

Microsoft
Flight Simulator 2000
As Real as it Gets

Pilot's Handbook

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Microsoft Flight Simulator 2000 Pilot's Handbook

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Before You Fly

A low-wing, high-wing aircraft is shown in flight, viewed from a low angle looking up. The aircraft is white with a dark fuselage. The wings are positioned high above the fuselage. The background is a bright, cloudy sky. The overall image has a light, airy feel.

chapter one

1

Whether you're a rookie, a Microsoft® Flight Simulator veteran, or a licensed pilot, you probably can't wait to climb into the cockpit. Before you start flying Microsoft Flight Simulator 2000 though, there are a few things you need to do. This chapter tells you how to get started.

Installing Flight Simulator

1. Turn on your computer and start Microsoft Windows® 95 or later.
2. Insert *Flight Simulator 2000 Disc 1* into your CD-ROM drive.
3. Follow the instructions on the screen.

If your computer doesn't support automatic installation, follow these steps:

1. Click **Start** on the taskbar.
2. Point to **Settings**, and then click **Control Panel**.
3. Double-click **Add/Remove Programs**.
4. On the Install/Uninstall tab, click **Install**.
5. Follow the instructions that appear on your screen.

During Setup you'll have the option of selecting a Minimum, Typical, or Custom installation. If you need to conserve hard disk space on your computer, choose the **Minimum** setup option. If you want to optimize flying performance, choose **Typical**. If you are an advanced user and want to choose exactly what gets installed, choose **Custom**.

Note: Installation may require one or more of the Flight Simulator compact discs, depending on the options you choose.

Starting Flight Simulator

1. Insert *Flight Simulator 2000 Disc 1* into your CD-ROM drive.
2. Click **Start**, point to **Programs**, point to **Microsoft Games**, point to **Flight Simulator 2000**, then click **Flight Simulator 2000**.

-or-

Double-click the **Flight Simulator 2000** icon on the Windows desktop.

Note: You'll always need to have *Flight Simulator 2000 Disc 1* in the drive when you start Flight Simulator 2000.

When you start Flight Simulator 2000, you'll see the opening screen, from which you can select one of the following options:

- **Getting Started:** Watch an introductory video, produced by King Schools, that explains how to get into the air quickly.
- **What's New:** Learn about the new features that make Flight Simulator 2000 "As Real As It Gets."
- **Flying Lessons:** Start with an Intro Flight, just like you would in the real world. Continue with lessons linked to the Tutorials in Chapter 7 of this *Pilot's Handbook*. You'll be amazed at how much you'll learn—and how much fun you'll have!
- **Fly Now!:** Hop into the cockpit and start flying. When you first start Flight Simulator, you'll be flying the Cessna 182S out of Meigs Field in Chicago. Later, you can change the "default flight" to any airplane and flight conditions you want.

Setting Up and Using Joysticks and Other Game Controllers

Flight Simulator 2000 is more realistic when you use a joystick, yoke, or other controller. You can fly more precisely, and the buttons and controls make it easy to change views, adjust the throttle, extend or retract the landing gear and flaps, and operate other aircraft controls.

Flight Simulator 2000 is compatible with joysticks, yokes, gamepads, and other controllers supported by Microsoft Windows and DirectInput®. Use the device that works best for you as your primary control; it can be customized to suit your needs. Different products have different configurations, so refer to your controller's documentation for its button assignments.

Before you fly, make sure your joystick or other controller is:

- plugged into your computer
- set up in Microsoft Windows
- calibrated properly
- enabled in Flight Simulator 2000 (on the **Options** menu, point to **Controls**, and click **Enable Joystick**)

Also make sure you have the latest device drivers. If in doubt, download and install them from the manufacturer's Web site.

For more information about setting up and using game controllers, see the **Simulator Help** section of onscreen Help.



John and Martha King, King Schools

“Clarify, Simplify, and Make it Fun!” That’s the mission of King Schools, founded by John and Martha King. King Schools has been providing aviation software and video instructional materials for over 17 years. Nearly one-third of all pilots in the United States have used King Schools courses to attain their licenses.

John and Martha have the distinction of being the first husband and wife team (and Martha, the first woman) to have every possible category rating, class rating, and instructor’s certificate offered by the FAA. They made their mark by developing learning materials that express their enthusiasm and share it with others. Click the **Getting Started** button on the opening screen to see a short video in which the Kings explain how to get up and flying in Flight Simulator.

Using the Mouse

As you fly, you can use the mouse to manipulate the buttons, knobs, and levers in the cockpit. Just click the appropriate control. Some controls are toggles (for example, clicking the landing gear lever once retracts the wheels; clicking it again extends them). Other controls, such as the throttle and trim wheel, move through a series of positions. You can drag these controls with the mouse, much as you would move them with your hand in a real airplane.

If you don't own a joystick, yoke, or gamepad, you can also use the mouse as the primary flight control. Right-click anywhere on the aircraft instrument panel and choose **Mouse as Yoke** from the menu that appears. Any movement you make with the mouse controls the aircraft just like a joystick would. (Moving the mouse to the left makes the aircraft bank left, and so on.) To return to using the mouse to manipulate cockpit controls, right-click on the panel again.

Using the Keyboard

The keyboard is often the best way to view and operate certain aircraft controls and to choose commands and options. By learning which keys do what you can be more efficient in the Flight Simulator cockpit. And although it's best to use a joystick or yoke as the primary flight control, you *can* fly the aircraft by using the keyboard to control the ailerons, elevator, and rudder.

The Key Commands tab on the Kneeboard in Flight Simulator (press **F10** to display the Kneeboard) features a list of the basic keyboard



commands you'll need. The same information is on the back cover of this book. The complete list of commands is in the **Simulator Help** section of Help.

Customizing the Controls

In real aircraft, each button, lever, or knob serves a specific function. In Flight Simulator, you can customize the joystick and keyboard commands so that your simulated cockpit works the way you like best. For example, you could reassign the key used to extend and retract the landing gear from the **G** key to another. On the **Options** menu, point to **Controls**, and click **Assignments**. To adjust how sensitive your joystick is, on the **Options** menu, point to **Controls**, then click **Sensitivities**.

Note: For assistance with any Flight Simulator 2000 dialog box, click the **?** button, or right-click any item and choose **What's This?**

Making Flight Simulator 2000 Really Fly

When talking about a flight simulation's graphics, *quality* refers to how real the images look on the screen, and *performance* refers to how quickly and smoothly the images move. Higher quality typically means decreased performance, since displaying complex, richly-detailed, three-dimensional graphics puts a heavy load on your system. If you're not seeing the graphics quality and performance you expect, this section explains some choices and tradeoffs you can make to optimize your experience.

Improving both quality and performance

To achieve maximum quality and performance, consider the following options:

✓ Shut down other applications

When you're flying, you probably won't be using other applications such as word processors and email programs, so close them to free up more of your computer's brainpower for Flight Simulator.

✓ Get a 3-D graphics accelerator card

To display Flight Simulator graphics, your computer must convert a three-dimensional world into a two-dimensional image. A 3-D graphics accelerator makes this task easier, by taking some of the burden away from the main processor. This leaves the main processor more resources to handle the simulation's flight model. The result? Better performance and graphics quality.

If you have a 3-D card, make sure you:

- set the display options in Flight Simulator to take full advantage of it (see "Change display options," later in this chapter)
- download and install the latest drivers from the manufacturer's Web site

If you have problems getting your 3-D card to work properly, make sure you've read the Flight Simulator 2000 Readme file and the card manufacturer's documentation.

✓ Get more RAM

Random access memory (RAM) is your computer's short-term memory. Generally, the more of it there is, the faster your computer's brain (the CPU) can process data. Your computer needs to have *at least* 32 megabytes (MB) of RAM to run Flight Simulator 2000.

✓ Get a faster processor

Although Flight Simulator 2000 will run on a Pentium 166 machine, a faster processor will provide better performance.

Making a tradeoff between quality and performance

Choosing between quality and performance depends on what you want to do. If you want to spend an evening reading signs and billboards as you fly the Bell 206B JetRanger III helicopter down the glittering streets of Las Vegas, then you're probably willing to sacrifice a little performance for a better view. If, however, you want to test your instrument flying skills by guiding the Concorde into Heathrow in a storm, then smooth movement of the aircraft and the instruments will take precedence over scenery details. No matter what kind of hardware you have, you can make tradeoffs between graphics quality and performance.

Try the following options to find the balance between quality and performance that's right for your needs.

✓ Watch your windows

Flight Simulator runs in a window. The simulation's views and instrument panels are also

windows. Increasing the size of windows and displaying multiple windows simultaneously decreases performance, so use as few windows as possible and keep them as small as you can (with the exception of Full Screen mode, described below).

✓ **Change the resolution**

Depending on the type of video card and monitor you have, you can run Flight Simulator 2000 at a variety of screen resolutions. The instrument panels were optimized for readability in 640 x 480 and 1024 x 768 screen resolutions. A screen resolution of 1024 x 768 will provide the best overall graphics quality. Note though that as you increase resolution to see more detail, you may notice a decrease in performance. Experiment with different resolutions to find the best combination of detail and performance for your system. For more information about adjusting the screen resolution on your computer, on the Windows **Start** menu, click **Help**, and look up “resolution.”

✓ **Use Full Screen mode**

Full Screen mode makes the Flight Simulator window fill the entire screen (no menu bar or taskbar) and will likely improve performance. To toggle between Full Screen and Normal modes, press **ALT+ENTER**, or on the **Views** menu select or deselect **Full Screen**. To bring up the menu bar while in Full Screen mode, press **ALT**. To set the resolution used in Full Screen mode, click the **Options** menu, point to **Settings**, and click **Display**.

✓ **Change display options**

One way to improve performance is to change the display options in Flight Simulator. Each option has a different effect, and changes you make apply to all flights. Turning an option on or off is

noticeable only when you see an effect related to that option on the screen. For example, reducing the scenery complexity won't have much effect if you're flying in the clouds.

To change display options, click the **Options** menu, point to **Settings**, and click **Display**.

✓ **Change sound preferences**

Depending on your machine, changing sound preferences (or turning sound off) may improve performance. To change sound options, on the **Options** menu, point to **Settings**, and click **Sound**.

✓ **Change visibility and other weather settings**

Generally speaking, the less scenery you see out of the window, the better the performance will be. Reducing visibility is a simple way to improve performance. On the **World** menu, click **Weather**.

✓ **Monitor the frame rate**

Monitoring the *frame rate* (the number of times the screen is redrawn each second) is an easy way to assess Flight Simulator's performance. Press **SHIFT+Z** twice to display the frame rate counter. When you try the options listed above, check the frame rate to see whether it has improved. Remember though: it's how the simulation looks and feels to you that matters most.

✓ **Experiment**

The best way to make Flight Simulator really fly on your machine is to experiment. Change something, then see if things look or feel any different. Read the Readme file in the Flight Simulator directory on your hard drive for additional tips.



Finding Information

chapter two

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Let's face it, flying is a complex endeavor. The information and assistance provided with Microsoft® Flight Simulator 2000 let you spend more time doing what you want—flying—and less time searching for the information you need to do it. This chapter helps you find the information you're looking for.

Pilot's Handbook

This *Pilot's Handbook* gives you an overview of Flight Simulator 2000 and suggests ways you can

use it to learn about aviation, practice what you already know, or just have fun. Interspersed with information about getting up and running, learning to fly, and using the simulator, are interesting facts about aviation history. Think of the *Pilot's Handbook* as the view from 30,000 feet; if you need detailed procedures and specifications, use Flight Simulator Help.

Flight Simulator Help

Want to learn about Flight Simulator commands and techniques? Aviation? The Flight Simulator 2000 aircraft? Aviation terminology? Look in Flight Simulator Help, which you can access from the **Help** menu.

Just like surfing the Web with a browser, you can move from topic to topic using the navigation bar at the top of the Help screen or by clicking "hot" text. Flight Simulator Help is divided into four sections: Simulator Help, Aviation Articles, Aircraft Information, and Glossary.

Simulator Help	Want to choose another airplane, add some turbulence, or figure out what all those gauges in the cockpit are for? To learn about Flight Simulator 2000 menus, screens, buttons, knobs, and levers, check out Simulator Help for step-by-step procedures.
Aviation Articles	Want to learn more about aviation? Aviation Articles explain subjects from the basics of flight to complex aerobatic maneuvers. The Aircraft Owners and Pilot's Association (AOPA) contributed many of the articles, which are of interest to novices and real-world pilots alike. Videos and animations help explain it all.
Aircraft Information	Looking for data about the aircraft in the Flight Simulator 2000 fleet? The Aircraft Information section provides statistics, cockpit diagrams, and more.
Glossary	Not sure what an unfamiliar aviation or Flight Simulator term means? Look in the comprehensive Glossary .

Help While You're Flying

When you're on final approach to a short runway, the last thing you want to do is stop everything and go searching for that keyboard command to


lower the flaps. Use the onscreen assistance described below to get the information you need exactly when you need it.

<p>The Kneeboard</p>	<p>Many real-world pilots use a "kneeboard" to hold reference material they need during a flight. In some cases, the kneeboard is literally strapped to the pilot's thigh for easy access. The Flight Simulator 2000 "kneeboard" is accessible from the Aircraft menu or by pressing F10. It has four tabs:</p> <ul style="list-style-type: none"> ▪ Key Commands: A list of the most important Flight Simulator 2000 keyboard commands. ▪ Checklists: A series of checklists for the aircraft you're currently flying, one checklist for each phase of flight. ▪ Reference: Useful aircraft-specific data, such as performance tables. ▪ Notes: Notes you write yourself. <p>Each tab of the kneeboard is customizable. For more information, see Simulator Help, described on page 8.</p>
<p>Instrument Panel Labels</p>	<p>To learn the name of an instrument or control in the cockpit, just hold the mouse pointer over the item—a label will appear.</p>
<p>"What's This?" Help</p>	<p>To learn more about any item in the cockpit, right-click it and choose What's This? from the pop-up menu that appears.</p>

Help in Dialog Boxes

You'll use dialog boxes to set options such as flight location, weather, and aircraft settings. Use Help to get information about any item in a dialog

box or step-by-step assistance for everything from choosing an aircraft to using the Global Positioning System (GPS).

<p>Screen Labels</p>	<p>Hold the mouse pointer over any item in a dialog box, and a short, descriptive name appears.</p>
<p>"What's This?" Help</p>	<p>To learn more about any item in a dialog box, right-click it and choose What's This? from the pop-up menu that appears.</p>
<p> Button</p>	<p>Click the ? button in any dialog box to see a Help topic that explains how and why to use the screen.</p>



Further Information and Assistance

The Flight Simulator 2000 Web site contains news, tips, articles, reference material, and links to other interesting simulation and aviation sites. You can connect to the Flight Simulator 2000 Web site from the **Help** menu, or type the following URL into your Web browser:

<http://www.microsoft.com/games/fsim>

The Flight Simulator 2000 Readme file contains late-breaking information about Flight Simulator. It's a good idea to read the Readme file to check for any known compatibility problems with hardware you're using. You can find the Readme file in the Flight Simulator folder on your hard drive.

If you're having problems running Flight Simulator 2000, you can obtain product support by using the services described in Appendix D, "Microsoft Product Support Services."

Exploring the Features

chapter three

3



In many ways, Microsoft® Flight Simulator 2000 is even better than reality—with just a few clicks of the mouse, you can instantly change your aircraft, location, and the weather. In this chapter, we'll take a look at these options and many other features you should know about.

To learn more about all these features, see the **Simulator Help** section of the onscreen Help. For an overview of any dialog box, click the **?** button at the bottom of the dialog box. For an explanation of a specific item, right-click it and choose **What's This?** from the pop-up menu that appears.

Aircraft

When you start Flight Simulator, by default you'll be flying the Cessna Skylane 182S. Whether you're on the ground or in the air, you can easily switch to another aircraft or change options that affect the aircraft you're flying.

Feature	Description	Command
Select Aircraft	See pictures, descriptions, and specifications for each aircraft in the Flight Simulator 2000 fleet, and select the one you want to fly.	On the Aircraft menu, click Select Aircraft .
Fuel	Change the amount of fuel in each tank to change your aircraft's weight, performance, and range.	On the Aircraft menu, click Fuel .
Realism Settings	Quickly set the realism of your Flight Simulator 2000 experience using sliders, or manually select specific realism options that affect: <ul style="list-style-type: none"> ▪ the aircraft's flight characteristics ▪ the instruments and lights ▪ the engines and propeller ▪ crashes and damage ▪ the flight controls 	On the Aircraft menu, click Realism Settings .
System Failures	Set failures for instruments, systems, and radios (either randomly or for a specific instrument) to make your Flight Simulator 2000 flights more realistic and challenging.	On the Aircraft menu, click System Failures .

Views and Windows

You can use the features on the **Views** menu to see the things you'd see from the cockpit of a real airplane—and more. Different views serve different purposes—experiment with them to find your favorites. Use your joystick's *hat switch* (or use key commands) to “turn your head” within a view.

To learn more about using views and windows, see the **Simulator Help** section of Help. For a list of view-related key commands, see the back cover of this book. You can easily assign your favorite views to joystick buttons or your own custom key commands.

Feature	Description	Command
Cockpit View	See the world as a pilot usually does, over the instrument panel. This is the default view.	On the Views menu, point to View Mode , and then click Cockpit . Or, press S to cycle through Cockpit, Tower, Track, and Spot Plane views.
Tower View	See yourself from the control tower window.	On the Views menu, point to View Mode , and then click Tower . Or, press S to cycle through Cockpit, Tower, Track, and Spot Plane views.
Track View	Track another aircraft from your cockpit. <i>Available only in multiplayer flight.</i>	On the Views menu, point to View Mode , and then click Track . Or, press S to cycle through Cockpit, Tower, Track, and Spot Plane views.
Spot Plane View	Watch your aircraft from a spot plane that you can reposition.	On the Views menu, point to View Mode , and then click Spot Plane . Or, press S to cycle through Cockpit, Tower, Track, and Spot Plane views. To jump to Spot Plane view directly from Cockpit view, press Shift+S .
Top-down View	A bird's eye view of the earth beneath your aircraft.	On the Views menu, point to View Mode , and then click Top-down .
Secondary Instrument Panel Components	Display secondary instrument panel windows to view radios, GPS, throttle quadrants, and other cockpit items.	On the Views menu, point to Instrument Panel , then click one of the panel components to display it.

Flight Planning and Navigation

Flight Simulator 2000 starts with your Cessna 182S on the ground at the end of runway 36 at Merrill C. Meigs Field in Chicago. After you get to know your way around the city, you'll probably want to try flying somewhere else. You can

instantly reposition your aircraft to a new location on the ground or in the air, or plan an entire flight. Flight Simulator 2000 has many new features that simplify flight planning and navigation.

Feature	Description	Command
Go to Airport	Position your aircraft on a specific runway at any of more than 20,000 airports. If you don't know an airport's name or alphanumeric identifier, you can search for it by geographical area.	On the World menu, click Go To Airport .
Map View	Look at airports, navigational aids, airways, airspace, general geographical information, and the course you've been flying. You can enter your desired latitude, longitude, altitude, heading, and airspeed, or drag the aircraft symbol across the map to reposition it. Clicking on airports and navigational aids displays information about them.	On the World menu, click Map View .
GPS (Moving Map)	Navigate the modern way, directly from waypoint (a point of reference along your route) to waypoint, using a Global Positioning System (GPS) receiver displayed in its own window.	On the Views menu, point to Instrument Panel , then click GPS .
Flight Planner	Create or load a VFR or IFR flight plan. Define your own route or select auto-routing via: <ul style="list-style-type: none"> ▪ direct GPS ▪ low altitude airways ▪ high altitude airways ▪ VOR to VOR 	On the Flights menu, click Flight Planner .
Navigation Log	View the details of your flight plan. Information provided for each leg includes: <ul style="list-style-type: none"> ▪ altitude ▪ true airspeed ▪ magnetic heading ▪ estimated groundspeed ▪ fuel consumption ▪ time en route 	On the Flights menu, click Navigation Log .
Slew Control	Rapidly change your aircraft's attitude, location, or altitude without actually flying in real time. A great way to check out the scenery.	Press Y . Or, on the Aircraft menu, click Slew Control .

Weather

From a clear blue sky to one filled with clouds, wind, turbulence, rain, freezing rain, hail, snow, lightning, and thunderstorms, Flight Simulator 2000 gives you as much control over the weather conditions as you want. For the ultimate in

realism, you can download the latest real-world weather provided by Jeppesen DataPlan, and have those conditions automatically recreated in Flight Simulator.

Feature	Description	Command
Real-World Weather	Download the current real-world weather conditions and forecast winds aloft for thousands of weather reporting stations. Flight Simulator automatically connects your computer to a server on the MSN™ Gaming Zone, downloads the real-world conditions, and then recreates them in Flight Simulator.	On the World menu, click Weather , and then click the Real-World Weather button.
Basic Weather	Set general levels for clouds, precipitation, visibility, and the wind's strength and direction. You can set weather for the entire Flight Simulator 2000 world, or for individual reporting stations as displayed on a map.	On the World menu, click Weather .
Advanced Weather	Gain even more control over the weather you fly through. You can define individual layers of weather, each with its own: <ul style="list-style-type: none">▪ cloud type and coverage▪ icing and precipitation▪ wind speeds, gusts, turbulence, and shear strength▪ temperature, dew point, and pressure▪ visibility	On the World menu, click Weather , then click the Advanced Weather button.

Videos and Logging

While real-world pilots have to carry cameras and journals to memorialize their flights, in Flight

Simulator 2000 you can track your flight time and review your performance automatically.

Feature	Description	Command
Flight Video	Record "videos" of your flights to impress your friends.	On the Options menu, click Flight Video .
Instant Replay	Replay the last portion of flight at any time and watch the drama unfold at any speed and from any view.	On the Options menu, click Instant Replay .
Logbook	Track your Flight Simulator flight time, either automatically or manually.	On the Options menu, click Logbook .
Flight Photograph	Take an aerial snapshot for your electronic "scrapbook."	Press the PRINT SCREEN key on your keyboard and then paste the image into any graphics program.

Simulator Settings

Some Flight Simulator settings are maintained from one session to another. Here are some of the most useful. For complete documentation of every

menu item and dialog box, see the **Simulator Help** section of the onscreen Help.

Feature	Description	Command
Control Assignments/ Sensitivities	Customize which keys and joystick buttons do what, and how your joystick behaves.	On the Options menu, point to Controls , then click Assignments or Sensitivities .
General Settings	Change the default Flight and other general settings.	On the Options menu, point to Settings , then click General .
Display Settings	Configure Flight Simulator to effectively use your video card and choose display options that make tradeoffs between graphics quality and performance.	On the Options menu, point to Settings , then click Display .
Instrument Settings	Change whether the airspeed indicator shows <i>indicated</i> or <i>true</i> airspeed, and how radio frequencies are displayed.	On the Options menu, point to Settings , then click Instrument .
International Settings	Define the units of measurement used in various features.	On the Options menu, point to Settings , then click International .
Sound Settings	Change the volume of individual sounds.	On the Options menu, point to Settings , then click Sound .

A high-wing aircraft is shown in flight, viewed from a low angle. The aircraft's wingspan is wide, and it has a single engine mounted on the fuselage. The background consists of a bright sky with scattered white clouds and a green field below. The overall image has a light, airy feel.

Having Some Fun

4
chapter four

For fledgling and veteran Flight Simulator pilots alike, there are many fun and challenging activities available. Not only can you learn to fly with the help of expert instructor Rod Machado, but you can extend that passion for flight by completing the curriculum for Flight Simulator pilot certificates and ratings. If you just want to get in the cockpit and get off the ground, you can

visit interesting destinations, view spectacular scenery, fly a new plane or helicopter, or even fly with friends. There are numerous possibilities, whatever your skill level.

The following table offers some ideas for having fun with Microsoft® Flight Simulator 2000.

Type of Activity	Description
Learn to Fly and Get Certified	Study the Tutorials created by expert flight instructor Rod Machado, and then fly the Lessons and Checkrides to earn Flight Simulator certificates and ratings.
Take a Fun Flight	Choose from a variety of interesting flights in locations throughout the world.
Check Out Cool Scenery	Visit cities around the world that feature highly detailed landmarks and scenery.
Have an Adventure	Keep the seatbelt tight while flying one of the many heart-pounding Adventures.
Create a Flight	Use the Flight Planner to customize a flight of your own by selecting the aircraft, weather, and airports for your flight.
Fly a Sailplane	Challenge yourself to stay aloft in a sailplane. Practice thermal and ridge soaring at some great sailplane locations.
Fly a Helicopter	Try flying a helicopter. You'll have to stay busy just to keep it upright.
Make a Movie	Turn on the video recorder and make a movie of one of your flights. Then, sit back and watch yourself in action.
Perform Aerobatics	Learn from aerobatic champion Patty Wagstaff, who'll show you how to perform loops and rolls in the small, maneuverable Extra 300S.
Fly with Other Pilots Online	Challenge your Flight Simulator comrades to air races and demonstrations of flying prowess.
Take Flight Simulator to the Limit	Take it to the limit by flying upside down or backwards. You can also give "deadsticking" a try.

Learn to Fly and Get Certified

If you picked up your copy of Flight Simulator because you want to learn the basics of how airplanes fly or how to navigate and understand the flight instruments, then you've come to the right place. In "Learning to Fly with Rod Machado" later in this book, expert flight instructor Rod Machado provides a series of tutorials to get you off the ground and back again. Want to find out if you've got the mettle to earn a Flight Simulator Private Pilot Certificate? In "Getting Certified" later in this book, you'll find a complete curriculum for achieving Flight Simulator pilot certificates and ratings that parallel real-world pilot certificates.

Note that while Flight Simulator is a great *complement* to flight training, it's not a substitute for instruction from a Certified Flight Instructor and is not part of an approved training program under the standards of the FAA or any other regulatory authority.

Take a Fun Flight

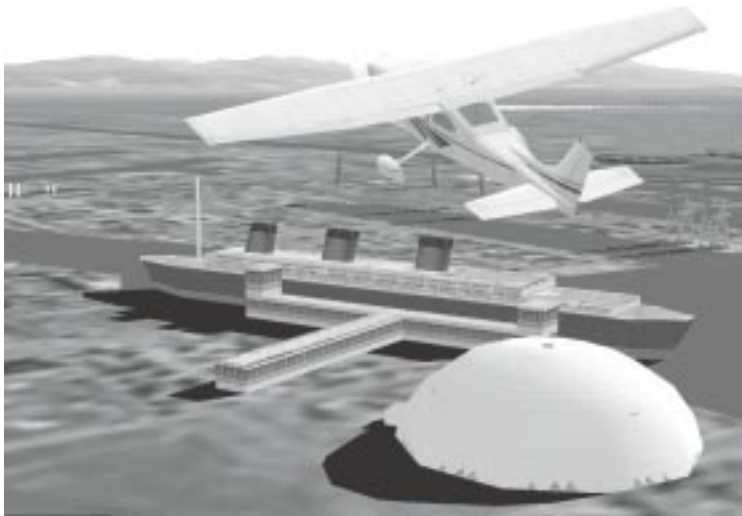
Choose **Select Flight** from the **Flights** menu to choose one of many intriguing flying situations we've provided for you. The flights in the list take place in many different locations and aircraft, and often start with you already in the air. Fly past the 1983 eruption of Kilauea, or fly through Athens, Greece, past the Acropolis. As you do your fly-by, take a quick look to your right at the Olympic Stadium, site of the first modern Olympic games.



The options don't end there. You can take a flight over Beijing—past the Forbidden City and Tiananmen Square. Or, try the canyon approach to Hoover Dam and fly as close as you dare to the canyon bottom—but don't forget to pull up when you get to the dam! Fly your way through situations in many of the major cities of the world, including Rome, Las Vegas, Tokyo, London, Chicago, Paris, and New York. The sky's the limit!

Aviation Wisdom

Don't run out of airspeed, ideas, and altitude all at the same time.



Check out Cool Scenery

Flight Simulator 2000 includes more detailed scenery than any previous version. In many of the world's greatest cities you'll find new scenery objects such as buildings, antennas, towers, unique skyscrapers, stadiums, and other famous landmarks.

Detailed Scenery in Six Cities Worldwide

Scenic flights are a great way to get started with Flight Simulator. Just hop into the airplane of your choice and fly around the cities with the most detailed scenery. We've included a few sightseeing suggestions along with coordinates to enter into the Map View dialog box.

The United States cities featuring great detail include New York, Los Angeles, San Francisco, and Chicago. In New York City, try circling the World Trade Center, the Statue of Liberty, or Yankee Stadium. Ever wonder what the La Brea tar pits look like from the air, or what the RMS Queen Mary looks like? Just enter the coordinates in your GPS or take off from Los Angeles International or Whiteman Airport and take a look.

To start your sightseeing in Europe, check out famous landmarks in Paris: the Arc de Triomphe and Jardin de Tuileries, found at either end of the Avenue des Champs Élysées. Or in London, tip a wing to the Houses of Parliament and Big Ben, the Tower of London, and the Tower Bridge. Flight Simulator opens up a world of sightseeing options for you.

Pilot-speak

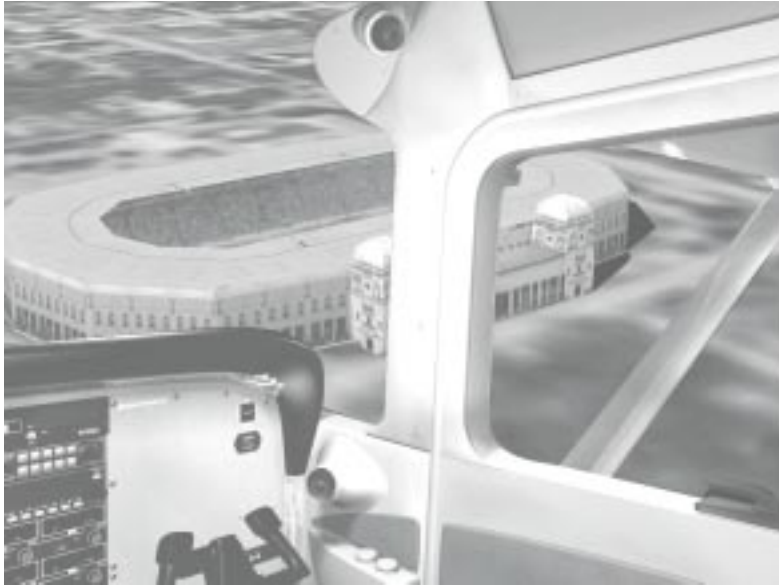
\$100 hamburger: Why go to your local burger shop when you can fly to another airport and get one there? Any excuse to fly!

The following table lists coordinates for the landmarks mentioned in this section.

Note: The syntax for entering coordinates in the

Map View dialog box in Flight Simulator 2000 may be different than the way they're depicted in the table. Follow the examples shown in the dialog box.

Landmark	City	Coordinates
World Trade Center	New York City	40° 42' N, 74° 00' W
Statue of Liberty	New York City	40° 41' N, 74° 02' W
Yankee Stadium	New York City	40° 49' N, 73° 55' W
La Brea Tar Pits	Los Angeles	34° 03' N, 118° 21' W
RMS Queen Mary	Los Angeles	33° 45' N, 118° 11' W
Arc de Triomphe	Paris	48° 52' N, 2° 17' E
Jardin des Tuileries	Paris	48° 51' N, 2° 19' E
Houses of Parliament	London	51° 29' N, 0° 07' W
Tower of London	London	51° 30' N, 0° 04' W



Create a Flight

You can also create your own customized flights in the Flight Planner. Choose an aircraft, departure and destination airports, the date and time, weather, and so on, and you're ready for takeoff. You can also use auto-routing or GPS, and Flight Simulator will find a route for you. Nearly every detail of a flight can be determined ahead of time. You can even download real-time weather. The following is an example of a flight you might create.

Have an Adventure

When you're ready for a flight complete with instructions from air traffic control (ATC) and even some help from a copilot, try flying one of the many Adventures. Flight Simulator 2000 offers new Adventures that test your skills in a variety of aircraft and take you to interesting places. Adventures aren't just guided tours: fly in under the radar to land in Red Square; beat the clock in a helicopter by landing in three different locations in a set amount of time; or land your Cessna on an aircraft carrier off the coast of San Francisco after you experience an engine failure.

Fly Over Wembley Stadium

Perhaps you've always lived and breathed soccer and rather than join the fans down below, you decide to fly over Wembley Stadium in London, England, home of the Football Association (FA) Cup soccer finals. In the Flight Planner, start by choosing an aircraft, such as the Cessna Skylane 182S. Next, look up airports in the London area. For example, you can take off from Roberts airport. Set the date for game day, and plan a departure time of around noon so that you have plenty of time to make the kickoff. Finally, set the weather as clear skies with a light wind, so you'll be able to see the match! Actually, you won't be able to see the match, but you certainly will have the best seat in the house.

Fly a Sailplane

In Flight Simulator you can fly an aircraft that doesn't have an engine. Try soaring in the Schweizer 2-32 sailplane and experience what it's like to be whisked away by the wind. Actually, it's not as easy as it sounds. The Schweizer 2-32 is an aerobatic sailplane that offers easy handling characteristics and good performance, but you still need to know where to find lift and how to use it to your advantage.

For more details about flying a sailplane, see the **Aviation Articles** and **Aircraft Information** sections in Help.

Fly a Helicopter

Another exciting challenge in Flight Simulator is flying the Bell 206B JetRanger III. Helicopter flying demands small, smooth control inputs. Unlike airplanes, helicopters are inherently unstable. The key to understanding helicopter aerodynamics is



Aviation History

June 26, 1936. First successful helicopter flight.

remembering that a helicopter's main rotor system is its "wings." Because the rotors are airfoils, they produce lift much like an airplane's wings, and they react to changes in angle of attack and stall just like a wing. Abrupt or large movements of the controls quickly lead to ever-larger oscillations that can rapidly escalate to complete loss of control, so take it slow and easy. You can learn more about flying the JetRanger in the **Aviation Articles** and **Aircraft Information** sections of the onscreen Help.

Make a Movie

Another fun thing to do in Flight Simulator is to make a movie of yourself flying. For example, turn on the Smoke System, and then the Flight Video. Let the film run while you take off and fly in and around Paris or any of the other highly detailed cities. When you're done, save the flight video and play it back. Change the view to Spot Plane while you sit back and watch yourself in flight. Look in **Simulator Help** for additional instructions.

Perform Aerobatics

When you're ready to try something more daring, take a shot at aerobatics. Flying aerobatic maneuvers gets your head out of the clouds real fast. Aerobatic maneuvers you can attempt include the loop, aileron roll, hammerhead, and Cuban Eight. Further test your skill by trying an Immelmann, a Split-S, or some spins. Enhance the experience by turning on the Smoke System and Flight Video so you can play back your flight and see yourself performing the maneuvers.



Descriptions of each maneuver are available in the **Aviation Articles** section of Help and highlight the abilities of Patty Wagstaff, a three-time U.S. National Aerobatic Champion and world-class air show pilot. Wagstaff performs the maneuvers in her Extra 300S, the same airplane you can choose to fly in Flight Simulator.

Background topics and videos about aerobatics are also available in the **Aviation Articles** section of Help.

