pressure is commonly referred to as the center of lift.

Centrifugal Force
An outward force, that opposes centripetal force, resulting from the effect of inertia during a turn. For instance, when in a high bank turn, it's the force pushing you down in your seat.

Centripetal Force
A center-seeking force directed inward toward the axis of rotation created by the horizontal component of lift in turning flight. For instance, when in a high bank turn, it's the force that the seat exerts on the you to offset the centrifugal force.

Certified Flight Instructor (CFI)
A flight instructor authorized by the FAA to provide flight instruction in a designated category of aircraft.

CFI
See CERTIFIED FLIGHT INSTRUCTOR.

CFR
See CODE OF FEDERAL REGULATIONS.

CG
See CENTER OF GRAVITY.

Chart Supplement U.S. (formerly Airport/Facility Directory)
An FAA publication containing information on all airports, communications, and NAVAIDs.

Checklist
A list of procedures that provides a logical and standardized method to operate a particular make and model aircraft.

Checkride
A practical test administered by an FAA examiner or designated examiner for the purpose of issuing an FAA certificate or rating.

Chord Line
An imaginary straight line drawn through an airfoil from the leading edge to the trailing edge.

Chute
See WING.

Class A Airspace
Airspace from 18,000 feet MSL up to and including FL600, including the airspace overlying the waters within 12 NM of the coast of the 48 contiguous states and Alaska; and designated international airspace beyond 12 NM of the coast of the 48 contiguous states and Alaska within areas of domestic radio navigational signal or ATC radar coverage, and within which domestic procedures are applied.

Class B Airspace
Airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports. The configuration of each Class B airspace is individually tailored and consists of a surface area and two or more layers, and is designed to contain all published instrument procedures once an aircraft enters the airspace. For all aircraft, an ATC clearance is required to operate in the area, and aircraft so cleared receive separation services within the airspace.

Class C Airspace
Airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports having an operational control tower, serviced by radar approach control, and having a certain number of IFR operations or passenger numbers. Although the configuration of each Class C airspace area is individually tailored, the airspace usually consists of a 5 NM radius core surface area that extends from the surface up to 4,000 feet above the airport elevation, and a 10 NM radius shelf area that extends from 1,200 feet to 4,000 feet above the airport elevation.

Class D Airspace
Airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored, and when instrument procedures are published, the airspace will normally be designed to contain the procedures.

Class E Airspace
Airspace that is not Class A, Class B, Class C, or Class D, and it is controlled airspace.

Class G Airspace
Airspace that is uncontrolled, except when associated with a temporary control tower, and has not been designated as Class A, Class B, Class C, Class D, or Class E airspace.

Clean Configuration
A configuration in which all flight control surfaces have been placed to create minimum drag. In most aircraft this means flaps and gear retracted.

Clearance
ATC permission for an aircraft to proceed under specified traffic conditions within controlled airspace, for the purpose of providing separation between known aircraft.

Code of Federal Regulations (CFRs)
Regulations issued by the U.S. Federal Government as published in the Federal Register.

Coefficient of Lift (C_L)
The ratio between lift pressure and dynamic pressure.

Cold Front
The boundary between two air masses where cold air is replacing warm air.

Combustion
Process of burning the fuel-air mixture in the engine in a controlled and predictable manner.

Common Traffic Advisory Frequency (CTAF)
A frequency designed for the purpose of carrying out airport advisory practices while operating to or from an airport without an operating control tower. The CTAF may be a UNICOM, MULTICOM, FSS or tower frequency and is identified in appropriate aeronautical publications.

Compass Course
A true course corrected for variation and deviation errors.

Compass Rose
A small circle graduated in 360° increments, to show direction expressed in degrees.

Complex Aircraft
An aircraft with retractable landing gear, flaps, and a controllable pitch propeller.

Condensation
A change of state of water from a gas (water vapor) to a liquid.

Condensation Nuclei
Small particles of solid matter in the air on which water vapor condenses.

Configuration
This is a general term, which normally refers to the position of the landing gear and flaps.

Consensus Standard
Used for certificating light-sport aircraft. An industry-developed standard that applies to aircraft design, production, and airworthiness. It includes, but is not limited to, standards for aircraft design and performance, required equipment, manufacturer quality assurance systems, production acceptance test procedures, operating instructions, maintenance and inspection procedures, identification and recording of major repairs and major alterations, and continued airworthiness.

Constant-Speed Propeller
A controllable-pitch propeller whose pitch is automatically varied in flight by a governor to maintain a constant RPM in spite of varying air loads.

Control Lines
See STEERING LINES.

Control Pressures
The amount of physical exertion on the control column necessary to achieve the desired attitude.

Control Tower
A terminal facility that uses air/ground communications, visual signaling, and other devices to provide ATC services to aircraft operating in the vicinity of an airport or on the movement area. Authorizes aircraft to land or take off at the airport controlled by the tower or to transit the Class D airspace area regardless of the flight plan or weather conditions. May also provide approach control services (radar or non-radar).

Controllability
A measure of the response of an aircraft relative to the pilot's flight control inputs.

Controlled Airport
An airport that has an operating control tower.

Controlled Airspace
An airspace of defined dimensions within which air traffic control service is provided to IFR flights and to VFR flights in accordance with the airspace classification.

Note: *"controlled airspace"* is a generic term that covers Class A, Class B, Class C, Class D and Class E airspace.

Controlled Firing Area
An area established to contain activities, which if not conducted in a controlled environment, would be hazardous to nonparticipating aircraft.

Convective SIGMET
A weather advisory concerning convective weather significant to the safety of all aircraft. Convective SIGMETs are issued for tornadoes, lines of thunderstorms, thunderstorms over a wide area, embedded thunderstorms, wind gusts to 50 knots or greater, and/or hail 3/4 inch in diameter or greater.

Convective Weather
Unstable, rising air found in cumiliform clouds.

Coordinated Turn
Turn made by an aircraft where the horizontal component of lift is equal to the centrifugal force of the turn.

Coriolis Illusion
The illusion of rotation or movement in an entirely different axis, caused by an abrupt head movement, while in a prolonged constant-rate turn that has ceased to stimulate the brain's motion sensing system.

Course
The intended direction of flight in the horizontal plane measured in degrees from north.

Crab Angle
The angle formed between the direction an aircraft is pointed and the direction it is tracking over the ground resulting from a crosswind component.

Crew Member
A person assigned to perform duty in an aircraft during flight time. Also referred to as crewmember in many regulations.

Crew Resource Management (CRM)
The application of team management concepts in the flight deck environment. It was initially known as flight deck resource management, but as CRM programs evolved to include cabin crews, maintenance personnel, and others, the phrase *"crew resource management"* was adopted. This includes single pilots, as in most general aviation aircraft. Pilots of small aircraft, as well as crews of larger aircraft, must make effective use of all available resources; human resources, hardware, and information. A current definition includes all groups routinely working with the flight crew who are involved in decisions required to operate a flight safely. These groups include, but are not limited to pilots, dispatchers, cabin crew members, maintenance personnel, and air traffic controllers. CRM is one way of addressing the challenge of optimizing the human/machine interface and accompanying interpersonal activities.

Critical Angle of Attack
The angle of attack at which a wing stalls regardless of airspeed, flight attitude, or weight.

Critical Areas
Areas where disturbances to the ILS localizer and glide slope courses may occur when surface vehicles or aircraft operate near the localizer or glide slope antennas.

CRM
See CREW RESOURCE MANAGEMENT.

Cross-check
The first fundamental skill of instrument flight, also known as *"scan,"* the continuous and logical observation of instruments for attitude and performance information.

Crosswind
Wind blowing across rather than parallel to the direction of flight. In a traffic pattern, the crosswind leg is a flight path at right angles to the landing runway off its upwind end.

Crosswind Correction
Correction applied in order to maintain a straight ground track during flight when a crosswind is present.

Crosswind Landing
Landing made with a wind that is blowing across rather than parallel to the landing direction.

Crosswind Takeoffs
Takeoffs made during crosswind conditions.

CTAF
See COMMON TRAFFIC ADVISORY FREQUENCY.

Cross-Country Time
For the purpose of meeting the aeronautical experience requirements for a sport pilot certificate with powered parachute privileges or a private pilot certificate with a powered parachute category rating, time acquired during a flight conducted in an appropriate aircraft that -

(1) Includes a point of landing at least a straight line distance of more than 15 nautical miles from the original point of departure; and
(2) Involves, as applicable, the use of dead reckoning; pilotage; electronic navigation aids; radio aids; or other navigation systems to navigate to the landing point.

Dark Adaptation
Physical and chemical adjustments of the eye that make vision possible in relative darkness.

Datum
An imaginary vertical plane or line from which all measurements of moment arm are taken. The datum is established by the manufacturer.

DC
Direct current.

Dead Reckoning
Navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction and speed, groundspeed, and elapsed time.

Death Spirals
See STEEP SPIRALS.

Decide Model
Model developed to help pilots remember the six-step decision-making process: Detect, Estimate, Choose, Identify, Do, Evaluate.

Deck Angle
The angle of the airframe's lower frame (from the front wheel to the rear wheels), to the landing surface.

Delta
A Greek letter expressed by the symbol Δ to indicate a change of values. For example, ΔCG indicates a change (or movement) of the CG.

Density Altitude
Pressure altitude corrected for variations from standard temperature. When conditions are standard, pressure altitude and density altitude are the same. If the temperature is above standard, the density altitude is higher than pressure altitude. If the temperature is below standard, the density altitude is lower than pressure altitude. This is an important altitude because it is directly related to aircraft performance.

Departure Leg
The leg of the rectangular traffic pattern that is a straight course aligned with, and leading from, the takeoff runway.

Deposition
The direct transformation of a gas to a solid state, in which the liquid state is bypassed. Some sources use sublimation to describe this process instead of deposition.

Designated Pilot Examiner (DPE)
An individual designated by the FAA to administer practical tests to pilot applicants.

Detonation
The sudden release of heat energy from fuel in an aircraft engine caused by the fuel-air mixture reaching its critical pressure and temperature. Detonation occurs as a violent explosion rather than a smooth-burning process.

