

ULTRA-REALISTIC FLIGHT SIMULATION

X-PLANE 10



For X-Plane 10 Global, Regional, and Demo versions

MANUAL

Laminar
Research

About This Manual

This is version 10.203 of the manual to the home and professional versions of X-Plane (X-Plane 10 Global and X-Plane 10 for Professional Use, respectively), last updated February 26, 2013. The latest version of the manual will always be available for download from the X-Plane.com web site.

Throughout the text, there will be cross-references to other parts of the manual, as well as hyperlinks to web pages. These will be formatted as gray text. For instance, clicking the following reference to this section will bring you to the top of the current page:

About This Manual

The Table of Contents is also cross-referenced; click on the section you're looking for to travel there instantly. Alternatively, the PDF's bookmarks can be used to navigate quickly through the manual. If you are using the Adobe Acrobat or Apple Preview PDF viewers, you can display these bookmarks by clicking the buttons shown in Figure 1, respectively.



Figure 1: Buttons to show bookmarks in Acrobat (left) and Preview (right) PDF viewers [Full size →]

If you would like to receive a free guide to many of the most important features of X-Plane, you can sign up for our free email course. By signing up, you'll be able to learn all the most important features of X-Plane at your own pace, without having to search through the manual for the feature you're interested in. This course will show you how to:

- add new aircraft to X-Plane for free,
- simulate out-of-this world situations (literally!), like flying the Space Shuttles re-entry into the atmosphere,
- dogfight against your friends or X-Planes artificial intelligence,
- shoot approaches to your favorite runways, and more!

Sign up for the free course to get the most out of X-Plane.

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Chapter 1

About X-Plane

1.1 Overview

X-Plane is the world's most comprehensive and powerful flight simulator for personal computers, and it offers the most realistic flight model available.

X-Plane is not a game, but an engineering tool that can be used to predict the flying qualities of fixed- and rotary-wing aircraft with incredible accuracy.

Because X-Plane predicts the performance and handling of almost any aircraft, it is a great tool for pilots to keep up their currency in a simulator that flies like the real plane, for engineers to predict how a new airplane will fly, and for aviation enthusiasts to explore the world of aircraft flight dynamics.

Welcome to the world of props, jets, single- and multi-engine airplanes, as well as gliders, helicopters and VTOLs. X-Plane contains subsonic and supersonic flight dynamics, allowing users to predict the flight characteristics of the slowest aircraft or the fastest. X-Plane also includes more than 30 aircraft in the default installation, spanning the aviation industry and its history. Aircraft included range from the Bell 206 JetRanger and Cessna 172 to the Space Shuttle and the B-2 Bomber. Additionally, some 2,000 additional aircraft models can be downloaded from the Internet (X-Plane.org, the X-Plane.com Links page, and Google are good places to start looking), many of which are completely free. If those aren't enough, users can design their own airplanes and test-fly them!

The full X-Plane scenery package covers the Earth in stunning resolution from 74° north to 60° south latitude. Users can land at any of over 33,000 airports or test their mettle on aircraft carriers, oil rigs, frigates (which pitch and roll with the waves), or helipads atop buildings. They can also realistically model the flight of remote-controlled model aircraft, perform an air-launch in an X-15 or Space Ship One from the mother ship, fly re-entries into Earth's atmosphere in the Space Shuttle, fly with friends over the Internet or a LAN, drop water on forest fires, or shoot approaches to aircraft carriers at night in stormy weather and rough water conditions in a damaged F-4. The situations that can be simulated are unbelievably diverse!

Weather in X-Plane is variable from clear skies and high visibility to thunderstorms with controllable wind, wind shear, turbulence, and micro bursts. Rain, snow, and clouds are available for an instrument flying challenge, and thermals are available for the gliders. Actual weather conditions can be downloaded from the Internet, allowing users to fly in the weather that really exists at their current location!

X-Plane has detailed failure modeling, with multitudes of systems that can either be failed manually at an instructor's command, or randomly when users least expect it! Users can fail

instruments, engines, flight controls, control cables, antennae, landing gear, or any of dozens of other systems at any moment. They can also have a friend or flight instructor (locally or via the Internet, working from an Instructor's Operating Station) fail components on the aircraft without the pilot's knowledge. The instructor can alter the time of day, weather conditions, and failure status of hundreds of aircraft systems and components. Additionally, the instructor can relocate the aircraft to a location of his or her choice at any time.

Aircraft models are also extremely flexible, allowing users to easily create paint jobs, sounds, and instrument panels to modify any airplane you choose. Custom airplane or helicopter designs can even be created and flown using X-Plane and the included Plane Maker software.

X-Plane is used by world-leading defense contractors, air forces, aircraft manufacturers, and even space agencies for applications ranging from flight training to concept design and flight testing.

For example, X-Plane has been used in crash investigations to depict the view pilots experienced moments before a mid-air collision, or to graphically present to juries and judges the forces that impact an aircraft in flight. Scaled Composites used X-Plane to visualize Space Ship One's flights to the edge of the atmosphere in their pilot training simulator. Kalitta has used X-Plane to train their pilots to fly freight 747s in the middle of the night. Northwest and Japan Airlines use X-Plane for flight review and training. Cessna uses X-Plane to train new customers in the intricacies of the Garmin G1000. Dave Rose has used X-Plane to optimize airplanes for his many wins at Reno. NASA has used X-Plane to test the re-entry of gliders into the Martian atmosphere, and the list goes on. These customers serve as perhaps the most significant endorsement of the incredible capabilities of this simulator.

Furthermore, X-Plane has received certification from the FAA for use in logging hours towards flight experience and ratings. This experience can provide credit towards a private pilot's license, recurrence training, hours towards instrument training, and even hours towards an Airline Transport Certificate—it's that good.

1.2 What X-Plane Includes

Windows, Mac, and Linux installers are included with X-Plane 10 Global (the version of X-Plane available from X-Plane.com). It includes over 70 GB-worth of scenery (covering essentially the entire world) and over thirty aircraft, with thousands of planes available on the web. The DVDs contain everything needed to run X-Plane—there is nothing more that you need to buy. You'll receive free updates to X-Plane 10 until Version 11 is released, as well some of the best customer service and tech support available.

While on its own X-Plane represents the world's most comprehensive flight simulator, the installation DVD also comes with Plane Maker, allowing users to create custom aircraft or modify existing designs, and Airfoil Maker, allowing users to create airfoil performance profiles.

The stock installation includes the following aircraft:

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| Cirrus Vision SF50 | North American X-15 |
| Beechcraft Baron 58 | Lancair Evolution |
| Cessna 172SP | McDonnell Douglas KC-10 Extender |
| Piaggio P.180 Avanti | Boeing 747-400 and 747-100 |
| Stinson L-5 Sentinel | Robinson R22 Beta helicopter |
| ASK-21 glider | Boeing B-52G Stratofortress |
| Beechcraft King Air C90B | Bombardier Canadair CL-415 |
| F-22 Raptor | Viggen JA37 |
| Lockheed SR-71 Blackbird | F-4 Phantom II |
| Boeing AV-8B Harrier II | Bell 206 helicopter |
| Lockheed C-130 Hercules | Space Shuttle Orbiter |
| Thunder Tiger Raptor 30 v2 RC helicopter | Great Planes PT-60 RC plane |

Of course, the thousands of aircraft available on the Internet provide even greater variety. The following is a (small) sample of what's out there:

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|---------------------------|--------------------------|
| Beechcraft Bonanza | Boeing 727/737/747/787 |
| Mooney M20J 201 | Piper PA-16 Clipper |
| de Havilland DH-106 Comet | Pitts "Mountain Dew" S2C |
| Sikorsky S76 | StratoCloud Ram-Air |
| P-51D Mustang | Piper Twin Comanche PA30 |
| Beechcraft King Air 350 | Cessna 195 |
| Cessna C150 | Bell 222 |
| Douglas A-4B Skyhawk | Ilyushin IL-76 |
| Fiat CR.42 Falco | Paris Jet III |
| Bell 407 | Peregrine F222 Firenze |
| Beechcraft Staggerwing | Curtis P-6 Hawk |
| Ford Tri-motor | Cessna 120 |
| Hawker Sea Harrier FRS1 | Airbus A320/A340/A380 |

1.3 About the Versions of the X-Plane Simulator

X-Plane can be used in a wide array of situations, ranging from home use to commercial flight training. The standard installation of X-Plane is X-Plane 10 Global, and it is perfect for almost all home users. Situations that go beyond the standard home use (including use in commercial simulators) require the purchase of a USB "key" (a simple flash drive) that is used to unlock the features of X-Plane Professional.

Note that FAA certification of a simulator requires not only that the user has X-Plane 10 Professional but also the appropriate hardware (cockpit and flight controls) available through companies like Precision Flight Controls and Fidelity. This is because flight-training systems can only be certified as a complete package (a software and hardware combination). The commercial, FAA-certifiable software is available for \$750 to \$1,000 per copy and the hardware runs from \$5,000 to \$500,000. The retail version of X-Plane purchased at X-Plane.com is *not* certified for flight training right out of the box, since certification requires a software and hardware combination. However, the software available for about \$80 at X-Plane.com is almost identical what is found in the \$500,000 full-motion, FAA-certified platforms. The biggest difference is that the FAA-certified versions have custom aircraft files with larger instrument panels, which are set up to work with hardware radios like those found in the physical cockpits. The FAA-certifiable version also has some of the purely fun

stuff (like space flight) removed even though those situations are simulated accurately in X-Plane, just like the FAA-certified subsonic terrestrial flight.

1.3.1 X-Plane 10 Global

The standard X-Plane simulator is the retail copy of X-Plane. It requires one X-Plane 10 Disc 1 DVD for each copy of X-Plane on the network.

This simulator is what users get when they purchase X-Plane from the X-Plane.com site and use it for whatever they desire. It requires no USB key to be plugged in. Many copies of X-Plane on many computers can be networked to act as external visuals, external cockpits, instructor stations, and the like. One X-Plane Disc 1 DVD is required for each computer networked together running the simulator. This system *cannot* be certified by the FAA or any other authority for logging flight training, due to the fact that it does not self-test for the presence of flight controls or a usable frame rate. However, since only one X-Plane Disc 1 DVD is needed for each computer, this setup is amazingly affordable and easy to assemble at almost no cost, even though a user could never *certify* the system.

1.3.2 X-Plane 10 Regional

Unlike X-Plane 10 Global, the X-Plane 10 Regional discs include only part of the world's scenery (e.g., Europe or North America). These versions of X-Plane are available at a lower cost than the X-Plane 10 Global distribution. Apart from the scenery, however, X-Plane 10 Regional is identical to the Global distribution, the version sold at X-Plane.com.

1.3.3 X-Plane 10 Professional

This version of X-Plane is for commercial use, FAA-approved simulators, and the EFIS App. It requires one X-Plane Professional USB key for each copy of X-Plane or EFIS App on the network.

This is similar to the X-Plane 10 Global simulator, but it adds EFIS App, a standalone program that runs on its own computer that gives a very realistic Avidyne primary flight display (PFD) and modular flight deck (MFD). All that is required to run this is a copy of X-Plane or EFIS App from X-Plane.com and a Professional key for each computer that will be networked into the simulator. Of course, *two* monitors can be hooked up to *one* computer running EFIS App so that one only has to buy one computer to run both the Avidyne PFD and MFD, which will save some money.

Furthermore, this key enables X-Plane to drive real Garmin G430 and G1000 GPS units. Note that in order to interface with a real G430 or G1000, users must get a Simulator G430 or G1000 from Garmin, then make the wiring harnesses to plug them in to the serial or Ethernet cables to the computer. Users unsure on how to do this are better off buying a simulator boxed and ready to go from Precision Flight Controls. PFC does provide ready-made units with real G430s and G1000s installed and running.

Additionally, this is the key that needs to be used for commercial purposes and FAA-approved simulators for flight training. It gives a Commercial Use message as X-Plane starts up, causing X-Plane to check for flight controls and self-test the frame rate, as required for FAA certification.

Finally, this key enables cylindrical and spherical projections.

This is the option designed to replace Microsoft ESP.

Note that the Professional key, along with the simulator itself, can be purchased from X-Plane.com's Ordering page. EFIS App can be downloaded from the X-Plane.com site. USB key drivers for both Mac OS and Windows can be downloaded from the X-Plane.com site. Run those installers to make X-Plane recognize the USB keys.

1.4 History

Many people ask us about the history of X-Plane, how we got started and where we're going. Here's some background information about Austin Meyer (the author) and the history of X-Plane.

As you may know, the most popular flight simulator on the market historically is Microsoft Flight Simulator. This may be predominately due to their early start with their flight simulator, which dates back to about 1982 or so. Over the years, there have been many other upstart companies that have attempted to compete against Microsoft (Flight-Unlimited, Fly and Fly-2k are a few examples). All but X-Plane have failed. From the very beginning, the greatest advantage of using X-Plane was in the way the flight model is generated and the high frame-rate at which X-Plane can run. This has long given us an advantage in being able to accurately calculate and depict the flight response and feel of an aircraft in flight. In the past, Microsoft had scenery that was superior to X-Plane's, as well as many more add-ons. Microsoft's advantage here mostly died about mid-way through the X-Plane 8 run. X-Plane 10 marks another leap forward in our simulator, what we unhesitatingly believe to be the greatest flight simulator available.

Over the years, we've consistently seen increasing sales, with a total of about 750,000 copies of X-Plane shipped through either Internet orders or retailers as of April 2009 (not counting the 500,000 copies of the new iPhone apps!). Furthermore, X-Plane is the only single commercial flight simulator available for the Macintosh, Windows, and Linux platforms. The set of discs sold at X-Plane.com includes copies for all three, so there is no possibility that a user will pick up the wrong version for his or her computer. (Note that some retailers have been known to stock Windows-only or Macintosh-only copies of X-Plane or sell X-Plane without global scenery to keep costs down. Read the box carefully if buying from a store shelf.)

Aside from the improved accuracy and fluidity found in X-Plane, another big difference between Microsoft's simulator and our own is that, whereas Microsoft releases updates about every three years or so, we release updates for X-Plane about every ten weeks! Thus, instead of buying a disc and having the software remain stagnant for the next thirty-six months, X-Plane encourages users to go to our website every three months or so and download cool new (and free) updates to their software!

In short, we are a few very driven and talented people that have made the improvement and accuracy of X-Plane pretty much our life's mission.

1.4.1 Austin's Bio, As of Mid-2006

Hi! I am a private pilot with about 1,500 hours in a handful of light and medium-size Cessna and Piper singles (the airplanes I grew up flying) and a Cirrus SR-22 Centennial Edition 8141Q, which I purchased in 2003. In a month or so, I will be switching to a Lancair Columbia 400 for maximum speed to hop around the country serving customers. (My customer support guy, Randy Witt, flies a Beech Baron. I'm telling you this to make the point that the guys that write and support X-Plane are pilots, aircraft owners, and engineers. Aviation is a huge part of our lives, and we love what we're doing.)

Anyway, back in 1988 or so, after I had gotten my instrument rating in the calm and friendly skies of Columbia, South Carolina, I found myself in San Diego, California, working for DuPont Aerospace, a small aerospace tech firm working, on some excellent but unusual designs that I cannot discuss in detail.

I must digress here for a moment because this is interesting and also applicable to one of the aircraft in X-Plane. One of the projects that DuPont was working on back then was the well-known NASP, or National Aerospace Plane, a single-stage-to-orbit aircraft that can, in theory, take off

from a runway and fly clear to orbit. Tony DuPont, the president of the company, was the founder of this ingenious NASP concept. While the Space Shuttle and other conventional rockets use rocket engines to blast up to their orbital speed (18,000 mph), the NASP breathes air to run its engines, so it must do most of its acceleration in the atmosphere. This use of the oxygen in the atmosphere, rather than carrying liquid oxygen on board, makes the vehicle much more light and efficient, but it also means that the aircraft must fly at many, many thousands of miles per hour in the air, which creates tremendous heat and drag. Circulating cool fuel through the skin of an aircraft is not a new idea... in fact the bell-shaped nozzles on most rocket engines employ this technology to keep them from melting! For the NASP, this is one of the few options that will keep the skin temperatures down and allow hypersonic flight (that is, flight at five times the speed of sound or greater). You might think that using an insulated tile system like the one the Space Shuttle has would be a good option, but maintaining and replacing thousands of small tiles would be problematic, bulky, and expensive. Of course, circulating fuel to keep the skin cool has its drawbacks too! The SR-71 Blackbird uses its cool fuel to keep its surface temperatures down, and in fact is limited to much lower speeds than Mach 3 when low on fuel because there is nothing left to absorb the heat! Open the SR-71 in X-Plane and rather than seeing a red line on the airspeed indicator (like just about every other aircraft) to indicate maximum allowable speed, there is a whole red arc! That big red region is the speed range that you can only operate in if you have enough fuel in the tanks to soak up the heat from atmospheric friction! How far into the red zone you are allowed to fly depends on your remaining fuel load—Now you know.

Anyway, enough about the fascinating NASP concept. That summer in 1988, while living in San Diego, I took an instrument currency flight to keep my IFR skills sharp, and had a very difficult time getting up to speed in the crowded, fast-paced, hectic ATC system of San Diego after the relative slow and laid-back ATC operations back home in South Carolina. After finally getting my IFR skills up to a comfortable level (requiring about three or four flights), I decided that I wanted an instrument trainer to keep my IFR skills up to snuff. Microsoft Flight Simulator was pretty much the only game in town back then, and I was pretty disappointed in what I found. Microsoft was running on the little baby Macintoshes back then, which was great, but there were a few other little things I wanted done differently as well, and I knew Microsoft would not change their sim just to suit me. Thus, X-Plane was born, at the time called “Archer-II IFR.” I used this program for several years to keep up my instrument currency.

A bachelors degree in Aerospace Engineering at Iowa State University soon followed, and during my engineering studies there I expanded “Archer-II IFR” to be able to simulate almost any airplane imaginable by simply plugging in the blueprints for that airplane, and letting the sim then figure out how the plane should fly based on those blueprints. This is completely opposite how most any other simulator works and is by far the largest and most important differentiator between X-Plane and its competitors. I started to use the simulator to test out various aircraft designs I had conceived, and quickly learned that Cessna, Piper, Lancair, and Mooney build the way they do for a very good reason—my designs were efficient, but too difficult to fly safely. Later, I renamed the program “X-Plane” in honor of the series of aircraft tested at Edwards Air Force Base in the ’60s and continuing through today.

More about Austin can be read on the Austin’s Adventures blog.

1.5 X-Plane Today

Today, X-Plane is still written and developed on the Macintosh (as it has been since day one) and ported to Windows and Linux machines to allow cross-platform sales and distribution. Thus,

the single set of discs available from X-Plane.com's Ordering page will run on nearly any personal computer available in the world.

Engineers at Velocity, NASA, Scaled Composites, and Carter Aviation have all used X-Plane to do design, evaluation, and simulated flight testing. The National Test pilot school uses X-Plane to train pilots in non-conventional aircraft and flight-control systems. I know an eight-year-old Italian girl who likes to taxi the planes around to see the Corvettes parked around the airport fence. Other kids try their own designs in X-Plane, and countless youngsters gleefully crash their simulated F-22s into the ground at Mach 2 as well.

Most X-Plane customers are pilots, or people who want a simulator that has a level of realism appropriate for pilots. Many airline pilots take X-Plane with them on their (real) overseas flights on their laptop computers and simulate the next day's flight and possible approaches while on layover. Many airline and freight pilots keep their currency up on X-Plane to breeze through their bi-annual reviews and flight currency checks. Countless private pilots use X-Plane to help maintain currency when time and money constraints keep them from making it out to the airport as often as they would like. While we have received a handful of orders from the DOD, the CIA, and Microsoft, the majority of X-Plane customers are simply people who want to experience the joy of flight. A copy of X-Plane provides a fun, easy (and safe!) way to do just that.

Many pilots have regular access to old Cessnas, but what would it be like to get dropped from the wing of a B-52 in an X-15 and head to the fringes of space at 4,000 mph? Or to fly a full re-entry in the Space Shuttle? Or take the SR-71 to 70,000 feet at Mach 3? Or fly a rocket plane on Mars?

X-Plane will show you, but even better, it will let you experience it for yourself.

Chapter 2

Quick Start Guide

This chapter is designed to allow a first-time X-Plane user to get the simulator up and running in as short a time as possible. The goal is to be in the air and flying within ten minutes of completing the installation while still learning the essentials of the simulator.

This chapter will gloss over a great deal of background information, and configuration of many non-essential options will be skipped entirely. It assumes that the computer X-Plane is being installed on is capable of running the simulator with its default rendering options. Note that the minimum system requirements to run X-Plane are a 2 GHz processor, 2 GB of RAM, and a DirectX 9-capable video card with 128 MB of on-board, dedicated video RAM (VRAM). However, the recommended specifications are a 3 GHz multi-core processor, 4 GB of RAM, and a DirectX 10-capable (DirectX 11 preferred) video card with 1 GB of on-board, dedicated VRAM. X-Plane will take advantage of as many cores or distinct processors as you can afford. Having 16 cores split among 4 CPUs is not required by any means, but Version 10 would be able to use every one. No more than 4 GB of RAM is necessary, but the more VRAM you have, the better—X-Plane 10 can easily use 1.5 GB of VRAM at the maximum settings.

Where the process differs between installing on Windows and Mac OS X, the differences have been noted.

After getting off the ground initially, you may want to continue reading the full manual, or simply keep it for reference. If you have any issues while following this guide, check the rest of the manual—the problem is very likely addressed there, and you’ll save time for both yourself and customer support.

Detailed information on installing and configuring X-Plane can be found in Chapters 3 and 4. Detailed information on joystick configuration can be found in Chapter 4, and Chapter 5 contains more information on setting up and flying the aircraft.

2.1 Installing X-Plane

Before installing, we recommend uninstalling any old or demo versions of X-Plane. You can do this by simply dragging the old X-Plane folders to your Recycle Bin (called Trash in Mac OS X).

1. Insert the first X-Plane DVD into your DVD-ROM drive and wait for it to spin up.

If you are using the earliest set of X-Plane 10 discs (printed around November 2011), download the updated X-Plane installer from our web site. Launch *that* installer rather than the one on your installation DVDs, then skip to step 3.

2. In Windows, if the operating system does not launch the X-Plane installer automatically, click the Start menu, then My Computer. Double click on the XPLANE10 DVD, then Installer_Windows.exe.

Mac users will need to double click on the X-Plane DVD icon on the desktop, then double click the Installer_Mac.app to launch the installer.

3. When the installer window appears, click **Continue** to begin the installation process.
4. By default X-Plane will install to the Desktop. Though it can be installed elsewhere, it is strongly recommended that it be placed on the Desktop so that it can be found in the future. For the purposes of this guide, we will assume it is installed there. Click **Continue**.
5. Accept the user agreement and click **Continue** once again.
6. Select the scenery you would like to install. Depending on the installer on your disc, either all of the world or none of it will be selected by default. An unselected tile will appear bleached in color, while a selected tile will have its full color (as all tiles do in Figure 2.1).

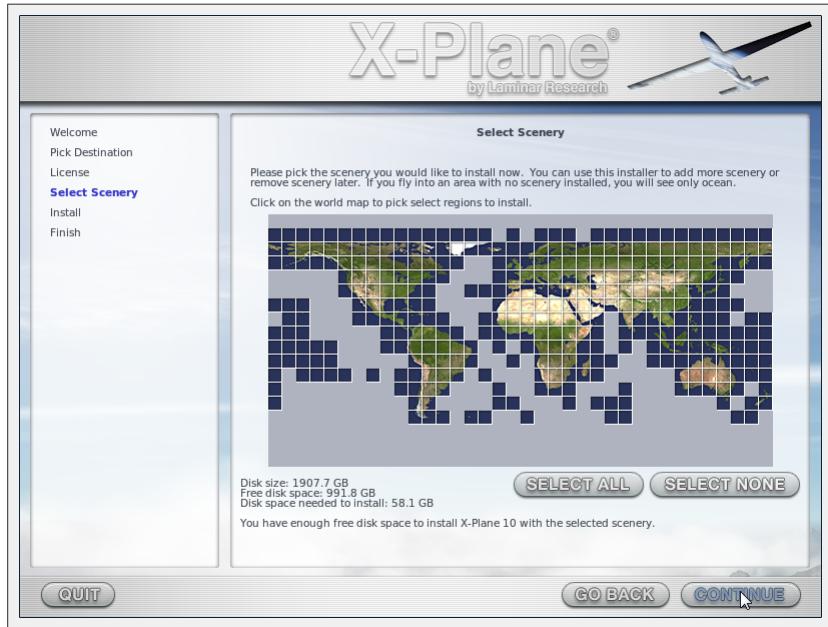


Figure 2.1: All scenery selected for installation after clicking “Select All” [Full size →]

If you are unsure what areas are currently selected, just click **Select None** to turn everything off (as seen in Figure 2.2). From there, select the individual tiles you would like to install by clicking on them. Additionally, you can click and drag to select large areas quickly.

Note that for regions where no scenery is installed, only oceans and airports will be visible. When you’re finished selecting scenery, click **Continue** to begin installing.

For the purposes of the ?? section later in this guide, be sure to select the two tiles that make up America’s West Coast, as we will be traveling to Los Angeles International Airport (KLAX).

7. The installer will begin displaying its progress. When the installer prompts you to do so, remove the current disc and insert the next. Note that installation may take anywhere from

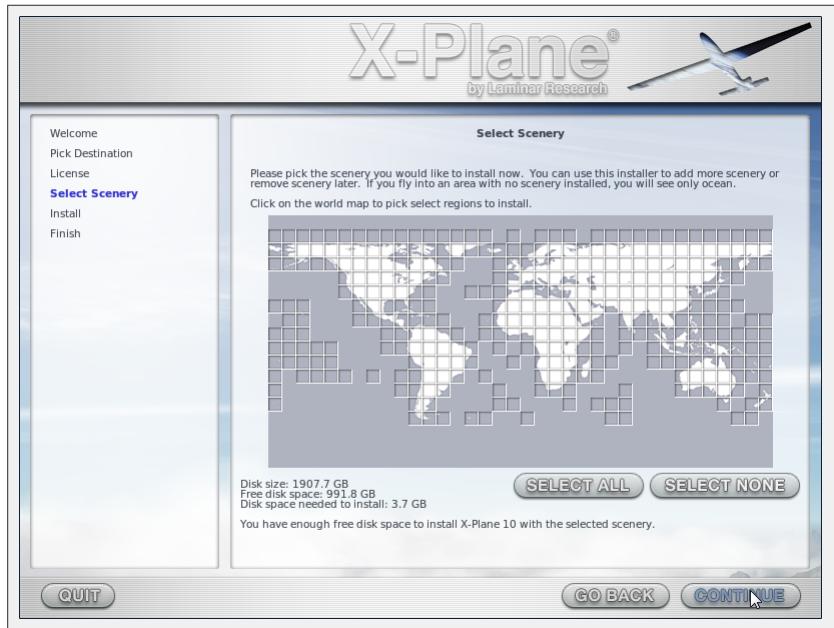


Figure 2.2: No scenery selected for installation after clicking “Select None” [Full size →]

thirty to sixty minutes per disc, and that only one X-Plane disc can be in the system at once (the installer won't recognize a disc placed in a second DVD-ROM).

Installing the complete scenery package will consume about 75 GB of hard drive space and will take between five and six and a half hours to install.

Scenery can be added or removed at any point in the future by inserting Disc 1 and re-running the installer. When the X-System installer comes up saying “You already have X-Plane 10 installed on this computer,” click the **Add or Remove Scenery** button and proceed just like in step 4 above.

Note: Having finished the installation, Mac users will probably want to exclude their X-Plane installation directory from their Time Machine backups (as described in Chapter 3, in the section “Special Considerations for Mac Users.”)

2.2 Launching X-Plane

1. Make sure your USB joystick is plugged in. If this isn't plugged in prior to launching X-Plane, the simulator will not be able to interface with it. To avoid any possible problems, it is recommended that the flight controls be plugged directly into the machine rather than into a hub.
2. Put Disc 1 into your DVD-ROM drive. Starting X-Plane without this will force X-Plane to run in demo mode only.
3. Open the X-Plane 10 folder (located by default on the Desktop) and double click on “X-Plane.exe” in Windows, or “X-Plane.app” on a Mac.



Figure 2.3: Selecting Joystick & Equipment from the Settings menu [Full size →]

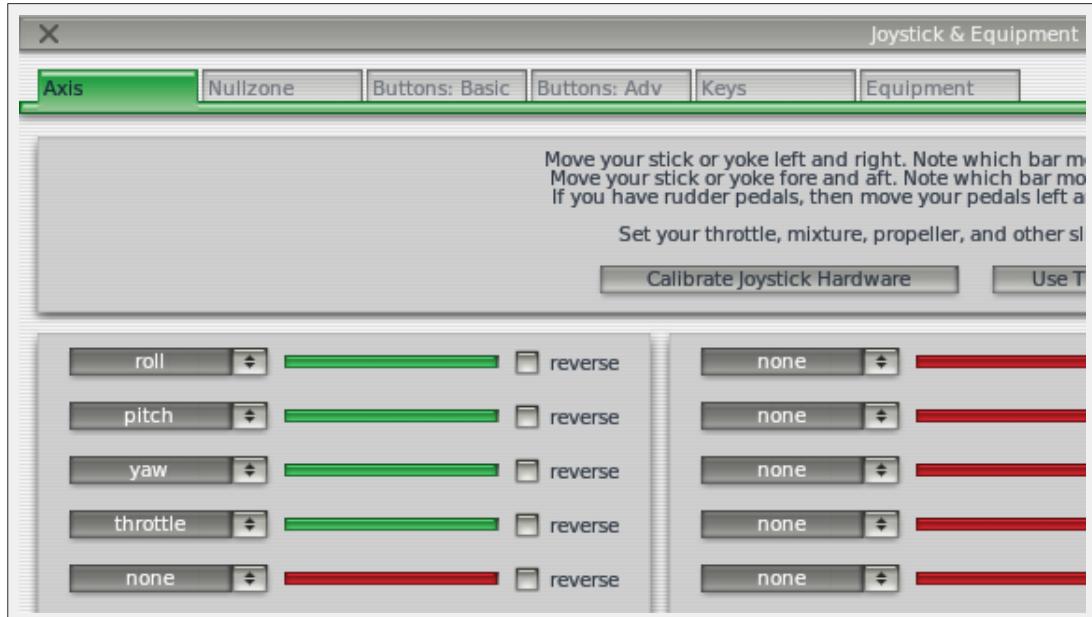


Figure 2.4: The relevant portion of the Joystick & Equipment dialog's Axis tab [Full size →]

2.3 Configuring Essential Yoke/Joystick Functions

Note that a mouse may be used to fly if neither a yoke or a joystick is available, though it will (of course) be unrealistic and cumbersome. If the mouse will be used, however, skip to the section “??” below.

- Once the program loads, move your mouse to the top of the screen, causing the menu to appear.
- Click on Settings (per Figure 2.3), then Joystick & Equipment. The relevant portion of the dialog box that appears is shown in Figure 2.4.
- Move your joystick or yoke forward and back. A green or red bar should move as you do so. Click the drop-down menu next to it and set it to pitch. Do not check the reverse box next to this control unless, when flying, the aircraft's pitch control is working backward.
- Move your joystick/yoke left and right. The green or red bar that moves should be set to roll. Do not check the reverse box next to this control unless, when flying, the aircraft's roll control is working backward.

5. Twist your joystick (if applicable). The bar that moves should be set to yaw. If you do not assign a yaw axis, X-Plane will attempt to stabilize it for you. Once again, do not check the reverse box unless, when flying, the aircraft's yaw control is working backward.

If you are using rudder pedals instead of a twisting joystick, slide them forward and backward and set the green/red bar that moves then to yaw.

Additionally, only when using rudder pedals, press the left pedal down with your toes. The green or red bar that moves should be set to left toe brake. Do the same for the right pedal, and set that green bar to right toe brake. If this is done, you may also skip steps 8 through 10 below.

6. Move your throttle forward and back (on a yoke, this is typically the leftmost lever). Set this bar to throttle. Check the reverse box only if, when flying, the aircraft's throttle control works backward.
7. Move all the joystick's control axes (that is, pitch, yaw, roll, and throttle) through their full range of motion to calibrate the controls.
8. Once again, skip this step and steps 9-10 if the rudder pedals are set up as toe brakes. Click the Buttons: Basic tab at the top of the screen.
9. Press the button on your joystick that you would like to assign to brakes, then release it.
10. Using the mouse, click the round button to the left of **Toggle brakes regular effort** (found near the bottom of the second column and already selected in Figure 2.5).
11. Close the Joystick & Equipment menu with either of the X buttons at the top of the screen, or by pressing the Enter key on your keyboard.

2.4 Setting Up a Flight

As of X-Plane 10.10, the first thing you see when you launch X-Plane (unless you disable it) is the Quick Flight screen, as seen in Figure 5.1. If you don't see this screen, you can open it by moving your mouse to the top of the screen (causing the menu to appear), then clicking File, then clicking Quick Flight Setup. This screen combines miniature versions of the dialogs which are used to open aircraft, choose an airport, and set up the weather.

Choose an airport from which to take off by using the upper-left box in this window. You can either type the airport's name or identifier in the text box to search for it, or scroll through the full list. Click on an airport to select it.

To the right of the airport selection is a box displaying your X-Plane directory. This is used, in combination with the "cover flow"-like view in the bottom left of the window, to select an aircraft. By selecting the X-Plane 10 folder, or the Aircraft folder, you will be able to scroll through all the aircraft you have installed. Clicking on a more specific folder will expand it, and the cover flow view will show you only the aircraft in that folder. The frontmost aircraft in the cover flow is the one which is selected.

For the purposes of this guide, select the Cessna 172 by clicking the Aircraft folder (thus displaying all the aircraft), then using your mouse's scroll wheel to scroll to the 172.

Set the time of day and weather using the rightmost boxes. Click on one of the rectangular panels to select the time of day and weather conditions shown in that panel. By checking the **always track real date and time** box will make the time in the simulator match your computer's time. Checking

the **use real weather** will cause X-Plane to occasionally download the real-world weather in your aircraft's location.

Finally, when you've finished setting up the flight, press the **Fly with these options** button.

2.5 Getting Off the Ground

Once again, these instructions are written for the Cessna 172—flying an airliner or another heavy aircraft will require flaps/slats, a great deal more speed, and a very different technique, all of which is beyond the scope of this chapter.

1. The airplane's engine is already running. Press the button that was assigned to brakes when the joystick/yoke was configured. If no button was configured (e.g., if you are flying with the mouse), press the 'b' key on the keyboard.
2. Move the throttle all the way up.
3. If applicable, use the joystick's twist or the rudder pedals to control the plane's left and right motion to track the centerline of the runway (don't worry if you go off it—you'll still get up to speed for take off). If no yaw axis was configured above (or if using the mouse), the simulator will attempt to control the yaw for you.
4. Watch your airspeed indicator (seen in Figure 2.7), and when it hits 60 knots, pull back slightly to get the plane off the ground.

If using a mouse, you will have to click the white + sign (found near the center of the screen) with the mouse in order to grab the controls with the mouse. From there, move the mouse within the white box that appears in order to control the aircraft's flight—moving it up within the box will pitch the nose down, and moving the mouse down will pitch the nose up. Moving it left within the box will cause the craft to roll left, and moving it right will cause the craft to roll right. Click the mouse again to release the controls, freeing you to open a menu, adjust controls on the aircraft panel, etc.

5. Gently level the plane off in order to build a little airspeed, then, when the plane hits, say, 80 knots, pull back again to begin climbing. Building airspeed this way will help to keep the plane from stalling.
6. Fly away!



Figure 2.7: The airspeed indicator in the Cessna 172 [Full size →]

2.6 Updating X-Plane

Updating X-Plane will ensure that the copy of X-Plane you are using is the most stable, most feature-rich version available. Updates within a given version of X-Plane (e.g., from Version 10.0 to 10.1 to 10.2) are free, and recommended for virtually all users.

1. In X-Plane, move your mouse to the top of the screen (causing the menu to appear) and click About.
2. In the About menu, click About X-Plane.
3. In the window that appears, there will be an **Update X-Plane** button if an update is available. Clicking this will cause X-Plane to download the latest update and run the updater for you.
4. The installation files will be downloaded and installed, after which you will be ready to fly.

2.7 Further Considerations

Among the more important options skipped in the guide above was the configuration of flap and trim switches. If your joystick or yoke has switches or buttons you would like to use for this purpose, you can configure them similarly to the brakes that we assigned in part 3 of this guide. The difference is that when using a switch, pressing it “up” assign it one function and pressing it “down” will assign it another. Remember to click the button on your joystick before trying to assign it a function. Further information on this can be found in the section “Configuring Flight Controls” of Chapter 4.

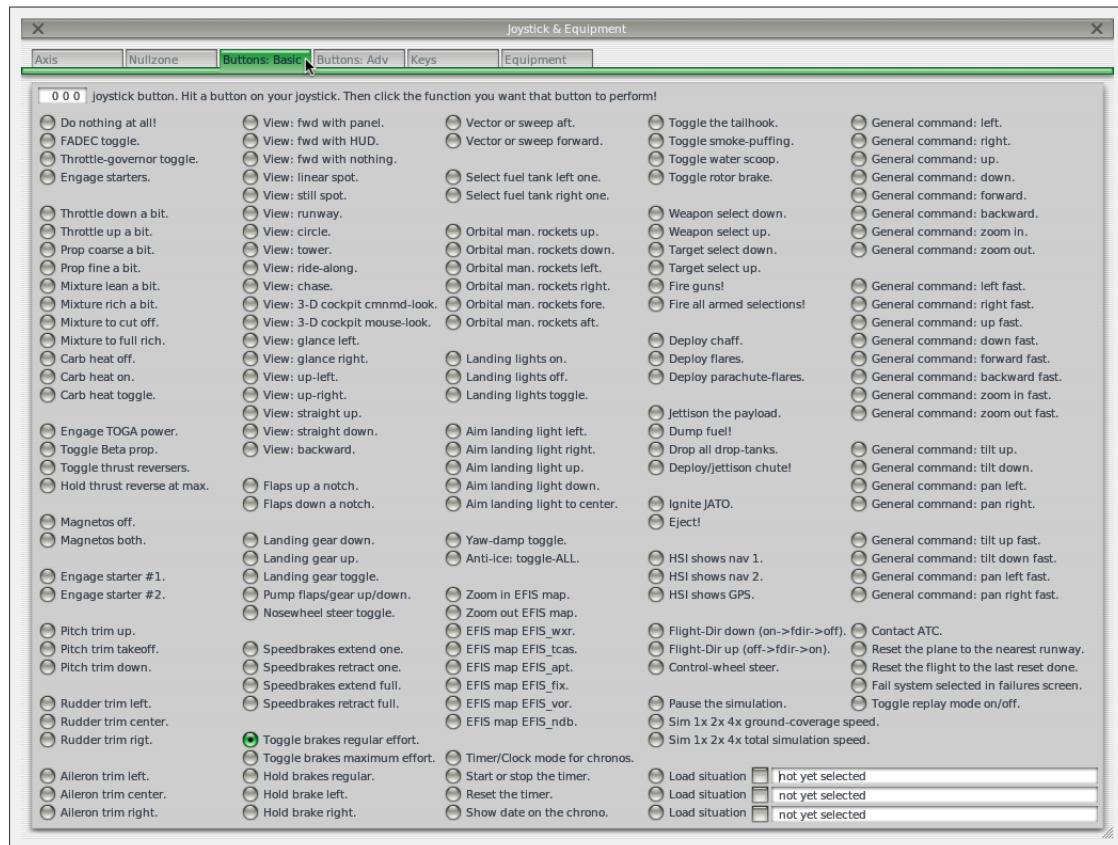


Figure 2.5: The Buttons: Basic tab of the Joystick & Equipment menu, with a button set to **Toggle brakes regular effort** [Full size →]

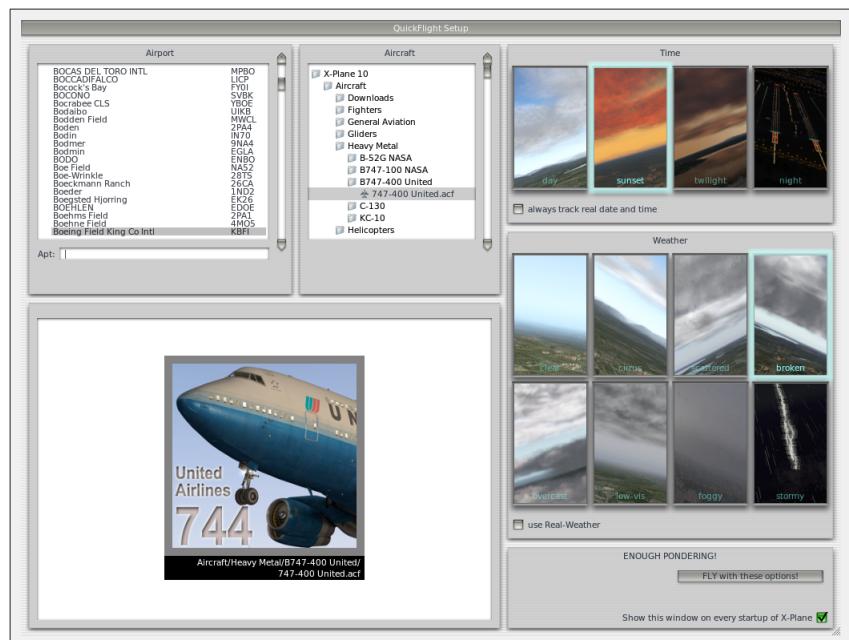


Figure 2.6: Setting up a quick flight upon launching X-Plane [Full size →]

Chapter 3

Preparation and Installation

3.1 System Requirements

Given X-Plane's incredible capabilities and accuracy, it is not possible to run a current release of X-Plane on an exceptionally old computer. A good rule of thumb is that any machine built in the last 18 to 24 months will probably be able to run the simulator acceptably. Computers up to about 36 months old may be fine if they were top-of-the-line machines when manufactured. Even if they weren't, X-Plane may still be able to run, albeit with its rendering options turned down.

X-Plane 10 requires a computer with *at least* the following specifications:

- A 2 GHz, dual-core processor,
- 2 GB of RAM (physical memory),
- a DirectX 9-capable video card with 128 MB of on-board, dedicated video RAM (VRAM),
- 10 GB of hard drive space, and
- a DVD-ROM drive.

However, for the best experience, we recommend the following:

- a 3 GHz, multi-core CPU (or, even better, multiple processors),
- 4 GB of system RAM (physical memory), and
- a DirectX 10-capable (DirectX 11 preferred) video card with 1 GB of on-board, dedicated VRAM, and
- 10 GB of hard drive space, and
- a DVD-ROM drive.

To find your computer's CPU speed and amount of RAM, Mac users can simply open the Apple Menu and click "About This Mac."

For Windows Vista and Windows 7 users, you can open the Start menu and type System to search for the Control Panel's "System" item. Opening this will display the processor, its speed, and the amount of RAM installed. Windows XP users can get the same information by:

1. Opening the Start menu,
2. Selecting the Control Panel,
3. Clicking Performance and Maintenance, and
4. Clicking System.

Additionally, X-Plane 10 has been optimized for dual- and quad-core processors, as well as multiprocessor systems—some CPU cores can be used for the flight models of the simulated aircraft, others for loading scenery, taking input, etc.

Note: X-Plane 10 does not support PowerPC-based Macs, or versions of OS X prior to 10.6.8.

3.1.1 Display Hardware

X-Plane can display on any screen, with resolutions ranging from 1,024 x 768 pixels to 9,999 x 9,999 pixels. It makes no difference to X-Plane what aspect ratio your screen has; if your aspect ratio doesn't match that of the instrument panel you are using, X-Plane will simply zoom or stretch the panel as appropriate to fill your screen.

X-Plane allows the use of any number of screens to depict anything you like. Multiple computers can be used to drive multiple monitors, thereby networking up to about 20 screens to show any combination of views imaginable. If your computer's graphics card is especially powerful, technology like AMD's Eyefinity (built in to high-end Radeon cards since 2009) or a video splitter (like the Matrox TripleHead2Go) can be used to drive three forward visuals with one machine. In that case, a second machine could be used to drive the cockpit display and/or IOS, as described in the section "Configuring a Multi-Monitor Simulator" of Chapter 9. Of course, X-Plane only *requires* a single monitor to function.

3.1.2 Graphics Drivers

X-Plane, of course, needs a decent graphics card in the computer you wish to run it on. Essentially any modern, discrete (i.e., non-integrated) video card will do just fine, though a more powerful, more expensive graphics card will allow for higher detail in the simulator's graphics. Just as important as the graphics card itself, though, are the computer's graphics *drivers* (essentially, the instructions that let X-Plane know how to use your graphics card).

On many systems the required graphics drivers will already be installed. However, it may be necessary to periodically update the computer's video drivers, either to fix a problem or to get the very best performance the system can deliver. Users of ATI/AMD video cards can download drivers from the AMD web site, and NVIDIA users can download drivers from NVIDIA's web site.

Before updating the graphics driver, we recommend installing and launching X-Plane (per the section "Installing X-Plane" of this chapter) and seeing how it runs. If any of the following problems are experienced, the system's graphics drivers probably need to be updated:

- a screen consisting only of splashes of color
- a screen with horizontal or vertical bars running through it
- random images of various pieces of the airplane or instrument panel

Additionally, if an error appears referring to a corrupt or missing ".dll" file, the drivers most likely need to be replaced.

3.1.2.1 Updating Graphics Drivers in Windows

A high percentage of Windows-based computers are operating with drivers that are out of date or that do not currently support OpenGL (caused by using the default Windows drivers rather than those of the manufacturer). If you conclude that your graphics drivers need to be updated, the following (general) steps should guide you through the process.

1. Go to your video card manufacturers driver download page (ATI's site or NVIDIA's) and download the latest drivers, being sure to save it to a place that you'll be able to find it (for example, the Desktop).
2. Uninstall your old graphics drivers.
 - (a) Click on the Start menu and open the Control Panel.
 - (b) Click either **Add or Remove Programs** (in Windows XP) or **Uninstall a program** (in Windows Vista and 7).
 - (c) Scroll down to either the Catalyst Display Driver (for AMD/ATI video cards) or the NVIDIA Drivers (for NVIDIA cards).
 - (d) Click the **Change/Remove** button. (This may be replaced by a Remove button only; it does not affect the process.)
 - (e) Follow the instructions provided by the uninstaller and reboot if necessary.
3. After rebooting, find the driver file that was downloaded in Step 1 and double click on it. The steps vary from here depending on the type of graphics card, but we will continue with a general outline for all companies.
4. Choose a destination folder to extract the files to. Again, make it something easy to find like `C:\video drivers\` and continue clicking **Next**, **Install**, etc.
5. If the installer (which you just extracted in Step 4) does not run automatically, navigate to `C:\video drivers` and double click on setup.exe or a similar launch file.
6. Agree to the license agreement, choose the “express” installation, and click **Next** (or its equivalent) until the installation finishes.
7. Reboot your PC and you’re ready to fly!

3.1.2.2 Graphics Driver Requirements in Linux

When running X-Plane in Linux, please note that you must install the proprietary Nvidia or AMD drivers. X-Plane will not run using Gallium or Mesa open-source drivers.

3.2 Selecting Flight Control Hardware

While it is physically possible to fly X-Plane with only the mouse and keyboard, this can be cumbersome and unrealistic (for obvious reasons). While instructions for flying this way are included in the section “How to Fly” of Chapter 5, it is strongly recommended that users fly with at least a joystick for a realistic experience.

