X-Plane® 9

by Austin Meyer







X-Plane 9

X-Plane Operation Manual

About This Copy of the Manual

This is revision 9.61 of the manual to the desktop and professional versions of X-Plane, last updated on November 13, 2014.

Using This Manual

Throughout the manual, there will be cross-references to other parts of the manual. These will generally be in the form of a dark gray page number—for instance, Chapter 4 is on page **54** (clicking the number there will go directly to page 53). 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.

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1. About X-Plane

I. Overview

X-Plane is the world's most comprehensive and powerful flight simulator for personal computers.

X-Plane offers the most realistic flight model available for home use.

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 to the fastest. X-Plane also includes 35 aircraft on its master disk, spanning the aviation industry (and its history), sporting aircraft from the Bell 206 JetRanger and Cessna 172 to the Space Shuttle and the B-2 Bomber. Additionally, more than 1,400 additional aircraft models can be downloaded from the Internet (X-Plane.org[1], the X-Plane.com Links page[2], and Google[3] are good places to start), nearly all of which are free. If those aren't enough, users can design their own airplanes and test fly them!

[1] http://forums.x-plane.org/index.php?autocom=downloads
[2] http://www.x-plane.com/xworld.html
[3] http://www.google.com

The full X-Plane scenery package covers the Earth in stunning resolution from 74˚ north to 60˚ south latitude. Scenery is also available for Mars thanks to the Mars Orbiting Laser Altimeter, which mapped that planet's elevation. On Earth, 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, 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 incredible!

Weather is variable in X-Plane 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 currently exists at the location of the flight!

X-Plane also 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.

Note: This certification requires not only that the user has the certified X-Plane software, but also the certified hardware (cockpit and flight controls) available through companies like Precision Flight Controls[4] and Fidelity[5]. This is because flight-training systems can only be certified as a complete package (a software and hardware combination). The certified software is available for $500 to $1,000 per copy from PFC and Fidelity and the hardware runs from $5,000 to $500,000. The retail version of X-Plane purchased at X-Plane.com[6] 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 $50 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-certified version also has some of the purely fun stuff (like Mars and space flight) removed—even though those situations *are* simulated accurately in X-Plane, just like the FAA-certified subsonic terrestrial flight. When the FAA certifies the first Martian business jet, we'll be there.

II. What X-Plane Includes

Windows, Mac, and Linux installers are included on the discs purchased from X-Plane.com[7]. There are approximately 74 GB worth of scenery (covering essentially the entire world) and thirty-five aircraft, with thousands of planes available on the web. The DVDs contain everything needed to run X-Plane—there is nothing more that users need to buy. You'll receive free updates to version 9 until version 10 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

[4] http://www.flypfc.com/
[5] http://www.flightmotion.com/
[6] http://www.x-plane.com/order.html
[7] http://www.x-plane.com/order.html

comprehensive flight simulator, the installation DVD also comes with Plane-Maker (allowing users to create custom aircraft or modify existing designs), Airfoil-Maker (allowing users to create airfoil performance profiles), and Weather-Briefer (to give users a weather briefing before the flight when using real weather conditions downloaded from the Internet).

The stock installation includes the following thirty-five aircraft:

Cirrus Vision SF50	X-15 and X-30 X-Planes
Cessna 172SP	KC-10 Extender
Piaggo P-180 Avanti	Boeing B747-400
Stinson L-5 Sentinel	Bell-Boeing V-22 Osprey
ASK-21 glider	Boeing B-52G Stratofortress
Bell 47	Van’s RV-3/4/6/7/8/9/10
Beechcraft King Air B200	Rockwell B-1B Lancer
F-22 Raptor	Viggen JA37
Lockheed SR-71 Blackbird	F-4 Phantom
Bombardier Canadair CL-415	Mars Jet, Mars Rocket
Boeing B777-200	Bell 206
Piper PA-46 Malibu	Boeing AV-8B Harrier II
Northrop B-2 Spirit	Sikorsky S-61
Robinson R22 Beta	Space Shuttle Orbiter
Great Planes PT-60 RC plane	Thunder Tiger Raptor 30 v2 RC helicopter

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:

Beechcraft Bonanza	Boeing 727/737/747/etc
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	

III. 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 users are probably aware, the most popular flight simulator on the market 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 have failed... except X-Plane, which has traditionally enjoyed a relatively small market of fanatic users. From the very beginning, the largest 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 largely died with the release of the first set of high-definition, world-wide scenery disks on December 1, 2004, about midway through the X-Plane Version 8 run.

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.

A. Austin's Bio, Last Updated 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 bachelor's 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[8] web page.

B. 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[9] 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 likes to taxi the planes around to see the Corvettes parked around the airport fence in Version 7. 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 sim that has a level of realism that is 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

[8] http://www.x-plane.com/adventures.html

[9] http://x-plane.com/order.html

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.

i. Versions of X-Plane

X-Plane can be used in a wide array of situations, ranging from home use to commercial flight training. Different situations require a different software "level." Situations that go beyond the standard retail use require the purchase of a USB "key" (simply a flash drive) that is used to unlock a specific level's features.

a. The Level 1 X-Plane Simulator

This is the standard retail copy of X-Plane. It requires one X-Plane DVD for each copy of X-Plane on the network.

A Level 1 simulator is what users get when they purchase X-Plane[10] from the X-Plane.com site and use it for whatever they desire. This 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.

[10] http://www.x-plane.com/order.html

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 useable 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.

b. The Level 2 X-Plane Simulator

This version of X-Plane is for commercial use, FAA-approved simulators, and the EFIS-App. It requires one Level 2 USB key for each copy of X-Plane or EFIS-App on the network.

This is similar to the Level 1 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 Level 2 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.

Additionally, *this* is the key that needs to be used for commercial purposes and FAA-approved simulators for flight training. This gives a "Commercial Use" startup message. It checks for flight controls and it self-tests the frame rate for FAA certification.

This is the option designed to replace Microsoft ESP.

Note that the Level 2 key, along with the simulator itself, can be purchased from X-Plane.com's Ordering[11] page. EFIS-App can be

[11] http://www.x-plane.com/order.html

downloaded here[12].

c. The Level 3 X-Plane Simulator

This version of X-Plane requires one Level 3 USB key for each copy of X-Plane or EFIS-App on the network.

The Level 3 key for X-Plane will do everything that the Level 2 will do, in addition to driving *real* Garmin G430 and G1000 GPS units. It can do cylindrical and spherical projection as well.

Note: 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[13]. PFC *does* provide ready-made units with real G430s and G1000s installed and running.

Once again, the Level 3 key, along with the simulator itself, can be purchased from X-Plane.com's Ordering[14] page, and EFIS-App can be downloaded here[15].

d. The Level 4 X-Plane Simulator

This version of X-Plane requires one Level 4 USB key for each copy of X-Plane or EFIS-App on the network.

A Level 4 simulator does everything that the Level 3 sim does. It adds the ability, though for EFIS-App to simulate the AVIO system in the Eclipse Jet. This option is currently only available from Excel Aviation. Email info@x-plane.com for more information on this.

e. Summary

Since X-Plane has been approved for flight training in many countries to many levels, users should be able to use it to build their own flight simulators by simply purchasing a copy (or copies) of X-Plane, purchasing the appropriate USB key, and possibly downloading EFIS-App. From there, all that's left is to build the hardware.

USB key drivers for both Mac OS and Windows can be downloaded here[16]. Run those installers to make X-Plane recognize the USB keys.

12 http://www.x-plane.com/EFIS.html
13 http://www.flypfc.com/
14 http://www.x-plane.com/order.html
15 http://www.x-plane.com/EFIS.html
16 http://dev.x-plane.com/update/usb_drivers.zip

2. Installing and Configuring X-Plane

I. System Requirements

Given X-Plane's incredible capabilities and accuracy, it is not possible to run a current release of X-Plane on a really 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.

Note: X-Plane 9 is not compatible with the Mac operating system 10.10 Yosemite.

X-Plane 9 requires a computer with at least the following specifications:

- A 2 GHz processor
- 1.0 GB RAM (physical memory)
- 64 MB VRAM (video memory on your video card)
- 10 GB of hard drive space

To find out the specifications of the computer being used, Mac users can simply open the Apple Menu and choose About This Mac. For Windows users, it is a bit more difficult, but still isn't too bad. The easiest way to get all the necessary information is to download the free PC Wizard application[17] (3MB) from CPUID. The installer is very user friendly, and the program, once installed, will show nearly everything about the system on one page.

Alternatively, for Windows users that don't want to download the application, the system's processor speed and amount of memory can be found by doing the following:

1. Go to the Start menu and select Control Panel.

2. In the window that opens, click on System (Performance and Maintenance may need to be clicked first).

3. Near the bottom of the window that opens you will see your CPU speed (for example, 2.0 GHz) and the amount of memory in the system (for example, 1.0 GB of RAM).

Additionally, Version 9 has been optimized for dual- and quad-core processors, as well as multiprocessor systems—one CPU core is used to output video, while the other core(s) handle the background processes of loading scenery, taking input, etc. This eliminates the tenth of a second stutter usually associated with transitioning from one scenery file to another (which is still experienced when using a single-core processor).

Please note that X-Plane *will* run on Windows Vista and Windows 7, both 64- and 32-bit. However, it will require more RAM to do so (2 GB is recommended).

II. Flight Control Selection

While it is physically possible to fly X-Plane with only the mouse and keyboard, this is both cumbersome and unrealistic (for obvious reasons). While instructions for flying like this are included in the Using the Mouse Instead of a Joystick section (found in Chapter 4, Section V on page **64**), 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 on the market that we have seen recently will work with

[17] http://www.cpuid.com/pcwizard.php

X-Plane, but, like 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 five or six years, but if a user has a non-USB device, an adapter will be needed to change it to a USB input.

A. Joysticks

Joysticks typically provide pitch, roll, and sometimes even 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, users 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 like the Airbus, Cirrus, or Lancair, for the simple reason that those planes, in reality, are controlled with joysticks!

B. 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 will 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.

C. 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 tops of the left or right pedal to activate the brakes on that side of the plane.)

Actively controlling the rudder is needed to realistically steer the airplane on the ground, track the runway centerline when taking off and landing, slip the airplane, take off or land in a crosswind, or recover from stalls and spins.

If neither a set of rudder pedals and the joystick is set to control yaw (see Chapter 3, Section II, Part A, Axis Assignment on page **32**), then 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 this to fly.

D. Other Considerations

For added realism in certain situations, users may want an independent throttle quadrant. CH Products' Multi-Engine Throttle Quadrant[18] 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[19], Logitech[20], and Saitek[21] 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 with any additional questions. Contact information can be found on the Contact page[22] of X-Plane.com.

Instructions on configuring control hardware are found in Chapter 3, Section II, Joystick Configuration and Calibration on page **32**.

III. Display Requirements and System Architecture

X-Plane can display on any screen ranging from 1,024 x 768 pixels to 9,999 x 9,999 pixels. Fifteen years ago, nearly every monitor sold had a 4:3 (or "full screen") aspect ratio. Many of the monitors and screens available today, though, have widescreen aspect ratios, such as 16:9 or 16:10. While X-Plane can easily fill a screen with a wide aspect ratio, most aircraft have only been set up with cockpits that can be stretched in a 4:3 ratio.

To find your screen's current aspect ratio, divide its width in pixels by its height. For example, 1024 divided by 768 (a common "full screen" resolution) equals 1.3333, or four-thirds (the 4:3 "full screen" aspect ratio). On the other hand, 1440 divided by 900 (a common widescreen resolution) equals 1.6, or sixteen-tenths (a 16:10 "widescreen" aspect ratio).

When using a wide aspect ratio in X-Plane, many aircraft's cockpit image will be flanked on each side of the screen by scenery, with a sharp line dividing it from the cockpit image. To avoid this, set the size of the X-Plane window to a 4:3 ratio by moving the mouse to the top of the screen, clicking Settings, and selecting the Rendering Options window. In this window, change the **screen res** field. Note that the change will occur on X-Plane's next launch. (More information on changing the resolution can be found in Chapter 3, Section III, Part B, Subsection iv on page **40**.)

With one computer it is possible to draw any view desirable and, assuming that the computer's video card has two video outputs, an Instructor's Operating Station (IOS). The IOS (also available on a different computer if via a LAN or Internet connection) provides the ability to alter the weather, relocate the aircraft, and fail multitudes of different systems and components. Here an instructor can do nearly anything imaginable to the aircraft, including nearly every failure simulated at Flight Safety and the other simulator-based flight training companies.

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 the computer's graphics card is especially powerful, a video splitter (like the

[18] http://www.chproducts.com/retail/t_tq_quad.html
[19] http://www.chproducts.com/retail/index.html
[20] http://www.logitech.com/index.cfm/gaming/pc_gaming/joysticks/&cl=us,en
[21] http://www.saitek.com/uk/prod/joysticks.htm
[22] http://www.x-plane.com/contact.html

Matrox TripleHead2Go[23]) 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.

IV. Graphics Drivers and X-Plane

On most 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 video cards can download drivers here[24], and NVIDIA users can download drivers here[25].

Before updating the graphics driver, we recommend installing and launching X-Plane (as per Section V of this chapter on page **21**) and seeing how it runs. If any of the following is 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", the drivers most likely need to be replaced.

A. 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 it is determined that the drivers need to be updated, please see Appendix I: Updating the Computer's Graphics Drivers in Windows of this manual for a step-by-step guide (with screenshots) for both ATI and NVIDIA graphics cards. Alternatively, the following general steps may be used for both manufacturers:

1. Go to your video card manufacturer's driver download page (linked to above) 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. Click on the Start menu and open the Control Panel.

3. Click Add or Remove Programs.

4. Scroll down to either the Catalyst Display Driver (for ATI video cards) or the NVIDIA Drivers (for NVIDIA cards).

5. Click the Change/Remove button. (This may be replaced by a Remove button only; it does not affect the process.)

6. Follow the instructions provided by the uninstaller and reboot if necessary.

7. 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 and the company it's manufactured by, but we will continue with a general outline for all companies.

8. Choose a destination folder to extract the files to. Again, make it something easy to find like C:\video drivers\ and continue clicking Next or Install.

9. If the installer (which you just extracted in Step 8) does not run automatically, navigate to C:\video drivers and double click

[23] http://www.matrox.com/graphics/en/products/gxm/th2go/
[24] http://support.amd.com/us/gpudownload/Pages/index.aspx
[25] http://www.nvidia.com/Download/index.aspx?lang=en-us

on setup.exe.

10. Agree to the license agreement, choose the Express installation, and click Next until it finishes.

11. Reboot your PC and you're ready to fly!

V. Installing X-Plane

In order to avoid confusion, be sure to delete any installations of the X-Plane demo before installing the full version from the DVDs.

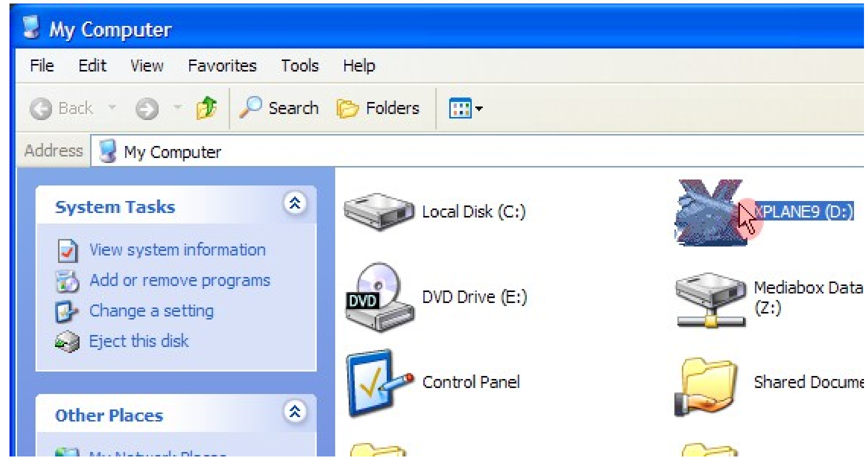
Note: The instructions that follow are for the X-Plane 9 gray colored six-DVD set, available from X-Plane.com. For installation instructions using the eight-disc “Beta” set of discs, please see Appendix K. For instructions on using the yellow colored six-disc set, please email amy@graphsim.com or call (214) 884-5571.

A. Installation on a Windows PC

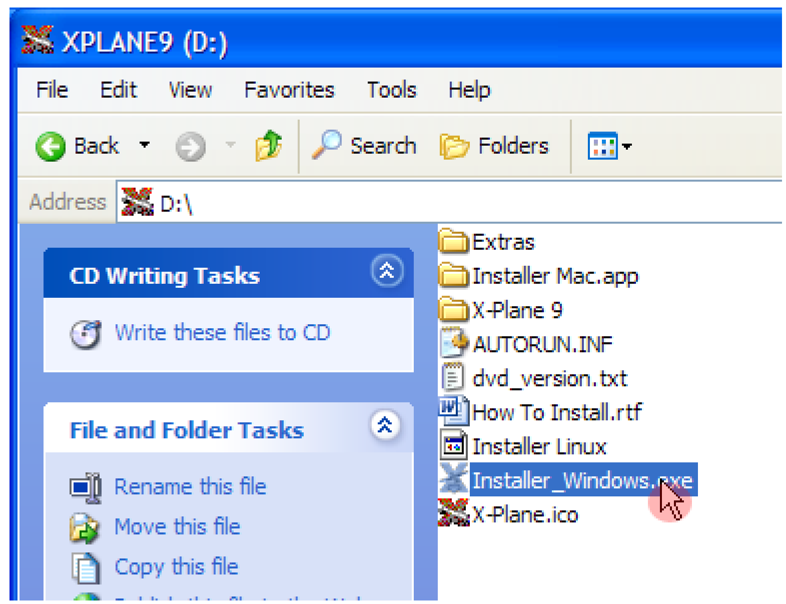
To install X-Plane on a Windows-based computer, do the following:

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

2. If the X-System window doesn’t open automatically, open My Computer and navigate to the drive now labeled XPLANE9 (usually the D drive—see the screenshot below). 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.

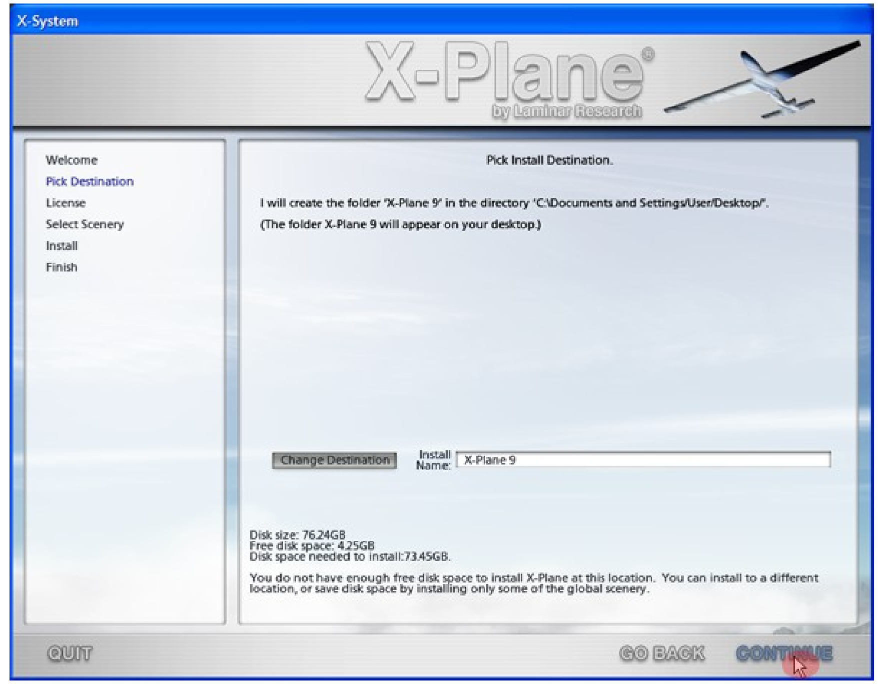


4. When the installer window appears, click **Continue**, as

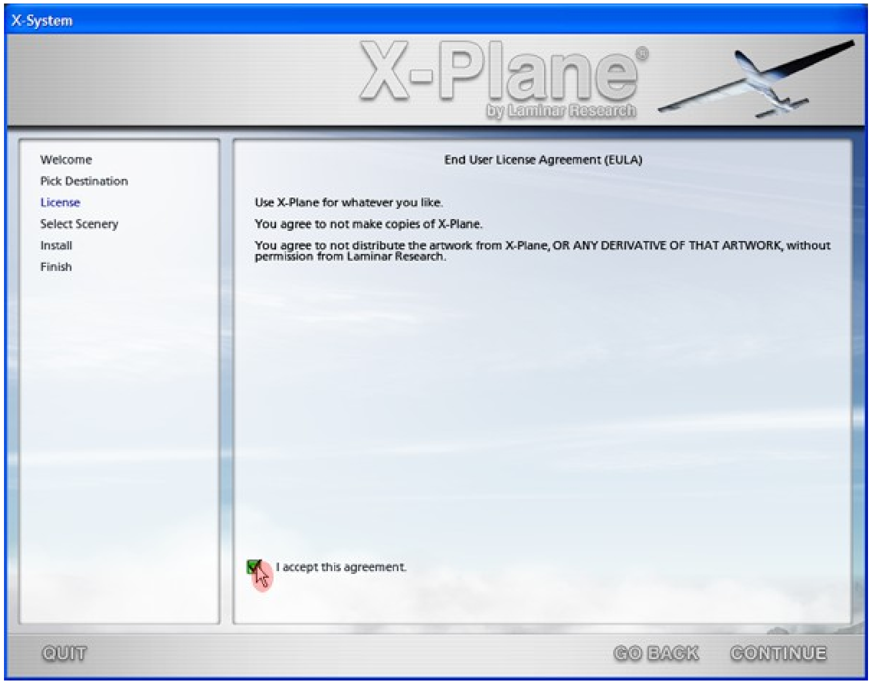
shown in the following image.

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 Ctrl+Alt+Del) and increase the screen's resolution in Windows to at least 1,024 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**.



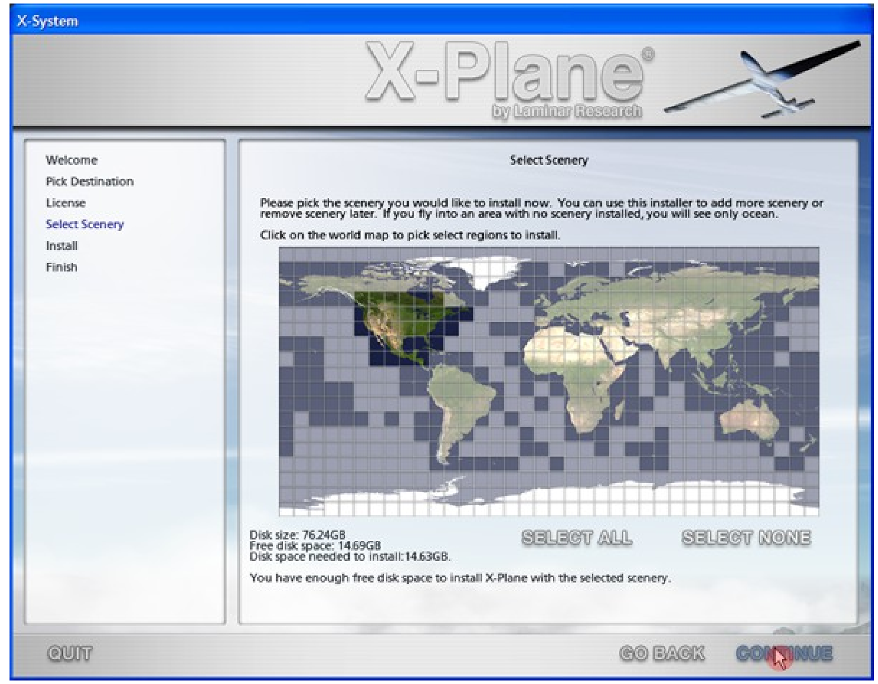
6. Accept the user agreement (as shown in the following screenshot) and click **Continue** once again.



7. 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. For instance, in the following image, only the United States and Mexico are selected.

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, users may 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.



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 and will take between five and six and a half hours to install.

9. 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 9 installed on this computer," click the **Add or Remove Scenery** button and proceed just like in step 7 above.

i. 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 here[26]. Most newer installations of Windows XP have this installed 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, do the following:

1. Open the Start menu and click Run.

2. Type "dxdiag" and click OK.

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.

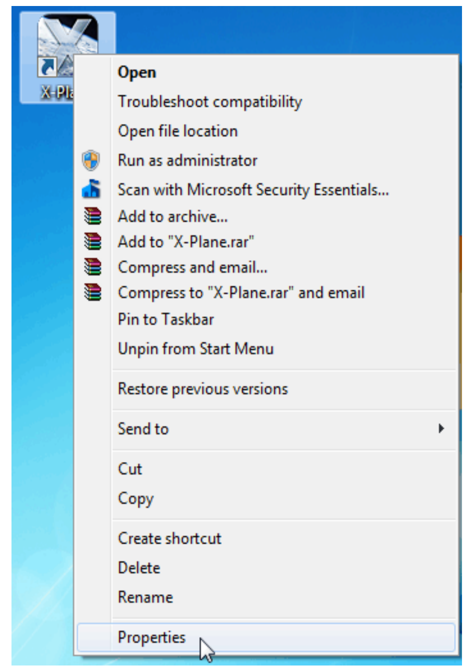
ii. Special Considerations for Windows Vista and 7 Users

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:

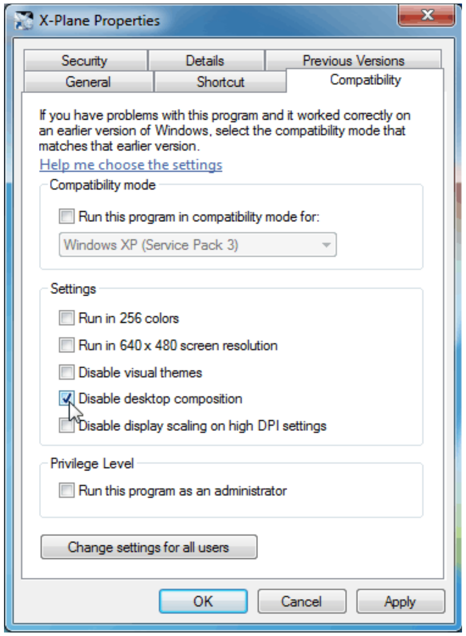
1. Locate either the X-Plane.exe (found in the X-Plane 9 installation folder) or the shortcut you use to launch X-Plane and right click on it.

2. Click Properties from the menu that appears, as in the following image.



3. Go to the Compatibility tab and check the **Disable desktop composition** box, as in the following image.

[26] http://www.microsoft.com/downloads/details.aspx?FamilyId=2DA43D38-DB71-4C1B-BC6A-9B6652CD92A3&displaylang=en



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

B. Installation on a Macintosh

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

2. Double click on the X-Plane DVD icon on the Desktop, then 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**, **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 in Windows to at least 1,024 x 768.

3. 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.

4. Accept the user agreement and click **Continue** once again.

5. 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, users may 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.

6. 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 and will take between five and six and a half hours to install.

7. 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 9 installed on this computer," click the **Add or Remove Scenery** button and proceed just like in step 5 above.

i. Special Considerations for Mac Users

By default, Mac OS X 10.5 Leopard is set to automatically back up the entire hard drive using Time Machine. This includes a user's X-Plane directory. Most users would prefer not to have this backed up, due to the fact that it demands a significant amount of spaced (for something already backed up to DVDs, no less) and generally also comes with a performance hit.

For this reason, it is recommended that users disable Time Machine while installing X-Plane, then re-enable it after telling it to exclude the X-Plane directory from its backup. This can be done using the following instructions:

1. Before installing X-Plane, choose System Preferences from the Apple Menu.
2. Click the Time Machine icon.
3. In the window that appears, turn Time Machine off.
4. Install X-Plane according to the previous instructions, noting where it was installed to.
5. With X-Plane installed, open the Time Machine preferences as before and click the **Options** button.
6. Click the **+** button to add a folder to the "Do not back up" list and select the X-Plane installation directory.
7. Click the **Done** button and turn Time Machine back on.

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 the Finder as Disc 2, thus forcing X-Plane to run in demo mode. To correct this, do the following:

1. Download and install OnyX[27] from Apple.
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." The Volumes directory, which was hidden before, is now visible at the bottom.
5. Go into the Volumes directory and delete the unwanted XPlane volumes by moving them to 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.

[27] http://www.apple.com/downloads/macosx/system_disk_utilities/onyx.html

C. Installation in Linux

Please see Appendix H: X-Plane and Linux for information on installing X-Plane in Linux. There, step-by-step instructions (with screenshots) are given for three major distributions (openSUSE, Fedora, and Ubuntu). Additionally, there is a general procedure for distributions not listed above.

VI. Launching X-Plane

When the installation of X-Plane is complete, the user will need to locate the X-Plane application and launch it (for example, by opening the X-Plane 9 folder and double clicking on X-Plane.exe).

Note that X-Plane does not infest the hard drive by creating shortcuts, subdirectories, or registry entries. We don't do this because we find it annoying when other applications do it to us. We see countless people with their desktop littered with shortcuts, most of which they have no use for. Hundreds of hours of time are wasted in frustration when people

1) install software and use only the shortcut to it,
2) get an updated version of the software in a new location, and
3) keep using the shortcut to the *old* software while *thinking* they are using the new software.

Needless to say, these people are unable to figure out why things aren't working as expected.

X-Plane does not install a shortcut that might one day lead to nothing (or worse, an outdated copy of the software). The X-Plane installer creates a folder called X-Plane 9 on the hard drive (at whatever path was selected in the installer—the Desktop is typical), and we recommend running X-Plane by going into that folder and double-clicking on X-Plane.exe.

With that said, if the user acknowledges the potential pitfalls of using a shortcut but decides to use one anyway, do the following in Windows:

1. Open the installation directory (usually by clicking on the X-Plane 9 folder found on the Desktop).

2. Right click on X-Plane.exe and select Create Shortcut.

3. Drag the shortcut to wherever it is desired.

VII. Updating to a Newer Version of 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, the X-Plane.com site will post a new update to the simulator, at which point it can be downloaded and installed as per the following instructions. 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 Part A, Using 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 the user to free updates through that full X-Plane version run. This means that if the Version 9 discs were purchased, the user will get the Version 9.10 update, the Version 9.20 update, etc., all the way through Version 9.99 if it exists—all free of charge. Of course, users do not have to take advantage of these updates, but it is recommended that they do so.

As with the X-Plane version supplied on the purchased DVD, Disc 1 (the master disc) must be inserted into the system 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!

Additionally, while 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.

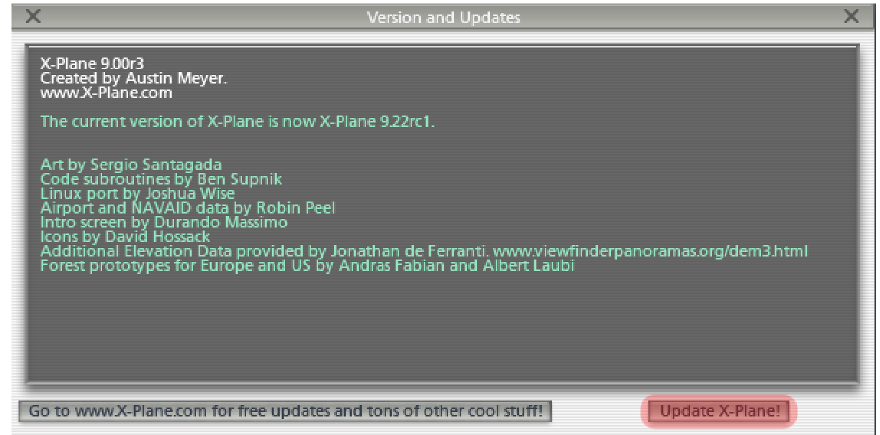
There are two ways to update X-Plane. The first is done within X-Plane itself, while the second is done by going to the X-Plane website. Both end up downloading the same updater application.

To update within X-Plane:

1. Launch the copy of X-Plane that you have been using.

2. Once it opens, move your mouse to the top of the screen and click About (as seen below), then About X-Plane.

3. Click the **Update X-Plane** button (highlighted in the following screenshot). X-Plane will automatically download the latest version of the updater program and launch it.



4. Continue with the instructions below labeled Within the X-System Updater.

To update via the Internet:

1. Go to the Update page[28] on X-Plane.com.

2. Select the appropriate updater (Mac, Windows, or Linux) from the list and click on it to begin downloading. Be sure not to download the demo installer!

3. Run the updater.

4. Continue with the instructions below labeled Within the X-System Updater.

Within the X-System Updater:

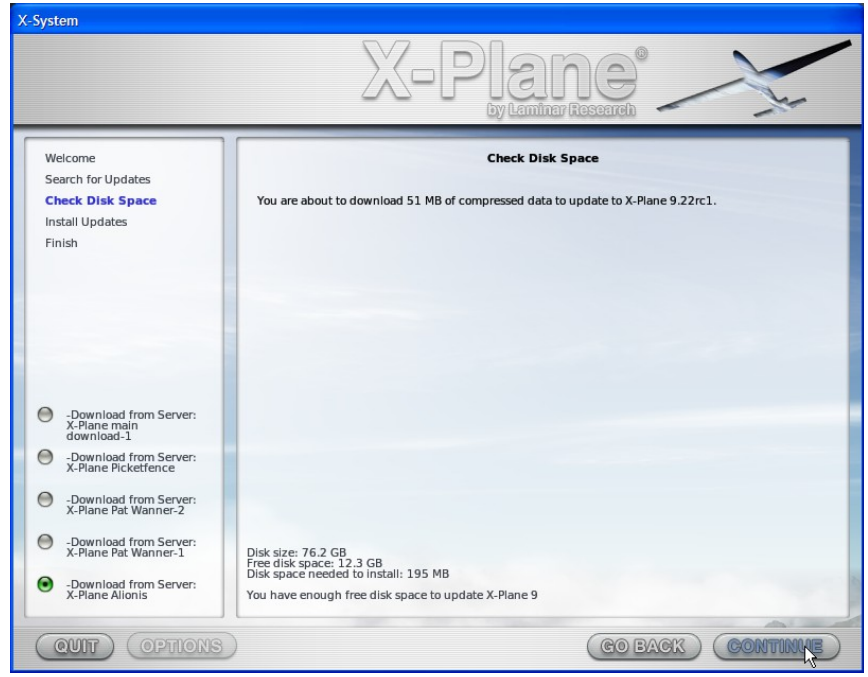
1. Please do not select the **Check for new betas** box unless you are prepared to work out the some kinks (see the following

[28] http://www.x-plane.com/demo.html

subsection, Using X-Plane Betas, found on page **29**). Click **Continue** (as shown in the following image) to begin the program's scanning of your X-Plane directory. This allows it to determine which files need to be updated.

2. Make sure the program selects the correct copy of X-Plane to update. If your X-Plane installation isn't in the list, click **Find It** to locate it manually. Note that this only applies to running the updater that was manually downloaded from the web; launching the updater from within X-Plane will skip this step. With the correct copy selected, click **Continue**.

3. Assuming there is enough disk space to download the required updates, click **Continue** (as in the following image) to begin the installation.



4. The installation files will be downloaded and installed.

5. When the installation finishes, open the X-Plane 9 installation directory. Go to the Output folder, then open the Preferences folder. Delete the files within this folder (not the folder itself) to reset X-Plane's preferences. This is recommended in order to avoid any bugs arising from changes to the way X-Plane handles the preferences.

A. Using 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[29] for information on the current beta builds.

VIII. Compatibility with Earlier Versions of Scenery, Models, and Plug-Ins

X-Plane is designed to be backwards compatible with previous versions. This is only possible, though, to a certain extent. Each version of X-Plane will always have the ability to use airplanes written for the previous version. That is, X-Plane 9 will be able to use aircraft files created for either Version 8 or Version 9, but it might not be able to use a plane created for Version 7. Likewise, scenery add-on packages will be backwards compatible for at least one version, but possibly more.

Plug-ins are small programs that have been written by third parties to modify X-Plane in some way. With plugins, users can build multiplayer gaming modifications, re-program the built-in ATC, extend the cockpit, add scenery, and more.

For example, XSquawkBox is a plug-in that allows players to connect X-Plane to the VATSIM or IVAO global air traffic control network. With XSquawkBox , users can fly online with hundreds of other pilots (who may be running X-Plane or Microsoft Flight Simulator), receive ATC instructions from real people acting as air-traffic controllers over the Internet via voice-over-IP, see other aircraft ahead on the approach and hear ATC sequencing the craft in. This is really approaching what real pilots experience every day.

Plug-ins should *not* be affected by the update process, but it is impossible for the X-Plane development team to keep track of all the different plug-ins that have been written for X-Plane. Thus, if users suspect that an update has created a problem for a plug-in being used, they should contact the plug-in administrator or author for assistance.

Check out the X-World: Links and Lists[30] page for a listing of third party add-ons available for X-Plane. The list there links to more than 1,500 additional aircraft files that can be downloaded—almost all of which are free—as well as custom scenery add-on packages. Note that all of these files were written by X-Plane customers and some are better than others. Additionally, because X-Plane actually computes the forces acting on an aircraft in flight, the simulator will fly the aircraft the way it was built by the author, not necessarily the way the manufacturer built it. If a downloaded aircraft was constructed with the wrong airfoil, camber, incidence, sweep, dihedral, chord, décollage (and the list continues!), then X-Plane will predict how that aircraft would fly if it were *actually built this way*. Thus, the old adage applies—garbage in, garbage out. Keep this in mind when searching the Internet for free aircraft downloads.

Finally, note that further information about installing plug-ins and custom aircraft may be found in Chapter 7, Expanding X-Plane on page **114**.

IX. Uninstalling X-Plane

The X-Plane installer does not infest a hard drive or create multiple subdirectories or shortcuts on your machine. Therefore, it is remarkably simple to uninstall the program—simply delete the

[29] http://www.x-plane.com/beta.html

[30] http://www.x-plane.com/xworld.html

primary X-Plane folder, such as "X-Plane 9," where the 9 indicates the version that was in use. As the software creates no shortcuts or registry entries, this is all that is required to remove the software from a computer completely.

X. Getting Help and Support

X-Plane is subject to continuous development and improvement; therefore, the version supplied on a purchased DVD may already have been superseded by a later version. Check for updates after X-Plane is installed by following the steps described in Section VII, Updating to a Newer Version of X-Plane, found above on page **27**. The bug fixes contained in these updates often make further tech support unnecessary.

Appendix D: FAQ and Troubleshooting of this manual can help with many common problems. Additionally, help is available through X-Plane customer support. Current contact information for versions of X-Plane *purchased from the website* can be found on the Contact Info[31] page of the X-Plane.com site. For copies of X-Plane that were purchased on a store shelf somewhere, or through an on-line store like Amazon, users should contact Graphsim Entertainment (X-Plane's retail distributor) directly at their website[32].

[31] http://x-plane.com/contact.html
[32] http://www.graphsim.com/support.html

3. Initial Flight Setup

I. General Access

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. 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 help 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 (see Chapter 4, Section IV on page **63**) to anything desired. 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 a user navigate quickly through the options after he or she becomes more 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.

Before using X-Plane, the user may need to configure and calibrate the joystick (if applicable) and set the display options to optimize the software for use with the system.

II. Joystick Configuration and Calibration

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

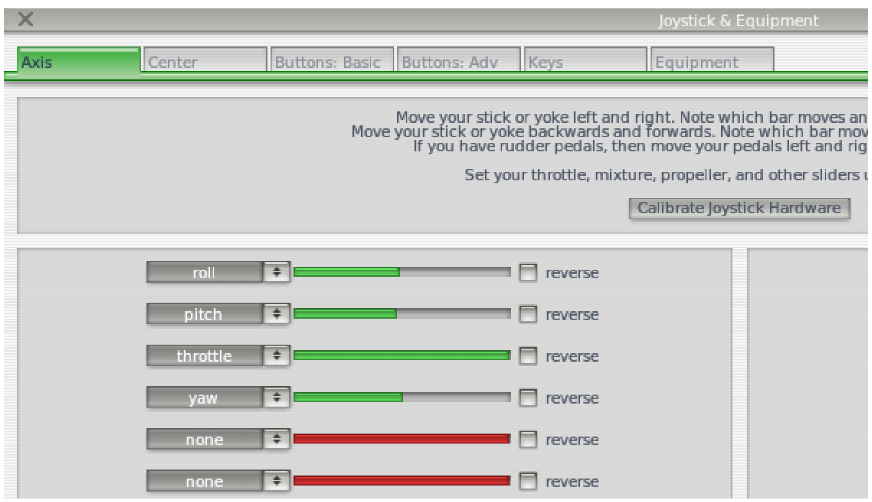
The first thing that must be done to use a joystick (or other input device) with X-Plane is to properly configure it within the program. Throughout this section we will refer to any input device as a joystick; the instructions apply to yokes, throttle quadrants, and rudders also.

A. Axis Assignment

Once X-Plane is running, move the mouse to the top of the screen and click Settings, then select Joystick & Equipment, as in the following screenshot.

This will bring up the window allowing the user 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. 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.

The normal configuration is as follows:

1. 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.

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 it for you. Once again, do not check the **reverse** box unless, when flying, the aircraft's yaw control is working backward.

If 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.

B. Control Calibration

Control calibration is a step of vital importance that often gets left out. It is, however, necessary due to the vast array of hardware that X-Plane can interface with. Some devices 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 the joystick's input is for the user to "teach" it.

All it takes 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. All of this can be done quite rapidly, as X-Plane can monitor all the different inputs at once.

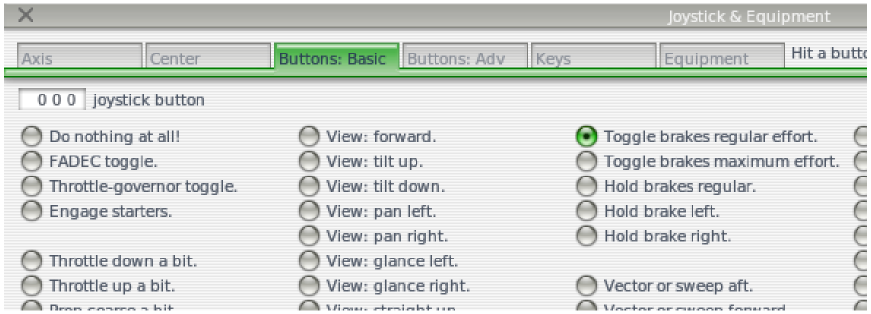
C. Button Assignment

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 (outdated versions of X-Plane have only a Buttons tab). 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 it. Repeat this operation for as many buttons as need functions assigned. Close the Joystick & Equipment window and the settings will be saved.

For instance, in the following screenshot, a button was pressed on the joystick—it happened to be button 000. The round button next to **Toggle brakes regular effort** was clicked, thus setting button 000 to toggle the brakes.

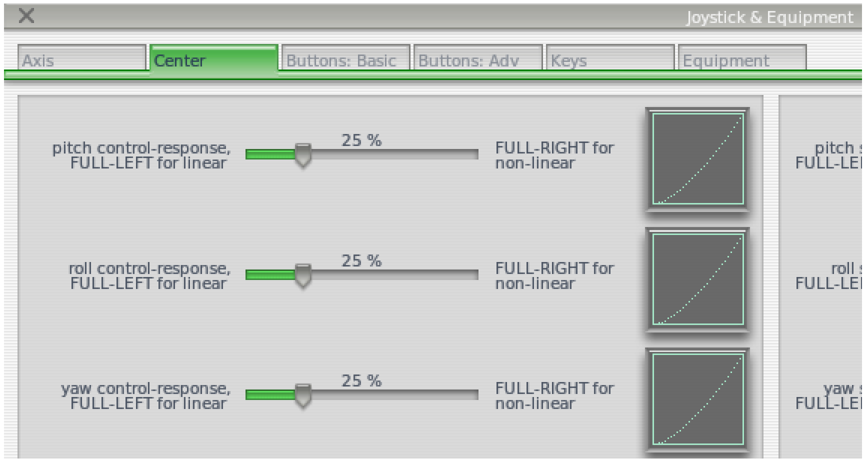


Note: Users must select the desired button by pressing and releasing it *prior* to assigning it a function. If this is not done, the assignment of the last button pressed will be overwritten.

D. Controlling Joystick Sensitivity and Aircraft Stability

i. Sensitivity

To modify the joystick's sensitivity or the stability of the aircraft, open the Center tab at the top of the Joystick & Equipment screen. The top-left sliders (seen below) control the response curves for the pitch, roll, and yaw axes of the joystick.

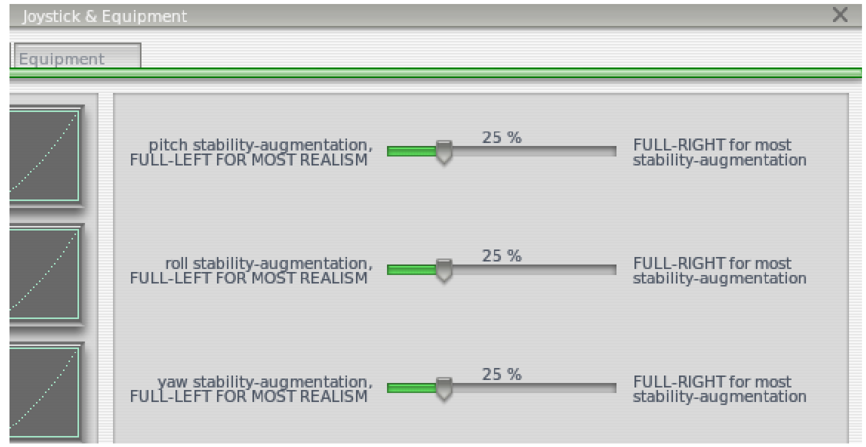


If these sliders are set all the way to the left, the aircraft's response to that axis' input will be completely linear. This means that a 50% deflection of the joystick will deflect the airplane's flight controls 50% of their travel. As these sliders are moved to the right the response becomes curved. 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.

ii. Stability

In the upper right portion of the Center tab's screen is another set of sliders, seen in the following image.

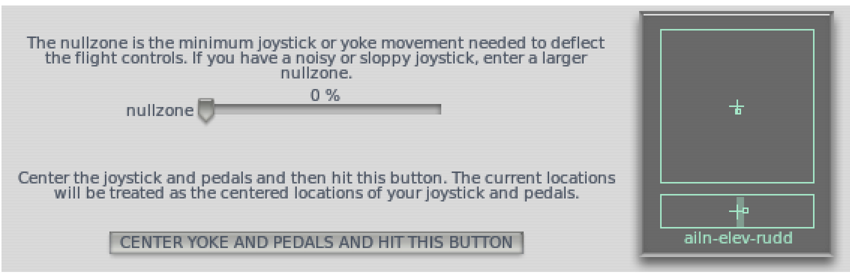


These control X-Plane's stability augmentation mode by dampening the predicted forces acting on the aircraft flight control surfaces. If these sliders are all the way to the *left*, then there is no stability augmentation of the aircraft. As the sliders are moved to the right, X-Plane will automatically 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).

E. 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 Center tab of the Joystick & Equipment window. Now drag the **nullzone** slider (on the lower half of the window, seen in the following image) to the desired position; the greater the percentage, the higher the “dead range” that will not affect the airplane’s controls.



Close the dialog and these axis positions will be saved.

F. Centering the Controls

Directly beneath the **nullzone** slider (seen in the image above) is the **CENTER YOKE AND PEDALS** button. Using this button will allow the user 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 the user lets go of it. Without centering such a joystick, the craft would constantly roll to the right.

G. Adding Special Equipment

The final tab in the Joystick & Equipment window, Equipment, is used to setup 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.

H. Troubleshooting Flight Controls

If the joystick and other flight controls appear to be configured correctly according to the above sections 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.

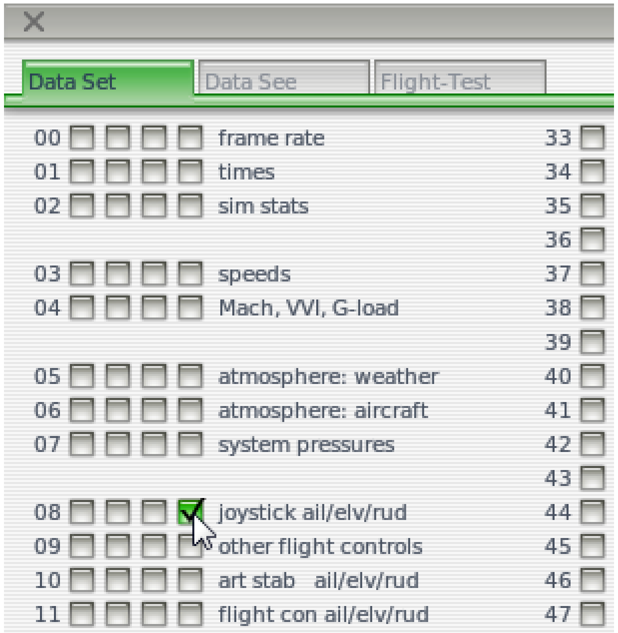
In the following example we’ll assume that the plane’s pitch, yaw, and roll are not matching the way the joystick is being moved. A similar procedure may be used for other malfunctioning controls.

1. Move your mouse to the top of the screen and open the Settings menu.

2. Click Data Input & Output, as seen below.

3. Select the rightmost box next to **joystick 1 ail/elv/rud** (found in the fourth group from the top in the far left column, as

seen in the following screenshot). 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) being received from the joystick.

For instance, in the following screenshot, the stick is being pulled back and to the left with a neutral yaw axis (thus deflecting both the **elev** and **ailrn** inputs from zero, but leaving the **ruddr** at about zero).

6. Now, center the stick and pedals. Each axis should indicate 0.0000, or close to it.

7. Move the stick full left. The **ailrn** should indicate -1.0000 or near -1.0000.

8. Move the stick full right. The **ailrn** should indicate 1.0000 or near 1.0000.

9. Move the stick full aft. The **elev** should indicate 1.0000 or near 1.0000.

10. Move the stick full forward. The **elev** should indicate -1.0000 or near -1.0000.

11. Move the rudder full left. The **ruddr** should indicate -1.0000 or near -1.0000.

12. Move the rudder full right. The **ruddr** should indicate 1.0000 or near 1.0000.

By moving the stick and pedals and seeing what values they are sending X-Plane, the user can see if X-Plane is getting proper stick input.

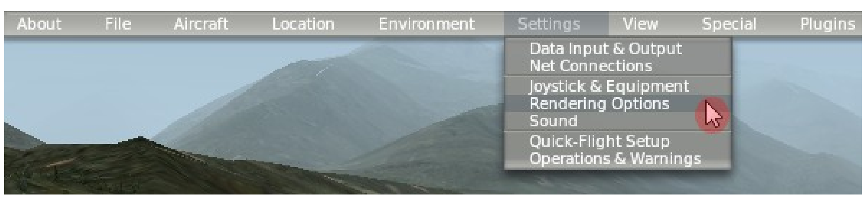
If the correct values (according to the tests above) are not being received in X-Plane, then the issue is with the hardware's calibration in Windows (not X-Plane). If it is indeed calibrated correctly in Windows, the hardware itself is malfunctioning. On the other hand, if the correct values from the above tests are being received, then the hardware is working fine.

III. Rendering Options Setup

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 provides the user with the option to make changes to numerous settings to optimize performance with a particular system set up. For this reason, this is one of the most critical portions of this manual. The Rendering Options window allows users to match X-Plane's settings (and thus the demands the simulator puts on the computer) to their computers' capabilities.

The Rendering Options screen is where all the settings affecting the display quality and X-Plane's performance are set. The settings in this window will likely need to be experimented with to get the best results from X-Plane on a specific computer. Generally speaking, the higher the rendering options are set, the lower the performance and frame rate achieved. The rendering options that are set will have a greater effect on X-Plane's performance than any other changes that users can make.

The Rendering Options screen can be found by moving the mouse to the top of the screen, opening the Settings menu, and clicking Rendering Options, as in the following screenshot.



A. Frame Rate and the Quality of Flight Simulation

Here is why frame rate is so important to the realism of X-Plane's simulation.

The simulator's performance is measured in frames per second (FPS). This number is referred to as frame rate. This is how many times per second the complete set of programming (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—first, the computer's capabilities and second, 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 thirty mile visibility with 8,000 three-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.

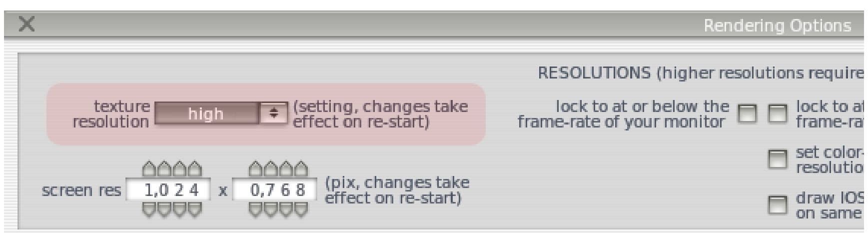
The faster a computer can run X-Plane the more realistic and rewarding the simulation will be. Testing has shown that the human brain can separate individual frames at frame rates of less than about 20 FPS, causing the simulation to appear "choppy." Coincidentally, this is also about the same place that 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.

B. Setting Up the Monitor

The following options (Texture Resolution, Screen Res, Anti-Alias Level, etc.) are all found on the Rendering Options Screen, accessed by moving the mouse to the top of the screen (thus making the menu appear), clicking Settings, then Rendering Options, as seen below.

i. Texture Resolution

The Texture Resolution drop-down box (highlighted in the image below) 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 rather 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 very badly reduced, though, if a texture resolution is selected that requires more VRAM than the computer's video card has.

Users can easily determine how much VRAM is required to render the given level of detail—the very bottom of the Rendering Options screen reads "Total size of all loaded textures at current settings: xx.xx meg." For instance, in the image below, X-Plane has loaded 75.44 MB of textures into VRAM.

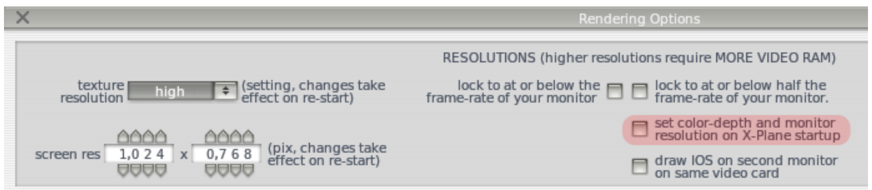
In most cases, this number will only be updated *after* X-Plane is restarted—that is, users cannot change the texture resolution, close the Rendering Options window, and reopen it to check the amount of VRAM used.

If the system has a 128 MB video card and the VRAM currently used is only 32 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 sim's frame rate will be *massively* impacted as the computer begins to use system RAM to store textures—a very slow process.

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.

ii. Set Color Depth and Monitor Resolution on X-Plane Startup

If the **set color depth and monitor resolution on X-Plane startup** box (highlighted in the screenshot below) is checked, X-Plane will automatically reset the computer's monitor to the resolution that X-Plane is set to every time the program loads.



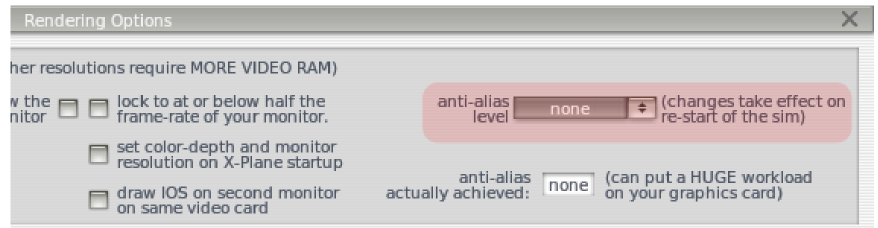
This forces the sim to always run full-screen. Note that this does *not* set X-Plane to the current resolution in Windows; to do that, read down to Part iv, Screen Res (Resolution).

If this box is checked, the user will also get to choose a color depth of 16-bit or 32-bit. 32-bit looks a little better. If this box is not checked, then X-Plane will run in whatever the color depth is set to in the operating system, which is probably 32-bit (or "millions of colors" as described on Macs).

Note: If the system's monitor does not have a 4:3 aspect ratio, everything on the screen will be distorted if X-Plane is forced to run in full screen (by checking the **set color depth and monitor resolution on X-Plane startup** button) with a screen resolution of 1024x768. This is caused by X-Plane trying to stretch a 4:3 image into a 16:9 or 16:10 space. For a detailed discussion on these aspect ratios, please see Chapter 2, Section III, Display Requirements and System Architecture on page **19**.

iii. Anti-Alias Level

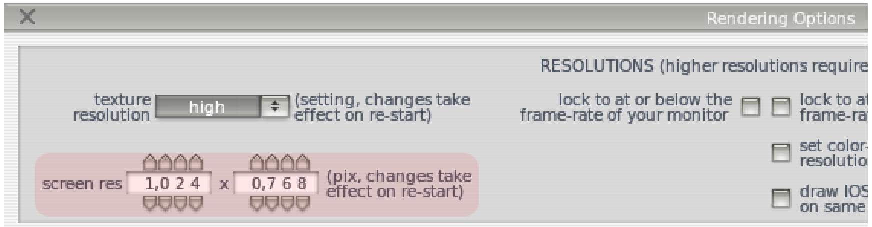
The anti-alias option (highlighted in the following image) is pretty interesting.



There are only about a million pixels on a computer's monitor. This may seem like a lot, but in reality, it's not for what X-Plane is doing. When a computer tries to draw diagonal lines across the rectangular pixels of a monitor, "jaggies" result—pixelated-looking "stair-stepped" lines. These jaggies may be (somewhat) eliminated by selecting 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. This will completely kill the sim'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.

iv. Screen Res (Resolution)

This control (highlighted in the image below) sets the screen resolution of the X-Plane window.