Deviation
A compass error caused by magnetic disturbances from electrical and metal components in the airplane. The correction for this error is displayed on a compass correction card placed near the magnetic compass in the airplane.

Dew
Moisture that has condensed from water vapor. Usually found on cooler objects near the ground, such as grass, as the near-surface layer of air cools faster than the layers of air above it.

Dew Point
The temperature at which air reaches a state where it can hold no more water.

Differential Pressure
A difference between two pressures. The measurement of airspeed is an example of the use of differential pressure.

Direct User Access Terminal Service (DUATS)
A system that provides current FAA weather and flight plan filing services to certified civil pilots, via personal computer, modem, or telephone access to the system. Pilots can request specific types of weather briefings and other pertinent data for planned flights.

Directional Stability
Stability about the vertical axis of an aircraft, whereby an aircraft tends to return, on its own, to flight aligned with the relative wind when disturbed from that equilibrium state. The pendulum design is the primary contributor to directional stability, causing a powered parachute in flight to align with the relative wind.

DoD
Department of Defense

Downwash
The downward flow of air behind an airfoil or other aerodynamic surface. It occurs as the air is deflected downwards by the trailing edge of the airfoil. Downwash is a byproduct of lift generation and contributes to the overall aerodynamic behavior of the aircraft, including induced drag and wake turbulence.

Downwind Leg
Leg of the traffic pattern flown parallel to the landing runway, but in a direction opposite to the intended landing direction.

DPE
See DESIGNATED PILOT EXAMINER.

Drag
The net aerodynamic force parallel to the relative wind, usually the sum of two components: induced drag and parasite drag.

Drag Coefficient (C_D)
A dimensionless number used to define the amount of total drag produced by an aircraft.

Drag Curve
The curve created when plotting induced drag and parasite drag.

Drift Angle
Angle between heading and track.

Drift Correction
Correction that is applied to counter the effects of wind on an aircraft's flight and ground track.

Dual Flight
Flight time that is received and logged as training time. Dual flight time must be endorsed by a Certified Flight Instructor.

DUATS
See DIRECT USER ACCESS TERMINAL SERVICE.

Dynamic Hydroplaning
A condition that exists when landing on a surface with standing water deeper than the tread depth of the tires. When the brakes are applied, there is a possibility that the brake will lock up and the tire will ride on the surface of the water, much like a water ski. When the tires are hydroplaning, directional control and braking action are virtually impossible.

Dynamic Pressure (q)
The pressure a moving fluid would have if it were stopped.

Dynamic Stability
The property of an aircraft that causes it, when disturbed from straight-and-level flight, to develop forces or moments that restore the original condition of straight-and-level.

EFD
See ELECTRONIC FLIGHT DISPLAY.

EGT
See EXHAUST GAS TEMPERATURE.

EIS
"Engine Information System" The model of electronic flight display most often used in powered parachutes

Electronic Flight Display (EFD)
For the purpose of standardization, any flight instrument display that uses LCD or other image-producing system (cathode ray tube (CRT), etc.)

ELSA (Experimental Light Sport Aircraft)
An aircraft issued an experimental certificate under Title 14 of the Code of Federal Regulations (14 CFR) Part 21.

Emergency
A distress or urgent condition.

Emergency Frequency
Frequency that is used by aircraft in distress to gain ATC assistance. 121.5 MHz is an international emergency frequency guarded by Flight Service Stations and some military and civil aircraft. Reference AIM paragraph 6-3-1.

Empty-Field Myopia
Induced nearsightedness that is associated with flying at night, in instrument meteorological conditions and/or reduced visibility. With nothing to focus on, the eyes automatically focus on a point just slightly ahead of the airplane.

Encoding Altimeter
A special type of pressure altimeter used to send a signal to the air traffic controller on the ground, showing the pressure altitude the aircraft is flying.

Engine-Out
When the engine on the powered parachute stops or is shut off during flight.

Equilibrium
A condition that exists within a body when the sum of the moments of all of the forces acting on the body is equal to zero. In aerodynamics, equilibrium is when all opposing forces acting on an aircraft are balanced (steady, unaccelerated flight conditions).

Error Chain
A series of mistakes that may lead to an accident or incident. Two basic principles generally associated with the creation of an error chain are: (1) one bad decision often leads to another; and (2) as a string of bad decisions grows, it reduces the number of subsequent alternatives for continued safe flight. Aeronautical Decision Making is intended to break the error chain before it can cause an accident or incident.

Evaporation
The transformation of a liquid to a gaseous state, such as the change of water to water vapor.

Examiner
Any person who is authorized by the Administrator to conduct a pilot proficiency test or a practical test for an airman certificate or rating issued under this part, or a person who is authorized to conduct a knowledge test under this part.

Exhaust Gas Temperature (EGT)
The temperature of the exhaust gases as they leave the cylinders of a reciprocating engine or the turbine section of a turbine engine.

FA
See AREA FORECAST.

FAA
See FEDERAL AVIATION ADMINISTRATION.

FAA Inspector
FAA personnel who can administer practical and proficiency tests and can issue pilot certificates.

FAA Knowledge Test
Written exam administered by the FAA as a prerequisite for pilot certification. Passing the knowledge and practical exams are required for pilot applicants to be issued FAA certificates or ratings.

False Horizon
Inaccurate visual information for aligning the aircraft, caused by various natural and geometric formations that disorient the pilot from the actual horizon.

Fan Guard
See PROP GUARD.

FAR
See FEDERAL AVIATION REGULATIONS.

FDC NOTAM
Flight Data Center NOTAM. Notice to Air Missions that is regulatory in nature.

Federal Airways
Class E airspace areas that extend upward from 1,200 feet to, but not including, 18,000 feet MSL, unless otherwise specified.

Federal Aviation Administration (FAA)
The federal agency responsible for promoting aviation safety through regulation and education.

Federal Aviation Regulations (FARs)
A set of rules and regulations established by the Federal Aviation Administration (FAA) to govern all aspects of civil aviation in the United States. These regulations cover a wide range of topics, including pilot certification, aircraft operations, airworthiness standards, airspace usage, and aviation safety.

Field Elevation
The highest point of an airport's usable runways measured in feet from mean sea level.

Final
Leg of the traffic pattern that is a descending flight path starting from the completion of the base-to-final turn and extending to the point of touchdown.

Fixating
Staring at a single instrument, thereby interrupting the cross-check process.

Fixed-Pitch Propellers
Propeller with fixed blade angles. Fixed-pitch propellers are designed as climb propellers, cruise propellers, or standard propellers.

Fixed-Wing Aircraft
An aircraft whose wing is rigidly attached to the structure. The term fixed-wing is used to distinguish these aircraft from rotary-wing aircraft, powered parachutes, and weight-shift-controlled trikes.

FL
See FLIGHT LEVEL.

Flare
The transition from a normal approach attitude to a landing attitude. This maneuver is accomplished in a powered parachute by pulling down on the steering lines to increase drag (reducing the forward speed) and increase lift (decreasing the rate of descent.)

Flight Level (FL)
A measure of altitude (in hundreds of feet) used by aircraft flying above 18,000 feet with the altimeter set at 29.92 *"Hg.*

Flight Path
The line, course, or track along which an aircraft is flying or is intended to be flown.

Flight Plan
Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an FSS or an ATC facility.

Flight Time
Pilot time that commences when an aircraft moves under its own power for the purpose of flight and ends when the aircraft comes to rest after landing.

Flight Training
Training, other than ground training, received from an authorized instructor in flight in an aircraft.

Flight Visibility
The average forward horizontal distance, from the flight deck of an aircraft in flight, at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.

FOD
See FOREIGN OBJECT DAMAGE.

Fog
Cloud consisting of numerous minute water droplets and based at the surface; droplets are small enough to be suspended in the earth's atmosphere indefinitely. (Unlike drizzle, it does not fall to the surface; differs from cloud only in that a cloud is not based at the surface; distinguished from haze by its wetness and gray color.)

Force (F)
The energy applied to an object that attempts to cause the object to change its direction, speed, or motion. In aerodynamics, it is expressed as F, T (thrust), L (lift), W (weight), or D (drag), usually in pounds.

Foreign Object Damage (FOD)
Damage to a gas turbine engine caused by some object being sucked into the engine while it is running. Debris from runways or taxiways can cause foreign object damage during ground operations, and the ingestion of ice and birds can cause FOD in flight.

Form Drag
The drag created because of the shape of a component or the aircraft.

Four Forces
The four fundamental forces of flight: lift, weight, drag and thrust.

Four-Stroke Engine
The principle of operation for some reciprocating engines involving the conversion of fuel energy into mechanical energy. The strokes are called intake, compression, power, and exhaust.

Front
The boundary between two different air masses.

Frost
Ice crystal deposits formed by sublimation when temperature and dew point are below freezing.

FSS
FAA Flight Service Station.

Fuel Load
The expendable part of the load of the airplane. It includes only usable fuel, not fuel required to fill the lines or that which remains trapped in the tank sumps.

Fuselage
The section of the aircraft that consists of the cabin and/or flight deck, containing seats for the occupants and the controls for the aircraft.

Glide Path
The path of an aircraft relative to the ground while approaching a landing.

Glide Ratio
The ratio of the forward distance traveled to the vertical distance an aircraft descends when it is operating without power. For example, an aircraft with a glide ratio of 10:1 will descend about 1,000 feet for every two miles (10,560 feet) it moves forward.

G-loads
Loads imposed on an airframe due to inertia (centrifugal force). 1G of load factor represents the weight of the actual aircraft. 2G represents effectively twice the aircraft's actual weight.

Global Navigation Satellite System (GNSS)
Satellite navigation system that provides autonomous geospatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to within a few meters using time signals transmitted along a line of sight by radio from satellites.

Global Positioning System (GPS)
A satellite-based radio positioning, navigation, and time transfer system.

GNSS
See GLOBAL NAVIGATION SATELLITE SYSTEM.

Go-around
The termination of a landing approach. Reference the AIM Pilot/Controller Glossary.

Go or No-Go Decision
Decision of whether or not to make a flight based on environmental, personal or mechanical factors. A focus area for human factors study.