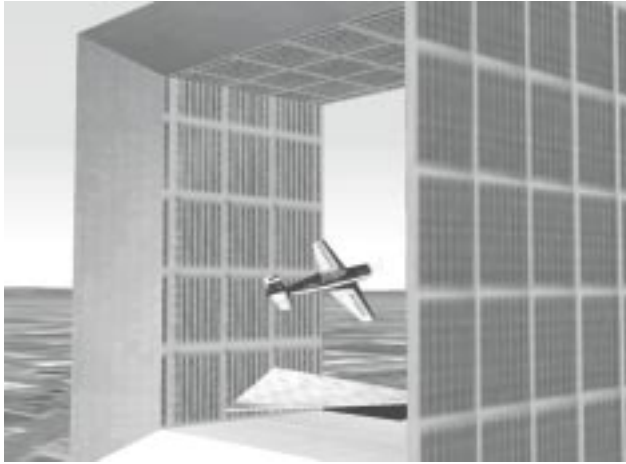
Fly with Other Pilots Online

Time to fly with some Flight Simulator buddies? In Flight Simulator 2000 you can enjoy formation flights, aerobatic competitions, and similar activities with other Flight Simulator pilots. An ideal place to try this is on the MSN™ Gaming Zone (<http://zone.msn.com>). A multiplayer session can host up to eight Flight Simulator aircraft at the same time. You can also join a session as an observer, which can be a helpful learning tool.

There are a number of multiplayer activities to help you learn or just have some fun. For instance, you and your fellow pilots can take turns being the flight instructor, directing the flight and determining the altitudes and headings to use. Or, play follow-the-leader as one of you dives or climbs away from the pack. Make the game more interesting by choosing San Francisco or another highly detailed city as your training ground. You can also fly in helicopters and play hide and seek using the skyscrapers to hide from view. If you want to turn a chase into a real competition, set up air races from one location to another. Time yourselves from takeoff to landing and see who's got the time to beat.

For more details about how to set up your multiplayer connection, see the **Simulator Help** section of Help.

“Mayday” is an English spelling of the latter part of the French phrase *venez m’aider*, “come help me.”



Take Flight Simulator to the Limit

In addition to the real-world-oriented activities you can perform in Flight Simulator, there are a variety of fun things to do that don't resemble anything a pilot should try in the real world.

Since it's a simulator and there's no risk of injury, try using the following activities to push Flight Simulator to the limit:

- **Fly Inverted:** Flying inverted (upside down) is not a typical activity in most airplanes unless you are practicing aerobatics, but it's a fun thing to do in Flight Simulator. Try any of the flights in the Flights list, but do them upside down. Or, how about weaving your way through Paris or one of the other highly-detailed cities upside down in the very maneuverable Extra 300S!
- **Fly Backwards:** In the **Weather** dialog box, set the wind to be greater than the regular cruising speed of the aircraft you're flying. Once you're in the air, observe yourself actually flying backwards. Good luck trying to land!

- **Try Deadsticking:** Deadsticking is landing without engine power. You can simulate this by cutting the engine. This is good practice for an actual engine failure. To make it even tougher, try deadsticking above a city such as New York City and putting it down in an open area, such as Central Park. Or, for a more serious challenge, try deadsticking an ILS (instrument landing system) approach.
- **Fly a "Zero-Zero" Approach:** Set the weather for zero visibility and a zero-foot ceiling, and then try to follow an ILS approach all the way to the runway ... without the autopilot.

Aviation Wisdom

The three most useless things in aviation:

- (1) altitude above you;
- (2) runway behind you;
- (3) fuel back at the airport.

Flight Simulator 2000 opens up a world of flying to beginners as well as experts. Whether you just want to get a sense of what flying an airplane might be like, or you're a serious student of flight and want to work on and perfect your piloting skills, Flight Simulator 2000 has a lot to offer. So, get into the cockpit and give it a try, but don't forget to have some fun along the way!



Aircraft Owners and Pilots Association

With 350,000 members—56% of all pilots in the United States—AOPA (the largest, most influential aviation association in the world) represents pilots of all levels from Student to Commercial pilot and aircraft owner. AOPA's mission is to make flying more productive, safe, affordable, and fun. It provides a wealth of services to pilots, represents the interests of General Aviation before government agencies and Congress, and offers continuing pilot education through its AOPA Air Safety Foundation.

AOPA helps members stay up-to-date on aviation news, regulatory and technical developments, and new information to increase the productivity and fun of flying. Its toll-free hotline answers technical questions, offers advice on flight training and aircraft purchase, and provides flight planning assistance.

AOPA's award-winning Web site offers up-to-the-minute aviation news; a comprehensive airport directory; feature articles and photos from *AOPA PILOT* and *AOPA Flight Training* magazines; real-time aviation weather, radar, and satellite images; the latest FAA rules, reports, and policies; and a flight planning service. In addition, some 30,000 pages of information and a library of databases make AOPA Online a virtual aviation encyclopedia!



You'll find many articles from *AOPA PILOT* (General Aviation's biggest and best magazine) and *AOPA Flight Training* magazine (the leading publication for prospective new pilots, flight students, and flight instructors) throughout the Flight Simulator 2000 Help system.

To take the next step to becoming a pilot in the real world, visit AOPA's Web site specially designed for Microsoft Flight Simulator users at <http://www.aopaflighttraining.org>.

Expanding Your Hobby



5
chapter five

If you can't get enough of Microsoft® Flight Simulator 2000, you're not alone. The Flight Simulator community includes thousands of individuals, organizations, and companies that share your passion for aviation, both real and simulated. When you're ready to make your hours in the Flight Simulator cockpit even more rewarding, explore some of the suggestions in this chapter.



The Flight Simulator 2000 Web Site

The Flight Simulator Web site is the best place to start browsing for Flight Simulator-related information and products. You'll find:

- news
- tips
- articles
- reference material
- downloadable add-ons
- links to interesting and useful Flight Simulator sites all over the world

In short, it's the first place to turn for *anything* Flight Simulator-related. Start surfing by clicking **Flight Simulator on the Web** on the **Help** menu in Flight Simulator. Or, open your browser and go to www.microsoft.com/games/fsim.

Virtual Airlines

If you've always wondered what it would be like to be an airline pilot, join a virtual airline and find

out! Virtual airlines provide a structured environment in which to conduct your Flight Simulator flights. There are dozens of virtual airlines in operation today on the Web, and usually becoming a pilot for one of them is simply a matter of signing up. Each airline has its own style and emphasis: some specialize in cargo operations, some fly passengers. From continent-spanning majors flying the latest glass-cockpit jets, to island-hopping charter operators flying beat-up old bush planes, there's a virtual airline for everyone.

Once on board, you'll download the airline's aircraft, scenery, and training materials, then use Flight Simulator to complete the assigned flights. You'll send reports of your flights back to the airline and work your way through different ratings, aircraft, and routes.

Participating in most virtual airlines is free; some charge a small fee for the experience. The virtual airline community on the Web is growing rapidly. There are new airlines every day, and a number of organizations are taking leadership roles within

the community—providing enthusiasts with news, airline directories, and bulletin boards.

Add-Ons

Amateur and professional software developers all over the world have created products that can enhance your Flight Simulator experience. Check the shelves of your local computer store, and be sure to look on the Web (many downloadable add-ons are freeware or shareware). Add-ons are usually easy to install and fun to use.

If you like flying a variety of aircraft, there are literally thousands to choose from. There are also add-on avionics packages that simulate the latest display and navigation technology, and specialized scenery areas that make the simulated world even more realistic. If you like air traffic control, there are a number of products that add simulated radio communications to your Flight Simulator flights. A few even enable Flight Simulator pilots to fly together in a radar-controlled environment over the Internet—with

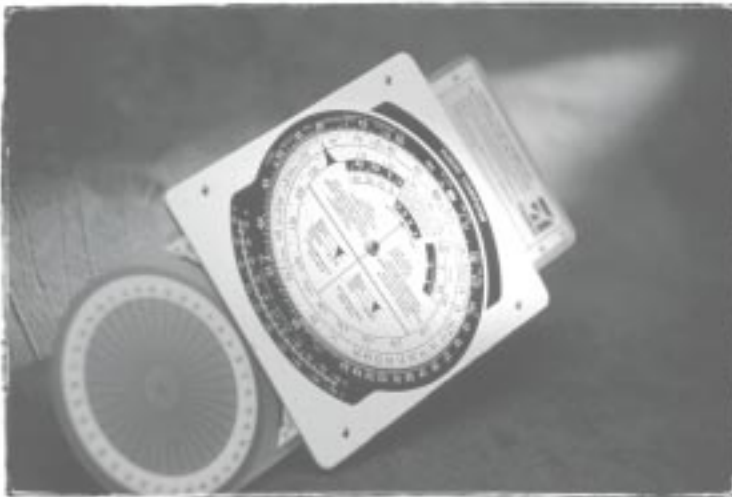
real people acting as the air traffic controllers. Create your own add-ons with utilities such as aircraft, panel, scenery, and adventure builders.

Your Desktop Cockpit

If you want to make your desktop seem more like the cockpit of a real airplane, add some hardware. The options range from full desktop consoles with working switches down to the basics described here: a joystick or a yoke, and rudder pedals. You can find these accessories at many computer stores and on the Web.

Joystick or Control Yoke

While you don't *need* a joystick or control yoke to use Flight Simulator, veteran pilots agree that it's almost essential to a realistic, enjoyable experience. There are many models to choose from, ranging from stripped-down basic models to full-blown controls with more buttons and knobs than you'll probably ever use. The best ones come with a throttle control built-in, and some feature mixture and propeller controls too.



Rudder Pedals

Pilots fly using their hands *and* feet. Plug in a pair of rudder pedals, and you'll find that you have much greater control over the aircraft you fly. The coordinated use of rudder and aileron in turns will become more intuitive, and you'll become a better pilot. Pedals are especially useful if you like flying the Bell 206B JetRanger III helicopter.

Pilot Supplies

As a Flight Simulator pilot, you'll find many real-world pilot supplies useful. Find a local flight school or pilot's shop in the phone book, then head on down and see what they've got. The salesperson will be glad to show you around (and will most likely try to sign you up for flying lessons!). At best you'll become a student pilot. At worst, you'll walk out with an armload of toys. If you'd rather do your shopping from the comfort of home, there are a number of well-known pilot supply companies that do business on the Web.

Take a look at aviation charts (some stores give them away when they're out-of-date), calculators, course plotters, and radio scanners. Most stores have a lot of aviation books too, on subjects such as aircraft and aircraft systems, weather, navigation, communications, and training.

Fly for Real

Flight Simulator 2000 is a game, a simulation, and a training aid all rolled into one. Many Flight Simulator enthusiasts have gone on to become licensed pilots, and many pilots (both recreational and professional) fire up Flight Simulator to have fun and practice their skills. It's not unusual these days for a new student to arrive at the airport for his or her first flight lesson already knowing about control towers, stalls, and the horizontal component of lift.

Flight Simulator provides a comfortable, relaxed atmosphere in which to learn and practice the fundamentals of visual and instrument flying, including:

- Operating flight and engine controls
- Using and interpreting flight instruments
- Using navigational aids
- Flying in an airport environment
- Flying solely by reference to instruments
- Understanding and managing systems failures

Student pilots using Flight Simulator can isolate specific tasks and focus on them without the distractions and complexities of flying a real aircraft in busy airspace. Instructors can use Flight Simulator as an interactive tool for pre- and post-flight demonstrations, as well as for classroom presentations. The ability to save specific situations as Flights, record and playback "videos" of Flight Simulator flights, and induce systems failures is particularly useful to instructors. Keep in mind though that while Flight Simulator is a great *complement* to flight training, it's not a substitute for instruction from a Certified Flight Instructor and is not part of an approved training program under the standards of the FAA or any other regulatory authority.

The next chapter, "Getting Certified," describes the path real-world pilots take in their training and lays out a curriculum you can follow to climb the career ladder within Flight Simulator.

A woman in a pilot's uniform is shown working on the propeller of a small airplane. She is holding a tool and appears to be adjusting or inspecting the propeller. The background shows a cloudy sky and the side of the aircraft.

Getting Certified

chapter six

6

Whether attracted to the technology, the speed, or the simple beauty of the sky, all pilots share a passion for what they do. They climb up the aviation ladder one step at a time, increasing and improving their skills along the way. They study hard, spend many hours getting instruction and building flight time, and pass knowledge and practical examinations to mark their progress.

A similar systematic approach will help you build your skills as a Microsoft® Flight Simulator 2000 pilot. You're free, of course, to explore the simulation on your own. But if you really want to learn to fly in Flight Simulator, read on. First we'll take a look at the training real-world pilots receive. Then we'll present a step-by-step course you can follow to work your way up the ranks from zero experience to the cockpit of a Flight Simulator jet.

Getting Certified In the Real World

Requirements for pilot certification vary from country to country, but the training is similar no matter where you are. In this section, we'll examine the typical career path a pilot takes in the United States. The Federal Aviation Regulations concerning pilot certification are quite detailed. What follows is a simplified overview.

Private Pilot Certificate

Becoming a private pilot is the first step in an aviation career, and one many pilots never go beyond. Although it's possible to get a Private Pilot Certificate in a multi-engine airplane, seaplane, glider, helicopter, balloon, blimp, or gyroplane, most students do their initial training in a single-engine, land-based airplane.

In *ground school*, a pilot-to-be learns about regulations, navigation, radio communication, weather, aircraft operation and performance, aerodynamics, aircraft systems, emergency procedures, and decision-making.

In *flight training*, the work focuses on acquiring basic skills: preflight preparation and procedures, airport operations, flight maneuvers, navigation, basic instrument maneuvers, emergency operations, night operations, and post-flight procedures. A typical student spends 20 to 30 hours flying *dual* with an instructor, and practices his or her skills by flying *solo* for another 20 hours or so.

To get the Private Pilot Certificate, the student must pass a simple medical examination, a computerized knowledge test, and oral and flight examinations given by an examiner designated by the Federal Aviation Administration (FAA).

While some private pilots use an airplane as a means to the end of personal or business transportation, most fly just for the fun of it. Private pilots can take their family and friends flying during the day or at night. Without an Instrument Rating (described below) private pilots can fly only when they can stay out of the clouds and when the visibility is good enough to see other aircraft and the ground. While private pilots can share expenses with their passengers, they can't be paid for their flying. The Private Pilot Certificate has its limitations to be sure, but for thousands of recreational aviators, it's all they need to have fun on the weekends or to get from here to there quickly and in style.

Instrument Rating

For private pilots who are tired of being stuck on the ground when the weather's bad, or for those pilots with career aspirations, the next logical step

is to add an Instrument Rating. Instrument training gives a private pilot the skills to fly in the clouds and in reduced visibility, using only the instruments in the cockpit. A pilot with an Instrument Rating operates under different rules than a pilot flying visually. In the clouds, the responsibility for keeping aircraft apart from one another rests with air traffic controllers, who use radar to keep track of each airplane's position.

Just as in private pilot training, the Instrument Rating requires ground school and a knowledge test. The focus is on learning to fly and navigate using only the instruments, and on learning to communicate effectively with air traffic controllers. During the required 40 hours of instrument flight training, the student usually wears a *view-limiting device* (a special visor or goggles) that prevents him or her from looking out the window.

Getting the Instrument Rating is both challenging and rewarding. It makes flying a more reliable mode of transportation, refines basic flying skills, and enables a private pilot to fly in the same air traffic control system that airline pilots use. For pilots attracted to aviation gadgetry, there's nothing better than flying "on the gauges."

Commercial Pilot Certificate

For pilots looking to make a career out of flying, or to hone their skills, the next step after adding an Instrument Rating is the Commercial Pilot Certificate. (While a pilot doesn't have to have an Instrument Rating to get a Commercial Certificate, most commercial flying jobs require it.) The only real difference between a Private Pilot Certificate and a Commercial Pilot Certificate is that the latter allows a pilot to legally carry passengers and cargo for hire. With a Commercial Pilot Certificate in hand, a pilot can finally get paid to fly!



FlightSafety International

FlightSafety International's mission is clear: providing the highest standard of training for the safe and effective operation of complex, high-risk equipment. FlightSafety trains over 50,000 pilots and aircraft maintenance technicians each year, in facilities located across the United States and Canada and in Paris, France.

FlightSafety's instructors and facilities are equipped to train pilots and technicians in practically every make and model of corporate and commercial aviation aircraft. FlightSafety is known around the world for the training of pilots in all categories: private, commercial, airline, and military. The training of aircraft maintenance technicians, dispatchers, and additional aircraft support teams has added to FlightSafety's reputation as an all-encompassing aviation training company.

Commercial Pilot ground school, flight training, and examinations are very similar to those faced by private pilots, but there are new regulations, calculations, and maneuvers to master. Additionally, the tolerances for errors are much smaller. At least some of the training must be done in a *complex* aircraft (an aircraft with an adjustable propeller, flaps, and retractable landing gear). The flight training consists of 20 hours or more of instruction, and a pilot needs at least 250 hours of total flight time before taking the oral and flight examinations.

Entry-level commercial pilots typically spend their days flying charter flights and scenic tours, towing banners, hauling freight, or carrying sky divers. Adding a Multi-engine Rating or a Flight Instructor Certificate makes commercial pilots more marketable, as does the Airline Transport Pilot Certificate (described below).

After accumulating about 1,000 hours of flying time and some experience in complex single-engine and multi-engine aircraft, a commercial pilot may be ready to fly for a corporation or a commuter airline. On twin-engine or turbine-powered aircraft, the rookie will likely act as the copilot.

Airline Transport Pilot Certificate

The Airline Transport Pilot Certificate (known as the ATP) is the Ph.D. of aviation, and is a prerequisite for many airline and corporate flying jobs. It allows a pilot to act as *pilot in command* during the commercial operation of an airliner.

ATP ground school and the knowledge test emphasize airline-oriented information and skills, focusing on subjects like weight and balance, aircraft performance, and crew resource manage-

ment. The flight training takes a pilot's existing skills to even higher levels of precision. Before undergoing the ATP oral and flight examinations, a pilot needs to have logged at least 1,500 hours total time as a pilot.

Once a pilot secures a position (usually Copilot, also known as First Officer) with a major airline or corporation, advancement to better routes, larger aircraft, and Captain is usually based on seniority.

Aviation History

March 8, 1910, Madame la Baronne de la Roche becomes the first certified woman pilot (license issued in France).

Getting Certified In Flight Simulator 2000

As in the real world, learning to fly with Flight Simulator is easy if you view the task as a series of steps. You can follow this curriculum at your own pace. Complete the Tutorials, Lessons, and Checkrides in the order they're presented.

Remember that while Flight Simulator is a great complement to flight training, it's not a substitute for instruction from a Certified Flight Instructor and is not part of an approved training program under the standards of the FAA or any other regulatory authority.

Tutorials are found in the next chapter of this book. In them, renowned flight instructor, aviation educator, and humorist Rod Machado walks you through the basics of flying. Each tutorial starts with some homework; read the suggested material in the onscreen Help, watch the videos, and you'll be better prepared to absorb the information to come. The tutorials themselves are hands-on. You'll read a section, then use Flight Simulator to apply what you've learned. With Rod's assistance, learning is fun, and you'll be in the air before you know it.

Lessons team you up with a virtual instructor who guides you through maneuvers step-by-step. The Lessons complement the Tutorials and increase in difficulty as your skills increase. Rod will be your virtual instructor for the Private and Instrument Lessons.

Checkrides put you in the cockpit with an Examiner who will test your mastery of certain tasks. Before you take a Checkride, make sure you've met the prerequisites listed in the Preflight Briefing. Once you pass, you'll be awarded a certificate that you can print, frame, and hang on your wall.

Lessons and Checkrides are real-time, interactive experiences in the cockpits of Flight Simulator 2000 aircraft. To get to them, click **Lessons** on the **Flights** menu. Be sure to watch any associated videos and study the Preflight Briefings before you go flying.

After you've completed a series of Lessons and passed the associated Checkride, try flying some of the suggested Adventures—they're a fun way to use your new skills. Adventures range from short dramatic scenarios lasting a few minutes to lengthy realistic flights of several hours, complete with air traffic control. On the **Flights** menu, click **Adventures**.



Renting an Airplane

There are more than 600,000 pilots in the United States. Some own their own airplanes, but the majority take to the sky in aircraft they rent. Most flight schools, flying clubs, and *fixed-base operators* (businesses at airports that provide training, rentals, fuel, supplies, maintenance, and so on) charge a “wet” hourly rate, meaning that the rate includes fuel. Renting an airplane isn't cheap, but because renters usually pay only for the time the engine is running, a rented airplane can be a feasible way to get from one place to another.

Private Pilot Certificate

The first step in a Flight Simulator 2000 career is to become a private pilot. This training is the foundation for everything else you'll learn. In these Tutorials and interactive Lessons, you'll fly a

Cessna 182S to learn basic flight maneuvers and radio navigation. Master these skills, and the rest of your training will go more smoothly. Complete these steps in sequence:

Task to Complete	Description
Tutorial 1: Straight-and-Level	Learn the secrets of flying the most basic maneuver of them all: straight-and-level flight.
Tutorial 2: Turns	Master the coordinated use of ailerons, rudder, and elevator that result in a turn.
Private Lesson 1: Reviewing the Basics, 182S	Review straight-and-level flight and turns in the Cessna 182S over Chicago.
Tutorial 3: Climbs and Descents	Discover how to use pitch and power to make an airplane go up and down.
Tutorial 4: Slow Flight	Master the subtle art of flying an aircraft near its stall speed.
Tutorial 5: Stalls	Learn how to prevent, detect, and recover from stalls.
Tutorial 6: Steep Turns	Become proficient at steep turns—you'll learn to fly more precisely and to divide your attention between the instruments and the view outside.
Tutorial 7: Landings	Learn what it takes to get your aircraft back on the ground.
Private Lesson 2: Practicing Landing, 182S	Guide the Cessna 182S down to the runway at the Ohio University Airport.
Tutorial 8: Takeoffs and Traffic Patterns	Learn to fly a standard traffic pattern around the runway.
Private Lesson 3: Flying the Pattern, 182S	Put it all together and practice flying the traffic pattern in the Cessna 182S at Meigs Field.
Tutorial 9: VOR Navigation	Master a basic form of radio navigation using a VHF Omnidirectional Range (VOR).
Private Lesson 4: VOR Intercept and Tracking, 182S	Intercept and track VOR radials in the Cessna 182S over the Honolulu International Airport.
Private Pilot Checkride	Hop into the Cessna 182S and strut your stuff for an examiner. Meet the high standards, and you'll be awarded a Private Pilot Certificate.

Congratulations! Now that you're a certified Flight Simulator 2000 pilot, it's time to have some fun. Try flying some of the Beginner Adventures.

Instrument Rating

Just like in the real world, getting an Instrument Rating in Flight Simulator 2000 will make you a more versatile pilot. You'll also be able to take better advantage of Flight Simulator's navigation and weather features. You'll do your instrument training in the same aircraft you used for your private pilot certification, the Cessna 182S. While the basic maneuvers are the same, this time you'll learn to perform them solely by reference to your instruments. You'll also master the art of the

instrument scan and learn the intricacies of flying *instrument approaches*.

There are few thrills in aviation like taking off into the clouds, flying for a few hours, and breaking out with a runway at another airport directly ahead. By the time you finish your instrument training, you'll be capable of getting from here to there in almost any weather. Here are the steps:

Task to Complete	Description
Tutorial 10: Attitude, Power, and Trim	Start learning the basics of flight by reference to instruments.
Tutorial 11: Radial Scanning the Primary Instruments	Further your understanding of instrument flight and the "scan."
Tutorial 12: Trimming Using the VSI and Monitor Scanning the Big 6 Instruments	Learn how to reduce your workload by using trim and your peripheral vision.
Tutorial 13: Understanding Approaches	Discover the different approaches to the runway when flying on instruments.
Tutorial 14: Flying a VOR Approach	Learn how to use a VOR to get to the runway.
Instrument Lesson 1: VOR Hold, 182S	Practice instrument flying by "holding" like the airliners over the Richmond, Virginia, VOR. You'll be flying the Cessna 182S in Visual Meteorological Conditions (VMC).
Instrument Lesson 2: VOR Approach with Procedure Turn, 182S	Take the Cessna 182S through a full VOR approach to the Flying Cloud Airport near Minneapolis, Minnesota, in VMC.
Tutorial 15: Flying an ILS Approach	Learn the art of "flying the needles" to the runway, using an Instrument Landing System (ILS).
Instrument Lesson 3: ILS Approach, Straight-In, 182S	Guide the Cessna 182S down an ILS approach to Space Center Executive Airport in Titusville, Florida, in VMC.
Instrument Lesson 4: ILS Approach with Procedure Turn, 182S	Fly a full ILS approach in the Cessna 182S to Long Island Mac Arthur Airport in Islip, New York, in VMC.
Instrument Rating Checkride	Take an Examiner for a cloudy ride in the Cessna 182S. Pass, and you'll be awarded the Instrument Rating.

As an instrument-rated Flight Simulator 2000 pilot your flying is now more precise. Give some of the Intermediate Adventures a try, and see how you do.



Commercial Pilot Certificate

In the real world, commercial training focuses on advanced flight maneuvers. In Flight Simulator 2000, we'll stray from the real-world curriculum so that you can perfect the instrument flying skills you already have. This time, you'll be flying an aircraft with retractable landing gear—the Cessna 182RG. The training will be similar to your instrument training, except that all the tolerances will be tighter and you'll do all the flying in the clouds (in what pilots call *instrument meteorological conditions*, or IMC). After passing the Commercial Pilot Checkride, you'll be ready to try flying more advanced aircraft. That journey begins with these steps:

Task to Complete	Description
Commercial Lesson 1: VOR Hold, 182RG	Hold the Cessna 182RG over the Richmond, Virginia, VOR in instrument meteorological conditions (IMC).
Commercial Lesson 2: VOR Approach with Procedure Turn, 182RG	Take the Cessna 182RG through a full VOR approach to the Flying Cloud Airport near Minneapolis, Minnesota, in IMC.
Commercial Lesson 3: ILS Approach, Straight-In, 182RG	Guide the Cessna 182RG down an Instrument Landing System (ILS) approach to Space Center Executive Airport in Titusville, Florida, in IMC.
Commercial Lesson 4: ILS Approach with Procedure Turn, 182RG	Fly a full ILS approach in the Cessna 182RG to Long Island Mac Arthur Airport in Islip, New York, in IMC.
Commercial Pilot Checkride	Ready to get paid to fly? Prove it in the Cessna 182RG, and you'll be awarded the Commercial Pilot Certificate.

Now try flying some of the Advanced Adventures: they'll help you keep your new commercial-level Flight Simulator 2000 flying skills sharp.

Airline Transport Pilot Certificate

Most commercial airline pilots who fly jets have an ATP certificate, and if you're serious about developing your skills, you should too. In the real world, the training is often done in a single-

engine propeller-driven airplane. In Flight Simulator 2000, you'll have to prove yourself in the cockpit of a Boeing 737 jet. Up for the challenge? Follow these steps:

Task to Complete	Description
ATP Lesson 1: VOR Hold, 737-400	Hold the Boeing 737-400 over the Richmond, Virginia, VOR, in VMC.
ATP Lesson 2: VOR Approach with Procedure Turn, 737-400	Take the Boeing 737-400 through a full VOR approach to JFK International Airport in New York, in VMC.
ATP Lesson 3: ILS Approach, Straight-In, 737-400	Guide the Boeing 737-400 down an ILS approach to Space Center Executive Airport in Titusville, Florida, in VMC.
ATP Lesson 4: ILS Approach with Procedure Turn, 737-400	Fly a full ILS approach in the Boeing 737-400 to Long Island Mac Arthur Airport in Islip, New York, in VMC.
Airline Transport Pilot Checkride	Share the cockpit with an examiner one last time. It doesn't get any more challenging than this test in the Boeing 737-400. Pass, and you'll get the ATP certificate.

Ready for some real challenges? Try flying some of the Expert Adventures. Successfully completing these is the mark of a true Flight Simulator 2000 professional.



LEARNING TO FLY

with

Fred Machado





For the past 25 years, pilots across the United States and Europe have been laughing and learning with Rod. Rod learned to fly at 16 and currently holds an Airline Transport Pilot certificate, all fixed-wing flight instructor ratings, and degrees in psychology and aviation science.

Enjoy Rod's humor and insights in his monthly AOPA Pilot and Flight Training magazine columns, as well as in Rod Machado's Private Pilot Handbook.

Meet Your Instructor

I'm Rod Machado, your flight instructor. I'm going to take you flying, so buckle up and adjust that seat. We're going to learn a lot and have fun.

Over the years I've taught many people how to fly. My methods were straightforward. We'd review the concepts on the ground, hop in the airplane for a flight lesson, then discuss our accomplishments after landing.

We'll do the same here. I'll treat you as if you're learning to fly a real airplane. All I ask is that you complete the required homework before each tutorial.



Homework is very important. One day, when I was in grade school, I didn't bring my homework to class. The teacher asked me why and I said, "Ahh, the dog ate it." The savvy teacher responded by saying, "Rod, do you really expect me to believe the dog ate your homework?" I replied, "Well, I had to force him, but he ate it." Of course, I won't force you to do your homework; but if you do, I guarantee you'll learn real flying skills like everyone else I've taught.

A Little Extra Help

Your ally in this process is the *Help* system, accessed from the menu bar at the top of the Microsoft® Flight Simulator 2000 screen.

From the **Help** menu, choose **Overview** to open the Help system. Then choose one of the four main sections of Help (Simulator Help, Aircraft Information, Aviation Articles, and Glossary), or click **Search** to search the Help index. I've added a shortcut for you: choose **Homework** from the **Help** menu to get quickly to the homework for each Tutorial.

There's no better way to learn than by doing, so let's get started. You'll learn what you need as you go along instead of trying to learn isolated bits of information out of context. This way, you won't need to keep five pounds of facts swirling around in a three-pound brain.

You may have heard the phrase, "Don't try this at home." But, in this case, you should try this ONLY at home. Don't even think about trying to fly in a real plane without taking real flying lessons from a Certified Flight Instructor—a virtual instructor isn't enough!



Tutorial 1: Straight-&Level Flight

The very first thing you need to do is (yes, you've guessed it) homework! Watch or read all of the selections for Tutorial 1 before you go on. These will give you a good foundation for some things we'll be talking about.

Homework for this tutorial is found in the **Help** menu under **Homework**. When you first start Flight Simulator 2000, click the **Fly Now!** button on the opening screen. When the menus at the top become visible, click **Help** and then click **Homework**. Read all the topics and watch the videos for Tutorial 1.

Your first tutorial is one of the most important. You're about to practice *straight-and-level flight*, one of aviation's most fundamental maneuvers. Does this sound like two separate maneuvers instead of one? Well, it is. *Straight flight* means the airplane's nose remains pointed in one direction and the wings are parallel to the earth's horizon. *Level flight* means the airplane doesn't gain or lose altitude. Let's see what this looks like from the air.

1. On the menu bar located at the top of the screen, click the **Flights** menu, then click **Select Flight**, then choose **Tutorial 1, Situation 1** from the list of available flights. We'll combine our first flight with a little European vacation: this situation puts you in a Cessna 182S over Rome.
2. Click the **OK** icon (that's the check mark, *not* the X).
3. As soon as the simulation starts, press **P** on your keyboard to pause the simulation.

Now you want to activate the autopilot. Why? It allows me to demonstrate a maneuver and gives you a chance to relax so I can explain things and give you pep talks. The autopilot has several features, but you'll only use two: the *wing leveler* and *altitude hold*. The *wing leveler* keeps the wings from banking, thus it keeps the airplane flying straight ahead. *Altitude hold* adjusts the airplane's nose-up or nose-down pitch, which helps it maintain a constant altitude.



We'll use keyboard commands to control the autopilot, but you can also select Autopilot from the Aircraft menu to see and change the autopilot settings.

4. Press **Z** to activate the autopilot from the keyboard, then press **Ctrl+V** to activate the *wing leveler*, and press **Ctrl+Z** to activate the *altitude hold* function. These keys program the autopilot to fly the airplane *straight* (no bank) and *level* (constant altitude).
5. Now press **P** again to reactivate the simulation.

This is what straight-and-level flight looks like from the left seat, where you, the pilot, normally sit (Figure 1). Don't worry if you seem to be headed for a distant mountain village. I'm with you. Besides, this is Rome and those Romans are very good at repairing villages.



Figure 1

How to Tell You're Going Straight

Okay, how do you know you're actually flying straight and level? The easiest way is to look over the instrument panel out the windscreen (the front window) as shown in Figure 1. It appears that the top portion of the instrument panel is approximately parallel with the earth's distant horizon. This implies that your wings are not banked, which means you're flying *straight* and not turning.

There is, however, another way to tell if you're flying straight.

1. Press the hat switch on your joystick to the left (the hat switch is the button that sticks straight up out of the middle, near your thumb) to take a look out the left window. (You can also use **Shift+4** on the numeric keypad to look left.)

Notice how far the wing is above the earth's horizon.

2. Now press the hat switch to the right and take a look out the right window. (You can also use **Shift+6** on the numeric keypad to look right.)

In straight flight, both wings should be the same distance above the horizon (refer to the horizon, not the mountains).



Figure 2

Having the Right Attitude

In airplanes, I prefer that my students almost strip the gears in their neck by looking right and left out the windows. This helps them check the wing's position and keeps their eyes out of the cockpit looking for traffic. In the simulator, it's inconvenient to keep shifting views to the left and to the right. So, you'll use the *attitude indicator* to help maintain straight-and-level flight. The attitude indicator is located at the top of the six main flight instruments directly in front of you (Figure 2).

The attitude indicator is an artificial representation of the real horizon. Just as its name suggests, the attitude indicator displays the airplane's attitude (its upward or downward *pitch* and the *bank* the wings make with the horizon). The upper half of the attitude indicator is blue (like the real sky, unless, of course, you fly in Los Angeles), the bottom half is brown (like the surface below us). The thin white line between these colors is the *artificial horizon line*. Pilots use the attitude indicator when they can't see the earth's horizon because of restrictions to visibility or when it's inconvenient to look at the wing tips (which is your situation right now).

You've Got It

Okay, I think you're ready to take the controls.

1. First, press **Ctrl+V** to disengage the autopilot's *wing leveler*. This leaves only the *altitude hold* feature active.
2. Place your hand on the joystick or flight yoke (I'll use the term *joystick* from now on), and gently move it about one inch to the left of its center (default) position.
3. Hold this position for about three seconds, then let the joystick return to its center position.
4. Watch the airplane's response both on the attitude indicator and out the front windscreen.



Figure 3A

Moving the joystick to the left banks the airplane to the left, which dips the left wing downward toward the ground. This is how you begin a left turn. Notice that the miniature, orange-winged airplane in the attitude indicator also appears to dip its left wing toward the ground as shown in Figure 3A.

Mechanically speaking, it's really the background of the attitude indicator that moves and creates a

picture of the airplane's attitude. Nevertheless, you can always tell which way you're banking by determining which one of the small orange wings in the attitude indicator dips toward the ground (this is easy since you only have two choices).

5. Gently move the joystick to the right in the same manner described above. The attitude indicator now indicates a right turn since the right wing dips toward the ground (Figure 3B).
6. Move the joystick to the right or left until both wings are parallel to the artificial horizon line (Figure 3C), then return the joystick to its center (default) position.

This is how you make the airplane fly straight. After all, if the wings aren't banked, the airplane isn't turning.

7. Push **Ctrl+V** to reactivate the wing leveler and take a short break.



Figure 3B



Figure 3C

The airplane will return to straight-and-level flight on its own. Now that you understand *straight* flight, let's move on to *level* flight.

Making Sure You're on the Level

Let's see what happens to your altitude when you pitch the airplane's nose up or down.

1. Even though the *altitude hold* mode is still active, gently pull the joystick back about one inch from its center position, hold it there, and watch the response.



Figure 4

Directly below the altimeter is the *vertical speed indicator* (VSI). Its needle also deflects upward showing a *rate of climb* (Figure 4C). This is another indication that you're climbing and not maintaining level flight.

3. Return the joystick to its center position and let the airplane settle back into level flight (remember, the autopilot's altitude hold and wing leveler features are still active).

Once the altimeter's hands and the VSI's needle stop moving, proceed to the next step for a pitch-down demonstration.