To change the resolution, click the up or down arrow next to each digit of the setting. For example, to change the resolution from 1024 x 768 in the image above to, say, 1280 x 768, one would click twice on the arrow *above* the zero in 1024, six times on the arrow *above* the two in 1024, and four times on the arrow *below* the four in 1024.

The default and recommended resolution setting is 1024 x 768 pixels. Other screen resolutions can be used, but the simulation's frame rate will deteriorate a little as the screen area increases.

a. Making X-Plane Full Screen

The **screen res** control can also be used to cause X-Plane to fill the entire screen. If the X-Plane window does not fill the screen, determine what screen resolution the computer is running at and enter that resolution here. This can also be done the other way around, by setting the resolution of the computer to match the resolution in X-Plane. Changes to this setting will take effect after X-Plane is restarted.

Windows XP users can determine their current resolution (and change it) by doing the following:

1. Right click on the Desktop and click Properties.
2. In the window that opens, click the Settings tab.
3. Drag the Screen Resolution slider to the desired resolution.

In Vista:

1. Right click on the Desktop and choose Personalize.
2. Click Display Settings.
3. Drag the resolution slider to the desired resolution.

In Windows 7:

1. Right click on the Desktop and click Screen Resolution.
2. Click on the Resolution drop-down box and drag the slider to the desired resolution.

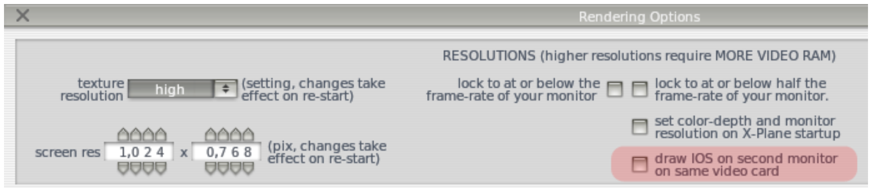
Mac users can do the same by doing the following:

1. Open the System Preferences from either the dock or the Apple menu.
2. Open the Displays menu and click on the Display tab.
3. Select the desired resolution under "Resolutions."

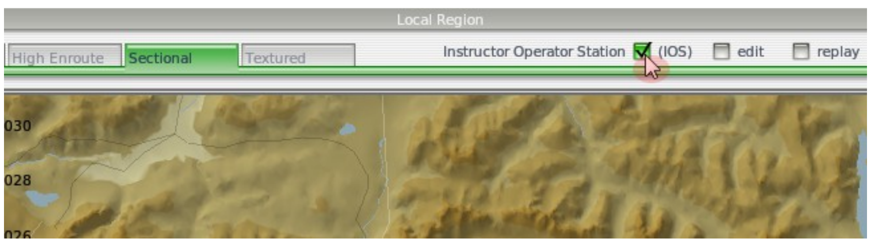
Changing X-Plane's resolution to match the resolution of a *widescreen* monitor will cause most 2-D cockpits to have blank bars on their left and right, through which scenery outside the plane will be visible. Common widescreen resolutions are 1920 x 1080, 1440 x 900, 1360 x 768, 1280 x 720, etc. For more information on this problem, see Chapter 2, Section III, Display Requirements and System Architecture on page **19**.

v. Draw IOS on Second Monitor on Same Video Card

An Instructor's Operating Station (IOS) may be run from the same computer as the sim when using a dual output video card. To enable this, check the box next to **draw IOS on second monitor**, highlighted below.



The video card must first be configured to output to both screens in the operating system. Checking this box will cause a second X-Plane window to open on the second screen. In this window, move the mouse to the top of the screen and click Location, then Local Map. There, check the IOS box, as shown in the following image.

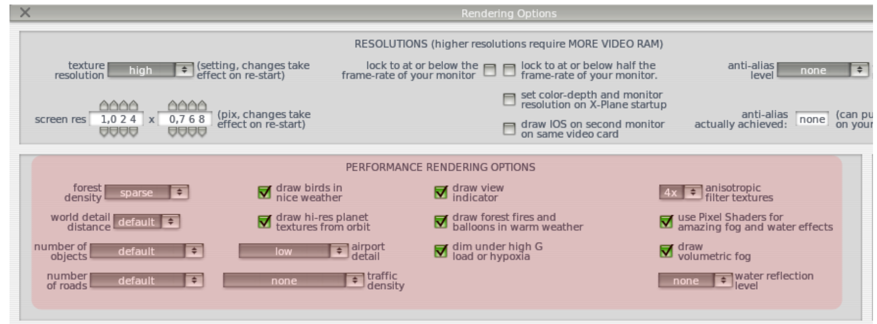


On the left will appear the options to load different aircraft, relocate the aircraft, fail systems, and alter the weather for the "student" pilot. Note that this IOS functionality is available not only on a second screen on the same computer, but also from a second computer networked to the student computer via a LAN or the Internet. This option has no effect on frame rate.

For more information on running an IOS, see Chapter 5, Section IV, Part B, Subsection vi on page 80.

C. Setting Up the X-Plane World

Each of the controls in this part of the chapter (Setting Up the X-Plane World) is found in the PERFORMANCE RENDERING OPTIONS section of the Rendering Options window, highlighted in the following image.



i. Forest Density

This control determines how dense the forest and shrubbery are in X-Plane. Keep in mind that drawing more and more dense forestry will have a moderate effect on the simulator's ability to maintain frame rate.

ii. World Detail Distance

This will set the level of detail for objects in the world scenery, and from how far away this detail will be visible. Changes to this setting will take effect after X-Plane is restarted and have a large effect on frame rate. Be careful with this one.

iii. Number of Objects

This will determine how many three-dimensional objects (e.g., buildings) are drawn in the world scenery. This will have a *very strong* effect on the simulator's performance—flying over New York City with 8,000 little 3D buildings is much more difficult for X-Plane to draw than flying over rural Iowa with only 20. Changes to this setting will take effect after X-Plane is restarted.

iv. Number of Roads

This will set the number and complexity of roads and rivers being displayed in X-Plane. Changes to this setting will take effect after X-Plane is restarted and have a moderate to large effect on frame rate.

v. Airport Detail

This drop-down menu modifies the level of detail rendered at airports, adding windsocks, beacon lights, and texture and markers to runways. It has a minimal effect on frame rate.

vi. Traffic Density

This control modifies the amount of air traffic, as well as the amount of the associated ATC communications heard over the radio. It has a minimal effect on frame rate.

vii. Anisotropic Filter Textures

Anisotropic filtering is a somewhat complicated concept.

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 degrees 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 degrees. 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.

viii. Draw Birds in Nice Weather

This is a relatively new feature in X-Plane that arose from a near-miss between Austin (the author of X-Plane) and a small flock of birds. He was departing from Columbia, South Carolina one day in his Cirrus. As he was climbing out, a flock of birds flew in front of his aircraft and Austin thought he was about to incur multiple collisions. As it turned out, the birds did not collide with him, but it was enough to open his eyes to realize that this potential hazard needed to be modeled in X-Plane.

Each bird in X-Plane is modeled independently and has its own “mission.” For this reason, the flocks of birds look very realistic. Colliding with the birds will cause damage to the aircraft as well as engine failures and other things, just like in reality. This control has a marginal effect on frame rate.

ix. Draw Hi-Res Planet Textures from Orbit

X-Plane can simulate orbital and sub-orbital flight using the Space

Shuttle and other spacecraft. If selected, this option 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.

x. Draw Forest Fires and Balloons in Warm Weather

When checked, this option will draw randomly generated forest fires for practicing water bombing. X-Plane can realistically simulate such operations, requiring the user to fly a water bomber such as the CL-415 (found in the Seaplanes folder) and scoop up water from the ocean or a nearby lake. This option has a negligible effect on frame rate.

xi. Draw View Indicator

This is a handy feature that will draw a little orange triangle in the top center of the screen when looking any direction other than forwards. It rotates about a depiction of the aircraft and points in the direction that the screen is viewing. This is helpful in maintaining situational awareness. This option has a negligible effect on frame rate.

xii. Dim Under High G Load or Hypoxia

When this box is checked, X-Plane will simulate the effects of gravity, creating G-force blackouts under tight maneuvers or hypoxia from high altitude flying. These effects are true to life, causing the screen to either "black out" or "red out," just as a pilot would experience a loss of vision under extreme high or low G situations. Additionally, a black out will occur when flying at too high an altitude without first setting the pressurization or oxygen system, just like in real life. This option has a negligible effect on frame rate.

xiii. Use Pixel Shaders for Amazing Fog and Water Effects

Using pixel shaders allows X-Plane to add 3D lighting on a per-pixel basis. 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. Depending on the graphics card, this can have a large effect on frame rate.

a. Draw Volumetric Fog

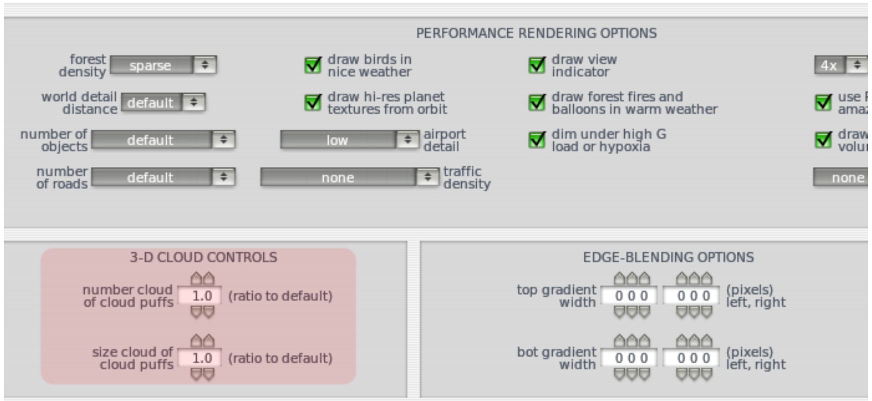
This option only appears when using pixel shaders. Normally, fog is applied to the entire scene with the same density. Using volumetric fog creates a number of small, localized fog effects, causing the density to vary. This can have a significant effect on frame rate.

b. Water Reflection Level

This option also appears only when using pixel shaders. Changing the reflection level of the water also changes how many calculations the computer must do on each pixel in the water. Its effect on frame rate varies based on the amount of water in the scene.

D. Setting up Clouds

The following two settings are found in the 3-D CLOUD CONTROLS section (highlighted in the following image) of the Rendering options window.



X-Plane's 3D 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. Experiment with the following settings to obtain a balance between performance and visual appeal.

i. Number of Cloud Puffs

This option sets the number of cloud puffs, as a ratio to the default value of 1.00. Increasing the number of puffs will have a massive impact on frame rate. Be careful with this one.

ii. Size Cloud of Cloud Puffs

This option sets the size of each cloud puff, as a ratio to the default value of 1.00. The larger the size of cloud puffs, the slower X-Plane will perform, although this may not be too noticeable on modern video cards.

E. Expert Rendering Options

The following three controls are found in the EXPERT RENDERING OPTIONS section (highlighted in the following image) of the Rendering options screen.

i. Compress Textures to Save VRAM

Checking this 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 may cause some of the crispness and precision to be lost from textures. Try it out and see what happens.

ii. Do Any Scenery Loads in the Background

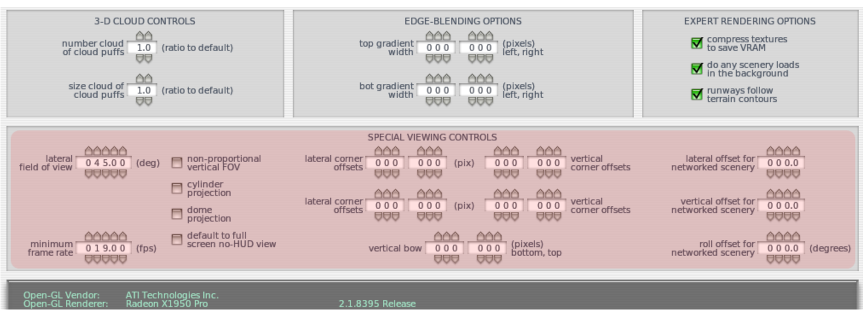
This causes X-Plane to try to load as much scenery as possible without pausing. This is where a dual- or quad-core processor really shines.

iii. Runways Follow Terrain Contours

X-Plane includes a feature whereby runways and taxiways can follow the elevations 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.

F. Special Viewing Controls

The following controls are found in the SPECIAL VIEWING CONTROLS section (shown in the screenshot below) of the Rendering Options window.



i. Lateral Field of View

The field of view setting 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 degrees, which generally gives good performance and a natural view.

ii. Minimum Frame Rate

As discussed at the beginning of Part A of this section (found on page **38**), the frame rate is the number of unique pictures ("frames") that the simulator displays per second. The term comes from the motion picture industry, where each frame was a separate picture taken by a movie camera. In X-Plane, as frame rate increases, so does the accuracy of the flight model and its visual appeal. This control will set a minimum frame rate that X-Plane will attempt to maintain. If the system has too many rendering options set too high, X-Plane will automatically reduce the visibility in an attempt to maintain the frame rate specified here.

The frame rate should not go below 20 frames per second (fps) because the flight model needs at least 20 fps to do a decent job simulating most airplanes. On smaller, lighter planes, though, which have less inertia and more speed and maneuverability, X-Plane will need *more* than 20 fps to fly accurately. This is due to these planes' ability to flicker around the sky so quickly. A high frame rate is needed to accurately track the plane's rapid accelerations.

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.

iii. Multi-Computer Simulators

The following options in the Special Viewing Controls are used for multi-monitor or multi-computer simulators. A setup like this allows X-Plane to run different views on different monitors (for example, a left, center, and right view on three different monitors, or an instrument panel on one screen and the forward view on a second screen). Note that in a multi-computer setup, each computer requires its own copy of X-Plane.

To set up a multi-computer simulator, the various computers 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 Data Input & Output. On this screen go to the Inet 1 or Inet 2 tab and enter the various IP addresses of the different machines in the appropriate location.

See Chapter 8, Sections V and VI (beginning on page **132**) for more information on multi-computer setups, and call customer service if you have difficulty and would like some assistance.

Under normal, single computer configurations, these options can all be left at their default values

a. Lateral, Vertical, and Roll Offsets

Let's say that you have three networked computers for additional visuals to form a wrap-around cockpit. Each computer might have a 40 degree FOV. You should enter a lateral offset of -40 degrees for the left visual, 0 for the front visual, and +40 degrees for the right visual. If each visual has a field of view of 40 degrees, these images will blend together seamlessly if you don't consider the width of the frame around the 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 won't be able to see the part theoretically under the border) then you might try a field of view of maybe 38 degrees, based on whatever fraction of the monitor is visible.

Vertical and roll offsets are the up/down and tilt equivalents of the lateral offset.

Please note that lateral, vertical, and roll offsets are *only* available in degrees; ratio values are no longer supported.

Note: While the view offsets do indicate how much to the left or right or up or down each view is looking, people still 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. It is like taking the wheels off the left side of one's car and then thinking the problem is solved by holding the steering wheel to the right to drive straight. It is *not* the correct response to the problem. In this case, users should go to the viewpoint screen in Plane-Maker and set the cockpit viewpoint center to 384 pixels (that is, half of the 768 pixel height of the screen) so that the viewpoint center in the cockpit window is the same as the viewpoint center in the side-view screens. 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. If a user has to enter a vertical offset for one of two monitors that sit beside each other, s/he is doing something wrong! The problem *should* be solved by making sure that the viewpoint *center* is at the same pixel height on all the computer monitors that are side-by-side, and that height is always 384 pixels (halfway up a 768 pixel screen) for the external visuals.

iv. Lock View to Forward Cockpit

When views are changed within X-Plane, that changed view propagates to all the external visuals. Checking this box causes a view to *always* be forward-with-cockpit.

G. Setting up X-Plane to Achieve the Best Results

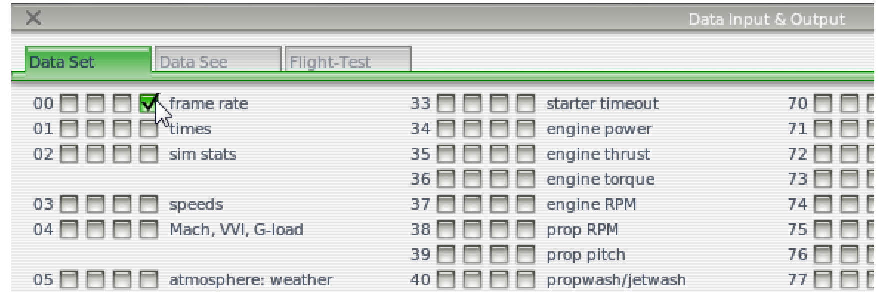
The following procedure will allow the user to optimize X-Plane's performance for his or her computer, regardless of the power of that computer or any limitations it may have.

i. Displaying the Frame Rate

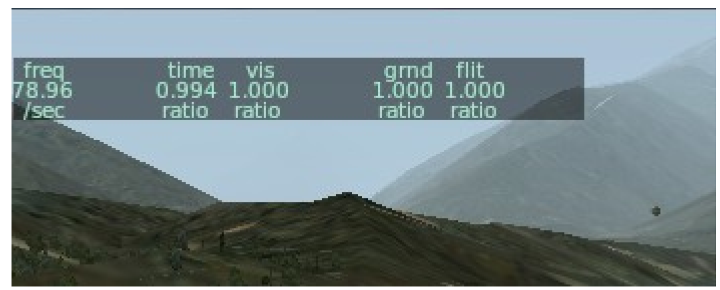
Before we begin, we will need to be able to tell how fast X-Plane is running on the computer. To do this, launch X-Plane and:

1. Move your mouse to the top of the screen (causing the menu to appear) and click Settings, then Data Input & Output, as in the following image.

2. Check the far right box next to **frame rate** (as seen in the following screenshot). 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 in the box in the upper left of the screen (as seen below). 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, 35 fps when rendering lots of buildings, other aircraft, etc.

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

- 15 fps is terrible and barely adequate to run the simulator.
- 30 to 50 fps is the ideal range. Higher frame rates indicate the computer isn't rendering with as much detail as it

could. Studies have shown that starting at about 50 frames per second, users' subconscious minds forget that they are looking at a simulator and begin thinking they are actually flying.

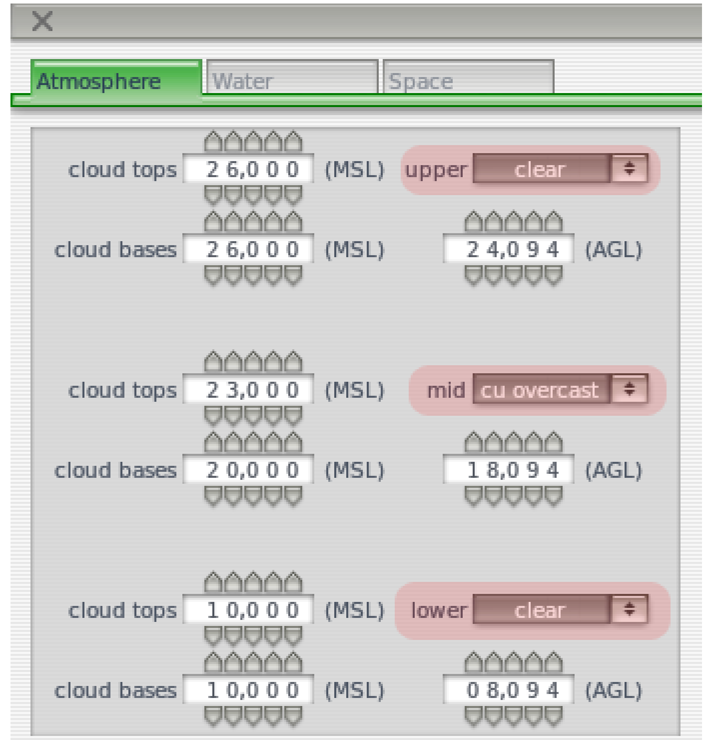
- 100 fps is excessively high and indicates that the system has plenty of capacity to draw more buildings, clouds, and other objects.

ii. Modifying Visibility and Cloud Rendering

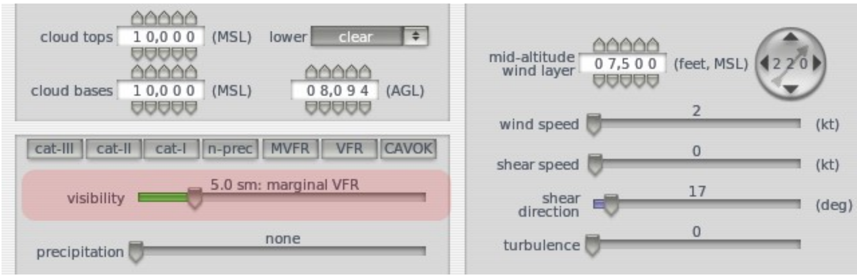
If the simulator's frame rate isn't as high you would like, you can raise it by doing the following:

1. Bring down the menu as above and click Environment, then Weather, as seen below.

2. Using the **upper**, **mid**, and **lower** drop-down menus (found in the upper left of the screen, highlighted in the following image), set the cloud types to **clear** or **cu overcast** for max frame rate. For a good frame rate, set them to **hi cirrus** or **lo stratus**. **Cu scattered** or **cu broken** take a ton of computing power to display.



3. Set the visibility (found on the left side, near the middle of the screen) to about five miles or so, as seen in the following image. Higher visibility takes more computing power because the computer has to calculate what the world looks like for a much larger area.

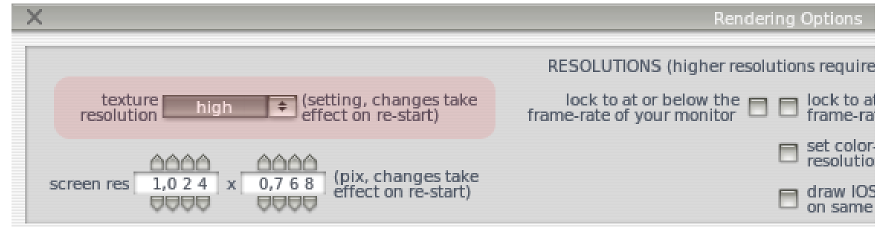


With that done, close that screen and check the frame rate again. To improve it even more, continue on to modifying the texture resolution.

iii. Changing Texture Resolution for Best Performance

1. Make the menu bar appear as in the above processes and click Settings, then click Rendering Options, as seen below.

2. The **texture resolution** drop-down menu (highlighted in the following screenshot) 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: xx.xx meg." For instance, in the following image, the textures loaded are using 75.44 MB of VRAM.

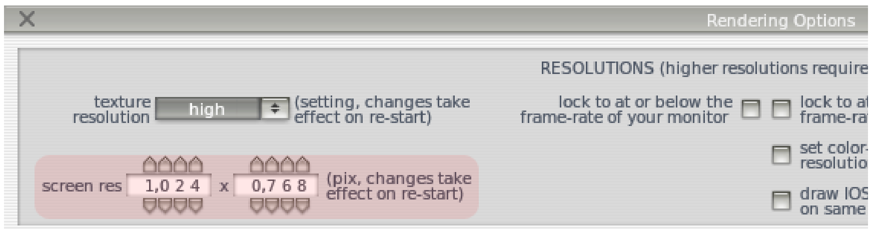
While it is possible in some cases to load more textures than can be stored in VRAM without a performance hit (as not all textures will be used all the time), the size of the loaded textures should not be significantly greater than the VRAM on the system's video card.

4. Lower the **texture resolution** if the current settings require much more VRAM than your video card has.

Note: 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.

iv. Setting Screen Resolution for Best Performance

Next, look at the **screen res** (resolution) setting on the Rendering Options screen, shown in the following image.



Higher resolutions use up some extra VRAM, but not much. The screen resolution is the size of the image that X-Plane is drawing, in pixel width by pixel height. A user might have a large, wide monitor, but that does not mean that drawing a large, wide screen *must* be more difficult for X-Plane. A relatively low number of pixels can be drawn on that screen by setting the resolution in the operating system accordingly.

For instance, on a monitor that tops out at a resolution of 1920 x 1080, one might set its resolution in the operating system to 1360 x 768. This way, X-Plane will be less demanding of the graphics card while still filling the entire screen.

Windows XP users can change their resolution by doing the following:

1. Right click on the Desktop and click Properties.

2. In the window that opens, click the Settings tab.

3. Drag the Screen Resolution slider to the desired resolution.

In Vista:

1. Right click on the Desktop and choose Personalize.

2. Click Display Settings.

3. Drag the resolution slider to the desired resolution.

In Windows 7:

1. Right click on the Desktop and click Screen Resolution.

2. Click on the Resolution drop-down box and drag the slider to the desired resolution.

Mac users can do the same by doing the following:

1. Open the System Preferences from either the dock or the Apple menu.

2. Open Displays menu and click on the Display tab.

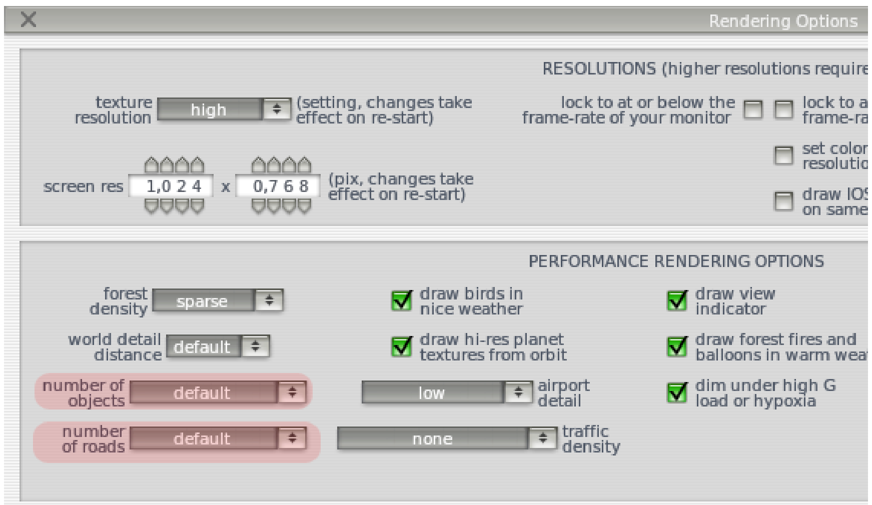
3. Select the desired resolution under “Resolutions.”

Note that drawing a large screen with few pixels will look 'grainier' than drawing a smaller screen with more pixels—assuming that the monitor is viewed from the same distance in each case. Drawing more detail (with a higher screen resolution) uses up some of the video card’s processing power, but not too much. In most cases the biggest bottleneck when using a higher resolution is the processor, as it must calculate the view for a larger, more detailed area.

Play with the screen resolution a bit and set the resolution as you see fit. Many computers will run best at 1024 x 768. Remember that X-Plane will have to be shut down and restarted for the changes to take effect.

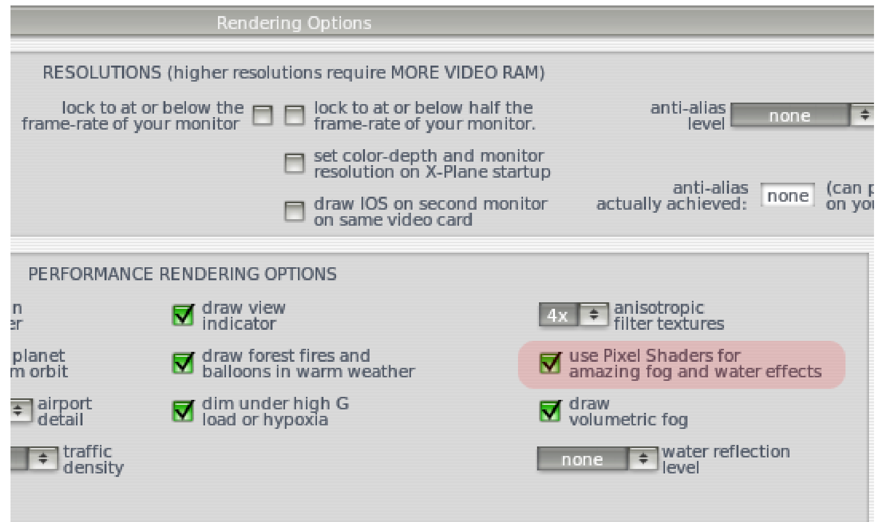
v. Optimizing Other Rendering Options

These are the really critical options—the all-important **number of objects** and **number of roads** settings, highlighted in the image below.

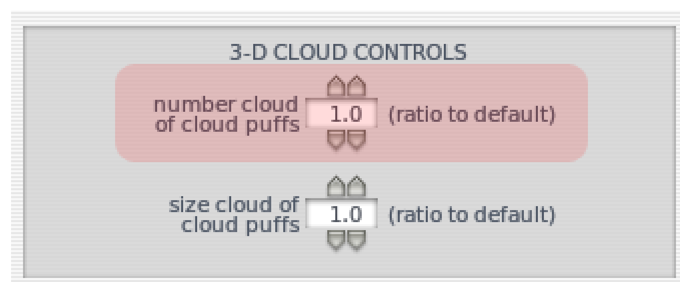


These have a *huge* impact on frame-rate. Set them to **none** for the most speed, then restart X-Plane for the changes to take effect. Check the frame rate, bring both settings up one level, and repeat, restarting the sim each time to see how performance is affected. Setting these options to higher levels will look much nicer but will negatively impact the X-Plane's frame rate.

The many different boxes in the PERFORMANCE RENDERING OPTIONS section of this window were reviewed in detail in Part III, Section C, Setting Up the X-Plane World (beginning on page 42). Most of these do not impact the frame rate much, with the exception of **use Pixel Shaders for amazing fog and water effects** (highlighted in the following image). Therefore, set these up as desired, but make sure **use Pixel Shaders** is *unchecked* for greatest speed.

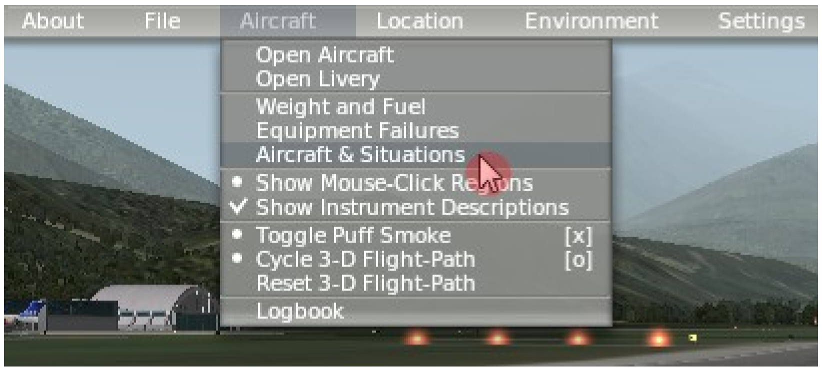


In the 3-D CLOUD CONTROLS section of the window, the **number of cloud puffs** control (highlighted in the following image) has a *huge* impact on frame rate when there are scattered, broken, or overcast clouds, but those settings should already have been avoided when trying to optimize frame rate.

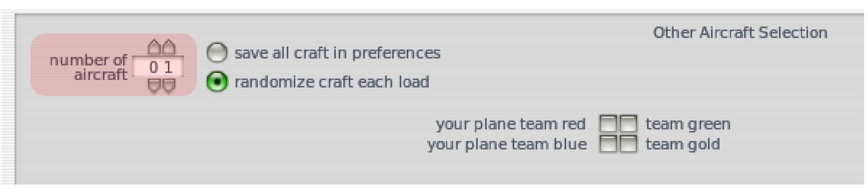


vi. Changing the Number of Other Aircraft

The final setting that really impacts the simulators 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, as seen below.



The **number of aircraft** setting (found on the left of the screen, about halfway down, highlighted in the following image) should be set to one (yours) for maximum speed.



Setting this number higher will cause X-Plane to use artificial intelligence (AI) to fly any specified number of other aircraft in the sky. Note that there is no logic to determine what type of aircraft to place or where (for example, a hot air balloon may be seen flying around New York City).

With the system's frame rate optimized, it's time to fly!

4. Flight

I. Opening an Aircraft

When launching X-Plane for the first time, the default airplane will be loaded—in Version 9 this is the Cirrus Jet. After that, X-Plane will load the aircraft that was being used when the program last closed.

It's a good idea to take your first flights in something simple, like the Cessna 172 SP. To open this aircraft:

1. Move your mouse to the top of the X-Plane window to cause the menu to appear.

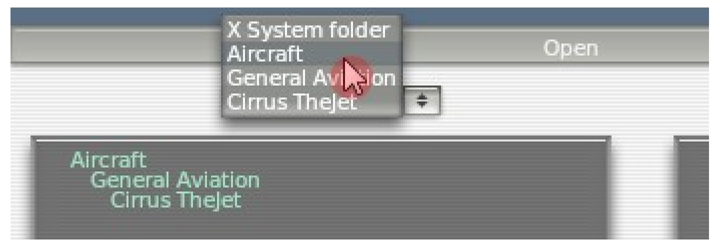
2. Click Aircraft, then Open Aircraft, as in the screenshot below.

3. At the top of the window now open is a drop-down menu. It is currently displaying the name of the folder that the current aircraft is located in. Click the up/down symbol on the right side of the folder name, as seen in the following image.

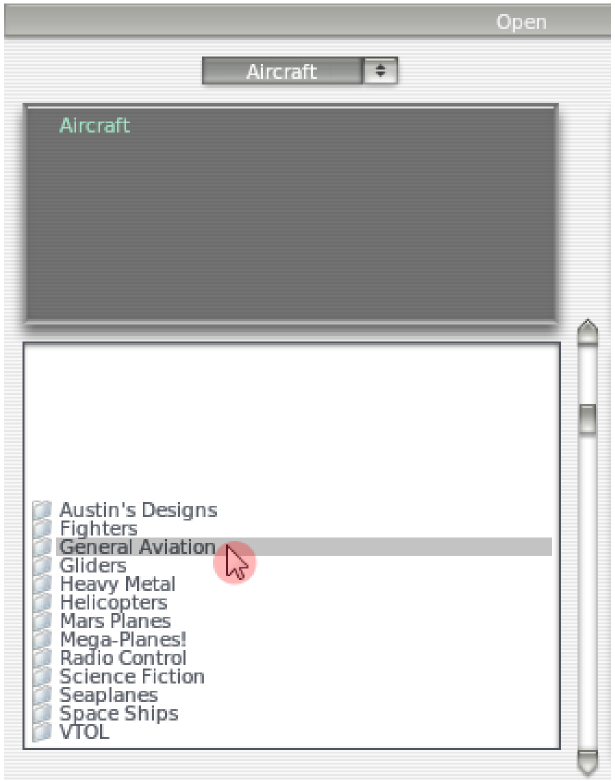
4. Now a list of the folder hierarchy (the organization of the folders) opens from the drop-down menu. It starts with the main X-Plane folder and goes down to the folder that the current aircraft is in. For example, if the Cirrus Jet is open at the moment, the hierarchy shows:

- X-System folder
- Aircraft
- General Aviation
- Cirrus Thejet

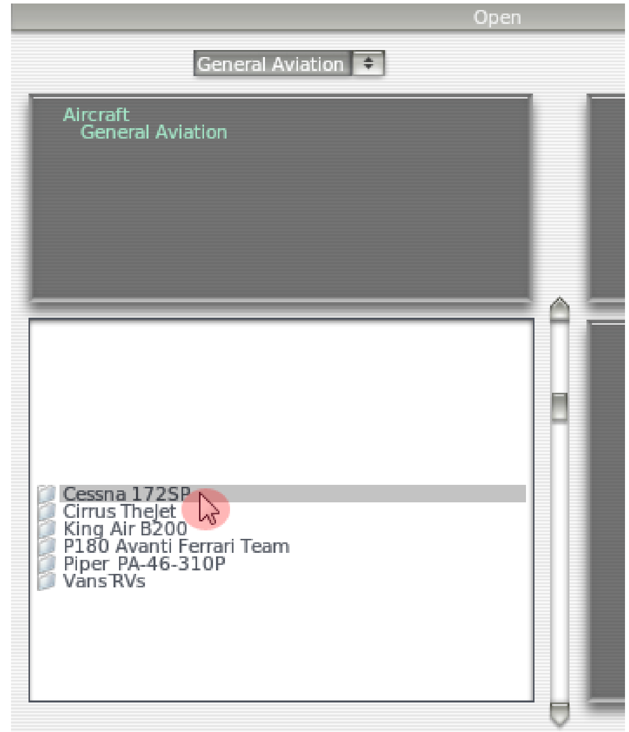
Click on the line that says Aircraft, as in the following image.



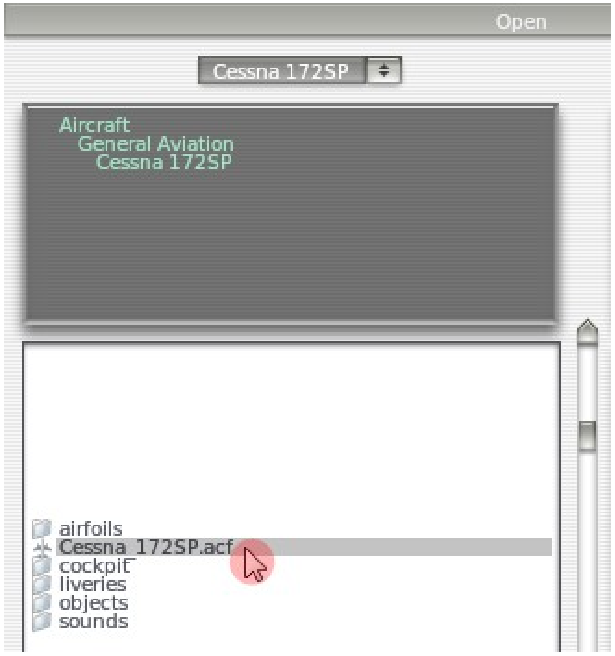
5. The Aircraft folder opens. The folders here divide X-Plane's aircraft into classes—for example, there are fighters, general aviation craft, gliders, helicopters, seaplanes, etc. Double click on General Aviation (shown in the following screenshot).



6. Now the navigation box in the lower left of the window shows the different aircraft classified as general aviation planes. Double click on the Cessna 172SP folder, as per the following image.



7. X-Plane aircraft files—which are what we need to click on to open an airplane—are denoted by an ".acf" extension. Double click on the Cessna_172.acf file (as seen in the following screenshot) to load the aircraft.



In a few moments the screen will go black. Shortly thereafter the cockpit of a new Cessna 172 Skyhawk will appear.

II. Choosing an Airport

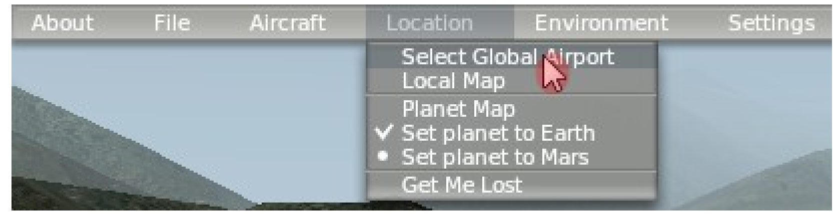
X-Plane's aircraft can be relocated to anywhere on Earth using the Select Global Airport window. This provides a listing of all the airports in the X-Plane database (currently more than 32,000), representing nearly every airport on the planet.

Note: If the aircraft is relocated to an area that *does not* have any scenery installed, it will 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 L: Water Everywhere!.

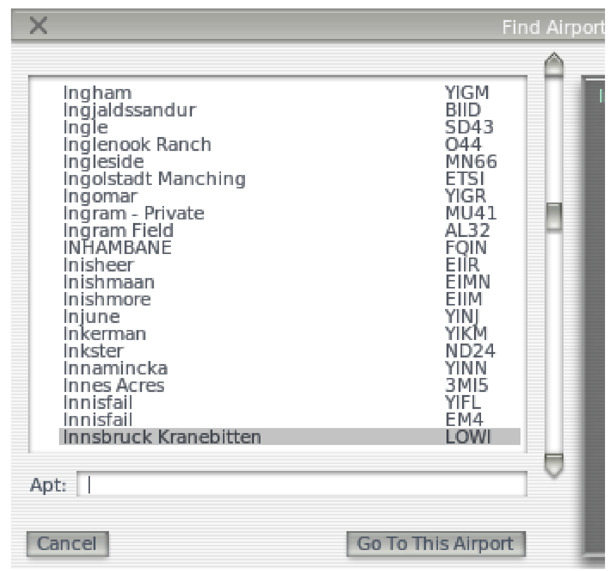
To open the Select Global Airport screen:

1. Move the mouse to the top of the screen, causing the menu to appear.

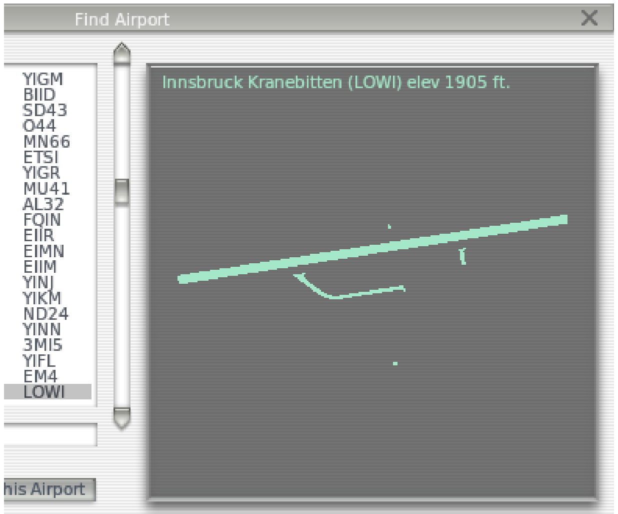
2. Click Location, then click Select Global Airport, as in the screenshot below.



This screen is divided into three parts. In the top left (shown in the following image) is a listing of every airport name, arranged by city. Both this format and these names are the official standard for that local area (which, for US airports, is the FAA).



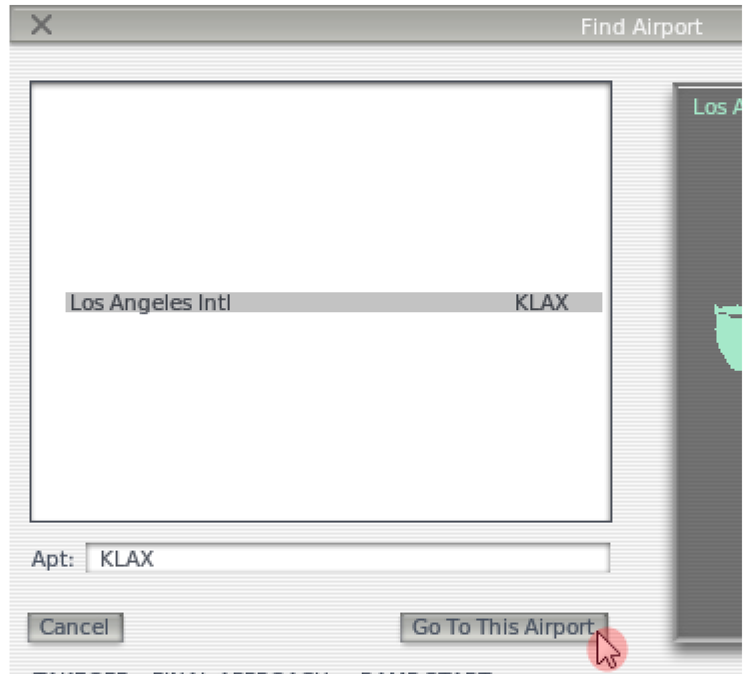
To the right of the list pane (shown in the screenshot below) is an overhead view of the currently selected airport's layout.



The bottom half of the window (shown in the following image) 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 to the right of it. Finally, the RAMP START button will transport the aircraft to the specified ramp for takeoff.

To search the available airports, type either the city name or the airport ID into the white box below the list pane (labeled "Apt:"). For instance, in the image below, the user typed in "KLAX" to find Los Angeles International Airport. The same results could be obtained by typing "Los Angeles Intl," or by simply typing "Los Angeles" and scrolling 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, as seen in the previous image.

A. Airport IDs Explained

Every airport on Earth has a unique identifier used to refer to the field in flight plans, instrument approach plates, and GPS navigators. In the United States, the airport identifiers are comprised of three characters, which can be letters only or a combination of letters and numbers. This sounds easy, but wait…

VORs, a type of navigation radio, also use the same identification system and, in some cases, the very same identifier. A VOR located on a field, for example, will have the same identifier as the field itself. To prevent confusion, the letter K is added before the identifier of the airport in the US *if that identifier contains only letters*. All VOR identifiers are letters only, so any airport identifier that has any numbers in the ID stays as is.

Here are some examples:

- 3CK stays as 3CK since it has a number in it.
- OJC (Johnson County Executive Airport) becomes KOJC for the airport because its identifier is letters only.
- The VOR on the field at Johnson County is also called just OJC with no "K" to denote that it's a VOR.
- AMW becomes KAMW for the airport. There is no VOR on this field so there is no other identifier for this airport.

For an interesting read on the history of the airport code naming conventions, check out Skygod's page[33].

III. Setting Weather

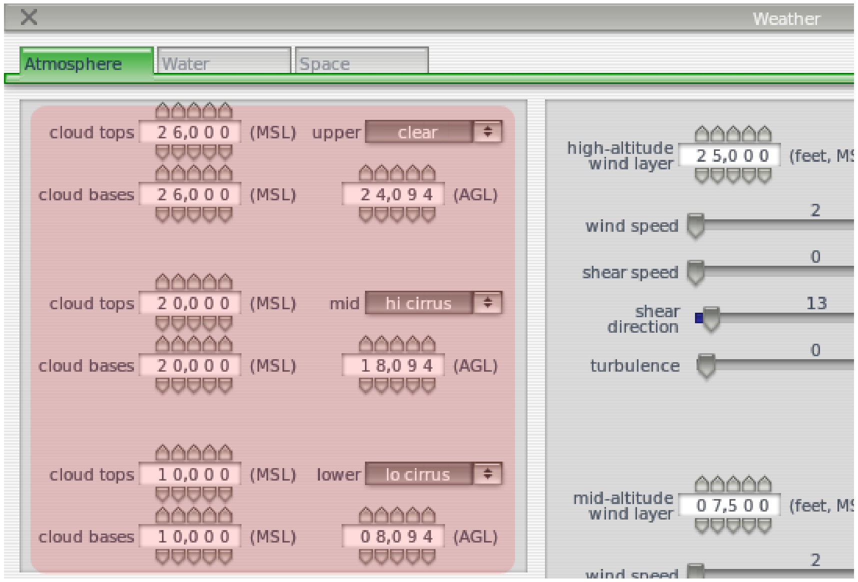
X-Plane's weather simulation is highly configurable and remarkably realistic. To edit the weather settings, cause the menu to appear by moving the mouse to the top of the screen. Click Environment, then click Weather (as shown below).

Click the leftmost tab in this window (Atmosphere) to begin editing the weather.

A. Basic Cloud Configuration

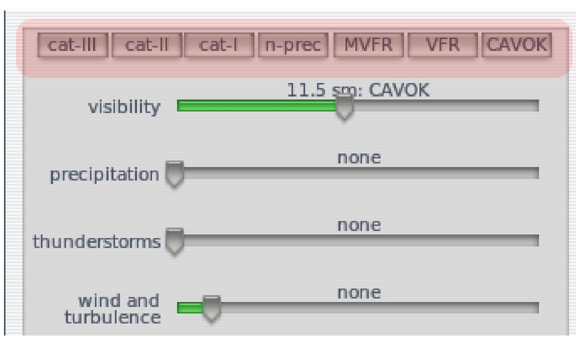
In the upper left of the Atmosphere window (shown in the following screenshot), cloud types as well as the top and base levels for three different cloud layers can be set. The boxes designated MSL (found on the left side of this section of the window) are measured in feet above average sea level. The boxes designated AGL are measured in feet above average ground level.

[33] http://www.skygod.com/asstd/abc.html



B. Quick-Set Buttons

The pane below the basic cloud configuration has a number of buttons, labeled **cat-III**, **cat-II**, **cat-I**, **n-prec**, and so on (seen in the following image). 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.

C. Weather Sliders

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 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 pretty cool 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 **wind and 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.

The turbulence in X-Plane is simulated very realistically. To see how incredible the turbulence in X-Plane is, drag the **wind and turbulence** slider up to the right and then close the Weather window (with either the Xs in the top or the Enter key). Now select an external view like Chase (by default bound to the ‘A’ key). Next, hit the ‘/’ key twice to see the wind vectors, then use the ‘+’ and ‘–’ keys to zoom in and out. For instance, in the following image, a Cessna 172 is getting tossed around the Austrian skies.

The green lines visible in the image above are the actual wind vectors acting on the airplane. Each of those vectors represents a wind speed and direction in the flow field around the pane, and that flow field will interact with each of the elements of each of the wings (and propellers!) of the plane. Additionally, the little green lines sprouting out of the bottom surface of the wings in the image above show the lift vector for each segment of the wing (in the example, these vectors are pushing the plane *down*).

Of course, when the aircraft is flying the lift vectors will be very prominent but even with the airplane just sitting stationary at the end of the runway, the wing can indeed be producing some measurable lift. The air may be blowing *up* on part of the left wing and *down* on part of the right wing, causing the craft to roll to the right. Or it might be pushing up on the wings and down on the tail, causing the craft to pitch up. Or, as it does in real life all the time, the air might be doing a combination of those at multiple points on the aircraft.

With the visual vectors turned on it becomes apparent just how much math is going on in the background within X-Plane. The flow field is continuous, variable, and covers the entire aircraft for any scenario that can be simulated, and all the different parts of each airfoil surface see different relative directions and speeds.

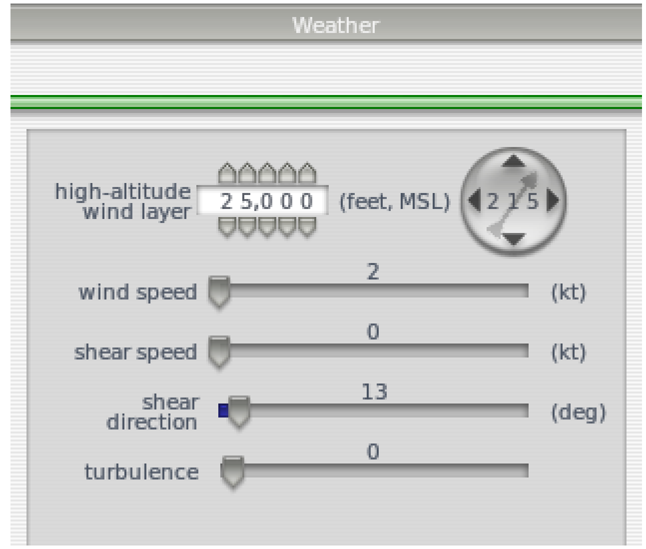
The bottom slider in the basic weather settings is the **rate of change**, which modifies how quickly the weather conditions are changing.

D. Temperature and Pressure

In the bottom left corner of the Weather window, the temperature and barometric pressure (air pressure) can be set, as seen in the following image. Both conditions will take effect at the nearest airport. Keep in mind that the "standard atmosphere" is 59˚F (15˚C) and 29.92 inches mercury (1013 millibars).

E. Wind Layers

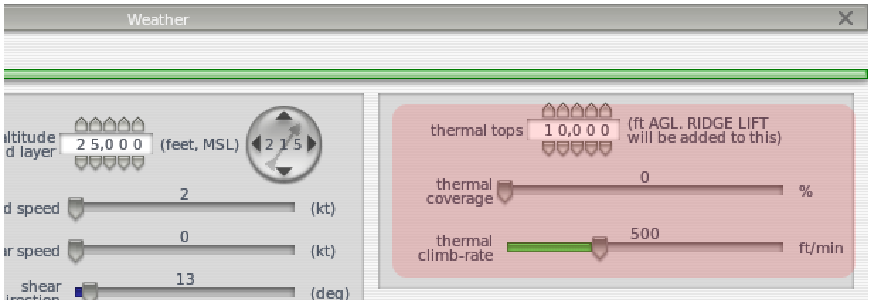
The middle column of this window controls three wind layers; the high altitude layer is shown in the following image.



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).

F. Thermals

Enter the **thermal tops**, **thermal coverage**, and **thermal climb rate** in the upper-right of this window, shown in the following screenshot.



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!

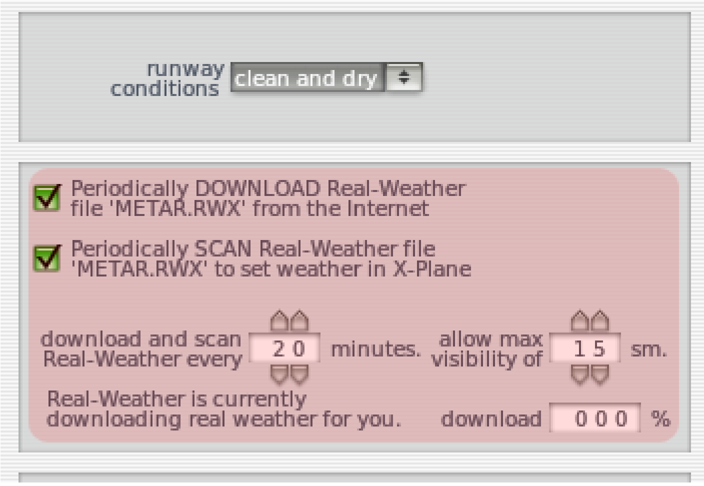
G. Runway Conditions

The **runway conditions** drop-down box is found on the right side of the Weather screen, directly beneath the thermals controls, as shown in the following image.

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.

H. Using Real Weather

Below the runway conditions controls is the Real Weather section. When the **Periodically download Real-Weather** box (seen in the following image) is checked, X-Plane will download actual weather conditions from the Internet (which are current within an hour) and apply that weather in the simulator. X-Plane will scan the thousands of airports that report weather and apply the weather from the nearest reporting airport to the simulation.



Of course, Internet access is required to use this option, but once the weather is downloaded (and automatically saved as a file called Metar.rwx) the same conditions can be used again (though they may be out of date) until X-Plane downloads an updated file. It is still nice to have the file, though, because it includes a global snapshot of the weather across the planet, giving weather that varies as the aircraft travels.

Just below the **Download Real-Weather** box is a check box labeled **Periodically scan Real-Weather**. This needs to be enabled for X-Plane to update the weather in the sim with the data from the Metar.rwx file. In other words, if the real weather is downloaded once per hour, but the user flies out of the area the craft started in *without* scanning the weather file, the weather experienced at the new airport may be different than what the real weather download contained.

Here's an example to clarify: A pilot is about to take off from Ames, Iowa (KAMW), and she downloads the real weather. This weather (clear sky and 15 mile visibility) is loaded onto her machine and she takes off. It takes 40 minutes to get to the Johnson County Executive Airport in Kansas City (KOJC), and as she approaches the area, she notes that X-Plane is still showing clear sky and 15 miles of visibility. She knows, however, from watching the news that Kansas City is actually experiencing low IFR conditions, with thunderstorms and significant turbulence. This indicates that X-Plane did not change the weather as she flew because she did not have the **Periodically scan Real-Weather** box checked.

Finally, when using the real weather downloads, the **allow max visibility of** control allows the user to (artificially) limit the visibility in order to keep the simulator's frame rate at a desired level; for example, if a user knows from experience that a visibility over 10 miles causes the sim to slow to an unacceptable frame rate (say, 20 frames per second), he or she might allow a max visibility of 8 miles to be on the safe side.

IV. Using the Keyboard/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. X-Plane.org has created a guide to the default key assignments in X-Plane 9 that can be found here[34].

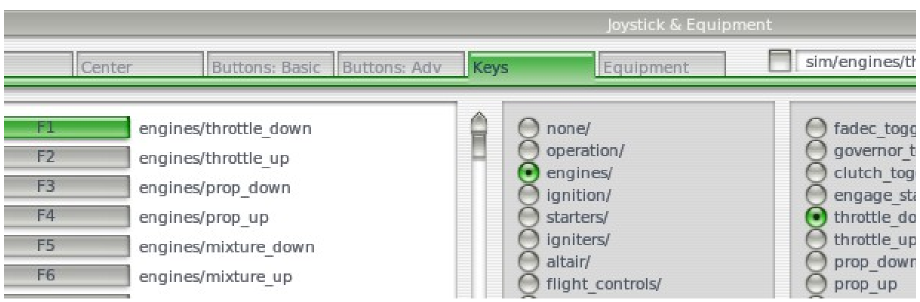
To see which keys are tied to which functions, simply go to the Joystick & Equipment screen's Keys tab and look at the keys assigned to the various functions. Find this screen by moving the mouse to the top of the screen (bringing down the menu), clicking Settings, then clicking Joystick & Equipment, as seen in the following screenshot.

[34] http://forums.x-plane.org/index.php?autocom=ibwiki&cmd=article&id=41

In the window that opens, click the Keys tab at the top.

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 its key should control.

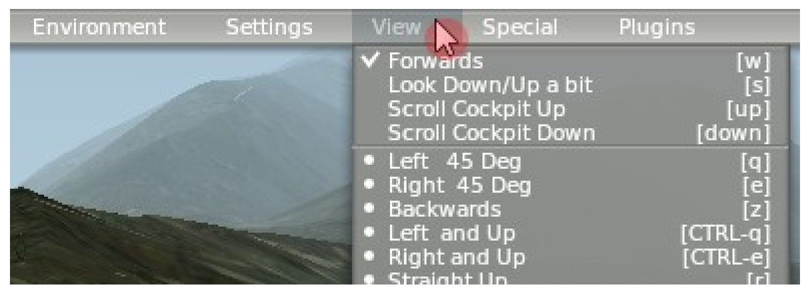
Functions are classified into a number of categories (operation, engines, ignition, etc.), found in the middle pane of this window. The functions themselves are found in the right pane of the window. Click on the radio button (that is, the small, circular button) beside the category you're looking for, then click the radio button next to the function itself. For instance, in the following screenshot, the F1 key has been assigned to the **throttle down** function, found in the engines category.