Graphical Forecasts for Aviation (GFA) Tool
The GFA Tool is a set of web-based displays intended to provide the necessary aviation weather information to give users a complete picture of the weather that may impact their flight operations. It's a one-stop shop for multiple data fields. The AWC website (aviationweather.gov) includes observational data, forecasts, and advisories including thunderstorms, clouds, flight category, precipitation, icing, turbulence, and wind.

GPS
See GLOBAL POSITIONING SYSTEM.

Ground-Adjustable Propeller
A type of aircraft propeller whose blade pitch angle can be adjusted when the engine is not running. The adjustment requires loosening the blades in the hub.

Ground Effect
The condition of slightly increased air pressure below an airplane wing or helicopter rotor system that increases the amount of lift produced. It exists within approximately one wingspan or one rotor diameter from the ground. It results from a reduction in upwash, downwash, and wingtip vortices, and provides a corresponding decrease in induced drag.

Groundspeed (GS)
The actual speed of an aircraft over the ground. It is true airspeed adjusted for wind. Groundspeed decreases with a headwind and increases with a tailwind.

Ground Track
An aircraft's path over the ground when in flight.

Ground Training
Training, other than flight training, received from an authorized instructor.

Ground Visibility
Prevailing horizontal visibility near the earth's surface as reported by the United States National Weather Service or an accredited observer.

Gyroscopic Precession
An inherent quality of rotating bodies, which causes an applied force to be manifested 90º in the direction of rotation from the point where the force is applied.

Hazardous Attitudes
Five aeronautical decision-making attitudes that may contribute to poor pilot judgment: anti-authority, impulsivity, invulnerability, machismo, and resignation.

Hazardous Inflight Weather Advisory Service (HIWAS)
An en route FSS service providing continuously updated automated of hazardous weather within 150 nautical miles of selected VORs, available only in the conterminous 48 states.

Heading
The direction in which the nose of the aircraft is pointing during flight.

Headwind
A wind which blows from the direction the aircraft is flying. The groundspeed of an aircraft (the speed the aircraft is moving over the ground) is less than the speed through the air by the velocity of the headwind.

Headwork
Required to accomplish a conscious, rational thought process when making decisions. Good decision-making involves risk identification and assessment, information processing, and problem solving.

HF
High frequency.

Hg.
Abbreviation for mercury, from the Latin hydrargyrum.

High Performance Aircraft
An aircraft with an engine of more than 200 horsepower.

Histotoxic Hypoxia
The inability of the cells to effectively use oxygen. Plenty of oxygen is being transported to the cells that need it, but they are unable to make use of it.

HIWAS
See HAZARDOUS INFLIGHT WEATHER ADVISORY SERVICE.

Horsepower
The term, originated by inventor James Watt, means the amount of work a horse could do in one second. One horsepower equals 550 foot-pounds per second, or 33,000 foot-pounds per minute.

Hour Meter
An instrument installed in many aircraft to show the actual number of hours the engine has operated. The hour meter is an electrical clock that starts when the engine oil pressure builds up, and runs until the engine is shut down and the oil pressure drops to zero.

Human Factors
The study of how people interact with their environments. In the case of general aviation, it is the study of how pilot performance is influenced by such issues as the design of flight decks, the function of the organs of the body, the effects of emotions, and the interaction and communication with the other participants of the aviation community, such as other crew members and air traffic control personnel.

Hydroplaning
A condition that exists when landing on a surface with standing water deeper than the tread depth of the tires. When the brakes are applied, there is a possibility that the brake will lock up and the tire will ride on the surface of the water, much like a water ski. When the tires are hydroplaning, directional control and braking action are virtually impossible. An effective anti-skid system can minimize the effects of hydroplaning.

Hypemic Hypoxia
A type of hypoxia that is a result of oxygen deficiency in the blood, rather than a lack of inhaled oxygen. It can be caused by a variety of factors. Hypemic means *"not enough blood."*

Hyperventilation
Occurs when an individual is experiencing emotional stress, fright, or pain, and the breathing rate and depth increase, although the carbon dioxide level in the blood is already at a reduced level. The result is an excessive loss of carbon dioxide from the body, which can lead to unconsciousness due to the respiratory system's overriding mechanism to regain control of breathing.

Hypoxia
Hypoxia means *"reduced oxygen"* or *"not enough oxygen."* Hypoxia can be caused by several factors including an insufficient supply of oxygen, inadequate transportation of oxygen, or the inability of the body tissues to use oxygen. State of oxygen deficiency in the body sufficient to impair functions of the brain and other organs.

Hypoxic Hypoxia
This type of hypoxia is a result of insufficient oxygen available to the lungs. A decrease of oxygen molecules at sufficient pressure can lead to hypoxic hypoxia.

ICAO
See INTERNATIONAL CIVIL AVIATION ORGANIZATION

IFR
See INSTRUMENT FLIGHT RULES.

IFR Conditions
Weather conditions below the minimum for flight under visual flight rules.

ILS (Instrument Landing System)
A precision instrument approach system, which normally consists of the following electronic components and visual aids: localizer, glide slope, outer marker, and approach lights.

IMC
See INSTRUMENT METEOROLOGICAL CONDITIONS.

Incident
An occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

Indicated Airspeed (IAS)
Shown on the dial of the instrument airspeed indicator on an aircraft. Indicated airspeed (IAS) is the airspeed indicator reading uncorrected for instrument, position, and other errors. Indicated airspeed means the speed of an aircraft as shown on its pitot static airspeed indicator calibrated to reflect standard atmosphere adiabatic compressible flow at sea level uncorrected for airspeed system errors. Calibrated airspeed (CAS) is IAS corrected for instrument errors, position error (due to incorrect pressure at the static port) and installation errors.

Indicated Altitude
The altitude read directly from the altimeter (uncorrected) when it is set to the current altimeter setting.

Induced Drag
Drag caused by the same factors that produce lift; its amount varies inversely with airspeed. As airspeed decreases, the angle of attack must increase, in turn increasing induced drag.

Instrument
A device using an internal mechanism to show visually or aurally the attitude, altitude, or operation of an aircraft or aircraft part. It includes electronic devices for automatically controlling an aircraft in flight.

Instrument Flight Rules (IFR)
Rules and regulations established by the Federal Aviation Administration to govern flight under conditions in which flight by outside visual reference is not safe. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals.

Instrument Meteorological Conditions (IMC)
Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling less than the minimums specified for visual meteorological conditions, requiring operations to be conducted under IFR.

Interference Drag
Type of drag produced by placing two objects adjacent to one another. Combines the effects of form drag and skin friction.

International Civil Aviation Organization
An agency of the United Nations that codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth.

International Standard Atmosphere (ISA)
Also known as a standard day. A representative model of atmospheric air pressure, temperature, and density at various altitudes for reference purposes. At sea level, the IAS has a temperature of 59°F or 15°C and a pressure of 29.92 in. Hg or 1013.2 millibars.

Interpolation
The estimation of an intermediate value of a quantity that falls between marked values in a series. Example: In a measurement of length, with a rule that is marked in 1/8's of an inch, the value falls between 3/8 inch and 1/2 inch. The estimated (interpolated) value might then be said to be 7/16 inch.

Inversion
An increase in temperature with altitude.

Inverted Layout
A method of laying out the wing with the top surface on the ground and the wing completely spread out.

ISA
See INTERNATIONAL STANDARD ATMOSPHERE

Isobars
Lines which connect points of equal barometric pressure.

Isogonic Lines
Lines on charts that connect points of equal magnetic variation.

Judgment
The mental process of recognizing and analyzing all pertinent information in a particular situation, a rational evaluation of alternative actions in response to it, and a timely decision on which action to take.

KIAS
Knots Indicated Airspeed.

Kinesthesia
The sensing of movements by feel.

Kite
To pressurize and raise the wing overhead the powered parachute airframe.

Kiting
Taxiing a powered parachute on the ground with the wing inflated and overhead.

Knot
The knot is a unit of speed equal to one nautical mile (1.852 KM) per hour, approximately 1.151 mph.

Knowledge Test
See FAA KNOWLEDGE TEST.

Kollsman Window
A barometric scale window of a sensitive altimeter

Lag
The delay that occurs before an instrument needle attains a stable indication.

Land Breeze
A coastal breeze flowing from land to sea caused by temperature differences when the sea surface is warmer than the adjacent land. The land breeze usually occurs at night and alternates with the sea breeze that blows in the opposite direction by day.

Lateral Axis
An imaginary line passing through the center of gravity of a powered parachute and extending across the powered parachute from one side of the aircraft to the other side.

Lateral Stability (Rolling)
The stability about the longitudinal axis of an aircraft. Rolling stability or the ability of an airplane to return to level flight due to a disturbance that causes one of the wings to drop.

Latitude
Measurement north or south of the equator in degrees, minutes, and seconds. Lines of latitude are also referred to as parallels.

Leading Edge
The part of an airfoil that meets the airflow first.

Lift
One of the four main forces acting on an aircraft. On a powered parachute, an upward force created by the effect of airflow as it passes over and under the wing.

Light Sport Aircraft (LSA)
An aircraft, other than a helicopter or powered-lift that, since its original certification, has continued to meet the following:
(1) A maximum takeoff weight of not more than
(i) 1,320 pounds (600 kilograms) for aircraft not intended for operation on water; or
(ii) 1,430 pounds (650 kilograms) for an aircraft intended for operation on water.
(2) A maximum airspeed in level flight with maximum continuous power (VH) of not more than 120 knots CAS under standard atmospheric conditions at sea level.
(3) A maximum never-exceed speed (VNE) of not more than 120 knots CAS for a glider.
(4) A maximum stalling speed or minimum steady flight speed without the use of lift-enhancing devices (VS1) of not more than 45 knots CAS at the aircraft's maximum certificated takeoff weight and most critical center of gravity.
(5) A maximum seating capacity of no more than two persons, including the pilot.
(6) A single, reciprocating engine, if powered.
(7) A fixed or ground-adjustable propeller if a powered aircraft other than a powered glider.
(8) A fixed or autofeathering propeller system if a powered glider.
(9) A fixed-pitch, semi-rigid, teetering, two-blade rotor system, if a gyroplane.
(10) A nonpressurized cabin, if equipped with a cabin.
(11) Fixed landing gear, except for an aircraft intended for operation on water or a glider.
(12) Fixed or retractable landing gear, or a hull, for an aircraft intended for operation on water.
(13) Fixed or retractable landing gear for a glider.

