TECHNICAL SUPPORT

If you are experiencing problems with this software and have followed the instructions in this manual carefully, please call our customer support help line and speak with one of our technical support representatives, or alternatively visit our website at http://www.xicat.com where the majority of common problems and solutions will be displayed.

When you contact our support line, please try to have information about your PC configuration available, together with a detailed description of the problem you are experiencing. If at all possible, try to be seated in front of your computer. Our representatives will endeavor to structure their instructions according to your level of PC competency, but it may not be possible to avoid technical jargon. Always have a pen and paper ready to take down their instructions.

Xicat Interactive Customer Support is available from 9:30 a.m. – 5:00 p.m. (EST) M-F with the exception of national holidays. The number is (954) 522-3900.

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MISSION STATEMENT

So you need to keep your instrument flying skills up to date and you don't relish paying $80.00/hour to keep going up with instructors for instrument currency?

So you want to keep your airmanship skills up to date and want a good sim to do it in without paying $50.00/hour?

So you fly a Glasair homebuilt and you've noticed that there are no instrument trainers for your airplane? Maybe you don't need instrument training, but just want to fly the Glasair on the sim a few times before you take it up for real!

Maybe you're getting your helo lessons and want to practice hovering in the R-22 to get your hovering and helo airmanship skills up to speed before your first solo, or even before your next flight.

Maybe you want to design and test-fly your own aircraft concept?

Maybe you love flying, can't get enough of it, and want to fly the sim when you're not in the real plane.

If you want any of these things or more, X-Plane is for you.

The X-Plane design system is based on the following principals:

- You measure the dimensions of any airplane.
- You enter those dimensions into the computer.
- You fly the airplane on your desktop.

X-Plane was designed to simulate aircraft by using an engineering process called "**blade element analysis**", a procedure frequently used by engineering companies to predict the performance of aircraft propellers and helicopter rotors. The process is actually quite simple: The propeller or rotor blade is broken down into a number of pieces (usually about 5 to 20), and the exact speed of each "piece" is found by considering the movement of the airplane and the rotation of the propeller. Once the speed and angle of attack of each piece of the propeller are known, the forces on the propeller can be found. **X-Plane** uses this theory not just on the propeller, but also on the entire aircraft. The props, rotors, wings, horizontal stabilizer, and vertical stabilizers are each broken down into several pieces and the forces are found on each piece. These forces are then added up to give the total force on the aircraft. Once the total forces on the aircraft are known, **X-Plane** can easily determine what the aircraft will do next.

The flight physics of **X-Plane** are designed to handle subsonic, compressible, and even supersonic flow, so the flight-model is good across a wide range of mach numbers from the 96 knots of the Cessna 152 to the Mach-2.02 flight of the Concorde. Rolls and stalls are possible, although loops and spins are not entirely accurate due to the limitations of Eulerian flight propagation and turbulence simulation, respectively. (Eulerian flight propagation, which X-Plane uses, has a hard time tracking the heading when you are pointed straight up, and the turbulent airflow of a stalled wing is still not completely mathematically simulate-able by any computer).

System Requirements for the X-System

Minimum System Requirements:

	X-Plane 5.52	**X-Plane Classic**
Windows CPU	Pentium 300	Pentium 150
Macintosh CPU	Power Mac 200	Power Mac 100
RAM	96 MB	32 MB
Disk Space	80 MB	20 MB
CD ROM	2x	2x
Video	Open GL Compatible with at least 8 MB of Video Memory (VRAM)	Any
Monitor	800x600	800x600
Joystick/Yoke	Optional	Optional

The Lowdown:
X-Plane 5.52 is a 3-D accelerated program, which means that it needs a decent CPU and a 3-D accelerator card to run. 3-D accelerator cards are designed specifically to do high-speed graphics, so they work many times faster than your CPU ever could. The three languages of 3-D accelerator cards are OpenGL, Direct-3D, and Glide.

X-Plane Classic is an older version of X-Plane that does not have the modern 3-D graphics, so does NOT require a 3-D card with OpenGL. Both X-Plane 5.52 and Classic come on your X-Plane CD, so you can use version Classic now if you have an older machine, and switch to version 5.52 later when you upgrade machines or get an OpenGL 3-D accelerator card.

The faster your CPU, the better the frame-rate, so get a fast Pentium or Power-Mac if possible. Pentiums are OK, Pentium-II's are nicer, Pentium -III's are great.

In the Mac world, Power-Mac's are nice, G-3's are really nice, and G-4's rock incredibly. I-Macs with the Rage-PRO cards are OK, and I-Macs with the Rage-128 cards are great!

X-Plane will be better if you install speech synthesis on your machine. This will give verbal Air Traffic Control!

Windows Users:
Get speech synthesis: **Microsoft Speech Engine (40 meg!)** (ftp://ftp.prisidian.net/links/microsoftspeech4.exe)

Mac Users:
Install the Apple Speech Manager, using the apple system installer on your system CD...you can opt to install the speech manager ONLY.

Check our website for news on the latest and recommended graphics cards, and use X-Plane CLASSIC if you do not have a required 3-D card.

Some remarks about peripherals

On Apple systems you can use any joystick you like with X-Plane 5.52, or stick to *CH-Products, Gravis,* or *Thrust-Master* joysticks if you are using X-Plane CLASSIC. If you have no joysticks then you can simply fly with the mouse (click in the center of the windshield) or keyboard (using the numeric keypad).

On Windows you can use any joystick, yoke, or rudder pedals that you can calibrate in Windows. (On your desktop, go to **“My Computer” / “Control Panel” / “Game Controllers”** to calibrate your joystick).

You can also use the "Fly-It" instrument panel if you want a panel for your PC. Call *Fly-It* at 760434-1940 or see: *www.flyit.com.*

For helicopter controls, *Flight-Link* makes a cyclic stick and collective control, and can be reached at 530-891-4987 or *www.flight-link.com.*

For throttle quadrants, *Flight-Link* makes one that works with X-Plane, and can be reached at 530-891-4987 and *www.flight-link.com.*

For a hydraulic chair that pitches and rolls as the aircraft does in X-Plane, check out *www.tvcknride.com.*

Installation

Windows Users:

Insert the CD into your CD ROM drive and choose one of the following install options to install X-Plane.

1. If your CD ROM drive has AutoPlay enabled, the launch screen will appear automatically. Click install and follow the on-screen installation instructions.
2. If AutoPlay is not enabled, double-click on the “**My Computer**” icon on your desktop. Double-click on the CD ROM drive icon. Double click on “**Setup**” icon. Click install and follow the on-screen installation instructions.
3. You may also install X-Plane directly from the self-extracting executable files on the CD. Double-click on the “**My Computer**” icon on your desktop. Double-click on the CD ROM drive icon. Double-click on either the “**X-Plane 552 Windows**” icon or the “**X-Plane Classic Windows**” icon. The version you choose to install will be based on your system. Please read the **System Requirements** for more information. These files will automatically extract to their own directories on the hard drive you choose.

Macintosh Users:

Just **double-click** on the file on the CD for the appropriate version of **X-Plane**. The version you choose to install will be based on your system. Please read the **System Requirements** for more information. When asked what directory to extract the file to, simply choose the hard drive of your computer or wherever you want X-Plane to be installed.

Macintosh and Windows users:

If you are running X-Plane 5.52 and experience a crash at runtime, you probably need *up-to-date drivers* for your video card. Go to the website of the manufacturer of your video card, and follow the instructions carefully for installing their latest drivers. The driver that came with your video card is probably obsolete already (because of the high advance time on production).

The *latest version* of Microsoft *Direct-X* at www.microsoft.com is also a common solution for PC users.

Do not change the names of the **"additional nav data"** folder or the folders within it. Ditto this on the **"airfoils", "flaps", "planes", "bitmaps", "textures", and "sounds"** folders. X-Plane needs these folders to get to it's scenery, graphics, airplanes, and sounds.

The **"additional nav data"** folder contains "**.env**" files, (scenery files), "**apt.dat**" (airport data), "**nav.dat**" (NAVAID data) and "**fix.dat**" (fix data) files, as well as any custom objects and textures. Most of the scenery for the world is on the X-Plane CD in the form of thousands of "**.env**" files, but any "**.env**" files in the **"additional nav data"** folder overrides the data on the CD. This allows you have your own custom-edited scenery that overrides the default scenery on the CD.

World-Maker will allow you to edit scenery, and the scenery files that you edit will be in the **"additional nav data"** folder where they can over-ride the standard scenery on the CD.

Part-Maker will allow you to create and edit airfoils and flaps, which sit in the **"airfoils" and "flaps"** folders.

Plane-Maker will allow you to create and edit airplanes and helos, which sit in the "**planes**" folder.

Note: X-Plane reads **scenery data** from the CD-ROM periodically as you fly and checks the disk for copy protection. You must therefore leave the X-Plane CD in your CD ROM drive. Removing the CD will put X-Plane in demo mode!

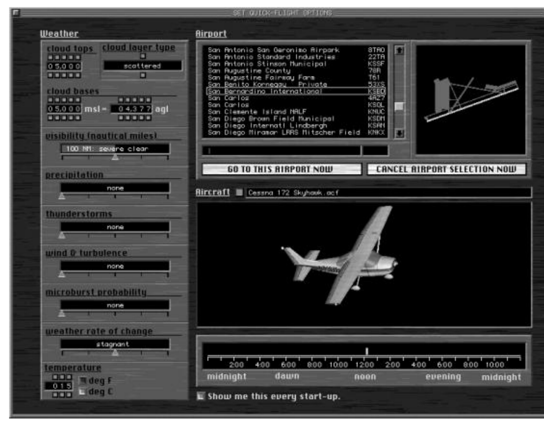
YOUR FIRST FLIGHT

Windows Users
Click on the “**Start**” button in your Windows toolbar. Select “**Programs**” / “**X-Plane**” / “**X-Plane 552**” or “**X-Plane Classic**” (Depending on the version you installed.)

Macintosh Users
Double-click on the **"X-Plane"** icon on your hard drive, thus launching X-Plane. X-Plane will be in your "**X-System**" folder, which is wherever you just extracted it to.

Quick Flight
X-Plane begins with a “**Quick Flight Options**” window. From this menu you can set your weather options, choose your airport as well as your aircraft. For this demonstration, choose the default Cessna 172 which is spinning in the menu. After you have made your option selections, click “**Go To This Airport Now**”.

Wait until you are settled on the runway in a Cessna 172.



Disengage the brakes. (Click the red brake button.)

Operate the throttle with the mouse or joystick. You can configure your joystick in the “**Settings**” “**Joystick Axis…**” and “**Hardware & Flight Mode**” menus. (The throttle is the gray knob on the lower-right... drag it up all the way to go to full power.)

Pull the joystick lightly to rotate and take-off at about 60 knots.

Upon reaching 3,000 feet or so throttle back to 75%.

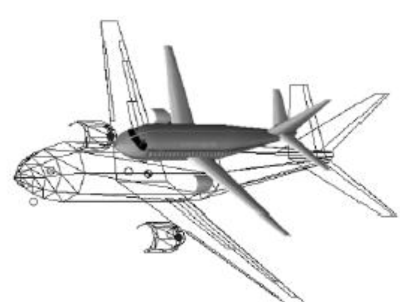
Fly the plane for a few minutes with the joystick.

Now you can fly the simulator.

Select **"Quit"** from the "**File Menu**".

Open **"Plane-Maker"**. Plane-Maker is located in the same location where you found X-Plane. Go to the "**File**" menu and select "**Open**". Select the Cessna 172 from the "**General Aviation**" folder. Select "**Wing 1**" from the "**Design**" menu. Reduce the length a bit, and/or make any other changes you want. Select "**Save As**" from the "**File**" menu. Type in "**Modified Skyhawk**" for your new modified airplane after backspacing over the earlier name and press Return.

Now you know how to edit your own airplane designs.



Select **"Quit"** from the "**File**" menu.

Open "**X-Plane**" again.

Select **"Open Aircraft"** from the **"File"** menu.

Choose the airplane that you just saved in Plane-Maker.

Fly it. (If you still can!)

Now you are an aircraft designer and test pilot!

CHAPTER 1
X-PLANE EXPLAINED

Operating the Controls

Joystick The joystick, rudder pedals and throttle-quadrant operate the flight controls of the airplane. If you don't have any such peripherals hooked up, you can use the mouse and keyboard instead. To use the mouse, click in the center of the windshield and you will be able to fly the plane with the mouse that way. Click again in the center of the windshield to stop flying the plane with the mouse. You can use the numeric keypad to fly the plane with the keyboard.

It is very important to calibrate your joystick before flying **X-Plane!** Do this using the regular control panels for your joystick and operating system. (Windows users should go to **"My Computer" / "Control Panel" / "Game Controllers"**).

Keyboard
Keyboard use is not required. Command key equivalents, if any, are listed in the X-Plane menus. There are also command key equivalents for views in the "**View**" menu. They are surrounded by brackets like this: "**[W]**". Just hit those keys without hitting the shift, option/alt or control keys to select those views.

The default key layout, which is referred to for the rest of this manual, is for the US English keyboard, which means that international users may find keys in different locations. If you have a French or German keyboard, then you can switch to that key layout in the "**Hardware and Flight Mode**" window in the "**Settings**" menu. This will change the keys used in X-Plane to map to the same locations on your keyboard despite being different actual letters of the alphabet. To see where on the keyboard the keys will go, look at the English key layout to the right when referring to the American keyboard shortcuts.

NOTE: Not all airplanes use all keys. In **X-Plane** different cockpit configurations may require a subset of all available keys! For example, a Cessna 172 does not have wing-sweep and a B-52 does not have carb heat.

Enter/Return	activate ATC if not up already	%	autopilot nav course 1
Enter/Return	accept ATC blinking selection	^	autopilot nav course 2
Enter/Return	close/open a window	&	autopilot alt hld
arrow keys	select an ATC option	*	autopilot glide slope 2
arrow keys	rotate view angle if in Free-View or Spot View from the View menu		
		Q W E R (shift-key!)	com 1 radio frequency
Spacebar	kill engine	T Y U I	nav 1 radio frequency
. (point)	reverse thrust (if available)	A S D F	com 2 radio frequency
y u (small caps!)	adjust directional gyro (heading)	G H J K	nav 2 radio frequency
i o	adjust barometric pressure	O P L : > ?	ADF frequency
h j	adjust OBS 1	Z X C V B N M <	transponder setting
k l	adjust radar altimeter bug		
n m	adjust OBS 2	1 2	Flaps up or down one
c v	ADF compass rose	3 4	Carb heat off or on
p	pause	5 6	Speedbrake up or down one
b	brakes	7 8	Aileron Trim
g	gear	9 0	Rudder Trim
!	autopilot disconnect	[ ]	Elevator trim
$	autopilot heading	d	display en route map

Keyboard commands

Function keys control the throttle, prop, and mixture... with one exception: use the **Backspace** key instead of the **F10** key in Windows. In Windows, Microsoft reserves the **F10** key for menu-operations.

If you have a **Flight-Link** throttle quadrant, then: “**Shift**”+ “**function key**” increases, function key alone decreases.

F-1/2	increase/decrease all throttles
F-5/6	increase/decrease all props
F-9/backspace key	increase/decrease all mixtures

If you fly a **helicopter** the **F-1/2** function key control the collective pitch of the main rotor. Here **FI** decreases and **F2** increases the pitch. Be sure to have the hardware throttle handle (serving as collective pitch control in helos) in the full upward position to keep the helicopter on the ground first. Apply the collective pitch very gently with the mouse, hardware throttle, or function keys to lift off. You should probably find the hover position first by pressing **F2** notch by notch or easing back on the mouse or hardware throttle gradually until the helo lifts off the ground.

Mouse
You can drag engine controls, set frequencies, and manipulate any other on-screen controls with the mouse. Realize that no one airplane can have all of these controls, so some will be missing from any given airplane. If you ever wish that the airplane you were flying had additional instruments or controls, go into Plane-Maker and modify the airplane design to get the features you want in that airplane. Experiment with the many options available!

Note: For aircraft with **reverse thrust**, such as the Boeing 737, you need to drag the throttle all the way to the bottom of the throttle travel with the mouse and hold the mouse button down for a few seconds at the very bottom of the throttle travel to drop the engines into reverse thrust.

Other Hardware

If you have a Flight-Link panel or collective, a motion cockpit or moving map or other such hardware, be sure to check out the "**Hardware and Flight Mode**" and "**Serial Output**" options in the "**Settings**" menu. This is where you can tell X-Plane about your esoteric hardware.

Touring X-Plane

Let's take a tour to see all the instruments. Start X-Plane now. Go to the "**File**" menu and select "**Open Airplane**". Go to the "**Planes**" folder and from there to the "**General Aviation**" folder, and select the "**Cessna 172 Skyhawk**". This airplane is rather easy to fly and will give non-pilots a good idea of flight instrumentation. We will use the panel of this aircraft for discussion for the time being.

Menu Bar
The Menu Bar is at the very top of the X-Plane window. We'll discuss the various options later in this manual. Here are a few initial remarks:

- Under the "**File**" menu you can open airplanes, open and save situations and exit the simulator.
- Under the "**Locations**" menu you can place yourself in different situations and at different airports. You can fly formation, extinguish forest fires, land on an oil rig or take-off from an aircraft carrier. You can get towed by a Husky or dropped from a B-52.
- Under the "**Settings**" menu you can quickly set up weather, visibility, aircraft reliability, sounds, graphics and your various peripherals.

Status Bar
Look above the scenery, right under the menu bar. This is the status bar. Control sensitivity, flight easiness mode, the magnetic compass, the aircraft you are currently flying, and the O.A.T. (outside air temperature) are here. The compass heading is shown in 10's of degrees, so 27 in fact means a magnetic heading of 270', or heading to the west. In case you forgot, north is 360', east 900, and south 180'. In flight jargon: three-six-zero, niner-zero, and one-eight-zero. X-Plane's compass simulates magnetic variation and bank-angle-induced error and aircraft acceleration-induced error, so do not count on the compass when turning or accelerating.

Primary Instruments

Airspeed Indicator
Upper left clock-like instrument. Notice the **airspeed arcs** (the colored arcs on the edge of the instrument) that you can use to familiarize yourself with the airplane.

These are the "standard-six" primary flight instruments. Make sure you are familiar with them before continuing past this page.

- **Vso**: The bottom of the **white arc** is the stall speed with flaps (and gear) down. In other words it is the stall speed in the landing or "**dirty**" configuration.

- **Vs**: The bottom of the green arc is the stall speed with flaps (and gear) up. This is the so-called "**clean**" configuration.

- **Vfe**: The top of the **white arc** is the max flap extension speed. Don't extend your flaps above this speed.

- **Vno**: The top of the **green arc** is the maximum normal operation speed and the max speed in rough air.

- **Vne**: The **red line** is the maximum allowable speed, or the velocity to never exceed. You can lose your wings above this speed.

Artificial Horizon
This displays the plane's attitude in the air. Note the "**level adjust**" knob. Use it on the ground to adjust the "**nose-level**" or horizontal reference to your liking.

Altimeter
Reading 1,400 feet above sea level, note its barometric pressure setting knob. Use it to adjust the altimeter setting. The barometric pressure is preset to 29.92"/ 1013,2 mbar (hPa), the standard altimeter setting. The altimeter should be adjusted for the local barometric pressure from time to time. Get the barometric pressure by checking ATIS, which can be done by hitting the "**Enter**" key to activate radio communications.