Alternatively, click the **Add New Key Assignment** button found in the bottom center of the window (shown in the following image).

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: 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 screenshot below, the forward view has a "[w]" next to it, so it can be selected with the 'w' key.



V. Using the Mouse Instead of a Joystick

As alluded to in previous chapters, it is possible to fly with only a mouse for a flight control, though this is both cumbersome and unrealistic (since real airplanes all have either a stick or yoke).

When flying with the mouse, keyboard shortcuts (found in the preceding section) become essential for controlling the engine(s), flaps, gears, radio frequencies, and views. Control of the plane via the mouse is available from most viewpoints.

Any time that the **roll** and **pitch** axes have not been assigned by the user in the Joystick & Equipment screen (see Chapter 3, Section II on page **32**), X-Plane assumes that the mouse is the control device. In this case, a small white plus sign will show up on the screen, typically located near the center of it. Note that this may be difficult to see at times, as parts of the aircraft may blend in with it when using an external view.

If only the cross is visible and there is 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 down 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.

Again, it is not necessary to hold down the mouse button down, only to move the mouse within the confines of the white box. The little cross signifies the center of the control range over which the control surfaces are deflected. 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.

Here is a summary of control with the mouse:

- Grab and let go of the stick by clicking the mouse button on or near the white plus sign. This will turn on and turn off the white box.
- Move the mouse right and left, up and down within the confines of the box to move the flight controls. For example, moving the mouse to the right edge of the box means that you are moving the aircraft control stick all the way to the right and the ailerons will be fully deflected at that point, causing the aircraft to bank right at its maximum rate.
- Let go of the stick (by clicking again within the white box) before you take the mouse down to the panel to change a control on the panel or else the flight controls will be deflected fully, causing the plane to gyrate out of control.

VI. Controlling Instruments and Avionics with the Mouse

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 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, as in following image.

Of course, this control will look different in different aircraft. Keep in mind that the 'g' key could also be used (see Section IV, Keyboard Shortcuts on page **63**) or a joystick button could be assigned to toggle the gear (see Chapter 3, Section II, Part C, Button Assignment on page **34**).

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. For instance, in the following screenshot, the pilot is turning the OBS knob in the Cessna 172.

To easily see the controls within the cockpit that the mouse can operate, enable the **Show Mouse-Click Regions** option found in the Aircraft menu. This will draw a thin yellow square around the areas of the instrument panel that can be manipulated with the mouse.

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. The outside arrows are larger and adjust the integer.

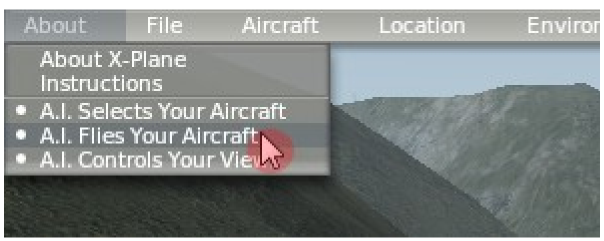
For instance, in the following image, the integer portion of the NAV 1 radio's frequency is being turned up using the outer knob.

Conversely, in the following image, the decimal portion of the NAV 1 radio's frequency is being turned down with the inner knob.

VII. Artificial Intelligence (AI) Demo Flight

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 About, then select **A.I. Flies Your Aircraft**, as seen in the following screenshot.



With the AI controlling the airplane, the user is 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.

VIII. Flying Yourself

When first flying (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 Section I of this chapter (found on page **54**).

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 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 back elevator by pulling back on the yoke or stick) at about 60 knots in the Cessna 172. Once the aircraft leaves the ground, feed in a bit of forward stick to momentarily level off and allow the airplane to build speed. Once the craft reaches 80 knots or so, again pull back gently on the stick and resume climbing. Building airspeed before climbing this way will help to keep the plane from stalling.

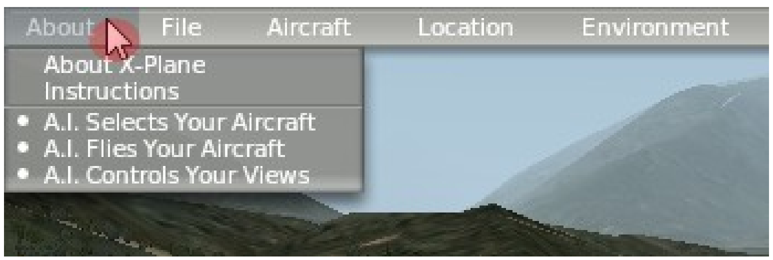
Note that if a crash occurs that damages the airplane too badly, X-Plane will automatically open a new airplane and place it at end of the nearest runway (which in some cases may be a grass strip). If the impact is only hard enough to damage the airplane without necessarily killing the occupants, the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

5. X-Plane Menus

X-Plane has perhaps the most flexible and powerful interface of any flight simulator. The key to mastering it is learning to poke around the various menus and windows to discover all the things that the user can change. This chapter is a sort of "guided tour" through those options.

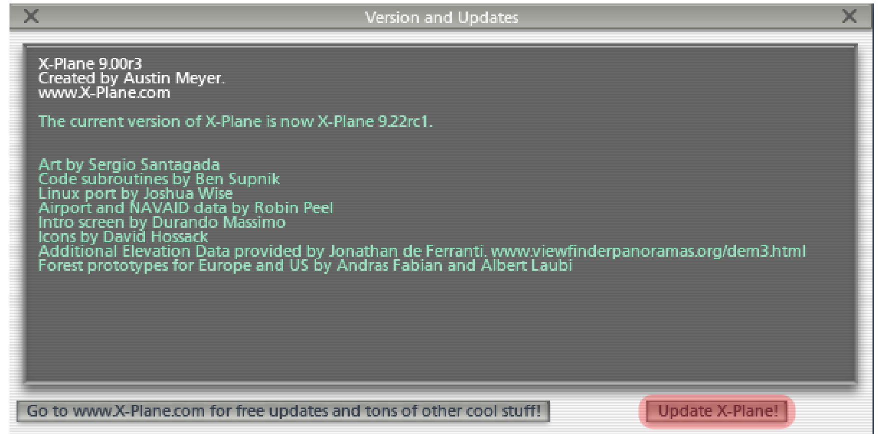
I. The About Menu

The About menu is accessed as in the following screenshot:



A. About X-Plane

Clicking About X-Plane will open the Version and Updates window, seen in the following screenshot.



Here, the text in white gives the version of the software on your computer, and the text in green below this gives the most recent version of X-Plane available. This is important because X-Plane is always being updated, either to fix or improve old features or to add new ones. When things go wrong, it is important to let customer service know which version of X-Plane they're working with.

The button in the bottom left of the window will open X-Plane.com, where more information on the latest updates can be found, and the button in the bottom right, **Update X-Plane** (highlighted in the previous image), will download and launch the latest updater.

In order to keep X-Plane up to date, open this window from time to time to see what the latest version is and to upgrade as desired.

See Chapter 2, Section VII (found on page **27**) for more information on updating X-Plane.

B. Instructions

The Instructions window provides basic in-sim instructions for (listed in the order of the tabs across the top of the window):

- Using flight controls
- Controlling objects in the cockpit
- Using keyboard shortcuts
- Working with the simulated air traffic control
- Getting technical support

C. A.I. Selects Your Aircraft

Clicking this control will cause X-Plane to load a new aircraft at its "discretion"—that is, randomly. Note that even with this enabled, the user can still change aircraft manually. Additionally, the choice of craft isn't especially "intelligent"—the AI will sometimes load a glider and stick it on the nearest runway.

D. A.I. Flies Your Aircraft

This control is covered in depth in Chapter 4, Section VII, Artificial Intelligence (AI) Demo Flight (found on page 67). Note that even with this enabled, user input will override AI control of the craft.

E. A.I. Controls Your Views

Selecting this control will cause X-Plane to periodically switch views, making for a much more interesting demo flight when AI is also flying. Note that even with this enabled, the user can still change views manually.

II. The File Menu

The File menu appears as shown in the following screenshot.

A. Save/Load Situation

These buttons are used for storing and using situations—snapshots of the current conditions of the atmosphere, aircraft, etc. A situation stores the aircraft's position in the air (or on the ground), its payload, the amount of fuel in the tanks, everything. This is especially useful for quickly loading and practicing a specific type of approach. These situations can even be sent to other X-Plane users by giving them the .sit file that is created.

The Situations folder is found in the Output folder, which itself is located in the X-Plane directory (by default found on the Desktop). For example, the default path in Windows would be:

C:\Documents and Settings\[User Name]\Desktop\X-Plane 9\Output\situations

To transfer situation files from one computer to another, copy the .sit files located in this folder to the Situations folder of the other computer.

B. Save/Load Replay

When the Save Replay control is selected, X-Plane saves a "movie" of the current flight from the time that the aircraft and scenery were loaded up to the point at which the Save button was clicked. This "movie" is actually just a large collection of data on the flight which X-Plane saves as a situation movie file (.smo).

These .smo files can be saved, emailed, shared, or reloaded later to evaluate or share a flight. In Windows, they are stored by default in the folder:

C:\Documents and Settings\User Name\Desktop\X-Plane 9\Output\movies

Because the .smo file records so much information about the flight, the user is able to change views, look at instruments, stop and rewind, etc. while viewing the recorded movie. The raw data for the flight is what is recorded, so the viewing options are unlimited.

To save a replay movie:

1. Select Save Replay from the File menu. A dialog window will appear.

2. Type a name for the movie.

3. Select the location to which you would like to save the movie (by default this is the folder X-Plane 9\Output\movies).

4. Hit the Enter key on the keyboard to complete the process.

To load a replay movie:

1. Select Load Replay from the File menu. A dialog window will appear.

2. Browse for and open the folder that contains the movies you have previously saved by using the drop down menu at the top of the window. (By default, X-Plane will have saved your situation files to the folder X-Plane 9\Output\movies.)

3. To open the replay, double click on the movie file that you would like to load.

C. Quicktime Movie Specs

This window allows the user to modify the frame rate and resolution of a QuickTime movie created with X-Plane. Information on creating a QuickTime video can be found in the following section.

A QuickTime movie is not the same as a situation replay movie. A replay movie stores all the raw data that defines the flight, only to be used in X-Plane, whereas a QuickTime movie simply stores what is seen on the screen during flight. These movies may be viewed by anyone with QuickTime, whether they are running X-Plane or not.

QuickTime is an Apple video format that is now supported by almost every operating system, including Microsoft Windows. Windows users, however, may need to install a suitable QuickTime package in order to use these features! See the Quicktime Download page[35] for more information.

D. Toggle Movie

The Toggle Movie control begins recording a QuickTime movie. When it is pressed once, red text will appear in the bottom left corner of the screen that reads "QuickTime Movie Recording…".

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[35] http://www.apple.com/quicktime/download/

When it is pressed again, the text will disappear and a file named "X-Plane movie take-*x*.mov" will appear in the X-Plane 9 directory, where *x* is the number of the take.

Toggle Movie can also be used by pressing Ctrl + Space.

E. Load Flight Data Recorder File

X-Plane is sometimes used in accident investigation or re-creation, and in that case people need to be able to take the data from a black box and put it in a format that X-Plane can read. That format is the Flight Data Recorder (or .fdr) format. Unlike the SMO files, which are compressed binary, and the MOV files, which are for showing movies only, the FDR file is text. This means that users can make their own FDR files as easily as possible from whatever data they have and then re-create these flights in X-Plane. Look in the Instructions folder within the X-Plane directory for the file "Example FDR file.fdr." This is a sample FDR file.

So, to summarize the above sections:

The SMO file is for Situation Movies, which anyone can use *within* X-Plane to replay a flight from any view or angle.

The MOV file is a QuickTime Movie, which anyone can view *outside* of X-Plane.

The FDR file is a text file which is made to be easy to create so that anyone can make a file to view a flight in X-Plane.

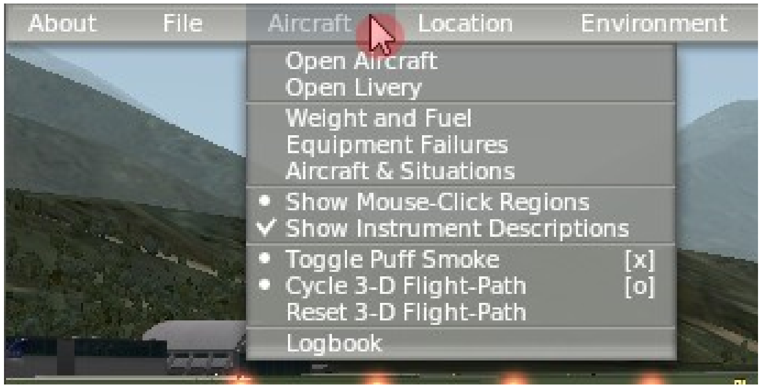
F. Take Screenshot

This creates an image of the entire X-Plane window when selected. To get an image without the menu bar in it, use the keyboard shortcut Ctrl + '.' (that is, the control key and the period key).

Each screenshot is saved in the X-Plane 9 folder as a PNG file named screenshot_*x*.png, where *x* is a sequential number starting at 0. The hard drive's capacity is the only limit to the number of screenshots that can be taken (each screenshot at a resolution of 1024 x 768 is about 0.4 MB).

III. The Aircraft Menu

The Aircraft menu is accessed as in the following image.



A. Open Aircraft

This menu option is covered in depth in Chapter 4, Section I, Opening an Aircraft, found on page **54**.

B. Open Livery

This control is used for selecting user-created paint schemes created for the aircraft.

C. Weight and Fuel

The Weight and Fuel menu option will open the Weight & Balance & Fuel window.

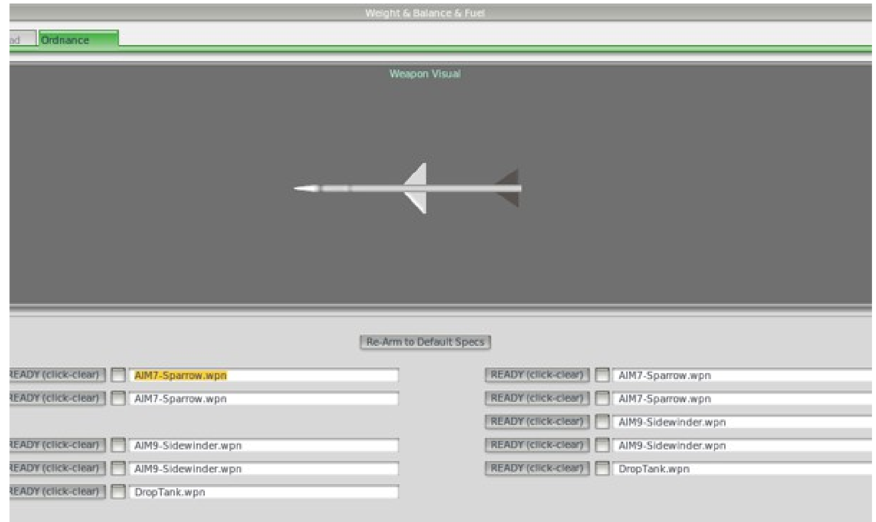
i. The Fuel/Payload Tab

In the first tab of the Weight & Balance & Fuel menu, the aircraft's weight and its distribution can be modified. 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 un-flyable because the plane becomes unstable. 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.

The fuel and payload can also be modified in this screen. 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.

ii. The Ordnance Tab

On aircraft that are equipped with internal or external stores (such as weapons or drop tank hard points), this tab allows various hardware to be equipped on the various hard points of the aircraft. Take an F-4 Phantom from the Fighters folder, for example. The Ordnance tab will show a number of weapons that can be put on a number of hard points, as seen in the following image.

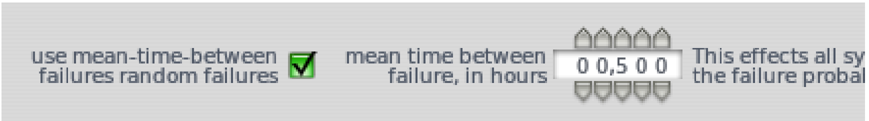


Users can select weapons from the Weapons folder that is found inside the folder containing the aircraft, or from the Weapons folder directly inside the X-Plane 9 folder. The weight and mass distribution on aircraft inertia and moment of inertia, as well as aerodynamic forces of stores are all considered by X-Plane's flight model.

D. Equipment Failures

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

The World/MTBF tab of this window controls things outside of the airplane, such as bird strikes and airport equipment failures. Additionally, at the bottom of this window is the **mean time between failure** setting, as seen in the following screenshot.



When the **use mean-time-between failures** box is checked, the simulator will use the setting to the right to determine how often a 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

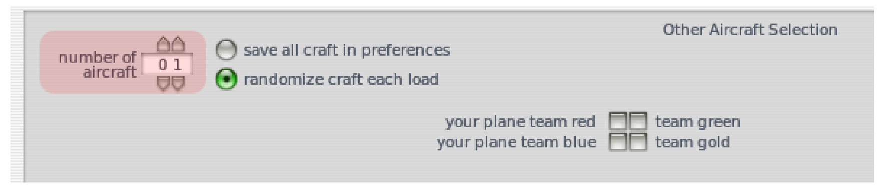
E. Aircraft & Situations

The Aircraft & Situations window, selected from the Aircraft menu, allows the user to configure the aircraft used in special situations and to load other (AI-controlled) aircraft.

The top pane of the window, labeled Situation Presets, controls which aircraft are used in the special situations (see Section II, Part A of this chapter on page **70** for information on loading situations). These situations are found as special buttons on the right side of the Load Situation window.

The center pane of the window, Other Aircraft Profiles, controls the speed, direction, and altitude of refuelers, carriers, and formation aircraft. The large circular controls operate the same way as the wind layer directional controls, described in Chapter 4, Section III, Part E, found on page **61**.

Additionally, the bottom pane of the window is labeled Other Aircraft Selection. The most important control here is **number of aircraft**, highlighted in the image below.



The value set here will determine the number of aircraft that X-Plane will simulate at once. A value of 1 will simulate only the user's own airplane. Higher values will simulate the user's aircraft and a number of other aircraft in the region. Note that simulating more craft in flight requires more processing power from the computer. Also, as in reality, these airplanes will wander hither and yon, maneuvering in a way that makes sense to them.

F. Show Mouse-Click Regions

All X-Plane cockpit panels have clickable buttons, switches, or dials, which can be operated using the mouse (in addition to any keyboard keys or joystick buttons that may be assigned to them). Selecting **Show Mouse-Click Regions** from the Aircraft menu will cause a thin yellow square to appear around those controls in the cockpit which can be manipulated with the mouse.

G. Show Instrument Descriptions

Selecting **Show Instrument Descriptions** from the Aircraft menu will make X-Plane show a description of each instrument's function whenever the mouse hovers motionless for a few moments over the instrument.

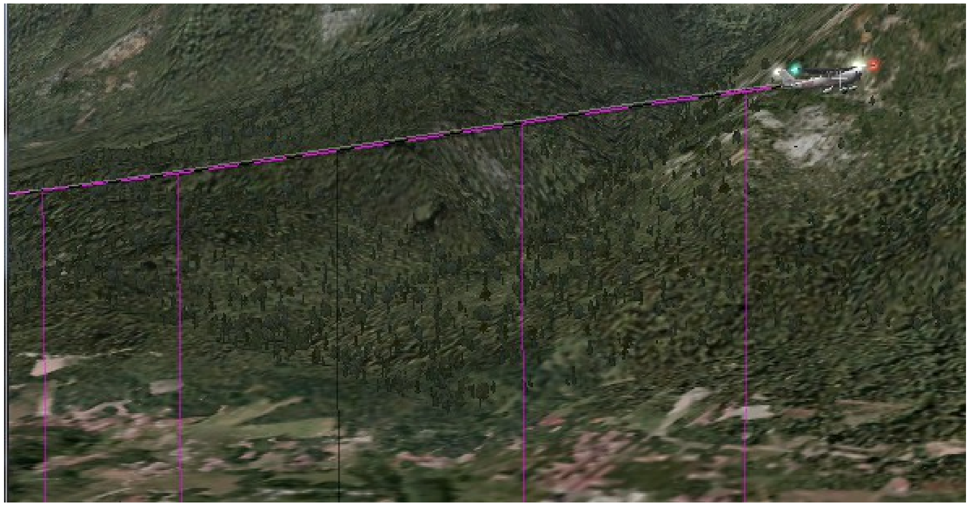
H. Toggle Puff Smoke

Selecting this option (which is also accessible using the 'x' key by default) will cause a smoke/condensation trail to follow the aircraft, even if the craft might not have this in reality.

I. Cycle 3-D Flight Path

This control is also assigned to the 'o' key by default. Clicking it once will cause three lines to "follow" the craft—a black line from the port (left) wingtip of the craft, a white line from the starboard (right) wingtip of the craft, and a pink-and-black line from the center of the craft. These lines will extend all the way back to the runway from which the craft took off, as seen in the following image.

Pressing the **Cycle 3-D Flight Path** button again (or, of course, the 'o' key) will cause vertical pink and black lines extending to the ground to appear along the center line, as seen in the following image. This is useful for looking back on the flight and easily seeing the flight path.



Pressing it a third time will replace the vertical lines with a semi-transparent, vertical, black bar, as seen in the following screenshot.

Pressing the button once more will turn all the flight path lines off.

J. Reset 3-D Flight Path

Pressing the Reset 3-D Flight Path button when the flight path is visible will get rid of the flight path created previously and start fresh from that point. Pressing this button when the flight path is turned off will have no effect—that is, if the flight path is later turned on, it will extend all the way back to the runway.

K. Logbook

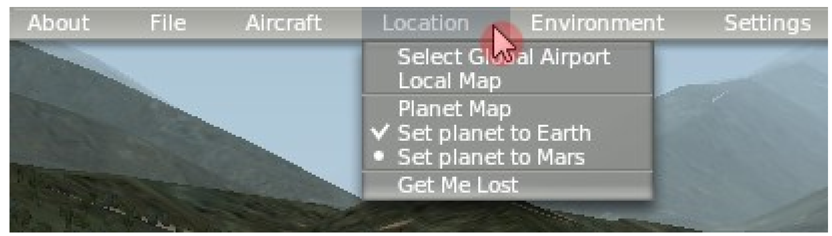
Each time an aircraft is flown in X-Plane, the program logs the flight time in the electronic Logbook. By default, X-Plane creates a text file called 'X-Plane Pilot.txt' in the X-Plane 9\Output\logbooks folder. Inside this text file are details of previous flights, including:

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

The **Choose Pilot Logbook** and **New Pilot Logbook** buttons allow the user to select a previously created logbook file or create a new one.

IV. The Location Menu

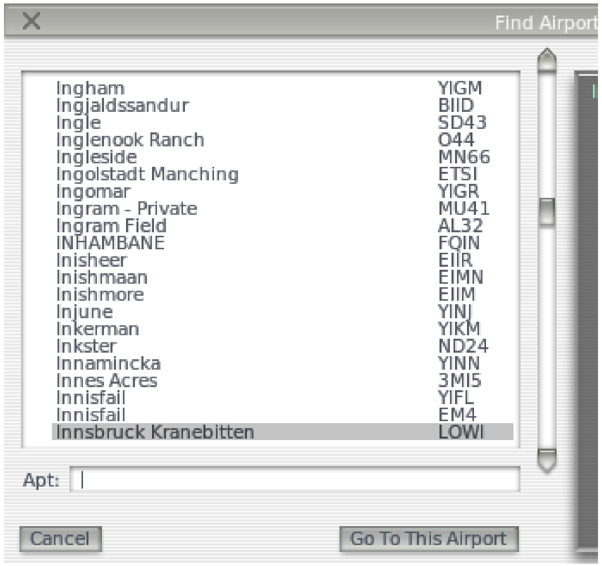
The Location menu appears as in the following screenshot.



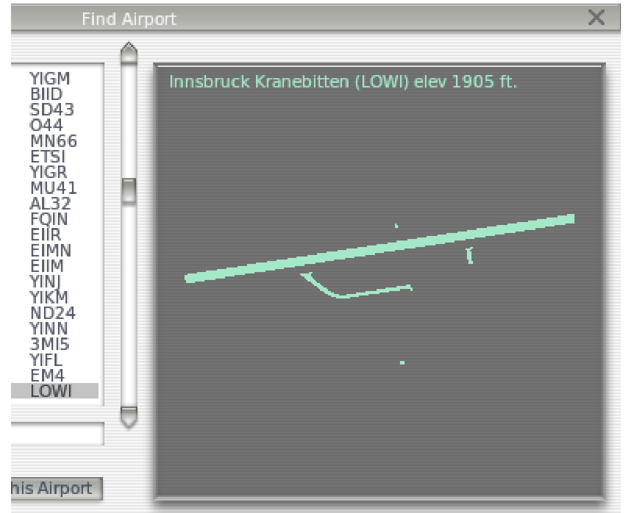
A. Select Global Airport

The aircraft can be relocated to anywhere on Earth using the Select Global Airport screen. This provides a listing of all the airports in the X-Plane database (currently more than 32,000), representing nearly every airport on the planet.

This screen is divided into three parts. In the top left (shown in the following image) is a listing of every airport name, arranged by city. Both this format and these names are the official standard for that local area (which, for US airports, is the FAA).



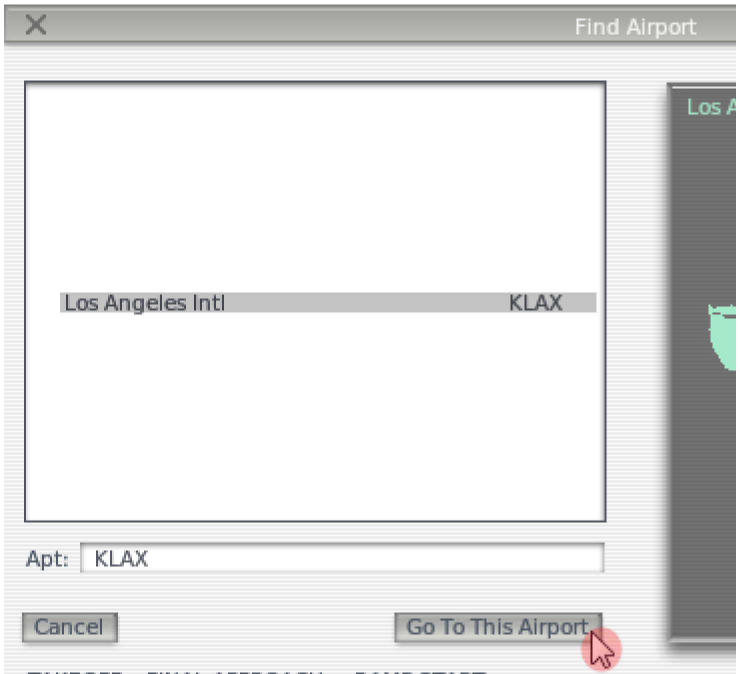
To the right of the list pane (shown in the following screenshot) is an overhead view of the currently selected airport's layout.



The bottom half of the window (shown in the following image) 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 to the right of it. Finally, the RAMP START button will transport the aircraft to the specified ramp for takeoff.

To search the available airports, type either the city name or the airport ID into the white box below the list pane (labeled “Apt:”). For instance, in the image below, the user typed in “KLAX” to find Los Angeles International Airport. The same results could be obtained by typing “Los Angeles Intl,” or by simply typing “Los Angeles” and scrolling through the results.

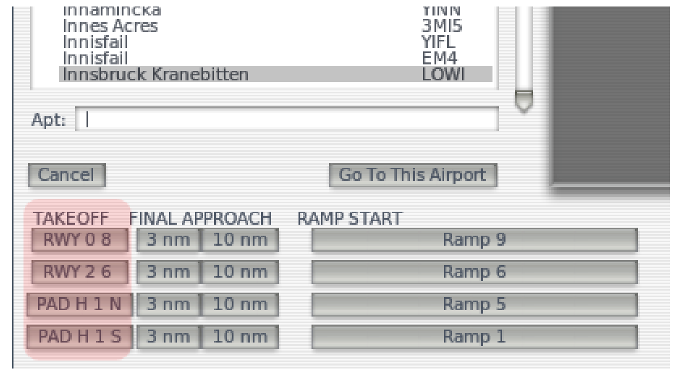


Alternatively, use the up and down arrows on the keyboard to move through the full list. To travel to an airport, click on it once in the list pane to highlight it (causing a grey box to appear around it), then click the **Go To This Airport** button, as seen in the previous image.

Additionally, an explanation of airport IDs can be found in Chapter 4, Section II, Part A, found on page **58**.

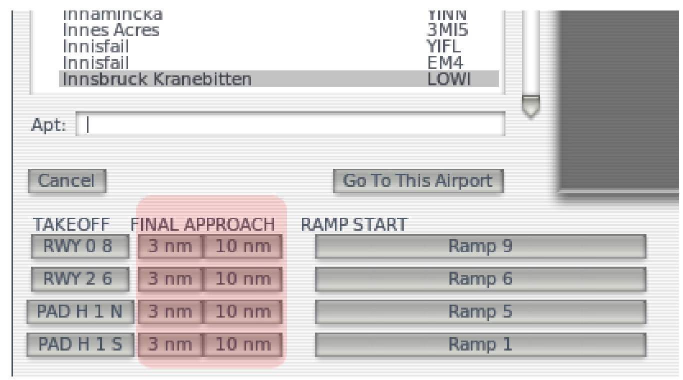
i. The Take Off Buttons

The buttons under the label TAKEOFF (highlighted below) in the Find Airport window are a quick way to choose a runway to fly from.



ii. The Final Approach Buttons

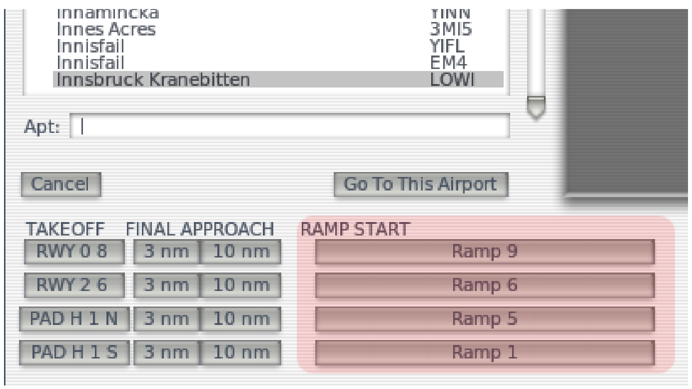
The buttons under the FINAL APPROACH label (highlighted below) provide a quick way to practice runway approaches.



The buttons are labeled with a distance, which is measured from the end of the runway whose TAKEOFF button the FINAL APPROACH button is next to. For instance, in the image above, clicking the top left button under FINAL APPROACH will place the craft three nautical miles away from the end of runway 08 at the Innsbruck airport.

iii. The Ramp Start Buttons

A ramp is effectively a parking space for aircraft. To begin a flight from the terminal and taxi the distance to the runway (as a real pilot would), choose to begin from a ramp (as highlighted below). Note that, in many cases, the default ramp is what is loaded when using the **Go To This Airport** button.



B. Local Map

Selecting the Local Map menu option from the Location menu opens the Local Region window. This window is divided into five tabs—Hi-Speed, Low Enroute, High Enroute, Sectional, and Textured. Please note that the elements of these maps—the ILS, VOR, and NDB transmitters—are described in Chapter 6, Section I, Part B (found on page **96**).

i. The Hi-Speed Tab

This 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.

ii. The Low Enroute Tab

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

iii. The High Enroute Tab

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

iv. The Sectional Tab

The Sectional map view 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.

v. The Textured Tab

The textured map view 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.

vi. Check Boxes

At the top of the Local Region window is a row of check boxes (shown below) which are used to put the map in different “modes.”

a. The Instructor Operator Station (IOS) Box

This 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.

b. The Edit Box

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 this PDF[36], available from the X-Plane Airport and Navigation Data website.

c. The Replay Box

This check box brings up a replay slider with which the flight may be replayed while viewing the map.

d. The Slope Box

Enabling this check box opens a vertical profile of the flight at the bottom of the map screen.

e. The Inst Box

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) with receiving a continuously updated data, one of the following must be done:

1. Use the **draw IOS on second monitor** option in the Rendering Options screen if two monitors are available for use.

2. Check the **address of master, this is IOS** box in the Data

[36] http://data.x-plane.com/file_specs/XP%20NAV810%20Spec.pdf

Output screen's Inet 2 tab (only applicable when using a second copy of X-Plane running on a different computer, with the other computer being used as the master machine and this one as the IOS).

f. The 3-D Box

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.

vii. Aircraft Controls

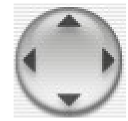
At the top right of the map window are controls to adjust the heading, altitude, and speed of the airplane by first clicking on the aircraft, then modifying the values by clicking on the up or down arrows. If X-Plane is configured to draw multiple planes, then the other panes can be dragged around and have their speed, heading, and altitude set as well.

Additionally, below the aircraft controls, carrier and frigate headings can be modified.

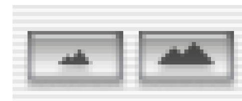
viii. Viewing Controls

Finally, in the bottom right corner of the map window are viewing controls. The checkboxes control what is displayed on the map, such as navigational aids or the compass rose.

Below these checkboxes is a round button (as seen below) 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 (seen below).



On the left is the "zoom out" button, and next to it (labeled with two larger triangles) is the "zoom in" button.

Below the zoom buttons is the **center on acft** button, which, when clicked to "on" (turning the button green), keeps the map view centered on the aircraft.

C. Planet Map

The Planet Map, selected from the Location menu, is used to visually choose a location to fly from by displaying the Earth in 3-D. The controls in the bottom right corner work just like in the Local Map window (see Part B, Subsection viii, Viewing Controls above). Clicking a location on the 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.

D. Set Planet to Earth or Mars

These two options, obviously mutually exclusive, select which planet the aircraft is on. While the laws of physics are the same on Mars as on Earth, the atmosphere there is thinner and there is considerably less gravity. These variances are modeled in X-Plane, so flying on Mars is just as realistic as flying on Earth. Chapter 8, Section IX, found on page **142**, explains how to fly on Mars (and what to fly there!) in more detail.

E. Get Me Lost

Selecting this option will cause X-Plane to teleport the aircraft to a random location anywhere in the area, allowing users to test their navigation skills.

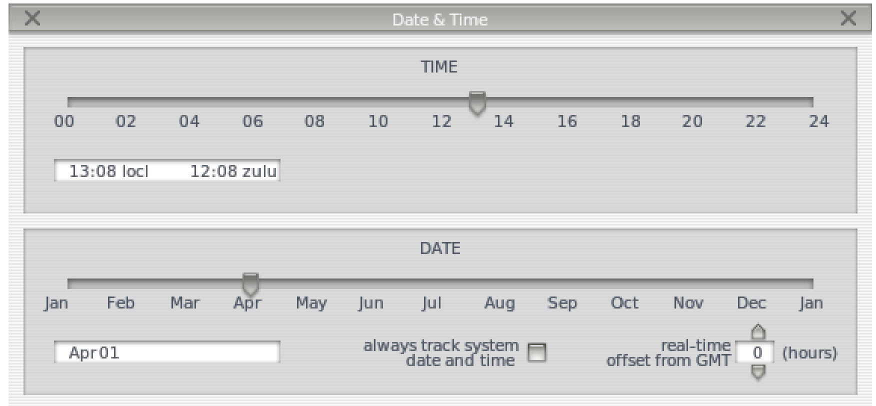
V. The Environment Menu

A. Weather

The Weather window is covered in depth in Chapter 4, Section III, Setting Weather, found on page **58**.

B. Date & Time

Selecting this menu option will bring up a screen with two prominent sliders, seen in the following image.



Dragging the first 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—that is, there are fewer daylight hours in December than in June in North America, as in the real world.

The **real-time offset from GMT** control is used in places where the local time is not what X-Plane expects.

Additionally, the **always track system date and time** check box does as its name suggests.

VI. The Settings Menu

The settings menu, seen in the following image, is the largest menu in X-Plane and is used to get “under the hood” of the program.

A. Data Input & Output

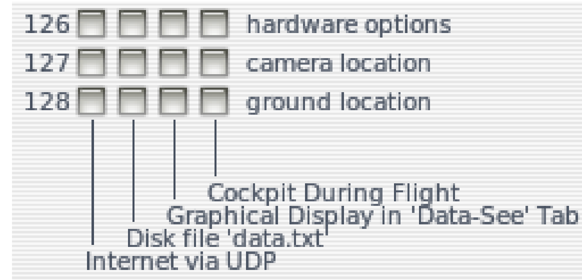
The Data Input & Output screen is used to view or save data about what X-Plane is doing, as well as to interface different copies of X-Plane running on different computers together.

This window can be used to output the simulator's frame rate (a very common choice) or any of hundreds of other parameters as well.

This is by far one of the most powerful tools in X-Plane. It can be used to diagnose a variety of problems because it allows the user to see what X-Plane is "thinking" and determine why it may be doing something unexpected. This screen can also output a host of engineering conditions.

i. The Data Set Tab

Over one hundred different data sets (which can all be output) are visible in the Data Set tab. Next to each of the lines is a series of four checkboxes. The last line, number 128, has a key showing what each of the boxes do, as seen below.



The first checkbox (moving from left to right) outputs the selected data to the Internet. The second box outputs it to a file on the hard disk—be careful with this one, as it can quickly fill up the hard drive. The third box outputs the data to a graphing function within X-Plane, and the fourth outputs it to the flight screen. Each of these checkboxes is covered in depth on the following page.

Additionally, there are four special data sets (shown in the following image), found in the lower right corner, labeled **detail**, which can only be output to the screen while in flight.

These checkboxes provide a host of engineering data for the flying surfaces of the aircraft.

To understand why the Data Input & Output screen is so powerful, imagine for a moment that your "BRAKE" light is illuminated on the instrument panel, but you don't know why. You've tried to turn it off by clicking on it with the mouse and you've also tried to use the 'b' key (for 2/3 braking force) and the 'v' key (for maximum braking effort), but it is still illuminated. You have previously set up a set of rudder pedals to control the rudder and brakes but cannot find anything wrong with the way they were set up, and you are not pressing the brake pedals.

To find out what is causing X-Plane to engage the brakes, you could try checking the rightmost box on line 14 (labeled **gear/brakes**) in the Data Set tab. After closing the Data Input & Output window, note that a line of green text appears in the upper left corner of the screen. There are four data fields in it, showing a value of between 0 and 1 for:

- the landing gear status (1 is gear down, 0 is gear up)
- the wheel brakes (on both main gear evenly), and
- the left and right brakes (if you're using a set of pedals or have programmed the brakes to be activated by some other control)

For this example, suppose that the right brake was showing a value of 1.0. This indicates that that brake is locked. You remember that you had mapped individual brake controls to your rudder pedals. Perhaps the problem is there. Apparently, X-Plane thinks that you are commanding the right brake to be on. There may be a problem with the calibration of your equipment, so you go to the Settings menu and open the Joystick & Equipment page. There, in order to calibrate the joystick hardware, you move all of your control inputs through their full range of motion. This teaches X-Plane what kind of data the rudder pedals are sending out for the full range of brake applications. For the purposes of the example, you go back to the sim and the problem is solved.

The prior example shows the importance of the Data Input & Output screen in diagnosing problems that may occur—the **joystick ail/elv/rud** option (line 08) for joystick problems, the **frame rate** option for “jumpiness,” and etc.

a. The Four Checkboxes in Depth

Broad descriptions of the checkboxes’ functions were given above; here we will go into greater detail on where exactly the output is being sent to.

aa. Internet via UDP (First Checkbox)

Using this option, the selected data is sent via the UDP network protocol to the address assigned in the Inet 2 tab of the Net Connections window (see Part B, Net Connections below). This is useful if another copy of X-Plane is running on a computer with that IP address, and the data needs to be sent from one copy of X-Plane to another (for example, if one copy of X-Plane is a pilot's machine and the other is a copilot's). Users may also write their own programs to read X-Plane UDP data. The format is very easy, and is explained in the “UDP reference.html” file in the Instructions folder of X-Plane.

bb. Disk File 'Data.txt' (Second Checkbox)

Using this option, the selected data goes to a file located in the main X-Plane folder called data.txt. Once there, it can be opened with a word processor or spreadsheet application—the data is saved as simple columns of text.

cc. Graphical Display in 'Data-See' Tab (Third Checkbox)

This option causes the selected data to be displayed in the Data See tab of the Data Input & Output window as a graphical display. Note that simulation is paused while in the Data Input & Output window, so it must be closed and reopened before any data will be displayed in the Data See tab.

dd. Cockpit During Flight (Fourth Checkbox)

Selecting this option causes the selected data to be displayed on the simulator screen while flying.

ii. The Data See Tab

This tab displays a graphical representation of any data sets that were selected in the Data Set tab. This is useful primarily for seeing trends in flight characteristics or the computer's performance.

B. Net Connections

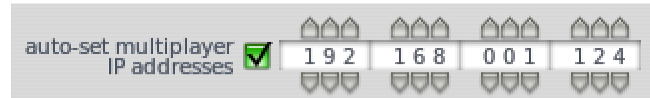
The Net Connections window, selected from the Settings menu, is used to configure multiplayer simulations as well as multi-computer, single user simulations.

Note: Whenever problems are encountered when using the Net Connections window, the first thing to check is the computer's firewall. If it is blocking X-Plane from connecting to the outside world, there is nothing the program can do. Blue Side Up Bob has written an excellent tutorial on configuring both the firewall and X-Plane for multiplayer. Covering both Mac OS and Windows XP, that tutorial can be found here[37].

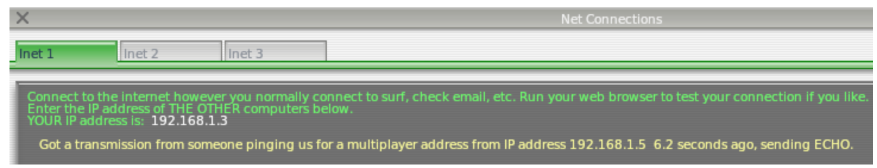
i. Inet 1

This tab is used to setup a multiplayer session. Up to twenty X-Plane systems can be connected together in this way simply by assigning each system a unique Internet Protocol (IP) address. These addresses can be either on a Local Area Network (LAN) or true Internet IP addresses. Note that IP addresses need to be on the same subnet. This makes it easy to set up a multiplayer gaming session on a LAN.

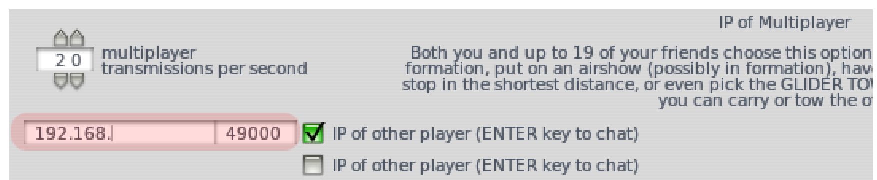
Checking the **auto-set multiplayer IP addresses** box (seen in the image below) will cause X-Plane to scan all 255 possible IP addresses on the subnet to try to find other copies of X-Plane.



When the scan of the IP addresses finds another copy of X-Plane, yellow text will appear near the top of the window with the computer's IP address, as seen below.



Next, check one of the **IP of other player** boxes and enter the IP address that the scan found there.



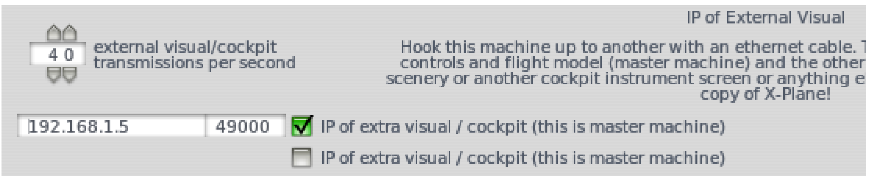
When both copies of X-Plane have "agreed" to connect to one another, each screen will momentarily go black as one computer loads the other's aircraft.

Additionally, the lower third of the Inet 1 screen is used to connect to other computers when setting up a multi-computer simulation.

[37]http://rogerthat.ca/TUTORIALS.html

Only configure this in Inet 1 on the *master* machine when using other computers for visuals—that is, use the Inet 2 tab to configure the copies of X-Plane running on the extra display systems, as well as to configure everything involving IOSs, map display systems, etc.

Upon entering the IP address of another copy of X-Plane in the IP of External Visual section of the window (as seen in the following screenshot), the copy running on that computer will automatically go into the external visual mode.



Opening up the Net Connections window on that second computer will display yellow text at the top that reads "Got a transmission from someone talking to an external monitor from IP address xxx.xxx.xxx.xxx 0.0 seconds ago, sending SNAP." This will also automatically configure the Inet 2 tab on the external visual machine to point to the master machine.

Remember when using an external visual to also set a lateral, vertical, and/or roll offset (all found in the Rendering Options window, described in Chapter 3, Section III, Part F, found on page **46**) on the secondary displays.

More on advanced networks can be found in Chapter 8, Section V, found on page **132**.

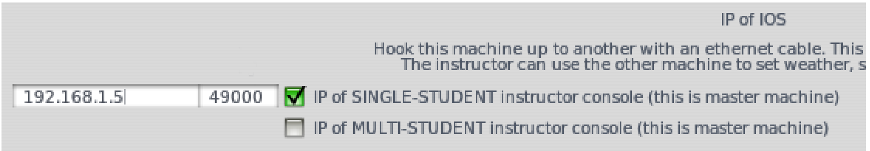
ii. Inet 2

This tab is used to configure computers in a multi-computer X-Plane system. When using multiple computers, the user can use this tab to tell X-Plane which Internet Protocol (IP) addresses each computer is assigned to in the network. The user might, for example, have a master machine (the plane with the joysticks connected to it, which is always the one that runs the flight model and has the most detail on the instrument panel), a few external visuals (the machines that show the scenery out the window), a copilot's machine (more instruments, possibly on different pitot-static and electrical systems), and maybe an IOS (Instructor Operator's Station, where an instructor can set weather or locations, fail systems, etc.).

Each of these stations would be composed of one computer, one monitor, and one copy of X-Plane, and each would have its own IP address. Keep in mind, though, that they should all have IP addresses that are the same for the first three numbers. Only the last number should be different between computers. For example, a setup with six computers and six copies of X-Plane could wisely be set up like as in the following chart:

IP Address	Description
192.168.1.1	Master machine—joysticks plugged in here
192.168.1.2	Copilot's machine (.acf file with copilots instrument panel used here)
192.168.1.3	IOS (instructor's station for initiating failures, setting weather, moving the plane, etc...)
192.168.1.4	External visual, left view
192.168.1.5	External visual, center view
192.168.1.6	External visual, right view

When setting up an IOS using this tab, check the appropriate box at the bottom of the screen (as in the following screenshot) on the master machine—that is, the one that the "student" pilot will be flying.



Typing in the IP of the IOS machine here will cause the IOS machine to automatically configure itself, opening up the Local Map window. See Section IV, Part B, Subsection vi of this chapter (found on page **80**) for more on using the IOS options in the Local Map window.

Chapter 8, Section V, Setting up Advanced Networks (found on page **132**) has more information on this tab, as well as a step-by-step guide to setting up a copilot's machine.

iii. Inet 3

The Inet 3 tab is used primarily to set the IP to which data feeds (set in the Data Input & Output window) are sent. It can also be used to interface with computers running the EFIS-app (available at X-Plane.com[38]) and with camera displays.

C. Joystick & Equipment

Information on the Axis, Center, Buttons, and Equipment tabs of the Joystick & Equipment menu can be found in Chapter 3, Section II, Joystick Configuration and Calibration (found on page **32**). Information on the Keys tab of this window can be found in Chapter 4, Section IV, Using the Keyboard/Keyboard Shortcuts on page **63**.

[38] http://www.x-plane.com/EFIS.html

D. Rendering Options

Information on the Rendering Options screen can be found in Chapter 3, Section III, Rendering Options Setup on page **38**.

E. Sound

The Sound window allows the user 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, go here[39] to download it.

F. Quick-Flight Setup

The Quick Flight Setup dialog offers one convenient location in which to change a number of basic flight options.

Clouds are set in the upper left corner, with other basic weather settings below that. These are configured just as in the Weather window (see Chapter 4, Section III, Setting Weather on page **58**).

In the upper center of the window, X-Plane’s airport database can be searched like in the Select Global Airport window (see Chapter 4, Section II, Choosing an Airport, found on page **56**).

Below and to the left of the airport description is a single **Open Aircraft** button, used like the Open Aircraft Window (Chapter 4,

[39] http://www.microsoft.com/downloads/details.aspx?FamilyID=5e86ec97-40a7-453f-b0ee-6583171b4530&displaylang=en

Section I, Opening an Aircraft on page **54**).

Finally, at the bottom of the screen, the time can be set, as in Section V, Part B of this chapter (found on page **82**).

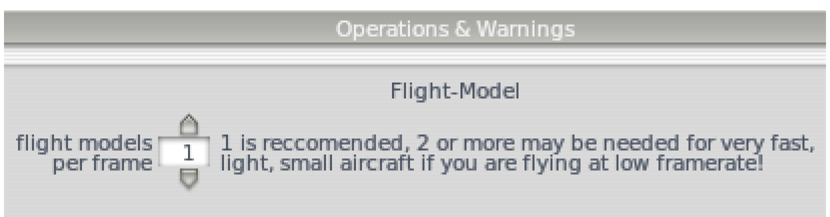
Once a quick flight has been configured, click the **Go To This Airport** button to begin the flight. This flight setup can then be saved using the Save Situation menu option (see Section II, Part A of this chapter, found on page **70**), making it available for future use.

G. Operations & Warnings

The Operations & Warnings window lets the user specify a few little odds and ends about where the plane starts, how the flight model works with the aircraft, whether the sim breaks the airplane if it gets overstressed, what warnings the simulator gives if things are going wrong, and other little things like that.

i. Flight Model

The **flight models per frame** control (seen in the following image) is used to double sample the simulator’s calculations on the aircraft’s flight.



This is only needed when flying quick, light, small aircraft, which may accelerate beyond the rate at which X-Plane can keep up when running at a low frame rate.

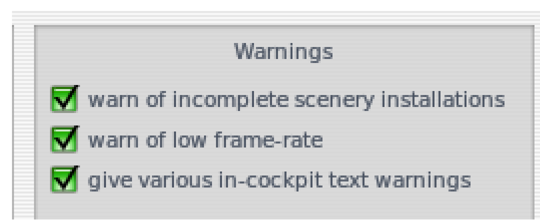
ii. Startup

When X-Plane is started or when a new aircraft is loaded, the **Start each flight with engines running** option (seen in the following image) will ensure that all engines and associated battery and control systems are running and ready to go.

If this option is not selected, the user will need to perform manual system and engine starts using the correct procedures for that particular aircraft before he or she can begin to taxi or take off.

iii. Warnings

With the **warn of incomplete scenery installations** box (seen in the following image) checked, X-Plane will open a quick dialog box for the user when a section of scenery is required that isn’t installed. This may be a useful reminder of why the world outside is only water.

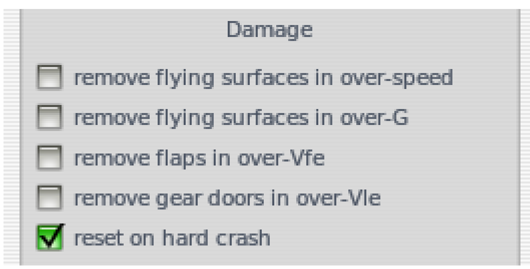


With the **warn of low frame-rate** option (seen above) enabled, X-Plane will bring up a dialog box if the simulator’s frame rate drops below the value specified in the Rendering Options screen. Chapter 3, Section III, Part G, Setting Up X-Plane to Achieve the Best Results (on page **48**) has instructions on configuring the simulator for maximum speed.

With the **give various in-cockpit text warnings** option (seen in the previous image) enabled, X-Plane will show text warnings such as those for airframe ice, carburetor ice, and blown landing gear tires on screen.

iv. Damage

The **remove flying surfaces in over-speed** and **remove flying surfaces in over-G** (seen in the following image) cause X-Plane to remove flying surfaces (e.g. the wings) when too much stress is placed on the craft. As in real life, this is likely to have disastrous results.

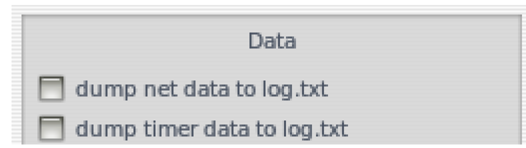


Checking the **remove flaps in over-Vfe** box (seen above) will cause X-Plane to rip off flaps if the Vfe (Velocity flap extended) value is exceeded while they are down. Checking the **remove gear doors in over-Vle** box (seen above) will do the same for gear doors if the Vle (Velocity landing gear extended) value is exceeded while they are open.

When the **reset on hard crash** box (seen in the previous screenshot) is checked, X-Plane will reposition the aircraft at the nearest airport if it is crashed too hard.

v. Data

When the **dump net data to log.txt** box (seen in the following image) is checked, X-Plane will save the data that it receives over the network in the UDP format to the log.txt file (found in the X-Plane 9 folder).

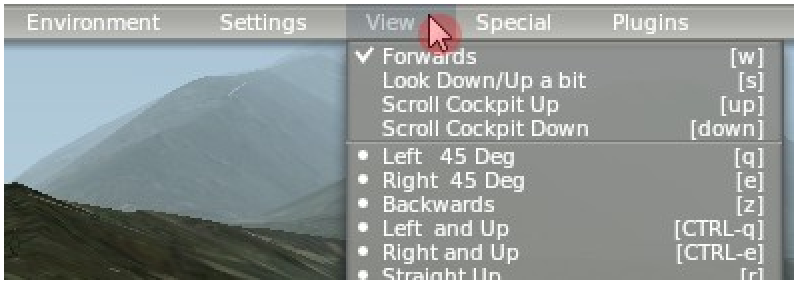


It will also save the data that it sends to the same file. This is useful for monitoring communication between computers in a multi-computer setup. If the computer is sending data to the X-Plane software on other computers, but the other computers are not responding correctly, then outputting this diagnostic data can help the user determine why the messages between computers are being rejected.

When the **dump timer data to log.txt** control (seen in the previous image) is enabled, X-Plane will save data to the log.txt file detailing how long X-Plane is spending on each of its critical processes. It allows the user to see which processes within X-Plane are consuming the most CPU time and may be useful in determining which settings should be turned down to get better performance.

VII. The View Menu

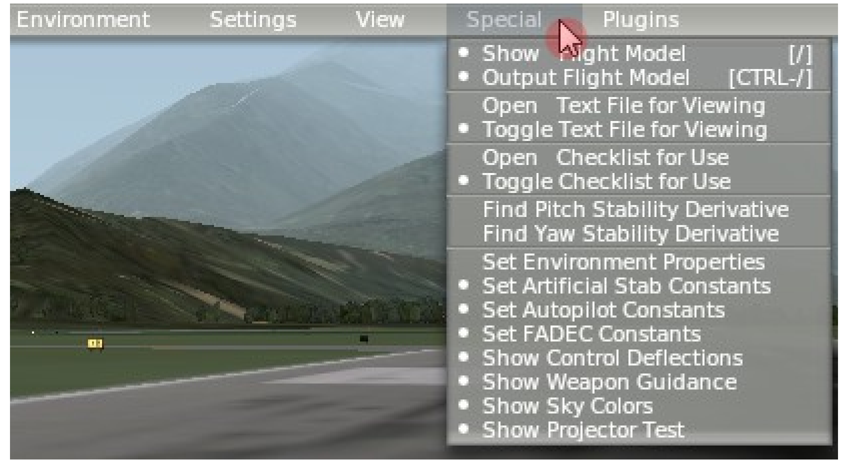
The View menu (seen in the following screenshot) changes the user's view of the aircraft. These options are much more easily seen than described, so for the purposes of this manual, it is suggested that the user simply experiment with the possible settings.



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 select the left 45 degree view, one would press the Q key.

VIII. The Special Menu

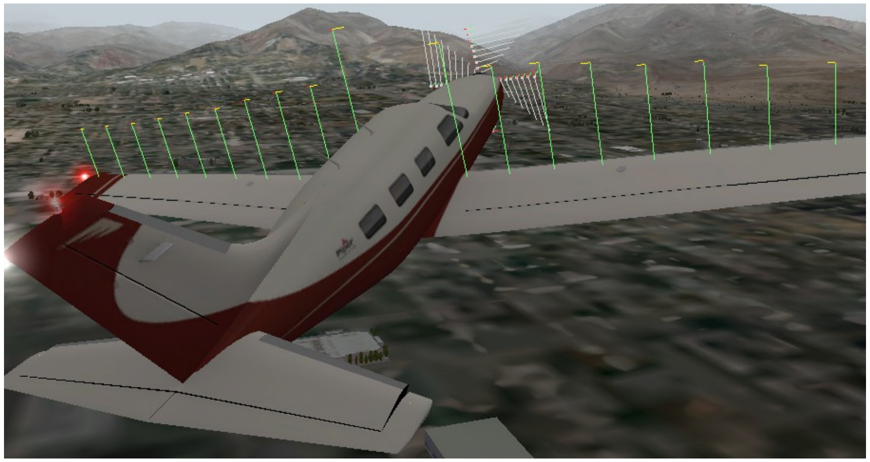
The Special menu (shown below) lets the user configure a number of odd-ball things in the sim.