So which joystick should a user purchase? Every USB joystick and yoke made in the last 10 years or so will work with X-Plane, but, as with most things in life, you get what you pay for. Be leery of joysticks advertised for \$29.95 at a local retailer. In our experience the cheaper hardware typically does not last as long or work as well as more moderately priced equipment.

Note: X-Plane can only interface with USB devices. This covers nearly all the controllers manufactured in the last ten years, but if you have a non-USB device, an adapter will be needed to change it to a USB input.

3.2.1 Joysticks

Joysticks typically provide pitch, roll, and throttle control, as well as a few buttons that can be programmed to do different things. For example, you may program one button to raise and lower the landing gear, and two additional buttons to raise the flaps and lower them. Also, some joysticks can have their handle twisted left and right to control yaw movement. If the joystick being used does not offer yaw control, you will probably want a set of rudder pedals to provide realistic yaw control in the airplane. A joystick will be best for flying fighter or sport airplanes, or planes made by companies like Airbus, Cirrus, or Lancair, for the simple reason that those planes, in reality, are controlled with joysticks!

3.2.2 Yokes

A yoke consists of a steering wheel-like control that rotates left and right and also slides back and forth. These are the best option for users primarily interested in flying older-style general aviation planes, business jets, and non-Airbus airliners, since these planes are flown with yokes in reality.

Yokes are typically clamped to the user's desk for stability. They may have a built-in throttle quadrant, which allows for independent control of the propeller, throttle, and mixture for a single propeller engine. Also, note that yokes do not control yaw movement (they do not twist left and right for yaw control like some joysticks), so rudder pedals are required for realistic yaw control.

3.2.3 Rudder Pedals

Rudder pedals allow users to realistically control the airplane's yaw by pushing the left or right pedal to turn. While in flight, the pedals control the rudder, whereas on the ground they're used to steer. The pedals also control the brakes to help the airplane stop or turn sharply while on the ground. (Push the top of the left or right pedal to activate the brakes on that side of the plane.)

If neither a set of rudder pedals nor the joystick is set to control yaw, X-Plane will automatically slew the rudder to try and keep the airplane flying true. This auto-rudder function, however, is not smart enough to take off or land properly in a crosswind, slip, or do various other things that rudders might be used for. For this reason, rudder pedals (or at least a twisting joystick) are highly recommended.

Please note that, when flying a helicopter, pedals must be used for the anti-torque controls—this can not be assigned to keyboard commands, simply because it is not practical to try to use the keyboard to fly.

3.2.4 Other Considerations

For added realism in certain situations, you may want an independent throttle quadrant. CH Products' Multi-Engine Throttle Quadrant is perhaps the most popular and offers independent and variable control of six different functions. Normally, this would be set up to control the throttle, propeller, and mixture controls for each engine on a twin-engine airplane. This controller can also be used to control throttle and condition (fuel cutoff) for jet engines, allowing independent control of jet aircraft with up to three engines. A multi-engine throttle quadrant is recommended for users interested in realistically flying airplanes with more than one engine.

To purchase joysticks or other equipment, check out the CH Products, Logitech, or Saitek websites. Each of the sites allows users to browse the available products and find where to buy them. Also, feel free to call or e-mail X-Plane customer support (info@x-plane.com) with any additional questions.

Note that instructions on configuring flight control hardware are found in Chapter 4, in the section “Configuring Flight Controls”.

3.3 Installing X-Plane

In order to avoid confusion, be sure to delete any installations of the X-Plane demo, or older versions of X-Plane, before installing the full version from the DVDs. (Uninstalling the demo is as straightforward as locating the “X-Plane 10 Demo” folder and moving it to the Recycle Bin/Trash.)

Note: If you are using the earliest set of X-Plane 10 discs (printed around November 2011), you will need to download an updated X-Plane installer from X-Plane.com and launch *that* rather than the installer on your discs.

3.3.1 Installation on a Windows PC

To install X-Plane on a Windows-based computer, do the following:

1. Insert Disc 1 of the X-Plane installation DVDs into your DVD-ROM drive and wait for it to spin up.

If you are using the earliest set of X-Plane 10 discs (printed around November 2011), download the updated X-Plane installer from our web site, then skip to step 3.

2. If the X-System window doesn’t open automatically, open My Computer and navigate to the drive now labeled “X-Plane 10” (usually the D: drive). If the X-System window *does* appear automatically, skip to step 4.
3. Double-click on Installer_Windows.exe to launch the X-Plane installation.
4. When the installer window appears, click **Continue**.

Note that if the buttons at the bottom of the X-System screen labeled **Quit**, **Go Back**, and **Continue** are not visible, then the system is probably running at a minimal resolution like 800 x 600. Using this resolution will not allow the computer to display the bottom of the X-Plane screen and you will need to force the installer to exit (via Ctrl+Alt+Del) and increase the screen’s resolution in Windows to at least 1024 x 768.

5. By default, X-Plane will install to the Desktop. Though it can be installed elsewhere (by clicking the **Change Destination** button), it is strongly recommended that it be placed on the Desktop so that the folder can be found in the future. When an acceptable location has been selected, click **Continue**.
6. Accept the user agreement and click **Continue** once again.

7. Select the scenery you would like to install. Depending on the installer on your disc, either all of the world or none of it will be selected by default. An unselected tile will appear bleached in color, while a selected tile will have its full color (as all tiles do in Figure 3.1).

If you are unsure what areas are currently selected, just click **Select None** to turn everything off (as seen in Figure 3.2). From there, select the individual tiles you would like to install by clicking on them. Additionally, you can click and drag to select large areas quickly.

Note that for regions where no scenery is installed, only oceans and airports will be visible. When you’re finished selecting scenery, click **Continue** to begin installing.



Figure 3.1: All scenery selected for installation after clicking “Select All” [Full size →]

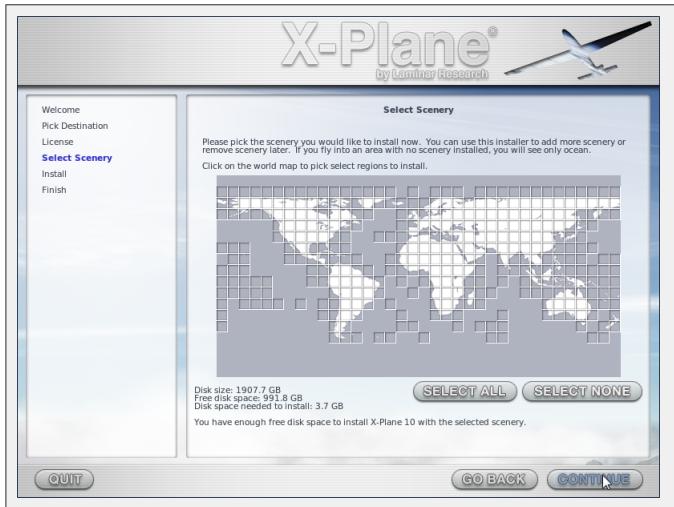


Figure 3.2: No scenery selected for installation after clicking “Select None” [Full size →]

8. The installer will begin displaying its progress. When the installer prompts you to do so, remove the current disc and insert the next. Note that installation may take anywhere from thirty to sixty minutes per disc, and that only one X-Plane disc can be in the system at once (the installer won't recognize a disc placed in a second DVD-ROM). Installing the complete scenery package will consume about 75 GB of hard drive space; doing so will take between five and six and a half hours.
9. When the installation completes, reinsert Disc 1 and go fly!

At any point in the future, scenery can be added or removed by inserting Disc 1 and re-running the installer. When the X-System installer comes up saying “You already have X-Plane 10 installed on this computer,” click the **Add or Remove Scenery** button and proceed just like in step 7 above.

3.3.1.1 Special Considerations for Windows XP Users

Running X-Plane on Windows requires Microsoft DirectX 9.0c (or later) to be installed. Without this, X-Plane cannot interface with audio and joystick hardware. This free software can be downloaded from Microsoft's DirectX 9.0c Runtime Installer page. All newer installations of Windows XP have DirectX 9 already, and all copies of Windows Vista and Windows 7 have DirectX 10 (which is more than sufficient) installed by default.

To find out which version of DirectX is currently installed in Windows XP, do the following:

1. Open the Start menu and click Run, or press Windows + R on the keyboard.
2. Type “dxdiag” and press Enter.
3. If a box appears asking if you want to check for signed drivers, click **No**.
4. The lower half of the window that appears is labeled System Information. At the bottom of that list of stats is the system’s DirectX Version.

3.3.1.2 Special Considerations for Windows Vista and 7 Users

Some of X-Plane’s menus may render strangely when using the default Aero themes in Windows 7 and Windows Vista. For this reason, it is recommended that users switch to the Basic theme when running X-Plane.

To make Windows automatically switch to the Basic theme when you launch X-Plane (and switch back when you’re done), do the following:

1. Locate either the X-Plane.exe file (found in the X-Plane 10 installation folder) or the shortcut you use to launch X-Plane and right click on it.
2. Click Properties from the menu that appears.
3. Go to the Compatibility tab and check the **Disable desktop composition box**.

With that done, X-Plane will launch with the Basic theme and all menus will render correctly.

3.3.2 Installation on a Mac

To install X-Plane on a Mac, do the following:

1. Insert Disc 1 of the X-Plane installation DVDs into your DVD-ROM drive and wait for it to spin up.

If you are using the earliest set of X-Plane 10 discs (printed around November 2011), download the updated X-Plane installer from our web site, then skip to step 3.

2. Double click on the X-Plane DVD icon on the Desktop.
3. Double click the “Installer Mac” app to launch the installer.

Note: If the buttons at the bottom of the X-System screen labeled **Quit**, **Go Back**, and **Continue** are not visible, then the system is probably running at a minimal resolution like 800 x 600. Using this resolution will not allow the computer to display the bottom of the X-Plane screen and you will need to force the installer to exit (via the Option + Command + Escape keys) and increase the screen’s resolution to at least 1024 x 768.

4. By default, X-Plane will install to the Desktop. Though it can be installed elsewhere (by clicking the **Change Destination** button), it is strongly recommended that it be placed on the Desktop so that the folder can be found in the future.
5. Accept the user agreement and click **Continue** once again.
6. Select the scenery that should be installed. Depending on the installer on the disc, either all of the world or none of it will be selected by default. An unselected tile will appear bleached in color, while a selected tile will have its full color. If you are unsure what areas are currently selected, just click **Select None** to turn everything off. From there, select the individual tiles to install by clicking on them. Additionally, you can click and drag to select large areas quickly.
Note that for regions where no scenery is installed, only oceans and airports will be visible. When you're finished selecting scenery, click **Continue** to begin installing.
7. The installer will begin displaying its progress. When the installer prompts you to do so, remove the current disc and insert the next. Note that installation may take anywhere from 30 to 60 minutes per disc, and that only one X-Plane disc can be in the system at once (the installer won't recognize a disc placed in a second DVD-ROM). Installing the complete scenery package will consume about 75 GB of hard drive space; doing so will take between five and six and a half hours.
8. When the installation completes, reinsert Disc 1 and go fly!

Additionally, scenery can be added or removed at any point in the future by inserting Disc 1 and re-running the installer. When the X-System installer comes up saying “You already have X-Plane 10 installed on this computer,” click the **Add or Remove Scenery** button and proceed just like in step 6 above.

3.3.2.1 Special Considerations for Mac Users

By default, Mac OS X versions 10.5 (Leopard) and greater are set to automatically back up the entire hard drive using Time Machine. This includes a user's X-Plane directory. Most people would prefer not to have this backed up, due to the fact that it requires a significant amount of space on the backup disk (for something already backed up to DVDs, no less) and the fact that it takes a great deal of time to complete the backup.

For this reason, it is recommended that users exclude the X-Plane directory from Time Machine's backup, either during or shortly after the X-Plane installation, by doing the following:

1. Open the Time Machine preferences, either from the task bar (by clicking the Time Machine icon and selecting “Open Time Machine Preferences”) or from the System Preferences (by clicking the Time Machine icon there).
2. With the preferences open, click the **Options...** button.
3. Click the + icon to add a folder to the list of excluded directories.
4. Select the X-Plane installation directory (located by default on the Desktop) and click **Exclude**.
5. Exit the Time Machine preferences.

Additionally, some users have had issues with Time Machine creating a “locked” copy of their X-Plane discs. This can cause the X-Plane Disc 1 to appear in Finder as Disc 2, thus forcing X-Plane to run in demo mode. The issue seems to have disappeared in the latest versions of OS X. To correct the problem if it does occur, however, do the following:

1. Download and install the version of the OnyX system utility appropriate to your version of OS X.
2. Run OnyX and select the Parameters tab.
3. Select Finder from the OnyX menu bar and then select **Show hidden files and folders** from the Misc Options section.
4. Open Finder and click on “Macintosh HD” (or whatever your installation disk is called). The Volumes directory, which was hidden before, is now visible at the bottom.
5. Go into the Volumes directory and delete the unwanted X-Plane volumes by moving them to the Trash.
6. Eject the X-Plane DVD, empty the Trash, and reboot.
7. After rebooting, the system should be ready to fly as normal using X-Plane’s Disc 1.
8. At this point, Onyx may be reopened to turn off the **Show hidden files and folders** option.

3.3.3 Installation on a Linux PC

For the most up-to-date instructions on installing X-Plane in Linux, please see the Linux category on the X-Plane Wiki.

3.4 Launching X-Plane

Unlike many of the programs you may be familiar with, X-Plane does not create shortcuts to itself across your hard drive. We recommend launching X-Plane by opening the X-Plane 10 installation directory (located by default on the Desktop) and double-clicking the X-Plane icon. However, if you would like, you can create a shortcut (called an alias in OS X) by doing the following:

1. Open the X-Plane installation directory (located by default on the Desktop).
2. In Windows, right-click on the X-Plane.exe icon and select Create Shortcut. In Mac OS, right-click on the X-Plane.app icon and select Make Alias.
3. Drag the shortcut wherever you wish to launch X-Plane from.

Chapter 4

Configuring and Tuning Your X-Plane Installation

Having installed X-Plane as described in the previous chapter, you can configure the simulator in a number of ways. These include downloading the latest free update (giving you the latest set of features available), setting up flight controls, and tuning the performance of the simulator both in terms of graphics quality and frame rate.

4.1 General Use of the X-Plane Interface

X-Plane has been written to operate on Windows, Macintosh, and Linux systems. For consistency's sake, the layout and appearance of X-Plane is the same across all three operating systems. This may be slightly different than the interface that users are accustomed to, but once they pass the learning curve, they generally find it easy to use.

Here are a few pointers to aid in the learning process:

- X-Plane's menu is hidden when the simulator is first launched. To access the menu bar, just move the mouse pointer to the top of the screen. When the mouse is within a centimeter or so of the top edge of the screen, the menu bar will appear. There is no keyboard command to access the menu bar.
- Any window within X-Plane can be closed by clicking either of the Xs found in the upper left and upper right corners. Alternatively, those windows may be closed by hitting the Enter/Return key.
- Key commands can be found by opening the Joystick & Equipment screen and going to the Keys tab. Key command assignments can also be changed using this screen (per the section "Configuring Keyboard Shortcuts" of this chapter) to anything you like. Also, note that many of the keyboard shortcuts are shown in the X-Plane menus. For example, opening the View menu will display the list of available views on the left side of the drop down menu, with the list of corresponding keyboard shortcuts on the right.

Like most programs, the simplest way to navigate around X-Plane is using the mouse, though there are many shortcut key commands to help you navigate quickly through the options after you become familiar with the program. These shortcuts are particularly important when using the mouse to fly. In that case, it is much easier to use the '2' key to drop a notch of flaps than it is to let go of the controls, reach down with the mouse to adjust the flaps, and then reach back up and grab the controls again.

Also note that most instruments and controls inside the cockpit are interactive, meaning that the mouse can be used to alter switches, set frequencies, manipulate the throttle(s), change the trim, etc.

4.2 Setting the Language

To change the language used throughout X-Plane, move your mouse to the top of the screen (causing the menu to appear) and click Settings. Then, click the Operations and Warnings menu item. In the dialog box that appears, select your language from the list in the box labeled “Language.”

4.3 Updating X-Plane

The X-Plane simulator is designed for both realism and longevity. Maximizing both of these requires that X-Plane be updated often. Every few months, we will make available a new update to the simulator. In between these official (or “stable”) releases, users can download beta versions of the upcoming update. These are treated as a kind of “update in progress”—new features and bug fixes are included, but in the beta stage, the updates have not been fully tested in a range of situations. This means that they may create incompatibilities or create other problems that would not be experienced in the stable releases. For more information, see the section “Using the X-Plane Betas” below.

Newer versions of X-Plane often contain feature enhancements, bug fixes, stability improvements, aircraft and resource updates, flight model improvements, and even new feature additions.

A purchase of X-Plane entitles you to free updates through that full X-Plane version run. This means that if you purchase the Version 10 discs, you will get the Version 10.10 update, the Version 10.20 update, etc., all the way through Version 10.99 if it exists—all free of charge. Of course, you do not have to take advantage of these updates, but it is recommended that you do so.

As with the version of X-Plane on the DVDs you purchased, Disc 1 (the master disc) must be inserted into your computer to use these updated versions. X-Plane uses this as a “key” to unlock the software. Be sure to have the disc spinning in the DVD drive prior to starting up the program so that X-Plane can find it!

Note that although previous versions of X-Plane required users to have all the desired scenery installed before updating to a newer version, this is no longer the case. New scenery may be installed regardless of updates.

To update X-Plane, do the following:

1. Launch the copy of X-Plane that you wish to update.
2. Once it opens, move your mouse to the top of the screen and click About, then About X-Plane. The dialog box that appears will show both your version of X-Plane and the latest version available. If these differ, there will be an **Update X-Plane** button in the bottom right of the window.
3. Click the **Update X-Plane** button. X-Plane will automatically download the latest version of the updater program and launch it.
4. In the window that appears, please do not select the “Check for new betas” box unless you are prepared to potentially work with some kinks (per the section “Using the X-Plane Betas” below).

5. Click **Continue** to begin the program's scanning of your X-Plane directory. This allows it to determine which files need to be updated.
6. Assuming there is enough disk space to download the required updates, click **Continue** to begin the installation.
7. The installation files will be downloaded and installed. When the installation finishes, you're ready to fly.

4.4 Using the X-Plane Betas

The X-Plane beta updates are for users who want to help test the newest refinements to the X-Plane software. The advantage to doing so is that these users get access to the latest enhancements to the software (flight model refinements, new features, etc.). The downside is that there is a greater risk of encountering problems with third-party models or other general bugs. We recommend that most users stick to the stable version releases, as these are the ones known to “just work.”

See the X-Plane Beta page for information on the current beta builds.

4.5 Uninstalling X-Plane

The X-Plane installer does not infest your hard drive with shortcuts and directories. Therefore, all it takes to uninstall the program is to delete the X-Plane installation folder (located by default on the Desktop) by dragging it to the Recycle Bin or Trash. After you empty the Recycle Bin/Trash, the program will be removed completely from your hard drive.

4.6 Configuring Flight Controls

When using a joystick or other hardware, the hardware must be plugged in *before* starting X-Plane. If it is not, X-Plane will not see the input devices.

With your flight controls plugged in and X-Plane running, you can configure how the simulator responds to input from each axis and button. Throughout this section we will refer to any input device as a joystick; the instructions apply to yokes, throttle quadrants, and rudders also.

4.6.1 Setting Up the Control Axes

In X-Plane, move the mouse to the top of the screen and click Settings, then select Joystick & Equipment, as seen in Figure 4.1. This will open the dialog box allowing you to configure and calibrate the flight controls. If it isn't already selected, click on the Axis tab at the top of the screen.

To begin, move the joystick's controls around to see how the axes are mapped in X-Plane. As this is done, one of the green or red bars will move for each input that is actuated. (Note that if you are using a trim wheel, you may have to roll the wheel continuously to see which axis it is mapped to.) Thus, when the stick is rolled left and right only one green or red bar will move; when it is pushed back and forth another bar will move. Each control's desired function is selected from the drop down box to the left of its bar.

The axis bars are green when they are assigned a function, and they are red when they are not assigned a function. For instance, before the throttle axis has been configured, moving the throttle might move a red bar. After assigning that bar to **throttle**, it will turn green.



Figure 4.1: Selecting Joystick & Equipment from the Settings menu [Full size →]

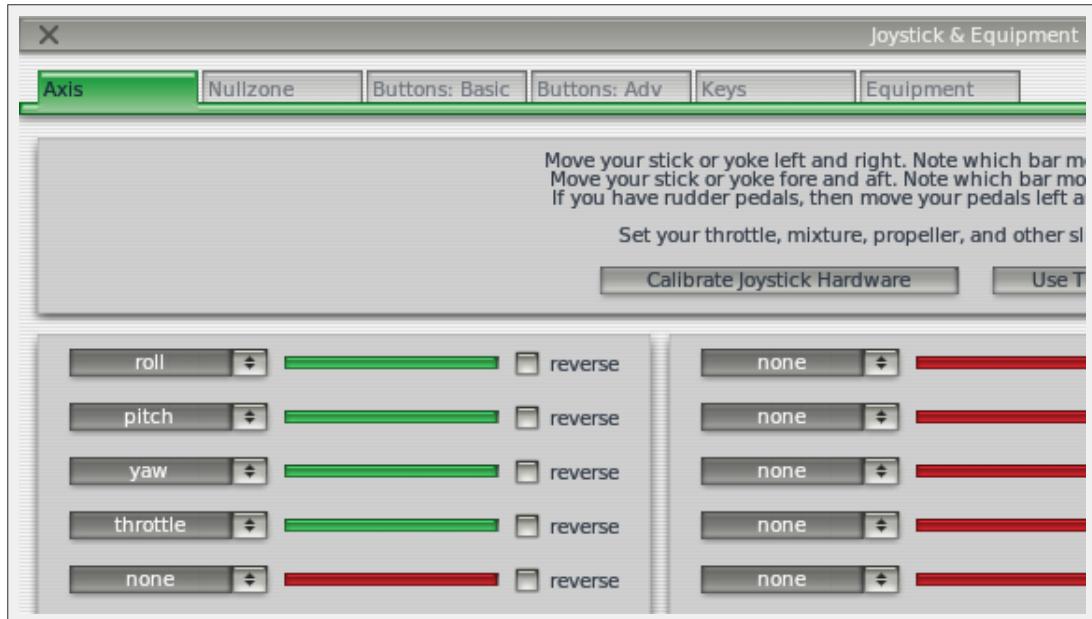


Figure 4.2: The relevant portion of the Joystick & Equipment dialog's Axis tab [Full size →]

The normal configuration of flight controls goes as follows:

1. Move your joystick or yoke forward and back, or spin your trim wheel continuously. A green or red bar should move as you do so. Click the drop-down menu next to it and set it to **pitch**. Do not check the **reverse** box next to this control unless, when flying, the aircraft's pitch control is working backward.
2. Move your joystick/yoke left and right. The green or red bar that moves should be set to **roll**. Do not check the **reverse** box next to this control unless, when flying, the aircraft's roll control is working backward.
3. Twist your joystick (if applicable). The bar that moves should be set to **yaw**. If you do not assign a yaw axis, X-Plane will attempt to stabilize yaw movement for you. Once again, do not check the **reverse** box unless, when flying, the aircraft's yaw control is working backward. If you are using rudder pedals, slide them forward and backward and set the green/red bar that moves then to **yaw**.

Additionally, only when using rudder pedals, press the left pedal down with your toes. The green or red bar that moves should be set to **left toe brake**. Do the same for the right pedal, and set that green bar to **right toe brake**.

4. Move your throttle forward and back (on a yoke, this is typically the leftmost lever). Set this bar to **throttle**.

Note: Any green bar which is not actively controlled by your hardware *needs* to be set to none. When this is set, the bar will turn red, indicating that X-Plane is not using the axis.

4.6.2 Centering the Controls

With the control axes configured, you can tell X-Plane to treat your joystick's current position as the center of its travel by pressing the **Use this position as center** button. Using this button will allow you to correct for flight controls that don't return to the center of their range—for instance, a joystick that moves left to right in a range of 0 to 100, but returns to 55 when you lets go of it. Without centering such a joystick, the aircraft would constantly roll to the right.

4.6.3 Calibrating the Hardware

Some flight control hardware may send a signal from 0 to 1,000 when a user moves a given control from one limit to the opposite, while another device may send a signal (given the same movement of a user's hand or foot) from, say, -6,000 to 3,992. The only way for X-Plane to know the range of a given joystick's input is for the user to "teach" it.

All it takes to teach X-Plane how to interpret your joystick's signal—that is, to calibrate the joystick hardware—is to move all the axes of the joystick through their full range of motion while on the Axis tab of the Joystick & Equipment window. Be sure to move each of the joystick's variable controls (that is, all sliders, joysticks, rudders, etc.) through their full range of motion. Take them all the way forward, all the way back, left, and right. If you are using a trim wheel, roll it continuously through 10 or 15 revolutions in each direction. All of this can be done quite rapidly, as X-Plane can monitor all the different inputs at once.

4.6.4 Assigning Functions to Buttons

Each of the buttons and switches on the joystick can be assigned a function within X-Plane (for example, toggling the brakes or landing gear). To do this, open the Buttons: Basic tab of the Joystick & Equipment window. As you operate your joystick's buttons and switches you will see the box in the upper left corner change the number it displays. This indicates that X-Plane has received the input and is ready to assign that button/switch a function.

The instructions below reference only buttons. They apply, however, to switches too, though a switch can have a function assigned to both its "up" and "down."

To change a button assignment, simply operate that button on your joystick and then select the function that should be assigned to it by clicking on the circular toggle next to that function. For instance, in Figure 4.3, button 0 has been assigned to the "Toggle brakes regular effort" function. Repeat this operation for as many buttons as need functions assigned. Close the Joystick & Equipment window and the settings will be saved.

Note: You must select the desired button by pressing and releasing it *prior* to assigning it a function. If this is not done, the assignment of the last button pressed will be overwritten.

To assign a function to a joystick beyond what is available in the Buttons: Basic tab, you can use the Buttons: Adv tab to assign any command function available to a button. As in the other tab, simply press the button you would like to assign, click on the command you would like to assign that button in the right half of the screen, and close the window.

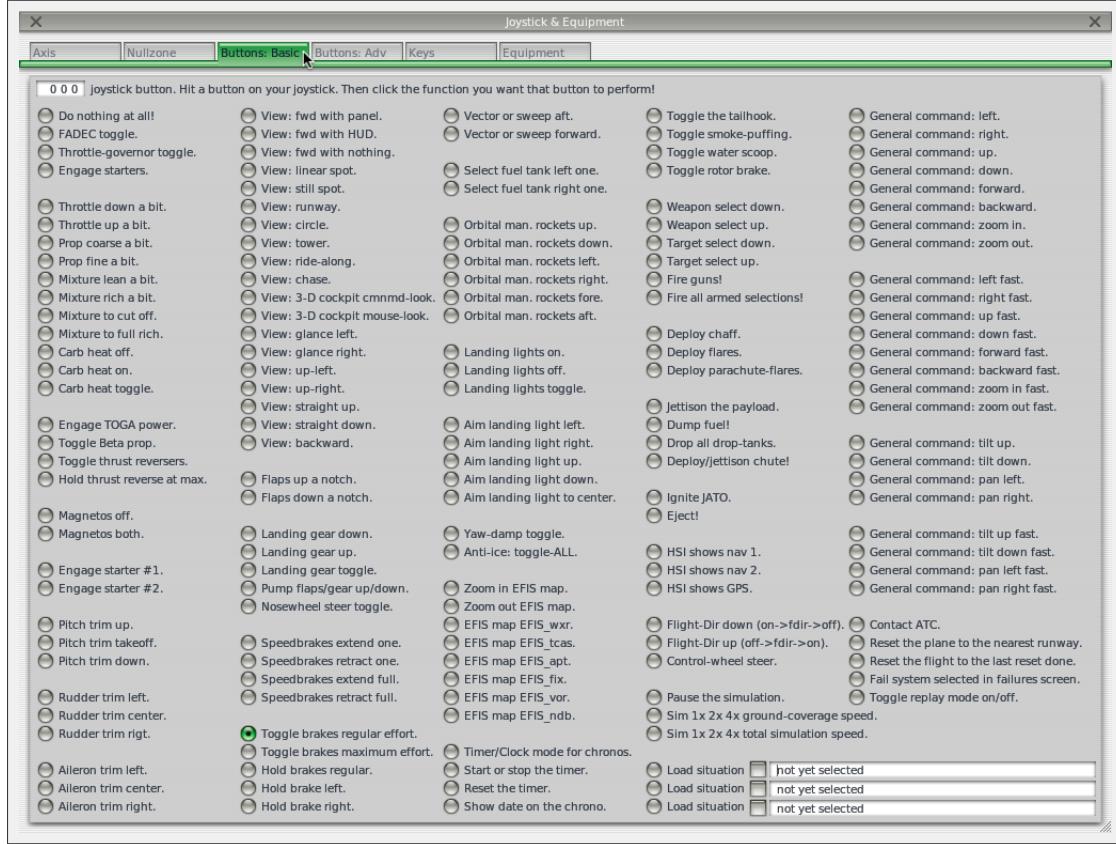


Figure 4.3: The Buttons: Basic tab of the Joystick & Equipment menu, with a button set to **Toggle brakes regular effort** [Full size →]

4.6.5 Controlling Joystick Sensitivity and Aircraft Stability

To modify the joystick's sensitivity or the stability of the aircraft, open the Nullzone tab at the top of the Joystick & Equipment screen. The three sliders in the upper right of this window control the response curves for the pitch, roll, and yaw axes of the joystick.

If these sliders are set all the way to the left, the aircraft's response to that axis' input will be completely linear. This means that a 50% deflection of the joystick will deflect the airplane's flight controls 50% of their travel. As these sliders are moved to the right the response becomes curved. In this case, a deflection of the joystick from center to its halfway point may only deflect the aircraft's controls by 10%. This will dampen any aircraft movements and desensitize the user's controls. Keep in mind, however, that in this case, the remaining 90% of the control surface deflection must take place in the last 50% of joystick movement. Thus, the controls will be dampened for the first half or so of their travel and then become hyper-sensitive for the remainder of their throw. This gives the user plenty of fine-tune control near the center of the flight control envelope to hold altitude and roll precisely, but still allows for full control authority at the extremes.

Try flying with the sliders in various different positions to see what setting works best.

In the upper left portion of the Nullzone screen is another set of sliders, labeled "stability augmentation." These control X-Plane's stability augmentation by damping the predicted forces acting on the aircraft's flight control surfaces. If these sliders are all the way to the left, then there is no stability augmentation of the aircraft. As the sliders are moved to the right, X-Plane will automatically add some stability augmentation to the aircraft, adding some elevator input to level

the nose, some aileron input to minimize the roll rate, and some rudder input to counter any aircraft yaw rates. In other words, the simulator will try to make the plane easier to fly by adding control inputs for the user. The downside, of course, is that as X-Plane adds stability, the aircraft becomes less responsive (and less realistic).

4.6.6 Setting Null Zones

Null zones determine how much the joystick must be moved before X-Plane actually starts to take action. A null zone may be set for each joystick axis to fine-tune how responsive the control surface inputs are, but this function is typically used to prevent hardware from “creeping” in flight or to ignore the constant jittering that many older controllers will send to X-Plane.

To set a null zone, first open the Nullzone tab of the Joystick & Equipment window. Now drag the **nullzone** slider (found in the lower half of the window) to the desired position; the higher the percentage, the larger the “dead zone” that does not affect the aircraft’s controls will be in the joystick’s input.

4.6.7 Adding Special Equipment

The final tab in the Joystick & Equipment window, labeled Equipment, is used to set up special equipment for use in X-Plane. This tab is generally used on multi-computer X-Plane configurations in professional, FAA-certified simulators or to tie in various GPS navigators (such as a real Garmin 96/296/396 or a 430 GPS radio). After being connected to the computer, this equipment should be set up per the manufacturer’s recommendations, then checked off on the Equipment screen to tell X-Plane that it is connected.

4.7 Configuring Keyboard Shortcuts

X-Plane has been designed to be both extremely flexible and easily usable. For this reason, most of the keys on the keyboard do something.

To see which keys are tied to which functions, first open the Joystick & Equipment dialog box by moving the mouse to the top of the screen, clicking Settings, and clicking Joystick & Equipment. There, select the Keys tab. In the Keys tab, you can look at the functions assigned to the keys of the keyboard.

There are two ways to change a key’s function here. The window has each key of the keyboard represented by a rectangular button (found on the far left of the screen), and it has that button’s function to the right of it. One way to program a key is to click one of the square buttons in the left-hand pane and select the function (found in the left-hand pane) that the key should control.

Functions are classified into a number of categories (operation, engines, ignition, etc.), found in the middle pane of this window. The functions themselves are found in the right pane of the window. Click on the radio button (that is, the small, circular button) beside the category you’re looking for, then click the radio button next to the function itself.

Alternatively, click the **Add New Key Assignment** button found in the bottom center of the window. This will add a new gray button at the bottom of the left-hand pane, labeled **NONE**. Click this button and press the key you would like to program. Next, find the function you’re looking for in the right-hand pane of the window and select it.

Note that it is not necessary to try and remember all of the keyboard shortcuts. Instead, many of them are shown in the menus when flying. For example, while in flight, move the mouse to the top of the screen and click the View menu to see each view (listed on the left) and the keyboard

shortcut it's assigned to (found on the right within a set of brackets). For instance, in the view menu, the “Forward with Panel” view has a “[w]” next to it, so it can be selected with the ‘w’ key.

4.8 Configuring the Rendering Options

X-Plane is a very advanced simulator that has been designed for use across a broad range of computers with varying specifications. As such, X-Plane offers the ability to change numerous settings to optimize performance on your computer. For this reason, this is one of the most critical portions of this manual. The Rendering Options window allows you to match X-Plane’s settings (and thus the demands the simulator puts on the computer) to your computer’s capabilities.

The simulator’s performance is measured in frames per second (FPS, or frame rate). This is how many times per second the X-Plane physics and rendering code (currently more than 700,000 lines of code!) can be run. Each time the computer runs through the program it advances the aircraft and recalculates the images that are seen (cloud formations, scenery, aircraft instruments, other aircraft, etc.).

Obviously, X-Plane has to be tremendously flexible to be able to run on a three year old computer and also take full advantage of the latest and greatest hardware available. There are two things that affect X-Plane’s frame rate: the computer’s capabilities and how much it is being asked to simulate (e.g., how much visibility is set, how many buildings, clouds, and other aircraft are being drawn, etc.). It will be much harder for the computer to compute images when flying an airplane in 30-mile visibility with 8,000 3-dimensional buildings and cloud puffs than it would be if X-Plane were set up with only two or three miles of visibility and no clouds. Thus, generally speaking, the higher the rendering options are set, the lower the performance and frame rate achieved.

The faster a computer can run X-Plane the more realistic and rewarding the simulation will be. Testing has shown that the human brain can separate individual frames at frame rates of less than about 20 FPS, causing the simulation to appear “choppy.” Coincidentally, this is also about the same place that the engineering behind the simulation begins to fall apart. For this reason, X-Plane has set the minimum operating speed at this level. If a computer is not capable of delivering a frame rate of 20 FPS while rendering the level of detail set up in the Rendering Options page, X-Plane will automatically introduce fog to help the simulation to run more smoothly. The fog keeps X-Plane from having to draw the world to as great a distance, allowing the simulation to run faster.

The Rendering Options dialog box is used to configure the level of detail in the simulator. This window can be found by moving the mouse to the top of the screen, opening the Settings menu, and clicking Rendering Options.

4.8.1 Setting the Basic Rendering Options

The broadest-reaching graphics settings are located at the top of the Rendering Options dialog box, in the section of the window labeled “Resolutions.” These include the texture resolution, the resolution of the window when in full-screen mode, the level of anti-aliasing, and more.

4.8.1.1 Texture Resolution

The **texture resolution** drop-down box determines the clarity and detail of the textures displayed in X-Plane. Textures are the image-maps that are draped over the terrain and aircraft to make them look realistic. If the **texture resolution** is set to low, the runway and terrain will look blurry and blocky. While this will not look very good, it will use very little video memory (VRAM), so a high frame rate will be more easily achievable. The more powerful a computer’s video card is,

though, the higher the texture resolution can be set in X-Plane without hurting the frame rate. The frame rate will be significantly impacted, though, if a texture resolution is selected that requires more VRAM than the computer's video card has.

You can easily determine how much VRAM is required to render the current scene. At the bottom of the Rendering Options dialog box is a line that reads "Total size of all loaded textures at current settings: *xxx.xx meg.*"

In most cases, this number will only be updated after X-Plane is restarted—that is, you cannot change the texture resolution, close the Rendering Options window, and reopen it to check the amount of VRAM used.

If your system has a video card with 512 MB of memory and the VRAM currently used is only 128 MB, then a higher texture resolution can be set without problems. This will cause the scenery, runway, and airplane to all look sharper and crisper. As long as X-Plane is not requiring more VRAM than the system's video card has, the simulation's frame rate will not be impacted. Note that if a texture resolution is set which requires substantially more VRAM than the video card has, the simulator's frame rate will be massively impacted as the computer begins to use system RAM to store textures—a very slow process.

Do not worry if the total size of all textures loaded is larger than the amount of VRAM in your system; in a perfect world, the VRAM used will be about equal to or a bit more than the VRAM of the system's video card. This will give maximum texture detail without overflowing the video card's memory and reducing the frame rate. Machines with faster graphics busses (like PCIe x16) will be less sensitive to VRAM use.

4.8.1.2 Gamma

The **gamma** setting controls the overall brightness of the dark parts of the X-Plane world. Versions of Mac OS prior to 10.6 Snow Leopard used a default gamma of 1.8, whereas newer versions of OS X, as well as all versions of Windows, use a default gamma of 2.2. Increase this by a small amount (0.1 or so) if X-Plane looks too dark.

4.8.1.3 Anisotropic Filtering

Anisotropic filtering is a bit complicated.

Imagine taking a photograph and looking at it from about two feet away, with your eyes directly above the image and perpendicular to it. Things are clear and sharp, right? Now imagine taking the same picture and rotating it 90° away from you so you're looking at the edge. Obviously, the image is no longer visible. Now rotate it back towards you 5 or 10°. You can just start to make out the image, but since you're looking at it from such a low angle, the picture is fuzzy and poorly defined.

This is analogous to looking at the X-Plane scenery from a low altitude on a clear day. The images directly in front of the aircraft will be relatively clear, but the closer the scenery gets to the horizon, the fuzzier the image becomes. The anisotropic filter helps to clear this fuzziness away, making the image clearer. This option has a minimal effect on most machines and a moderate impact on some machines. Try it out and see if you like it and if you can live with the performance penalty.

4.8.1.4 Full-Screen Resolution

The box labeled **run full-screen at this resolution**, when checked, will cause X-Plane to run in full-screen mode at the resolution you choose from the drop-down box. Selecting the "Default

Monitor Settings” will make X-Plane use the same resolution as your operating system. If you choose a resolution with a different aspect ratio than your monitor has, X-Plane will appear stretched. This would happen, for instance, if your monitor had a native resolution of 1920 x 1080 (a widescreen, 16:9 aspect ratio) and you selected a resolution of 1024 x 768 (a “standard” 4:3 aspect ratio).

4.8.1.5 Frame Rate Locking

The **frame rate lock to monitor** drop-down box allows you to steady the simulator’s frame rate by not allowing the frame rate to exceed a certain value. If X-Plane generally runs as a high frame rate on your computer, but does not do so smoothly and consistently, you can lock the frame rate to some ratio of your monitor’s refresh rate to keep the frame rate steady.

4.8.1.6 Anti-Aliasing

The **anti-alias level** parameter is used to smooth the edges of the objects drawn in the simulator. When a computer tries to draw diagonal lines across the finite number of rectangular pixels in a monitor, “jaggies” result—pixelated-looking, stair-stepped lines. These jaggies may be (somewhat) eliminated by turning on anti-aliasing. This will cause X-Plane to actually draw the simulated world several times per frame and blend those frames together, resulting in a better looking image. Thus, it is similar to using a higher screen resolution; running at a resolution of 2048 x 2048 without anti-aliasing is similar to running at 1024 x 1024 and 4x anti-aliasing. Both situations tax the video card with virtually no increase in CPU use. This will completely kill the simulator’s frame rate if the system doesn’t have a strong video card, but if the video card can take it, crank this option up.

Please note that in HDR rendering mode, standard anti-aliasing using this parameter is *not* recommended; it will impact frame rate without providing any real benefit—this is simply a function of the way the new deferred rendering system works. Since HDR rendering is really the way X-Plane 10 was meant to be seen (since it is the only mode where the beautifully realistic global shadows are available), the **anti-alias level** parameter should probably be left at “none.” Instead, use an HDR-specific method of anti-aliasing described in the section “Special Effects” below.

4.8.1.7 Field of View

The final of the basic graphics settings is the **lateral field of view**, found near the bottom center of the screen in the section of the window labeled “Special Viewing Options.” Older monitors with a 4:3 aspect ratio (corresponding to a resolution like 1024 x 768 or 1600 x 1200) probably want to stick to a 45° field of view. Widescreen monitors (those with an aspect ratio of, say, 16:10 or 16:9 and a resolution of, say, 1920 x 1080, 1600 x 900, and so on) may benefit from a wider field of view (60° or so).

4.8.2 Setting Up the X-Plane World

Many features of the X-Plane world are turned on or off using controls found in the portion of the window labeled “Stuff to Draw.” These are discussed below.

4.8.2.1 Miscellaneous Drawing Settings

When the box on the far left labeled **draw view indicator** is checked, you will see a small orange airplane in the top of the screen when you rotate your view left or right using the Q and E keys, respectively.

X-Plane can simulate orbital and sub-orbital flight using the Space Shuttle and other spacecraft. If the box labeled **draw hi-res planet textures from orbit** is checked, X-Plane will display high-resolution images of the Earth when simulating space flights. These high-resolution images will typically be displayed at altitudes of 100,000 feet or higher. This has no effect on frame rate except when flying above that altitude.

The **runways follow terrain contours** box should always be checked. This causes runways and taxiways to follow the elevation of the terrain upon which they are drawn. In some cases, the changes in elevation of the terrain may be very abrupt, which can make airport runways overly bumpy. Unchecking this box will cause X-Plane to flatten the terrain under runways to alleviate potential problems. This option has no effect on frame rate.

When the box labeled **draw forest fires and balloons** is checked, X-Plane will randomly generate forest fires, which can be put out after scooping up water in a water bomber such as the CL-415 Bombardier. It will also cause hot air balloonists to meander through the world when the weather is nice. This option has a negligible effect on frame rate.

Checking the box labeled **draw birds and deer in nice weather** will put randomly generated deer near the airport which may bolt across the runway and cause a collision. It will also generate very realistic-looking flocks of birds, each of which is modeled independently and has its own “mission.” Colliding with the birds will cause damage to the aircraft as well as engine failures and other things, just like in reality. This setting has only a marginal effect on frame rate.

The box labeled **draw aircraft carriers and frigates** will cause X-Plane to put boats and aircraft carriers in the water near your aircraft.

The box labeled **draw Aurora Borealis** will make X-Plane show the Aurora Borealis at night when in the North.

4.8.2.2 Objects on the Ground

The **number of trees**, **number of objects**, **number of roads**, and **number of cars** determine how many of each type of ground object are drawn. In general, the **number of objects** will have the greatest effect on the simulator’s performance. Each of these options are CPU-intensive; if you do not have a fast, multi-core CPU, you may want to leave them at the default.

4.8.2.3 World Detail Settings

The **world detail distance** controls how much detail to use when drawing objects and other things in the X-Plane world, as well as how far away that level of detail should be used. You should almost always use the “default” setting here, ensuring that what you see is what a scenery artist intended. Lowering this parameter may improve frame rate on slower computers, though.

The **airport detail** setting controls how much detail is used in drawing portions of the scenery at airports. It can have a significant impact on performance when flying near airports. The highest settings will ensure that you see all there is to see around an airport.

The **shadow detail** setting controls how realistic the shadows in the simulator are. “Static” shadows simply draw a flat, unchanging shadow of your aircraft on the ground below it. “Overlay” shadows vary the shadow cast by your aircraft on the ground by the position of the sun in the sky. “3-D on aircraft” shadows use X-Plane 10’s new shadow rendering to allow the aircraft to cast shadows *on itself* as well as on the ground; this would be most visible with a high-wing aircraft. “Global” shadows allow all objects, trees, etc. in X-Plane to cast shadows on everything else. Global shadows, of course, are much more difficult to render; they are both CPU- and GPU-intensive. The

degree to which your frame rate is affected by shadows will be a function of the number of objects you’re using; lots of objects combined with global shadows may massively impact your frame rate.

Finally, the **water reflection detail** controls how thoroughly water reflections are calculated using pixel shaders; it changes how many calculations the computer must do on each pixel in the water. This can have a significant impact on the simulator’s performance when near water.

4.8.2.4 Expert Rendering Options

Checking the **compress textures to save VRAM** box and restarting X-Plane may enable the simulator to use about twice the VRAM as before without overflowing the video card. However, doing so will cause some of the crispness and precision to be lost from textures. Try it out and see what happens.

The **3-D bump-maps** and **gritty detail textures** will make surfaces in X-Plane appear more realistic. They will have some impact on frame rate (they use both the CPU and some VRAM), but for most modern graphics cards, the benefits will certainly outweigh the small cost associated with them.

4.8.2.5 Special Effects

In X-Plane, fog is used to control the visibility. Thus, enabling the **draw volumetric fog** option creates a number of small, localized fog effects, causing the density to vary whenever X-Plane draws fog. The result is that objects and scenery fade into the distance in a much more gradual (and pleasant) way than they otherwise would. On some computers, this can have a significant effect on frame rate, but for newer machines, the benefits significantly outweigh the costs.

The checkbox labeled **draw per-pixel lighting** toggles pixel shaders. Using pixel shaders allows X-Plane to add 3-D lighting on a per-pixel basis, to incredible effect. Rather than having the simulator tell the graphics card how to light an area, the graphics card determines it in real time, creating a very realistic image. If you have an older graphics card, this can have a large effect on frame rate.

HDR rendering is the new method X-Plane 10 uses for drawing the world. It allows an unlimited number of light sources, resulting in very convincing shadows across the whole world. If you have a newer graphics card (one that supports DirectX 10 or later), you will probably love using this effect; as this option is GPU-intensive, however, if you have an older graphics card, you may want to avoid it.

With HDR rendering on, two new rendering options become available: **atmospheric scattering** and **HDR anti-aliasing**. Enabling the **atmospheric scattering** option causes objects that are far away to appear more washed-out, just as they do in the real world. Once again, this shouldn’t have a great impact on frame rate on newer computers. The **HDR anti-aliasing** setting allows for more effective means of smoothing otherwise jagged lines than the older **anti-alias level** control. The “FXAA” version of HDR anti-aliasing is both high quality and computationally inexpensive, so it is recommended for almost all users. The “4xFSAA” version, on the other hand, simply has the graphics card draw the image at four-times the normal size, then scale it down. This will have a much greater impact on frame rate than FXAA.

4.8.2.6 Cloud Effects

The clouds in X-Plane can be configured in a number of ways. X-Plane’s 3-D clouds are generated from many smaller cloud sprites, or “puffs.” They give the appearance of a true, volumetric cloud,

which can be flown through or around. They also develop over time, just as in real life, depending on weather conditions.

The **number of cloud puffs** slider sets the number of cloud puffs. Increasing the number of puffs will have a significant impact on frame rate. Be careful with this one.

