SAFE MANEUVERING FLIGHT TECHNIQUES

By Jim Dulin

DEDICATION

To my wife, Margie, whose gift of discernment has kept me out of jail all these years.

INTRODUCTION

As aviation has delved more deeply into artificial intelligence, a crisis of confidence has developed among its pilots. Flight safety professionals are concerned about professional pilots who, during a crisis, have transitioned too slowly from managing the computer that manages the airplane to actually flying the airplane. This slow transition has been cited as a causal factor in accidents.

What has caused this lack of our pilot's confidence in their ability to simply fly the airplane? If pilots trust computers, they surely trust basic instruments to give them situational awareness when there is no visual horizon. If there is a visual horizon, is it not reasonable to expect that they will use contact flying skills to recover and fly the airplane?

After fifty-seven years and over 17,000 hours instructing, flying Army helicopters, crop dusting, and flying pipeline patrol, I believe this crisis of confidence is the result of incomplete training in basic contact flying. It would be unfair to criticize the instructor who just teaches what he was taught. But, how do we criticize a large bureaucratic establishment? Very carefully, if we still have current paper. Let us, rather, just propose techniques and practices that have been safe and effective in our operations and instructional programs. The International Association of Flight Training Professionals, iaftp.org, is a good place to do this. Also there are many other training forums on the internet now days.

I wrote <u>Contact Flying</u> mainly to address low altitude maneuvering techniques not covered in normal training texts. Agricultural application schools cover specific techniques for crop dusting, but there is little in print about those techniques. Few techniques for pipeline patrol pilots are in print. Short field takeoff and landing techniques, covered in normal training texts, don't fully address the needs of bush and spray pilots operating from unimproved fields, nor do they address the needs of pilots operating low powered airplanes from high density-altitude fields.

I hope <u>Safe Maneuvering Flight Techniques</u> will give all pilots insight into the world of the crop duster, pipeline patrol pilot, and bush pilot. The corporate, airline, and recreational pilot may avoid maneuvering flight, except on takeoff and landing. I truly believe, however, that an objective look at these techniques can improve the understanding and capabilities of any pilot.

Chapter One

The Basic Low Ground Effect Takeoff

Maneuvering safely, on or near the ground, requires that we move the rudders or anti-torque petals and elevator or collective both dynamically and proactively to bracket the taxi line, centerline, or distant target between our legs until liftoff in ground effect or transitional lift and fly a directed course on the approach to landing. Because they are used for correction rather than bracketing, we move the ailerons statically and reactively. We move the throttle statically and reactively in calm air but dynamically and reactively in strong gusts. We all need to move the controls. Experienced pilots don't appear to be moving the controls dynamically and proactively because they need only move them a bit. Because students are learning what the controls do, they need to move the controls significantly. Otherwise, much time will be required to learn what the controls actually do. We use dynamic and proactive control movement because exact balance in a natural world is uncommon and more importantly, we will get behind the aircraft using a static reactive control movement or pressure. Just as an experienced tennis player, waiting for the service, dynamically and proactively shifts his weight too far left, too far right, etc. repetitively, we move our rudder or anti-torque petals too far left of target, too far right of target repetitively to bracket the target between our legs. As Sundance said to the old miner in <u>Butch Cassidy and the Sundance Kid</u>, "I'm better when I move."

I speak of bracketing the target or centerline between our legs because looking over the nose or prop in a side-by-side aircraft will cause us to yaw the longitudinal axis to the left, when sitting in the left seat, or to the right, when sitting in the right seat. This is why most small airplanes land on the left side of the centerline on all landings and squeak the misaligned tires. If the centerline is between the instructor's legs, it is also between the student's legs. It's optical magic. Just step out and see. The nose wheel or tail wheel will be on the centerline. An extreme example to illustrate this point is attempting visual alignment of the very short nose on a Chinook with the centerline. We would be in a forty-five degree crab.

In tail wheel airplanes, we dynamically and proactively walk the rudder full travel to the stops during taxi. This gross, dynamic and proactive rudder usage brackets the taxi centerline, between our legs, and indoctrinates the student in proper dynamic proactive rudder usage. This technique gives the student kinetic knowledge of the rudder stops, a ground loop mitigating memory in an emergency. It also forces the student to taxi slowly.

In nose wheel airplanes, we just take the slack out of the rudder control cables or push pull tubes by dynamically and proactively walking the rudder left, right, left, right, etc.

In helicopters, we just take the slack out of the tail rotor pitch change links by dynamically and proactively walking the anti-torque petals left, right, left, right, etc.

The change in pressure-airspeed (speed of relative wind over and under the airplane's body, wings, and control surfaces) on the takeoff roll, liftoff in ground effect, and acceleration in low ground effect will require continuously greater pressure and continuously less movement of rudder and elevator. We move the ailerons only for drift control in a crosswind while on the surface and leveling the wing upon liftoff. We use rudders or anti-torque pedals to keep the directed course of our butt down the runway after liftoff.

In nose wheel airplanes, we start the takeoff roll with the wheel full back. As the pressure-airspeed increases and the nose wheel comes off the surface, we move the control wheel dynamically and proactively fore and aft to hold the nose wheel just off the surface. We simply cannot accelerate rapidly with the weight on the nose wheel. With the elevator neutral, there will be extra weight on the nose wheel as the wings begin to lift (wheel barrowing.) Don't let the wheel neutralize. Hold full back until the nose wheel comes off.

In tail wheel airplanes, while still at a relatively slow pressure-airspeed, we will need to move the stick forward aggressively to get the tail up to a level pitch attitude as soon as possible. We simply cannot accelerate quickly in a high pitch attitude. We bracket the proper level pitch attitude on the mains with dynamic and proactive fore/aft wiggling of the stick. We maintain a directed course down the centerline with dynamic proactive rudder movement. We need to be aware of the gyroscopic precession effect on the prop that will yaw us left. If we are dynamic and proactive with the rudder, this is not much of a problem as we are already ahead of the airplane.

With either airplane, as pressure-airspeed increases, less dynamic, proactive, gross movement of the rudders and more dynamic, proactive, fine pressure of the rudder left, right, left, etc. is required. However, we always walk the rudders dynamically and proactively to bracket the centerline between our legs, staying ahead of the airplane.

With either airplane, we use aft elevator to lift off as soon as we feel sufficient buoyancy, see sufficient groundspeed, hear sufficient relative wind noise, and feel sufficient stick pressure. We bracket low (one to three feet) ground effect with dynamic fore/aft wiggling of the stick. We cannot accelerate rapidly with any wheels on the ground or with any pitch attitude. We cannot accelerate rapidly without the extra kinetic energy of pressure-airspeed attained by hovering (yes airplanes do it as well) on a bubble of high-pressure air.

These newer Cubs and backcountry airplanes with the flap handle up by the pilots head allow easy popping of the flaps to get off into ground effect. This technique also makes it easier to stay in low ground effect because the pitch attitude does not need to be very high followed by down and then level as when flaps are set before beginning the takeoff roll.

We use any excess engine thrust for climb and the extra kinetic energy of pressure-airspeed, (from flying level in low ground effect) to zoom over any obstruction, around which we cannot maneuver. Every second we can remain in low ground effect prior to zooming over any obstruction is going to give us extra kinetic energy of pressure-airspeed. Attempting early pitch up to Vx gives up this extra free energy. With low powered airplanes, we may not be able to sustain the high Vx pitch attitude until clearing the obstruction. Pitching up to Vx well before the obstruction is dangerous with low powered airplanes. Don't pitch up to Vx until near the obstruction or at maximum pressure-airspeed.

The aerodynamic basis is that airplane design does not allow acceleration very well on the ground. Initially, the real ground was grass, rocks, and weeds. One was expected to get off into ground effect as soon as possible.

Airplane design is to climb at Vy. Vx is sustainable with very high-powered aircraft because they have tremendous excess engine thrust for climb. Low powered airplanes do not always have available excess engine thrust for climb at Vy, much less Vx. Sometimes they have only engine thrust sufficient to maintain level flight, at Vy pitch attitude and airspeed. The greater the gross weight and/or density altitude, the less excess engine thrust is available for climb.

In normal GA operations, we deal with insufficient excess engine thrust for climb by using the POH to determine weight and balance, runway length needs, projected rates of climb, etc. In crop dusting or bush operations, loads can be progressively increased or decreased based on recent past experience. Creeping fire rather than dynamic and proactive management is appropriate here. We increase the load incrementally based on our experience that the last one under the same conditions went well. With many takeoff and landings per day, we gain empirical experience that is more accurate than POH data.

Robert Reser, in his very useful text, How to Fly Airplanes, explains ground effect better than I am scientifically capable of:
"The greater displaced airmass under than over the body and wings of the aircraft occurs during all motion of flight. Restriction of airmass displacement under the wings begins when operating near the surface. There becomes a cushioning effect of the aircraft riding on the displacing air as the surface restricts the normal downward air displacement. Every takeoff and landing passes through this ground effect. Ground effect improves aircraft performance while operating at these very low altitudes. The effect is greatest with the increased proportion of mass displacement at high angles of attack from low airspeed when operating within a few feet of the ground.

When landing, decreased drag of the surface restricting the normal displacement of airmass below the aircraft wings results in reducing the descent rate causing floating while keeping the aircraft very low at liftoff, allows faster acceleration to desired climbing indicated-airspeeds."

Ground effect starts and is greatest at liftoff and decreases with increased altitude, essentially disappearing when above an approximate altitude of the wingspan. The wingspan of most small aircraft is less than 30-40 feet.

Ground effect relates to the height of the wing above the ground, so there is considerable difference between the ground-effect with high-wing versus low wing aircraft. A pilot must train to fly an aircraft low to the ground learning to utilize this phenomenon to extend glide distance when approaching a landing area, or to utilize the technique of remaining low for increased acceleration at takeoff from short, soft, or high altitude runways.

Ground effect is present anytime the aircraft is near the surface, and not restricted to being over the runway. Very low level flight during an approach to landing can extend gliding distance by utilizing ground effect or at takeoff; continued low-level flight after passing the runway end will allow continued acceleration to safe climb indicated-airspeeds.

Being close to the rocks and trees could be an unnerving experience if not familiar with techniques of very low flight, so all pilots should practice experiencing the phenomenon."

Pilot operating handbooks generally give a 10% greater excess kinetic energy of pressure-airspeed for the free energy of ground effect, but that figure is calculated at high (fifteen or twenty feet) ground effect and is thus much less than what is available in low ground effect. Data for ground effect only aircraft (mostly ground effect flying boats) give a 40% extra lift figure for the extra free energy of low ground effect. Unofficial research data from over 50,000 low ground effect takeoffs, in 17,000 hours of gunship flying, crop dusting, and pipeline patrolling, indicate the extra lift to be 30%.

Crop dusters flying overloaded, 235 hp piston engine airplanes generally get off in about two thirds the distance of a fully loaded people airplane with a similar power to weight ratio. In the crop field, on a swath run, low ground effect gets more spray onto the target pest and gives relative low power to weight aircraft extra zoom reserve in the form of airspeed. This extra kinetic energy of pressure-airspeed exchanges dynamically for zoom reserve in the form of altitude (potential gravity thrust of altitude.) This extra kinetic energy of pressure-airspeed is sufficient to maneuver aggressively or climb at a high pitch attitude (zoom reserve in the form of airspeed) for a limited time.

This rapid increase in pressure-airspeed kinetic energy is most useful at short fields with heavy loads and/or at high density-altitude airports. You can observe the inefficiency of the early Vx zoom out of ground effect takeoff any hot day at the airport.

The official school solution of pitching off the surface to Vx prior to developing sufficient kinetic energy of pressure-airspeed is inefficient energy management. This assumes using excess engine thrust for Vx climb, but it keeps the wheels on the ground longer than the low ground effect technique. The official school solution takes zero advantage of the excess kinetic energy of pressure-airspeed available in low ground effect. It also calls for attempting to climb at Vx as soon as Vx is obtained. Again, this leaves free ground effect kinetic energy behind and below when we most need it to clear the obstruction comfortably.

Using normal short field over obstructions technique in high load and/or high density altitude conditions may require a rapid pitch down to Vy, level, or dive pitch attitude to prevent altitude loss or stall in a possible behind the power curve mush. Failure to recognize this behind the power curve condition and/or failure to push the stick forward, has resulted in many takeoff mush or stall accidents.

This school solution Vx short field takeoff technique in low powered airplanes of insufficient excess engine thrust for sustained Vx pitch attitude, is energy inefficient and often impossible.

The design of the tail wheel airplane with the center of gravity behind the main gear causes a strong tendency of the tail to attempt to get in front of the nose (ground loop.) This happens when the longitudinal axis is not proactively and dynamically aligned (slightly too far left, right, left, etc.) with the direction of movement. Perfect, static longitudinal alignment is a false concept in a dynamically stable world. Perfect, static pitch attitude is also a false concept. Close to the runway/terrain, in low ground effect, this becomes obvious.

Delay in getting the tail up (tail wheel airplanes) or getting the nose wheel off (nose wheel airplanes) greatly increases the runway distance required to get airborne. This is because low powered tail wheel airplanes have insufficient excess thrust for climb to get off into ground effect in the tail down pitch attitude. As the wing begins to lift the total weight of the nose wheel airplane, the nose wheel will gain weight (wheel burrow) initially, unless lifted free of the surface with elevator control. If not at least lightened with aft elevator, there will be delayed acceleration.

Elimination of mechanical drag of the wheels/skids occurs as soon as we get the mains off. By flying in low ground effect, we have reduced induced drag. Normal curriculums teach soft field takeoff technique similar to the low ground effect takeoff technique. The problem, which results in many accidents, is that the soft field technique is not taught as the short field technique.

Following are some Common Errors in the execution of the Basic Low Ground Effect Takeoff:

1. Failure to walk the rudders dynamically and proactively to bracket the centerline between our legs until liftoff and after liftoff in ground effect, to bracket the directed course of our butt down the centerline. We deal with gyroscopic precession by the prop with dynamic and proactive rudder movement.
2. Failure to wiggle the stick fore/aft, dynamically and proactively to:

    a. keep the airplane level on the mains or to keep the nose wheel just off the surface.
    b. maintain three feet altitude until zoom reserve in the form of airspeed (excess ground effect kinetic energy of pressure-airspeed) increases as much as is possible before obstacle encounter.
    c. In tail wheel airplanes, many pilots have difficulty pushing the stick forward sufficiently or aggressively because they worry about catching the prop.
        i. Dynamic fore/aft stick usage mitigates this problem.
        ii. We bobble just a bit when learning, but at least we learn to level the airplane and allow acceleration.
3. Allowing the tail to remain low rather than aggressively pushing the stick forward followed by dynamic wiggling of the stick.
    a. In tail wheel airplanes many pilots allow the tail to come up on its own when increasing pressure-airspeed brings it up.
        i. With no tail wheel contact and poor rudder effect, (tail half up or half down,) ground loop is much more likely.
        ii. With the tail on the ground at very fast speeds, ground loop is more likely.
4. Failure to make wheel takeoffs by wiggling the stick fore and aft dynamically to accomplish rapid transitions.
    a. We aggressively push the tail up at the appropriate time.
    b. Looking at the airspeed indicator to find the appropriate time increases the likelihood of a ground loop.
5. In nose wheel airplanes, failure to lighten or bring the nose wheel off or failure to wiggle the stick sufficiently to maintain the nose wheel just off.
6. Failure to get the mains off as soon as possible and into low ground effect.
7. In both types of airplanes, many pilots have difficulty pushing the stick forward aggressively to stay in low ground effect and wiggling the stick to maintain it.
    a. This causes porpoising because we are late in recognizing that we are high or low.
    b. New students generally assume that the experienced pilot does not move the controls dynamically.
        i. This is because the dynamic movement, when at slow speed, and dynamic pressure, when fast, is not gross and obvious.

ii. We wobble when we first learn to ride a bike; and at first, when we learn to fly, we need to move the controls, grossly.
iii. Old pilots want to appear professional, even if they are a bit rusty.

8. Attempting to engine climb or even zoom over an obstruction when a fifteen-degree or less heading change would allow us to bypass the obstruction in ground effect.
9. The most common error on the Flight Review is not walking the rudders a bit.