A. Show Flight Model

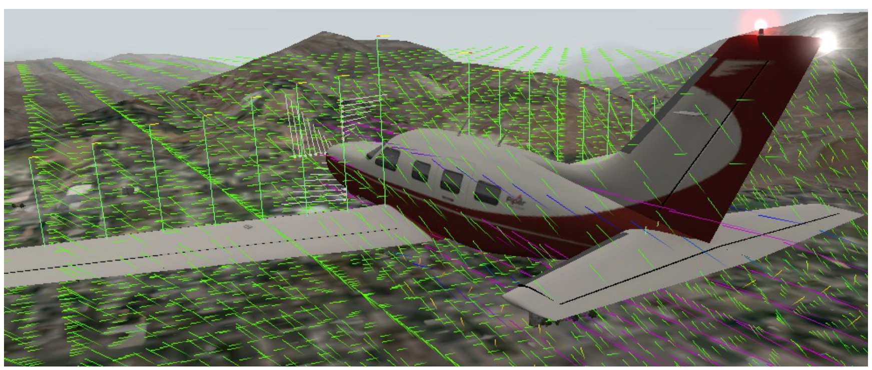
X-Plane models flight by breaking the plane down into a number of little pieces and finding the forces acting on each piece. By choosing the Show Flight Model option one or two times (or by hitting the '/' key a couple times) and moving to an outside view (e.g., by using the '|' key), the user can actually see all those forces. With some wind and turbulence turned on in the Weather screen, the user can even see the pseudo-random velocity vector flow field around the airplane. The velocity vectors seen are the actual vectors interacting with the plane, and the force vectors (the green lines coming off the plane) are the actual forces on the plane—nothing is just for show here. This is the actual work that X-Plane is doing.

For example, in the following image, the Show Flight Model button has been pressed once, and the aircraft has been pulling into an upward climb.



The green bars extending from the wings indicate how much lift each section of the wing is generating; longer bars represent greater force.

In the next image, the Show Flight Model has been pressed a second time, making the flow field around the aircraft also visible.



i. Fun with the Flight Model

To really see the flight model shine, try turning off all the wind and turbulence and flying up close behind another airplane (use the Aircraft and Situations window from the Aircraft menu and the Local Map window from the Location menu as needed to help here). Watch the flow field around the airplane become chaotic as it enters the wake of the plane in front of it!

To take this to the extreme, select about ten other planes in the Aircraft and Situations window, all with equal performance (all airliners or all light planes). Set them all to be on the **red** team, and put your airplane on the **blue** team, for example. Then, put your plane on autopilot in flight and walk away from X-Plane for 30 minutes or so. Come back in half an hour and all the other planes should be on your tail, each one in the wake turbulence of all the planes in front it! This is the type of flight model math that X-Plane does.

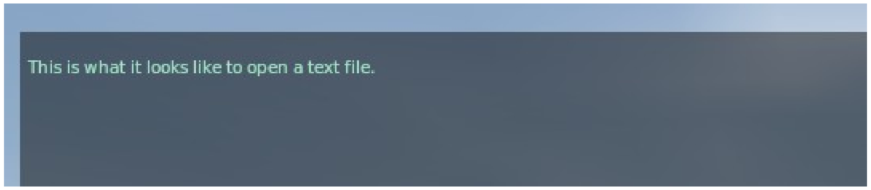
B. Output Flight Model

This menu option will save the next cycle of calculations of the flight model directly to the file “Cycle Dump.txt” in the X-Plane 9 folder. From there, it can be viewed with any text editor.

C. Open/Toggle Text File for Viewing

This option allows the user to open and display a text file that was previously created and saved within the X-Plane 9 folder. This is useful for notes and information about aircraft, airports, or procedures—a sort of in-flight notepad. After the file has been opened, it can be toggled on or off using the toggle option selected from the menu.

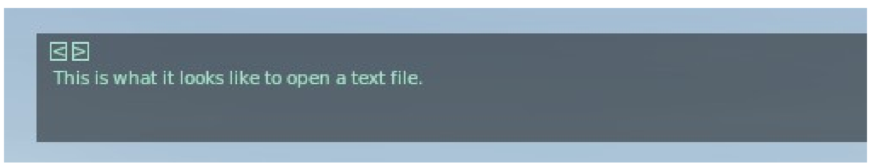
An open text file is shown in the following screenshot.



D. Open/Toggle Checklist for Use

This option allows you to open a previously created text file saved in the X-Plane folder. It will display each line in the text file one by one, allowing the user to scroll forward and backwards using the buttons on the top left of the popup window. This is useful for going through user-created checklists in X-Plane. Once opened, the checklist can be toggled on or off using the menu.

An open checklist is shown in the following screenshot. Note that, unlike when this file was opened as a text file above, it now displays one line at a time.



E. Find Pitch/Yaw Stability Derivative

Use this setting to displace the aircraft nose by one degree in pitch or yaw for X-Plane to measure the acceleration back to level flight. This information can then be used to calculate the Pitch and Yaw Stability Derivatives. The results are placed in the text file ‘Cycle Dump.txt’ in the X-Plane folder on the hard disk. The quicker the nose pops back to level flight, the greater the static stability of the airplane. The quicker the resulting oscillations dampen out, the greater the dynamic stability of the airplane.

F. Set Environment Properties

This setting allows the user to change the virtual world's environmental, atmospheric, and gravitational properties. This can be used to experiment with some of the environmental factors that affect an aircraft in flight, including temperature, pressure, density, viscosity and gravity. Flight on other planets can also be simulated this way.

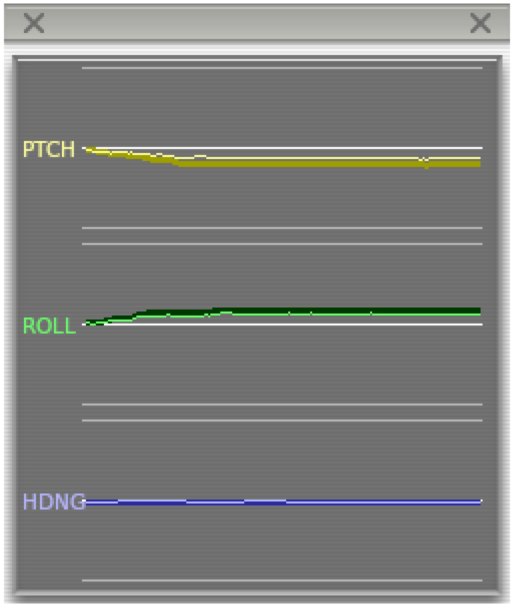
G. Set Artificial Stability, Autopilot, and FADEC constants

These constants are normally set in Plane-Maker, and their workings are explained in depth in the Plane-Maker manual. Adjusting these values changes the way the craft handles, though these changes *cannot* be saved within X-Plane. Instead, write down the settings and enter them into Plane-Maker to save them. If something gets changed too drastically and the airplane becomes unflyable, just reload the aircraft with the Open Aircraft window.

H. Show Control Deflections

This option was developed for the National Test Pilot School. It lets the user see a running graph of the control deflections in the bottom left corner of the screen as the craft is flown.

For instance, in the following image, the pilot is gently pulling up and to the left.



I. Show Weapon Guidance

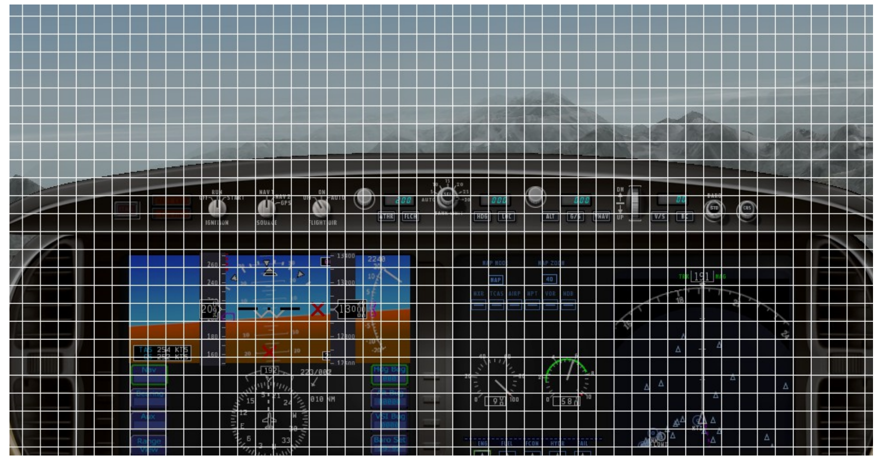
Developed for a Military Simulation Contract, this option lets the user see how the guided missile flight controls are being deflected. It should be used to tune missile guidance algorithms. (The missile guidance algorithms are set in the Weapons screen in Plane-Maker.)

J. Show Sky Colors

Developed for Chief Artist Sergio Santagada, this option shows the user what images X-Plane is currently using to generate its sky colors.

K. Show Projector Test

The Show Projector Test option (enabled in the image below) will overlay the screen with a horizontal and vertical line grid, as in the following image. This is useful for finding wrinkles in the viewing screen when using X-Plane with a projector.



IX. The Plugins Menu

The Plugins menu appears as in the screenshot below.

A. Plug-in Admin

The X-Plane Plug-In Software Developers Kit is a combination of code, DLLs, and documentation that allows programmers to write additions that work inside X-Plane, without modifying X-Plane or having a copy of X-Plane's source code. The Plug-in Admin menu option provides a set of features to administer any installed plug-in software. By default, there are no plug-ins installed, but a number of them are available on the Internet. This menu can be used to enable or disable plug-ins, view information about installed plug-ins, and assign “hotkeys” so that the enable/disable actions can be easily performed from within the simulator.

6. 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 detail, but it is recommended that if users are really serious about mastering these facets of aviation they down to a local general aviation airport and hire a CFI (Certified Flight Instructor) for an hour or two. Users with a laptop can by all means bring it along and have the instructor detail many of 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.

I. Navigation

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 conditions (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.

A. History

i. Dead Reckoning

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 I, Randy Whitt, once piloted a Cessna 172 from Kansas City to Chicago after our second (of two) navigation radios gave up and died in mid-flight. No, this is not a typical experience in the aviation world, but it demonstrates that a pilot always needs to be thinking ahead and be prepared for contingencies. That particular aircraft was a well-used rental and Nav 1 was dead from the time we signed it out. When Nav 2 died, we had no operable navigation radios at all and used dead reckoning to fly the last 300 or so miles of our trip, which was most of the journey. We would never have allowed ourselves to get into that position had the weather been poor or had we been flying on instruments—we would have refused to take off into such conditions given the failure in the first radio. But since the weather was nice, we 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 bon-fires 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.

ii. Aural Navigation

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.

B. Modern 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:

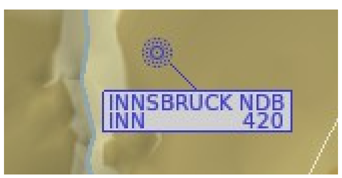
- High-Speed—used as high altitude charts by jet and turbo-prop pilots.
- Low Enroute—used as low altitude IFR navigation charts by piston (propeller) aircraft pilots. One of the most important aspects of this chart is the addition of Vector Airways that are virtual highways in the sky that connect different 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 more information on the Local Map screen can be found in Chapter 5, Section IV, Part B (found on page **79**).

i. 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. They appear as in the following image.



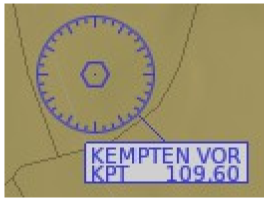
For example, in the image above, the Innsbruck NDB (whose identifier is INN) transmits at a frequency of 420 kHz.

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

ii. 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. In the hi-speed and enroute maps, they are black, while in the sectional map, they are blue, as seen in the image below.



They are tagged with boxes that have their name and identifier on the left side and their VOR frequency on the right. For instance, in the image above, the Kempton VOR, whose identifier is KPT, transmits at a frequency of 109.60 MHz.

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). In X-Plane, this is labeled as in the image on the following page.

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. A VORTAC in X-Plane is labeled as in the following image.

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.

iii. 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). In X-Plane, a standalone LOC transmitter is marked as in the following image.

In the example above, the LOWI runway 26 localizer transmits at a frequency of 111.10.

An ILS combines the functionality of a localizer, which provides lateral guidance, with a glideslope 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.

In X-Plane, an ILS transmitter is marked as in the following screenshot.

iv. GPS Navigation

Global Positioning Systems were first invented 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 into 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 than 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 a 'D' with an arrow through it, from left to right) 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 Chapter 4, Section VI, Part A on page **66** for more info on using the knobs). Also, keep in mind the ID conventions discussed in Chapter 4, Section II, Part A (on page **58**) and enter the beginning 'K' as appropriate.

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.

II. Autopilots

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 never taken the time to learn—Randy Witt has even been on *airliner* where the plane was jerking left and right for five minutes or so as the flight crew tried to figure out how to program and engage their autopilot.

The following autopilot functions are available in X-Plane. Each of these can be chosen for an aircraft’s panel in the Panel-Editor of Plane-Maker. They 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.

A. Descriptions of Autopilot Functions

i. WLV

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

ii. HDG

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

iii. LOC

The **localizer** button. This will fly a VOR or ILS radial, or to a GPS destination. Note that *the GPS may be programmed by the FMS* (explained in the following sections).

iv. HOLD

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

v. V/S

The **vertical speed** button. This will hold a constant *vertical speed* by pitching the aircraft nose up or down.

vi. SPD

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

vii. FLCH

The **flight-level change** button. 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 by simply letting 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 s/he takes it away, the plane descends. **SPD** and **FLCH** are currently *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 or descents. The difference is, if you *have* auto-throttle on the airplane, **FLCH** will automatically add or take away power for you to start the climb or descent. **SPD**, on the other hand, will *not*.

viii. PTCH

The **pitch sync** button. 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.

ix. G/S

The **glideslope** button. This will fly the glideslope portion of the ILS.

x. VNAV

The **vertical navigation** button. This will automatically load altitudes from the FMS (Flight Management System) into the autopilot for you in order to follow route altitudes (explained in following sections).

xi. BC

The **back course** button. 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** (back course) 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: HSIs do *not* reverse the visible needle deflection in the back-course because you turn the housing that the deflection needle is mounted on around 180 degrees to fly the opposite direction (it would be reversing the reversal).

Note: The glideslope is *not* available on the back course, so you have to use the localizer part of the procedure only

B. Using the Autopilot

i. Turning It On

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 is, at that point, following whatever autopilot modes are selected, and you, in turn, are following the flight director as you 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 to AUTO (as shown in the following image) 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.

Note: If the system is turned on with less than 7 degrees of bank, then the system will assume you want the wings *level*, thus leveling the wings for you.

Now that you have set the flight director to the right mode, let's look at the various modes you can use to command the flight director and autopilot servos.

ii. Using the Controls

a. Wing Leveler and Pitch Sync

Hit either of these and they hold wings at the current bank (or level the wings if you engage it with less than 7 degrees of bank) and pitch-attitude at the current pitch.

b. Heading, Altitude, Vertical Speed, Speed Hold, Flight Level Change, Auto-Throttle

Hit these buttons and they will hold whatever values are entered into the selectors, with most values auto-set to your current speed or altitude at the moment they are hit for smooth transitions. Now, this makes perfect sense at first: Simply hit the VVI (vertical velocity indicator) button and the autopilot will grab and hold your current VVI. The same goes for airspeed and altitude.

If you want the autopilot to guide the aircraft to a new altitude that has *not yet been reached*, 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 indicate 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. Imagine, though, that you want to climb to 9,000 feet. You would first dial 9,000 into the altitude window. The plane, though, does *not* go there yet. The next step requires you to choose *how* you want to get to 9,000 feet.

If you decide to get there via a vertical velocity, hit the V/S button and the plane will capture your current vertical velocity (possibly 0). Then, simply dial the VVI (vertical velocity indicator) up or down to get to 9,000 feet more or less quickly. 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 there 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 make the plane pitch the nose up or down to maintain your current indicated airspeed. Now, simply add a dose of power (if needed), causing the nose of the plane to rise 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 they reach the specified altitude*, at which point they 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 are all *armed*, and sit there in standby (armed) 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* s/he gets there (including the *initial* altitude before s/he takes 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 pilot is told to maintain 3,000 feet. S/he is give a runway heading and is cleared for takeoff.

2. The pilot enters 3,000 feet into the ALTITUDE window and a runway heading (for instance, 290) into the HEADING window.

3. The pilot takes off.

4. In the initial climb, around maybe 500 feet, the pilot sets the flight director to AUTO. The autopilot notes the plane's current pitch and roll and holds the plane steady.

5. The pilot hits the **HDG** button, and the plane follows the initial runway heading.

6. The pilot hits either the **V/S**, **FLCH**, or **SPD** buttons. 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. The pilot is given a new heading and altitude by ATC.

8. The pilot dials the new heading into the window, dials the new altitude into its window, and then hits **V/S**, **FLCH**, or **SPD** to let the plane zoom to the new altitude.

9. The pilot is cleared to the plane's destination or some other fix. Those coordinates are entered into the GPS and the HSI source is set to GPS (as the autopilot follows the HSI). The pilot hits 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.

c. Pitch Sync with the Pitch Sync Joystick Button

You can assign a joystick button to the **pitch sync** 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.

To assign a button to **pitch sync**, do the following:

1. Move the mouse to the top of the screen, causing the menu to appear.

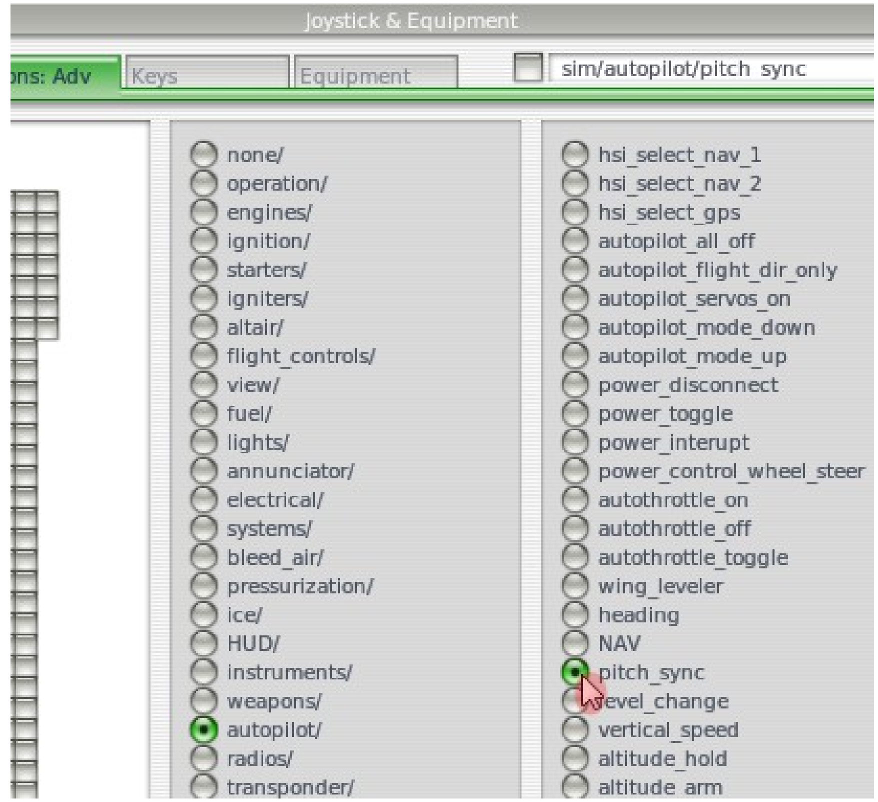
2. Click Settings, then click Joystick & Equipment, as seen in the following image.

3. Click the Buttons: Adv tab, as seen in the following image. If the Buttons: Adv tab does not exist and there is only a Buttons tab, X-Plane has not been updated to the latest version (see Chapter 2, Section VII on page **27** for information on fixing this).

4. Press the button on the joystick that you would like to assign to **pitch sync**.

5. Click the round button next to **autopilot**, found near the center of the screen.

6. Press the round button next to **pitch_sync** (seen in the following screenshot), found about halfway down the first column of the options that appeared in Step 5.



7. Exit the Joystick & Equipment window.

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: If the bank angle is less than 7 degrees, the autopilot will just level the wings, as it assumes that you want nose level.

d. LOC and G/S

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 HSI folder), which is the HSI source selector.

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

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.

Now let’s discuss how to actually use the **LOC** and **G/S** buttons.

aa. LOC

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 LOC 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 **LOC** mode 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.

bb. G/S

Just like the lateral nav (that is, **LOC** mode), the vertical nav (**G/S** mode) *will not do anything* until *the glideslope needle starts to move*. Unlike with the localizer, though, the **G/S** mode 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 **G/S** mode 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** settings into use to fly an ILS.

cc. 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 **altitude** 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 **heading** 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.

iii. Flying an FMS Plan

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

a) You must enter your entire flight plan into the FMS.
b) 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).
c) You must have the **LOC** button selected ON since that button causes the autopilot to follow the localizer (or whatever is on the HSI).
d) You must have the FLIGHT DIR switch set to AUTO, so that the servos are running.
e) 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 (see Chapter 4, Section I on page **54**). 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 (as shown in the following image) on the FMS. This gets the FMS ready to receive a flight plan.

3. Now hit the **AIRP** button (shown in the following screenshot), 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. For instance, in the screenshot below, we're starting at San Diego International Airport (KSAN) and we're flying to San Bernardino International (KSBD).

Remember that more information on airport IDs can be found in Chapter 4, Section II, Part A on page 58.

5. If you like, hit the line-select button on the left side of the FMS next to the text "FLY AT ______ FT" (seen in the following screenshot) 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, shown in the following screenshot) 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.

iv. Turning the Autopilot Off

Now, to turn *off* an autopilot mode, simply hit the currently selected mode button once again. When that mode is turned off, the autopilot will revert to the default mode that was selected when the autopilot is first turned on—pitch and roll hold modes.

To turn the autopilot off altogether, simply turn the **FLIGHT DIR** switch to OFF. Alternatively, hit the '!' key on the keyboard or assign a joystick button to turn it off in the Joystick & Equipment screen of X-Plane.

III. Flying on Instruments

A. History

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 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.

B. The Inner Ear and Your 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 fell 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 degrees. 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 degrees 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, BAM! They're 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.

C. Gyroscopes and Their Application to 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 electronically 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 and simultaneously 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.

D. The Six 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).   A summary of these instruments follows.

The “standard six” are shown in the following image, taken from the Cessna 172 cockpit.

i. The Airspeed Indicator (ASI)

The airspeed indicator (labeled 1 in the image above) 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.

ii. The Attitude Indicator (AI)

The attitude indicator (labeled 2 in the previous image) 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.

iii. The Altimeter (ALT)

The altimeter (labeled 3 in the previous screenshot) 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.

iv. The Turn Coordinator (TC)

The turn coordinator (labeled 4 in the previous screenshot) 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.

v. The Directional Gyro (DG)

The directional gyro (labeled 5 in the screenshot on the previous page) is a simple instrument that points north and thus allows the pilot to tell which way she or he is flying.

vi. The Vertical Speed Indicator (VSI)

The vertical speed indicator (labeled 6 in the previous image) 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. Expanding X-Plane

I. Adding Third-Party Aircraft

Perhaps the easiest place to find new aircraft is the X-Plane.org "Download Manager" page[40]. As of this writing, all the planes in that subsection of the site are free, though X-Plane.org does have plane models (some of them very, very good) for sale.

When downloading a custom plane, it will typically be in a compressed folder (usually with a .zip extension) that contains the airplane and all its various paint jobs, airfoils, custom sounds, and instrument panels. Once the compressed folder is downloaded, users 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 9 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:

C:\Documents and Settings\User\Desktop\ X-Plane 9\
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 (see Chapter 4, Section I on page **54** for more information on opening an aircraft).

Of course, users can also upload their own planes to X-Plane.org and similar sites. To do so, first create a custom airplane (using Plane-Maker—see the Supplement beginning on page **160**) with airfoils, panels, sounds, etc. All the files making up the plane then need to be compressed into a ZIP folder to be uploaded to the Internet.

[40] http://forums.x-plane.org/index.php?autocom=downloads

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, control-click (that is, press the Ctrl key on the keyboard while clicking with the mouse) on the aircraft folder in the Finder, and choose "Create Archive" from the resulting popup menu to make a compressed ZIP archive of that plane.

These custom aircraft may be uploaded and shared at will. There are no copyright restrictions of any sort on planes made by users with Plane-Maker.

II. Adding Third-Party Scenery

Custom scenery packages, too, can be found on the "Download Manager" page[41] 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 9\Resources\Custom Scenery folder. Additionally, the XAddonManager[42] 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 scenery.x-plane.com[43]. A good tutorial for the

[41] http://forums.x-plane.org/index.php?autocom=downloads
[42] http://forums.x-plane.org/index.php?autocom=downloads&showfile=4886
[43] http://scenery.x-plane.com/tools.php

tool can be found here[44].

III. 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[45]) 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 XSquawkBox site[46].

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[44] http://data.x-plane.com/designers.html
[45] http://forums.x-plane.org/index.php?autocom=downloads&showcat=9
[46] http://www.xsquawkbox.net/xpsdk/mediawiki/Main_Page

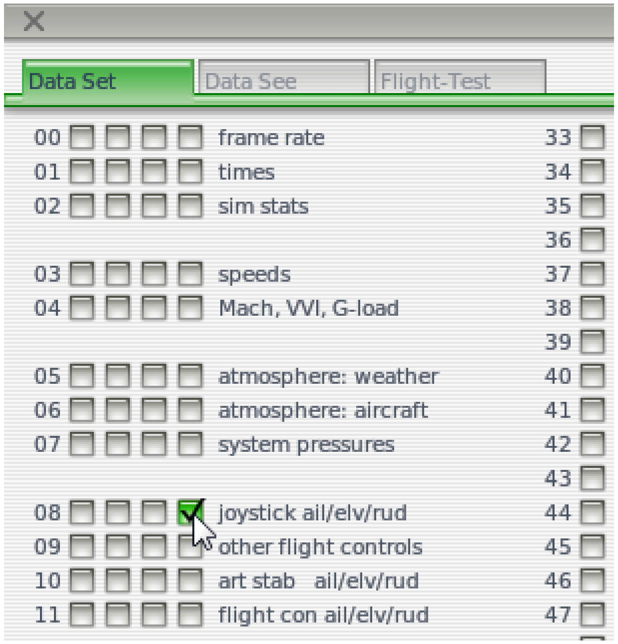
8. Expert Essays

I. Tuning the Handling in X-Plane

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

Before performing the following, make sure the joystick and/or other control devices are calibrated. See Chapter 3, Section II (found on page **32**) for instructions on this.

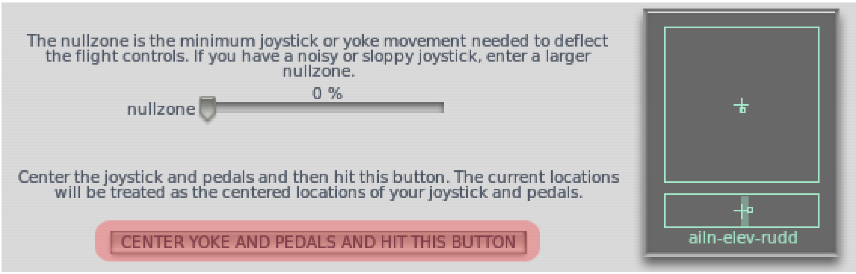
To easily see whether the controls are properly calibrated, go to the Settings menu and click Data Input & Output. There, select the rightmost checkbox next to **joystick ail/elv/rud**, as seen in the following image.



This will cause X-Plane to display on the flight screen the aileron, elevator, and rudder inputs from the flight controls (such as a joystick, rudders, yoke, etc.). With this done, close the Data Input & Output screen. The inputs for the various stick deflections should now be visible the top left corner of the screen, as seen in the image below.

With properly configured controls, when the stick/yoke/pedals are centered, the aileron, elevator, and rudder joystick inputs all read around 0.0. 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 these are the results obtained, then the joystick is calibrated. If not, the joystick is *not* calibrated—no wonder the plane is not flying correctly! See Chapter 3, Section II, Part B on page **34** for information on calibration.

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 window, click the Center tab. Move the stick or yoke around. Doing so should move little rectangles around in a box on the lower half of the screen, and when the stick is centered, the rectangles should (ideally) go to zero size. Since no hardware is perfect, though, simply center the controls and hit the button labeled **CENTER THE YOKE AND PEDALS AND HIT THIS BUTTON**, as highlighted in the following screenshot.

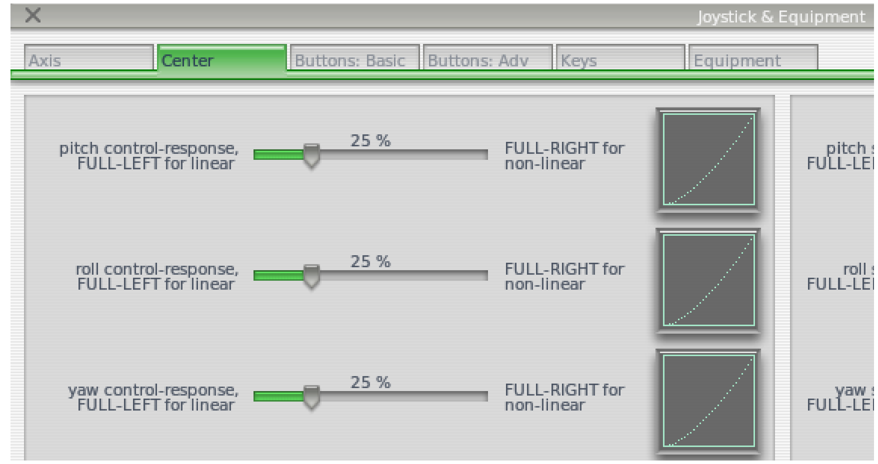


This will tell X-Plane that the hardware is indeed centered. When using PFC hardware, there will be little buttons across the bottom of the window that will set the center position of each axis.

With that done, close the Joystick & Equipment window 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 Center tab once again. Look at the three sliders labeled **control-response** (one labeled **pitch**, one **roll**, and one **yaw**) at the top left of the screen, as seen in the following screenshot.

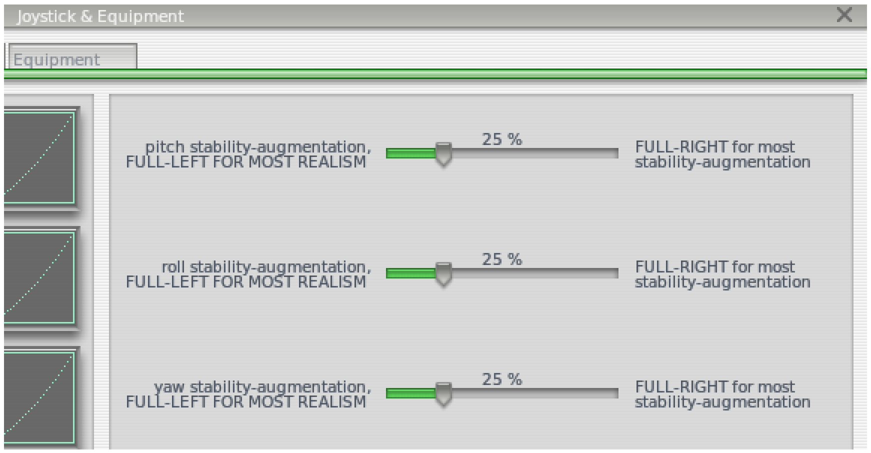


If these three sliders are fully left, then the control response is linear; that is, a 50% stick deflection in the hardware will give 50% control deflection in the aircraft. Likewise, 100% stick deflection in the hardware will give 100% control deflection in the aircraft.

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 sim, 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 sim. In other words, while the *hard-over roll rate* in the sim will remain *unchanged* no matter what these sliders are set to, 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.

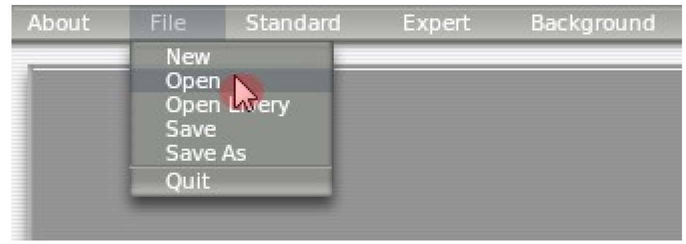
The next level of control tuning is stability augmentation. If the plane still feels squirrelly or overly sensitive, go back to the Center tab of the Joystick & Equipment window and try dragging the three sliders on the right side of the screen (labeled **stability-augmentation**—shown in the following image) all the way to the right.



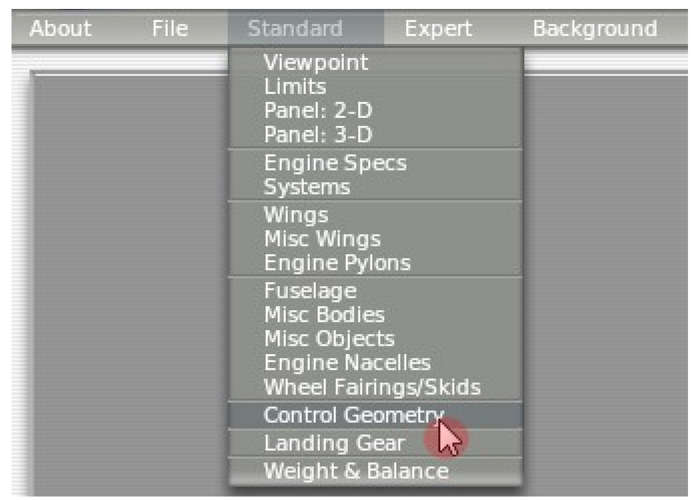
This will cause X-Plane to automatically counteract any stick input to some degree, resisting rapid or large deflections in pitch, heading, and roll. Basically, it is like always having an autopilot on that smooths things out. This is obviously very fake, but in the absence of a perfect flight control system and 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. 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 or dynamics of the propwash or mass distribution inside the plane. The same thing can be done in X-Plane—one can bend a trim tab a bit one way or the other to make the plane fly true.

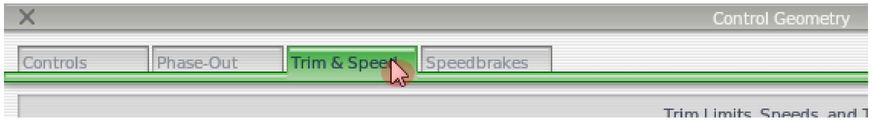
To do this, first exit X-Plane and open Plane-Maker (found in the X-Plane 9 installation folder). Go to the File menu and open the plane that is pulling left or right, as shown in the following screenshot.



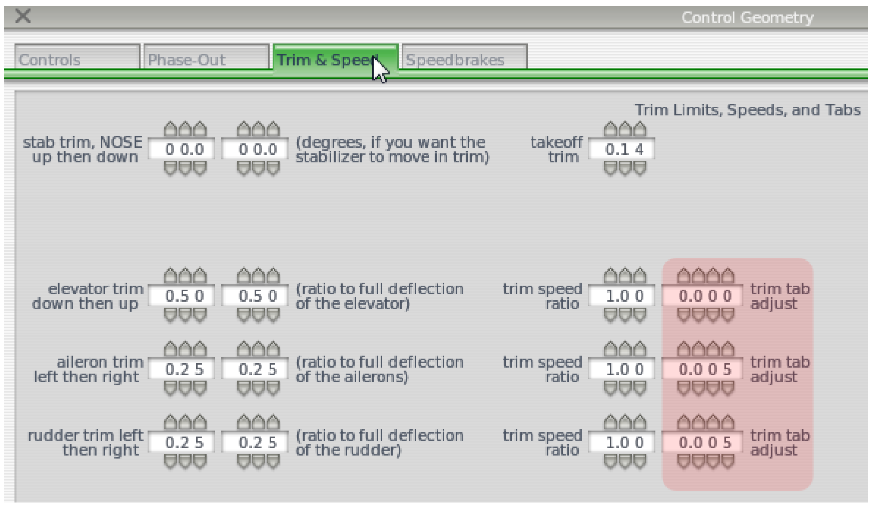
Go to the Standard menu and click Control Geometry, shown in the following image.



In this window, click the Trim & Speed tab, as shown in the following screenshot.



Look at the far right-hand column of controls in the top half of the screen, labeled **trim tab adjust**, highlighted below.



This is a measure of how much the trim tabs are bent on each axis. The top control is the elevator, the middle is the aileron, and the bottom is the rudder (as per on the far left side of the screen). A value of 0.000 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% 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, or for the elevator if the plane needs to pull *up* a bit more. Tweak the trim tabs as needed, save the plane, and exit Plane-Maker. Then, open up X-Plane and try flying the plane again. The plane 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.

II. Factors Affecting X-Plane's Performance

X-Plane users tend to notice either that the simulator runs extremely fast, giving them 100 frames per second (fps), or that it is dismally slow, topping out at 20 fps. At identical rendering settings, this is due almost entirely to the hardware in the computer.

Some people today have computers with a 500 MHz Pentium III processor, 128 MB of RAM, and 8 MB of VRAM (perhaps an 8 year old system), while others have quad-core 3000 MHz processors, 4096 MB of RAM, and 512 MB of VRAM (perhaps only one year old). There is *more* than a 6x difference in speed between those two setups, since the RAM speed, bus speed, video card speed, and many other things also influence the computer's performance.

Many people do not understand what determines a computer's performance. The three biggest factors are the amount of RAM in the system, the speed of the CPU, and the speed of the graphics card. A fourth factor, which determines a system's ability to display high quality video textures, is the amount of RAM on the video card (called VRAM).

Coming up short in any of the above categories will create a “bottleneck” in system performance, limiting the ability of the rest of the components.

For instance, using higher quality textures than can be stored in VRAM will slow X-Plane significantly (see Chapter 3, Section III, Part B, Subsection i on page **39** for more information on VRAM and textures), regardless of any other factors.

Conversely, even if the system’s video card has 2 GB (that is, 2048 MB) of VRAM and X-Plane is running at a low screen and texture resolution (eliminating any RAM problems), if the computer’s CPU or video card are too slow, then X-Plane’s performance will be poor.

For information on optimizing X-Plane’s frame rate, see Chapter 3, Section III, Part G on page **48**.

III. Tuning the Autopilot

Occasionally, the autopilot in X-Plane might act up. It may sort of wander down the localizer or wander around in pitch when it should be holding altitude. It might wander around in heading, or perhaps flicker its wings madly left and right as it tries *too hard* to hold a heading. Whatever the problem, the autopilot constants can be adjusted by the user in order to make the plane hold its desired path more tightly.

These autopilot constants can be adjusted in Plane-Maker by doing the following:

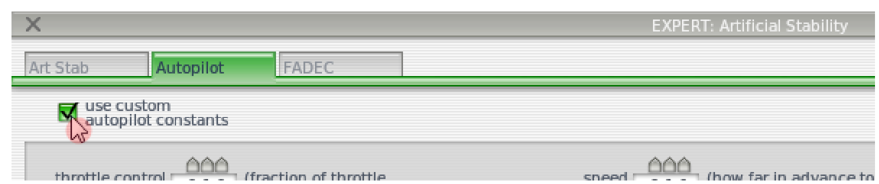
1. Open Plane-Maker by opening the X-Plane 9 folder and double clicking on Plane-Maker.exe.

2. Load the airplane that needs adjusting by clicking the File menu and selecting Open, as shown below.

3. Find the .acf file just as you would when selecting a craft within the X-Plane sim (see Chapter 4, Section I, Opening an Aircraft, found on page **54**).

4. Go to the Expert menu and click on Artificial Stability, as below.

5. Go to the Autopilot tab and check the **use custom autopilot constants** box, as seen in the following image.



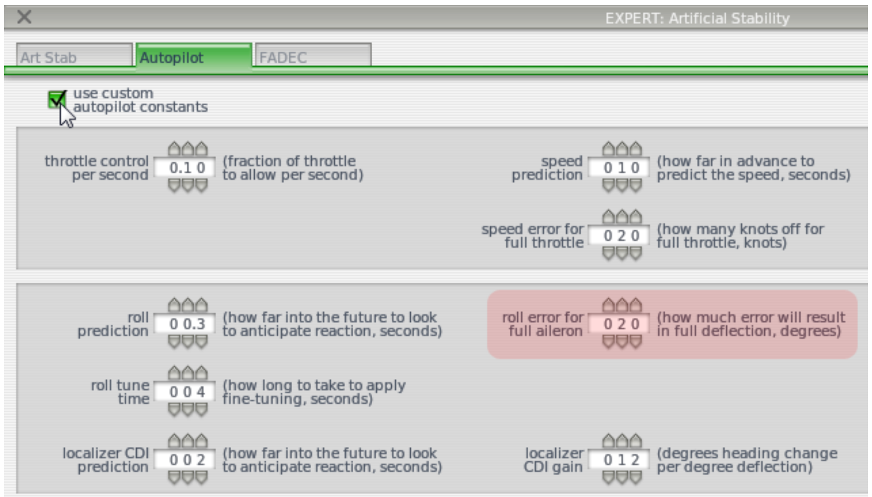
6. A number of controls will appear that specify the autopilot constants for your airplane.

Let’s examine what each of these **autopilot constant** controls do. First, let's talk about correcting heading.

A. Tuning Autopilot Roll

i. Roll Error for Full Aileron

This control is found in the middle box of the Artificial Stability window, in the right column, highlighted in the following image.



When flying a real plane, a pilot decides on a roll angle to make a turn. He or she then decides to deflect the ailerons a certain amount to achieve the desired bank angle.

Imagine that you *want* 45 degrees of bank, and the plane is currently at 0 degrees of bank. You wouldn’t apply just a touch of aileron to get there, but rather a strong dose of it. After all, you are a whole 45 degrees away from the desired roll angle. Conversely, imagine you are at 29 degrees of roll, and you *want* 30 degrees of roll. You only need *one more degree* of roll, so you wouldn’t put in full aileron to get to 30 degrees—that would overshoot it for sure. Instead, you would look at the controls and notice that you are only a *little* off of from the desired bank angle, so the plane would need only a *little bit* of aileron.

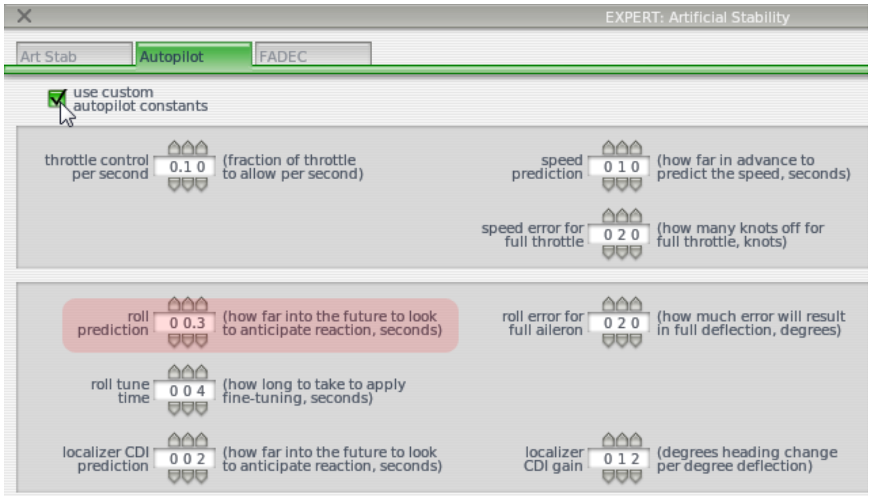
Now, how many degrees off of a desired bank angle would a pilot have to be to put in *full* aileron? One degree? Ten? One hundred? The **roll error for full aileron** control specifies to the autopilot how many degrees off the aircraft must be from the *desired* roll angle before it puts in *full* aileron. If this is set to a very small number, the autopilot will put in full aileron for even the *tiniest* of roll errors—not good! This will cause the plane to over-control and flutter madly left and right like an over-caffeinated pilot! On the other hand, if this control is set to a very large number, like 100 degrees, then the autopilot will hardly put in any aileron input at all. In that case, the plane will always wander off course a bit, because it will never move quickly enough to *get back on course*.

Now, a smart pilot might say, "I would never input full aileron, ever." Fair enough. But realize that the autopilot *will* be limited to about 50% travel or so, and it will *automatically* back off of the controls as the airplane speeds up, just as a good pilot would. Thus, what this control really determines is how aggressively the ailerons are applied. If the plane tends to steer too *unaggressively* to the command bars, a *smaller* number is probably required here. This will tell the autopilot to require a smaller deflection to really crank in the ailerons. Conversely, if the plane flutters left and right like a plastic bag in a 50-knot wind, then the autopilot needs to be told *not* crank in so much aileron. To do that, enter a *larger* number here, so that the autopilot waits for a *larger* error to develop before responding with so much force.

A good starting point for this control is 30 degrees. This means that if the roll angle is off by 10 degrees, the plane will apply one-third aileron to correct when at low speed—not a bad idea.

ii. Roll Prediction

This control is found in the middle box of the Artificial Stability screen, at the top of the left column, highlighted in the following image.

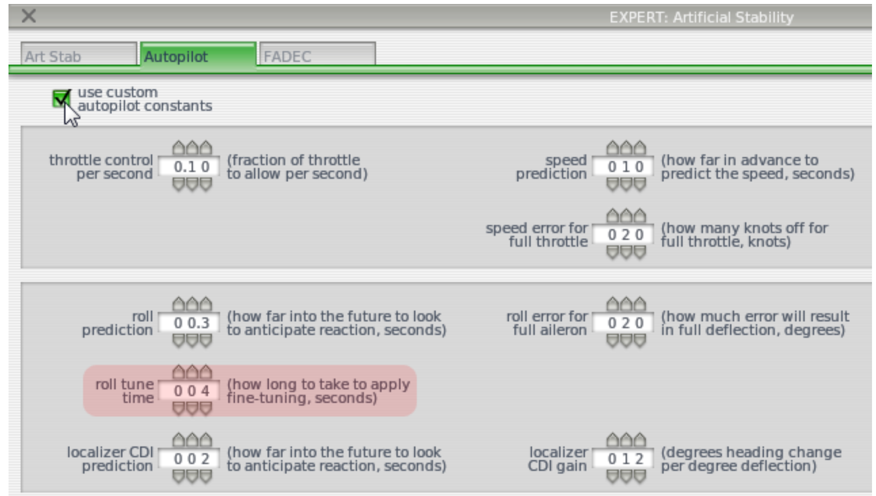


When a pilot flies, he or she tends to look *into the future* to decide when to add to or back off from the flight controls. This is simple anticipation. The **roll prediction** control tells the autopilot how far into the future it should look. If the plane tends to wander slowly left and right, always behind its mark, or it overshoots and then wanders slowly off in the wrong direction like a tired drunk driver, then it clearly is *not* anticipating enough. In that case, an *increase* is required in the **roll prediction** to make the autopilot anticipate more. If, however, the airplane starts flopping back and forth hysterically every frame, the autopilot is clearly anticipating *too much*; a *smaller* **roll prediction** is needed.

One second is a good starting point for this control—after all, when real pilots fly, it's a good bet that they enter controls based on *where the plane will be* in one second, rather than where it is at the moment.

iii. Roll Tune Time

This control is found in the middle box of the Artificial Stability window, in the middle of the left-hand column, seen in the following screenshot.

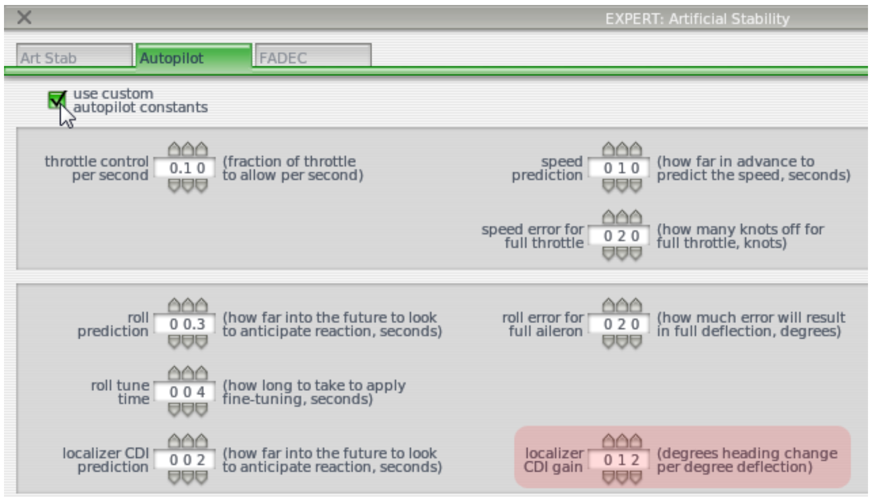


In the real plane, a pilot will *trim out* any loads with trim if it is available. The **roll tune time** determines how long the autopilot takes to run the trim. A real pilot probably takes more than just a few seconds to do this. However, if the autopilot waits *too* long to trim out the loads, it may be slow and late in getting to the correct angle.

A good starting point for this control is 5 seconds.

iv. Localizer CDI Gain

This control is found in the middle box of the Artificial Stability window, at the bottom of the right-hand column, highlighted in the following image.

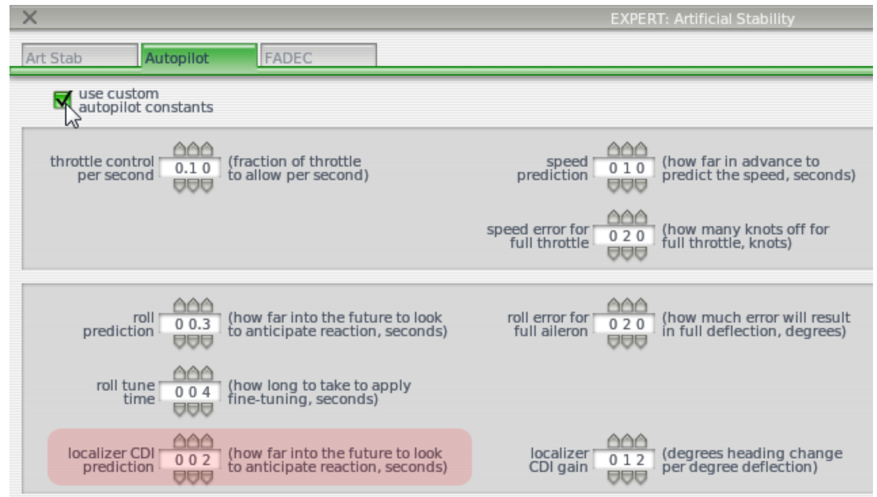


If a pilot is one degree off the localizer when flying an ILS, he or she needs to decide how many degrees of *heading correction* are called for to correct that. If s/he corrects only *one* degree, the craft will be flying right towards the airport, never intercepting the localizer until it gets to the transmitter on the ground. Usually, if a pilot sees a one degree error in the localizer (one dot on the CDI), s/he would enter about 10 degrees of heading correction, thus forcing the plane to nail that HSI *now*. The **localizer CDI gain** control sets the number of degrees of heading change that the autopilot will pull for each degree of error on the localizer (which is the same as saying for each dot of CDI deflection).

A good starting point for this control is 10 degrees.

v. Localizer CDI Prediction

This control is found in the middle box of the Artificial Stability window, at the bottom of the left column, as seen in the screenshot below.



A good pilot does *not* fly an ILS based on where the CDI is at the moment. A pilot that flies like that wanders around in S-turns all the way down the localizer! A good pilot flies the plane based on where the HSI CDI *will be* in the near future. The **localizer CDI prediction** control tells the autopilot how far into the future it should be looking when following the CDI. It should be looking at least a few seconds into the future. The *higher* this number is, the *more* the autopilot will anticipate. If the plane is wandering back and forth slowly across the localizer, always S-turning, it probably needs a bigger number here. More anticipation will prevent those endless S-turns. However, if *too big* a number is entered here, then the plane might *never* join the localizer. This is caused by the autopilot anticipating so far ahead that it turns away from the localizer *as soon as the needle comes alive*, shying away to avoid an over-shoot. Obviously, that is too much anticipation!

A reasonable number for this control is between 2 and 4 seconds.

B. Summary of Roll Settings

In summary, enter the number of degrees of bank error that should give a very strong aileron response in the **roll error for full aileron** control. Enter the number of seconds the system should anticipate in the **roll prediction** control, the number of seconds required to trim out the load in the **roll tune time**, the number of degrees of heading change per degree localizer error in the **localizer CDI gain**, and the number of seconds of anticipation in HSI CDI deflection in the **localizer CDI prediction**.

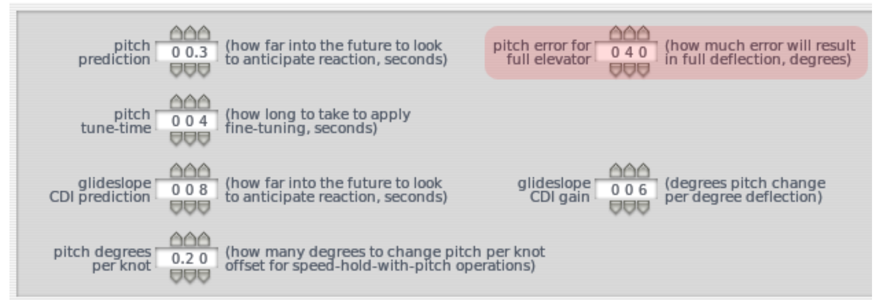
To tune these controls, it is a good idea to first *forget about the ILS* and simply try to *get the aircraft to perfectly hold a heading*. Tweak the **roll error for full aileron** to give as strong a response as desired, and tweak the **roll prediction** to give the desired anticipation. Fly the plane around *in **heading** mode*, snapping the heading bug left and right and tweaking those constants until the plane follows the heading bug perfectly. Then, after the heading mode is perfect, adjust the localizer values while flying ILSs to tune the localizer. If the plane flies S-turns across the localizer, the **localizer prediction** needs to be greater. If the autopilot never even latches on to the localizer, continually turning away from it, then the **localizer prediction** needs to be decreased—the craft is clearly over-anticipating.

Next we will discuss correcting pitch; the discussion will be almost exactly the same as roll, really.

C. Tuning Autopilot Pitch

i. Pitch Error for Full Elevator

This control is found in the bottom box of the Artificial Stability window, at the top of the right column, as seen in the following screenshot.



This control is to pitch as the **roll error for full aileron** (from Part A above) control is to roll. It determines how much error between desired and actual pitch is required for full elevator deflection. Remember that the autopilot will automatically reduce the control deflections as the plane speeds up, limiting to maybe 50% control deflection, so it isn't necessary to worry about the system really going to *full* deflection.

To configure this control, *forget about the ILS* for a minute and just fly **vertical speed** or **pitch sync** mode. If the plane is sloppy about getting the nose up to track a new vertical speed and just takes too long to get there, then a *smaller* **pitch error for full elevator** value is needed. This will cause the plane to be more aggressive with the elevator. Of course, if the plane starts flapping about madly, a *larger* value is needed, telling the plane to stop deflecting the elevator so much unless it has a larger error between the actual and desired pitch. Put the autopilot in **pitch sync** mode, then hold the CWS button down and quickly pitch the nose, letting go of the CWS button. If the autopilot is slow and sloppy in holding that new pitch, then a smaller number needs to be entered here to make the thing more aggressive.

ii. Pitch Prediction

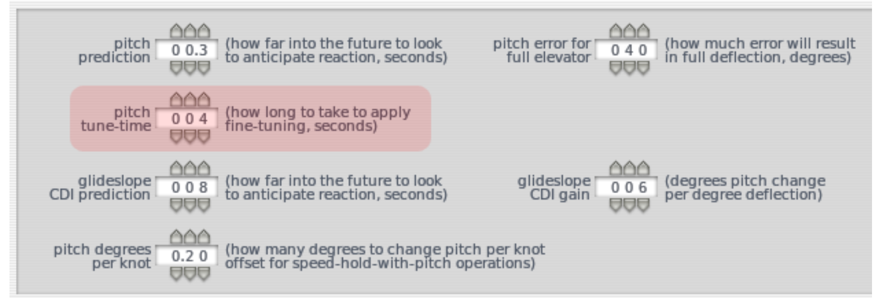
This control is found in the bottom box of the Artificial Stability window, at the top of the left column, highlighted in the following screenshot.

A good pilot will input flight controls by predicting where the plane will soon be. The **pitch prediction** control determines how far into the future the autopilot will look. If the plane is always wandering up and down when trying to hold a given vertical speed, always a few steps behind where it needs to be, then more anticipation is clearly called for—the **pitch prediction** control needs to be set to a larger number. Conversely, if the plane is always afraid to get where it needs to be, resisting motion towards the desired pitch, then it is probably anticipating too much, and a smaller number is called for. Once again, these numbers need to be tuned in pitch and roll modes, or maybe **heading** and **vertical speed** modes, to get them set perfectly, with nice, snappy, precise autopilot response, *before* the autopilot is tested on an ILS.

A good starting point for this control is one second.

iii. Pitch Tune Time

This control is found in the bottom box of the Artificial Stability window, in the left-hand column, as seen in the following image.

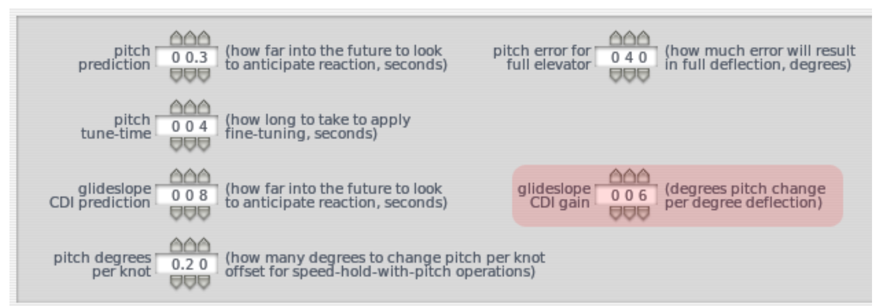


It sets the time require to trim, similar to the **roll tune time** control described above in Part C. If this is set to too *small* a number, the plane will constantly be wandering up and down as it plays with the trim, as it will always be *too quick* to modify the trim. A real pilot would wait until s/he is *sure* that the trim needs modifying.