The **size of cloud puffs** sets the size of each cloud puff. The larger the size of cloud puffs, the slower X-Plane will perform, although this may not be too noticeable on modern video cards.

4.8.3 Setting the Rendering Options for Best Performance

The following procedure will allow you to optimize X-Plane's performance for your computer, regardless of the power of that computer or any limitations it may have.

Before we begin, we will need to be able to tell how fast X-Plane is running on your computer. To do this, launch X-Plane and:

1. Move your mouse to the top of the screen (causing the menu to appear) and click Settings, then Data Input & Output.
2. Check the far right box next to **frame rate** (item 0, in the upper left corner of the window). This will cause X-Plane to display the current frame rate in the upper left of the screen during flight.
3. Close the Data Input & Output window (either with one of the Xs in the corners of the window or with the Enter key on the keyboard). You should now see how fast the simulation is running, in the **freq / sec** output on the far left. This is the current frame rate, given in frames per second (fps).

Note that the frame rate will change depending on what is happening in the simulation. It is not uncommon for a computer to output 50 fps while sitting on an empty runway, but drop down to, say, 30 fps when rendering lots of buildings, other aircraft, etc.

Refer to the following to determine the significance of this number.

- 19 fps is terrible and barely adequate to run the simulator.
- 25 to 35 fps is the ideal range. Higher frame rates indicate the computer isn't rendering with as much detail as it could.
- 50 fps is very high and indicates that the system could probably draw more buildings, clouds, and other objects. Studies have shown that starting at about 50 frames per second, your subconscious mind forgets that you are looking at a simulator and begins thinking you are actually flying.

4.8.3.1 Increasing the Frame Rate

If the simulator's frame rate isn't as high you would like, you can raise it by following the instructions below. We recommend following these instructions in order, checking the frame rate after each major change until you find settings that give an acceptable frame rate.

Changing Texture Quality If your graphics card has too little VRAM for the textures X-Plane is loading (a very real possibility in Version 10), you may see a huge drop in frame rate. To correct this, try the following.

1. Move the mouse to the top of the window, making the menu bar appear, and click Settings, then click Rendering Options.
 2. The **texture resolution** drop-down menu determines how much video RAM (VRAM) the computer will use. If your graphics card has plenty of VRAM, you can set it as high as you want with no loss in frame rate, but as soon as the texture resolution requires more VRAM than the graphics card has, the simulator's frame rate will plummet.
 3. To determine how much VRAM is being used at the current settings, look at the very bottom of this window. The last line reads "Total size of all loaded textures at current settings: xxx.xx meg."
- While it is in some cases possible to load more textures than can be stored in VRAM without a performance hit (as not all textures will be used all the time), the size of the loaded textures should not be significantly greater than the VRAM on the system's video card.
4. Lower the texture resolution if the current settings require much more VRAM than your video card has.

After changing the texture resolution, X-Plane must be restarted for the change to take effect. We recommend putting the texture resolution on its lowest setting, exiting the sim, restarting it, and noting the frame rate. From there, raise the texture detail up one level and repeat until the frame rate decreases. This is the point at which all of the video card's RAM is being used. Back the texture resolution off to one level lower than where the decrease was noted and restart X-Plane one more time.

If, after restarting X-Plane, your frame rate is still low, you may want to disable some of the newer features of the X-Plane renderer, such as HDR rendering and global shadows.

Disable HDR Rendering, Simplify Shadows, and Lower Water Reflections The latest rendering features in X-Plane 10 (HDR rendering, global shadows, and water complex water reflection) can be very costly on older computers. HDR rendering is potentially quite GPU-intensive, and global shadows and water reflections are both CPU- and GPU-intensive. Therefore, if you are having issues with the frame rate, should be some of the first options to go.

Uncheck the **HDR rendering** option (located in the Special Effects portion of the window). Next, set the **shadow detail** (located in the Stuff to Draw portion of the window) to either "overlay" or "3-D on aircraft." Finally, set the "water reflection detail" to "none." Restart X-Plane, and you should see a dramatic rise in frame rate. If, however, the frame rate is still unacceptable, you may need to change the resolution as well.

Changing the Resolution The screen resolution refers to the number of pixels that X-Plane must fill. The lowest available (and default) resolution is 1024 x 768. Increasing the resolution will cause a drop in frame rate if your graphics card is not powerful enough.

When using X-Plane in windowed (i.e., not full-screen) mode, simply dragging the window size down will lower your resolution. When using X-Plane in full-screen mode, open the Rendering Options by moving the mouse to the top of the screen, clicking Settings, then clicking Rendering Options. Since the **run full-screen at this resolution** box must be checked for full-screen mode, you can use the drop-down menu to the right of that box to choose a lower resolution. Try 1024 x 768 first to see if lowering the resolution does indeed improve your frame rate. Note, however, that choosing a resolution different from the resolution set in your operating system may cause X-Plane to display a black border around the simulator.

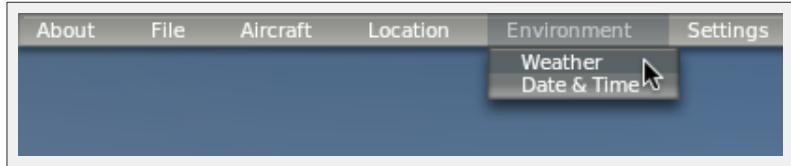


Figure 4.4: Selecting the Weather option from the Environment menu [Full size →]

Optimizing Other Rendering Options A few more rendering options are very important in getting the best performance in X-Plane on your computer. Once again, to modify the rendering options, move your mouse to the top of the screen, click Settings, and click Rendering Options.

On most computers, the rendering options with the greatest impact on performance are the **number of objects**, **number of roads**, and **number of cars**, simply because these are CPU-limited rather than being GPU-limited. These settings have a *huge* impact on frame rate. Set them to **none** for the most speed, then restart X-Plane for the changes to take effect. Check the frame rate, bring both settings up one level, and repeat, restarting the simulator each time to see how performance is affected. Setting these options to higher levels will look much nicer but will negatively impact the X-Plane's frame rate.

Another important factor for X-Plane's performance is the **world detail distance** setting. This setting determines how far away from your aircraft the simulator's 3-D objects will be rendered in high quality. Doubling the detail distance will cause X-Plane to draw *four times as many* objects. This is due to the fact that, from the aircraft's point of view, the number of objects rendered will grow in all directions equally. You may want to change this from **default** to **low** if frame rate is at issue.

Higher values in the **airport detail** field will give, among other things, nice 3-D runway lights, center line lights, and runway edge lights instead of simple, bodiless spots of light. These effects contribute to a very authentic look for airports, but since these are only visible near the ground, you may find the default value an acceptable compromise; lowering this setting can improve performance significantly.

Modifying Cloud Rendering and Visibility Another group of settings that can be modified for performance are the weather effects.

The number of "puffs" in each of X-Plane's clouds can significantly affect performance. To get a boost in frame rate, first open the Rendering Options as described above. There, drag the **number of cloud puffs** slider down, perhaps to 10%.

A further increase in frame rate can be obtained by drawing only a few simple clouds, with relatively low visibility. To set this, do the following:

1. Bring down the menu as above and click Environment, then Weather, as shown in Figure 4.4.
2. Select the radio button labeled "set weather uniformly for the whole world," located near the top of the screen.
3. Using the three cloud drop-down menus (found in the upper left of the screen, and pictured in Figure 4.5), set the cloud types to "clear" or "cumulus overcast" for max frame rate. For a good frame rate, set them to "thin cirrus" or "stratus." "Cumulus scattered" or "cumulus broken" take a lot of computing power to display.

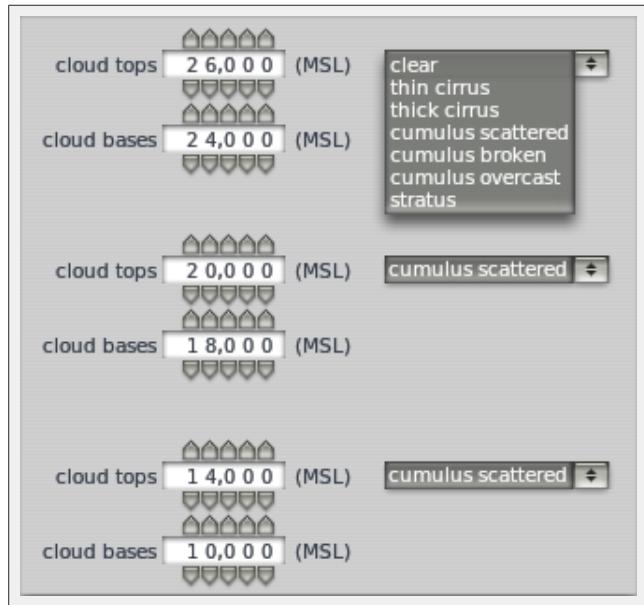


Figure 4.5: Setting the cloud coverage for the whole world [Full size →]

- Set the visibility (found on the left side of the screen) to about five miles or so. Higher visibility takes more computing power because the computer has to calculate what the world looks like for a much larger area.

Changing the Number of Other Aircraft The final setting that really impacts the simulator's frame rate is the number of other airplanes. Access this by moving the mouse to the top of the screen, clicking Aircraft, then selecting Aircraft and Situations. In the dialog box that appears, go to the Other Aircraft tab.

There, the **number of aircraft** setting (found in the upper left of the screen) should be set to one for maximum speed. This means X-Plane will only have to calculate physics on your aircraft, providing a significant speed increase on slower CPUs.

With that done, your performance should be optimized, and you're ready to fly.

4.9 Configuring the Sound

To configure the sound, move your mouse to the top of the screen and click Settings, then Sounds. The dialog box that appears allows you to configure the relative volumes of all sounds in X-Plane using the sliders on the right side of the window. On the left side, sounds can be turned off by category. By default, all sounds are enabled, with volumes set at 100% (sliders fully to the right).

The bottom of this window will also check the status of speech synthesis software. If the software is not installed on Windows, download the Microsoft Speech SDK 5.1.

4.10 Allowing X-Plane through Your Firewall

Some features of X-Plane require that X-Plane be able to communicate across your network. These features include:

- networked multiplayer flights,

- multi-computer simulations,
- integration with EFIS App for iPad, and
- integration with X-Plane Remote.

In order for your computer to “see” the other computers in the situations above, you must first allow X-Plane to communicate through your firewall. If your computer is not running a firewall, of course, this is of no concern to you.

To allow a program through the firewall in Windows XP, follow Microsoft’s instructions in Knowledge Base Article 842242.

To do this in Windows Vista and Windows 7,

1. Open Windows Firewall by clicking the Start button, clicking Control Panel, clicking Security, and then clicking Windows Firewall.
2. In the left pane, click **Allow a program through Windows Firewall**. If you are prompted for confirmation, click **Allow**.
3. (Windows 7 only:) Click **Change settings**, then click **Allow** if asked for confirmation.
4. Select the check box next to X-Plane, and then click **OK**.

To allow X-Plane through the firewall in Mac OS,

1. Open **System Preferences** from the **Apple** menu.
2. Click Security (called Security & Privacy in OSX Lion).
3. Click the Firewall tab.
4. Unlock the pane by clicking the lock in the lower-left corner and enter the administrator username and password.
5. Click **Advanced...** to customize the firewall configuration.
6. Click the + (plus) button, then select your copy of X-Plane.app. This is found in the X-Plane 9 or X-Plane 10 installation directory, which is located by default on your desktop. With X-Plane selected, click **Add**.

4.11 Expanding X-Plane

X-Plane can be modified in a number of ways. You can add aircraft or custom scenery, or you can download plug-ins that can radically alter the functionality of the simulator. If you don’t find the aircraft, scenery, or plug-ins you’re looking for, you can create your own with a bit of programming know-how. The X-Plane Wiki has a wealth of information on creating both scenery and aircraft, and the X-Plane SDK site has documentation on developing plug-ins. The Plane Maker manual will prove especially useful for users creating aircraft files.

4.11.1 Adding Aircraft

Perhaps the easiest place to find new aircraft is the X-Plane.org “Download Manager” page. All the aircraft in that section of the site are free, though X-Plane.org does have models (some of which are very, very good) for sale. Other noted sources of high-quality, payware aircraft are the folks at X-Aviation, as well as Jason Chandler of AIR.C74.NET.

When downloading a custom aircraft, it will typically be in a compressed folder (usually a ZIP file) that contains the airplane and all its various paint jobs, airfoils, custom sounds, and instrument panels. Once the compressed folder is downloaded, you should be able to double-click on it to open or expand it on Macintosh, Windows, or Linux boxes.

From here, the folder can be expanded out into the Aircraft folder within X-Plane 10 directory, or the files within can be dragged and dropped into the Aircraft folder. Be sure to place the new aircraft files in a folder with the name of the aircraft—for instance, for a newly downloaded Piper J-3 Cub, the folder path in Windows might look like this:

```
C:\Documents and Settings\User\Desktop\X-Plane 10\Aircraft\Piper Cub\
```

With the new aircraft in the proper directory, open up X-Plane. Move the mouse to the top of the window (causing the menu to appear). Click Aircraft, then click Open Aircraft. Find the file there and double click on it to load.

Of course, users can also upload their own aircraft to X-Plane.org and similar sites. To do so, first create a custom airplane (using Plane Maker) with airfoils, panels, sounds, etc., per the Plane Maker manual. All the files making up the aircraft then need to be compressed into a ZIP folder to be uploaded to the Internet.

To compress a folder in Windows, right click on the file containing all the files needed for the plane, move the mouse down to Send To, then click “Compressed (zipped) Folder.” A new .zip file will appear in the directory.

On the Mac, right-click or control-click (that is, press the Ctrl key on the keyboard while clicking with the mouse) on the aircraft folder in Finder. In the resulting menu, click “Compress [file or folder name]” to make a compressed ZIP archive of that aircraft.

These custom aircraft may be uploaded and shared (or sold) at will. We place no copyright restrictions of any sort on aircraft made by users with Plane Maker.

4.11.2 Adding Scenery

Custom scenery packages, too, can be found on the “Download Manager” page of X-Plane.org, among other places. These may be downloaded and installed at will. Typically, custom scenery packages will need to be unzipped into the X-Plane 10\Custom Scenery folder. Additionally, the XAddonManager utility may be helpful for managing a large amount of custom scenery or downloaded objects.

To create new custom scenery, use the World Editor tool (WED), downloadable from the Scenery Tools page of the X-Plane Wiki. A good number of tutorials for the tools can be found in the Scenery Development section of the X-Plane Wiki.

4.11.3 Installing Plug-Ins

Plug-ins are little programs that let the user modify X-Plane. People write plug-ins to do all sorts of interesting things like hang weights on the dashboard that move around accurately, run little tugs around to push your airplane on the ground, or draw interesting terrain visualization systems, among other things. Once again, X-Plane.org (and specifically the Downloads > Utilities page) is a good place to go to find various plug-ins and other things to tweak your copy of X-Plane.

For information on creating custom plug-ins, see the X-Plane SDK site.

Chapter 5

Flight in X-Plane

X-Plane, of course, is a flight simulator. A typical flight consists of some, if not all, of the following steps:

- choosing an aircraft,
- going to a location (either an airport's runway, a location some distance out from an airport in order to make an approach to the airport, or a random location),
- setting the weather and time of day, and
- actually flying.

In addition, you might take advantage of a number of features of the simulator either before or during a flight. These include using instruments in the aircraft's panel, switching your view of the aircraft, visualizing your flight (either on a 2-D map or in 3-D), and creating files to share your flight with others.

5.1 Setting Up a Quick Flight

As of X-Plane 10.10, the first thing you see when you launch X-Plane (unless you disable it) is the Quick Flight screen, as seen in Figure 5.1. This screen combines miniature versions of the dialogs which are used to open aircraft, choose an airport, and set up the weather.

Choose an airport from which to take off by using the upper-left box in this window. You can either type the airport's name or identifier in the text box to search for it, or scroll through the full list. Click on an airport to select it.

To the right of the airport selection is a box displaying your X-Plane directory. This is used, in combination with the "cover flow"-like view in the bottom left of the window, to select an aircraft. By selecting the X-Plane 10 folder, or the Aircraft folder, you will be able to scroll through all the aircraft you have installed. Clicking on a more specific folder will expand it, and the cover flow view will show you only the aircraft in that folder. The frontmost aircraft in the cover flow is the one which is selected.

Set the time of day and weather using the rightmost boxes. Click on one of the rectangular panels to select the time of day and weather conditions shown in that panel. By checking the **always track real date and time** box will make the time in the simulator match your computer's time. Checking the **use real weather** will cause X-Plane to occasionally download the real-world weather in your aircraft's location.

Finally, when you've finished setting up the flight, press the **Fly with these options** button.

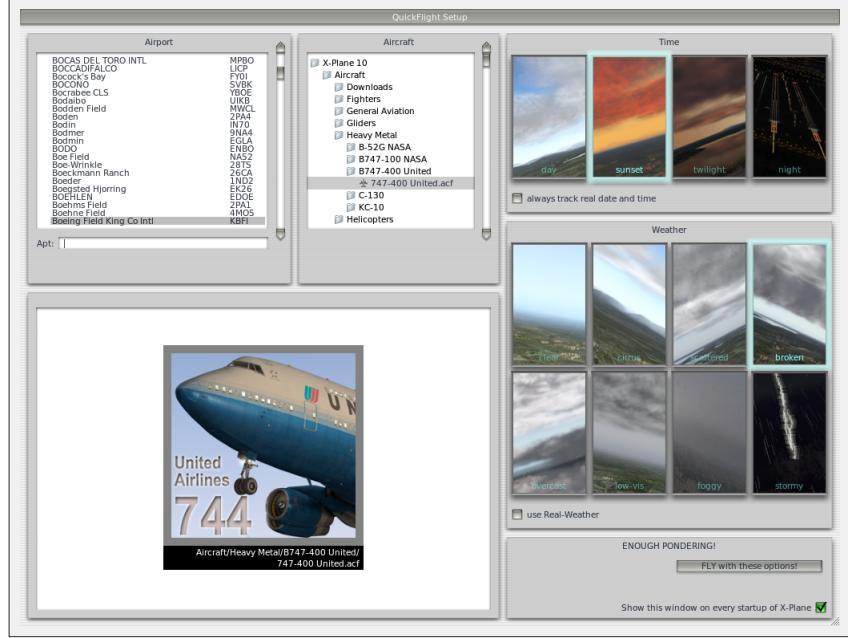


Figure 5.1: Setting up a quick flight upon launching X-Plane [Full size →]

To set up a quick flight in the future, bring down the menu by moving your mouse to the top of the screen, click File, and click Quick Flight Setup.

5.2 Opening an Aircraft and Selecting a Livery

When launching X-Plane for the first time, the default airplane will be loaded. After that, X-Plane will load the aircraft that was being used the last time you quit the program.

To open an aircraft in X-Plane:

1. Move your mouse to the top of the X-Plane window, causing the menu to appear.
2. Click Aircraft, then click Open Aircraft.
3. The Open Aircraft dialog appears, as seen in Figure 5.2. In the left half of this dialog box is a display of the X-Plane directory and its subfolders. To the right is a “cover flow”-type display of all the aircraft contained in whichever directory is selected in the left-hand pane. You can scroll through this cover flow view using your mouse’s scroll wheel—whichever aircraft is foremost in that view is the one selected.
4. Select an aircraft, either by clicking its folder and the corresponding “.acf” file in the left-hand pane, or by scrolling to it in the right-hand pane.
5. With an aircraft selected, you can change its livery (i.e., its paint scheme) by clicking the bullets in the lower right pane in this window.
6. Once you’ve selected the aircraft and livery you’d like, click the **Open Aircraft** button.

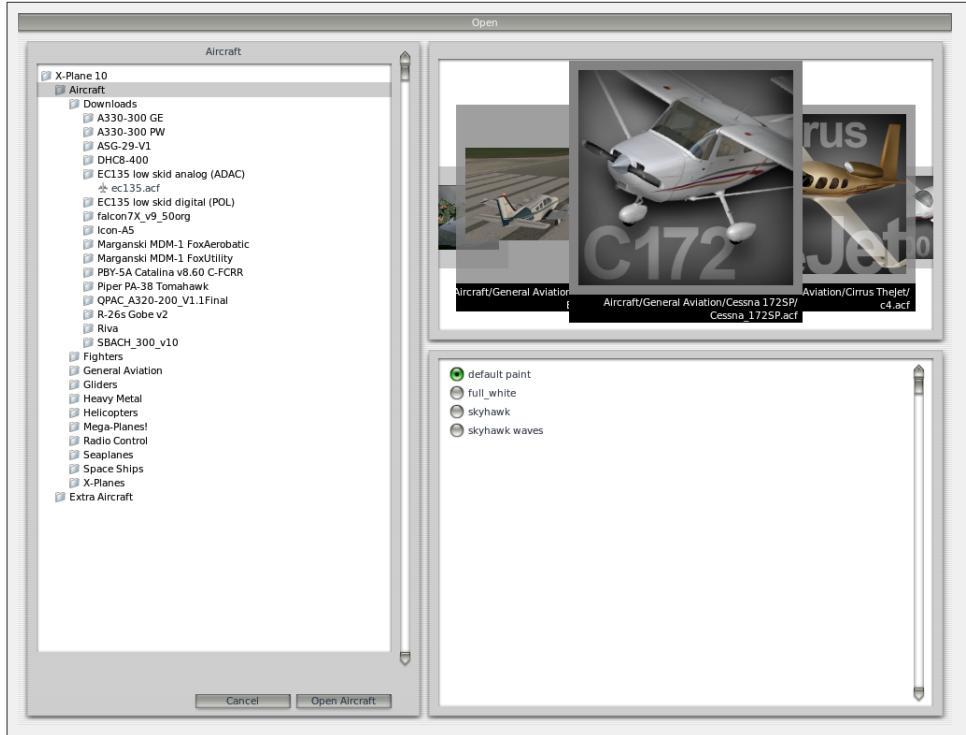


Figure 5.2: Selecting the Open Aircraft dialog from the Aircraft menu [Full size →]

5.3 Choosing an Airport or Location

X-Plane's aircraft can be relocated to virtually any airport on Earth. It can place your aircraft on a runway or apron, or it can start you in the air on a 3 or 10 nautical mile approach to a runway.

To select an airport, first move your mouse to the top of the screen, causing the menu to appear. Click on the Location menu, then click Select Global Airport. In this dialog box, you can search by name or ICAO identifier through the complete X-Plane airport database. This represents nearly every airport on the planet (currently more than 32,000).

The Select Airport dialog box is divided into three parts. In the top left is a listing of every airport name, arranged by airport name, with the airport's identifier listed to the right. To the right of the list pane is an overhead view of the currently selected airport's layout. The bottom half of the window displays rows of "quick start" buttons. The buttons in the "Takeoff" column (on the far left) will transport the aircraft to the specified runway. To the right of these buttons are the "Final Approach" buttons, which will transport the aircraft to the specified distance away from the runway on the button's left. Finally, the "Ramp Start" buttons will transport the aircraft to the specified ramp for takeoff.

To search the available airports, type either the airport name or the airport ID into the white box below the list pane (labeled "Apt:"). For instance, you could obtain the same results by searching for "KLAX" or "Los Angeles Intl." You could even just type "Los Angeles" and scroll through the results.

Alternatively, use the up and down arrows on the keyboard to move through the full list. To travel to an airport, click on it once in the list pane to highlight it (causing a grey box to appear around it), then click the **Go to This Airport** button.

Note that if the aircraft is moved to an area that does not have any scenery installed, it will

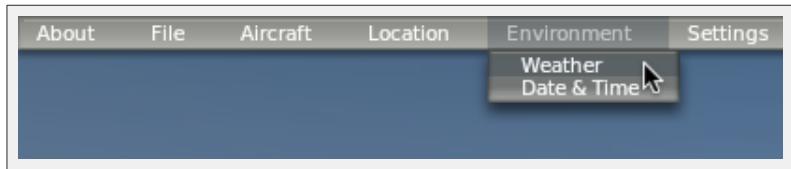


Figure 5.3: Selecting the Weather option from the Environment menu [Full size →]

end up on a runway which is hovering above the ocean down below. This is referred to as “water world” and it is covered in detail in Appendix F, Water World.

For a full explanation of the airport identifiers used in X-Plane, see the X-Plane Airport and Navigation Data site’s FAQ for X-Plane Users.

5.3.1 Other Ways to Choose a Location

You do not have to choose a location for your flight using the list of world airports. You can have X-Plane choose a random location near you by moving the mouse to the top of the screen, clicking Location, and selecting Get Me Lost. You can also choose a location visually from the 3-D globe by selecting the Planet Map from the Location menu. The controls in the bottom right corner of this dialog box move your view of the globe as follows.

The large round button spins the globe up, down, left, or right, depending on where along its edge the button is clicked. The buttons below this each have two small triangles. On the left is the button to zoom out, and next to it (labeled with two larger triangles) is the one to zoom in. Below the zoom buttons is the **center on acft** button, which, when clicked, centers the map view on the aircraft.

Clicking a location on the planet map will transport the aircraft to the airport nearest where the map was clicked. To close the window without relocating the craft, click one of the Xs in the top corners or press the Enter key.

5.4 Changing the Environment

The X-Plane environment consists of weather, time of day, and date, each of which can be modified at will.

5.4.1 Setting the Weather

X-Plane’s weather simulation is highly configurable and remarkably realistic. Weather in X-Plane can be set in four ways. The first, and most complicated, is to simply set the weather uniformly (and statically) for the whole world. This is the way most people set the weather in older versions of X-Plane. New in Version 10 is the ability to set randomly generated, highly plausible weather patterns based on a few parameters such as cloud coverage, intensity, and temperature. Using a similar system, you can manually “paint” weather patterns using the mouse, indicating where you want cloud systems to be. Finally, you can download the real-world weather from the Internet and have X-Plane reproduce it.

To edit the weather settings, bring down the menu by moving the mouse to the top of the screen. Click Environment, then click Weather, as in Figure 5.3.

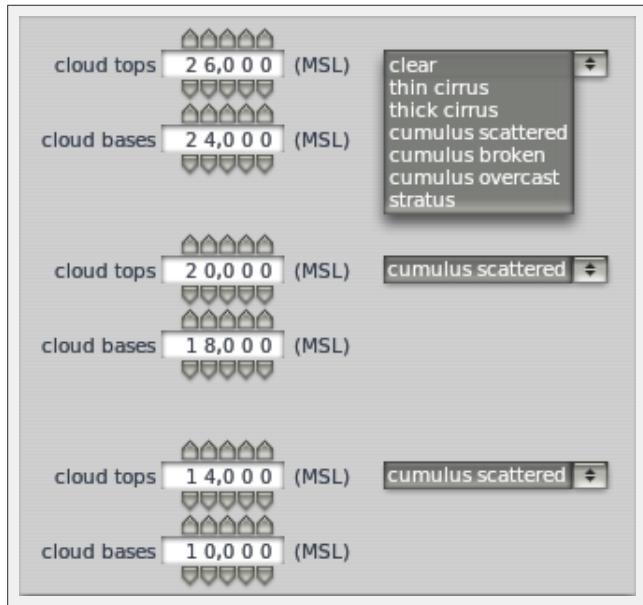


Figure 5.4: Setting the cloud coverage for the whole world [Full size →]

5.4.1.1 Setting Uniform, Static Weather for the Whole World

To set static weather for the world, first open the Weather dialog box from the Environment menu. There, select the large radio button at the top of the window labeled “set weather uniformly for the whole world.” Here, there are portions of the window devoted to clouds, wind, precipitation, thermals, and water conditions.

In the upper left of the window, cloud types as well as the top and base levels for three different cloud layers can be set (as seen in Figure 5.4). These heights are measured in feet above mean sea level (MSL).

The pane below the basic cloud configuration has a number of buttons, labeled **cat-III**, **cat-II**, **cat-I**, **n-prec**, and so on. These are quick-set buttons, and pressing them will automatically set some general weather conditions.

- **Cat-III** sets the weather up for a Category-III ILS approach. These are extremely low instrument conditions, with basically zero ceiling and visibility.
- **Cat-II** sets the weather up for a Category-II ILS approach, with terribly poor ceiling and visibility.
- **Cat-I** sets the weather up for a Category-I ILS approach, with poor ceiling and visibility.
- **N-prec** sets the weather for a non-precision approach, with a 3 mile visibility and a 400 foot ceiling.
- **MVFR** sets the weather marginal VFR flying conditions, with about four miles of visibility and a 1,500 foot ceiling.
- **VFR** sets the weather to good visual flight rule conditions—clear, sunny skies.
- **CAVOK** sets the weather to clear and visibility OK. Typically pilots refer to this as “CAVU”—Clear And Visibility Unlimited.

Below the quick-set buttons is a set of sliders. Click these and drag them to change their setting. The **visibility** slider adjusts what its name suggests, measured in statute miles.

The **precipitation** slider sets the level of precipitation. Depending on the temperature around the airplane and in the clouds where it is formed, this will be in the form of rain, hail, or snow.

The **thunderstorms** slider adjusts the tendency for convective activity. The weather radar map in the lower-right of the window shows where the cells are forming. Flying into these cells results in heavy precipitation and extreme turbulence. The turbulence is great enough that in reality, airplanes can fly into thunderstorms in one piece and come out in many smaller pieces.

Taking helicopters into these icing and thunderstorm situations is interesting because their very high wing-loading on their rotor and the fact that the rotor is free teetering causes them to have a pretty smooth ride in turbulence. They are still not indestructible, though, and they are subject to icing on their blades just like an airplane.

The **turblnc** (turbulence) slider automatically sets all the sliders in the center of the screen that control the wind and turbulence. Drag this slider down to the left and hold it there for a few seconds to set all of the wind and turbulence to zero for a smooth flight.

Next, in the bottom left corner of the window, the temperature at the nearest airport and the barometric pressure (air pressure) at sea level can be set. Keep in mind that the “standard atmosphere” is 59° F (15° C) and 29.92 inches mercury (1013 millibars).

The middle column of this window controls three wind layers. Each layer has an altitude, wind speed, shear speed, shear direction, and turbulence associated with it. X-Plane will use the high, middle, and low altitude settings to interpolate between the layers. The circles to the right of each altitude setting change the direction from which the wind is coming. Click and drag near the edge of the circle and the wind will come from the direction that you let go of the mouse button (for instance, for wind moving from the south to the north, click the very bottom of the circle and release the mouse button there).

Enter the **thermal tops**, **thermal coverage**, and **thermal climb rate** in the upper right of this window. These controls are mainly used when flying gliders. In addition to thermals, X-Plane also runs air up and down the terrain as wind blows into mountains, simulating the effects that real glider pilots have to keep in mind and try to take advantage of. Try setting the wind at 30 knots or better at a right angle to a mountain range and running along the upwind side of the mountain range in a glider—you should be able to stay aloft on the climbing air if you stay pretty low. Drift to the downwind side of the mountain, though, and an unstoppable descent is assured!

The **runway conditions** drop-down box is found on the right side of the window, directly beneath the thermal controls. Conditions can be set to **clean and dry**, **damp**, or **wet**, and wet and damp conditions can be either patchy or uniform. At low enough temperatures, as in real life, a wet runway will become an icy one. This control is automatically modified when increasing the amount of precipitation.

Beneath the **runway conditions** is the wave height and wave direction for bodies of water. Changing the wave height, in feet, will also modify the wave length and speed.

Finally, beneath the runway conditions is a visual representation of the weather X-Plane generated based on your parameters. Clicking the **Regenerate weather now** button will cause X-Plane to generate a new weather system with those same parameters.

5.4.1.2 Setting Randomly-Generated, Realistic Weather

By far the simplest way of generating weather is to use weather that you exercise only a small degree of control over. In this case, X-Plane creates a weather system with some amount of uncertainty in it, allowing you some control over the features of the weather system without bogging you down in the details.

To use this randomly generated weather, first open the Weather dialog box from the Environment menu. There, select the large radio button at the top of the window labeled **set random and only semi-controlled weather patterns**.

In the left side of the window now are five sliders. These are as follows:

- **Coverage**, which controls the amount of cloud coverage in the weather system. With the slider all the way to the left, there will be no clouds at all; with it all the way to the right, there will be full cloud coverage.
- **Intensity**, which controls the degree of storminess to the weather system. With the slider all the way to the left, there will be no storms, whereas with it all the way to the right, there will be a great deal of storms.
- **Temperature**, which controls the probability of encountering icing or thunderstorms. With the slider all the way to the left, the weather will be very cold, with a high probability of icing. With it all the way to the right, the weather will be hot, with a higher probability of encountering thunderstorms.
- **System size**, which sets the size of the weather systems in the area. With this all the way to the left, there will be many small systems. With it all the way to the right, there will be only a few large systems.
- **Randomness**, which controls how closely the weather matches the parameters you set. With this all the way to the left, it will match very closely to what you specified. With it all the way to the right, the incidence of random changes is greatly increased.

After setting the sliders as you want them, click the **Regenerate weather now** button to have X-Plane create a weather system with those characteristics. Close the Weather window and you'll be ready to fly.

5.4.1.3 Drawing or Adding to Weather Patterns by Hand

You can add to an existing weather pattern, or create a completely new one, using your mouse to specify the location and intensity of clouds.

To do this, open the Weather window from the Environment menu and select the large radio button in the top of the window labeled **paint weather patterns by dragging the mouse**.

Here, the largest pane in the window represents the airspace around your aircraft. You can click and drag anywhere in this box to have X-Plane randomly generate clouds there. Drawing clouds twice in the same area will increase the intensity of the clouds there. Finally, at any time, you can click the **Clear weather** button to clear all weather features in your area.

When you've finished drawing the weather patterns, close the Weather window and you'll be ready to fly.

5.4.1.4 Downloading Current Real-World Weather from the Internet

The final method of setting the weather in X-Plane is to download the weather from the Internet. To enable this, first open the Weather dialog box from the Environment menu. There, select the large radio button at the top of the window labeled **grab real weather from the net**. Check the box labeled **Download Real Weather file ‘METAR.RWX’ from the net**. X-Plane will automatically download the weather in your current location, and it will set a timer to re-download

weather in one hour. If you want to download weather at some other time, you can always come back to this window and press the **Download right now** button.

5.4.2 Setting the Date and Time

The date and time in X-Plane can be set by first moving the mouse to the top of the screen (causing the menu to appear), clicking Environment, then clicking Date & Time. Dragging the top slider changes the time, given as both local and Zulu time (that is, Greenwich Mean Time or UTC). Changing the date, the second slider, will accurately track changes in the length of days and nights within X-Plane. For instance, there are fewer daylight hours in December than in June in North America, as in the real world.

If the local time offset from GMT in your location is not what X-Plane expects, you can modify it using the **correction from GMT**, measured in hours.

Finally, you can check the **always track real date and time** box to keep X-Plane in sync with the date and time set in your operating system.

5.5 How to Fly

When flying for the first time (both in X-Plane and the real world), it's a good idea to use a relatively simple aircraft. The Cessna 172 is an excellent choice in this regard, a fact attested to by the millions of real-world pilots trained in this model. For instructions on opening an aircraft, see the section "Opening an Aircraft and Selecting a Livery" of this chapter.

Before beginning, be sure you have configured your flight controls, if applicable, per the section "Configuring Flight Controls" of Chapter 4. If you are not using flight controls, you will have to fly with the mouse. In this case, there will be a small white plus sign (+) in the center of the screen. If only this cross is visible, with no white box around it, X-Plane is indicating that the pilot's "hand" is not on the stick. This means that the mouse is free to move anywhere without impacting the flight controls. To grab the stick (and thus take control of the aircraft), click the left mouse button in the vicinity of the little white cross and a white box will appear around the cross. The mouse button should not be held down, only clicked once to turn the box on (i.e., to grab the stick) and again to turn the box off (to release the stick). When the box is visible, the pilot's hand is on the stick and any movements of the mouse within the box will position the flight controls accordingly. Thus, moving the mouse directly below the cross will command some up elevator (causing the plane to climb) and not will not impose any roll commands (which should keep the aircraft from changing its bank). Likewise, keeping the mouse lined up exactly with the cross but deflecting it to the right a bit will cause the plane to bank to the right without altering its pitch.

To take off, the airplane must first be located at the end of a runway. X-Plane relocates the craft here whenever the program opens, an aircraft is loaded, or the location is changed. To take off in the Cessna 172, slowly advance the throttle, then release the brakes (for instance, by using the 'b' key) when the throttle reaches its halfway point. Continue to advance the throttle and be ready to feed in some right yaw (using the right rudder or the twist on the joystick, if applicable) as the airplane accelerates. The tendency to turn to the left is normal in single engine aircraft due to the turn of the propeller.

Don't worry if it takes a few tries to learn how to keep the aircraft on the runway—a Cessna can take off in the grass just fine. If the airplane turns off the runway as it's accelerating, just keep on going. Normally, the pilot will rotate (that is, apply some up elevator by pulling back on the yoke or stick) at about 60 knots in the Cessna 172. Once the aircraft leaves the ground, push the stick forward a bit to momentarily level off and allow the airplane to build speed. Once the craft

reaches 80 knots or so, pull back gently on the stick again and resume climbing. Building airspeed before climbing this way will help keep the plane from stalling.

Note that if a crash occurs that damages the airplane too badly, X-Plane will automatically open a new airplane and place it at the end of the nearest runway (which in some cases may be a grass strip). If the impact is only hard enough to damage the airplane without necessarily destroying it, the aircraft will just sit there and smoke. If this happens, you will need to move your mouse to the top of the screen, click Aircraft, then click Open Aircraft to get things fixed. If only it were so easy in the real world!

5.6 Using the Instruments and Avionics

When using the forward cockpit view, the mouse can be used to control the instruments in the panel, just as the pilot's hand would be used to manipulate the instruments, switches, and other controls.

To operate a button, just click it and release. To operate a switch, do the same to change its position. For example, to bring the landing gear down (on planes that are able to), click with the landing gear switch. Of course, this control will look different in different aircraft. Keep in mind that the 'g' key could also be used or a joystick button could be assigned to toggle the gear.

To turn knobs, move the mouse to the "plus" or "minus" side, whichever is necessary, and click to move the knob. Click repeatedly for greater movements.

To easily see the controls within the cockpit that the mouse can operate, open the Instructions dialog box from the About menu and check the box labeled **Show mouse click regions in the cockpit**. This will draw a thin yellow square around the areas of the instrument panel that can be manipulated with the mouse.

If you have trouble interacting with (or even seeing) a control, you can switch to the 3-D cockpit mode by pressing Shift+9, then move your view backward by pressing the comma key (','). This will allow you to see the whole of the cockpit, provided the aircraft you are using has a 3-D cockpit. Alternatively, you can use the up, down, left, and right arrow keys to move your view around in the 2-D panel view.

To get a quick description of the instruments in the panel, open the Instructions dialog box from the About menu and check the box labeled **Show instrument instructions in the cockpit**. After closing the window, you'll see a description of an instrument whenever you hold the mouse over it.

5.6.1 A Note on Radio Tuning

Avionics in most airplanes utilize twin concentric knobs that allow the pilot to tune the radio. For example, there will typically be a large knob on the surface of the radio, with a smaller knob sticking out from the large one. The large knob controls the integer ("counting number") portion of the frequency and the smaller knob controls the decimal portion.

For example, imagine that the COM1 radio (the communications radio number 1) needed to be tuned to 128.00 MHz. In a real aircraft, the pilot would turn the big, lower knob until 128 was visible in the window, then turn the small, upper knob until 00 was visible.

X-Plane is set up the same way. When hovering the mouse in the vicinity of one of the radio tuning knobs, two counter-clockwise arrows will appear on the left of the knob and two clockwise arrows on the right. The arrows closest to the knob are physically smaller than those on the outside—these adjust the decimal portion of the frequency. The outside arrows are larger and adjust the integer portion of the frequency.

| Movement Name | Keyboard Shortcut | Effect |
|-------------------------------------|---|---|
| Translate left, right, up, and down | Corresponding arrow key | Shifts the view a bit in the direction you choose |
| Translate fore and aft | ‘,’ (aft) and ‘.’ (fore) | Shifts the view toward the front and rear of the aircraft, respectively |
| Rotate left, right, up, and down | q (left), e (right), r (up), and f (down) | Spins the view in the corresponding direction |
| Zoom in and out | ‘=’ (zoom in) and ‘-’ (zoom out) | Simple zooming |

Table 5.1: Controls for the 3-D cockpit view

5.7 Using the Views

You can change your view of the aircraft using the View menu, or by using the keyboard shortcuts listed in the View menu. Note that the characters in brackets to the right side of each menu option are the keyboard shortcuts for each view. For example, to select the forward view, one would press the W key, and to turn the view 45° left, one would press the Q key.

Using the menus or the appropriate keyboard shortcuts, you can *select a view or modify your current view*. The controls for view selection affect the *type* of view that you are using. For instance, you may choose to be in the cockpit, looking forward at the instrument panel, or you may select an external view, perhaps where you look at your aircraft from the point of view of the nearest air traffic control tower. View selection controls are described in Table 5.2.

After selecting some view, you can modify the view using translation (moving left, right, fore, or aft), rotation (spinning about your point of focus), or zoom (changing the angle of view). The default keyboard shortcuts for these effects are listed in Table 5.1.

In previous versions of X-Plane, *zooming* was used in place of the much more appropriate *translation* view modification effect (unlike translation, zooming changes the field of view significantly). Hence, in the 3-D cockpit mode, if you want to move your view closer to the instrument panel, you would press the ‘.’ (period) key, *not* the ‘=’ key. To move your view farther from the instrument panel, you would press ‘,’ (comma), *not* the ‘-’ key. Furthermore, you cannot zoom out past your camera’s actual location; you have to translate backward (using the ‘,’ key) to move farther away.

You can enable 3-D cockpit mode by opening the View menu and clicking “3-D Cockpit Command Look,” or by pressing Shift + 9 on the keyboard. In this mode, you can move your view around the cockpit in one of a few ways:

- by clicking the right mouse button and dragging your mouse around the screen,
- by using the keyboard shortcuts listed in Table 5.2,
- by selecting different views from the View menu, or
- by pressing a button on your flight controls which you previously configured to modify the view.

This mode leaves the mouse free to click on things in the cockpit without affecting where you are looking.

In 3-D cockpit mode, you can use the keyboard shortcuts or the View menu itself to change where you are looking. These are described in Table 5.1.

5.7.1 Using the Quick Look Feature

“Quick Look” is a new feature in the X-Plane 10.10 update. Quick Look allows you to set up a view just the way you like it, and then save it as a hot key or command. Then, in the future, whenever you press that key on the keyboard (or button on your joystick, as the case may be), you can go right back to that view again.

For example, suppose you’re flying the default King Air and you find yourself frequently positioning your view in the cockpit by tilting down and zooming in on the throttle quadrant to see how you have the aircraft configured. This can take some time to set up and if you do it often, it can get tedious.

The solution, then, is to set up a Quick Look. Set the view to however you like it, and assign it to Quick Look 1 by pressing Ctrl+Num Pad 1 (i.e., the control key, with the 1 key on the number pad). Note that the Num Lock must be on in order to do this. Now, no matter how your view changes, when you press the shortcut for Quick Look 1 (by default, Num Pad 1), your head position, orientation and zoom goes right back to your memorized view of the throttle quadrant.

By default, the numbers 0 through 9 on your keyboard’s numeric keypad (a.k.a. the num pad or tenkey) are used to bring you back to Quick Looks 0 through 9. When pressing the Ctrl key along with any of those numbers, you will store your current view to be recalled later by that number key. Thus, to set a view for Quick Look 3, you would get the view to the way you like it, then press Ctrl + Num Pad 3, and to go back to that view, you would press Num Pad 3. However, like most keys in X-Plane, you can modify these settings if you like.

Quick Looks are not just for 3-D cockpit mode, either. They work in all aircraft-relative views, such as 3-D Cockpit, Ridealong, Chase, Circle, and Forward with HUD.

Note that the Quick Looks are *aircraft-specific* preferences. This means that your Quick Look views in the Cessna 172 do not interfere with your views in the King Air, and so on.

5.8 Letting X-Plane Fly Your Aircraft

X-Plane has the capability to fly an aircraft using artificial intelligence (AI). The AI system can both take the aircraft off and fly it around.

To enable the AI’s control of the craft, move the mouse up to the top of the screen to bring down the menu bar. Click Aircraft, then select A.I. Flies Your Aircraft.

With the AI controlling the airplane, you are free to experiment with the different views and also to practice raising and lowering the aircraft’s landing gear, flaps, and so on. Furthermore, this is an excellent way to practice tuning radios.

In addition, you can have the AI control your view by opening the Aircraft menu and selecting A.I. Controls Your Views.

5.9 Getting Quick Instructions

If you need simple, sparse instructions on performing common tasks in X-Plane, you can move your mouse to the top of the screen, click the About menu, and click Instructions. Here, the tabs labeled “Flight Controls,” “Cockpit Control,” “Keyboard,” “ATC,” and “Tech Support” describe these common questions relating to the X-Plane simulator.

| Inside the Cockpit | | |
|--|--------------------------|---|
| Name of View | Keyboard Shortcut | Effect |
| Forward with panel | w | Shows the instrument panel as though you were in the cockpit, facing forward |
| Forward with HUD | Shift+w (i.e., 'W') | Shows a front-facing view with no instrument panel, only a head-up display (HUD) |
| Forward with nothing | Ctrl+w | Shows a front-facing view unencumbered by an instrument panel or any other display |
| 3-D cockpit, using key commands to look around | Shift+9 (i.e., '(') | Displays the in-cockpit view of the 3-D instrument panel, where available. Uses translation and rotation commands (listed in Table 5.1) to move and look around. |
| 3-D cockpit, using the mouse to look around | Shift+0 (i.e., ')') | Displays the in-cockpit view of the 3-D instrument panel, where available. Uses translation commands (listed in Table 5.1) to move around and the mouse to look around. |
| Outside the aircraft | | |
| Name of View | Keyboard Shortcut | Effect |
| Moving spot | Shift+1 (i.e., '!') | Moves the camera with your craft's initial velocity. |
| Hold at location | Shift+2 (i.e., '@') | Fixes the camera's location some distance in front of your craft's initial position. |
| On the runway | Shift+3 (i.e., '#') | Fixes the camera's location on the ground at the nearest runway. |
| Circling the aircraft | Shift+4 (i.e., '\$') | Moves the camera with the aircraft, allowing you to use the rotation and translation keys (see Table 5.1) to circle the craft. |
| Tower view | Shift+5 (i.e., '%') | Fixes the camera at the nearest ATC tower. |
| Ride-along | Shift+6 (i.e., '^') | "Mounts" a camera to the aircraft, which can then be moved using the rotation and translation keys (see Table 5.1). |
| Track fired weapon | Shift+7 (i.e., '&') | Causes the camera to follow any fired weapon. |
| Chase | Shift+8 (i.e., '*') | Sets the camera directly behind the aircraft. |

Table 5.2: Controls for view selection

Checking the **Show mouse click regions in the cockpit** box will display a yellow box around the controls in the cockpit which can be manipulated with the mouse. Checking the **Show instrument instructions in the cockpit** box will display a short description of an instrument when you hold the mouse over it.

5.10 Saving and Sharing Your Flight

X-Plane offers a number of ways to save and share a particular flight. These are:

- Situations, which note the current location, environmental conditions, and properties of the aircraft in use.
- Replays, which store a “recording” of your entire flight since the last load. These are only replayable in X-Plane, but they have the advantage of being made up of X-Plane data points storing your aircraft’s location, so you can change your views during the replay.
- Movie files, which begin and end when you toggle them and record exactly what you see on the screen. These have the advantage of being playable in Quicktime and other video players.
- Screenshots, which store an image of a single moment in your flight and are viewable on any computer.