Limit Load Factor
Amount of stress, or load factor, that an aircraft can withstand before structural damage or failure occurs.

Line-Over
A dangerous situation when the suspension line goes over the top of the wing instead of going straight from the wing to the riser system. This condition will prevent proper inflation of the wing.

Line Twist
When the parachute suspension lines on both sides of the wing are spiraled together. Flying with a line twist is unsafe; the wing is unairworthy until it is corrected.

Load Factor
The ratio of a specified load to the total weight of the aircraft. The specified load is expressed in terms of any of the following: aerodynamic forces, inertial forces, or ground or water reactions. Also referred to as G-loading.

LOC
A preflight check: L – Lines Free, O – Cells Open, C – Wing Centered.

Logbook
A record of activities: flight, instruction, inspection and maintenance.

Longitude
Measurement east or west of the Prime Meridian in degrees, minutes, and seconds. The Prime Meridian is 0° longitude and runs through Greenwich, England. Lines of longitude are also referred to as meridians.

Longitudinal Axis
An imaginary line through an aircraft from nose to tail, passing through its center of gravity. The longitudinal axis is also called the roll axis of the aircraft.

Longitudinal Stability (Pitching)
Stability about the lateral axis. A desirable characteristic of an airplane whereby it tends to return to its trimmed angle of attack after displacement.

LSA
See LIGHT SPORT AIRCRAFT.

Lubber Line
The reference line used in a magnetic compass or heading indicator.

MAC
See MEAN AERODYNAMIC CHORD.

Magnetic Bearing (MB)
The direction to or from a radio transmitting station measured relative to magnetic north.

Magnetic Compass
A device for determining direction measured from magnetic north.

Magnetic Dip
A vertical attraction between a compass needle and the magnetic poles. The closer the aircraft is to the pole, the more severe the effect. In the Northern Hemisphere, a weight is placed on the south-facing end of the compass needle; in the Southern Hemisphere, a weight is placed on the north-facing end of the compass needle to somewhat compensate for this effect.

Magneto
A self-contained, engine-driven unit that supplies electrical current to the spark plugs; completely independent of the airplane's electrical system. Normally there are two magnetos per engine.

Magnus Effect
Lifting force produced when a rotating cylinder produces a pressure differential. This is the same effect that makes a baseball curve or a golf ball slice.

Maintenance
Inspection, overhaul, repair, preservation, and the replacement of parts, but excluding preventive maintenance.

Major Alteration
An alteration not listed in the aircraft, aircraft engine, or propeller specifications:
(1) That might appreciably affect weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness; or
(2) That is not done according to accepted practices or cannot be done by elementary operations.

Major Repair
A repair:
(1) That, if improperly done, might appreciably affect weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness; or
(2) That is not done according to accepted practices or cannot be done by elementary operations.

Make/Model
Refers to the manufacturer and model of a specific aircraft.

Maneuverability
Ability of an aircraft to change directions along a flight path and withstand the stresses imposed upon it.

Maneuvering Altitude
An altitude above the ground that allows a sufficient margin of height to permit safe maneuvering.

Manifold Absolute Pressure
The absolute pressure of the fuel-air mixture within the intake manifold, usually indicated in inches of mercury.

Mass
The amount of matter in a body.

Maximum Gross Weight
The maximum authorized weight of the aircraft and all of its equipment as specified in the TCDS for the aircraft.

Maximum Takeoff Weight
The maximum allowable weight for takeoff.

Mean Aerodynamic Chord (MAC)
The average distance from the leading edge to the trailing edge of the wing.

Mean Sea Level
The average height of the surface of the sea at a particular location for all stages of the tide over a 19-year period.

Mechanical Turbulence
Type of turbulence caused by obstructions on the ground interfering with smooth flow of the wind. Trees, buildings and terrain can all cause mechanical turbulence.

Medical Certificate
Acceptable evidence of physical fitness on a form prescribed by the Administrator.

Medium-Banked Turn
Turn resulting from a degree of bank (approximately 20 to 45 degrees) at which the powered parachute remains at a constant bank.

Meridians
Lines of longitude.

Mesosphere
A layer of the atmosphere directly above the stratosphere.

METAR
See AVIATION ROUTINE WEATHER REPORT.

Microburst
A strong downdraft which normally occurs over horizontal distances of 1 NM or less and vertical distances of less than 1,000 feet. In spite of its small horizontal scale, an intense microburst could induce wind speeds greater than 100 knots and downdrafts as strong as 6,000 feet per minute.

Military Operations Area (MOA)
Airspace of defined vertical and lateral limits established for the purpose of separating certain military training activity from IFR traffic and to identify for VFR traffic where these activities are conducted. These are depicted on aeronautical charts.

Military Training Routes (MTR)
Airspace of defined vertical and lateral dimensions established for the conduct of military training at airspeeds in excess of 250 knots indicated airspeed (KIAS).

Mindset
A factor in Aeronautical Decision Making where decision-making is influenced by preconceived ideas about the outcome of events. For example, an expectation of improving weather conditions can lead to increased risk during a flight.

Minimum Drag
The point on the total drag curve where the lift-to-drag ratio is the greatest. At this speed, total drag is minimized.

Minimum Equipment List (MEL)
A list developed for larger aircraft that outlines equipment that can be inoperative for various types of flight including IFR and icing conditions. This list is based on the master minimum equipment list (MMEL) developed by the FAA and must be approved by the FAA for use. It is specific to an individual aircraft make and model.

Minor Alteration
An alteration other than a major alteration.

Minor Repair
A repair other than a major repair.

MOA
See Military operations Area.

Mode C Transponder
A receiver/transmitter which will generate a radar reply signal upon proper interrogation; the interrogation and reply being on different frequencies. Mode C means the reply signal includes altitude information.

Moment
A force that causes or tries to cause an object to rotate. The product of the weight of an item multiplied by its arm. Moments are expressed in pound-inches (lb-in). Total moment is the weight of the powered parachute multiplied by the distance between the datum and the CG.

Moment Arm
The distance from a datum to the applied force.

MOSAIC (Modernization of Special Airworthiness Certification)
An initiative by the Federal Aviation Administration (FAA) aimed at updating and streamlining the certification processes for various categories of aircraft, particularly those that are not subject to standard type certification.

MSL
Mean Sea Level.

Multi-Function Display (MFD)
Small screen (CRT or LCD) in an aircraft that can be used to display information to the pilot in numerous configurable ways. Often an MFD will be used in concert with a primary flight display.

MULTICOM
A mobile service not open to public correspondence used to provide communications essential to conduct the activities being performed by or directed from private aircraft. The normal frequency is 122.9 MHz.

NAS
See NATIONAL AIRSPACE SYSTEM.

National Aeronautical Charting Group (NACG)
A Federal agency operating under the FAA, responsible for publishing charts such as the terminal procedures and en route charts.

National Airspace System (NAS).
The common network of United States airspace—air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information; and manpower and material.

National Security Area (NSA)
Areas consisting of airspace of defined vertical and lateral dimensions established at locations where there is a requirement for increased security and safety of ground facilities. Pilots are requested to voluntarily avoid flying through the depicted NSA. When it is necessary to provide a greater level of security and safety, flight in NSAs may be temporarily prohibited. Regulatory prohibitions are disseminated via NOTAMs.

National Transportation Safety Board (NTSB)
A United States Government independent organization responsible for investigations of accidents involving aviation, highways, waterways, pipelines, and railroads in the United States. NTSB is charged by congress to investigate every civil aviation accident in the United States.

NAVAID
Navigational aid.

NAV/COM
Navigation and communication radio.

Negative Static Stability
The initial tendency of an aircraft to continue away from the original state of equilibrium after being disturbed.

Neutral Static Stability
The initial tendency of an aircraft to remain in a new condition after its equilibrium has been disturbed.

Newton's Third Law Of Motion
Whenever one body exerts a force on another, the second body always exerts on the first, a force that is equal in magnitude but opposite in direction.

Night
The time between the end of evening civil twilight and the beginning of morning civil twilight, as published in the American Air Almanac, converted to local time.

NM
Nautical mile.

NOAA
National Oceanic and Atmospheric Administration.

NOTAM
See NOTICE TO AIR MISSIONS.

Non-towered Airport
An airport without an operating control tower.

Notice to Air Missions (NOTAM)
A notice filed with an aviation authority to alert aircraft pilots of any hazards en route or at a specific location. The authority in turn provides means of disseminating relevant NOTAMs to pilots.

NSA
See NATIONAL SECURITY AREA.

NTSB
See NATIONAL TRANSPORTATION SAFETY BOARD.

NWS
National Weather Service.

Obscuration
A weather phenomenon that reduces visibility in the atmosphere. Obscurations can significantly affect flight safety by impairing pilots' ability to see and navigate. Common types of obscurations include fog, mist, haze, smoke, volcanic ash, dust, sand, and precipitation such as heavy rain or snow.

Obstruction Lights
Lights that can be found both on and off an airport to identify obstructions.

Occluded Front
A frontal occlusion occurs when a fast-moving cold front catches up with a slow moving warm front. The difference in temperature within each frontal system is a major factor in determining whether a cold or warm front occlusion occurs.

Operate
With respect to aircraft, means use, cause to use or authorize to use aircraft, for the purpose of air navigation including the piloting of aircraft, with or without the right of legal control (as owner, lessee, or otherwise).

Operating Limitations
Limitations published by aircraft manufacturers to define limitations on maneuvers, flight load factors, speeds and other limits. Presented in the aircraft in the form of placards and printed in the limitations section of the aircraft flight manual.

Optical Illusion
A misleading visual image. For the purpose of this book, the term refers to the brain's misinterpretation of features on the ground associated with landing, which causes a pilot to misread the spatial relationships between the aircraft and the runway.

Orientation
Awareness of the position of the aircraft and of oneself in relation to a specific reference point.

Otolith Organ
An inner ear organ that detects linear acceleration and gravity orientation.