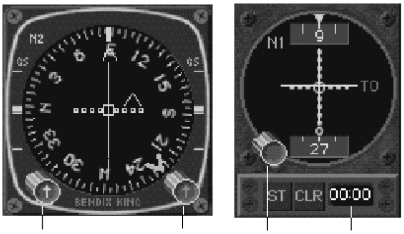
Flaps have a significant effect on both lift and drag. The first bit of flaps (say 10°, or 1 notch) increases the lift (upward force) signifigantly, yet does not add much drag (braking force). As the flaps are FULLY deployed, however, the lift does not increase that much more, but the DRAG goes up a lot. In short, deploy only a LITTLE flaps to get a LIFT boost (like for take-off) but deploy them FULLY to get maximum lift AND drag (like for landing). Cessnas in particular have very effective flaps for steep approaches and low minimum-flight speeds. It is not uncommon to have the airspeed indicator pegged on the lower end of the dial while in flight in a Cessna with the flaps down at minium speed.

Turn-Slip Indicator Look at the instrument below the airspeed indicator. That is the turn-slip indicator. The airplane symbol indicates the rate of turn (not bank!) and the ball indicates sideslip. Use your pedals to keep the ball in the center.

Horizontal Situation Indicator Very important navigational instrument with 2 arrow pointers controlled by the 2 buttons on either side of the instrument... see the next page for further explanation.

Vertical Velocity Indicator The VVI indicates climb and descent rate in steps of 100's of feet per minute.

Navigation Instruments



HSI OBS HSI HDNG VOR-NAV1 TIMER

Horizontal Situation Indicator The horizontal situation indicator, or "**HSI**", is below the artificial horizon. The gyrocompass part of this instrument is obviously your heading, but notice the yellow arrow (with line) on this instrument. This is the Omni-Bearing Selector (OBS). It is a course deviation indicator for a VOR or ILS.

The **yellow arrow** points **to or from** the radial that you have selected to fly. The little knob on the lower-left of the instrument is its "**HSI OBS**" selector knob. Use that knob to adjust the OBS setting for the direction (radial) to a VOR/ILS beacon with its frequency set in Nav2 (in the radio stack).

- Click on the left or right part of the OBS selector to decrease / increase the 013S.

The HSI is hooked up to Nav2 (N2) in the radio stack. This is the lower of the two navigation radios in the stack.

The small **orange arrow** on the HSI is the heading-select pointer. This is the heading the autopilot will fly when the "**heading-select**" (HDG SEL) button on the autopilot in the radio stack is pressed.

VOR selector for Nav 1 Radio
This is a standard VOR selector with glideslope indicator (horizontal line) for the ILS. Note the little round knob on the VOR gauge. This is the OBS selector for Nav I (see Nav I radio in radio stack). Remember that the frequency on the left of the radio stack is used for communications, the frequency on the right is used for navigation.

- Click on the left or right part of an OBS selector to decrease / increase the 013S.

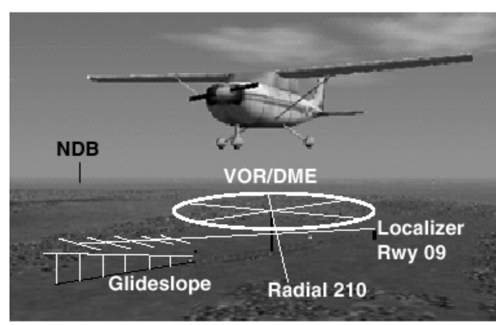
Timer
The timer can be started (ST) or cleared (CLR) by pressing its buttons. It can be used to calculate distances traveled for navigation or keeping track of elapsed time when flying at full engine power (jets may have a 3 minute limit for this).

Let's talk about how to dial in an ILS. The "Output" menu has instrument approach charts showing the ILS and VOR and NDB frequencies for navigation and instrument landing. To fly an ILS, enter the appropriate frequencies from the instrument approach chart for the airport you wish to land at into the appropriate nav radio and dial the appropriate runway heading into the OBS. For the Cessna, the TOP radio frequency goes to the VOR reciever pictured just to the right, and the BOTTOM radio frequency goes to the HSI reciever pictured at the far right.

At right, we seen an HSI and VOR set to fly an ILS to runway 09, heading 90 degrees. The HSI and VOR both show us as being right on course. The little yellow boxes on either side of the HSI are centered vertically and the horizontal needle on the VOR is centered vertically, indicating that we are on the glideslope (the vertical part of the ILS guidance system).The CDI's (course deflection indicators, which are vertical lines) are centered laterally on both instruments, indicating that we are right on the localizer (the horizontal part of the ILS guidance).

If we wander off to the left of the localizer part of the ILS, the CDI's will drift off the right. If we wander below the glideslope part of the ILS, the CDI's wll drift up above the center. A perfect approach will have all needles centered for the entire approach.

Both receivers above can pick up VORs as well, which you can use to navigate from place to place. VOR's are shown as large circles on the Low Enroute map.. enter their frequency into whichever radio you would like to use.



The localizer is situated several hundred meters behind the centerline of the runway and indicates the horizontal path to it. The glideslope beacon sits next to the touchdown zone and indicates the glideslope or vertical path to the runway.

Marker Beacon & Audio Selector Panel

Look at the top of the radio stack. The blue, yellow, and white squares are **marker beacon indicators.** They will flash when you pass over outer, middle, or inner markers during an ILS approach. The buttons to the right are the audio selectors. They select what radios go to the speakers, and are only used for the Nav radios and the ADF in current versions of X-Plane. To hear and test a VOR, dial the VOR frequency into the NAV2 (bottom) radio, then hit the "**NAV2**" button in the audio selector panel: you should hear the morse code for the VOR if the VOR is in range. The same can be done for a Nav I VOR on airplanes that have a VOR for NavI radio instead of a GPS (global positioning system or satellite navigation), and it can also be used for the ADE

Radio stack.

DME

The next instrument down is the distance-measuring equipment. This instrument gives the distance, speed, and time to a VOR. Like a real DME, this one takes a little while to give an accurate answer. The two buttons to the right of the display select which Nav radio you want to get the distance to. NI gets the distance to the VOR selected in the top Nav radio, N2 gets the distance to the VOR selected in the bottom Nav radio.

Nav and Com Radios

The next two boxes down are the Nav/Com radios. Com frequencies are on the left, Nav frequencies on the right. Frequencies for Nav I are on top, frequencies for Nav 2 on the bottom. You'll be advised by ATC which frequencies to use for communications (press "**Enter/Return**" key to activate ATC).

- Click on the selector knob to change the frequency

Transponder

The transponder code your plane should send out is given by ATC and must be set in the transponder by turning the knobs. The code can vary during a flight. After setting ("**squawking**") the code you can cause your plane to light up on radar by pressing the ID button. The blinking reply light indicates ATC's radar is tracking you. Set the transponder to 1200 if you are not talking to ATC.

- Click on the selector knob to change each digit.

Autopilot

The three buttons under the "**HDNG bar**" are as follows:

HDG SEL fly the heading selected by the orange arrow on the HSI. Adjust the orange arrow with a knob on the HSI.

NAV 1 fly the VORALS selected on Nav I (or GPS module)
NAV 2 fly the VORALS selected on Nav 2 (HSI left button)

The three buttons under the "**ALT bar**" are as follows:

ALT HLD hold the altitude selected in the glareshield.

VVI HLD hold the vertical velocity selected in the glareshield.

NAV 2 fly the ILS glideslope selected on Nav 2
Note: a glideslope for the ILS must be available

The button under the "**AS bar**" is as follows:
AS HLD auto-throttle to maintain the airspeed selected in the glareshield.

The autopilot console in the glareshield presets the altitude, vertical speed, and airspeed. Pressing the ALT SEL, VVI SEL or AS HLD button on the autopilot will cause the plane to follow the numbers entered above.

ADF for NDB beacons

GPS - Global Positioning Satellite System

Open the Glasair-II in the "**Homebuilts**" folder. ("**File / Open Aircraft**" in X-Plane, then navigate out a level from the "**General Aviation / Cessna**" folder over to the "**Homebuilt / Glasair**" folder). Notice that in the Glasair, a GPS replaces the Navl radio. The 3 buttons labeled APT, VOR, and NDB select whether you want to fly to an airport, VOR, or NDB. After making the appropriate selection, dial the identifiers with the digit and scroll knobs. As usual, click on the knobs to proceed. Once you have dialed in your destination you can fly to it using the GPS. You get a CDI (course-deflection indicator; the dot between the three I lines), which works just like the horizontal deflection on a VOR to help you fly to your destination. In our above example Lyon Satolas-France is centered and straight on course.

Here is a radio stack withg a GPS, a NavCom radio that sends data to an HSI, and retractable gear as well. The aileron and rudder trim for fine-tuning the airplane are to the left of the gear handle.

DIGIT	moves the cursor across the GPS-selection display
SCROLL	when pressed at top or bottom scrolls up or down the list or characters and names

ADF - Automatic Direction Finder

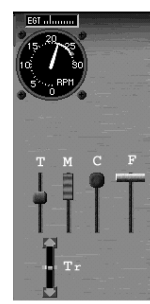
Get back in the Cessna to use an ADE The needle of the Automatic Direction Finder will simply point at whatever radio station the ADF is tuned to. Notice the three knobs under the ADF indicator. These select the ADF frequency. The ADF compass rose can be slaved to the compass in Plane-Maker.

- Click on the upper part of the knob to increase the frequency.
- Click on the lower part to decrease the frequency.

Piston Engine Instruments & Management

OK get back in the Glasair again. To move any of the engine controls, use the mouse to drag the handle up or down, or use the function keys. X-Plane offers carbureted and fuel injected engines. Here are the basic controls:

EGT	Exhaust gas temperature, influenced by (red) mixture handle
RPM	Engine speed, set by (blue) prop handle
MP	Manifold pressure, set by (gray) throttle handle.
Throttle	gray handle (**T**) up is full
Mixture	red handle (**M**), up is full rich
Carb heat	little square (**C**), up is full cold
Flaps	(**F**) pull down handle in 4 stages, up is retracted
Trim	(**Tr**) with arrows on it (right) to trim the plane up/down



NOTE: Aircraft with constant-speed propellers use the throttle to control engine TORQUE (as seen in the manifold pressure indication), the prop to control RPM (as seen in the RPM indication), and mixture to obtain the optimum fuel/air ratio (as seen in the Exhaust Gas Temperature, or EGT). Set the mixture so that the EGT is near maximum. You can practice this in the Glasair.

In the Glasair, take off under normal weather conditions for a test flight. Set flaps to I notch extended. Dial autopilot altitude 3000 feet in the panel glareshield. Prop full forwards (top position) mixture full rich (top position). Throttle up and release the brakes. Steer along the runway and lean back on the stick a moment upon reaching 70 knots. Now maintain 100 knots or so and retract the flaps. Press autopilot button **ALT SEL**. Set the VVI in the autopilot to 1000 fpm again if needed. Set autopilot to HDNG SEL as well, steering with the little yellow bug on the HSI. Let the plane climb to 3,000 ft at full power. The autopilot should level the plane at 3,000.

Now reduce the mixture (pull it back) gradually and watch the exhaust-gas temperature. As you lean the mixture, the engine runs hotter. This is more efficient but could damage some engines. On the other hand, if you keep flying 'cool' or 'rich' and land, one finger (briefly!) in the exhaust pipe reveals tarnish and oil, indicating that you have wasted fuel. The optimum setting is a bit on the rich or knob-up side of maximum exhaust-gas temperature for most engines.

Variable-Pitch Props typically have a "cruise" setting when en-route. When we climb we want (nearly) all the pulling power, but en-route we feather the prop a bit to reduce RPM. Bring the prop in the Glasair back to about 2,300 rpm for efficient cruise, and the throttle back to about 23" of manifold pressure for moderate engine power.

Carburetor heat is needed when landing a carbureted plane, or ice may form in the engine air intake and strangle the engine. A warning will appear in the top "**status**" bar in X-Plane. If this happens then activate the carb heat found in the lower right of the Cessna 172 panel.

Modern Jet Instruments

OK open a jet, like the Boeing 777 in the heavy metal folder. Airspeed, Horizon, and Altitude are in the top left display. Note the yellow squares on either side of the artificial horizon and the little line on top: these are the glideslope and sideslip indicators, which you know from the HSI and turn/slip indicator in the other planes. The glideslope is hooked up to whatever instrument landing system (ILS) is tuned in on Nav 2 radio. A red dot appears on the altitude tape when surface contact is imminent. Flight Mach number is under the speed tape. Barometric pressure is under the altitude tape.

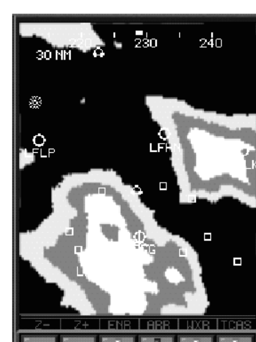
Horizontal Situation Indicator The **horizontal situation display,** or "HSI", is below the artificial horizon. It is the same as the HSI you have already played with in the light planes, but has a digital DME indication on the lower left.

Vertical Velocity Indicator

The VVI indicates climb or descent in 1,000's of feet per minute.

Altimeter

Note the barometric pressure setting knob on the HSI. Use it to adjust the altimeter setting. Note that the barometric pressure is preset to 29.92"/1013.2 mbar (hPa), the standard altimeter setting (SAS).



EFIS with weather and traffic information activated

EFIS

The large display to the right is the moving-map portion of the Electronic Flight Instrumentation System, or EFIS. It shows airports, NAVAIDs, weather, and other traffic (tiny boxes with numbers indicating the altitude in hundreds of feet above or below you). Note the gray buttons at the bottom… z- and z+ zoom in and out, the range being depicted in the upper-left comer of the display. The "**enr**" and "**arr**" buttons are for selecting the "enroute" or "arrival" modes of the display:

Enroute Mode displays the map oriented with your heading upward. Many pilots like to see the flight direction on top for easier recognition of airports and NAVAIDs to come. A VFR pilot with a huge map upside down over his knees knows the benefit of nice EFIS display that can always show your direction as the orientation of the map. **Arrival** displays the map with North at the top. This is useful in verifying your approach.

The "**WXR**" and "**TCAS**" selectors turn the weather and traffic warning displays on the EFIS on and off.

Heads-Up Displays The HUD, when activated presents data to the windshield for easy viewing. X-Plane offers 2 types of HUDs:

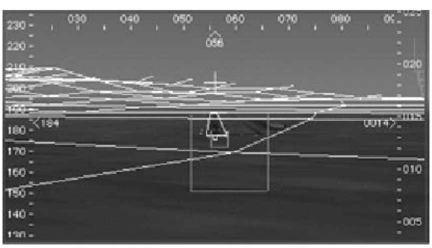
Actual Hoops-style HUD.

HUD's may give an unjustified feeling of safety though

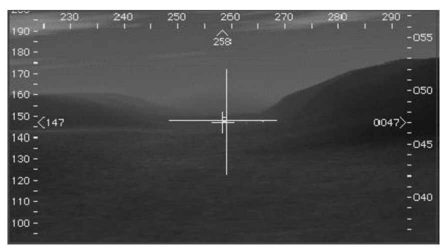
1. **Hoops HUD**, which is a highly experimental concept that draws terrain and hoops leading up to each runway.
2. **HUD** with course deviation crosshair coupled to Nav2 in the radio stack, which is most commonly used in reality.

Select the HUD you want for any given airplane in Plane-Maker. The little green square that wobbles around is the **velocity vector,** indicating the true flight path. The small cross in the middle indicates the direction that the nose is pointing. The angle between waterline and velocity vector represents the angle of attack, or angle between the relative wind and the airplane.

Speed, Heading and Altitude appear along the sides of the HUD.



Simulated Hoops-HUD



HUD with Nav2 crosshair

ECAM Display

Most jets have an ECAM system-providing engine and other aircraft parameters. The ECAM in ENGINE mode provides the following:

ENG mode

N1 intake compressor rotor speed in %
FF main engine fuel flow in pounds per hour

BURN this indicates that the afterburners are running, which will tremendously increase fuel consumption!

ECAM for jet engine management.

FUEL mode
fuel flow and fuel-on-board indicators

FCON mode
flaps, slats, and other flight control status

HYDR mode:
status of the hydraulic system

FAIL mode:
indication of systems failures

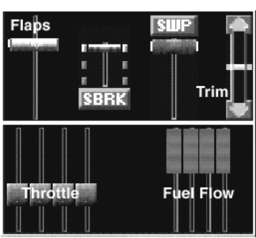
X-Plane offers 3 types of turbine engines:

1. Turboprop engine (typical for prop commuters)
2. Low-Bypass engine (typical for military jets)
3. High-Bypass engine (typical for civil jets)

Control of these engines is somewhat similar to a propeller engine, but the red knob that you are used to using as a mixture control simply shuts down or starts up a turbine engine, since the engine's computer controls the fuel/air ratio automatically in a turbine engine. Also for turboprop engines, you get a direct torque indication to indicate how hard the engine is pulling, rather than a manifold pressure indication like you get in a reciprocating engine.

JATO
Some airplanes may use Jet-Assisted Take-Off by igniting a solid fuel rocket during take-off. The C 130 military transport, for example, can use JATO to kick itself into the air rapidly. Hit the "**JATO**" button on the right side of the glareshield on so-equipped aircraft to light up the JATO. The X-I and X-15 aircraft in X-Plane use JATO to simulate their rocket engines, although in fact those aircraft were powered by LIQUID-fuel rockets. Either way, rocket thrust is rocket thrust (it is thrust that does not vary appreciably with speed or altitude) and the simulation will fly like the real plane. Put JATOs on any plane in the simulator to see what it is like to get dragged into the air by a pack of wild horses, which is what a real JATO feels like during actual operation.

Special Instruments & Controls



Special controls are above the throttle and fuel flow handles. Check out the variable-sweep B-1 (pictured below) in the "Heavy metal" folder.

B-1 B bomber with variable-sweep wings in a medium-sweep position.

Above the throttle and fuel flow console is a panel for special controls. Leftmost sits the handle for **flaps** (linked automatically to slats if available), which can be pulled down from retracted (top position) to maximum in 4 stages. Do not extend the flaps above We (Velocity Flap Extension). Find the VFE for your plane in the "**Viewpoint**" option in the "**Standard**" menu in Plane-Maker.

Next to this handle is the **speedbrake.** leave it alone for no deployment, drop the handle down I for half deployment, or down full for full deployment. Airliners can have the speedbrake lifted UP I for AUTO-deployment, which will deploy the speedbrakes automatically on touch-down.

Depending on your type of airplane you may find a handle for either **wingsweep or thrust vector** (not both). The B-1 bomber has swept wings, the AV-813 Harrier has vectored thrust.

Sweeping the wings back allows the airplane to go through Mach 1 with reasonable efficiency, since the wings do not have to battle supersonic airflow head-on. The surprise is that it also scoots the center of lift of the airplane back, causing the plane to act like a lawn dart (always wanting to dive) at low speeds. B-1 pilots do not like to have the wings swept back below about Mach 0.70 or so, but like to start sweeping them above that speed.

Thrust-vectoring allows vertical take-off and landing, but an airplane in hover has no natural stability or gliding ability, so woe to the pilot who loses the artificial stability system or has an engine failure in hover! Set the reliability of these systems in the "**Settings**" menu.

The **trim** sits in the right side of the panel and is used to adjust the "resting point" of the airplane in pitch. For airliners it actually pivots the entire stabilizer, and for Mooneys it pivots the whole tail! The trim, by adjusting the "resting point" of the airplane in pitch, serves to vertically trim the airplane (nose up or down) to relieve the arms of the pilot holding the stick and the mechanical controls for the horizontal stabilizer or stabilator. This also applies to the rudder and aileron trims to keep the plane un-crabbed and level respectively.

Thrust vectoring handle as can be found in the AV-8B harrier.

Radar Altimeter
Some cockpit displays offer a Radar Altimeter. Dial its knob to set the warning altitude. Height is given in 100's of feet. A value of 200 feet typically leaves enough room for a go-around.


AV-8B Harrier has thrust vectoring.

Braking parachute
Some aircraft use drag-chutes to help slow down on landing. Planes that land fast as heck (like the F-104 Starfighter) need the drag chute the most. In X-Plane the button to deploy the drag chute is in the glareshield beside the JATO and anti-ice. The chute can be assigned in Plane-Maker if desired. The XB-70 Valkyrie and X-3 Stiletto in the "**X-Planes**" folder in X-Plane have (and badly need) braking chutes.