4. Pitch the airplane downward with a gentle forward push of about one inch on the joystick.

The attitude indicator's miniature airplane points toward the surface (the brown color) as shown in Figure 5A. Notice that the altimeter unwinds (rotates counter-clockwise) indicating a loss of altitude (Figure 5B). The VSI also shows a rate of descent as its needle deflects downward (Figure 5C). It's safe to say that if the big hand of the altimeter stops moving and the VSI needle indicates *zero*, then you're in level flight. Let's see.

5. Gently move the joystick to place the attitude indicator's miniature airplane directly over the

The airplane pitches up and the attitude indicator's miniature airplane also points upward, toward the sky (the blue) as shown in Figure 4A.

2. Look at the *altimeter*, which is located directly to the right of the attitude indicator (Figure 4B).

The biggest hand (the *hundred foot* hand) is moving clockwise. And, just like the hands of a watch, clockwise movement means something is increasing. In this case it's your altitude.

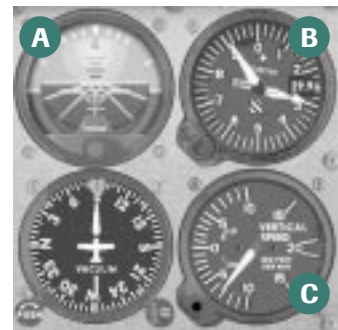


Figure 5

artificial horizon line (Figure 6).

Or you can let go of the controls and the autopilot will return the airplane to level flight. In a real airplane, however, letting go of the controls often makes the passengers nervous (especially if you simultaneously say, “Hmmm, let’s see, I thought I remembered how these things work”).



Figure 6

6. Look at the altimeter’s *hundred foot* hand (the long one) and the VSI needle. They’ve settled down and have stopped moving. This is how pilots confirm that their airplane is in level flight.
7. Push **P** to pause the simulation and relax for a bit.

It takes practice to keep these needles stationary (in real life, they’re always moving just a tiny bit). The average private pilot does a great job if he or she remains within 100 feet of a chosen altitude. Unfortunately, when I was a student, I found it much easier to keep changing the target altitude at which I wanted to be (until, of course, I finally perfected this skill). Challenge yourself to remain within private pilot tolerances.

So, here’s your assignment. When you’re ready:

1. Press **P** to reactivate the simulation.
2. Press **Z** to take the simulator off autopilot.
3. Practice maintaining straight-and-level flight; keep the attitude indicator’s miniature airplane (the orange wings) parallel to the artificial horizon line.

If a wing dips right or left, raise it by moving the joystick left or right.

The altimeter’s *hundred foot* hand shouldn’t move. If it does:

4. Use the joystick to change the pitch slightly until the needle stops moving. This is the pitch attitude required for level flight.

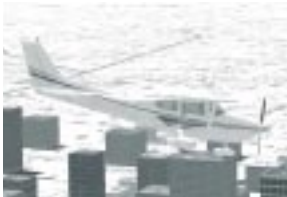
If things get a little crazy, press **Z**, then **Ctrl+V**, then **Ctrl+Z** to activate the autopilot’s wing leveler and altitude hold feature, then relax and give it another try.

This is exactly how we’d do it in the real airplane except I play the part of the autopilot (and you’d activate me by saying the word “Help!”).

5. When you’re done, push **P** to pause the simulation and read on.



Think of trim as an imaginary hand that holds the airplane in the desired attitude while eliminating the pressure you apply to the joystick.



Use two keys on the numeric keypad to trim the airplane for the proper pitch attitude. Key number 1 provides nose-up trim and key number 7 provides nose-down trim.



Time for a Trim?

Having fun roaming around Rome? Have you chased everyone out of the city yet? I'm glad you're practicing. Let's try another experiment.

1. Press **P** to reactivate the simulation.
2. Press **Z** to disengage the autopilot (if it was on), and manually fly straight and level.

It's possible that you may need a little forward pressure or back pressure on the joystick to keep the airplane in level flight. This means you need a little trim. No, I'm not referring to your flowing locks.

3. Press **P** to pause the simulation before continuing.

Airplanes are subject to an assortment of aerodynamic forces. Some try to pitch the nose up, others try to pitch it down. Engine power, weight placement, and lift are just a few of these forces. What does this mean to you? Well, if the airplane wants to pitch forward, you can't sit there pulling back on the joystick for the entire flight. You'll get tired fast. So let's use the *trim control* to keep the airplane in the desired attitude.

Here's how it works:

1. Press **P** to reactivate the simulation.
2. Ease up the pressure you're applying to the joystick to maintain level flight.
3. Watch the needle in the VSI. If it begins to show a climb (rotates upward), then apply a little forward pressure on the joystick to return to level flight just as you did in the previous exercise.
4. Press the **7** key on the numeric keypad once for a little *nose-down* trim. (Make sure the NUM LOCK on your keyboard is off). Release the pressure on the joystick and see what happens.

The more you push the trim button, the more trim you apply. Be patient; you may have to repeat this same process several times until the VSI's needle remains relatively horizontal, near the *zero* climb rate value.

5. If the VSI's needle shows a descent (rotates downward), apply a little back pressure on the joystick to return the airplane to level flight.
6. Press the **1** key on the numeric keypad a few times for *nose-up trim*. Release the joystick pressure and watch the VSI's needle response.
7. Repeat the process as necessary until the airplane neither climbs nor descends.

8. When the airplane is perfectly trimmed, let it fly by itself for a while, then press **P** to pause the simulation.

I prefer to use the VSI's needle for trimming since it's very sensitive. I don't mean that it will cry if you tell it that it's ugly. I mean that its needle is very sensitive to small changes in pitch. This makes it easier to detect deviations from level flight. Later on I'll show you how to use the VSI's needle for trimming in a climb or descent.

Many airplanes have trim for bank control. Bank trim is sometimes necessary when the wing's fuel load is unbalanced or if you have heavier passengers sitting to one side of the airplane.

Regardless of how well the airplane is trimmed, it may oscillate up or down slightly, varying its altitude by perhaps 100 feet up or down. That's the way airplanes are. Each one likes to do its own thing and may vary slightly in altitude and heading even when properly trimmed. Let them go, unless they wander too far off. Your job is to make the airplane as easy as possible to fly so you have more time to think and look outside.

Okay, time for more practice. Return to the simulation and teach those Romans a thing or two about flying straight and level. Try not to hit anything, especially an ancient ruin (although, how would anyone know if you did?). I'm here (in the book) if you need me. You're doing a great job and I'm proud of you. If you're following the curriculum in Chapter 6 ("Getting Certified"), then check off Tutorial 1 in the chart. You've completed it! In our next tutorial I'll introduce you to the basics of turns.

Tutorial 2: Turns

If you ended our last tutorial by flying into the sunset, you're probably still headed that way. After all, I didn't teach you how to turn the airplane—a very important maneuver that all pilots need to know. It's time to learn about turns: right ones, left ones, steep ones, and shallow ones. Perform turns well and every heading of the compass is open to you for discovery.

Let's begin this tutorial by reactivating our European vacation:

1. From the **Flights** menu, click **Select Flight**, then choose **Tutorial 2, Situation 1**, and click the **OK** icon.
2. Press **Z**, then **CTRL+Z** to activate the autopilot's altitude hold.
The airplane is paused in straight-and-level flight and I've given you an external (Spot Plane) view.
3. Continue reading.

Turn Aerodynamics

To understand how an airplane turns we need to know something about the forces that keep it airborne. Figure 1 shows the four forces acting on an airplane in flight. (And you learned about these when you did your homework, right? Right?) *Thrust*, produced by the engine-propeller combination, pulls the airplane through the air. *Drag* acts opposite to thrust and is the air's resistance to a moving airplane. *Weight* is the force exerting a constant downward pull on the airplane. And *lift*, which acts opposite to weight, is the upward-acting force that keeps an airplane airborne.

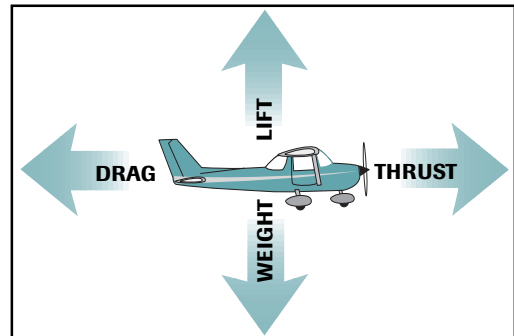


Figure 1

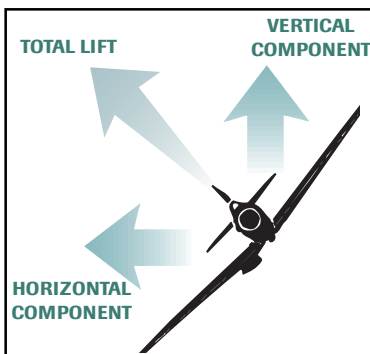


Figure 2

Important point here: *Lift* is also the force responsible for allowing an airplane to turn.

I want you to think of lift as a force that *pulls* the airplane upward. Since lift pulls upward, could it also pull a little to the right or the left? Absolutely. *Tilting the lift force* allows it to pull the airplane horizontally, right or left, as well as upward (Figure 2). The small horizontal component of lift that's pulling to the side is the part responsible for making the airplane turn.

Let's watch a video and see this horizontal component of lift in action. Get that popcorn ready, then:

1. From the **Help** menu, choose **Homework**.
2. In the homework for Tutorial 2, click the *Turns* video and watch the presentation.
Eat that popcorn fast because the video isn't very long. After you're done watching, leave the Help screen up, because we're going to use it again very soon.

There you have it. Proof that airplanes turn by deflecting some of their lift sideways. Now, let me play the role of Socrates, the philosopher, and ask you a very important question. (Don't mind the bed sheet I'm dressed in. If, however, I show up wrapped in a mattress, that means we're ready to practice landings.) The question is, "How do we tilt lift so as to make the airplane turn?" The answer is, "With the ailerons."

Banking on Ailerons

I see you have some popcorn left over, so let's finish it off by watching another video.

In the homework for Tutorial 2, click the *Axes of Flight* video and watch the presentation.

Did you see the ailerons move on the wings? Ailerons, shown in Figure 3, are the moveable, flap-like appendages on the outer half of the wings that allow the airplane to *roll* (no, the ailerons are not used to wave to pilots in other airplanes). Ailerons are controlled from inside the airplane by the joystick (or control wheel). Picture this: moving the joystick to the left raises the aileron on the left wing while simultaneously lowering the aileron on the right wing. When one goes up, the other goes down. Don't worry, this doesn't mean they're broken. They're designed to work this way.

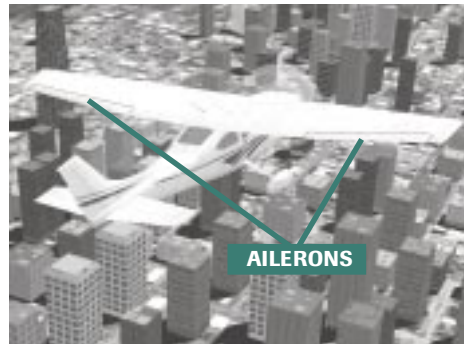


Figure 3

Remember what happened last time you stuck your hand out the window of a moving car? Yes, everyone thought you were preparing to turn. In actuality, you were doing an aerodynamic experiment. (Too bad the police officer didn't see it that way.) Twisting your hand upward (so the front edge is higher) simulates the position of a lowered aileron, which forces the hand, as well as the wing, upward. Twisting your hand downward simulates the position of a raised aileron, which forces the hand, as well as the wing, downward. This is how the airplane *rolls* to the right or left about its longitudinal axis—the *long* axis running from the tail to the airplane's nose.

It's the roll and eventual bank that tilts the lifting force to the right or left. To turn, you simply deflect the joystick (when I say "deflect" I mean to lean it slowly) in the desired direction of the turn and roll the airplane until reaching a specific *bank angle*. Then you return the joystick to its neutral (center) position and the airplane *usually* remains established at this bank angle. If the airplane drifts from the desired bank, then give the joystick a nudge or two to maintain the bank angle. Let's give this a try.

Your Turn

Time to try it yourself.

1. Press **P** to activate the simulation.
Remember, the altitude hold is active, the wing leveler is not.
2. Move the joystick slowly to the left and put the airplane in a medium bank turn of approximately 30 degrees (you can eyeball this by banking until the Cessna's wing strut is parallel with the horizon).
3. Once the airplane is established in the bank, return the joystick to its neutral or center position. (Remember, the altitude hold feature is still active in the autopilot, so don't pull or push on the joystick.)
Notice how the airplane tends to remain in the bank you've established (unless it's a very steep or very shallow bank).
4. Now roll out of the left turn back to level flight by deflecting the joystick slowly to the right.



Did you notice that the amount of joystick deflection determines how fast you roll into or out of a bank? Good pilots roll into a bank slowly and smoothly. It not only feels better, it keeps the passengers from returning the lunch you bought them.

Okay, now I want you to fly around for a while and practice making turns. Try making a few steeper turns (more than 30 degrees) and a few shallow ones (less than 30 degrees). Get the feel of the airplane. Any time you feel like you're losing control, activate the *wing leveler* feature (**CTRL+V**). Learn by doing and have a little fun too, but don't forget to come back; there's still much to learn.

When you want to learn more about turns, press **P** to pause the simulation and continue reading.

You Can Bank on This

Let's continue with our tutorial by seeing what turns look like from inside the cockpit.

1. While the simulation is still paused, press **S** on your keyboard for the cockpit view.

Let me roll myself up in that sheet and play Socrates again by asking, "From the inside of the cockpit, how can you tell how steeply you're banking?" After all, you can't have another pilot follow you around just to tell you what your bank is. Here's a better way.

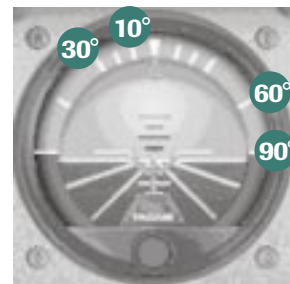


Figure 4

Figure 4 shows the attitude indicator that we learned about earlier. At the top of the attitude indicator, immediately to the right and left of center, are three white bank marks. Each mark indicates 10 degrees of bank, up to 30 degrees. Beyond the 30-degree mark are the 60-degree and 90-degree bank marks as shown in Figure 4. To establish a bank, roll the airplane until a white bank mark rests over the little orange triangle. Time to try another experiment.

2. Press **P** to reactivate the simulation.
3. If you activated the wing leveler, press **CTRL+V** to deactivate it.
4. Gently roll the airplane to the right into a 10-degree bank as shown in Figure 5A.

Remember, the autopilot's altitude hold mode is still active.

5. Try a 30-degree bank as shown in Figure 5B.

Not too tough, is it? But what if you want to bank at 15 or 45 degrees?

There are two white diagonal lines angled downward from the middle of the attitude indicator. These are bank lines for 15 and 45 degrees of bank, respectively.



Figure 6A



Figure 6B

6. Gently roll the airplane to the right until the attitude indicator's miniature airplane (the one with little orange wings) is parallel to the first diagonal line as shown in Figure 6A. Now you're in a 15-degree bank.
7. Try a 45-degree bank by gently rolling the airplane until the miniature airplane's wings are parallel to the second diagonal line (Figure 6B).
8. When you're finished, roll the airplane back to straight-and-level flight.

There's one more thing you need to understand before I cut the leash and send you off to practice turns on your own without using the autopilot. You guessed it, time for one more experiment.



Figure 5A



Figure 5B

Here's a Good Pitch

If you did your homework, you learned about *pitch* in *The Axes of Flight*. See, I told you homework was important. Make your dog cough it up.

With altitude hold active and the wing leveler still disengaged, place the airplane in straight-and-level flight. Observe the position of the miniature airplane (especially the orange ball between the wings). In straight-and-level flight, notice that the miniature airplane (and orange ball) rests almost directly over the artificial horizon line as shown in Figure 7. In a bank, however, it's hard to identify the airplane's pitch on the attitude indicator since the miniature airplane is no longer aligned with the artificial horizon line. Therefore, use the position of the orange ball (Figure 7) in relation to the artificial horizon line as a pitch reference in a turn. Here's how it works:



Figure 7

1. Roll the airplane into a 15-degree bank to the right (remember, altitude hold is still on).



Figure 8A

Observe the attitude indicator to see how the autopilot changes the airplane's pitch to maintain altitude. Pay attention to the orange ball's position in relation to the artificial horizon line. It's obvious the autopilot had to pitch the airplane's nose up a little to maintain altitude in a turn, as shown in Figure 8A.

2. Increase the bank to 30 degrees.

Once again, the autopilot had to pitch the airplane up a little bit more to maintain altitude, as shown in Figure 8B.



Figure 8B

3. Press **P** to pause the simulation before reading further.

The point here is that **steeper turns require an increase in pitch to maintain altitude**. Why? You'll learn why in the upcoming section on slow flight. For now, when banking the airplane, make whatever pitch-up adjustment is necessary to maintain altitude. In steeper turns, you'll need to pull back a little more on the joystick to keep the VSI's needle reading zero and the altimeter's big (*hundred foot*) hand steady. Use the orange ball's position relative to the artificial horizon line to determine the airplane's pitch while banked. And remember to lower the pitch when returning to straight-and-level flight.

Now's a good time to practice turns of varying banks with the autopilot disengaged. Try steep turns at 45 degrees of bank. They are a challenge. At 60 degrees of bank it's very difficult to hold altitude. Don't even think about doing turns at 90 degrees of bank. They're impossible in this airplane.

And remember, this isn't a shoot 'em up game. Since you're not saving the universe from space aliens, make smooth movements on the flight controls. In other words, move the joystick like a surgeon, not like a jackhammer technician. We're not churning butter here.

4. Press **P** to reactivate the simulation.
5. Press **Z** to turn the autopilot off.
6. When you're done, press **P** to pause the simulation before reading any further.

Have fun!

Know Where You're Heading

As a student pilot I got lost a lot. In fact, instead of heading for a specific destination, I found it easier to keep changing where it was I wanted to go. You won't have this problem because I'm going to show you a practical purpose for making turns. It's called *flying a specific heading*.

Figure 9 shows the airplane's *heading indicator* (sometimes called the *directional gyro*). It's found in the middle of the bottom row of the six main flight instruments that we discussed in Tutorial One. Think of the heading indicator as a mechanical compass that shows which way your airplane points. Notice the numbers on the face of the heading indicator. Add a single zero to any number on the face to get the airplane's actual heading. In other words, *6* is really a heading of *60* degrees (spoken as *zero-six-zero degrees*). The number *33* is actually a heading of *330* degrees. (When we say that aloud, we say "*three-three-zero degrees*" for extra clarity. It's important to be extra clear when you're flying.) These numbers appear at 30-degree intervals. Between these numbers are 5- and 10-degree heading increments.



Figure 9

To fly a specific heading, simply turn the airplane in the shortest direction to the heading desired. For example, turn the airplane until the nose of the white airplane in the heading indicator points to the letter *W* for *West* (this is a heading of 270 degrees).

1. Press **P** to reactivate the simulation and give this a try (make sure the altitude hold and wing leveler are disengaged). I recommend that you make all turns at 20 to 30 degrees of bank. This makes the turn easier to manage.
2. When you are within 5 degrees of the desired heading of 270 degrees, start rolling out to straight-and-level flight.
With more experience you'll learn the precise amount of lead necessary to roll out on the desired heading.

Now that you have a basic idea of which way the airplane's heading, try turning to specific headings.



What You've Learned So Far

Believe it or not, in these first two tutorials you've learned around 50% of all the basic flying skills you'll need to fly an airplane. But hold on, we're not done yet, so hold off a little longer before you apply for that airline job. We still need to learn how to make an airplane climb and descend. After all, when you become an airline pilot, you'll want to climb to take advantage of favorable winds. You just can't fly around at low altitudes knocking buildings over. And, once up there, you've got to come down. We'll learn how to do this in our next tutorial.

Extra Credit!

I promised you I'd provide training that was as close to real airplane training as possible and I mean to keep my word. Here's a short section on rudder usage in case you're one of the Flight Sim users who have such things. You don't need to know this to have a realistic flight simulator experience. You will, however, need to know about rudder usage if you plan on flying real airplanes. Don't worry if this is difficult at first; it's difficult for all student pilots. It requires coordination between your hands (joystick) and feet (rudder pedals), or for some of you, your wrists (if you joystick gets its rudder action by twisting). So, if you look funny when you dance, then you'll probably need a little practice to perfect this skill.

Your simulator has a feature called Auto-Rudder, which you access by choosing **Realism Settings** from the **Aircraft** menu. When Auto-Rudder is active, the simulator works the rudder for you. Simply stated, the rudder points the airplane's nose in the direction it's turning. Yes, the airplane's nose doesn't always point in the same direction as the airplane is banking. You have a phenomenon known as *adverse yaw* to thank for this.

Adverse Yaw

When banking to the right, the aileron on the left wing lowers, causing that wing to lift up. While the lowered aileron increases the lift on the left wing, it also causes a slight increase in drag. "Wait a minute," you say, "I didn't order any drag with my lift." True, but this isn't a pizza either. Mother Nature always accompanies lift with a little drag—like a chaperone on a high school date (which would really be a drag).

In a right turn, the aileron on the left wing goes down to lift that wing. The wing rises but the slight increase in drag pulls the left wing aft a little. This has the effect of pulling (or *yawing*) the airplane's nose *adversely* to the left as the airplane banks to the right. Thus the name *adverse yaw*.

Obviously, if you're banked to the right you want the nose to point in the same direction you're banking, don't you? This is where rudders come in handy.

The rudder is controlled by pedals on the cockpit floor, or by a twisting action in some joysticks. Let's do another experiment.

1. From the **Aircraft** menu, choose **Realism Settings**, deactivate the Auto-Rudder feature, and then click the **OK** icon.
2. Press **P** to reactivate the simulation.
Leave the altitude hold and wing leveler off. Okay, here we go.

3. Give the airplane a little right and left rudder and watch what happens.
4. The airplane yaws to the right and left respectively, while the wings remain fairly level.
5. Neutralize the rudder (take the pressure off both rudder pedals).
6. Press **P** to resume the simulation.



Figure 10

Look at the instrument called the *turn coordinator*, which is found at the bottom left of the six main flight instruments (Figure 10). Notice the black ball located in the curved glass tube. This combination is called the *inclinometer*. When the ball is in the bottom center of the tube, the airplane's nose is perfectly pointed in the direction of turn. If the ball is deflected to the right of center, add a little right rudder to center it. If it's deflected to the left of center, add a little left rudder to center it. Moving the ball to the center of the glass tube is known as making a coordinated turn. The inclinometer is one way pilots tell if the airplane's nose is pointed precisely in the direction of turn.

Okay, you're ready for more practice.

7. Press **P** to resume the simulation. Have fun!
8. Make a few shallow turns.
Watch the inclinometer and apply enough rudder pressure to keep the ball centered.

Remember, adverse yaw affects the airplane as it rolls into or out of a bank. Therefore, more rudder pressure is needed when rolling into or out of a bank. Once you're established in a turn, you can neutralize the rudder and the nose should remain pointed in the direction you're headed. (Later, you'll learn about situations where it's necessary to keep a little rudder pressure applied in a turn.)

Practice, Practice, Practice

There's a joke you've probably heard about a tourist in New York City who asks a native, "How do I get to Carnegie Hall?" The answer is, "Practice, practice, practice." Well, that's good advice if you want to be good at anything, so now I'd like you to spend some quality time in the first online lesson.

On the **Flights** menu, click **Lessons**, then choose **Private Pilot Lesson 1**.

When you're done, come back to the book, and we'll talk about the ups and downs of flying.

Tutorial 3: Climbs & Descents

The homework is always easy to find. Just click the **Help** menu, then click **Homework**. All of the stuff there is important, but I want to emphasize the section on *Using Engine Controls*, because if you don't read this, you'll find yourself really up in the air, but in a bad way.

In the fifth grade my teacher asked me to come to the front of the class and name the parts of speech. I walked up, turned around, and calmly replied, "Lips, tongue, lungs, and oxygen." Apparently that wasn't the answer she was looking for.

Speech has its basic components, and so does aviation. So far, we've practiced two of the four most important fundamentals of flight: *straight-and-level flight* and *turns*. Now it's time to practice the final two: *climbs* and *descents*.

I hope you're not tired of Europe, because we're going there again. Let's reactivate our European vacation.

1. From the **Flights** menu, click **Select Flight**.
2. Choose **Tutorial 3, Situation 1**. (Rome? Again? Yes. I'll take you somewhere else soon. I promise.)
3. Click the **OK** icon.
4. Activate the autopilot's altitude hold and wing leveler (press **Z**, then **Ctrl+Z**, then **Ctrl+V**). This time I want you to add the Spot Plane View window. This window allows you to view the airplane from its side during climbs and descents.
5. On the **Views** menu, point to **New View**, then click **Spot Plane**.
6. Press **P** to activate the simulation.



Figure 1

As the flight commences, you should be viewing the airplane from its right side as shown in Figure 1. If not, simultaneously press **Shift** and the number **6** on your keypad for the right side view. Now you're ready.

Trust Your Thrust

In Tutorial 2, we mentioned that *thrust* (produced by the engine-propeller combination) is the force that moves the plane forward. The engine's *manifold pressure* gauge is your means of measuring that thrust. Figure 2 shows the manifold pressure gauge, which is located at the lower left side of the instrument panel (don't get it confused with the fuel flow gauge on the right).



Figure 2

Think of the manifold pressure gauge as the engine's power meter. Applying full throttle gives you more manifold pressure, which means the engine's producing more power (thrust). Reducing the power to idle gives you less manifold pressure, which means the engine's producing less power (thrust).

Look carefully at the calibrations on the manifold pressure gauge. They range from a low of 10 inches to a high of 35 inches. Inches? Huh? Don't worry. This is just another means of calibration (it's like using liters instead of quarts). For now, just use the calibrations on this gauge to adjust your throttle. If I say "set the manifold pressure (MP) to 22 inches," then move the throttle until the needle on the MP gauge points to a value of 22. (That's two tiny increments above a reading of 20 on the MP gauge. If you can't read those increments, don't worry. Just use a ballpark estimate.) If I say give me full power, then move the throttle all the way forward and don't worry about the MP reading. A request to reduce the power to flight idle means to pull the throttle all the way back and, once again, don't worry about the MP reading. Easy enough, right?

Now look in the upper left corner of the six main flight instruments, and you'll find the *airspeed indicator* (Figure 3). The airspeed indicator shows the speed of the wind blowing on your airplane (which is not necessarily the same thing as how fast your airplane is moving). It's calibrated to read in *knots* (or nautical miles per hour) and has nothing to do with what's going on in a pilot's stomach. You're presently flying at an indicated airspeed of 110 knots.

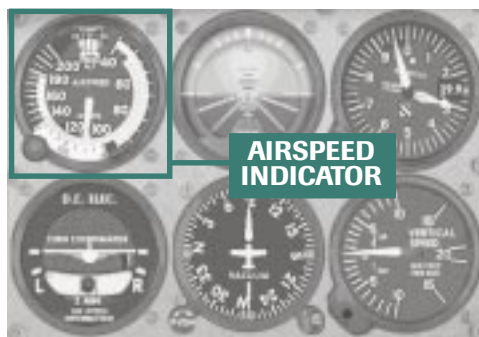
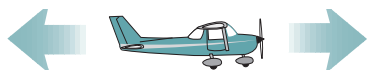


Figure 3

Beginning a Climb

Get that lab coat because it's time for another experiment.



Before we start flight training, let's pretend that you're listening to the philosophical radio station KYMI. Let's also assume that it's aviation question night. Here's your question. With the power set to 17 inches of MP, why does the airspeed reading remain at a steady value of 110 knots? Drag is the reason. This power setting produces enough thrust to accelerate the airplane to approximately 110 knots. When the rearward pull of drag precisely matches the forward pull of thrust, the airplane's speed remains constant.

1. Keep the autopilot's wing leveler active but disengage its altitude hold feature (press **Ctrl+Z**).
2. Raise the airplane's nose by applying a little back pressure on the joystick until the upper-middle part of your instrument panel touches the distant horizon as shown in Figure 4.
3. Apply enough nose-up trim to hold the airplane in this attitude and examine the results.



Figure 4

- Notice that the airspeed drops as the vertical speed indicator shows a climb. The airplane appears to be in a slight nose-up attitude as seen in the Spot Plane View.
4. Press **P** to pause the simulation once you're established in the nose-up attitude.

Believe it or not, you've just entered your first climb and this is what it looks like. Here's the aerodynamic explanation:

In straight-and-level flight at 17 inches of manifold pressure, the engine produces enough thrust to pull the airplane forward at 110 knots. As you raised the nose, the airplane began to slow down in much the same way a car slows down when it begins to climb a hill. In a sense, when you placed the top middle part of the instrument panel on the distant horizon, you pointed the airplane up a relatively shallow hill.

As the airplane's speed decreased, its drag also decreased. Therefore, since you didn't change the setting, you had more thrust than you needed to fly at a slower speed. (As you'll learn later on, there are two basic types of drag. One type decreases as the airspeed slows. Then, as the airspeed continues to slow, another type of drag starts to increase. But you don't need to worry about that yet.)

So what's the airplane doing with its extra thrust? It's allowing you to climb at a few hundred feet per minute. In fact, excess (unused) thrust is the reason an airplane climbs in the first place. Let's make our airplane climb at a greater rate on the VSI.

1. Press **P** to reactivate the simulation.

Remember, we have a lot of thrust we haven't even used. So let's develop maximum thrust by applying full throttle while keeping the airplane at precisely the same attitude as before. In other words, keep the top of the instrument panel on the distant horizon. This represents an approximate 10-degree nose-up pitch attitude as shown in Figure 5.

2. Give the airplane some nose-down trim to keep the attitude constant and observe what happens to the airspeed and rate of climb.
3. When the airplane is stabilized at its new settings, press **P** to pause the simulation.



Figure 5

Figure 5 shows your airplane climbing at 85 knots and 500 feet per minute. The extra thrust allows you to climb at a faster airspeed and a larger rate of climb. This explains why pilots usually climb with full throttle. After all, it makes sense to get the airplane up in the air as fast as is reasonable, to take advantage of favorable winds (among other reasons).

You're on Your Way Up

Engineers (not the kind that drive trains) tell us that efficient climbs are conducted at specific airspeeds. In fact, these same engineers discovered that your Cessna 182S climbs most efficiently at 80 knots. Since you're at 85 knots, how do you get the airplane slowed down to 80 knots while continuing to climb at full power?



Think of the airplane as a car climbing a hill. If you have the “pedal to the metal” (full throttle), the car’s speed is determined by the steepness of the hill. If the hill suddenly becomes steeper, the car slows down; shallower, the car speeds up. It works the same for airplanes. But you have an advantage over car drivers: you get to choose how steep your hill is. All you have to do is adjust the size of the hill you’re climbing by changing your pitch to obtain the climb airspeed desired.

Give it a try.

1. Press **P** to reactivate the simulation.
2. Raise the airplane's nose (increase the steepness of the hill you're climbing) to a *slightly* higher climb attitude. Hold it there, and watch the response on the airspeed indicator.
3. Adjust the pitch up or down *slightly* until the airspeed indicator shows 80 knots. Be patient. Airplanes have inertia and take a moment or two to settle into a new speed once the pitch is changed.
4. Once you're established at this speed, press **P** to pause the simulation.

To maintain an 80-knot climb speed, you should show a pitch of approximately 13 degrees on the attitude indicator (for now we'll use the attitude indicator for our bank and pitch reference since it's difficult to see the real horizon over the instrument panel). The little lines on the attitude indicator are worth five degrees each, so you read them (from bottom to top) 5, 10, 15, and 20 degrees of pitch. 13 degrees of pitch would be just below the third line up.

Of course, the pitch for a climb varies a little from day to day, depending on several variables like airplane *weight*, *configuration*, or *engine power*, to name a few. All that matters is that you find the proper pitch that gives you the climb airspeed desired.



Care to Waltz?

Now you know the secret to climbing an airplane. The next time you want to climb, raise the nose to approximately 13 degrees pitch-up on the attitude indicator, add full throttle, and trim the airplane to maintain this attitude. It's as simple as that. Then adjust the pitch slightly (perhaps only a degree or two) to give you the airspeed desired. Think of entering a climb as a three-step waltz. Think: one-two-three, one-two-three, or attitude-power-trim. Change the attitude, change the power, and then trim the airplane once it's stabilized at its new attitude.

Of course, you may elect to climb at a slightly faster speed. Sometimes I prefer climbing at 90 knots simply because it makes it easier to look over the instrument panel (so I can watch for other airplanes and see pretty things). When a rapid, efficient climb to altitude isn't necessary, find the airspeed that gives you both a good climb rate and a reasonable view over the panel.

What Goes Up...

Now that we've almost climbed out of our atmosphere (just kidding), we should talk about coming back down. This is a good time to show you a neat little trick about how airplanes fly.

1. Press **P** to reactivate the simulation.
2. Keeping in mind that the wing leveler is on, slowly reduce the throttle to flight idle (throttle all

the way back) but don't touch the joystick.

3. Observe the airplane's response as it pitches nose down and goes through a few pitch cycles until its attitude stabilizes.
4. Press **P** to pause the simulation.

Even though we've reduced power, the airspeed stays relatively constant at approximately 80 knots. Once the airplane is trimmed to maintain a specific airspeed, it will *attempt* to maintain that airspeed even with a power change (many factors affect this, so the airspeed will vary a little.)

The VSI shows a 700 foot per minute (FPM) descent while the airplane is at a 3-degree nose-up attitude (an attitude lower than the previous climb attitude). Whether you know it or not, you've just made your first successful descent.



Think of descending in an airplane as you would going down a hill in a car. First, as the car points down a steep hill, you normally take your foot off the accelerator and coast downward (especially near a donut shop—that's where the police are). The steepness of the hill determines the car's eventual speed. Steep hills result in faster coasting speeds, while shallow hills result in slower coasting speeds. Airplanes work similarly.

We've reduced the power to flight idle. In a sense we're coasting down a hill. Our airspeed stabilized at 80 knots because the previous trim setting determined the steepness of our hill. Now, let's change the steepness of the hill.

But first, let's give ourselves a little more altitude. If we go too low in this part of the country, we'll need permission from the Bureau of Land Management—because we'll hit something.

1. On the **World** menu, click **Map View**.
2. Click in the Altitude (MSL) text box (make sure it's the aircraft one, not the tower one) and type the number *5000*, which represents 5,000 feet above sea level.
3. Click the **OK** icon.
You're automatically boosted to 5,000 feet without having to rub a genie's lamp.
4. Press **P** to reactivate the simulation (remember, the wing leveler is still active).

Pitch Change Means Airspeed Change

Let's see how a small change in pitch affects the airspeed. Without readjusting the trim, I want you to lower the nose *slightly* (make a steeper hill) and find an attitude that produces an airspeed reading of 90 knots.

1. Using the attitude indicator, make a *small, slight* pitch adjustment—perhaps a *degree* or *two*—, hold it, and watch the airspeed's response.
Observe the change, but don't chase the airspeed needle. If you want to descend at this speed, you'd simply trim the airplane to maintain this attitude.

2. Now raise the nose (make a shallower hill) and find an attitude that produces an airspeed reading of 70 knots.
3. Since the airplane is trimmed for an 80-knot glide, slowly release the back pressure on the joystick and resume the 80-knot descent.
4. Once the airspeed stabilizes at 80 knots, press **P** to pause the simulation.
5. Click **World**, click **Map View**, and type *5000* in the Altitude (MSL) field. Click the **OK** icon and we're back to 5,000 feet above sea level.

The reason I had you change pitch with the power set at flight idle was to give you an idea of how we control the airplane's airspeed. This becomes very important when you prepare for landings. After all, you'll need to fly at different speeds when making your landing approach. By making changes in pitch you can descend at any airspeed you desire.

Changing Descent Rates

What if you want to descend at the same airspeed but at a slower descent rate (a smaller reading on the VSI)? Well, here's your chance for power. (Sorry, I mean engine power. No world domination today!) Power has a direct bearing on your rate of descent.