Following is a measure of the Effectiveness of the Basic Low Ground Effect Takeoff:

1. Most instructors agree that pilots indoctrinated early in dynamic proactive rudder and elevator movement, especially in tail wheel airplanes, have fewer flight test and flight review problems.
2. As they learn to wiggle the stick fore and aft, students gain confidence in flying in low ground effect on takeoff and in the crop field or desert.
3. Flight review pilots appreciate the need to wiggle the stick fore and aft in performing safer low ground effect short field takeoffs, especially over rough terrain.
4. The low ground effect takeoff has allowed crop dusters to spray more acres with each load.
5. This has contributed to the amazing production of the American farmer, who feeds 155 people.
6. The low ground effect takeoff has made it possible for small, low powered airplanes to operate safely from high density-altitude airports.

Chapter Two

The Dutch Roll

Maneuvering safely, near the ground, requires that we:

1. move the rudders aggressively,
2. use the energy management turn, to turn to or return to a ground target.
3. bring a wing up with rudder to counter an upset or to roll out of a steep, energy management turn,
4. use rudder to keep the horizontal nose (between our legs) speed of movement appropriate for the angle of bank.
5. indoctrinate the student in the necessity of using the rudder aggressively to counter adverse yaw in low level work, including takeoff and landing.

The use of 45% banks in Dutch Rolls in modern aircraft (those with wing engineering to mitigate but not eliminate adverse yaw) indoctrinates this.

Aileron movement, except in the Ercoupe, creates adverse yaw. The down aileron creates more camber and greater lift on that wing. The down aileron also creates more induced drag on that wing. This extra induced drag, this adverse yaw, is greater at slow pressure-airspeed than at high pressure-airspeed.

At slow pressure-airspeed, we need more aileron deflection for the same roll rate about the longitudinal axis. At high pressure-airspeed, we need less aileron deflection for the same roll rate about the longitudinal axis.

The Ercoupe, the "Safety Airplane," was, in 1939, one hundred years ahead of its time. The down aileron movement was less initially than was the up aileron to balance adverse yaw. As you moved the control wheel further, the down aileron movement became greater and the up aileron movement lesser than initially. The Ercoupe was never popular because it will not kill us very fast. No macho.

When flying more modern, wing engineered airplanes, we may be deceived by our ability to make shallow and medium banked turns without rudder. This may lead to a deadly belief that we can always make turns without rudder. In an emergency near the ground, we must know how to use the rudder aggressively to turn quickly and especially to get a wing up.

With all airplanes, except the Ercoupe, the down aileron creates greater lift/drag on the wing away from the direction of roll. In older airplanes, without wing engineering to mitigate adverse yaw, the use of aileron only will cause bank and slip but no turn. Danger! Danger! Danger! In modern airplanes with wing engineering (outboard wing wash-in, Frise ailerons, bungee rudder/aileron interconnect) to mitigate adverse yaw, slipping (insufficient rudder in the direction of the turn) turns of shallow or even medium bank are possible without any rudder usage to eliminate adverse yaw. Danger! Danger! Danger!

Because we have insufficient engine thrust, in a steep turn, to overcome the designed tendency of the airplane to pitch down, we may pull back on the stick to maintain altitude. This, pulling back, sets up a dangerous situation. We decelerate continually in this turn. To return to level, we must use more aileron and thus more rudder to get the wing up. Overuse of the rudder or even skidding, as we bring the wing smartly back up, is preferable to using the rudder mildly or not at all. At this slower speed, aggressive rudder movement in the direction we want the wing to roll is necessary. That is why we lead rudder to bring the wing back up during steep turns including Dutch Rolls.

Steep Dutch Rolls absolutely require proper rudder usage to eliminate adverse yaw. Thus, Dutch Rolls are an excellent evaluation of rudder usage for turn quality. Medium banked Dutch Rolls in older airplanes is adequate, as they have no modern wing engineering.

To execute Dutch Rolls, we turn to a distant target, upwind or downwind, and use dynamic rudder movement to center said target between our legs. We demonstrate the using of ailerons only, in an attempt to hold the target between our legs, while making alternating, shallow banks right and left. We point out that the airplane is slipping and that the nose initially moves opposite from the bank each time we move the ailerons. We demonstrate holding the target with aggressive rudder movement in the direction of desired roll using forty-five degree banks each way. We have the student practice Dutch Rolls starting with steep banks (indoctrination first) and then at medium banks. We tell him not to worry about some altitude loss.

When the student has gotten a handle on Dutch Rolls, we have him practice steep turns left and right while coaching him on slips and skids. We point out how the nose (between the legs) hangs up going into a turn. This is slipping. We see slower horizontal nose movement than appropriate for the angle of bank. We hear disturbed relative wind noises. We feel more weight in the butt cheek in the direction of the turn. Using too little rudder causes all this slipping and is most common.

We now have the student stomp the rudder in the direction of the turn. This is skidding. We see faster nose movement than appropriate for the angle of bank. We hear disturbed relative wind noises. We feel more weight in the butt cheek away from the direction of the turn because we are being slung away from the direction of the turn. Using too much rudder causes all this skidding and is very uncommon.

Following is a measure of the effectiveness of Dutch Roll training and practice:

1. Students who are exposed to this on the first flight and every flight until solo will have no rudder management problems while taking off, making circuits, and landing.
2. Review pilots appreciate pointers on how to stay current on proper rudder usage.
3. Ercoupe pilots, especially Mr. Fred Weick, are just very wise and safe people.

Chapter Three

The Energy Management, No Load Factor, Turn

With the exception of instrument flying, is there any good reason for making level turns? Are level turns safer than descending turns? Can we avoid the load factor problem of steep, level turns in the interest of safety? If you answered yes, yes, and no, I hope the energy management turn technique will convince you that just the opposite is true in each case.

Maneuvering flight is illegal, results from poor judgment, and can be fatal. However, crop dusters and pipeline pilots engage in maneuvering flight every hour of every flight on a daily basis. Every pilot engages in maneuvering flight on every takeoff and on every landing.

In order to maneuver safely, near the ground, we must indoctrinate our students:

1. in the safety of dynamically trading zoom reserve in the form of airspeed (the kinetic energy of pressure-airspeed sufficient to maneuver aggressively or climb at a high pitch attitude for a limited time) for zoom reserve in the form of altitude (potential gravity thrust of altitude.)
    a. This is to store potential gravity thrust in altitude and to slow the airplane.
    b. Use of this stored potential gravity thrust will safely allow the turn to be made in a dive toward the target.
2. in the safety of turning, at the necessary bank angle, to a visible target on the earth's surface while allowing the nose to fall through (go down) as designed.
    a. There is no need to add power or pull back on the stick in the energy management turn.
    b. This keeps both the instructor's and the student's head out of the cockpit 100% of the time.
    c. This is not a turn to a heading.
    d. This is a turn of 180 degrees or less.
3. in the necessity of leveling the wing, prior to pulling up over the target, to prevent graveyard spiral.
4. in our ability to zoom back to near original altitude and original cruise airspeed to finish the turn.
    a. This is using the kinetic energy of airspeed, converted from gravity thrust in the dive. We must remember that while we

have eliminated the load factor of bank (leveling the wing,) we want to avoid increased g loading by pulling up too fast.

5. in the necessity of banking aggressively to get a good rate of turn early.
    a. We avoid load factor, by not pulling back on the stick, throughout the turn
    b. This helps crop dusters get the nose around onto the target before diving into the ground.
6. in the importance of making all contact turns using the energy management technique.
    a. Even shallow and medium turns can be energy management turns.
    b. The way we turn normally will be the way we turn in an emergency.

According to Wolfgang Langewiesche, “Airspeed is altitude, and altitude is airspeed.” This works out to be true in the energy management turn. According to Robert Reser, “The kinetic energy of pressure-airspeed can, with elevator pitch angle of attack, be converted to excess thrust for climb and the potential gravity thrust of altitude can be converted to the kinetic energy of pressure-airspeed.” This works out to be true in the energy management turn.

Increased pressure-airspeed, in a level turn, decreases rate of turn and increases load factor on the fuselage, not the wing. High-powered airplanes can always safely add thrust to maintain a given bank without increasing wing loading. Low-powered, common, airplanes do not always have this extra power. Pilots of common general aviation airplanes commonly pull back to maintain altitude in turns. Pulling back, when we run out of excess engine thrust to replace the lift lost due to the bank, increases load factor. This makes level turns dangerous near terrain and obstacles.

Decreased airspeed increases rate of turn and decreases load factor. The slower we go, the faster we turn. We take advantage of this by pulling up, wings level, to begin the energy management turn.

“Airplanes are incapable of stalling themselves. Only the pilot can cause a stall, by pulling back. Another instance is when the pilot of a fairly powerful airplane elevator-trimmed in descent to a very low pressure-airspeed adds a significant amount of thrust without pushing forward on the wheel.” Robert Reser. This is an advantage of allowing the nose to fall through naturally (not pull back) in the energy management turn.

Avoid level turns. Load factor increases with angle of bank in a level turn. Avoid level turns. The airplane, without a pilot pulling back on the stick, will not experience load factor. Avoid pulling back to maintain a level turn. Use the energy management procedure with bank angles that require more than maximum thrust to maintain altitude. While requiring us to stay ahead of the airplane, I find the energy management turn the most comfortable in all non-instrument situations.

Airplane design automatically reduces pitch attitude when thrust no longer equals drag. Airplanes are designed so that pitch attitude is automatically reduced in a bank. The greater the bank, the further down the automatic pitch change. When we turn without adding power or increasing angle of attack to replace the lost vertical component of aerodynamic lift, the nose automatically goes down. Aerodynamic design of airplanes does not oblige the pilot to maintain altitude in a turn.

A turn at any bank angle, without pulling back on the stick, results in no load factor. Short duration zoom climb at greater than Vy pitch attitude can be achieved by trading excess (greater than Vy) airspeed for altitude. We are limited by degradation of the kinetic energy of pressure-airspeed. Our zoom reserve in the form of airspeed is limited. We achieve short duration gravity thrust (greater than Vy) by trading altitude for airspeed. Our zoom reserve in the form of altitude is limited only by Vne and/or impact with terrain.

With cruise power throughout, a wings level zoom climb followed by a steep turn (don't pull back on the stick in the turn) followed by a steep dive followed by a wings level pull up will result in little altitude loss. The kinetic energy of pressure-airspeed can be exchanged, in a short zoomed elevator pitch climb, for one or two hundred feet greater altitude. We then exchange that potential gravity thrust of altitude for kinetic energy of pressure-airspeed. Likewise, we exchange kinetic energy of pressure-airspeed for potential gravity thrust of altitude returning to the original altitude.

You may have noticed that the energy management of airspeed and altitude, for a no load factor turn, is dynamic. Energy management means that we cannot zoom climb indefinitely. Energy management means that we cannot gravity dive indefinitely. Airspeed is altitude and altitude is airspeed, but the zoom reserve of each is limited.

Executing the Energy Management, No Load Factor Turn:

Start by viewing this video: http://www.youtube.com/watch?v=tar7reZuU5s

While cruising, we pick a visible target to turn to. The closer the target, the greater will be the angle of bank. The further behind us is the target, the greater will be the angle of bank. Anticipating the target, we pull the elevator control to zoom up, rapidly but smoothly trading airspeed for altitude. The nearer and/or more behind us the target, the longer we need to pitch up and bleed off the extra kinetic energy of airspeed. The slower we go, the faster we turn and we need to get around quickly for engaging a near or already passed target. The nearer and/or more behind us the target, the steeper must be the angle of bank. Regardless of the desired bank, we do not continue the zoom up too long or we will go behind the power curve and mush and eventually stall.

We smoothly but rapidly roll the nose onto the target while allowing the nose to fall through the horizon and pitch down naturally, trading altitude for airspeed. The nose moves smoothly from level pitch up to horizontal acceleration (rate of turn increases) while still pitched up and then down through the horizon in a dive angle onto the target. We take care not to pull back for most energy management turns. The old lazy eight was like this. The new PTS instrument controlled lazy eight is nothing like this.

There is an exception to the no pull back rule. When we return to the target after a gun run or return to the field from a crop duster turn, we often turn at banks greater than sixty degrees. Because the aircraft attempts rapidly returning to cruise pressure-airspeed, the nose tucks to dive angles greater than thirty degrees pitch down. We pull back on the stick enough to prevent the extreme tuck, but not enough to significantly increase load factor.

The greater the bank angle, the faster must be the horizontal and vertical nose movement. The greater the bank angle, the greater must be the rudder movement. We must push the nose around or the nose will drag around the turn in a slip. If we err, and everybody errs, we must err on the side of skidding rather than on the side of slipping. This is critical when bringing the wing back up. Not bringing the wing back up smartly causes what the old guys called, “the aileron going out.” We need positively accurate turns near terrain and obstructions. We need to think, “Push the wing back up with rudder.”

We may be slow when we wish to return to wings level. This may cause the pilot who expects the aileron to do most of the lifting to deflect the aileron significantly. This great downward deflection of aileron without standing on the rudder will cause tremendous drag on the low wing or adverse yaw. This tremendous drag on the low wing slows the roll out of the bank. In the old days, they talked about the aileron going out. What actually happens is adverse yaw, which gets worse as we get slower. Adverse yaw drags the wing back with considerable force if we try to bring the wing up with aileron only.

As the nose comes around and down below the horizon and onto the target, we level the wings first. We use lots of rudder to level the wing and then pull up to fly a directed course to or over the target. We have converted the potential gravity thrust of altitude into the kinetic energy of pressure-airspeed. We have traded altitude for airspeed. Failure to level the wings first will cause both load factor and the graveyard spiral. Attempting to bring the down wing up with insufficient rudder movement is very dangerous here. If very low, there is danger of putting the down wing into obstructions or the ground.

This pull up will cause wings level g-loading of the aircraft but not the load factor of turning and pulling up. This pull up converts the kinetic energy of pressure-airspeed into altitude. We now trade airspeed for altitude.

The energy management, no load factor, turn need not be just the aggressive return to target of the crop duster. High load factor turns are not comfortable or safe anywhere. For IMC work, we limit the angle of bank creating little load factor. In all other flying, shallow and medium banked turns can take advantage of energy management as well. In 3,500 miles of pipeline work each week, I made thousands shallow and medium banked turns. I simply observed a change in the pipeline's direction, picked up the nose a bit to slow down going outside the turn of the right of way, and rolled the nose back onto the right of way in the new direction while allowing the nose to fall back through the original altitude. After leveling the wings and upon pulling up from this slight dive, I would return to the original altitude. Just as with the crop duster turn, I traded airspeed for altitude, that gained altitude for airspeed, and that gained airspeed for altitude.

In summary, after pulling up and rolling/diving onto the target and then leveling the wings and pulling up to fly over the target, we find ourselves at or near the entry altitude. We have managed energy by trading airspeed for altitude in the initial pull up and from that gained altitude the descending/diving turn regains airspeed which is traded for altitude in the final pull up.

Throughout this dynamically variable pitch, dynamically variable bank, dynamically variable pressure-airspeed, dynamically variable altitude maneuver, we continuously vary the rudder pressure a lot to continuously manage the variable adverse yaw problem, which is caused by variable aileron pressure. We must push the nose around and not let the nose (adverse yaw) pull us back. As the bank nears ninety degrees, the rudder increasingly is necessary to help get the nose down. Beyond 45-degrees bank, relative the surface, the rudder is primary nose up/down pitch control.

Following are some common errors associated with the energy management turn:

1. Failing to pick a target to turn to (turning to heading.)
2. Turning IFR, by using the airspeed indicator and DG. This is a contact turn.
3. Pulling up too aggressively, to start the maneuver, and bleeding kinetic airspeed energy, creating wings level load factors of weight and curved flight.
4. Starting the maneuver by pulling up too slowly, bleeding kinetic airspeed energy in an unsustainable pitch up.
5. Insufficient original banking. This causes very steep late banking to capture a near target. This can put the down wing into an obstruction.
6. Dragging the nose around with insufficient rudder usage (slipping.)
7. Not allowing the nose to fall through naturally (pulling back in the turn.)
8. Pulling up too fast, to end the maneuver, bleeding kinetic energy by creating wings level load factors of weight and curved flight.
9. Pulling up too slowly, to end the maneuver, thereby failing to regain altitude or, so low, putting the main wheels into the crop.
10. Failing to plan ahead so that all contact turns, even shallow and medium banked turns, can be energy management turns.

Following is a measure of the effectiveness of the energy management turn:

1. Zero timers learn this safety turn more quickly than they learn flat turns for testing purposes.
2. Flight Review pilots appreciate learning how to maneuver safely near the ground when necessary.
3. This turn makes possible a safer box canyon turnaround.
4. Thousands of crop dusters and pipeline patrol pilots owe their lives to learning this technique.
5. It is not new, just not written about much.