Cockpit Instruments

You'll find that different planes have different panels. Some jets may have a digital panel, others a conventional display.

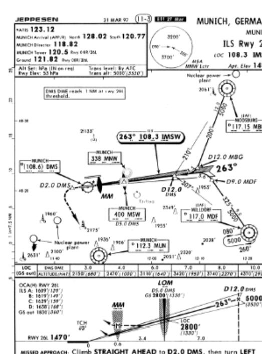
In Plane-Maker you can change these panels and select specific combinations of instruments.

With graphics editors like PaintShop or PhotoShop you can even create your own panels.

Check out **www.xicat.com** for all the ways to customize graphics and sound for X-Plane!

NOTE: EFIS shows you other traffic and ATC will try to vector you around it. However, if you fly VFR (visual flight rules) look for other traffic yourself. A mid-air collision is possible. If you ever get near another plane, try flying formation on it if you can. Formation flying is fun but very challenging... just try it!

The bar above the instrument panel has several useful buttons varying with the aircraft. Military aircraft can jettison their load, firefighters can jettison water, some planes may have parachutes for braking, or an arrestor hook for landing on a carrier. The **anti-ice** button can help you out in cold weather conditions. Left is the bright red **stall warning light** with beeper.



Jeppesen Sanderson, Inc. provides the professional flight world with up-to-date maps. You can use these maps to fly X-Plane, but don't use X-Plane maps to fly for real.

In X-Plane you can fly full instrument approaches, simulate aircraft behavior and learn the basics of navigation. For non-pilots, if this has aroused your interest for actual flying, visit your local airport, ask for the nearest flight-school, and go for a true hands-on experience... you will be allowed to fly the plane under the instructor's guidance on your first flight!

Putting the theory to the test

Flight from San Bernardino to Riverside Municipal

1. Click "**K S B D**" in the "**Location / Place aircraft by airport / Airport ID**" option. KSBD is the ICAO-code for your departing airport **San Bernardino.** In a few seconds you're on runway 06 of San Bernardino, ready for a short instrument flight to "**KRAL**", Riverside Municipal airport - situated some 13 miles west-north-west.

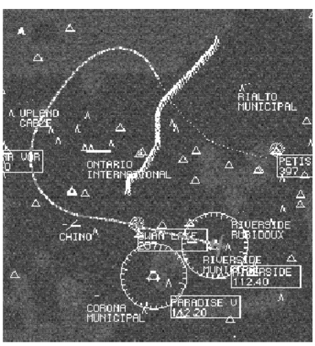
2. Load the Glasair from the "**File / Open Aircraft**" option. It is in the "**Homebuilts**" folder, as you recall.

3. Press "**Enter/Return**" and the up-arrow to file your flight plan. Set altitude to **4000** feet and destination to **KRAL.** Click **IFR** (top left). Close your flight plan now by clicking the window close-button, top left.

Activate ATC Communications in X-Plane by pressing Enter/Return key. You may also assign a button on your joystick to call ATC in the "Settings:Hardware and Flight Mode" window.

Once you activate ATC, you will be able to make selections with the mouse or arrow keys. The recommended option is always flashing.

Choose "Say again" to have the last instruction repeated.



4. Next use the **knobs** in the **instrument bar** below the glareshield to set ALT 4000 feet, VVI 1000 feet per minute.

5. Set NAV I/GPS to the destination VOR (set "KRAL" - read 215'- 13 nm). 6. Check the **airport map** of "**Riverside Municipal**" in the "**Output**" menu.

Note the **heading** of the landing runway and its ILS frequency. You will go for runway 9 with ILS frequency 110.9.

7. Set the HSI needle to 90 (left yellow knob) and NAV2 to the ILS 110.90.

8. Select "**Settings / Weights and Fuel**" to adjust the weight of your Glasair. Enter your own weight as the fixed payload, plus the weight of any other people watching over your shoulder while you fly. Enter 1/2 tanks of fuel.

9. **Preflight check:** flaps 1 notch; GPS/Navs set; ALT and VVI values set; the engine at idle.

10. Press **Enter/Return** and select "**Pick-up Flight Plan**" Check and write down the ATC instructions that follow. Set **transponder** and tower frequency to **Com 2.11**. Call ATC for take-off permission and note the instructions.

12. **Throttle up** when cleared, and then release the brakes. At about 70 knots gently pull the stick to rotate and take-off. At a positive climb press the autopilot for VVI SEL and climb to the altitude indicated by Air Traffic Control. If climb to 4000 feet is approved, press ALT SEL, and re-enter the VVI selection if needed.

13. Follow the **instructions** from ATC, change radio frequency C2 to Departure (if advised) and Riverside's airport. Don't misread ATC. Ask for a "**Say again**" when in doubt.

14. Follow the **heading instructions** from ATC using Autopilot Nav1 to Riverside VOR or by switching to HDNG/HDG SEL and turning the **orange** bug in the HSI with the **orange** (second left) **knob** under the HSI to the compass direction ATC has given.

15. You'll be vectored to the ILS of Riverside in a wide curve.

16. At 13 nm DME from Riverside reduce your airspeed to 120 knots, and set 1 notch flaps. Follow the approach instructions from ATC carefully now.

17. You will be advised to "**intercept the localizer for runway 09**" - press HDNG NAV2 and ALT NAV2 in the autopilot**.** The Glasair will turn to the Riverside ILS, flying the ILS until you disengage the autopilot and land.

18. When you visually see the runway, deselect the autopilot to fly the Glasair gently to the down. Glasair like to fly their approaches at about 80 to 100 knots with partial or full flaps. Gently raise the nose when close to the ground to ease out of your descent and touch down. Power off, hit the brakes, and taxi clear of the runway. Hit enter again to tell the tower that you are clear of the active runway and ready to taxi to the ramp.

Touring the X-Plane Menus

The File Menu

Open Aircraft
Just select your favorite airplane, provided it is available on the disk, and go fly it! The aircraft file must be in the "**Planes**" folder or in the same folder/directory as the simulator itself!

Load/Save Situation
Just set up the airplane any way you want and save the situation. You can load that situation again whenever you want. Situations are saved in the "**Situations**" folder in the "**additional nav data**" folder.

Quit/Exit
Exit the simulator. X-Plane usually remembers the nearest airport when you left the simulator. So it's a good habit to land your plane first, then quit

The Location Menu

This starts you off wherever you want... You can experiment to see which options you like to use. You can also get lost, found, go to any airport, try situations like buzzing forest fires, approaching an aircraft carrier, and much more. **Experiment with these options.** The B-26 water bomber is good for forest fires, a helicopter is good for the helipads or frigates, the F-4 Phantom is good for carrier approaches, the Scwiezer 2-32 is good for glider-towing, and the X-15 should be dropped from a B-52.

This is also where you choose the planet Mars for a special out-of-this-world flight. Be sure to read the chapter "**Flying on Mars**" for more information.

The Settings Menu

Data Output Window
There are three places you can send flight data using the "**Set Data Output**" window:

1. **Disk File**
The data requested goes to the file "**X-Plane.out**" in a "black-box" format. You can view the data after the flight by opening "**X-Plane.out**" with any word processor.

2. **Graphic Display**
The data requested goes to a graphical display where it can be accessed by selecting "**Graphic Flight Record**" from the "**Output**" menu. Up to four variable groups may be chosen.

3. **Cockpit Display**
Data is sent numerically to the windshield, where it is shown in real time. Several variables may be chosen, but the frame rate will deteriorate if you view too many options.

Data Output Parameter

The left buttons are for disk output to the file "**X-Plane.out**", the middle are for the graphic display in the output menu, and the right buttons are for values to go to the cockpit in flight.

Let's walk through the list of output variables:

Frame rate, or cycles per second, of the simulator. About 18 fps. is sufficient for a smooth display. **Real Time Ratio** is how close to real time the sim is running. On average 0.99 is a good value. Less than 0.9 is fast motion, more than 1.1 is slow motion. **Local Time / Z-Time** is the difference between the actual system time and world time.

Sigma is the fraction of sea-level air density that exists at the current altitude. **Rho** is the air density at the current altitude.

Alpha and Beta are the angles of attack and sideslip, respectively. The angle of attack is simply the angle at which the airplane strikes the air. **Positive angle** of attack means the airplane is pointed up with respect to the airflow (trying to climb) and **negative angle** of attack means the airplane is pointed down with respect to the airflow (trying to descend). **Horizontal Path** is the course over the ground in degrees, 0 is North, 180 is South. **Vertical Path** is the climb or descent angle in degrees, positive is climbing, negative descending.

Throttle is the part setting for each engine (0.0 is idle, 1.0 is full throttle).

Prop is the prop control position (blue handle), in RPM. This doesn't necessarily mean the revolutions per minute the prop is making.

Wing Sweep and Thrust Vector are the wing sweep in degrees and thrust vector in degrees, where 0 is vector straight back, 90 is straight down.

Stick & Rudder ail/elv/rud are the pitch, yaw, and roll control input that are being received from the joystick and rudder pedals, where 0.0 is centered and 1.0 is full deflection.

Flight Control all/elv/rud are the amount of pitch, roll, and yaw control deflection that are actually being sent to the control surfaces, which may be different from the data above if the aircraft has an artificial stability system and/or the flight control sensitivity is not at 100%.

Trim, Flaps, and Slats indicate the deflections of those surfaces.

Gear, Brake, and Speedbrakes are deployed or not.

Vtrue, Vindicated are the true and indicated airspeeds. Remember that the airspeed indicator tells how fast you are going by looking at the air pressure, and as you climb the air gets thinner, so the INDICATED airspeed will be lower than the true airspeed.

Vertical Velocity is in feet per minute.

Mach Number indicates fraction of speed of sound... the simulator loses some realism above about Mach 0.90 due to transonic and supersonic effects.

G-Loading is the number of G's you are currently pulling.

Local Speed of Sound is the speed of sound at your current altitude and temperature.

Dynamic Pressure is the air pressure on the airplane from moving through the air. The faster you go, the greater the air pressure. This dynamic pressure is converted into lift by the wings, so the dynamic pressure is an indication of how much lift your airplane can produce at the current airspeed, air density, Mach number and air temperature.

Angular Moments are the **torques** on the airplane.

Angular Accelerations are the **accelerations** in pitch, heading, and roll of the airplane.

Angular Velocities are the pitch, roll, and yaw rates, or the speeds at which the aircraft is rotating.

Pitch, Roll, and Heading are just what you think they are.

Distance traveled is the distance covered (it resets to zero each time you open this window).

Lat, Lon, and Altitude are the latitude, longitude, and altitude of the airplane at the moment. X, Y, and Z are the location in **meters** from the southwest corner of the first environment file you opened.

Power is the power output of each engine in horse power.

Thrust is the thrust output of each engine in pounds.

Engine Torque is the torque in foot-pounds that each engine is putting out.

Propeller RPM is the current RPM of the propellers. Prop Pitch is the pitch of the propellers, in degrees.

Propwash speed is the speed of the propwash well behind the propellers. This is added to the aircraft's airspeed to find the airspeed over parts of the airplane that are in propwash.

Manifold Pressure is the pressure in the intake manifold of each engine, and is used to set power.

N1 is the percentage RPM that the compressor fan is turning on jet engines - the 'intake' pressure.

FF is the fuel flow ratio in pounds per hour.

Aerodynamic Forces are the total forces on the airplane due to aerodynamic loading (i.e. lift, drag, and side force). Engine Forces are the total forces on the airplane due to the thrusts (or drags!) of the engines. Landing Gear Deflections are the deflections of the landing gear from their fully-extended positions, in feet (1 feet = 0.3048 meter).

Lift Over Drag Ratio is the ratio of lift of the airplane to drag of the airplane, and is a measure of the efficiency of the airplane. Look for a value of at least 10 for reasonably efficient flight.

Prop Efficiency is the propulsive efficiency of the propellers. It is simply a measure how efficiently the props are converting the engine's horsepower into usable thrust. Look for at least 0.85 or so for efficient cruising.

Ailerons control aircraft roll. Deflection in degrees.

Roll Spoilers are on the wings, and spoil lift on the wings to roll the aircraft. Roll spoilers can be used instead of ailerons. Deflection in degrees.

Elevators are on the canard or horizontal stabilizer and control pitch. Deflection in degrees.

Rudders are on the vertical stabilizer and yaw the airplane. Deflection in degrees.

Yaw-Brakes are speedbrakes on the wing tips that can be deployed left or right to yaw the airplane if no rudders are available, as is the case with flying wings.

Cyclic and Differential Yaw are helicopter and VTOL rotor blade deflections.

Payload Weights are the weights of fixed payload, fuel, and water in pounds.

Total Weights are the weights of the airplane when empty and the current total weight of the airplane, in pounds.

Serial Output
This screen is here for you to hook up special accessories like a hydraulic cabins, moveable seats, real cockpits, or moving maps.

Rendering Options Window
This allows you to set the graphics options for the sim. Set to higher color depths and texture resolutions if your card can handle it, otherwise leave them at the defaults. When in doubt, experiment.

Time of Day Window
Use this to set the time of day for your flights. *Dawn (06:00) and Dusk (17:00) are recommended.* Evening (19:00) with an overcast cloud layer is recommended for instrument flight (IFR) training. Time will advance in real-time.

Joystick Axis Assignment
Assign functions to your joystick axis.

Hardware & Flight Mode
Assign functions to your joystick buttons as well as adjust the realism and sensitivity levels. You can also choose your keyboard language.

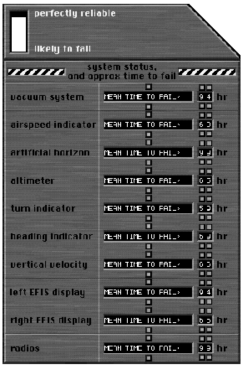
Weather Conditions Window
(Space, Atmosphere, Ground, and Water) Note that you have slider control over the meteorological situation at various altitudes. These innovative double sliders outline the limits you set for the weather at various altitudes. The "**rate of change**" slider controls how fast the weather is changing. The computer's internal weather generator will keep the weather changing until your limits are reached.

You can also fly in actual real-time weather!
Visit: http:\\www.menet.umn.edu/-curt/weather/x-plane.htmI Put the **"WORLD.rwx"** file in the "**X-Plane**" folder.

Conditions for ground, water and space may also be set. Don't slide on a wet runway, crash into a Tsunami, or get hit by meteorites!

Flight Mode Window
For technically realistic flying, all the damping should be completely turned off, and the joystick sensitivity cranked to full. Simulators are harder to fly than real airplanes, though, so you may want to add some artificial damping and lower the joystick sensitivity to make the airplane feel more realistic. If you are flying helicopters, then it is a good idea to put in some extra damping and reduce the control sensitivity.

Weights and Fuel Window
Use the sliders to set the weights and fuel you want to fly. Watch the maximum take-off weight! If you fly over this weight you are asking for trouble.



One of the reliability windows.

Realistic, Instrument and Equipment Reliability Windows
- Engine failure will cause immediate lack of power.
- Vacuum system failure is realistic, complete with gyro tumble as the gyros spin down.
- Instrument failures will cause the instruments to stay in the position they were in when the failure occurred.
- Control failures will cause the controls to snap to the center position and stay there.

Sound Window
Sounds are set here. ATC verbal communications are possible if the appropriate speech drivers are installed.

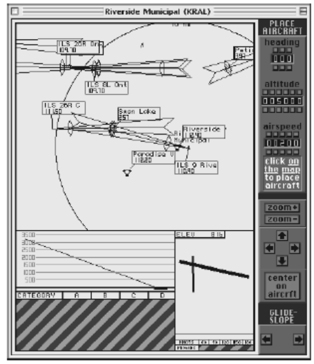
Warnings Window
This sets how "strict" the sim is. All boxes should be checked "**on**" for maximum realism. Check them "**off**" if you want to do free-flight without worrying about aircraft limitations.

Quick Flight Setup
Takes you back to the opening "**Quick Flight Setup**" screen.

The Output Menu

Graphic Flight Record Window
This is where the **graphic data** selected from the "**Data Output**" in the "**Settings**" menu can be observed. Point the mouse at whatever part of the curve you are interested in (no need to click) and the numerical value of that data appears underneath the labels at the left side of the screen. Clicking on the "**starting time**" controls at the bottom of the screen controls how many seconds since data selection was made you wish to start viewing.

Low Enroute, Local Virtual-World, Weather Radar Map, 3-D Path, and Isometric Region Windows
These plot the local area with your flight path plotted in red and black. The weather radar map shows fine details if you have thunderstorms selected in the "**Set Weather**" window. You may position your aircraft in various maps by setting altitude, speed and direction, then clicking in the map.



Approach Chart with simulation set-up buttons.

Logbook
Setup your own personal real time logbook

Plates Menu

Approach Plates for the Local Airports
Plots the approach plate of the selected airport. This chart is used for setting VOR, ILS, and ADF frequencies as well as planning ILS approaches. Notice the elevation of your airport! Fly an instrument approach and then open these windows to see how your approach looked.

Planet Map
Place your aircraft according to a map view.

The View Menu

Views
Several view options are available for watching your flight. The letters in brackets are keyboard equivalents. Just hit those keys to get the views. On some European Macintosh keyboards the "**I**" is "**Option+7**".

Enter / Leave Flight Replay Mode offers a video replay of your flight. In the glareshield some recorder like buttons appear, which can be ' pressed to wind up or down, start or stop the replay, or study interesting situations (like crashes). If your monitor or video card has video out you can output the movie to a video recorder. You can change the view of the replay with the usual keys from the "**View**" menu.

The Special Menu

Output one flight engine cycle
This saves an extended text file to disk with all current simulator data. You can read this file with any word processor. This option is useful for people with an aeronautical engineering background, or the extremely curious. Use this data to check the simulator output, or observe loads or other data pertaining to the aircraft at the moment that you clicked on this menu item.

Reset Prefs and Exit
In the unusual case that **X-Plane** starts behaving in a fashion that you can't recover from (i.e. it keeps crashing the airplane or something weird like that), you can select this menu item to reset the simulator to it's original factory settings.

Instructions Windows
These are brief but self-explanatory. X-Plane uses help-screens when you leave the mouse-pointer over an unclear subject for a few seconds.

About Helicopters

Go to the **"Hardware & Flight Mode"** option in the "**Settings**" menu and set the **control sensitivity** down a bit. Put in some extra **damping.** This is just to smooth things out for your first practice. You can make things more realistic later. Now open the Special Ops Blackhawk for your first flights. This is a big heavy helo that has a nice solid feel.

A helicopter is in fact a marginally stable flying machine. The main rotor produces somewhat more lift than the weight of the helo, allowing the machine to take off vertically.

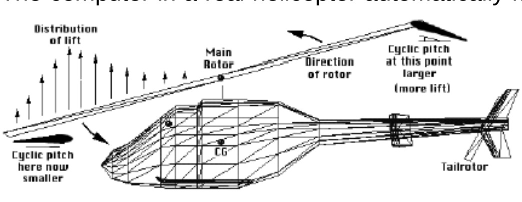
To pitch or roll the helicopter the main rotor blades change pitch as they move around the rotor disc. This causes the rotor to put out more thrust on one side than the other, causing the helicopter to pitch or roll. This change in rotor blade pitch is referred to as cyclic pitch.

The helo cockpit is smaller than that of airplanes. There is a piece of yarn tied to the base of the windshield that serves as a sideslip indicator. The throttle handle serves here as collective pitch grip and should be upward to keep the helo on the ground. Gently drag it down to take-off and learn to hover at low altitudes first. Watch your flight with the replay option in the 'View' menu.

The cyclic pitch is controlled by the "**cyclic**" stick, which is the main control for the helicopter and is equivalent to the stick or yoke of an airplane. To climb or descend, a helo increases or decreases the pitch of the rotor blades overall, not just when the blades are at one part of their path around the disc. This "overall" change in pitch is referred to as "**collective pitch**".