In each case, you can save the flight and replay it yourself, or you can upload it to the Internet for others to see.

5.10.1 Creating a Reusable Situation

A “situation” in X-Plane is a file readable only by X-Plane. It is essentially a “snapshot” that makes a note of the aircraft you are using, its position in the air or on the ground, its payload, the amount of fuel in its tanks, and so on. It also includes information on the environmental conditions of the flight, including cloud conditions, temperature, and time of day. Furthermore, any other aircraft you have loaded will also be noted.

To create a situation (a .sit file), move the mouse to the top of the screen, click File, then click Save Situation.

By default, X-Plane saves your situation file to the following directory:

`X-Plane 10/Output/situations/`

This is especially useful for quickly loading and practicing a specific type of approach, or for recreating a specific combat situation. The situations can even be sent to other X-Plane users; all they need is the .sit file that you created.

To load a situation in order to fly it again, open the File menu and click Load Situation. Navigate to the location of your .sit file and double click on it to load the situation.

5.10.2 Creating an Replay

A “replay” in X-Plane is essentially a “movie” of your flight which notes the aircraft’s location and attitude at each time step, beginning at the last time you loaded an aircraft or traveled to an airport and ending at the moment you click the “Save Replay” button. This file is only viewable in X-Plane, but because it is so complete, you can change your view as much as you like while replaying. This is in contrast to a Quicktime movie, which records only what you see while you’re recording.

These files, like situations, can be shared with and replayed by any X-Plane user.

To create a replay (a .smo file), move your mouse to the top of the screen, click File, and click Save Replay. By default, X-Plane will store your replay in the following directory:

X-Plane 10/Output/replays/

To load a replay, open the File menu as before, but select Load Replay. Navigate to the location in which you saved your .smo file and double click on it to load.

5.10.3 Creating a Movie

In addition to file types readable only by X-Plane, you can also create more universally readable movies. The downside to these Quicktime movie (.mov) files is that they record exactly what you see when you record them. You will toggle the recording on, fly around a bit, then toggle the recording off; the resulting .mov file will contain what you saw on your screen while flying around.

To record these movies, you need Quicktime 6 or later installed on your computer. After recording the movie, you can edit it in a program like iMovie (installed on new Macs by default) or Windows Live Movie Maker.

Before recording your movie, you may want to set up the Quicktime movie's specifications. Do so by moving the mouse to the top of the screen, clicking on the File menu, then clicking Quicktime Movie Specs. In the dialog box that appears, you can set:

- the frame rate of the movie (measured in frames per second)
- the resolution of the movie (width only; height will be calculated automatically from the width), and
- the time multiplier, indicating how many frames to skip when doing a time lapse video.

In choosing a frame rate, know that videos produced at 15 frames per second will look jittery. Film and television use 24 and 30 frames per second, respectively. In choosing a resolution, keep in mind that an x-resolution of 720 pixels is 720p, and that increasing beyond the resolution you're using on your screen will give no benefit.

To begin recording a movie, either press Ctrl + Spacebar or open the File menu and click Toggle Movie. After flying whatever you intended to record, turn the recording off by either pressing Ctrl + Spacebar or clicking Toggle Movie from the File menu. A file called "X-Plane [aircraft name]-[number].mov" will appear in your top-level X-Plane directory, found by default on the Desktop.

Your Quicktime file can be played back on virtually any computer. If Quicktime is not installed on the computer you want to play the file on, you can get it from the Quicktime Download page on Apple's web site.

5.10.4 Capturing a Screenshot

The final method of saving or sharing your flight is to take a simple screenshot. This can be done either by pressing Shift + Spacebar, or by moving your mouse to the top of the screen, clicking the File menu, and clicking Take Screenshot. The captured image (a .png picture file) will appear in your top-level X-Plane directory, located by default on your Desktop.

These .png screenshots can be opened and viewed on any modern computer, regardless of whether X-Plane is installed.

5.11 Visualizing and Replaying Your Flight

In addition to being able to save replays for later playback (as described in the section Saving and Sharing Your Flight above), you can visualize your flight up to your present location in a few different ways. You can view your flight path on X-Plane’s 2-dimensional maps, or you can toggle the 3-D flight path and view that path in the main simulator. If you want to replay your flight, beginning at the last time you loaded an aircraft or location, you can use X-Plane’s built-in replay function, which has shuttle controls to play, rewind, and fast forward, just like you would expect. Finally, if you want to visualize the path taken by a real-world aircraft, you can format its flight data recorder information in a way that X-Plane can interpret. X-Plane will treat the data in the FDR file just like a regular replay, so you can play, fast forward, and rewind as usual.

5.11.1 Viewing the Path Taken by Your Aircraft

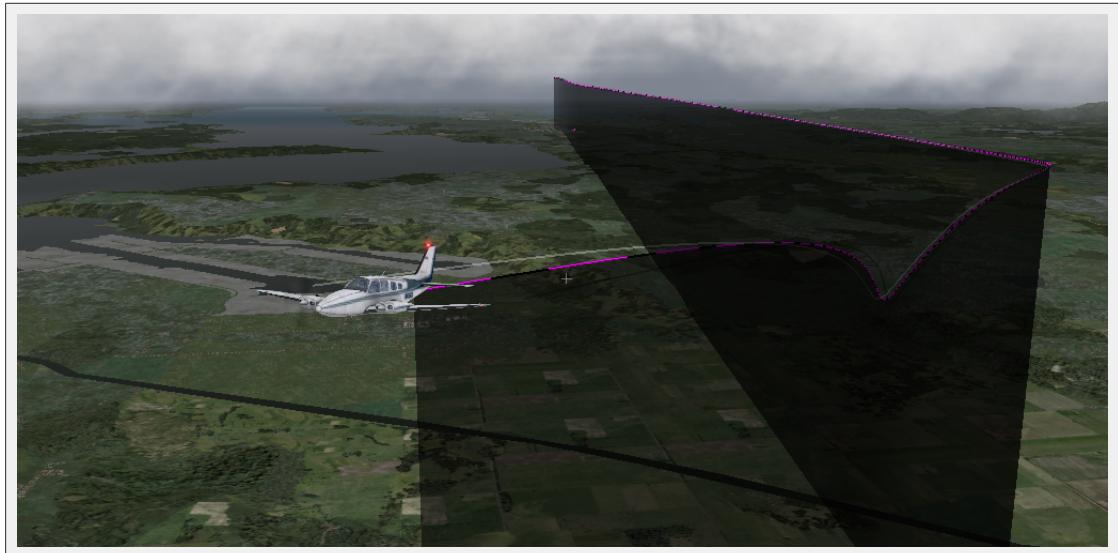


Figure 5.5: Visualizing a 3-D path [Full size →]

The path taken by an aircraft up to its current location can always be seen as a trail behind the aircraft when you toggle the 3-D flight path on. To do so, either press **Ctrl + P** on the keyboard, or move the mouse to the top of the screen, click on the Aircraft menu, and click **Cycle 3-D Flight Path**. Doing so once will cause X-Plane to display a violet-striped line behind the aircraft. Cycling the flight path again will put that line into perspective by drawing lines intermittently from the flight path to the ground. Cycling it once more will give a semi-transparent black bar extending from the flight path to the ground (seen in Figure 5.5). Cycling the path once more will turn off the flight path lines.

To reset the 3-D flight path, either press **Alt + P** on the keyboard, or open the Aircraft menu and click **Reset 3-D Flight Path**. The flight path will also be reset whenever you load an aircraft or a location.

A similar effect can be had in 2 dimensions, from an overhead perspective, by opening the Local Map dialog box. The aircraft’s flight path since the last reset will be shown on each of the map views. For more information on using the navigation maps here, see the section “Using X-Plane’s Navigation Maps” of Chapter 7.

5.11.2 Using the Built-In Replay

You can replay your flight, from the last time you loaded an aircraft or a location up to your current location, by toggling the replay mode on. This can be done either by pressing Ctrl + 'r' or by opening the Aircraft menu and clicking Toggle Replay Mode. In the top of the window, you will see shuttle controls to (listed left to right):

- stop playback,
- play backward faster than real-time,
- play backward at real-time speed,
- play backward slower than real-time,
- pause playback,
- play forward slower than real-time,
- play forward at real-time speed,
- play forward faster than real-time, and
- stop playback.

Additionally, you can click the shuttle slider and drag it to quickly jump around in the playback.

To return to the flight, either press Alt + ',' or open the Aircraft menu and click Toggle Replay Mode once again.

5.11.3 Replaying a Flight from a Flight Data Recorder (FDR)

The final method of visualizing a flight is to load a information from a flight data recorder (FDR). This is useful primarily in accident investigation and re-creation. In that case, you would need to take the data from the “black box” of the aircraft you’re interested in and put it in a format that X-Plane can read. That format is the Flight Data Recorder (or .fdr) format. This is plain text file formatted in a particular way, which means that you can make your own FDR files relatively easily from the data you have and then re-create the flight in X-Plane.

The FDR file specification can be found in X-Plane by moving the mouse to the top of the screen, click on the File menu, and clicking Load Flight Data Recorder File. The lower half of this dialog box lists both the preceding data values (file version, aircraft, tail number, and so on) that are required, as well as each of the 100 or so data values that each instant in the flight data can have. These include the time stamp of that instant, the aircraft’s location (in latitude, longitude, and altitude), the indicated airspeed, and more.

You can use the scroll bar above the file specification box to look through all the data values, and you can mouse over individual values to get a description of them. Note that even if your instantaneous “snapshots” of the aircraft do not use a given parameter (such as the engine pressure ratio, perhaps), your data file must use a dummy value as a placeholder.

After formatting your data for X-Plane as an FDR file, you can load it using the Load Flight Data Recorder File dialog box. Click the silver square labeled “Flight Data Recorder file,” navigate to your file, and double click on. Then, when you close the dialog box, you will be greeted with the standard replay shuttle buttons with which you can replay the flight.

5.12 Viewing the Behind-the-Scenes Flight Model

X-Plane models flight by breaking an aircraft down into a number of little pieces and finding the forces acting on each piece. By clicking the Show Flight Model option from the Special menu (or



Figure 5.6: Illustrating the forces acting on a Baron 58 [Full size →]

by pressing Ctrl + M on the keyboard) and moving to an outside view (e.g., by pressing Shift + 8 on the keyboard for the chase view), you can actually see all the forces calculated on each piece of the craft. With some wind and turbulence turned on in the Weather screen, you can even see the pseudo-random velocity vector flow field around the airplane. The velocity vectors seen are the actual vectors interacting with the aircraft, and the force vectors (the green lines coming off the plane) are the actual forces acting on the plane—nothing is just for show here. This is the actual work that X-Plane is doing.

The green bars extending from the control surfaces of the aircraft indicate how much lift each section of the surface is generating; longer bars represent greater force. The red bars, likewise, represent drag, and the yellow bars represent lift from vertical control surfaces.

Chapter 6

Advanced Simulation in X-Plane

X-Plane is the most comprehensive and powerful flight simulator available. As such, there are a great number of features available that go beyond simply taking off, flying around, and landing. These include tools like the logbook and checklists, and features like equipment failures and damage modeling.

6.1 Keeping a Logbook

Each time an aircraft is flown in X-Plane, the program logs the flight time in a digital logbook. By default, X-Plane creates a text file called “X-Plane Pilot.txt” in the `X-Plane 10/Output/logbooks` directory. Inside this text file are the following details of previous flights:

- Dates of flights
- Tail numbers of aircraft
- Aircraft types
- Airports of departure and arrival
- Number of landings
- Duration of flights
- Time spent flying cross-country, in IFR conditions, and at night
- Total time of all flights

To see your logbook, open the About menu and click Logbook. You can load a logbook by clicking the **Choose Pilot Logbook** button and navigating to your logbook, or you can create a new logbook using the **New Pilot Logbook** button.

6.2 Working with the Air Traffic Control

X-Plane 10’s air traffic control (ATC) system is powerful and realistic when you want to practice real-world protocols, but completely unobtrusive when you want to just fly. Although AI aircraft (i.e., those that you have turned on using the Aircraft & Situations dialog box) will *always* follow the guidance of the air traffic control, they will also work around your aircraft if you are not interacting with the ATC.

Note: You will only be able to hear the air traffic control chatter if ATC audio output is enabled; to confirm this is the case, open the Settings menu, then click Sound.

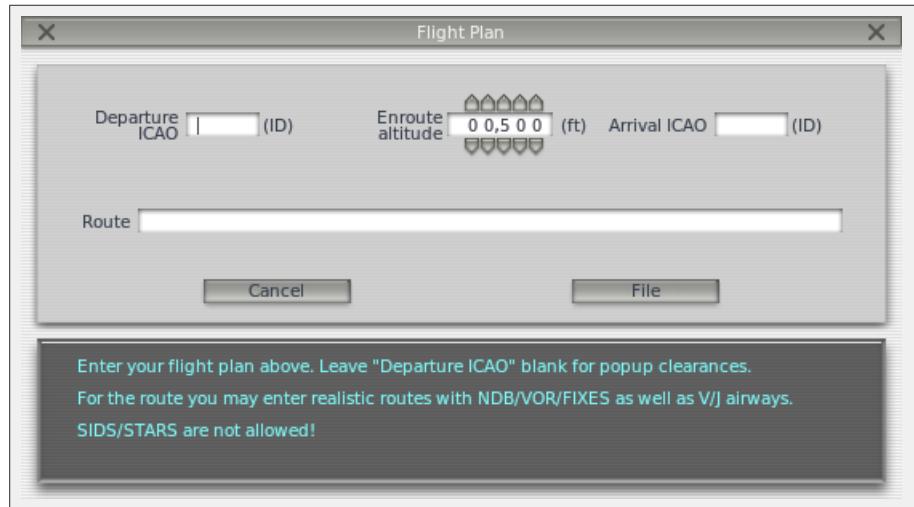


Figure 6.1: The Flight Plan dialog box [Full size →]

All interactions with the air traffic control occur via the on-screen ATC menu. To access this menu, simply press Enter (Return) on the keyboard. Alternatively, you can use the Joystick & Equipment dialog box to program your joystick to access this menu.

In order to make a request or hear from the air traffic controllers, you must have your COM 1 radio tuned to the proper frequency for the request. Filing a flight plan is independent of any controller, so that option is always available. However, once the flight plan is filed, you must tune to the Clearance Delivery, Ground, or Tower frequencies (if available, in that order as in the real world) to get clearance for takeoff. After you get clearance, you tune to the Ground (if available) or Tower frequencies for your taxi clearance. When you get to a hold short line, ground control will hand you off to tower and then you'll receive handoffs throughout the rest of your flight when necessary; keep tuning to the proper frequency to continue to receive air traffic control guidance. Note that the Local Map dialog box (opened from the Location menu) will display the relevant frequencies for any airport that you mouse over.

As in the real world, any ATC interaction begins with filing a flight plan. Thus, the first time you press Enter during a flight, the only option available will be “File Flight Plan.” Click that line of text to display the Flight Plan dialog box (shown in Figure 6.1).

You must enter your departure and arrival points, in the same ID format as the points appear in the X-Plane maps, as well as your planned cruising (enroute) altitude. Pressing the File button will register your flight plan with the X-Plane air traffic control.

With your flight plan filed, you can bring up the ATC menu again by pressing Enter, then click “Request Clearance.”

The following is a brief walkthrough on how to depart the KSEA area:

1. Use the Open Aircraft dialog to load a small aircraft, such as the Cessna 172, as this will be a quick flight. Use the Select Global Airport dialog box to position yourself at a gate at KSEA.
2. Press Enter on the keyboard to bring up the ATC menu, then select “File Flight Plan.”
3. Enter KSEA as the departure ICAO, set your altitude to 3,000 feet, and then set your destination to KBFI. We’re going to leave the route blank because we want to go *direct*, but you could also enter any NDB/VOR/FIX/Airway to get real routings. When you’re done click **File**.

4. You now have a flight plan in the system. If you wish to change your mind, you can return to the flight plan dialog in the same way and update it.
5. You need an IFR clearance before you can proceed, so tune your COM1 radio to 128.00, the clearance delivery frequency at KSEA. Now bring up the ATC menu and you'll see an option for "Request Clearance." Click that and you'll receive your clearance.
6. Bring up the ATC menu and read back your clearance. You must read back all instructions from ATC. Note that if you hear a beep when you click on any ATC menu items, that means that another aircraft or controller is busy talking on the radio. As in the real world, you must wait for them to finish talking before you can talk. You must also respond within a reasonable amount of time or they will repeat their instructions.
7. Once you've received and read back your clearance, tune the COM1 radio to 121.70, the frequency for the ground controller at KSEA. You must call ground to receive a taxi clearance. Acknowledge his clearance and then look around you. You'll see yellow arrows painted on the ground directing you to where he wants you to go. Where the arrows stop, you must also stop and wait for further instructions.
8. Taxi to where the arrows are taking you. When you reach the side of the runway, ground will instruct you to contact the tower. Read back the command and then tune to the tower frequency of 119.90.
9. Go to the ATC menu and check in with this new controller. This is how you tell the controller you're now on his frequency waiting for his command. If there are aircraft using the runway, you will have to wait until they are done. This may take some time! At that time, Tower will call you and instruct you to cross 16L/34R and to taxi to 16C/34C. Respond and then start taxiing.
10. Upon reaching your departure runway, you will again have to wait until the runway is safe to use. Tower will then call you and give you your takeoff clearance. Respond and then depart. Unless otherwise instructed, fly the runway heading up to your cleared altitude of 3,000 feet.
11. At some point, you will be handed off to the center controller on 124.20. Check in with him in the same manner. Continue on your heading and altitude and eventually he will begin vectoring you to an approach at your destination of KBFI. Follow his commands.
12. Once the approach is set up, you will be handed off to KBFI's tower for landing and the process continues until you've arrived back at the gate.

6.3 Using ForeFlight for Real-Time Charts and Plates

New to X-Plane 10.10 is the ability to integrate with ForeFlight, a tool for real-world pilots to view charts and approach plates for their current location (or locations they plan to visit). When you install ForeFlight on your iPhone or iPad, though, you can connect it to X-Plane. X-Plane, in turn, will send a simulated GPS signal to the ForeFlight app, causing ForeFlight to behave as though you were actually flying in your location in X-Plane.

To connect ForeFlight to X-Plane, do the following:

1. Download ForeFlight from the App Store and copy it to your iPhone or iPad. Configure ForeFlight per their <http://www.foreflight.com/support/pilots-guide>.

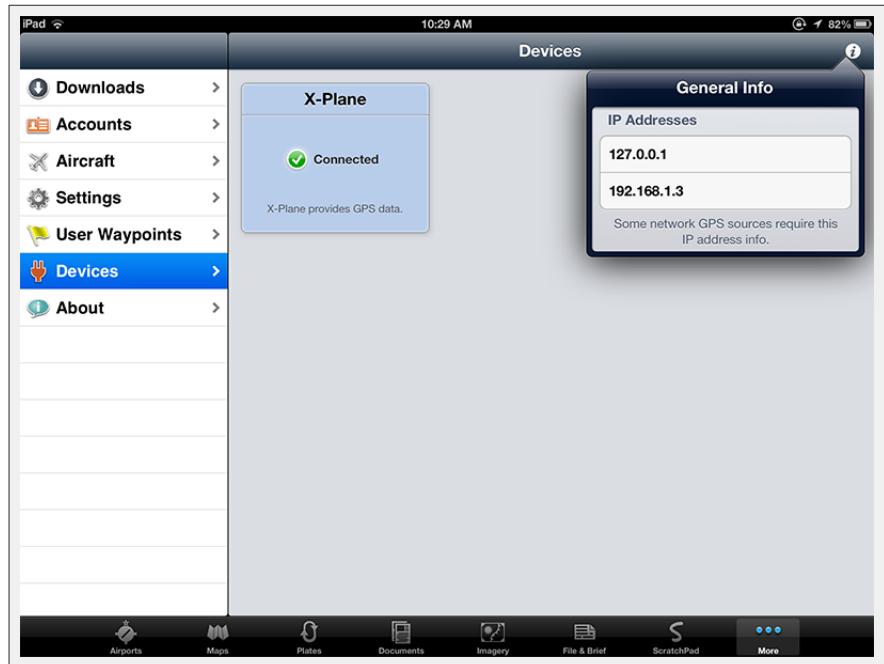


Figure 6.2: The ForeFlight settings after connecting to X-Plane [Full size →]

2. Connect your iPhone/iPad to the *same* wireless network as your computer that runs X-Plane.
3. Launch X-Plane on your computer, and launch ForeFlight on your iPhone/iPad.
4. In X-Plane, open the Settings menu and click Net Connections.
5. Select the “iPhone/iPad” tab in the Net Connections dialog box.
6. Check the box near the bottom of the screen labeled **send GPS data to ForeFlight Mobile or WingX Pro7 on ALL iPads or iPhones on the local network**. At this point, yellow text should appear in the top of the Net Connections window saying something like “Sending to a device running ForeFlight Mobile or WingX Pro7 at IP address 192.168.1.3 0.1 seconds ago, and the send was successful.”
7. If you’re using ForeFlight for iPad, click the **More . . .** button in the bottom right corner of the screen, then select the “Devices” tab. If you’re using ForeFlight for iPhone, swipe over to the second list of buttons on the main menu and tap the **Devices** button.
8. If your devices are configured per the above steps, you should have a small square labeled “X-Plane” in the Devices window of ForeFlight, as seen in Figure 6.2. (Note that you may need to click on this box in order to enable the connection.) If this is not the case, make sure X-Plane is able to get through your firewall by following the steps in the section “Allowing X-Plane through Your Firewall” of Chapter 4.
9. At this point, X-Plane and ForeFlight should be communicating, so if you tap the **Maps** or **Plates** buttons in ForeFlight, you will be able to track your aircraft’s location. By tapping on a particular airport (or by looking it up in the **Airports** section of the app) you can get information such as radio frequencies that you can use in X-Plane. To center your the map



Figure 6.3: Using ForeFlight with X-Plane. Tapping the crosshairs button (highlighted in green in the upper right corner of the screen) will center the map view on your aircraft. [Full size →]

view on your aircraft, just tap the crosshairs button in the upper right corner of the screen, highlighted in green in Figure 6.3.

6.4 Changing How and Where the Aircraft Starts

By default, X-Plane starts your aircraft with engines running on a runway, ready to take off. If you prefer to start your own engines or taxi from an apron (also called a ramp) onto the runway, you can do so by opening the Settings menu and clicking Operations & Warnings. There, in the pane labeled “Startup,” you can un-check the box labeled **Start each flight with engines running** or check the box labeled **Start each flight on ramp**.

Note that not all aircraft models have engine starters built in to their instrument panels. If yours does not, you can either add one in Plane Maker, or you can simply come back to the Operations & Warnings menu and toggle the engine start box again.

6.5 Using a Checklist

X-Plane has the ability to display a simple checklist in the simulator. This checklist must be stored somewhere in the X-Plane directory as a plain text (.txt) file.

To load a check list, open the Special menu and click Open Checklist for Use. After locating your .txt file, you will see the checklist displayed line-by-line in the upper center of the screen. You can use the forward and back buttons to go to the next and previous lines, respectively. When you finish, you can go back to the Special menu and click Toggle Checklist for Use to hide the file.

If you prefer to see the text file all at once (rather than line-by-line as in the checklist view), you can select Open Text File for Viewing from the Special menu, then use Toggle Text File for Viewing to turn it on and off.

6.6 Changing How Damage Affects the Aircraft

By default, X-Plane does not remove parts of the aircraft when the craft's limits are exceeded. However, by opening the Operations & Warnings dialog box from the Settings menu, you can enable the following (located in the bottom left of the window):

- **remove flying surfaces in over-speed**, which causes X-Plane to remove wings and other flight surfaces when you exceed the aircraft's maximum speed by some percentage.
- **remove flying surfaces in over-G**, which causes X-Plane to remove wings and other flight surfaces when the g-forces acting on the aircraft exceed the rated maximum by some percentage.
- **remove flaps in over- V_{fe}** , which causes X-Plane to remove the flaps if they are extended at speeds greater than V_{fe} (the maximum flap extension speed, noted with a white arc on the airspeed indicator).
- **remove gear doors in over- V_{le}** , which causes X-Plane to remove the gear doors if they are extended at speeds greater than V_{le} (the maximum gear extension speed).

Additionally, with the **reset on hard crash** box checked, X-Plane will automatically reload your aircraft at the nearest airport in the event of a fatal crash.

By making these damage modeling features optional, X-Plane allows both easy, possibly unrealistic flights, as well as much more accurate, more challenging simulations.

6.7 Setting the Weight, Balance, and Fuel

To modify an aircraft's weight, balance, and fuel, move your mouse to the top of the screen, click on the Aircraft menu, and click Weight and Fuel.

The dialog box that appears will have the Fuel/Payload tab selected. Here, you can use the sliders to set the aircraft's center of gravity, the weight of its payload, and the amount of fuel in its tanks.

An airplane can typically stay in the air at very high weights, but it will have a hard time getting off the ground initially. Additionally, moving the center of gravity forward (left on the slider) makes the plane behave more like a dart, and moving the center of gravity aft (right on the slider) makes the plane more unstable, and potentially unflyable. Flying a plane with the center of gravity far aft is like shooting an arrow backwards—it wants to flip around with the heavy end in the front and the fins in the back.

Since X-Plane calculates in real time how the plane is burning fuel, and the engines need fuel to run, and the weight distribution of the fuel is considered in the simulation, the fuel put on board does indeed matter.

6.8 Simulating Equipment Failures

X-Plane can simulate countless aircraft systems failures. The Equipment Failures window, found in the Aircraft menu, lets you experience what happens when important pieces of equipment don't do what they're supposed to in flight.

The World/MTBF tab of the Equipment Failures window controls things outside of the airplane, such as bird strikes and airport equipment failures.

With the World/MTBF tab selected, the **mean time between failure** setting is visible at the bottom of the screen. When the **use mean time between random failures** box is checked, the simulator will use the value to the right to determine how often, on average, each piece of equipment will fail. For instance, if the MTBF is set to 1000 hours, X-Plane will decide that each piece of hardware in the plane has about a one in a thousand chance of breaking each hour. Since the airplane has a few hundred pieces of hardware, that means a failure might occur every 5 to 20 hours or so.

The other tabs in this window let the user set the frequency of such failures, or command specific failures, for hundreds of different aircraft systems.

The general failure categories are:

- Equipment
- Engines
- Flying Surfaces
- G1000 (if you have a real G1000 attached to X-Plane)
- All Instruments, and
- NAVAIDs

6.9 Enabling a Smoke Trail

A smoke trail, as might be used by an aerobatic airplane in an airshow, can be enabled behind your aircraft by opening the Aircraft menu and clicking Toggle Puff Smoke. This control is assigned to the ‘x’ key by default.

6.10 Speeding Up the Simulation

By pressing Alt+T on the keyboard, you can increase the simulation speed to 2× the standard speed. Pressing Alt+T repeatedly will increase the speed to 4×, then 6×, and then it will finally return the simulator back to standard speed.

Note that if your computer cannot run the simulation at the required frame rate, X-Plane will slow its measurement of time to compensate. This is seen most often for users running at standard speed, but failing to maintain 20 frames per second. When X-Plane runs slower than 20 fps, it slows down its simulation of real-time so that the simulator is “effectively” running at 20 fps. For instance, if the simulator is running at 10 fps due to extreme rendering settings, X-Plane will run the flight model at half speed. The result is that the physics are integrating in slow-motion in order to avoid destabilizing from the low framerate. Thus, if you need real-time simulation, you must run the simulator at 20 fps or faster.

6.11 Taxiing More Accurately

In commercial aircraft, a nosewheel tiller is used to more accurately align the nosewheel to the taxi lines, and to get the aircraft safely docked at jetways. You can assign an axis on your joystick to control this tiller by opening the Joystick & Equipment dialog box (from the Settings menu) and, in one of the drop-down menus in the Axis tab, selecting **nosewheel tiller**. Note that this is the same procedure used in setting up the joystick axes normally, as described in the section “Configuring Flight Controls” of Chapter 4.

Chapter 7

Navigation, Autopilots, and Flying on Instruments

People often call customer support asking about some of the more advanced things that pilots do in the real world—how to navigate, use an autopilot, or fly on instruments. This chapter will cover these areas in a fair amount of detail, but we recommend that, if you are really serious about mastering these facets of aviation, you head down to a local general aviation airport and hire a CFI (Certified Flight Instructor) for an hour or two. If you have a laptop, by all means bring it along and have the instructor detail these things in practice. There is much more to review here than this manual could ever cover, so a quick search for information on the Internet will also be of assistance.

7.1 Navigating

Navigating over the Earth’s surface is as easy as knowing where your aircraft is and how to get to where you want to go. This isn’t quite as easy as it sounds. Imagine that you’re flying IMC (Instrument Meteorological Conditions—that is, in the clouds). You have no reference to the ground and are flying over St. Louis in the middle of an overcast layer. As you might guess, this looks pretty much identical to the view you would have flying over Moscow on instruments. The only way to know that you’re over St. Louis and not over Moscow is to be able to navigate. Navigation is the art of being able to tell where your aircraft is and how to make it go where you’d like.

7.1.1 Air Navigation History

For the first 30 years or so the best pilots could do was to fly around using what is known as dead reckoning—that is, by confirming their position on a map as they flew, then looking ahead on the map to see when they should be crossing some known landmark, like a road, railroad, town, or lake. Then, the pilots periodically compared their progress over the real ground with the anticipated progress over the map to see how things were going. This really is as simple as it sounds. The biggest trick is to always know where you are and what to be looking for next.

Dead reckoning isn’t too difficult to get down. Shortly after college, Austin Meyer (the author of X-Plane) and Randy Witt once piloted a Cessna 172 from Kansas City to Chicago after their second (of two) navigation radios gave up and died in mid-flight. Clearly this is not a typical experience in the aviation world, but it’s a reminder that a pilot always needs to be thinking ahead and preparing for contingencies. That particular aircraft was a well-used rental and NAV 1 was dead from the

time the plane was signed out. When NAV 2 died, there were no operable navigation radios at all, and the two had to use dead reckoning to fly the last 300 or so miles of their trip, which was most of the journey. They would never have allowed themselves to get into that position had the weather been poor or had they been flying on instruments—they would have refused to take off into such conditions given the failure in the first radio. But since the weather was nice, they took off with only one navigation radio and were soon flying along on none. X-Plane allows you to practice this all you like.

During the heyday of dead reckoning, the US Mail pilots that were flying on overnight mail routes actually flew from bonfire to bonfire that had been set up along their route, using the light to guide their progress. Just imagine what this must have been like—flying in the mid 1920s in an open cockpit biplane (a Curtis Jenny, perhaps) trying to keep your goggles clean (the engines of the day routinely sprayed oil) and to stay out of the clouds on a cold winter night, flying along a chain of bonfires to your next destination. Keep in mind these were not closed-cockpit aircraft and the pilot continually had the outside air blowing all around. Wow! I hope you dressed warm and that you are good at folding maps in 80 MPH slipstreams of below-freezing air.

In the mid 1930s or so a system was devised where pilots would fly using aural navigation—that is, they would tune into a new radio system such that if they were to the left of their course they would hear a series of dashes (long radio tones, as in Morse code), and if they were to the right of their course they would hear a series of dots (short tones). If on course, they would hear nothing as the signals containing the dashes and dots canceled each other out. The closer the pilot was to the transmitter the smaller the “Cone of Silence,” as it was known, was and the more defined the boundaries between the dashes, dots, and silence. As the aircraft’s range from the station increased, the central target (where no signals were heard) was much wider and weaker. Imagine sitting in a cold, dark cockpit listening intently to try and hear over the drone of the engine and whistle of the wind on your wires to see which side of the cone you were on. Airline pilots used this system for years to successfully carry passengers all around the world. This type of navigation is not modeled within X-Plane.

7.1.2 Modern Means of Navigation

We now come into the area of “modern” navigation based on ground-based transmitters. You’ll need a good set of charts if you’d like to actually fly in X-Plane using any of these methods, but the software does contain a full set of (mostly) current charts as well. To see them go to the Location menu, click Local Map, and select one of the five map types that are available in the tabs on top of the window. They are:

- High-Speed—used as high altitude charts by jet and turbo-prop pilots.
- Low Enroute—used as low altitude IFR navigation charts by piston (propeller) aircraft pilots. One of the most important aspects of this chart is the addition of Vector Airways that are virtual highways in the sky that connect different VOR transmitters. These vector airways are given names (for example, V503) and are used by air traffic controls to assign clearances.
- High Enroute—very similar to Low Enroute but only showing the information of interest to pilots flying above 18,000 feet and making use of vector airways that are much longer, based on larger VORs with longer ranges.
- Sectional—the standard chart that VFR pilots are familiar with. This map has ground elevation data superimposed via a shaded background and information about the airports that are local to that area.

- Textured—a nice map that is not used in pilot circles. This overlays the X-Plane terrain images on top of the navigation charts to give the user a good bird's eye view of the area he or she is flying over.

Note that the maps in X-Plane are covered in more detail in the section “Using X-Plane’s Navigation Maps” later in this chapter.

7.1.2.1 NDB Navigation

Non-directional beacons were invented in the late 1940s and consisted of a ground-based transmitter that broadcast a homing signal. A receiver in the aircraft could be tuned to one of about 300 discrete frequencies in order to tune to a particular transmitter. With that done, an instrument in the panel, called the NDB (or, interchangeably, the ADF, or Automatic Direction Finder), would point to the station. This system was a large technological leap forward over the older aural-based system and was actually quite easy to use, provided that the wind was perfectly calm or blowing in a direction that was exactly parallel to the direction of flight. Of course, that pretty much never happened, resulting in the aircraft always being blown off course. As a result, the pilots had to watch the trend of movement in the needle over a relatively long period of time (e.g., five to eight minutes) to see if the angle to the station that was depicted stayed constant or was changing. If it was changing, it indicated that the aircraft was being blown off course and the pilot had to turn in the opposite direction by half of the deviation. After holding that heading for another five minutes or so the pilot would again observe the relative trend of the needle and correct again.

The trick was to fly as straight as possible from one station to another. Although nearly abandoned in the United States, NDBs are still used in many countries around the world. It is for this reason that they are modeled in X-Plane.

An ADF is located in the instrument panel for the Cessna 172 that comes with X-Plane. It is located above the mixture knob and trim wheel, below the dual VOR CDIs.

7.1.2.2 VOR Navigation

Very High Frequency Omni-Range navigation (or VOR) was introduced in the mid-1950s and represented a large improvement in navigation accuracy. Instead of an NDB that a pilot could home in on, the VOR sends a series of 360 discrete little carrier tones on a main frequency. Each of these carriers is oriented along a different radial from the station, one of 360 just like a compass rose. Thus, when you are flying along and tune in the main VOR frequency, you then fine tune your navigation display to tell you which of the 360 radials you are flying and also whether the transmitter station is in front of or behind you. Impressive! This finally gave pilots a means of telling exactly where they were in relation to a fixed spot on earth, and this system “automatically” adjusted for any winds aloft as the system would quickly display any error in track that the plane was making. This error could only be due to two factors—either the pilot was not flying along the radial or the wind blew the airplane slightly off of course. VORs are modeled in X-Plane.

VOR stations appear in the X-Plane maps as relatively large circles with notches around the edges, similar to a clock face. They are tagged with boxes that have their name and identifier on the left side and their VOR frequency on the right.

A specific type of VOR, a VOR-DME, combines the lateral guidance (that is, guidance left and right) of a VOR with the distance guidance of a DME (distance measuring equipment). Another type of VOR beacon, a VORTAC, is also found throughout the X-Plane maps. This is a transmitter that combines both VOR and TACAN features. TACAN (or tactical air navigation) provides

special information to military pilots similar to a civilian VOR. However, for our purposes, this is functionally identical to a VOR-DME.

To use a VOR, first look on either the sectional or low enroute map to find a VOR station that is fairly close the location of the aircraft. Tune this station's frequency into your VOR radio (in the Cessna 172SP, the NAV 1 radio is found on the far right of the cockpit, beneath the GPS). The little red 'nav1' or 'nav2' flags on your CDI (Course Deviation Indicator) should disappear (keep in mind that you may have to hit the flip-flop switch to bring the frequency you just tuned into the active window). Now rotate the OBS (Omni Bearing Selector) knob so that the vertical white indicator is perfectly centered in the little white circle in the middle of the instrument. At this point the vertical white line should be truly vertical and your aircraft is either on the radial from the station indicated by the arrow at the top or at the bottom of the instrument, labeled TO or FR. Now fly that exact heading and you will be flying directly towards or away from the station, as shown by the little white up or down (to or from, respectively) arrow that will be on the right side of the CDI, either above or below the white horizontal glide slope indicator.

Note that the vertical reference line indicates how far you are from your desired radial. To the left and right of the center target (the little white circle) the instrument displays five dots or short lines on each side. Each of these dots indicates that you are two degrees off of course. Thus, a full scale left deflection of the vertical reference indicates that the aircraft is 10 degrees right of the desired radial if the station is in front of you. Of course, if the station is behind you then the instrument is reverse sensing and that means that a left deflection indicates that the plane is to the left of your desired radial—yes, it can be a bit confusing. Just remember that *as long as you are flying towards the VOR, the line on the CDI indicates the location of the desired course*. If the reference line is on your left that means that your target radial is on your left.

With only one VOR you really don't know where you are along a given radial, only that you are in front of or behind a station and what radial you're on. You have no way of telling if you are 15 miles from the station or 45 miles away. The solution is to use two VOR radios so that you can plot your location from two different VORs. If you can determine that you're on the 67th radial from the OJC VOR and on the 117th radial from the MKC VOR then you can pinpoint your location on a sectional chart. Don't forget that you'll have to work fast as your position will be continually changing.

7.1.2.3 ILS Navigation

An ILS (or instrument landing system) differs from a VOR in that it provides both lateral guidance (left and right, as given by a VOR) and vertical guidance (up and down). An ILS is therefore made up of *two* transmitters, a localizer and a glideslope—one for each component of the navigation. Both these components of the ILS are tuned together; tuning an ILS is just like tuning in to a VOR.

A localizer (LOC) transmitter provides lateral guidance to the centerline of a runway. It works by sending out two signals on the same channel, one of which modulates at 90 Hz and the other of which modulates at 150 Hz. One of these signals is sent out slightly to the left of the runway, while the other sent out slightly to the right of it. If an aircraft is picking up more of the tone modulated at 150 Hz, it is off to the left. If it is picking up more of the tone modulated at 90 Hz, it is off to the right. The course deviation indicator (or CDI) in the instrument panel then indicates this so that the pilot can correct it. When both tones are being received in equal amounts, the craft is lined up with the physical centerline of the runway. These LOC transmitters do not necessarily have to be paired with a glideslope (thus making them an ILS).

An ILS combines the functionality of a localizer, which provides lateral guidance, with a glides-

lope transmitter, which provides vertical guidance to the runway. The glideslope beacon functions similarly to the localizer, sending out two tones that have the same frequency, but different modulations. The difference is that the glideslope tells the plane that it is either too high or too low for its distance from the runway. The pilot uses this information to push the craft's nose up or down as needed. The ILS will allow a pilot to fly on instruments only to a point that is a half mile from the end of the runway at 200 feet (depending on the category of the ILS) above the ground. If the runway cannot be clearly seen at that point the pilot is prevented from executing a normal landing. If this happens, the pilot in real life is required to fly a "missed approach" and climb back to altitude in order to try again or go somewhere else.

7.1.2.4 GPS Navigation

The Global Positioning System was first created for the US military and introduced to the public in the early 1990s. This system consists of a series of satellites orbiting the Earth which continuously send out signals telling their orbital location and the time the signal was sent. A GPS receiver can tune in to the signals they send out and note the time it took for the signal to travel from the satellite to the receiver for several different satellites at once. Since the speed at which the signals travel is known, it is a simple matter of arithmetic to determine how far from each satellite the receiver is. Triangulation (or, rather, quadrangulation) is then used to determine exactly where the receiver is with respect to the surface of the Earth. In an aircraft, this information is compared with the onboard database to determine how far it is to the next airport, navigational aid (NAVAID), waypoint, or whatever. The concept is simple, but the math is not. GPS systems have turned the world of aviation on its head, allowing everyday pilots to navigate around with levels of accuracy that were unimaginable 20 years ago.

There are several types of GPS radios available, and about 11 of these have been modeled in X-Plane. While the intricate workings of the various GPS radios are complex, the basic principals are pretty consistent. If you want to navigate from one location to another just launch X-Plane, open the aircraft of your choice, then press the "Direct To" key on the GPS radio (sometimes shown as the symbol ) and enter the airport ID you'd like to navigate to. On the Garmin 430, entry is performed using the control knob on the bottom right of the unit. Use the outer knob to select which character of the identifier to modify, the use the inner knob to scroll through the characters (see the section "A Note on Radio Tuning" for more information on using the knobs).

The databases in these radios are not limited simply to the identifiers of the airports you may wish to fly to. You can enter the IDs for any VOR or NDB station you'd like, or the name of any waypoint or fix you'd like to go to.

7.2 Using X-Plane's Navigation Maps

X-Plane's navigation maps come in a few different varieties, each of which is useful for a different situation. These navigation maps are found in the Local Map window, which is launched from the Location menu. This window is divided into five tabs, corresponding to the five different maps available: Hi-Speed, Low Enroute, High Enroute, Sectional, and Textured. Note that a discussion of the elements of these maps (the ILS, VOR, and NDB beacons) can be found above, in the section "Modern Means of Navigation."

The Hi-Speed map gives maximum speed. It is useful for scrolling around the map quickly, changing NAVAIDS quickly, or, if the "Draw Cockpit on Second Monitor" option is checked in the Rendering Options screen, using the map drawn on one monitor while flying in the cockpit drawn

on the other. In this case, the fastest map available is desirable so that the simulation is not slowed down too much.

The Low Enroute map displays the aircraft's general area, along with airports, airport and beacon frequencies, ILS indicators, and low level airways.

The High Enroute map is essentially the same as the Low Enroute view, but it displays the medium and high level airways instead of low level ones.

The Sectional map is designed as a VFR sectional chart. It shows airports, airport and beacon frequencies, ILS indicators, roads, rivers and railway lines. It also uses a terrain shader to depict the ground types and elevations.

The Textured map displays airports, roads, rivers and railway lines. In addition, the terrain shader used on this map gives an overview of the landscape as it would be seen from the cockpit in X-Plane. This view uses the actual scenery installed in X-Plane as its basis.

To move your view around a map, you can either click the map and drag (similar to the way you click and drag in many PDF readers), or you can use the arrow keys on the keyboard. You can also zoom in and out using the ‘-’ and ‘=’ keys.

Additionally, you can use the viewing control buttons located in the bottom right corner of the map window to alter your view. Below these checkboxes is a round button used to move the map view up, down, left, or right, depending on where along its edge the button is clicked. The buttons below this each have two small triangles. On the left is the button to zoom out, and next to it (labeled with two larger triangles) is the one to zoom in.

Finally, below the zoom buttons is the **center on acft button**, which, when clicked, centers the map on your aircraft.

7.2.1 Additional Features of the Maps

You can control what features of the map are shown using the checkboxes on the right side of the screen. These boxes toggle things like clouds, NAVAIDs, aircraft, and airports.

At the top of the Local Map window is a row of check boxes which are used to put the map in different “modes.”

The **Instructor Operator Station (IOS)** check box puts the map in Instructor Operator Station mode, causing this copy of X-Plane to run as an instructor’s console. Once this box is checked, the left side of the Map window will show a number of buttons with which to control the flight. The instructor can enter an airport ID in the space in the upper left. With an ID entered, the aircraft can be placed at the airport or on an approach to it.

The Instructor’s Console can be used either when drawing a two monitors from the same video card or in a multi-computer X-Plane setup. This is a great feature for flight training because the instructor can fail systems, set date and time, change the aircraft location, etc. for maximum training benefit. The buttons along the left of this window allow the instructor to perform all these tasks from one location, while maintaining a watch on the X-Plane pilot using the map view.

The **edit** check box opens a number of buttons on the left side of the screen which are used to edit the various NAVAIDS on the map. Just click on a NAVAID to modify it, or to add a new one. For a detailed description of the format used in the NAVAIDs on the Local Map, please see the X-Plane Airport and Navigation Data website.

Enabling the **slope** check box will display a vertical profile of the flight at the bottom of the map screen.

The **inst** check box makes a few key flight instruments appear within the map screen in order to see what the plane is doing. By default, opening the map screen pauses the simulation, though, so in order to use the map (and thus these gauges) in real time, one of the following must be done:

1. The **draw IOS on second monitor** option must be enabled in the Rendering Options screen, thus setting one of your available monitors to be used for flight and the other for an instructor operator station.
2. A networked IOS must be set up using the IOS tab of the Net Connections window.

Note that more information on these multi-monitor simulator setups can be found in the section “Using an Instructor Operator Station (IOS) for Flight Training” of Chapter 8.

Toggling the **3-D** check box will shift the map into 3-D mode. When in 3-D view mode, the arrow keys can be used to rotate the view and the ‘+’ and ‘-’ keys to zoom in and out.

Finally, the **shut down tailwind ILSs** box can be used to ignore the ILSs which are not aimed in the direction you need. This is useful if you are flying at an airport with ILSs in opposite directions on the same frequency, as is the case at KLAX.

7.3 Using the Autopilot

One of the most frequently asked questions from X-Plane users is the same as one of the most frequently asked questions from real-world pilots—how do I work the autopilot? Many pilots have simply never taken the time to learn—you might even find some real-world airliners jerking left and right for five minutes or so as the flight crew tries to figure out how to program and engage their autopilot.

The autopilot works by implementing a number of different functions. These include, among other things, the ability to automatically hold a certain pitch, altitude, heading, or speed, or to fly to a commanded altitude.

The following autopilot functions are available in X-Plane. A button for enabling each of these can be chosen for an aircraft’s panel using the Panel Editor of the Plane Maker software. In the Panel Editor, these buttons are located in the “autopilot” instrument folder. Each of these is a mode that the aircraft can be put into simply by clicking that button on the panel with the mouse. The actual use of these autopilot functions will be discussed in the following sections.

The **WLV** button is the wing leveler. This will simply hold the wings level while the pilot figures out what to do next.

The **HDG** button controls the heading hold function. This will simply follow the heading bug on the HSI or direction gyro.

The **LOC** button controls the localizer flight function. This will fly a VOR or ILS radial, or to a GPS destination. Note that the GPS may be programmed by the FMS (discussed in the section “Flying an FMS Plan”).

The **HOLD** button controls the altitude hold function. This will hold the current or pre-selected altitude by pitching the nose up or down.

The **V/S** button controls the vertical speed function. This will hold a constant vertical speed by pitching the aircraft’s nose up or down.

The **SPD** button controls the airspeed function. This will hold the pre-selected airspeed by pitching the nose up or down, leaving the throttle alone.

The **FLCH** button controls the flight-level change function. This will hold the pre-selected airspeed by pitching the nose up or down, adding or taking away power automatically. This is commonly used to change altitude in airliners, as it allows the pilot add or take away power while the airplane pitches the nose to hold the most efficient airspeed. If the pilot adds power, the plane climbs. If they take it away, the plane descends. **SPD** and **FLCH** are almost identical functions in X-Plane—they both pitch the nose up or down to maintain a desired aircraft speed, so adding or

taking away power results in climbs and descents, respectively. The difference is that if you have auto-throttle on the airplane, **FLCH** will automatically add or take away power for you to start the climb or descent, whereas **SPD** will not.