Outside Air Temperature (OAT)
The measured or indicated air temperature (IAT) corrected for compression and friction heating. Also referred to as true air temperature.

Overcontrolling
Using more control movement than is necessary to achieve the desired pitch-and-bank condition.

Overshooting
The act of over flying an intended spot for landing or flying through a course intended for intercept.

Over the Top
Above the layer of clouds or other obscuring phenomena forming the ceiling.

Parachute
See WING

Parafoil
See RAM AIR WING.

Parallel Runways
Two or more runways at the same airport whose centerlines are parallel. In addition to runway number, parallel runways are designated as L (left) and R (right) or if three parallel runways exist, L (left), C (center) and R (right).

Parallels
Lines of latitude.

Parasite Drag
That part of total drag created by the design or shape of powered parachute parts. Parasite drag increases with an increase in airspeed.

Part 1
Federal Aviation Regulation from 14 CFR, pertaining to definitions and abbreviations of terms.

Part 43
Federal Aviation Regulation from 14 CFR, pertaining to maintenance, preventive maintenance, rebuilding, and alteration of aircraft.

Part 61
Federal Aviation Regulation from 14 CFR, pertaining to the issuance of pilot and instructor certificates and ratings.

Part 67
Federal Aviation Regulation from 14 CFR, pertaining to medical standards and certification for pilots.

Part 91
Federal Aviation Regulation from 14 CFR, pertaining to general operating and flight rules.

Part 103
Federal Aviation Regulation from 14 CFR, pertaining to ultralight aircraft and pilots.

Pattern Altitude
The common altitude used for aircraft maneuvering in the traffic pattern. Usually 1,000 above the airport surface for GA aircraft.

Payload (Gama)
The weight of occupants, cargo, and baggage.

Pendulum
A body so suspended from a fixed point as to move to and fro by the action of gravity and acquired momentum.

Pendulum Effect
The characteristic of the powered parachute airframe weight hanging below the wing that stabilizes the wing pitching moment and the airframe underneath the wing for unaccelerated flight. This weight (pendulum) can also create momentum of the airframe rotating around the wing.

Personality
Personal traits and characteristics of an individual that are set at a very early age and extremely resistant to change.

P-Factor
A tendency for some aircraft to yaw to the left due to the descending propeller blade on the right producing more thrust than the ascending blade on the left. This occurs when the aircraft's longitudinal axis is in a climbing attitude in relation to the relative wind. The P-factor is to the right if the aircraft has a counterclockwise rotating propeller.

PFD
See PRIMARY FLIGHT DISPLAY.

PIC
See PILOT IN COMMAND.

Pilotage
Navigation by visual reference to landmarks.

Pilot in Command
(1) Has final authority and responsibility for the operation and safety of the flight;
(2) Has been designated as pilot in command before or during the flight; and
(3) Holds the appropriate category, class, and type rating, if appropriate, for the conduct of the flight.

Pilot Time
(In powered parachuting) That time in which a person
(1) Receives training from an authorized instructor in an aircraft.
(2) Gives training as an authorized instructor in an aircraft.

Pilot Weather Report (PIREP)
Report of meteorological phenomena encountered by aircraft.

Pilot's Operating Handbook (POH)
FAA-approved documents published by the airframe manufacturer that list the operating conditions for a particular model of aircraft.

PIREP
See pilot weather report.

Pitch
The rotation of a powered parachute about its lateral axis.

Pitch Angle
The angle between the wing and the horizontal plane of the earth.

Pitch Attitude
The angle of the longitudinal axis relative to the horizon.

Pitch Setting
The propeller blade setting as determined by the blade angle measured in a manner, and at a radius, specified by the instruction manual for the propeller.

Placards
Small statements or pictorial signs permanently fixed in the flight deck and visible to the pilot. Placards are used for operating limitations (e.g., weight or speeds) or to indicate the position of an operating lever (e.g., parachute trim locks).

Pitot Pressure
Ram air pressure used to measure airspeed.

Planform
The shape or form of a wing as viewed from above. It may be long and tapered, short and rectangular, or various other shapes.

POH
See PILOT'S OPERATING HANDBOOK.

Poor Judgment Chain
A series of mistakes that may lead to an accident or incident. Two basic principles generally associated with the creation of a poor judgment chain are:
(1) One bad decision often leads to another; and
(2) As a string of bad decisions grows, it reduces the number of subsequent alternatives for continued safe flight.
ADM is intended to break the poor judgment chain before it can cause an accident or incident.

Porpoising
Oscillating around the lateral axis of the aircraft.

Porpoising Effect
The rapid increase in throttle resulting in a rapid initial pitch-up, which results in the pendulum effect that dampens out into a steady state climb.

Positive Control
Control of all air traffic, within designated airspace, by air traffic control.

Positive Dynamic Stability
The tendency over time for an aircraft to return to a predisturbed state.

Positive Static Stability
The initial tendency to return to a state of equilibrium when disturbed from that state.

Power
Implies work rate or units of work per unit of time, and as such, it is a function of the speed at which the force is developed. The term power required" is generally associated with reciprocating engines.

Powered-Lift
A heavier-than-air aircraft capable of vertical takeoff, vertical landing, and low speed flight that depends principally on engine-driven lift devices or engine thrust for lift during these flight regimes and on nonrotating airfoil(s) for lift during horizontal flight.

Powered Parachute (PPC)
A powered aircraft comprised of a flexible or semi-rigid wing connected to a fuselage (airframe) so that the wing is not in position for flight until the aircraft is in motion. The fuselage of a powered parachute contains the aircraft engine, a seat for each occupant and is attached to the aircraft's landing gear.

Powered Paraglider (PPG)
A powered aircraft comprised of a flexible or semi-rigid wing connected to a harness. Thrust comes from a motor and propeller mounted on a backpack unit which allows the pilot to climb and fly level without needing thermals. Generally single-place, foot-launched machines.

Power-Off Descent
Aircraft configuration where a descent occurs with power at idle.

Powerplant
A complete engine and propeller combination with accessories.

PPC
See POWERED PARACHUTE.

PPCL
Powered parachute land.

PPCS
Powered parachute sea.

PPG
See POWERED PARAGLIDER.

Practical Test
A test on the areas of operations for an airman certificate, rating, or authorization that is conducted by having the applicant respond to questions and demonstrate maneuvers in flight. Test is administered by an FAA examiner or a designated pilot examiner (DPE).

Practical Test Standards (PTS)
An FAA published document of standards that must be met for the issuance of a particular pilot certificate or rating. FAA inspectors and designated pilot examiners use these standards when conducting pilot practical tests, and flight instructors use the PTS while preparing applicants for practical tests.

Precession
The tilting or turning of a gyro in response to deflective forces causing slow drifting and erroneous indications in gyroscopic instruments.

Precipitation
Any or all forms of water particles (rain, sleet, hail, or snow), that fall from the atmosphere and reach the surface.

Preflight Inspection
Aircraft inspection conducted to determine if an aircraft is mechanically and legally airworthy.

Pre-ignition
Ignition occurring in the cylinder before the time of normal ignition. Pre-ignition is often caused by a local hot spot in the combustion chamber igniting the fuel-air mixture.

Pressure Altitude
The altitude indicated when the altimeter setting window (barometric scale) is adjusted to 29.92. This is the altitude above the standard datum plane, which is a theoretical plane where air pressure (corrected to 15°C) equals 29.92 in. Hg. Pressure altitude is used to compute density altitude, true altitude, true airspeed, and other performance data.

Prevailing Visibility
The greatest horizontal visibility equaled or exceeded throughout at least half the horizon circle (which is not necessarily continuous).

Preventive Maintenance
Simple or minor preservative operations and the replacement of small standard parts not involving complex assembly operation as listed in Appendix A of 14 CFR Part 43. Certificated pilots may perform preventive maintenance on any aircraft that is owned or operated by them provided that the aircraft is not used in air carrier service.

Primary Flight Display (PFD)
A display that provides increased situational awareness to the pilot by replacing the traditional six instruments used for instrument flight with an easy-to-scan display that provides the horizon, airspeed, altitude, vertical speed, trend, trim, and rate of turn among other key relevant indications.

Private Airport
Airport that is privately owned and not available to the public without prior permission. They are depicted on aeronautical charts for emergency and landmark purposes.

Private Pilot Certificate
An FAA-issued pilot certificate permitting carriage of passengers on a not-for-hire basis.

Proficiency Check
An evaluation of aeronautical knowledge and flight proficiency for pilots transitioning to a new category/class of aircraft. Upon successful completion of the proficiency check the authorized instructor will endorse the applicant's logbook indicating the added category/class of equipment that the applicant is authorized to operate and send the completed 8710-11 to FAA's Airmen Registration.

Prohibited Area
Designated airspace within which flight of aircraft is prohibited. Prohibited areas are established for security or other reasons associated with the national welfare.

Prop Ring
See PROP GUARD.

Prop Guard
A tubing structure (normally ring-shaped) designed to keep the canopy lines out of the turning propeller on kite-up and takeoff.

Propeller
A device for propelling an aircraft that, when rotated, produces by its action on the air, a thrust approximately perpendicular to its plane of rotation. It includes the control components normally supplied by its manufacturer.

Propeller Blast
The volume of air accelerated behind a propeller producing thrust.

PTS
See PRACTICAL TEST STANDARDS.

Public Airport
Airport that is available to the aviation public.

Pullover
See ROLLOVER.

Pusher Configuration
Propeller configuration where the propeller shaft faces the rear of the aircraft. Thrust produced by the propeller pushes the aircraft, rather than pulling it.

Quick Links
Threaded connectors used to connect the parachute lines to the risers and the risers to the airframe off the powered parachute.

Radar
A system that uses electromagnetic waves to identify the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, weather formations, and terrain. The term RADAR was coined in 1941 as an acronym for Radio Detection and Ranging. The term has since entered the English language as a standard word, radar, losing the capitalization in the process.

Radar Services
Radio waves are transmitted into the air and are then received when they have been reflected by an object in the path of the beam. Range is determined by measuring the time it takes (at the speed of light) for the radio wave to go out to the object and then return to the receiving antenna. The direction of a detected object from a radar site is determined by the position of the rotating antenna when the reflected portion of the radio wave is received.