Chapter Four

The Apparent Brisk Walk Rate of Closure Approach

Where did the 1.3 Vso approach speed come from? How much different is 1.2 Vso for short field landings? What happened to the “stall down” approach used, according to Wolfgang Langewiesche, by experienced pilots? Why do we takeoff so slow and land so fast these days? Since the round out, flair, and hold off following the 1.3 Vso approach are the most difficult landing techniques, why not manage the descent with power, the airspeed with elevator, and decelerate prior to the intended touchdown point? Or, we can get down into low ground effect, prior to the desired touchdown point, where no obstructions prevent this hover taxi to the desired touchdown point. Both techniques are useful on very short fields.

The Army teaches helicopter pilots of all American services and many foreign services an apparent brisk walk rate of closure approach that puts every landing, 100% of them, on the numbers every time. That is 100%, every, every time. When landing, we don’t have to come to a stop on the numbers to softly and safely put it on the numbers every time. We just have to get it decelerated to, very nearly to, or in the case of the hover up to the numbers approach below Vso at the numbers, rather than one thousand feet down the runway.

While cruising at 500’ AGL, the speed at which objects appear to be moving toward us is a brisk walk. On final approach, we need to keep that apparent brisk walk rate of closure with the numbers constant. This will cause a constant deceleration from five hundred feet AGL and ¼ mile out until arriving at the numbers very near stall speed.

Following are the objectives we need to consider in order to land slowly on the numbers every time:

1. Cause all, 100%, of our approaches to end up with a touchdown on the numbers.
2. Get rid of zoom reserve in the form of altitude (potential gravity thrust of altitude) as soon in the approach as practicable.
    a. Any pattern altitude greater than 500’ makes dissipation of zoom reserve in the form of altitude, potential gravity thrust, more difficult.
3. Manage wind, as much as practicable, so that we make the low altitude base to final and the final approach into the wind.

        a. Any distance greater than ¼ mile from the landing zone/airport makes observation of activity and other aircraft in the landing zone area more difficult.
4. Maintain longitudinal axis alignment with the centerline, or directed course line, with dynamic proactive rudder movement.
    a. The crab to short final and then side slip is acceptable for those who use greater than ½ mile wide patterns.
    b. This crab also requires that we keep the wing level with aileron while dynamically and proactively walking an angle between our butt and the numbers down the centerline with rudder only.
    c. Lock the wing either level or in the bank that will counter any crosswind drift.
5. Keep power dynamically and reactively alive to manage glide angle and gust spread throughout the approach.
    a. We make available the fourth dynamic control, power, rather than fly the approach with a static un-reactive throttle.
6. Maintain the apparent brisk walk rate of closure with dynamic reactive elevator movement.
7. Maintain the glide angle with static reactive throttle movement or dynamic reactive throttle movement as necessary
8. Flair to protect the nose gear and touch down, perhaps with power, in a mush or stall, on the numbers.

Following are some aerodynamic facts that support the apparent brisk walk rate of closure approach:

1. The kinetic energy of pressure-airspeed is potential altitude. Airspeed is altitude. During takeoff, this is good. During landing, too much airspeed can make us go long.
2. The potential gravity thrust of altitude becomes gravity thrust on the approach. Too much altitude can make us go long.
    a. 1,000’ of altitude is a huge amount of potential gravity thrust.
    b. Pattern altitudes were changed from 600’ to 1,000’ or 1,200’ for fast airplanes using a very wide pattern and long final or just a long final
    c. DC-3 Airline pilots had no problem with the 600’ pattern altitude.
3. While zoom reserve in the form of both airspeed and altitude are takeoff design aspirations, neither zoom reserve in the form of altitude nor zoom reserve in the form of airspeed is an approach to landing design aspiration.
    a. 1.3 Vso at the fence makes landing on the numbers improbable.

    b. 1.3 Vso works fine when we change to the apparent rate of closure technique ½ mile out.
4. The apparent rate of closure is the speed at which an object or point on the ground appears to be closing with us as we approach it.
    a. From 500' AGL and ¼ mile out, it will appear to speed up the lower and closer we get.
    b. We use dynamic reactive elevator control to maintain what appears to be a brisk walk rate of closure to the target (numbers.)
    c. Maintaining an apparent brisk walk with dynamic reactive stick movement will cause both airspeed and, more importantly, groundspeed to decrease as we get lower and closer to the target (numbers.)
    d. In a headwind, the pressure-airspeed will be faster than in a no wind or downwind condition.
        i. The groundspeed will be the same as in a no wind or downwind condition, but can safely be reduced by reducing the apparent rate of closure.
    e. In a no wind condition, the pressure-airspeed will be slower than in a headwind and faster than in a downwind.
        i. The groundspeed will be the same as in a headwind or downwind.
    f. In a downwind, the pressure-airspeed will be slower than in a headwind or no wind condition.
        i. The groundspeed will be the same.
        ii. We can expect to go behind the power curve on short final.
        iii. Controlling elevator to keep the apparent rate at what appears to be a brisk walk in a strong downwind may cause the airplane to go behind the power curve and sink/mush on short final.
            1. This will require the addition of considerable throttle to maintain glide angle and prevent descent into obstructions.
            2. If there are no obstructions, descent to ground effect is advisable, but the addition of power will slow the sink rate.
            3. Ground effect will also slow the sink rate.
            4. When obstructions prevent descent to ground effect, application of considerable power is required to arrest the sink/mush.

5. Dynamic proactive rudder movement is the fastest and most effective longitudinal alignment control.
6. Coordinated turns are the slowest and least effective longitudinal alignment control.
7. Coordinated turns, very near the surface, can easily put a wing into a wire, the trees, the crop, or the runway.
8. In behind the power curve flight, pulling the elevator back causes descent.
9. In behind the power curve flight, pushing the elevator forward causes ascent.
10. Full flaps and/or slats, when available, allow the airplane to fly at the slowest pressure-airspeed possible without stalling.
11. Full flaps allow the slowest possible touchdown on the desired touchdown point.
12. Full flaps decrease the likelihood of touchdown beyond the desired touchdown point.

We do everything possible, given safety considerations, to get rid of zoom reserve in the form of altitude and zoom reserve in the form of airspeed prior to the desired touchdown point. At an uncontrolled field, we get close (1/4 mile) and low (500') before turning base. We make any pattern close in to allow good observation and, in an emergency, to allow a powerless glide to the landing zone. We make base to final into any crosswind, unless denied at a tower field.

On final to a landing zone with obstructions, we use a glide angle that will allow us to just see the numbers or desired touchdown point over the obstruction. If there are no obstructions, we can safely get into slow flight in ground effect prior to the numbers. In either situation, we get rid of zoom reserve in the form of altitude (potential gravity thrust of altitude) as soon as practicable. We pick the numbers or an object near the desired touchdown point for what Bob Reser, in <u>How to Fly Airplanes</u>, calls a "directed course" to the target (numbers.)

We get rid of zoom reserve in the form of altitude as soon as practicable. Remember that altitude (potential gravity thrust) is airspeed. That is why crop dusters fly final in ground effect, to the extent possible.

We walk the rudder dynamically and proactively. We keep the centerline between our legs (yes it will be between the instructor's as well) by walking the rudders all the way down and throughout the roll out and taxi. We walk the rudder dynamically and proactively.

We lock the wing. With a student, I jam the stick or control wheel with my stiff thumb. When he tries to use the aileron and hits my thumb, I say, "don't use the aileron. Walk the rudder." That is, we only use aileron to either keep the wing level or hold sufficient bank to prevent drift from a crosswind. We don't want to be flying dynamic and reactive, coordinated turns on final. We want to walk the centerline with dynamic proactive rudder only. We continue walking the rudders all the way down and after touchdown. We want to manage drift with static reactive aileron only. It's like rubbing our tummy while patting our head. It is uncoordinated.

We use dynamic reactive throttle control (move the throttle in gusty air) to maintain glide angle. This is much easier in ground effect. Downdrafts don't go into the ground. They spread out and move us sideways. Headwind shears require aggressive throttle reduction. Tailwind shears require aggressive throttle increase. In very rough air, we may add full throttle and then adjust or completely close the throttle and then adjust.

We use full flaps on short final. This gives us a slower stall speed and a more nearly level attitude. We use dynamic reactive elevator control to maintain what appears to be a brisk walk rate of closure to the target (numbers.) This is a hard concept for non-helicopter pilots. The brisk walk is apparent! It is not airspeed. It is not groundspeed. It is apparent, a visual illusion. It is not on the panel; it is outside. It is a visual, mentally estimated, apparent slow speed, at which the target seems to be coming toward us.

We continue dynamically and proactively walking the rudder to bracket the centerline. As we get closer to the numbers and as we get lower, the numbers constantly appear to speed up in their closure with us. The rate of closure appears to speed up, especially on short final. We arrest that apparent speed increase by pulling back a bit and adding power as we slow down continuing dynamically and proactively walking the rudder to bracket the centerline.

Somewhere on short final, depending on the height of our panel, we will lose sight of the numbers or desired touchdown spot. We shift our focus just over the panel on down the runway and use kinetic, aural, and stick position as well to feel it on down.

On short final, with the brisk walk appearing to speed up, we will have to reduce groundspeed by pulling back on the stick. On short final, when unsure about approach speed, we test for zoom reserve in the form of pressure-airspeed. We pull back a bit on the stick. If we balloon up a bit, we are going too fast. We hold that back pressure and prepare to add throttle if we then sink.

If we sink in a behind the power curve mush, we are going too slow. We add power to cushion the aircraft onto the surface. If we stay on the same glide angle, we are fine. We wait until just before touchdown to protect the nose wheel (pull back) or we wait until touchdown to push the stick forward to wheel land. We continue dynamically and proactively walking the rudder to bracket the centerline.

When making slow, nearly behind the power curve approaches, it is imperative to control glide angle with the throttle control. Any attempt to arrest the sink with up elevator will increase the sink rate causing mush and possibly a stall.

We continue walking the rudder dynamically and proactively.

With a steep glide angle to go over obstructions, while seeing the numbers all the way, there will be only short-term ground effect to cushion the touchdown on the numbers. Significant power must be applied to arrest the greater than normal sink rate.

We continue walking the rudder dynamically and proactively.

With a short final in ground effect hover taxi (zero glide angle,) power can be backed off just a bit to touch down on the numbers. We pull the stick back a bit to protect the nose gear in nose wheel airplanes. We simply run the mains on and dynamically push the stick forward/aft (wheel landing) in tail wheel airplanes.

We continue walking the rudder dynamically and proactively.

When we truly have our zoom reserve in the form of airspeed and our zoom reserve in the form of altitude under control, there will be no need to round out, flair, and hold off. We do need to protect the nose gear, hanging down on an extended strut, with a bit of flair.

In a strong headwind, we must be careful to maintain some forward groundspeed. A very strong headwind may stop forward motion or move us backwards when we reach ground effect over the numbers. We prevent that by reducing the angle of attack with elevator but we hold the nose gear off when we reduce power to touch down.

In a downwind, we expect a behind the power curve sink/mush on short final. We arrest that sink/mush by adding power. When we touch down, we close the throttle. When we touch down in tail wheel airplanes, we push the stick forward, pull back a bit, etc. to dynamically and proactively level the pitch attitude. In nose wheel airplanes, we pull full back on the stick for air breaking If she comes off, we are going much too fast. We add power to again land softly.

We continue walking the rudder dynamically and proactively.

On the surface in a tail wheel airplane, when we slow enough that the pitch attitude increases (tail coming down,) we pull full back on the stick to the stop.

We continue walking the rudder dynamically and proactively.

I have found the apparent rate of closure approach to be the hardest technique to teach experienced pilots, especially instructors. This is because of indoctrination in the use of the airspeed indicator for landing and many iterations of landing using the airspeed indicator.

I have also found the apparent rate of closure approach to be very easy to teach to zero time student pilots and to anyone with the mental flexibility to honestly try it. And I have flown with many pilots who use the apparent rate of closure without even knowing it.

We of the USA have many hours experience driving autos and many iterations of slowing at what appears to be a brisk walk to a stop at an intersection. Almost every North American subconsciously use the apparent brisk walk rate of closure on every stop.

Following are some common errors concerning the apparent brisk walk rate of closure approach:

1. Failure to dissipate zoom reserve in the form of altitude, potential gravity thrust, early in the approach.
    a. Any altitude above zero, at the desired touchdown point, is excess potential gravity thrust of altitude.

    b. Excess potential gravity thrust of altitude, at the desired touchdown point, takes us further down the runway before touchdown.
    c. We obviously cannot land on a point we are flying over in ground effect.
2. Failure to dissipate zoom reserve in the form of airspeed, excess kinetic energy of pressure-airspeed, before the desired touchdown point.
    a. Any excess kinetic energy of pressure-airspeed (any airspeed above Vso) at the point of desired touchdown, takes us further down the runway before touchdown.
    b. We obviously cannot land on a point we are flying over in ground effect.
3. Looking at the airspeed indicator.
    a. The airspeed indicator gives no indication of the apparent rate of closure.
    b. Looking at the airspeed indicator prevents seeing anything outside the aircraft at a very critical time.
    c. Instrument flying causes us to more likely ignore:
        i. relative wind noise that indicates trim and speed.
        ii. engine noise that indicates rpm.
        iii. outside visual cues:
        iv. height
        v. distance
        vi. obstructions
        vii. other aircraft
        viii. stick position (by feel not look) that indicates probable speed and buoyancy.
        ix. the feeling of decreased buoyancy as we continually lose pressure-airspeed.
4. Failure to anticipate the rapid increase of the apparent rate of closure on short final.
    a. This is the most common problem for those who have flown many iterations of the standardized 1.3 Vso approach (the instrument approach.)
    b. Failure to control the rapid increase of the apparent rate of closure on short final with elevator.
5. Attempting to control rate of closure with power.
    a. Adding power gives us excess engine thrust for climb thus we descend more slowly.
    b. Reducing power gives us less engine thrust for climb or causes us to descend more quickly.

6. Attempting to maintain the glide angle with elevator.
    a. Pulling back will decrease the rate of closure
    b. When behind the power curve, pulling back will cause descent in a mush and finally a stall.
7. Failure to control gusts and wind shears with dynamic reactive, and if necessary aggressive, throttle movement.
    a. The same pilots who fuss about engine abuse make long descents with the throttle closed for shock cooling.
    b. Going long (overrun) with metal props is much harder on engines.
8. Failure to use full flaps, when available, on all approaches.
9. Failure to move the stick forward smartly to wheel land.
10. Failure to wiggle the stick fore and aft dynamically and proactively to keep the tail wheel airplane level until deceleration.
11. Failure to get the wheel full back for air braking in nose wheel airplanes.
12. Failure to get the stick full back, when the tail first starts down, in tail wheel airplanes.
13. Overuse of the three-point landing.
    a. This has lead to many ground loops.
    b. Poor visibility from the back seat of tandems.
    c. Inadequate longitudinal axis control in crosswinds.
14. Overuse of brakes, especially in tail wheel airplanes.
15. Most nose-over accidents are the result of excessive or panic braking.

The apparent rate of closure approach, is the most unpopular, most complained about, most negatively critiqued, most declared heresy, of any technique I teach. However, zero timers love it because it allows them to solo tail wheel airplanes in six hours. Crop dusters love it because it allows them to use unimproved satellite fields and landing zones.

For those of you with lots of standardized approaches at 1.3 Vso, it is a hard, hard concept and many iterations of it are necessary to extinguish the stimulus to approach fast, round out, flair, hold off, and float a long way down the runway for that perfect kiss down.

Finally, when an emergency comes up, we are going to play the game we have practiced the most. We are not going to rise to the challenge and demonstrate and entirely different approach. If we have practiced landing long, we will touch down in the middle, not the beginning, of the chosen forced landing zone.

My good friend, Bob Reser, advocates lots of power off, spot landing practice. I think this is a very good prescription for the forced landing event in our future. The thing comes down quite a lot faster with the prop windmilling, by the way.

Chapter Five

The Low Level Forced Landing

After ten engine failures, only one of which started above 200' AGL, it had become obvious that normal forced landing techniques were inadequate and even dangerous for the low level forced landing. In the best practices and techniques database of iaftp.org, International Association of Flight Training Professionals, I outlined my technique for the six second forced landing. I pointed out that one had to be in the failure mode, spring loaded to the failure. In a critical response, the author of an analytical technique, "How to Handle and Critical, Emergency, or Abnormal Event," said, "Your training practice stresses your students to be proactive (prepared to react quickly to an abnormal event rather than totally reactive to the situation (making it up as you go along.) Since you know what you are going to do before you fly, the analysis is already done." This more positive analysis of the low level forced landing is better than I could have done myself.