The **PTCH** button controls the pitch sync function. Use this to hold the plane's nose at a constant pitch attitude. This is commonly used to just hold the nose somewhere until the pilot decides what to do next.

The **G/S** button controls the glideslope flight function. This will fly the glideslope portion of an ILS.

The **VNAV** button controls the vertical navigation function. This will automatically load altitudes from the FMS (Flight Management System) into the autopilot for you in order to follow route altitudes (as discussed in the section "Flying an FMS Plan" below).

The **BC** button controls the back course function. Every ILS on the planet has a little-known second localizer that goes in the opposite direction as the inbound localizer. This is used for the missed approach, allowing you to continue flying along the extended centerline of the runway, even after passing over and beyond the runway. To save money, some airports will not bother to install a new ILS at the airport to land on the same runway going the other direction, but instead let you fly this second localizer backwards to come into the runway from the opposite direction of the regular ILS! This is called a back course ILS.

Using the same ILS in both directions has its advantages (e.g., it's cheaper), but there's a drawback: the needle deflection on your instruments is backwards when going the wrong way on the ILS. Hit the **BC** autopilot button if you are doing this. It causes the autopilot to realize that the needle deflection is backwards and still fly the approach.

Note that HSIs *do not* reverse the visible needle deflection in the back-course; you must turn the housing that the deflection needle is mounted on around 180 degrees to fly the opposite direction.

Note also that the glideslope is not available on the back course, so you have to use the localizer part of the procedure only.

7.3.1 Turning It On and Off

Before using the autopilot, it needs to be turned on. The autopilot power switch is labeled "Flight Director Mode," or simply "FLIGHT DIR." It has OFF, ON, and AUTO modes.

If the flight director is OFF, nothing will happen when you try to use the autopilot. If it is ON, then the autopilot will *not* physically move the airplane controls, but will rather move little target wings on your artificial horizon that you can try to mimic as you fly. If you do this, you will be following the guidance that the autopilot is giving you, even though you are the one actually flying. The flight director, then, is following whatever autopilot mode you selected, and you, in turn, are following the flight director to actually fly the plane. If the flight director is set to AUTO, then the autopilot servos will actually fly the airplane according to the autopilot mode you have selected.

In other words, turning the flight director ON turns on the brains of the autopilot, displaying the commands from the modes above on the horizon as little magenta wings you can follow. Turning the Flight Director switch to AUTO turns on the servos of the autopilot, so the plane follows the little magenta wings for you without you touching the stick.

Therefore, if you have a flight director switch, make sure it is in the right mode for the type of autopilot guidance you want—none, flight director only, or servo-driven controls.

When you first turn the flight director to ON or AUTO, it will automatically engage in the pitch sync and wing leveler modes, which will simply hold the craft's current pitch and roll until some other mode is selected. If the system is turned on with less than 7 degrees of bank, however, the flight director will assume you want the wings level, and it will automatically do so for you.

With the flight director set to the right mode, you can engage the autopilot functions by simply pressing the desired button in the instrument panel. To turn off an autopilot function, simply hit its button once again. When all other autopilot functions are turned off, the autopilot will revert to the default functions—pitch and roll hold modes.

To turn the autopilot off altogether, simply turn the FLIGHT DIR switch to OFF. Alternatively, assign a key or joystick button to turn it off in the Joystick & Equipment dialog box of X-Plane.

7.3.2 Using the Controls

With the autopilot turned on (either to the flight director-only mode or the servo-driven control mode), you are ready to use the autopilot functions. We will discuss when it would be appropriate to use some of the most common functions.

7.3.2.1 Wing Leveler and Pitch Sync

Hit either the wing leveler (**WLV**) or the pitch sync (**PTCH**) to hold the current roll and pitch attitude, respectively. This is useful when switching between autopilot functions.

7.3.2.2 Heading, Altitude, Vertical Speed, Speed Hold, Flight Level Change, and Auto-Throttle

Hit the heading hold (**HDG**), altitude hold (**ALT**), vertical speed (**V/S**), speed hold (**SPD**), flight level change (**FLCH**), or auto-throttle (**ATHR**) buttons and the autopilot will maintain whatever values are entered into their respective selectors. For the sake of smooth transitions, many of these values will be set by default to your current speed or altitude at the moment the autopilot function buttons are hit.

If you want the autopilot to guide the aircraft to a *new* altitude, you have to ask yourself: Do you want the airplane to hold a constant vertical speed to reach that new altitude, or a constant airspeed to reach it? Since airplanes are most efficient at some constant indicated airspeed, climbing by holding a constant airspeed is usually most efficient.

Regardless, we'll start with the vertical speed case.

Imagine you are flying along at 5,000 feet and you hit ALT, causing the autopilot to store your current altitude of 5,000 feet. Now, though, you want to climb to 9,000 feet. You would first dial 9,000 into the altitude window. The plane will not go there yet; before it will, you must choose how you want to get to this new altitude.

If you decide to get there via a constant vertical speed, hit the V/S button and the plane will capture your current vertical speed (possibly 0). Then, simply dial the VVI (vertical velocity indicator) up or down to set how fast you will reach your target of 9,000 feet. When you get to 9,000 feet, the autopilot will automatically disengage the vertical speed mode and drop right back into altitude mode at your new altitude.

Now, to get to your new altitude via a given airspeed (as airliners do), after dialing in 9,000 feet in the altitude window, you would hit the FLCH or SPD buttons. This will cause the plane to pitch the nose up or down to maintain your current indicated airspeed. Now, simply add a dose of power (if needed) to cause the nose of the plane to rise (which the autopilot will command in order to keep the speed from increasing). When you reach 9,000 feet, the autopilot will leave speed-hold mode and go into altitude-hold mode, holding 9,000 feet until further notice.

As you can see, both the airspeed and vertical speed modes will be maintained until you reach the specified altitude, at which point the autopilot will abandon that mode and go into altitude-hold mode. The same thing will happen with the glideslope control. If the glideslope is armed (that

is, lit up after you pushed the button), then the autopilot will abandon your vertical mode when the glideslope engages. This will also happen with the localizer control. If the localizer is armed, the autopilot will abandon your heading mode when the localizer engages. This is referred to as “capturing” the localizer or glideslope.

The key thing to realize is that the vertical speed, flight level change, and heading modes are all modes that command the plane the moment they are engaged. Altitude, glideslope, and localizer, on the other hand, are all armed (in standby) until one of the modes above intercepts the altitude, glideslope, localizer, or GPS course.

An exception to the above rule is altitude. If you hit the altitude button, the autopilot will be set to the current altitude. This is not the way a smart pilot flies, though. A smart pilot with a good airplane, a good autopilot, and good planning will dial in the assigned altitude long before he or she gets there (including the initial altitude before take off) and then use vertical speed, flight level change, or even pitch sync to reach that altitude.

Here is how the system in a real plane would be used (and thus how the system in X-Plane is best used):

1. While on the ground, short of the runway, the you are told to maintain, say, 3,000 feet. You are given a runway heading and is cleared for takeoff.
2. You enter 3,000 feet into the ALTITUDE window and a runway heading (for instance, 290) into the HEADING window.
3. You take off.
4. In the initial climb, around maybe 500 feet, you set the flight director to AUTO. The autopilot notes the plane’s current pitch and roll and holds the plane steady.
5. You hit the **HDG** button, and the plane follows the initial runway heading.
6. You hit either the **V/S**, **FLCH**, or **SPD** button. The autopilot automatically notes the current vertical velocity or airspeed, and the plane flies at that airspeed or vertical velocity until it gets to 3,000 feet, where it levels off.
7. You are given a new heading and altitude by ATC.
8. You dial the new heading into the window, dial the new altitude into its window, and then hit **V/S**, **FLCH**, or **SPD** to let the plane zoom to the new altitude.
9. You are cleared to the plane’s destination or some other fix. You enter those coordinates into the GPS and the HSI source is set to GPS (since the autopilot follows the HSI). You hit the **LOC** button. The autopilot will then follow the HSI needle deflection laterally as it climbs to the new altitude.

Do this, and you can get where you are going.

7.3.2.3 Pitch Sync with the Pitch Sync Joystick Button

You can assign a joystick button to the pitch sync (**PTCH**) control. When pressed, this button will make the autopilot match its settings to whatever you are doing as you fly the plane. Then, when you release the pitch-sync joystick button, the autopilot servos will take hold of the yoke and maintain the vertical speed, altitude, airspeed, or pitch that you were just flying.

Instructions on assigning a joystick button to this function can be found in Chapter 4, in the section “Assigning Functions to Buttons.”

Here’s how the pitch sync works. Imagine you are at 3,000 feet. The flight director is in altitude mode, so the autopilot is holding 3,000 feet for you. You hit the pitch sync joystick button. When you do this, the autopilot servos release control of the yoke and let you fly. You fly to 3,500 feet (with the autopilot still in altitude mode) and let go of the pitch sync joystick button. At that point, the autopilot will hold 3,500 feet, since you were in altitude mode at 3,500 feet at the moment you let go of the pitch sync button.

If you are in vertical speed mode, the autopilot will try to maintain the vertical speed that you had at the moment you released the pitch sync button.

If you are in speed or level change mode, the autopilot will try to maintain the airspeed (by pitching nose up or down) that you had at the moment you released the pitch sync button.

So, when you press the pitch sync joystick button, the autopilot turns the servos *off* and lets you fly, but when you *release* the button, the servos take hold and try to maintain the speed, altitude, or vertical speed that you had at the moment when you released the pitch sync joystick button. The same applies to bank angle. If you are in wing level or heading mode when you hit pitch sync, then the plane will try to maintain the bank angle you had at the moment you released the button.

Note, once again, that if the plane’s bank angle is less than 7 degrees, the autopilot will just level the wings, as it assumes that you want nose level.

7.3.2.4 Localizer and Glideslope

These are the options that nobody can figure out, partially because the right frequencies and HSI mode must be selected to use them, and partially because they will do nothing until they capture the approach path they are looking for. For that to happen, some other mode (any of the ones discussed above) must be engaged to do that.

These modes capture an ILS, VOR, or GPS course, so they must obviously be able to fly either NAV 1, NAV 2, or GPS. The autopilot only knows which of these three to use when you tell it which one. This is done with the button labeled “NAV-1 NAV-2 FMC/CDU” (with filename “but_HSI_12GPS” in the Panel Maker’s HSI folder), which is the HSI source selector.

Note: In some aircraft, this is instead a three-position switch labeled SOURCE.

The autopilot will fly whatever course the HSI is showing (if you have one), so you need to decide what you want the HSI to show: NAV 1, NAV 2, or GPS (labeled FMC/CDU, for Flight Management Computer, which gets its signal from the GPS). Once you decide, use this button to tell the HSI what to display. The autopilot will then fly to that course.

If you set this button to NAV 1, the HSI will show deflections from the NAV 1 radio, and the autopilot will fly VOR or ILS signals from the NAV 1 radio when you hit the **LOC** or **G/S** buttons.

Similarly, if you set this to NAV 2, then the HSI will show deflections from the NAV 2 radio, and the autopilot will fly VOR or ILS signals from the NAV 2 radio when you hit the **LOC** or **G/S** buttons.

If you set this switch to FMC/CDU, then the HSI will show deflections from the GPS, which can be set manually or by the FMS, and the autopilot will fly to the GPS destination when you hit the **LOC** button. Remember that if you enter destinations into the FMS, they will automatically feed into the GPS, so the autopilot will follow them if you select **LOC**.

To repeat: be sure to send the right signal (NAV 1, NAV 2, or GPS) to the autopilot when using the **LOC** and **G/S** (lateral and vertical navigation) buttons.

The **LOC** button will immediately begin lateral navigation (navigating to a GPS destination) once engaged. It will, however, only track a VOR radial or ILS localizer after the needle has come off of full-scale deflection. This means that if you have a full-scale ILS needle deflection (simply because you have not yet gotten to the localizer) the localizer mode will simply go into armed (yellow) mode, and will not do anything yet to the plane. Your current heading or wing level mode (if engaged) will remain in force (or you can fly by hand) until the localizer needle starts to move in towards the center. Once that happens, the **LOC** will suddenly go from armed mode (yellow) to active mode. This causes the autopilot to start flying the plane for you, disengaging any previous modes.

The reason that the localizer function disengages previous modes is that you will typically fly heading mode until you get to the localizer, and as soon as the localizer needle comes in, you want the autopilot to forget about heading and start flying the localizer down to the runway. Alternatively, you may simply fly the plane by hand to the localizer (with no autopilot mode on at all) and have the autopilot take over once the ILS needle starts to come in, indicating you are entering the localizer. Interestingly, this is much the same as the altitude modes. Just as the localizer is armed by hitting the **LOC** button, and you can do anything until the localizer arms take over lateral control, the altitude is also armed (always and automatically) and you can fly any vertical speed, airspeed, or pitch (manually or on autopilot) until the altitude is reached, at which point the autopilot will go into altitude hold mode.

Just like the lateral navigation (that is, the localizer function), the vertical navigation (glideslope, or **G/S** mode) will not do anything until the glideslope needle starts to move. Unlike with the localizer, though, the glideslope function won't do anything until the glideslope needle goes all the way through the center position. It does this because you typically have the airplane on altitude hold until you intercept the glideslope, at which point the plane should stop holding altitude and start descending down to the runway. In other words, the glideslope function will automatically go from armed to active once the plane hits the center of the glideslope.

Let's now put the **LOC** and **G/S** functions into use to fly an ILS.

7.3.3 Flying an ILS Using LOC and G/S

To fly an ILS, do the following while still far away from the ILS and below glideslope:

1. Hit the **ALT** button to hold the current altitude.
2. Enter a heading in the heading window to be followed until you intercept the ILS.
3. Hit the **HDG** button to hold that heading.
4. Hit the **LOC** button. It will go to “armed” (yellow).
5. Hit the **G/S** button. It will also go to “armed” (yellow).
6. As soon as you intercept the localizer, the **LOC** button will go from yellow to green, abandoning the heading mode to instead fly the localizer.
7. As soon as you intercept the center of the glideslope, the **G/S** button will go from yellow to green, abandoning the altitude hold mode to instead fly the glideslope.
8. The autopilot will track you right down to the runway, and even flare at the end, cutting power if auto-throttle is engaged.

Just as in a real airplane, these things only work well if you:

- intercept the localizer far away (outside of the outer marker) and below the glideslope,
- intercept the localizer at less than a 30° angle, and
- hold altitude when you intercept the glideslope.

If you come in above the glideslope, cross the localizer at a wide angle, or intercept the localizer too close to the airport, the autopilot will not be able to maneuver the airplane for landing (again, just as in a real plane).

Now that we've detailed flying with the autopilot, let's talk about flying an FMS (flight management system) plan.

7.3.4 Flying an FMS Plan

To fly a flight management system plan, a few things must happen:

1. You must enter your entire flight plan into the FMS.
2. You have to have the HSI set to GPS, *not* NAV 1 or NAV 2 (because the autopilot will fly whatever it sees on the HSI).
3. You must have the **LOC** button selected ON since that button causes the autopilot to follow the localizer (or whatever is on the HSI).
4. You must have the FLIGHT DIR switch set to AUTO, so that the servos are running.
5. You must hit the **VNAV** button *if* you want the FMS to also load altitudes into the altitude window.

Do all these things and the plane will follow any FMS plan, assuming, of course, that the plane you are flying has all this equipment (which of course some do not).

To demonstrate the use of an FMS, we'll go through the procedure in a typical aircraft (a Boeing 777). The steps will be similar in any aircraft.

1. Open up the Boeing 777 using the Open Aircraft dialog box. It is found in the Heavy Metal aircraft folder.
2. The FMS is found on the right half of the screen, near the middle of the panel (it should be displaying the text "PLAN SEGMENT 01"). Hit the **INIT** button on the FMS. This gets the FMS ready to receive a flight plan.
3. Now hit the **AIRP** button, telling the FMS that you are about to go to an airport.
4. Now enter the ID of the destination airport by hitting the keypad keys with the mouse. Let's imagine we are starting at San Diego International Airport (KSAN) and flying to San Bernardino International (KSBD).
5. If you like, hit the line-select button on the left side of the FMS next to the text "FLY AT _____ FT" and enter the altitude you want to fly at using the keypad.

6. Now, if you want to do more than just fly to an airport, hit the **NEXT** button on the FMS and repeat the steps above for the next waypoint.

There is a back arrow to erase mistakes, as well as **VOR**, **NDB**, **FIX**, and **LAT/LON** buttons to enter those types of destinations. The **PREV** and **NEXT** buttons will cycle through the various waypoints in your plan, and the **LD** and **SA** buttons will load or save flight plans if you would like to use them again.

7. Once you have entered the plan into the FMS, take off and set the SOURCE switch for the HSI (found near the left edge of the panel) to GPS so that the HSI is getting data from the GPS (rather than the NAV 1 or NAV 2 radios).
8. Move the FLIGHT DIR switch to AUTO so the autopilot servos are actually running, and hit the **LOC** autopilot button (at the top of the panel) to follow the HSI lateral guidance (which was just set to get data from the GPS), with the servos actively flying the plane. If you entered an altitude into the FMS, you'll also need to hit the **VNAV** autopilot button to track the entered altitude.
9. Sit back and let the autopilot take you to your destination.

7.4 Flying on Instruments

Though for a long time considered impossible in aviation circles, the ability to fly an aircraft through a large cloud or fog bank relying completely on the aircraft's instruments was made possible in the 1920s. Before then, nearly everyone that attempted this had become just another part of the wreckage, smoldering in a field. Now it is commonplace for even relatively inexperienced pilots to fly long distances in clouds. An instrument rating only requires 125 hours total flight time—although it would certainly not be wise for a 130- or 140-hour pilot to attempt an instrument approach in a 200 ft overcast with $\frac{1}{2}$ mile visibility or to take off on a foggy day. Modern gyroscope-based instrumentation and continual training make it possible to safely fly with reference to only the instrument panel.

7.4.1 Keeping a Sense of Balance

To begin a discussion on instrument flight, we must first discuss why it is so difficult. It isn't that the principles behind flying on instruments are so difficult or that interpreting what the instruments are telling you is that difficult. Rather, the difficulty lies in believing what the instruments are saying. Your body had developed a system of balance and equilibrium that has evolved in humans over millions of years, and forcing your brain to ignore these signals and to believe what the instruments are telling you is very difficult. To put it bluntly, in a real aircraft, your life depends on ignoring your feelings and senses and flying based solely on the information in front of you.

This is why it's so difficult. Your sense of balance comes from three sources within your body. These are, in order of prerogative, your inner ear, your eyes, and your sense of touch and even hearing. You should remember from high school that your inner ear is a series of semi-circular canals that are filled with fluid. They are positioned in your head in different planes and each is lined with thousands of small hairs. The root of each hair is connected to your nervous system. As your body changes position in space, the fluid is moved due to momentum. The resulting bending of these hairs feeds your brain signals that indicate the orientation of your head in space. This information is continually updated and corrected by what your eyes are sending your brain as

well as by your sense of touch. While standing stationary on the ground, your ears tell you that your head is positioned vertically and not moving, your eyes tell you that the ground is stationary beneath your feet, and the skin on the bottom of your feet tells you that it is standing on the ground. All of these inputs align to say the same thing—that you’re standing on the ground.

One limitation to your sense of balance is seen when you are accelerating very slowly, or when you accelerated briefly and have now stopped. Think of a post on a playground that stands vertically in the sand with a seat affixed to it a couple feet from the ground. It can be extremely disorienting to sit on the seat, close your eyes, and then have someone spin you at a constant rate. It doesn’t matter if you’re being spun to the left or the right—what is critical is that you are quickly accelerated and then kept at a constant angular velocity. When you first begin to spin, your inner ear will detect that you are accelerating and spinning. Before long, however, the fluid in your ears will stop moving, since you are no longer accelerating but rather just spinning. Stay like this for a few seconds and it will feel like you’re just sitting stationary. You may still feel a breeze on your face or hear sounds “spinning” about you, but your inner ear will be telling your brain that you’re sitting stationary and your brain will believe it. Now if you’re suddenly stopped, you will instantly feel an incredible sense of angular acceleration in the opposite direction, like you are being spun wildly the other way. Open your eyes and they will tell your brain that you are stationary, but the feeling within your head (a primal, driving sensation) is that you have just started to spin. In scientific circles, this is called “vertigo,” but the sensation is commonly referred to as being dizzy.

The same thing can happen in a cockpit pretty quickly. Imagine for a moment that there is a large bank of clouds in front of you on a calm day. With a few passengers on board you can enter the cloud in a left bank of, say, 20° . Then, after entering the cloud very slowly and very smoothly, you start to bank the aircraft to the right. If you do this slowly and smoothly enough, no one on board will notice. Before you come out of the cloud, you get to a substantially different attitude (perhaps banked 30° right). The unsuspecting passengers may feel the very beginning of the change in bank, but they will probably suspect you’re banked to the left. When you suddenly fly through the other end of the cloud, they’re suddenly in a right-hand turn! While this was fun and harmless to do to unsuspecting friends in college, it underlines the difficulty that unsuspecting pilots can find themselves in if they are not careful.

7.4.2 Gyroscopes and Their Application in Flight

The gyroscope was invented many decades before aircraft, but its tremendous implications for flying were not realized until the mid- to late-1920s. The basic principal that they work on is that if you take a relatively heavy object and rotate it at a high rotational velocity it will hold its position in space. You can then mount this stable, rigid gyroscope in an instrument that is fixed to your aircraft and measure the relative motion of the instrument case (and thus the airplane) about the fixed gyro. The gyroscope is physically attached to an indicator of some sort, and these indicators then relay critical information to the pilot concerning the aircraft’s attitude (that is, its orientation relative to the horizon). There are three primary gyroscopic instruments in the panel. They are:

- the attitude indicator (or AI, normally driven by a vacuum pump on the engine),
- the turn coordinator (or TC, typically electrically driven), and
- the directional gyro (or DG, typically vacuum powered, though possibly electric).

The AI indicates what attitude the aircraft is flying at—how far the nose is above or below the horizon, as well as how far the wings are banked and in which direction. The TC indicates the rate of turn—that is, how steep or shallow your bank is in relation to a standard 2 minute turn rate,

and the DG is nothing more than a gyroscopically driven compass that is more stable and accurate than the old standby, the magnetic (or “whisky”) compass.

7.4.3 The Primary Flight Instruments

There are six primary instruments that have become standard in any instrument panel. Since the early 1970s, these have been arranged in a standard layout referred to as “the six pack.” They are laid out in two rows of three instruments each. The top row, from left to right, contains the airspeed indicator (ASI), the attitude indicator (AI) and the altimeter (ALT). The bottom row contains the turn coordinator (TC) the directional gyro (DG) and the vertical speed indicator (VSI).

The airspeed indicator shows the speed at which the aircraft is traveling through the air. In its simplest form, it is nothing more than a spring which opposes the force of the air blowing in the front of a tube attached under the wing or to the nose of the aircraft. The faster the airplane is moving the stronger the air pressure is that acts to oppose the spring and the larger the deflection of the needle from which the pilot reads the craft’s speed. Obviously, it’s quite a bit more complicated than this, as the pressure exerted by the stream of air varies with the local air density (which continually changes as the airplane climbs or descends), and the ASI must account for this.

The attitude indicator informs the pilot of his or her position in space relative to the horizon. This is accomplished by fixing the case of the instrument to the aircraft and measuring the displacement of the case with reference to a fixed gyroscope inside.

The altimeter looks somewhat like the face of a clock and serves to display altitude. This is measured by the expansion or contraction of a fixed amount of air acting on a set of springs. As the airplane climbs or descends, the relative air pressure outside the aircraft changes and the altimeter reports the difference between the outside air pressure and a reference, contained in a set of airtight bellows.

The turn coordinator measures the rate of turn for the aircraft. The instrument is only accurate when the turn is coordinated—that is, when the airplane is not skidding or slipping through the turn. A skid is the aeronautical equivalent to a car that is understeering, where the front wheels do not have enough traction to overcome the car’s momentum and the front of the car is thus plowing through the turn. In a car, this results in a turn radius that is larger than that commanded by the driver. A slip is a bit more difficult to imagine unless you’re a pilot already. It results from an aircraft that is banked too steeply for the rate of turn selected. To correct the slip, all the pilot has to do is increase back pressure on the yoke, pulling the airplane ‘up’ into a tighter turn, such that the turn rate is in equilibrium with the bank angle.

The directional gyro is a simple instrument that points north and thus allows the pilot to tell which way she or he is flying.

The vertical speed indicator reports the craft’s climb or descent rate in feet per minute. Typically, non-pressurized airplanes will climb comfortably at about 700 fpm (if the plane is capable) and descend at about 500 fpm. Descent rates faster than this cause discomfort on the occupants which is felt in passengers’ ears. Pressurized airplanes can climb and descend much more rapidly and still maintain the cabin rate of change at about these levels, since the cabin altitude is not related to the ambient altitude unless the pressurization system fails.

7.5 Flying an Instrument Approach in X-Plane

Nearly all of the airplanes included with X-Plane have basic navigation radios and instruments built into them, and all of these are used in more or less the same way. We will go through an example for flying an ILS approach (that is, an approach using an instrument landing system) to

the default airport (Seattle-Tacoma International, identifier KSEA), but similar steps can be used for any airport in any application.

7.5.1 Setting Up the Approach

To begin, move your mouse to the top of the screen (causing the menu to appear), and click Location, then Select Global Airport. Just like in the Quick Flight Setup window, you can search for an airport either by name or by ICAO identifier. Unlike in the Quick Flight Setup window, though, the bottom half of this window displays rows of “quick start” buttons. The buttons in the “Takeoff” column (on the far left) will transport your aircraft to the specified runway, while the buttons just to the right of the Takeoff column are the “Final Approach” buttons. Clicking one of these will transport your aircraft to the specified distance away from the runway on the buttons left.

So, let’s fly a full final approach. Search for KSEA (the default airport), and click one of the buttons labeled **10 nm**. X-Plane will put your airplane 10 nautical miles from that runway, at a decent altitude.

7.5.2 Finding the Frequencies

To fly an instrument approach, we first need to know the local navigational aid (NAVAID) frequencies. To find this, move your mouse to the top of the screen, causing the menu to appear. Click Location, then Local Map.

The map in the window that appears shows the ILS, LOC, VOR, and VORTAC frequencies for the area. Zoom in and out of the map by moving your mouse over the map and scrolling with the scroll wheel on your mouse (or by pressing the -- and + keys on the keyboard). To pan the map, simply click on a part of it and drag the mouse.

Now, Sea-Tac is a busy airport, so you may have to zoom in to find the ILS for the runway you are approaching. When you find the ILS, though, you can click on it to highlight in red the ILS path that it will help you fly. If you chose to fly into runway 16L, the frequency to use is 110.30 Hz. If you chose 16C, use 111.70. For 16R, use 110.75. For 34L, use 110.75. For 34C, use 111.70, and for 34R, use 110.30. (Remember this frequency, because we’ll need it when setting up our instruments!)

Recall from the discussion of ILSs previously in this chapter that an ILS combines the functionality of a localizer (providing lateral guidance to the centerline of the runway) with a glideslope transmitter (providing vertical guidance down to the runway).

7.5.3 Setting Up the CDI or HSI

Having found the relevant ILS frequency, tune your NAV1 navigation radio to that frequency (per the section “??” of Chapter 5). Then, make sure your navigation source selector switch (labeled “Source”) is pointing at NAV1 (and if it is not, click it to switch it).

Now let’s discuss the instruments we’ll use to follow this ILS.

The default aircraft in X-Plane will either have an omni-bearing indicator (OBI), a steam-gauge instrument, or a horizontal situation indicator (HSI), part of a glass-cockpit primary flight display (PFD).

In an OBI, the broken yellow arrow going across its face is called the course deviation indicator (or CDI). Each end of the CDI touches the directional gyro, which serves the same function as a compass. The yellow rectangles on the outside of the directional gyro are the glideslope indicators. The OBI has a knob in its lower left, called the omni-bearing selector (OBS). This knob is used to turn the CDI to point to a specific heading. For instance, if we were flying into runway 16L, we

would know that it had a magnetic heading of about 160, so it would be a good idea to use the OBS to turn the CDI so that it points at 160 on the directional gyro. That way, when the airplane was directly on course, the CDI would be pointing straight up.

If instead your airplane has a glass cockpit, the functionality of the CDI is incorporated in your horizontal situation indicator (HSI) in your primary flight display. The course deviation indicator (CDI) portion of the HSI is represented by a vertical purple line. When it is in the center of the attitude indicator, it means that the aircraft is lined up almost perfectly with the physical centerline of the runway. The glideslope indicator portion of the HSI is represented by a horizontal purple line. When this is in the center of the instrument, the aircraft is perfectly in line with the glideslope.

Below the attitude indicator is the directional gyro. The directional gyro works like a compass in that it indicates the aircraft's heading. You can use this to line up your approach with a known heading (e.g., about 160 degrees for runway 16L).

7.5.4 Flying the Approach

Now that we've found the relevant ILS frequencies and set up the navigation instruments, let's begin flying the actual approach.

Once again, we're flying into Seattle-Tacoma International Airport (KSEA), the default airport in X-Plane 10, and we set ourselves up for a 10 nm final using a button in the Select Airport dialog. We have tuned our navigation radio, used the navigation source selector to choose the right radio, and we've set up the CDI or HSI.

As you're flying toward the airport, the CDI will begin to wander left or right to indicate which direction your airplane needs to move in order to point down the centerline of the runway. Aim *toward* the deflection to intercept the localizer course; when the CDI wanders right, point the aircraft's nose right, and so on.

Additionally, the glideslope indicator will begin to move. If its needles are above the center of the instrument then the craft needs to fly up, and if they are below the center of the instrument, it needs to fly down to intercept the glideslope. The goal is to keep the localizer CDI centered to stay on the localizer, and the glideslope CDI centered to stay on the glideslope.

Follow the guidance of the localizer and glideslope until the craft reaches an altitude of about 300 feet above the runway. At this point, if everything was done correctly, the runway will be right in front of the aircraft. If the landing itself was managed properly, the aircraft will be at its stalling speed plus 30% with the gear and flaps down as it comes in for a landing. In the Cirrus Vision, this is about 90 knots. In the Cessna 172, it's about 65 knots, and in the Boeing 747, it's about 140 knots.

Chapter 8

Special Situations in X-Plane

8.1 Using an Instructor Operator Station (IOS) for Flight Training

An Instructor Operator Station is a sort of console used by a flight instructor or someone standing in for an instructor. This console can be used to fail multitudes of aircraft systems, alter the weather and time of day, or relocate the aircraft. The IOS can be run either on the same computer as the simulator (using a second monitor), or it can be a separate computer which connects to the computer used as the simulator either via a local network or over the Internet.

Using one computer it is possible to draw whatever view of the aircraft or panel you wish in addition to an Instructor Operator Station (IOS), assuming your graphics card has two video outputs. To enable output of an IOS on your second monitor, open the Rendering Options from the Settings menu. There, check the “draw IOS on second monitor on same card” box (located in the Special Viewing Options portion of the window). A second window will appear displaying your view of your aircraft, and when you close the Rendering Options window, you will have a standard Local Map dialog box open in the other. Then, simply ensure the **IOS** box is checked in the upper right of the window and you will be ready to go. Use the button on the left to load different aircraft, relocate the aircraft, fail systems, and alter the weather for the “student” pilot.

Note that the mouse cannot be used to fly the aircraft when running an IOS on a second monitor.

Alternatively, to use a second computer as an IOS. To do so, launch X-Plane on both computers and open the Net Connections dialog box (found in the Settings menu). There, select the IOS tab. You need only tell the “master” machine (the one running the simulator, used by the student pilot) and the IOS how to “talk” to one another. On the master machine, check the box labeled **IP of single student instructor console (this is master machine)**. Then, enter the IP address of the computer used as the IOS. Correspondingly, on the computer used as an IOS, check the box labeled **IP of master machine (this is instructor console)** and enter the IP address of the student’s computer.

In both cases, it should not be necessary to change the port number from 49000.

8.2 Flying Gliders

To fly a glider, such as the ASK 21 included with X-Plane 10, you will want to first be towed aloft by another aircraft. To do so, first load your glider as usual (using the Open Aircraft dialog box, found in the Aircraft menu, or using the Quick Flight Setup dialog, found in the File menu),

then open the Aircraft & Situations dialog box (found in the Aircraft menu). Here, you have two options. The **Glider Tow** button will load another aircraft (by default, the Stinson L-5) to which your glider will be attached. This aircraft will pull yours along behind it, and you will be able to release the line connecting you to the towplane at your desired altitude. On the other hand, the **Glider Winch** button will set up a stationary winch on the ground which will quickly pull in a wire attached to your glider, which you will release once you are 1500 feet or so above the ground. In either case, you can release the tow line by pressing the space bar.

When using the towplane, you will start behind the plane with its engine running and ready to go. Releasing the glider's brakes (using the 'b' key by default) commands the towplane to take off, dragging your glider with it.

The towplane, once in flight, will take the glider as high as you like. While being carried up to altitude, though, you must keep your glider in formation behind the towplane. Pressing the space bar will release the line between the aircraft, allowing you to soar freely.

Notice, of course, that until you have unhooked yourself, the tow rope connecting your glider to the towplane is attached to your nose and the towplane's tail. X-Plane models the real physics of this situation, so if your glider pulls left, right, up, or down, it will drag the towplane's tail in that direction. This could result in simply pulling the plane off course, or ultimately in dragging the plane into a stall or spin. If that happens, things will get very complicated very quickly—the towplane (which will likely be crashing) will be dragging the glider with it! The dynamics of the resulting crash are interesting if nothing else.

According to the FAA Glider Handbook, a glider pilot should keep the glider in one of two positions when being towed to altitude. It should either be in a "low tow" position, wherein the glider is just below the wake from the towplane, or it should be in a "high tow" position, just above the wake from the towplane. Hold this position carefully to keep from dragging the towplane around!

A glider pilot must watch the wind and the slope of the terrain carefully to hold inside the upward-moving currents of air, using the lift of the air flowing up the mountain slope to hold the craft aloft. With a good 25-knot wind set in the simulator, you can get a nice, free elevator ride to 10,000 feet when flying along the windward side of a nice, steep mountain. This is called ridge lift.

X-Plane will also model the columns of rising hot air, called thermals, that are useful for prolonging a glider flight. To turn on the thermals, open the Weather dialog box from the Environment menu. Select the **set weather uniformly for the whole world** radio button, then drag the **thermal coverage** slider up—15% coverage or more makes for a nice flight. A 500 ft/min **thermal climb rate** is fine, but you can raise that value, too, if you like. Additionally, as you're starting out in gliders, you may want to keep the various **wind speed**, **shear speed**, and **turbulence** sliders set to minimum.

Now, to take full advantage of both ridge lift and thermals, gliders have a unique instrument known as the total energy variometer. This indicates your glider's rate of climb or descent. You can see the visual representation of this instrument in the panel (it is labeled "Total Energy"); if the needle is above the center of the dial, you are climbing (perhaps due to ridge lift or a thermal), and if it is below the center, you are falling. Even better, you can flip on the switch labeled "Audio" in the instrument panel to get auditory feedback from the variometer. If it is beeping, then the aircraft is in a nice updraft from the air following the terrain. Circling in that area will let the glider ride the climbing air to altitude. When the variometer is emitting a steady tone, the craft is in descending air—the glider has been blown to the wrong side of the mountain, and a crash will follow soon if you do not find a way out of that area!

To land the glider, simply circle down to runway level. The trick is to approach the runway with just enough speed to set the craft down safely. Remember, pulling the speedbrakes in can help

slow the craft down, but if it doesn't have enough speed to reach the landing strip, the glider has no way of generating thrust. Ideally, you will reach the runway at just above stalling speed, but it's always better to have too much speed (which you can burn off using the speedbrakes) than too little.

8.3 Flying Helicopters

The following is a description of how helicopters are flown in the real world, along with the application of this in X-Plane. Note that helicopters are loaded in X-Plane just like any other aircraft, using the Aircraft menu's Open Aircraft dialog box. Note also that you can move to the helipad nearest you at any time by opening the Aircraft menu, clicking Aircraft & Situations, and pressing the **Helipad Takeoff** button.

All manner of different helicopter layouts can be found in reality, but we will discuss the standard configuration here—a single overhead rotor with a tail rotor in the back. Here's how this works: First, the main rotor provides the force needed to lift the craft by continuously maintaining the same rotor RPM for the entire flight. The amount of lift generated by the main rotor is only varied by adjusting the blade pitch of the main rotor blades.

So, imagine the one-and-only operational RPM of a helicopter is 400 RPM. When the craft is sitting on the ground, the rotor is turning 400 RPM, and the pitch of the rotor's blades is about *zero*. This means that the rotor is giving about *zero* lift! Because the blades have zero pitch, they have very little drag, so it is very easy to move them through the air. In other words, the power required to turn the rotor at its operational RPM is pretty minimal. Now, when the pilot is ready to go flying, he or she begins by pulling up on a handle in the cockpit called the “collective.” When this happens, the blades on the rotor go up to a positive pitch. All the blades on the main rotor do this together at one time—“collectively.” Of course, they are then putting out a lot of lift, since they have a positive pitch. Equally apparent is the fact that they are harder to drag through the air now, since they are doing a lot more work. Of course, since it is a lot harder to turn the blades, they start to slow down—if this were allowed to happen, it would be catastrophic, since the craft can't fly when its rotor isn't turning! To compensate, at that point any modern helicopter will automatically increase the throttle as much it needs to in order to maintain the desired 400 RPM in the rotor.

To summarize, this is the sequence for getting a helicopter in the air in X-Plane:

1. While on the ground, the collective handle is flat on the floor. This means the rotor pitch is flat, with minimum drag and zero lift. In X-Plane, a flat collective corresponds to the throttle being *full forward*, or farthest from the user. The automatic throttle in the helicopter is obsessively watching the rotor's RPM, adjusting the throttle as needed to hold exactly 400 RPM in the example above. On the ground, with the collective pitch flat, there is little drag on the blades, so the power required to hold this speed is pretty low.
2. When you decide to take off, you do so by raising the collective up—that is, by pulling it up from the floor of the helicopter. In X-Plane, this is done by easing the throttle on a joystick back down toward you. This increases the blade pitch on the main rotor and therefore increases its lift, but it also increases the drag on the rotor a lot. The rotor RPM begins to fall below 400 RPM, but the auto-throttle senses this and loads in however much engine power it has to in order to keep the rotor moving at exactly 400 RPM.
3. More collective is pulled in until the blades are creating enough lift to raise the craft from the ground. The auto-throttle continues adding power to keep the rotor turning at 400 RPM

no matter how much the collective is raised or lowered.

Once the craft is in the air, the first-time helicopter pilot's first crash is no doubt beginning. This inevitability can be delayed for a few moments using the anti-torque pedals.

The main rotor is of course putting a lot of torque on the craft, causing it to spin in the opposite direction (because of course for every action there is an equal and opposite reaction—the rotor is twisted one way, the helicopter twists the other way). This is where the anti-torque pedals come in. The rotational torque on the helicopter is countered with thrust from the tail rotor. Just push the left or right rudder pedal (such as the CH Products Pro Pedals) to get more or less thrust from the tail rotor. If rudder pedals aren't available, the twist on a joystick can be used for anti-torque control. If the joystick used does not twist for yaw control, then X-Plane will do its best to adjust the tail rotor's lift to counter the main rotor's torque in flight.

Incidentally, the tail rotor is geared to the main rotor so that they always turn in unison. If the main rotor loses 10% RPM, the tail rotor loses 10% RPM. The tail rotor, like the main rotor, cannot change its speed to adjust its thrust. Like the main rotor, it must adjust its pitch, and it is the tail rotor's pitch that is being controlled with rudder pedals or a twisting joystick.

Once the craft is in the air and the *collective pitch* of the main rotor is being adjusted (in X-Plane, using the joystick throttle), try holding the craft 10 feet in the air and adjusting the tail-rotor pitch with the anti-torque pedals (i.e., rudder pedals or a twisting stick) to keep the nose pointed right down the runway. From here, the joystick should be wiggled left, right, fore, and aft to steer the helicopter around.

Here is how this works: If the stick is moved to the *right*, then the rotor blade will *increase* its pitch when it is in the *front* of the craft, and *decrease* its pitch when it is *behind* the craft. In other words, the rotor blade will change its pitch through a full cycle every time it runs around the helicopter once. This means that it changes its pitch from one extreme to the other 400 times per minute (7 times per second) if the rotor is turning at 400 RPM. Pretty impressive, especially considering that the craft manages to stay together under those conditions! Now, while it seems that the right name for this might be the "helicopter destroyer," the fact that moving the stick sends the blade pitch through one cycle every rotation of the rotor blades means we call the control stick the *cyclic* stick. So, we have the collective, cyclic, and anti-torque controls.

Let's talk more about the cyclic. When the stick is moved to the right, the rotor increases pitch when it is in the part of its travel that is in front of the helicopter. This will increase the lift on the front of the rotor disc, causing it to tilt to the right, since the gyroscopic forces are applied 90° along the direction of rotation of the gyroscope. Now that the rotor is tilted to the right, it will of course drag the craft off to the right as long as it is producing lift.

The fascinating thing is that the rotor on many helicopters is totally free-teetering; it has a completely "loose and floppy" connection to the craft. It can conduct *no torque* (left, right, fore, and aft) to the body of the helicopter. Maneuvering is only achieved by the rotor tilting left, right, fore, and aft, dragging the top of the craft underneath it in that direction. The helicopter body is dragged along under the rotor like livestock by a nose-ring, blindly following wherever the rotor leads.

Once you master hovering in place, push the nose down to tilt the rotor forwards. The lift from the rotor acting above the center of gravity of the aircraft will lower the nose of the helicopter, and the forward component of lift from the rotor will drag the craft forward as it flies along.

8.4 Flying the Space Shuttle

Read this chapter before attempting Space Shuttle landings in X-Plane if you want your virtual pilot to live!

The first rule of flying a glider—quite unlike flying a powered plane—is this: *Never come up short*. When bringing a powered plane in for landing, if the pilot thinks the craft will not quite make it to the runway, it is no big deal. She or he just adds a bit more power to cover the extra distance. If a little more speed is needed, it is again no problem—just add power.

Gliders play by a different set of rules, though. There is no engine to provide power, so when setting up a landing, a pilot must be sure to have enough altitude and speed to be able to coast to the airport, because if s/he guesses low by even one foot, the craft will hit the ground short of the runway, crashing. Gliders must never be low on speed or altitude, because if they ever are, there is no way of getting it back—a crash is assured. (Thermals, or rising currents of air, provide the exception to this rule. These can give efficient gliders enough boost to get the job done, but thermals will typically provide less than 500 feet per minute of vertical speed—not enough to keep even a lightweight Cessna in the air!)

Now, with the Space Shuttle, it is certainly true that the aircraft has engines—three liquid-fuel rockets putting out 375,000 pounds of thrust each, to be exact. (To put this in perspective, a fully-loaded Boeing 737 tips that scales around 130,000 pounds, so each engine of the orbiter could punch the Boeing straight up at 3 Gs indefinitely. That is not even considering the solid rocket boosters attached to the Shuttle’s fuel tank that provide millions of pounds of thrust!)

So, the Space Shuttle has engines; the problem is fuel. The orbiter exhausts everything it’s carrying getting up into orbit, so there is nothing left for the trip down. Thus, the ship is a glider all the way from orbit to its touch-down on Earth. With the final bit of fuel that is left after the mission, the orbiter fires its smaller de-orbit engines to slow it down to a bit over *15,000 miles per hour* and begins its descent into the atmosphere.

So, if you want to fly the Space Shuttle, and the Space Shuttle is a glider from the time it leaves orbit to the time it touches down on Earth, you must bear in mind the cardinal rule of gliding: *Always aim long* (past the landing point), not short, because if ever you aim short, you are dead, because you cannot make up lost speed or altitude without engines. Aim long since the extra speed and altitude can always be dissipated with turns or speedbrakes if the craft winds up being too high, but nothing can be done if it comes up short.

In observance of this rule, the Orbiter intentionally flies its glide from orbit extra high to be on the safe side. But there is one problem. It would appear that if the Orbiter flies its entire approach too high, it will glide right past Edwards. In reality, this doesn’t happen for one reason. For most of the re-entry, the Shuttle flies with the nose way up for extra drag, and it makes steep turns to intentionally dissipate the extra energy. The nose-up attitude and steep turns are very inefficient, causing the Shuttle to slow down and come down to Earth at a steeper glide angle. If it ever looks like the Orbiter might not quite be able to make it to the landing zone, the crew simply lowers the nose to be more efficient and level it out in roll to quit flying the steep turns. This makes the Orbiter then glide more efficiently, so the crew can stretch the glide to Edwards for sure. The extra speed and altitude is the ace up their sleeve, but the drawback is they have to constantly bleed the energy off through steep turns (with up to 70° bank angle!) and drag the nose up (as high as 40° !) to keep from overshooting the field.

We will now walk through the re-entry process from the beginning as it is done both in the real Shuttle and in X-Plane.

After de-orbit burn, the shuttle heads for the atmosphere at 400,000 feet high with a speed of 17,000 miles per hour and a distance of 5,300 miles from Edwards (equivalent to landing in the

Mojave Desert after starting a landing approach west of Hawaii—not a bad pattern entry!). In reality, the autopilot flies the entire 30-minute re-entry, and the astronauts do not take over the controls of the shuttle until the final 2 minutes of the glide. The astronauts could fly the entire re-entry by hand, but it is officially discouraged by NASA, for obvious reasons. These speeds and altitudes are way outside of normal human conception, so our ability to “hand-fly” these approaches is next to nil.

During the first one hundred NASA Shuttle missions, the craft was hand-flown for the entire re-entry only once, by a former Marine pilot who was ready for the ultimate risk and challenge. In contrast, users flying the Space Shuttle in X-Plane will have to complete the entire mission by flying by hand.

8.4.1 Walkthrough

To open the Space Shuttle for a re-entry flight into the atmosphere, go to the Aircraft menu and select Aircraft & Situations. In the window that opens, click the **Space Shuttle: Full Re-entry** button. X-Plane will load the craft at around 450,000 feet, in space, coming down at a speed of Mach 20. Control will be limited in space (the craft is operating off of small reaction jets on the Orbiter, set up as “puffers” in Plane-Maker), but once the shuttle hits atmosphere, there will be some air for the flight controls to get a grip on and the craft will actually be able to be controlled. The ship will first hit air at about 400,000 feet, but it will be so thin that it will have almost no effect.

The airspeed indicator at this point will read around zero—interesting, since the craft is actually moving at over 17,000 mph. The reason for this is that the airspeed indicator works based on how much air is hitting it, just like the wings of the Orbiter do. In space, of course, that’s very little. The indicated airspeed will build gradually as the craft descends. Under these conditions, even though the Shuttle is actually *slowing down*, the airspeed indicator will rise as it descends into thicker air that puts more pressure on the airspeed indicator. This oddity of the airspeed indicator, though, is useful, since the air is also putting more pressure on the wings. This means you should get some help with your research paper and the airspeed indicator is really measuring how much force the wings can put out, which is really what a pilot is interested in here.

Restated, the airspeed indicator indicates the craft’s true airspeed times the square root of the air density. It indicates lower speeds in thin air, but the wings put out less lift in thin air as well, so the airspeed indicator works very well to tell the pilot how much lift can be put out by the wings.

If the airspeed indicator reads more than about 250 knots, the wings have enough air to generate the lift to carry the aircraft. If the airspeed indicator is showing less than about 250 knots, then the wings do not have enough air hitting them to lift the Shuttle, so it is still more or less coasting in the thin upper atmosphere, where the air is too thin to do much for controlling flight.