1. Press **P** to reactivate the simulation.

At 80 knots, with the power at flight idle, the airplane descends at approximately 700 FPM.

Suppose, for example, you're approaching to land and need less of a descent rate to make it to the runway. What do you do?

2. Simply increase your MP to a higher value, say 11 inches and adjust the pitch slightly to maintain 80 knots.
3. Retrim as necessary.

With this slight increase in power, the airplane descends at 300 FPM. Of course, as more power is added, the airplane will stop descending. And, if you give it even more power, the airplane will fly level or even start climbing at 80 knots.

4. Press **P** to pause the simulation.

At this stage of your training, it's a good time to agree on how you'll control the airplane. Power (throttle position) should be your means of adjusting the rate of descent (what the VSI reads). The airplane's pitch attitude (controlled by the joystick) is your means of maintaining a specific airspeed. And, in a climb, you'll always use the maximum allowable power (usually full throttle) while adjusting the airplane's attitude with the joystick for the airspeed desired. Since you're familiar with the procedure for making climbs and descents, let's combine these with the skills we developed in tutorial two.

Things Are Turning Up

It's time to combine climbs and descents with turns. I want you to press **Ctrl+;** (that's the Ctrl key and the semicolon key) to reset this flight. You'll return to a condition of straight-and-level flight. Read the following steps all the way through before trying them, since this will take some concentration.

I want you to enter a 20-degree right banking turn. Once established, you will start a climb to 4,000 feet, and then roll into straight-and-level flight. Here's how you might do it:

1. Press **Z** to deactivate the autopilot.
2. Start your 20-degree bank turn.
3. Increase the pitch to a 13-degree nose-up attitude. Since you're in a turn, you'll need to use the attitude indicator's orange ball as the pitch reference.
4. Adjust the attitude slightly to give you the desired 80-knot climb airspeed, then trim to maintain this attitude.
5. When you approach within 50 feet of 4,000 feet (that's 3,950 on your altimeter) lower the nose and roll out into a straight-and-level flight attitude. (In case you're wondering, we'll use a 50-foot altitude lead when climbing or descending to any new altitude so as to prevent overshooting or flying through the target altitude.)
6. Then reduce power to a cruise setting of 20 inches of MP.
7. Once the airspeed stabilizes, trim for this attitude.
8. When you're done, press **P** to pause the simulation.

Ready? Give it a try.

Well, how did you do? Believe it or not, that wasn't necessarily a simple maneuver. Remember, the secret to going from one attitude to another (such as from *straight-and-level* to a *climb*) is to do it like a waltz: *Attitude*, *power*, and *trim*. You adjust the *attitude* to a known value that puts your airplane in the ballpark for a climb (13 degrees for a climb at 80 knots). Then you adjust the *power* (you'll climb with full power in this airplane). And finally, you provide enough *trim* to hold this attitude. *Attitude*, *power*, and *trim* is the secret when making any pitch change.

Time for a Turn Down

Now that we're at 4,000 feet, let's descend to 2,500 feet while in a left turn at 20 degrees of bank. And to make this a little more challenging, do it at 90 knots. Here's how it's done. (Don't do it till you've read through all the steps.)

1. Roll into a 20-degree left turn.
2. Reduce power to flight idle.
3. Lower the nose to an attitude that you suspect gives you an airspeed of 90 knots. Since three degrees positive pitch gives you 80 knots, perhaps you'll attain 90 knots at one degree positive pitch (a slightly lower attitude). Remember, because you're in a turn, you'll use the attitude

indicator's orange ball as the pitch reference.

4. When you're at 2,550 feet (a 50-foot lead above 2,500), put the airplane in the attitude for straight-and-level flight.
5. Increase power to a cruise setting of 20 inches of MP and trim when the airspeed stabilizes. *Attitude, power, and trim, right?*

Ready? Let's go. Press **P** to reactivate the simulation. When you're done with this exercise, press **P** to pause the simulation and stand by for your impromptu motivational pep talk.

You did it! You now know how to make climbs, turns, and descents as well as perform straight-and-level flight. Yes, you understand the basics. Now you need practice. I'm soloing you, cutting you loose to practice without using the autopilot. I want you to practice straight-and-level flight, climbs, turns, and descents alone and in combination with each other. Practice on your own before beginning the next tutorial.

Remember, you've learned the basics of moving the airplane through the air, but next we're going to learn all the little things that allow you to get it down on the runway. In fact, our next tutorial deals with flying at slower speeds, just like the speeds you'll fly at during a landing approach.



Reading the Altimeter

Reading the altimeter is very similar to reading a watch. I say this with caution knowing that some readers have been raised on digital watches and no longer know what it means when Mickey's little hand is on the 3 and his big hand is on the 12. Some may not even know which way Mickey's hands used to turn.

Figure 6 shows a typical altimeter found in most airplanes. It has three hands, which is how many you'll wish you had sometimes when things get busy in the cockpit.



Figure 6

The shortest hand points to numbers representing the airplane's height in tens of thousands of feet. The medium, thicker hand represents altitude in thousands of feet. And the long, thin hand represents the airplane's altitude in hundreds of feet.

The easiest way to read an altimeter is to read it just like you would read a clock. For instance, if Altimeter A in Figure 6 were a clock, what time would it read? Yes, it would read 3 o'clock. Since Altimeter A isn't a clock, it shows an altitude of 3,000 feet. The long (hundreds) hand points to zero hundred feet, and the medium (thousands) hand points to 3,000 feet.

If Altimeter B were a clock, what time would it say? It would read 3:30, or half past 3 o'clock. As an altimeter it reads half past three thousand or 3,500 feet. The long (hundreds) hand points to 500 feet and the medium (thousands) hand points between 3,000 and 4,000 feet. The altitude is 500 feet past 3,000 feet (3,500 feet). Not too tough, is it?

Try reading Altimeter C like a clock. What time is it? Yes, it looks like it's 3:00, but take a closer look at the very short (ten thousands) hand. This hand points a little past a value of 1, meaning you need to add 10,000 feet onto the value shown by the altimeter's medium and long hand. Altimeter C indicates an altitude of 13,000 feet.

Tutorial 4: Slow Flight

Okay, here's the deal. I'm going to stick you in an airplane that's capable of doing 120 knots—twice as fast as the cars on the freeway below—and I have only one request: I want you to fly as slow as you can. Sounds reasonable, right? Not really. This is like asking an Indy race driver not to take his machine out of first gear. There is, however, a good reason for flying slowly.

The practice of slow flight is the proving ground on which you prepare for aviation's biggest event: landing. After all, you don't want to land at cruise speeds, because airplanes weren't designed to maneuver on the surface at high velocities. You don't want to burn the tires off the rims, do you? (Just kidding, but it's not far from the truth.) In general, the slower you are upon touchdown, the easier it is to control the airplane on the runway.

Additionally, airplanes can't fly too slowly, or they'll cease flying and start falling (this is called *stalling*, but it has nothing to do with the engine stopping, as you'll learn later). That's why I want you to feel comfortable operating at slower speeds so you'll know where the dangers are. And, as you'll eventually discover, it's sometimes necessary to follow slower airplanes. You need to know how to adjust your airspeed to prevent chewing up their tail feathers. These are only a few of the reasons we practice slow flight. It's an important maneuver. Let's get started.

Guess where we're going? You got it, Europe. "Oh no, not again!" Yes, you must redeem yourself. Many Italians think a strike by your landing gear put the "lean" in the Leaning Tower of Pisa. You must show them you're a masterful pilot by slow-flying your airplane over their country. So, let's reactivate our European vacation.

1. On the **Flights** menu, click **Select Flight**.
2. Choose **Tutorial 4, Situation 1**.
3. Click the **OK** icon.
4. Press **Z**, then **Ctrl+Z**, then **Ctrl+V** to activate the autopilot's altitude hold and wing leveler.
5. Let's also add the *Spot Plane View*: click the **Views** menu, then point to **New View**, then click **Spot Plane**.
6. Drag the new window to the upper-left corner of your screen, if it's not there already.
The airplane should be established in straight-and-level-flight at 110 knots at 3,000 feet above sea level.

Slow Flight in Action

In Tutorial 3, we mentioned that *thrust* (produced by the engine-propeller combination) balances *drag*, which acts opposite to thrust and is the air's resistance to a moving airplane. Our present power setting produces enough thrust to pull the airplane through the air at 110 knots at a pitch attitude of approximately 4 degrees nose up, as seen on the attitude indicator. Notice how the airplane looks from the side (Spot View) as shown in Figure 1.



Figure 1

Look at the *Spot Plane View*. Compared to the slight nose-up pitch attitude for straight-and-level-flight at 110 knots, it looks like your airplane is popping a wheelie.

3. Increase the power to 20 inches of MP and observe the airplane's reaction.

An increase in power allowed the airplane to fly faster and at a lower pitch attitude.

4. When the airplane accelerates to 110 knots, reduce power to 17 inches of MP and press **P** to pause the simulation.



Figure 2

What's going on here?

You're in a Relationship

You've just witnessed an important relationship between airspeed and the angle at which the wing meets the wind. To better understand this, I think we need to go to the movies. This is a rerun (you did it for your homework in the last tutorial) but I want you to watch it again.

Click the **Help** menu, then click **Homework**. Under Tutorial 4, select *How Wings Work* and play the video.

As you see, wings develop lift when air passes over them. The wing separates the airflow into two streams: one stream flows above the wing; the other, below. Air flowing above the wing undergoes an

artificial curve induced by the wing's *engineered shape* (Figure 3). Air flowing below the wing's *flat-bottom* surface remains relatively unbent as it moves aft.

Because air flowing over the wing bends, it is forced to travel a greater distance than the air flowing underneath. Because it travels a greater distance, the bent air must move faster on its journey over the wing. It's this relative increase in wind speed above the wing that lowers pressure and produces lift.

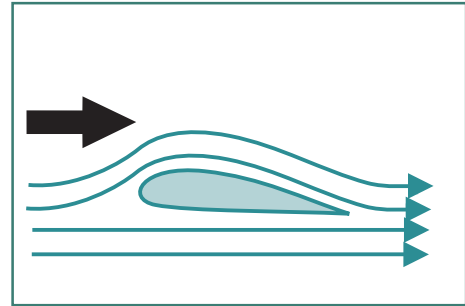


Figure 3

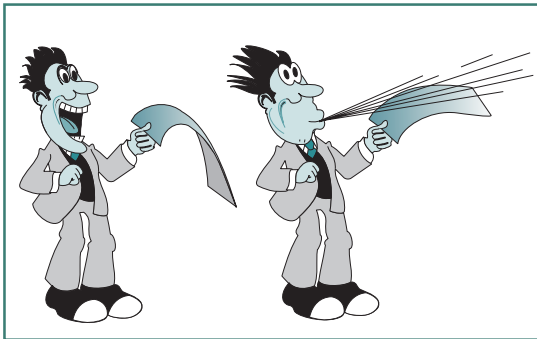


Figure 4

It's test tube and Bunsen burner time again; let's try another experiment.

1. Take a piece of writing paper and hold it in such a way that the top surface is curved downward as shown in Figure 4. With a little imagination, you can see how the top of the bent paper is similar in appearance to the wing's upper curved surface.
2. Blow over the top of the paper.

What happens? The paper should rise upward. (Do this for kids sometime. They'll think you're magic.)

Increasing the velocity of air over a surface *reduces* the atmospheric pressure on that surface. This means you have low pressure above the wing and high pressure underneath. Since high pressure always moves toward low pressure, the wing (which just happens to be in the way) is pushed upward in the process. Known as Bernoulli's (pronounced *Brr-NEW-lee*) principle, this effect is responsible for much of the lift produced by the wing (and explains the sightings of at least one or two toupees on windy days).

At a cruise speed of 110 knots, the wing's shape (its engineered curvature) produces enough lift to counterbalance the airplane's weight. The airplane maintains its altitude at a relatively low pitch attitude. When power is reduced, the airplane slows down, resulting in the airflow over the wing decreasing in speed. This, in turn, results in a decrease in lift unless we take corrective action to keep the lift constant. Remember, if lift is less than weight, the airplane will be unable to maintain altitude. What do we do? We must increase the *angle of attack*.

Angle of Attack

The angle between the wing and the wind that blows on it is called the *angle of attack*, as shown in Figure 5.

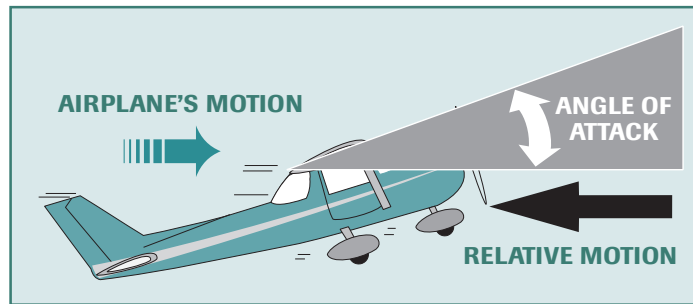


Figure 5

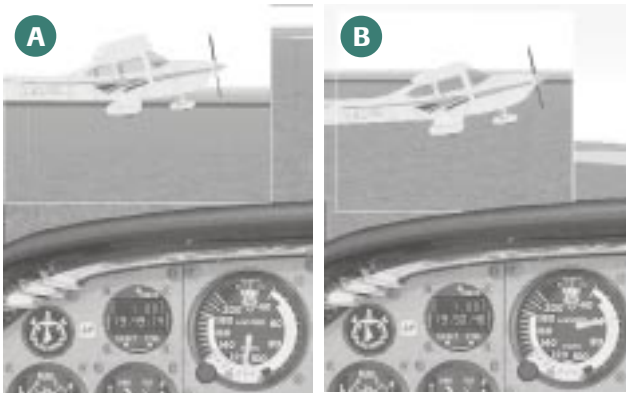


Figure 6

In cruise flight at 110 knots, the angle of attack is relatively small, resulting in a near-level pitch attitude, as shown in Figure 6A. When we slowed the airplane down, the autopilot, in order to hold altitude, increased the angle of attack by raising the airplane's pitch attitude, as shown in Figure 6B.

In cruise flight, the wing's engineered shape curves the air

enough to provide the necessary lift for flight. This allows us to fly at a small *angle of attack*. When the airspeed decreases, however, the wing's engineered shape can't bend or curve the air sufficiently to produce adequate lift. Therefore, we needed to *artificially* bend the air flowing over the wing by making the wing *attack* the air at a larger *angle*. A larger *angle of attack* imparts a larger bend or curve to the wind, causing the wind's speed to increase as it flows aft. This results in an increase in lift even though the airplane is flying at a slower airspeed.

At this point you're probably thinking, "Hmmm, instead of learning to fly, maybe I should try something simpler, like neurosurgery." Don't fret. You now have enough information to understand the process of slow flight. Do you see the relationship between *angle of attack* and *airspeed*?

As the airspeed decreases, you must increase the angle of attack to maintain altitude. In other words, to maintain level flight, you must increase the airplane's pitch attitude by applying rearward pressure on the joystick. At higher airspeeds, the wing's engineered shape produces sufficient lift for level flight at a near-level pitch attitude. Now you know why commercial airliners need large nose-up pitch attitudes on liftoff since their takeoff speeds are so low. Once the jetliner accelerates to its cruise speed, it flies along at a lower pitch attitude. Let's put our knowledge to practice.

A Demonstration by the Autopilot

For any given power setting, the airplane requires a specific angle of attack to maintain altitude (assuming all other variables remain the same: air density, weight, etc.). Let's assume that we're preparing the airplane for landing.

1. Return to the simulation and press **P** to resume straight-and-level-flight. The first thing we need to do is slow down to 80 knots while remaining in level flight. Let's see how the autopilot handles the controls during this process.
2. Reduce power to 14 inches of MP. (Remember, the autopilot is still active.)

Notice how the pitch attitude increased to approximately 8 degrees nose-up, as shown on the attitude indicator in Figure 7. From the Spot Plane View, you can see that the angle of attack has increased. The autopilot raised the airplane's nose just enough to maintain altitude (or keep the VSI and altimeter needles from moving) as the airplane decelerated. The selected power (14 inches of MP) was sufficient to keep the airplane in level flight at this pitch attitude.

Okay, suppose we want to return to cruise speed. Let's watch the autopilot do it.

3. Apply 20 inches of MP.
As the speed increases, the autopilot decreases the angle of attack by lowering the airplane's pitch attitude just enough to keep the altitude from increasing as the airplane accelerates to 110 knots.
4. When you reach 110 knots, reduce the MP to 17 inches.
5. Press **P** to pause the simulation.



Figure 7

Entering Slow flight

It's time for you to hand-fly this airplane and practice entering and leaving slow flight. Let's do this with the wing leveler active (altitude hold inactive) so you need to concentrate on only two variables: power and pitch attitude.

Let's suppose you're following another airplane as you're preparing to land. While maintaining straight-and-level-flight you must slow the airplane to 75 knots to keep from weed-whacking the airplane ahead of you. Here's the general procedure you should use for entering slow flight while maintaining altitude.

1. First, press **Ctrl+Z** to deactivate the altitude hold mode, then follow the sequence below.
2. Press **P** to activate the simulation.
3. Reduce power to flight idle (with experience you'll eventually learn the power settings for the speed desired and will reduce power to that value).
4. Raise the nose just fast enough to keep the VSI needle steady at zero (or the altimeter's hundred-foot hand steady).
5. As the airplane decelerates, apply a little nose-up trim to help maintain the nose-up pitch attitude (this is approximately 9 degrees nose-up pitch as shown on the attitude indicator).
6. When the airplane is at the desired airspeed, apply enough power to hold your altitude (around 13 inches). Use small adjustments in pitch to maintain the desired airspeed.
7. Make a final trim adjustment (if necessary) to maintain the pitch attitude that gives you the desired airspeed.
8. Press **P** to pause the simulation.

Leaving Slow flight

Let's suppose the tower controller wants you to increase your speed from 75 to 85 knots. How do you accomplish this? Simply reverse the process used to enter slow flight:

1. Press **P** to activate the simulation.
2. Increase power to a tad less than 15 inches of MP.
3. Lower the nose just fast enough to keep the VSI needle steady at zero (or the altimeter's hundred-foot hand steady).
4. As the airplane accelerates, apply a little nose-down trim to help maintain the desired pitch attitude (which is approximately six degrees nose-up pitch as shown on the attitude indicator).
5. When the airplane is at the desired airspeed, apply enough power to hold your altitude. Use adjustments in pitch to maintain the desired airspeed.
6. Make a final trim adjustment (if necessary) to maintain the pitch attitude which gives you the desired airspeed (85 knots in this instance).
7. Press **P** to pause the simulation.



Here's What You've Learned

So far, you've learned how to fly the airplane at several different speeds. At this stage of your training, you've learned that the throttle is best used to maintain your altitude or rate of descent. The airspeed is maintained by adjusting the airplane's pitch attitude. But what about when you're not trying to maintain a specific speed, such as in cruise flight? After all, in cruise flight, you don't maintain your altitude with throttle adjustments, do you? No, you don't. Here's why.

In cruise flight, you typically set the throttle to a power setting that won't harm the engine (for simplicity in teaching we'll assume that the application of full throttle in any of our simulations won't hurt the engine). Then, for the most part, you leave the throttle alone. You're not necessarily concerned with maintaining a specific airspeed in cruise flight. In this case, power is fixed at a specific setting and you make slight adjustments in pitch attitude to hold or modify your altitude. In slow flight, however, you'll use power to control your altitude, and pitch (joystick) to control your airspeed. This might be the opposite of what you'd guess. But as you'll soon see, this is the technique I want you to use when landing an airplane.

You're On Your Own

Now I want you to practice slow flight with the autopilot completely disengaged. Your objective is to maintain altitude and heading while trying to fly at various slow flight speeds of your choosing. At first, you'll find it a bit tricky to maintain airspeed and altitude while flying a precise heading. So establish priorities with these items. First, adjust pitch to attain the desired airspeed. Then, while maintaining that pitch attitude, make small adjustments in power to hold your altitude.

If you feel lucky, try slow flight in turns. But be careful in those turns. Remember from the second tutorial that a slight increase in pitch attitude was necessary to maintain altitude in a turn. Now that you know how to use the throttle, you'll want to add a little bit of power (perhaps one or two inches of MP) if necessary to help maintain altitude in a turn. The steeper the turn, the more power you'll need. Be generous with your use of trim in slow flight (although, it's best not to trim in turns since turns are transient conditions). This prevents the airplane slinking away from the desired pitch attitude if your attention is diverted from the instrument panel.

Above all, have fun. And that's what we'll continue to do in our next tutorial which, by the way, is about stalls.

Tutorial 5: Stalls

You did your homework, right? (Click the **Help** menu, then click **Homework**.)

Several years ago a farmer called the fire department to report that his barn was on fire. The fireman said, “Okay, we’ll be right over, but how do we get there?” With his country drawl the farmer replied, “Well, you still have that big red truck, don’t ya?”

That’s what psychologists call a communication problem. Flight instructors have a similar problem with the term *stall*. Some people think a *stall* is where the airplane is kept at night or what you do when you have a lot of aviation homework to complete. Seriously, though, many people think it has to do with the airplane’s engine faltering, since that’s how a car stalls.

Actually, it’s none of these; stalls have nothing to do with the engine at all. *Stall* is a term identifying what happens when the smooth airflow over the wings is disrupted, thereby preventing the airplane from developing sufficient lift for flight.

Sharp student that you are, I’m sure you’re thinking, “Why do I need to learn about stalls in the first place?” The sad fact is that pilots continue to accidentally stall airplanes. They may become distracted and let their airspeed get too slow for a given condition of flight or they get a little too aggressive on the flight controls. Either one can cause an airplane to stall. The solution to this dilemma is to recognize the onset of a stall and prevent it from occurring in the first place. And, if you accidentally enter one, know how to recover quickly with a minimum loss of altitude.

When stalls happen close to the ground, such as when approaching to land, it can be a real downer for the pilot. And I mean that both figuratively and literally. That’s why I’m here: to teach you to identify a stall, prevent it from happening and, if it happens, show you how to recover. So let’s get started.

First, a Little Theory

I’ve assumed that you’ve completed your homework assignment. If not, now is a good time to do so. No stalling here!

In Tutorial 4, I showed how, in order to maintain sufficient lift for flight, the wing’s angle of attack increased as the airspeed decreased. Perhaps you’ve wondered if there is a limit to how much the angle of attack could increase. After all, common sense suggests there are limits to all things. The ancient Egyptians had common sense limits, especially regarding the size of pyramids they could build (I think this is known as Tut-an-kommon sense). Wings have limits, too.

In the stall homework you observed air begin to burble over the top of the wing when the wing reached a very large angle of attack (about 18 degrees for most airplanes). The angle at which the air begins burbling, followed by the wings stalling, is known as the *critical angle of attack*.

Okay, here comes an idea that's like the biggest fish you ever caught—it's a real keeper. Since wings always stall when they exceed the *critical angle of attack*, you can recover from the stall by decreasing the angle of attack to less than the critical value. Now it's time to start stalling.

Stop Flying, Start Stalling

Let's hop on over to Hong Kong for some stall practice.

1. On the **Flights** menu, click **Select Flight**, then choose **Tutorial 5, Situation 1** and click the **OK** icon.
2. Press **Z**, then **Ctrl+Z**, then **Ctrl+V** to activate the autopilot's altitude hold and wing leveler.

The airplane will settle down into straight-and-level flight at 110 knots at 4,000 feet above sea level. Notice that I've also included the Spot Plane View in the upper-left corner of your screen.

The best way to understand stalls is to jump right in and see what they look like. Then I will talk about what you observed. For this demonstration, we'll forgo some of the formalities regarding the stall. Things like doing *clearing turns* before each stall (this allows you to observe other airplanes below you and keeps you from literally dropping in on them).

Additionally, because this is a simulator, we're going to have to exaggerate things a bit for you to see how stalls really work. In the actual airplane, you'd have many sensory cues to alert you to the onset of a stall. Like the airplane actually shaking a bit when the stall occurs. (If you find *yourself* shaking, it's time to cut back on those cappuccinos.)

Here we go.

Your First Stall

1. Press **P** to activate the simulation.
2. Press **Ctrl+Z** to deactivate the autopilot's *altitude hold*, leaving the *wing leveler* function active, and reduce the power to flight idle.
3. Slowly pull the joystick all the way back (towards you) and hold it there.
4. In the *Spot Plane View* window, you should observe the airplane pitch up (Figure 1), then stall (Figure 2), then pitch forward (Figure 3).



Figure 1



Figure 2



Figure 3

You're in the beginning of a stall when the stall horn activates (it's an audible cockpit warning that activates when the airplane is at or near the critical angle of attack). In the simulator, the word **STALL** appears in the spot plane view window. At that point:

5. Return the joystick to neutral and let the airplane cycle through two up and down pitch changes.
6. Press **P** to pause the simulation when done.

You've just witnessed the reason aeronautical engineers get paid the big bucks. They design airplanes to pitch forward after exceeding the critical angle of attack. And this allows most airplanes to recover from stalls all by themselves. Neat, huh?



Here's What You Observed

Pulling way back on the joystick caused the wings to exceed their critical angle of attack and stall. During the stall, airflow burbles instead of flowing smoothly over the top of the wing. This results in insufficient lift for flight, causing the airplane to pitch forward (if the baggage, passengers, and fuel are loaded properly in the airplane). This *automatic* nose-down pitch is somewhat like doing the Heimlich maneuver on yourself; the airplane reduces its own angle of attack to less than the critical value and regains its ability to fly.

If airplanes are built to recover from stalls themselves, why do you need to learn any of this? The problem is that pilots often do things which prevent stall recovery. You need to know what these things are so you know not to do them. Also, an accidental stall close to the ground requires that you know how to quickly recover in order to minimize your altitude loss. Let's try another stall, but this time, let's see what happens if you prevent the airplane from pitching forward on its own.

Doing the Wrong Thing in a Stall

We'll stall again but prevent the airplane from recovering from the stall. Since we're kind of low out there, let's reset this simulation before we go through the window of that downtown high-rise over there.

1. Press **Ctrl+;** to reset the simulation; then press **Z** followed by **Ctrl+V** to activate only the autopilot's wing leveler.
2. Press **P** to resume the simulation.
3. Reduce the throttle to flight idle, raise the nose, and slow the airplane to 70 knots while in level flight. Once done, lower the nose a little and begin a descent at 70 knots. Make sure you use trim for the descent.
4. Slowly pull back on the joystick and this time hold it all the way back (this is what you *shouldn't* do in real life!). The airplane will eventually stall.
5. While still pulling the joystick back, let the airplane pitch up and down once or twice, and then press **P** to pause the simulation.



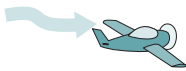
How do you know if you've decreased the angle of attack sufficiently? In a simulator, you should sense these things: the stall horn stops blaring, the word **STALL**



disappears from the screen, the airplane begins to fly again, the airspeed begins to increase, and the flight controls become



more responsive. If your instructor were onboard, his or her voice would also reduce in pitch and whales would no longer be inclined to beach themselves.



The airplane stalled and *remained* stalled with the joystick held full aft. It did not climb, not matter how hard you pulled on that joystick. Think about this carefully. You could remain stalled all the way to the ground while the joystick is pulled *full aft* (that's all the way back). Which doesn't bring you much joy, right? Holding the joystick full aft keeps the wing's angle of attack at or beyond its critical value. Unfortunately, this is what some pilots do after stalling an airplane.

Stall recovery requires that you do just the opposite of what caused the stall in the first place: you must release any back pressure on that joystick and move it forward until the wings are at less than their critical angle of attack.

With a few exceptions, this is the way pilots have *always* recognized stalls and recovered from them. You'll also want to add full power immediately after reducing the angle of attack. This helps accelerate the stall recovery process. Be careful not to let the nose pitch up as you add power. This might, once again, increase the angle of attack sufficiently to induce another stall.

Doing the Right Thing in a Stall

All right, let's see what it's like to do the *right* thing in a stall. Here's how we'll do it (remember, you're still in a stall from the last demonstration).

1. Press **P** to resume the simulation.
2. Lower the nose.

The proper attitude for recovery is subject to many variables, so we'll use a 5- to 10-degree nose-down pitch for simulator stall recoveries. You don't want an excessively steep nose-down attitude since it results in excessive altitude loss and airspeed increase.

3. Add full power to help with stall recovery.
4. When the airplane is no longer stalled (i.e., the stall horn stops blaring), raise the nose to climb attitude and establish climb airspeed.

For this demonstration, assume you're no longer stalled when the stall horn is no longer heard, and the airplane is once again controllable.

5. Press **P** to pause the simulation when you've completed a single stall recovery.

Be careful not to get over-enthusiastic when recovering from a stall, or you'll end up in another. This happens after you initiate a recovery from the stall, then pull too hard on the joystick before the airplane has time to accelerate to a more normal speed and attitude. We even have a special name for this kind of stall. It's called a *secondary* stall.

Departure Stalls

What happens if you stall with full power already applied? Let's say that you've just lifted off from an airport and are climbing with full power (as you normally do in this airplane). Suddenly you find a big bumblebee in the cockpit. You're distracted and forget to fly the airplane as you swat the critter with both hands. Of course, all your flailing in the air makes the cockpit look like the set of a Kung Fu movie as the airplane stalls. What do you do?

Well, Grasshopper, all the Kung Fu in the world won't help you now unless you do one thing: reduce the wing's angle of attack to less than its critical value. Once the airplane is no longer stalled, you can recover back to climbing attitude. Don't worry about touching the throttle since full power is already applied.

Here's how we'll do it.

Departure Stall Sequence

1. Press **Ctrl+**; to reset the simulation and press **Z** and then **Ctrl+V** to activate only the autopilot's wing leveler.
2. Press **P** to activate the simulation.
3. Establish a climb at 70 knots with full power. Make sure you trim for this condition.
4. Raise the nose high enough to exceed the critical angle of attack. This simulates the attitude the airplane may default to when you're distracted.

You'll know when the airplane stalls because the stall horn activates, the word **STALL** appears, and the airplane begins to pitch forward.
5. Recover from the stall by lowering the nose sufficiently to decrease the angle of attack.
6. When the airplane is no longer stalled, raise the nose and resume your climb. Be sure to avoid a secondary stall by not raising the nose too fast or raising it beyond a normal climb attitude.
7. Press **P** to pause the simulation when finished.

There you have it: your first introduction to the aerial entertainment theme park known as *Stall World*. The only problem, however, is that you didn't visit one corner of the park called *Reality Land*. Here's what you missed:

I didn't lie to you when I said that airplanes stall because they exceed their critical angle of attack. I just didn't tell you that this can happen in any *attitude*, at any *airspeed*, and at any *power setting*. Time now for more truth.



In reality, if the airplane were pointed straight down and you pulled back hard enough on the controls, the airplane would stall. Of course, we wouldn't do this in the actual airplane (even if it was a rental). Remember, this is a simulator. We can do things you'd never dream of doing in a real airplane. It's like visiting Fantasy Land in that we're not exposed to great risk in the demonstration. So, let's take advantage of our technology and see what others only talk about and never actually do.

Trouble in Fantasy Land

Here's how you'll demonstrate a stall with the nose pointed nearly straight down (something we only want to do in a simulator).

1. Press **P** to reactivate the simulation.
2. With full power applied, pull the airplane into a near vertical nose-up attitude until the airplane is near, but not yet in, a stall. (Remember, all these examples are highly exaggerated! You're not going to be doing this in a real airplane.)
3. Immediately push the nose of the airplane over until it's pointed straight down toward the ground. At this point, pull back *abruptly* and *fully* on the joystick until the airplane stalls. (You don't want to do *this* in a real airplane, either! If you do, your non-simulated passengers won't be *simulating* heart attacks.)
4. The airplane is stalled and it's pointed nearly straight down towards the ground. You can recover by doing what doesn't come naturally: move the joystick forward enough to reduce the angle of attack to less than critical. Then, after recovering from the stall, pull back, but only gently to prevent entering a secondary stall. Of course, in real life we'd want to avoid excessive indicated airspeeds.
5. Press **P** to pause the simulation.

I wanted you to see this for a very important reason. It's a common misconception to think that stalls only occur at slow speeds. The beginning of the green arc on the airspeed indicator is the speed at which this airplane stalls without flaps extended (more on flaps during the tutorial on landings). It is, however, just as common for pilots to stall at higher speeds.

For instance, if you pull back too hard to correct for an excessive rate of descent while on final approach, the airplane might stall at a higher speed. The difficulty here is that you must recover from the stall while fighting the almost *instinctual response* to pull the nose up to climb. At this point, pulling up won't help you. You've already seen why. You must actually go against your natural inclination and push forward slightly (or decrease the back pressure applied to the joystick) to reduce the angle of attack to less than its critical value. Simultaneously adding power also helps assist in the stall recovery. Then, and only then, will the airplane recover from a stall, at which point you can select a nose-up pitch attitude and climb.

One of the key things to remember about stalls is, if you sense one coming on (an *imminent* stall), you do the things necessary to prevent a *full* stall from occurring. This is just common sense. In other words, if you hear the stall horn (which typically activates 5 to 7 knots above a stall) you immediately apply stall recovery procedures.

If you understand this point, you understand the most important thing about stalls. But, whoa, Lone Ranger! One more thing to do before I take you into the traffic pattern to practice takeoffs and landings. Stalling at higher than normal speeds is something you want to avoid. That's why we'll practice steep turns in our next tutorial. These turns show us how the airplane handles (or how it doesn't) in steep banks or when applying a lot of back pressure on the joystick.



One additional note: stalls are serious things for pilots. There's a lot more to them than can be shown on a simulator. If and when you decide to take flight training in an actual airplane, your instructor will cover all the intricacies we can't even begin to cover here.

Tutorial 6: Steep Turns

I like steep turns! They're fun, challenging and, in many cases, a good test of a pilot's ability to recognize the limits of airplane performance. And, if you play Microsoft® Combat Flight Simulator, they're useful to get away from a bandit who is trying to shoot your tail off!

Steep turns (those typically done between 45 and 55 degrees of bank) are used to develop flight proficiency. Practice them often and you'll find yourself becoming smoother on the flight controls. Steep turns also help you learn to handle the natural division of attention that accompanies such a high-performance maneuver.

There's another benefit of which you may not be aware. Steep turns demonstrate that airplanes have limits and that exceeding those limits has a cost. Making too steep a turn may result in a stall. This isn't necessarily dangerous if you're several thousand feet above the ground. But don't try making a steep turn to align yourself with the runway when you're at a low altitude with insufficient airspeed. This is a sure-fire way to get into a new line of work, like geology. You'll really get into it—about *six feet* deep into it.

Steep Turn Aerodynamics

First, a little review. In an earlier tutorial you learned that banking the wings allows lift to pull the airplane sideways. The airplane turns because some of its lifting force acts in the horizontal direction.

Of course, once an object is set in motion, it wants to remain in motion. A fellow named Newton said that (that's Isaac, not Wayne). When an airplane turns, its entire mass still wants to maintain its original direction. That's why you feel yourself forced down in your seat on a roller coaster when the track changes direction. The roller coaster is changing directions but your body wants to continue moving straight ahead. Coupled with the downward pull of the earth, you feel like you'll go right through the roller coaster's seat.

While airplanes don't fly on tracks, you'll feel a similar force that seems to pull you down in your seat when making a steep coordinated turn. The steeper the turn, the greater the seat-pulling force. This force is sometimes called the *G-force* (or *load factor*). The "G" in G-force is derived from the word *gravity* and has nothing to do with the sound passengers make when they feel themselves forced down in their seats during steep turns: "Gee!"