This "**collective**" is physically set up like a side-mounted parking brake in a car: you pull it up to go up, you push it down to go down. The collective is somewhat analogous to the throttle in an airplane. But who controls the **actual throttle?** A computer!

The computer in a real helicopter automatically manipulates the throttle to maintain operational RPM. There is a catch though: If you force the rotor to a very high collective pitch by pulling up on the collective too much, then the engine might not have enough power to keep a constant rotor speed, even at full throttle! RPM will drop and you are in a rotor-underspeed situation that must be remedied! The cure is simple: lower the collective stick enough that the pitch on the blade lowers to the point that the engine can keep the rotor turning at the right speed.



The pitch of the main rotor can vary with its position around the disc during a single revolution. This cyclic pitch pitches and rolls the machine. Changine the pitch of the blades overall causes the machine to climb or descend. The tail rotor cancels out the torque of the main rotor.

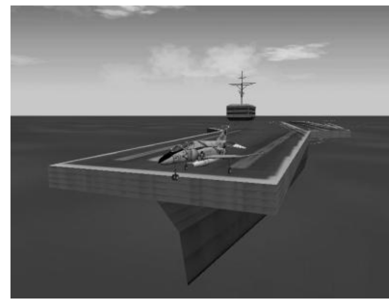
Thrust-Master or *CH-Products throttle* quadrants act like the collective when you are flying helos in X-Plane. Throttle full **forward** is full flat (DOWN), collective. Ease the throttle back towards you to INCREASE the collective. The throttle handle is acting like a collective pitch grip in the helo, and the computer is actually controlling the engine throttle to maintain the correct RPM, which should stay the same for the entire flight.

Your **rudder pedals, if you have them,** act as anti-torque pedals, which simply increase or decrease the pitch on the **tail rotor** to yaw the helicopter left or right and counteract the torque of the engine.

A well-designed helicopter should hover with the tail rotor, main rotor, and rotor cant all canceling each other out nicely so that the machine hovers at moderate power with almost no deflection of the controls.

About Aircraft Carriers

Landing on an aircraft carrier seems tricky at first, but gets easier with practice. Head on over to a coastal airport like LAX, get in an F-4 Phantom, and ask for a carrier approach or catshot in the "**Location**" menu. The F-4 is one of the hardest airplanes to fly, so you might try getting an A-4, A-6, F-18, or some other plane from **www.xicat.com** to test your mettle at first. If the weather is good you can fly your approach visually, otherwise tune an ILS to 108.00 to pick up your ILS signal to the carrier... real carriers use somewhat different frequencies and ILS equipment, but the general result is the same.



At any rate, get set up on or near the carrier in the "**Location**" menu or navigate to the carrier using the "**Local Virtual World**" by looking for a little square with a "**C**" in the middle.

For a cat-shot you are placed on one of the catapults. Throttle up and release the brakes to be shot off the deck. For a carrier approach you are aligned with the glideslope. Don't forget hook and gear down! You might also (quickly!) get full flaps down and reduce your weight somewhat by jettisoning your load. Carrier approaches are almost always made at minimal weight.

At about I mile out you will see the **Fresnel lens** (or "**meatball**") on the deck just to the left of the wires. It has a row of green lights with a yellow light in the middle. The Airboss will inform you when to "**call the ball**" (you need not respond in the sim). You now fly an approach path that keeps the meatball centered. The voice of the Landing Signal Officer warns you of errors in speed, attitude and heading. If the Landing Signal Officer is not happy with your approach he will shout "**wave off**" at you. Go around and try again. After landing you may select the "**carrier cat shot**" again or taxi to the left-front catapult to be automatically hooked up for another shot.

The visual glideslope indicator with "**meatball**" indicates the following:

- If the center light is **above** the row of green lights, you are **high.**
- If the center light is **below** the green lights, you are **low** or swimming…
- If the center light is right in the **middle,** between the green lights, you're on **glideslope** like you should be.

The trick to the carrier landing is:

- Keeping the plane aligned laterally with the extended centerline of the deck. (Do this with heading, of course)

- Keeping the airspeed low enough that the nose is aimed a bit up from the horizontal, at a nice positive angle of attack. (Do this with pitch)

- Keeping the velocity vector of the HUD pointed right at the touchdown zone on the deck. (Do this with pitch and throttle)

- Keeping the meatball centered. (Do this with throttle)

- Keeping all the parameters centered until you crash into the deck. There is no technique to landing on a carrier other than keeping these parameters perfectly centered until you impact the deck and let the arresting gear take care of the rest.

About Trans-Atmospheric flight

The NASP "X-30" is to be the next generation of orbital delivery vehicle. It will take off with jet engines, then switch to rocket engines at high altitude where the jet engines quit putting out any thrust. The rocket engines will take the plane into orbit, where payload can be deployed. Then a re-entry into the atmosphere follows, the jet engines fire up again, and a normal landing can be made.

Flying the NASP takes practice, but this will get you started. Open up the NASP in the "**Mega-Planes**" folder and fill it up with fuel ("**Settings**" "**Weights and Fuel**"). Go to LAX or some other huge runway and blast off in full afterburner. Throttle back to 100% no burner and climb to 30,000 feet or so. Hit the burner again when the engine thrust starts feeling sort of weak. At about 45,000 feet, or as far as you can climb with the engines, shut them down. (Yank the red fuel levers back). Hit the JATO (Jet-Assisted Take-Off) button to simulate the rocket engines that will punch you into space. The JATO is simply a solid-fuel rocket motor. The real NASP will use liquid fuel, but that is a technicality.

During the rocket assisted climb, gradually level the nose so that the artificial horizon is horizontal at about the time you reach 300,000 feet. **X-Plane's** atmosphere goes up to about 250,000 feet, so you will be "in space" at 300,000 feet. If you climb into space at 45 degrees upside down, you will never get a decent re-entry, so gradually level the nose as to level out at 300,000 feet. Watch the artificial horizon carefully. You must level off in the top of a gentle curve at a reasonable altitude to have a chance of making a survivable re-entry.

At this moment, your indicated airspeed will be zero, but of course this is because there is no air to push against the Pitot tube. Your actual speed is extreme, and can be output from the data output window. 18,000 mph is orbital velocity. You will have noticed during the climb that the indicated airspeed was going down as you entered thinner air and the airspeed indicator encountered less air pressure, but the true airspeed was always increasing.

Once in space, keep the space-bird pointed straight ahead until the rocket bums out. Use stick and rudder to always keep the nose pointed right at the flight path velocity vector (the small green moving box) on the HUD. This keeps the nose pointed in the direction you are going. You will need this during re-entry! Once your rocket bums out (4 minutes is up, you can't climb further and your engine thrust from the "**Data Output**" window is 0) it is time for the re-entry. Hit the "**Jettison**" button in the glareshield to jettison the satellite you just carried into orbit. Ease the plane into the atmosphere at a shallow angle! Don't go diving straight down at the planet or you will break and bum up like a meteorite for sure! The Space Shuttle skips along in the upper atmosphere to gradually bleed off airspeed, and you must do the same. 18,000 miles per hour at sea level would tear any aircraft ever made apart in a micro-second! While you keep the nose up a bit and skip across, gradually descending down into the atmosphere and decelerating, look for an airport on your EFIS display and fly to it for landing.

CHAPTER 2
FLYING THE SPACE SHUTTLE

The Concept
What do you think the first rule of flying a glider is?

"Never come up short".

When you are bringing a powered plane in for landing, if you think you are not quite going to make it to the runway, it is no big deal; just add a bit of power to cover the extra distance! Need a little more speed maybe? Again, no problem; just add power.

Gliders play be a different set of rules, though. There is no engine to provide power, so when setting up your landing, you must always have enough altitude and speed to be able to coast to the airport, because if you guess low by even one foot, you will hit the ground short of the runway, crashing. You can never be low on speed or altitude, because if you ever are, you have no way of getting it back. A crash is assured. (The exception is thermals, or rising currents of air, which 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 even keep a lightweight Cessna in the air!)

Now with the Space Shuttle, it is certainly true beyond doubt that it has engines. Three liquid-fuel rockets putting out 165,000 pounds of thrust each, to be exact. To put this in to perspective, a fully loaded Boeing 737 tips the scales around 130,000 pounds or so. So each engine of the orbiter could punch the Boeing straight up indefinitely, and that’s not even considering the solid rocket boosters attached to the Shuttle's fuel tank that provide millions of pound of thrust!

This safely establishes the Space Shuttle has engines.

The problem is FUEL. The orbiter exhausts everything it's got getting up into orbit, and there is nothing left for the trip down: Thus the ship is a glider all the way from orbit to touch down on Earth. With the final bit of fuel that was left after the mission, the orbiter fires it’s smaller de-orbit engines to slow it down to a bit over 15,000 miles per hour (Can you imagine... SLOWING DOWN TO A BIT OVER 15,000 MILES PER HOUR) and begins it's descent into the atmosphere.

Now we have to remember the cardinal rule of gliding: **always aim long** (past your landing point, not short), because if you ever aim short you are dead since you can never make up lost speed or altitude with no engines. Aim long since you can always dissipate the extra speed and altitude with turns or speedbrakes if you wind up being too high, but you are toast if you come up short.

Following this rule, the orbiter intentionally flies it's glide from orbit extra high to be on the safe side.

But there is one problem. If the orbiter flies its entire approach too high, won't it glide right past Edwards?

Nope.

And here is why. For most of the re-entry, the shuttle flies with the nose wwwaayyy up for EXTRA drag, and making 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 in a steeper glide-angle... and if it ever looks like the orbiter might not quite be able to make it to the landing zone, they simply lower the nose to be more efficient and quit flying the steep turns... the orbiter then glides better, and they 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 to keep from overshooting the field!!!

The Walk Through

OK, so let’s walk you through the re-entry process from the beginning, as it is done in the real Shuttle, and all of this carries over perfectly to the Shuttle landing in **X-Plane**, which you will fly after reading this chapter.

After de-orbit burn, the shuttle heads for the atmosphere at 400,000 feet, 15,000 miles per hour, and 5,300 miles away from Edwards. (Yes, you are landing in the Mojave Desert and you are starting your landing approach West of Hawaii). Not a bad pattern entry, huh? 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. It is something about the gruesome death of hurling through the upper atmosphere on fire if the pilot messes up.

In the history of Shuttle missions (the 100th mission has just come to a close as this is written), the real Space Shuttle has been hand-flown for the entire re-entry only ONCE, by an ex-marine pilot, as the story goes, who was ready for the ultimate risk and challenge.

Oh yes, did we mention that ***YOU*** will be hand-flying the entire mission in **X-Plane**, as well?

So you start in **X-Plane** around 400,000+ feet, in space, coming down to eat air like a bag of bricks at Mach-20. Your control will be limited in space, but once the Shuttle hits Earth’s atmosphere, there will be some air for the flight controls to get a grip on and you will actually start to be able to fly the thing.

You will first hit air at about 400,000 feet, but it will be so thin it will have almost no effect at all. Your airspeed indicator will read around ZERO. Kind of odd since you are actually doing over 15,000 miles per hour, huh? Not really. The airspeed indicator works just like the wings of the orbiter: based on how much air is hitting it! And in space, that ain't much!

It will build gradually as you descend. The odd thing is that even though you are actually slowing down, the airspeed indicator will rise as you descend into thicker air that puts more pressure on the airspeed indicator! You like this, though, since the air is also putting more pressure on the wings, so the airspeed indicator is really measuring how much force the wings can put out for you, which is really what you are interested in. (Word to the wise: If the airspeed indicator is putting out more than about 250 knots, your wings can have plenty of lift to carry you. If the airspeed indicator is indicating less than about 250 knots, then the wings do not have enough air hitting them to lift you, and you are still more or less coasting in the thin upper atmosphere where the air is too thin to do much for you.)

So as the airspeed indicator on the HUD gradually starts to indicate a value, you know it means you are starting to ease down into the atmosphere at 15,000 mph like a sunburned guy trying to ease into a boiling-hot Jacuzzi… carefully and slowly. Remember, if you were going 15,000 mph in the thick air of sea level, you would break up into a million tiny pieces in a microsecond... the only reason you can survive 15,000 mph up here is the air is so thin it has almost no impact on the ship. (And again, the airspeed indicator tells you how much the air is really impacting the Orbiter... 250 is a "comfortable" amount). The trick is for you to be going a lot slower than 15,000 mph by the time you get down to the thick air of sea level. And be at Edwards. And that is what the re-entry is for... disspating speed as you descend so that you are never going too fast for the thickness of the air that you are in. You only descend into the thicker air once you have lost some speed in the thinner air up higher. The whole thing is a smooth process where you never ram the ship into thick heavy air at too high a speed.

Entering Earth’s Atmosphere

Now as you begin to feel the out tinges of the earth's atmosphere, you will notice a slight ability to fly the ship as you get some air over the wings and speed on the HUD. Now look at the picture of the orbiter on the right-hand EFIS display... the Atlantis already has this display retrofitted over its old steam gauges (The EFIS's from the Atlantis are modeled very accurately in **X-Plane**. Astronauts could use it for familiarization for sure). You see yourself and the path down to Edwards. Your goal is to stay on the center path. If you get above it, you are too fast or too high. You might overshoot! If you get below it, you are too slow or too low. You might not make it! You must stay right on the center green line. The 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 altitude for the final phase of the re-entry. Don't blame us, that is the way NASA set it up. If you are too fast or high (above the center line) then it is time to dissipate some energy. Put the thing in a steep bank, pull that nose up and hang on!

The REAL orbiter will be about 30 degrees nose up, in a 70 degree bank to try to lose energy, going 14,000 mph, glowing red hot, hurtling through the upper atmosphere on autopilot leaving a 10-mile long trail of ionized gas behind it while the astronauts just watch.

So how was YOUR day?

Anyway, you will do steep turns to dissipate energy as needed to keep the orbiter from going above the center green line. Look at the little blue pointer on the far left-hand side of that right-hand display. That indicates how high the nose is supposed to be. The green pointer is where the nose is now. Get that nose up. The pointers just to the right indicate the desired and current deceleration... you will not fly those, though. Look at the little pointer up top on the horizontal scale. That is the computer's estimation of how much bank angle you probably need to stay on the center green line. Follow the computer's recommendation or your own intuition for how much bank to fly, but keep that nose up for sure to keep you in the upper atmosphere and fly steep banks to dissipate the extra speed and altitude. You might be tempted to just push the nose down if you are high. Don't. You will drop down into the thick air and come to an abrupt stop from the tremendous drag, and then you will never make it to Edwards. You will wind up swimming in the Pacific for sure.

Now, as you make your steep turns, you will be pulled gradually off course. Switch your turn direction from time to time to stay on course... turn left a while, then right, then back to the left again. That is what they do in the real Orbiter... you are slalom skiing through the upper atmosphere at Mach-20. Not too shabby.

Watch Edwards in your center EFIS display. You want to go there. Hit the "@" key to see yourself on a flyby. Fast enough for you? Hit the "**W**" key to get back in the cockpit.

The Home Stretch
As you approach Edwards, right on your center green line on the right-hand display, you will notice there is sort of a circle or something out past Edwards. This is your Heading Alignment Cylinder, or H.A.C. You will fly PAST Edwards at about 80,000 feet or so, fly around the outside of the H.A.C. like you are running around a dining room table or something, and then after you come around you will be pointed right at Edwards. And if you are on the green line still, your altitude will be just right for landing as well. This is usually where they turn off the autopilot and hand-fly the real Shuttle.

Now you are 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. Do we really need to tell you what will happen if you hit the ground with that 125 miles per hour descent rate? Do not aim for the runway or you will wind up smeared along it in a thin buttery paste. Aim for the flashing glide slope lights 2 miles short of the runway that we (and NASA) have thoughtfully provided for you. If they are all red, you are too low. (Oops) If they are all white, you are too high (Hit your speedbrakes, key "**6**" or use the mouse). If the lights are half red and half white, you are right on your glide slope. (About 20 degrees... airliners fly their approach at 125 knots, 3 degrees descent angle.. we use 250 knots, 20 degrees descent angle... not too unusual when you consider pattern-entry started West of Hawaii, actually).

OK so you are at 250 knots, on the green line, lined up with the runway, looking at half red, half white glide slope lights with the flashing strobes by them. Hold that approach configuration until you are pretty close to the ground (3-degree glide slope to the runway), then level the descent and get your gear down. ("**g**"-key or mouse) Get the nose up for a flare as you approach, and touch down smoothly. Now lower the nose. Now hit the parachute and even the brakes if you want and let it roll out.

Now do it 100 times in a row without a single hitch and you are as good as NASA.

CHAPTER 3
FLYING ON MARS

About Flight on Mars

First of all, the atmosphere is one percent as thick on Mars as it is on earth. Indicated airspeed is proportional to 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)

While there is almost no air for you, you do have the advantage (sort of) of only about one third the gravity, so it is three times easier to get airborne! Result? A take-off in a well-designed aircraft 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 earths, 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!
Crashes are interesting on Mars. 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!

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.

Cruising along over mars is spectacular, with the scary red-orange Martian sky, new Martian rocky-red terrain textures, and 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!

What Can You Fly

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 the Mars-plane concepts in **X-Plane** 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!

These 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 is unsure since Mars has so little oxygen in the atmosphere it may be impossible to keep a turbofan engine running. (The Mars jet-plane has twice the average fuel-consumption, though, to simulate injection of liquid oxygen or nitrous oxide). The jet plane needs a JATO to take off!

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. There is just barely enough to keep the airplane in flight at mach-0.85.

So how do you stop? We finally went with an arresting gear. Landings are impossible without an 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.

Bottom line, it is possible to build and fly a piloted plane on Mars, though we used a 10,000 ft runway with arresting wires, and now you will know what it would be like too.

Of course, none of this is currently on Mars today. Or is it?

CHAPTER 4
WORLD MAKER EXPLAINED

Touring World-Maker

Be honest! You wanted to land in your own backyard or maybe you were looking for the beautiful vistas of the Spanish planes, the Eiffel tower in Paris, the White House in Washington, or the Kremlin in Moscow. **World-Maker** is an editing tool for the "**.env**" scenery files that allows you to do these things and more.

The scenery data for **X-Plane** was created by an adaptive-gridding program that uses world-wide elevation maps. This approach offers the great **advantage** of providing world-wide elevation. However, the disadvantage of this method is that it doesn't offer "custom-crafted" maps and is not aware of exact coastline locations. While the elevation data is good, some lakes, rivers and other (smaller) details may be left out, and some low areas may be portrayed blue and "under water".

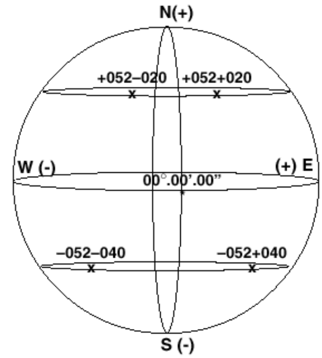
Here is where **World-Maker** comes into play. It is a tool to iron out coastlines, lakes, rivers, and complete scenery files with obstacles and textures of your choice.

Three components are responsible for **X-Plane's** world: the files **"nav.dat" and "apt.dat"** and a multitude of "**.env**" (environment) files plotting the landscape of most parts of the world.

The **"navdat"** file contains all NAVAIDs for **X-Plane, The "apt.dat"** file contains all the airports. The "**.env**" (environment) files contain all the *objects and* terrain, thus creating the **X-Plane** virtual world. You may notice by looking in your "**additional nav data**" folder and "**data**" folder on the **X-Plane** CD that almost all the “**.env**” files are on the CD where they cannot be modified. This will never do at all! You need to get scenery to your "**additional nav data**" folder where you can modify it with World-Maker.