As the airspeed indicator on the HUD gradually starts to indicate a value (as the aircraft descends into thicker air), it means the craft is starting to ease down into the atmosphere at 15,000 mph like a sunburned baby trying to ease into a boiling-hot Jacuzzi—*very* carefully and *very* slowly. Remember, if the craft was going 15,000 mph in the thick air of sea level, it would break up into a million pieces in a microsecond. The only reason it survives at 15,000 mph up here is the air is so thin that it has almost no impact on the ship. Again, the airspeed indicator tells how much the air is really impacting the craft; 250 knots is a “comfortable” amount. The trick is to get the craft moving much slower than 15,000 mph by the time it gets down to the thick air of sea level—and to have it doing so at Edwards Air Force Base. This is what the re-entry is for, to dissipate speed while descending so that the Orbiter is never going too fast for the thickness of the air that it is in. It should only descend into the thicker air once it has lost some speed in the thinner air up higher.

The whole thing should be a smooth process wherein the ship doesn't get rammed into thick, heavy air at too high a speed.

Now, as the Orbiter begins to touch the outer molecules of the Earth's atmosphere, you will notice a slight ability to fly the ship as some air begins to pass over the wings. At the same time, the HUD should begin showing speed. Notice the picture of the Orbiter on the right-hand EFIS display. The Atlantis already has this display retrofitted over its old steam gauges (the EFISs from the Atlantis are modeled very accurately in X-Plane—astronauts could use it for familiarization for sure). Both the Orbiter and the path down to Edwards should be visible. The goal is to stay on the center path. If the craft gets above it, it is either too fast or too high and might overshoot the landing. If it gets below it, it is either too slow or too low and might not make it.

Remember that the line is drawn with a large margin for error, so if a pilot stays on the line, he or she will have plenty of extra energy. Getting below the line a *little* will only tap into the speed/altitude reserve. Getting below the line a *lot* will keep the craft from reaching Edwards.

The Orbiter must stay near the center green line. This green line represents the desired *speed* for the early part of the re-entry, the desired total *energy* for the middle part of the re-entry, and the desired *altitude* for the final phase of the re-entry. This is the way NASA set up the EFIS. If the craft is too fast or too high (meaning it is above the center line) then it is time to dissipate some energy. Put the Shuttle in a steep bank, pull the nose up, and hang on!

The real Orbiter will have it nose up about 40° and be in a 70° bank to try to lose energy while moving at 14,000 mph, glowing red hot, hurtling through the upper atmosphere on autopilot, and leaving a ten mile-long trail of ionized gas behind it while the astronauts just watch.

Go into some steep turns to dissipate energy as needed to keep the ship from going above the center green line. Look at the little blue pointer on the far left-hand side of the far right display. That indicates how high the nose is supposed to be. The green pointer is where the nose is now—they need to match. The pointers just to the right indicate the desired and current deceleration. These indicators, though, will not be used to fly by. Look at the little pointer up top on the horizontal scale. That is the computer's estimation of how much bank angle the craft probably needs to stay on the center green line. Pilots should follow the computer's recommendation or their own intuition for how much bank to fly, but they must certainly keep the nose up (in order to stay in the upper atmosphere) and fly steep banks to dissipate the extra speed and altitude. It might be tempting to just push the nose down if the craft is high, but don't. The aircraft would drop down into the thick air and come to an abrupt stop from the tremendous drag, keeping it from ever making it to Edwards. It would wind up swimming in the Pacific somewhere around Hawaii.

Now, as the pilot makes those steep turns, the aircraft will gradually be pulled off course. For this reason, the turn direction should be switched from time to time to stay on course. Turn left awhile, then right, then back to the left again. This is what the real Orbiter does—it slalom-skis through the upper atmosphere at Mach 20. Watch Edwards on the center EFIS display.

As the ship approaches Edwards, right on the center green line on the right-hand display, there should be a sort of a circle out past Edwards. This is the Heading Alignment Cylinder, or H.A.C. The aircraft will fly past Edwards at about 80,000 feet, then fly around the outside of the H.A.C. like it's running around a dining room table. After coming around, it will be pointed right at Edwards. If the craft is still on the green line, its altitude will be just right for landing as well. In the real Shuttle, this is usually where the pilot will turn off the autopilot and hand-fly in.

The craft should now be doing about 250 or 300 knots, coming down at about 15,000 feet per minute or so (about 125 miles per hour of descent rate). Needless to say, pilots do not want to hit the ground with that 125 miles per hour descent rate. Do not aim for the runway without expecting to become a smear on it. Instead, aim for the flashing glideslope lights 2 miles short of the runway that NASA has thoughtfully provided. If they are all red, the craft is too low. If they are all white,

it is too high, so the speed brakes need to be brought in. If the lights are half red and half white, the Orbiter is right on its glideslope (about 20°). Airliners fly their approach at 125 knots with a 3° angle of descent, while the Space Shuttle uses 250 knots and a 20 degree descent angle—not too unusual considering pattern-entry started west of Hawaii, actually.

To recap: the craft should be at 250 knots, on the green line, lined up with the runway. It should be facing half red, half white glideslope lights with the flashing strobes by them. This approach configuration should be held until the craft is pretty close to the ground (3° glideslope to the runway), then the descent should be leveled and the gear put down (using the ‘g’ key or the mouse). Pull the nose up for a flare as the runway approaches, causing the Orbiter to touch down smoothly. Lower the nose then and hit the parachute and even the brakes if the craft will be allowed to roll out.

Now, if you can just repeat that process another hundred times in a row without a single hitch, you will be as good as NASA.

Special thanks to Sandy Padilla for most of the Shuttle re-entry information!

8.5 Flying the X-15

The North American X-15 is a rocket-powered speed demon. With a top speed of Mach 6.72 (4520 miles per hour), it is the fastest manned aircraft in the world. To begin flight, this craft is dropped, uniquely, from the B-52 “mothership.” Its top speed is over double that of the SR-71 (the world’s fastest jet airplane), and its maximum altitude of over 50 miles qualifies its pilots for astronaut status.

The craft’s absurdly high top speed requires a blast shield to be installed over one side of the windshield—without it, the windows would burn up. The X-15 pilots would fly the high speed portion of the mission with the shield on the right side, looking out the left side only. After the craft slowed down (and the left window was sufficiently charred), the pilot would jettison the blast shield and move to the right window in order to land.

To open the X-15, open the Aircraft menu and click Aircraft & Situations. In the dialog box that appears, click the **Air Drop from B-52** button. X-Plane will load up both the X-15 and its drop ship (by default, the B-52). When you are ready, press the space bar to release the rocket from the drop ship. Give it full throttle, with no flaps, and watch your airspeed “rocket”—that is, until it gains enough altitude, at which point its *indicated* airspeed will drop to maybe 15 knots, while it is actually moving at Mach 6.

8.6 Simulating Combat in X-Plane

X-Plane is not intended to be a combat simulator. Therefore, while combat functionality exists in the form of guns and missiles, damage from weapons is not simulated realistically—getting hit will simply cause your engines to die, allowing you to glide to the ground.

Simulating combat in X-Plane involves four steps:

- configuring your controls,
- adding enemy aircraft,
- equipping your own aircraft with guns and/or missiles, and
- dogfighting.

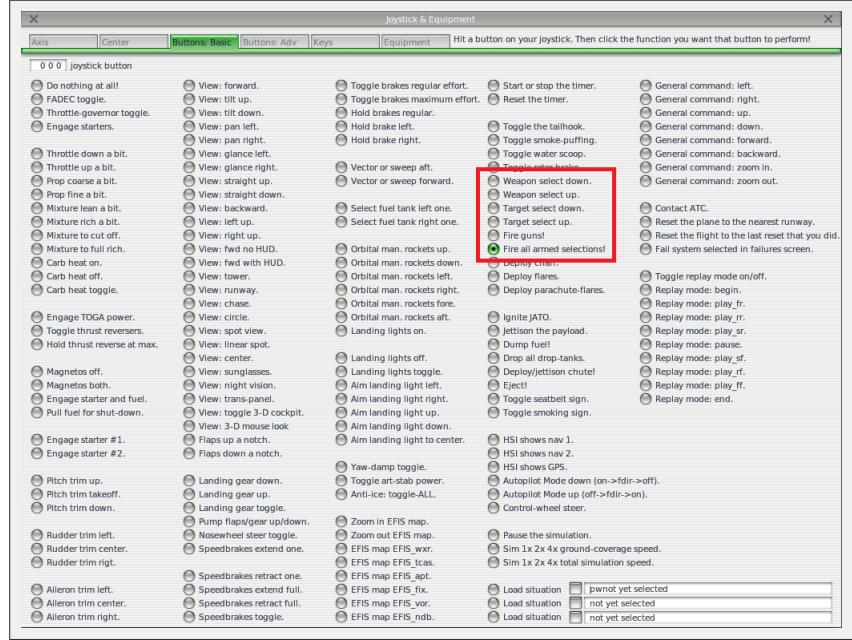


Figure 8.1: The weapon controls found in the Buttons: Basic tab [Full size →]

8.6.1 Configuring Your Controls

In order to use your flight controls to control your weapons, either to fire them or to cycle through the currently armed weapons, open the Settings menu and click Joystick & Equipment. There, go to the Buttons: Basic tab and configure the buttons as you desire. Remember to *first* press the button on the joystick that you intend to assign, *then* select its function.

You can also assign weapons controls in the Buttons: Adv tab or the Keys tab. The “weapons/” category contains the relevant settings there.

Note that assigning joystick controls is especially important if your aircraft does not have controls in the instrument panel for arming weapons. If you intend to use missiles, you must assign buttons to select targets, using the “target select up” and “target select down” functions.

8.6.2 Adding Enemy Aircraft

To set up a combat situation, first open the Aircraft menu and click Aircraft and Situations. The bottom panel, labeled Other Aircraft Selection, is the one we’re interested in. Set the number of aircraft (in the upper left of the box) to 2 or more. Boxes will appear below corresponding to the other aircraft, as seen in Figure 8.2.

Clicking the box to the left of an aircraft file name will open a standard “Load Aircraft” dialog box; use these boxes to load the aircraft you would like to battle.

To the right of each aircraft file is the plane’s “team color.” Aircraft which have the same color will be teammates, and all other colors will be enemies. In Figure 8.2, “your plane” is on the red team, while the three other aircraft are on the green team. In this case, all three enemy aircraft will target you alone.

Having selected the enemy aircraft to fly against, you can choose their skill level, ranging from very easy to very hard, using the drop down box near the top of the Other Aircraft Selection portion of the window.



Figure 8.2: Adding enemy aircraft using the Aircraft and Situations window [Full size →]

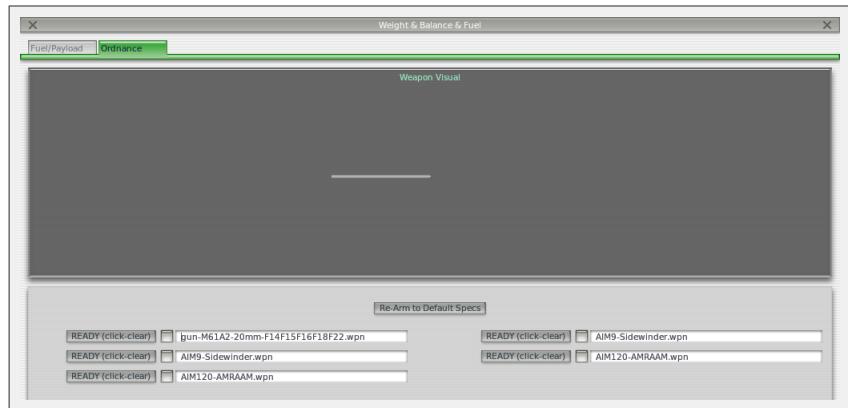


Figure 8.3: Adding weapons using the Weight and Fuel window [Full size →]

Finally, you can choose to either save the aircraft you have selected to your preferences or have them randomized at each load using the radio buttons next to the number of aircraft setting. Having set up the combatants, you can close the Aircraft and Situations window.

8.6.3 Equipping Your Aircraft

Many military craft, such as the F-22 Raptor, F-4 Phantom II, and Saab JA 37 Viggen come equipped with guns and missiles by default. If your aircraft does not have weapons, or if you would like to change the loadout, you can do so using the Weight and Fuel window, launched from the Aircraft menu. There, the Ordnance tab can be used to add a weapon to the aircraft's hardpoints (or weapon stations).

Clicking the small squares to the left of each weapon slot will bring up a dialog box to load a weapon. Opening the Weapons folder (found in the main X-Plane directory) will display a number of weapon options. For instance, in Figure 8.4, a GAU-8 Avenger 30mm gun is selected.

Clicking Open will arm the weapon you chose.

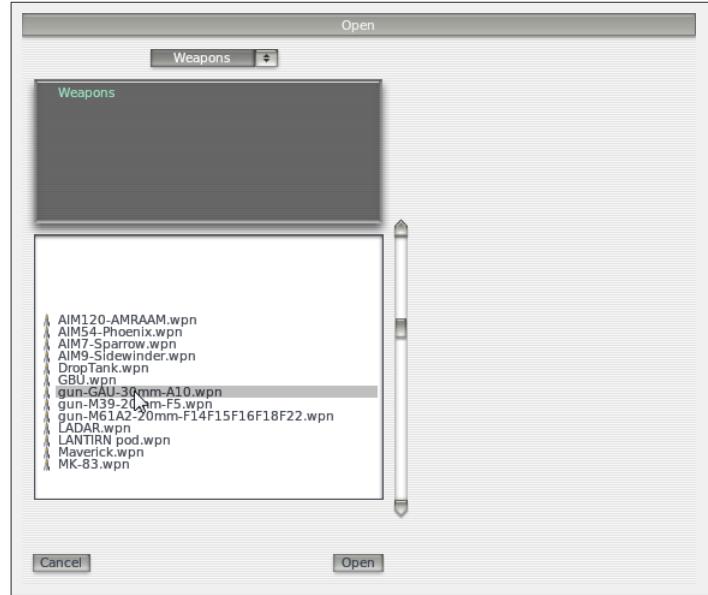


Figure 8.4: Selecting a gun [Full size →]



Figure 8.5: The weapon controls in the panel of the F-22 Raptor [Full size →]

8.6.4 Arming Weapons and Fighting

With enemy aircraft in the sky, weapons equipped to your aircraft, and your joystick or yoke configured for weapons, it's time to dogfight. If your aircraft was designed with combat in mind, it will have a toggle for arming a weapon, and potentially a weapon rate of fire control as well. For instance, Figure 8.5 shows the weapons controls in the F-22 Raptor. The Raptor's gun is currently selected, with its rate of fire set to the maximum. Similar controls appear in the F-4 Phantom II, seen in Figure 8.6.

With your weapon selected, whether guns or missiles, all it takes to fire is to press the button on your joystick assigned to fire weapons.

8.6.4.1 Targeting Enemy Aircraft and Using Missiles

In order to lock on to a target using missiles, you must have a joystick or key assigned to the “target select up” and/or “target select down” functions, as described in the section “Configuring



Figure 8.6: The weapon controls in the panel of the F-4 Phantom II [Full size →]

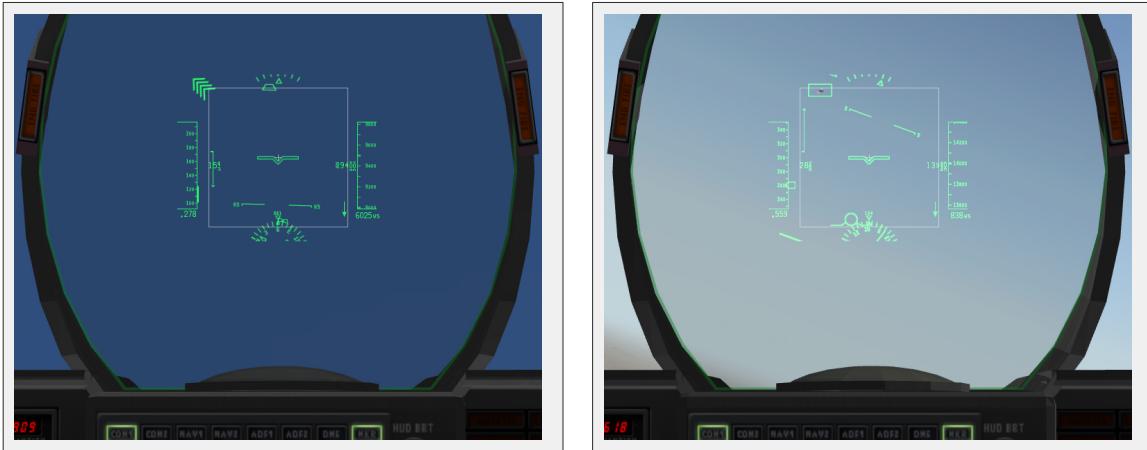


Figure 8.7: Two HUD views; on the left, a target is high and to the left, off screen, while on the right, the target is in view. [Full size 1 →] [Full size 2 →]

“Your Controls” above. In order to usefully target, the aircraft must have either a head-up display (HUD) or moving map, and preferably both.

When enemy aircraft are nearby, you can use the target select controls to assign targets for your missiles to seek out. With a target which is not currently visible selected, the HUD will show an arrow pointing in the direction of the target, as the image on the left in Figure 8.7. If the active target is visible on screen within the HUD, however, a targeting reticle will appear around the aircraft, as in the image on the right in Figure 8.7.

In aircraft with a moving map display, there is often much more data visible than what is relevant in a dogfight. Therefore, by pressing the green buttons beneath the standard EFIS moving map, you can turn off all but the TCAS (traffic collision avoidance system) indicators—that is, the indicators for other aircraft. For instance, compare the two displays in Figure 8.8.

With only the other aircraft displayed on the map, it is much easier to see the location of enemy fighters and to distinguish the active target. For instance, in Figure 8.9, the aircraft approximately 30° to the right was selected as the target, so it is highlighted in red on the display.

Additionally, note that the dial above the moving map labeled TFC (traffic) controls the radar system’s range. Moving the dial clockwise will increase the range, and turning it counterclockwise



Figure 8.8: Two moving map displays; the display on the left is showing all available data, whereas the one on the right is showing only other aircraft [Full size 1 →] [Full size 2 →]

will decrease it. At low ranges, finer detail is available on the EFIS display.

8.6.5 Strategy

The key to winning a dogfight lies in creating a situation where *your* aircraft's strengths are emphasized and an opponent's weaknesses are exploited. This means trying to force a tight, up-close battle when flying a more maneuverable fighter than the enemy, or aiming for dive-bombs and other tactics requiring speed and weight when flying a faster, larger craft.

Additionally, do not underestimate the value of quick combat maneuvers, such as:

- corkscrews—rolling your craft left or right while continuously varying its pitch
- feints—rolling to one side as though to go into a banked turn (i.e., a turn with the craft on its side, while pulling back on the controls in order to pull “in” to the turn), but pushing the nose forward instead
- barrel rolls—often described as “a cross between a roll and a loop” (see Figure 8.10)

For more information on combat tactics, see the Dicta Boelcke, a list of tactics developed by World War I ace Oswald Boelcke.

8.7 Performing Carrier Operations

To begin carrier operations, select the aircraft you will use. The F-22 Raptor or the JA 37 Viggen (both found in the Fighters folder, in the Aircraft directory) are good choices. Then, open the



Figure 8.9: The moving map display with a target selected, located about 30 degrees to the right, in front of the aircraft and travelling at 393 kts [Full size →]

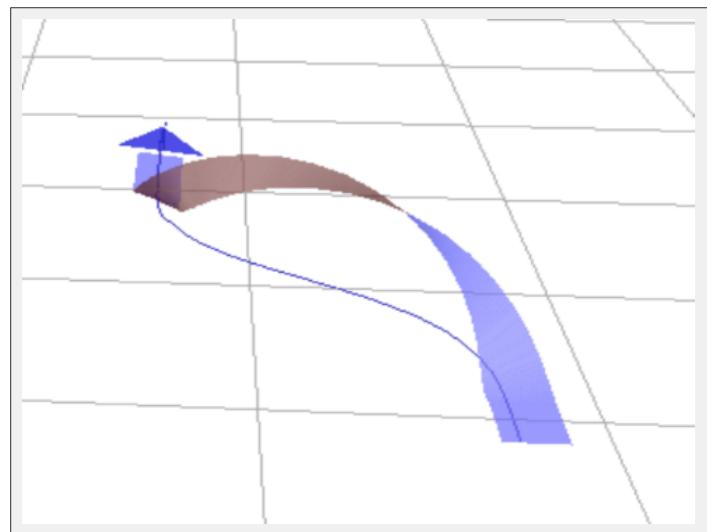


Figure 8.10: Diagram of a barrel roll. Thanks to MioUzaki for releasing this image into the public domain. [Full size →]

Aircraft & Situations window and press the **Carrier Catshot** or **Aircraft Carrier Approach** buttons to set up a catapult launch from a carrier or a final approach to one, respectively.

To take off from a carrier, a few things must be done in quick succession. First, give the aircraft full throttle, and pull in about half flaps. Release the brakes (using the ‘b’ key by default) to activate the catapult propelling your aircraft off the deck. From there, simply guide the craft down the flight deck and, once clear, pull the nose up. When you’re safely in the air, bring the gear up (using the ‘g’ key by default) and you’re off.

Landing on the carrier is a bit more difficult. First, be sure you have an aircraft with an arresting hook, such as the default fighters in X-Plane.

To set up an approach to a modern carrier, such as the USS Nimitz included with X-Plane 10, bear in mind that the landing runway is angled 30° to the port (left) side—it is not straight down the flight deck like in older carriers. This change was made in order to prevent the all-too-common overruns that occurred in WWII when a landing plane crashed into the stacked line of planes at the far end of the carrier. A pilot landing on such a carrier must correct for this angling. With your ADF tuned to the carrier, then, you must wait until the ADF is pointing either 15 or 60° to the right before turning in for a landing.

When approaching the flight deck to land, a glidepath of about 3.5° is standard. At this time, the tail hook should be lowered. This will allow the tail of the aircraft to catch the arresting wires on the deck. These wires will accelerate the craft from well over 100 knots down to zero in little more than a second.

Unlike in a conventional landing, there should be no “flare” before touching down on the carrier. Whereas, say, an airliner would raise its nose up just before touching the runway (thereby ensuring a smooth landing), a carrier approach should maintain a constant glideslope until the craft hits the deck.

Also, rather counter-intuitively, a real fighter pilot must slam the throttle to full the instant that the aircraft touches the deck. This is because, even when the pilot has done everything right, the craft’s tail hook can bounce over the arresting wires in what is called a “bolter.” When this happens, the pilot must be ready to get off the deck safely and come around for another try. Don’t worry—even when the throttle revs up like this, the arresting wires will still pull the craft down to zero velocity.

8.8 Flying a Boeing 747 with the Piggybacking Space Shuttle

The piggybacking Space Shuttle situation in X-Plane 10 was inspired by the following email, which was circulated by United Technologies corporate. It is a “trip report” from the pilot of the 747 that flew the Shuttle back to Florida after the Hubble repair flight.

Well, it’s been 48 hours since I landed the 747 with the shuttle Atlantis on top and I am still buzzing from the experience. I have to say that my whole mind, body and soul went into the professional mode just before engine start in Mississippi, and stayed there, where it all needed to be, until well after the flight... in fact, I am not sure if it is all back to normal as I type this email. The experience was surreal. Seeing that “thing” on top of an already overly huge aircraft boggles my mind. The whole mission from takeoff to engine shutdown was unlike anything I had ever done. It was like a dream... someone else’s dream.

We took off from Columbus AFB on their 12,000 foot runway, of which I used 11,999 $\frac{1}{2}$ feet to get the wheels off the ground. We were at 3,500 feet left to go of the runway,

throttles full power, nose wheels still hugging the ground, copilot calling out decision speeds, the weight of Atlantis now screaming through my fingers clinched tightly on the controls, tires heating up to their near maximum temperature from the speed and the weight, and not yet at rotation speed, the speed at which I would be pulling on the controls to get the nose to rise. I just could not wait, and I mean I *could not wait*, and started pulling early. If I had waited until rotation speed, we would not have rotated enough to get airborne by the end of the runway. So I pulled on the controls early and started our rotation to the takeoff attitude. The wheels finally lifted off as we passed over the stripe marking the end of the runway and my next hurdle (physically) was a line of trees 1,000 feet off the departure end of Runway 16. All I knew was we were flying and so I directed the gear to be retracted and the flaps to be moved from Flaps 20 to Flaps 10 as I pulled even harder on the controls. I must say, those trees were beginning to look a lot like those bushes in the drive-through car washes, so I pulled even harder yet! I think I saw a bird just fold its wings and fall out of a tree as if to say “Oh, just take me.” Okay, we cleared the trees, duh, but it was way too close for my laundry. As we started to actually climb, at only 100 feet per minute, I smelled something that reminded me of touring the Heineken Brewery in Europe... I said “Is that a skunk I smell?” and the veterans of shuttle carrying looked at me and smiled and said “Tires!” I said “*Tires?! Ours?!*” They smiled and shook their heads as if to call their captain an amateur... Okay, at that point I was. The tires were so hot you could smell them in the cockpit. My mind could not get over, from this point on, that this was something I had never experienced. Where’s your mom when you *really* need her?

The flight down to Florida was an eternity. We cruised at 250 knots indicated, giving us about 315 knots of ground speed at 15,000 feet. The miles didn’t click by like I am used to them clicking by in a fighter jet at Mach 0.94. We were burning fuel at a rate of 40,000 pounds per hour or 130 pounds per mile, or one gallon every length of the fuselage. The vibration in the cockpit was mild, compared to down below and to the rear of the fuselage where it reminded me of that football game I had as a child where you turned it on and the players vibrated around the board. I felt like if I had plastic clips on my boots I could have vibrated to any spot in the fuselage I wanted to go without moving my legs... and the noise was deafening. The 747 flies with its nose 5° up in the air to stay level, and when you bank, it feels like the shuttle is trying to say “Hey, let’s roll completely over on our back.” Not a good thing, I kept telling myself. So I limited my bank angle to 15° and even though a 180° course change took a full zip code to complete, it was the safe way to turn this monster.

Airliners and even a flight of two F-16s deviated from their flight plans to catch a glimpse of us along the way. We dodged what was in reality very few clouds and storms, despite what everyone thought, and arrived in Florida with 51,000 pounds of fuel too much to land with. We can’t land heavier than 600,000 pounds total weight and so we had to do something with that fuel. I had an idea... Let’s fly low and slow and show this beast off to all the taxpayers in Florida lucky enough to be outside on that Tuesday afternoon. So at Ormond Beach we let down to 1,000 feet above the ground/water and flew just east of the beach out over the water. Then, once we reached the NASA airspace of the Kennedy Space Center, we cut over to the Banana/Indian Rivers and flew down the middle of them to show the people of Titusville, Port St. Johns and Melbourne just what a 747 with a shuttle on it looked like. We stayed at 1,000 feet and since we were dragging our flaps at Flaps 5, our speed was down to around 190 to 210 knots. We could

see traffic stopping in the middle of roads to take a look. We heard later that a Little League Baseball game stopped to look and everyone cheered as we became their 7th inning stretch. Oh say can you see...

After reaching Vero Beach, we turned north to follow the coast line back up to the Shuttle Landing Facility (SLF). There was not one person laying on the beach... They were all standing and waving! "What a sight," I thought, and figured they were thinking the same thing. All this time I was bugging the engineers, all three of them, to recompute our fuel and tell me when it was time to land. They kept saying "Not yet Triple, keep showing this thing off," which was not a bad thing to be doing. However, all this time the thought that the landing, the muscling of this 600,000 pound beast, was getting closer and closer to my reality. I was pumped up! We got back to the SLF and were still 10,000 pounds too heavy to land so I said I was going to do a low approach over the SLF going the opposite direction of landing traffic that day. So at 300 feet, we flew down the runway, rocking our wings like a whale rolling on its side to say hello to the people looking on! One turn out of traffic and back to the runway to land... still 3,000 pounds over gross weight limit. But the engineers agreed that if the landing were smooth, there would be no problem. "Oh thanks guys, a little extra pressure is just what I needed!" So we landed at 603,000 pounds, and very smoothly if I have to say so myself. The landing was so totally controlled and on speed, that it was fun. There were a few surprises that I dealt with, like the 747 falls like a rock with the orbiter on it if you pull the throttles off at the "normal" point in a landing and secondly, if you thought you could hold the nose off the ground after the mains touch down, think again... *It is coming down!!!* So I "flew it down" to the ground and saved what I have seen in videos of a nose slap after landing. Bob's video supports this!

Then I turned on my phone after coming to a full stop only to find 50 bazillion emails and phone messages from all of you who were so super to be watching and cheering us on! What a treat, I can't thank y'all enough. For those who watched, you wondered why we sat there so long. Well, the shuttle had very hazardous chemicals on board and we had to be "sniffed" to determine if any had leaked or were leaking. They checked for Monomethylhydrazine (N_2H_4 for Charlie Hudson) and nitrogen tetroxide (N_2O_4). Even though we were "clean," it took way too long for them to tow us in to the mate-demate area. Sorry for those who stuck it out and even waited until we exited the jet.

I am sure I will wake up in the middle of the night here soon, screaming and standing straight up dripping wet with sweat from the realization of what had happened. It was a thrill of a lifetime. Again I want to thank everyone for your interest and support. It felt good to bring Atlantis home in one piece after she had worked so hard getting to the Hubble Space Telescope and back.

—Triple Nickel, NASA Pilot

To select this situation, open the Aircraft & Situations dialog box from the Aircraft menu. There, click the button labeled **Piggyback Shuttle on 747**.

8.9 Fighting Forest Fires

In order to do water bombing on forest fires in X-Plane, load up your desired water tanker, such as the Bombardier 415 seaplane. Then, in order to increase the likelihood of encountering forest

fires, open the Environment menu and open the Weather dialog box. There, click the radio button labeled **set weather uniformly for the whole world**. Set all cloud layers to “clear,” with no precipitation, and set the temperature to 70° F (21° C) or more.

At this point, you should be able to find some forest fires, especially in mountainous areas. To jump instantly to the nearest forest fire, you can open the Aircraft menu and click Aircraft & Situations. In the dialog box that appears, click the **Forest Fire Approach** button. Alternatively, the forest fires will show up in the X-Plane maps (available in the Local Map dialog box, found in the Location menu) as a small fire icon.

In the Bombardier 415, you will have to first scoop up water into the aircraft’s underside. With your water payload ready to be dropped, you can assign a key (as described in the section “Configuring Keyboard Shortcuts” of Chapter 4) to the “jettison payload” function (categorized under flight controls). Press that button to drop your load of water on the fire.

8.10 Flying in Non-Standard Gravity

You can change the X-Plane world’s gravitational properties using the Environment Properties dialog box, which is found in the Special menu. The planet’s gravity is calculated based on the radius and mass of the planet. This can be used for some interesting experiments.

8.11 Flying Other Special Situations

In the Aircraft & Situations dialog box (opened from the Aircraft menu), you will find a number of other special ways to take off and fly. Pressing the **Grass field takeoff**, **Dirt field takeoff**, **Gravel field takeoff**, or **Waterway takeoff** buttons will take you, in your current aircraft, to the nearest airstrip of that type. Be sure not to use the **Waterway takeoff** button unless you are in a seaplane!

Using the **Frigate Approach**, **Medium Oil Rig Approach**, or **Large Oil Platform Approach** buttons will give you excellent targets for a helicopter landing.

Chapter 9

Expert Essays—Unleashing the Simulator’s Full Potential

9.1 Tuning the Handling of Aircraft X-Plane

If X-Plane is set up and flying, but aircraft seem to be too sensitive in pitch, or if they pull to one side, the simulator’s handling may need to be tuned.

Before performing the following, make sure the joystick and/or other control devices are set up and calibrated. See the section “Configuring Flight Controls” of Chapter 4 for instructions on doing this.

To easily see whether the controls are properly calibrated, go to the Settings menu and click Data Input & Output. There, select the rightmost of the check boxes labeled **joystick ail/elv/rud**. When you close the Data Input & Output dialog box, you will see, in the upper left corner of the screen, the aileron, elevator, and rudder inputs from the flight controls (such as a joystick, yoke, rudders, etc.).

With properly configured controls, the aileron, elevator, and rudder joystick inputs all read around 0.0 when your flight controls are centered. When the controls are pushed full left and forward, they should read around –1.0. When the controls are pulled full aft and right, they should read around 1.0. If this is what you see, then your controls are properly calibrated. If not, it’s no wonder the plane is not flying correctly! You need to configure the controls as described in the section “Configuring Flight Controls” of Chapter 4.

If the controls are indeed properly calibrated as per the above test, but the plane still is not flying correctly, it’s time to look at the first level of control response tuning. Go to the Settings menu and click Joystick & Equipment. In that dialog box, select the Axis tab. Leave the flight controls centered and hit the button labeled **Use this position as center**.

With that done, close the Joystick & Equipment dialog box and move the flight controls to the centered position. Check to see if the data output (which should still be on the screen from the pre-test in the above paragraphs) is around 0.000 when the controls are centered. If it is, then the hardware works fine and the center point was set successfully. If the data output does not read near 0, the hardware is either of poor quality (or failing) or the center point was not properly set.

With the center point set correctly, try flying the plane once again. If it still does not handle correctly, read on to tune the next level of control response.

Open the Joystick & Equipment window and select the Nullzone tab. Look at the three sliders labeled **control-response** (one each for pitch, roll, and yaw) in the upper right of the screen.

If these three sliders are fully left, then the control response is linear; that is, a 50% stick

deflection in the hardware will give 50% control deflection in the aircraft. Likewise, 100% stick deflection in the hardware will give 100% control deflection in the aircraft.

If the problem being experienced is that the plane feels too responsive in the simulator, try dragging the sliders all the way to the right. This will give a non-linear response. Set this way, 0% hardware deflection will still give 0% control deflection in the simulator, and 100% hardware deflection will still give 100% control deflection. The difference lies in between—50% stick deflection in the hardware might only give 15% control deflection in the simulator. In other words, while the hard-over roll rate in the simulator will remain unchanged no matter how these sliders are set, fine control will be increased for smaller, partial deflections, since the flight controls will move less for a small-to-moderate stick deflection in the hardware joystick or yoke. This will give a nice, fine pitch control and slow, detailed roll control.

If, after changing the control response, the aircraft still does not fly as it should, read on.

The next level of control tuning is stability augmentation. If the plane still feels squirrelly or overly sensitive, go back to the Nullzone tab of the Joystick & Equipment window and try dragging the three sliders in the upper left of the window (**labeled stability augmentation**) all the way to the right.

This will cause X-Plane to automatically counteract any stick input to some degree, resisting rapid or large deflections in pitch, heading, and roll. Basically, it is like always having an autopilot on that smooths things out. This is obviously very fake, but in the absence of a perfect flight control system, g-load, and peripheral vision feedback, this can help smooth out the airplane's flight characteristics. Try flying with those sliders at various places, bearing in mind that full left should be most realistic (with no artificial stability added).

If, after doing all of the above, the aircraft still does not fly as it should, nothing more can be done within the simulator. It is now time to tweak the airplane model itself. In the real world, if a plane is pulling to one side or the other, a pilot will bend the little trim tab on the aileron one way or another. This bending of the aileron trim tab counteracts any imperfections in the shape of the airplane, the dynamics of the propwash, or the mass distribution inside the plane. The same thing can be done in X-Plane—you can bend a trim tab a bit one way or the other to make the plane fly true.

To do this, first exit X-Plane and open Plane Maker (found in the X-Plane installation folder, located by default on the Desktop). Go to the File menu and select Open. There, select the plane that is pulling left or right and load it using the **Open** button.

Then, go to the Standard menu and click Control Geometry. In this window, select the Trim & Speed tab. Look at the far right-hand column of controls in the top half of the screen, labeled trim tab adjust. This is a measure of how much the trim tabs are bent on each axis. The top control is the elevator, the middle the aileron, and the bottom the rudder (per the labels on the far left). A value of 0.000 in the **trim tab adjust** means that the trim tab is not bent at all. A value of 1.000 means the tab is bent so far that the control is fully deflected by the trim tab—this is way too far. Try bending the trim tab just a little bit—maybe set the value at 0.05 or at most 0.10. This would correspond to being enough force to deflect the controls 5% or 10%, respectively, due to the trim tab. A positive value corresponds to bending the trim tab up or right, depending on whether it is pitch, yaw, or roll. Thus, if the plane needs to roll right a bit more (or needs to stop rolling left), then enter a positive number for the aileron control. The same goes for the rudder: if the plane needs to pull right a bit more, enter a positive rudder trim tab adjust. If the plane needs to pull up a bit more, give it a positive elevator trim tab adjust. Tweak the trim tabs as needed, save the aircraft file (using Plane Maker's File menu), and exit Plane Maker. Then, open up X-Plane and try flying the plane again. It should noticeably pull one way or another based on how the trim tabs were bent. The trim tab controls may need to be tuned again to get the plane to fly as straight as

is desired.

9.2 Setting Up a Copilot's Station

A copilot's station is a second computer networked to the main simulator, set to view a portion of the cockpit intended for the copilot. To use a copilot's station, you will first need two computers, each running their own copy of X-Plane. These need to be on the same network, or then need to be joined together with a single crossover Ethernet cable. The computers should form a simple LAN, configured as normal within Mac OS X or Windows, whatever the case may be.

You will need two copies of the aircraft file you intend to fly, both either created or modified using Plane Maker. The first copy of your aircraft should have the pilot-side instrument panel. If you are content with the default panel layout, any of the stock planes could be used.

With the first version (the pilot-side version) of the plane ready, simply make a copy of the entire airplane folder and add some suffix, such as “_copilot” to the end of the folder’s name—for instance, if the aircraft you wanted to fly was in the folder “Boeing 747”, you might name the copilot-side version “Boeing 747_copilot”.

Next, open the copilot-side copy of the aircraft in Plane Maker and tweak the instrument panel (as described in the chapter “Creating an Instrument Panel” of the Plane Maker manual) as desired for the co-pilot’s side of the craft. Save it when finished and close Plane Maker.

There should now be two copies of the same aircraft folder, where each aircraft file within has its own instrument panel. These folders should have names like “[*Plane name*]” and “[*Plane name*]-copilot”. Both folders should be in the same place within your X-Plane directory.

Simply copy that entire aircraft folder from one of the computers over to the other, putting the aircraft folder in the same directory (relative to the X-Plane installation directory) on the second computer. For example, the folder location might be `X-Plane 10\ Aircraft\Boeing 747\` on the pilot’s computer and `X-Plane 10\ Aircraft\Boeing 747_copilot\` on the copilot’s computer.

With that done, open X-Plane on each computer, move the mouse to the top of the screen, click on the Settings menu, and select Net Connections. In the Net Connections dialog box, go to the “External Vis” tab. From here, the procedure for the pilot’s and copilot’s machines differ.

On the pilot’s machine, check one of the boxes labeled **IP of extra visual/cockpit (this is master machine)** and enter the IP address of the copilot’s machine.

Now, on the copilot’s computer, check the box labeled **IP of master machine (this is extra cockpit)** and enter the IP address of the pilot’s computer. In the lower left, click on the “folder name suffix” text box and enter “_copilot” (or whatever suffix you decided on previously). After that, no matter what aircraft is opened on the pilot’s machine, this computer will add “_copilot” to the name of the aircraft folder that it needs to open.

Next, on the pilot’s (and thus “master”) computer, open the pilot version of the aircraft file you are using. If everything is set up correctly, the pilot’s machine will send all the appropriate data to the copilot’s machine, the copilot’s machine will get the message. The copilot’s machine will then apply the suffix “_copilot” to the name of the aircraft folder, and it will open the copilot’s version of the aircraft cockpit on the copilot’s machine.

9.3 Configuring a Multi-Monitor Simulator

There are a number of different ways in which a multi-display simulator can be used. You might want many displays linked together to form a super wide cockpit view, or you might want one display for your cockpit and others for external visuals.

There are two general ways of configuring multiple monitors. You can either have your monitors all connected to one computer, running one copy of X-Plane, or you can have multiple different computers all networked together, each one with its own monitor and its own copy of X-Plane.

In general, using multiple displays on one computer will be more restrictive regarding the ways in which you can configure the simulator. Networking many computers together will be more flexible, but it will also be much more expensive.

9.3.1 Driving Multiple Displays from One Computer

Multiple displays can be used with one computer in three ways. You can either:

- configure plug two monitors into your graphics card (if it supports multiple monitors) and configure the monitors as entirely separate in your operating system;
- purchase a video splitter like the Matrox TripleHead2Go, plug your monitors into that, and configure all your monitors as a single, super-large display in your operating system; or
- using a technology like AMD’s Eyefinity (included with the Radeon 5xxx and later series video cards), plug your multiple monitors directly into your video card and configure them in the operating system like a single, super-large display.

If your multiple monitors are configured as a single large display in your operating system, all you need to do to have X-Plane fill the screen with a single large window is to check the **run at full screen** box in the Rendering Options dialog box. If, on the other hand, your monitors are configured in the operating system as separate displays, your best option is to have a regular, windowed version of X-Plane which you manually resize to fill as much of your display as possible. If you want to use your secondary monitor as an instructor operator station, refer to the section “Using an Instructor Operator Station (IOS) for Flight Training” of Chapter 8.

9.3.2 Networking Multiple Computers for Multiple Displays

To set up a multi-computer simulator, each of the computers you want to use must first be linked together over a network. X-Plane should then be launched on each computer. On each computer, open the Settings menu and click Net Connections. In this dialog box, select the “External Vis” tab. Here, the steps differ between the “master” machine (the computer which is hooked up to all your flight controls) and the other computers. On the master machine, you need to check as many of the **IP of extra visual/cockpit** boxes as you have extra computers, then enter the IP addresses of each of the other computers. On the computers used as other displays, however, you need only check one box labeled **IP of master machine** and enter the master machine’s IP address. Note that in no case should you need to change the port number from 49,000.

How should these extra displays be configured? Let’s assume we are to use four computers and four monitors: one cockpit and three external visuals (a common setup). On each of the three computers used for external visuals, we first need to open the Rendering Options dialog box from the Settings menu. There, we will enter a **lateral field of view** of 45° for each of them. Enter a **lateral offset for networked scenery** of -45° for the left screen, 0° for the center screen, and 45° for the right screen, with no vertical offset on all screens. This will simply yield a 135° ($45 \cdot 3$) field of view. If this is drawn out on paper, it becomes apparent that the 45° offsets on the left and right screens will cause them to perfectly sync up with the center screen.

From there, the monitors need to physically be moved around the “cockpit” (that is, where a user will sit when flying the simulator) in a semi-circle describing a 135° field of view. If this is not done, then the horizon will not appear straight as the craft pitches and rolls, caused by the “fisheye

lens” effect. If a 135° field of view is described in a flat plane or in an arc of monitors that describe less than 135° of arc, fisheye distortion will result, apparent as a horizon that seems to bend and distort between monitors.

9.3.2.1 Lining Up the Horizon (Without Vertical Offsets)

Now, sometimes people sit on the ground and see the horizon does not line up, so they enter vertical offsets on some of the display machines only in order to get the horizons to line up. They quickly become confused when everything breaks down as they pitch and especially roll. If vertical offsets are used, they must be used on all networked machines in your simulator, *unless you have one monitor physically above another*. If some but not all of your computers have vertical offsets, things start getting messed up. What often happens is that a user will fly with a cockpit in the center screen, which shifts the center of that screen *as far as scenery is concerned* to be around 75% of the way up the monitor; this is done in order to leave room for the instruments. The external visuals, on the other hand, have screen centers in the center of the monitor, since they do not have to reserve space for the instrument panel. In this case, you need to do the following:

1. Open Plane Maker from the X-Plane installation directory.
2. Click on the File menu, then click Open Aircraft.
3. Navigate to the aircraft you wish to fly and open it.
4. Click on the Standard menu, then click Viewpoint.
5. In the Viewpoint dialog box, go to the View tab.
6. Set the **view center Y, panel view** (i.e., the y coordinate of the center of the screen when in the panel view) to be one-half the height of your monitor in pixels (assuming you run X-Plane in full screen mode). For instance, if your monitor has a resolution of 1920 x 1080 pixels, you would enter 540 here (1080/2).
7. Close the Viewpoint dialog box, either by pressing Enter or by clicking an X in the corner of the window.
8. Open the File menu and click Save As (*not* Save, since you do not want to overwrite the original file).
9. Type in a name for this copy of the aircraft file (for instance, “Triple Monitor [*aircraft name*]”) and press **Save**.
10. Close Plane Maker.

Now, when you load the new copy of the aircraft up in X-Plane, the screen center will be just where you like it.

9.3.2.2 Correcting for Monitor Bezels

Let’s imagine that you have three networked computers for additional visuals to form a wrap-around cockpit. Each computer might have a 45° **lateral field of view** (as set in the Rendering Options). You would enter a **lateral offset for networked scenery** of -45° for the left visual, 0° for the front visual, and 45° for the right visual, as discussed above. If each display has a field

of view of 45° , these images will blend together seamlessly *if* you don't consider the width of the displays' bezels (the frame around each monitor). If you cannot set up the monitors to run their effective image all the way to the edge (as you can with some, even though you wouldn't be able to see the part under the border), you might instead try a field of view of maybe 43° based on whatever fraction of the monitor is visible. Vertical and roll offsets, of course, are the up/down and tilt equivalents of the lateral offset.

Note: While the view offsets do indicate how much to the left or right or up or down each view is looking, people make the same mistake over and over: they run a center view with a cockpit in the center screen, and external visuals on the left and right—which is fine—but they notice that the horizon in the center (cockpit) screen does not line up with the horizons on either side. The reason for this is that the center-point of the screen where the horizon rests in a level flight attitude is up near the top of the screen in the cockpit view (to make room for the instrument panel) and the center of the screen for the external visuals (which do not need room at the bottom for the instrument panel). Often, people will incorrectly lower the vertical offset of the center panel (with the cockpit).

This results in countless problems with the views not lining up. The way to correct this is to do as in the “Lining Up the Horizon (Without Vertical Offsets)” section above and change the screen center for your aircraft; only then will the horizon always line up across all the visuals. In other words, the only time a vertical offset should be used is if there is one monitor on top of another.

9.3.2.3 Using Other Special Viewing Controls

The **lateral field of view** setting, located in the Rendering Options window, will change the way X-Plane displays the view of the outside world. Higher settings will allow more of the terrain to be viewed at any one time, but will reduce performance. Higher settings will also increase the “fish eye” effect of the simulator. The default value is 45° per display, which generally gives good performance and a natural view. Note, of course, that changing the field of view of a monitor in a multi-display setup will require you to re-evaluate your **lateral offset** values as well.

Now, suppose you are using multiple monitors, some for external visuals and others for cockpit displays. You may notice that when views are changed within X-Plane, the change propagates to *all* the visuals. To stop this from occurring, you can select the radio button labeled **lock to panel view** near the bottom right of the Rendering Options dialog box. Selecting this will cause the display to always show the forward-with-cockpit view.

Appendix A

Airfoil Maker Supplement

Let's talk about the Airfoil Maker application, found in the X-Plane installation directory.

A.1 Menus

The menus of Airfoil Maker are very simple.

A.1.1 About

The About menu's only option, Version, will display the version of the program and check for updates from the x-plane.com website.

A.1.2 File Menu

The file menu works just like the file menu of any word processor or spreadsheet application. Files are created, loaded, and saved here; the only difference is that, instead of text documents, Airfoil Maker is opening and saving files that represent airfoils.