Radar Summary Chart
A weather product derived from the national radar network that graphically displays a summary of radar weather reports.

Radar Weather Report (SD)
A report issued by radar stations at 35 minutes after the hour, and special reports as needed. Provides information on the type, intensity, and location of the echo tops of the precipitation.

Radiosonde
A weather instrument that observes and reports meteorological conditions from the upper atmosphere. This instrument is typically carried into the atmosphere by some form of weather balloon.

Ram Air Wing
A ram air inflated and pressurized fabric airfoil that produces the lift necessary to support the powered parachute in flight; includes the lines that attach to the airframe. Also called a parachute, chute, canopy, or airfoil.

Rapide Links
See QUICK LINKS

Rating
A statement that, as a part of a certificate, sets forth special conditions, privileges, or limitations.

Reciprocating Engine
An engine that converts the heat energy from burning fuel into the reciprocating movement of the pistons. This movement is converted into a rotary motion by the connecting rods and crankshaft.

Registration Certificate
A federal certificate that documents aircraft ownership.

Relative Bearing
An angular relationship between two objects measured in degrees clockwise from the twelve o'clock position of the first object.

Relative Humidity
The ratio of the existing amount of water vapor in the air at a given temperature to the maximum amount that could exist at that temperature; usually expressed in percent. The amount of water vapor contained in the air compared to the amount the air could hold.

Relative Wind
Direction of the airflow produced by an object moving through the air. The relative wind for a powered parachute in flight flows in a direction parallel with and opposite to the direction of flight; therefore, the actual flight path of the powered parachute determines the direction of the relative wind.

Restricted Areas
Areas that denote the existence of unusual, often invisible hazards to aircraft such as artillery firing, aerial gunnery, or guided missiles. An aircraft may not enter a restricted area unless permission has been obtained from the controlling agency.

Rhodopsin
The photosensitive pigments that initiate the visual response in the rods of the eye.

Ribs
The parts of a wing structure that give the wing its aerodynamic cross-section. Fabric covers the ribs and gives the ram air wing its airfoil shape.

Rigging
The final adjustment and alignment of an aircraft and its flight control system that provides the proper aerodynamic characteristics.

Rigidity in Space
The principle that a wheel with a heavily weighted rim spun rapidly will remain in a fixed position in the plane in which it is spinning.

Risers
Straps that attach the airframe to the suspension lines. Sometimes referred to as "*V lines*," risers are the intermediate link between the suspension lines and the rest of the aircraft.

Risk
The future impact of a hazard that is not eliminated or controlled.

Risk Elements
The four fundamental areas of exposure to risk: the pilot, the aircraft, the environment, and the type of operation that comprise any given aviation situation.

Risk Management
The part of the decision-making process which relies on situational awareness, problem recognition, and good judgment to reduce risks associated with each flight.

Roll
The rotation of an aircraft about its longitudinal axis.

Rolling Preflight
After kiting the wing, the process of quickly inspecting the lines and wing for proper deployment before adding full power to take off.

Rollover
When the powered parachute airframe is pulled over onto its side or upside down by the parachute. Happens usually during takeoff.

Rolling Stalled Wing
An improperly deployed powered parachute wing. Occurs when attempting to kite the canopy and it does not come up fully overhead. Instead the wing hangs back at an approximately 45-degree angle.

Roundout
Adding power during landing approach to reduce rate of descent prior to touchdown.

RPM
Revolutions per minute. A measure of rotational speed. One RPM is one revolution made in one minute.

Rudder
The movable primary control surface mounted on the trailing edge of the vertical fin of an airplane. Also found on some powered parachutes. Movement of the rudder rotates the aircraft about its vertical axis.

Runway
A defined rectangular area on a land airport prepared for the landing and takeoff run of aircraft along its length. Runways are normally numbered in relation to their magnetic direction rounded off to the nearest 10 degrees; e.g., Runway 1, Runway 25.

Runway Edge Lights
A component of the runway lighting system that is used to outline the edges of runways at night or during low visibility conditions. These lights are classified according to the intensity they are capable of producing.

Runway End Identifier Lights (REIL)
One component of the runway lighting system. These lights are installed at many airfields to provide rapid and positive identification of the approach end of a particular runway.

Runway Incursion
Any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to takeoff, landing, or intending to land.

SAR
See SEARCH AND RESCUE.

Scan
The first fundamental skill of instrument flight, also known as "*cross-check;*" the continuous and logical observation of instruments for attitude and performance information.

Scanning
Systematic means of searching for other aircraft. Scanning is most effective when successive areas of the sky are brought into focus using a series of short, regularly spaced eye movements.

Sea Breeze
A coastal breeze blowing from sea to land caused by the temperature difference when the land surface is warmer than the sea surface. The sea breeze usually occurs during the day and alternates with the land breeze that blows in the opposite direction at night.

Sea Level Engine
A reciprocating aircraft engine having a rated takeoff power that is producible only at sea level.

Search and Rescue (SAR)
A lifesaving service provided through the combined efforts of the federal agencies signatory to the National SAR plan along with state agencies.

Sectional Aeronautical Charts
Designed for visual navigation of slow- or medium-speed aircraft. Topographic information on these charts features the portrayal of relief, and a judicious selection of visual check points for VFR flight. Aeronautical information includes visual and radio aids to navigation, airports, controlled airspace, restricted areas, obstructions and related data. Scale is 1:500,000.

See and Avoid
When weather conditions permit, pilots operating IFR or VFR are required to observe and maneuver to avoid other aircraft.

Segmented Circle
A visual indicator around a windsock or tetrahedron designed to show the traffic pattern for each runway.

Selective Availability (SA)
A satellite technology permitting the Department of Defense (DoD) to create, in the interest of national security, a significant clock and ephemeris error in the satellites, resulting in a navigation error.

Semicircular Canal
An inner ear organ that detects angular acceleration of the body.

Service Ceiling
The maximum density altitude where the best rate-of-climb airspeed will produce a 100 feet-per-minute climb at maximum weight while in a clean configuration with maximum continuous power.

Servo
A motor or other form of actuator which receives a small signal from the control device and exerts a large force to accomplish the desired work.

Set of Aircraft
This is a term that was used in the early days of the sport pilot rule. It referred to aircraft that share similar performance characteristics, such as similar airspeed and altitude operating envelopes, similar handling characteristics, and the same number and type of propulsion systems.

Shallow-Banked Turn
Turns in which the bank (less than approximately 20 degrees) is so shallow that inherent lateral stability of the powered parachute is acting to level the wing unless the pilot maintains the bank.

Shore
The area of the land adjacent to a body of water which is above the high water mark and excludes land areas which are intermittently under water.

SIGMET
"Significant Meteorological Information." An in-flight weather advisory that is considered significant to all aircraft. SIGMET criteria include severe icing, severe and extreme turbulence, dust storms, sandstorms, volcanic eruptions, and volcanic ash that lower visibility to less than three miles. SIGMET is warning information, hence it is of highest priority among other types of meteorological information provided to the aviation users.

Significant Weather Prognostic Chart
Presents four panels showing forecast significant weather and forecast surface weather.

Single Pilot Resource Management (SRM)
The ability for a pilot to manage all resources effectively to ensure the outcome of the flight is successful.

Situational Awareness
Pilot knowledge of where the aircraft is in regard to location, air traffic control, weather, regulations, aircraft status, and other factors that may affect flighty before, during, and after the flight.

Skills and Procedures
The procedural, psychomotor, and perceptual skills used to control a specific aircraft or its systems. They are the airmanship abilities that are gained through conventional training, are perfected, and become almost automatic through experience.

Skin Friction Drag
The type of parasite drag resulting from a rough surface which deflects the streamlines of air on the surface, causing resistance to smooth airflow.

SLSA
See SPECIAL LIGHT SPORT AIRCRAFT

Small Airplane
An airplane of 12,500 pounds or less maximum certificated takeoff weight.

Solo Flight
Flight that is conducted and logged when a pilot is the sole occupant of an aircraft.

Spatial Disorientation
The state of confusion due to misleading information being sent to the brain from various sensory organs, resulting in a lack of awareness of the aircraft position in relation to a specific reference point.

Special Flight Permit
A flight permit issued to an aircraft that does not meet airworthiness requirements but is capable of safe flight. A special flight permit can be issued to move an aircraft for the purposes of maintenance or repair, buyer delivery, manufacturer flight tests, evacuation from danger, or customer demonstration. Also referred to as a ferry permit.

Special Light Sport Aircraft (SLSA)
An aircraft issued a special airworthiness certificate in accordance with 14 CFR 21.290 in the light-sport category. These aircraft meet the ASTM industry-developed consensus standards.

Special Use Airspace
Airspace in which flight activities are subject to restrictions that can create limitations on the mixed use of airspace. Consists of prohibited, restricted, warning, military operations, and alert areas.

Speed
The distance traveled in a given time.

Sport Pilot Certificate
An FAA-issued pilot certificate, allowing the holder to operate a light sport aircraft in the category and class for which they are endorsed to do so.

SRM
See SINGLE PILOT RESOURCE MANAGEMENT.

Stability
The inherent quality of an aircraft to correct for conditions that may disturb its equilibrium, and to return to or continue on the original flight path.

Stabilized Approach
A landing approach in which the pilot establishes and maintains a constant angle glide path towards a predetermined point on the landing runway. It is based on the pilot's judgment of certain visual cues, and depends on the maintenance

of a constant final descent airspeed and configuration.

Stacked Layout
See ACCORDION LAYOUT.

Stagnant Hypoxia
A type of hypoxia that results when the oxygen-rich blood in the lungs is not moving to the tissues that need it.

Stall
A rapid decrease in lift caused by the separation of airflow from the wing's surface brought on by exceeding the critical angle of attack. A stall can occur at any pitch attitude or airspeed.

Standard Airport Traffic Pattern
The left-hand turn traffic flow that is prescribed for aircraft landing at, taxiing on, or taking off from an airport.

Standard Atmosphere
At sea level, the standard atmosphere consists of a barometric pressure of 29.92 inches of mercury (in. Hg.) or 1013.2 millibars, and a temperature of 15°C (59°F). Pressure and temperature normally decrease as altitude increases.