In order to make the low level forced landing as safe and as survivable as possible, we must:

1. be spring loaded to the failure mode.
    a. We must have accepted the fact that the engine will fail before pushing the throttle in.
    b. The normal two or three seconds to accept the failure is unacceptable in the six second forced landing.
2. immediately zoom up to trade zoom reserve in the form of airspeed for zoom reserve in the form of altitude.
3. pick a survivable landing zone within the close hemisphere to our front.
4. use the energy management turn to align with the long axis of the landing zone.
5. bank sufficient to get the turn completed quickly so that we can level the wing going over any obstructions.
6. use full flaps and full forward or full side slip, as necessary, to get rid of zoom reserve both in the form of altitude and in the form of airspeed prior to touchdown in the very beginning of the landing zone.
7. alert passengers to prepare for off field landing.

Six seconds is not enough time for cockpit resource management, checklist, switches or gauges, or radio call or anything inside the cockpit. Outside observation is mandatory seeing where we are going and how we are going to get there.

Airspeed is altitude and we don't want to land fast. . We want to see what is available within gliding distance. The trade of the kinetic energy of pressure-airspeed, which can destroy the airplane and hurt us, for altitude would be aerodynamically wise here

At 200' or below, we cannot go back. We have available only the close hemisphere to our front. The good news is that the right landing zone will be obvious with few or no distractions.

The energy management turn will allow us a much higher rate of turn than a flat turn and the energy management turn will cause no load factor. It will get us up a bit to see better and slow us down initially. Spring loaded to the "On" means, "That one!"

We will invariably be high and fast to the landing zone. Altitude is airspeed. Flaps, especially the fourth notch with Fowler flaps on the Cessna, will slow us rapidly and get us down into the first part of the landing zone without floating. Full cross-controlled slips will slow us rapidly and get us down into the first part of the landing zone without floating. The dynamic, nose up nose down, wobble of the Cessna with full flaps and full slip does not go beyond the slight pitch up and pitch down.

Many iterations, hopefully every landing, of the apparent rate of closure approach will well prepare us for the slow pressure-airspeed (don't look, we don't have time and we need to see outside) needed on this approach.

Using the low ground effect takeoff, we will have zoom reserve in the form of airspeed within fifteen hundred feet in normal, low power to weight aircraft. If the engine fails prior to achieving maneuverability, zoom reserve in the form of pressure-airspeed, we simply land on the remaining runway. Mentally, we need to mark the commitment point, where insufficient runway remains. At this point, we need to be in low ground effect with zoom reserve in the form of airspeed.

When the engine quits, we smoothly zoom up, trading reserved kinetic energy of pressure-airspeed for altitude, and immediately pick a survivable landing zone within the near hemisphere. At low altitude, only those attainable will be visible. Usually the right landing zone is obvious, because of lack of choices.

We are generally (nine iterations) high and fast. We immediately add full flaps and enter a full slip, usually in a steep turn. Full Cessna Fowler flaps, in a full slip, will cause the pitch attitude to oscillate uncontrollably a bit. This does not change the steep descent, nor does it cause a mush or stall.

We have no power control but we maintain the apparent brisk walk rate of closure to touchdown with elevator. We are on short final; we started out there. If we encounter a downdraft, we can make up the altitude loss in ground effect to touchdown on the desired spot. If we encounter a downdraft or downwind shear while making a steep approach over obstructions, we will make a good Navy touchdown on the desired spot. Much grief is avoided by being slow and touching down on the desired touchdown spot.

Following are common errors associated with the low level forced landing:

1. Not being spring loaded to the engine failure.
    a. This is the low altitude failure, a six- second deal.
    b. Reaction to the failure with cockpit resource management tools must have taken place before the power application for takeoff.
2. Leaving ground effect prior to attaining at least Vy.
    a. We need stay in ground effect until zoom reserve in the form of pressure-airspeed is developed on every takeoff.
    b. If we attempt to climb out at or below Vy, we give up ground effect energy that cannot be regained.
    c. Leaving ground effect early is giving up free energy that could be used in a takeoff engine failure.
    d. How can the FAA ask a guy who has flown junk all his life, who has had nine low altitude engine failures, who has always been spring loaded to the failure, and who is alive because he has always been spring loaded to the failure and doesn’t believe an airplane will necessarily climb; how can they ask this old guy to fly or teach the pitch up early to a desperate Vx, out of ground effect, short field takeoff technique?
3. Approaching the desired touchdown spot with zoom reserve in the form of airspeed and/or zoom reserve in the form of altitude.
    a. Many iterations of fast landing will cause us to land in the middle of the desired forced landing zone.
    b. After using the extra ground effect energy to zoom up, we need to get rid of all zoom reserve in the form of airspeed and all zoom reserve in the form of altitude prior to the desired touchdown point.

4. Not using the energy management turn to get to the desired touchdown point.
    a. Avoidance of steep turns while letting the nose fall through, gives us no good option on many forced landings.
5. Failing to allow the nose to fall through naturally in a steep turn results in mush and finally stall.

I have survived ten low level forced landings using this technique. I extensively damaged one Pawnee, one Callair, and no pipeline patrol airplanes. Many of my crop dusting students and two of my readers have survived low-level engine failures using this technique.

Chapter 6

Managing Wind Energy in Low Level Work, Including Landing

To make safe and efficient use of natural wind energy when turning to a target, we must:

1. always fly crosswind, where possible, from the downwind border to the upwind border of the site for ground reconnaissance work including:
    a. crop spraying,
    b. target acquisition and engagement,
    c. animal count,
    d. or landing.
2. always, when possible, fall off downwind of any target we wish to return to upwind and crosswind.
    a. We need always know the wind direction.
    b. We always fall off the target downwind.
3. always, when possible, make base to final to an upwind target.
4. always, when possible, use energy management turns rather than level, high load factor, turns.
    a. make sure we are using proper rudder movement to completely control adverse yaw in steep turns.
    b. We need steep turns of high rates (16 to 30 seconds) to get through the half circle (180 degree) turn and back onto target, while keeping the target in sight.
    c. Over controlling the rudder (skidding) is preferable to under controlling the rudder (slipping.) This is because slipping slows the turn and the important recovery from the turn. Rolling out of a turn, we need bring the wing back up smartly with aggressive rudder movement. It might be helpful to tell our students to rudder out of turns.
5. use greater rudder movement to get the wing level after the steep turn.
    a. We are slower when finishing the turn than when entering it. Thus we need more rudder movement to overcome greater adverse yaw with a weaker kinetic energy of pressure-airspeed on the rudder.
6. level the wing prior to any pull up.
    a. We don't want to increase the bank by pulling back prior to leveling the wing. We don't want to create the graveyard spiral condition.

While crop spraying absolutely requires wind management, wind management can make all ground reference work safer and easier. Wind management is necessary when maneuvering at low altitude for any reason.

When spraying, we work the field crosswind and from the downwind border to the upwind border of the field. At the end of the spray run, we pull up and turn downwind. Spray off. The pitch up at the end of the spray run also decreases airspeed, which increases the rate of turn. The speed of the crosswind determines the angle and length of time we must fly downwind before reversing course to align with the next swath row fifty feet upwind. However, at the end of a run, we always fall off or turn away from the field at some angle downwind. Thus the more important, for accuracy and safety, return to target is made into a headwind. When working race track rather than back and forth return to target, we just make continuous energy management turns in the same direction. Back and forth would be alternating direction of turns but always into the wind. Race track must end and back and forth begin when the wind gets much greater than ten knots. We older guys, before Satlock, always went back and forth because of the flagman.

This turn into a headwind at the base to final portion of the return to target reduces the groundspeed and drifts the aircraft downwind in the final portion of the turn. Thus, we are at a slower groundspeed when having to maneuver around and over obstructions going into the field. We are also drifting toward the target (crop row,) as the turn comes around to final. This allows an earlier rollout than in a no wind or downwind condition. Finally, we roll out into a crab heading into the crosswind. Spray on. This means we don't have to continue the turn as far.

The opposite, falling off the target upwind, would put us at a much higher groundspeed in the return to target. Also, the crosswind would drift us past the desired target (crop row.) This would make getting around and onto target much harder, even impossible, and would cause relatively fast approaching obstructions to be more difficult to negotiate.

We need turn at a faster rate in low altitude work; getting the greater part of the turnaround done early while slowed. The slower we go the faster we turn. Later, toward the final portion of the turn, pointing the nose well down at the target increases kinetic energy of pressure-airspeed as potential energy of gravity thrust from altitude becomes realized gravity thrust.

At an uncontrolled airport, where a crosswind is present, we make our first turn downwind after takeoff. This downwind crosswind leg allows flying the downwind leg of the pattern crabbed toward the airport. This reduces the downwind to final turn radius to less than one hundred eighty degrees. For those who crab initially on final, this also reduces the radius of the base to final turn to less than ninety degrees.

This falling off the target downwind also causes the base to final to be into a headwind and then a reduced radius (from drift) turn into the crosswind on final.

The headwind slows the groundspeed allowing easier maneuvering around or over obstructions going into the airport or spray strip. The headwind/crosswind alters the curve of our base to final turn so that as we turn from base in a headwind to final in a crosswind we drift toward the runway centerline extended. This free decreasing radius of turn does not affect the g loading of the airplane in any way.

When crosswind and in low ground effect in the field crop spraying, we add full power short of the border and pull up trading airspeed for altitude. We clear the wing to make sure we don't put it down into a wire or tree. Turning the spray off, we turn downwind at a slight angle in a strong wind and at a greater angle in a light wind or no wind. We level the wing and again pull up if zoom reserve in the form of airspeed is yet available. This depends on the gross weight, which decreases 20 to 50 pounds with each swath run. We start an energy management turn into the wind.

The angle of bank will be dependent on the amount of standoff gained from the initial downwind turn. But we need be slow and at a significant bank angle to get back into the next swath run fifty feet upwind from the last swath run.

We do not hold the stick back trying to maintain altitude (50 to 200 feet) but allow the nose to fall through (pitch down) naturally. We only hold some backpressure in a very steep (greater than sixty degrees) turn when the airplane pitches down beyond thirty degrees and tries to regain trimmed cruise speed sooner than necessary. We don't want to go down that fast. We level the wing with a lot of rudder movement against the adverse yaw of the down wing prior to going back into the field turning the spray on.

At this point, going extremely fast (ground speed) in a downwind condition simply would not work. We would be drifted beyond the target crop row and we would be going too fast (ground speed) to safely negotiate the obstructions and wires going into the field. We would have a wing down late in the turn trying to make the target. Catching the down wing on a wire becomes a great danger. GPS guidance and alignment computers on modern spray planes have made the racetrack pattern the norm. It greatly concerns us older spray pilots and spray instructors when these young kids stay with the racetrack pattern in a strong crosswind. This causes every other turn to be a dangerous downwind turn. The fast turboprops go wide to have more room for this. However, they lose sight of the field for a greater length of time. Losing situational awareness, when very close to the ground, is less safe. That, and the price of the airplane, is why they also do not always get into low ground effect in the field. They have enough engine thrust for this higher, out of ground effect, work. However, having more engine thrust means that they will usually be hauling a much greater load. Older pilots in turboprop airplanes generally use the wingover to slow enough for back and forth work, thus still keep situational awareness and stay in ground effect in the field.

When doing other low level work like pipeline patrol, bush, animal count/control, crosswind landings, or even buzzing, energy management turns and wind management contribute greatly to safety of the operation.

When re-entering the pipeline right of way after fueling, a strong downwind will push us across the line too quickly to find the right of way or marker poles. We cross and fall off the target downwind, make a 270-degree energy management turn, and pick up the right of way in the upwind base to final part of the turn. Two hundred feet and cruise airspeed are needed to start a 270-degree energy management turn.

When landing in a crosswind on a remote landing zone, we stay close to keep the field in sight and turn base to final into the wind.

When counting or shooting animals, we make any base to final into the wind and always fall off the target downwind so as to come back around onto target with base to final into the wind.

When making crosswind takeoffs and landings at an uncontrolled airport, we always fall off the target (fly crosswind) downwind to make base to final into the wind.

When at a tower controlled airport, we can ask to make traffic in the proper direction to best manage wind in the base to final turn.

If you ever buzzed home, school, or whatever, you got into some scary situations unless you used the energy management turn and made base to final turns/returns to target into the wind.

Following are some common errors in wind management:

1. Attempting to make flat, high load factor turns to maintain altitude.
    a. Airspeed is altitude and altitude is airspeed when zoom reserve is dynamically managed.
    b. Energy management turns are the only safe low altitude turns.
2. Attempting downwind turns near obstructions or terrain.
    a. The extra groundspeed makes maneuvering around or over obstacles and terrain difficult and dangerous.
3. Not staying ahead of the airplane or forgetting to pitch up trading airspeed for altitude and reducing airspeed and groundspeed to enter the energy management turn.
    a. This results in no altitude gain.
    b. This results in a level, high load factor, turn.
    c. Lots of gs may be fun in aerobatics, but they are deadly in low altitude work.
4. Not banking aggressively in the early stages of the turn, necessitating aggressive banking in the later stages of the turn, when we are closer to obstacles and terrain.
    a. This causes a wing to be down late in the turn when near obstructions.
5. Attempting to bring the down wing up with insufficient rudder movement.
    a. In the old days, they talked about the aileron going out. What actually happens is that adverse yaw increases as we get slower, dragging the wing back with as much force as the extra camber of the aileron is trying to lift the wing.
6. Attempting to pull up out of a turning dive prior to getting the wings level with mostly rudder movement.
    a. This deepens the bank angle and creates the graveyard spiral condition.
7. Watching the airspeed indicator.
    a. This causes loss of situational awareness.
8. Not using kinetic and sound information.
9. Making left traffic in a left crosswind and right traffic in a right crosswind when not required by tower.

   a. With no one in the pattern at an uncontrolled airport, we have pilot in command authority to make traffic in the safest direction based on the direction of the crosswind.

Following is a measure of the effectiveness of wind management in low-level work:

1. Crop dusters are well aware of the negative effect of increased groundspeed and increased radius during downwind turns to near targets.
2. For all who fly low daily, and especially for those who only fly low occasionally, the downwind turn is an unacceptable risk.
3. The prevailing afternoon strong crosswinds at single runway airports in the west do not intimidate students indoctrinated in wind management
4. Flight review pilots appreciate the greater ease of making base to final turns into the wind rather than downwind.

Chapter 8 covers extreme crosswind techniques.

Chapter 7

The Low Level, Low Technology Cross Country

We live in a world where automation, and even artificial intelligence, is not only accepted it is expected. Incident and accident data is beginning to show that this is a dangerous mind set. While few today face a common crop duster situation where a cross country flight to a distant job must be accomplished with no airspeed indicator, altimeter, compass, VOR, ADF, or GPS, peace of mind can be derived from knowing that this is possible and easy.

In order to perform a totally contact, no instrument, cross country we must:

1. fly a true course using a map and observation of natural and manmade features (pilotage.)
2. favor natural over manmade features.
3. draw a true course with pencil on a sectional or a less than 1:500,000 topographical map.
4. pick and mark checkpoints that will be visible from the departure field or the prior checkpoint.
5. identify checkpoints and other features on the ground prior to finding them on the map. Read from the ground up.
6. in a crosswind, offset the longitudinal axis (sight between our legs) into the crosswind such that our butts are moving in a directed course to the target (checkpoint.)
7. observe and memorize the offset angle that the longitudinal axis passes over N-S and E-W section lines (straight roads, fence lines, tree lines, etc.)
8. maintain the observed and memorized angle and change only when that angle no longer puts our butts over each checkpoint (change in crosswind.)
9. be aware that Spanish Land Grants were surveyed on a NW-SE and NE-SW grid.
    a. They will mess with our minds.
10. enjoy active contact flying.