New

Use this to generate a new airfoil.

Open

Use this to open an existing airfoil for viewing or modification.

Save

Use this to save an airfoil that was created or modified.

Save As

Use this to save an airfoil that was created or modified under a different name.

Exit

Exit Airfoil Maker.

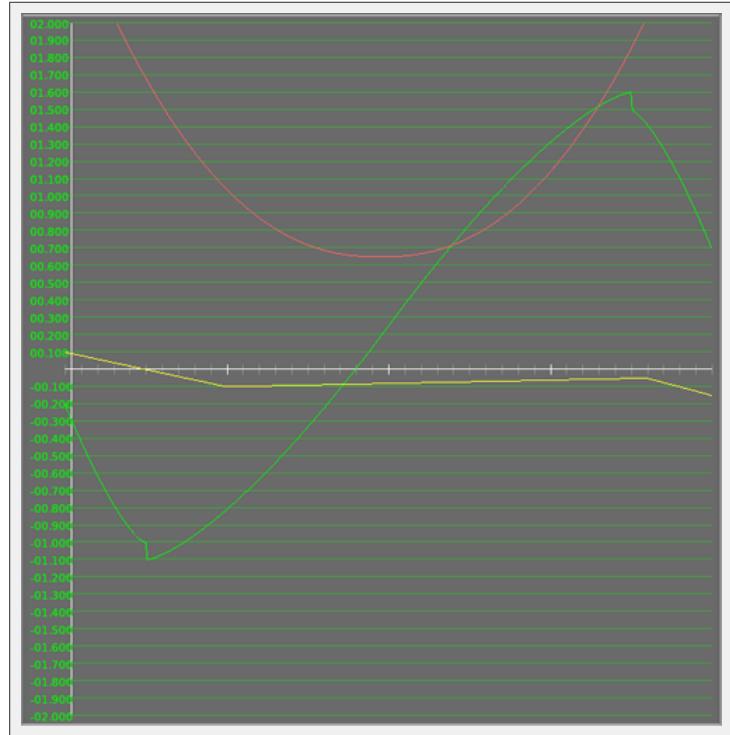


Figure A.1: The graph of the airfoil's coefficients [Full size →]

A.2 Designing an Airfoil

Every airfoil ever designed has its own specific characteristics, which are its coefficients of

- *lift* (how much the airfoil wants to lift up),
- *drag* (how much the airfoil wants to pull back), and
- *moment* (how much the airfoil wants to pitch up).

A.2.1 The Coefficient Graph

Dominating the design screen is a large black graph with green, red, and yellow lines on it, like Figure A.1.

Moving the mouse around in the graph will cause the numbers displayed in the black box in the bottom left of the screen (seen in Figure A.2) to change in real time.

This is the coefficient display box, and it displays, for whatever angle of attack the mouse is pointing at, the coefficients of the airfoil at that angle of attack. Just point the mouse at the part of the curve you are interested in, and look at the exact coefficients in the coefficient display box.

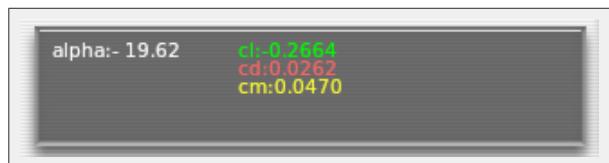


Figure A.2: The coefficient display box [Full size →]

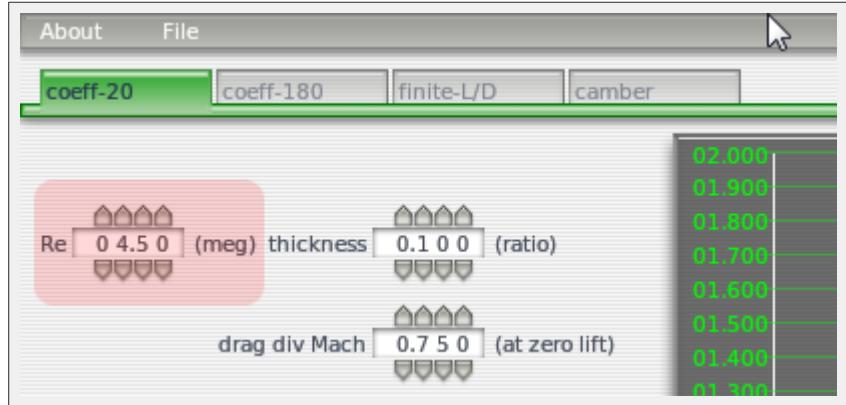


Figure A.3: The Reynolds number parameter [Full size →]

The left edge of the graph corresponds to an angle of attack of -20 degrees, and the right edge corresponds to an angle of attack of +20 degrees. Therefore, moving the mouse to the left edge of the chart will cause the **alpha**: reading in the black box to go to -20, corresponding to the -20 degree angle of attack. The same goes for the right edge with its +20 degree angle of attack.

The center of the chart represents an angle of attack of zero degrees. (Remember that the angle of attack is the angle of the wing to the air. It is the angle at which the wing hits—*attacks*—the air).

The green line in the graph is the coefficient of *lift*, called **cl** in the coefficient display box in the bottom left. The red line is the coefficient of *drag*, called **cd** in the coefficient display box. The yellow line is the coefficient of *moment*, called **cm** in the coefficient display box. We'll look at the behavior of each of these lines below.

A.2.2 Reynolds Number

In the upper left of the screen is a number labeled **Re**, for Reynolds number, as highlighted in Figure A.3.

The Reynolds number is simply the air density times the speed of the airplane times the chord of the wing divided by the viscosity of air (wow!). Experiments have shown that a wing's coefficients of lift, drag and moment vary somewhat with Reynolds number. For recreational purposes, we can probably neglect any change in performance with Reynolds number, thus ignoring this setting altogether. The number entered in the Reynolds number box may have some impact, however, on the simulation. For highest realism, users can generate two *different* airfoil files for the *same* airfoil in Airfoil Maker, each file at a different Reynolds number, and assign them both to a wing in Plane Maker! X-Plane will figure out the Reynolds number on each piece of the plane at least 10 times per second and interpolate between the two airfoil files to give the most realistic coefficients for that flight Reynolds number.

Pilots should realize that very good accuracy can be obtained without touching the Reynolds number at all, and without generating two airfoil files for each airfoil. Most users can ignore the above paragraph and the “Reynolds number” slot in the airfoil generation screen without sacrificing a good simulation.

In this section, we also have the thickness ratio and the drag-divergence Mach number. *Thickness* only affects the visual appearance of the wing when it is shown in Plane Maker and X-Plane. The thickness ratio is an important characteristic of the airfoil so it is usually easy to find in the airfoil data or even the airfoil name. NACA 2412 has a thickness of 12% so you would enter 0.120 here.

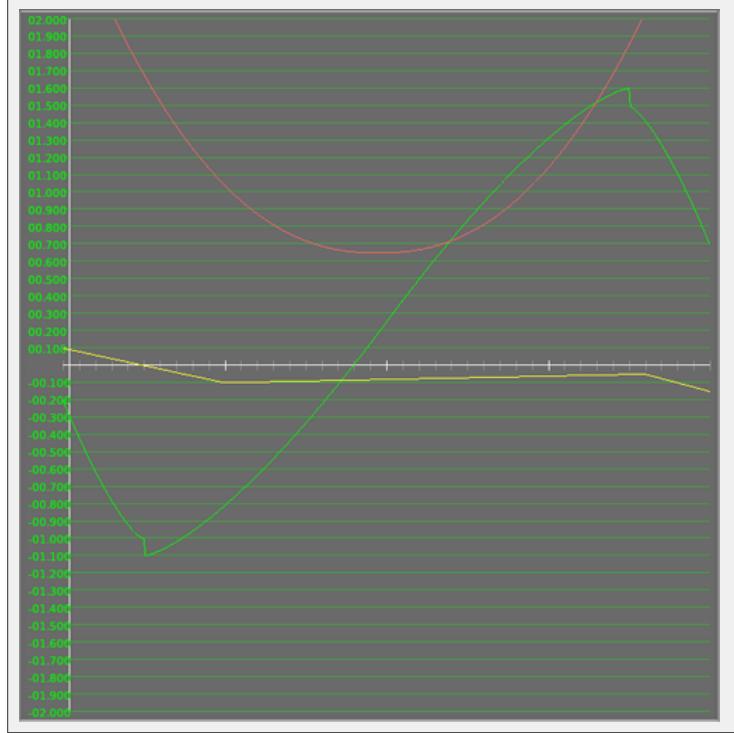


Figure A.4: A graph of an airfoil's coefficients [Full size →]

Drag div Mach is the airspeed when drag starts to increase dramatically. The Mach number is a fraction of the speed of sound. Hence, 0.75 is 75% of the speed of sound or about 750 km/h. Most aircraft never get close to this speed so you don't need to set this number for your airfoil. If you are designing a near-supersonic aircraft like an airliner or a supersonic aircraft then you will either need to find this number in the published specifications or adjust it until you get the resulting performance you want in X-Plane.

A.2.3 Coefficients

A.2.3.1 Coefficient of Lift

The green line in Figure A.4 is the coefficient of lift.

Notice that at zero degrees angle of attack (the center of the graph) the coefficient of lift is fairly low; it is close to the thin white line that represents zero. As the angle of attack increases, the coefficient of lift increases right along with it, until it reaches around 16 degrees angle of attack, at which point the coefficient of lift falls abruptly. That represents the stall. Looking at the negative angles of attack, one sees that the coefficient of lift actually gets negative. If you go to a large enough negative angle of attack, the airfoil stalls then, too. It is possible to stall upside down! A good wing will have a decent coefficient of lift (maybe 0.4) at angles of attack close to zero, and a nice high coefficient of lift (maybe 1.6) at the maximum angle of attack. A safe airfoil will also have a stall that is not too abrupt. In other words, the coefficient of lift will fall off gradually at the stall, rather than sharply.

A.2.3.2 Coefficient of Drag

The red line on the graph in Figure A.4 is the coefficient of drag.

Notice that the coefficient of drag is lowest close to zero degrees angle of attack. The drag gets higher and higher as the wing goes to larger and larger angles of attack. That is not surprising, is it? The higher the angle the wing is offset from the airflow, the greater the drag!

It doesn't matter much whether the wing moves to positive or negative angles of attack (that is, whether the wing is aimed up or down); moving the wing away from its most streamlined position increases its drag. A good airfoil will obviously have the lowest drag possible. (Notice that this drag coefficient does *not* include the drag due to the production of lift. X-Plane will figure this drag out automatically).

A.2.3.3 Coefficient of Moment

The yellow line in the graph in Figure A.4 is the coefficient of moment.

The coefficient of moment is the tendency of the wing to pitch up about its axis, or rotate upwards about the spar. Most wings actually want to pitch down, so the coefficient of moment is usually negative. The moment varies a bit with angle of attack, often in ways that are a little bit surprising. Typically the moment will be negative for all normally encountered angles of attack, decreasing (that is, becoming more negative) especially as the angle of attack is increased. This continues until the stall, at which point the moment heads back to zero. A desirable characteristic of an airfoil is usually to have a low coefficient of moment.

A.2.4 General Information

A.2.4.1 Finding Coefficients

Many users wonder how to find what the coefficients are for the airfoils of their own airplane. To do this, the user must first find what airfoil the aircraft uses, probably from the manufacturer. Then, check to see if that airfoil is included with X-Plane. If a user is flying a Cessna 182, for example, that aircraft uses the NACA 2412 airfoil, which is included. Cessna 182 owners, then, do *not* need to generate their own airfoil for that wing. Users who do not know what airfoil to use should leave them as the defaults of Plane Maker.

A.2.4.2 Recommended Background Reading

Airfoil selection is a fun and interesting process, because one looks for the best possible combination of lift, drag, and moment characteristics for a particular airplane. For users that will be experimenting with their own airplane designs and are new to the matters discussed in this chapter, we highly recommend the following book to get started:

R/C Model Airplane Design
A.G. Lennon
Motorbooks International Publishers and Wholesalers, Inc.

The book is intended for radio control designs, but is very straightforward, easy to understand, and all of the principles apply to full-scale aircraft.

Once you understand the basics of airfoil theory and nomenclature, we recommend:

Theory of Wing Sections
Abbot and Von Doenhoff
McGraw-Hill, New York (1949)

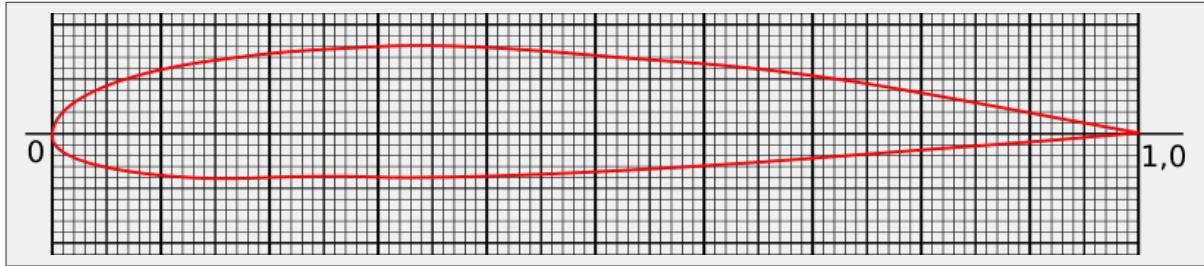


Figure A.5: A NACA 2412 airfoil [Full size →]

An oldie but goodie! This book has the lift, drag, and moment plots of many airfoils in it, so the reader can choose their favorite airfoil for a design and then enter it into the computer using the technique described below.

A.2.4.3 Types of Airfoils

In the following discussion, thin and symmetrical, thick and highly cambered, and “normal general aviation” airfoils will be discussed. These types of airfoils serve as a good introduction because they are so different from one another.

Thin, symmetrical airfoils are thin and have the same shape on both the top and bottom surfaces. They do not produce very much lift or drag. They typically are used for vertical stabilizers and often horizontal stabilizers as well because they are not called upon to produce a lot of lift, and are not expected to produce much drag, either.

Use thick, high-cambered airfoils in the foreplanes of canards, or other applications where you want a *large* amount of lift from a *small* wing area. These foils are known for providing a large amount of drag as the penalty for providing a large amount of lift.

So-called “normal general aviation airfoils,” like the NACA 2412 (seen in Figure A.5), are compromises between the two, and are good candidates for the wing of a general aviation aircraft.

Supercritical, laminar-flow, and other possible groupings of airfoils exist, but for the purposes of our discussion we will concentrate on the thin and symmetrical, thick and highly cambered, and “normal general aviation” airfoils just outlined.

A.2.5 Generating Airfoils

A.2.5.1 Coefficient of Lift Intercept

Now let’s actually generate an airfoil. The control to modify first is the coefficient of lift **intercept** control, found in the upper left, as highlighted in Figure A.6.

To increase this number, just click right above the digits that you want to increase, and below the ones that you want to decrease. For example, if the lift intercept on the screen is 0.25 (as in Figure A.6), and you want to change it to 0.33 to model your airfoil, just click above the “2” in “0.2500” and twice below the “5” in “0.2500.” This is how all of the data for the entire design and simulation system is changed.

The coefficient of lift intercept is the coefficient of lift at an angle of attack of 0 degrees. For a symmetrical airfoil, this will always be zero, since, in such an airfoil, the air is doing exactly the same thing on the top and bottom of the wing at zero degrees angle of attack. Symmetrical airfoils are sometimes used for horizontal stabilizers, and are almost always used for vertical stabilizers. Sleek, skinny wings with low camber might have a lift intercept of 0.1. Fat, highly cambered foils

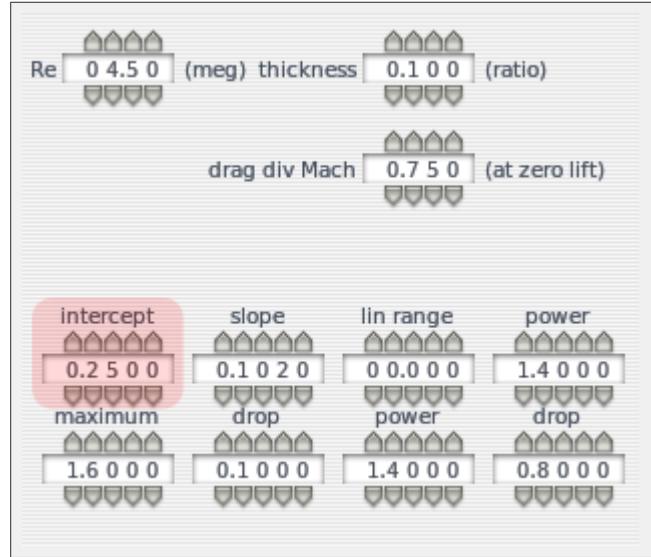


Figure A.6: The parameters used in generating an airfoil [Full size →]

have a value around 0.6. A typical airfoil like the NACA 2412 (commonly used in general aviation) has a value of about 0.2.

A.2.5.2 Coefficient of Lift Slope

This is the increase in coefficient of lift per degree increase in angle of attack. A thin airfoil has a value of about 0.1. A really fat airfoil has a value of about 0.08. Fatter airfoils have slightly lower lift slopes. (You will find, however, that lift slopes are almost always very close to 0.1).

The coefficient of lift slope is modified using the **slope** control, seen in Figure A.6.

A.2.5.3 Coefficient of Lift Curvature Near the Stall

As the angle of attack gets close to stall, the lift slope is no longer linear. Instead, it gradually levels off as it approaches the maximum, or stalling, coefficient of lift.

This value is modified by the first **power** control, seen in Figure A.6.

Just play with this control until you find a power curve that connects the linear and stalling regions smoothly. Chances are a power of around 1.5 will work pretty well. Just play with it until the lift comes up smoothly, then gradually levels off to the stall, since that is what happens with a real airfoil.

A.2.5.4 Coefficient of Lift Maximum

This is the maximum coefficient of lift, or the coefficient of lift right before the stall. A very thin, symmetrical airfoil has a value of around 1.0. A thick, highly cambered airfoil has a value of around 1.8. A typical general aviation foil might have a value of around 1.6.

This value is modified using the **maximum** control, seen in Figure A.6.

A.2.5.5 Coefficient of Lift Immediate Drop at Stall

This is the drop in lift that immediately follows the stall. For thin airfoils, which tend to stall sharply, this value might be 0.2. For many airfoils, however, there is no immediate drop, but instead a more

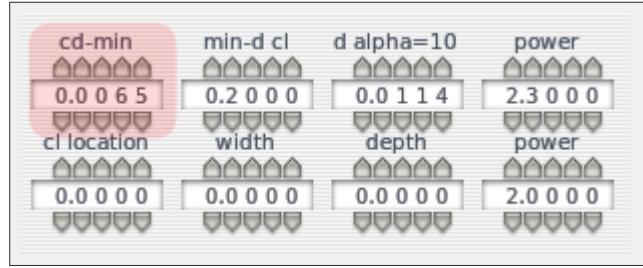


Figure A.7: Further specifications for an airfoil's constants [Full size →]

gradual one as the angle of attack is further increased. In most cases, this number will be zero or very close to zero.

This is modified using the **drop** control, seen in Figure A.6.

A.2.5.6 Coefficient of Lift Curvature After the Stall

Different airfoils have different lift slopes after the stall. For skinny airfoils that stall sharply, the power should be fairly low, perhaps around 1.4. For fat airfoils (which usually have more gentle stalling characteristics) this number may be closer to 2.0.

This setting is controlled via the box, seen in Figure A.6.

Just play with the **power** control until the graph looks like the data you are trying to model from the airfoil chart in whatever book you are getting your airfoil data from.

A.2.5.7 Coefficient of Lift Drop from Stall to 20 Degrees

This is the decrease in coefficient of lift from the stall to an angle of 20 degrees. This number, modified using the **drop** control seen in Figure A.6, might be in the 0.4 range for a thicker airfoil, 0.6 for a thinner one. The NACA 2412 has a value of about 0.4. (The coefficient of lift goes from around 1.6 to 1.2 as the angle of attack goes from around 16 to 20 degrees).

A.2.5.8 Coefficient of Drag Minimum

The coefficient of drag minimum, labeled **cd-min** in Figure A.7, is the minimum coefficient of drag of the airfoil. Once again, this does not include *induced* drag, which is determined automatically by the X-Plane simulator.

This minimum coefficient of drag also should not include the “low-drag bucket” of a laminar flow wing. A thick or highly cambered airfoil has a value of about 0.01. A typical older general-aviation airfoil such as the NACA 2412 has a value of about 0.006, and a really thin, symmetrical airfoil has about a 0.005 value. Laminar flow airfoils can approach values of 0.004, but that number should not be entered here, because it will be addressed in the laminar drag bucket controls discussed below.

A.2.5.9 Coefficient of Lift at Which Minimum Drag Occurs

Enter the coefficient of lift at which the minimum drag occurs in the **min-d cl** control, seen in Figure A.7. This value is probably very close to the coefficient of lift at zero degrees angle of attack, called the lift intercept—the very first number we entered. If anything, the minimum coefficient of drag occurs at a coefficient of lift a little lower than the lift intercept coefficient of lift. This is because an airfoil usually has the least drag at an angle of attack of about zero degrees or just a hair lower.

A.2.5.10 Coefficient of Drag at Angle of Attack of 10 Degrees

This value is modified using the **d alpha=10** control seen in Figure A.7. For a thin, symmetrical airfoil, this value might be around 0.015. The NACA 2412 comes in with a surprisingly good 0.012. A really highly cambered airfoil might be around 0.025, though.

A.2.5.11 Coefficient of Drag Curvature

This value is set by the first **power** control in the drag section, seen in Figure A.7. The power curve is simply the curvature of the drag curve as it changes with angle of attack. You will have to fiddle with the curvature until the curve looks like the experimental data, but theoretically this number will be around 2.

A.2.5.12 Laminar Drag Bucket Location

Some airfoils, called “natural laminar flow” or “NLF” airfoils, have perfectly smooth airflow across a large part of the wing. This flow pattern is called “laminar flow” (hence the company name “Laminar Research”). This super smooth, low-drag flow can only happen at fairly small angles of attack, though, so there is a “low-drag bucket,” or area in a small angle of attack range, that has lower-than-normal drag. The drag bucket location is usually thought of in terms of the coefficient of lift. In other words, the center of the drag bucket occurs at some coefficient of lift of the airfoil. This might happen at a coefficient of lift of around 0.6.

The laminar drag bucket location is set using the **cl location** control, seen in Figure A.7.

A.2.5.13 Laminar Drag Bucket Width

The laminar drag bucket width, set using the **width** control (shown in Figure A.7), refers to how “wide” the bucket is, or what range of coefficient of lift the drag bucket covers. A decent guess would be 0.4.

A.2.5.14 Laminar Drag Bucket Depth

This is the all-important variable. The **depth** control, seen in Figure A.7, determines how much the airfoils drag is reduced by going to laminar flow. Ideally, this will be around 0.002. That is actually quite a bit, though; it might turn a coefficient of drag of 0.006 to 0.004—quite a large percentage difference.

A.2.5.15 Laminar Drag Bucket Curvature

This is set using the second **power** control in the drag section of the window, seen in Figure A.7. The power curve is simply the curvature of the low drag bucket. You will have to fiddle with the curvature until the curve looks like the experimental data, but chances are this number will be around 3 to 5.

A.2.5.16 Coefficient of Moment Low-Alpha Change Point

The coefficient of moment is usually linear across the non-stalled angle of attack range. In other words, if the airfoil is not stalled, the moment curve is usually a straight line. After the stall, however, the moment coefficient tends to change direction. For the NACA 2412, the moment coefficient has

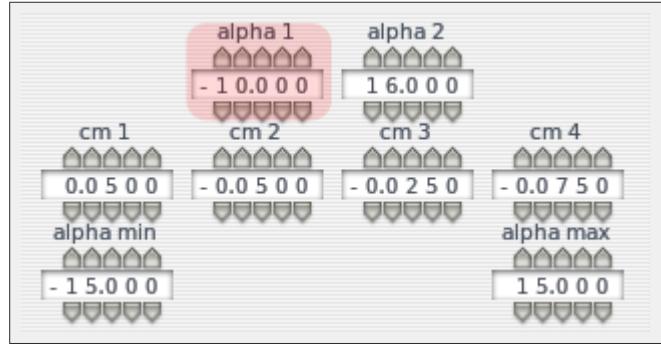


Figure A.8: Further specifications for an airfoil's constants [Full size →]

its low angle of attack moment change at 10 degrees, a point corresponding to roughly +4 degrees before the stall.

This point of change is set using the **alpha 1** control highlighted in Figure A.8.

A.2.5.17 Coefficient of Moment High-Alpha Change Point

This characteristic, set using the **alpha 2** control (seen in Figure A.8), determines where the moment coefficient changes direction with a positive angle of attack. The NACA 2412 airfoil has its high angle of attack moment-change right at the positive stalling angle of 16 degrees.

A.2.5.18 Coefficient of Moment at 20 Degrees

This is set using the **cm 1** control, seen in Figure A.8.

For the NACA 2412, this number is about 0.075. Notice that this is a positive number. This means that if the airfoil is at a clear negative angle of attack, it will stall and try to pitch back up to an angle of attack closer to zero. This is a nice effect, because the airfoil tends to try and recover from the stall automatically.

A.2.5.19 Coefficient of Moment at Low-Alpha Change Point

This is set using the **cm 2** control, seen in Figure A.8. For the NACA 2412, this number is about -0.05, which is a light pitch-down. A wing with a higher camber will have a value of around -0.10, perhaps even -0.13. A symmetrical airfoil will have no pitch tendency at all here, so 0.0 should be entered for that type of airfoil.

A.2.5.20 Coefficient of Moment at High-Alpha Change Point

This is set using the **cm 3** control, seen in Figure A.8. For the NACA 2412, this number is about 0.025, which is a very light pitch-down. A wing with a higher camber will have a value of around 0.10, perhaps even 0.13. A symmetrical airfoil will have no pitch tendency at all here, so 0.0 should be entered for that type of airfoil.

A.2.5.21 Coefficient of Moment at 20 Degrees

This is the coefficient of moment well into the stall, set using the **cm 4** control seen in Figure A.8. For the NACA 2412, it is about -0.10. This is a moderate pitch-down, which is desirable because this pitch-down will help recover from the stall.

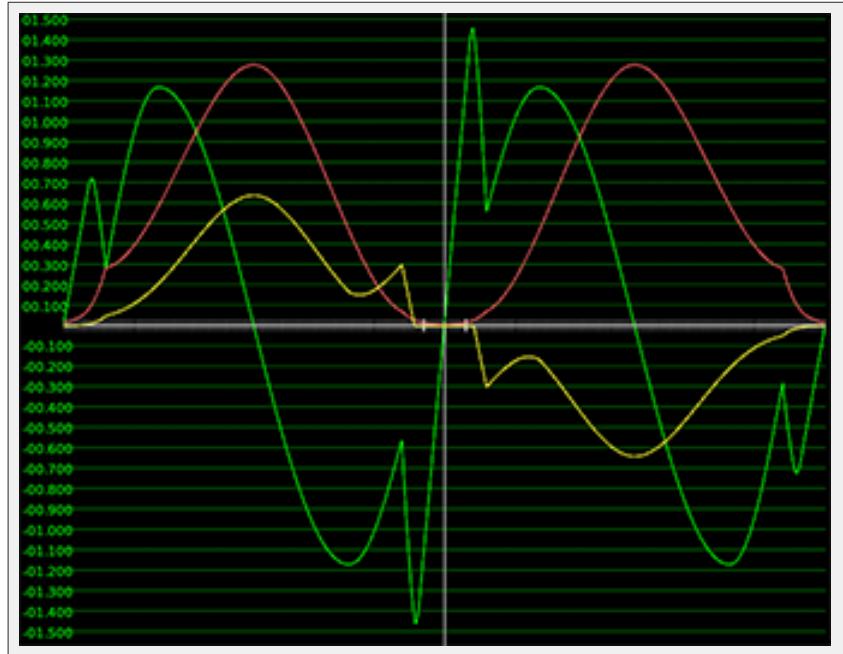


Figure A.9: A graph of the -180 to 180 degree coefficients [Full size →]

A.2.6 Finishing Up

Change all of the parameters around a bit as discussed above, then select Save As from the File menu. Type in an airfoil name and hit Enter. Congratulations! You have just generated your own airfoil! Drop it in the Airfoils folder in your X-Plane folder (so that it will be usable by *all* planes), or in a folder that you make called “Airfoils” in the same folder as your airplane designs (to be used only by that airplane).

A.3 Other Airfoil Maker Screens

There are three other pages of information in Airfoil Maker. These are not required to make a successful airfoil, but you would probably look at them at least once during the development of an airfoil.

A.3.1 -180 to +180 Coefficients

This window is just an information display. This shows the complete airfoil coefficients from -180° to $+180^\circ$. These coefficients would only be used if you were flying backwards or some other unusual attitude.

If you change any of the parameters on the left, you will see that all of the editing you did above was only working on the small section from -20° to $+20^\circ$. There is normally no need to change the coefficients outside this range because it doesn’t matter if your airfoil was designed by Boeing or by Airbus; the performance of any airfoil is about the same when your plane is fluttering through the air like a falling leaf.

It is possible to change these values by editing the .afl text file directly but that is only useful if you have a gigantic amount of data on your airfoil. If you do do that, then never open the .afl

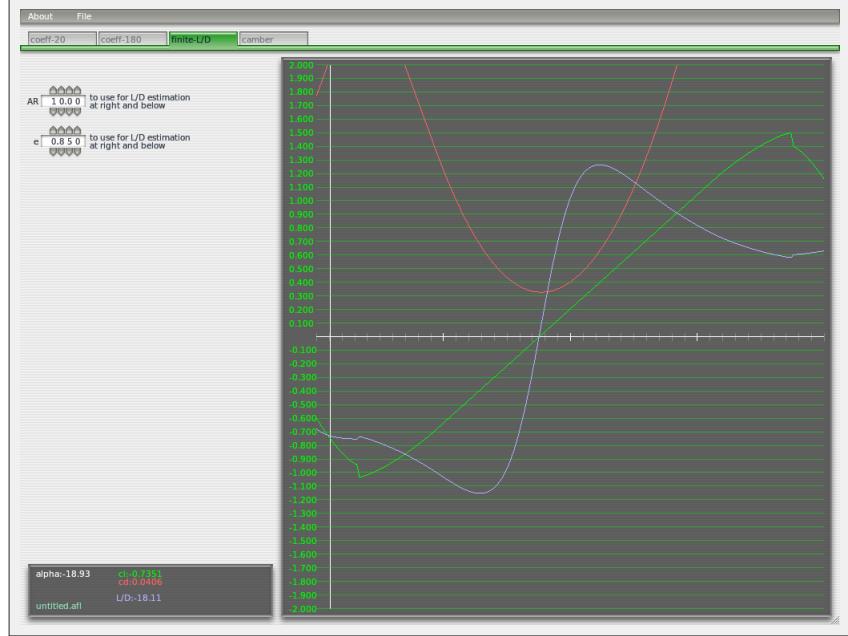


Figure A.10: The Finite L/D tab [Full size →]

file in Airfoil Maker as it will overwrite your coefficients with its own in the +/-20° region. The intercept/slope/power numbers are not used by the simulator, only the tabulated coefficients.

A.3.2 Finite L/D

This is another information page. It is useful to check the results of your entries by calculating the L/D (lift over drag ratio) for a hypothetical wing. Remember the coefficients on the previous pages are never found in real life because they refer to an imaginary wing of infinite length. Even wind tunnel data must be corrected for the effect of only having a specific length of the theoretical infinite wing.

Enter the aspect ratio (AR) for your plane and the efficiency factor e . A glider or U-2 Dragon Lady with extremely long wings might have an aspect ratio of 30. A light aircraft such as a Cessna 180 has an aspect ratio of 7.3. The aspect ratio of a straight wing is the wingspan divided by the chord. For any other shape of wing, the easiest way to calculate AR is to square the wing span and divide by the wing area:

$$AR = \frac{s^2}{A}$$

A.3.3 Camber

The camber page is used to influence the visual representation of the wing profile in X-Plane. Many real wings are almost flat on the bottom or have different bulges to the typical airfoil.

This has no effect on the way the plane flies in X-Plane—it is only for the visual model. There are only a couple of points here, so you can't make a detailed 3-D model of your wing. There should be enough adjustment here so that your model of the Concorde doesn't look completely silly with fat wings.

The yellow lines visually indicate the thickness ratio which you set on the first page.

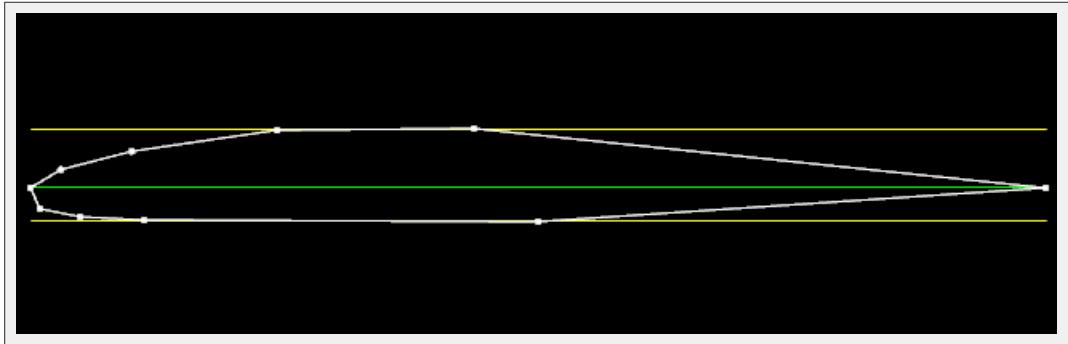


Figure A.11: A view of the wingfoil's camber [Full size →]

If you are modeling an aircraft that has different airfoils at different positions along the wing span you need to pay attention to this camber page. Each wing can have a different airfoil at the root and the tip and X-Plane smoothly interpolates between them. If two X-Plane wing segments are attached together root-to-tip then there will be an obvious step if the two cambers don't match. Either use the same camber in both airfoil files (difficult) or always make sure the tip airfoil of the inner wing uses exactly the same airfoil file as the root airfoil of the outer wing section.

This feature can also be useful when you need to make small fairings or fittings out of dummy wings. Engine Pylons, Misc Bodies or Misc Objects should be considered first but sometimes a small stub wing is required. Remember a pylon or a misc body is a Plane Maker body like a fuselage which contributes to the simulated drag on the aircraft. An object is a 3-D model produced in an external modeling program which is just a visual effect with no aerodynamics. But a wing can also produce lift, roll or yaw, affecting the plane's flight path.

Appendix B

Troubleshooting X-Plane

This chapter is designed as a reference for when you encounter common problems in X-Plane. Each of the following sections describes a common problem and its solution.

B.1 The X-Plane Installer Fails to Extract a File

If the X-Plane installer gives an error about a failed file extraction, it is almost always because your DVD drive cannot read the disc. X-Plane is distributed on dual-layer DVDs, which are sometimes more difficult to read in older DVD drives. Take note of the file reported in the error message and try to copy it from the DVD (using the Finder in Mac OS or Windows Explorer on Windows). If possible, try copying the file into a different folder. If multiple DVDs cannot be read, it is likely that your DVD drive is to blame. If, however, only a single DVD is causing problems, it is more likely the DVD is defective. Defective discs will be replaced by Laminar Research free of charge; simply email our tech support at info@x-plane.com.

B.2 X-Plane Gives Errors about Missing DLLs, or There Are Strange Graphical Anomalies

Most graphics- and DLL-related issues in X-Plane are due to a lack of video drivers. Make sure your graphics drivers are up to date by following the instructions in the X-Plane Wiki article entitled Updating the Computer's Graphics Drivers in Windows.

B.3 X-Plane Crashed

A hard crash in X-Plane 10 is most likely caused by the system running out of usable system memory (RAM). Symptoms of this include (1) segmentation faults, which occur when a request for memory failed and wasn't properly detected, and (2) X-Plane's `uncaught exception: std::bad_alloc` error.

This may occur (rarely) when your computer has truly used up all available RAM. More commonly, however, it occurs when X-Plane runs out of *virtual address space*. Because X-Plane is a 32-bit application, it can only access 2–4 GB of virtual memory (address space) at a time, *regardless* of how much RAM is installed in your computer. The specific limits are as follows:

- In 32-bit Windows (including Windows XP and some installations of Windows Vista and Windows 7): 2 or 3 GB, depending on the operating system's settings

- In 64-bit Windows (including most installations of Windows Vista and Windows 7): 4 GB
- In Mac OS X: 3.5 GB
- In Linux: 3 GB or so

When X-Plane reaches the address space limit of your system (listed above), it will crash. You can confirm that this is occurring by using your system's memory monitor and watching the memory use of the X-Plane process.

To check memory usage on a Mac, do the following:

1. Click on the Applications folder in the task bar. In the menu that opens, click Utilities, then click Activity Monitor.
2. Launch X-Plane as normal.
3. In the Process Name column of Activity Monitor, look for the X-Plane process.
4. Look at the Real Mem column corresponding to the X-Plane process. It should have a value like 950 MB or 1.5 GB listed. If this value is beyond 3.5 GB, X-Plane is liable to crash.

To check memory usage in Windows, do the following:

1. Right-click on an empty area of the task bar and click Start Task Manager. In the window that opens, click on the Processes tab.
2. Launch X-Plane as normal.
3. In the Image Name column of the Task Manager, look for the X-Plane process.
4. Look at the Memory column corresponding to the X-Plane process. It should have a value like 950,000 K listed. If this value is beyond your operating system's address limits (listed above), X-Plane is liable to crash. Note that there are $1,024 \cdot 1,024 = 1,048,576$ kilobytes in 1 gigabyte, so the 2 GB memory limit in Windows XP would be represented as 2,097,152 K.

If this is indeed your problem, you can correct it by doing the following:

- Turn down rendering settings. The major ones are: airport detail (set to default), forests (set to something moderate if you are using autogen too), and texture res (first run with compressed textures). Don't use 4x SSAA when in HDR mode—use FXAA instead.
- If you are on 32-bit Windows, consider moving to 64-bit Windows, at least in the long term.
- If you are on 32-bit Windows with 2 GB per process, increase that limit to 3 GB as described on the X-Plane Wiki.

B.4 My Joystick or Yoke Isn't Working

If the joystick and other flight controls appear to be configured correctly according to the steps outlined in Chapter 4 but are not giving the desired response in the simulator, it's time to troubleshoot. Thankfully, X-Plane makes it easy to find out how the software is perceiving the flight controls' input.

In the following example we'll assume that the plane's pitch, yaw, and roll are not matching the way the joystick is being moved. A similar procedure may be used for other malfunctioning controls.

1. Move your mouse to the top of the screen and open the Settings menu.
2. Click Data Input & Output.

3. Select the rightmost box next to **joystick ail/elv/rud**. This box will cause X-Plane to display the input it is receiving while running the simulation.
4. Close the Data Input & Output window.
5. A box in the upper right should be displaying the **elev**, **ailrn**, and **ruddr** commands (elevator, aileron, rudder, respectively) being received from the joystick.
6. Now, center the stick and pedals. Each axis should indicate 0.0, or close to it.
7. Move the stick full left. The **ailrn** should indicate -1.0 or near -1.0.
8. Move the stick full right. The **ailrn** should indicate 1.0 or near 1.0.
9. Move the stick full aft. The **elev** should indicate 1.0 or near 1.0.
10. Move the stick full forward. The **elev** should indicate -1.0 or near -1.0.
11. Move the rudder full left. The **ruddr** should indicate -1.0 or near -1.0.
12. Move the rudder full right. The **ruddr** should indicate 1.0 or near 1.0.

By moving the stick and pedals and seeing what values they are sending X-Plane, you can see if X-Plane is getting proper stick input.

If the correct values (according to the tests above) are not being received in X-Plane, and you have calibrated the controls in X-Plane per the section “Calibrating the Hardware” of Chapter 4, then the issue is with the hardware’s calibration in your operating system, not X-Plane. If the hardware is indeed calibrated correctly in the operating system, the hardware itself is malfunctioning. On the other hand, if the correct values from the above tests are being received, then the hardware is working fine.

Note: If your frame rate is below 20 frames per second (which you can confirm by checking the box labeled **frame rate** in the Data Input & Output window, just like you did with the **joystick ail/elv/rud** box), X-Plane may behave erratically *regardless* of your joystick settings. See the section “Setting the Rendering Options for Best Performance” of Chapter 4 for help improving your frame rate.

B.5 My Frame Rate is Low

For a step-by-step guide to increasing frame rate, see the section “Setting the Rendering Options for Best Performance” of Chapter 4.

B.6 My PC Freezes after Running X-Plane Awhile

When a computer freezes after running X-Plane for awhile, the problem is almost always heat related. When the system is running X-Plane, the video card and processor get very hot because they are running at 100% utilization. This causes the temperature to rise inside the case. To eliminate heat as an issue, remove the computer’s cover and aim a fan into the case. Run X-Plane for a while and see if the problem goes away. If it does, then you need to add some additional cooling.

Note that this assumes that the system has enough RAM. Running out of RAM will cause crashes as well. At least 2 GB of RAM should be used for current versions of X-Plane. This also assumes that the computer is not overclocked.

B.7 Airplanes Flutter and Crash in the Simulator

The tendency for some aircraft to flutter and crash is a *known limitation*. Just as a car can only go a certain speed with a given horsepower, the X-Plane simulator can only accurately model flight at a certain speed with a given frame rate.

If the frame rate gets too low for the flight model to handle, then the plane is likely to start oscillating quickly back and forth (referred to as “simulator flutter,” often occurring with autopilot on) as the flight model tries unsuccessfully to predict what the plane will do next. At this point, the computer is running too slowly to take small enough steps in the flight model to see what the plane will really do at each moment. Smaller and more maneuverable planes will accelerate more quickly, and greater accelerations require a higher frame rate to simulate.

This occurs due to the way that X-Plane moves aircraft within the simulation. X-Plane calculates the acceleration of the craft for each frame, then adds up the acceleration between frames to move the plane. This works fine if the frame rate is reasonably high and the accelerations are reasonable low. In fact, for any reasonably normal aircraft that has reasonably normal accelerations, a frame rate of 20 fps or more is fine.

Problems occur, though, when you have very light aircraft with very large wings going very fast, or sitting on the ground with landing gear spread very far out from the center of gravity.

All of these things add up to the same result—high acceleration. A light aircraft gives high acceleration because there is little mass, and therefore little inertia. Big wings give high acceleration because they put out lots of force. High speeds give high acceleration because there are high forces under all that air pressure. A widely spaced landing gear gives high acceleration because it has a huge lever arm on the center of gravity.

X-Plane, of course, can handle these high accelerations, but it needs a high frame rate to do it. For the flight model to work, there can only be a certain amount of velocity change per frame of the simulation. If the accelerations are high, then the frame rate better be high so that there is a reasonable velocity change (i.e., acceleration) per frame.

To determine how high a frame rate is enough to handle a given acceleration, just find the frame rate at which there is no flutter.

For example, imagine a Boeing 747 at approach speed. It slowly lumbers along, hardly accelerating at all. One frame per second could track that flight accurately. Now imagine holding a paper airplane out the window of a car at 80 miles per hour and letting go. The plane doesn’t smoothly, gradually, accelerate up to speed, it disintegrates in a thousandth of a second! To simulate that may require a simulator to run at one thousand frames per second!

So, while a simple 20 frames per second works fine for most any aircraft, when small, light, big-winged craft with widely spaced landing gear designs start flying fast, the accelerations come up enough that in extreme cases, 100 fps might be needed to model accurately.

This is more of a problem with planes that:

- are small because they maneuver much more quickly than big planes,
- are light because they have less inertia and react faster,
- have long wings because they have more leverage on the center of gravity, thus reacting faster,
- have big wings because they get more lift, thus reacting faster, or
- have widely spaced landing gear because the gear has more leverage on the craft, causing it to torque the plane faster.

When using an airplane that reacts extremely quickly to the environment, the computer needs to react just as quickly to simulate it. This can be achieved by reducing the rendering options and visibility in X-Plane enough to raise the frame rate to a non-fluttering level. More info on this can be found in the section “Setting the Rendering Options for Best Performance” of Chapter 4.

B.8 The Simulator’s Measurement of Time is Slow

If the simulator’s measurement of time is incorrect (e.g., the “elapsed time” field has a value less than it should), check your frame rate. If your computer cannot maintain 20 frames per second, simulator time will not match real time; when X-Plane runs slower than 20 fps, it slows down its simulation of real-time so that the simulator is “effectively” running at 20 fps. For instance, if the simulator is running at 10 fps due to extreme rendering settings, X-Plane will run the flight model at half speed. The result is that the physics are integrating in slow-motion in order to avoid destabilizing from the low framerate. Thus, if you need real-time simulation, you must run the simulator at 20 fps or faster.

B.9 Getting Help with Other Problems

If your issues do not match those above, please email tech support at info@x-plane.com. If your problem involves a system crash, please include the following in your email:

- The “crash-log.txt” file (found in your X-Plane directory after a crash),
- The “log.txt” file after encountering your error (also found in your X-Plane directory)
- The Apple crash log (if you are using a Mac)

Appendix C

Tech Support

Before calling or emailing, save both yourself and customer service time by checking this manual or the X-Plane Wiki for answers. Also, be sure you have the latest version of the software you’re using before calling (you can check this by following the instructions found in the section “Updating X-Plane” of Chapter 4).

To contact customer service, email info@x-plane.com or call (913) 269-0976 (Central Standard Time).

For questions regarding your order status from X-Plane.com, email our shipping department at xplaneorders@gmail.com.

Appendix D

How to File a Bug Report

When sending a bug report, please include as much information as possible—anything that the X-Plane development crew might need to know in order to reproduce the malfunction. This includes (but is not limited to) the following information:

- The software in question (X-Plane, EFIS App, Plane Maker, etc.)
- The operating system being used
- The version of X-Plane in question
- The hardware in use (if the issue only occurs when using certain hardware)
- The exact steps (as specific and step-by-step as possible) required to reproduce the problem

Additionally, before filing a bug report, please:

- Be sure you are using the latest version of X-Plane (this includes making sure you aren't using an outdated shortcut).
- Delete (or change the name of) your preferences file in order to rule that out.
- Disable any plug-ins or third-party add-ons. (Please report bugs in third-party software to the software's developer, not the X-Plane team.)
- Be sure you understand the feature you are reporting a bug on.
- Contact X-Plane customer support at info@x-plane.com if you are not sure whether you have a bug or a tech support problem.
- Attach a log.txt file from X-Plane (or the installer or other X-Application) when filing the report, as well as PNG screenshots for any visual problems. The log.txt file will tell us a lot of information about your system that will speed up bug analysis.

To file a bug report, please use the following web page:

<http://dev.x-plane.com/support/bugreport.html>

Please note that, if the report was filed correctly, you will not receive any feedback on it. The report will be saved and looked into, and, depending on its priority, fixed in a future update.

Very often, people will report a bug like, "My speed indicator does not work." Well, I might crash my Corvette into a tree, pick up my cell phone as the airbag deflates in my lap, call General Motors, and say, "My speed thing indicates zero!"

In a case like that, how good a job can GM do in deciphering that report?

Filing a report with X-Plane saying "My speed indicator does not work" can be that incomplete for two reasons. The first is that with about 20 or 30 instruments available in the X-Plane world

(accessible via Plane Maker) that indicate speed, saying “speed Indicator” does not really isolate what instrument is being discussed. The second reason is that you have not really given a checklist of steps that you took to find yourself with the apparent bug. For example, it may take certain conditions for the airspeed indicator to not work, conditions you may cause without thinking about based on your airplane selection, weather, etc.