Static Longitudinal Stability
The aerodynamic pitching moments required to return the aircraft to the equilibrium angle of attack.

Static Pressure
The pressure of air that is still, or not moving, measured perpendicular to the surface exposed to the air.

Static Stability
The initial tendency an aircraft displays when disturbed from a state of equilibrium.

Stationary Front
A front that is moving at a speed of less than 5 knots.

Steep Spirals
An extreme turn that is initiated by braking one side of the wing past its normal full deflection. When the turn is held, the powered parachute will go into a steep diving maneuver that will continue until the pilot releases the turn. Can be used to quickly descend.

Steep Turn
Turn resulting from a degree of bank (45 degrees or more) at which the overbanking tendency of a powered parachute overcomes stability, and the bank increases unless the steering controls are applied to prevent it.

Steering Bars
Located just aft of the nosewheel and mounted on each side of the aircraft, the steering bars move forward and back when the pilot applies foot pressure. Pushing either one of the steering bars causes the steering lines to pull down on the corresponding surface of the trailing edge on the wing which banks the PPC into a turn.

Steering Lines
Connected to the steering bars and routed through pulleys up to the trailing edge of the parachute.

Straight-In Approach
Entry into the traffic pattern by interception of the extended runway centerline (final approach course) without executing any other portion of the traffic pattern.

Stratosphere
A layer of the atmosphere above the tropopause extending to a height of approximately 160,000 feet.

Stress Management
The personal analysis of the kinds of stress experienced while flying, the application of appropriate stress assessment tools, and other coping mechanisms.

Strobe
A high intensity white flashing light. Strobe lights are located on the top or sides of the airframe to increase powered parachute visibility in low light conditions.

Student Pilot Certificate
An FAA issued certificate that permits student pilots to exercise solo pilot privileges with limitations. A student's medical becomes their student pilot certificate once it is endorsed by their flight instructor.

Student Pilot Seeking a Sport Pilot Certificate
A person who has received an endorsement:
(1) To exercise student pilot privileges from a certified flight instructor with a sport pilot rating; or
(2) That includes a limitation for the operation of a light sport aircraft specified in §61.89(c) issued by a certified flight instructor with other than a sport pilot rating.

Sublimation
Process by which a solid is changed to a gas without going through the liquid state.

Supercooled Water Droplets
Water droplets that have been cooled below the freezing point, but are still in a liquid state.

Surface Analysis Chart
A report that depicts an analysis of the current surface weather. Shows the areas of high and low pressure, fronts, temperatures, dew points, wind directions and speeds, local weather, and visual obstructions.

Suspension Lines
Lines that run from several attachment points on the parachute wing down to a set of cables called risers, which connect to the airframe.

Synthetic Vision
A realistic display depiction of the aircraft in relation to terrain and flight path.

Tailwind
Wind blowing in the same direction the aircraft is moving. When an aircraft is flying with a tailwind, its speed over the ground is equal to its speed through the air, plus the speed the air is moving over the ground.

Takeoff Clearance
ATC authorization for an aircraft to depart a runway. It is predicated on known traffic and known physical airport conditions.

Taxi
The movement of an aircraft under its own power while on the ground.

Taxiway
Airport area designated for aircraft surface movement.

Taxiway Lights
Omnidirectional lights that outline the edges of the taxiway and are blue in color.

TCDS
See TYPE CERTIFICATE DATA SHEET.

Technique
The manner in which procedures are executed.

Telephone Information Briefing Service (TIBS)
An FSS service providing continuously updated automated telephone recordings of area and/or route weather, airspace procedures, and special aviation-oriented announcements.

Temporary Flight Restriction (TFR)
Restriction to flight imposed in order to:
(1) Protect persons and property in the air or on the surface from an existing or imminent flight associated hazard;
(2) Provide a safe environment for the operation of disaster relief aircraft;
(3) Prevent an unsafe congestion of sightseeing aircraft above an incident;
(4) Protect the President, Vice President, or other public figures; and,
(5) Provide a safe environment for space agency operations.
Pilots are expected to check appropriate NOTAMs during flight planning when conducting flight in an area where a temporary flight restriction is in effect.

Tension
Maintaining an excessively strong grip on the control column, usually resulting in an overcontrolled situation.

Terminal Aerodrome Forecast (TAF)
A report established for the five statute mile radius around an airport. Utilizes the same abbreviations as the METAR report.

Terminal Radar Service Areas (TRSA)
Areas where participating pilots can receive additional radar services. The purpose of the service is to provide separation between all IFR operations and participating VFR aircraft.

TFR
See TEMPORARY FLIGHT RESTRICTION.

Thermal
A buoyant plume or bubble of rising air.

Thermosphere
The last layer of the atmosphere that begins above the mesosphere and gradually fades away into space.

Throttle
The control in an aircraft that regulates the power or thrust the pilot wants the engine to develop.

Thrust
The force which imparts a change in the velocity of a mass. This force is measured in pounds but has no element of time or rate. A forward force which propels the powered parachute through the air.

Thrust Line
An imaginary line passing through the center of the propeller hub, perpendicular to the plane of the propeller rotation.

Title 14 of the Code of Federal Regulations (14 CFR)
Includes the federal aviation regulations governing the operation of aircraft, airways, and airmen.

Torque
(1) A resistance to turning or twisting.
(2) Forces that produce a twisting or rotating motion.
(3) In a powered parachute, the tendency of the aircraft to turn (roll) in the opposite direction of rotation of the engine and propeller.

Total Drag
The sum of the parasite and induced drag.

Touch-and-Go
An operation by an aircraft that lands and takes off without stopping.

Touchdown Point
The point or intended point at which an aircraft first makes contact with the landing surface.

Touchdown Zone
The portion of a runway, beyond the threshold, where it is intended that landing aircraft first contact the runway.

Track
The actual path made over the ground in flight.

Tracking
Flying a heading that will maintain the desired track to or from the station regardless of crosswind conditions.

Traffic Pattern
The traffic flow that is prescribed for aircraft landing at or taking off from an airport.

Traffic Pattern Indicators
Ground-based visual indicators that identify traffic pattern direction at certain airports.

Trailing Edge
The portion of the airfoil where the airflow over the upper surface rejoins the lower surface airflow.

Training Time (For Powered Parachutes), Training Received
(1) In flight from an authorized instructor
(2) On the ground from an authorized instructor

Transcribed Weather Broadcast (TWEB)
An FSS service, available in Alaska only, providing continuously updated automated broadcast of meteorological and aeronautical data over selected L/MF and VOR NAVAIDs.

Transponder
The airborne portion of the secondary surveillance radar system. The transponder emits a reply when queried by a radar facility.

Tricycle Gear Configuration
Landing gear configuration employing a third wheel located on the nose of the aircraft.

Trim
To adjust the aerodynamic forces on the control surfaces so that the aircraft maintains the set attitude without any control input.

Tropopause
The boundary layer between the troposphere and the mesosphere which acts as a lid to confine most of the water vapor, and the associated weather, to the troposphere.

Troposphere
The layer of the atmosphere extending from the surface to a height of 20,000 to 60,000 feet depending on latitude.

TRSA
See TERMINAL RADAR SERVICE AREAS.

True Airspeed (TAS)
Actual airspeed, determined by applying a correction for pressure altitude and temperature to the CAS.

True Altitude
The vertical distance of the aircraft above sea level–the actual altitude. It is often expressed as feet above mean sea level (MSL). Airport, terrain, and obstacle elevations on aeronautical charts are true altitudes.

Truss Structure
A canopy wing has diagonal reinforcing tape sewn into the load bearing ribs. These diagonal tapes form a truss structure, spreading the load over the entire rib and up to the upper surface of the wing.

Tucking
Used to modify both the accordion and inverted methods of laying out a canopy. Done by turning the canopy leading edge cell openings under the rest of the canopy to keep the wind and the prop blast from prematurely inflating and kiting the parachute.

Turning Error
One of the errors inherent in a magnetic compass caused by the dip compensating weight. It shows up only on turns to or from northerly headings in the Northern Hemisphere and southerly headings in the Southern Hemisphere. Turning error causes the compass to lead turns to the north or south and lag turns away from the north or south.

Two-Stroke Engine
A reciprocating engine that completes its operating cycle in two-strokes of its piston–one down and one up. Two-stroke engines are inefficient in their use of fuel, but their simplicity makes them popular for powering light sport aircraft and ultralight vehicles where light weight and low cost are paramount.

Type Certificate (TC)
A type certificate is an approval issued by the FAA to signify the airworthiness of an aircraft design or modification to a design. This certificate confirms that the design of a particular aircraft, engine, or propeller meets the necessary safety and performance standards set forth by the FAA.

Ultimate Load Factor
In stress analysis, the load that causes physical breakdown in an aircraft or aircraft component during a strength test, or the load that according to computations, should cause such a breakdown.

Ultra-High Frequency (UHF)
The range of electromagnetic frequencies between 300 MHz and 3,000 MHz.

Ultralight
A vehicle as defined by 14 CFR 103.1.

Uncontrolled Airport
An airport that does not have an operating control tower. Two-way radio communications are not required at uncontrolled airports, although it is good operating practice for pilots to transmit their intentions on the specified frequency.

Uncontrolled Airspace
Class G airspace that has not been designated as Class A, B, C, D, or E. It is airspace in which air traffic control has no authority or responsibility to control air traffic; however, pilots should remember there are VFR minimums which apply to this airspace.

Unusual Attitude
An unintentional, unanticipated, or extreme aircraft attitude.

Unstabilized Approach
The final approach of an aircraft that has not achieved a stable rate of descent or controlled flight track by a pre-determined altitude, usually 500 feet AGL.

Upwash
The upward flow of air ahead of an airfoil or other aerodynamic surface. It occurs as the air is deflected upwards by the leading edge of the airfoil. Upwash plays a crucial role in generating lift by increasing the velocity of the airflow over the upper surface of the wing, thereby reducing pressure and creating lift.

Upwind Leg
A flight path parallel to the landing runway in the direction of landing.