Exploring Latitudes, Longitudes and env Files

To edit a scenery file to create or adjust obstacles, change the height of mountains or fix a lake or river, the correct "**.env**" (environment) file must be in **the "additional nav data"** folder. First look in the "**data**" folder on your **X-Plane** CD. Each "**.env**" file is named based on the latitude and longitude of the data in it. A file named **"+010-160",** contains scenery data with its **lower left corner** at a latitude of +0100 and longitude -160'.



Latitudes and longitudes are used for X-Plane's world mapping.

Recall: **Latitude** or "**parallels**" are imaginary lines running east-west, whereas **longitude** or "**meridians**" run north-south. Both divide the Earth into degrees. Each degree is divided into 60 minutes and the minutes are divided into 60 seconds. The location of Washington D.C. is given by the crossing of latitude and longitude: 'lat' 039'00'00" North and 'Ion' 077'00'00" West. Latitudes to the North of the equator are positive values. Longitudes East of the 0' meridian (over Greenwich, UK) are given in positive values.

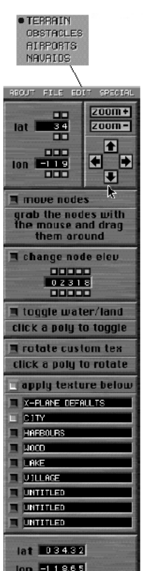
Each "**.env**" rile is marked by its name which is the lat and Ion of the lower left (south-west) corner of the covered area. So, if you want to edit the +025 -120 area you should put the corresponding env folder ("+020-120", with all of it's "**.env**" files) in the **"additional nav data"** folder on your hard drive.

Each "**.env**" file covers one square degree of latitude and longitude. Each FOLDER covers an area that is 10 degrees latitude by 10 degrees longitude, so a folder can contain up to 100 env files. (No env files are required for empty ocean). For **X-Plane** to find "**.env**" files, the "**.env**" files must be in a correctly-named folder, which you see in the "**data**" folder on your **X-Plane** CD... we recommend that you simply copy whole folders-full of "**.env**" files from the CD to the "**additional nav data**" folder for editing... that will save you from having to create and properly name folders. The "**.env**" files in the "**additional nav data**" folder will OVERRIDE the files on the CD, so you can edit your own scenery for flight in **X-Plane**.

When you open **World-Maker** you will see at the top left the latitude and longitude of the present "**.env**" file. Scroll around to find the area you want to edit. If nothing is present but a dark blue grid, then the files for the area in question are simply not present in your "**additional nav data**" folder, or they are in folders that are not properly named.

Remember, once you copy the "**.env**" files from the CD to the hard drive, Windows will think they are read only since they came from a CD. You will have to change them to NOT read only in Windows by **right-clicking** on each file you want to edit and then selecting the "**Properties**". In the "**Attributes:**" section of the Properties menu, click on the "**check mark**" next to the "**Read Only**" option. Macintoshes can figure these details out for themselves.

Terrain in World-Maker



World-Maker has four editing modes: Terrain, Obstacle, Airport, and NAVAID. Select the modes in the "**Edit**" menu. Use Terrain editing mode to adjust coastlines, elevations, rivers, etc.

Now suppose you want to adjust the scenery of "**.env**" file "**+034119**". Simply press the **"lat" and "Ion"** buttons to get to the right environment file after copying that region from the CD to the "**additional nav data**" folder. Lat and Ion can have either positive or negative values, so you can reach any region.

The displayed "**.env**" file shows the geographical properties of the map, like hills and lakes in various green or blue shades, yellow parallel lines showing runways and various obstacles.

The geographical properties are modifiable with the **"Terrain"** option in the "**Edit**' menu. The obstacles (buildings, towers etc.) are modifiable with the **"Obstacles"** option in the "**Edit**" menu. Both information on geographical properties and obstacles are saved in the relevant "**.env**" file, while airports and NAVAIDs are saved in the **11apt.dat" and "navdat"** files.

To modify the geographical properties you can move nodes and change their altitudes or toggle water on and off by clicking in a quadrilateral field with the mouse. A quadrilateral is a tiny building block within the "**.env**" file that you can see when zooming in on the map. You can also see the map with its textures by pressing the “**Spacebar**”. Zoom in and out with the “**+ / -**“ keys. Move around with the “**Arrow**” keys.

Objects in World-Maker

The FAA lists over 30,000 obstructions to air navigation (obstacles) and **X-Plane** has them all, but most of these are represented in **X-Plane** simply as generic-looking buildings. These obstacles that come with **X-Plane** include buildings, radio towers, power lines, cooling towers, and smokestacks. You can easily modify their height and heading, or add new obstacles. Simply get World-Maker into "**Obstacle**" mode in the "**Edit**" menu and select your choice from the left-hand side of the screen. You may delete, move, add, or edit the various objects. Press “**M**” (see the "**Special**" menu) to cycle through these options. While the default obstacles are functional from an aviation point of view, they are not very exciting to look at since they are simply generic towers, smokestacks, and a few generic building types. This being the case, you may want to customize certain buildings so that they really look just like their real-world counterparts. Examples of buildings that you may want to look just like their real-world counterparts may include the World Trade Centers, the Sears Tower, the Statue of Liberty, or your house. This is easy to do using CUSTOM OBJECTS in **X-Plane**. Here's how:

Custom Objects in X-Plane are 3-dimensional structures that are defined by x,z,y-points and have textures on them in 24-bit BMP-format. Read "**World-Maker Instructions.txt**" in your "**X-System**" folder to see a description of the current format, and how to add your own custom obstacles. The basic idea, though, is that you create a text file in the word processor of your choice that contains the geometry of the custom object, and lists what textures you want to be used on that object.

A quick custom object example:

```
A   // ALL OBJ START A (Apple) or I (PC)

4 grassmarker.bmp  // its 1. side >cw
 2  1  1     // X  Z  Y vector startpoint
 5  1  1     // X = distance from 0 in mtr.
 5  0  2     // Z = mtr. in depth from 0
 2  0  2     // Y = mtr. in height from 0

4 grassmarker.bmp  // its 2. side >ccw !
 5  1  1
 2  1  1
 2  0  -1
 5  0  -1

99  // ALL OBJECTS MUST END WITH A
99 TO DENOTE THE END OF FILE!

// 4 = object is square, 3 = triangle...
2 = line and 1 = point have RGB (fe. 8,4,5)
grassmarker.bmp = BMP file with texture
```

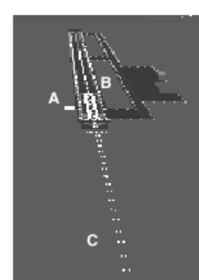
Note: The surfaces of the custom objects must be designated clockwise as seen from the outside: top left - top right -bottom right - bottom left.

Note: When you are done creating the objects in your favorite word processor, be sure to save them, and their textures, in the **"Custom Objects"** folder inside the **"additional nav data"** folder. SAVE THAM AS ASCII TEXT FILES!

After you have created and saved your custom objects, get World-Maker into "**Obstacle**" mode from the "**Edit**" menu, and then choose "**add custom**" and click on the desired location to place your custom obstacle. A small cross will appear. Click in the **"change name"** box to open the custom object file that you created and saved (with a word processor) in the "**custom objects**" folder.

Airports in World-Maker

To create or edit airports with World-Maker, go to **"Edit / Airports"** in World-Maker, or open the file "**apt.dat**" with a word processor. Each airport in X-Plane CLASSIC may have up to 3 runways. X-Plane 5*x* offers unlimited runways, though, and a variety of runway surfaces like asphalt, concrete, gravel, dirt, and grass are available. Runways have approach-light options, such as glideslope indications, approach lights leading up to the runway, and the runway lights themselves.



Runway surface may be asphalt, concrete, grass, dirt, or gravel.

To create or edit airports with a word processor, see the "**World-Maker Instructions.txt**" file in your X-System folder. If you ever make any modifications to the "**apt.dat**" file with a word processor, be sure to save those changes as ASCII TEXT!

The World-Maker instructions in your X-System folder have more complete info, but here is a quick example from **"apt.dat"** for X-Plane 5*x*, which you can edit with any word-processor:

Various runway lights are available as follows:

(A) Glideslope lights:
- none
- vasi
- papi

(B) Runway lights:
- none
- mirl
- reil
- rcls
- tdzl

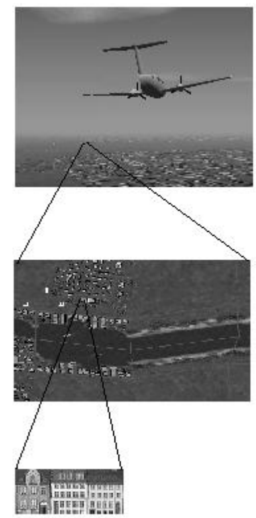
(C) Approach lights:
- none
- sals1
- sals2
- alsf1
- alsf2
- odals

A	Apple file, may be I for files created on IBM's
500	version#
I	object is airport, then elevation
01	no control tower but standard buildings
CZ	airport ID and name
10	facility type/runway

lat and lon of center of runway, runway number, L or R or G or none, heading, length, width, surface code + lighting systems

Textures in World-Maker

X-Plane uses default, generic textures for water, grass, mountain, snow, and the borders between them. X-Plane automatically applies the borders between these textures. All of these default textures are found in the **"textures"** folder inside your "**X-System**" folder. They are simply 256x256 pixel bitmaps in 24-bit color.



A demonstration of the effects of various textures.

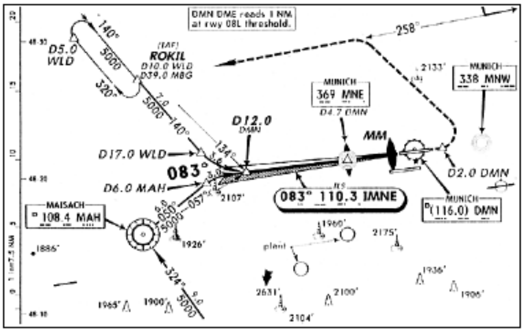
In many cases, though, you may want to customize these textures to ones that are more appropriate for any given area. Perhaps you want city, desert, or harbor textures. These can easily be created and added. If required you can assign up to **20** different custom textures for each "**.env**" file. To do this, simply create a custom texture (for example desert) in PaintShop, PhotoShop, or any other program you like. Once you have created the custom texture that you want to see in the sim, save it as a 24-bit bitmap in the **"custom textures"** folder inside your "**additional nav data**" folder. Now launch World-Maker and drop it into terrain editing mode with the "**Edit**" menu and add the custom textures that you just created by using the toolbar on the left side of the screen.

When creating custom objects and textures, remember that fine lines will cause "jitter" and resulting eye-fatigue! The same applies for high-contrast textures, or too many colors. Many simulators manifest such line-jitter and interference by having textures with too high a contrast. A smart combination of minimally varying greens and grays (steps of max. 3-5%) will do for a landscape, provided the pattern does not repeat itself. Houses can be simulated by rectangular dark grayish shapes with a black 2 pixel wide border (shadow) at one side. Seamless welding of any BMPs is achieved by carefully copying *one* 5 pixel wide border to all 3 remaining sides and turning it either vertically or horizontally. Without this you would see the border of the texture. Minimize disturbances of the border pattern while working under very high magnification.

NAVAIDs in World-Maker

Ancient Roman sailors realized: 'navigare necesse est'... It is necessary to stay on course. They erected lighthouses along the Mediterranean Sea, something we can hardly think of when flying above clouds nowadays. X-Plane uses the standard aeronautical navaids, like non-directional beacons (NDB's), very high frequency omni-range beacons (VOR's) and instrument landing systems (ILS's).

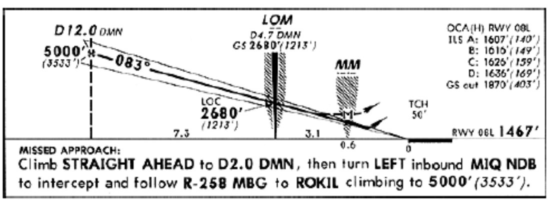
You can use **World-Maker** to edit and add these navaids, or simply open the "**nav.dat**" file with a word processor. Here are the NAVAID types as defined in the "**nav.dat**" file:



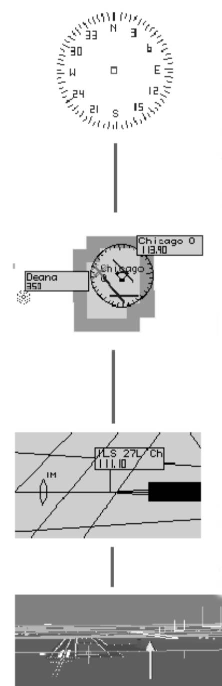
Nav.dat	Type
2	NDB
3	VOR
4	ILS Localizer portion
5	Localizer for the approach
6	ILS Glide Slope portion (may have same freq. as 4)
7	Outer marker (OM)
8	Middle marker (MM)
9	Inner marker (IM)

Look at the picture (left) to see some NAVAIDs as depicted by a Jeppesen chart.

From Maisach MAH VOR (freq. 108.4) your plane should follow radial 0501 to reach an intersection at "D12.0" (12 mile DIVIE distance from (to) VOR DIVIN (freq. 116.0) along the 08L runway. This point is the "Final Approach Fix", a point where the approach procedure starts. You now follow radial 830 on ILS IMNE at freq. 110.3 on the Nav-2 radio (set the HSI to the right heading). You are supposed to reach the FAF at some 5000 feet altitude IVISL (above sea level), which is about 3533 feet above the ground (AGL). Now set the autopilot to HDNG Nav-2, ALT Nav-2 (a glideslope portion is available) and you'll automatically descend towards the runway as the autopilot flies the ILS for you. Alternatively you can use the ILS portion in Nav-1 and the glideslope portion in Nav-2.



When we start following the localizer and glideslope we will cross the OUTER MARKER and MIDDLE MARKER on our way down. The markers tell us how far along we are, although we may not see the runway yet. At the middle marker we should see the runway and decide to land, or if we do not see the runway or it's environment than we need to go around (and execute the missed approach procedure).



Editing and Adding Navaids

Here is the airport data as found in "**apt.dat**" for KORD Chicago O'Hare Intl.

1 41.976776 -87.917770 14 R 140 13000 200 155154
41.969040 -87.902382 9 R 90 10141 150 154154 41.991917 -87.903549
14 L 140 10003 150 155154 668 1 KORD Chicago 0'Hare International

You would expect some NAVAIDs to be associated with this large airport, like perhaps some ILS's, marker beacons, and maybe even a VOR.

Here we consider runway 09R and check the navaids for it:

3	41.975671	-87.904900	650.0	113	90	0		ORD Chicago O'Hare VOR
4	41.969040	-87.924774	647.9	111	10	270	TSL	ILS 27L Chicago O'Hare Intl
6	41.969040	-87.887520	668.0	111	10	270	TSL	ILS GS 27L Chicago O'Hare Intl
7	41.969040	-87.789619	0.0	0	0	270	——	Outer marker 27L (KORD)
8	41.969040	-87.873260	0.0	0	0	270	——	Middle marker 27L (KORD)
9	41.969040	-87.907625	0.0	0	0	270	——	Inner marker 27L (KORD)

As you can see Chicago has a regular VOR (3) at the lat, Ion, elevation, and frequency listed (with a heading of 0 for all VOR's) then the prefix and the name are displayed as well.

The direction for the ILS however is set to 270 degrees, which is the **magnetic** heading of the runway. The OM (7), MM (8) and IM (9) are set to the airport's prefix, which is KORD. Also note, that 4 and 6 have the same frequencies i.e. 111. 10, implying glideslope coupling to the localizer when the ILS is dialed into Nav I or Nav 2 in your airplane.

Note: Misalignment of an ILS may cause a situation as shown in the left illustration. Be sure that your ILS localizer transmitter is just off the far end of the runway with the exact same heading as the runway, and make sure the glideslope is right beside the near end of the runway.

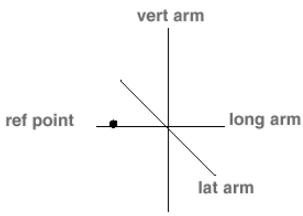
CHAPTER 5
PLANE-MAKER EXPLAINED

Introduction

In this chapter we will walk through the aircraft design-entry process. For engineers, this should be easy. For pilots not as well versed in the fundamentals of aircraft design, fear not! We will explain things for all audiences as we go.

- Launch **"Plane-Maker",**
- Go to the "**File**" menu and select "**Open**",
- Select an airplane, like the **Mooney** in the "**General Aviation**" folder that you wish to modify.

Start by defining a reference point!



As we go through this tour, change any of the design data you want to customize the airplane that you just opened. You then can fly the modified design when you are done.

The Aircraft-Defining Variables
You will have to enter the locations of various parts of the aircraft (of course), so the first thing you should do is pick a reference point (such as the top center of the firewall, for example, or the back of the spinner) to make all of you measurements from.

Plane-Maker will ask for the following dimensions for each part:

"longitudinal arm" (abbreviated "**long arm**"), which is the distance the item is behind the reference point (use negative numbers for items forward of the reference point).

"vertical arm" (abbreviated "**vert arm**"), which is how far the long arm item is above the reference point (use negative numbers for items below the reference point).

"lateral arm", (abbreviated "**lat arm**"), which is how far the item is to either side of the reference point. (All aircraft are assumed to be symmetrical, so most lateral arms are positive, indicating simply the distance from the fuselage centerline. In other cases, the lateral arm is positive-right. You will be able to figure out which convention to use based on the situation).

Again, you may use any reference point you wish, just be sure to use the same reference point for all of the items on each aircraft design!

Touring Plane-Maker's Menus

Ok fire up the program and open up a plane if you have not already and we'll start right away with Plane-Maker's menus.

File Menu

New
This menu item creates a new aircraft file, suffix "**.acr**"

Open
This command opens the aircraft file that you want to look at or edit.

Save
This saves the aircraft file you are currently editing to the disk. If you are not sure your design corrections will work, use "**Save As**" instead to avoid overwriting the original aircraft.

Save As
This saves the aircraft file you are currently editing under a different file name. Backspace over the old name and give your design a new name.

Quit
This exits Plane-Maker.

Standard Menu

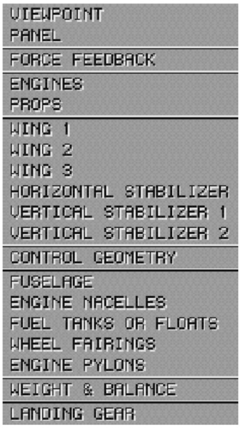
Viewpoint

The left-most box contains the airspeed-indicator markings. These speeds are not used to determine airplane performance in any way, but are ONLY for **airspeed indicator markings.** Make test flights to determine specific speeds for your design if needed. Be sure to set Vne high enough, because X-Plane will break the airplane up if you exceed Vne!

Here is a quick review of the V-speeds in case you need them:

- Vso stall speed flaps down ("dirty" approach configuration)
- Vs stall speed flaps up ("clean" configuration)
- Vfe maximum flap extension speed (don't get them torn off)
- Vno maximum rough-air speed or "normal operation"
- Vne maximum allowable speed or "never exceed"
- Mmo maximum allowable mach number (if required)

The pilot's eye viewpoint is also entered here. This is simply the location of the pilot's viewpoint while flying.



Don't be overwhelmed by the design options you'll see. Work step-by-step from top to bottom. When you are done, go quickly through the menus again, checking each item from top to bottom. Once you have done that you should be ready to fly.

Panel

Enter the instruments you want and the locations of those instruments on the panel by simply pointing and clicking.

Note: glass cockpits are not as customizable as conventional cockpits, and helicopters do not have room for all supplementary instruments.

Two different types of HUD are available. The "conventional HUD" works like the HUD of a typical fighter: airspeed, heading, and altitude are displayed on sliding tapes, Course Deviation Indicators (a horizontal and vertical line becoming a crosshair when on course) for targeting an ILS. Set the frequency of the required ILS in Nav1 / GPS and Nav2. The "**Hoops-HUD**" projects digital map outlines as well.