Following are some aerodynamic considerations concerning the low technology cross country:

1. Directed course point to point to point flight will describe an accurate great circle course over continental distances.
2. A straight line is the shortest distance to a destination:
    a. on the horizon.
    b. on sectional and topographical maps.
3. Observed point to observed point to observed point is as accurate as a GPS, more accurate than a VOR, and much more accurate than a compass.
4. Angles across section lines will be very slightly inaccurate as there are survey line adjustments across the entire US to correct for earth curvature.
5. Spanish Land Grant areas were surveyed on NE to SW and NW to SE base lines.
    a. While limited in area, they require mental adjustment when encountered.
6. We must crab into a crosswind just as when following mechanical or electronic devices,
    a. however the visual directed course to cross the next section line at the same true angle is much more accurate than wind vector angle math using questionable variables like winds aloft forecast, compass error, installation error, etc.
7. We gain groundspeed using lower altitudes into headwinds and we lose groundspeed with tailwinds when compared to higher altitude flying. Winds aloft are generally greater than surface winds.
8. Flying at low altitude, low tech into the wind and at high altitude, high tech on the return with a tailwind works well, if the mission is not dependent on close visual reconnaissance.
9. We gain true airspeed at altitude while losing excess engine thrust for climb.
10. Surface winds tend to be less than winds aloft and wind speeds tend to increase most rapidly in the first 1,000’ as surface friction is lost.
11. In marginal ceiling and visibility conditions, low level (500’ or below) flight will usually result in significantly better visibility.

We start with the true course to our destination drawn on a good topographical map. 1:25,000 topographical, including military maps are best for short distances but awkward for long distances. 1:500,000 sectionals are good. 1:1,000,000 WAC charts are lousy.

We plot many checkpoints, favoring those close to the true course line. The first three checkpoints are the most important for establishing a directed course to our destination. Here we establish and memorize the exact angle of the true course across N-S and E-W sections lines on the map. We pick a tall first checkpoint, if possible, within sight from the departure field. We need have more than enough fuel for the trip or plan appropriate fuel stops on long trips. Dead reckoning between near checkpoints, however, would lead to too much in the cockpit work and not enough outside observation.

On takeoff, we turn as necessary to go over the first section line at the proper angle while flying to the first checkpoint. At all times the map should be oriented north and the true course, marked on the map, should line up with a directed course to the next checkpoint. What we see left of our directed course on the earth should appear left of the true course line drawn on the map. What we see right of our directed course on the earth should appear right of the true course line on the map. We read from earth to map, not vies-versa.

We first identify a feature on the ground near the course, and then find that same feature on the map. If we read from map to earth, too much human projection takes place. We try to find two corroborating features for each checkpoint to mitigate commonality of features. Once we have successfully crossed the first three checkpoints we should have memorized the angle across both N-S and E-W section lines. The angle of the directed course of our butts will not change, even when the crab angle changes with wind speed and or wind direction changes.

If desired, take short deviations to pass near water towers for town name confirmation and peace of mind. When off course for any other reason, including being lost, we return to the last know or any visible checkpoint. This is another reason for having many checkpoints.

From a low level altitude, distant, higher features can be seen many miles. A two hundred mile directed course to a distant feature, in the clear air of high deserts and mountains, is common. Buildings, grain elevators, and towers can be used in the low country. If near our true course, a directed course may be flown to them.

Following are some common errors associated with the low level low technology cross country:

1. Not drawing a true course line on the map.
2. Not orienting the map to true north.

3. Not keeping the course line, drawn on the map, oriented with the directed course on the ground so that everything left of the airplane is left of the drawn line.
4. Using a WAC or any map of greater than 1:500,000 scale.
5. Heavy reliance on manmade features.
6. Not picking a first checkpoint within sight of the airport.
7. Reading from map to ground.
    a. Features are very easy to find this way, and very unreliable.
8. Using the prop/nose rather than between our legs for longitudinal alignment.
9. Using longitudinal alignment with the checkpoint or for directed course across section lines in a crosswind.
    a. We need to offset the longitudinal alignment sufficient to cause our butts to fly a directed course toward the checkpoint or to scribe the true course angle across section lines.
10. Flying too high into a headwind or too low with a tailwind.
11. Allowing dead reckoning computations and re-computations to reduce time for visual observation of features.
    a. This can contribute to getting us totally lost.
    b. This can get us dangerously close to towers before we notice them.
12. Continuing lost without soon confirmation of position or return to last know checkpoint.
13. Not looking for other features to confirm a checkpoint.
14. Not stopping for fuel and breaks every couple of hours.
    a. Low level, low tech cross-country, like flying pipeline, is fun but tiring.

Using the low level, low technology map reading technique, I was able to keep my low bird's (OH6-A Light Observation Helicopter) location fixed for medevac if necessary, provide helicopter gunship support to ground troops, and call accurate artillery. Students find this technique gives them confidence.

Chapter 8

Extreme Crosswind Landing Techniques

Twenty-five years of high desert and mountain flying have convinced me that a new technique is needed for more safely dealing with prevailing high winds in this type terrain. Too often, I have personally witnessed, and accident data support my conclusions, numerous unsuccessful attempts to land crosswind at single-runway airports. Distance and wind can lead to fuel starvation while enroute when diverting to the nearest airport with a runway more aligned with strong afternoon winds.

I started instructing at Flagstaff, Arizona in 1974 and soon began to teach wind management to avoid downwind base to final turns and to alter the centerline on wide single runway airports.

In order to survive extreme crosswind landings we need to:

1. always fall off the target (numbers) downwind to approach the target into a headwind on base and into a crosswind on final.
2. make all base to final turns into the headwind and finally the crosswind.
3. visualize a centerline from the extreme downwind corner of the runway to the upwind big airplane touchdown zone marking (upwind white square.)
4. make the base to final turn to line up with this altered centerline.
5. maintain the altered centerline with, now sufficient, dynamic proactive rudder and manage drift with aileron to bank into the now less extreme crosswind. This is not a coordinated maneuver.
6. use full flaps on short final.
    a. We have only one thousand feet available on the angled runway.
    b. Gusts can be handled with dynamic reactive throttle movement, possibly stop to stop followed by adjustment.
7. use the elevator to control the apparent brisk walk rate of closure with the downwind corner of the runway.
8. use static reactive throttle to control the glide angle in strong, stable crosswinds.
9. touch down on the downwind corner of the runway at a very slow ground speed.
    a. Strong crosswinds give us strong headwinds on final, using this technique.

10. on touchdown ,push the stick forward smartly, in tail wheel airplanes, (wheel landing.)
11. on touchdown, pull the wheel full back in nose wheel airplanes, (air braking.)
12. pull the stick full back, in tail wheel airplanes, when deceleration causes the tail to start down.
13. roll out, in the one thousand feet, to the upwind big airplane touchdown zone marking.
    a. Faster, heavier airplanes can make a fast taxi turn at the big airplane touchdown zone marking to continue rolling down the upwind side of the runway

Upwind hills or mountains, in crosswind conditions, generally create venturi between the hills. When present, a venturi causes the crosswind to be stronger. Common afternoon crosswinds of fifty degrees at thirty knots can easily become fifty degrees at forty knots in those places along the runway.

When downwind of any landing zone or runway, we will be crabbing into the wind to maintain a parallel course. This will cause the base turn to be less than ninety degrees. The base to final turn will also be of less than ninety degrees for those who crab initially on final. Drift will make up for the shallower bank necessary to make the turn to target. This is a decreasing radius turn free of any extra bank, load factor, or extra g force. Groundspeed is less and the radius of the turn is less on turns into the wind.

Conversely, if we were making traffic in the other direction, we would have to bank much steeper to prevent the downwind drift from causing us to overshoot final. Groundspeed is greater and the radius of the turn is greater on turns away from the wind direction (downwind turns.)

The apparent rate of closure approach results in a continuous reduction in groundspeed from short final to touchdown. With the apparent rate of closure approach, no wind approaches can be made in most four place or smaller airplanes with less than one thousand feet of runway used. With a strong crosswind, using the downwind corner to upwind big airplane touchdown zone mark, most small airplanes will stop within one thousand feet without the use of brakes. Full flaps give the best speed control and the best visibility. This is a visual (apparent rate) approach, not an instrument approach using the airspeed indicator or graphics or whatever is on the panel.

At most high desert and mountain airports, no manmade or natural obstructions prevent a safer ground effect approach. However, many high desert and mountain airports are on mesa tops preventing a ground effect approach. A high angle glide angle is necessary at these airports to prevent going under the declination line on short final.

If the airport is controlled, we can ask for the pattern direction that will cause us to make an upwind and crosswind base to final turn. If the airport is uncontrolled, we can give way to any in a dangerous pattern that will cause them to make a downwind base to final turn and then set up for a pattern that will give us an upwind base to final.

We always plan to fly the downwind leg of the pattern downwind of the runway or landing zone. This allows greater rates of turn, even using lesser bank, in the upwind base to final turn. This allows a decreasing radius turn free of any extra g loads or load factor. When making circuits in a crosswind, we always fall off the target (runway) downwind after takeoff so that we end up with a headwind and crosswind on base to final.

When approaching the downwind leg from a route, we enter either downwind of the runway or cross the runway to fly the downwind leg downwind of the runway. When the crosswind is significant, we immediately look for the new centerline as soon as we turn base into the wind.

We turn final early to fly a directed course to the downwind corner toward the upwind big airplane touchdown zone mark. We maintain an apparent brisk walk rate of closure with the immediate downwind corner of the runway or landing zone. We apply full flaps on short final. The gust spread will require aggressive, dynamic reactive throttle movement, possibly stop to stop.

We test for zoom on short final by pulling back on the stick a bit. If we go high on the glide angle, we are too fast. We hold the extra pitch up angle with elevator and adjust descent with power. If we mush, we are too slow. We add power to cushion the airplane onto the surface.

We control drift with bank into the crosswind. We control the new centerline with dynamic proactive rudder only. We use aileron independently to counter drift. This is a rub your tummy while patting your head kind of deal. We are now aiming between our legs to a directed course to the downwind corner that lines up with the upwind big airplane landing zone mark.

Just prior to touchdown on the downwind corner, we pull back a bit to protect the nose gear. In very strong crosswinds, the groundspeed may slow to zero. On touchdown on the downwind corner, we level the tail wheel airplane with dynamic proactive fore/aft movement of the stick. With either airplane, we touchdown with the upwind wing still banked sufficient to prevent drift. We should touch down on the upwind main wheel.

We brake only as necessary (usually not necessary) and turn down the runway, when at slow taxi speed, toward the nearest turnoff.

Following are some common errors associated with the extreme crosswind landing technique:

1. Allowing intimidation by government officials or fellow pilots to influence poor wind management decisions like downwind base to final turns and running out of rudder in strong crosswinds.
2. During circuits, not remembering to turn to fly the crosswind leg downwind.
    a. We always fall off the target downwind.
    b. This allows the return to target to be made upwind.
3. Failure to make most, or all, normal landings using the apparent brisk walk rate of closure with full flaps.
    a. Only this will prepare us for the day we have to make a severe crosswind landing from the downwind corner to the upwind big airplane touchdown zone mark.
4. Attempting to round out and flair.
    a. We are too slow for this.
    b. In strong winds, we will be at very slow groundspeeds and high airspeeds.
    c. If we round out or flair, other than to protect the nose gear, we will stay up until the next negative gust and/or deceleration brings us down hard.
5. Failure to use full flaps
    a. If we are willing to use the throttle aggressively to manage gust spreads, flaps give us incredible control here (as elsewhere.)
6. Attempting to use the centerline in strong crosswinds and running out of rudder or bending the airplane in the crab and slip (kick over.)
    a. With the sideslip, into the wind , the upwind side of the cowl is lower giving better visibility.

Students and review pilots out west appreciate not having to make the hard judgment to go perhaps 150 miles in a very strong headwind to the nearest airport with facilities and a runway aligned with the wind.

Conversely, I flew pipeline with a former airline pilot who absolutely refused to learn either the apparent rate of closure approach or this angle across the runway technique. He was killed in a Cessna 172 after multiple attempts to land in a strong crosswind at an airport on the front range of the Rocky Mountains.

Chapter 9

Low Power, On Course Thermalling

Thermalling inflight is a technique of utilizing vertical air movement for additional lift. In order to cash in on the tremendous lift available in thermals, we must:

1. refrain from any attempt to maintain altitude by adding power and/or pitching up in downdrafts.
2. fly slow in updrafts.
    a. Attempting to maintain altitude by reducing power or pitching down throws this free energy away.
3. fly fast in downdrafts.
    a. Attempting to maintain altitude by adding power and or pitching up, when very little or no excess engine thrust for climb is available doesn't work.
    b. Attempting to maintain altitude by pulling back on the elevator causes us to stay in the downdraft longer and lose more altitude than if we had done nothing.

Following are some aerodynamic considerations concerning low power, on course thermalling:

1. Summer diurnal rate, as much as forty degrees in deserts and sparsely vegetated mountains, creates natural wind and thermal energy vastly greater than small aircraft excess engine thrust for climb.
2. When taking off at a density altitude at or near ceiling for the aircraft, excess engine thrust for climb will be marginal or non-existent.
    a. In this condition, getting the aircraft off the surface quickly and into low ground effect will be necessary for safe takeoff.
3. Downdrafts do not go to the surface but rather the descending shaft of air compresses above the surface and spreads out.
    a. The stronger the downdraft is descending in feet per minute, the higher above the surface it will compress and quit descending.
4. The first indication of a strong updraft or downdraft will be a significant bump.
5. A rise in rpm indicates an updraft.
6. Conversely, a drop in rpm indicates a downdraft.
7. Finally, a few seconds later, the VSI will indicate the rate of ascent or descent.

8. The indication of the end of the down or up draft often is by another bump and also always by a rapid fluttering of the VSI, while it is still indicating fully up or down.

By simply flying slow in updrafts and fast in downdrafts, rather than trying to maintain altitude, we can gain altitude and ground speed free of any engine power increase. While maintaining course in significant thermals (up to 3,000 fpm up and down drafts), we wait for the sharp bump that either indicates an up or down draft is present.

If the RPM increases, indicating an updraft, we pull up to Vy. After a few seconds of visible climb, the VSI will show the rate of climb. The VSI will probably be pegged up. We want to fly as slow as practicable to stay in the free (no engine needed) lift as long as possible. When the VSI, still pegged up, begins to wiggle significantly, we level the aircraft. The VSI lags, so we have to level when it wiggles indicating an end to the updraft.

In strong thermals, the end of the ride up is signaled by another bump. If the RPM decreases following the bump (indicating a downdraft), we push over to maneuver speed. After a few seconds of visible descent, the VSI will show the rate of descent. The VSI will probably be pegged down. We want to fly through the down shaft of air as fast as practicable. When the VSI, still pegged down, begins to wiggle significantly, we level the aircraft. The VSI lags, so we have to level when it wiggles indicating an end to the downdraft.

We don't worry about flying into the desert floor because the more violent the downdraft, the higher it will compress against the desert floor and the higher we will feel a significant bump (maybe at 200′ AGL) that indicates the end of the downdraft.
headed east, this can be very helpful. When headed west, we may not want to be that high in strong headwinds.

Following are some common errors associated with low powered thermallin:

1. Not considering that natural energy is at least ten times greater than excess engine thrust for climb in the high desert and mountains.
2. Attempting to maintain altitude with engine and elevator control.
3. In an updraft, pushing forward on the stick or reducing power or both and thus lowering the angle of attack and increasing pressure-airspeed.
    a. This will cause us to fly through the updraft quickly.
    b. A lost opportunity to gain altitude.

4. In a downdraft, pulling back on the stick or adding power (we are probably at full throttle just to maintain seventy percent or less of rated engine power) or both.
    a. This will cause us to fly through the downdraft slowly.
    b. We will lose more altitude than if we had pushed over and flown through the downdraft quickly or had done nothing.
5. Attempting to level gust upsets with aileron rather than rudder.
    a. Opposite rudder only will bring the down wing up quickly without as much pressure-airspeed loss and adverse yaw.
6. Failure to level the aircraft when the VSI wiggles (bump is usually felt.)
    a. Generally, a downdraft follows an updraft and an updraft follows a downdraft.
    b. Failure to level the aircraft after the first ends will generally cause the wrong pitch attitude going into the next, opposite direction, shaft of air.

This method is very effective in allowing 65 hp airplanes to climb at 3,000 fpm on windy afternoons in the high desert and mountains. The main effectiveness of this technique is that it gets the pilot out of the energy harmful habit of trying to maintain altitude.

Trying to maintain altitude will cause the low powered airplane to fly at very slow ground speeds and have extreme difficulty maintaining altitude. This is because the pilot is flying fast in updrafts (pushing over to maintain altitude) and flying slow in downdrafts (pulling up to maintain altitude.)