G-force is a predictable force for all airplanes. Figure 1 shows a graph representing the increase in G-force for a given bank. The example shows that in a 60-degree bank you and the airplane will feel a G-force of 2 (2 *Gs*). In other words, you and the airplane *feel* like you weigh twice as much as you normally do. Imagine that. You experience an apparent increase in weight, all without letting even one bag of greasy fries slip past those disciplined lips of yours. Of course, you can lose that weight by rolling out of the turn and back into straight-and-level flight where you'll feel a G-force of 1—just like you feel right now (which is determined by how many fries you've eaten up till this point in your life).



Here's the catch. If you and the airplane feel heavier because of an increase in G-force, then you, the pilot, must compensate for the artificial weight increase. You must increase the airplane's lift if it is to keep flying. Without compensating for this, the airplane won't be able to maintain altitude in a steep turn. It may even stall. And you don't want to become known as a pilot who stalls whenever he or she makes a steep turn. Imagine the kind of nickname you'd get for that: Imelda Impact, Steve Splatdown, or Chris Crater.

Increasing lift in a steep turn means you must increase the angle of attack by applying back pressure on the joystick. Lift must equal weight—*real* weight or *apparent* weight—if the airplane is to remain flying. That's why steep banks require large angles of attack to produce the lift necessary for flight. You see what's coming, right?

If you make too steep a turn, the airplane may reach its *critical angle of attack* before producing sufficient lift for flight. The airplane will stall. Now you're forced to recover from the stall before you can continue flying.

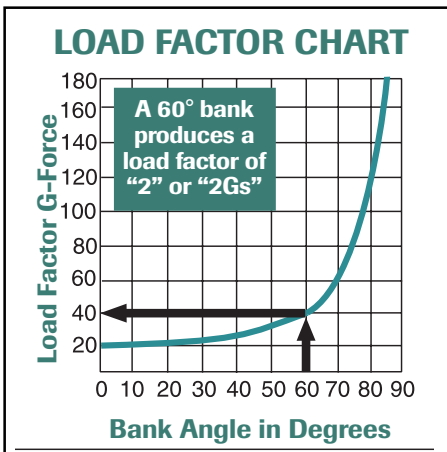


Figure 1

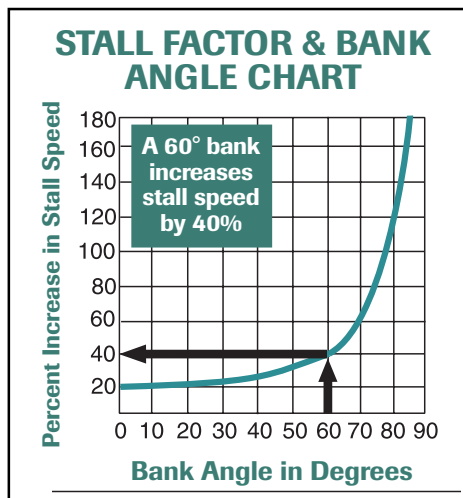


Figure 2

You've just learned that an airplane's stall speed increases in a steep turn. While you may stall at 50 knots in straight-and-level flight, you may need 70 knots to keep from stalling when turning steeply. Figure 2 is another graph, which allows you to predict this increase in stall speed based on an increase in G-force.

For example, in a 60-degree bank (Figure 1), the airplane and its contents experience 2 G's (that's a G-force of two). Figure 2 shows that 2 G's gives you a 40% increase in stall speed. Therefore, an airplane stalling at 50 knots in level flight will stall at 70 knots in a 60-degree bank (40% of 50 added to 50).

Here's what this means to you. If you're planning on doing a steep turn at 60 degrees of bank, you'd better have an airspeed of at least 70 knots if you want to avoid a stall. Isn't that amazing? You made a prediction and didn't need to peek at a magic crystal ball, throw bones, or read tea leaves (you can save these things for weather predictions).

That's why you'll need to add additional power when doing steep turns. In most cases this provides the necessary increase in speed which helps prevent a stall. Of course, if your airplane doesn't have a big engine, it may not be able to produce the thrust necessary to keep the speed high enough to prevent a stall during a steep turn. Well, I remember going to a doctor and saying, "Doctor, it hurts when I do this!" Her advice, of course, was "Don't do that."

If you don't have sufficient power, then you can't go around making really steep turns. And the author's decision is final on that.

Okay, enough theory. Time for a little action. Let's practice a few steep turns. You'll do your first turn at 45 degrees of bank. This won't cause a large increase in G-force, so the turn will be a little more manageable.

Your First Steep Turn

This time you're going to sunny Southern California to practice your maneuver. You'll like it. It's a crazy place. (I can say that; I live there.) In fact, if aliens from space landed in Hollywood, it's doubtful that you could tell. That's part of its charm.

1. On the **Flights** menu, click **Select Flight** and choose **Tutorial 6, Situation 1**, then click the **OK** icon.

The airplane should be established in straight-and-level flight at 110 knots at 3,000 feet above sea level. (You can see the Hollywood sign in the distance. And it's pretty tough to see anything at that distance in Los Angeles.)

2. Click **Views**, point to **New View**, then click **Spot Plane** to add the Spot Plane View.



Figure 3

You're starting out as shown in Figure 3. Your airspeed is 110 knots, your attitude is about 3 degrees nose up and your MP is about 17 inches. As you do the steep turn pay attention to the airspeed and attitude. Notice what happens to these. To make the first steep turn less complicated, you won't add any power.

I can't fool you, can I? Oh well, you caught me. Yes, you're doing an experiment again. So, Doc, get that white lab coat on.

Here's what I want you to do:

3. Press **P** to activate the simulation.
4. Note your present heading, using the orange heading marker at the top of the heading indicator as a reference.
5. Enter a steep turn at 45 degrees of bank (Figure 4).

Remember from Tutorial 2 that you're in a 45-degree bank when the small orange wings are parallel to the second white diagonal line in the lower half of the attitude indicator.



Figure 4

6. While holding the bank steady, adjust the pitch on the attitude indicator until you find an attitude that allows you to hold your altitude. To compensate for the increase in G-force, you'll need to increase the angle of attack by applying rearward pressure on the joystick.
7. When you're established in the turn and the altitude and bank are steady, press **P** to pause the simulation.

Don't worry about technique right now. You want to examine the aerodynamics first, and then we'll talk about the art of making turns.



Figure 5

What This Means to You

You should see a panel similar to that shown in Figure 5. It appears that you need a 6-degree nose-up attitude to hold your altitude in this turn. Since your angle of attack increased, more of the wing's underside is exposed to the air stream. This creates more lift—but also more drag. Thus, the airplane slows down a bit, as shown on the airspeed indicator.

The Tough Part

Here's where pilots often get themselves into trouble. When maneuvering for landing with power at idle, they make steep turns to align themselves with the runway.



Given their slow speed and steep bank, the airspeed and stall speed converge. In other words, while in a steep turn, the stall speed increases because of increasing G-force and the airspeed decreases because of increasing drag.

When the airspeed and stall speed meet, the airplane stalls. If this happens close to the ground, it's a real bad deal.

You'll often hear this type of stall called an "accelerated" stall. It's accelerated because of the high G-force caused by a steep turn.

Your experiment reveals that a steep turn with a constant altitude is accompanied by a decrease in airspeed. Coupled with an increase in stall speed, you may find yourself caught between the proverbial rock and a hard place if you're not careful.

As the stall speed increases and the airspeed decreases, the two may eventually meet. What happens then? Yes, the airplane stalls. How might you prevent this in a steep turn? Try adding power to prevent airspeed loss. Let's try this. Once again, don't worry about making beautiful steep turns yet; ugly ducklings are fine for right now. Hack your way through it, and I'll teach you the proper steps to the dance in a bit.

More Power to You

Start from the steep turn you were in prior to pausing the simulation.

1. Press **P** to reactivate the simulation.
2. Maintain the 45-degree bank in which the airplane is already established.
3. Add full power.
4. Once the bank and altitude are established, press **P** to pause the simulation.

Notice that the increase in power allowed you to maintain approximately 110 knots.

There you have it. A nice steep turn without a decrease in airspeed. But suppose the turn is really steep? Let's say it's at 60 degrees of bank. As we've already discussed, at this bank angle, your stall speed increases from 50 knots to 70 knots. The question is, "Do you have enough power to keep the airspeed above 70 knots in a 60-degree bank turn?" You won't know until you try another experiment. Put that lab coat back on. Here you go.

2 G or Not to G

Start from where the simulation is paused.

1. Press **P** to reactivate the simulation.
2. While at full power, increase the bank to 60 degrees.

You'll find that you'll need a large increase in angle of attack to maintain altitude. Be generous with that pull on the joystick.



Figure 6

Your airspeed will decrease to approximately 90 knots, as shown in Figure 6.

3. Make a couple of circles to get the feel of a *really* steep turn.
4. Choose a heading to roll out on, and bring the airplane back to level flight.
5. Press **Z**, **Ctrl+Z**, **Ctrl+V** to reactivate the autopilot.
6. Reduce power to 17 inches of MP.
7. Let the airplane return to straight-and-level flight, then press **P** to pause the simulation.

A Touch of Class Before You're Out of Gas

One secret to making a good steep turn is to have a *predetermined* idea of the *attitude* necessary to hold altitude in that turn. While there are many variables affecting this, you can still approximate it. Normally, you'd also use outside visual references while doing steep turns in the actual airplane. This allows you to keep a lookout for other airplanes as well as identify the airplane's attitude. Using outside visual references for steep turns, however, is a little tough to do in a simulator, so you'll focus on the attitude indicator instead.

Take a look at Figure 7. This is the approximate attitude necessary for a turn at 45 degrees of bank. As you roll into the turn, progressively increase the pitch until reaching a 6-degree nose-up attitude. Then use the altimeter to determine what type of *small* pitch correction is necessary to hold altitude. You can also use the VSI as an additional source of information if you like. The secret is to make *small* corrections and always keep an eye on your attitude.



Figure 7

Overcorrection is sure to send you wandering all over the sky as you try returning to your assigned altitude. A steep turn is considered acceptable by private pilot standards when the following things are all true:

- Your altitude doesn't vary more than 100 feet.
- The heading on rollout is within 10 degrees of the direction you started with.
- The bank varies no more than 5 degrees.
- The airspeed remains within 10 knots of the entry speed.

Now you know why steep turns develop and test your skill at handling distractions. Let's try a steep turn (45 degrees of bank) from a heading of north and make two complete circles to the right (that's two 360-degree turns to the right).

Here you go:

1. Press **Ctrl+** to reset this simulation.
2. Press **P** to activate the simulation.
3. On your present heading, roll into a right turn and *gradually* increase the pitch to 6 degrees nose up.



Figure 8

Your pitch increase is proper when the altimeter's hundred foot hand remains *stationary* during the roll in. (You'll find that you don't need much increase in pitch until passing approximately 30 degrees of bank, because of *G-force* increase and loss of some *vertical* lift. Then you'll need to increase the pitch quickly, as shown in Figure 8).

4. Scan back and forth between the *attitude indicator* and the *altimeter*. If the altimeter hand moves up or down, return to the attitude indicator and make a 1- or 2-degree change in pitch to *stop* the altimeter needle's *movement* and return it to the desired altitude.

Don't make large changes in pitch. This is one of the biggest mistakes pilots make during steep turns.

5. Add power to maintain your airspeed within 10 knots of the entry speed.
6. If the steep turn starts to get away from you, go directly to the attitude indicator and establish a 6-degree nose-up pitch and the proper bank. Then make small pitch corrections to return to the assigned altitude.
7. When you're within approximately 20 degrees of your assigned heading, look at the attitude indicator and roll back to the attitude for straight-and-level flight.
The secret to a good rollout is sensing when to release the back pressure on the joystick that you held during the turn.
8. Reduce the power to 17 inches of MP after the rollout is complete.
9. Press **P** to pause the simulation, put a dollar in the nearest soda machine, and have a cold one. You've earned it!

Congratulations! That's your first *official* steep turn.

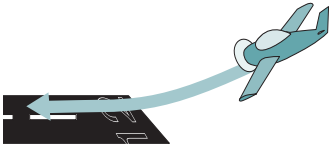
Did you notice that pulling back on the joystick increased the bank a little? That's why you must be careful not to let the bank increase during a steep turn. This is a rather common occurrence when applying back pressure on the joystick.

Additionally, at steep bank angles, airplanes have a natural tendency to steepen their bank without the pilot doing anything to cause this. Be prepared to compensate for this with aileron pressure, if necessary.

Have you noticed that you didn't trim for the steep turn condition? Well, you only use trim to hold the controls in one place for a long time. So since steep turns are transitory, trim isn't normally used. Besides, steep turns help you to recognize the onset of an *accelerated stall*. In the actual airplane, you can feel yourself being forced down in the seat by increasing G-force. You can't feel this in a simulator. Therefore, you must rely on the back pressure you're applying to the joystick to warn you of an approaching stall at higher airspeeds. So, there's another good reason not to trim in steep turns.

You're now qualified to try steep turns at larger banks. Go all the way to 55 degrees, which is the bank required for commercial license certification. Roll into and out of the turns while holding altitude within 100 feet, airspeed within 10 knots, and rollout headings within 10 degrees of the entry direction. Have as much fun as you can. Why? Because it will all pale in comparison to the fun you're going to have as you practice landings in our next tutorial.

Tutorial 7: Landings



We're going to approach this tutorial a little differently than I would in an actual airplane. I plan on teaching you how to land before teaching you takeoffs and flying the traffic pattern. That way, when I teach you to take off and fly a traffic pattern, you can actually land, instead of dropping to earth with all the grace of a butterfly overdosed on caffeine. Besides, something tells me that if we don't do landings now, you'll be out there practicing them yourself. So let me help you put your hand in the cookie jar.

You remember how to get to the homework, right? Click the **Help** menu, then click **Homework**. There. No excuses.

Landings are to a pilot what a beautiful painting is to an artist. When you look at Leonardo's *Mona Lisa* (or its famed counterpart the *Mona Larry*), you see a beautiful work of art. To pilots, a good landing offers the same satisfaction. I intend to show you how to paint that beautiful picture on any runway of your choice.

I always tell my students that airplanes will land themselves (well, almost). All the pilot has to do is nudge the machine toward the runway and twiddle with the throttle a bit. But who believes that? So, let me prove it to you. Close the door, strap on that seat belt, and let's go to where the rubber meets the runway as I show you how to land an airplane.

Landing Setup

From the **Flights** menu, click **Select Flight** and choose **Tutorial 7, Situation 1** in which we'll land at the Mojave airport. To aid you in these examples, I've activated the *wing leveler*. This is just like having me on board to keep you from overbanking the airplane while on final approach (a common problem for students). Nevertheless, you can still make shallow banks while it's active.

On your first try, you're going to land this airplane by doing absolutely nothing other than maintaining 65 knots in a power-off glide. Once the simulation starts, simply adjust the pitch to maintain your airspeed and fly that speed all the way to the ground. Yes, there's a runway ahead of you, but don't worry about landing on it. Remember, this is a simulation. No one's going to get hurt, except for a few simulated groundhogs who picked a bad time to raise their little periscopes.

Your First Landing

1. Press **P** to activate the simulation.
2. With power set to idle, adjust the pitch (about 10 degrees nose-up) to maintain 65 knots as shown in Figure 1.
3. Trim to maintain 65 knots airspeed and fly that speed all the way to touchdown.

In other words, don't allow the pitch to vary one bit. Do not attempt to raise the nose before touchdown. Watch what happens.

4. When the airplane is firmly established on (or off!) the runway, press **P** to pause the simulation. There you have it. The touchdown was a little rough, but you landed the airplane with only the help of the wing leveler. Even if the airplane didn't end up on the runway, it still landed successfully (conked groundhogs notwithstanding).
5. Press **Ctrl+;** to reset the simulation, then try the landing two more times.
6. Press **P** to start the simulation, and press **P** again when you're done. Then we'll talk.

Here's the skinny: the secret to a good landing is to keep from working too hard. This airplane almost landed itself. You hardly did a thing. That's the point. If the airplane's trimmed for the proper airspeed, there's little else to do other than keep the wings level and make small adjustments in power to vary the glidepath. Now for the details.

Landing Details

Why did I choose 65 knots as the speed to fly the final approach? (Final approach is the portion where you're lined up with the runway.) Pilots typically use a final landing speed that is 30% above the airplane's stall speed. In our case, the airplane's "no flap" stalling speed is 50 knots (this is where the green arc begins on the airspeed indicator). Thus, our "+30%" speed is 65 knots. Fly a little faster than that and the airplane will tend to *float* and resist touching down on the desired landing spot. Fly a little slower and the airplane is uncomfortably close to the stall speed. Controlling your airspeed is perhaps the *most* important quality for a successful landing.

Additionally, for our simulated airplane, 65 knots keeps the nose gear just a little higher in relation to the main gear as shown in Figure 2. The Cessna 182 is a *tricycle gear* airplane. It's designed to be landed on the two *main gear* wheels first, after which the *nose gear* is gently lowered to the ground.



Figure 1



Figure 2

Land on the nose gear first and you could invoke the scariest phrase in a pilot's vocabulary: *insurance deductible*. You could also *porpoise*, which is a bouncing action, not a tuna's playmate.

This simulated landing is a little too hard for my tastes. I'll eventually show you how to make softer landings. But first, let's see how power can change the flight path.

Playing with Power

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 7, Situation 2**.
The wing leveler is also active for this example. Here's what you're going to do.
2. Press **P** to activate the simulation.
3. Trim the airplane for a power-off descent at 65 knots. Maintain 65 knots all the way to touchdown (which will be short of the runway, but that's what I want).
4. Land short of the runway.
5. Press **P** to pause the simulation.

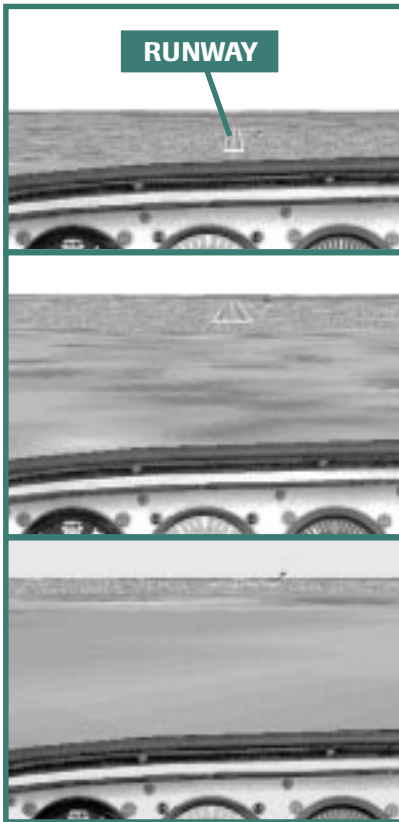


Figure 3

You landed short because I started you at a lower altitude than in the first example. Could you sense that you were too low on the approach and wouldn't make the runway? You can tell that you're descending too quickly when you observe the runway geometry changing as shown in Figure 3. First, the distance between the far end of the runway and the distant horizon decreases. Second, both ends of the runway appear to converge. Finally, you know you're too low when desert shrubbery appears at eye level and you skid your tires on a desert tortoise. Here's how to handle this.

Run this simulation again. Don't worry about being precisely on the runway centerline in this example. If you're off to the side in the dirt, that's okay for now. And use the wing leveler. You'll have plenty of time to practice without it later.

1. Press **Ctrl+;** to reset this simulation, then press **P** to begin (remember, the wing leveler is active).
2. Increase the power to approximately 12 inches of MP (which will change the glidepath as shown in Figure 4).
3. Maintain 65 knots as before.

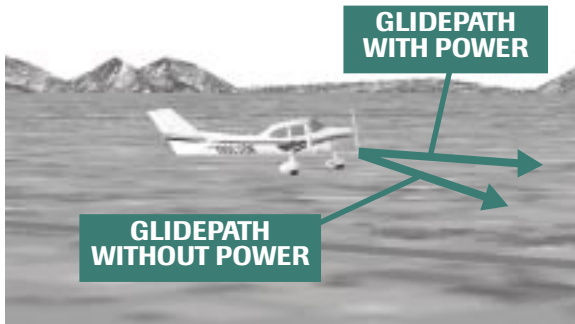


Figure 4

Any time power adjustments are made, you'll have to adjust the pitch to maintain the desired airspeed. In a previous tutorial you learned that, with power *fixed* at a specific setting, you'll need to lower the nose to go faster and raise it to slow down.).

Make sure you trim for this attitude, too.

4. After completing the simulation, press **P** and read on.

Glidepath Adjustment if You're Too Low

You'll immediately notice that your descent rate decreased a little after adding power as shown in Figure 5. Small adjustments of power make small adjustments in glidepath. Ideally, your glidepath should take you straight to the runway without numerous vertical bends or curves in the airplane's trajectory. Ah, if this were only a perfect world, eh? It's not. Therefore, pilots frequently adjust power and vary the glidepath as necessary to make it to the runway.

In fact, if you're too low, it's perfectly reasonable to add power and hold your altitude until you're in a position for a normal glide to the runway. Experience will tell you when you're in a position to reduce power for a normal glide to the runway. Of course, if you've misjudged and are really low, you should start a climb. Then, when you're high enough for a normal glide to the runway, you simply reduce power and commence the descent.

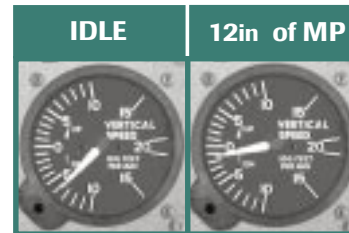


Figure 5

What do you do if you're too high? We'll talk about that in a bit. First, I want you to practice landing the airplane directly on the runway centerline. Why? Aiming for the runway's center reduces your chances of running wheels into soft sod or catching wing tips on snow banks. Either one may invoke that word, *deductible*.

A Landing on Your Own

1. Press **Ctrl+;** to reset the previous simulation.
Remember, in this simulation you begin at a lower altitude. Therefore, you'll need at least 12 inches of MP to make the runway. Here's what I want you to do.
2. Press **P** to activate the simulation.

3. Fly this approach at 65 knots all the way to touchdown.
4. Adjust power in small amounts to modify the glidepath for a landing beyond the runway numbers (the large white numbers painted on the beginning of the runway).

Even though the wing leveler is active, you can still make small (2-3 degree) bank changes with the joystick. Remember, the wing leveler prevents you from overcontrolling the airplane. Please keep it activated.

5. When you're over the runway, *slowly* reduce power to idle and maintain 65 knots until touching down (hold the attitude for 65 knots all the way to the ground). Make sure the wings are perfectly level before landing.
6. Press **P** again to stop the simulation when finished.
7. After touchdown, rerun this simulation at least two more times by pressing **Ctrl+;**

Feeling more confident about getting an airplane on the runway? Good. Now let's work on the finer points of landing. Then I'll show you how to get down if you're too high.

The Landing Flare

Until now you've flown the airplane onto the runway at a final approach speed of 65 knots. You could do this because, at 65 knots, the simulated airplane is in a minimally acceptable landing attitude (i.e., the airplane is pitched nose-up, putting the nose gear above the main gear). Additionally, the descent rate in this simulation isn't excessive at this speed and doesn't put undue stress on the landing gear. But this *isn't* the way it is with all airplanes. Nor is it necessarily this way with the same airplane when flaps are extended for landing. Therefore, to land properly *under all conditions*, you must learn to *flare* the airplane to ensure a soft, safe touchdown.



Figure 6

The landing flare begins at approximately 10 to 20 feet above the runway. At this point, raise the nose with a *slight* and *gentle* pull on the joystick. How much of a pull? Once again, that's a matter of experience. The objective is to "shallow" your descent angle and decrease the airspeed for landing. Now the airplane can settle onto the runway at a smaller descent rate and at a slightly higher nose-up attitude. This makes for a softer touchdown and keeps the nose gear higher than the main gear (Figure 6).

What if the airplane stalls during the flare? No problem, as long as it stalls a few inches above the ground. If you try to flare at 50 feet above the ground, plan on settling *into* the runway instead of *onto* it. (Ouch! Deductible!) Big difference. As you'll soon see, the flare requires a little timing but there's a lot of latitude in how it's accomplished.

A Flair for the Flare

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 7, Situation 2**.

Yes, the wing leveler is still active and I want you to use it for these demonstrations. (Trust me. It's important to do this.) Here's what I want you to do:

2. Press **P** to activate the simulation.
3. Make the approach at 65 knots using whatever power is necessary to reach the runway (about 12 inches of MP or so).
4. When you're approximately 15 feet above the ground, you're ready to begin your flare.

How can you tell your height? In the real airplane you have peripheral vision to help. Here, it's best to use the first appearance of the runway at the bottom of the Spot Plane View as an aid in determining this height (Figure 7). Since this airport's elevation is 2,787 feet above sea level, you can begin your flare when the altimeter reads 2,800 feet (this is a helpful hint when learning to land in a simulator, but we don't use altimeters to help us flare in the actual airplane).



Figure 7



Figure 8

5. At this position, gradually reduce any power, then gently raise the nose as shown in Figure 8. Let the airplane settle onto the runway at this attitude. Remember, left alone, this airplane will almost land itself.
6. Once you've touched down, gently release any joystick pressure to lower the nose gear onto the runway (in airplanes, the nose gear provides directional control after landing).
7. Press **P** to pause the simulation.
8. Rerun this simulation at least two more times by pressing **Ctrl+**:

Wonderful! You have a flair for the flare. Of course, there's somewhat of an art to perfecting this, but you can do it mechanically until you gain more experience. At flare height, gently raise the nose to a 14-degree pitch attitude on the attitude indicator (for this simulation). At this attitude the airplane will settle onto the runway. If your airspeed is too high, the airplane will balloon upward. Now you must add power, lower the nose a bit and descend to a point

where you can flare again. That's why it's *EXTREMELY* important to control your airspeed during the approach. If the airspeed is too low, raising the nose might not arrest the descent rate in the flare and the airplane may land very hard. You'll know it's hard when you leave more rubber on the runway than on the tire.

Now that you understand the flare, let's put it to practical use with a *full flap* landing. When do we use flaps? When the airplane is high and we need to increase our *rate* and *angle* of descent.

Flap over Flaps

Flaps doesn't refer to that thing a bird does to its wings to remain airborne. As you've learned in the homework assignment (you've done it, right?), flaps allow the airplane to descend steeply, without an increase in airspeed. You can apply flaps with the flap handle (Figure 9) or by pressing **F7** on your keyboard (you can retract them by pressing **F6**).



Figure 9

Since flaps alter the lift and drag characteristics of the wing, be ready to adjust the pitch to maintain the desired airspeed. Applying full flaps creates a lot of drag. They also cause the airplane to pitch up, requiring forward pressure on the joystick to maintain your airspeed. Let's jump right in there and see how this works.

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 7, Situation 3**.

Yes, the wing leveler is still active but you can still make small turns for runway alignment. Remember, the wing leveler is like having me on board to keep you from making excessive bank corrections while on approach.

This flight sequence places you higher on the final approach course. You'll have to apply full flaps to get down. Since the full flap stalling speed for this airplane is 40 knots (that's where the white arc begins on the airspeed indicator), you'll want to approach at a slightly slower speed.



Figure 10

For this simulation, let's use 60 knots. Here you go.

2. Press **P** to activate the simulation.
3. Begin flying the approach without flaps at 65 knots.

Notice how the beginning of the runway is disappearing below the top of the airplane's panel (Figure 10).

This is one cue that you're going to be high on the approach.

4. Press **F7** once to lower 10 degrees of flaps.
5. Apply a little forward pressure to correct for a flap-induced pitch-up, then readjust the pitch for a final approach speed of 60 knots. Don't forget to trim!
6. Apply the other 20 degrees of flaps in 10-degree increments by pressing **F7** two more times until 30 degrees of flaps are extended (that's full flaps for this airplane). As you press **F7**, make sure you adjust the pitch for 60 knots of airspeed.

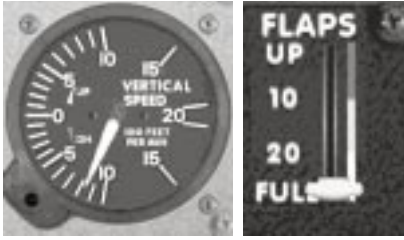


Figure 11

Notice how the runway disappearing underneath the airplane. The airplane has pitched forward a bit, allowing a better runway view. The descent rate has also increased (Figure 11) and the spot plane view shows the airplane at slightly less of a nose-up pitch as a result of flap application as shown in Figure 12. With flap application, the nose gear isn't as far above the main gear, an additional reason for the flare.

7. When you're at flare height, raise the nose from its present attitude to about 14 degrees nose-up pitch. Hold that attitude until touchdown. Since this airport's elevation is 2,787 feet above sea level, you should begin the flare at around 2,820 feet. Yes, you may indicate a stall as you touch down, but that's okay since you're just inches above the ground.
8. Press **P** to pause the simulation after you touch down.



Figure 12

Did you notice that the rate of descent is greater with flaps applied? That's why the flare needs to happen a little sooner when using flaps.

So why use flaps? They allow you to touch down at slower speeds, which means less energy to dissipate when stopping. Additionally, flaps come in handy when you're too high on approach. They are also useful when landing over an obstacle or when landing on a short runway.

Rerun this simulation at least two more times by pressing **Ctrl+;**.

After you gain a little experience with flap usage and glidepath control, run the simulation without the wing leveler active.

As you'll learn in Tutorial 8, pilots typically fly a rectangular traffic pattern in preparation to land at an airport. In your homework assignment on traffic patterns you observed the airplane turn from base to final. To give yourself enough time to trim and establish the proper airspeed for the approach, try to make your final approach at least 1 to 2 miles in length (preferably 2 miles). Short finals make it very difficult to properly prepare for the landing.

Yes, landings are exciting. And your success at them is based on airspeed control. Without the wing leveler active, you must have the airplane trimmed for the proper airspeed. If not, it's likely distractions will result in your airspeed needle swooshing all over like a saber at a Zorro convention.

The principles presented here apply to all airplanes, both big and small. Make it a point to remember the very first demonstration of this tutorial. Airplanes will almost land themselves if you maintain the proper airspeed and keep the wings level. The rest of the skill is polish that comes with practice. Doing little seems to mean a lot where landings are concerned.

You're now ready for **Private Lesson 2: Landing**. On the **Flights** menu, click **Lessons**. Go for it!

Next, we're ready to tackle takeoffs and traffic patterns. This will complete our basic visual flying lessons, and you'll be free to wander the skies alone in search of new adventures.

Tutorial 8: Takeoffs, Traffic Patterns, and Landings

Years ago a fellow flight instructor had a student who spent a few too many hours on the high seas. On his first flight lesson, he walked out to the airplane, loosened all three tie-down ropes, tossed them aside and yelled, “Cast off!” Hmmm, apparently he still had a little sea water on the brain.

Sorry, but airplanes don’t do *castoffs*, they do *takeoffs*. And once you’re in the air, you need a practical way to return to an airport in preparation for landing. It’s similar to bringing a boat in to dock. You don’t just barge into the herd of boats heading for port. You get in line and follow the other boaters and fishermen back home. This way they don’t get upset, which can lead to *fishcuffs*. And that will put the fear of *cod* in you.

This approach and alignment with the runway is called a traffic pattern—a rectangular pattern as shown in Figure 1. It has five major legs or segments:

- The departure leg
- The crosswind leg
- The downwind leg
- The base leg
- The final approach

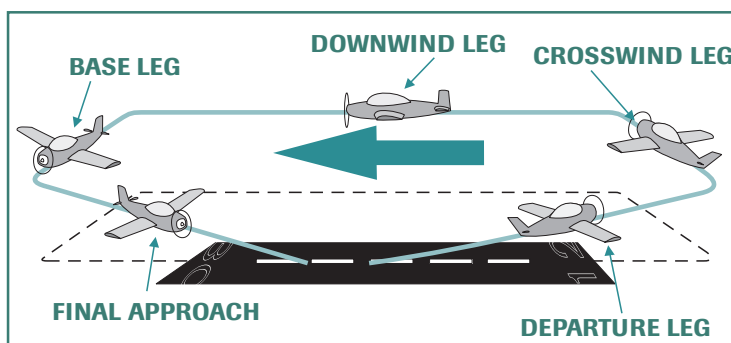


Figure 1

Let’s review each segment and discuss its purpose.

From the **Flights** menu, click **Select Flight**, then choose **Tutorial 8, Situation 1**, which puts you in beautiful Honolulu, Hawaii!

That’s right, baby! You’re in town for a little pattern practice and some R & R. You’re lined up with Runway 26 (that’s a direction of 260 degrees). In the bottom-left corner of your screen is an undocked Top-down View window. This will be your eye-in-the-sky to help you fly the pattern properly.

Here’s what you’ll do. Follow my directions as I take you around the pattern. At each segment, I’ll have you pause the simulation. Then I’ll talk about what you’re seeing. Let’s start with the *takeoff*.

Take Off, eh!

I've chosen runway 26 for takeoff. (We'll assume this runway is aligned into the wind.) This is also a good choice considering that everyone else is using the same direction for takeoffs and landings. This is not a good time to express your individuality.



Figure 2

On takeoff, your objective is to accelerate the airplane to a sufficient speed where you can raise the nose to climb attitude. This is sometimes known as *rotating*. I recommend rotating at least 5 knots above the airplane's *no-flap* stalling speed (which is 50 knots—the beginning of the airspeed indicator's green arc). When the airspeed indicator shows 55 knots, raise the nose to the attitude that results in an 80-knot climb (you'll learn what this attitude is from experience. In this case, it's 11 degrees nose-up pitch). Ready? Give it a try.

The Departure Leg

1. Press **P** to activate the simulation.
2. Apply full power and accelerate down the runway centerline as shown in Figure 2.
3. When the airspeed indicator shows 55 knots, rotate the nose to an 11-degree positive pitch as shown in Figure 3. (It takes a little extra initial backpressure on the joystick to unstick the airplane from the runway during rotation.) Be patient. The airplane will eventually accelerate to 80 knots at this attitude.



Figure 3

4. Keep the airplane headed in the direction of the little orange heading bug that I've placed over the runway's direction on your heading indicator. I placed this reference here for your convenience because I'm a very nice man (Figure 4).
5. Once you're established at 80 knots, press **P** to pause the simulation.



Figure 4

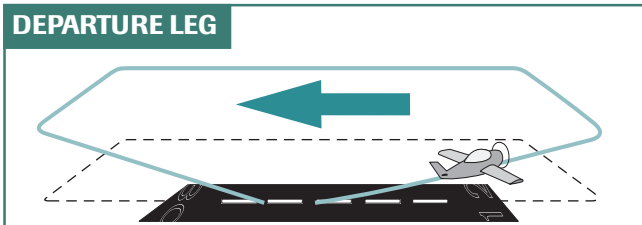


Figure 5

Congratulations! You're now on the *departure leg* (Figure 5) of the traffic pattern.

Crosswind Leg

Since you'll remain in the traffic pattern for training, you'll make a turn (most traffic patterns use left turns) to the *crosswind leg* (Figure 6). Make this turn when the airplane is beyond the departure end of the runway and within 300 feet of *traffic pattern altitude* (TPA).

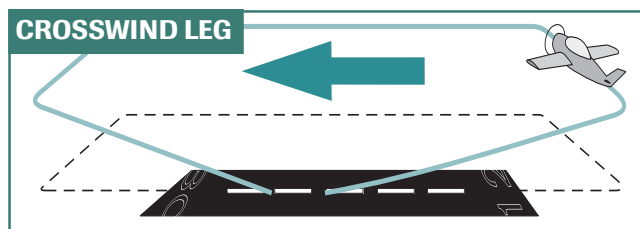


Figure 6

(TPA is the maximum altitude at which you'll fly the pattern.)

For this tutorial, I want you to fly the pattern for this simulation at 1,000 feet MSL, which puts you approximately 1,000 feet above the ground. (In this case, above the

water too, so watch out for flying fish.)

Since Honolulu has a long runway, it's likely that you'll reach TPA before arriving at the departure end of the runway. Therefore, continue to climb on the *departure leg* and level out at 1,000 feet. I recommend you use 16 inches of MP for level flight, which results in a speed of approximately 90 to 95 knots. (You'll see why I chose this speed later.)