Force-Feedback

Force-feedback joysticks are joysticks with motors in them that actually move the stick in your hands. **X-Plane** supports force-feedback joysticks. Parameters that are relevant to force-feedback are entered here.

Note: In X-Plane you can set the serial port to output variables for hydraulic and electronic cockpit components such as the "Rock 'n' Ride" seat.

Engines

Engine Type
Select reciprocating, fuel injected, turboprop, or jet here.

Number of Engines
For prop airplanes, enter the number of propellers here. If you have multiple engines going to one propeller, just enter the number of engines as one, and enter the power of all the engines added together as their (total) engine power.

Engine Specs
Enter the RPM, fuel consumption, and thrust data for your engine. The specific fuel consumption (SFC) varies with the type of engine, and X-Plane will give you a default.

Engine Location and Cant (or "thrust-angle")
Enter the point that **X-Plane** will put the propeller for prop airplanes or the thrust-center for jet airplanes. The cant is the angle the **prop** (for prop airplanes) or the **exhaust** of the engine (for jet airplanes) makes with the centerline of the fuselage.

Props

Number of Blades
Your props may have 2, 3 or more blades each. Remember, this is the number of blades for EACH PROP.

Prop is Variable-Pitch
Enter "**yes**" if you have a variable-pitch (otherwise known as "constant-speed" prop). X-Plane will then adjust the prop pitch in flight to maintain the RPM selected by you with the blue knob.

Propeller Radius
The length from the center of the spinner (or axis) to the tip of one blade of the prop. Don't confuse this with its diameter**,** which is the distance from tip-to-tip of the prop!

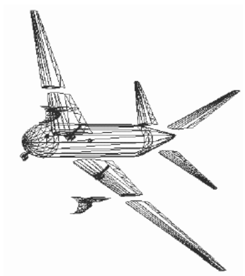
Prop Chord
Enter the average "**width**" or distance from the leading edge to the trailing edge of the prop.

Prop Rotation Direction
Read the on-screen instructions carefully. The convention is a bit odd for helicopters, but makes sense for the internal code of the simulator. You may assign clockwise (cw) or counterclockwise (ccw).

Design Point (RPM, advance and associated speed)
Enter the prop design point here. The design point is the speed and RPM that prop is designed for. It is probably close to the climb or cruise speed and their associated RPM's, but this up to you! Test several options to see.

Prop Pitch Limits
When you fill data in the design-point boxes, Plane-Maker will guess at the pitch-limits automatically. You may override Plane-Maker's guesses, though, by entering data here. As soon as you change the design point, however, Plane-Maker will put in it's own best guess again. Be sure to enter zero if you have a fixed-pitch prop.

Wings

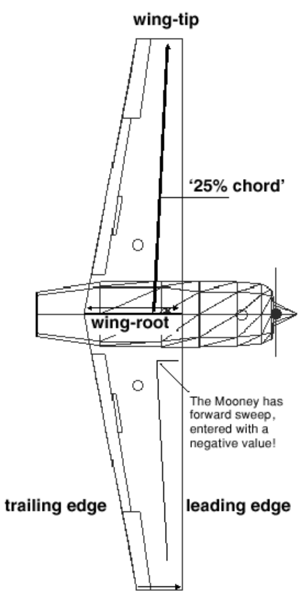


You can easily join wings to shape one complete wing. Each wing becomes a wing-segment. Some airplanes have unusual-planform wings that can be designed in Plane-Maker by adding Wing 2 to the tip of Wing 1, etc. Zoom in on your design to see if both wings line up correctly!

Note: For any surface (like wing numbers 2 and 3, vertical stabilizer number 2, or whatever) that your design does **not** have, enter "**Zero**" for the semi-length. This will tell **X-Plane** that your aircraft is **not equipped** with that particular part.

Semi-Length, Root Chord, and Tip Chord
Enter the **"semi-length".** This is the length of the wing from the root to the tip, measured along the so-called **25% chord.** This is the length of the wing from its root to its tip, as measured along an **imaginary lime** that is 25% of the way back from the leading edge of the wing to the trailing edge. See the illustration if you are unclear on this. The 25% chord is generally near the wing's center or lift.

Note that the **wing root** is usually thought of as being inside the fuselage, at the aircraft's centerline. There are exceptions to this rule, but we usually put the wing root here, since air pressure from the wings carries over the fuselage to a large extent. As far as the air is concerned, the wings really do go all the way to the centerline of the fuselage!

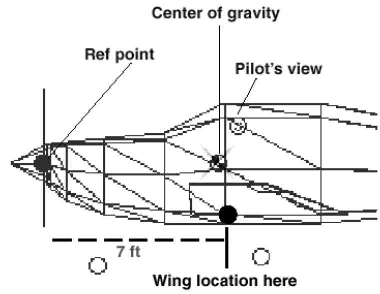


Enter the **root chord** ("width" of the root) and **tip chord** ("width" of tip). Remember that the **chord** is the distance from the leading edge to **'25% chord'** the trailing edge of the wing.

Sweep and Dihedral
Enter the wing sweep. This is the sweep of the 25% chord. Aft (backward) sweep is positive. Forward sweep is fine, just enter it as negative. The Mooney wing (see illustration) has a slight forward wing sweep. Enter the dihedral (angle of each wing above the horizontal plane). Positive (wingtip-up) dihedral is entered as positive. Negative dihedral, or "anhedral" is fine as well. Just enter it negative. For variable sweep wings this value is the MINIMUM sweep value!

Wing sweep makes sense above about 70% of the speed of sound or so, where there is a large drag penalty associated with trying to meet the air head-on. Dihedral helps with stability in roll. If the wings have some healthy dihedral, the plane will tend to roll wings-level, eventually, if you take your hands off the stick. The drawback is that if you ever get into a SIDESLIP situation due to losing an engine on one side or something like that, the plane will try hard to roll into the sideslip because of the dihedral effect. (Sweeping the wings actually causes the plane to act somewhat like it has dihedral, even if it really doesn't!)

Arms (Wing Position)
Enter the longitudinal and vertical position of the center of pressure (25% chordline) **at the wing root,** which should probably be at the aircraft centerline, or some point very close to it, or where the wings would come together if the fuselage were not there, see illustrations.



Number of elements
Remember that the simulator works by breaking the airplane down into a finite number of elements, and finding the forces on each element. This is where you decide how many elements you want the wing to be broken down into. The simulator will automatically break the wing down into the number of elements you specify, with each element being identical in its span. (In other words, the wing is broken down into a number of equally span wise-sized pieces). Enter the number of elements you want to break the wing down into here. More elements allow greater precision in placing flight controls.

Incidence
Enter the angle of incidence for each element (or piece) of the wing. Positive incidence is where the wing has a higher angle of attack than the fuselage. The AOA is what makes a barn door fly!

Enter whether or not each element of the wing...

Has an aileron trailing that pat of the wing
If your ailerons are on the outer 40% of the wing span, and you have 7 elements selected, then select the outer (right-most) 3 elements as being equipped with an aileron. This is actually 43% of the wing for those with greater math-skills...

Has a roll spoiler on that par of the wing
Spoilers can be used for roll control. Here you set them.

Has a flap and leading edge devices at that part of the wing
Just enter the elements with flap trailing. If you have full-span flaps, check all the boxes. No flaps? Check none. Flaps that go out halfway down the wing? Check the inside (left-most) half of the flap boxes. The effect of slats (LED's) can be set in the "**Control Geometry**" option.

Has speedbrakes on that part of the wing
Speedbrakes are like spoilers on the wing, only they are not used for roll. Instead, they deploy halfway or all the way and increase your drag and decrease your lift. They may be used in flight or be deployed at touchdown (airliner-style) for a proper breaking action.

Has drag-rudders trailing that wing element
The Northrop B-2, among other flying wings, has things that look just like ailerons on the wing tips. The difference is, they split open rather that going up and down. This produces drag, which acts like a rudder for the flying wing. You can try that with your flying wing designs here. (Just remember to enter a horizontal stabilizer area of zero for your flying wing designs!)

Note to flying-wing designers
You can have the "ailerons" on the trailing edge of the outboard part of the wing deflect in unison to act as elevators. You will use the *"***deflect ailerons with elevators***"* option in the **"Special Controls"** menu coming up soon. Just select the part of the wing that has elevons as having ailerons on this screen.

Horizontal Stabilizer

Horizontal stabilizers are designed like wings, but with a special consideration: You need to select one of two **"stab types":**

(a) Select **"stabilizer"** if you want the stabilizer fixed, with an elevator on the back (like on most Cessna's), or

(b) A **"stabilator",** if you want the whole surface to move with joystick deflection (like on the Sabre).

If you want the whole stabilizer to pivot with **trim,** but still want an elevator for pitch control (like on Mooneys and Boeings) then select "**stabilizer**" here and set the "**degrees of stab trim**" at the bottom of the screen.

Note: See the illustration in the "**Wings**" section to see how the location of the horizontal stabilizer is defined. Wings, horizontal stabilizers, and vertical stabilizers are all placed in the same way.

Canards

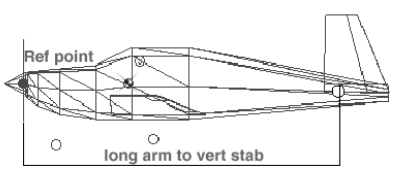
If you want to fly a **canard** airplane, no problem! Just enter a long arm for the horizontal stab that is in front of the wing. X-Plane will see that you have put the stabilizer **in front** of the wing and automatically deduce that you are flying a canard. It will then reverse the elevator or stabilator deflections from a conventional plane to give the correct response.

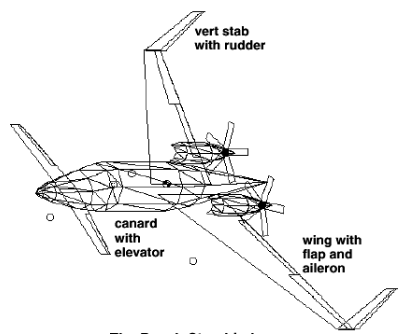
X-Plane will automatically cast downwash from the canard onto the part of the aft wing that is behind the canard. If you are flying a conventional design, X-Plane will cast downwash from the wing onto the stabilizer or stabilator. See the file **"X-Plane.out"** after flying your design to see what X-Plane is doing with downwash on your design, if you want. Do this by opening "**X-Plane.out**" with your favorite word processor and using "**Courier**" as the font.

Vertical Stabilizers

The location of the vertical stabilizer is the same as for the other flying surfaces. Look at the illustrations:

Notice that there are 2 vertical stabilizer windows.





The Beech Starship has a vertical stabilizer at each wingtip and a canard as it's horizontal stabilizer

This is so you can have two vertical stabilizers. This can happen:

side by side ... like with the Beech Starship or F-22, or
top-and-bottom ... like with many pusher-prop planes.

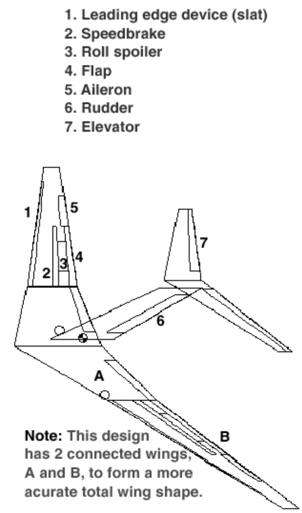
If your design only has one vertical stabilizer, just enter zero for the span of vertical stabilizer number two.

Control Geometry

Set control surface sizes and deflections here. For the controls that you don't use (for example roll spoiler in a plane without roll spoilers) just enter zero.

The **"chord ratio"** is the fraction of the distance from the leading edge to the trailing edge that the surface takes up. It is the part of the total wing chord taken up by the control surface. Almost all controls will be in the 15% to 25% range, depending on the control response required. If you have no blueprint or picture on hand it requires some testing to find the optimum values.

Ailerons
Ailerons for roll-control might go up 20 degrees and down 10. If you are simulating an existing design, measure the actual deflection 1 on a picture of the airplane or blueprint. If you are trying out a new design, you may end up flight-testing these figures, seeing whether roll control "feels" acceptable with various deflections.



Elevators
Elevators for pitch might go up and down 20 degrees. Stabilators (where the whole stabilizer moves for pitch control, like most single-engine Pipers) might go up and down 16 degrees. You can use elevators or stabilators on your airplane, but not both at the same time. You set which type you are using in the "**Horizontal Stabilizer**" window, and then enter their deflections in the "**Control Geometry**" window.

The deflection in the "**elevator**" or "**stabilator**" box in the "**Control Geometry**" window applies to whichever design you are using. If you are using a stabilator the chord ratio is completely meaningless since the whole surface moves, not simply a part of it.

Rudder Roll Spoiler, Drag Rudder, and Speedbrakes
Design them just like the ailerons and elevators. See the descriptions of roll spoilers and drag rudders in the wing definition section if you don't know what they are.

High-lift devices
Select a flap by clicking on the select button. If your design doesn't use any flaps, don't worry about the current selection. It is meaningless and has no impact on the simulation. In *X-Plane Classic* you can assign and use flaps independently from slats.

Leading-edge devices (slats and leading-edge flaps) increase the stalling angle of the wing. Enter the stall-angle increase that the leading-edge devices give your airplane, or enter zero if you don't have them on your machine. In X-Plane 5*x* they are coupled to flaps.

Fuselage & Nacelles

Most of the contents in these windows are self-explanatory.

Fuselage coefficient of drag (c.d.)

The fuselage drag coefficient must include the drag due to fuselage/wing interference, fuselage/stabilizer interference, and any other drag that is not accounted for by the wings, stabilizers, and landing gear. If you do not have firm data on what the coefficient of drag is, you can make a guess along the following guidelines:

- Use 0.05 for a super-sleek machine (like the Lancair 360).
- Use 0.10 is a decent guess for a reasonably "clean" airplane.
- Try 0. 15 for a somewhat "dirty" design.

Remember, this is the coefficient of drag of the fuselage and miscellaneous appendages, including interference drag, based on the frontal area of the fuselage.

If you want to get this data more scientifically, and you already have a coefficient of drag for your entire aircraft that is based on the wing area, just subtract out the drag associated with the wing, horizontal stabilizer, and vertical stabilizer to get the drag of the fuselage.

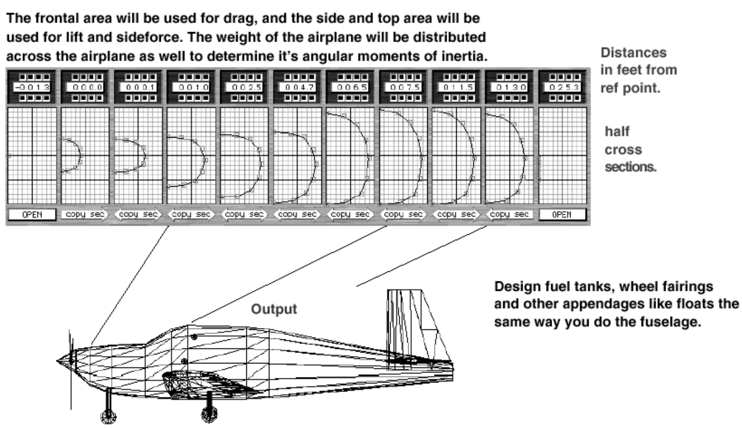
This requires an example:
Assume the coefficient of drag (at zero-lift) of your airplane is 0.015, based on a wing area of 150 square feet, with a fuselage frontal area of 10 square feet. Let us further assume that your wings, horizontal stabilizer, and vertical stabilizer have a coefficient of drag of 0.005 at zero lift. (In "**Part-Maker**" you may verify these numbers).

Follow this process to find the coefficient of drag of the fuselage, including interference drag, based on fuselage frontal area:

- Find Wing area = 150
- Find Horizontal Stabilizer area = 30
- Find Vertical Stabilizer area = 30
- Add those to get the total airfoil area (150+30+30) = 210
- Divide total airfoil area by wing area (210/150) = 1.4
- Multiply this by the airfoil coefficient of drag (1.4x0.005) = 0.007
- Subtract this from the total coefficient of drag (0.015-0.007) = 0.008
- Find the ratio of wing area to fuselage area (150/10) = 15.0
- Multiply this by the coefficient of drag (15x0.008) = 0.12

The final number is the fuselage coefficient of drag (including interference drag) based on fuselage frontal area. Now enter this into **"Plane-Maker".** Fun, quick, and easy, particularly when calculated on a rainy afternoon!

Section Cuts
Drag the little squares around with the mouse to define the fuselage geometry. Close the window and look at the airplane on the main screen to see the results of your handiwork. X-Plane will determine aerodynamic and mass properties of your airplane based on the fuselage geometry, so enter this data accurately.



Weight & Balance

Center of gravity location
Enter the longitudinal and vertical centers of gravity. The longitudinal center of gravity may be close to or just behind the longitudinal location of the wing that you entered in the "Wing" section. The vertical center you can more-or-less guess... it's in the fuselage of the airplane somewhere. Scoot it up a bit if you are flying a plane like the "Lake Amphibian" which has the engine way up over the fuselage. Scoot it down a bit for airliners that have large engines hanging below the plane.

Weights
Enter the weights of the airplane. Empty weight is the weight with no fuel, water, or other payload aboard. Maximum weight is the maximum weight you are allowed to fly at. The fuel load is simply the maximum fuel you

can put in the machine, the water load (used for forest-fire bombers) is the jettisonable load that you carry. There will be a water-dump button next to the anti-ice button in the cockpit if your aircraft carries water. Dumping the water over a forest fire puts the fire out.

Landing Gear

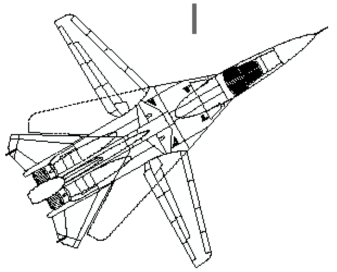
Gear Frontal Area
Enter the frontal area of all the landing gear apparatus, including wheels, struts, and gear doors.

Gear "contact-point" locations
Use this to set the landing gear tire contact point (with the ground) locations. Remember that the "longitudinal arm" is how far back the contact-point of the wheel (with the pavement) is from the reference point, the "vertical arm" is how far UP the contact point of the wheel is from the reference point, and the "lateral arm" is how far the wheel is out to the side of the center of the airplane. Vertical arms are typically negative.

Nosewheel steering
This is how many degrees the nose wheel turns with full joystick or rudder-pedal deflection. 2.0 degrees might work well for you. (Remember that in a real airplane, the nose wheel may end up being turned more than this by differential braking). To see what your maximum deflection is, taxi around with 5-10 knots speed and one rudder pedal to the floor, but without braking. If the movement is too "nervous", waving the wings around, then lower the deflection of the nose gear in the simulator.

The Expert Design Menu

Props, Wings, and Horizontal and Vertical Stabilizers



Variable Sweep Wing
Enter whether or not the wing has variable sweep (like the F-14 and B-1). In this case the wing sweep will vary from the degrees of sweep already assigned to the wing in the regular "**Wing**" window to the amount you enter here in the "**wing sweep**" box. Control the sweep during flight by moving the wing-sweep control in the cockpit. Aerodynamic effects of both wing sweep and moving of the center of lift fore or aft are simulated by X-Plane.

Do Reynolds Number Interpolation / Extrapolation
"Reynolds number" is the air density times the speed of the plane times the chord of the wing divided by the viscosity of air. (whew!) Experiments have shown that the coefficients of wings vary with Reynolds number. This variation is usually fairly small and can usually be neglected for recreational purposes. If you use X-Plane on a slow computer or just for fun then just leave the "**Do Reynolds...**" box unchecked**,** but if you want the coefficients of lift, drag, and moment of the airfoil to vary with Reynolds number to get the absolute highest realism, then proceed as follows: Generate two different airfoil data files with Part-Maker, each for the same airfoil but each at a DIFFERENT Reynolds number. Save the files with names like:

"**NACA 2412-Re=2-4 meg.afl**" and
"**NACA 2412-Re=4-5 meg.afl**"

Make sure you assign the right Reynolds number to each airfoil in Part-Maker, and then X-Plane will interpolate airfoil performance based on Reynolds number. If it can't interpolate because the Reynolds number of the airplane is not between the Reynolds numbers of the airfoils you entered, it will just use the closest available data.