This control should probably be set between 5 and 10 seconds.

iv. Glideslope CDI Gain

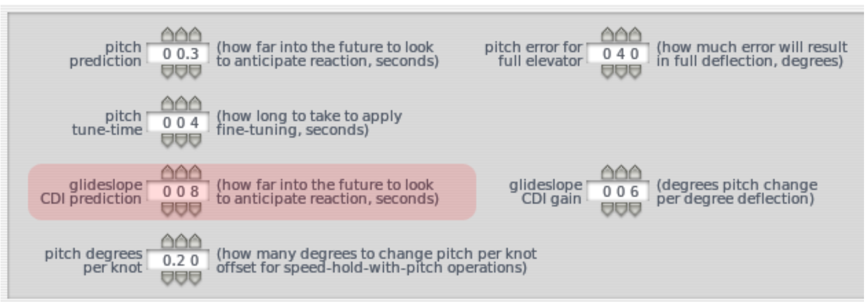
This control is found in the bottom box of the Artificial Stability window, at the bottom of the right column, as seen in the following screenshot.



It tells the autopilot how much it should change the pitch for each degree of glideslope error. For example, if it is set to 5 degrees (a reasonable value), the autopilot will pitch up 5 degrees for each degree it is below the glideslope. The greater the number entered here, the more the command bars will move to meet the glideslope.

v. Glideslope CDI Prediction

This control is found in the bottom box of the Artificial Stability window, in the left-hand column, highlighted in the following image.

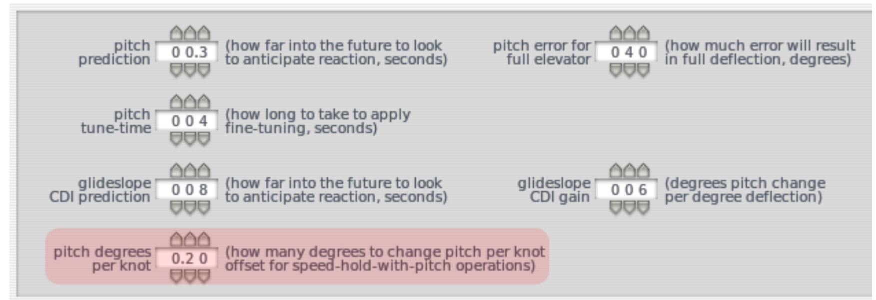


A good pilot will anticipate where the glideslope will be *in the near future* as he or she controls the pitch. If the pitch is not anticipated enough, the aircraft will be correcting up and down all the way down the glideslope. If the pitch is anticipated too much, the craft will never *get* to the glideslope, as it will always be shying away from it as soon as the needle starts to close in.

A good starting point for this control is 8 seconds.

vi. Pitch Degrees per Knot

This control is found in the bottom box of the Artificial Stability window, at the bottom of the left column, seen in the following image.



It determines how many degrees the autopilot will pitch the craft up or down in order to correct for a one-knot difference between the actual speed and the one set in **flight level change** mode. A good starting point is 0.2 degrees.

D. Summary of Both Pitch and Roll Controls

To summarize, remember that there are two things happening with these controls: the amount the autopilot *moves the command bars*, and the amount it *moves the controls* to capture those command bars (see the table on the following page). Therefore, if the command bars are not behaving as they should, one of the *command bar variables* needs to be set. On the other hand, if the command bars are fine, but the airplane *isn't tracking those bars correctly*, one of the *flight control tracking variables* needs to be set so that the autopilot will "grab" the bars.

Remember there are two steps to tuning these autopilot controls:

1. Decide how to move the bars (**CDI gain** and **CDI prediction**), then

2. Decide how to move the controls (**pitch** and **roll error**, **pitch** and **roll prediction**).

Finally, remember that there is one number that controls how *hard* we try to *get* to our target (**CDI gain**, **roll** and **pitch error**—think of this as a “spring constant”) and one number that controls our *anticipation* (**CDI prediction**, **roll** and **pitch prediction**—think of this as a damping constant).

Amount to Move the Command Bars on the ILS	**Amount to Move the Controls to Track the Bars**
localizer CDI gain	roll error for full aileron
glideslope CDI gain	pitch error for full aileron
Amount to Anticipate the Command Bars on the ILS	**Amount to Anticipate the Attitude to Track the Bars**
localizer CDI prediction	roll prediction
glideslope CDI prediction	pitch prediction
Time to Trim the Forces	
pitch tune time	
roll tune time	

E. Setting Autopilot Constants Quickly

Now that we’ve discussed what each control does, let's look at how to set these things up quickly. First, launch X-Plane and open the aircraft that needs modifying. Go to the Special menu and click the Set Autopilot Constants menu item. A window (shown in the image below) will appear that looks identical to the Artificial Stability window discussed above.

The settings here can be changed *while flying* in order to determine what the autopilot constants need to be for the plane. Be aware, though, that these settings will be *lost* the second X-Plane is closed or another aircraft is opened. This in-simulation version of the Artificial Stability window from Plane-Maker is *for experimentation only*. Once desired settings have been determined, be sure to write them down on a piece of paper or enter them into a text document so that they can later be entered into Plane-Maker, where the settings can actually be *saved*.

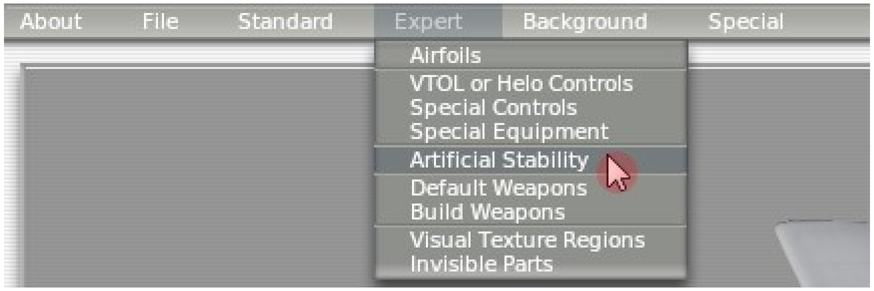
One final note: Some users try to configure a really aggressive autopilot system that has *huge* anticipation, *huge* gains, and *tiny* maximum pitch and roll errors for full deflections. That would be a very strong, very aggressive autopilot that may *seem* to work perfectly. A problem arises, though, as soon as the craft is flown at a low frame rate. When this happens, the plane will start shaking violently on autopilot because that autopilot is not being run *fast enough* to see the very rapid *results* of its overly strong inputs. If such settings are to be used, be sure to configure the scenery or weather so that they will really slow the simulator down (ideally to its minimum frame rate) while tuning the autopilot. Only then can it be certain that the constants entered that will *always* work, because a *higher* frame rate will never hurt. The easiest way to slow the sim down for this is to set three broken layers of clouds and plenty of buildings to be rendered (see Chapter 3, Section III, found on page **38**, for more on setting rendering options).

IV. Designing an Artificial Stability System

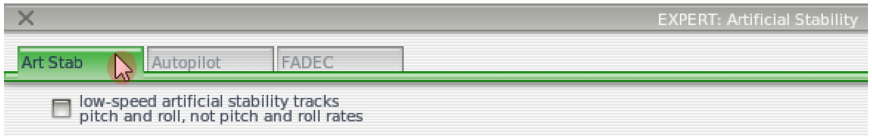
For users creating a VTOL (a vertical take-off and landing aircraft) or a fighter, it may be necessary to design an artificial stability system in order to make the craft feel stable, even though, in reality, it isn't. This is especially common in fighter jets and helicopters—fighters are most maneuverable if unstable, and helicopters simply have nothing to naturally *make* them stable. Control systems are designed to make these craft *seem* stable. These typically work by adding some input in addition to the joystick/yoke input in order to make the craft do what the pilot wants.

A common example of this kind of stability system in the civilian world is the yaw damper. A pilot's feet still move the rudders, but the yaw damper system adds some additional rudder deflection for the pilot to damp out the rotation rates of the plane. The amount of rudder deflection added depends on what the control system engineer decides is necessary—in the case of designing custom aircraft for X-Plane, that "engineer" is the user.

To create a system to add stability in Plane-Maker, first load the aircraft to be modified. Open the Expert menu and select the Artificial Stability menu option (as shown in the image below).



In the window that opens, select the Art Stab tab.



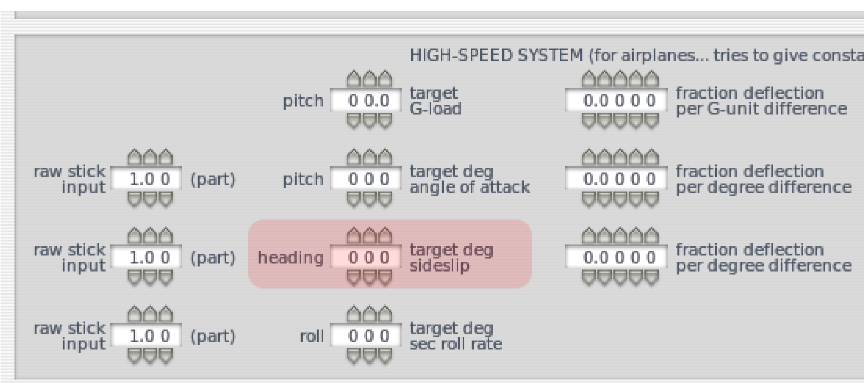
A. Designing a Yaw Damper

By way of example, consider a yaw damper again. Its purpose is to add some rudder deflection to whatever the pilot inputs with his or her feet, stopping the aircraft's rotation. This is seen in high-end Mooneys and most jets. The yaw damper's designer must consider how much rudder is desired to stop the rotation—full rudder? Half? Perhaps just 1/10 of the max rudder deflection is needed. Obviously, if the plane is only wagging its tail a *little bit*, only a *little* rudder is needed to stop it. However, if the plane swings around quickly, then the damper system needs to put in a *lot* of rudder to stop the rotation quickly.

To decide how much extra rudder input is necessary, the designer first needs to know how much "wag" the system needs to compensate for. In X-Plane, designers enter a fraction of the rudder input *per degree per second of rotation rate*.

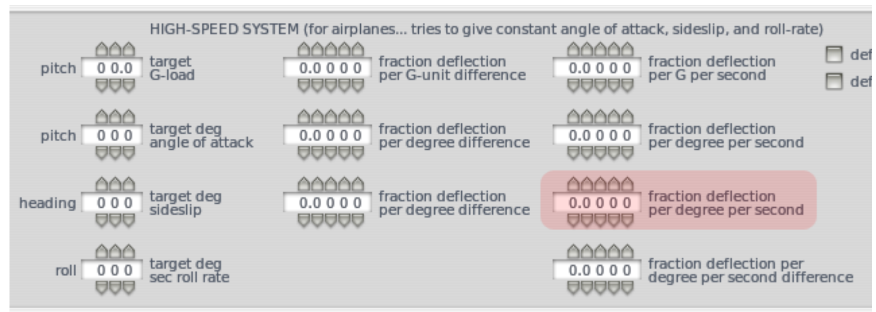
For instance, imagine the plane's tail is swinging (from turbulence, varying crosswind, the pilot stepping on the rudder, etc.) at 90 degrees per second—that is, the tail moves in one second from being straight in line to pointing full left or full right. In a real airplane, 90 degrees per second of tail-wagging will feel like a *lot*. Kicking the rudders a bit in a Cessna 172, for example, will shake its tail at about 35 degrees per second. So, let's imagine that 90 degrees per second is such a high rotation rate that the control system needs to put in *full rudder* to oppose it. That means that if the plane is rotating at 90 degrees per second, the yaw damper will put in full rudder to oppose that motion, and at 45 degrees per second it will put in half rudder to oppose that motion. At a measly 9 degrees per second, the yaw damper will put in only 1/10 rudder to oppose that motion. At the 35 degree per second tail-wag of a Cessna 172, the control system would put in as much as about 35% rudder deflection to stabilize the plane's yaw motion. This does not sound like an unreasonable constant.

To enter those settings in X-Plane, once again open Plane-Maker's Artificial Stability window from the Expert menu. Select the Art Stab (that is, artificial stability) tab. The above example deals first with the **heading: target deg sideslip** control, found in the second column from the left in the bottom box of this window, highlighted in the following image. A value of 0 would be entered here, meaning the plane always tries to stabilize at 0 sideslip.



For the **fraction deflection per degree difference** control *immediately to the right of the **heading: target deg sideslip** control*, simply enter 0, meaning the system is not trying to achieve a desired sideslip, only to damp out the tail wagging by opposing rotation.

For the **fraction deflection per degree per second** control to the right of that (highlighted in the following image), enter a value 0.0111.



This number comes from dividing 1.000 (that is, full rudder) by 90 (the rotation rate in degrees per second that *full* rudder should be applied at). 1 / 90 = 0.0, which is rounded to 0.0111 in Plane-Maker. Put another way, that equation is 1 / rate for max yaw. A value of 0.01111 is pretty reasonable. Try entering this for the 172, saving the plane in Plane-Maker, and loading it again in X-Plane. Pop the rudders left and right and notice how the plane damps out faster, as would a real plane if such a yaw damper were installed.

Now, if even *more* stabilization is needed, try entering 0.1 in the **fraction deflection per degree per second** control. This means that if the plane is rotating at 10 degrees per second, the rudder will deflect fully to oppose it. (10 degrees per second times 0.1 control per degree per second = 1.00, or *full deflection*.) A rotation rate of 10 degrees per second means that it will take 9 seconds for the plane's tail to move 90 degrees—a very slow rotation rate. With a constant of 0.1, even this rate will be opposed by *full* rudder. Yikes! If such a plane were taken into turbulence, the air would certainly be kicking the plane around at over 10 degrees per second, so the craft would give *full rudder deflection* first one way, then the other. The plane would over react to every angular rotation induced by the turbulence by kicking the rudder to full in order to oppose that rotation.

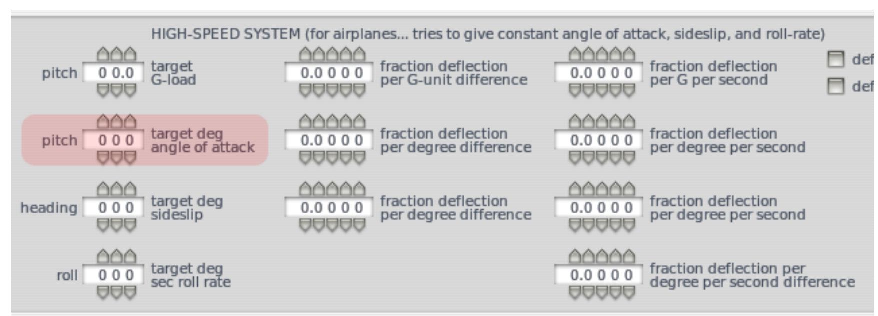
Obviously, this constant of 0.1 is high. Customer support had a call, though, with someone who had entered a constant of 3.0—*thirty times higher* than the hypothetical case above. This means that for a rotation rate of 1/3 degree per second (at which rate it would take a whole four and a half minutes to move thru 90 degrees of heading), the system would put in *full opposing rudder*. Even the tiniest hint of rotation in a given direction would make the rudder slam hard over to counter it. Needless to say, any time this plane met even a touch of wind, the rudder would slam from one stop to the other in a wildly exaggerated effort to counter the turbulence. If one must kill a fly buzzing around in a china shop, don't do it with a sledgehammer—the results won't be pretty. This particular plane handled alright if there was no turbulence—since nothing was rotating the plane, the flight controls didn't have to move to oppose that rotation. As soon as the slightest imperfection came along to move the plane, though, such as turbulence, movement from the pilot hitting a flight control, a bird-strike, an engine-failure, a bumpy landing, or flying into changing winds, the controls went crazy.

One thing that can only be learned by actually getting a pilot's license and getting up in the sky is that it is a *very imperfect world up there*. The plane is constantly barraged by all manner of imperfections, perturbations, and external winds and forces, and, much like with a boat, these imperfections must be *anticipated* in the design.

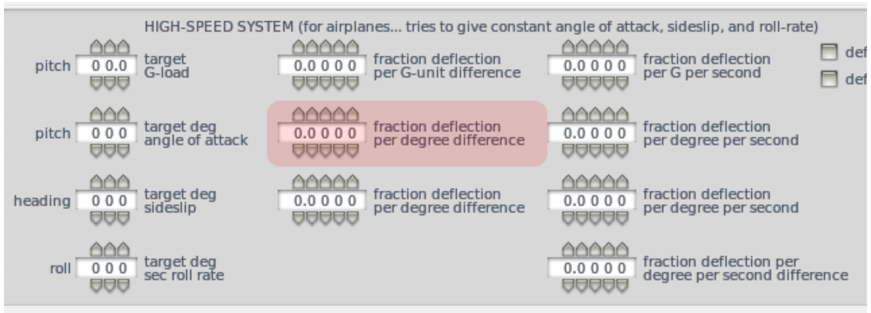
B. Stabilizing Pitch

Now that we've discussed heading stability, let's move on to pitch. If a plane is not very stable in pitch, users may want to "lock it down" a bit. Plane-Maker's Artificial Stability window is used as above if users want to avoid artificial stability controls found in X-Plane (these are applied to all aircraft in the sim and thus aren't applicable any particular craft—see Chapter 3, Section II, Part D on page **34**), but rather want to design their own to mimic one that might be installed in a real plane.

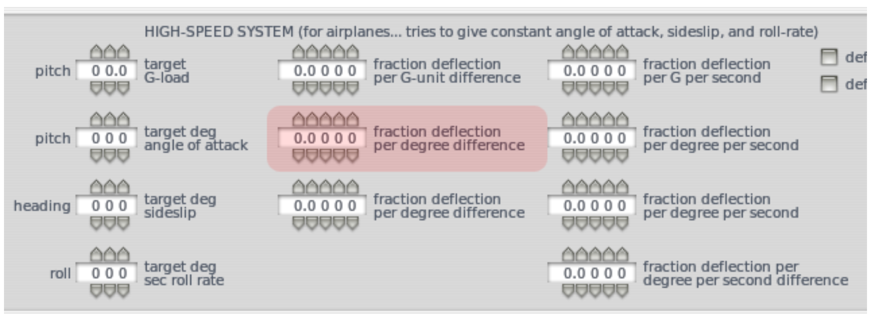
For our example airplane, we will again open Plane-Maker, click the Expert menu, and open the Artificial Stability Window. Once more, select the Art Stab tab. This time, enter maybe 20 degrees in the **pitch: target deg angle of attack** (highlighted in the following image)—this should be enough to stall the plane.



Enter 0.1 for the **fraction deflection per degree difference** (highlighted in the image following), so that if the angle of attack is 10 degrees off, the plane applies full elevator to capture the desired angle of attack.



Finally, enter 0.05 for the **fraction deflection per degree per second** (highlighted in the following image) so that if the nose is coming up at a rate of 20 degrees per second, the system will apply full elevator to stop it.

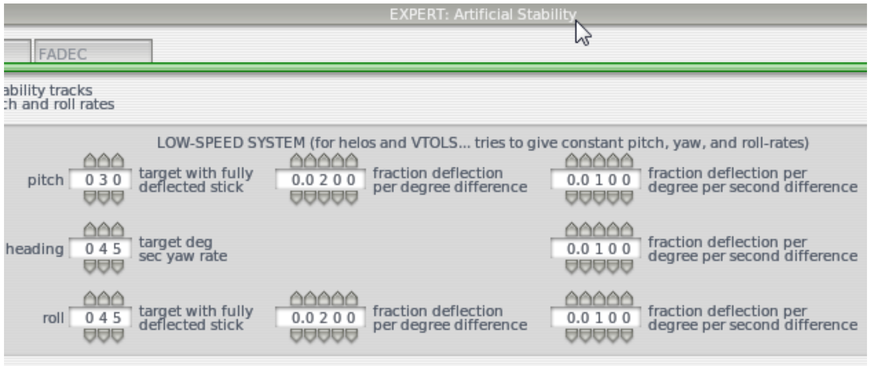


These are all pretty aggressive constants (meaning a lot of elevator is brought in to counteract a small amount of motion), but they aren't extreme.

There are two reasons for using these aggressive constants. First, the plane needs to have lower rates in pitch than in yaw. This is because if the plane is moved left and right a bit, not that much will change in terms of flight control—the vertical stabilizer, which is being broadcast to the air, is small. But, if the plane is tilted up or down a bit, then the *entirety of both the wing and horizontal stabilizer* is exposed to the air. The effect will be much greater than in yaw, where only the vertical stabilizer is offset, simply because the wing is so much bigger. A plane sees a much greater effect for each degree of change in the angle of attack than in sideslip, so it needs lower rates of pitch than yaw to keep within comfortable (safe) G-loads. For this reason, we enter *higher* constants in pitch than in yaw to really work hard to counter those pitch rates.

The second reason for entering higher constants in pitch than might seem advisable is that, quite simply, X-Plane cheats. The simulator will automatically *reduce these settings* as the plane speeds up, because it knows that at high speeds it is better to enter smaller control deflections to keep from breaking things! This means that the constants entered here are only fully applied near stall speeds where control authority is mushy. The artificial stability controls relax and phase out as the indicated airspeed (air pressure on the controls) builds up.

To see this scheme in practice, open up "Austin's Personal VTOL" in Plane-Maker. Go to the File menu, click Open Aircraft, open the Austin's Designs folder, and select Austin's Personal VTOL. Now open the Artificial Stability screen again from the Expert menu. Notice that only low-speed constants (in the top box of the screen rather than the bottom, highlighted in the following image) are set here, designed to phase out rotation rates to make the craft easy to fly.



Look at the rotations that are targeted with full-scale stick deflections in hover—a max of 30 degrees pitch, 45 degrees roll, and 45 degrees per second rotation rate in yaw (now you know what the 0.02 and 0.01 do as well).

Next, open up X-Plane and load up this aircraft (noting that it starts off with its thrust vector at 90 degrees, straight up). Add power to rise up off the ground and work on hovering. Slide left and right, then fore and aft, up and down, all using small control deflections. Then, click on the little switch on the panel labeled ART STAB. This will turn the stability augmentation *off* in order to fly *without* it. Viva la difference! For an even more extreme case, try turning off the artificial stability in Austin's Death Trap at 300 knots.

V. Setting Up Advanced Networks

Suppose a user wants to have two computers running X-Plane, one with the instrument panel on the pilot's side, and one with a panel on the copilot's side. This is called having a master machine and a copilot's machine. Or, suppose a user wants two panels, and maybe a center radio panel as well. Maybe she or he wants an Instructor Operator's Station (called an IOS) to control weather, time of day, and aircraft failures. Or maybe s/he wants a separate computer for an out-the-window view (called an external visual), or to set up a multiplayer session to fly formation with friends.

Maybe the user wants all of the above, all at once!

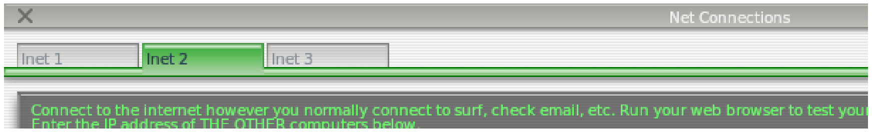
What all of these setups have in common is the use of multiple computers. Each of these computers needs X-Plane installed (scenery and all). They also need to be on the same network, with IP addresses that are the same for the first three numbers (e.g., 10.2.2.*** or 192.168.1.***) and subnet masks of 255.255.255.0.

Once each of the computers has an IP address that meets this requirement, they may be set up something like this, for example:

IP Address	Description
192.168.1.1	Master machine—joysticks plugged in here
192.168.1.2	Copilot's machine (.acf file with copilots instrument panel used here)
192.168.1.3	IOS (instructor's station for initiating failures, setting weather, moving the plane, etc...)
192.168.1.4	External visual, left view
192.168.1.5	External visual, center view
192.168.1.6	External visual, right view

Of course, the LAN must be set up so that the computers can talk to each other, and the network must be ready for an X-Plane multi-computer setup.

With the network configured, open the Net Connections window from X-Plane's Settings menu on each of the computers. Select the middle tab, Inet 2, as seen below.



This tab allows the user to configure a multi-computer X-Plane system. On each computer, simply check the box describing the job of each computer and enter the IP address of whatever *other* computers are called for by the text description. With that done, the sim should be ready to fly!

Let's go through the specific example of setting up a copilot's instrument panel using a second computer. This is requested often by people who are really pushing for a thorough simulation.

A. Setting Up a Networked Copilot's Station

Be aware that there is more than one way to set up a copilot's station. The method described here uses two computers joined over a network. The other method, which uses two monitors attached to one computer, is less expensive, but the results may not be as good as when using two computers (in which case each computer only has to draw half as much). Instructions on using two monitors with one computer to set up a copilot's station are found beginning on page 136.

To set up a networked copilot's station, we will need two computers, each running their own copy of X-Plane. These need to be joined together with either a single crossover Ethernet cable or a pair of Ethernet cables hooked to an Ethernet hub. The computers should form a simple LAN, configured as normal within the Mac OS or Windows, whatever the case may be.

The airplane file to be used will need two copies, both either created or modified using Plane-Maker. The first copy (for instance, named "Boeing 747.acf") should have the *pilot-side instrument panel*. If the user is content with the default panel layout, any of the stock planes could be used.

With the first version of the plane ready (the pilot-side version), simply make a copy of the airplane file and add "_copilot" to the end of the name—for instance, if the file "Boeing 747.acf" was used for the pilot-side version, the copilot-side version would be named "Boeing 747_copilot.acf". The copilots-side airplane should be saved in the same folder as the pilot-side plane.

Next, open the copilot-side copy in Plane-Maker and tweak the instrument panel 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 plane, each with its own instrument panel, with names in the format of "*Insert plane name*.acf" and "*Insert plane name*_copilot.acf". Both files should be in the same folder.

Simply copy that whole aircraft folder from one of the computers over to the other, putting the aircraft folder in the same directory on the second computer. For example, if, on the first computer, the folder was located in:

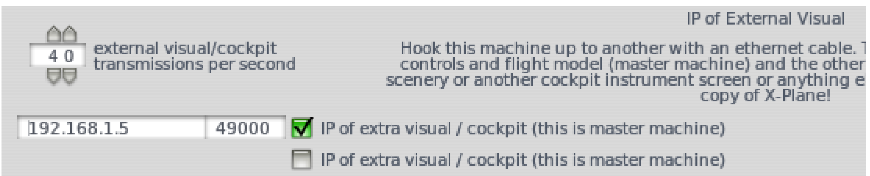
C:\Documents and Settings\Pilot\Desktop\X-Plane 9\Aircraft\Boeing 747\

then, on the second computer, it would be located in:

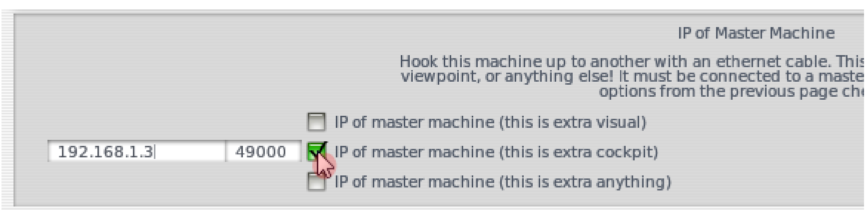
C:\Documents and Settings\Copilot\Desktop\X-Plane 9\Aircraft\Boeing 747\

With that done, open X-Plane on each computer, move the mouse to the top of the screen, click on the Settings menu, then select Net Connections, as shown in the following image.

On the pilot's machine, go to the Inet 1 tab of the Net Connections window. Check the first check box labeled **IP of extra visual/cockpit (this is master machine)** and enter the IP address of the copilot's machine. For instance, in the image below, the copilot's machine has an IP address of 192.168.1.5.



On the copilot's computer, go to the Inet 2 tab of the Net Connections window. Check the box labeled **IP of master machine (this is extra cockpit)** and enter the IP address of the first machine (the pilot's, configured in the paragraph above). For instance, in the following image, the pilot's machine has an IP address of 192.168.1.3.



Now, on the lower left, click on the 'aircraft name reading suffix' and enter "_copilot". This means that *no matter what plane is opened on the pilot's machine*, this computer will add "_copilot" to the name of the plane that it needs to open.

Now, on the pilot's machine, open the "*Insert plane name*.acf" file. If everything is set up correctly, the pilot's machine will send all the appropriate data to the copilot's machine (because the **IP of extra visual/cockpit** box is checked), the copilot's machine will get the message (because the **IP of master machine** box is checked), and the copilot's machine will apply the name "_copilot" to the aircraft name (because of the name suffix that was entered), and it will open the copilot's plane on the copilot's machine.

VI. Setting Up Multiple Monitors

A very commonly asked question deals with how to set up a multiple-monitor simulator. Often, this is in reference to using three monitors in particular. There are two ways to do this. The first is to use one computer with multiple monitors (either hooked directly to the video card or to a video splitter, like the Matrox TripleHead2Go[47]), and the second is to use multiple computers with one monitor attached to each.

Obviously, with all other things being equal (e.g., hardware, rendering options), having one monitor per computer with multiple computers will give the highest frame rate, simply because there is more computing power behind each bit of display. However, using a powerful video card with a high fill rate, it should be possible to use one video card or computer to drive many monitors.

We will first examine the better of the two options (in terms of performance rather than cost efficiency)—using one computer per monitor, with the computers networked as specified in the preceding section, Setting Up Advanced Networks (beginning on page 132).

[47] http://www.matrox.com/graphics/en/products/gxm/th2go/

A. Multiple Computers, Multiple Monitors

Let's assume we are to use four computers and four monitors: one cockpit and three external visuals (a common setup). Go to the Rendering Options screen on each of the three external-view computers in X-Plane. Enter a field of view of 45 degrees for each of them. Enter a lateral offset of -45 degrees for the left screen, 0 for the center screen, and 45 degrees for the offset, with 0 vertical offset on all screens. This will simply yield a 45+45+45 degree field of view. If this is drawn out on a piece of paper, it becomes apparent that the 45-degree 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 sim) in a semi-circle describing a 135-degree field of view. If this is not done, then the horizon will *seem* to not be straight as the craft pitches and rolls, caused by the "fisheye lens" effect. If a 135 degree field of view is described in a *flat* plane or in an arc of monitors that describe less than 135 degrees of arc, fisheye distortion will result, apparent as a horizon that seems to bend and distort between monitors.

In some cases it is *not* desirable for the monitors to wrap *around* the "cockpit," but instead to simply be lined up beside one another *in a flat plane* (as when the monitors are stacked against a flat wall). In that case, an offset in *degrees* should not be used, but rather an offset *ratio*. In the case of using offset ratio, a ratio of 1.0 will cause the lateral offset for that copy of X-Plane (in linear distance) to be an amount equal to the distance between the user and the monitor. So, if the user is six feet from the monitor, and an offset ratio of 1.0 is used, then the center of that monitor should be 6 feet off to the right to line up.

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. Vertical offsets *should not be set* on some machines but not others. As soon as this is done, things start getting messed up. What often happens is that a user will fly with a cockpit in the center screen, where the center of the screen as far as scenery is concerned is probably about 3/4 of the way up the monitor (in order to leave room for the instruments), while using external visuals on the lateral displays, whose screen centers as far as scenery is concerned is right in the center of the monitor. In that case, the viewpoint center needs to be set in Plane-Maker for whatever airplane is being flown. This should be set to the center of the monitor—384 pixels as of this writing, or halfway up the 768 pixel height.

B. One Computer, Multiple Monitors

If the cost of a multi-computer setup is prohibitive, a single computer can be used to drive multiple monitors. Since the virtual demise of the Matrox Parhelia video card, a video splitter like the Matrox TripleHead2Go[48] is most often used. These video splitters trick the operating system (Windows or Mac OS) into seeing the three monitors together as a single super-wide display. To configure this in X-Plane, simply specify the "single" display's resolution in the Rendering Options screen, being sure to also set a wide field of view. The video splitter will distribute X-Plane's output automatically across all three monitors. Of course, to do this with a decent frame rate, the computer will need a very powerful video card.

There are plenty of other ways to have multiple monitors on both Mac and Windows computers, but the rule of using them in X-Plane is simple: If the monitors appear to be one big desktop in

[48] http://www.matrox.com/graphics/en/products/gxm/th2go/

the operating system, then they can form one big window in X-Plane (using the wide resolution and wide field of view that results). Just set the pixel resolution and field of view in the Rendering Options screen in X-Plane to match whatever monitor real-estate is available. This will allow wrap-around visuals from *one* computer.

C. Setting Up a Copilot's Station Using Two Monitors with One Computer

As mentioned in the preceding pages, there are two ways of setting up a copilot's station. One method (which is described on page 133) involves two computers, each running their own copies of X-Plane. The other (described here) involves one computer outputting to two monitors.

With this method, we will create a single, double-width instrument panel, with one side belonging to the pilot and one to the copilot. To begin, create a custom panel in Photoshop that is 2048 x 768 pixels (double the width of the standard panel), to allow room for both sides of the panel. See the following directory for examples of these panel images:

X-Plane 9\Instructions\Example Plane-Basic\cockpit\-PANELS-

The .png files in that directory are examples (though they are obviously only half the width that is needed for the panel we need here).

Once the 2048 x 768 instrument panel image (which is big enough for both sides of the panel) has been created, load the airplane you wish to use in Plane-Maker.

With this open, click the Standard menu and select “Panel” (either 2-D or 3-D). This brings up the panel editing screen where, if the cockpit image was named and sized properly, you will see that the panel is in fact 2048 pixels wide! From here, things are easy: Just drag in instruments so that the pilot side instruments are on the left, and the copilot side instruments are on the right. For the copilot instruments, be sure to do the following:

- Check the **Copilot** button in the bottom center of the window. This indicates what pitot-static-vacuum system each instrument runs on.
- Check each instrument as being on a different electrical bus than the pilot's-side instruments, if desired, in the lower-left.

This will put the copilots instruments on different electrical and pitot-static systems, preparing the craft for the very fun failure-modes of only failing one system or another when in flight!

Now, to fly with this aircraft, two monitors must be used on the computer showing the instrument panels. Both monitors must appear as *one extended desktop* in Windows. To do this in Windows XP, right click on the desktop, select Properties, and go to the Settings tab. Click on the representation of the secondary monitor there and make sure the “Extend my Windows desktop onto this monitor” box is checked. If this is not done, the simulator will run very slowly.

Once both monitors are setup as one extended desktop (with a resolution of, say, 2048 x 768), launch X-Plane on the computer and set its resolution to 2048 x 768. Load the aircraft whose panel was just modified (or created) and it's ready to fly!

VII. 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.

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 *continually 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 ground*. 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 the user decides to take off, s/he does so by *raising the collective up* 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[49]) 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.

[49] http://www.chproducts.com/retail/pedals.html

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 (e.g., 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*—remember that the gyroscopic forces are applied 90 degrees 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 *zero 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.

Use the above information to hover perfectly. Once that is mastered, 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.

VIII. Flying the Space Shuttle

Read this section 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 (that's right—it *slows down* to a bit over *15,000 miles per hour!*) and begins its descent into the atmosphere.

So, if a user wants 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, that user 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 the following 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 (up to 70 degrees bank angle!) and drag the nose up (up to 40 degrees!) 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 Shuttle in X-Plane will have to complete the entire mission by flying by hand. There is not yet an autopilot for the Space Shuttle in X-Plane yet.

A. Walkthrough

Go to the File menu and select Load Situation, then 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 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.

Note: 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, users 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 degrees and be in a 70 degree 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. This is the destination. Hit the '@' key to see the Orbiter on a flyby. Watch carefully—it's going fast. Hit the 'w' key to get back in the cockpit (being sure that the caps lock is off).

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 hit using the '6' key or the mouse. If the lights are half red and half white, the Orbiter is right on its glideslope (about 20 degrees). Airliners fly their approach at 125 knots with a 3 degree 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 degree 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 a user can just repeat that process another hundred times in a row without a single hitch, s/he will be as good as NASA.

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

IX. Flying on Mars

NASA has very exact data on the atmospheric pressure, density, and temperature on Mars. They also have very exact data on the gravity of Mars, as well as rough topographic maps for the entire planet and very detailed maps for some areas. Furthermore, the laws of physics, which are programmed into X-Plane, are exactly the same on Earth as on Mars. X-Plane needs atmospheric pressure, density, temperature, gravity, and topographic maps to deliver an engineering-accurate flight simulation.

X-Plane can simulate flight on Mars.

A. Introductory Letter

The following is an email sent by Austin Meyer, author of X-Plane, to the X-Plane community, at 4:35 AM on February 24, 2000. It is reprinted here in its original, coffee-fueled form.

I DID POSSIBLY THE MOST EXCITING THING I HAVE EVER DONE TONIGHT. (OK, technically I finished it THIS MORNING).
As some of you may know, I have been gathering data on Martian atmosphere, gravity, surface "texture", and topography for X-Plane from various NASA sites
(http://ltpwww.gsfc.nasa.gov/tharsis/mola.html[50], for example)
I do NOT yet have the TOPOGRAPHY for Mars, but I DO have everything else, and I have gotten it all entered into X-Plane and designed two planes to fly on Mars as well, and have been experimenting with deign and flight on Mars for the last 6 hours or so. (Could I be the first human to fly a real-time flight simulation of Mars? I have seen many "movies" of "flying" over Mars terrain, but NONE have been hooked to an actual realistic FLIGHT MODEL... has NASA done a REAL-TIME simulation of Mars flight in a PILOTED aircraft? Has ANYONE?) Well, I have for the last 6 hours, AND IT IS FRIGGIN FASCINATING.
First of all, the atmosphere is ONE PERCENT as thick on Mars as it is on earth... INDICATED airspeed is proportional the square root of the air density, so the INDICATED airspeed is ONE TENTH the true airspeed.
The result? If you take off with 60 knots on the airspeed indicator, your REAL speed is SIX HUNDRED KNOTS! (about Mach 1)
Take it from me, Mach-1 takeoffs are quite a thing to behold, when the plane will barely leave the runway at that speed.
While there is almost no AIR for you, you do have the (sort of)

[50] http://ltpwww.gsfc.nasa.gov/tharsis/mola.html

advantage of only about ONE THIRD the GRAVITY, so it is three time easier to get airborne!

Result? A take-off in a well-designed airplane can occur at a "mere" 400 knots or so, indicating all of 40 knots on the airspeed indicator!

Sound easy? IT ISN'T, BECAUSE WHILE YOUR GRAVITY (WEIGHT) IS ONLY ONE-THIRD OF EARTH'S, YOUR ==>INERTIA<== IS STILL THERE IN FULL FORCE! So you are flying with only 1/3 the total lift of what you are used to having to stay in the air, which seems fine UNTIL IT COMES TIME TO TRY TO TURN OR FLARE!!!!! THEN you see that while the lift for STAYING airborne is only 1/3 of Earth's, the INERTIA, and thus the lift needed to CHANGE DIRECTION (this includes the landing flare!) IS STILL THERE IN FULL FORCE! The problem is, you DON'T HAVE THAT KIND OF LIFT, SINCE THE AIR IS SO THIN!

Bottom line: All airplanes on Mars are AIRBORNE TITANICS: Ripping blissfully along, unaware of their impending doom due to their inability to TURN against their tremendous inertia.

Landings are impossible without arresting gear. If you can work the flare out right (it IS possible with advance planning) then you will touch down doing about 400 mph. Now how do you stop?

->PARACHUTE? NOPE!!!! 400 mph is only 40 mph worth of drag due to the thin air. You will run off the end of the runway going 100 mph with the chute only "seeing" 10 mph: USELESS for slowing down

->BRAKES? NOPE!!! You only have one-third gravity, so only 1/3 of your weight on the wheels. NO TRACTION!

->Reverse thrust? NOPE!!!! With only 1% atmosphere, jet or prop engines can put out basically no thrust... just barely enough to keep the airplane in flight at mach-0.85.. the jet plane needs a JATO to take off!

So how do you stop? I finally went with ARRESTING GEAR. I know of no other way to avoid blasting off the end of the runway at 200 knots with the chute uselessly deployed and brakes uselessly locked.

Speaking of which, CRASHES are interesting. No air drag to slow the tumbling planes down, and little gravity to drag them to a stop against the ground! Crashes look like "the Agony of Defeat" from the Olympics where the guy on the downhill ski-jump bites it near the top of the ramp and tumbles on and on and on, powerless to stop an accident that started hundreds of yards earlier! (though on mars, at 400 mph, your plane will tumble across the plains for MILES!)

CRUISING ALONG OVER MARS is SPECTACULAR, with the scary red-orange Martian sky, new Martian rocky-red terrain textures, VISIBLY thinner air(!) (due to modified lighting in OpenGL, modified fog in OpenGL, and visibility of stars).. you really can tell you are halfway between air and space! Returning to Earth, you feel like you are flying in soupy water! Yuk!

So what sort of planes can fly on Mars? Not anything from Earth, that's for sure. Not enough lift or thrust. A Cessna or Boeing will just sit there on the ground without even moving. Put them in the air and they drop like beveled bricks with no wings. Both of my Mars-plane concepts are much like the U-2 Spy plane (designed to operate at around 100,000 ft, in similar density air) one with a HUGE high-bypass jet engine built AROUND THE FUSELAGE, and another with a smaller rocket engine in the tail, like the X-15. The rocket plane has a lower-thrust engine, with plenty of fuel, for about 30 minutes of flight or so... the JET plane can fly for hours! My designs are realistic (again, based on the U-2, with reduced weight for the lower structural needs (lower gravity) and modern (composite) materials). The rocket-plane is pretty much guaranteed feasible (known technology across the board) but the jet-powered one I am not sure about since Mars has so little OXYGEN in the atmosphere it may be impossible to keep a turbofan engine running. (My Mars jet-plane has twice the average fuel-consumption, though, to simulate injection of liquid oxygen or nitrous oxide). Bottom line, I now know it IS possible to build and fly a piloted plane on Mars and I now know what it would be like. (though I used a 10,000 ft runway with arresting wires... none of those on Mars now I admit).

B. Tips

With the latest versions of X-Plane, the Martian terrain is finally available. We'll now discuss touring that terrain.

X-Plane has *planet-wide* Mars elevation data thanks to NASA's Mars Orbiting Laser Altimeter (or MOLA, a satellite orbiting Mars that gathered terrain elevation data on the entire planet). All of this scenery has been gridded for X-Plane. Contrary to common assumption, Mars is not flat, with a few meteor impacts here and there—not even close!

For example, even though Mars is one half the radius of Earth (with one quarter the surface area), it has canyons that make our Grand Canyon look like a fish pond (30,000 feet deep!). It has a volcano 65,000 feet tall. The atmosphere is gone to essentially pure vacuum at 155,000 feet, so if one climbs the volcano, he or she is about halfway to *space*! Mars has *far more* topographic variety than Earth, on a planet with only a quarter of the surface area, so the sight-seeing by air is *intense*. The max allowable visibility in X-Plane has been raised to 60 miles when on Mars so that the grand vistas can be taken in.

Aircraft designed for Earth will simply not fly on Mars. It is recommended that one of the aircraft found in the Mars Planes folder (within the Aircraft folder) be used.

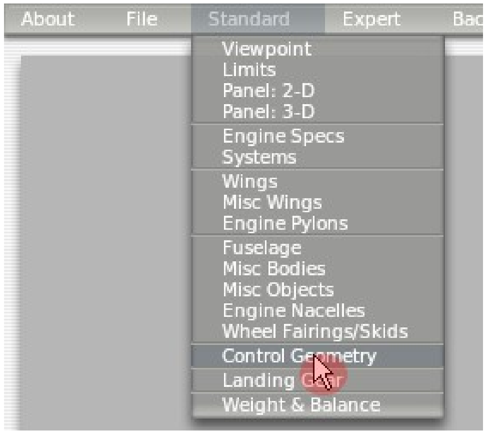
Taking off and landing is interesting. A pilot is tempted to pick a nice, high spot to make an airport so that there are no obstructions to a landing approach. However, the air is so thin up there that aircraft can hardly fly! In that case, maybe a pilot wants an airport at the bottom of a canyon or meteor crater where the air is thicker. That could work, but watch out for the canyon or crater wall when approaching and departing, or face impacting the crater wall at the speed of sound! Of course, the speed of sound is around the minimum speed needed to fly on Mars.

X. Force Feedback in X-Plane

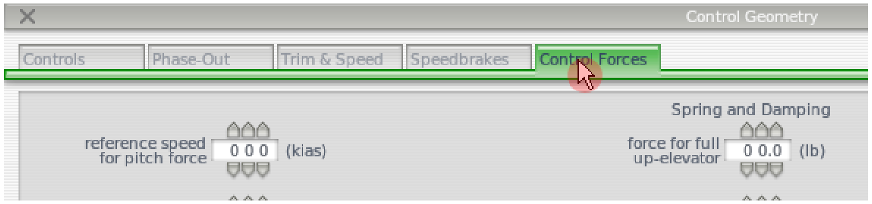
One interesting addition to X-Plane 9.31 and later is the option to drive force-feedback controls.

This unlocks the potential to build some amazing simulators with X-Plane that could achieve very high levels of certification.

To the force feedback options, first open up Plane-Maker (found in the X-Plane 9 installation directory). Load the aircraft for which the force feedback controls will be modified (by clicking on the File menu and selecting Open). With the aircraft open, open the Standard menu and click Control Geometry, as shown below.

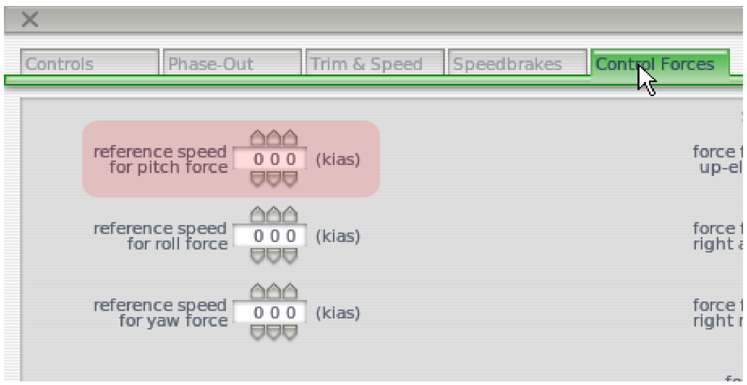


In the window that opens, go to the Control Forces tab, as shown in the following image.



Let's go through each variable that can be set here.

A. Reference Speed for Pitch Force



Imagine you take the airplane up, fly it at 90 knots indicated airspeed (kias), and it takes 10 pounds of force to move the elevator aft 50% of it's travel.

In this case, your **reference speed for pitch force** is 90 knots. This is the speed for which you recorded the elevator force in the real plane.

B. Force for Full Up-Elevator

To the right of the **reference speed for pitch force** is the **force for full up-elevator** control. Using the previous example, where it took 10 pounds of force to move the elevator 50%, one would enter 20 pounds for the **force for full up-elevator**; because it took 10 pounds to go halfway, it must take 20 pounds to go all the way to the stops, assuming that the control force is linear with displacement. Of course, in reality, the control force might not be perfectly linear with displacement, but this is probably a decent approximation.

C. Pitch Damping

Start by entering 0 here, and then increasing the force a bit if needed.

This simply is the number of pounds that will resist the SPEED of the control deflection to damp out oscillations.

Depending on your hardware, it may be that none is required. Of you may need to enter some value damp out rapid motions of the yoke.

D. Roll, Yaw, and Brake Reference Speeds and Forces

Same as for pitch, of course. Just enter the speeds at which you deflected the controls in the real plane, and the force required to fully-deflect those controls. For safety, it makes sense to only PARTIALLY deflect the controls in flight (WARNING! FULL-DOWN ELEVATOR IS EXTREMELY DANGEROUS IN THE REAL-PLANE.. IT CAN OVER-STRESS THE AIRPLANE EVEN >BELOW< MANEUVERING SPEED!!!) and then multiply the force that you enter into Plane-Maker to be the force that would be required to get full-scale deflection, using linear extrapolation.

E. Turbulence and Ground

I think you should probably enter 0 here, but if you want the stick to thrash around a bit in turbulence or on the ground, then try entering values here to get a nice response.

F. Stall and Shaker

For the aerodynamic stall, enter the number of oscillations per second that are desired to flop the stick back and forth, and the number of pounds of force that result. Ditto that for the artificial stick-shaker.

G. Hydraulic Force Increase

If you are simulating a plane that operates with hydraulic boost that can be lost, then enter how much stiffer the controls get here when hydraulic pressure is lost.

H. Force Maximums

For safety, we can limit all forces to pre-determined values... enter those maximums here!

9. Supplement: Airfoil-Maker

Now let's talk about the Airfoil-Maker application, found in the X-Plane 9 installation directory.

I. Menus

The menus of Airfoil-Maker are very simple:

A. 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.

B. 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.

i. New

Use this to generate a new airfoil.

ii. Open

Use this to open an existing airfoil for viewing or modification.

iii. Save

Use this to save an airfoil that was created or modified.

iv. Save As

Use this to save an airfoil that was created or modified under a different name.

v. Exit

Exit Airfoil-Maker.

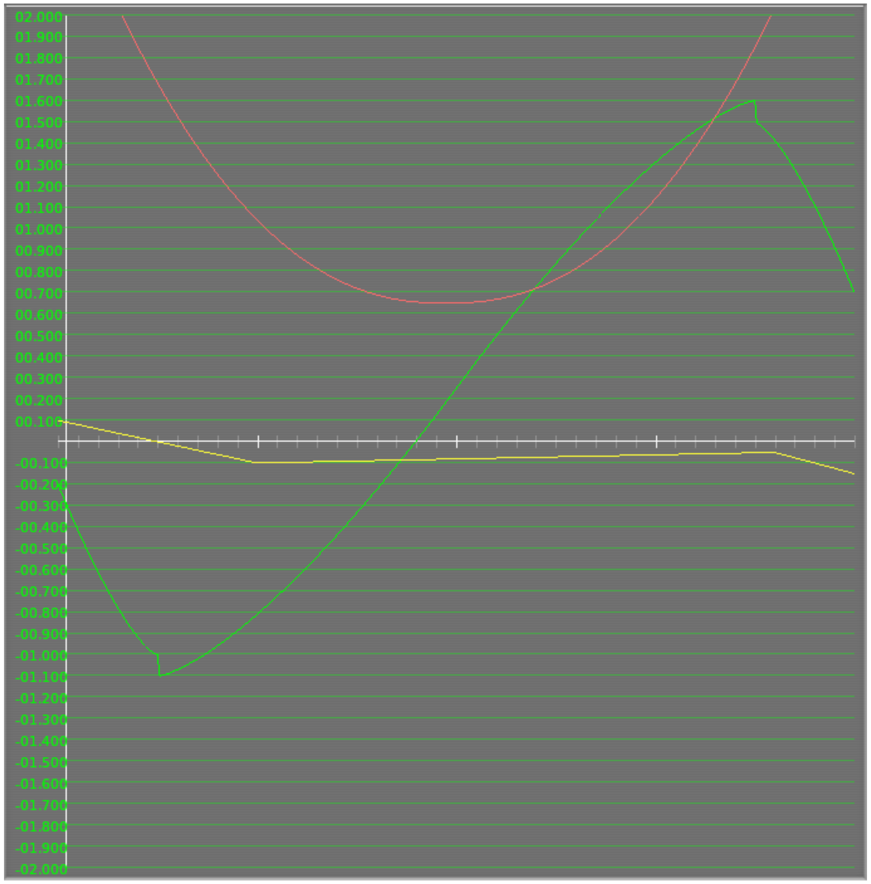
II. Designing an Airfoil

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. The Coefficient Graph

Dominating the design screen is a large black graph with green, red, and yellow lines on it, like the following image.



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 the following image) to change in real time.

This is the coefficient display box, and it displays, for whatever angle of attack the mouse it 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.

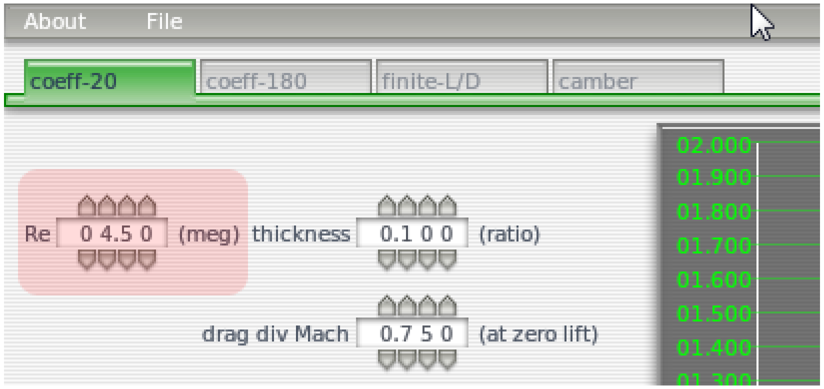
The left edge of the graph corresponds to an angle of attack of -20 degrees, and the right edge corresponds to an angle of attack of +20 degrees. Therefore, moving the mouse to the left edge of the chart will cause the **alpha:** reading in the black box to go to -20, corresponding to the -20 degree 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.

B. Reynolds Number

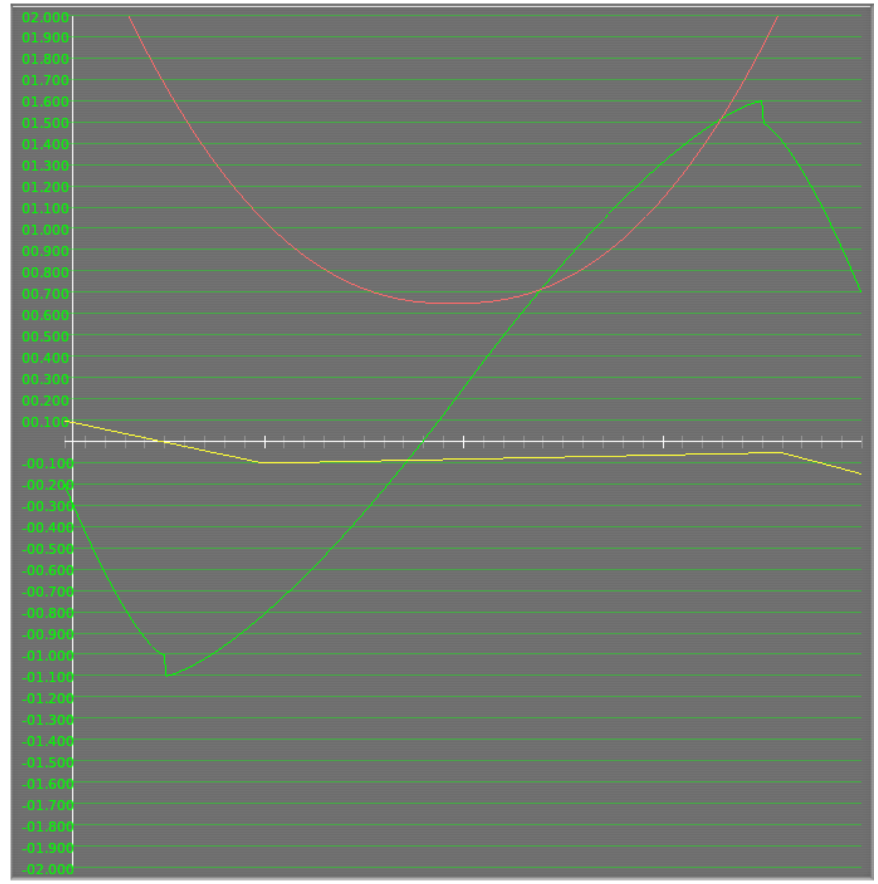
In the upper left of the screen is a number labeled **Re**, for Reynolds number, as highlighted in the following image.



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.

C. Coefficients



i. Coefficient of Lift

The green line in the graph above 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 is representing 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.

ii. Coefficient of Drag

The red line on the graph on the previous page 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).

iii. Coefficient of Moment

The yellow line in the graph on the previous page 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.

D. General Info

i. 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.

ii. 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 users understand the basics of airfoil theory and nomenclature, we recommend:
Theory of Wing Sections
Abbot and Von Doenhoff
McGraw-Hill, New York (1949)

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.

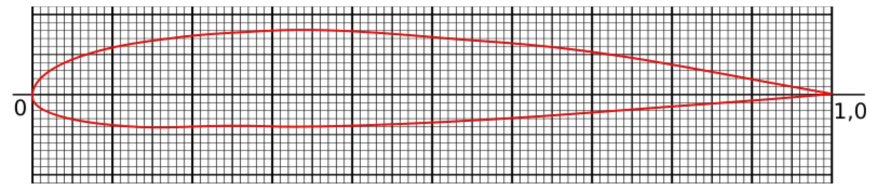
iii. Types of Airfoils

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 the following image), are compromises between the two, and are good candidates for the wing of a general aviation aircraft.

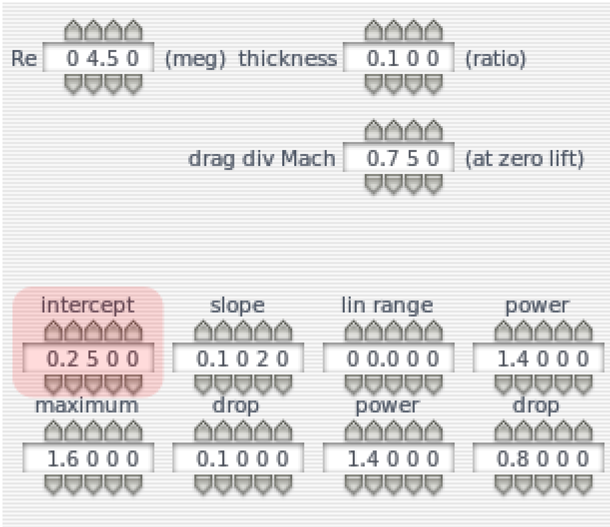


Supercritical, laminar-flow, and other possible groupings of airfoils exist, but for the purposes of our discussion we will concentrate on the thin and symmetrical, thick and highly cambered, and "normal general aviation" airfoils just outlined.