Useful Load
The weight of the pilot, copilot, passengers, baggage, usable fuel, and drainable oil. It is the basic empty weight subtracted from the maximum allowable gross weight. This term applies to general aviation aircraft only.

User-Defined Waypoints
Waypoint location and other data which may be input by the user, this is the only GPS database information that may be altered (edited) by the user.

Vapor Lock
A problem that mostly affects gasoline-fueled internal combustion engines. It occurs when the liquid fuel changes state from liquid to gas while still in the fuel delivery system. This disrupts the operation of the fuel pump, causing loss of feed pressure to the carburetor or fuel injection system, resulting in

transient loss of power or complete stalling. Restarting the engine from this state may be difficult. The fuel can vaporize due to being heated by the engine, by the local climate or due to a lower boiling point at high altitude.

Variation
Compass error caused by the difference in the physical locations of the magnetic north pole and the geographic north pole. This variation must be taken into consideration when determining an aircraft's actual geographic location. Indicated on charts by isogonic lines, it is not affected by the airplane's heading.

VASI
See VISUAL APPROACH SLOPE INDICATOR (VASI).

Vector
A vector is a graphic representation (usually an arrow) both the magnitude and direction.

Vehicle
Man-made means of transportation; an ultralight aircraft (not a light-sport aircraft).

Velocity
The speed or rate of movement in a certain direction.

Venturi
A specially shaped restriction in a tube designed to speed up the flow of fluid passing through in accordance with Bernoulli's principle. Venturis are used in carburetors and in many types of fluid control devices to produce a pressure drop proportional to the speed of the fluid passing through them.

Venturi Effect
The effect of Bernoulli's principle, which states that the pressure of a fluid decreases as it is speeded up without losing or gaining any energy from the outside.

Verified
Confirmation of information or configuration status.

Vertical Axis (Yaw)
An imaginary line passing vertically through the center of gravity of an aircraft. The vertical axis is called the z-axis or the yaw axis.

Vertical Card Compass
A magnetic compass that consists of an azimuth on a vertical card, resembling a heading indicator with a fixed miniature airplane to accurately present the heading of the aircraft. The design uses eddy current damping to minimize lead and lag during turns.

Vertical Speed Indicator (VSI)
An instrument that uses static pressure to display a rate of climb or descent in feet per minute. The VSI can also sometimes be called a vertical velocity indicator (VVI).

Vertical Stability
Stability about an aircraft's vertical axis. Also called yawing or directional stability.

Very High Frequency (VHF)
A band of radio frequencies falling between 30 and 300 MHz.

Vertigo
A type of spatial disorientation caused by the physical senses sending conflicting signals to the brain. Vertigo is especially hazardous when flying under conditions of poor visibility and may cause pilot incapacitation, but may be minimized by confidence in the indication of the flight instruments.

Vestibule
The central cavity of the bony labyrinth of the ear, or the parts of the membranous labyrinth that it contains.

Victor Airways
Airways based on a centerline that extends from one VOR or VORTAC navigation aid or intersection, to another navigation aid (or through several navigation aids or intersections); used to establish a known route for en route procedures between terminal areas.

VFR
See VISUAL FLIGHT RULES.

VFR Over the Top
A VFR operation in which an aircraft operates in VFR conditions on top of an undercast.

VFR Terminal Area Charts
At a scale of 1:250,000, a chart that depicts Class B airspace, which provides for the control or segregation of all the aircraft within the Class B airspace. The chart depicts topographic information and aeronautical information including visual and radio aids to navigation, airports, controlled airspace, restricted areas, obstructions, and related data.

Visual Approach Slope Indicator (VASI)
The most common visual glide path system in use. The VASI provides obstruction clearance within 10° of the extended runway centerline, and to 4 nautical miles (NM) from the runway threshold.

Visual Flight Rules (VFR)
Flight rules adopted by the FAA governing aircraft flight using visual references. VFR operations specify the amount of ceiling and the visibility the pilot must have in order to operate according to these rules. When the weather conditions are such that the pilot cannot operate according to VFR, he or she must use instrument flight rules (IFR).

Visual Meteorological Conditions (VMC)
Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling meeting or exceeding the minimums specified for VFR.

V Lines
See RISERS.

VMC
See VISUAL METEOROLOGICAL CONDITIONS (VMC).

VOR
Very high frequency omnirange station.

Vortex
A fluid motion characterized by swirling, rotating flow around an axis line.

Vortices
Plural of vortex

VSI
See VERTICAL SPEED INDICATOR.

Wake Turbulence
Wingtip vortices that are created when an aircraft generates lift. When an aircraft generates lift, air spills over the wingtips from the high pressure areas below the wings to the low pressure areas above them. This flow causes rapidly rotating whirlpools of air called wingtip vortices or wake turbulence.

Warm Front
The boundary area formed when a warm air mass contacts and flows over a colder air mass. Warm fronts cause low ceilings and rain.

Warning Area
An area containing hazards to any aircraft not participating in the activities being conducted in the area. Warning areas may contain intensive military training, gunnery exercises, or special weapons testing.

Washout
A condition in aircraft rigging in which a wing is twisted so its angle of incidence is less at the tip than at the root. Washout decreases the lift the wing produces to improve the stall characteristics of the wing.

Waypoint
A designated geographical location used for route definition or progress-reporting purposes and is defined in terms of latitude/longitude coordinates.

WCA
See WIND CORRECTION ANGLE (WCA).

Weather Briefing
Means for pilots to gather all information vital to the nature of the flight. Most often obtained from FSS specialist.

Weather Depiction Chart
Details surface conditions as derived from METAR and other surface observations.

Weathervane
To turn or rotate into the wind.

Weight
The force exerted by an aircraft from the pull of gravity.

Weight-Shift-Control Aircraft
Powered aircraft with a framed pivoting wing and a fuselage controllable only in pitch and roll by the pilot's ability to change the aircraft's center of gravity with respect to the wing. Flight control of the aircraft depends on the wing's ability to flexibly deform rather than the use of control surfaces.

Wind Correction Angle (WCA)
Correction applied to the course to establish a heading so that track will coincide with course.

Wind Direction Indicators
Indicators that include a windsock, wind tee, or tetrahedron. Visual reference will determine wind direction and runway in use.

Wind Drift Correction
Correction applied to the heading of the aircraft necessary to keep the aircraft tracking over a desired track.

Wind Shear
A sudden, drastic shift in wind speed, direction, or both that may occur in the horizontal or vertical plane.

Winds and Temperature Aloft Forecast (FD)
A twice daily forecast that provides wind and temperature forecasts for specific locations in the contiguous United States.

Wing
See RAM AIR WING

Wing Area
The total surface of the wing (square feet or square meters).

Wing Loading
The amount of weight that a wing must support to provide lift.

Wingspan
The maximum distance from wingtip to wingtip.

Wingtip Vortices
The rapidly rotating air that spills over an airplane's wings during flight. The intensity of the turbulence depends on the airplane's weight, speed, and configuration. Also referred to as wake turbulence. Vortices from heavy aircraft may be extremely hazardous to small aircraft.

Work
The product of force and the distance through which the force acts. Usually expressed in foot-pounds.

World Aeronautical Charts (WAC) (1:1,000,000)
A standard series of aeronautical charts covering land areas of the world at a size and scale convenient for navigation by moderate speed aircraft. Topographic information includes cities and towns, principal roads, railroads, distinctive landmarks, drainage, and relief. Aeronautical information includes visual and radio aids to navigation, airports, airways, restricted areas, obstructions and other pertinent data.

Yaw
The rotation of a powered parachute about its vertical axis.

Zulu Time
A term used in aviation for coordinated universal time (UTC) which places the entire world on one time standard.

Index

D

G

S

T

U

V

About the Author

Roy Beisswenger has been piloting and training other powered parachute pilots since 1993. He has trained pilots, equipment dealers and students from other countries as well as US government and military members.

He organized the World Powered Parachute championships in 2000 and continued the event for five years, attracting competitors from four continents. Also in 2000, Roy started the *UltraFlight Radio Show* which became the *Powered Sport Flying Radio Show*, which he hosted for ten years. In 2009, Beisswenger took over publishing *UltraFlight Magazine*, which he continues to help produce under its new name of *Powered Sport Flying Magazine*.

Before the Sport Pilot rules were introduced in 2004, Beisswenger held the designations of Ultralight Flight Instructor-Examiner with the Experimental Aircraft Association as well as Advanced Flight Instructor with the United States Ultralight Association.

In late 2004, Beisswenger was chosen to participate in the Federal Aviation Administration's first Designated Pilot Examiner training class for the sport pilot program. In January of 2005, he was the first to become a Sport Pilot and Certified Flight Instructor for powered parachutes. There he also became one of the country's first two examiners for powered parachute pilots as well as one of the country's first Designated Sport Flight Instructor Examiners. He's also the first Sport Pilot Certified Flight Instructor to become an FAA Gold Seal CFI.

Before Sport Pilot, Roy assembled aircraft from kits and serviced them for his school and customers. In 2006, he became a Repairman, Light Sport Aircraft Maintenance with designations for airplane, powered parachute and weight shift control aircraft. For several years he was also an FAA designated airworthiness representative for those same categories of aircraft.

He helped author the FAA's *Powered Parachute Flying Handbook (FAA-H-8083-29)* which was published in 2007. In 2014 he published the original *Roy's Powered Parachute Book* which he wrote and illustrated.

Beisswenger has been involved in many industry organizations over the years. Currently Roy is president of the United States Ultralight Association. He's also a member of the board of directors of the Light Aircraft Manufacturing Association and Chairman of ASTM's Powered Parachute Subcommittee, which is part of the larger ASTM Light Sport Aircraft Committee.

He has the highest subscribed channel on YouTube dedicated to powered parachutes, https://www.youtube.com/c/EasyFlight.

Roy was inducted into the Experimental Aircraft Association's Ultralight Hall of Fame in 2021, the Illinois Aviation Hall of Fame in 2018, won the Light Aircraft Manufacturers Association President's Award in 2014, and Flying Magazine's Bax Seat Trophy in 2011.

Prior to his work in aviation, Beisswenger was schooled in Mechanical Engineering, graduating from Washington University in 1984. Following that, he served as an officer in the US Army.