Do Different Airfoil Root-To-Tip Interpolation

If you are using different airfoils at root and tip of the wing, then generate each airfoil file with the Part-Maker if the right foils are not already included with the simulator, and check the "Do different airfoil root-to-tip interpolation" box. This varies the airfoil linearly from root to tip. Otherwise save computing time by leaving this option off.

Airfoil Selection
Click on the buttons to select the airfoil files you want to use.

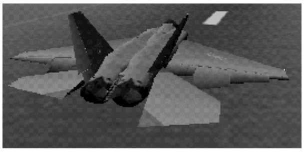
If you are not doing Reynolds number interpolation, don't worry about the "**Re#2**" slots. They have no impact on the simulator whatsoever.

If you are not doing different root-to-tip airfoils, don't worry about the "at tip" slots. Then they too have no impact on the simulator.

Special Controls

JATO
Jet Assisted Take Off is a takeoff where a solid-rocket fuel booster is strapped onto a C- 130 or the like to boost the airplane into the air in hurry, making extremely short-field takeoff possible. Just enter the location, thrust direction (0 is straight back, 90 straight down), thrust force, and duration. A properly-mounted JATO will have its thrust line go through a point close behind the airplane's center of gravity.

Stabilator / Elevator Differential Roll Deflection
F-22's deflect their stabilators in opposite directions to help roll. Question: How will a Piper Arrow roll if you do the same thing? Answer: The stabilators are so short you won't get much response. They can complement the ailerons, but not replace them. This feature also works on elevator deflection if you are flying an airplane with stabilizer rather than a stabilator.



This modified F-22 not only shows stabilator/elevator roll differential (see its horizontal stab), but also aileron with elevator defelction to sustain high maneuverability. Flaps are in take-off position

Aileron With Elevator
The "aileron with elevator" coupling may seem strange, but flying wings might use the same control surface for both pitch and roll. If the "aileron with elevator" coupling is set to 0.5 x the *control geometry value* of the aileron (i.e. 20'), then pulling full back on the stick will deflect the ailerons up halfway, causing the flying wing to pitch up. (Remember the flying wing has a swept wing, so raising the ailerons is like raising the elevator on a conventional plane: it pushes the back of the plane down, raising the nose). This poses an interesting idea for conventional airplanes: What if pulling back on the stick pushed the tail down (regular elevator) and the main wings up (with aileron-droop)? This would increase pitch response and help lift the airplane! This is something you might try on the Cessna 172. Note that a positive numbers pull the aileron upward when the elevator goes up, and negative numbers will push the aileron down. Test this phenomenon while viewing the airplane from the outside with the "**I**" key to see the controls move.

Anti-Ice Equipped
Anti-ice equipment keeps ice from building on the airplane in icing conditions. Watch the outside air temperature!

Arresting-Gear Equipped
Arresting gear is used for carrier landings. If you shoot a carrier approach remember to lower your arresting gear! Use the little button in the glareshield’s auxiliary instrument bar.

Aural Warning Equipped
Aural warning system equipment warns you of being too low, coming down to fast, not lowering your landing gear, etc.

Automatic Deployment

Automatic deployment of slats, brakes, and speedbrakes (like airliners have) can be had. You can also select automatic wing sweep with flap retraction. This is used by the Beech Starship. As the flaps retract, the canard sweeps aft to keep the plane in balance. This option only works with airplanes that have variable-sweep wings or variable sweep horizontal stabilizers.

Speedbrake Frontal Area

Enter the frontal area of the speedbrakes when fully deployed here. This doesn't include speedbrakes, or spoilers, that are mounted on the wing. This option only applies to speedbrakes that are mounted on the fuselage (or maybe other places) that do not affect the lift of the airplane, but only the drag.

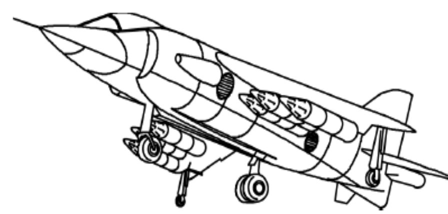
VTOL Controls

Vectored-Thrust

Designing a VTOL (Vertical Take-Off and Landing) aircraft is fun but challenging. Enter "**yes**" or "**no**" in the selection box to indicate whether you want your aircraft to vector thrust or not.

The **tilt-rotor** VTOL (Vertical Take-Off & Landing) aircraft can obtain its flight control in the same way a helicopter does: by adjusting what is known as the **"cyclic pitch"** of the rotor blades. This is a process whereby the pitch of the blades varies depending on where the blade is on its trip around the hub. This creates a lift asymmetry that will pitch or roll the aircraft. In this window you enter the degrees of pitch that a blade is increased or decreased with full joystick pitch and roll deflections.

Another way to obtain control of a VTOL aircraft is to do it the same way the AV-813 Harrier does: "puffers". The concept is simple. Bleed air is taken from the compressor and then sent out through little jets on the tail and wing tips to steer the airplane around when in hover. **X-Plane** takes the simplest possible approach to simulating this. Just enter the pitch, roll, and yaw moments associated with full joystick deflections. (Remember if you don't know what the maximum moment is, just multiply the force exerted by the puffer times the distance from the puffer to the center of gravity of the airplane to get the moment).



If you don't know how much force you need, try some values to see if they give you comfortable authority. That is what the simulator is for!

Note on propeller-equipped *VTOL* aircraft: The control that you are used to seeing as a throttle acts instead as a collective pitch, with the computer controlling the throttle to maintain some rpm. This is how a helicopter is typically managed. The collective pitch travel and redline rpm are set in the usual places for prop pitch and rpm in Plane-Maker.

Artificial Stability

Unstable airplanes don't want to point in the same direction they are going. Once they start to point away from the direction they are traveling, they continue to move away from the flight path! No human is able to fly such an aircraft for long, so a computer is implemented in these aircraft to keep the airplane from ever diverging from the desired heading and attitude. This computer system is called an artificial stability system, sometimes referred to as "**fly-by-wire**" because there are no direct control linkages between the pilot and control surfaces.

The F-16 and airplanes that are basically just neutrally stable in hover (like the V-22 Osprey), have this control system. This system looks at the control input from the pilot, then determines what the pilot wants the airplane to do and based on this, looks where the airplane is actually going, moving the control surface to obtain the desired result.

You will probably need an artificial stability system in your plane if it is unstable or is a VTOL design. If it is a VTOL design, you may wish to have the system turn off at conventional flight speeds, and only "phase in" as you slow down to hover. This is because there is little or no inherent stability in hover. (As first-time helicopter pilots learning to hover can attest!) You enter the speed below which the artificial stability system is completely engaged (say 60 knots) and the speed above which the artificial stability system is completely out of the loop (say 180 knots). The system will automatically phase gradually from one extreme to the other at intermediate speeds. If you are flying an unstable aircraft and always want the system to remain on, just enter a phase-in and phase-out speed of 999 knots. The system will always be on below 999 knots indicated airspeed. Remember that your true airspeed may be much higher than this at high altitudes, while your indicated airspeed is still under 99 knots, thanks to the thin air that causes the pressure on the airplane to be lower, and thus the indicated airspeed to be lower as well.

The fly-by-wire, or artificial stability system, used by X-Plane is simple yet effective: You enter what pitch and roll rates you want the artificial stability system to shoot for with full joystick deflections. Look at some examples in the your airplane files. Output the control deflections to the graphical output display (Settings: Set Data Output in X-Plane to see if the controls are moving too far or not far enough.

NOTE: **To give you some grasp over this matter here are some average parameter you can test:**

	Minimum speed: 160 KIAS		Maximum speed: 380 KIAS	
	Low		High	
Pitch	**40°**	**0.01 diff**	**10°**	**0.1 diff**
Heading	**4°**	**0.001 diff**	**4°**	**0.08 diff**
Roll	**40°**	**0.02 diff**	**20°**	**0.1 diff**

Fuel Tanks / Floats / Wheel Fairings

- Flying boats have a floating hull with little balancing floats outward on the wing.

- Seaplanes sit (way) up and above a pair of floats.

Enter the floats for seaplanes here... the fuselage of your flying boat will serve for flotation with no extra work required in Plane-Maker.

Engine Pylons

Engine pylons attach the engines to the wings of the airliners.

Background Menu

This is rather self-explanatory when previewing your work.

Special Menu

To clean up your design use the “**Ellipse-Smooth**” options. This will smooth out the fuselage a bit, kind of blending everything smooth.

Switch to helicopter mode if desired, and the "**Standard**" menu will adapt from airplanes to helicopters.

Show with Textures or Wire frames as desired... textures are not available in X-Plane Classic.

"**Output Texture-Map starting points**" saves the outlines of all the parts of your plane to the "**X-System**" folder. The various files are named "***Start*** **(*item*).bmp**". You must substitute "**Start**" with the name of your airplane, for example "**Mooney wngl.bmp**" etc. You can also customize your sounds and instruments panels. (Check out the "**King air.panl**", for example, in the "**King-Air**" folder in the "**General Aviation**" folder). The same applies to many engine sounds and warnings. See the various planes that come with the sim, and see the "**Hacking X-Plane**" section at **www.xicat.com** for info.

CHAPTER 6
DESIGNING HELICOPTERS

Introduction

Most of the windows that you use to design airplanes are the same as the ones you will use to design your helicopter, but there are a few that are different, so this short chapter will cover those windows that are specific to helicopters. You should read the previous chapter on airplane design before you read this chapter to get a tutorial on the functions of Plane-Maker that this chapter doesn't cover.

Main Rotor / Tail Rotor / Rotor System
See the descriptions for "**Props**" in the previous chapter to get a tutorial on how to enter the rotors into the **"Main Rotor"** and **"Tail Rotor"** slots. One possible area of confusion for you might be the "design speed", or in engineering jargon, "the design-point" of the rotor system. The **"aircraft speed"** box in these windows is actually the speed at which air will be moving through the rotor disc, when the rotor is operating at its design point. In other words: If the chopper is cruising at 90 knots, with the rotor aimed down 10 degrees, then the airflow through the rotor disc will be:

90 x sin(10) = 16 knots

plus an additional 15 knots due to the air being "sucked" through the disc (this is also referred to as "propwash"). The number will be about 30 knots or so, as a rule of thumb.

Note: If the total propwash is 30 knots, then the airspeed through the rotor disc is only about half of that amount (15 knots), because the rotor also pressurizes the air, causing it to continue to accelerate even after it has passed through the rotor disc.

To summarize:

For a helicopter, the airspeed through the rotor disc in cruise is:

cruise speed x sin (rotor pitch down angle) + propwash speed / 2

This is an idealized approximation. Here is an even further simplification, if you don't have all of the data required above:

design speed = cruise speed x 0.1 + 15 knots

Enter this number in the "**aircraft speed**" box in the "**Main Rotor**" window.

For the tail rotor, you should probably enter zero as the design speed, since tail rotors generally have no twist, and entering a design speed of zero will cause X-Plane to assign no twist to the rotor.

For the flat and open pitch, measure the angles of the real helicopter with the collective stick full down and full up, respectively. See the Pilot's Operating Handbook for exact numbers if possible. Be advised not to enter too high a value for the main rotor pitch or you will stall the main rotor blades! -5 to + 15 degrees is normal.

Rotor System
These numbers are all self-explanatory, though be sure to enter the rotor cants when the rotor is simply holding the helicopter at hover, and is not deflected due to maneuvering. Notice also that the tail-rotor gear ratio is the tail-rotor RPM ratio with respect to the main rotor and NOT the engine! This number is generally close to 5. If the main rotor rotates at 384 rpm and the ratio is 5, then the tail rotor runs at about 1920 rpm (as a rule of thumb). If you set the tail rotor correctly then your helicopter will show next to no yaw when starting to hover. Check the helos that come with the sim for reference values.

Designing a helicopter is fun but tricky. Start by looking at the models that come with X-Plane.

The center of gravity should be right under the main rotor. Main rotor RPM might be 350, but bigger rotors should turn slower. The main rotor should have a collective pitch range of maybe -5 to +20 degrees. The main rotor should have a cyclic pitch change of maybe 10 degrees. Over-sensitivity of your helo means you need to reduce your cyclic pitch. If the engine can barely turn the rotor then the rotor needs to be slowed down or reduced in size. If the rotor loses lift for no apparent reason when you go to high collective then you may be stalling the blades from entering too much positive collective pitch.

The tail rotor should turn about 5 times faster than the main rator, and have a pitch range of about -20 to +20 degrees. If the helo tends to yaw in hover then you need to increase or decrease the tail rotor pitch, size, or speed. Be aware of the direction of rotation of the main rotor (which the tail rotor must counteract) to determine if the tail rotor is too strong or not strong enough.

Skids
If your helicopter has landing gear rather than skids, enter "**no**" for skid equipped. Otherwise enter the skid data that follows. Remember that the skids are probably below your reference point, so you will enter a negative number for their vertical arm!

Expert Design Menu

Main Rotor, Tail Rotor, Horizontal Stabilizer, Stability Augm.

See the "**Expert**" menu options in the previous chapter for an explanation of this menu. Here you assign the rotor airfoils and add some stability augmentation (if required) to the helicopter.

CHAPTER 7
PART-MAKER EXPLAINED

Introduction

X-Plane uses aircraft designed with Plane-Maker. These aircraft use airfoils designed with Part-Maker.

The "**X-Plane Design System**" comes with a number of airfoils and flaps. It is probable that, for recreational purposes, these will be the only airfoils and flaps you will ever need. Additional models you might download from our and other Internet websites may have their own airfoils and/or flaps, so always look for additional "**.afl**" and "**.flp**" files that you must copy into the **"Airfoils"** and **"Flaps"** folders first.

Part-Maker is available to you, however, if your airplane designs use airfoils or flaps that were not included with the simulator.

The File Menu

The file menu works just like the file menu of any word processor or spreadsheet you have used. You create, load, and save your files just like you do with a word processor. The only difference is that you are opening and saving files that represent airplane parts rather than word processing documents. Your airplane will use these parts.

New
Use this to generate a new part.

Open
Use this to open an existing part for viewing or modification.

Save
Use this to save a part that you have created or modified.

Save As
Use this to save a part that you have created or modified, but under a different name.

Quit / Exit
Exit Part-Maker.

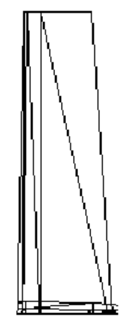
Airfoils

Getting Started

Double-click on the **"Part-Maker"** icon. Select **"Airfoil"** from the **"Part"** menu.

A quick review for novice pilots: **an airfoil is not a wing!** An airfoil is simply the cross-section of a wing! A Cessna 182 uses a NACA-2412 airfoil, and that may be the same airfoil that is used by various different airplanes. These airplanes may have a different wing area, different wing span, and even a different wing planform (shape) as seen from above the airplane and looking down. But if the cross-section of the wing is the same for the two aircraft, then they are both using the same airfoil.

Every airfoil ever designed has its own 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).



Planform of a wing (its "top-view")

Airfoil or "cross section" of a wing

What's an airfoil?
What's a planform?
What's a wing?

Airfoil + Planform = Wing

You'll see a big black box dominating the screen with green, red, and yellow lines on it.

The left edge of the chart corresponds to an angle of attack of - 20 degrees, and the right edge corresponds to an angle of attack of +20 degrees.

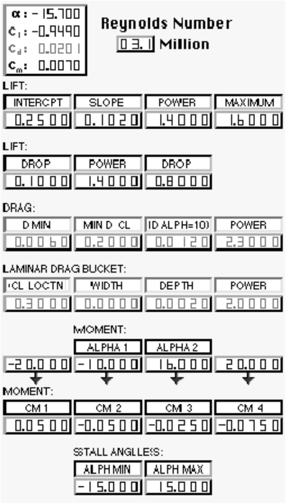
The center of the chart represents an angle of attack of zero degrees. (Remember the angle of attack is the angle of the wing to the air. It is the angle at which the wing hits (or "attacks") the air).

The **green line** is the coefficient of lift. The **red line** is the coefficient of drag. The **yellow line** is the coefficient of moment**.** We'll look at the behavior of each of these lines.

Reynolds number

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 the coefficients of lift, drag and moment of wings vary somewhat with Reynolds number.

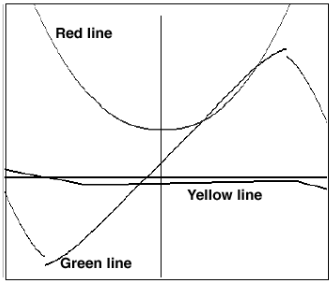
For recreational purposes, you can probably neglect any change in performance with Reynolds number, so you can just ignore this setting altogether The number entered in the Reynolds number box may have some impact however on the simulation. For highest realism you can generate 2 different airfoil files for the same airfoil, each file at a different Reynolds number, and assign them both to your wing! X-Plane will figure out the Reynolds number on each piece of the plane at least 10 times per second and interpolate between the 2 airfoil files to give the most realistic coefficients for that flight Reynolds number.



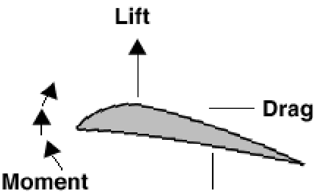
Pilots should realize:
Very good accuracy can be obtained without messing with the Reynolds number at all, and without generating two airfoil files for each airfoil. You can ignore the above paragraph and the "Reynolds number" slot in the airfoil generation screen without sacrificing a good simulation.

Coefficient of lift
Look at the *green line.* It is the coefficient of **lift**.

Notice that at zero degrees angle of attack (center of screen) the coefficient of lift is fairly low. (It is close to the thin white line, which represents zero). As the angle of attack increases, the coefficient of lift increases right along with it, until you get to around 16 degrees angle of attack, at which point the coefficient of lift falls abruptly... That is the stall!



Airfoil coefficients window



If you go to negative angles of attack, you see 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.

Coefficient of drag
Look at the *red line.* It 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 you offset the wing from the airflow, the greater the drag!

It doesn't matter much whether you are going to positive or negative angles of attack (aiming the wing up or down)... moving the wing away from it's most streamlined position increases it's 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).

Coefficient of moment

Look at the *yellow line.* It 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, getting especially large in the negative direction as the angle of attack is increased, 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.

Coefficient display box

One thing that you have probably noticed is that the axis are not labeled, and don't have numerical values to tell you exactly what the coefficients are. Look at the little box in the upper left-hand comer of the airfoil generation screen. The top number (white) is "alpha" or the angle of attack of the wing. The next numbers are the coefficients of lift, drag, and moment at that angle of attack. Wiggle the mouse back and forth all the way across the monitor, and notice that the angle of attack display changes, and the coefficients with it. The coefficient display box is giving the angle of attack and coefficients of the airfoil at the angle of attack that the mouse is currently pointing at. 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! Easy!

One question you might be asking yourself is: How *do I find what the coefficients are for the airfoils on my airplane?* First, you need to find what airfoil your aircraft uses, probably from the manufacturer. Then you need to see if that airfoil is included with our program. If you are flying a Cessna 182, for example, that aircraft uses the NACA **2412** airfoil, which is included, so you do NOT need to generate your own airfoil for that wing. If you do not know what foil to use, then just leave them as the defaults of Plane-Maker.