E. Generating Airfoils

i. 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 the following image.



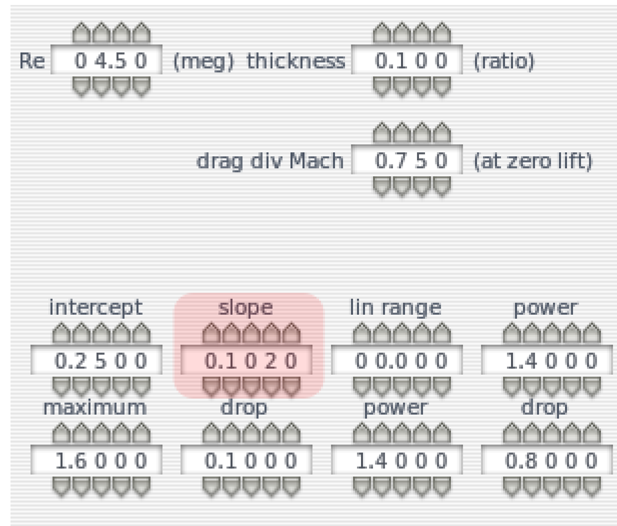
To increase this number, just click right above the digits that you want to increase, and below the ones that you want to decrease. For example, if the lift intercept on the screen is 0.25 (as in the previous image), and you want to change it to 0.33 to model your airfoil, just click above the "2" in "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 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.

ii. 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).

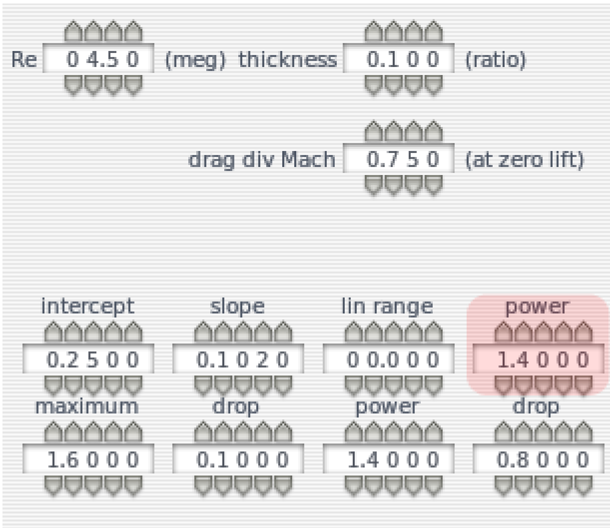
The coefficient of lift slope is modified using the **slope** control highlighted below.



iii. 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, highlighted in the screenshot below.

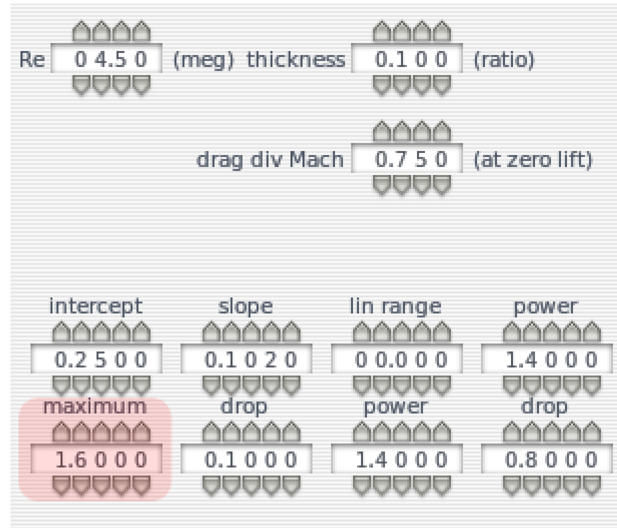


Just play with this control until you find a power curve that connects the linear and stalling regions smoothly. Chances are a power of around 1.5 will work pretty well. Just play with it until the lift comes up smoothly, then gradually levels off to the stall, since that is what happens with a real airfoil.

iv. 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.

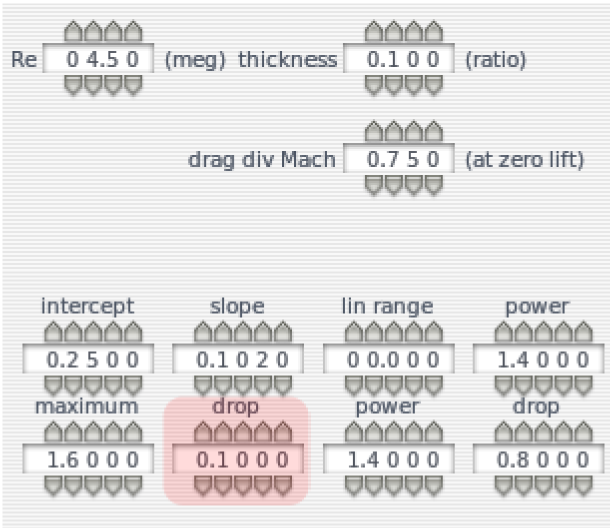
This value is modified using the **maximum** control, highlighted in the following image.



v. 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 gradual one as the angle of attack is further increased. In most cases, this number will be zero or very close to zero.

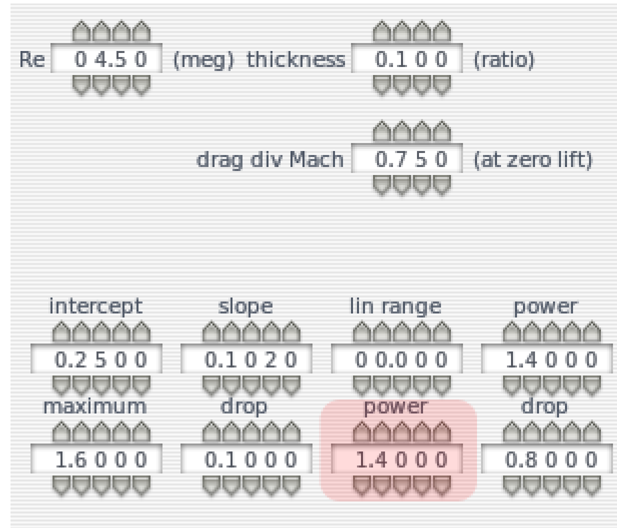
This is modified using the **drop** control highlighted in the following image.



vi. 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.

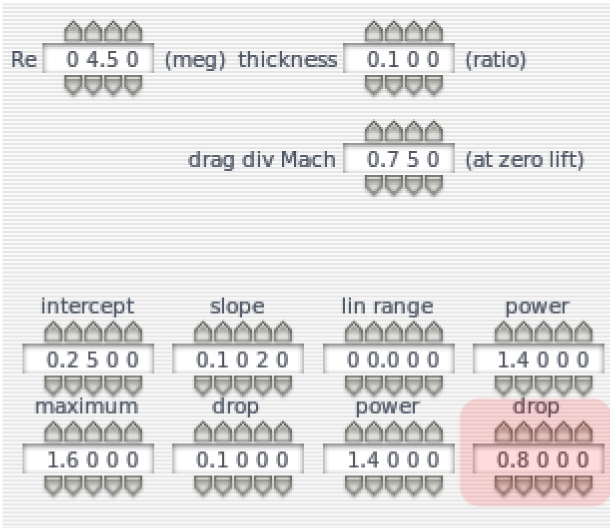
This setting is controlled via the box highlighted in the following image.



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.

vii. Coefficient of Lift Drop from Stall to 20 Degrees

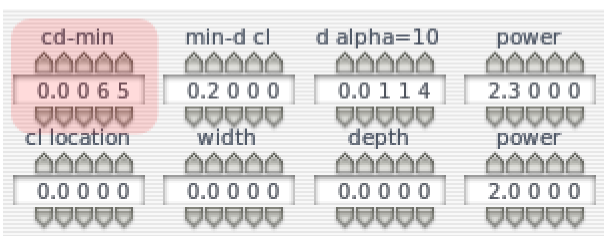
This is the decrease in coefficient of lift from the stall to an angle of 20 degrees. This number, modified using the **drop** control highlighted in the following screenshot, might be in the 0.4 range for a thicker airfoil, 0.6 for a thinner one.



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).

viii. Coefficient of Drag Minimum

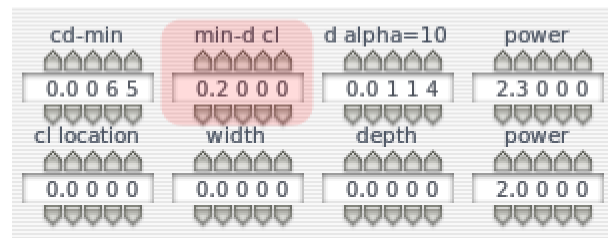
The coefficient of drag minimum, labeled **cd-min** in the image below, is the minimum coefficient of drag of the airfoil. Once again, this does not include *induced* drag, which is determined automatically by the X-Plane simulator.



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.

ix. Coefficient of Lift at Which Minimum Drag Occurs

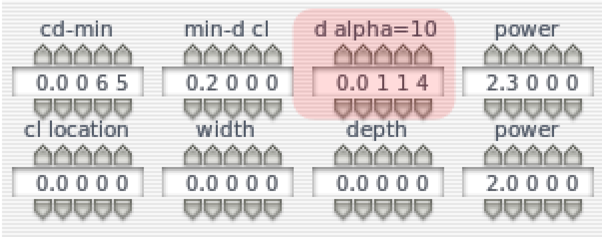
Enter the coefficient of lift at which the minimum drag occurs in the **min-d cl** control, highlighted below.



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.

x. Coefficient of Drag at Angle of Attack of 10 Degrees

This value is modified using the **d alpha=10** control highlighted in the following image.



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.

xi. Coefficient of Drag Curvature

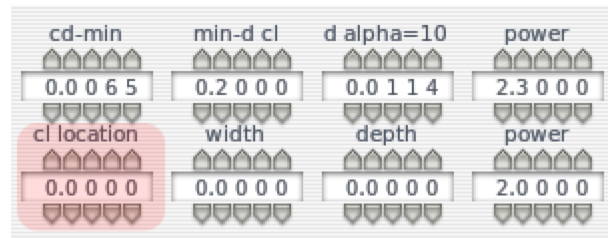
This value is set by the first **power** control in the drag section, highlighted in the following image.

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.

xii. Laminar Drag Bucket Location

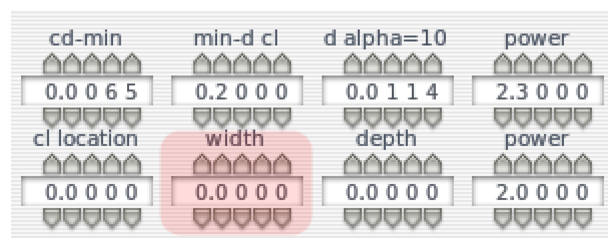
Some airfoils, called “natural laminar flow” or "NLF" airfoils, have perfectly smooth airflow across a large part of the wing. This flow pattern is called "laminar flow" (hence the company name "Laminar Research"). This super smooth, low-drag flow can only happen at fairly small angles of attack, though, 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 highlighted in the following screenshot.



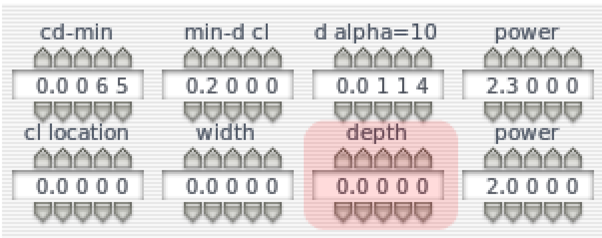
xiii. Laminar Drag Bucket Width

The laminar drag bucket width, set using the **width** control highlighted in the following screenshot, 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.



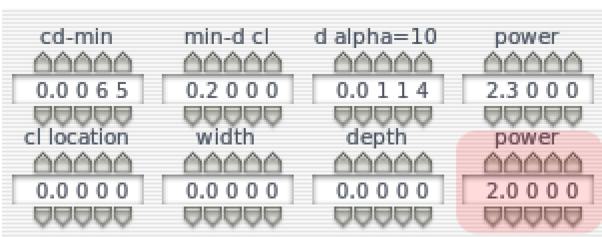
xiv. Laminar Drag Bucket Depth

This is the all-important variable. The **depth** control, highlighted in the image below, 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.



xv. Laminar Drag Bucket Curvature

This is set using the second **power** control in the drag section of the window, highlighted in the following image.

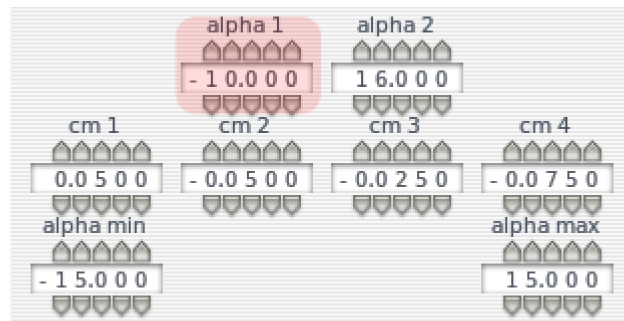


The power curve is simply the curvature of the low drag bucket. You will have to fiddle with the curvature until the curve looks like the experimental data, but chances are this number will be around 3 to 5.

xvi. Coefficient of Moment Low-Alpha Change Point

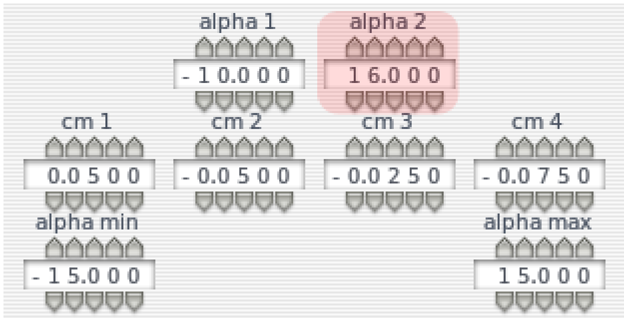
The coefficient of moment is usually linear across the non-stalled angle of attack range. In other words, if the airfoil is not stalled, the moment curve is usually a straight line. After the stall, however, the moment coefficient tends to change direction. For the NACA 2412, the moment coefficient has 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 below.



xvii. Coefficient of Moment High-Alpha Change Point

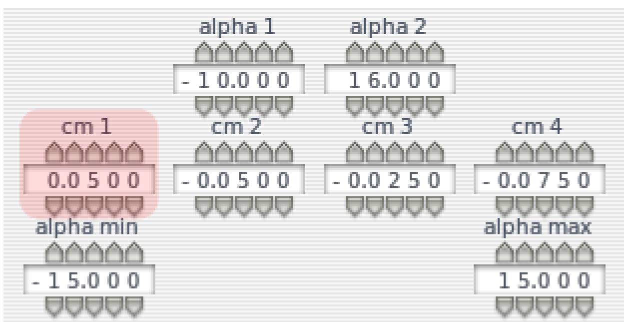
This characteristic, set using the **alpha 2** control (highlighted below), determines where the moment coefficient changes direction with a positive angle of attack.



The NACA 2412 airfoil has its high angle of attack moment-change right at the positive stalling angle of 16 degrees.

xviii. Coefficient of Moment at 20 Degrees

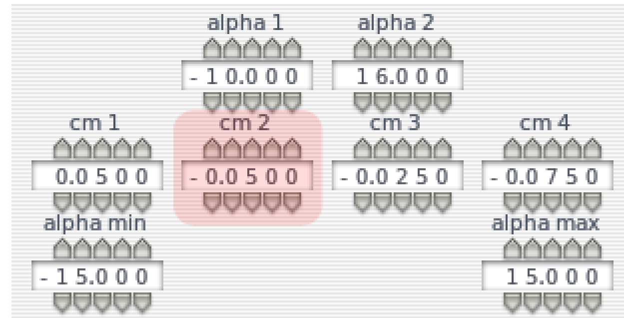
This is set using the **cm 1** control, highlighted in the following screenshot.



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.

xix. Coefficient of Moment at Low-Alpha Change Point

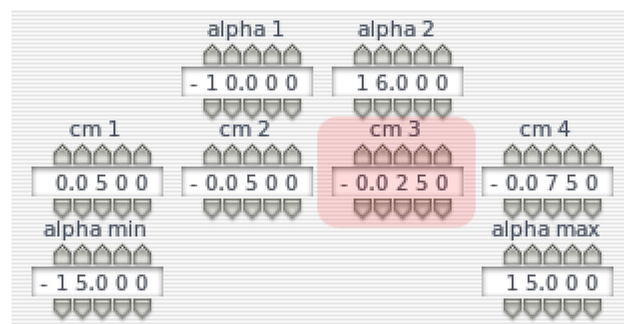
This is set using the **cm 2** control, highlighted in the following image.



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.

xx. Coefficient of Moment at High-Alpha Change Point

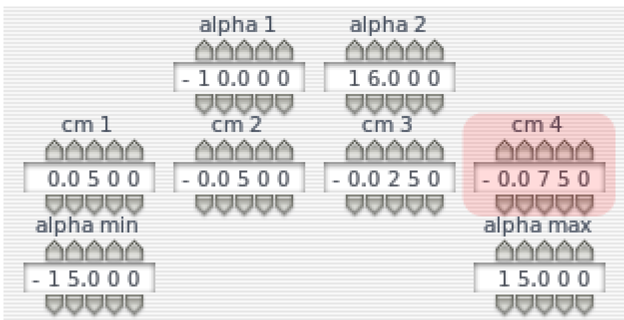
This is set using the **cm 3** control, highlighted in the following image.



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.

xxi. Coefficient of Moment at 20 Degrees

This is the coefficient of moment well into the stall, set using the **cm 4** control highlighted in the following image.



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.

F. 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 9 folder (so that it will be usable by *all* planes) or a folder that you make called "Airfoils" in the same folder as your airplane designs (to be used only by that airplane).

10. Supplement: Plane-Maker

I. Plane-Maker Description

Plane-Maker is a program bundled with X-Plane that lets users design their own aircraft—nearly any imaginable aircraft can be built! Once all the physical specifications of the airplane have been entered (weight, wing span, control deflections, engine power, airfoil sections, etc.), the X-Plane simulator will predict how that plane will fly. Airplanes are saved in Plane-Maker just as one would save a word processing file. These files are then opened in X-Plane and flown. Users can create a .zip file of all the components of the airplane and distribute that ZIP on the Internet for others to fly. Planes created by others can also be downloaded and used in the simulator. X-Plane.org's "Download Manager" page[51] is currently a good place to upload and download these planes.

Note that information on how to add aircraft to X-Plane is found in Chapter 7, Section I, Adding Third-Party Aircraft on page **114**.

This chapter will cover the basics of both the creation and distribution (likely over the Internet) of aircraft using Plane-Maker.

II. Licensing of Planes Created in Plane-Maker

Users are free to do *whatever they like* with planes they have created.

The end-user license agreement (EULA) of X-Plane is pretty simple. It begins, "You can use X-Plane for anything you want!" One excellent use for Plane-Maker is to create the airplane of one's dreams, fly it in X-Plane, and then upload it to the Internet for others to fly! Even better, if a company has an exciting airplane, it can be built in Plane-Maker, test flown in X-Plane, and then put on the company's web-site for customers or potential customers to download! Anyone that has X-Plane will be able to download the virtual version of the airplane and fly it in X-Plane. This is great because it will first teach more people to fly the airplane (creating potential customers) and then improve the currency of those that already fly it (creating safer customers). Of course, Plane-Maker can also be used to enter an aircraft that a user already has and flies every day, simply for the purpose of keeping up the pilot's stick-and-rudder and instrument skills.

III. Using Plane-Maker to Make a Plane

We may, at some point, write the 200-page book needed to explain every detail of entering a user's own design in Plane-Maker, but the following are the basics, which are enough to get users started and working on their own.

First, open the X-Plane 9 folder and double click on Plane-Maker.exe to get Plane-Maker running. Once it opens, go to the File menu and select Open. Select the Instructions folder and then select one of the Example Plane airplanes. One of the example planes has a 2-D instrument panel which is easiest to customize, and one of them has a 3-D cockpit which is harder to customize but provides an example of a 3-D virtual cockpit if the user decides to make one.

Once an airplane has been opened in Plane-Maker, the key to mastering the software is to simply go to every menu item in Plane-Maker, noting the hundreds of parameters of the airplane that can be changed. (Want to try flying with twice the power? Twice the weight? Half the wing-area? Try it!)

Once a few parameters have been changed, it is time to save the plane and fly it. To do this, go to the File menu and select Save

[51] http://forums.x-plane.org/index.php?autocom=downloads

Aircraft.

Now, launch X-Plane and select File > Open Aircraft. Select the airplane that was just saved in Plane-Maker and voila! The newly-modified airplane loads, ready to fly. This is the process for creating aircraft and flying them in X-Plane.

IV. Adding Airfoils to a Plane in Plane-Maker

It should be pretty self-explanatory how to enter all the data into Plane-Maker (all the buttons are clearly labeled), but one question that comes up a lot is, “How do I attach various *airfoils* to my aircraft, particularly at *different* Reynolds numbers?”.

Like everything in X-Plane, this is pretty easy once the basics are mastered.

First, note that X-Plane does *not* look at the *shape* of the wing and then decide how much lift, drag, etc. the foil will put out. X-Plane is *not* a computational fluid dynamics program. Instead, X-Plane uses pre-defined airfoils that list the *performance* of any airfoil (lift, drag, moment) to predict how the plane will fly with that foil. To learn how to enter that performance, read Chapter 9 (the Airfoil-Maker supplement, found on page **147**) of this manual, as it details how to enter the lift, drag, and moment of any given airfoil at any given Reynolds numbers.

Now, let's imagine that you have just created *two* foils in Airfoil-Maker, one for a NACA-2412 at Re = 3 million, and one at Re = 9 million. You might save the foils with names like "NACA 2412-Re3.afl" and "NACA 2412-Re9.afl". The Airfoil-Maker manual explains how to do this.

With this done, launch Plane-Maker and open the airplane. Then go to the Expert menu and select the Airfoils menu item.

In the window that opens, tab over to the area containing the various different wings that the airplane has. Let's take the Wings tab, for example. You will notice that there are 4 airfoils listed for the "Wing 1" box. How could *one* wing have *four* airfoils? Easy! There could be one type of wing at the tip, another at the root, with linear interpolation in between! There could be one airfoil file for *low* Reynolds numbers, and another for *high* Reynolds numbers, with X-Plane interpolating in between. That comes to *four* airfoil files—two Reynolds numbers at the *root* (on the left) and two Reynolds numbers at the *tip* (at the right). The lower Reynolds numbers go at the *top* of the box, the higher Reynolds numbers go at the *bottom*. Just hold the mouse over the gray box to the left of each airfoil name to get a reminder of this if needed.

Now, for the example of the hypothetical plane above, you would select (by clicking on the little gray box to the left of the airfoil names) "NACA 2412-Re3.afl" for the upper left, and "NACA 2412-Re9.afl" for the lower left, assuming the wing uses a NACA 2412 at it's root and X-Plane needs to give accurate performance at Reynolds numbers of 3 and 9 million, with linear interpolation in between.

The same goes, of course, for the wing *tip*, and all the other foils on the plane.

V. Finishing the Plane with Custom Cockpits, Paint, and Sounds

We’ve covered how to create, modify, upload, and download airplanes for X-Plane, but an aircraft has been created in Plane-Maker, the discerning user will notice that the instruments are all X-Plane standard, the sounds are all X-Plane standard, and the airplane is simply grey.

To take the aircraft to the next level of customization, with custom paint, instruments, and sounds, let’s look at some examples.

In the operating system, open the X-Plane 9 folder. Go into the Instructions folder and find the “Example Plane-Basic” folder. This is the example craft with a 2-D cockpit only. We will use this to see what sorts of things can be customized on the airplane.

The Example.acf file in this directory is the actual aircraft file that contains all the data that defines the airplane. This is what is saved in Plane-Maker.

A. Custom Paint

Open the various Example_paint.png files. These are the paintjobs for the plane. They can be painted any way a user likes in Photoshop (or even MS Paint) to make them perfect for a particular design. The files may be saved as either .bmp or .png. Notice the Example_prop.png file. Its name is self-explanatory. Of course, the prop images can be modified as well.

For any plane, simply follow the naming convention seen in this folder: name paintjobs as “*aircraft name*_paint.bmp” and “*aircraft name*_paint2.bmp.” Each bitmap may currently be up to 1024x1024 in size. All bitmaps must be powers of 2 in size (that is, 2, 4, 8, 16, 32, 64, 128, 256, 512, or 1024 pixels in width and height). To control what part of the plane lives in what bitmap (since you have up to two bitmaps), go to the Expert menu in Plane-Maker, and select the Texture Region Selector window.

B. Custom Panels and Instruments

Now look in the Cockpit folder within the Example Plane directory. In this folder are just a few custom panel and altimeter files. Needless to say, these particular custom files are just the tip of the iceberg. Look in the X-Plane 9\Resources\bitmaps\cockpit\ folder to see the approximately 750 instruments that can be added to an airplane. Each of the instruments seen there may be copied to an aircraft folder and customized just like the few sample cases seen in the Example Plane folder.

When opening the example craft in X-Plane, the instrument panel and altimeter will be stunningly ugly. This is simply to make it obvious at a glance that they are custom, non-standard instruments.

In conclusion, simply follow the model seen here, using the instrument names and folders as in the Resources\bitmaps\cockpit\ folder, and customize *all* of X-Plane's instruments for an airplane.

C. Custom Sounds

Look in the example plane’s Sounds folder to see some custom sounds associated with this plane. All it takes to add a custom sound is to make a WAV file and name it as "*Aircraft name* engn*x*.wav", where the *x* is the engine number (1 for left, 2 for right). Drop that file into the Sounds\engine\ folder and it’s ready to go. For a complete list of *all* the sounds that can be customized, look in the X-Plane 9\Resources\sounds\ folder. Just like the Resources\bitmaps\cockpit\ folder is a list of all the *instruments* that can be customized, the Resources\sounds\ folder contains a list of all the *sounds* that are customizable by placing them in an aircraft’s folder! Follow these simple conventions and add whatever custom sounds are needed.

D. Custom Weapons and Slung Loads

Plane-Maker can also be used to create missiles and bombs for an aircraft. In Plane-Maker, go the Expert menu and select Build Weapons. There, users can make and save a weapon. You will be saving a .wpn file that should go in the aircraft’s Weapons folder. For example, look in the example plane's Weapons folder. This is where the users would save weapons. The Example_weapon.bmp file is simply the paint that goes on the weapon. Note, of course, that one can have a good handful of weapons on a given plane.

The Weapons window can also work with slung loads (a Jeep carried by a Black Hawk helicopter, for example). These objects can be selected as a slung payload in the Weight and Fuel window, selected from the Aircraft menu in X-Plane. These objects can be saved in the 3-D editor AC3D. A custom texture for the slung load can be created by specifying an image to use in the OBJ file.

E. Custom 3-D Cockpits and Bodies

Now we come to the pinnacle of aircraft designing—making custom 3-D cockpit and bodies for an airplane with a 3-D editor. This goes beyond the basic 2-D cockpits and the simple shapes of the standard airplanes and up into the level of total customization and accuracy.

Look at the example plane's Example_cockpit.obj. This is the 3-D virtual cockpit, if you want your plane to have one. By default, pressing Ctrl + O (that is, the control key and the 'o' key) in X-Plane will send the cockpit into 3-D mode. From there, use the a, s, d, w, r, and f arrow keys and the mouse to move around in the 3-D cockpit. Look at the example plane's Example_cockpit_texture.png. This is the texture that will be used in the (totally optional) 3-D virtual cockpit, if one exists.

The 3-D panels are created as object files with a .obj extension. These OBJ files are simply 3-D objects that X-Plane can draw. To create them, users will need an editor that can create 3-D objects and save them in the OBJ format. AC3D (downloadable here[52]) is one such editor.

Full documentation on creating object files is found at scenery.x-plane.com[53], but a brief description follows.

VI. Creating Objects for X-Plane

Users sometimes mean different things when asking how to create objects to be used with X-Plane—some may mean the aircraft themselves, some the scenery objects, and some the 3-D cockpits. The answer as to how to create them varies depending on what is being discussed.

First of all, for the aircraft itself, there is only *one* answer—the X-Plane .acf file, as saved by Plane-Maker (bundled with the simulator and located in the X-Plane 9 directory). X-Plane looks at this file to determine flight physics, mass properties, engine power and limits… the works. As such, it is highly customized to X-Plane and could *never* be any sort of "all-purpose" format. This means that you can only use Plane-Maker, and *nothing but* Plane-Maker, to make the aircraft.

While Plane-Maker is perfectly adequate for entering the design of the plane (it is bug-free, easy to use, not too fancy, and reliable) Plane-Maker is *not* a 3-D model editor. Instead, it is used to lay out the basic aerodynamic shapes and properties which result in an airplane that looks okay, but would certainly *not* knock anyone's socks off. As such, it can *not* make the complex 3-D model that is needed to make a cool 3-D cockpit, or to make a highly detailed aircraft model that might overlay the basic Plane-Maker model from which flight physics are calculated.

These 3-D models *can also be used* to create buildings and other custom objects—*not just plane overlays and cockpits*.

So, to repeat:

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[52] http://www.inivis.com/downloads.html
[53] http://scenery.x-plane.com/

1. Plane-Maker can be used on its own to make a model for X-Plane. It will look okay and will fly fine. It will be pretty good.

2. In *addition* to this Plane-Maker model, you can make a 3-D cockpit to sit inside the plane, or a highly detailed aircraft model to overly the basic X-Plane model, which could actually be made with transparent textures to be invisible, if you desire.

Clearly, users can use Plane-Maker, which comes with X-Plane, to do part 1 above, but not part 2.

See the "Example Aircraft" in the "Instructions" folder for a very simple example.

So, what editor does one use for part 2?

To do part 2 of the above, you will need a 3-D editor capable of saving an object in the X-Plane OBJ format. **Note:** This is *not* the same as the Alias OBJ format.

The following file formats can be used to create X-Plane OBJ files:

- 3DS (Autodesk 3D Studio)
- DXF (Autocad)
- OBJ (Alias Wavefront)
- AC (AC3D)
- MD2 (Quake model)
- WRL (VRML)
- LWO (LightWave)
- TXT (Milkshape)

With each of these file extensions, users need to convert the objects to ones usable by X-Plane. This is often done by opening the file in AC3D, then using the X-Plane plugin downloadable here[54] to export the file as an X-Plane OBJ.

Alternatively, after an object has been created in 3DS or Autocad, ObjConverter may to be used to convert it. ObjConverter comes in the Scenery Tools pack, downloadable here[55].

Alternatively, direct export to an X-Plane OBJ file is available in the two *free* 3-D editors by Jonathan Harris—both Google Sketchup[56] and Blender[57].

Note: All of these exports are limited by file format issues:

- 3DS doesn't feature lines, only meshes.
- DXF/Autocad has no texturing info.
- Lightwave's texturing model doesn't correspond to ours very well.
- VRML conversion between programs doesn't usually work well.

There may be other issues, too, in converting between formats.

In all cases, though, the file needs one texture per object.

The bottom line is that there are a *lot* of ways to get objects into X-Plane from just about any 3-D editor imaginable. If it isn't on this list, and the 3-D editor is decent, it can probably export to one of these formats such as 3DS, Alias Waverfront OBJ, or similar.

For pure "meshes" made with one texture, no tricks, 3DS seems to be the most reliable conversion format for simple work.

VII. Distribution

Once an aircraft is complete, it's time to get it out there! Go to X-Plane.org[58] and create a free account. Then, make a single folder that holds your airplane, and a folder within that folder that holds any custom airfoils you may have made (if you have not already). People often upload airplanes but *forget to upload their airfoils*. That doesn't work!

54 http://scenery.x-plane.com/tools.php

55 http://scenery.x-plane.com/tools.php

56 http://sketchup.google.com/

57 http://www.blender.org/

58 http://www.x-plane.org/

Be sure to give the .acf file inside the folder a recognizable name. Put any custom airfoils you made inside a folder called “airfoils,” which lives inside the main folder for the airplane, and put the whole thing into a .zip file. Windows users can use right click on the folder, move the mouse down to “Send to,” and select “Compressed (zipped) folder.” Mac users can option-click on the folder and chose "Create Archive." All that’s left is to upload the plane.

This is a great way to let others see your design, especially for commercial purposes, like letting the world test-fly your company’s plane virtually... at zero cost to you!

VIII. Summary

We have now discussed how to make, modify, and upload custom airplanes to fly in X-Plane. As well, we’ve talked about customizing the paint, instruments, sounds, weapons, slung loads, and even 3-D cockpits.

Now it’s time to get to work!

11. Supplement: X-Plane Scenery Resources

The main resource for users interested in creating scenery for X-Plane is the X-Plane Scenery homepage[59].

Before doing anything that could affect X-Plane on your system, make sure you take steps to save important models, plug-ins, etc. Work with an X-Plane installation that is easily replaceable should it be corrupted or damaged in any way—to easily do this (assuming there is enough room on the hard drive), simply create a new folder and copy the contents of the X-Plane 9 folder already on the computer to it. This folder could be named “X-Plane Testing” or something similar. This way, if anything goes catastrophically wrong, all it takes to restore it the program to a working state is to delete the contents of the secondary folder and re-copy the simulator.

I. Downloading Pre-Made Scenery

A number of websites offer free, ready-made scenery for download. Among them are the X-Plane.org Scenery page[60] (a good resource for a wide variety of scenery) and Ted’s X-Plane Scenery page[61] (which has lots of very detailed airports).

II. Building Custom Airports

For users who just want to make an airport look lived in, the easiest thing to do is to install the OpenSceneryX tool[62]. This is a huge library of buildings, static aircraft, and other objects. One need only drop them in place with Overlay Editor[63]. Membership (free) at X-Plane.org is required to download.

Another great source of static aircraft are the libraries of CSL kits[64] downloadable at X-Plane.org. These are meant for use to display other aircraft when flying online with XSquawkBox, but they're simply aircraft object files. As such, they can be incorporated in scenery.

Please note that, when building scenery like this for personal use, no copyright restrictions apply. However, the CSL kits *are* copyrighted by their various authors, so one would need their permission before selling scenery using these kits. OpenSceneryX, on the other hand, is free to use in scenery packages. The developer’s one requirement is that users incorporate by reference, meaning that their scenery makes references to the OpenSceneryX objects but does not include copies of them. (Note that anyone who installs a package created this way would have to install OpenSceneryX as well.)

III. Converting Google Earth Scenery for Use in X-Plane

G2XPL[65] is a (Windows-only) utility that converts Google satellite photos into X-Plane terrain textures. A couple of pretty impressive videos are linked to on the download page showing what the tool is capable of.

[59] http://scenery.x-plane.com/
[60] http://forums.x-plane.org/index.php?autocom=downloads&showcat=6
[61] http://web.me.com/theosdavis/xpfiles/scenery.html
[62] http://forums.x-plane.org/index.php?autocom=downloads&showfile=2226
[63] http://forums.x-plane.org/index.php?autocom=downloads&showfile=726
[64] http://forums.x-plane.org/index.php?autocom=downloads&showcat=12
[65] http://forums.x-plane.org/index.php?autocom=downloads&showfile=4783

Chris Kern has written a tool called Xplage[66] that drives a Google Earth moving map display.

Gmaps for X-Plane[67] is a Mac utility that creates X-Plane scenery from Google Maps images.

Note: Test each of these utilities carefully, as things can change from version to version of X-Plane.

[66] http://www.chriskern.net/code/xplaneToGoogleEarth.html
[67] http://forums.x-plane.org/index.php?autocom=downloads&showfile=6983

Appendix A: How X-Plane Works

I. X-Plane's Blade Element Simulation Explained

X-Plane assimilates the geometric shape of any aircraft and then figures out how that aircraft will fly. It does this by an engineering process called "blade element theory," which involves breaking the aircraft down into many small elements and then finding the forces acting on each little element many times per second. These forces are then converted into accelerations which are then integrated to velocities and positions. Of course, all of this technical theory is completely transparent to the end users—they just fly!

X-Plane goes through the following steps to propagate the flight:

A. Element Breakdown

Done only once (during initialization), X-Plane breaks the wing(s), horizontal stabilizer(s), vertical stabilizer(s), and propeller(s) (if equipped) down into a finite number of elements. The number of elements is decided by the user in Plane-Maker. Ten elements per side per wing or stabilizer is the maximum, and studies have shown that this provides roll rates and accelerations that are very close to the values that would be found with a much larger number of elements.

B. Velocity Determination

This is done twice per cycle. The aircraft's linear and angular velocities, along with the longitudinal, lateral, and vertical arms of each element are considered to find the velocity vector of each element. Downwash, propwash, and induced angle of attack from lift augmentation devices are all considered when finding the velocity vector of each element. Propwash is found by looking at the area of each propeller disk, and the thrust of each propeller. Using local air density, X-Plane determines the propwash required for momentum to be conserved. Downwash is found by looking at the aspect ratio, taper ratio, and sweep of the wing, as well as the horizontal and vertical distance of the "washed surface" (normally the horizontal stabilizer) from the "washing surface" (normally the wing), and then going to an empirical look-up table to get the degrees of downwash generated per coefficient of lift.

C. Coefficient Determination

The airfoil data entered in Part-Maker is two dimensional, so X-Plane applies finite wing lift-slope reduction, finite-wing C_{Lmax} reduction, finite-wing induced drag, and finite-wing moment reduction appropriate to the aspect ratio, taper ratio, and sweep of the wing, horizontal stabilizer, vertical stabilizer, or propeller blade in question. Compressible flow effects are considered using Prandtl-Glauert, but transonic effects are not simulated other than an empirical mach-divergent drag increase. In supersonic flight, the airfoil is considered to be a diamond shape with the appropriate thickness ratio; pressures behind the shock waves are found on each of the plates in the diamond-shaped airfoil and summed to give the total pressures on the foil element.

D. Force Build-Up

Using the coefficients just determined in step three, as well as the areas determined during the first step and dynamic pressures (determined separately for each element based on aircraft speed, altitude, temperature, propwash and wing sweep), the forces are found and summed for the entire aircraft. Forces are then divided by the aircraft mass for linear accelerations, and moments of inertia for angular accelerations.

E. Back to Work

The process is repeated from step two, and the whole thing is run over again at least 15 times per second. Aren't computers great?

II. Advantages of Blade Element Simulation

This method of computing the forces on the airplane is much more detailed, flexible, and advanced than the flight model that is used by most other flight simulators. Most other simulators use something called "stability derivatives" to compute how an airplane flies. This technique involves simply forcing the nose to return to a centered position along the flight path with a certain acceleration for each degree of offset from straight-ahead flight of the airplane —for every degree of angle of attack the nose is raised, the nose should return to center with a certain acceleration. This is a perfectly nice rule of thumb, but is far too simplistic to use across the flight envelope of the airplane.

Stability derivatives will not normally take into proper account the asymmetric affects of engine failures, the chaotic effects of turbulence, stalls, and spins, and the myriad of dynamic effects that are generated by the props of planes and the rotors of helicopters, such as spiraling slipstream, P-factor, and translational lift. As well, these simplifications can not easily consider such effects as transonic drag rise and compressibility which effect different parts of the airplane in different ways at different speeds, angles of attack, sideslips, and rotation rates.

Stability derivatives will typically say, "Okay, we are flying at Mach 0.8, so we add 5% to our drag due to compressibility," in a situation where blade element theory will say, "Okay, we are flying at Mach 0.8, but the wings are swept at 45 degrees, and the plane is in a 5 degree right side-slip, so the effective sweep on the left wing is only 40 degrees, but the effective sweep on the right wing is 50 degrees, and the plane is rotating at 10 degrees per second to the right, so the advancing wing has an extra 10 knots of speed at the wingtip due to this rotation, but the retreating wingtip has 10 knots less speed due to this rotation, and the roll rate is 30 degrees per second to the right, which increases the angle of attack from nothing at the center of the plane to 2 degrees at the right wingtip and negative 2 degrees at the left wingtip, and the plane is pitching up at 10 degrees per second, which adds 1.5 degrees of angle of attack to the tail and takes away 0.1 degrees angle of attack on the main wing because it is in front of the center of gravity, and the changes in angle of attack cause increase in induced drag on the horizontal stab reduction in induced drag on the forward wing."

Furthermore, the above is only a gross approximation—the simulator does this for each *piece* of the wing, horizontal stabilizer, vertical stabilizer, and propeller blade to really build a model of what the airplane is doing.

In other words, the commonly-used "stability derivatives" are gross over-simplifications of how an airplane flies, and blade element theory figures out the forces on each little bit of the airplane. Blade element theory is much more robust, and it can give greater accuracy in a much wider variety of flight conditions. As well, stability derivatives *cannot predict how an airplane will fly*. The aircraft model's creator has to figure out how the plane will fly and then use the stability derivative to mindlessly spit that performance back out. *Only* blade element theory can accurately *predict* what an airplane of a given geometry will do. Microsoft Flight Simulator *cannot* predict how an airplane will fly for the user. Whoever designed the airplane has to *tell* the simulator how the airplane should fly, and the simulator then spits that information back to the user—nobody actually learns anything. With blade element theory, though, used in X-Plane, a user can enter the *shape* of an airplane and then fly that plane in the simulator. X-Plane will *figure out* how a plane of that shape and weight and power should fly!

Appendix B: Sending 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 this page[68].

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.

Below is an email that gets sent often when users send a bug report without enough information to diagnose the problem:

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 almost 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 my Corvette analogy, 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.

[68] http://dev.x-plane.com/support/bugreport.html

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:

1. I deleted my preferences 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 computer running [insert operating system here].

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 me what you are really doing. You are starting by deleting the preferences so that I can do the same as you (a first step toward solving the problem!), you are telling me what plane you are opening (so I can do the same), you are choosing one of the planes *that come with X-Plane* (so I can do the same as you) and you are listing which of X-Plane's dozens of speed indicators you are referring to, so I can see what the problem really is.

To summarize the above, 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 I can go through the same steps as you. I must be able to mirror your actions, step by step, to duplicate the bug on my computer, as this is the first step to solving the problem.

Another very common mistake 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 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 I 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), I do require 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 sim, 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.

I 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 deleting 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. Or turn on the “Show Instrument Descriptions” option in the Special menu of X-Plane to get the real name of the instrument that you think is wrong.

4. Explain *why* you think the result you are seeing is wrong. Provide *proof* if you think the sim is not doing what the real plane would do.

Remember, a bad report would say, "The pressure gauge does not work." (*What* 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, I deleted the preferences and opened the following plane with 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 that 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 me 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, 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 C: Glossary of Terms

Here is some basic terminology that people misuse every day. Knowledge of these terms is crucial to working with X-Plane. These are the same terms that will be used by customer support if or when a user calls.

I. 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 means to move a copy of something onto your computer so that it can be run. When a user gets a DVD with X-Plane on it, he or she runs the installer to install the program from the DVD—this is *not* downloading the program. It is *installing* it. One would only be *downloading* it if the files were coming from the Internet (though once such files were downloaded, one 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, the user first downloads and then installs a newer version. The updater program (available for free at X-Plane.com[69]) does both of these things for you very easily.

II. Parts of an Aircraft

Anti-torque pedals: In a helicopter, 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 lever that modifies the *collective* pitch of the main rotor's blades; 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 tiled 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 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.

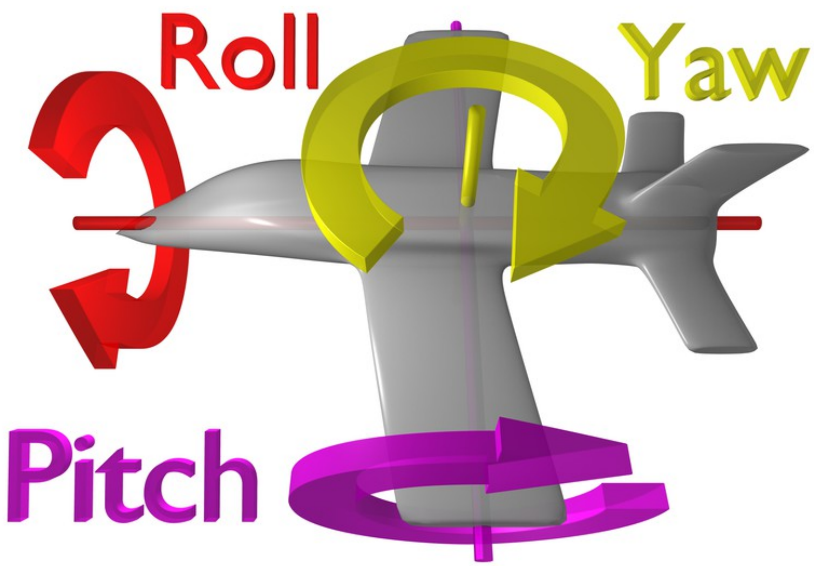
Rudder pedals: Foot pedals in an airplane used to steer the plane down the runway and to control its yaw motion in flight (that is, the wagging of its tail left or right). This becomes very useful when starting turns and counter-acting crosswinds. Note that these are *not* spelled “petals,” as they are 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

[69] http://www.x-plane.com/demo.html

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.

III. Movement of an Aircraft



Pitch: Movement of the aircraft's nose up or down (see the image above).

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 (see the image above).

Yaw: Movement of the aircraft's body left or right, most easily pictured as a wagging of the aircraft's tail (see the image above).

Thanks to Wikipedia contributor ZeroOne for releasing the image above under the Creative Commons Attribution 3.0 Unported license.

IV. Other Aviation Terms

ADF: Automatic Direction-Finder. 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.

AGL: Above Ground Level. When holding an altitude requested by air traffic control, a pilot will hold an altitude MSL (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* (MSL), 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 “Indicated airspeed (IAS)” below.

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.

ATC: Air Traffic Control.

BC: Back Course. This is the part of the ILS that goes *beyond* the touch-down zone. Read all about it in Chapter 6, Navigation and Autopilots, beginning on page **95**.

CDI: Course Deviation Indicator. 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 6, Navigation and Autopilots, beginning on page **95**.

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.

DME: Distance Measuring Equipment. 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.

EFIS: Electronic Flight Instrument System. A flight instrument system (found in an aircraft's panel) with electronic displays rather than the mechanical gauges of a standard panel.

GA: This can stand for either general aviation (light planes) or Go Around, 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 6 of the manual, beginning on page **95**.

GPS: Global Positioning System. 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.

HLD: Hold. Pressing this button will engage the autopilot in altitude hold mode. See Chapter 6, Section II (beginning on page **100**) for more information.

HSI: Horizontal Situation Indicator. 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 6 (beginning on page **95**) for more information.

IFR: Instrument Flight Rules. 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 is on a carefully mapped procedure to stay on a safe course. Seeing out the window in this case is an unneeded luxury.

ILS: Instrument Landing System. A ground-based system for guiding approaching aircraft into the runway via radio signals. See Chapter 6, Navigation and Autopilots (beginning on page **95**) for more information.

IMC: Instrument Meteorological Conditions. 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 6 (beginning on page **95**) 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 useable from about 50 miles away. See Chapter 6 (beginning on page **95**) for more information.

NDB: Non Directional Beacon. See the ADF note above.

OBI: Omni-Bearing Indicator. 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 6 (beginning on page **95**) for more information.

RPM: Rotations per minute; 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 pre-charted 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.

V_{fe}: Velocity Flap Extension. This is the maximum speed at which the aircraft can deploy its flaps without damaging or breaking them.

VFR: Visual Flight Rules. 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.

VMC: Visual Meteorological Conditions. These are environmental conditions suitable for flying by sight (VFR).

VOR: Very High Frequency Omnidirectional Range. 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 6 (beginning on page **95**) for more information.

V_{ne}: Velocity Never Exceed. This is the maximum speed that a given airplane can go. Going faster than Vne 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."

V_{no}: Velocity Normal Operating. 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.

VSI/VVI: Vertical Speed/Velocity Indicator. By looking at how fast the air pressure is changing, the VSI deduces how quickly the aircraft must be climbing or descending.

Appendix D: FAQ and Troubleshooting

This appendix will attempt to answer some of the most common questions sent to customer support, as well as to assist in troubleshooting some common problems. Sometimes, users simply cannot get X-Plane to work properly on their computers. In just about every case, though, this is not the fault of the X-Plane simulator itself.

I. How do I update or install X-Plane?

Please see Chapter 2 of this manual, beginning on page **17**.

II. Why does X-Plane not work on my Windows machine or crash upon exiting the sim?

This is a driver problem, assuming you have a useable operating system, video card, and RAM. This is very likely an issue on Windows Vista, where Microsoft does *not* install OpenGL drivers by default.

Let's start by making sure the operating system and hardware are useable.

First, the operating system (OS). Windows XP or Vista (both 32- and 64-bit) can be used, as well as Mac OSX.4 or later. There are simply too many distributions of Linux to keep track of them all, but X-Plane has users from virtually every major distribution (Ubuntu, Fedora, openSUSE, etc.).

Windows NT can *not* be used due to problems with Microsoft's joystick manipulation in that OS.

At least 1 GB of RAM is required to run X-Plane, as well as a video card with at least 32 MB or so of VRAM.

Virtually any modern ATI or NVIDIA video card may be used (anything that supports OpenGL), but an integrated Intel graphics chip will *not* work with the simulator. As of this writing, these chips are too slow to run X-Plane.

So, in Windows, assuming you have Windows XP or better and a video card capable of running OpenGL, and you get some sort of crash when trying to run or exit X-Plane, you probably need to update to the latest drivers for your video card. To do this, follow these steps:

1. Go to your video card manufacturer's driver download page (such as the ATI download page[70] or the NVIDIA download page[71]) 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. Click on the Start menu and open the Control Panel.

3. Click Add or Remove Programs.

4. Scroll down to either the Catalyst Display Driver (for ATI video cards) or the NVIDIA Drivers (for NVIDIA cards).

5. Click the Change/Remove button. (This may be replaced by a Remove button only; it does not affect the process.)

6. Follow the instructions provided by the uninstaller and reboot if necessary.

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[70] http://support.amd.com/us/gpudownload/Pages/index.aspx
[71] http://www.nvidia.com/Download/index.aspx?lang=en-us

7. 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 and the company it's manufactured by, but we will continue with a general outline for all companies.

8. Choose a destination folder to extract the files to. Again, make it something easy to find like C:\video drivers\ and continue clicking Next or Install.

9. If the installer (which you just extracted in Step 8) does not run automatically, navigate to C:\video drivers and double click on setup.exe.

10. Agree to the license agreement, choose the Express installation, and click Next until it finishes.

11. Reboot your PC and you're ready to fly!

If your card does not support OpenGL, it is recommended that any NVIDIA GeForce card.

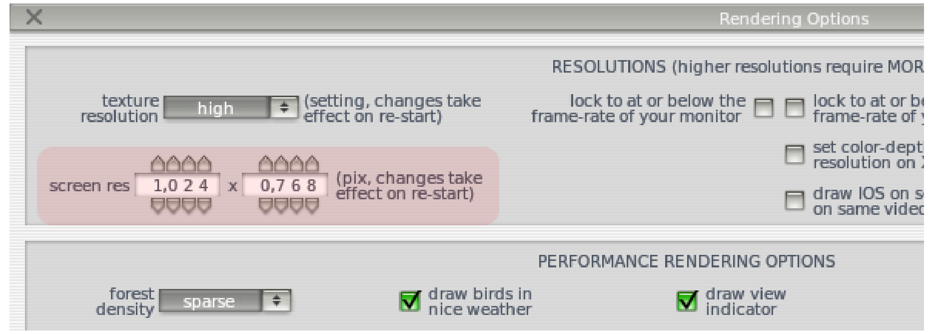
Now, if your video card’s manufacturer gives you instructions that are different than those above, then just follow their instructions.

If the old drivers are not removed before installing new ones, X-Plane is likely to crash when exiting.

III. How do I change the resolution?

Here we will walk through only the steps necessary to change the monitor resolution. Full detail on this (including how to choose which resolution to use) can be found in Chapter 3, Section III, Part B (on page **39**).

In X-Plane, move the mouse to the top of the screen. Click Settings, then click Rendering Options. The screen resolution setting is found in the upper left of the Rendering Options window (highlighted in the following image).



To change it, click the up or down arrow next to each digit of the setting. For example, to change the resolution from 1024 x 768 in the image above to, say, 1280 x 768, one would click twice on the arrow *above* the zero in 1024, six times on the arrow above the two in 1024, and four times on the arrow *below* the four in 1024.

IV. How do I set up a joystick, yoke, or rudder pedals?

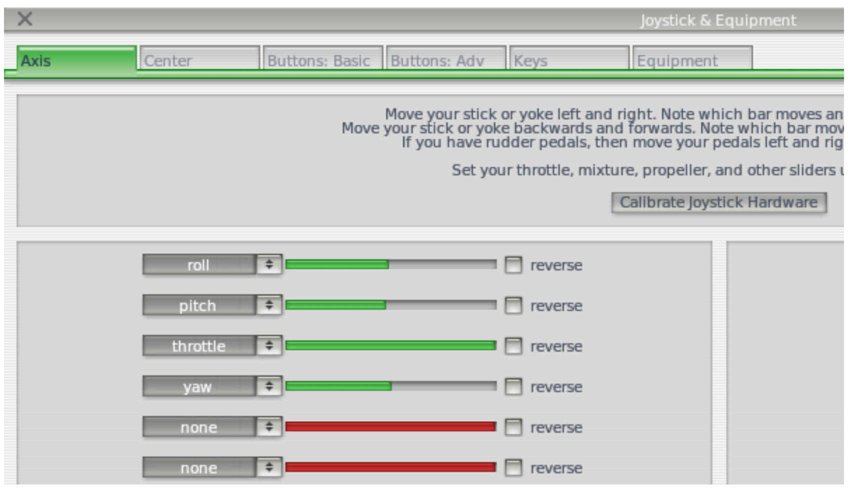
Let’s go through the basics of setting up flight controls. Full detail on this process (including troubleshooting) can be found in Chapter 3, Section II (beginning on page **32**). We will first set the axes (the forward/back and left/right movement of the controls), then we’ll discuss setting up the buttons on the controls.

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

1. Open X-Plane and move your mouse to the top of the screen, causing the menu to appear.

2. Click on Settings (as per the image at the top of the next page), then Joystick & Equipment.

3. Move your joystick or yoke forward and back. A green bar should move as you do so (see the screenshot below). 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 (movement of the nose up and down) is working backward.



4. Move your joystick/yoke left and right. The green bar that moves as you do so should be set to roll. Do not check the reverse box next to this control unless, when flying, the aircraft's roll control (movement of the wings up and down) is working backward.

5. Twist your joystick (if applicable). The green bar that moves should be set to yaw. If you don't 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 (movement of the nose side to side, like the reaction of a boat to rudder control) is working backward.

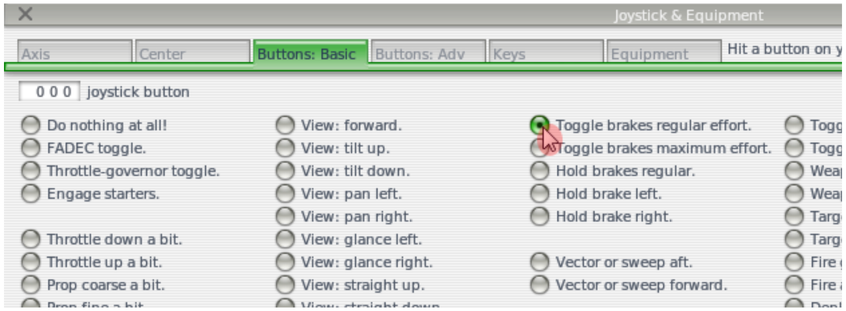
If using rudder pedals instead of a twisting joystick, slide them forward and backward and set the green bar that moves then to yaw.

Additionally, only when using rudder pedals, press the left pedal down with your toes. The bar that moves should be set to left toe brake. Do the same for the right pedal, and set that bar to right toe brake. If this is done, you may also skip steps 8 through 11 below.

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 control axes (that is, pitch, yaw, roll, and throttle) through their full range of motion to calibrate the controls.

8. To assign a button to the brakes, click the Buttons: Basic tab at the top of the screen (as seen in the screenshot at the top of the next page). If only a single Buttons tab is available, the software has not been updated to the most current release. Instructions on updating can be found in Chapter 2, Part VII on page **27** (though, in the mean time, the instructions may be followed using the outdated Buttons tab).



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 at the top of the third column of the window, selected in the previous screenshot).

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.

V. How do I install new scenery, aircraft, or plug-ins?

Please see Chapter 7 of this manual, beginning on page **114**.

VI. How do I use the autopilot?

Please see Chapter 6, Section II of this manual, beginning on page **100**.

VII. Why does my PC freeze after running X-Plane awhile?

This is almost always *heat* related. I have seen this many times in the past. 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: This assumes that the system has enough RAM. Running out of RAM will cause crashes as well. At least 1 GB of RAM should be used for current versions of X-Plane. This also assumes that the computer is not overclocked.

VIII. Why do I get an error about a missing DLL?

This indicates that DirectX 9.0c (or later) is not installed. This can be downloaded from Microsoft's DirectX page[72].

IX. Why does air traffic control speech not work on my Windows machine?

The first thing to check when diagnosing an ATC speech problem is the computer's speech synthesis software. Users can download the Speech Synthesis SDK v5.1[73] if they are not certain that speech synthesis software is currently installed. Download the file SpeechSDK51.exe (found near the bottom of the page). This is a self-extracting archive. When it is run, it extracts all of the files to the hard drive that are needed to install Microsoft speech. Be sure to choose a location to extract the files to that can be found later. When all of the files are extracted, the installation is *not* complete. To complete it, the user must browse to the location of the extracted files and run Setup.exe. Once the

[72] http://www.microsoft.com/directx
[73] http://www.microsoft.com/downloads/details.aspx?FamilyID=5e86ec97-40a7-453f-b0ee-6583171b4530&displaylang=en

setup is complete, users may delete the extracted files so they do not continue to take up hard drive space.