1. Press **P** to activate the simulation.
2. Level the airplane at 1,000 feet, accelerate to 90-95 knots, then reduce the MP to 16 inches and trim.
3. Make a 90-degree left turn to heading 170 and hold 1,000 feet (I recommend 20- to 30-degree bank turns). Turn so the orange heading bug is on the right wing of the heading indicator's pictured airplane as shown in Figure 7.
4. Press **P** when you've made the turn and rolled into level flight.

This portion of the pattern is called the *crosswind leg* because the flight path is perpendicular to the runway and generally crosswise to the wind direction.



Figure 7

Throughout the *departure* and *crosswind legs* (and sometimes part of the *downwind leg* too), the airplane may continue to climb until reaching traffic pattern altitude. This depends on how closely you fly the pattern, as well as airplane performance, runway length, and the number of hula dancers you have in the airplane with you. Since you're using a long runway with a quick-climbing airplane, you'll reach TPA before turning crosswind.

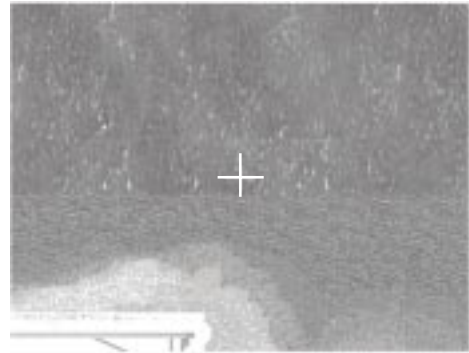


Figure 8

The Downwind Leg

As the airplane continues on the crosswind leg, another 90-degree turn is made. This places the airplane parallel to the runway, going opposite the direction in which it will land. This is called the *downwind leg* because you're now going *with* the wind instead of *into* it. Give it a try.

1. Press **P** to activate the simulation.
2. Begin your turn to the *downwind leg* when the runway is near the bottom of the Top-down View as shown in Figure 8.



Figure 9

3. Turn left to heading 080 and fly parallel to the runway. The orange heading bug should be at the bottom of the heading indicator's pictured airplane (Figure 9).
4. When you've rolled into level flight, press **P** to pause the simulation. Flying the *downwind leg* at between half a mile and one mile (for reference, the runway at Honolulu is about 2 miles long) out from the landing runway allows you to remain comfortably close to the runway. That way, in the event of an engine problem, you can glide to a safe landing on the runway instead of ending up in someone's lobster trap.



Figure 10

Preparing for the Base Leg Turn

You'll continue downwind until passing a point *abeam* (across from) the threshold of the landing runway as shown in Figure 10.

At this point you want to begin preparation for landing by applying 10 degrees of flaps. (Make sure you're below 95 knots when applying flaps. The end of the *white arc* on the airspeed indicator is the airplane's maximum flap extension speed.) Here's the sequence.

1. Press **P** to activate the simulation.
2. When you are abeam of the end of the runway, apply 10 degrees of flaps (press **F7** once).
3. Adjust the pitch with the joystick to hold altitude.
4. Trim the airplane as shown in Figure 11. (Remember, don't use trim to change the pitch. That's what the joystick's for. Use trim to take the pressure off the joystick once the desired attitude is established.)
5. Press **P** to pause the simulation once you're trimmed for level flight.



Figure 11

It's important to hold your altitude on the *downwind leg*. After all, airplanes are entering the pattern on the *downwind leg* and a premature descent from TPA could result in landing on someone (I think this is how biplanes were invented).

Base Leg

Now it's time for another 90-degree turn to the left. We call this *base leg*, and from here you have only one more 90-degree turn before you're on final approach. But where should you start your turn to base leg?

Assuming airplane traffic isn't a factor, it's convenient and practical to start your turn onto *base leg* when the landing threshold appears about 45 degrees between the wing (left wing in this instance) and the tail of your airplane (Figure 12). In other words, as you look out the left window, the runway's threshold appears to be at a 45-degree angle to the left of the wing (or midway between the wing and the tail).

This provides for a symmetrical, rectangular traffic pattern, instead of one having the shape of an enormous amoeba. Additionally, it provides you with enough distance from the runway to make a comfortable approach.

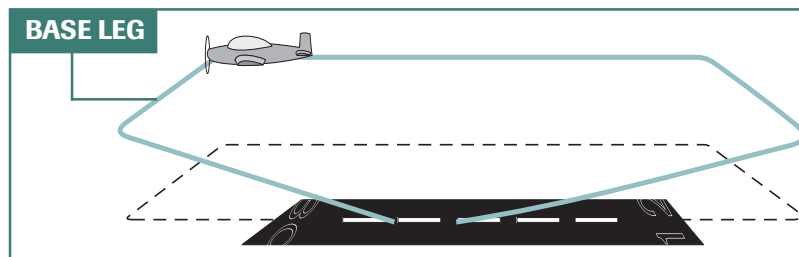


Figure 12

Base leg is a point of transition for landing. It's the place where important adjustments are made in the airplane's speed and landing configuration. This is why, even when you're not following other

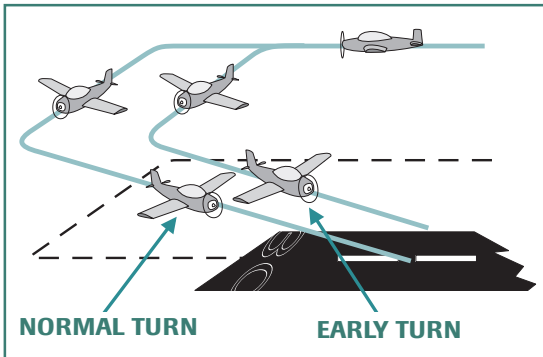


Figure 13

The descent for landing is normally started on base leg and continues throughout the final approach. Here's the sequence.

1. Press **P** to activate the simulation.
2. When the airplane's at a position similar to that shown in Figure 14 (use Top-down View), make a 90-degree turn to the left.
3. Roll out on heading 350 when the orange heading bug is on the left wing of the heading indicator's pictured airplane (Figure 15).
4. Reduce power to flight idle.
5. Establish a glide at 70 knots while on *base leg* (when possible, I like to use a speed 40% above the no-flap stall speed on base leg).
6. Make sure you trim for 70 knots!
7. Press **P** to pause the simulation.



Figure 15



Figure 14

Now you're ready to intercept the *final approach* leg.

Final Approach

The *final approach* (sometimes just called *final*) is a critical part of the landing sequence. Generally, a square turn from *base leg* onto *final approach* is best (Figure 16). This provides you with enough time to observe and

traffic (airplanes) on the downwind leg, you should avoid turning base too early, as shown in Figure 13. Things happen mighty fast as you approach the runway. You want to give yourself enough time to adjust your *airspeed*, *flaps*, and *glidepath*. That's why in the previous tutorial I recommended you give yourself a final approach length of a mile, preferably two (when possible).

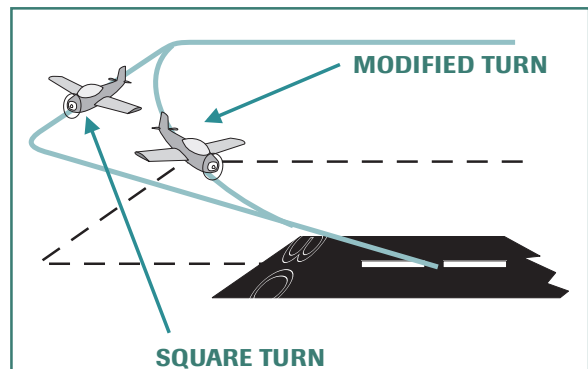


Figure 16

modify your airplane's descent path and alignment with the runway. During the final approach, the airplane's glidepath can be adjusted to make it easier for you to land on any selected runway spot.

When turning from base leg onto final approach, you have an additional opportunity to correct your glidepath. Let's assume that you are making a power-off approach from the base leg. After turning base, you retarded the power and commenced a descent. Your objective is to land on a specific spot on the runway. If you're too low, you can cut short the turn from the base leg to final approach as shown in Figure 17 (position A). Flying path 1 allows you to fly less distance during the descent, thus increasing your chances of landing on the desired spot. Path 2 is longer, and path 3 is a nice square turn onto final.

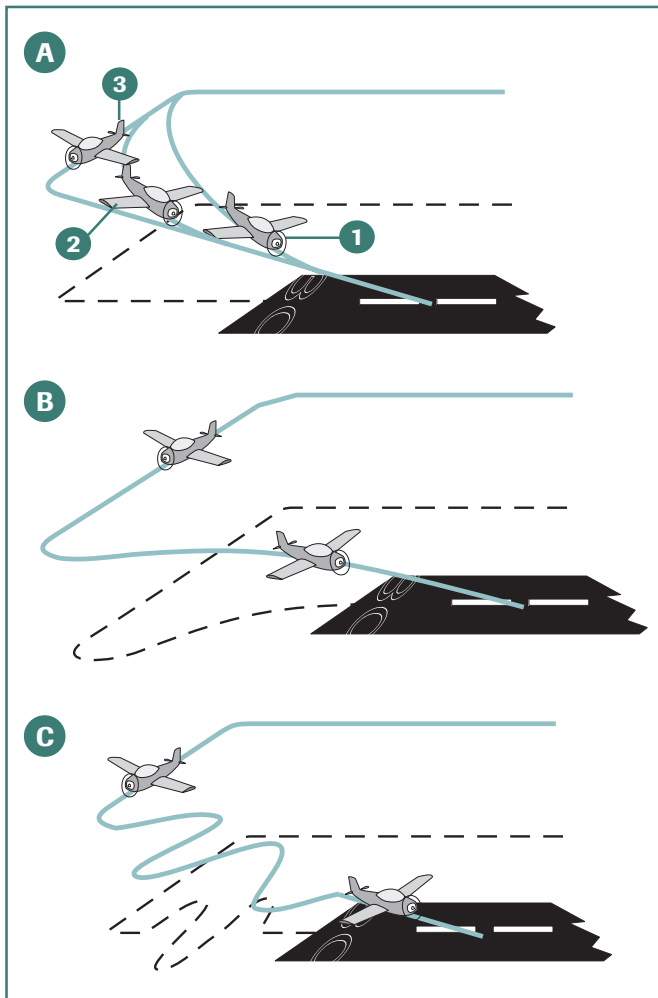


Figure 17

If you're too high, you can deliberately overshoot the turn onto final approach, giving you more distance to cover during your descent as shown in Figure 17 (position B). Another option is to *S-turn* on final as shown in Figure 17 (position C). *S-turns* are simply a series of alternating turns left and right of the direct glidepath. (They may make it look like you've had one too many mai tais!). Since the shortest distance between any two points is a straight line, anything you do to fly other than a straight line lengthens the trip. Assuming a constant rate of descent, taking the long way home will allow you to lose more altitude.

Let's complete this flight.

1. Press **P** to activate the simulation.
2. Continue on *base leg* until you can turn and align yourself with the runway centerline. Use the Top-down View to aid you in deciding when to turn final. (If you find that you've flown beyond the Top-down View's coverage of the runway, click your mouse once on any area of the Top-down View, and then change the scale by pressing your keyboard's **minus** [or **plus**] key (to the left of the BACKSPACE key). Then click the airplane's panel to ensure that the sounds you hear are from the cockpit, not one of the other views.)

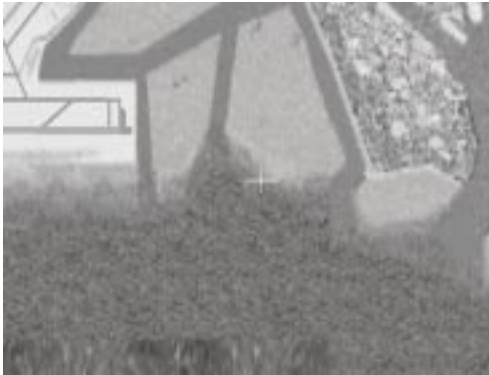


Figure 18

3. Figure 18 shows a good place to start the turn. (Remember, if you lose control of your airspeed, all bets are off for a good landing.)
4. Once lined up on final approach, establish a speed of 65 knots (if you decide to use 20 or 30 degrees of flaps, I recommend an approach speed of 60 knots). Don't forget to trim.
5. Now you're on your own and should be able to handle the landing from here.

Congratulations! You've landed the plane! This is a very important thing to do. As any pilot will tell you, all takeoffs are optional, but all landings are required.

Now that you've mastered the basics, it's time to climb into the plane together and review what you've learned. On the **Flights** menu, click **Lessons** and select **Private Lesson 3: Flying the Pattern**.

Tutorial 9: VOR Navigation



Figure 1

The Big Picture

VOR navigation requires two things: airborne VOR equipment like that shown in Figure 1 and a ground transmitting station which, from an altitude of several thousand feet, looks like an itty-bitty taco stand. The ground transmitter produces 360 electronic courses, each of which runs through the center of the station as depicted in Figure 2. Each course is aligned with a specific degree on the compass, with 0 degrees pointing north, 90 degrees pointing east, 270 degrees pointing west, and so on. Using your airborne VOR equipment, you can navigate on any one of these 360 courses while going directly to or from a VOR station.

Have you ever been so lost in your car that you actually considered pulling into a used car lot, selling the car, and using the money to purchase a new identity? If so, you were really lost. Getting unlost is easy, especially in a car. You simply drive into a gas station and ask for directions. You can't do that in an airplane. It attracts way too much attention, even if you buy gas and check the oil. Fortunately, you don't need to worry about getting lost in an airplane if you know how to use a little navigational device known as a *VOR*, which stands for *Very high frequency Omnidirectional Range*.

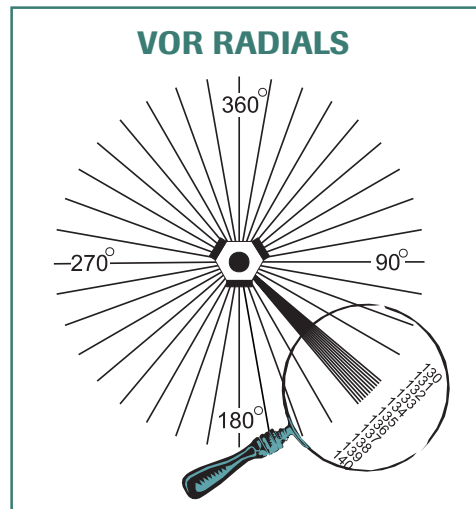


Figure 2

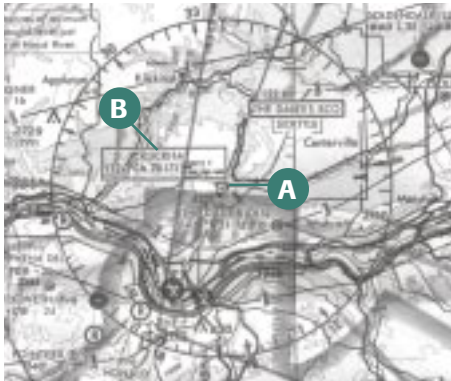


Figure 3

Of course, navigation to or from a VOR station does no good unless you know where that station is. Fortunately, pilots always fly with aeronautical sectional charts (Figure 3), which depict the locations of VOR stations. The VOR station (position A) is located in the middle of the compass rose, which has markings every 5 degrees, larger markings every 10 degrees, and numbers every 30 degrees.

A box in the vicinity of the compass rose lists the name, Morse code identification, and frequency of the VOR ground station (position B). In Figure 3, the VOR frequency is 112.3. Don't worry about the "CH 70". That's the frequency for military pilots.

Your VOR Equipment

Most airplanes have one or more VOR receivers on board; each one is connected to a VOR display that looks similar to the one shown in Figure 4. When pilots refer to "the VOR in their airplane," they are usually talking about the display, which consists of five main components:

- An *index* at the top of the display, which points to the selected course.
- A vertical needle (also known as a *course deviation indicator*, or *CDI*) that swings right or left.
- A *flag* in the form of a triangle that points up or down, or a red-and-white striped flag. A triangle pointing up represents a "TO" indication; a triangle pointing down represents a "FROM" indication; and a red-and-white striped flag represents an "OFF" indication. In this chapter, I'll use the words TO, FROM, and OFF to represent these three flag indications.
- An *omni-bearing selector (OBS)*—the knob you turn to select a course.
- A circular, moveable *compass card*, which is adjusted by rotating the OBS. (Rotating the OBS causes a different course value on the compass card to move to the *index*.)

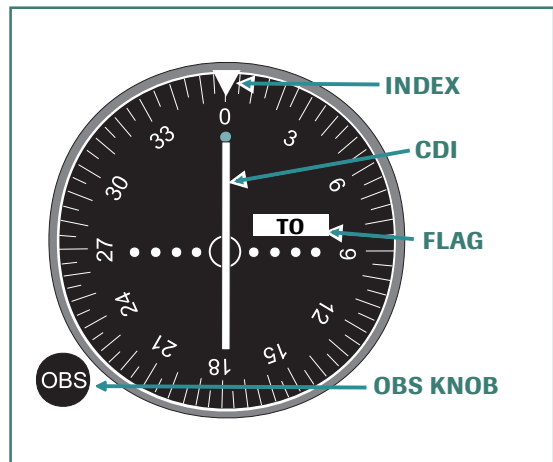


Figure 4

How to Navigate by VOR

To navigate by VOR, you must first tune and identify the VOR station on which you wish to navigate. With the appropriate frequency in the navigation receiver, you're ready to select a course to fly (a *highway in the sky*).

Rotating the OBS and placing a specific number above the *index* (Figure 4) allows you to select any one of the VOR station's 360 flyable courses. Let's suppose you select 360 degrees (or 0 degrees, they're the same thing) with the OBS, as shown in Figure 5 (position A). Your VOR display now

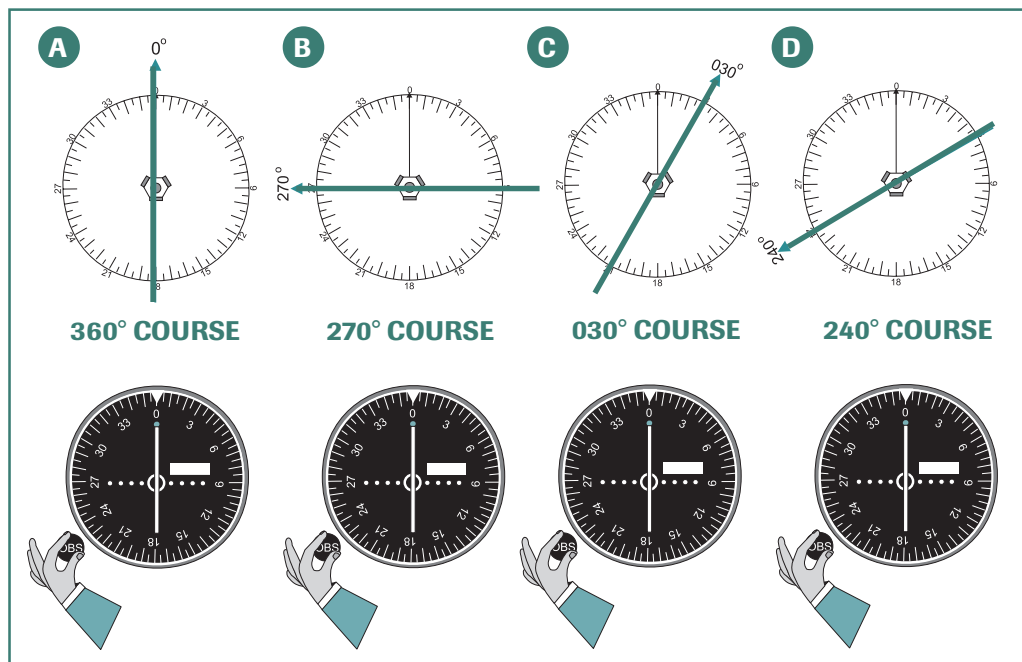


Figure 5

automatically orients itself to show you where the 360-degree course is located relative to your airplane. As you can see, the 360-degree course runs completely through the VOR in a direction of 360 degrees. If you had selected the 270-degree course, your VOR display would orient itself to the 270-degree course as shown in Figure 5 (position B). Selecting 030 degrees with the OBS orients the display to the course shown in Figure 5 (position C). And selecting 240 degrees orients the display to the course shown in Figure 5 (position D). Let's try selecting a few different courses with the OBS.

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 9, Situation 1**. Leave this simulation paused.

- Place your mouse cursor over the OBS. Move the little hand slightly to the left, then slightly to the right. You should notice the appearance of a “+” or “-” symbol within the cursor. By clicking the mouse button when a “+” or “-” symbol is in view, the course selector knob rotates, so you can select a specific course. Practice selecting all four course values shown in Figure 5.

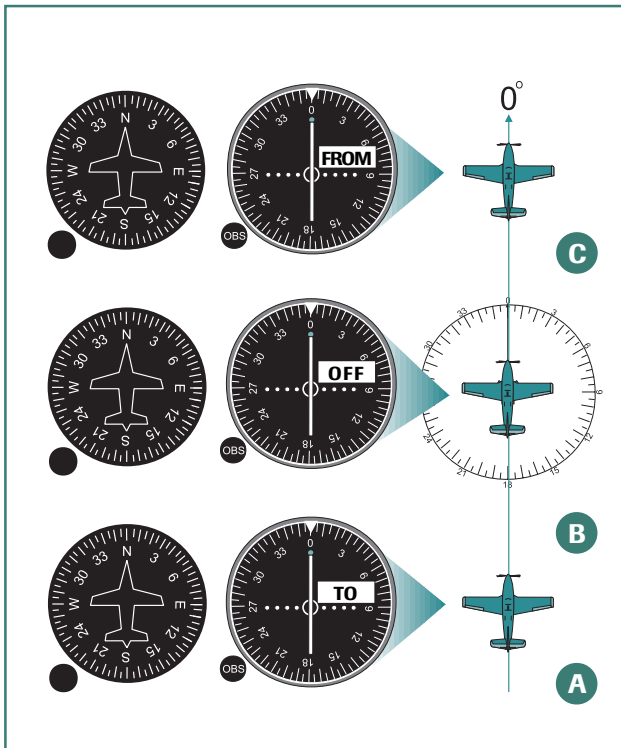


Figure 6

Simply stated, if the airplane is headed in the direction of the selected course and the needle is centered, the TO or FROM flag tells you if you're going to or from the VOR station.

Let's see how this works in real life.

Choose **Tutorial 9, Situation 2**. In this exercise, you're flying to a VOR station on the 360-degree course (OBS set to 360) while heading 360 degrees. You have just a few miles to go before crossing

Figure 6 shows that you've selected the 360-degree course (360 is shown above the index). To fly this course, you'd turn to a direction of 360 degrees on the heading indicator. Assuming you've done this, and your airplane is in position A, the VOR indicator should show a centered needle with a TO flag (upward-pointing triangle) indication.

As you fly along the selected course, the TO flag automatically changes to a FROM flag (downward-pointing triangle) as you pass the VOR station (position C). When you are directly over the station (position B), the flag reads OFF (red-and-white stripes), indicating that you're neither going to nor from the VOR at the time.

the station. Press **P** to activate the simulation and watch how the flag changes as you cross the station. Don't worry about flying since the autopilot's *heading* and *altitude* mode are active. Just sit back, relax, and watch. Press **P** to pause the simulation after the flag changes to a FROM indication. A flag change from TO to FROM is one of the ways pilots can tell when they're over a VOR station.

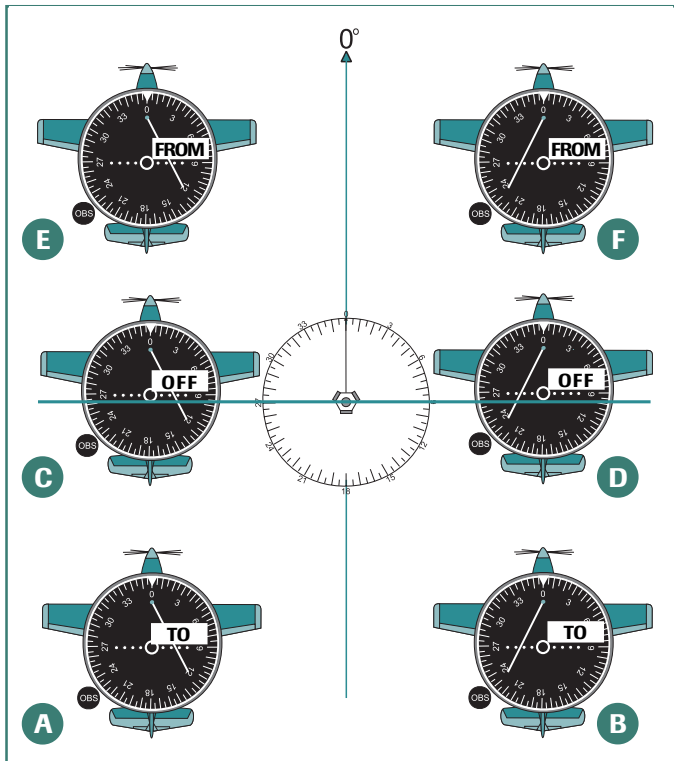


Figure 7

Figure 7 shows several airplanes and their respective VOR indications. Airplane A is heading 360 degrees (the direction of the selected course). Its VOR display shows a right needle with a TO indication. This means that the selected course is to the right and, if Airplane A were on the course, it would be headed directly to the station. Airplane A must turn to the right to intercept the selected course. So must Airplanes C and E. Airplanes B, D, and F must turn left to intercept the course. Notice that when you are abeam (90 degrees to the side of) the station, the flag shows OFF. No, this doesn't mean you're off course. It means that you are *momentarily* neither going to or from the station. Now, here's a chance to put your knowledge to practical use.

Intercepting & Tracking a VOR Course

Let's assume you want to depart Whatzitz airport and fly the 030-degree course to and beyond the VOR as shown in Figure 8. (To be precise, degree values less than 100 are shown with a "0" in front of them. This prevents pilots from thinking that a value of "30" is 300 degrees. We pronounce "030" as

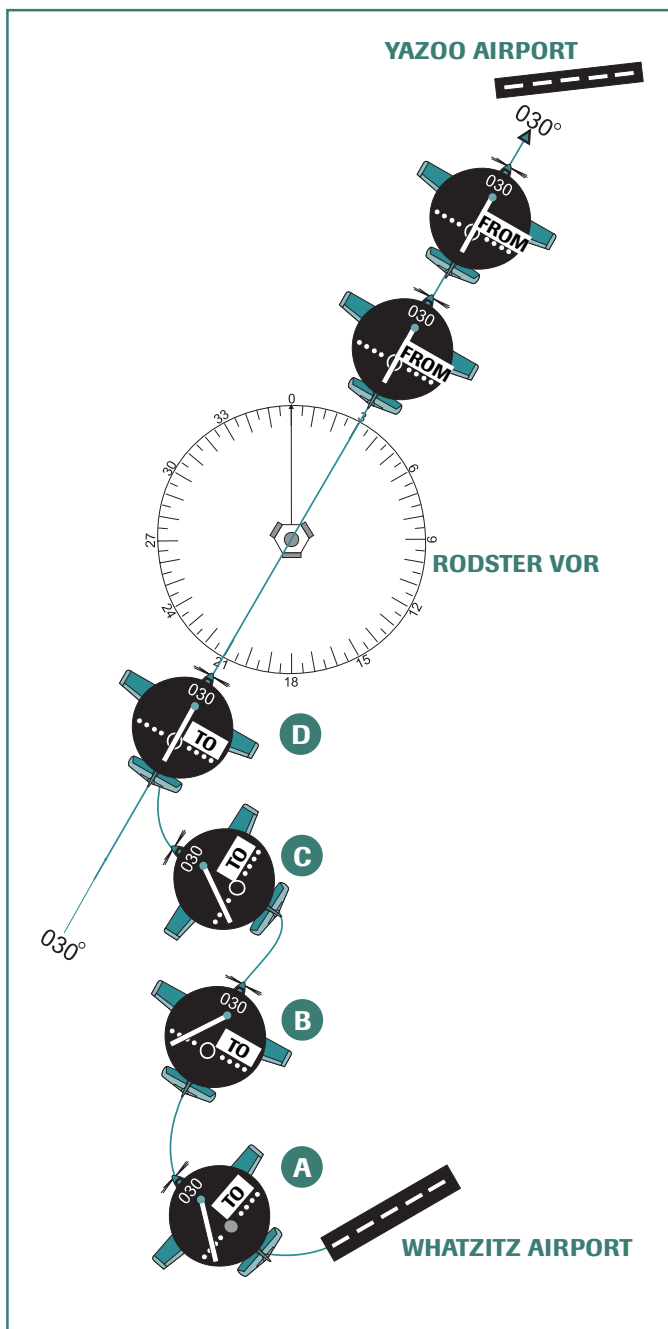


Figure 8

“zero-three-zero.” Say it like this and you’ll sound like an experienced airline captain.) Your destination is Yazoo airport, which lies on the 030-degree course from the Rodster VOR.

With your OBS set to 030, you depart Whatzitz as shown by Airplane A. The VOR display in Airplane A shows a left needle with a TO indication. A right or left needle indication doesn’t tell you on which side of the selected course the airplane is located. To determine this, you must physically point the airplane in the direction of the selected course (or at least imagine yourself pointed in this direction). Why? **The VOR needle and flag indications are completely independent of the airplane’s heading.**

I can’t emphasize this point enough: VORs don’t know which way your airplane is heading. That’s because the airborne VOR display is programmed to think of itself as *always pointing in the direction of the selected course*. The display only knows if it’s to the right or left of the selected course, and whether that course will take it to or from the station.

Obviously, the 030-degree course is not to the left of Airplane A; the course is ahead of the airplane. But if you turn the airplane to the direction of the selected course (030 degrees), then the needle and the flag properly orient you to that course as shown by Airplane B. Now, and only now, can the needle be said to tell you that the selected course is physically to the left of the airplane. The TO/FROM flag tells you that *once you're on the course and heading in a direction of 030 degrees*, you'll be going directly to the VOR station (we'll assume there's no wind to blow you off course in this example). Let's try this part in flight.

Choose **Tutorial 9, Situation 3**. In this example, I'll place you over the airport, heading 240 degrees (there's really no airport down there so don't try to find it). I've set your navigation radio to the VOR frequency. Before beginning the simulation, select the 030-degree course with the OBS. Then, as soon as the simulation begins, turn to a heading of 030 degrees. I've also disconnected the autopilot for this simulation. Ready? Go ahead and press **P** to begin the simulation. When you're established on a heading of 030 degrees, press **P** to pause the simulation.

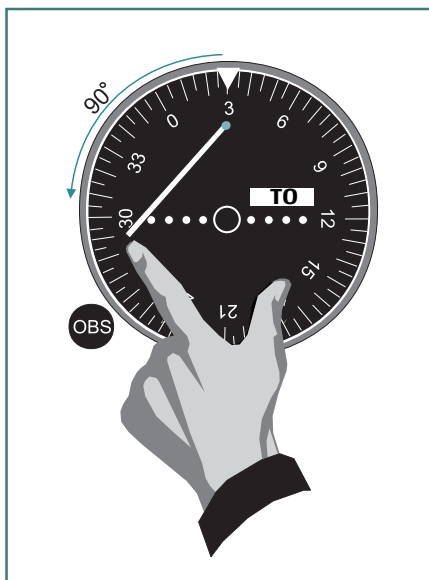


Figure 9

Looking back at Figure 8, Airplane B must turn to the left to intercept the 030-degree course. How many degrees to the left should it turn? The answer is, more than 0 degrees and less than 90 degrees. It all depends on how fast you want to intercept. For practical purposes, if the VOR needle is fully deflected, you won't necessarily know if the selected course is 1 mile away or 100 miles away. In these situations, your objective should be to get on the course as quickly as possible; therefore, intercept at a 90-degree angle. Ask yourself what heading is 90 degrees to the left of 030 degrees. Just look at the compass and count 90 degrees to the left of the selected course as shown in Figure 9. Flying a heading of 300 degrees (this is perpendicular to the selected

course), allows you to intercept in the shortest time, as shown by Airplane C in Figure 8.

Airplane C in Figure 8 should plan to turn back to 030 degrees (the direction of the selected course) as it intercepts the course. A precisely completed interception is shown by Airplane D. Notice how the VOR needle of Airplane D centers as the airplane heads 030 degrees (the selected course direction). Don't worry if you can't do this precisely at first. How quickly the needle centers depends on how close you are to the station. A little bit of experience will teach you to estimate the rate at which the needle approaches the center, and how soon to begin your turn on the course heading.

Why don't you try intercepting the 030-degree course on your own?

1. Activate the simulation by pressing **P**, then turn to a heading of 300 degrees.
2. When the needle begins moving toward the center of the instrument, begin a turn toward a heading of 030 degrees. (If you're lucky, you'll roll out on 030 degrees as the needle centers. But don't worry if you don't time the turn properly. This takes practice.)
3. If the needle isn't centered, just turn 10 or 20 degrees toward it (to the left in your case) until it does center. Then turn back to a heading of 030 degrees to center the needle.
4. Press **P** to pause the simulation when the VOR indicator looks like the one in Airplane D (Figure 8).

Airplane D in Figure 8 will eventually pass over the VOR station and its flag will automatically flip from TO to OFF to FROM. Obviously, the airplane is now on the 030-degree course from the station. Keeping the needle centered will eventually put Airplane D directly over Yazoo airport.



Figure 10

Many VOR stations come equipped with a second transmitting device known as *distance measuring equipment (DME)*. A DME receiver in the airplane (Figure 10) displays a readout of the airplane's distance from the VOR

station. Let's suppose you know Yazoo's distance from the VOR. Let's also suppose that the airplane has an airborne DME receiver. If you fly the selected course from the VOR until showing that distance on your DME display, you'll be directly over the airport. This provides a very accurate way of finding an airport.

Flying from the VOR on a Selected Course

Let's make VOR usage even more practical. Suppose you are airborne in the vicinity of Ulost airport (just like Airplane A in Figure 11) and want to fly to Wrongway airport. Since this is a VOR tutorial, let's use the VOR to find Wrongway.

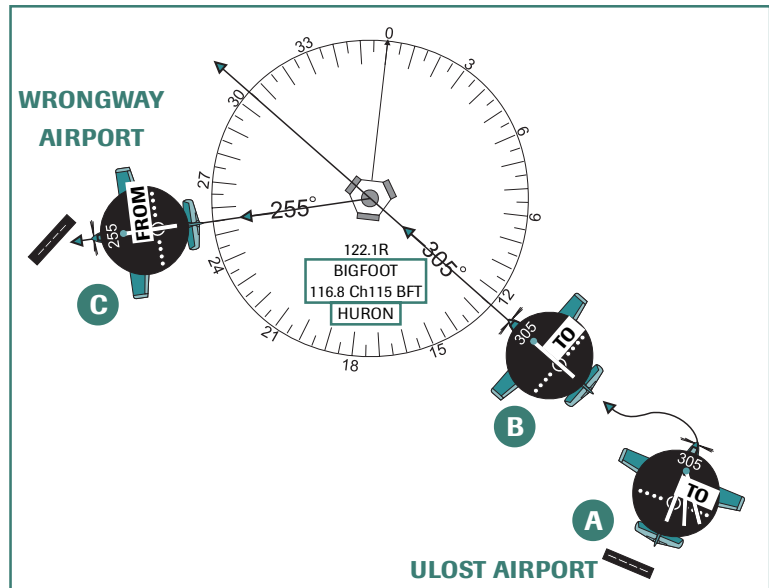


Figure 11

Ask yourself, “What’s the best way to get to the Bigfoot VOR?” It’s reasonable to assume you’re always on *some* course that goes to a VOR. But how do you know which course this is?