Airfoil selection is a fun and interesting process, because you will be looking for the best possible combination lift, drag, and moment characteristics for your particular airplane. If you will be experimenting with your own airplane designs, and are new to the matters discussed in this manual, we highly recommend:

R/C Model Airplane Design
A.G. "Andy" Lennon
Motorbooks International Publishers and Wholesalers, Inc.

to get you started. The book is intended for radio control designs, but is very straightforward, easy to understand, and all of the principles apply to full-scale aircraft.

Once you understand the basics of airfoil theory and nomenclature, we recommend:

Theory of Wing Sections
Abbot and Von Doenhoff
McGraw-Hill, New York (1949)

... an oldie but goodie! This books has the lift, drag, and moment plots of many airfoils in it, so you can choose your favorite airfoil for your design and then enter it into the computer using the technique that is about to be explained.

In the following discussion, thin symmetrical, thick highly cambered, and "normal general aviation" airfoils will be discussed. These are three types of airfoils that are good for discussion purposes because they are so different.

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, highly-cambered airfoils in the fore planes 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.

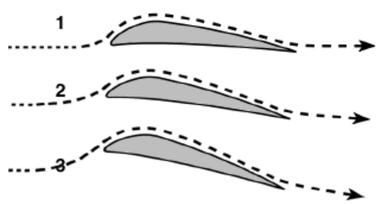
So-called "normal general aviation airfoils", like the NACA 2412, are compromises between the two, and are good candidates for the wing of a general aviation aircraft.

Supercritical, laminar-flow, and other possible groupings of airfoils exist, but for the purposes of our discussion we will concentrate on the thin symmetrical, thick and highly cambered, and "normal general aviation" airfoils just outlined.

Airfoil generation buttons

Now let's actually generate an airfoil. The first button to click on is the coefficient of lift intercept button, the green one labeled "**intercpt**" in the upper left hand comer. To increase this number, just click right above the numbers 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, and you want to change it to 0.33 to model your airfoil, just click right above the "**T**' in "**0.25**" and twice below the "**5**" in "**0.25**". You will change all of your data that way for the entire design and simulation system. Easy! Now what exactly is a coefficient of lift intercept, anyway? **Read on to find out!**

Airflow at various angles of attack



In the diagrams above, we see air flowing over a wing at various angles of attack. Note that the airflow is spead up above the wing by the shape of the airfoil and the angle of attack of the wing. Since the air has to speed up to cover a greater distance over the top of the wing, the air molecules are spread out a bit as they cover the greater distance. This spreading out of the molecules means there is less air pushing down on the wing from above than there is below the wing pushing up. This is effectively a suction on the top of the wing, otherwise known as lift.

The diagram above also shows that air is sucked up from below and ahead of the wing by the low-pressure region above the wing. This is sometimes called "upwash". The air is also given a healthy kick DOWNWARDS as it leaves the wing. This is called "downwash".

Notice that as the angle of attack is a maximum, air is almost pushing underneath the wing, really pushing the wing up AND BACK... this is an indication that the drag of the wing is very high, which is not surprising at high angles of attack. If the angle of attack gets too much higher, the airflow will seperate from the wing altogether and the wing will stall, thus losing the majority of it's lift in a great un-simulate-able turbulent mess of vortex-filled air. You will notice this loss of lift in the plane as it stalls.

Coefficient of lift intercept, "INTERCPT"
This is the coefficient of lift at an angle of attack of 0 degrees. For a symmetrical airfoil, this will always be zero, since the air is doing exactly the same thing on the top and bottom of the wing for a symmetrical airfoil 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.

Coefficient of lift slope, "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 real 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).

Coefficient of lift curvature near the stall, "POWER"
As the angle of attack gets close to stall, the lift slope is no longer linear, but gradually "levels off" as it approaches the maximum, or stalling, coefficient of lift. Just play with the power button 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.

Coefficient of lift maximum, "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.

Coefficient of lift immediate drop at stall, "DROP"
This is the drop 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.

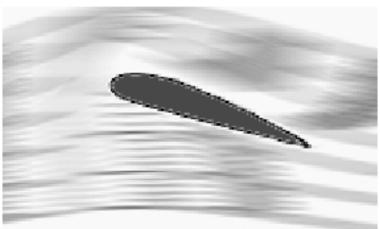
Coefficient of lift curvature after stall "POWER"
Different airfoils have different lift slopes after the stall. For skinny, sharply-stalling airfoils the power should be fairly low, perhaps around 1.4. For fat airfoils (which usually have more gentle stalling characteristics) this

number may be closer to 2.0. Just play with the power button until the data looks like the data you are trying to model from the airfoil chart in whatever book you are getting your airfoil data from.

Coefficient of lift drop from stall to 20 degrees "DROP"
This is the decrease in coefficient of lift from the stall to an angle of 20 degrees. This number 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).

Wind tunnel image of an airfoil



When a wing produces lift the air in FRONT of it is lifted UP, the air ABOVE it SPEEDS up, and the air BEHIND it is pushed DOWN.

Coefficient of drag minimum "DMIN"
This is the minimum coefficient of drag of the airfoil. (Again, not including induced drag, which is determined automatically by X-Plane). 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 real 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 buttons soon to come...

Coefficient of lift at which minimum drag occurs "MIN D CL11
Enter the coefficient of lift at which the minimum drag occurs. This value is probably very close to the coefficient of lift at zero degrees angle of attack, which is the "lift intercept". *The very first number you 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.

Coefficient of drag at angle of attack of 10 degrees "D ALPH=10"
For a thin, symmetrical airfoil, this value might be around 0.0 15. NACA-2412 comes in with a surprisingly good 0.0 12. A really highly-cambered airfoil might be around 0.025, though.

Coefficient of drag curvature "POWER"
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.

Laminar drag bucket location "CL LOCTN"
Some airfoils, called "natural laminar flow" or "NLF" airfoils, have perfectly smooth airflow across a large part of the wing, a flow pattern called "laminar flow". 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.

Laminar drag bucket width "WIDTH"
This refers to how "wide" the bucket is, or what range of coefficient of lift the drag bucket covers. 0.4 is a decent guess.

Laminar drag bucket depth "DEPTH"
This is the all-important variable: how much do you reduce your drag by going to laminar flow? Answer: 0.002 if you're lucky. (But that is actually quite a bit. That might turn a cd of 0.006 to 0.004. Quite a large percentage difference).

Laminar drag bucket curvature "POWER"
The power curve is the simply the curvature of this 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.

Coefficient of moment low-alpha change point "ALPHA 1"
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 **NACA2412,** the moment coefficient has its low angle of attack moment change at -10 degrees, a point corresponding to roughly +4 degrees before the stall.

Coefficient of moment high-alpha change point "ALPHA 2"
The **NACA-2412** airfoil has its high angle of attack moment change right at the positive stalling angle of 16 degrees.

Coefficient of moment at -20 degrees "CM 1"
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.

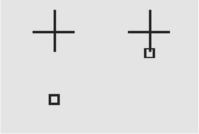
Coefficient of moment at low-alpha change point 11CM 211
For the **NACA 2412,** this number is about -0.05, which is a light pitch-down. A wing with a higher camber will have a value of around - 0.10, perhaps even -0.13. A symmetrical airfoil will have no pitch tendency at all here, so 0.0 should be entered for that type of airfoil.

Coefficient of moment at high-alpha change point 11CM
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.

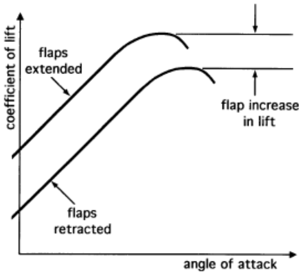
Coefficient of moment at 20 degrees 11CM 411
This is the coefficient of moment well into the stall. For the NACA 2412, it is about -0.10. This is a moderate pitch-down, which is desirable because this pitch-down will help recover from the stall.

Finishing Up
Change all of the parameters we just discussed around a bit, and select "**Save As**" from the "**File**" menu. Now type in a 'hi-tech' airfoil name and hit return. Congratulations! You have just generated your own airfoil!

Flaps



Angle of attack in the HUD of X-Plane is indicated by the distance between these two symbols. The + is the direction the nose is pointing, and the ❑ is the velocity vector or direction the aircraft is moving.



Remember that you can design a lot of realistic airplanes without ever generating your own flaps, because plenty of flaps are included with the program.

Getting Started

Select **"Flap"** from the **"Part"** menu.

Look at the chart (left), and notice that with the flap deployed, you actually stall at a lower angle of attack. This is due to the "induced angle of attack", which is the effective increase in angle of attack you get from lowering the flaps, and was shown as "up wash" in the previous pages.

If you are having a hard time believing that you stall at a lower angle of attack with the flaps deployed, go stall your airplane clean, and then do it again with the flaps down. You will notice then that the nose goes up higher before the stall when the flaps are retracted. Do this at a high altitude, with a forward center of gravity, without anyone else in the plane, and only if stalls are approved. Go over your spin-recovery procedure before you do the stalls!

X-Plane takes care of the "induced angle of attack" automatically, so all you have to do is enter the "flap increase in lift" as illustrated above. Be aware, it is easy to misread the flap increase in coefficient of lift by not measuring it exactly as shown on the chart!

So how much does a flap increase the coefficient of lift?

Flap type	**cl at full deflection**	**cd at full deflection**	**cm at full deflection**
plain	1.0	0.12	-0.30
split	0.9	0.14	-0.25
slotted	1.2	0.08	-0.38
fowler	1.4	0.08	-0.42

Remember the coefficients presented above are only what the flap adds directly to the wing. The "induced angle of attack" from deploying the flaps will increase the coefficients of lift and drag on the wing even more when you lower the flaps.

Play with the constant, linear, and quadratic buttons to get the lines to look the way you want them to. See the high-lift devices included with the program first to see the trends. Notice that with lift, you get a lot of lift for the first bit of deflection, but then go into a "point of diminishing returns", where the last bit of flap deflection just doesn't increase the lift much more. It is just the opposite for the drag, though. The drag isn't too bad at first, but once you get the flaps out more than about halfway, the drag really starts coming up fast.

Finishing Up

Change all of the parameters we just discussed around a bit, and select "**Save As**" from the "**File**" menu. Now type in a goofy flap name and hit return. Congratulations! You have just generated your own flap!

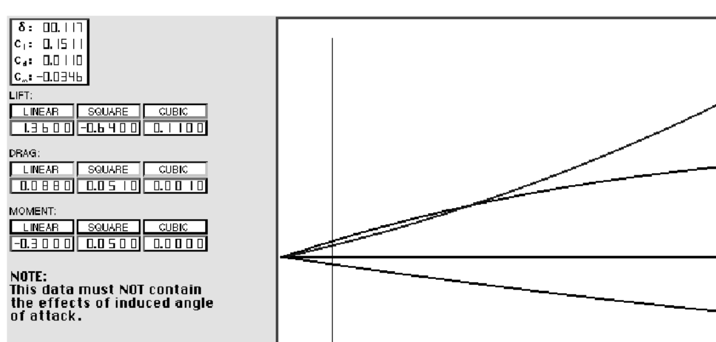
The View Menu

cl cd cm VS alpha

This view mode allows you to look at the coefficients of lift, drag, and moment as a function of angle of attack or flap deflection. In other words, the angle of attack or flap deflection is the x-axis. It is best used during the entry of the lift and moment data.

cd cm VS cl

This view mode allows you to look at the coefficients of drag and moment as a function of the coefficient lift. In other words, the coefficient of lift becomes the x-axis. Almost all airfoil charts use this format to present drag coefficients, so this view mode is best used during entry of the drag data. Only data up to the stall is presented.



Flap design window

CHAPTER 8
THE FLIGHT MODEL EXPLAINED

Many people have shown an interest in finding out exactly why and how X-Plane's flight model works. Well, some of the exact details are proprietary to Laminar Research, but, since you asked for it, here is the general explanation:

Step 1. **Element Break-Down**
This happens only once during read-in of the airplane from the disk. X-Plane breaks the wing(s), horizontal stabilizer, vertical stabilizer(s), and propeller(s) down into a finite number of elements. You choose the number of elements in Plane-Maker. The more elements you use, the more realistic the simulation. The maximum number of elements you can use is 10. Studies have shown that there is not much of a difference between using 10 elements and 100... In other words, you need to use more than 4 elements, but once you get above about 10 elements you don't get any additional realism.

2. **Velocity Determination**
This is done twice per cycle. The aircraft 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. Once the area of each prop disk and the thrust of each prop are known, X-Plane simply looks at the air density and determines how much the air must be accelerated for momentum to be conserved. Basically, for every action there is an equal and opposite reaction. For every pound of thrust produced, a certain number of pounds of air must be pushed back at a certain speed.

Downwash is found by looking at the aspect ratio, taper ratio, and sweep of the wing, and 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 lookup table to get the degrees of downwash generated per coefficient of lift.

3. **Coefficient Determination**
Once we know the geometry and velocity of the piece, we can find the angle at which the air hits each piece of the airplane... this is known as the angle of attack. Knowing the angle of attack, we can look up the coefficients of lift, drag, and pitching moment for whatever airfoil the airplane is using on that part of the airplane. This information (the coefficients of lift, drag, and moment of an airfoil at a given angle of attack) as described in Part-Maker but nature makes things a little more complicated...

The fact that the wings on the airplane have different aspect ratios (the wing span divided by the wing chord) and different taper ratios (how much smaller the wing tip is than the wing root) cause the coefficients of lift, drag, and moment to be a little bit different. The changes in these coefficients are called "finite-wing effects". X-Plane looks up these effects in look-up tables that have been gained from experimentation in wind-tunnels. These effects include:

- induced drag: Drag due to the production of lift.
- lift-slope reduction: Reduction in lift gained per degree increase in angle of attack.
- clmax reduction: Reduction in maximum lift available from the airplane.
- moment reduction: Reduction in pitch-moment.

Even after these corrections, we must use a rule called the **"PrandtlGlauert rule"** to find out how much the air is compressed by the airplane due to compressibility effects, and we also consider "drag divergent mach number" to increase the coefficient of drag when we get close to the speed of sound... the greater the coefficient of lift, the lower the speed at which we start to get high transonic drag.

4. **Force Build-Up**
We found the shapes of all the bits of the airplane during initialization. We found the speeds of all the bits of the airplane in step 2, considering geometry, velocity, propwash, and downwash. We found the coefficients of all the bits of the airplane in step 3, considering the effects of limited aspect ratio and taper ratio, and compressible and transonic effect.

Knowing these, we can determine the force on each piece using the equation:

force= speed x speed x coefficient x area x air density / 2

Knowing the force on each piece, we simply add up all the forces on all the pieces to get the total force on the airplane. Forces are then divided by the aircraft mass to get the linear accelerations, and by the aircraft moments of inertia to get the angular accelerations. Knowing the aircraft accelerations, we can see what the plane will do next.

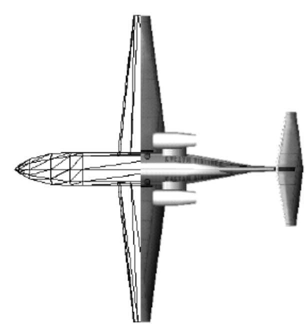
5. **Going over it again**

Go back to step 2 and do the whole thing over again at least 14 times per second for each element on the plane. Aren't computers great?

CHAPTER 9
TEXTURES EXPLAINED

The General Procedure

To make your own airplane textures for X-Plane and preview them in Plane-Maker, simply create the bitmap starting-points by using the "**Special**" menu "**Output Texture Map Output Points**" item. You'll find all created files in the "**X-Plane**" folder. Replace the prefix **"start"** with the name of your airplane followed by one space.



Designing textures is fun, but requires lots of work and practice to get the technical details just right and the weathering just right that is required to make the aircraft look real.

"fuse", 11 nace", "misc". 11wngl", 11wng2", 11wng3", "hstb". "vstbl' 11vstb2", "pnl", 11 pyln", "fair" and "hand" for handles.

Next save those files in the same folder as the airplane itself.

For example, set the files up like this to texture-map the **Citation Jet:**

X-Plane 5.52 Folder
Planes Folder
Biz Jets Folder
Citation X Folder

Citation Jet.acf	(the plane itself)
Citation Jet fuse.bmp	(left fuselage)
Citation Jet fuseR.bmp	(right fuselage)
Citation Jet nace.bmp	
Citation Jet misc.bmp	
Citation Jet wngl.bmp	

Citation Jet wng2.bmp
Citation Jet hstb.bmp
Citation Jet vstl.bmp (left vert stab)
Citation Jet vstlR.bmp (right vert stab)
Citation Jet panl.bmp (cockpit panel)

Make sure that all your bitmaps are of sizes that are powers of two (2) (i.e. 32, 64, 128, 256, or 512).

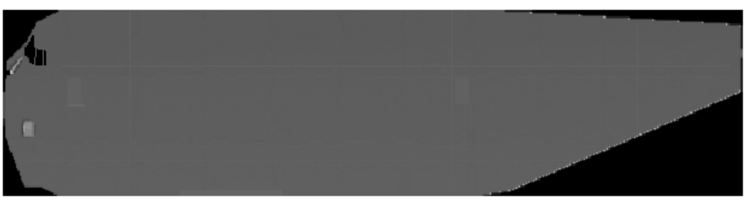
256 x 256 recommended for the **landscape** bitmaps: *grass.bmp, mountain.bmp, snow.bmp* and *water.bmp,* stored in " **Textures" and "Custom Textures"** folders.

800 x 583 pixels **obligatory** for the cockpit instrument panel.
To edit the panel make a screenshot and edit the bitmap removing needles and other variable stuff, which X-Plane itself will draw.

Make sure you save the bitmaps in 24-bit or 32-bit color BMP format, or X-Plane, Plane-Maker and World-Maker will not be able to read them!

Some Hints on Textures

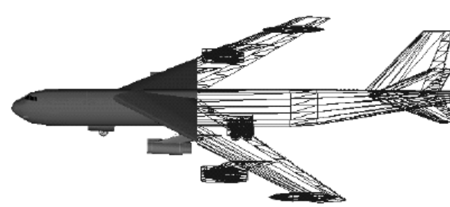
To add textures to your airplanes you'll need a graphics program capable of handling "**.bmp**" (bitmap) images. Examples are PhotoShop and PaintShop, which have abundant features to create cool airplane and scenery textures. When saving your textures look for the "**File**" menu option "**Save a copy as...**" to select the "**.bmp**" format from the appearing sub-menu button. Filenames must be as defined on the previous page (for example "**Citation Jet wng2.bmp**").



B-52H fuselage outline is saved as "B52H fuse.BMP" in the according" B52H" plane's folder

X-Plane supports hardware acceleration using the OpenGL standard. Hardware acceleration means that your video card does the graphics calculations instead of the main CPU of your computer. The OpenGL video card is designed to do things like texturing, fogging, light effects, anti-aliasing, and other stuff that makes the visual presentation of the simulator exciting. The results are dizzying scenery and silky frame rates, creating a photo-realistic environment.

Sounds can be added to your airplane as well. They must be in WAVE format and stored in the appropriate airplane folder. They can be special engine sounds, but also the other sounds, like the screech of the landing gear! See the "**Concorde**" folder in the "**Mega-Planes**" folder for examples. See "**Hacking X-Plane**" at **www.xicat.com** for all the latest sounds, panels, and textures that you can add!



Briefer

Run the Weather Briefer before your flight to get a weather forecast. If you have downloaded real-weather from the net, then you will get an accurate briefing for the flight you have planned. See **www.xicat.com** for the current places to get real weather from the net.

If you do not have real-weather downloaded from the net, then Briefer will give you a rather boring prediction. It will simply tell you to expect the weather that is currently stored in X-Plane's preferences.

Credits

Published By: Xicat Interactive, Ltd.
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Executive Producer: Reto Bodmer

Producer: Leonard Kohs

Associate Producer: Don Zabriskie

Lead Programmer: Austin Meyer

Graphic Designers: John Linn
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Quality Assurance: Leonard Kohs
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John Linn
Don Zabriskie

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The following is a partial list of the references used for the writing of the simulator and this instruction manual.

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