In the Corvette analogy above, the proper report to GM would be:

1. I got in my car.
2. I hit the starter button, the engine started, and I put the transmission in first gear.
3. I hit the gas and turned the wheel and drove until I hit a tree, which stopped me.
4. The speedometer in the instrument panel indicated zero.
5. I included a picture I took on my digital camera here, showing both the speedometer indicating zero and the car actually stopped.

In the X-Plane world, a proper checklist for the report would look like this:

1. I renamed my preferences file so I did not have any odd settings that may cause this that we might not know about.
2. I fired up X-Plane on my computer running [*some operating system*].
3. I went to the File menu and opened the “Austin’s Personal Transport” aircraft.
4. I noticed the EFIS airspeed indicator stayed at zero, no matter how fast I flew.
5. I included a screenshot of X-Plane showing the panel here, with the actual speed of the plane shown using the Data Output screen to show my real speed.

The difference between the five-lined report above and the one-liner at the top is that you have actually told us what you are doing. You are starting by resetting the preferences so that we can do the same as you (a first step toward solving the problem!). You are telling us what aircraft you are opening (so we can do the same). You are choosing one of the planes that come with X-Plane (so we can do the same as you), and you are listing which of X-Plane’s dozens of speed indicators you are referring to, so we can see what the problem really is.

To summarize, be sure to give a complete checklist to duplicate the issue, starting with deleting the preferences and choosing an airplane that comes with X-Plane so that we can go through the same steps as you. We must be able to mirror your actions, step by step, to duplicate the bug on our computers, as this is the first step to solving the problem.

Another common mistake, though, is to say something like, “I flip a switch and hit a button and an indicator goes to 56%.” The problem with this is that it doesn’t tell us what the issue actually is. What do you think the indicator should go to? And, above all, prove it.

In almost all filed bug reports, the report lacks any sort of proof that the value being cited as wrong is actually wrong. Since we sometimes get reports from people that think a Cessna cannot roll, an airliner cannot take off without flaps, or a helicopter cannot turn without pulling collective (all incorrect assumptions on the part of the “bug” reporter). We need proof that a characteristic that is claimed to be wrong actually is. Segments of pilot’s operating handbooks are typically just fine.

So, be sure to include proof that a characteristic of the simulator is wrong if you believe it to be so.

Another very common error is for people to install plug-ins that modify data in the simulator, third-party scenery packages that don't quite follow the standards, or third-party airplanes that may have problems, and then report it as a "bug" when something does not work correctly.

We won't be able to duplicate the problem if it is due to third-party modifications. So, be sure that starting from a freshly installed copy of X-Plane with the preferences (and any plug-ins) removed is the first item in your step-by-step walkthrough for recreating the problem. Build up from there as needed, including each step in the checklist so that I can go through it and see the same thing you see. Use only scenery and planes that come with X-Plane if possible, so that I can duplicate the bug.

Once again, be sure to:

1. Use a checklist to explain what you are doing, starting with renaming the preferences.
2. Include every step in the checklist that you send in your bug report.
3. Use proper terminology. If you do not know the name of an instrument, then go into Plane Maker and click on it with the mouse. The X-Plane instrument name will be displayed at right. Alternatively, you can get the real name of the instrument by turning on the instrument instructions option (by going to the About menu, clicking Instructions, and checking the **Show instrument instructions in the cockpit** box).
4. Explain why you think the result you are seeing is wrong. Provide proof if you think the simulator is not doing what the real plane would do.

Remember, a bad report would say, "The pressure gauge does not work." (Which pressure gauge? Why do you think it does not work? What do you expect it to show? What plane are you even flying?)

A good report would say, "On a Mac running OS X Lion, I renamed the preferences and opened [*an aircraft included with X-Plane*] via the File menu, then I set the controls as follows, then I observed the manifold pressure gauge to indicate manifold pressure of zero as I advanced the power, though in the real plane I would get 25" of manifold pressure in this plane, as I know from the following excerpt from the plane's pilot's operating handbook."

That report indicates what type of computer you are using, what you do to get the problem (in a way that lets us perfectly mirror it), what you think the problem is, and it gives proof that what you believe about the plane is in fact true. That is enough info for me to work with!

Also, be sure to send the log.txt file! This lists what type of computer you have. Hardly anyone even thinks to mention whether they are on Mac, Windows, or Linux!

Appendix E

Commissioning Custom Aircraft Files

Laminar Research now offers the capability to custom-create real aircraft for X-Plane on a contract basis. This work can duplicate an owner's airplane, down to the paint, tail number, avionics and instrument panel, including the proper placement of controls and switches. This process includes custom one-off engineering and design graphics work. Historically, we have even certified a few of these aircraft for use with the FAA-certified version of X-Plane. As you can imagine, this work is priced accordingly and is not inexpensive, typically about \$3,500 per file.

Please contact X-Plane Customer Service at (913) 269-0976 or email us at info@x-plane.com for more information. If either of these has become outdated, current contact information can be found at X-Plane.com.

Appendix F

Water World, or “Help, there’s water everywhere!”

When scenery is not installed for a given location, all that will be visible are airports and water. This is referred to as “water world,” and is a common problem, especially when using older installers.

To avoid water world, either install the scenery for the location in which you’re flying, or choose to fly somewhere else. To install scenery, insert the first X-Plane installation disc (the same disc used to run the simulator) and run the installer as before. Instead of installing a new copy of the program, though, when the installer window appears, press the **Add or Remove Scenery** button.

If scenery for the location is in fact installed, be sure that the copy of X-Plane for which it is installed is the one being used—for instance, if you have two copies of X-Plane installed (say, one running version 9.62 and one running 10.0), the two versions may have different amounts of scenery installed.

Appendix G

Data Output from X-Plane

The following table provides a brief description of the fields present in X-Plane 10's data output. This includes UDP output (output over a network), file output (to the Data.txt file located in your X-Plane installation directory), graphical display (in the Data See tab of the Data Input & Output window), as well as on-screen display in the cockpit during flight. Note that this list is current as of X-Plane 10.0.

To enable output from these fields, launch X-Plane and open the Data Input & Output window (found in the Settings menu). There, check the boxes corresponding to the fields you wish to output. Each field has four checkboxes, corresponding to the four places the data can be sent (i.e., to the network via UDP, to a file, to a graphical display, and to the display while in flight).

In this table, note that each group of data fields is labeled as it would be in the Data Input & Output window. For instance, to see the values of the “f-act” or “frame time” variables, you would consult the table and see that those variables are under the **frame rate** label. Simply check the box corresponding to “frame rate” in the Data Input & Output to see those variables. Alternately, if you know you want frame rate-related variables, you could consult the portion of the table under the **frame rate** heading to find out what data is available. Where the meaning of a label in the Data Input & Output window is not immediately obvious, a longer version of the label is given—for instance, “Simulator statistics (**sim stats**).”

| Field label | Description |
|-------------------|--|
| Frame rate | |
| f-act, /sec | The actual frame rate being displayed by X-Plane. Unless your computer is bogged down, this will be the same as f-sim. |
| f-sim, /sec | The frame rate the simulator is “pretending” to have in order to keep the flight model from failing. |
| frame, time | The time required to render one frame, in seconds. |
| cpu, load | The combined CPU and GPU load, as a decimal part of the full power available. |

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| Field label | Description |
| grnd, ratio | |
| flit, ratio | |
| Times | |
| real, time | The number of seconds, in the real world, elapsed since the simulator was launched. |
| totl, time | The number of seconds elapsed since the simulator was launched <i>minus</i> time spent in a loading screen. |
| missn, time | The time since the start of the “mission” (generally the time since the last time an aircraft or location was loaded). |
| timer, time | The time elapsed on a timer for general use. |
| zulu, time | “Zulu” time (Greenwich Mean Time, or GMT) in the simulator, in decimal hours (e.g., 3.5 for 3:30 a.m.). |
| local, time | Local time in the simulator, in decimal hours. |
| hobbs, time | The aircraft’s Hobbs time (a measurement of how long the aircraft’s systems have been run). |
| Simulator statistics (<code>sim stats</code>) | |
| explo, DIM | |
| explo, USE | |
| cratr, DIM | |
| cratr, USE | |
| puffs, TOT | |
| puffs, VIS | |
| tris, vis | |
| q, depth | |
| Speeds | |
| Vind, kias | The craft’s indicated airspeed, in knots indicated airspeed. |
| Vind, keas | The craft’s indicated airspeed, in knots equivalent airspeed (the calibrated airspeed corrected for adiabatic compressible flow at the craft’s current altitude). |
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| Field label | Description |
|---|--|
| Vtrue, ktas | The craft's true airspeed (the speed of the craft relative to undisturbed air), in knots true airspeed. |
| Vtrue, ktgs | True airspeed, in knots true ground speed. |
| Vind, mph | The craft's indicated airspeed, in miles per hour. |
| Vtrue, mphas | The craft's true airspeed, in miles per hour airspeed. |
| Vtrue, mphgs | The craft's true airspeed, in miles per hour ground speed. |
| Aircraft Mach speeds, vertical velocity, and g-loads (mach , VVI , G-load) | |
| Mach, ratio | The aircraft's current speed, as a ratio to Mach 1. |
| VVI, fpm | The aircraft's current vertical velocity, in feet per minute. If everything is working as it should, this is normal to the local horizon under the aircraft. |
| Gload, norml | The g-load across the aircraft, relative to the aircraft body-axis, if all is working as it should. |
| Gload, axial | The axial g-load on the aircraft. |
| Gload, side | The side g-load on the aircraft. |
| Atmosphere: weather | |
| SLprs, inHG | SL_{prs} , in inches mercury. |
| SLtmp, degC | SL_{tmp} , in degrees Celsius. |
| wind, speed | The wind speed around the aircraft, in knots. |
| wind, dir | The wind direction, in degrees clockwise deviation from north. Wind blowing from north to south has direction 0.0, while wind blowing from west to east has direction 270.0. |
| trb, locl | Amount of local turbulence. |
| prec, locl | Amount of local precipitation. |
| hail, locl | Amount of local hail. |
| Atmosphere: aircraft | |
| AMprs, inHG | AM_{prs} , in inches mercury. |
| AMtmp, degC | AM_{tmp} , in degrees Celsius. |
| LEtmp, degC | LE_{tmp} , in degrees Celsius. |

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| Field label | Description |
| dens, ratio | The aircraft's density ratio. |
| A, ktas | A, in knots true airspeed. |
| Q, psf | Q , dynamic pressure or velocity pressure, in pounds per square foot. |
| gravi, fts2 | Gravitational force, in feet per second squared. |
| System pressures | |
| baro, inHG | Barometric pressure, in inches mercury. |
| edens, part | |
| vacum, ratio | |
| elec, ratio | |
| AHRS, ratio | Pressure in the attitude heading reference system (AHRS), as a ratio to normal. |
| Joystick aileron, elevator, and rudder input (<code>joystick ail/elv/rud</code>) | |
| elev, yoke1 | The user's elevator input, as a ratio to full upward deflection. For instance, a value of -1.000 indicated the user is commanding the aircraft's nose down as fast as possible. |
| ailrn, yoke1 | The user's aileron input, as a ratio to full rightward deflection. For instance, a value of -1.000 indicated the user is commanding the aircraft to roll left as fast as possible. |
| ruddr, yoke1 | The user's rudder input, as a ratio to full rightward deflection. For instance, a value of -1.000 indicated the user is commanding the aircraft to yaw left as fast as possible. |
| Other flight controls | |
| vect, rqst | The requested thrust vectoring. |
| sweep, rqst | The requested wing sweep. |
| incid, rqst | The requested wing incidence. |
| dihed, rqst | The requested wing dihedral. |
| retra, rqst | The requested wing retraction. |
| water, jetts | Water jettisoned. |
| Artificial stability inputs for aileron, elevator, and rudder (<code>art stab ail/elv/rud</code>) | |
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| Field label | Description |
| elev, astab | The artificial stability system's elevator input, as a ratio to full upward deflection. |
| ailrn, astab | The artificial stability system's aileron input, as a ratio to full rightward deflection. |
| ruddr, astab | The artificial stability system's aileron input, as a ratio to full rightward deflection. |
| Flight control deflections for aileron, elevator, and rudder (flight con ail/elv/rud) | |
| elev, surf | The proportion of the elevator deflected for upward pitch. If the elevators and flight inputs are in sync, this will match the combined yoke and artificial stability system input. |
| ailrn, surf | The proportion of the aileron deflected for rightward roll. If the elevators and flight inputs are in sync, this will match the combined yoke and artificial stability system input. |
| ruddr, surf | The proportion of the rudder deflected for rightward yaw. If the elevators and flight inputs are in sync, this will match the combined yoke and artificial stability system input. |
| nwheel, steer | The nosewheel's direction, in degrees of deviation from pointing straight ahead. For instance, a value of -31.000 indicated the wheel is pointed left 31 degrees. |
| Wing sweep and thrust vectoring (wing sweep/thrust vect) | |
| sweep, 1, deg | The craft's wing sweep, in degrees back from normal. |
| sweep, 2, deg | The craft's wing sweep, in degrees back from normal. |
| sweep, h, deg | The craft's wing sweep, in degrees. |
| vect, ratio | |
| sweep, ratio | The craft's wing sweep, as a ratio to fully forward. |
| incid, ratio | The craft's wing incidence, as a ratio to fully angled. |
| dihed, ratio | The craft's wing dihedral, as a ratio to fully angled. |
| retra, ratio | The craft's wing retraction, as a ratio to fully retracted. |
| Trim, flaps, slats, and speedbrakes (trim/flap/slat/s-brakes) | |
| trim, elev | Elevator trim. |
| trim, ailrn | Aileron trim. |
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| Field label | Description |
| trim, ruddr | Rudder trim. |
| flap, handl | |
| flap, postn | Flap position. |
| slat, ratio | Slat position. |
| sbrak, handl | |
| sbrak, postn | Speedbrake position. |
| Landing gear and brakes (gear/brakes) | |
| gear, 0/1 | Gear extended status. |
| wbrak, part | |
| lbrak, part | Left toe brake depression. |
| rbrak, part | Right toe brake depression. |
| Angular moments | |
| M, ftlb | The aircraft's total mass. |
| L, ftlb | The aircraft's total angular momentum, including all forces (when all is working as it should). |
| N, ftlb | |
| Angular velocities | |
| Q, rad/s | Pitch rate, measured in body-axes (when all is working as it should). |
| P, rad/s | Roll rate, measured in body-axes (when all is working as it should). |
| R, rad/s | Yaw rate, measured in body-axes (when all is working as it should). |
| Pitch, roll, headings | |
| pitch, deg | The aircraft's pitch, measured in body-axis Euler angles. |
| roll, deg | The aircraft's roll, measured in body-axis Euler angles. |
| hdng, true | The aircraft's true heading, measured in body-axis Euler angles. |
| hdng, mag | The aircraft's magnetic heading, in degrees. |
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| Field label | Description |
| Angle of attack, sideslip, and paths (AoA, side-slip, paths) | |
| alpha, deg | The aircraft's angle of attack, in degrees. |
| beta, deg | The aircraft's angle of sideslip, in degrees. |
| hpath, deg | |
| vpath, deg | |
| slip, deg | |
| Magnetic compass (mag compass) | |
| mag, comp | |
| mavar, deg | |
| Latitude, longitude, and altitude (lat, lon, altitude) | |
| lat, deg | The aircraft's latitudinal location, in degrees. |
| lon, deg | The aircraft's longitudinal location, in degrees. |
| alt, ftmsl | The aircraft's altitude, in feet above mean sea level. |
| alt, ftagl | The aircraft's altitude, in feet above ground level. |
| on, runwy | |
| alt, ind | |
| lat, south | |
| lon, west | |
| Location, velocity, and distance traveled (loc, vel, dist traveled) | |
| X, m | Relative to the inertial axes. |
| Y, m | Relative to the inertial axes. |
| Z, m | Relative to the inertial axes. |
| vX, m/s | Relative to the inertial axes. |
| vY, m/s | Relative to the inertial axes. |
| vZ, m/s | Relative to the inertial axes. |
| dist, ft | |
| dist, nm | |
| Latitude for all aircraft (all planes: lat) | |
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| Field label | Description |
| lat n , deg | Aircraft n 's latitudinal location (zero if craft n does not exist). |
| Longitude for all aircraft (all planes: lon) | |
| lon n , deg | Aircraft n 's longitudinal location (zero if craft n does not exist). |
| Altitude for all aircraft (all planes: alt) | |
| alt n , ftmsl | Aircraft n 's altitude location (zero if craft n does not exist). |
| Commanded throttle (throttle command) | |
| thron, part | Aircraft n 's commanded throttle. |
| Actual throttle (throttle actual) | |
| thron, part | Aircraft n 's actual throttle. |
| Engine or propeller mode (feather-norm-beta-revers) | |
| moden, 0123 | Engine n 's current "mode," where 0 corresponds to feathered, 1 corresponds to normal, 2 to beta, and 3 to reverse thrust. |
| Propeller setting (prop setting) | |
| propn, set | Aircraft n 's propeller setting. |
| Mixture setting | |
| mixtn, ratio | Aircraft n 's mixture setting. |
| Carburetor heat setting (carb heat setting) | |
| heatn, ratio | Aircraft n 's carburetor heat setting. |
| Cowl flap setting | |
| cowl n , set | Aircraft n 's cowl flap setting. |
| Ignition settings | |
| ignin, set | Aircraft n 's ignition setting. |
| Starter timeout | |
| starn, sec | Aircraft n 's starter timeout. |
| Engine power | |
| power, n , hp | Engine n 's power, in horsepower. |
| <i>continued on next page</i> | |

| | |
|-------------------------------------|---|
| <i>continued from previous page</i> | |
| Field label | Description |
| | Engine thrust |
| thrst, n , lb | The thrust, in pounds, generated by engine n . |
| | Engine torque |
| trq n , ftlb | The torque, in foot-pounds, generated by engine n . |
| | Engine RPM |
| rpm n , engin | The current RPM of engine n . |
| | Propeller RPM (prop RPM) |
| rpm n , prop | The current RPM of propeller n . |
| | Propeller pitch (prop pitch) |
| ptchn, deg | The current pitch of propeller n . |
| | Slipstream/propwash/jetwash (propwash/jetwash) |
| pwash, kt | |
| | N1 |
| N1 n , pcnt | The current N1 for engine n . |
| | N2 |
| N2 n , pcnt | The current N2 for engine n . |
| | Manifold pressure (MP) |
| MP n , inhg | The current manifold pressure for engine n , in inches mercury. |
| | Engine pressure ratio (EPR) |
| EPR n , part | The current engine pressure ratio for engine n . |
| | Fuel flow (FF) |
| FF n , lb/h | The current fuel flow for engine n , in pounds per hour. |
| | Interstage turbine temperature (ITT) |
| ITT n , deg | The current interstage turbine temperature for engine n . |
| | Exhaust gas temperature (EGT) |
| EGT n , deg | The current exhaust gas temperature for engine n . |
| | Cylinder head temperature (CHT) |
| <i>continued on next page</i> | |

| | |
|-------------------------------------|---|
| <i>continued from previous page</i> | |
| Field label | Description |
| CHT n , deg | The current cylinder head temperature for engine n . |
| Oil pressure | |
| OILP n , psi | The current oil pressure for engine n , in pounds per square inch. |
| Oil temperature (Oil temp) | |
| OILT n , deg | The current oil temperature for engine n . |
| Fuel pressure | |
| FUEP n , psi | The current fuel pressure for engine n , in pounds per square inch. |
| Generator amperage | |
| genrn, amp | The current generator amperage for generator n . |
| Battery amperage | |
| battn, amp | The current batter amperage for battery n . |
| Battery voltage | |
| battn, volt | The current battery voltage for battery n . |
| Fuel pump on/off | |
| pump n , 0/1 | Fuel pump n 's status. |
| Idle speed lo/hi | |
| idlen 0/1 | Engine n 's idle speed. |
| Battery on/off | |
| battn, 0/1 | Battery n 's status. |
| Generator on/off | |
| genrn, 0/1 | Generator n 's status. |
| Inverter on/off | |
| invrn, 0/1 | Inverter n 's status. |
| FADEC on/off | |
| fadec, 0/1 | The FADEC's status. |
| <i>continued on next page</i> | |

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| <i>continued from previous page</i> | |
| Field label | Description |
| | Igniter on/off |
| ignin, 0/1 | Igniter n 's status. |
| Fuel weights | |
| fuel, n lb | Fuel tank n 's weight, in pounds. |
| Payload weights and center of gravity (payload weights and CG) | |
| empty, lb | The aircraft's empty weight, in pounds. |
| payld, lb | The aircraft's payload weight, in pounds. |
| fuel, totlb | The total weight of the aircraft's fuel, in pounds. |
| jetti, lb | The aircraft's jettisonable weight, in pounds. |
| curnt, lb | The aircraft's current weight, in pounds. |
| maxim, lb | The aircraft's maximum weight, in pounds. |
| cg, ftref | The aircraft's center of gravity, measured in feet behind the reference point. |
| Aerodynamic forces, in wind axes (aero forces) | |
| lift, lb | The lift acting on the aircraft, in pounds. |
| drag, lb | The drag acting on the aircraft, in pounds. |
| side, lb | The side forces acting on the aircraft, in pounds. |
| Engine forces | |
| norml, lb | |
| axial, lb | |
| side, lb | |
| Landing gear vertical force (landing gear vert force) | |
| gear, lb | |
| Landing gear deployment | |
| gear, rat | |
| Lift-to-drag ratio and coefficients (lift over drag & coeffs) | |
| L/D, ratio | The aircraft's lift-to-drag ratio. |
| cl, total | |
| <i>continued on next page</i> | |

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|--|--|
| <i>continued from previous page</i> | |
| Field label | Description |
| cd, total | |
| dihed, delta | |
| Propeller efficiency (<code>prop efficiency</code>) | |
| Peff n , ratio | Propeller n 's efficiency ratio. |
| Aileron deflections (<code>defs: ailerons</code>) | |
| Lailn, n ,deg | The deflection of left aileron n , in degrees. |
| Railn, n , deg | The deflection of right aileron n , in degrees. |
| Roll spoiler deflection (<code>defs: roll spoilers</code>) | |
| Lsplr, n , deg | The deflection of left spoiler n , in degrees. |
| Rsplr, n , deg | The deflection of right spoiler n , in degrees. |
| Elevator deflections (<code>defs: elevators</code>) | |
| elevn, deg | The deflection of elevator n , in degrees. |
| Rudder deflection (<code>defs: rudders</code>) | |
| rudrn, deg | The deflection of rudder n , in degrees. |
| Yaw brake deflections (<code>defs: yaw brakes</code>) | |
| Lyawb, deg | The deflection of the left yaw brake, in degrees. |
| Ryawb, deg | The deflection of the right yaw brake, in degrees. |
| Control forces | |
| pitch, lb | The pitch forces acting on the controls in the pilot's hands. |
| roll, lb | The roll forces acting on the controls in the pilot's hands. |
| hdng, lb | The heading forces acting on the controls in the pilot's hands. |
| l-brk, lb | The left brake forces acting on the controls at the pilot's feet. |
| r-brk, lb | The right brake forces acting on the controls at the pilot's feet. |
| Total vertical thrust vectors (<code>total vert thrust vects</code>) | |
| vert n , tvect | |
| Total lateral thrust vectors (<code>total lat thrust vects</code>) | |
| <i>continued on next page</i> | |

continued from previous page

| Field label | Description |
|--------------|---|
| latrn, tvect | |
| | Pitch cyclic disc tilts |
| pitch, cycli | |
| | Roll cyclic disc tilts |
| roll, cycli | |
| | Pitch cyclic flapping |
| pitch, flap | |
| | Roll cyclic flapping |
| roll, flap | |
| | Ground effect (lift) from wings (grnd effect lift, wings) |
| wingn, L cl* | |
| wingn, R cl* | |
| | Ground effect (drag) from wings (grnd effect drag, wings) |
| wingn, Lcdi* | |
| wingn, Rcdi* | |
| | Ground effect (wash) from wings (grnd effect wash, wings) |
| wingn, wash* | |
| | Ground effect (lift) from stabilizers (grnd effect lift, stabs) |
| hstab, L cl* | |
| hstab, R cl* | |
| vstb1, cl* | |
| | Ground effect (drag) from stabilizers (grnd effect drag, stabs) |
| hstab, Lcdi* | |
| hstab, Rcdi* | |
| vstbn, cdi* | |
| | Ground effect (wash) from stabilizers (grnd effect wash, stabs) |
| hstab, wash* | |
| vstbn, wash* | |

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| <i>continued from previous page</i> | |
| Field label | Description |
| Ground effect (lift) from propellers (grnd effect lift, props) | |
| prop n , cl* | |
| Ground effect (drag) from propellers (grnd effect drag, props) | |
| prop n , cdi* | |
| Wing lift | |
| wing n , lift | The lift generated by wing n . |
| Wing drag | |
| wing n , drag | The drag generated by wing n . |
| Stabilizer lift (stab lift) | |
| hstab, lift | The lift generated by the horizontal stabilizer. |
| vstbn, lift | The lift generated by the vertical stabilizer. |
| Stabilizer drag (stab drag) | |
| hstab, drag | The drag generated by the horizontal stabilizer. |
| vstbn, drag | The drag generated by the vertical stabilizer. |
| COM 1/2 frequency | |
| COM n , freq | The current frequency of the COM n radio. |
| COM n , stby | The standby frequency of the COM n radio. |
| COM, xmt | The transmit status of the COM n . |
| NAV 1/2 frequency | |
| NAV n , freq | The current frequency of the NAV n radio. |
| NAV n , stby | The standby frequency of the NAV n radio. |
| NAV n , type | |
| NAV 1/2 OBS | |
| NAV n , OBS | |
| NAV n , s-crs | |
| NAV n , flag | |
| NAV n deflections | |
| NAV n , n-typ | |
| <i>continued on next page</i> | |

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|-------------------------------------|--------------------|
| <i>continued from previous page</i> | |
| Field label | Description |
| NAV n , to-fr | |
| NAV n , m-crs | |
| NAV n , r-brg | |
| NAV n , dme-d | |
| NAV n , h-def | |
| NAV n , v-def | |
| ADF 1/2 status | |
| ADF n , freq | |
| ADF n , card | |
| ADF n , r-brg | |
| ADF n , n-typ | |
| DME status | |
| DME, nav01 | |
| DME, mode | |
| DME, found | |
| DME, dist | |
| DME, speed | |
| DME, time | |
| DME, n-typ | |
| DME-3, freq | |
| GPS status | |
| GPS, mode | |
| GPS, index | |
| dist, nm | |
| OBS, mag | |
| crs, mag | |
| rel, brng | |
| hdef, dots | |
| <i>continued on next page</i> | |

| | |
|---|--|
| <i>continued from previous page</i> | |
| Field label | Description |
| vdef, dots | |
| | Transponder status (XPNDR status) |
| trans, mode | |
| trans, sett | |
| trans, ID | |
| trans, inter | |
| | Marker status |
| OM, morse | Signal from outer marker (OM) |
| MM, morse | Signal from middle marker (MM) |
| IM, morse | Signal from inner marker (IM) |
| audio, activ | |
| Switches 1: electrical | |
| avio, 0/1 | The status of the AVIO switch. |
| nav, lite | The status of the navigation light switch. |
| beacn, lite | The status of the beacon switch. |
| strob, lite | The status of the strobe light switch. |
| land, lite | The status of the landing light switch. |
| taxi, lite | The status of the taxi light switch. |
| Switches 2: EFIS | |
| ECAM, mode | The ECAM mode. |
| EFIS, sel <i>n</i> | |
| HSI, sel <i>n</i> | |
| HSI, arc | |
| map, r-sel | |
| map, range | |
| Switches 3: Autopilot, flight director, and head-up display (switches 3: AP/f-dir/HUD) | |
| ap, src | |
| fdir, mode | |
| <i>continued on next page</i> | |

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|--|-------------|
| Field label | Description |
| fdir, ptch | |
| fdir, roll | |
| HUD, power | |
| HUD, brite | |
| Switches 4: anti-ice | |
| ice, all | |
| ice, inlet | |
| ice, prop | |
| ice, windo | |
| ice- <i>n</i> , pitot | |
| ice, AOA | |
| ice, wing | |
| Switches 5: anti-ice/fuel | |
| alt, air <i>n</i> | |
| auto, ignit | |
| manul, ignit | |
| l-eng, tank | |
| r-eng, tank | |
| Switches 6: clutch and artificial stability (switches 6: clutch/astab) | |
| prero, engag | |
| clutc, ratio | |
| art, ptch | |
| art, roll | |
| yaw, damp | |
| auto, brake | |
| Switches 7: miscellaneous (switches 7: misc) | |
| tot, energ | |
| radal, feet | |
| <i>continued on next page</i> | |

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|-------------------------------------|-------------|
| Field label | Description |
| prop, sync | |
| fethr, mode | |
| puffr, power | |
| water, scoop | |
| arrst, hook | |
| chute, deploy | |
| Annunciators: general | |
| mast, cau | |
| mast, war | |
| mast, accp | |
| auto, disco | |
| low, vacum | |
| low, volt | |
| fuel, quant | |
| hyd, press | |
| Annunciators: general | |
| yawda, on | |
| sbrk, on | |
| GPWS, warn | |
| ice, warn | |
| pitot, off | |
| cabin, althi | |
| afthr, arm | |
| ospd, time | |
| Annunciators: engine | |
| fuel, press | |
| oil, press | |
| oil, temp | |
| <i>continued on next page</i> | |

| <i>continued from previous page</i> | |
|--|--|
| Field label | Description |
| inver, warn | |
| gener, warn | |
| chip, detec | |
| engin, fire | |
| ignit, 0/1 | |
| Armed autopilot functions (autopilot arms) | |
| nav, arm | |
| alt, arm | |
| app, arm | |
| vnav, enab | |
| vnav, arm | |
| vnav, time | |
| gp, enabl | |
| app, typ | |
| Autopilot modes | |
| auto, throt | |
| mode, hding | |
| mode, alt | |
| bac, 0/1 | |
| app, | |
| sync, butn | |
| Autopilot values | |
| set, speed | The desired speed setting for the autopilot. |
| set, hding | The desired heading setting for the autopilot. |
| set, vvi | The desired vertical velocity setting for the autopilot. |
| dial, alt | |
| vnav, alt | |
| use, alt | |
| <i>continued on next page</i> | |

| | |
|---|--------------------|
| <i>continued from previous page</i> | |
| Field label | Description |
| sync, roll | |
| sync, pitch | |
| Weapon status | |
| hdng, delta | |
| pitch, delta | |
| R, d/sec | |
| Q, d/sec | |
| rudd, ratio | |
| elev, ratio | |
| V, kts | |
| dis, ft | |
| Pressurization status | |
| alt, set | |
| vvi, set | |
| alt, act | |
| vvi, act | |
| test, time | |
| diff, psi | |
| dump, all | |
| bleed, src | |
| Auxiliary power unit and ground power unit status (APU/GPU status) | |
| APU, eqipd | |
| APU, swtch | |
| APU, runng | |
| APU, ac | |
| fm N, AP | |
| , GP | |
| Radar status | |
| <i>continued on next page</i> | |

| | |
|--|--------------------------------------|
| <i>continued from previous page</i> | |
| Field label | Description |
| targ, selct | The status of the target selection. |
| Hydraulic status | |
| hydr, pump n | The status of hydraulic pump n . |
| hydr, qtn n | The hydraulic fluid in pump n . |
| hydr, pres n | The pressure of hydraulic pump n . |
| Electrical and solar power status (elec & solar status) | |
| batt n , volt | Battery n 's voltage. |
| bus n , volt | Bus n 's voltage. |
| batt, in W | |
| batt, out W | |
| batt, w-hr | |
| DC, voltm | |
| Icing status 1 | |
| inlet, ice | |
| prop, ice | |
| pitot, ice | |
| statc, ice | |
| Icing status 2 | |
| aoa, ice | |
| lwing, ice | |
| rwing, ice | |
| windo, ice | |
| Warning status | |
| warn, time | |
| caut, time | |
| warn, work | |
| caut, work | |
| gear, work | |
| <i>continued on next page</i> | |

| | |
|-------------------------------------|-------------------------------------|
| <i>continued from previous page</i> | |
| Field label | Description |
| gear, warn | |
| stall, warn | |
| VRS, ratio | |
| Flight plan legs (flite-plan legs) | |
| leg, # | |
| leg, type | |
| leg, lat | |
| leg, lon | |
| Hardware options | |
| pedal, nobrk | |
| pedal, wibrk | |
| yoke, PFC | |
| pedal, PFC | |
| throt, PFC | |
| cecon, PFC | |
| switc, PFC | |
| btogg, PFC | |
| Camera location | |
| camra, lon | The camera's longitudinal location. |
| camra, lat | The camera's latitudinal location. |
| camra, ele | The camera's elevation. |
| camra, hdg | The camera's heading. |
| camra, pitch | The camera's pitch. |
| camra, roll | The camera's roll. |
| camra, clou | The camera's cloud cover. |
| Ground location | |
| cntr, X | |
| cntr, Y | |
| <i>continued on next page</i> | |

| <i>continued from previous page</i> | |
|---|-------------|
| Field label | Description |
| cntr, Z | |
| slope, X | |
| slope, Z | |
| Travel statistics (<code>travel stats</code>) | |
| fob, lb | |
| ff, pph | |
| ff, gph | |
| speed, mph | |
| eta, mpg | |
| eta, nm/lb | |
| range, sm | |
| endur, hours | |

Table G.1: Descriptions of fields available in X-Plane 10's data output

Index of Menu Items

The following is a list of this manual's references to specific menu items in X-Plane 10. Note that for the sake of providing context, each page number indicates the beginning of the section in which the reference occurs.

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| Toggle Sunglasses | |
| Toggle Night Vision Goggles | |
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| Show Sky Colors | |
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Glossary

G.1 Working with the Program Itself

Download: To download something means to get files from some remote server on the Internet and receive those files on your computer. Users can download lots of airplanes and scenery packages for X-Plane from the Internet. Downloading is receiving files from the Internet; it is not the same as installing those files.

Install: To install something is to move a copy of the software onto your computer so that it can be run. When you get a DVD with X-Plane on it, you run the installer to install the program from the DVD—this is not downloading the program. It is installing it. You would only be downloading the program if the files were coming from the Internet (though once such files were downloaded, you would install them to have them ready for use).

Update: To update a piece of software is to convert it to a newer version. This should be done every couple months or so in order to take advantage of new features in the simulator. To update in X-Plane, a user first downloads and then installs a newer version. The updater program (available for free at X-Plane.com) does both of these things for you very easily.

G.2 Controls in an Aircraft

Anti-torque pedals: In a helicopter, the anti-torque pedals are the foot pedals which modify the collective pitch of the tail rotor. Because the helicopter’s throttle governor keeps the rotors turning at a constant RPM, changing the pitch also changes the thrust generated by the rotor, so the tail rotor can swing the helicopter’s tail to the left or right. This is referred to as yaw motion.

Collective: In a helicopter, the collective is the lever that modifies the collective pitch of the main rotor’s blades. It is called “collective” because the pitch of all the blades is modified at the same time. Because the engine keeps the rotor moving at a constant RPM, increasing the rotor blades’ pitch with this control will also increase their lift.

Cyclic: The control (a joystick in real life) which changes the pitch of the main rotor’s blades as they go through each cycle, used to steer the craft left, right, forward, or aft.

Joystick: A control device used in aircraft. It consists of a base with a handle attached to it. The handle can be tilted around within the base to control the pitch and roll movement of the aircraft. Computer joysticks often have the ability to twist the handle to control yaw movement also. Real



Figure G.1: The flight dynamics of an aircraft. Thanks to Wikipedia contributor ZeroOne for releasing the image under the Creative Commons Attribution 3.0 Unported license. [Full size →]

airplanes have either a joystick or a yoke to control them, while helicopters are controlled with joysticks only.

Rotor: The rotating part of a helicopter that generates the craft's lift; similar in appearance to an oversized airplane propeller, though different in its operation.

Rudder pedals: Foot pedals in an airplane used to steer the plane down the runway and to control its yaw motion in flight (that is, the wagging of its tail left or right). This becomes very useful when starting turns and counter-acting crosswinds. Note that these are not spelled "petals," as they are not named after the fragile leaves of a flower.

Yoke: The yoke, named after a wooden device draped across oxen to tow things, is the "steering wheel" of the airplane. It is used to steer the plane in flight by dipping the wings up or down and by pulling the nose up and pushing it down. Note that this is not spelled "yolk," as it is not named after the center of an egg.

G.3 Movement of an Aircraft

Pitch: Movement of the aircraft's nose up or down (illustrated in Figure G.1).

Roll: Movement of the aircraft's body along the line formed by its body; in an airplane, this is easily seen as the dip or rise of the wings (illustrated in Figure G.1).

Yaw: Movement of the aircraft's body left or right, most easily pictured as a wagging of the aircraft's tail (illustrated in Figure G.1).

G.4 Other Aviation Terms

Above Ground Level (AGL): When holding an altitude requested by air traffic control, a pilot will hold an altitude AMSL (above mean sea level). This lets the pilot stay at a constant level while flying. In order to avoid a horrific and instant death, however, pilots should be aware of their altitude AGL (above ground level) as well! The altimeter in the aircraft works on air pressure, so it measures the altitude above sea level, so awareness of minimum allowable altitudes in one's region is always needed in order to stay at least that high. The radio altimeter measures the height above the ground (AGL). Most planes, however, do not have these installed. This is increasingly okay, though, because in theory a pilot can follow the en route and approach charts, which list safe MSL altitudes, and more and more planes have moving maps that clearly show the terrain elevation, so pilots can be sure that their elevation is safe.

Airspeed indicator (ASI): The ASI is driven by the pressure of the air impacting a little tube on the nose or wing of the plane. More pressure means the craft is moving faster. See the discussion in the “Indicated airspeed (IAS)” entry below.

Air Traffic Control (ATC): The body governing aircraft operations in a given airspace.

Altitude: An aircraft's altitude is its height above sea level. This is typically displayed on the aircraft's altimeter, which is driven by air pressure.

Automatic Direction-Finder (ADF): This is the old-style navigation device that just points a needle at a transmitter on the ground. These are not used too often any more because modern navigation involves staying on a pre-defined course (a line), not just taking any random routing to get to a pre-defined point, like an ADF typically provides. Additionally, with GPS navigation, the whole idea of going to pre-defined points (like picking up bread-crumbs to find one's way home) is thankfully disappearing. The GPS will take pilots all the way to where they want to go in a straight line, not a zig-zaggy one like would be achieved in flying from one navigation transmitter to another, wasting fuel with an indirect routing simply because of the locations people chose to plant navigation transmitters fifty years ago.

Back Course (BC): This is the part of the ILS that goes beyond the touch-down zone. Read all about it in Chapter 7, Navigation, Autopilots, and Flying on Instruments.

Course Deviation Indicator (CDI): This instrument (part of the OBI or HSI) displays which direction the aircraft needs to turn in order to intercept the VOR course. This is discussed in Chapter 7, Navigation, Autopilots, and Flying on Instruments.

Density altitude: As the temperature of the air increases, its density decreases. The barometric pressure can vary based on a number of other factors, too, so at sea level on a hot, low-pressure day, the density of the air may be the same as standard air density at 10,000 feet up in the air! This is a 10,000 foot density altitude. This means there is less air for the engines, less air for the propeller, and less air for the wings. All of this adds up to say that it will take the aircraft longer to get off the ground.

Distance Measuring Equipment (DME): An instrument used in navigation which measures distance using the delay between the sending and receiving of a radio signal. Aircraft use this to determine their distance from a fixed NAVAID.

Drag: The aerodynamic force (created by a fluid such as air flowing around an object) that slows the object's motion.

Electronic Flight Instrument System (EFIS): A flight instrument system (found in an aircraft's panel) with electronic displays rather than the mechanical gauges of a standard panel.

Go Around (GA): An autopilot mode that raises the nose in a wings-level attitude and calls for lots of power in order to get back to altitude after a botched landing approach).

Glideslope (G/S): The angle at which an aircraft approaches (or needs to approach) a runway; often used when discussing navigation by instruments. See Chapter 7 for more information.

Global Positioning System (GPS): A form of navigation using data from satellites.

Heading (HDG): An aircraft's heading is the direction that its nose is pointing. This is also a mode in the autopilot that lets the pilot hold a pre-defined heading, typically magnetic. A magnetic heading is heading to the magnetic north pole, something a hair different than true north, which is a geographic heading that will take one to the true geographic North Pole. Remember, since the magnetic north pole is separated from the geographic north pole by a bit, true and magnetic heading are not typically the same! They may be off by 5 or 10 degrees in the medium latitudes. The difference between the true and magnetic north poles is called the magnetic variation.

Hold (HLD): Pressing this button will engage the autopilot in altitude hold mode. See the Autopilots section of Chapter 7 for more information.

Horizontal Situation Indicator (HSI): This instrument is found in the panel of many aircraft in X-Plane. It serves the same function as an OBI—that is, it indicates course deviation. See Chapter 7 for more information.

Instrument Flight Rules (IFR): The procedure for flying an aircraft based solely on the craft's instrument panel. Environmental conditions requiring such flight (such as the poor visibility on a rainy day) are referred to as IFR conditions. This is contrasted with VFR conditions (those operating under visual flight rules). In bad weather or above 18,000 feet, pilots need to fly by Instrument Flight Rules, following their instruments and air traffic control instructions carefully to avoid hitting the ground or other planes, or going off course and messing up the carefully laid plans of the air traffic controller. When flying IFR, it really makes no difference whether the pilot can see out the front of the plane or not, since he or she is on a carefully mapped procedure to stay on a safe course. Seeing out the window in this case is an unneeded luxury.

Instrument Landing System (ILS): A ground-based system for guiding approaching aircraft into the runway via radio signals. See the Chapter 7 for more information.

Instrument Meteorological Conditions (IMC): When pilots are in clouds or rain and cannot see out the window, they are required to fly by IMC rules. In such conditions, they need to be on an instrument flight plan.

Indicated airspeed (IAS): The presumed airspeed of a craft as determined by measuring the pressure acting on a little tube attached to the craft which points into the wind. This differs from true airspeed in situations where the air has very little density (for example, at 80,000 feet in an SR-71 Blackbird or in orbit in the Space Shuttle). This error, though, can be useful, because if there is less pressure pushing on the airspeed indicator, then there is also less pressure pushing on the wings of the aircraft. Therefore, the airspeed indicator tells how much air pressure is available for the props and wings (which is what a pilot really cares about, as more pressure gives more lift and drag). So, if a pilot is going 120 mph in thin air, but the pressure is only strong enough to measure 100 mph on the airspeed indicator, then that means the aerodynamic pressure on the wings is only 100 mph-worth of pressure! It is this pressure that determines how much lift and drag the wings can put out.

Lift: The aerodynamic force (created by a fluid such as air flowing around an object) that pushes an object upward.

Localizer (LOC): A localizer is part of an instrument landing system (ILS). It serves as a lateral (left and right) guide to the centerline of the runway.

Mach speed: The speed of sound through the air. Mach's number actually describes the speed of sound through any fluid (that is, liquid or gas). In application to aeronautics, though, it is implied that the fluid is air. Note that this number is dependent on a number of factors, such as temperature, humidity, and pressure. Generally, "Mach 1" is cited as 768 miles per hour (the speed of sound at sea level in dry air at 68° Fahrenheit).

NAV: Short for "navigate." This is an autopilot mode that follows an ILS, localizer, VOR, or GPS path. See Chapter 7 for more information.

NAVAID: A navigation aid transmitter (typically a VOR, NDB, or ILS) which is used as a reference when flying. These are often found on or near an airport, but they can also be scattered between airports to use a node points in an airway. Pilots often fly from NAVAID to NAVAID on long flights, as a VOR is only usable from about 50 miles away. See Chapter 7 for more information.

Non Directional Beacon (NDB): See the ADF note above.

Omni-Bearing Indicator (OBI): This instrument, used for navigation, is found in most general aviation aircraft. It consists of a moving arrow (called the course deviation indicator, or CDI) which points the way to whatever VOR frequency is tuned in the navigation radio. The instrument is set using the Omni-Bearing Selector (or OBS), the knob in its lower left corner. A more expensive version of this is an HSI. See Chapter 7 for more information.

Rotations per minute (RPM): a way of measuring the speed of a rotor or propeller. In a helicopter, the RPM of both the main rotor and the tail rotor are held constant.

Speed: The change in the position of an object over time; unlike velocity, speed does not take into account the direction of the object's movement.

Thrust vector: The direction in which the engine or rotor's thrust is going; for a helicopter sitting on a helipad with its controls at neutral, this is straight down.

Thrust vectoring: The ability of helicopters and some other aircraft (such as the Harrier or the F-22) to change the direction of the thrust from its engines/rotors.

Vector airways: Vector airways are the precharted airways that are defined by a series of VORs. Pilots fly from VOR to VOR until they reach their destination, thereby staying on a vector airway. Each segment of the vector airway thoughtfully lists the minimum altitude that pilots can fly that airway segment with to avoid crashing.

Velocity: The combination of an object's speed and the direction of its movement; for example, an aircraft might have a vertical velocity of 500 feet per minute (meaning it moves upward at a rate of 500 feet per minute) or a vertical velocity of -500 feet per minute (meaning it moves downward at 500 feet per minute).

Vertical speed/vertical velocity: The rate at which the aircraft is gaining or losing altitude, typically given in feet per minute.

Velocity of Flap Extension (V_{fe}): This is the maximum speed at which the aircraft can deploy its flaps without damaging or breaking them.

Visual Flight Rules (VFR): This is flying done using a combination of the pilot's view of the outside world and the aircraft's instruments. Environmental conditions permitting such flight (such as a sunny day with 10 mile visibility) are referred to as VFR conditions. It is assumed in such conditions that pilots are always able to see out the window well enough to avoid collisions with terrain and other aircraft. To use visual flight rules, one typically needs about 3 miles visibility and to stay about 1000 feet from the clouds.

Visual Meteorological Conditions (VMC): These are environmental conditions suitable for flying by sight (VFR).

Very high frequency Omnidirectional Range (VOR): This is a type of NAVAID that sends out signals that pilots can follow to get to or from the transmitter. While an NDB simply lets the aircraft's ADF needle point right to it, the VOR actually lets pilots fly to the station along a programmed radial. So, for example, rather than just "flying to the VOR," a pilot can be sure to fly to the VOR along the 090 radial (from the east), guaranteeing his or her location to be along an airway for the entire trip to the VOR. This is nice because once the airway is charted, the aircraft will be over mapped terrain height for the entire trip, and if the wind starts to blow it off course, then the pilot will see it quickly due to a deflected needle, at which point he or she can turn the nose into the wind to stay on the desired radial. Light airplanes often track these VOR signals using an Omni-Bearing Indicator, or OBI, while more expensive craft often use a Horizontal Situation Indicator, or HSI. See Chapter 7 for more information.

Velocity Never Exceed (V_{ne}): This is the maximum speed that a given airplane can go. Going faster than V_{ne} can result in “structural damage.” Please be aware that “structural damage” is very conservative language for “ripping your wings off so you plunge to a horrible death.”

Velocity Normal Operating (V_{no}): This velocity should not be exceeded unless the air is very smooth. Even then, it should be exceeded “with extreme caution,” as the operating handbooks say.

Vertical Speed/Velocity Indicator (VSI or VVI): By looking at how fast the air pressure is changing, the VSI deduces how quickly the aircraft must be climbing or descending.