Tune in the Bigfoot VOR frequency on your navigational radio, rotate the OBS until you get a TO flag indication with a centered needle as shown by Airplane B, Figure 11. Look up at the index to see what course is selected. In this instance, you’re on the 305-degree course to the Bigfoot VOR. Turn to a heading of 305 degrees on your heading indicator and fly that course to the VOR as shown by Airplane B. Easy, eh?

As you approach the VOR, ask yourself what course runs from the center of the station through Wrongway airport. Draw a line (or *eyeball* the value) to determine this course. It appears that the 255-degree course runs from the VOR through Wrongway airport. Therefore, when you’re over the station, turn the airplane to a heading of 255 degrees, and then rotate the OBS to 255 degrees. Now your VOR display is set to track the 255-degree course from the VOR to Wrongway airport, as shown by Airplane C. Let’s try this entire sequence in the air.

Choose **Tutorial 9, Situation 4**. In this example, imagine you’ve just departed Ulost airport (there’s no airport down there, so don’t go looking for it). Your objective is to track to the VOR, then track outbound on the 255-degree radial until your DME reads 7 miles from the station (we’ll assume this is Wrongway airport’s distance from the VOR station). Here’s how to do it.

1. If it’s not already displayed, display the radio stack (as shown in Figure 12) by clicking the white Avionics button at the bottom of the instrument panel.
2. With the simulation paused, set your navigation radio to the Bigfoot VOR frequency (114.1 MHz). Set this frequency in your No.1 navigation radio (Figure 12) by moving the mouse cursor directly over the values shown to the right or left of the decimal point. Move the cursor until a “+” or “-” indication appears, then click the mouse button to change frequency.
3. Click the Avionics button again to hide the radio stack.
4. Rotate the OBS until the needle centers and the VOR display shows a TO indication. You should end up with a course of approximately 305 degrees and an upward-pointing triangle.
5. Now press **P** to activate the simulation.
6. Track to the station by turning left to a heading of 305 degrees. Once you’ve reached 305



Figure 12

degrees you'll need to turn a little more to the left (try 295 degrees) to intercept the course and center the needle. Once the needle is nearly centered, turn back and fly the heading shown by the index (305 degrees).

7. When you're directly over the VOR (indicated by an OFF flag), turn to a heading of 255 degrees and rotate the OBS to 255. Fly the 255 course. (Once again, turn a little toward the needle if you need to intercept it. As the needle moves toward the center of the display, turn back and fly the heading shown by the course index.)
8. When the DME display shows 7 miles you can assume that you're over Wrongway airport and you've accomplished your objective.
9. Press **P** to pause the simulation.

Wind Correction While Tracking a VOR Course

I hope you aren't blown away by all this. But then again, how could you be blown away since I haven't talked about wind? Until now I've assumed a wind-free environment, but this seldom exists in the real world. Let's learn how to correct for wind when navigating with VOR.

Wind correction is broken down into three components:

- Identifying the effect of wind on the airplane
- Re-intercepting the course
- Applying a wind correction

Here's how this works.

1. Identifying the Effect of Wind - In Figure 13, Airplane A has just intercepted the 030-degree course to the VOR. Under a no-wind condition, Airplane A could hold a 030-degree heading and fly to the VOR with a centered needle. With a little wind, Airplane A is sure to drift off course. Determining wind direction and making the proper correction is vital to successful navigation.

To determine the effect of wind on the airplane, head the airplane in the direction of the selected course (030 degrees in this example). Now you must wait a bit. If there is no wind, the needle should stay centered (or nearly so). If a crosswind exists, the needle will eventually show a deflection, as depicted by Airplane B. How much of a needle deflection should you allow before re-intercepting the course? Perhaps the best advice in this instance is to let the needle move just a little (perhaps less than one dot on the VOR's display), then make a correction.

2. Re-intercepting the Course - If the needle moves to the left, then the selected course is to the left as shown by Airplane B. The airplane was blown to the right of the course (implying the crosswind is from your left). Once you've identified the wind direction you need to get back on course before applying a wind correction. You can get back on course by intercepting at a 20-degree angle as shown by Airplane C. (Strong winds sometimes require that you re-intercept at a 30- to 40-degree angle.)

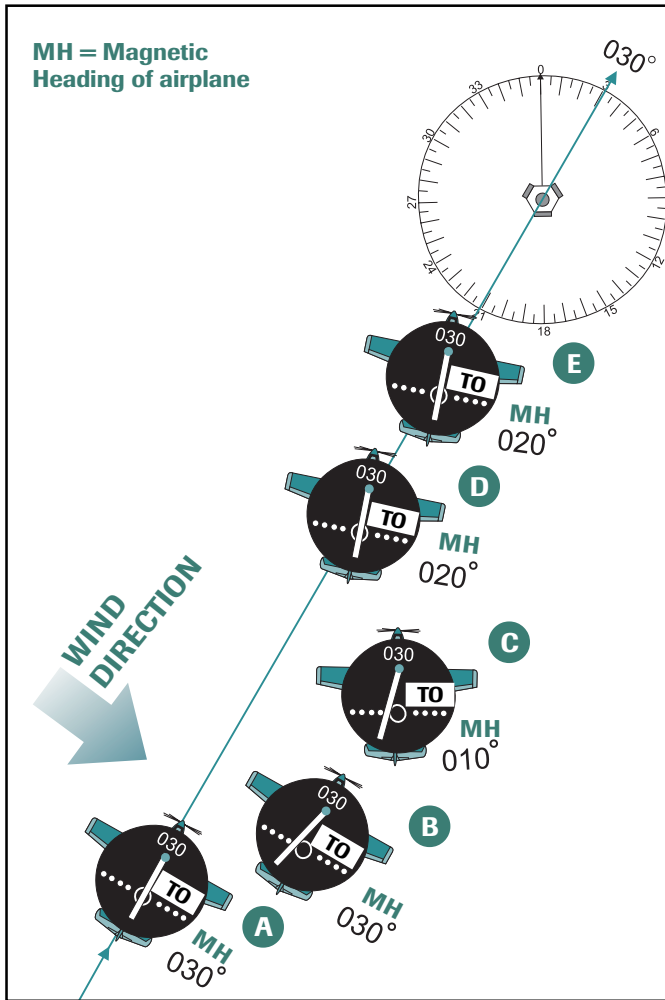


Figure 13

As you can see, Airplane E is tracking directly to the VOR station on the 030-degree course. The needle hasn't moved. Congratulations! You've successfully corrected for wind. And you're darn lucky if you, or for that matter any experienced pilot, can find the proper wind correction angle on the first attempt. Realistically, you'll probably need to make a minimum of two attempts at determining a wind correction angle before finding the proper value. The same wind correction principle applies when tracking from the VOR on a specific course.

Let's try some wind correction in the airplane. Choose **Tutorial 9, Situation 5**. In this example, I'll place you on the 030-degree course to the VOR while heading 030 degrees. I've commanded the winds to blow from your left, as shown in Figure 13. Let's give it a try.

1. Activate the simulation by pressing **P**.

3. Applying a Wind Correction

– Once you're reestablished on course, the third step is to apply a wind correction. You must compensate for the wind's push by heading the airplane into the wind. How much? That depends on several variables, one of which is the wind's speed and direction. Actually, these variables don't really matter all that much. Just start with a 10-degree wind correction angle and see what happens. You may not get it on the first try, but don't worry. Once you're on course, turn the airplane so it's pointed 10 degrees into the wind (which means it's now heading 020 degrees as shown by Airplane D in Figure 13). Be patient, Grasshopper. Wait to see what happens.

As you can see, Airplane E is tracking directly to the VOR station on the 030-degree course. The needle hasn't moved. Congratulations! You've successfully corrected for wind. And you're darn lucky if you, or for that matter any experienced

2. Fly heading 030 degrees until the needle deflects one dot to the left, which indicates that you have a wind from the left (Figure 13, position B).
3. Re-intercept the course at a 20-degree angle by flying a heading of 010 degrees (Figure 13, position C).
4. When the needle centers, turn to a heading of 020 degrees (Figure 13, position D). Try this value and see if it keeps the needle centered. If not, re-intercept the course and apply a larger or smaller wind correction angle until you find one that keeps the needle centered.

You did a great job! You're on your way to becoming a high priest of VOR tracking, master of all meteorological forces, and ruler of airway navigation. You'll be required to walk around the airport in white robes. Pilots from all over will come seeking your guidance. TV shows! Live appearances! Think of the possibilities. Well, at least you'll get to your destination with ease.

Advanced Stuff: VORs and Airborne Freeways

Until now I've referred to all VOR routes as *courses*, and for good reason too. It makes the whole process easier to understand. In order to do advanced things, like fly instrument approaches, you'll need to think about tracking to and from a VOR on a specific *radial* instead of a specific *course*. While pilots speak of traveling to and from a VOR on a specific course, they can also speak of traveling to and from the VOR on any one of its 360-degree radials. Technically, a *course* is just a path across the ground, while a *radial* is a spoke starting at the VOR and radiating out in one direction.

Let's begin our discussion with a recollection of your last car trip when you drove through a small town. Let's also say the freeway pointed due north as it passed straight through this town as shown in Figure 14 (position A). While entering and leaving the town your car pointed north (360 degrees), in the same direction as the freeway. If the portion of the freeway exiting this town had a different name than the portion entering the town, would this affect the direction your car pointed while passing through town? Of course not. So let's call the portion of the freeway south of the town *freeway 180*, and the portion north of the town *freeway 360*, as shown in Figure 14 (position B). Now we can say that we went to town on *freeway 180* and exited on *freeway 360*. Your direction never changed despite giving the freeway different names.

Navigation by VOR is basically the same, as shown by Figure 14 (position C). If you're headed northbound to *Town VOR*, you travel inbound on the 180-degree *radial* and outbound on the 360-degree *radial*. Either way, your airborne freeway points in a direction of 360 degrees, just like the ground-bound freeway. Referring to a single freeway by *radials* going *to* and *from* a VOR station is sometimes awkward. But this is the way instrument pilots are required to think of VOR navigation. Therefore, when you're asked to intercept and track *to* a VOR station on the 180 radial, you must think of setting your OBS to 360 degrees (or the 180-degree reciprocal of the radial on which you'll track to the station).

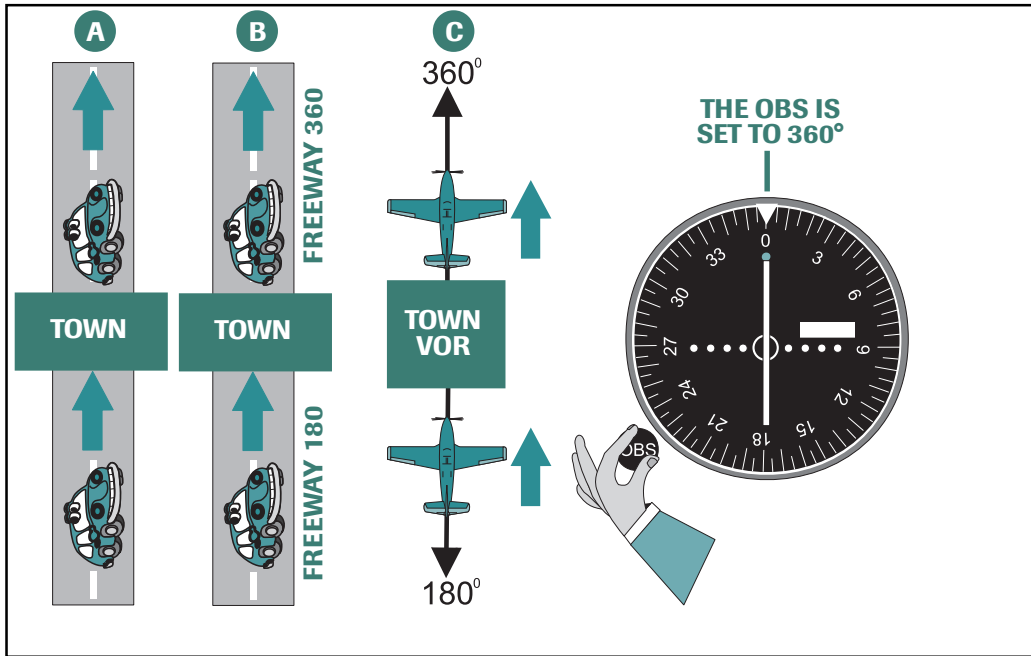


Figure 14

Well, this is a big day for you. There are two things I want you to do:

1. Go to the online lessons and take **Private Lesson 4: VOR Intercept and Tracking**. We'll review what you've just learned.
2. Then (drum roll, please), it's time for your **Private Pilot Checkride!** Congratulations! After you've passed the checkride, you'll be awarded the Flight Simulator Private Pilot Certificate.

Tutorial 10: Attitude, Power & Trim (Step One of the Three-Step Instrument Scan)

During the first nine tutorials, you saw what flying was like when looking at the earth's horizon through the windscreen. Suppose I took that away from you. (No, not the windscreen. I mean your outside visual references.) That's what would happen if you flew into a cloud. In case you don't know this, you can't see very far when you're inside a cloud, which means it's unlikely that you'd be able to see the earth's horizon. Without visual references, you'd need to rely on the airplane's instruments to maneuver. That's what the next three tutorials are about.

I plan to show you a three-step process for scanning your flight instruments. It's the same process I use in the real world when preparing students for their instrument rating (a license allowing them to fly inside clouds). If you take the time to master each step, you'll acquire skills similar to those possessed by airline pilots. The only difference is that you won't have 150 to 400 people sitting behind you trying not to spill coffee on themselves. First, let's make sure you understand what *instrument scan* actually means.

The Scan Plan

When pilots talk about *scan*, they don't mean CAT scan (which my cat doesn't like) or brain scan (which you'll need if you dent a lot of airplanes). They're talking about scanning the six flight instruments on the airplane's panel as shown in Figure 1. Scanning is not just moving your head quick enough to cause your eyes to rattle in their sockets like marbles in a shoebox. It's a strategic process of knowing what instrument to look at, when to look at it, and what to do after you look at it. That's why I've broken the scan process down into three easy steps. All three steps are shown below, but I want you to master one step at a time before combining them into a smooth, continuous, three-step process.



Figure 1

The Three Steps

Here are the steps in the order they should be performed:

Step 1: Select attitude, power, and trim.

Step 2: Radial-scan the primary instruments.

Step 3: Trim using the VSI and monitor scan the Big-6 instruments.

These three steps are executed in sequence *every time* you make a *major attitude change*. For instance, if you're in straight-and-level flight and wish to enter a climb, that's a major attitude change. Transitioning from a straight climb to a climbing turn is also a major attitude change. Any combination of the basic flight maneuvers involves a major attitude change. All three steps in sequence should take approximately 15 to 20 seconds to complete. In this tutorial you'll work on *Step one*, followed by *Step two* and *Step three* in the next two tutorials. Master each step and you'll master flight by reference to instruments. Let's get started.

From the **Flights** menu, click **Select Flight**, and then choose **Tutorial 10, Situation 1**.

The autopilot's *altitude hold* mode is activated but the *wing leveler* is not. You'll notice that the airplane is paused in flight and you can't see anything out the windscreen. Additionally, five of the six main flight instruments are blackened out. No, this isn't a simulation of a cheap, poorly maintained, discounted airplane. I've designed this panel especially for you.

The Most Important Instrument

Step one of the instrument scan involves one of the most important instruments on the airplane—the attitude indicator (called *AI* from now on). When you select the attitude in *Step one*, you are looking at the AI and nothing else. You can afford to do this because the AI provides both *pitch* and *bank* information. Other instruments in the group give you a form of either pitch or bank information, but not both. This is why the AI is so valuable. Before you practice Step one, however, you need to develop something known as a *wing-leveling reflex*.

A wing-leveling reflex is a skill necessary to help maintain any desired attitude. Maintaining a specific attitude isn't an easy thing to do. Pilots are often distracted from their scan, and turbulence frequently perturbs the airplane—both of which may induce a bank, resulting in an unwanted turn. Skilled pilots immediately correct this unwanted bank with their wing-leveling reflex. Without thinking about it, they reflexively move the joystick and return the airplane to the desired attitude. Unless you've practiced doing this, you'll have to think about it before reacting. While a slow reflex may work if you're flying a blimp, it won't work in an airplane.

Wing-Leveling Reflex

For now I want you to do nothing more than keep the wings level using the joystick. I've put a little turbulence into this simulation to help disturb the airplane from straight flight. Oh, the pain! Keep the wings level by moving the joystick to the right or left at the appropriate time. Don't worry about the airplane's pitch and don't correct for it. The autopilot will take care of that for now since the altitude hold mode is active. Here's what you'll do.

1. Press **P** to activate the simulation.
2. Practice keeping the wings level with appropriate joystick movements.
Practice until you're proficient, but stop before your hand feels like it's ready to fall off.

3. Press **P** to pause the simulation.

How was that? Not too bad, eh? Simple as this is, it's an important skill to have. I make all my airplane students master it before moving on to more complex skills.

Wing-Leveling and Pitch Reflex

Now let's try the same thing with the autopilot disengaged. I want you to maintain both the *pitch* and *bank* attitude for straight-and-level flight as shown in Figure 2. Yes, the turbulence is still active. Give it a try.

1. From the **Flights** menu, click **Select Flight** and choose **Tutorial 10, Situation 2**.
The autopilot is deactivated in this tutorial and there is still a fair amount of turbulence to discombobulate the airplane.
2. Press **P** to activate the simulation.
3. Practice maintaining the attitude for straight-and-level flight until you've got the hang of it (but stop before you experience a complete loss of circulation in your hand).
4. Press **P** to pause the simulation.

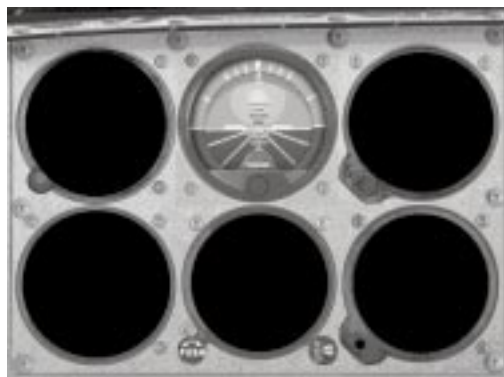


Figure 2

Do you feel like you should be getting minimum wage and a compensation package for all the work you're doing? Well, instrument flying isn't for the faint of heart (or for those who faint). It's a lot of work, but these exercises are worth it. Don't rush through them. I can't express how important they are. I spend several hours with students in airplanes making sure they've mastered both the *wing leveling* and the *pitch* reflexes. If you feel you've mastered these reflexes (and have some feeling left in your arms) then move on to *Step one* of the *three-step scan*.

Step One of the Scan

Step one of the three-step scan is to select the *attitude*, *power*, and *trim* conditions for the desired attitude. For instance, if you're in straight-and-level flight and desire to climb (a major attitude change), you'll need to select a climb *attitude*, apply climb *power*, and then *trim* for this condition. Do this by focusing entirely on the attitude indicator. From your previous experience, select the attitude that gives you the flight conditions desired. You still remember these attitudes from the previous tutorials, don't you? If not, review them by holding your now-weakened hands up in mock surrender and use your elbows to waffle through the pages of this book.

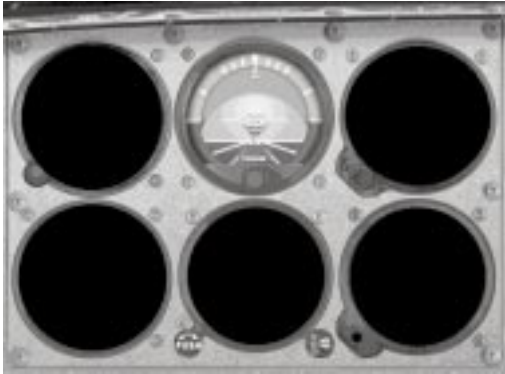


Figure 3

Figure 3 shows the approximate pitch required to climb at 80 knots with full power (13 degrees nose up). Let's practice entering a climb attitude from straight-and-level flight, and then returning to straight-and-level flight.

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 10, Situation 3**.

The autopilot is deactivated in this flight and I've removed the turbulence. Remember, the sequence for Step one of our scan is *attitude*, *power*, and *trim*.

Entering a Climb from Straight-and-Level

1. Press **P** to activate the simulation.
2. Pitch the airplane up to 13 degrees. You can't be sure that you're at precisely 80 knots, but that's okay for now.
3. After pitching up, apply climb power. (We'll use full power in this airplane. In an actual airplane, climb power may vary between airplane models.)
4. Apply trim to maintain climb attitude. (You're interested in a rough approximation of trim here. The final trim is applied in Step three of the three-step scan.)
5. Press **P** to pause the simulation when established in the climb.

Excellent! Muy bien. Now let's practice another major attitude change and return to straight-and-level flight from a climb.

Entering Straight-and-Level From a Climb

1. Press **P** to reactivate the simulation.
2. Pitch the airplane forward to the attitude for straight-and-level flight (Figure 2). You can't be sure you're in precise straight-and-level flight but that's still okay for now.
3. Wait approximately 10 seconds, then reduce power to a cruise setting of 20 inches of manifold pressure (MP).
Why wait 10 seconds? Because you want the airplane to accelerate quickly to cruise speed before making a power reduction. In the next tutorial, you'll wait until reaching a cruise airspeed of 100 or more knots before reducing power. Since you can't see the airspeed, use 10 seconds for now.
4. Once the power is reduced, apply trim to maintain the attitude for straight-and-level flight.
5. Press **P** to pause the simulation.

Take some time now to practice entering a climb, then leveling off in straight-and-level flight until you feel comfortable with the *attitude*, *power*, and *trim* sequence. Press **Ctrl+**; any time you want to reset the simulation to straight-and-level flight.

Entering a Descent from Straight-and-Level



Figure 4

Now let's see how you handle entering a descent. The important thing to know here is the proper attitude when descending. Descents are typically done at airspeeds higher than those used for climbing. So let's use a one-half-degree pitch-down attitude like that shown in Figure 4. This gives you a descent at approximately 100 knots. Okay, give it a try.

1. Press **P** to reactivate the simulation.
2. Select the proper attitude for the descent (Figure 4).
3. Immediately reduce power to flight idle.

It's considered good form to make the attitude and power change at the same time. Reducing power results in the nose automatically pitching forward on its own, which makes it easier to establish the nose-down attitude. Lowering the nose with power on results in an increase in airspeed, perhaps beyond what you intended.

4. Trim to maintain the desired nose-down pitch attitude.
5. Press **P** to pause the simulation.

Entering Straight-and-Level from a Descent

Now enter straight-and-level flight from a descent. Remember the sequence: *attitude*, *power*, and *trim*.

1. Press **P** to activate the simulation.
2. Select the attitude for straight-and-level flight (see Figure 2).
3. Add cruise power (20 inches of MP).

If you wait too long to add power, the airspeed will decrease. That's why it's usually good form to start increasing power as soon as the airplane approaches a level flight attitude.

4. Trim to maintain the desired attitude.
5. Press **P** to pause the simulation.

Practice entering a descent and then leveling off in straight-and-level flight until you feel comfortable with the *attitude*, *power*, and *trim* sequence. Press **Ctrl+**; any time you want to reset the simulation to straight-and-level flight.

This was a very important lesson. It's often the little things that give instrument pilots a difficult time, such as knowing how and when to change power. Granted, this practice may not be very exciting, but it's worthwhile. Now let's practice by entering a turn from straight-and-level flight (another major attitude change).

Entering Climbing and Descending Turns

From the previous tutorials you learned that turns were made at 20 to 30 degrees of bank. This is appropriate for instrument flying, too. What you don't want to do is make turns in excess of 30 degrees of bank. Why? Turning too steeply increases a pilot's workload while flying under instrument conditions. Instrument flying is hard work and the last thing a pilot needs is to struggle with the aerodynamic forces associated with steep turns. Let's agree to use 20 degrees of bank for all turns while flying instruments. Later, you'll learn advanced turning concepts like *standard rate turns*.

Entering a Climbing Turn

Since I know you're already skilled at turns, let's make them a little more challenging for you (yes, I want to see some sweat, enough to short-circuit that keyboard). In Step one of the scan, let's combine the turn and the climb entry. This is just like a fancy dance step where moves are combined but no one's toes are jeopardized. Enter a 20-degree bank turn while simultaneously pitching to climb attitude. Give it a try.



Figure 5

1. Reset the simulation to straight and level by pressing **Ctrl+**;
2. Press **P** to activate the simulation.
3. Roll into a 20-degree bank turn to the right and *simultaneously* pitch up to climb attitude (Figure 5).
4. After pitching up, apply climb power (full power).
5. Trim to maintain climb attitude.
6. Press **P** to pause the simulation.

Entering a Descending Turn

Now try entering a left-descending turn.



Figure 6

1. Press **P** to activate the simulation.
2. Select the attitude for a left-descending turn (Figure 6).
3. *Simultaneously* reduce power to flight idle.
4. Trim to maintain this attitude.
5. Press **P** to pause the simulation.

Practice maneuvering between a left-descending turn and a right-climbing turn. This is excellent practice. Remember, think *attitude, power, and trim*. You can press **Ctrl+**; any time you want to reset the simulation to straight-and-level flight.

Finally, try climbs, turns, and descents using **Tutorial 10, Situation 4**. What's so special about this? It has a little turbulence associated with it. My friend, if you can change attitudes and handle turbulence at the same time, you're ready for the next tutorial. Which you'll want to do once your carpal tunnel specialist leaves.

Tutorial 11: Radial Scanning the Primary Instruments (Step Two of the Three-Step Instrument Scan)

Step one, Step two, Step three: doesn't this sound like a Fred Astaire introductory dance lesson? Well, instrument scan is best taught in a similar way, by easily managed steps. In this sense, your partner is the instrument panel and your eyes dance from instrument to instrument in an organized way. You've learned *Step one* of the three-step scan, now on to *Step two*.

Step one allowed you to place the airplane in any attitude by sole reference to the attitude indicator (AI). But using the AI as your only means of attitude control is like using a thermonuclear weapon to kill fleas in your apartment. It works, but lacks the precision your neighbors have come to expect in a bug bomb. As an instrument flyer, you need precise control of headings, altitudes, and airspeeds. So, once you've selected a new attitude in *Step one*, you'll proceed to *Step two* where you'll *radial scan the primary instruments* and *fine-tune* the attitude selected in *Step one*.

Here are the three steps for your review. Remember, all three steps are done, in sequence, every time you make a major attitude change. In total, all three steps take from 15 to 20 seconds to complete.

Step 1: Select attitude, power, and trim.

Step 2: Radial scan the primary instruments.

Step 3: Trim using the VSI and monitor scan the Big-6 instruments.

The purpose of *Step two* is to look at one or more flight instruments and then make any necessary changes in *pitch*, *bank*, or *power* to obtain the flight attitude desired. This allows you to get the precise heading, airspeed, and altitude desired. The term *radial scan* signifies that your scan starts at the AI, goes to a *primary* instrument on the panel, then returns to the AI. The scan pattern is *out* and *in* along the same path. Think of the path your eyes make as they start from the center of a bicycle's wheel and follow a spoke *radiating* outward and inward, as shown in Figure 1.

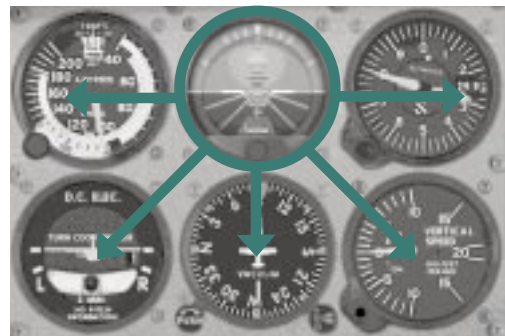


Figure 1

Anything that's primary is important. And primary instruments give you the most important information for precision control of *pitch*, *bank*, and *power*. Each attitude you select uses three primary instruments, one for pitch, one for bank, and one for power. But how do you know which instruments these are? After all, you have several to choose from. To answer that question let's go for a hamburger.

Instrument Names

When you order food from the hamburger emporium, the server pushes a button with a picture of the item you selected. Order a soda and he pushes a button with a soda on it. This neat visual method frees up the server's mind to think about more important things, like philosophy, ethics, and an alternate proof to Fermat's last theorem. Of course, if you say, "Beautiful weather," the server might say, "I'm sorry, I don't have that button." Let's use a similar labeling system to identify the primary instruments on your panel.

I'd like you to place the labels shown in Figure 2 directly onto your computer screen, under each instrument shown. (I'm assuming you've got your computer on and Flight Simulator running.) We won't label the VSI for now. Use a small quarter-inch strip off the sticky end of one of those sticky notes. Don't use labels with permanent adhesives. (There's always a job open for you at that burger joint if you do!) Also, create a label that says **POWER** and put it on the manifold pressure gauge, which is not one of the primary instruments shown in Figure 2. You'll need to check it, though, any time we talk about setting the power to a certain manifold pressure (MP).

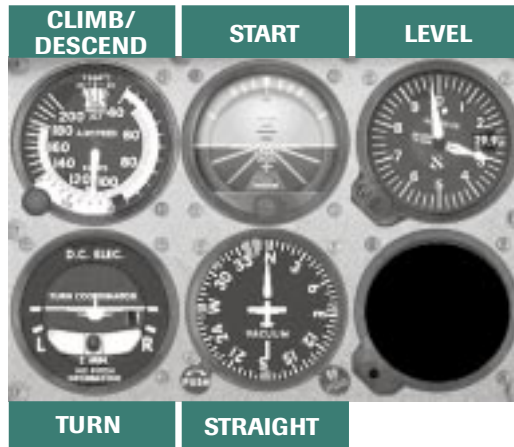


Figure 2

Identifying Primary Instruments

Figure 2 identifies the primary instruments for any given flight condition. Assume that you've just selected the attitude for straight-and-level flight. Which primary instruments should you radial scan? Look at the panel and find those instruments labeled *straight* (heading indicator) and *level* (altimeter). The heading indicator helps you fly *straight*, the altimeter helps you fly *level* and the MP gauge shows the *power* setting selected. In other words, you can fine-tune the attitude for straight-and-level flight by scanning only these three instruments. Easy, huh?

Suppose you've placed the airplane in the attitude for a straight climb (or descent). What primary instruments should you radial scan? Find the instruments labeled *straight* (heading indicator) and *climb* (airspeed indicator). The heading indicator helps you fly *straight*, the airspeed indicator helps you determine the proper pitch for a *climb* (or a descent), and the MP gauge shows the *power* setting selected.

Finally, place the airplane in the attitude for a level turn. What primary instruments should you radial scan? Find the instruments labeled *level* (altimeter) and *turn* (turn coordinator). The altimeter helps you fly *level*, the turn coordinator helps determine the amount of bank required for the desired *turn rate* (you'll see how shortly), and the MP gauge shows the *power* setting selected.

Now you know how to determine which instruments to scan for any condition of flight, so let's put that knowledge to use. Do the following procedures in which only the primary instruments for that condition of flight are visible. Radial scan the primary instruments and observe their indication or detect needle movement. Then return to the AI and make an attitude adjustment (if necessary) to stabilize the primary instrument. Let's begin with straight-and-level flight first.



Figure 3

adjust the attitude on the AI (if necessary) for precise straight-and-level flight. Before you begin, let's talk a little more about radial scanning.

In Figure 2, the AI has the word **START** above it since this is where all radial scanning begins. Like the hub of that bicycle wheel, your scan starts here and *radiates* outward to a primary instrument. You'll spend about one to two seconds on the primary instrument while checking for any deviations or needle movement. Then return to the AI and make corrections (if necessary).

Of course, you can radial scan more than one instrument. To do so you start at the AI, go to a primary instrument, then return to the AI. From there, go out to another primary instrument and return to the AI, repeating the process over again with any instrument desired, always returning to the AI.

For instance, in straight-and-level flight, you'll radial scan the heading indicator (straight), the altimeter (level) and the MP gauge (power). Starting at the AI, move down to the heading indicator.

The Basics of Radial Scanning

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 11, Situation 1**.

The autopilot isn't active in this flight, and all but the primary instruments for straight-and-level flight are blackened out (Figure 3). Assume that you've just completed Step one of the three-step scan by placing the airplane in the attitude for straight-and-level flight. You'll begin Step two by radial scanning the primary instruments, and you'll

Look for any deviation away from the desired heading. Return to the AI and make a small change in bank (if necessary) that stops the heading change or returns the airplane to the appropriate heading. From there, move to the altimeter and look for any deviation from the desired altitude. Return to the AI, making a small pitch change (if necessary) that stops the needle or returns it to the appropriate position. The MP gauge is radial scanned last. Look at the MP gauge and make a final adjustment in the setting (if necessary), then immediately return to the AI. Usually there is no need to radial scan the MP gauge more than once during a major attitude change. Now start over with the heading indicator, repeating the radial scan until both instruments indicate straight-and-level flight. Give it a try.

Straight-and-Level Flight

1. Press **P** to activate the simulation.
2. Make sure the throttle is set to 20 inches of MP.
3. Scan Step 1: select attitude (for straight-and-level flight), power (no change), then trim (no trim change needed).
4. Scan Step 2: start at the AI and radial scan the heading indicator.
5. Return to the AI and adjust the bank (if necessary) to maintain a heading of 270 degrees (not a bank of 270 degrees!).
6. Radial scan the altimeter.
7. Return to the AI and adjust the pitch (if necessary) to maintain 4,000 feet.
8. Radial scan the manifold pressure gauge and adjust the throttle position (if necessary) for a cruise power of 20 inches of MP. (There's usually no need to radial scan the manifold pressure gauge again. Once is usually enough.)
9. Keep radial scanning the heading indicator and altimeter, making small attitude corrections until the airplane is established in straight-and-level flight.
10. Press **P** to pause the simulation.

The secret to radial scanning is to quickly scan each of the primary instruments at least *once* before spending additional time radial scanning any one instrument in particular. This allows you to determine how close the airplane is to the desired attitude and gives you an idea about how much work will be involved in stabilizing the airplane. Let's try a straight climb.

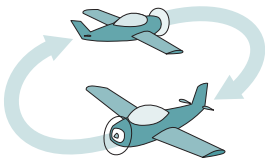


Figure 4

A Straight Climb

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 11, Situation 2**.

Once again, all but the primary instruments for a straight climb are blackened out (Figure 4). In this situation, I want you to enter a climb from



Standard Rate Turns

Standard rate turns allow the airplane to change headings at a rate of 3 degrees per second. In Tutorial 10 I suggested you make turns at 20 degrees of bank. That's perfectly fine, but for greater precision, I want you to make them at a standard rate. Do this by adjusting the bank until the wing of the turn coordinator's airplane is on the second white index mark as shown in Figure 5. Now the airplane changes heading at precisely 3 degrees per second. A standard rate turn gives you a sense of how long it takes to complete a turn. After all, at 3 degrees per second, it takes two minutes to make a 360-degree turn and one minute to make a 180-degree turn.

straight-and-level flight. Remember to use the techniques you learned from the previous tutorial (attitude, power and trim). Once established in the new attitude, begin with *Step two* of the *three-step* scan. Radial scan the primary instruments. Use Step two to make small attitude adjustments on the AI for a precise climb at 80 knots on a heading of 270 degrees. Give it a try.

1. Press **P** to activate the simulation.
2. Scan Step 1: select the attitude (about 14 degrees nose-up pitch), power (full power) for a straight climb, then adjust the trim.
3. Scan Step 2: start at the AI and radial scan the heading indicator.
4. Return to the AI and adjust the bank (if necessary) to maintain a heading of 270 degrees.
5. Radial scan the airspeed indicator.
6. Return to the AI and adjust the pitch (if necessary) to maintain 80 knots.
7. There's no need to radial scan the MP gauge since you're climbing with full power and that means throttle full forward. On some airplanes you don't climb with full power. Therefore, you may need to radial scan the MP gauge at least once to ensure the power is set correctly.
8. Keep radial scanning the heading indicator and airspeed indicator, making small attitude corrections until the airplane is established in a straight climb at 80 knots on a heading of 270 degrees.
9. Press **P** to pause the simulation.