Once Speech 5 is installed, go into X-Plane, open the Settings menu, and click Sound. In the box at the bottom, you should see the message "Speech synthesis for air traffic control voice output is installed on this machine." If you do not see this, then the installation has not been completed. To hear the speech, hit the Enter key while flying. You will see various things appear on the windshield for you to choose.

If you do that and you still get no audio ATC in X-Plane, then it is likely a compatibility problem between multiple technologies. We have been working extensively with Microsoft on this. We have determined that X-Plane is *not* the culprit. The problem is that the sound card cannot play a WAV file (sound effect) at the *same time* that it plays speech. We tested this by compiling X-Plane with the sound effects disabled and the speech started working.

X. Why is there no sound on my Mac?

For versions of OS X prior to 10.4, users needed to download the OpenAL drivers for OS X, available here[74]. However, using X-Plane 9 requires at least version 10.4, so users running anything prior to that need to run the Apple software update before running X-Plane—this also serves to ensure that the OpenAL drivers are already installed.

Assuming version 10.4 or later is being used and the computer still puts out no sound, here is what Apple has to say:

"Mac OS X: No audio from certain multimedia content

Some audio applications may change your computer's audio settings to a sample rate that is too high for other applications to use. In this situation, system alert sounds still work, as does iTunes, but other applications may have no sound (audio output). This document applies to Mac OS X 10.3 or later and applications that use QuickTime 6 or later for audio, such as Safari and QuickTime Player.

This can happen on Macs that support high sample rates (higher than 48000 Hz):

- iMac G5
- Mac mini (all models)
- Power Mac G5 models that support sample rates higher than 48000 Hz
- PowerBook G4 that support sample rates higher than 48000 Hz
- MacBook
- MacBook Pro
- iMac (Early 2006) and later
- Mac Pro

For example, if you play an Internet movie in Safari, it will make no sound; if you open a QuickTime movie on your computer, QuickTime Player reports the following error (and the movie will have no audio):

"You may experience problems playing a sound track in [Movie Name].mov because a software component needed by the movie could not be opened."

Solution

1. Open Audio MIDI Setup (/Applications/Utilities/), then check the Audio Output setting.

2. Change the Audio Output setting to 44100.0 Hz.

[74] http://connect.creativelabs.com/openal/Downloads/Forms/AllItems.aspx

3. Quit Audio MIDI Setup.

Why does this happen?
Some third-party audio applications may change your computer's audio output setting. In fact, if you use the third-party application again after applying the above solution, the issue might occur again. Observe changes by watching the settings in Audio MIDI Setup before and after running a third-party application you suspect might be causing the issue. Contact the manufacturer of the application for more information."

XI. How do I make my sim run faster?

Please see Chapter 3, Part III, Section G, Setting Up X-Plane to Achieve the Best Results, beginning on page **48**.

XII. What hardware should I buy?

X-Plane 9 requires a computer with at least the following specifications:

- A 2 GHz processor
- 1.0 GB RAM (physical memory)
- 64 MB VRAM (video memory on your video card)
- 10 GB of hard drive space

The simulator will run on Mac OS X version 10.4 or later, Windows XP or Vista (both 32- and 64-bit), and Linux. Note, however, that when using Windows Vista, it is recommended that at least 2 GB of RAM be used.

Of course, a computer with 4 GB of RAM, a quad-core processor, and 2 GB of VRAM can be used and X-Plane will take full advantage of it. CPUs with multiple cores are useful because X-Plane will use that second core to load scenery while flying. This eliminates the tenth of a second stutter usually associated with transitioning from one scenery file to another (which is still experienced when using a single-core processor).

Now, a few notes on hardware:

Hyperthreaded CPUs are little more than marketing "hype." The old Pentium 4 Hyperthreading chips are really just *one* CPU *pretending* to be two. This does not provide anything near the performance boost of using two discreet CPUs or a dual-core CPU.

Regarding video RAM (VRAM, present on the video card), some cheaper video cards advertise having more memory than they actually do. NVIDIA calls this TurboCache, while ATI calls it HyperMemory. The video card itself may have only 64 MB of memory, while advertising that it "supports" 256 MB of RAM. It does this by "stealing" the other 192 MB from the system RAM. While this might give some performance increase, it is nowhere near as desirable as having a true 256 MB of RAM on the video card. This is especially important for systems that *barely* meet the system requirements for RAM as it is—for instance, if the system has 1 GB of RAM, but 192 MB of that is being reserved for the video card, X-Plane only has 832 MB of system RAM to work with.

Also, while Intel makes a fine CPU, their integrated video cards are, at the moment, *awful* for X-Plane. They are the only cards at the moment that the software doesn't support outright, though their much-hyped "Larrabee" chip could change this.

Now, about VRAM speed—the "memory bus width" of a graphics card (such as 64-, 128-, or 256-bit) indicates how many bits of data it reads at once each time it reads data. Basically, the wider this is, the faster the graphics card can draw things. Today's most powerful high end cards have a 512-bit bus; most mid-range cards are 256-bit, and the cheapest cards are 128-bit.

XIII. Why does my airplane flutter and crash?

This 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.

Here is why:

X-Plane calculates the acceleration of the craft for each frame. It 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.

Can X-Plane *handle* these *high accelerations*?

Of course! 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
- 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 Chapter 3, Section III, Part G, Setting Up X-Plane to Achieve the Best Results, found on page **48**.

XIV. Does X-Plane use 64-bit processing?

A common question is, "When will X-Plane be compiled as 64-bit, to natively support 64-bit systems?"

The answer is not quite what one might think, because 64-bit processing does not really give more speed. Here is what 64-bit it does:

1. It allows access to more than 2 GB of RAM. Since X-Plane only uses half this much RAM, though, this function is *not useful* to X-Plane. Why have access to RAM the simulator will not use?

2. It allows "bigger numbers" to be used natively in some cases, thus allowing the program to work with 64-bit numbers. Again, though, when does X-Plane need *or even want* a 64-bit number? Never! 8-bit numbers are fine for 99.9% of cases, and 16-bit numbers are needed for the other 0.1% of the time when we need really high precision. There is no a need for a single 64-bit number in the entirety of X-Plane!

We went through this years ago with MMX. Everyone would ask "When do I get MMX? When do I get MMX?". When MMX was finally enabled, though, the frame rate gain was so tiny that it was not even worth having. This is because MMX did not actually address the stuff in X-Plane that actually took the most time—moving polys across the bus to the video card. Now we are going through this again with 64-bit operating systems. It *sounds* interesting, but, for now, there is *no reason to have it in X-Plane* because it is not useful for the kinds of things the simulator does.

Some day, this will change, of course, like when X-Plane uses more than 2 gig of RAM, or when it uses the *sun*, rather than the Earth, as its coordinate reference to allow real-time, engineering-accurate flights to Mars. It will be useful when X-Plane uses the *galactic center*, rather than the Sun, as its coordinate reference to allow engineering-accurate flights to other star systems. We'll need some big, big numbers then, and 64-bit operating systems will be needed to get the job done.

For now, for most home users, 64-bit OSs are all hype. When X-Plane can take advantage of native 64-bit compiling, it will.

Note, of course, that X-Plane *will* run on a 64-bit operating system—it will do so as a 32-bit application only, though.

XV. What are the differences between the standard desktop version of X-Plane and the FAA-certified version?

The FAA-certified version has a different set of aircraft than the standard desktop version. The certified version has only general aviation aircraft, rather than the huge variety of planes that come with the retail X-Plane. Additionally, these planes have custom instrument panels, fuel systems, and autopilot systems designed to work specifically with the hardware they are sold with (for example, the simulators sold by Precision Flight Controls[75]).

Furthermore, these panels are often used as in full-screen displays in multi-computer setups (with more computers providing external visuals). These allow the user to fly using full-screen cockpits, with separate external visuals, while enjoying full-screen panels that do not duplicate anything that exists in the PFC hardware, using systems that integrate perfectly with PFC fuel and autopilot systems.

The FAA-certified version does *not* have the Special menu in X-Plane, or the various "Special" take-offs, in-flights, and approaches found in the Location menu. These allow the user to take off from carriers, relocate to Mars, and do other unusual things. Of course, these things can confuse training, so they are removed.

As well, the certified version does not include helipads and super-short private airstrips. This too is designed to keep training focused. For the same reason, the certified version does *not* have night vision or sun glare effects.

A 15-minute demo is included with the certified version rather than the desktop's 10-minute demo to allow more time to evaluate the program before purchasing.

Finally, the FAA-certified version checks the simulator's frame rate and hardware to make sure that both are okay before allowing flight, something that is not done in the desktop version.

To summarize, the certified version of X-Plane just has a lot of the "extras" *removed* to focus the user's training, and it has a large suite of general aviation planes to allow training on appropriate aircraft, with instrument panels on those craft that are optimized to work with hardware they're bundled with. Finally, the certified version has no duplications of the controls and displays available on the hardware.

[75] http://www.flypfc.com/index.html

XVI. Why does SLI/Crossfire not speed up the sim?

Some applications benefit from SLI (the NVIDIA version of using dual video cards) and Crossfire (ATI's version of the same), and some do not.

X-Plane, typically, does *not* benefit.

This is because performance boosts using these technologies depend on whether or not the computer is limited by the *fill rate*.

For X-Plane, at a resolution of 1024 x 768, the simulator's speed is limited by the geometry going across the bus, not the fill rate. So, in that case, SLI and Crossfire are useless—*one* card can fill 1024 x 768 at 60 fps.

Furthermore, in SLI, the two cards must *communicate with one another*, sending textures back and forth between them. This can be *slower* than *one* card doing all the work! This is because sending these textures from one card to another can be *slower* than doing a whole frame, if the whole frame can be done *on* one card.

So, where the computer is not limited by the graphics card's fill rate, SLI can actually slow the simulator down, not speed it up.

There are performance testing programs (benchmarks) that can test SLI/Crossfire setups and show a *higher* performance with them enabled. This is because the test program does *not* have to draw the world from the sky when it tests (as X-Plane does), so when it tests fill rate, it does *nothing else*. Thus, you see *only* fill rate performance. This has nothing to do with X-Plane because X-Plane is typically *not* fill rate-limited. As well, the test program might *not* copy textures back and forth between the cards. Again, the performance you see in the program has nothing to do with X-Plane, which must copy cloud shadows, reflections, and the like around between video cards.

So, the bottom line is that these technologies can make the simulator *slower*, not faster, in many cases!

To learn more, read Benjamin Supnik's blog here[76].

[76] http://xplanescenery.blogspot.com/2007/04/im-not-fan-of-slicrossfire.html

Appendix E: Making Objects for X-Plane

A common question for customer support is, "I want to model objects for X-Plane—what formats do you use?".

There are a few parts to that answer.

First of all, for the aircraft itself, there is only *one* answer—the X-Plane .acf file, as saved by Plane-Maker (bundled with the simulator and located in the X-Plane 9 directory). X-Plane looks at this file to determine flight physics, mass properties, engine power and limits… the works. As such, it is highly customized to X-Plane and could *never* be any sort of "all-purpose" format. This means that you can only use Plane-Maker, and *nothing bu* Plane-Maker, to make the aircraft.

While Plane-Maker is perfectly adequate for entering the design of the plane (it is bug-free, easy to use, not too fancy, and reliable) Plane-Maker is NOT a 3-D model editor. Instead, it is used to lay out the basic aerodynamic shapes and properties which result in an airplane that looks okay, but would certainly *not* knock anyone's socks off. As such, it can *not* make the complex 3-D model that is needed to make a cool 3-D cockpit, or to make a highly detailed aircraft model that might overlay the basic Plane-Maker model from which flight physics are calculated.

These 3-D models *can also be used* to create buildings and other custom objects—*not just plane overlays and cockpits*.

So, to repeat:

1. Plane-Maker can be used on its own to make a model for X-Plane. It will look okay and will fly fine. It will be pretty good.

2. In *addition* to this Plane-Maker model, you can make a 3-D cockpit to sit inside the plane, or a highly detailed aircraft model to overly the basic X-Plane model, which could actually be made with transparent textures to be invisible, if you desire.

Clearly, you can use Plane-Maker, which comes with X-Plane, to do part 1 above, but not part 2.

See the "Example Aircraft" in the "Instructions" folder for a very simple example.

So, what editor do you use for part 2?

To do part 2 of the above, you will need a 3-D editor capable of saving an object in the X-Plane OBJ format. **Note:** This is *not* the same as the Alias OBJ format.

The following file formats can be used to create X-Plane OBJ files:

- 3DS (Autodesk 3D Studio)
- DXF (Autocad)
- OBJ (Alias Wavefront)
- AC (AC3D)
- MD2 (Quake model)
- WRL (VRML)
- LWO (LightWave)
- TXT (Milkshape)

With each of these file extensions, users need to convert the objects to ones usable by X-Plane. This is often done by opening the file in AC3D, then using the X-Plane plugin downloadable here[77] to export the file as an X-Plane OBJ.

Alternatively, after an object has been created in 3DS or Autocad, ObjConverter may to be used to convert it. ObjConverter comes in the Scenery Tools pack, downloadable here[78].

[77] http://scenery.x-plane.com/tools.php
[78] http://scenery.x-plane.com/tools.php

Alternatively, direct export to an X-Plane OBJ file is available in the two *free* 3-D editors by Jonathan Harris—both Google Sketchup[79] and Blender[80].

Note: All of these exports are limited by file format issues:

- 3DS doesn't feature lines, only meshes.
- DXF/Autocad has no texturing info.
- Lightwave's texturing model doesn't correspond to ours very well.
- VRML conversion between programs doesn't usually work well.

There may be other issues, too, in converting between formats.

In all cases, though, the file needs one texture per object.

The bottom line is that there are a *lot* of ways to get objects into X-Plane from just about any 3-D editor imaginable. If it isn't on this list, and the 3-D editor is decent, it can probably export to one of these formats such as 3DS, Alias Waverfront OBJ, or similar.

For pure "meshes" made with one texture, no tricks, 3DS seems to be the most reliable conversion format for simple work.

79 http://sketchup.google.com/
80 http://www.blender.org/

Appendix F: Custom Aircraft Files for Hire

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 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[81].

[81] http://www.x-plane.com/contact.html

Appendix G: The Log File Explained

log.txt for X-Plane 8.60 Beta-1 X-Plane build 86000 compiled on Nov 29 2006 11:23:04
This log file is generated automatically by Laminar Research applications and contains diagnostics about your graphics hardware, installation, and any error conditions. If you need to contact tech support or file a bug, please send us this file. NOTE: this file is rewritten every time you start ANY of your X-System applications.

This preamble is written by all the apps. Among other things, it gives you the exact app name and the date it was built, so you can be SURE the user is using the same build you are.

Mac OS X 10.4.8
CPU type: 1765095478 (Pentium) CPU speed (mhz): 2160Bus speed (mhz): 664RAM (MB): 2048

System info - varies by machine. Here we have the OS version. This is a "Pentium" Mac so we know it's a new Intel Mac. CPU is 2.16 GHz. Bus speed is 664 MHz - that's not usually important. I have 2 GB of RAM.

X-System folder=/code/design++/ case sensitive=0

Install location of my x-system folder...also my file system is NOT case sensitive.

CPU count = 2

This is a dual-processor machine.

AGL_RGBA :1
AGL_DOUBLEBUFFER :1
AGL_RED_SIZE :8
AGL_GREEN_SIZE :8
AGL_BLUE_SIZE :8
AGL_ALPHA_SIZE :8
AGL_DEPTH_SIZE :32

Mac specific - this tells us their screen resolution - 32-bit color. This is usually not important.

OpenGL Situation :
OpenGL Vendor :ATI Technologies Inc.
OpenGL Render :ATI Radeon X1600 OpenGL Engine
OpenGL Version :2.0 ATI-1.4.40

This is the most important stuff: the OpenGL vendor, renderer, and version. The renderer will give you a hint about what card they have, but doesn't tell you exactly. For example, a 6800GT and 6800 will both be listed as a "6800." But this info will tell you GENERALLY what kind of card they have, which is what matters, because cards come in families!

The OpenGL version is not quite the same as the driver version, but old drivers have old OpenGL versions, so from this we can tell if they have old drivers.

OpenGL Extensions:GL_ARB_transpose_matrix GL_ARB_vertex_program GL_ARB_vertex_blend GL_ARB_window_pos GL_ARB_shader_objects GL_ARB_vertex_shader GL_EXT_multi_draw_arrays GL_EXT_clip_volume_hint GL_EXT_rescale_normal GL_EXT_draw_range_elements GL_EXT_fog_coord GL_APPLE_client_storage GL_APPLE_specular_vector GL_APPLE_transform_hint GL_APPLE_packed_pixels GL_APPLE_fence GL_APPLE_vertex_array_object GL_APPLE_vertex_program_evaluators GL_APPLE_element_array GL_APPLE_flush_render

GL_NV_texgen_reflection GL_NV_light_max_exponent
GL_IBM_rasterpos_clip GL_SGIS_generate_mipmap
GL_ARB_shading_language_100 GL_ARB_imaging
GL_ARB_point_parameters GL_ARB_texture_env_crossbar
GL_ARB_texture_border_clamp GL_ARB_multitexture
GL_ARB_texture_env_add GL_ARB_texture_cube_map
GL_ARB_texture_env_dot3 GL_ARB_multisample
GL_ARB_texture_env_combine GL_ARB_texture_compression
GL_ARB_texture_mirrored_repeat GL_ARB_shadow
GL_ARB_depth_texture GL_ARB_shadow_ambient
GL_ARB_fragment_program
GL_ARB_fragment_program_shadow GL_ARB_fragment_shader
GL_ARB_occlusion_query GL_ARB_point_sprite
GL_ARB_texture_non_power_of_two
GL_ARB_vertex_buffer_object GL_ARB_pixel_buffer_object
GL_ARB_draw_buffers GL_ARB_shader_texture_lod
GL_EXT_compiled_vertex_array GL_EXT_framebuffer_object
GL_EXT_texture_rectangle GL_ARB_texture_rectangle
GL_EXT_texture_env_add GL_EXT_blend_color
GL_EXT_blend_minmax GL_EXT_blend_subtract
GL_EXT_texture_lod_bias GL_EXT_abgr GL_EXT_bgra
GL_EXT_stencil_wrap GL_EXT_texture_filter_anisotropic
GL_EXT_separate_specular_color GL_EXT_secondary_color
GL_EXT_blend_func_separate GL_EXT_shadow_funcs
GL_EXT_stencil_two_side GL_EXT_texture_compression_s3tc
GL_EXT_texture_compression_dxt1
GL_EXT_blend_equation_separate
GL_EXT_texture_mirror_clamp GL_EXT_packed_depth_stencil
GL_EXT_gpu_program_parameters
GL_APPLE_flush_buffer_range GL_APPLE_ycbcr_422
GL_APPLE_vertex_array_range GL_APPLE_texture_range
GL_APPLE_float_pixels GL_ATI_texture_float
GL_ARB_texture_float GL_APPLE_pixel_buffer
GL_NV_blend_square GL_NV_fog_distance
GL_ATI_texture_mirror_once GL_ATI_text_fragment_shader
GL_ATI_blend_equation_separate
GL_ATI_blend_weighted_minmax
GL_ATI_texture_env_combine3 GL_ATI_separate_stencil
GL_ATI_texture_compression_3dc
GL_SGIS_texture_edge_clamp GL_SGIS_texture_lod
GL_SGI_color_matrix

This huge list is all the "opengl tricks" the card supports - Austin and I print this so that we can see what the card does for debugging - you guys won't need this.

tex_clamp_avail=1
add_env_avail =1
combine_avail =1
dis_fog_avail =1
tex_comp_avail =1
vbo_avail =1
vprog_avail =1 (256)
fprog_avail =1 (1024/512/512/4)
automini_avail =1
aniso_avail =1
fsaa_avail =1
sprites_avail =1
depth_tex_avail=1
occlude_avail =1
shad_objs_avail=1
vshader_avail =1 (16/4096/32/16/0/4096)
fshader_avail =1 (4096)
glsl_avail =1 (1.10)
framebuf_avail =1
max tex units :8 (16/8)
max iso filtering:16.000000
max texture size :4096
max point size :64.000000

More OpenGL diagnostics...generally only needed by Austin and me, but sometimes we can tell you how to detect bugs.

Each of these "flags" will be 0 if we don't find the driver has a trick, or 1 if it does. For example, my card DOES support GLSL (GLSL_avail = 1). That means I have pixel shaders both on my card and drivers that understand them. So you can tell if a user is getting pixel shaders this way.

Also, if we detect a card with a bug, you may see some warning messages like "not using XXX for Intel graphics card" or something.

lowest free text index=82

Austin noting to himself the next "slot" for internationalized strings - ignore it!

WARNING: command sim/autopilot/airspeed in keys file unknown.
WARNING: the binding T/SHIFT+CTRL is bound to two commands: sim/operation/ground_speed_change and sim/engines/ignition_down_5

Warning from the keyboard shortcuts file -- on this machine, I have a key bound to an unknown command and two mappings for shift-ctrl-T. Ooops!

OpenAL version : 1.1
OpenAL hardware :
OpenAL extensions: ALC_EXT_CAPTURE ALC_ENUMERATION_EXT ALC_EXT_MAC_OSX ALC_EXT_ASA

Mac and Linux: sound info...usually this can be ignored! We don't seem to have a lot of sound bugs on Mac, and on Linux if sound drivers are bad, the sim won't launch.

Trying to find CFM at: Macintosh HD:code:design++:Resources:plugins:XPLM.shlb
failed CFM - frag load failed.

This means that old OS 9 plugin can't load. This happens on any Intel Mac, which can't support Mac OS-9 style plugins.

Fetching for Macintosh HD:code:design++:Resources:plugins
Loaded: Macintosh HD:code:design++:Resources:plugins:PluginAdminMac.xpl.
Loaded: Macintosh HD:code:design++:Resources:plugins:DataRefEditorMac.xpl.
dlerror:dlopen(/code/design++/Resources/plugins/PluginAdminLin.xpl, 9): no suitable image found. Did find:
/code/design++/Resources/plugins/PluginAdminLin.xpl: unknown file type, first eight bytes: 0x7F 0x45 0x4C 0x46 0x01 0x01 0x01 0x00
Failed: Macintosh HD:code:design++:Resources:plugins:PluginAdminLin.xpl. (This file is missing, not a DLL or could not be loaded due to another missing DLL.)
dlerror:dlopen(/code/design++/Resources/plugins/PluginAdminWin.xpl, 9): no suitable image found. Did find:
/code/design++/Resources/plugins/PluginAdminWin.xpl: unknown file type, first eight bytes: 0x4D 0x5A 0x90 0x00 0x03 0x00 0x00 0x00
Failed: Macintosh HD:code:design++:Resources:plugins:PluginAdminWin.xpl. (This file is missing, not a DLL or could not be loaded due to another missing DLL.)
dlerror:dlsym(0x910f9a0, XPluginReceiveMessage): symbol not found
Loaded: Macintosh HD:code:design++:Resources:plugins:Position.xpl.
Loaded: Macintosh HD:code:design++:Resources:plugins:PrivateCommands.xpl.
Loaded: Macintosh HD:code:design++:Resources:plugins:XPushBack.xpl.

Found stats plugin: 2
Found remote plugin: 4

Plugin discovery - each plugin is loaded...if it fails, the error message is here. If it does load, plugins may insert their own message and warnings . From this section you can figure out (1) what plugins the user has and (2) are they working?

For example in this case, PluginAdminLin.xpl didn't launch - it's not a real Mac plugin. (That's because it's for Linux)

If a user has problems and a lot of plugins, ask them to try again without the plugins...perhaps it's not our bug!

I found the following scenery packages (prioritized in this order):
0 Custom Scenery/a ksbd ground overlay/
1 Custom Scenery/a_fac_test/
2 Custom Scenery/beaches/
3 Custom Scenery/EDDT light/
4 Custom Scenery/EDTC/
5 Custom Scenery/forests/
6 Custom Scenery/KLIO Pursuit Field/
7 Custom Scenery/KSBD Demo Area/
8 Custom Scenery/Loire&LFOQ_FS2XP/
9 Custom Scenery/LSMD/
10 Custom Scenery/MakeItSo/
11 Custom Scenery/PARIS_Base/
12 Custom Scenery/roads/
13 Custom Scenery/Test1000m/
14 Custom Scenery/toulous/
15 Custom Scenery/us patch/
16 Custom Scenery/whacko_german_apt/
17 Resources/default scenery/700 roads/
18 Resources/default scenery/800 objects/
19 Resources/default scenery/800 roads/
20 Resources/default scenery/820 beaches/
21 Resources/default scenery/820 roads/
22 Resources/default scenery/820 us objects/
23 Resources/default scenery/820 us objects placeholder/
24 Resources/default scenery/820 world objects/
25 Resources/default scenery/820 world objects placeholder/
26 Resources/default scenery/820 world terrain/
27 Resources/default scenery/CVS.sandboxinfo/
28 Resources/default scenery/DSF 820 Earth Europe/
29 Resources/default scenery/DSF 820 Earth US/
30 Resources/default scenery/sim objects/
31 Resources/default scenery/x-plane terrain/

Scenery package list! This is all of the scenery we found, first ones listed are highest priority. if a user has a crash and custom scenery, ask them to remove it.

BUT if the custom scenery causes the crash AND the custom scenery USED to work, please make sure to get a bug report to ME!!!!!!!!!!

WARNING: Runway must have a 3-letter name, but we have Zx at College Park
WARNING: Runway has a bad number string Zx at College Park
We found a duplicate runway 36/18 vs. 18/36 at airport 30F
We found a duplicate runway 36/18 vs. 18/36 at airport 30F
WARNING: Runway has a bad suffix 05u at Lelystad
We found a duplicate runway 05u/23 vs. 05/23 at airport EHLE
We found a duplicate runway 14/32 vs. 32/14 at airport 4B2
We found a duplicate runway 14/32 vs. 32/14 at airport 4B2
We found a duplicate runway 18/36 vs. 36/18 at airport 6IL9
We found a duplicate runway 18/36 vs. 36/18 at airport 6IL9

Warnings about apt.dat file...with 20,000 entries there are still some screwed up ones. :-(Robin tries to fix these things.

Starting scenery shift at 0

DSF rotate time: 7 for 0 DSFs.
DSF load time: 365428 for file Resources/default scenery/DSF 820 Earth US/Earth nav data:+30-120/+32-119.dsf
DSF load time: 741874 for file Resources/default scenery/DSF 820 Earth US/Earth nav data:+30-120/+32-118.dsf
DSF load time: 949741 for file Resources/default scenery/DSF 820 Earth US/Earth nav data:+30-120/+32-117.dsf
DSF load time: 741496 for file Resources/default scenery/DSF 820 Earth US/Earth nav data:+30-120/+33-119.dsf
DSF load time: 1766254 for file Resources/default scenery/DSF 820 Earth US/Earth nav data:+30-120/+33-118.dsf
DSF load time: 1441793 for file Resources/default scenery/DSF 820 Earth US/Earth nav data:+30-120/+33-117.dsf
Preload time: 12134629.
Preload time: 719346.
Preload time: 207516.
Preload time: 126272.

Whenever we load scenery, some logging info goes out. In this way we can see what scenery they were last viewing and where they were flying.

Clean exit from threads.

If they exit the sim, this message is printed at the log. If you don't see this, it means one of two things:

(1) the user crashed.
(2) the user emailed you the log file before quitting!!

Appendix H: X-Plane and Linux

The X-Plane discs sold from X-Plane.com are compatible with Windows, Mac OS, and Linux. Installing the software on either Mac OS or Windows is pretty straightforward; in most cases, so long as one has the proper drivers, the steps to install will be nearly identical between computers. There are multiple versions of these operating systems (for instance, Mac OS 10.4 versus 10.5, or Windows XP versus Windows Vista), but for the purpose of installing X-Plane, each version functions about the same.

On the other hand, "Linux" is a very broad category of operating systems. Each distribution (or "flavor") of Linux is unique.

In some cases, the only thing that differentiates one distribution from another is the programs (also called software packages) that are included by default—for example, Ubuntu Studio simply adds tools for working with multimedia to the standard Ubuntu distribution.

In other cases, distributions may be differentiated by their user interface—for example, Xubuntu changes the desktop environment from Gnome (as in the standard Ubuntu distribution) to XFCE.

In yet other cases, distributions may vary in many more ways—for example, users of Gentoo (a highly configurable, highly involved distribution) choose to use it over something like Ubuntu largely due to the fact that the kernel (the "bones" of the operating system) is tailored to each system individually. On the other hand, Ubuntu users choose to use it largely for the fact that they *don't* have to custom-tailor anything.

None of these differences prevent X-Plane from being installed. However, the wide variations in software packages (as well as differences in the user interface and how packages are installed) make a step-by-step guide for each particular Linux distribution impossible.

We will discuss the installation of X-Plane on three of the most popular distributions: Fedora, openSuse, and Ubuntu. A helpful (though subjective) comparison of these three distributions can be found here[82]. Reading through the installation guide below will be helpful to users of other distributions, too, as the process is largely the same—copy the installer to the hard drive, gather the required libraries, and run the installer.

For users new to Linux, this installation may seem daunting. Don't give up, though! The installation *will* work, and the experience gained in installing X-Plane will be helpful when installing other software later. X-Plane customer support is top notch, and the X-Plane community—especially the Linux side of the community—is exceptionally helpful.

Please note that this guide is written for users new to Linux. Some information may seem annoyingly basic to Linux veterans, but it is necessary in order to make Linux a viable option for all our users.

For users trying to decide between the 32-bit version of their distribution of choice and the 64-bit version, know that X-Plane will run on both. The 32-bit version has the benefit of requiring fewer new software libraries compared to the 64-bit version. The downside to using a 32-bit operating system is that the system can only address 4 GB of memory; however, since X-Plane fits comfortably within 2 GB of memory, a system built strictly for X-Plane will be fine with a 32-bit operating system.

This guide assumes that the computer X-Plane is being installed

[82] http://news.helpero.com/article/UBUNTU-vs-SUSE-vs-FEDORA_20.html

on is capable of running the simulator with its default rendering options. Note that the minimum system requirements to run X-Plane are a 1 GHz processor, 1 GB of RAM, and 128 MB VRAM on an independent (non-integrated) video card. However, the recommended specifications are a 2 GHz processor, 2 GB of RAM, and 256 MB of VRAM. Of course, X-Plane can take advantage of even faster systems, too.

For help, please email customer support at info@x-plane.com, or get community support from the X-Plane.org Linux forums[83].

I. Installation

Before we begin, let's discuss the general steps that we'll be following in each distribution's specific installation instructions.

First, we'll copy the X-Plane Linux installer to the desktop. This is necessary because we will need to remove Disc 1 in the course of installing the scenery. Linux doesn't like having the installer present only in memory (as would be the case in a Windows or Mac installation), so we'll pacify it by moving it to the hard drive.

In the past, there were issues with the mounting of the Linux discs; in the distributions described here, this is no longer the case. The installation discs mount correctly and are usable without any extra input. More information can be found at the X-Plane Wiki[84].

Please note that the installation steps presented here are for the 9.00 set of gray-colored discs. When using a different set of discs (such as the older beta discs or the discs purchased in a retail store) it may be necessary to download the Linux installer from the X-Plane Wiki[85].

After getting the installer on the desktop, we will download any software libraries needed by X-Plane but not present on the system. On a 64-bit system, this usually means downloading the *32-bit versions* of Mesa (a free implementation of the OpenGL graphics library) and OpenAL (an audio library). Some 32-bit systems will already have these installed.

To find out what libraries the installer will need, open the terminal (also called the command line) and navigate to where the installer was saved. Assuming that the installer is on the desktop, and that the terminal opens in the [user name] folder, this is done by typing:

```
cd Desktop
```

and pressing Enter. The "`cd`" stands for "change directory," after which we tell the terminal where to go.

Once in the Desktop folder, we can check the dependencies of the Linux installer by typing:

```
ldd ./"Linux Installer"
```

and pressing Enter. The libraries listed there can be searched for either in the distribution's package installer or on Google. For the Linux distributions in this guide, we won't go through this step because we already know which packages are needed.

Once the proper libraries are installed, running the installer is as simple as opening a terminal, navigating to the desktop (via "`cd Desktop`" in most cases), and executing the file by typing:

```
./"Linux Installer"
```

and pressing Enter.

From there, the installer itself can walk the user through the setup. By default, the installation will default to the directory /home/[user name]/X-Plane 9.

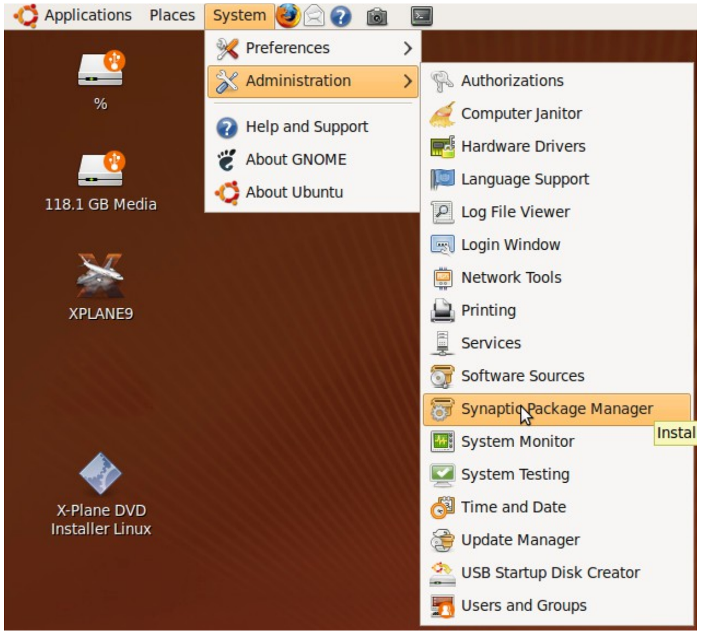
[83] http://forums.x-plane.org/index.php?showforum=49
[84] http://wiki.x-plane.com/Linux_DVD_Problems
[85] http://wiki.x-plane.com/DVD_Installers

A. In Ubuntu (32-bit)

The 32-bit version (that is, the i386 installation disc) of Ubuntu 9.04 "Jaunty Jackalope" will be used in the following instructions. Additionally, the X-Plane Wiki has guides for installing on versions 8.04[86] and 8.10[87], and further discussion of the libraries necessary for the 64-bit version of 8.10 can be found on the X-Plane.org forums[88].

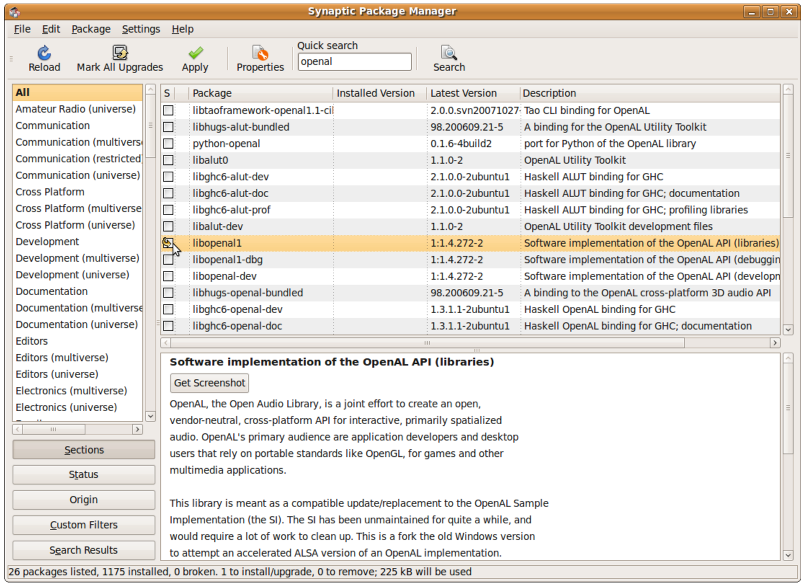
Some Ubuntu users report having issues with the file permissions of the installer found on the X-Plane DVDs. In order to avoid this entirely, we will simply download the latest installer from the web by clicking here[89]. When Firefox prompts, select to open the file with the Archive Manager, noting that may take a few minutes for the download to complete. When it does, drag the X-Plane DVD Installer Linux file to the desktop.

With the installer downloaded, we need to gather the required package libraries. Open the Synaptic Package Manager by clicking the System menu (in the upper left of the screen), going to Administration, and clicking Synaptic Package Manager, as shown in the following image.



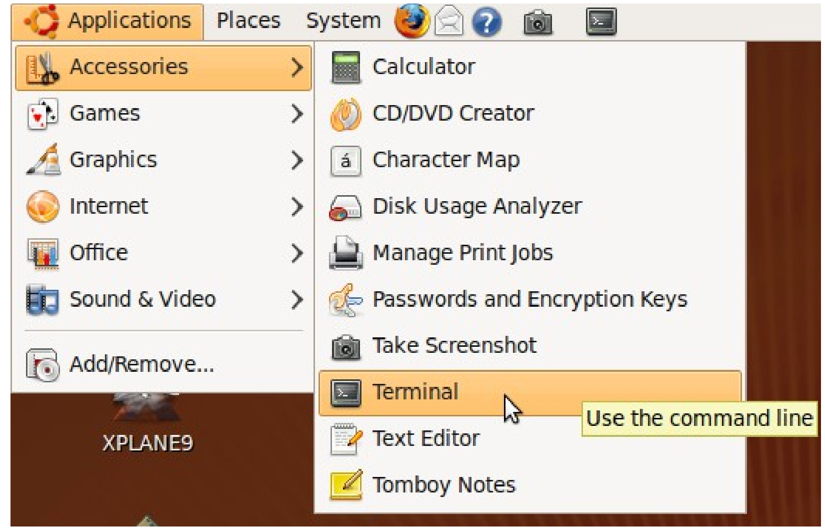
When Synaptic opens, search (in the top center of the window) for OpenAL. Find the line that reads "libopenal1" and click it (as shown in the following screenshot), then click Mark for Installation.

[86] http://wiki.x-plane.com/8.04_Hardy_Heron
[87] http://wiki.x-plane.com/8.10_Intrepid_Ibex
[88] http://forums.x-plane.org/index.php?showtopic=34824
[89] http://dev.x-plane.com/update/installers9/X-PlaneDVDInstallerLinux.zip



With libopenal1 marked, press **Apply** (found at the top of the window, to the left of the search bar). Click **Apply** once again in the Summary window that appears to install the package.

Due to an idiosyncrasy in Ubuntu 9.04, we will now need to link another library file (libopenal0) to the file we just downloaded (libopenal1). To do this, first open the terminal by clicking the Applications menu (found at the top left of the screen), going to Accessories, then clicking Terminal, as shown at the top of the next page.



In the terminal window that opens, type the following command:
sudo ln –s /usr/lib/libopenal.so.1 /usr/lib/libopenal.so.0

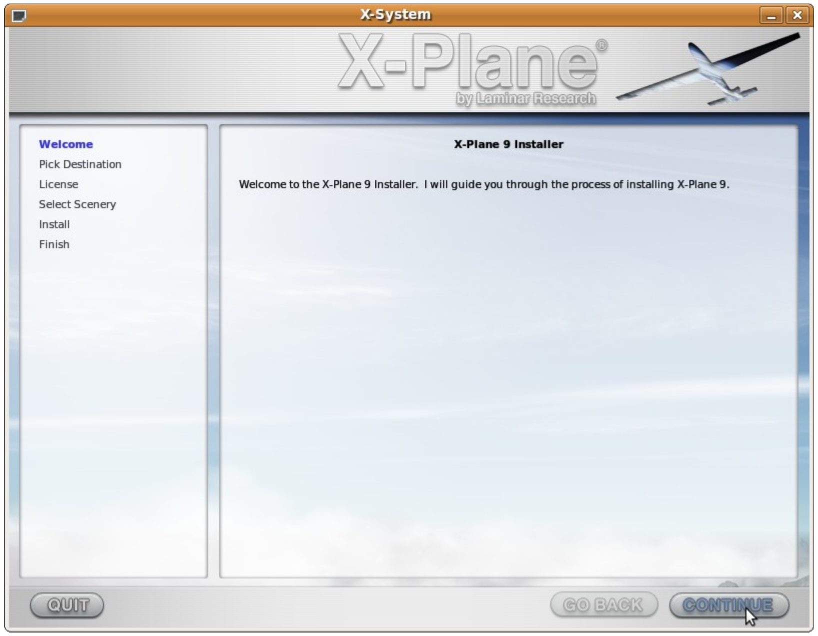
Press Enter and enter the root password to create the link.

Note that, in the 64-bit version of Ubuntu, users will need to replace the "lib" portion of the two directories above with "lib32".

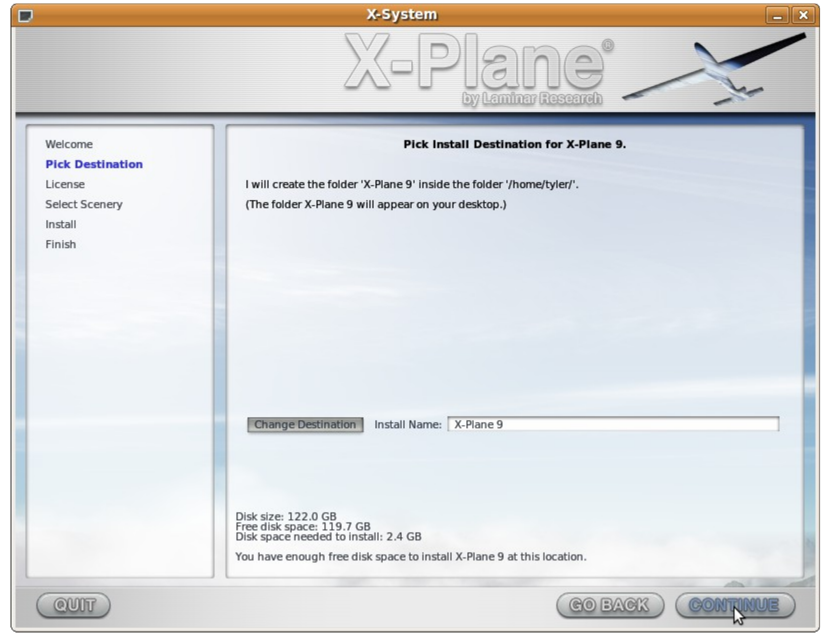
In the previous command, the “sudo” told the terminal to “do” what we told it as a super user (su). The “ln” told it that we wanted to create a link, and the “–s” modifier told it to make it a symbolic link rather than a hard link. Next, we told it which original file to use, then where to place the link.

With the link created, it’s time to run the installer. In a terminal window, type “cd Desktop” to move to the desktop, then type ‘./”X-Plane DVD Installer Linux”’ to launch the installer.

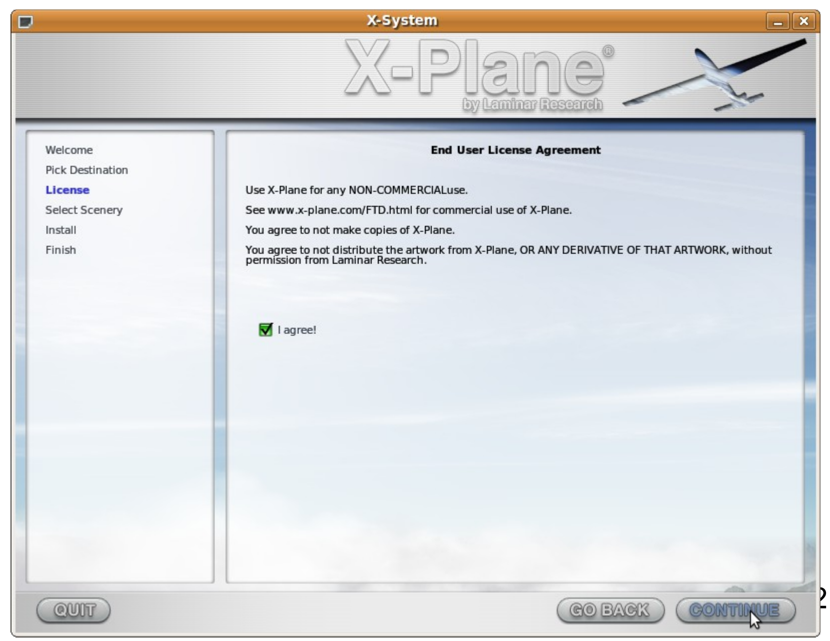
In the installer window that appears, click **Continue**.



By default, X-Plane will install to the /home/[user name]/ directory. If this is acceptable, click **Continue**, as in the following image.



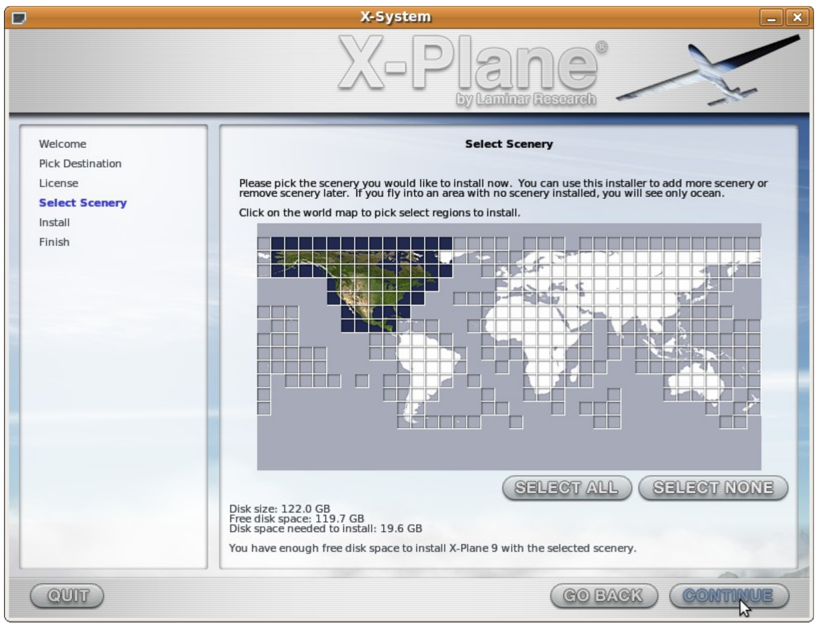
Accept the license agreement, the click **Continue**.



Select the area of the world for which scenery should be installed. With the newest installer, none of the world will be selected by default. Areas which are not selected will be gray and white, while areas which are selected will have their full color. For example, in the image below, only North America is selected.

Large areas can easily be selected by clicking and dragging the mouse cursor. Also, note that for areas with no scenery installed, airports will appear to be “floating” above an ocean. Installing that area’s scenery later (done using this same installer) will correct this issue.

When the desired scenery has been selected, click **Continue**, as shown in the image below.



Installation will now begin. Note that installation may take anywhere from thirty to sixty minutes per disc. 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.

When the installer prompts, remove Disc 1 from the drive and insert Disc 2. Note that this must be placed in the *same* DVD-ROM as the first disc for X-Plane to recognize it. Wait for the second disc’s icon to appear on the desktop (indicating that it is mounted and ready to use), then click **Continue**. Repeat this for all the required discs.

When the installer finishes, the simulator is ready to go.

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 9 installed on this computer,” click the **Add or Remove Scenery** button and proceed as before.

i. Note on Loss of Audio in Ubuntu 9.10

Some users of Ubuntu 9.10 have reported that, after flying in X-Plane for anywhere from a few minutes to a few hours, the sim will suddenly stop putting out sound, although it will still take input from the joystick, the menus will still work, etc. After this happens, the sim will lock up when the user tries to close it.

This is caused by a conflict between X-Plane and PulseAudio which, curiously, seems to be limited to Ubuntu 9.10. This can be fixed either by removing PulseAudio entirely (as described here in the Ubuntu forums) or by upgrading to Ubuntu 10.04.

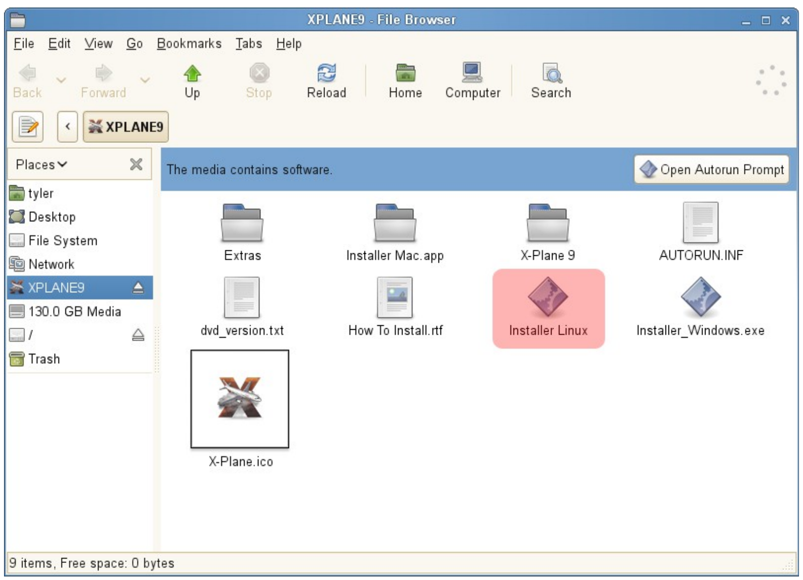
Both the problem and the solution are described further here on the X-Plane.org forums.

B. In OpenSUSE (64-bit)

This guide will use the openSUSE 11.1 x86-64 GNOME distribution. The software packages included with other versions may differ slightly, but the steps to install should be similar.

Let's get started.

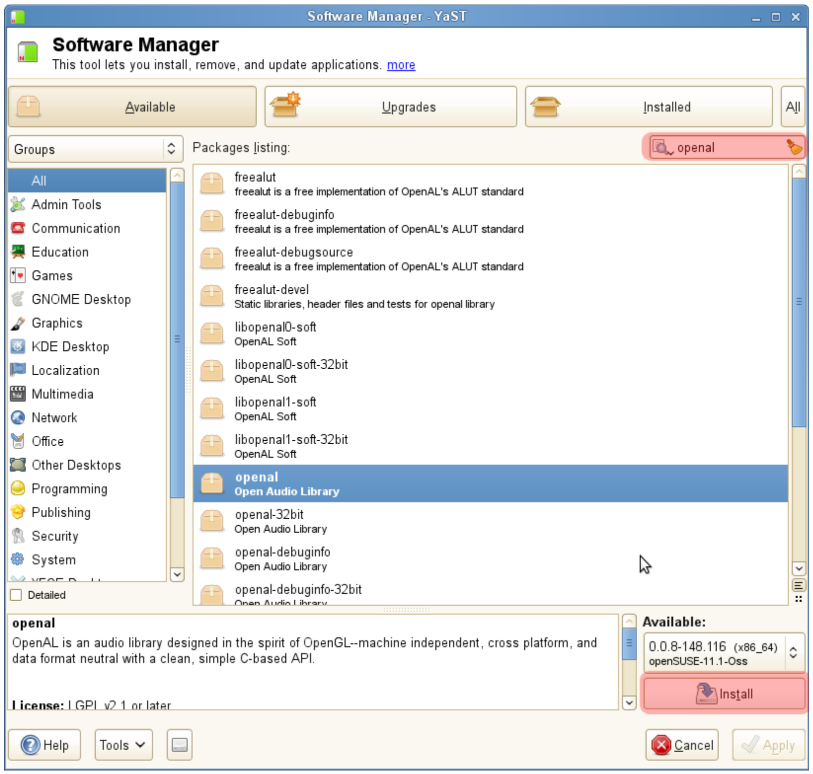
First, insert X-Plane 9 Disc 1 into the computer's DVD drive. If the File Browser does not appear automatically, double click on the XPLANE9 icon on the desktop. In that window, click the Installer Linux icon (as highlighted in the following screenshot) and drag it to the desktop. This is necessary so that we can switch discs during the installation.



With that done, we need to gather the necessary software libraries. Remember that these some of these libraries will only need to be downloaded when running the 64-bit version of openSUSE—the 32-bit version will likely have Mesa installed already.

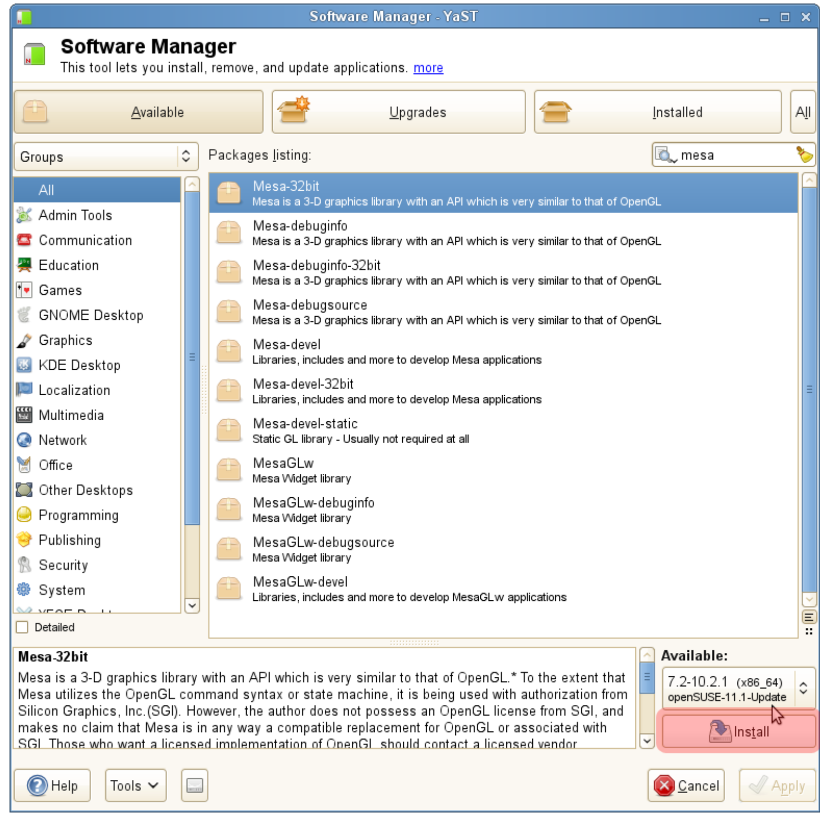
Click on the Computer button in the bottom left of the screen. In the menu that appears, click **Install Software**. Type the root password when prompted.

When the YaST Software Manager appears, type “openal” in the search bar in the upper right, as highlighted in the image below. Click on "openal" in the package list, then click **Install** (as highlighted below). Do the same for "openal-32bit." The OpenAL packages will be necessary for audio output in X-Plane.

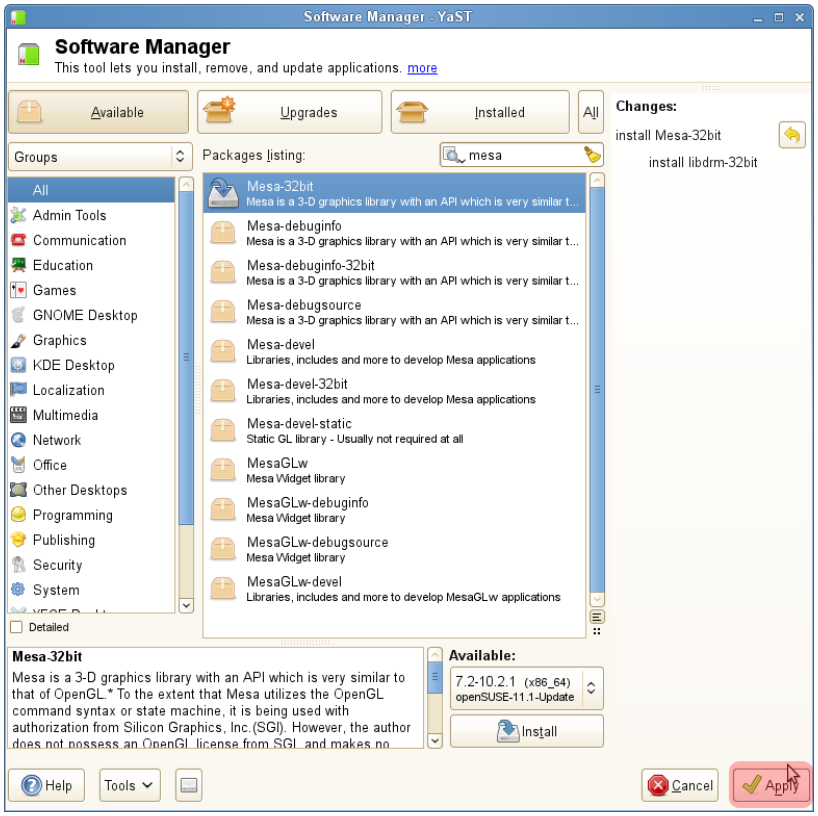


Next, search for “freealut.” Select it and click **Install** just like with the previous package. This too will be responsible for audio output in X-Plane.

Finally, search for Mesa. Click on "Mesa-32bit" and click **Install**, as shown in the image at the top of the next column. Mesa is a free implementation of OpenGL that will handle the video output in X-Plane.