My students find that it is possible to fly a more nearly straight line to their destination in the mountains using this technique rather than having to just fly the valleys.

Chapter 10

The High Density Altitude Takeoff

Any time we fly, especially in high desert or mountainous terrain, we need consider:

1. which way is downhill and how can we get there in ground effect if necessary.
2. the sources of natural energy in the mountains:
    a. ground effect
    b. gravity
    c. thermal lift
    d. orographic lift (ridge lift) (hydraulic lift)
    e. mountain wave (sympathetic hydraulic lift)
3. that manmade obstructions and trees are less prevalent in the desert and mountain west.
4. the lack of excess engine thrust for climb.
    a. We can gain significant engine rpm by leaning but never maximum rpm.
5. that getting the tail wheel airplane level or nose gear of a trike off the surface as soon as possible is imperative for acceleration.
6. that we must go much farther down the runway before we can get into low ground effect.
7. that leaving ground effect too early in the takeoff will eliminate this source of free kinetic energy of pressure-airspeed.
    a. With little or no excess engine thrust for climb, climb may not be possible until the pitch attitude is reduced.

When behind the power curve on takeoff, the only way to climb is to push forward on the stick. If we find ourselves at the end of the runway in ground effect and unable to climb, we want to continue out over the desert or mountain valley in ground effect. We do not want to pull back, mush down, and finally impact the ground in a mush or stall.

High density altitude, the combination of decreased air pressure and increased air temperature (humidity is seldom a problem in the high desert or mountains,) greatly decreases the pressure and volume of air entering our carburetor.
Thus, we have to reduce the amount of fuel entering the carburetor by leaning (not possible with the Stromsburg carburetor on small Continental

engines.) This is necessary to get the proper fuel/air mixture and thus the maximum rpm possible.

Maximum sea level thrust is not possible at this high density altitude.

Less excess thrust for climb means that climb may or may not be possible without ground effect, thermal lift, orographic ridge lift, or wave lift.

A Continental 145hp Cessna 172 can climb at greater than 600 feet per minute at sea level standard temperature. Its absolute ceiling is 13,000'. The density altitude at Alamosa, Colorado, when the temperature is over 80 F, is over 10,000'.

Leach's spray strip, up valley to the north, is uphill. Ground effect, except over wires, is possible.

Taos, down valley to the south, is downhill. Ground effect, except over wires, is possible.

At 2,500' AGL we will be out of ground effect so we cannot engine climb.

An 80 F afternoon, following a 40 F dawn can produce significant winds, which can create 3,000 fpm ridge lift. This amount of heat change can produce thermals commonly of 3,000 fpm up and down drafts.

We will need to be above 10,230' to cross La Manga pass on a southwest route, unless we go all the way down to Albuquerque and then west. We will need to be above 9,413' to cross La Veta Pass to the northeast.

The full power pitch attitude at these altitudes is similar to the Vy pitch attitude at sea level. The pressure-airspeed is near Vy when maintaining altitude in stable air. There is insufficient excess engine thrust for Vx pitch attitude climb in low powered airplanes.

On the positive side there is always more natural energy than engine thrust.

Excess gravity thrust is available from any position of actual altitude above terrain. While power limited aircraft are always near the surface in mountainous terrain, every mountain drains into the desert. Every drainage system consists of a valley defined by a ridge on either side.

If we have the good sense to fly very near the downwind ridge, we will not only have orographic lift, but also will always have potential gravity thrust for a dive into the valley.

Ground effect produced kinetic energy of pressure-airspeed is important in low powered airplanes. It increases in percentage of total potential thrust for climb energy as engines become less powerful. This means the smaller our engine the greater is our need for ground effect on takeoff with heavy loads and/or high density altitude.

Ground effect kinetic energy of pressure-airspeed decreases the higher we get above ground until it goes away at the height of the wingspan. The aerodynamically wise solution, especially at high density altitude, is to stay extremely low (six inches to one foot) on takeoff.

The heat energy of the tremendous daily radiation warming (diurnal rate) creates tremendous wind, orographic ridge lift, and thermal lift. Sympathetic orographic lifting and lee side downdraft descending air, at the right frequency across multiple ranges, can create extremely powerful updrafts and downdrafts called mountain wave.

While low ground effect takeoffs increase acceleration and therefore safety in the low lands, at high density altitude airports ground effect may make the difference in getting off or not. The technique is the same as in low lands, but, at high density altitude, we lean the mixture to max rpm prior to takeoff. We should get 100 rpm increase in very cool air and 300 rpm increase in very hot air.

With small Continentals, we expect to stay in ground effect until nature provides some thermal or hydraulic lift. Not getting the airplane level or nose wheel off as soon as possible could cause the need to abort. Not getting the mains off and into low ground effect as soon as possible could cause the need to abort.

Staying in low (six inches to one foot) ground effect as long as runway and lack of obstructions allow it increases the margin of safety. Any time an attempt to climb results in a behind the power curve mush/descent, we must push the stick forward to climb. Any time encountering a downdraft, we must push over to fly through it quickly.

We look for orographic or thermal lift to gain altitude. We stay near terrain until finding ridge or thermal lift.

Following are some common errors associated with the high density altitude takeoff:

1. Not considering that natural energy can be ten times greater than excess engine thrust for climb in the high desert and mountains.
2. Failure to consider/use ground effect and/or descending terrain egress.
3. Failure to lean the mixture before takeoff.
4. Failure to get the tail wheel airplane level as soon as possible.
5. Failure to get the nose gear just off as soon as possible.
6. Failure to get the mains off as soon as possible and into low ground effect.
7. Failure to push over hard to stay in low (six inches to one foot) ground effect until at least Vy.
8. Failure to stay in low ground effect until obstructions require a climb or maximum airspeed is achieved.
9. Attempting to climb at a greater angle of attack than is possible.
    a. Sustained Vx is not possible with low powered airplanes.
    b. Vy is marginally possible.
10. Pulling back on the stick when:
    a. going behind the power curve and descending.
    b. encountering a downdraft and descending.
    c. encountering a downwind sheer and descending.

This technique makes summer afternoon high desert and mountain takeoffs relatively safe. Normal takeoff procedures make afternoon high desert and mountain takeoffs relatively unsafe.

Chapter 11

High Pass Crossing in Small Aircraft

To fly small airplanes on relatively straight line true courses to westerly destinations in the Rockies on summer afternoons, we need to make use of the natural energy available. We can limit ourselves to early morning crossings with lower density altitudes. I have flown 65hp Taylorcraft, 75 hp Ercoupe, 90 hp Aeronca Champ, various hp C-172, AA1-A, AA1-B, various hp PA-22, 150 hp Cherokee, 180 hp PA-24, and C-182 airplanes throughout the Rockies. With the 65-150 hp airplanes, I found morning crossings to be more marginal than afternoon crossings. However, we must be willing to turn back down valley before becoming completely boxed in. We must be willing to turn back rather than attempt crossing an upwind ridge in a downdraft.

Following are some things we need to consider before attempting afternoon high pass crossings:

1. We need to do a map reconnaissance for any possible ridge lift (downwind ridge of valley or drainage systems leading up to the pass.)
2. We need to maintain lateral separation from upwind ridges by staying as close as possible to downwind ridges.
3. We need to maintain maximum orographic lift by staying as close as possible to downwind ridges.
4. We need to counter any significant downdraft with a course reversal turn of sufficient bank to miss the opposite ridge while allowing the nose to fall through into a dive toward the valley floor (the energy management turn.)
5. We need to fly as quickly as possible, from the highest point of the downwind ridge, to the pass while anticipating downdraft from the higher terrain upwind of the pass.
6. We need to get to updraft air on the higher terrain downwind of the pass.
7. The more the prevailing westerly wind aligns with the pass, the harder it is to make the pass without encountering significant downdrafts.

Following are some weather considerations that contribute to significant natural energy in the mountains:

1. Warm fronts are rare, because fast moving cold fronts occlude and drive them out quickly.
2. Kirtland AFB has 0.8 weather days per year.
3. The air temperature mid-afternoon will be as much as 40 degrees warmer than before morning nautical twilight (dawn.)
    a. This tremendous heat energy will create afternoon winds of greater than twenty knots at the airport; much higher on up.
    b. There can be standing lenticular clouds and airmass thunderstorms in the afternoon.
    c. It can be rough but updrafts can be found around the airmass thunderstorms.
    d. Thermals can provide tremendously more lift than that provided by excess engine thrust for climb.
4. Mountain waves often form under the lenticular clouds.
    a. If no rotor clouds are present, these can be used for extreme lift.
    b. Just be prepared for as much as 10,000 fpm up and down drafts.
        i. The downdraft will compress and spread out before going into the desert floor.
        ii. The updraft can easily carry us uncontrollably into oxygen need altitude.
5. The strong winds create orographic, ridge lift commonly two to three thousand feet per minute.
    a. This is more than most small airplanes are capable able to provide.
    b. Because air density reduces the power of our engine to seventy percent or less, we may be operating at near ceiling for our aircraft (zero excess engine thrust for climb.)
6. Cooler morning temperature reduces density altitude enough that we have excess engine thrust for climb.
7. If we get say 80% of our 65-150 hp engine, we might expect to climb at two or three hundred feet per minute.
    a. That is at airport elevation, however, and not at high pass elevation.
    b. We often cannot get enough engine thrust to climb over the pass, even on cool, calm mornings.
    c. We may have to wait for the greater lifting force of thermal or orographic lift in the afternoon.

Whether attempting high pass crossings from west to east or from east to west, we ride the upwind side of the downwind ridge of the valley leading up to the pass. With prevailing westerly winds in the western United States, we can reasonably expect orographic (hydraulic) lift all the way up when crossing from west to east. On peaks above ridge valley systems, we may have to switchback or angle back and forth rather than go straight over. Using ridge lift to the pass is generally as high as we want to go without oxygen.

We need to consider and overcome a number of problems when crossing from east to west: The prevailing westerly winds cause severe downdrafts on the downwind side of N-S mountain chains in the Rockies and Sierra Nevada's. We overcome this by staying on the upslope of the downwind ridge of valleys that are crosswind. We plan for this in our map recon.

All major passes have drainage systems. We can use the upslope of the downwind ridge for orographic lift.

We have a problem with this when the valley is straight and directly aligned with the wind direction, giving us no superior upwind ridge. We also have a problem with crooked valleys, which require us to repeatedly cross from the ridge, now on the upwind side of the valley, to the ridge now on the downwind side of the valley.

Where our map recon shows no crosswind valley, we must mentally prepare to perform an energy management turn into the vast vertical space of the valley and consider an alternate route. Winds are hard to predict until we get up there so it might go fine, but failure of mentally preparing for a return trip to the last airport to get gas could lead us to attempt a very dangerous engine climb.

While generally N-S, mountain ranges are irregular, our chosen downwind ridge only gives us orographic lift up to the height of the pass. There we may encounter significant downdrafts off the higher mountain upwind of the pass prior to finding significant updrafts from the higher mountain downwind of the pass.

If we cannot make the dive to the pass before being driven below the pass, we must immediately perform an energy management turn to the vast vertical space of the valley and consider an alternate route.

When a map recon gives us a valley up to the pass that is oriented crosswind to the strong prevailing westerly wind, we cling to the upslope of the ridge (fifty feet or so laterally) on the downwind side of the valley or drainage. As we are lifted up the ridge, we should encounter continuously stronger crosswinds. As the ridge rises and the crosswind increases, we would expect to gain altitude above the river or drainage below. We should expect 500 to 2,000 feet per minute on the VSI, depending on crosswind speed. If we do not gain vertical space above the river, we will have to perform an energy management turn to return down river to the desert. Failure to turn around will increasingly box us into the rising and constricting valley going up to the pass.

The critical, judgmental, decision point comes when the valley has narrowed to the point that a sixty degree or greater angle of bank is necessary to miss the upwind, across the now narrow valley, ridge. If we are not level with the pass and still climbing, or above the height of the pass and close to it, we need to bank aggressively while allowing the nose to fall naturally to a significant pitched down dive into the valley. At high density altitude, there is no pitch up to climb and slow down in the energy management turn. We are already pitched up to Vy just to stay level.

If we are level with the pass and still climbing or if we are higher than the pass and able to dive into it, we continue. Of course, we hug the mountain downwind of the pass. However, the pass will be above the tree line, level, and smooth. Often a small stream is wandering there, as flat as the Mississippi Delta. Usually, flying the level pass in ground effect is safer than going farther up on the ridge lift of the irregular mountain downwind of the pass. In addition, we are no longer interested in finding strong lifting winds, but in avoiding the very strong venturi headwinds up here.

We want to stay high, after making the pass, when flying from west to east, to catch the strong tailwind. We want to get back down low, after making the pass, when flying from east to west because:

1. very strong prevailing westerly winds will reduce our groundspeed significantly.
2. at pass altitude, we may not be able to make the next fuel stop into sixty mph or greater headwinds.
3. a power descent to five hundred feet or less above the desert floor is advisable here.

My wife and I taught sixteen years at Tohatchi, New Mexico. We made many summer trips to her parents home near Denver. Those trips were in the Ercoupe and Champ until our two boys required a Tri-Pacer 150 and later a Cessna 175. Going northeast somewhat directly to Denver was fast and easy. Coming back into prevailing summer southwest winds was more difficult. It was doable, with an open mind. Once she drove her Mustang back while I took the Ercoupe. Her Mustang arrived in Tohatchi a full day ahead of my Ercoupe.

Use the Denver Sectional to map recon and follow this cross country.

Consider a flight from Alamosa, Colorado to Gallup, New Mexico on a summer afternoon with strong southwest winds. A map recon shows La Manga and Cumbres passes the logical place to cross the mountains southwest of Alamosa. The strong southwest wind will give us good hydraulic lift up the north ridge of the Conejos River valley to northwest of La Manga Pass.

The problem will come when the Conejos branches east of "camp." The southerly branch going up to La Manga Pass is orientated south-southwest. We must stay on the north ridge of the Conejos valley until west of the lee side downdrafts off the north ridge of the 10,230' peak. Southwest winds should give us hydraulic lift east of the Conejos along that ridge.

We should be prepared to avoid downdrafts on the lee side of the hill southwest of Los Pinos. As Cumbres Pass is oriented northeast to southwest, we won't know which ridge to ride until we get there. Unless the wind goes straight down the pass, the northwest or southeast ridge will have the lift.

If the wind goes straight down the pass, we will have trouble getting from Los Pinos up to the pass. If the south ridge of the 10,230 peak has lifted us high enough to cross the pass south of Los Pinos to Osler, we can bail out down that valley. If not, we will have to reverse course with an energy management right turn and go back down the Conejos. Once through Cumbres Pass at 10,000,' we need to make a power descent to around 8,000' at Chama to get out of the strong headwinds up high.

Following are some common errors associated with low power, high mountain pass crossings:

1. Not considering that natural energy is at least ten times greater than excess engine thrust for climb in the high desert and mountains.
2. Not making probable wind direction and speed the major consideration in the afternoon flight map recon.
3. Staying too far laterally from the downwind ridge.
    a. Fifty feet is best, if it's not too ragged.
    b. The ridge is our friend when we're looking for ridge lift.

4. Flying in the middle of valleys.
    a. We don't get the good ridge orographic lift in the middle of the valley.
    b. The middle of the valley gives us too little horizontal clearance from the upwind ridge for the box canyon turnaround.
5. Bleeding kinetic energy of pressure-airspeed by pulling on the stick in a futile, behind the power curve, attempt to engine climb when excess engine thrust for climb is not available.
    a. If we pull back and don't go up, go behind the power curve, we need to push forward to go up or at least descend more slowly.
6. Attempting a level, high load factor, box canyon turnaround.
    a. This is very dangerous.
    b. Many fatalities in the mountains are a result of this flat, minimum banked turn into the upwind ridge.
    c. The downdraft over there can be as much as three thousand feet per minute.
    d. Any turn toward the upwind ridge must be an energy management turn to go back down the valley. We may get into the downdraft, but we are nose down and headed for much lower terrain.
    e. At high density altitude where the nose is up just to get Vy, the energy management turn is just a steep descending turn into the vast vertical space of the valley.

When attempting to cross the high mountain passes on a westerly course in small airplanes in the afternoon, we could thermal up higher than the pass. However, up high, using this method, we will encounter very strong headwinds for a very long period.

Using orographic lift to ride the downwind ridge of the valley leading up to the pass, we can avoid the stronger headwinds until in the pass.

We also can fly lower and longer routes along major river valleys to find lower passes.