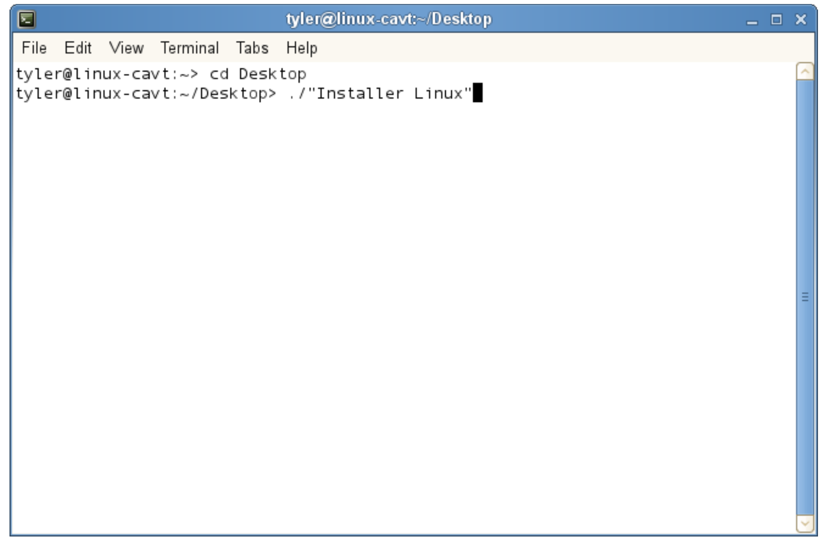


Click the **Apply** button to install all of the selected packages, as highlighted in the following image.

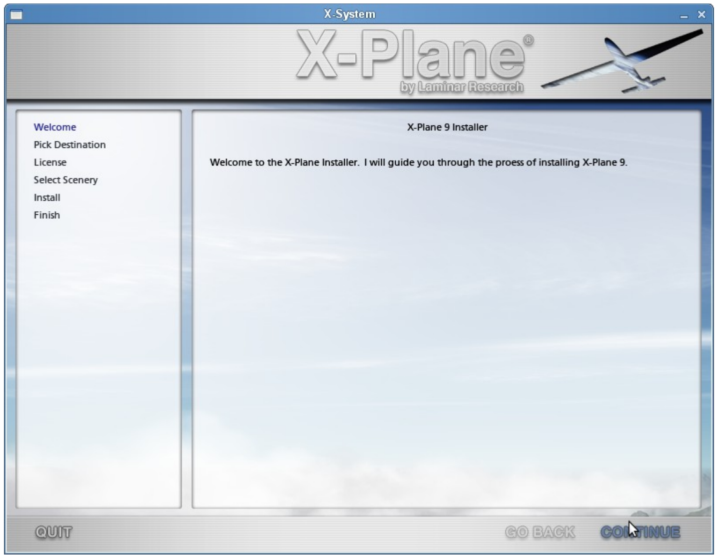


All the required software libraries are now installed. To launch the installer, we'll need to open a terminal window. Click **Computer** (found in the bottom left of the screen), then click **More Applications**. There, double click on the Terminal icon. As an aside, new users might want to drag this icon and place it on the task bar, as it will likely be used often.

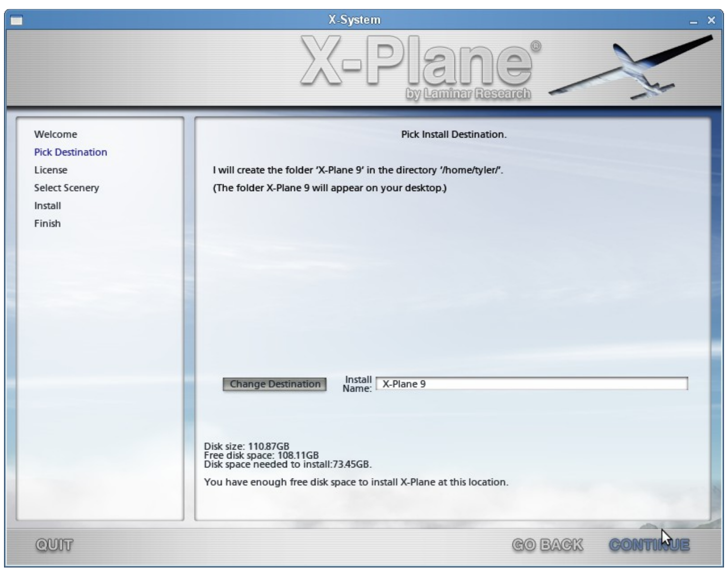
The terminal window that appears will be located (by default) in the /home/[user name]/ directory. To get to the X-Plane installer from here, we need to direct it to the desktop. Do this with the command "`cd Desktop`" as shown in the image below. Once there, launch in the installer by typing '`./"Installer Linux"`' and pressing enter, as in the image below.



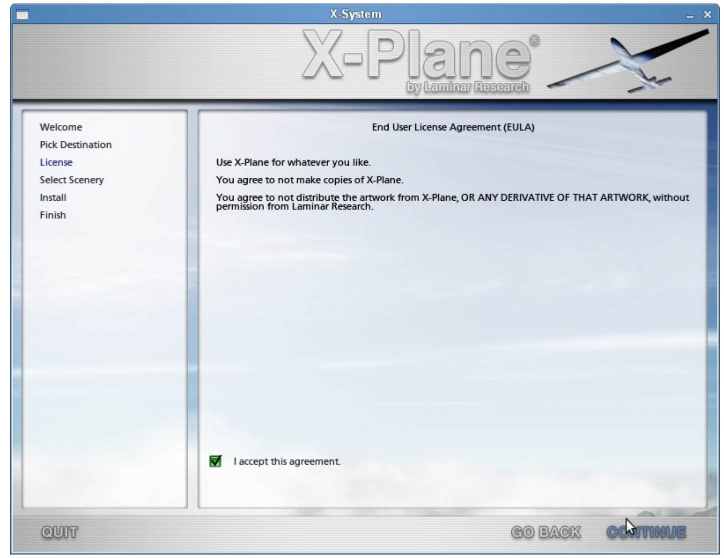
The X-Plane Installer will appear. Click **Continue**.



By default, X-Plane will install to the /home/[user name]/ directory. If this is acceptable, click **Continue**.



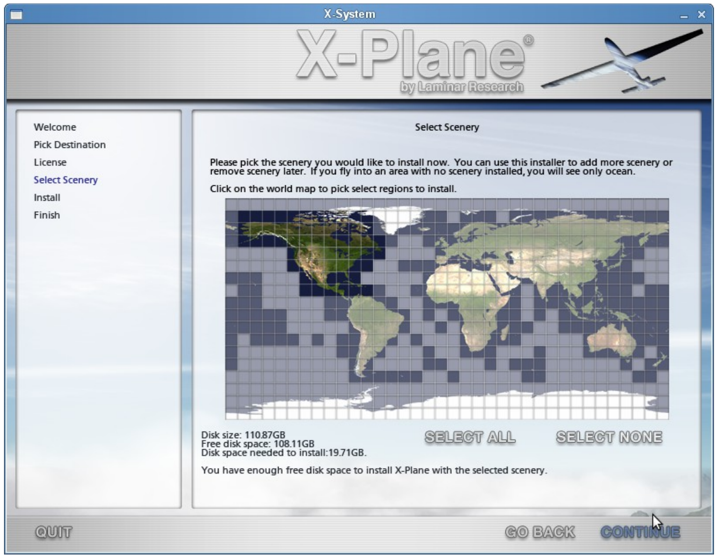
Accept the agreement, then click **Continue**.



Select the area of the world for which scenery should be installed. Depending on the version of the discs, either all or none of the world will be selected. Areas which are not selected will look washed out, while areas which are selected will have their full color. For example, in the image at the top of the next column, only North America is selected.

Large areas can easily be selected by clicking and dragging the mouse cursor. Also, note that for areas with no scenery installed, airports will appear to be “floating” above an ocean. Installing that area’s scenery later (done using this same installer) will correct this issue.

When the desired scenery has been selected, click **Continue**, as shown in the following image.



The installation will begin. When prompted to do so, remove Disc 1 and insert Disc 2. Note that this must be placed in the *same* DVD-ROM drive as the first disc; if it is placed in another drive, the installer may not recognize it. Wait for the disc to spin up, or for its File Browser window to appear, then click **Continue**.

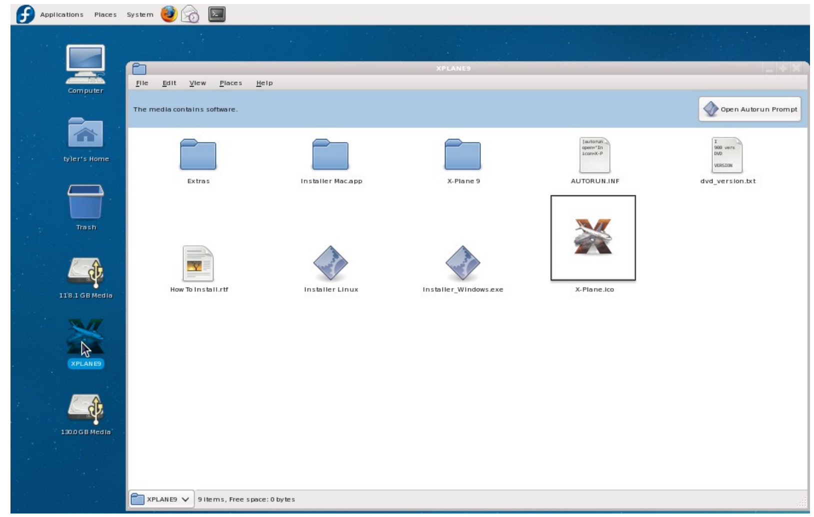
When the installation finishes, the computer is ready to fly.

Note that 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 9 installed on this computer," click the **Add or Remove Scenery** button and proceed as before.

C. In Fedora (64-bit)

This guide will use the x86-64 distribution of Fedora Core 10. The 32-bit distribution will likely not need the Mesa package.

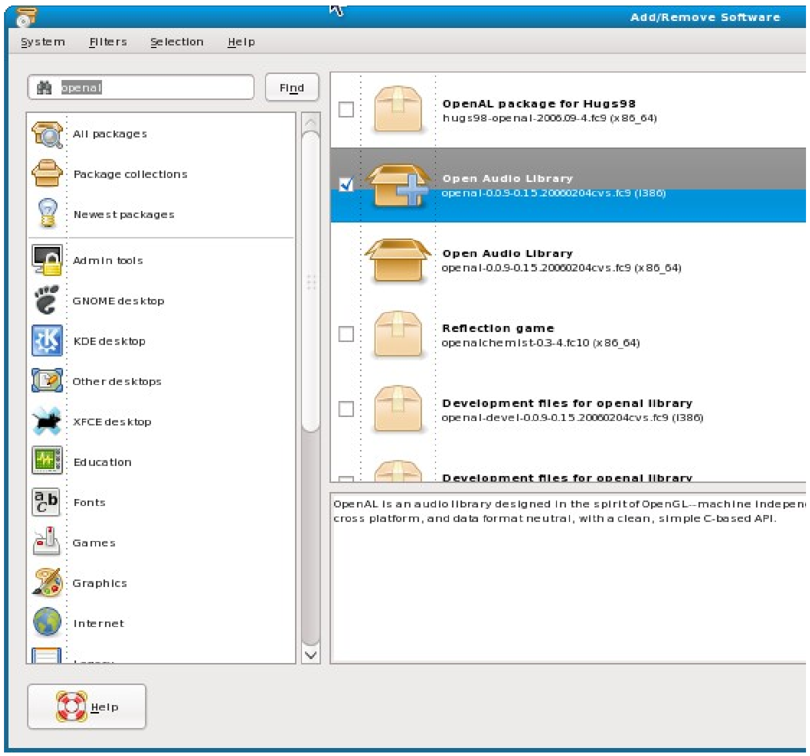
To begin, insert the first of the X-Plane installation discs into the DVD-ROM drive. When it spins up, double click on the XPLANE9 icon on the desktop, as shown in the image below.



Click on the Installer Linux icon and drag it to the desktop. This is necessary so that we can switch discs during the installation.

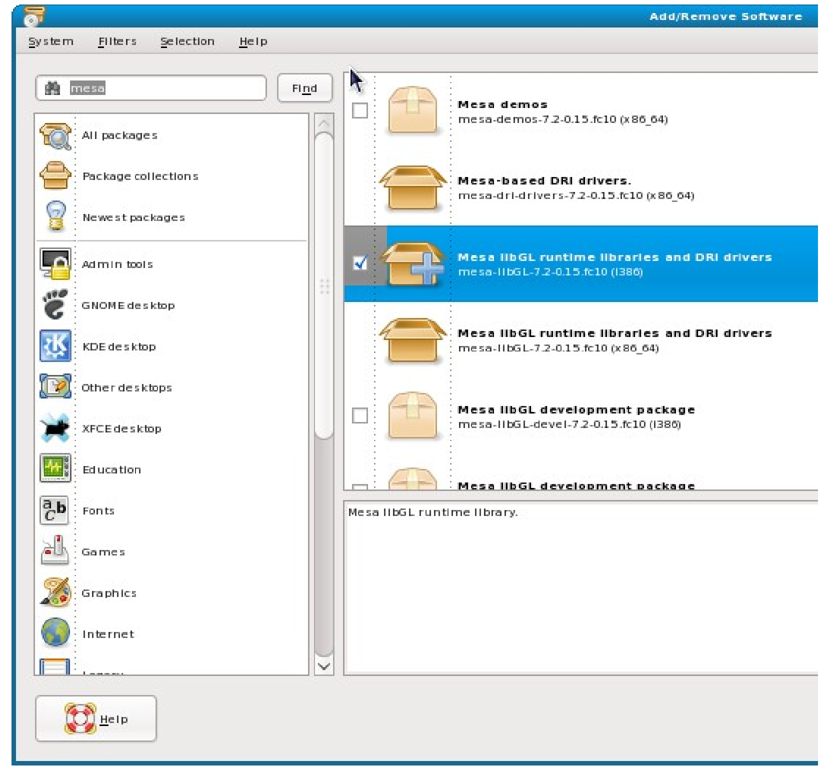
Next, we need to gather the software libraries that X-Plane will require. Click on System (found in the upper left of the screen), go to Administration, then click Add or Remove Software.

In the window that appears, search for OpenAL, then click on the Open Audio Library that notes on the second line that it is the *i386* version (that is, the 32-bit version, as shown in the following image), as opposed to the one which notes that it is the x86_64 version (the 64-bit version).

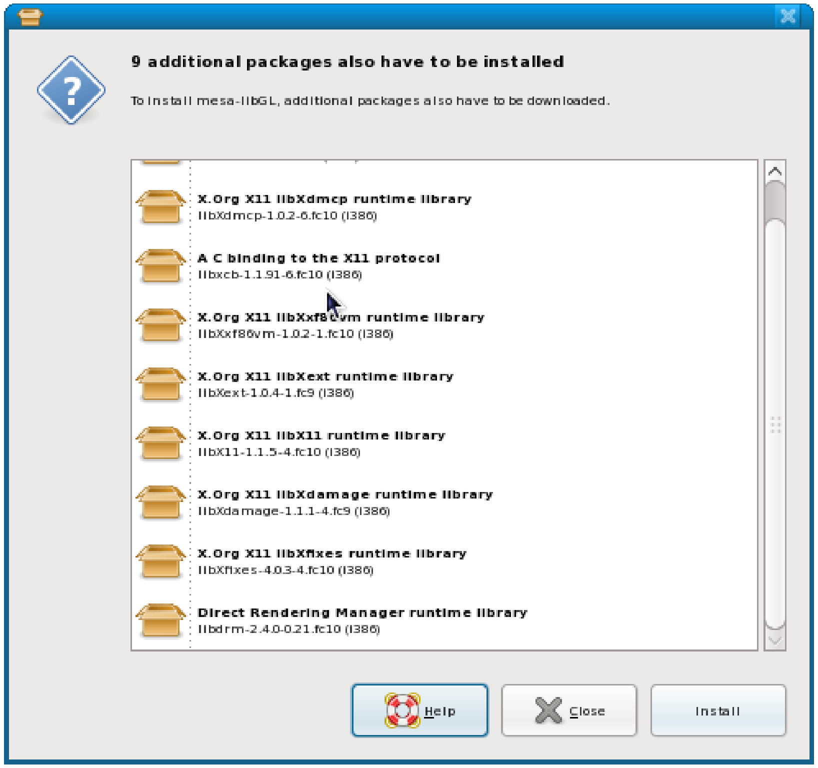


After selecting the correct version of OpenAL, click **Apply**.

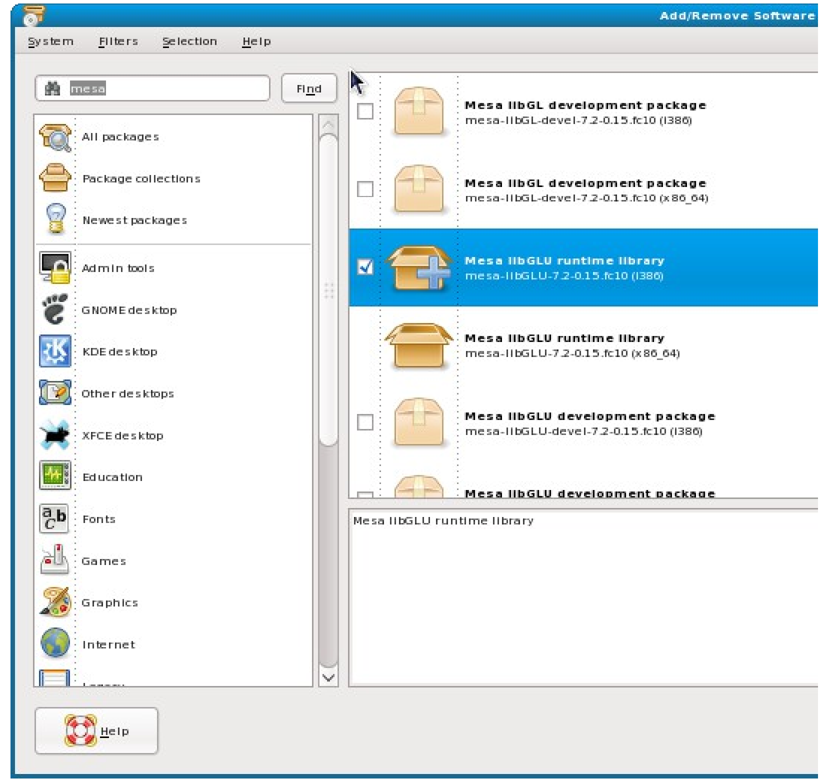
Next, search for Mesa. Click on the version of the “Mesa libGL runtime libraries and DRI drivers” that notes on the second line that it is the i386 version (as shown in the following screenshot), *not* the x86_64 version. Then, click **Apply**.



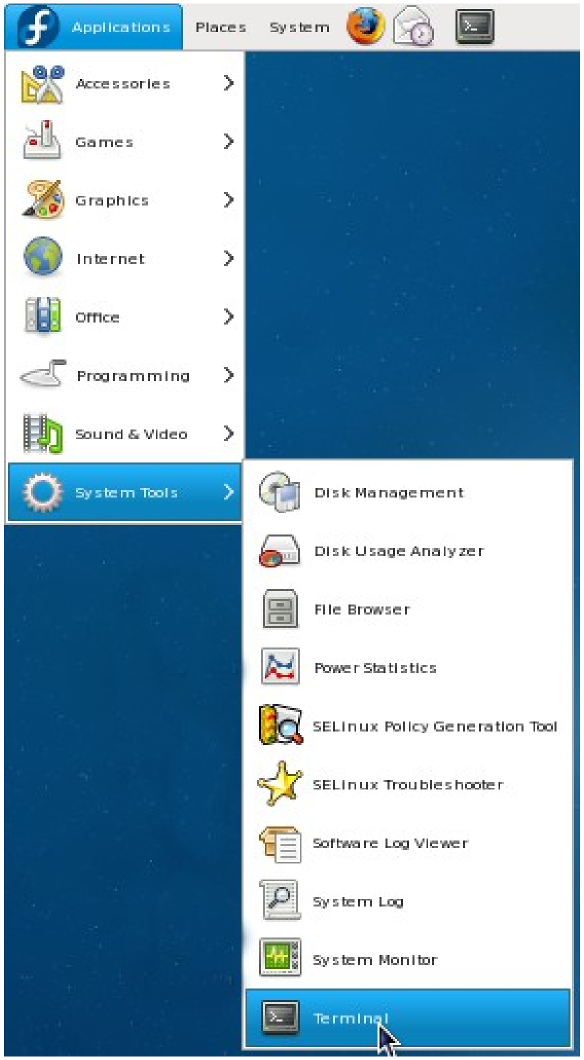
After clicking **Apply**, a dialog box will appear (shown in the following image) saying that a number of other packages must be installed in order to install Mesa. Click **Install**.



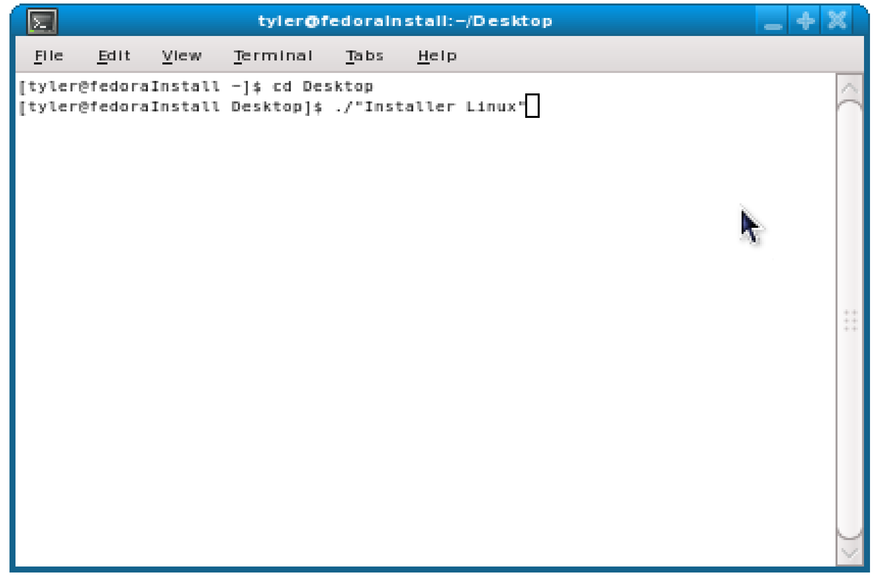
Next, while still having searched for Mesa, scroll down and click on the i386 version of “Mesa libGLU runtime library” (as shown in the following image), then click **Apply**.



With all the required software packages installed, it’s time to run the installer. Open the Applications menu, go to System Tools, and click on the Terminal icon (as shown in the following image).



The terminal window that opens will, by default, be set in the /home/[user name]/ directory. First, move to the desktop by typing “`cd Desktop`” and pressing Enter. Next, launch the installer by typing ‘`./ “Installer Linux”`’ and pressing Enter.



From there, using the X-Plane installer is identical to the steps detailed in the openSUSE guide in the preceding pages.

D. Troubleshooting

If, when trying to run the installer from the command line, an error about a missing library (for instance, libopenal) appears, try searching the operating system’s package manager for the missing file. If that fails, search Google with the library name and the name of the Linux distribution.

To quickly determine what libraries will be needed to run the installer, use the “lld ./[installer name]” command in a terminal (after moving to that directory with the cd command).

For further help, please email customer support at info@x-plane.com, or get community support from the X-Plane.org Linux forums[90].

Additionally, the following X-Plane Linux users have generously volunteered to provide support for fellow users:

- Jeff Sofferin—jeff@jlsworld.com
- Joe Giles—jgiles@cybermesa.com
- Dave Hagerty—dave@surfingpenguin.com
- Martin Leek—mleek@mllengineering.com
- Peter Smith—peter_albert_smith@yahoo.com

[90] http://forums.x-plane.org/index.php?showforum=49

Appendix I: Updating the Computer's Graphics Drivers in Windows

Many systems will have the necessary graphics drivers already 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 video cards can download drivers here[91], and NVIDIA users can download drivers here[92].

Before updating the graphics drivers, we recommend installing and launching X-Plane (as per Chapter 2, beginning on page **17**) and seeing how it runs. If any of the following is 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
- a system crash upon loading or exiting X-Plane

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

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 it is determined that the drivers need to be updated, users should first determine what graphics card they have. The easiest way to do this is to use the DirectX Diagnostic tool included with Windows.

Before we begin, note that, while most of the screenshots are taken in Windows 7, the steps should be almost identical in Windows Vista, and will be very similar in Windows XP. Where they are not similar, the differences are noted.

[91] http://support.amd.com/us/gpudownload/Pages/index.aspx
[92] http://www.nvidia.com/Download/index.aspx?lang=en-us

Note also that ATI has provided a series of four videos, found on this web page, detailing the step-by-step uninstallation, download, and installation of the new drivers. For users of ATI graphics cards, this may be the fastest way to get through the update process.

I. Determining the Graphics Card Maker and Model Using DirectX Diagnostic

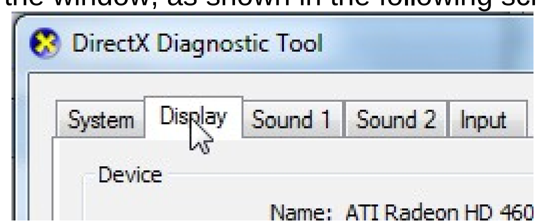
1. To open the DirectX Diagnostic, with which we'll determine what graphics card is in the system, open the Start menu and type "dxdiag.exe", as seen in the following image, then press Enter.

Windows XP does not have this integrated search in the Start menu. Instead, open the Start menu and click Run, as seen in the following image, or press the Windows + R keys.

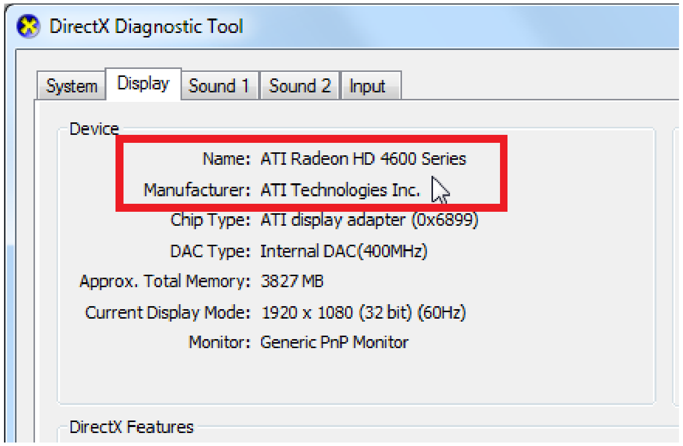
In the box that appears, type “dxdiag”, then press **OK**.

2. If a box appears asking whether the program should check for WHQL-signed drivers, click no—this is not important to what we’re looking for.

3. When the DirectX Diagnostic Tool appears, click the Display tab at the top of the window, as shown in the following screenshot.



4. The information we’re looking for (name and manufacturer of the graphics card) is highlighted in the following screenshot. For instance, in this screenshot, the video card is a Radeon 4670, made by ATI.



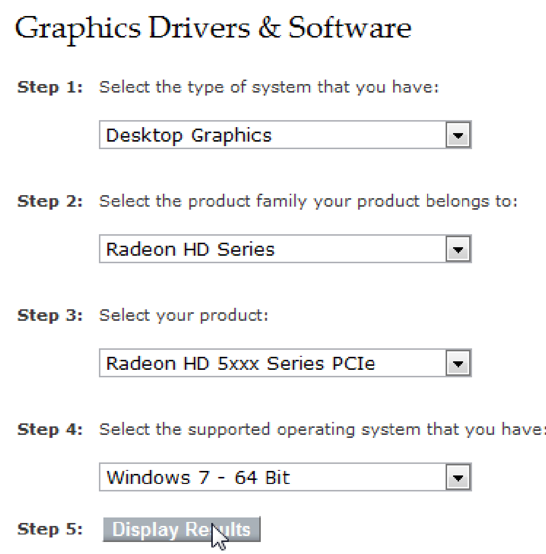
Additionally, it may be helpful to make a note of the "Approx. Total Memory" line in this screen. This is the amount of VRAM present on the video card. It is important to know this number when optimizing the rendering options in X-Plane (specifically, it determines the quality of textures that can be loaded).

Using the information we just found, either continue on to read how to install drivers for ATI video cards, or skip down to Part III to install drivers for NVIDIA cards.

II. Installing Drivers for Video Cards Made by ATI

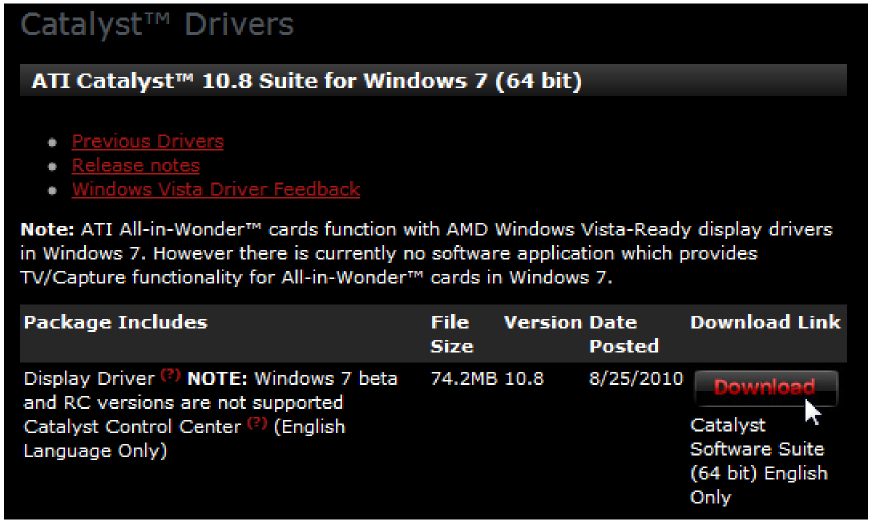
1. Go to the ATI download page[93] and select the computer's operating system, the video card series, and the video card model. Note once again that ATI has provided a series of four videos, found on the download page linked to above, detailing the step-by-step uninstallation, download, and installation of the new drivers. For users of ATI graphics cards, this may be the fastest way to get through the update process.

In the screenshot below, the computer that we're downloading drivers for is running Windows 7 64-bit and the graphics card is an ATI Radeon HD 5850. With the graphics card and operating system selected, click **Display Results** (as shown in the following image) to open the download page.

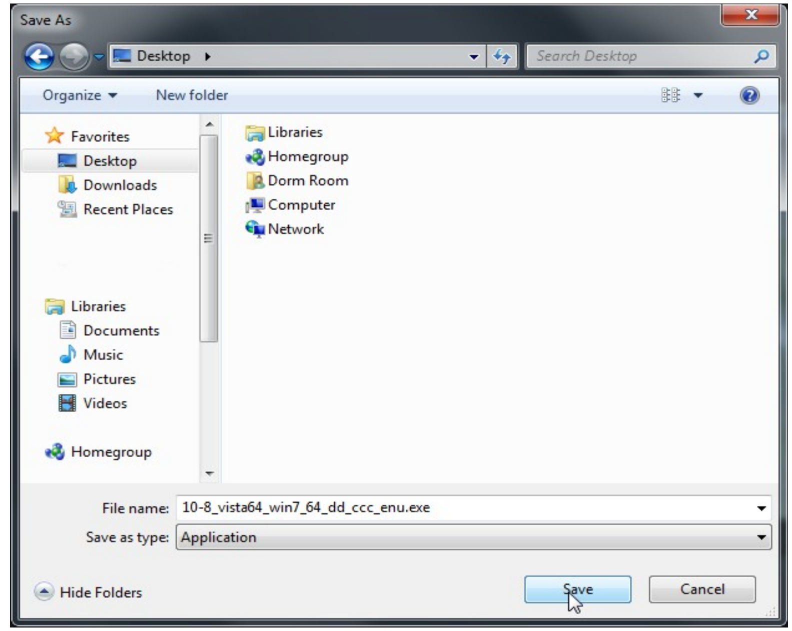


2. Scroll down to the Catalyst Software Suite and click the **Download** button, as shown in the following image.

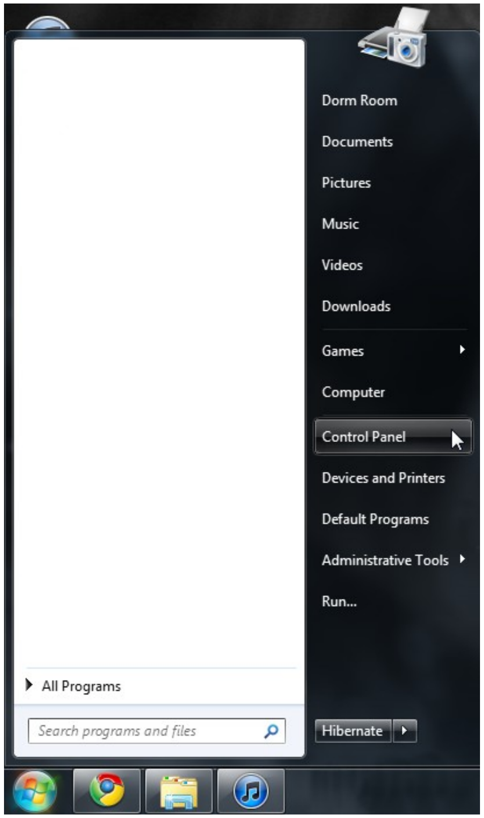
[93] http://support.amd.com/us/gpudownload/Pages/index.aspx



3. In the download dialog box that appears, navigate to the Desktop and click **Save** to begin downloading the file, as seen in the following image.

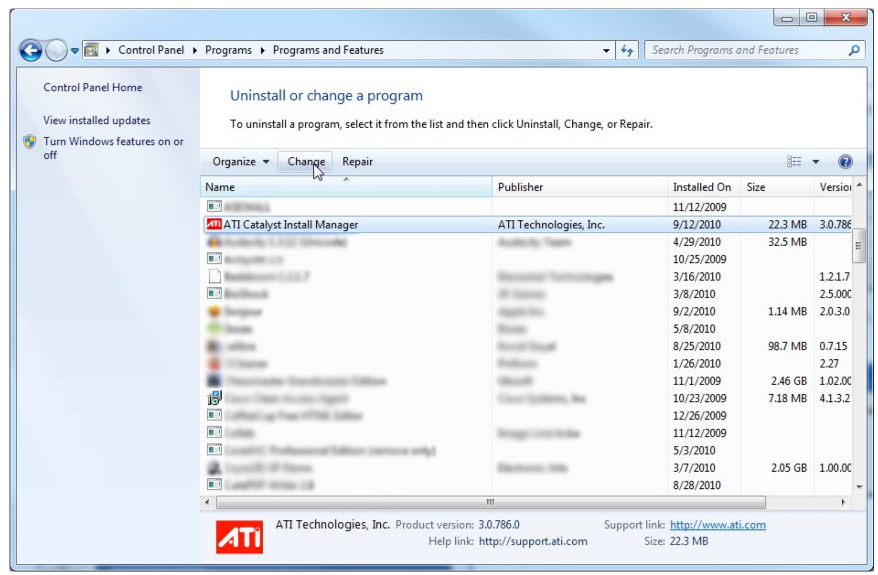


4. Before installing the drivers that were just downloaded, we need to get rid of the old graphics drivers. To do this, open the Start menu and click on the Control Panel, as in the following image.



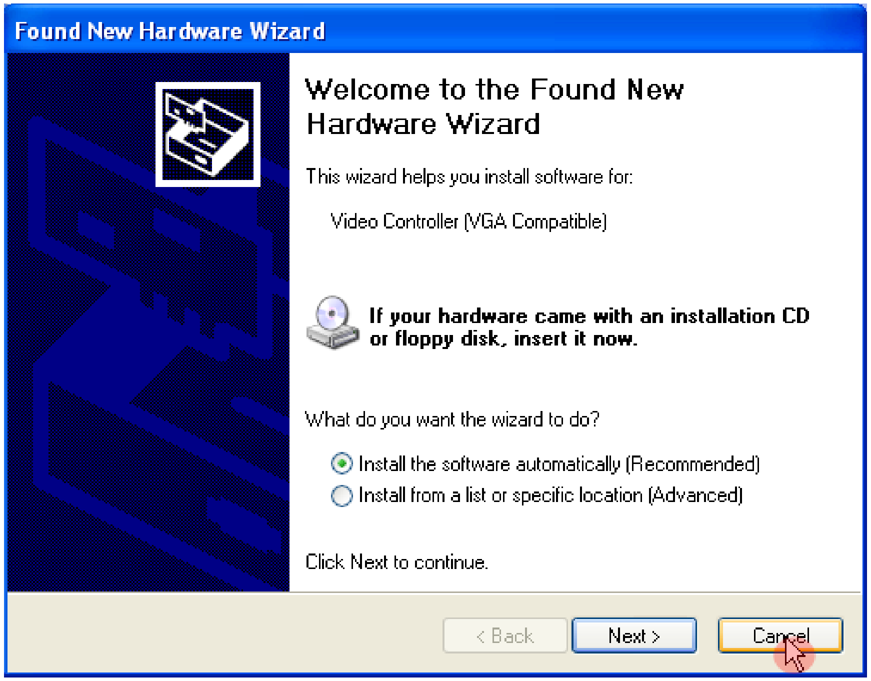
5. In the window that appears, click Uninstall a Program (labeled Add or Remove Programs in Windows XP), shown in the following screenshot.

6. Select the previous video display driver (in the image below, “ATI Display Driver”) and click the **Change** button (in Windows XP, this is labeled **Change/Remove**), as in the image below.



7. Click Next through the uninstall process (actual steps vary depending on which old driver is installed), and restart the computer if the uninstaller prompts to.

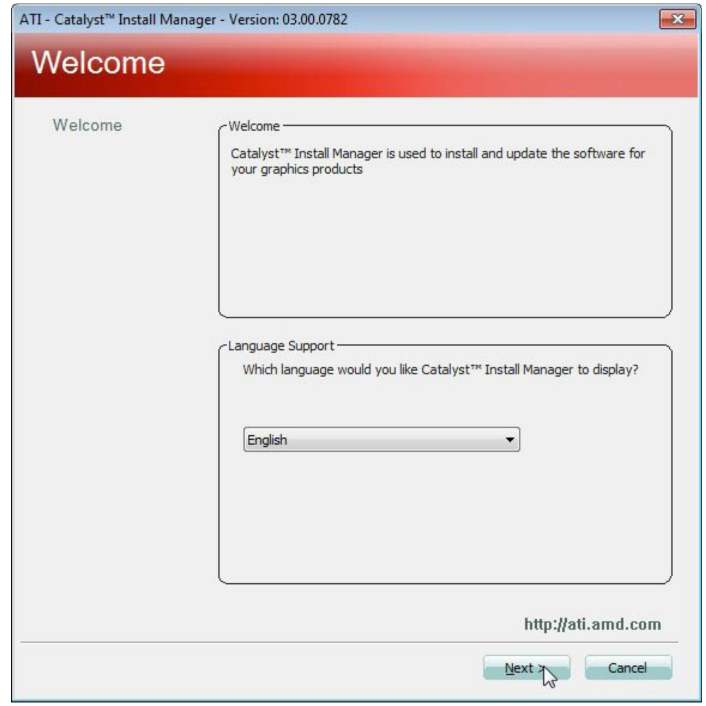
8. If, when Windows reboots, it asks to install drivers for a generic “Video Controller,” click **Cancel**, as shown in the image below, because we do *not* want to use Windows’ default drivers.



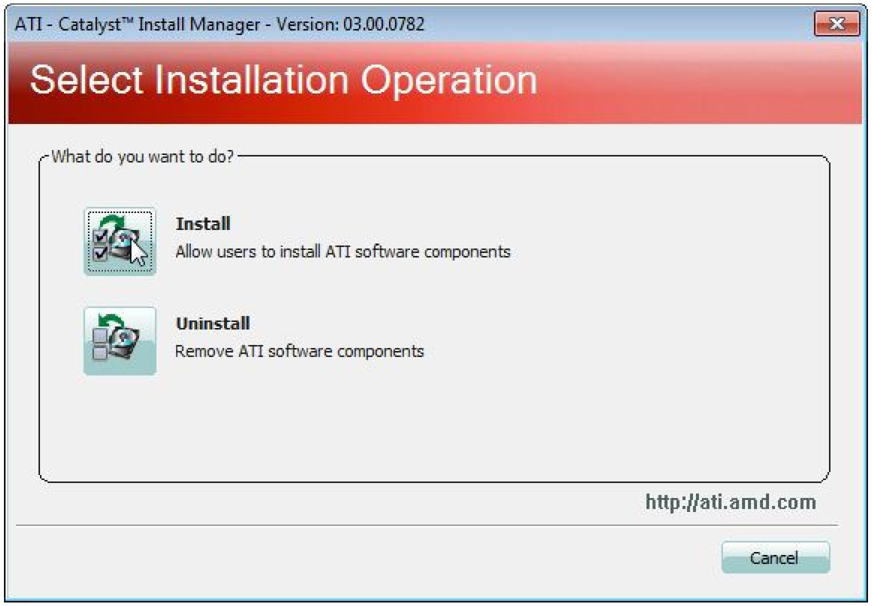
9. Double click on the driver file that was saved to the Desktop in Step 3 above.

10. In the window that opens, click the **Install** button, as seen in the following image. The installer will extract the files to the default temporary directory of C:\ATI\Support\[Driver version].

11. After extracting, the installer should launch automatically. In the window that opens, click the **Next** button, as seen in the following image.



12. Click the **Install** button, as seen in the following image.

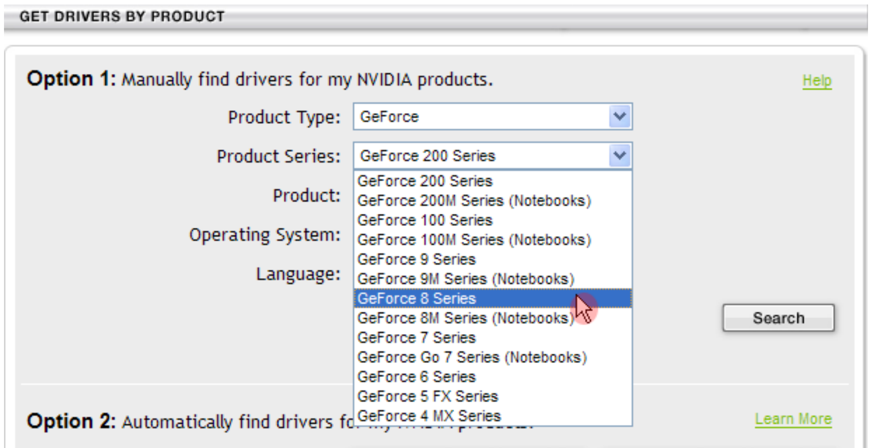


13. Select the Express radio button then click the **Next** button, as in the image below, to begin the installation.

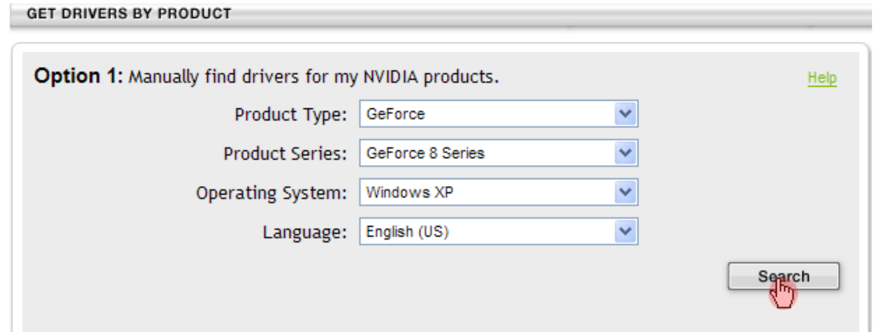
14. After a couple minutes, the installation will finish. Reboot if the installer requires it. After the computer reboots, you're ready to fly!

III. Installing Drivers for Video Cards Made by NVIDIA

1. Go to NVIDIA's [driver download](http://www.nvidia.com/Download/index.aspx?lang=en-us)[94] page. Select the video card that was found in Part A of this guide. For example, in the screenshot below, the card in use was an NVIDIA GeForce 8800 GTX, so the product series selected was the GeForce 8 series. Next, select the operating system to be used.

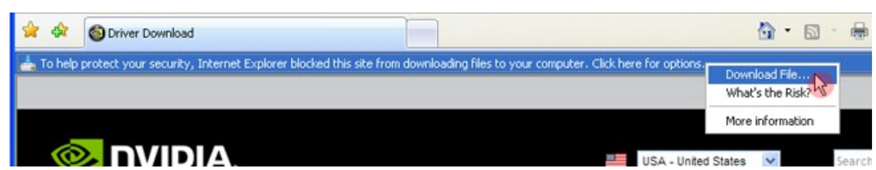


2. With that selected, click **Search** to find the required drivers.



3. When the web page loads, click the **Download** button, as seen in the following image. On the following page, click the **Agree & Download** button.

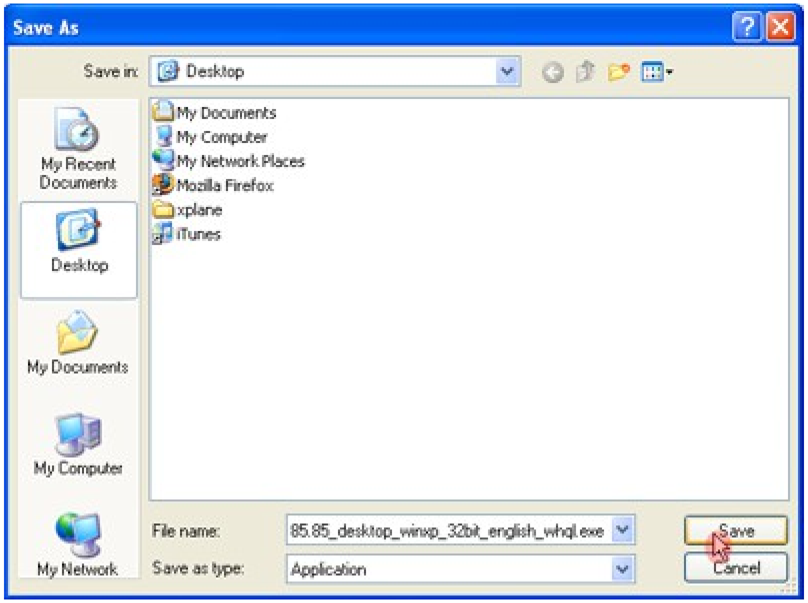
4. If Internet Explorer displays a security warning, right click on the information bar and select Download File, as shown in the following screenshot.



[94] http://www.nvidia.com/Download/index.aspx?lang=en-us

5. Click **Save** in the dialog box that appears, as in the following image.

6. Select the Desktop from the left pane, then click **Save** to save the file to the Desktop.

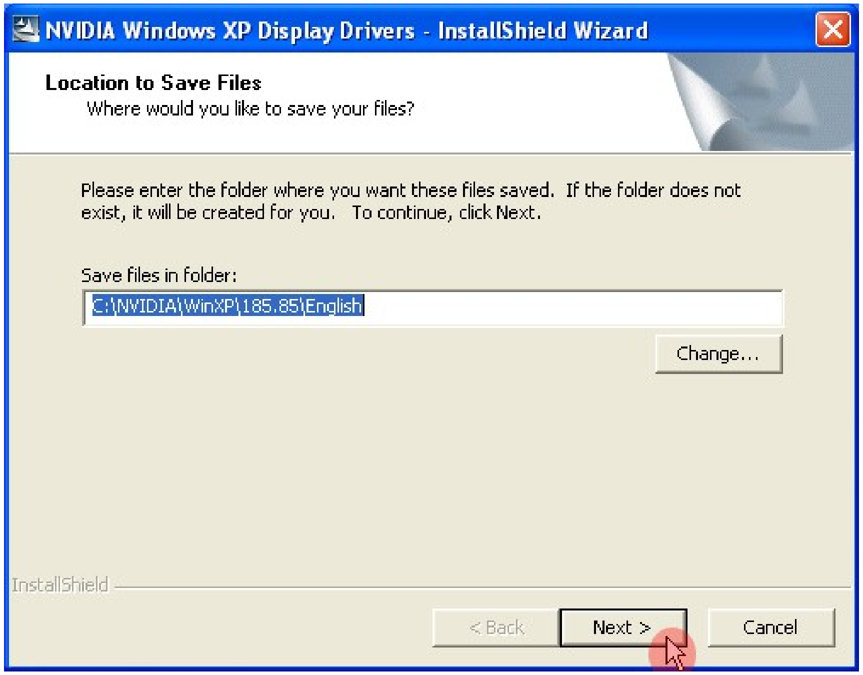


7. Unlike in the installation process for ATI drivers, NVIDIA recommends *not* uninstalling the previous drivers, per [their FAQ page].

12. After rebooting, double click on the drivers that were downloaded in Step 6.

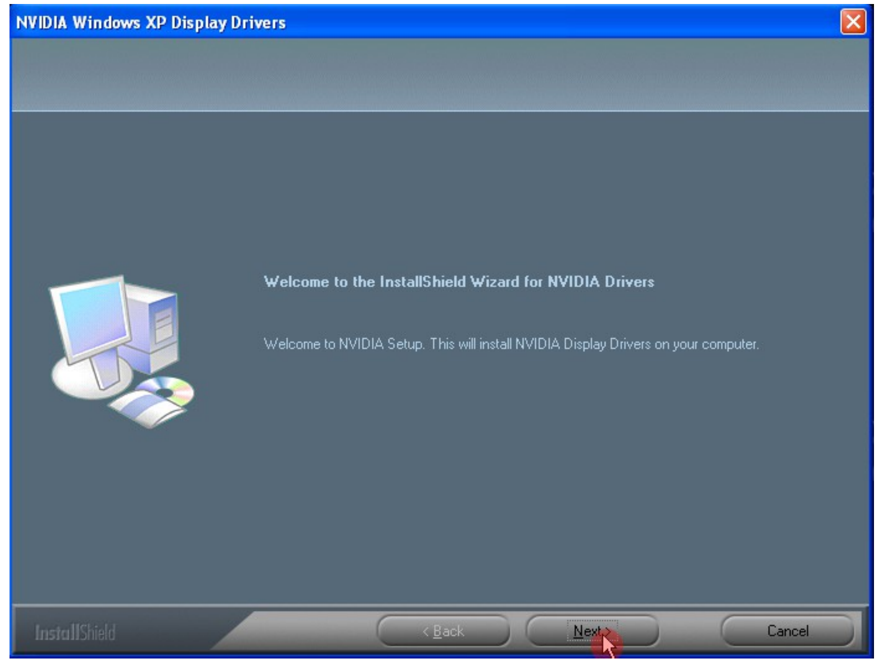
13. Click **Run** in the dialog box that appears.

14. Click **Next** when the file extractor appears.

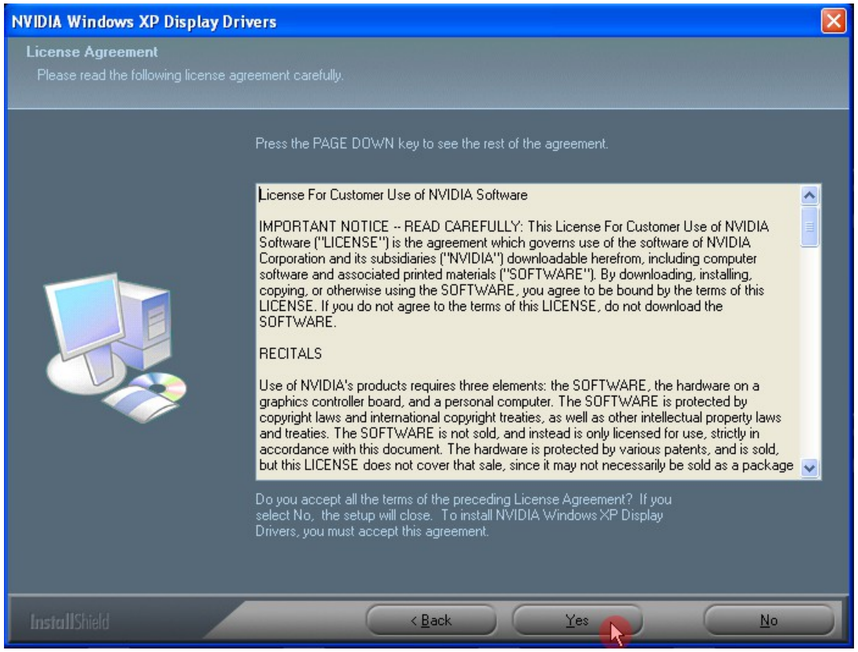


15. The installer should run automatically. If it does not, open My Computer and navigate to C:\NVIDIA*operating system name\driver version*\English and double click on the setup.exe file.

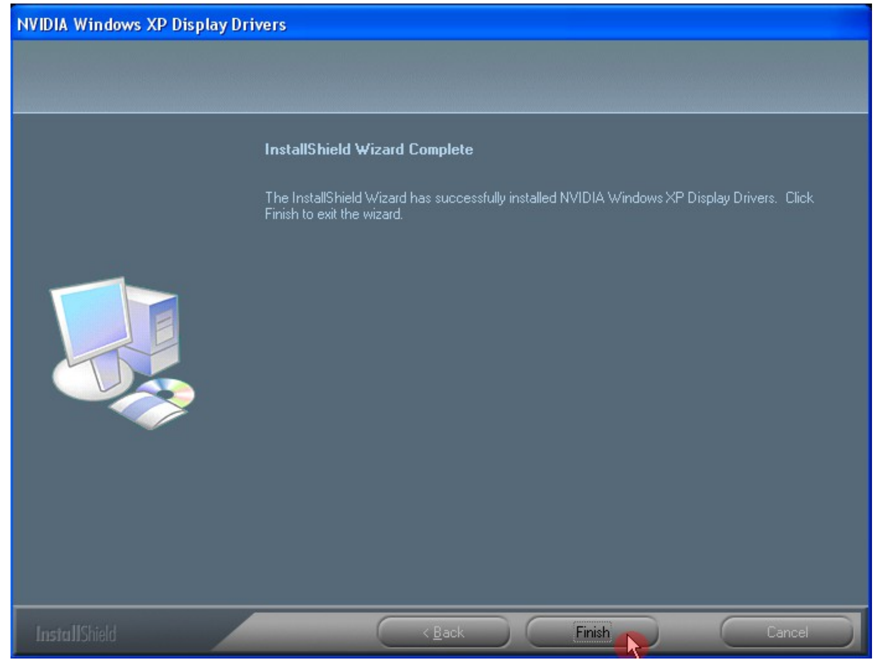
When the installer appears, click **Next**.



16. Click **Yes** to accept the license agreement.



17. The drivers will install automatically. When they are through, click **Finish**.



18. Restart the computer and you’re ready to fly!

Appendix J: Default Key Assignments

X-Plane.org has created a detailed (and colorful) "cheat sheet" for key assignments in X-Plane 9. It can be downloaded from their site here[95].

[95] http://forums.x-plane.org/index.php?autocom=ibwiki&cmd=article&id=41

Appendix K: Using Older Versions of X-Plane

The X-Plane 9 installation discs began shipping on 30 November 2007. Two different sets of discs have been shipped out from the X-Plane.com site so far. The first discs were the so-called "Beta" discs. These came as a set of eight DVDs. On the other hand, the discs currently being sold are the version 9.00 to version 9.22 discs, which come as a set of six DVDs. The installation procedure is quite different between these two. Instructions for installing the six-disc set are found in Chapter 2 of this manual (beginning on page **17**); instructions for the eight-disc set follow.

Additionally, Graphsim Entertainment, X-Plane's retail distributor, sells the X-Plane version 9 six-disc set. Unlike the discs available on X-Plane.com (which have gray labels), the Graphsim discs have yellow labels. These discs use a proprietary installer from Graphsim and are for Windows and Mac OS only. For customer support regarding these discs, please email amy@graphsim.com, or call (214) 884-5571.

Note that the end result of installing and updating from *any* of these X-Plane distributions is the same; installing from the Beta discs, then updating to version 9.22 is exactly the same as installing from, say, the v9.10 discs, then updating to version 9.22.

I. Installing X-Plane 9 from the Eight Disc Beta Distribution

The set of eight "Beta" installation discs were shipped before the final release of the X-Plane v9.00 set of six discs. Installation is quite different from v9.00 and later (described in Chapter 2, on page **17**), but the end result, after updating, is the same.

1. Insert the master DVD (Glider on grey label) into the computer's DVD drive. This is the disc with a glider on the gray label. If the installer window does not appear automatically, open up My Computer (or the Mac Finder, as the case may be) and navigate to the disc. Once there, double click on the appropriate installer to open it.

2. Select where X-Plane is to be installed. Look at the Destination box to see where the installer will automatically try to install the X-Plane. Click on the Destination label to cause a browser window appear for selecting the desired destination. Double click on this location to cause it to be placed in the Destination window.

3. Be sure to install X-Plane to an easy-to-find location, as the simulator, as well as Plane-Maker, Airfoil-Maker, and etc. will all be launched from here. The Desktop is always a good choice. It may be best to write this location down. On a Mac, avoid the C:\Applications folder.

4. Click the **Install** button, to begin installation of the simulator framework and scenery control files. (This will use about 2.5 GB.)

5. After the X-Plane code is installed and verified to be working, install Scenery from disks for areas you wish to fly over. Each scenery DVD (seven total) has the map highlighted on it highlighted with the scenery contained on that disc. It is not necessary to install all the scenery DVDs, and scenery not needed can be easily deleted later from the X-Plane Resources folder to recover disk storage.

   For reference, the version 9 framework plus United States scenery will take up about 10 GB. Of course, these scenery areas are not divided politically, so one will have to also install some Canada scenery in order to get all of the US.

6. When the installation finishes, put the X-Plane master disc into the DVD drive. Plug in any flight controls, then go to the main X-Plane folder and click on the X-Plane executable file. The simulator will load over the course of a few minutes. When it finishes, configure any flight controls, set the desired rendering options, choose an airplane and location, etc.—all per the rest of this manual.

   At this point, users may also want to create a shortcut to X-Plane on the Desktop. Additionally, be sure to update to the latest version as per Chapter 2, Section VII on page **27**.

Appendix L: 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 the eight-disc set of "Beta" installation discs.

To avoid water world, either install the scenery for the location in question, 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 a user has two copies of X-Plane installed (say, one running version 9.22 and one running 9.30 Beta), they may have different amounts of scenery installed.