Students and especially older pilots who have flown, even Commanches or Bonanzas, up and down the valleys for years appreciate the power and usefulness of natural energy.

Many continue to fly up and down big valleys. It is safer.

The box canyon turnaround in low country, involves the same energy management, no load factor, turn to reverse course. The greater danger here is that, at this lower altitude, some excess engine thrust for climb is available. This can tempt a pilot to try to get out over the upwind ridge in a downdraft. Reliance on limited engine power in this situation often results in fatalities.

Chapter 12

Pipeline Patrol Operations

Following are some considerations that make pipeline patrol effective and more comfortable:

1. Patrol (observe with the intent to see) every foot of the ROW (pipeline right of way,) the cleared swath in which a pipeline runs.
2. Maintain as low an actual altitude as is legally possible.
    a. With waiver, 200’ outside built up areas, 500’ over built up areas.
    b. From 500,’ a dive to 200’ is necessary to read the mile marker.
3. Make energy management turns to follow a crooked ROW.
4. Report, by distance from a mile marker, every:
    a. Oil leak.
    b. Oil stain.
    c. Piece of heavy equipment including backhoes, trackhoes, dozers, scrapers, skidders, loaders, borers, trenchers, drill rigs, draglines, sheepsfoot compacters, rollers, seismic thumpers, post hole diggers, cherry pickers, etc, on or near the ROW.
    d. Encroachment of any of the above toward the ROW.
    e. Dead cow or other large animal.
        i. A backhoe will bury it.
        ii. What killed it?
    f. Construction activity or equipment.
    g. Encroachment of new power lines or pipelines.
    h. Exposed pipe.
    i. Survey crew or flags.

The more modern a pipeline, the greater the number of turns it makes, mostly ninety-degree turns. Eminent domain applies, but lawyers need work. Oil companies avoid the hassle by just going around fussy landowners. Gathering system pipelines are numerous, compact, and very crooked.

As with any ground reference operation, we need to consider wind direction and speed. We need to have good observation of every foot of the pipeline right of way. We can’t allow a crosswind to drift us out of good position for observation. Wind speed and direction can alter the way we find and get back on a pipeline or even what seat we sit in. On a long stretch of pipeline with a strong left crosswind, we will want to stop and change to the right seat. If flying in a left crab, we would be looking across the entire cowl, too far ahead for accurate patrolling.

The pipeline right of way is fifty feet wide. The condition varies depending on the company that owns the line. Some are as clean as a mowed yard, some completely overgrown with weeds and woody re-growth. Some are brush hogged every year, some every five years, and some less often. Seldom are lines through desert terrain cleaned up. When a nicely mowed right of way gets to town, it often narrows and the sides become overgrown with untrimmed trees. While pipeline companies have the right to keep a fifty feet swath completely clean, they don't like legal expenses. Rather than go to court, they will simply explain to the owner what could happen. If there were a leak or need to upgrade pipe, they would use all of the fifty feet. They would then remove anything in the way to do their repairs.

With an altitude waiver, we fly line at 200' outside built up areas and 500' in built up areas. Some pilots fly well right of the ROW so are patrolling out the left side window. I find it much easier and more efficient to fly just right of the ROW and patrol out the left front windscreen. At 200,' I can read each mile marker out the front. I make a mental note of each mile marker (out west every five miles is marked) so that I will not have to return finding a problem within the next mile. For every spot report, we need to confirm it by reading the marker before and after the spot. Making the spot report using only one marker will come back to bite us. It is too easy to make an error, causing the pipeline employees extra time finding the problem. The Department of Transportation (DOT) requires every aerial spot report to be physically checked.

Patrolling is not just flying a route. We need see every foot of the right of way. We need see every marker pole and mile marker. We must patrol intensely with the intent to see. If we miss a mile marker, we fall off the ROW downwind and use the energy management turn to reverse course. We find the mile marker going the other way and then fall off the ROW downwind, use the energy management turn again reversing course to continue.

Energy management, no load factor, turns make flying pipeline safer and more comfortable. I had to quit spraying after having ruptured disk surgery. Very steep banked turns are not required on the pipeline, except the ninety-degree turns. However, in 3,500 miles per week, there are plenty of turns. The energy management turn works equally well with all bank angles.

Whatever the situation on the right of way, we need to set up for the turn by climbing a bit to slow down. If a steep turn is coming up, we need to slow down quite a bit, which will put us up a little higher. For a ninety-degree turn of the right of way, we may climb as much as one hundred feet. If the right of way turns to the left or makes an easy turn to the right, we continue looking out the front left windscreen. If the right of way turns sharply to the right, we turn a bit left to cross the line just before the big right turn. Pulling up steeply, we look out the left until crossing. Then we make a hard right while letting the nose fall back onto the line in the new direction, looking out the right front and right side window in the steep turn. We again cross the line and turn left to go on down the line in the new direction.

After stopping for fuel or to spend the night, pilots often have difficulty finding the line again, even with gps. The right of way, even if well mowed, is difficult to see until aligned with it. Pilots often turn on the gps spot and wander around for a mile or two before actually picking up the line. Usually this is due to the increased ground speed with a strong tailwind. With a strong tailwind, it is more efficient to cross the right of way and enter an energy management turn in the wrong direction. After pitching well up over the line, it is easy to make a steep descending 270 degree turn back down the line.

Attempting to reengage the ROW from a downwind turn will generally get us lost and cost more time than the 270 degree turn. When seeking the line upwind, we can generally just turn onto it with the help of the slower ground speed.

Safe operating practices can be somewhat different in pipeline patrol work. Low sun conditions, either sunup or sundown, prevent safe patrolling when the pipeline is fairly straight and oriented into the sun. Low stratus ceilings, while illegal under VFR, are safe for patrol operations. We can handle low visibility as well, but even moderate rain stops us. We have to have forward visibility.

The DOT requires an oil or product line to be shut down on the twenty-first day after the last patrol until a new patrol is flown. Stationary frontal conditions in the Midwest put pressure on oil companies either to contract weekly aerial patrols or be prepared to ground patrol if the aircraft only comes bi-weekly. This passes the pressure on to the aerial patrol company to complete patrols within the week. This pressure then is passed on to the pilot who must decide between: waiting for 1,000 and 3, and possibly finding another job or flying under low stratus with decent visibility.

In marginal conditions, the visibility is generally better at very low altitude. In a strong left crosswind over a considerable distance of pipeline, visibility is much better from the right seat. Out west where flying most lines is bi-weekly, we fly all day regardless of very severe afternoon winds.

Most oil and pipeline companies are requiring GPS spot reports. While very accurate in theory, in real life they are very inaccurate and irritating for pilot and ground man. I don't know of interface devices specific for pipeline patrol, but it doesn't really matter. Aerial patrols are bid very competitively. A Garmin 296 was the fanciest I ever used.

Looking at a rapidly moving, very long, digital long lat readout is not accurate. Trying to get a little arrow pointer to point at a place on a very small led map while traveling at 130 mph at 200' is not safe. Moreover, whatever method is used, the lat long usually puts the ground guy on the wrong side of the river or swamp. The ground man, and I, prefer mile marker posts on the ground.

The only useful GPS I ever used was an old Magellan marine GPS that had a man over board button. I could read a fixed lat long after pushing the MOB button. But, does it mark when you hit the bottom with the MOB button or when you let up? At 130 mph it makes a difference. Anyway, I always gave estimated distance from a ground mile marker post. Ground workers, for the most part, ignored the GPS and used the mile marker only.

Aerial patrol companies that are more interested in saving money than in patrolling effectively give us GPS cookie crumb pipeline depictions to learn a new line. After two runs, we need to turn the GPS off and make ourselves find every mile marker pole and every intermediate pole. Every second we look at the GPS screen is a second we are not patrolling our pipeline. The cookie crumbs were always left by a pilot who flew well off the line to the right. It put you in the general area, but was not specific enough.

Many oil, natural gas, and product pipelines use the same ROW. This makes for a nice wide right of way, but we are responsible for our line. Marker poles and mile markers are color coded to some extent. However, many companies use the same color. The only way to confirm our own line is to see every mile marker. If we come upon the right color but wrong number in sequence, we know we are on the other company's line. We have to go back and get re-orientated by number. Sometimes we are responsible for more than one line in the same ROW. Now we have to record the spot reports in two places using different numbers. This can get interesting.

Pre-training:

1. Student documentation to office.
2. Certificate/s
3. Medical
4. Ratings
5. Prior schools: flight, technical, academic
6. TSA requirements
7. Financial arrangements
8. Liability waiver

Flight evaluation

1. Ground Effect Takeoff
2. Dutch rolls (can student hold target consistently between his legs while making 45 degree banks to L and R?)
3. Medium bank level turn (can student maintain the required speed of horizontal nose movement for the angle of bank?)
4. Apparent Rate of Closure Landing

Ground School from "Contact Flying."

1. Aerodynamics specific to our work.
2. Nose and apparent nose in side-by-side aircraft.
3. Dynamic proactive control usage
4. Walk the rudder.
5. Wiggle the stick for/aft.
6. Throttle in/out as necessary to hold glide angle on apparent rate of closure approach.
7. Energy Management
8. Thrust
    a. Excess engine thrust for climb. The engine power available for climb after sufficient thrust is used to produce enough kinetic energy of pressure-airspeed to lift the gross weight of the aircraft and to offset drag.
    b. With full hopper, high density altitude, or both, there is little excess engine thrust for climb.
    c. We trade airspeed for altitude and altitude for airspeed maintaining zoom reserve in one or the other all the way around the energy management turn.
    d. We use the kinetic energy of pressure-airspeed to zoom up at an unsustainable pitch attitude.
    e. Excess engine thrust for climb.

f. Cruise kinetic energy of pressure-airspeed.
g. The extra kinetic energy of pressure-airspeed from low ground effect.

The ground effect takeoff.

1. Tail up (precession) as soon as possible.
2. Wiggle the stick. No tail low.
3. Mains off (p-factor happens as soon as the nose is raised) as soon as possible into ground effect slow flight.
4. Aggressive/dynamic stick for/aft to maintain low ground effect with airplane level or going downhill.
5. No, climb out until zoomy (Vy if you prefer.) We want to be able to make an energy management turn at any bank angle immediately if necessary.

Gravity

1. Downhill
2. potential gravity thrust of altitude (We trade airspeed for altitude and altitude for airspeed maintaining zoom reserve in one or the other all the way around.)
3. upwind shear or updraft

Drag

Aerodynamic

1. wing lift induced drag
2. relative wind not straight down the longitudinal axis
3. parasite
4. dirty airplane
5. booms and pump
6. spreader
7. automatic flagman

Lift

1. Camber/wing area
2. Lift deterioration and mush before the stall.

Weight

1. fuel management
2. load management

The four left turning tendencies

1. Precession as we bring the tail up sharply
2. P-factor as we raise the nose to get the mains off
3. Corkscrew (rigged out at cruise speed)
   a. Why do young spray pilots prefer to turn left?
   b. Slower w/load than rig.
4. Torque (rigged out at cruise speed)

Situational awareness.

1. Because we work so low, we cannot safely rely on computers and instruments to manage our situational awareness. This forces us to management our situational awareness with something much more capable and accurate: our brain.
2. We use sight, sound, kinetics, and smell to sort out how buoyant we are, where the stick, rudders, and throttle are, when we are ascending easily, when the engine is laboring, when we are mushing, when the nose is moving at the speed appropriate for the angle of bank, how fast we are accelerating or decelerating, etc.
3. We do not leave ground effect on takeoff until we feel buoyant and zoomy.
4. We are continuously aware of where the stick is fore/aft, left/right.
5. We know how near the stop our rudder pedal is on takeoff or landing roll out or when initiating a steep turn.
6. We know how fast (ground speed) a point on the ground appears to be moving toward us.
7. We know how to test for zoom reserve (which we don't want) on landing.
8. We know where to look to be sure of longitudinal alignment on landing.
9. We know where our butt will cross a target when in a crab.
10. We know how the wind will affect our ground speed, rate of turn, and ground track.

Techniques

1. The basic low ground effect takeoff. Chapter 2.
2. Rudder/nose speed vs. bank angle management of adverse yaw. Chapter 3.
3. The Energy Management Turn. Chapter 4.
4. The Apparent Rate of Closure Approach. Chapter 5.
5. The Downwind Turn. Chapter 7.
6. The Low Level Forced Landing. Chapter 8.
7. Agricultural Operations. Chapter 11.
8. Satloc Operation.

Spreader Training Lesson 1 w/o satlock, ten knot crosswind

1. Pre-flight/post-flight breafing before/aftr each flight.
2. Ground effect takeoff.
    a. Emphasize getting the tail up quickly, be sure airplane is level (no tail low) and get the mains off quickly into low ground effect flight. Stay in low ground effect until zoomy (Vy if you must.)
    b. Explain that we takeoff a lot and we need to always stay in low ground effect until we have things under control. Someday we will be glad we did.
3. Demonstrate a stall, explain that we are not in the stall training business. We would hit the ground in a mush before we stalled anyway.
4. Dutch rolls
5. Energy management turns to target
6. Field high recon (200')
7. Terrain check for uphill, downhill, ridges, valleys, and good forced landing areas.
8. Obstructions check for towers, high voltage power lines, trees or anything above low voltage power lines.
9. How does every wire get into the field? How does every wire get out of the field?
10. Liability check for fish farms, turkey farms, schools, hospitals, old folks homes, etc.
11. Field low recon (top of power lines or 50')
12. Terrain check for uphill, downhill, ridges, valleys.
13. Obstructions check for towers, high voltage power lines, trees or anything above low voltage power lines.
14. Explain smoker on Pawnee. Point out other methods of determining wind direction (smoke, water with smooth upwind and ripples downwind, flags, drift, etc.)Explain working crosswind and into the wind.
15. Explain working crosswind and into the wind.
16. Explain offset on first and last swath based on wind speed.
    a. Point out that this must be observed from the ground to really understand drift.
17. Explain “spreader on” and “spreader off” calls to simulate opening and closing the gate handle or electric gate handle.
18. Explain the lead time when downwind and lag time when upwind on an uncommon upwind/downwind application.

19. Explain narrow valley with high ridges, obstructions constraints, liability constraints, etc. that would make upwind/downwind application necessary.

Back and forth spreader work w/o sat loc. Ten knot crosswind.

1. Wings level into field. “Spreader on.”
2. Directed course down crop row or to parallel downwind border of the field or to distant target.
    a. We will be in a crab.
    b. We use rudder to maintain directed course.
    c. We use aileron only to keep wings level.
3. Emphasize clearing the wing before falling off the target downwind.
4. Throw Flag. A trigger on the stick grip activates a 14v solenoid plunger that pushes a cardboard square followed by some folded paper out of the Automatic Flagman mounted on the wing.
5. Energy management turn downwind.
    a. Shallowest in strong crosswind.
    b. Medium bank in light crosswind.
    c. Steepest in no wind condition.
6. Downwind offset.
    a. Shortest time in a strong crosswind.
    b. Medium time in a light crosswind.
    c. Longest in a no wind condition.
7. Energy management turn upwind.
    a. Point out how the pitch up trading airspeed for altitude decreases airspeed and increases rate of turn. Point out how that extra altitude can be traded for airspeed in the return to target. This pitch up reduces airspeed and thus increases our rate of turn.
    b. Explain how the upwind condition while returning to target (the next swath row) helps us by making the turn less severe. We only have to turn back to the crab heading rather than all the way to the crop row heading and we are constantly being drifted toward our target. Because we are at a slower ground speed we have to bank less to make the target than if we were flying downwind. Because we have to bank less, and we are going slower (ground speed), we have fewer issues with obstructions.
    c. Emphasize that there will be great loss of performance due to working out of ground effect and pulling a lot of air (parasite drag) with the spreader. Emphasize that there will be much less (compared to spraying) airspeed to trade for altitude leaving the

field and thus much less altitude to trade for airspeed entering the next spreader run.

   d. Explain getting the wing level before the tree line or wire after turning back into the next swath run.
      i. We don't want to put a wing into anything.
      ii. A cartwheel is a bad kind of crash.
   e. Explain using the poles/trees for height adjustment (ten feet above,) why we must maintain a consistent altitude (50'), the problem of descending in large fields, and making rudder turns only (no aileron) over the field.
      i. Descending or banking over the field will alter swath width.

8. "Spreader on."
9. Demonstrate the last spreader run over the road or adjoining field and explain how the material will drift into the field we are treating.
   a. Encourage the student to observe (from the ground) others spread to get a feel for how far different materials drift and judge the amount of drift in various crosswinds.
   b. Emphasize the danger of the cleanup runs.
   c. This is where we come upon the unexpected. We make many crosswind runs, but now we are working upwind/downwind and making only one or two runs on each side of the field.
   d. There may be terrain or obstacle problems we didn't notice while treating the field. We will have to exaggerate the "spreader on/spreader off" lead or lag while working downwind or upwind.
10. We will have to exaggerate the "spreader on/spreader off" lead and lag while downwind/upwind
11. Brisk walk apparent rate of closure approach to wheel landing. No, hold off landings.
   a. Explain that we do a lot of takeoff and landings. We often need to land short at satellite fields so we need to keep in practice.
   b. Our situational awareness is enhanced when we use the wheel landing.
   c. Statistically hold off and three point landing results in more problems than power/pitch controlled approaches to wheel landings.

Spreader training. Lesson Two. Satloc. Back and forth. No wind.

1. Completely explain Satloc operation on the ground before takeoff.
2. Ground effect takeoff
3. Field recon high and low
4. Liability check

Back and forth spreader work satloc. No wind.

1. Satloc directed course into field.
2. Use dynamic proactive rudder to maintain directed course.
3. Use aileron only to keep wings level.
4. Use border, crop row, or distant target to further direct course.
5. Throw flag.
6. Emphasize clearing the wing prior to falling off target downwind.
7. Energy management turn downwind.
    a. shallowest bank and for shortest time in a strong crosswind.
    b. medium bank and for a little more time in a light crosswind.
    c. steep bank and for the most time no crosswind condition.
    d. Point out how less angle away from next swath target is necessary as the wind speed increases.
8. Followed by an energy management turn back into the crosswind and on around to the next swath run fifty feet upwind from our just completed run.
    a. Point out how the pitch up reduces airspeed and thus increases our rate of turn. Our upwind (base) and crosswind (final) return to target helps by making the turn less severe (we only have to turn back to the crab heading rather than all the way to the crop row heading as we are constantly being drifted toward our target).
    b. Talk continuously to help the student with clearing the wing. Be sure he clears the wing (in the direction of the anticipated turn) prior to turning.
        i. We have to see the wire or tree line pass completely under to be safe.
        ii. Watch his head to see if he looks down at the poles at the appropriate time.
    c. Talk him through falling off the target at the proper angle down wind.
    d. How long to fly the offset.
    e. Talk him through the energy management return to target.
        i. How much airspeed to trade for altitude.

ii. How quickly to trade the altitude gained for airspeed turning into the target

f. Emphasize getting the wing level before the wire and maintaining wings level with rudder only, using aileron only to keep the wings level.
   i. We skip (miss rows) badly when in a bank over the field and are in danger of catching a wire with the down wing.
g. Talk to him about using the poles/trees for height adjustment throughout and the common error of descending in the middle of a large field.
   i. Insure that he looks only at the poles and never at the wire (very dangerous.)
h. Emphasize the danger of the cleanup runs.
   i. This is where we come upon the unexpected. We make many crosswind runs, but now we are working upwind/downwind and making only one run on each side of the field.
   ii. There may be terrain or obstacle problems we didn't notice while treating the field.

9. Apparent brisk walk rate of closure approach to wheel landing on the immediate beginning of the runway.
10. Fast on takeoff and slow on landing has to become habitual.
    a. Remember he may have had many, many iterations of approaching fast over the spot we want him to land on and he may be comfortable with a long, long hold off.
    b. Slow on takeoff and fast on landing is not safe in our business.
    c. This unsafe habit must be extinguished by many, many iterations of slow approaches.

Spray training. Lesson Three. Back and forth. Ten knot direct crosswind.

1. Ground effect takeoff.
2. High recon. (200')
3. Terrain check for uphill, downhill, ridges, valleys, and good forced landing areas.
4. Obstructions check for towers, high voltage power lines, trees, and equipment or pump stands.
   a. How does every wire get into the field?
   b. How does every wire get out of the field?
   c. Are there lateral wires away from field (guy wire?)
   d. Do any wires stop in the field (guy wire?).
   e. Are there any directional changes in any wire (guy wire?)
5. Low recon. (10')

    a. Terrain check for uphill, downhill, ridges, valleys, and irrigation ditches.
    b. Check for different levels in flood irrigated fields.
    c. Obstructions check for towers, high voltage power lines, trees, equipment, pump stands, pivots.
    d. Power lines: Over or under, where are we going?
6. Explain smoker on Pawnee. Point out other methods of determining wind direction (smoke, water with smooth upwind and ripples downwind, flags, drift, etc.)
7. Explain working crosswind and into the wind.
8. Explain that we will practice back and forth spraying in a field with significant wind before we do a field with no wind because it is much easier and more comfortable with the ground speed energy management available with a crosswind.
9. Wings level over wire/trees/ground into field. Rudder turns only when on final.
10. Stay high enough to see over wire into target.
    a. Common error: too low over wire then negative push over onto target.
11. Push nose down onto target.
12. Demonstrate dynamic proactive fore/aft stick movement (exaggerate so he can see that we don't hit the ground just because we moved the stick) to stay ahead of variances in altitude.
    a. Common error: reluctance to move stick fore/aft in the field (this reluctance is very dangerous.)
    b. Explain that if we are not already moving the stick fore/aft when we are shocked to see an obstruction in the field, we will be too slow to miss it.
    c. Explain that if we do not stay dynamic and proactive on the stick, we will be high and low in the field because our corrections will be late.
13. ¼ mile from the end of the spray run, go to full power if not already there.
14. Simulate moving the left hand from the throttle to the money handle.
15. At the end of a run, explain that we move our visual sight alignment from the bottom of the tree or pole to the top of the tree or pole and the smooth back pressure application will happen naturally. “Spray off.” Throw flag.
16. For your information only, it is almost impossible for a student to stay down long enough to hit a wire or tree.

   a. We just don't want him to jerk it out, losing more of his ground effect and engine zoom reserve in the form of airspeed than necessary (bleed energy.)

17. Talk continuously to help the student with clearing the wing.
18. Be sure he clears the wing (in the direction of the anticipated turn) prior to turning.
19. We have to see the wire or tree line pass completely under to be safe.
20. Watch his head to see if he looks down at the poles at the appropriate time.
21. Energy management turn downwind. Falling off the target downwind.
    a. shallowest bank and for shortest time in a strong crosswind.
    b. medium bank and for a little more time in a light crosswind.
    c. steep bank and for the most time no crosswind condition.
    d. Point out how less angle away from next swath target is necessary as the wind speed increases.
22. Energy management turn upwind.
    a. Point out how the pitch up trading airspeed for altitude decreases airspeed and increases rate of turn.
    b. Point out how that extra altitude can be traded for airspeed in the return to target.
    c. Explain how the upwind condition while returning to target (the next swath row) helps us by making the turn less severe.
    d. We only have to turn back to the crab heading rather than all the way to the crop row heading and we are constantly being drifted toward our target.
    e. Because we are at a slower ground speed we have to bank less to make the target than if we were flying downwind.
    f. Because we have to bank less, and we are going slower (ground speed), we have fewer issues with obstructions.
    g. In a downwind turn, however, the increased ground speed requires a much steeper bank.
        i. Steeper banks at higher speeds cause greater g loading.
        ii. Obstructions come at us much more rapidly.
    h. Point out how ground effect and not having the spreader increases the airspeed in the field and allows a greater altitude gain coming out of the field.
    i. Explain how quickly to trade the altitude gained for airspeed turning into the target and emphasize:
        i. getting the wing level before the wire.
        ii. maintaining wings level with rudder only.
        iii. centering light bar with rudder only.
        iv. staying high enough to constantly see target over wire.

j. When light bar centers, fly directed course to crop row or distant target.
    i. Remember we are in a crab and we are directing our butt, not the nose, to a crop row or distant target.
    ii. Remember we use rudder only to direct that course.
k. Do not allow the student to commit the common error of allowing the airplane to descend to near wire height before the wire requiring a negative push over into the field or big skip.
l. Teach him that we need to see the target (very beginning of next spray run) over the wire just as you would want to see the numbers over an obstruction on landing.

23. "Spray on."
    a. Demonstrate moving over a couple of rows in the field (in low ground effect) with rudder and cross controlled aileron.
        i. Emphasize that we redirect the course with rudder. We use aileron (cross controlled) only to keep the wings level.
        ii. A coordinated turn will result in putting the boom into the crop or even cart wheeling.
        iii. Explain that later we will control the light bar alignment the same, with rudder only and whatever cross controlled aileron is necessary.
24. Talk the student through the rest of the field.
25. Demonstrate the last spray run over the road or adjoining field upwind from the field.
    a. Explain the difference in displacement/drift over the road with no wires and over the road with wires.
    b. Depending of wind speed and altitude, two or more displaced (upwind) runs may be necessary.
    c. Explain that the actual displacement with various winds can only be learned from the ground watching someone else spray.
26. Emphasize the danger of the cleanup runs.
    a. This is where we come upon the unexpected.
    b. We make many crosswind runs, but now we are working upwind/downwind and making only one run on each side of the field.
    c. There may be return to target terrain or obstacle problems we didn't notice while spraying the field.
    d. We may encounter guy wires or obstacles in the field that were not a problem on the crosswind runs.
    e. We will have to start the pullup out of the field earlier on the downwind cleanup run and later on the upwind cleanup run.

Spray Training. Lesson Four. Back and forth. No wind.

1. Ground effect takeoff.
2. Use a very level field.
3. High recon. (200')
    a. Terrain check for uphill, downhill, ridges, valleys, and good forced landing areas.
    b. Obstructions check for towers, high voltage power lines, trees, and equipment or pump stands.
        i. How does every wire get into the field? How does every wire get out of the field.
        ii. Are there lateral wires away from field (guy wire) Do any wires stop in the field (guy wire).
        iii. Are there any directional changes in any wire (guy wire)
    c. Liability check
4. Low recon. (10')
    a. Terrain check for uphill, downhill, ridges, valleys, and irrigation ditches. Check for different levels in flood irrigated fields.
    b. Obstructions check for towers, high voltage power lines, trees, equipment, pump stands, pivots.
        i. Over or under, where are we going?
    c. Determine wind direction.
5. Explain working crosswind and into the wind.
6. Explain that we will practice back and forth spraying in a field with significant wind before we do a field with no wind because it is much easier and more comfortable with the ground speed energy management available with a crosswind.
    a. This no wind condition will make the energy management turn back into the field much tougher.
7. Wings level over wire/trees/nothing into field.
8. Rudder turns only on final.
9. Stay high enough to see over wire into target. Common error: too low over wire then negative push over onto target.
10. Push nose down onto target. “Spray on.”
11. Demonstrate dynamic fore/aft stick movement (exaggerate so he can see that we don't hit the ground just because we moved the stick) to stay ahead of variances in altitude.
    a. Common problem is reluctance to move stick fore/aft in the field (this reluctance is very dangerous.)
    b. Explain that if we are not already moving the stick fore/aft when we are shocked to see an obstruction in the field, we will be too slow to miss it.

    c. Explain that if we do not stay dynamic on the stick, we will be high and low in the field because our corrections will be late.

12. ¼ mile from the end of the spray run, go to full power if not already there.
13. At the end of a run, explain that we move our visual sight alignment from the bottom of the tree or pole to the top of the tree or pole and the smooth back pressure application will happen naturally. Throw flags.
14. "Spray off." (For your information only, it is almost impossible for a student to stay down long enough to hit a wire or tree.)
    a. We just don't want him to jerk it out, losing more than necessary of his ground effect and engine zoom reserve in the form of airspeed.
15. Talk continuously to help the student with clearing the wing.
16. Be sure he clears the wing (in the direction of the anticipated turn) prior to turning.
17. We have to see the wire or tree line pass completely under to be safe.
18. Watch his head to see if he looks down at the poles at the appropriate time.
19. Energy management turn downwind. Falling off the target downwind.
    a. shallowest bank and for shortest time in a strong crosswind.
    b. medium bank and for a little more time in a light crosswind.
    c. steep bank and for the most time no crosswind condition.
    d. Point out how more angle away from next swath target is necessary as the wind speed decreases.
    e. Talk him through falling off the target at the proper angle down wind.
20. Energy management turn upwind.
    a. Point out how the pitch up trading airspeed for altitude decreases airspeed and increases rate of turn.
    b. Point out how that extra altitude can be traded for airspeed in the return to target.
    c. Explain how the no crosswind condition while returning to target (the next swath row) will not help us by making the turn less severe, as with a crosswind.
        i. We have to turn back all the way back to the crop row heading and we have no crosswind help to drift us toward our target.
        ii. Because we are at a faster ground speed (than with a crosswind) we have to bank steeper to make the target than if we were flying upwind and crosswind.

    iii. Because we have to bank more, and we are going faster (ground speed), we have more issues with obstructions.
    iv. Steeper banks at higher speeds cause greater g loading.
    v. In a downwind turn, however, the increased ground speed requires a much steeper bank.

21. When light bar centers, use rudder only to fly directed course to crop row or distant target.
22. Do not allow the student to commit the common error of allowing the airplane to descend to near wire height before the wire requiring a negative push over into the field or big skip.
23. Teach him that we need to see the target (very beginning of next spray run) over the wire just as you would want to see the numbers over an obstruction on landing.
24. "Spray on."
25. Demonstrate moving over a couple of rows in the field (in low ground effect) with rudder and cross controlled aileron.
    a. Emphasize that the wing must be kept level with rudder movement and any aileron (coordinated) turn may result in putting the boom into the crop or even cart wheeling.
    b. Explain that later we will control the light bar alignment the same, with rudder only and whatever cross controlled aileron is necessary.
26. Talk the student through the rest of the field.
27. Emphasize the danger of the cleanup runs.
    a. This is where we come upon the unexpected. We make many crosswind runs, but now we are working upwind/downwind and making only one run on each side of the field.
    b. There may be return to target terrain or obstacle problems we didn't notice while spraying the field.
    c. We may encounter guy wires or obstacles in the field that were not a problem on the crosswind runs.
28. Apparent rate of closure approach to wheel landing.

Spreader/Spray Training. Lesson Five. Back and forth/Racetrack. Sat loc.

1. GPS setup
2. Ground effect takeoff.
3. High/low recon.
4. Emphasize the need to make the turn to a ground target as if you had no sat loc.
5. Emphasize the need to use rudder only to maintain the localizer.
6. Explain finding a ground target at the end of the run (get eyes off the light bar).

7. Emphasize maintaining the ground target, not the localizer.
8. Explain the danger of using the localizer in the field.
9. Explain crosswind and into the wind race track work: spreader/spray

Spreader/Spray training. Very hilly terrain

1. Special techniques
2. Moving over a row
3. Moving over a swath width
4. Going around obstructions in the field using rudder turns in ground effect
5. Jumping obstructions in the field
6. Up to 15 degree rudder turns in ground effect into and out of landing sites.
7. Hover taxi in ground effect
8. Land, hover in ground effect over bad place, re-land on unimproved landing sites.
9. No compass, no gps, map only ferry technique
10. Crosswind landings in strong crosswinds using downwind corner to upwind big airplane touchdown marking
11. Use of thermals and orographic lift in hilly and mountainous terrain
12. Sling shots to simulate low level forced landings.
13. Take off and fall off target downwind.
14. Energy management turns to return to runway going opposite direction.
15. Close throttle and land in opposite direction from takeoff.

Spray Training. Dual Practice.

1. Crosswin
2. No Wind
3. Upwind/downwind
4. Trees
5. Wires
6. Size of wire.
7. On border of field
8. In the field
9. Irregular border wires
10. Guy wires
11. Irregular shaped fields
12. High obstruction at end of run
13. High obstruction in turn
14. Narrow valley w/high terrain on downwind side
15. Under high voltage transmission wires

16. Under border wires?
17. Takeoff and landing training at satellite fields
18. Obstacles
19. Crooked ingress/egress in ground effect (Les Fetherson's)
20. Short field with no obstructions.
21. Stay in ground effect after liftoff.
22. Stay in ground effect and hover taxi to touchdown point.
23. Roads (after high recon and low recon
24. Land/ground effect hop/re-land.
25. Dumping.

Chemical training
Handling and safety
Label information
Mislabeled material (why we spray it all)
Mixing
Loading
Fueling
Wind screen cleaning (why up and down only?)
Disposal
Transportation to satellite field

1.