There you have it. Knowing ahead of time what instruments to look at for precise control of your attitude takes the mystery out of flying instruments.

Now let's try a level flight turn.



Figure 5

A Level Flight Turn

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 11, Situation 3**.

All but the primary instruments for a level turn are blackened out (Figure 5). I want you to enter a left turn at 4,000 feet and begin *Step two* of the *three-step* scan by

radial scanning the primary instruments. Adjust the attitude on the AI for a precise altitude of 4,000 feet and a standard rate turn.

Huh? What's a standard rate turn? See the sidebar on page 130.

Now, give it a try!

1. Press **P** to activate the simulation.
2. Make sure the throttle is set to a cruise power setting of 20 inches of MP.
3. Scan Step one: enter a 20-degree bank turn to the left. Select attitude, power, then trim.
4. Scan Step two: start at the AI and radial scan the altimeter.
5. Return to the AI and adjust the pitch (if necessary) to maintain 4,000 feet.
6. Radial scan the turn coordinator.
7. Return to the AI and adjust the bank (if necessary) to maintain a standard rate turn.
8. There's no need to radial scan the MP gauge since a power change isn't necessary in normal turns.
9. Keep radial scanning the altimeter and turn coordinator, making small attitude corrections until the airplane is established in level flight at 4,000 feet in a standard rate left turn.
10. Press **P** to pause the simulation.

Excellent job. You're improving so quickly that you'll soon be qualified to say, "Who's the greatest pilot ... and why am I?" Our final example will be a descending right turn.

A Power-off Descending Right Turn

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 11, Situation 4**.

All but the primary instruments for a descending turn are blackened out (Figure 6). I want you to enter a power-off descending right turn, then begin using *Step two* of the *three-step* scan by radial scanning the primary instruments. Adjust the attitude on the AI for a precise descent at 100 knots in a standard rate turn. Give it a try.

1. Press **P** to activate the simulation.
2. Scan Step one: select attitude for a 100-knot descent (a 20-degree bank to the right with a 1-degree nose-up pitch attitude), power (to flight idle) then trim.
3. Scan Step two: start at the AI and radial scan the airspeed indicator.
4. Return to the AI and adjust the pitch (if necessary) to maintain 100 knots.



Figure 6

5. Radial scan the turn coordinator.
6. Return to the AI and adjust the bank (if necessary) to maintain a standard rate turn.
There is no reason to radial scan the MP gauge since you've reduced the throttle to flight idle.
7. Keep radial scanning the airspeed indicator and the turn coordinator, making small attitude corrections until the airplane is established in a standard rate descending turn to the right at 100 knots.
8. Press **P** to pause the simulation.

What the Instructor Taketh Away, He Giveth Back

When a flight instructor blackens a flight instrument, that's called *partial panel* training. Apparently you never realize how *partial* you are to an instrument until it's gone from view. Now it's time to give them all back to you. In this final exercise, I want you to leave the labels under the instruments and practice *Step one* and *Step two* of the instrument scan. Your objective is to go from one major attitude of your choice to another, staying in that attitude only long enough to stabilize the primary instruments. Go from a *climb* to *straight-and-level* flight to a *descending turn* to a *straight climb*. You pick. All I ask you to do is apply the principles for Step one and Step two of the three-step scan.

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 11, Situation 5**.

When you're ready, have at it. I've placed your airplane at 4,000 feet on a heading of 270 degrees. You're in the soup (the clouds), as pilots say, so have fun.

In our next tutorial we'll complete the final step of the three-step scan. This is where we wrap up all the hard work of establishing the airplane in a new attitude. We trim, sit back, and enjoy the new attitude we've selected, at least until we decide to make another major attitude change.

Tutorial 12: Trimming Using the VSI and Monitor Scanning the Big 6 Instruments (Step Three of the Three-Step Instrument Scan)

By now, you know that instrument pilots are not folks who sit in airplanes and play piccolos or guitars. The closest they come to making music occurs as they follow a step-by-step instrument scan procedure when making a major attitude change. So far, we've covered two of the three steps. Let's complete our instrument scan procedure by studying the last step in the three-step scan.

Here are the three steps for your review. They're listed in the order you'd do them when making a major attitude change.

Step 1: Select attitude, power, and trim.

Step 2: Radial scan the primary instruments.

Step 3: Trim using the VSI and monitor scan the Big 6 instruments.

In Step one you made a major attitude change. In Step two, you fine-tuned the airplane's pitch, bank, and power. In Step three, you'll offer a final twist of the trim so the airplane stays put, then you'll relax a bit and *monitor scan* the six main flight instruments on your panel (also known as the Big 6 instruments). Monitor scanning is a more relaxed way of observing the flight instruments compared to the *radial scan* of Step two. Let's take a closer look at Step three of the scan.

Trimming with the VSI

Your main objective in Step three is to make a final trim adjustment by referencing the vertical speed indicator (VSI). The VSI is very sensitive to *small* pitch changes and will quickly indicate any deviation away from the desired attitude. Additionally, the length of the VSI's needle makes it easy to detect vertical movement.

The secret of the final trim is to look for a *constant* VSI indication. When leveling off, trim so that the VSI needle indicates a *zero* rate of climb. Since you may be using keyboard buttons to trim, make sure you don't sound like you're a telegraph operator. Give the trim wheel a slight twist (or the button a push) and then ease up on any control pressures you might be applying. Watch the VSI's needle. If it moves up or down, apply nose-down (**7** on your keyboard's numeric keypad) or nose-up (**1** on your keyboard's numeric keypad) trim to stop the needle's movement. (Remember that NUM LOCK has to be off.)

Trimming for a climb or descent is done in a way similar to trimming for level flight. Relax control pressure and watch for a constant VSI needle indication. Suppose the needle indicates a specific

Letting Go

There's never any reason to completely let go of the controls to see which way an out-of-trim airplane moves. This causes pilots more heartaches than it's worth. And whatever you do, don't let go of the controls while saying, "Accept this sacrifice, oh great lord of darkness."



Yikes! By letting go of the controls, instead of easing off a little on control pressures, an untrimmed airplane could rapidly deviate from the planned flight attitude, depending on just how out of trim it was. Now you must return the airplane to its previous flight condition before you re-trim. It's much easier to relax the control pressure, observe the beginning of any VSI needle movement, and make a corresponding change in the trim. Very small adjustments in trim can now be made without having to recapture a runaway airplane.

climb rate. If you relax control pressure and the needle moves, then the airplane needs trimming. Apply nose-up or nose-down trim as appropriate to stabilize the airplane at the previous climb rate (or descent rate). It may take two or three adjustments of trim to find a setting that works, but that's okay. You've got the time. It's not as if you're going anywhere, are you?

Also, keep in mind that it's very difficult to trim an airplane perfectly. Even if you're a high priest or priestess of trim, an airplane can still wander up or down a few hundred feet. There's not much you can do about this outside of making small manual pitch corrections. Airplanes are not all created equal. A little dent here, a little extra weight there—these have a subtle effect on aerodynamic performance which prevents an airplane from being perfectly trimmed.

Monitor Scanning

After the final trim adjustments are made, the six main panel instruments (Figure 1) are *monitor scanned*. This is often done in a clockwise fashion, going from the top row to the bottom row of instruments. Actually, you can select any particular pattern of eye movement that is comfortable to you. The objective is to monitor deviations from the established attitude. If you notice a deviation, make a *small* adjustment on the *attitude indicator* to maintain the desired flight conditions.

Monitor scanning is the condition in which you'll spend most of your time while on instruments. Step three, therefore, is performed continuously until a new flight attitude is desired (thus requiring a major change in attitude). All three steps of the scan procedure are repeated again when making this major attitude change.



Figure 1

The first two steps of the three-step scan process typically take 5 to 15 seconds to complete. There are instances where you've completed Step two of the scan and might not be able to move on to Step three. For example, in turbulence, or when you're on an instrument approach, you may find yourself obliged to rapidly radial scan the primary instruments to maintain precise control of the airplane.

Remember, radial scanning is a lot of work: physically, intellectually, and emotionally. It is possible to radial scan all the instruments on the panel, but this is usually unnecessary and can become very tiresome. Radial scan only those instruments necessary to control the airplane.

Tips from the Professionals

Over the years, some professionals have reported a rather unusual method of detecting instrument deviation once the airplane's attitude has been established and the aircraft trimmed. These pilots focus their vision in the center of the panel, just underneath the attitude indicator. Relying upon only their peripheral vision, they watch for any instrument movement. In much the same way a speed reader is taught to take in three or four words at a glance, instrument pilots can absorb information from clusters of instruments at a single glance. Developing peripheral vision takes practice, but it does seem to represent the higher art of instrument flying. Until then, keep your eyes moving around the panel while looking for attitude deviations.

Subtle Secrets

The VSI, once mastered, provides additional useful information for the precise control of an aircraft. Most pilots also find the VSI useful for helping maintain level flight within the 10- to 20-foot range. Sometimes it's easier to use the VSI than the AI to identify trends away from level flight because of the large swing arc and greater sensitivity of its needle. Taking time to learn to fly the VSI with precision pays off handsomely.

There are many boring things to do in life, but instrument flying isn't one of them. The art of flying instruments is a challenging test of your mettle. Instrument flying offers you the opportunity to master the airplane and yourself. Perhaps this is why most instrument pilots are so happy. They realize the scope of their accomplishment. I should warn you, however, that looking really happy at the airport is often inconvenient. Someone might become suspicious and require you to take a drug test. Be cautious!

Now that you've learned to fly with your instruments, the next tutorial will teach you how to get back on the ground when all you can see out the window is a cloud.

Tutorial 13: Understanding Instrument Approaches

Okay, time to sit back in your easy chair, grab a soda, and get prepared to sip and learn. That's right, get comfortable because this tutorial won't involve any flying. It'll consist mainly of a friendly little discussion about the principles of instrument flying. No, nothing super-secret is going to happen. No special handshakes. No passwords. Specifically, we'll talk about what an instrument approach is, and why, when, where, and how it's done. When you're finished, you should be familiar enough to handle a basic instrument approach—the kind the pros fly in their heavy-metal airliners.

VFR vs. IFR Flying

In our earlier lessons, we spent a great deal of time learning how to fly the airplane visually, by looking at the horizon through the window. Pilots refer to this as flying *VFR*, which stands for flying under *Visual Flight Rules*. But what happens when you can't see the horizon, such as when clouds are present? Can you still fly? Yes, you can fly *IFR*, otherwise known as flying under *Instrument Flight Rules*.



IFR flight allows you to fly in the clouds using your airplane's instruments to maintain control of the airplane and using your navigation equipment (such as VOR) to figure out where you are and take you where you're going. This can all be done in the clouds without having to see outside—at least until you're ready to land the airplane, that is. Landing the airplane always requires that you see the runway well enough to land. (Yes, even if you carry a lot of insurance and wear a helmet with a roll bar, you still need to see outside to land.)

To fly IFR, pilots need an *Instrument Rating*, which is obtained after acquiring the Private Pilot Certificate. It requires additional training in such things as maneuvering the airplane by its gauges, advanced navigation, and so on (and you must also promise not to tell other pilots how much fun it is, or everybody will want to do it). The bulk of instrument training deals with learning to scan the instruments, just like you practiced in the three-step scan tutorials.

So you're now ready to move beyond the instrument scan. You're ready for the next level, which in some computer games requires that you slay an enormous, fire breathing, multi-eyed beast. Well, not today. Reholster your laser-phaser and sip that soda, Yoda, because we're going to learn how to fly a full-blown instrument approach.

Instrument Flying: The Big Picture

Instrument flying works this way. First, a pilot files an IFR flight plan with Air Traffic Control (ATC). This is like making a dinner reservation at a fancy restaurant, in that it alerts the restaurant staff to reserve space for you. Same with ATC. After the plan is filed and you're ready to go, you typically call the air traffic control tower at your departure point, and tell them you have a flight plan on file. They'll say, "Okay, we've accepted your flight plan, and you're cleared for takeoff." It's pretty simple, and unlike the restaurant scenario, you aren't expected to leave a tip.

With flight plan and clearance in hand, you depart, climb into the clouds (if clouds are present), and head on your way. Your objective is to follow the airways aloft to your destination. These airways are constructed from VOR courses that crisscross the country. How do you know which routes to follow? The same way you know which highway to take when you travel on vacation—the roadmap. Pilots, however, use an aerial version of this roadmap that shows all these VOR routes along with the route's minimum altitudes. These altitudes keep you from getting so low that you end up knocking birds out of trees.

All the while, ATC and its big fancy radar is keeping track of you and anyone else who happens to be flying IFR in your vicinity. If airplanes get too close, the radar controller separates the airplanes with verbal commands. No, not commands like, "Hey, look out!" or "Dive! Dive! Dive!" or "Oh, the humanity!" The controller simply *vectors* airplanes (gives headings to fly) away from each other until the collision danger has passed.

As pilots approach the destination, they reach into their flight bag and bring out a special piece of paper that seems thin enough to be a nose tissue (but don't blow your nose with it or the passengers may think Zamfir, master of the pan flute, is flying the airplane). This paper is called an *instrument approach chart*. It contains detailed instructions on how to leave the *en route* portion of the flight, approach the airport and land, all the while using some means of electronic navigation (typically VOR). Most big airports have one or more of these instrument approaches (and charts). If you'd like to see an example of what I'm talking about, just peek ahead to the next tutorial for a moment. (Yes, it's cheating, but I won't tell.) Figure 1 in Tutorial 14 shows a typical VOR instrument approach chart.

The Approach Chart

Instrument approach charts have several things in common. At the top, they show the frequencies you'll use to talk to the local air traffic controllers (section A in Figure 1, Tutorial 14). Below this is a *plan view*, which shows the electronic navigation aids that you'll use to fly to the airport (section B). Below that is something known as the *profile view*, which gives you a few of the preliminary minimum altitudes you'll use as you descend to the airport (section C). Finally, at the bottom is the *minima section* (section D). This shows you the minimum altitudes to which you can descend as you fly toward the airport.

There is a point known as the *Missed Approach Point (MAP)*, and it's shown on all approach charts. (Don't get confused about this. If MAP is in all capital letters, it's not the kind of map you use to find directions in a car!) At the MAP, the pilot must see the runway clearly enough to land. This point is normally shown by the symbol "M" in the profile section (section C). If you can't see the runway clearly enough from the MAP, you must make a missed approach. This means you'll most likely go to another airport that has better weather.

Now that I've marinated your noodle with these ideas, I'm sure you're curious about how to fly an instrument approach. Let's find out. While there are several common types of instrument approaches, let's examine the most common one first. It's called the *VOR approach*, and you'll learn to fly it in the next tutorial.

Tutorial 14: Flying a VOR Approach

We talked about using VOR navigation to get around in the air back in Tutorial 9. Well, Grasshopper, you're about to get your black belt in VOR, and use it for landing.

Examining your First VOR Approach

Figure 1 is the VOR approach chart for the municipal airport in Santa Monica, California. Look at the thick black line located in the plan view (position E) running from right to left down toward the airport. This is the instrument approach course that takes you to the airport (position F). The VOR station (position G) that provides the navigation signal for the approach is located at the airport. Here's how you'd fly this approach.

Let's assume your airplane is located at DARTS *intersection*. (An intersection is a point where two VOR radials cross—this one is at position H in Figure 1.) This intersection shows the beginning of the VOR approach course. All instrument approach courses are identified by thick black lines in the plan view section. Notice that the VOR approach course consists of the 212-degree VOR course to the Santa Monica VOR. Your job is to get on that thick black line and fly the depicted course to the airport. While you're tracking this course, you're also descending to the lowest altitudes shown in the approach chart's profile section (position C).

So how do you get onto this approach course in the first place? Either ATC will give you radar vectors (headings) to intercept the thick black line, or you can fly another VOR course that leads you to it (more on this later).

Flying the Santa Monica VOR Approach

To fly the 212-degree course to the VOR, you'd tune your navigation receiver to 110.8 MHz (Santa Monica's VOR frequency, position I) then set your OBS to 212 degrees. Heading 212 degrees will align you with the approach course. From here you begin tracking the 212-degree course to the airport.

The profile section shows that once you're past DARTS intersection (position J) you can descend to an altitude of 2,600 feet. Many airplanes have *distance measuring equipment* (DME). If yours does, you can obtain a DME reading from the Santa Monica VOR. As you approach the VOR, the DME counter shows your distance from the VOR decreasing. When the DME shows 6.7 miles, you're at BEVEY intersection (position K). Now you can descend to 1,120 feet. What's the reason for making descents in steps? You're kept above the higher obstacles located along the approach course. As you get closer to the airport the obstacles usually aren't as tall (apparently, other pilots have already knocked the bigger ones down). Therefore, you're progressively lowered on the approach course as you approach the runway.

SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.

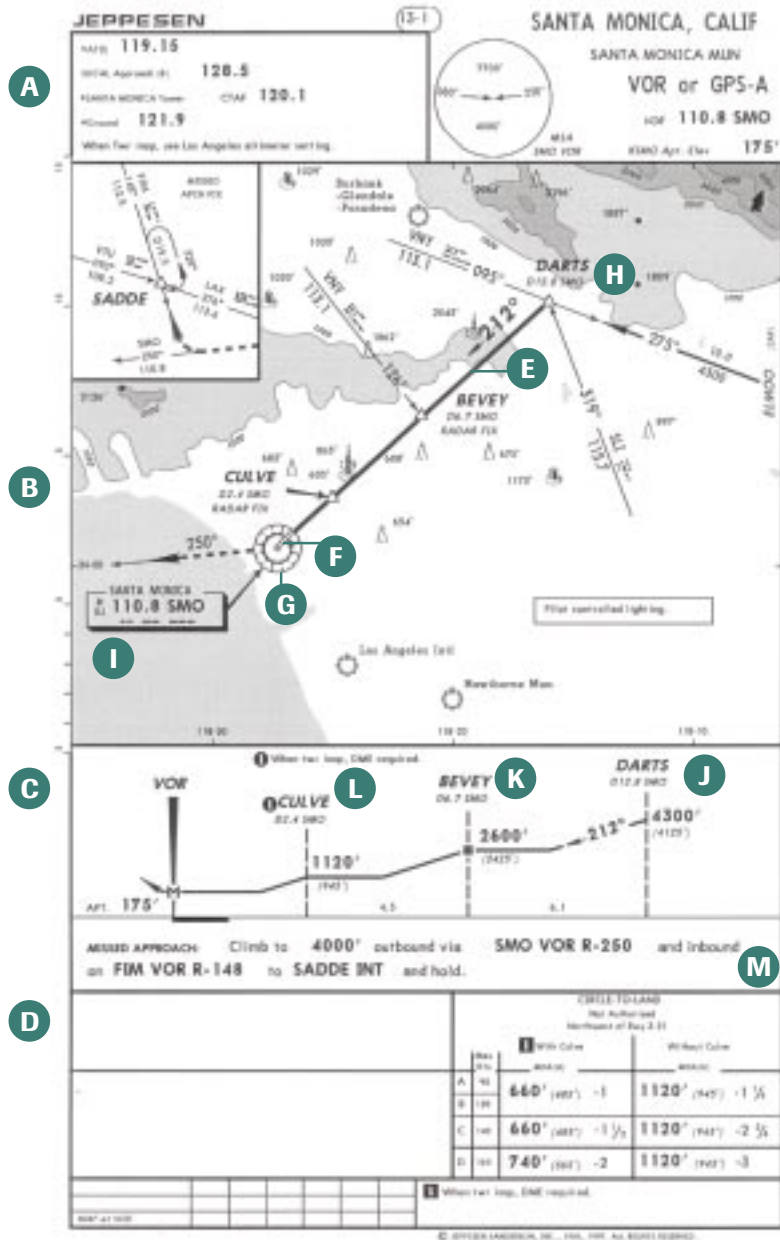


Figure 1

Finally, when the DME reads 2.4 miles, you're at CULVE intersection (position L). Since no lower altitudes are shown in the profile view, you need to go to the minima section (position D) for the final and lowest altitude to which you can descend. The minima section shows 660 feet as the *minimum descent altitude* (MDA). To go any lower, you must have the airport in sight. You must also have at least one-mile flight visibility (shown in the minima section next to the 660 feet) to go below the MDA.

If you don't have the airport in sight (and the one-mile visibility) by the time you fly over the VOR, you're required to execute a missed approach. Therefore, if the VOR flag flips from TO to FROM and you don't have the airport in sight, you must fly the missed approach procedure (position M). This procedure takes you to a safe altitude from which you can plan your next approach.

Would you like to try this approach? Great! Put down that soda and let's do it.

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 14, Situation 1**.
The simulation places you about 5 miles northeast of DARTS intersection in VFR conditions on a heading of 212 degrees at 4,300 feet. Your DME is set to read the distance from the SMO VOR (it now shows 18.0 miles from the VOR). The autopilot's altitude and heading hold modes are active.
2. Press **P** to activate the simulation, and deactivate the autopilot by pressing **Z**.
3. Descend to the MAP using the minimum altitudes shown on the approach course and try to keep your airspeed at 100 knots. Remember to use your DME to determine your location along the instrument approach course.
4. Press **P** again to pause when you're at the MAP.

Now let's try the same approach in instrument conditions.

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 14, Situation 2**.
This lesson has a ceiling of 700 feet with 1.5 miles flight visibility. If and when you make visual contact with the runway, attempt a landing. Remember, don't leave the MDA until you have the runway in sight and at least one-mile visibility (you'll have more than the required visibility because I programmed this simulation for a visibility of 1.5 miles). Give it a try.
2. Press **P** to activate the simulation and, when you've landed, press **P** to pause the simulation.

A Variation of the VOR Approach

There are several variations to the VOR instrument approach procedure. Once you master these, you'll have no problem interpreting any approach chart. For instance, Figure 2 is the VOR approach to Long Beach, California. (You'll notice that there is a slight difference in chart format between Figures 1 and 2. Within the next couple of years, all approach charts will eventually change to the format shown in Figure 2.)

The approach consists of two main segments. The first segment is the 300-degree course to the SLI VOR (tune the VOR to 115.7 MHz and set the OBS to 300 degrees). The minimum altitude along this route is 1,500 feet as shown by position A.

Once the TO/FROM flag flips and reads FROM, you need to turn and track outbound on the 275-degree course (position B), which leads you to the airport. Since the profile doesn't show any minimum altitudes for this section of the procedure, look at the minima section of the chart (position C). You're allowed to descend to 560 feet on this approach. Where's the missed approach point? It's based either on time (start your timer at the VOR and count down the time for a given ground speed) or a DME reading from the VOR. Both of the missed approach points are shown at position D.

Would you like to try this approach? Great!

1. From the **Flights** menu, click **Select Flight**, and choose **Tutorial 14, Situation 3**.
I've placed you approximately 5.5 miles southeast of the SLI VOR on the 300-degree course. Your navigation radio is set.
2. Fly this approach at 100 knots.
3. Press **P** to activate the simulation and, when you've landed, press **P** to pause the simulation.
If you'd like to try the approach with a ceiling of 600 feet (that's 40 feet above the lowest minima) and 1.5 miles flight visibility, try **Tutorial 14, Situation 4**.

The Racetrack Course Reversal

One last note on this approach chart. Notice the *racetrack* pattern shown in the plan view (position E). This is one of two means of course reversal. (A course reversal is sometimes called a *procedure turn*.) If you're heading to the VOR from the north, it's too sharp a turn to cross the VOR and fly the 275-degree course toward the airport. Therefore, you should cross the VOR and reverse course. Flying a heading of 120 degrees (position F) allows you to go opposite the inbound course. From here you'll turn to intercept the 300-degree course to the VOR and fly the 275-degree course toward the airport once you've crossed the VOR station. Simply stated, your objective is to try and stay within the boundaries of the racetrack as you reverse course (it's a tad more technical than this but at least you get the idea). If you stray outside these boundaries, you're not given protection for terrain. Of course, in a simulator, this is no big deal. You may conk a few simulated mountain goats on the head, but so what? Since we're practicing to develop real flying skills, however, let's pretend this is real. So, what's the minimum altitude to fly the racetrack course reversal? This is shown in the profile view as 1,500 feet (position G).

Therefore, if I'm heading down to SLI VOR from the north, I'll turn and fly a heading of 120 degrees after crossing the station. This should keep me close to the racetrack boundaries. After *one minute* (the time shown next to the racetrack in the profile view, position G), I'll turn left to intercept and track the 300-degree course back to the VOR and complete the instrument approach. Of course, this also assumes that I've previously set my OBS to 300 degrees. With slight simplification, that's pretty much how it's done in the real world.

As an additional note, there are routes leading to the VOR (called *feeder routes* because they *feed* you onto the instrument approach procedure) which don't require a course reversal. Position H shows one feeder route starting at MIDDS intersection and listing the letters *NoPT*, which stands for *no procedure turn*. Along this route, you should fly the instrument approach without doing the course reversal. In other words, fly directly to the VOR, then to the airport.

The Barb-type Course Reversal

The second type of course reversal is shown in Figure 3. This is known as a *barb-type* course reversal. Let's assume you're approaching from ITMOR intersection (position A). This route leading to the RDD VOR consists of flying the 224-degree course (tune the VOR to 108.4 MHz and set the OBS to 224). The minimum altitude along this route is 3,700 feet (position B). Once you cross the VOR, turn and track outbound on the 175-degree course as shown by position C (you must now set your OBS to 175). The objective here is to travel outbound, reverse your direction, then track inbound and fly the instrument approach course.

The profile view shows 2,000 feet as the minimum altitude for the procedure turn, which should be completed within 10 nautical miles (nm) of the VOR (position D). As you're descending, you'll travel outbound and, while still within 10 miles, you can turn to a heading of 220 degrees (position E). Fly this heading for a minute or less, then turn left to a heading of 040 degrees (position F) and intercept the approach course inbound. This means you must reset your OBS to track to the VOR (turn the OBS to 355 degrees). Once inbound, you may descend to 1,260 feet (position G). When your DME (from RDD VOR) reads 2.6 miles, you can descend to 860 feet, which is the altitude shown in the minima section (position H). The "M" shown in the profile section (position I) depicts the VOR as the missed approach point.

Notice the two feeder routes leading from ITMOR and RED BLUFF VOR to RDD VOR (positions A and J). Feeder routes are shown as slightly thinner than the instrument approach course and they are always accompanied by minimum flyable altitudes. Neither of these routes lists the letters *NoPT*. Therefore, as you approach RDD VOR along either of these routes, you *must* fly the procedure turn as a means of reversing course before flying the instrument approach procedure.

From the RED BLUFF VOR (position J), you'd track to the RDD VOR on the 336-degree course (set OBS to 336) then make a left turn after crossing the VOR and track outbound on the 175-degree course from the VOR. Then you'd repeat the same course reversal process listed above.

SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.

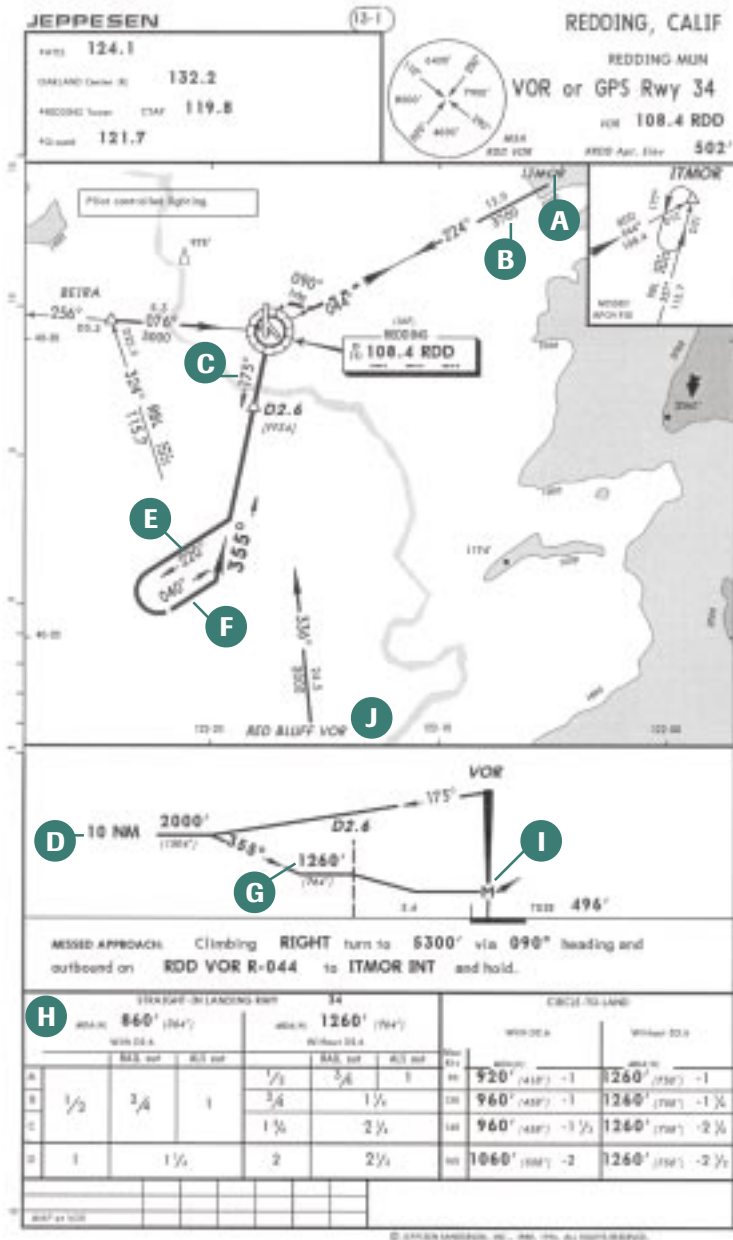


Figure 3

I'll bet you'd like to try this approach, wouldn't you? Okay, here's the setup.

Select **Tutorial 14, Situation 5**. (You know where to find it.)

I've placed you approximately 10 miles northeast of the RDD VOR on the 224-degree course inbound. Your navigation radio is set to RDD with the OBS set to 224. The autopilot is off and you're at 6,700 feet. ATC has cleared you for the approach, which means you can descend to the lowest altitude shown on the route you're flying. In this instance, you're inside ITMOR intersection (position A), so you can descend to 3,700 feet. Give it a try.

Press **P** to begin the simulation, and then press **P** to pause it once you've reached the MAP (which is the VOR located on the airport).

Just in case you'd like to try the same approach with a 1,000-foot ceiling and one mile visibility, select **Tutorial 14, Situation 6**. Have fun.

Did you get all that? I just took you through a quick course on VOR instrument approaches, something that usually takes instrument pilots months to understand. If you want to put an ice pack on your cranium, I'll understand. But, believe it or not, there's only one more approach you need to look at in order to have a general idea about how most instrument approaches work. It's called the *instrument landing system* (ILS). We'll talk about that in the next (and final!) tutorial, but first, hold everything!

Hold that Pattern!

When an airline captain comes over the intercom and says, "Umm. . . looks like we're gonna have to hold here for a while," you probably groan and think, "Great. A delay." Well, you know more about instrument flying than you think you do, because that's exactly what holding is designed to do—delay an aircraft. An airplane can't just pull over to a rest area when ATC needs to delay its arrival somewhere because of traffic congestion or weather conditions. So the controller tells the pilot to fly a *holding pattern*.

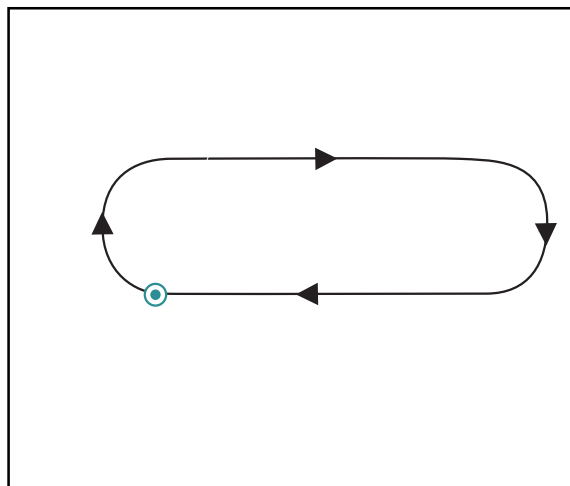


Figure 4

A standard holding pattern looks like an oval racetrack anchored at a *holding fix* (a VOR, nondirectional radio beacon (NDB), or intersection), as shown in Figure 4. The two straight legs are called the *inbound* and *outbound* legs. In a standard holding pattern, you make all turns to the right (non-standard patterns therefore have left turns). All turns should be at standard rate. How long are the legs of the pattern? Long enough so that flying the inbound leg will take about one minute. Wind will affect the leg length—so if there’s wind, you need to adjust the length of the outbound leg so the next inbound leg will take a minute.

Actually flying a holding pattern is pretty easy, but figuring out how to enter one is something most pilots dread. To keep airplanes within protected airspace, the FAA recommends specific entry methods. Which entry method to use depends on your heading when you initially cross the holding fix.

Direct Entry

Use a direct entry (as shown in Figure 5) when approaching the holding fix in the same direction as the inbound leg. Fly to the fix and turn right (standard holding pattern) or left (non-standard holding pattern), and proceed with the holding pattern.

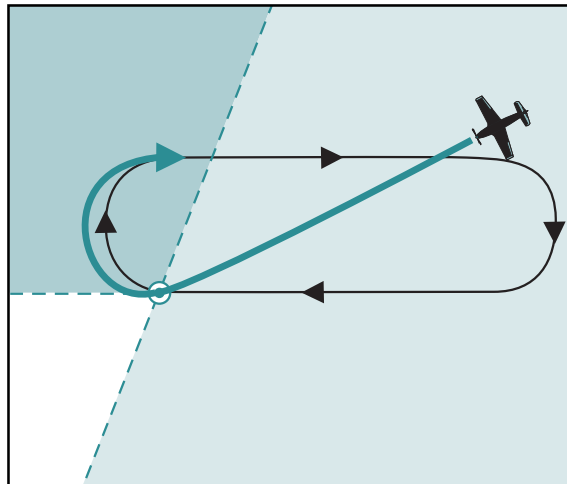


Figure 5

Parallel Entry

Use a parallel entry (as shown in Figure 6) when approaching the holding fix in the opposite direction as the inbound leg, and ending up *outside* the racetrack after crossing the fix. Turn to parallel the inbound course, fly outbound for one minute, then turn toward the racetrack to intercept the inbound course. Return to the fix and proceed with the holding pattern.

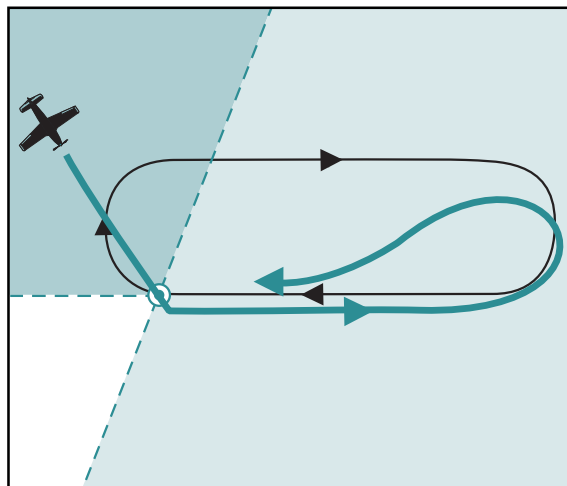


Figure 6

Teardrop Entry

Use a teardrop entry (as shown in Figure 7) when approaching the holding fix in the opposite direction as the inbound leg, but ending up *inside* the racetrack after crossing the fix. At the fix, turn toward the racetrack, to a heading that's 30 degrees off the outbound leg heading. Hold that heading for one minute, then turn in the opposite direction to intercept the inbound course. Return to the fix and proceed with the holding pattern.

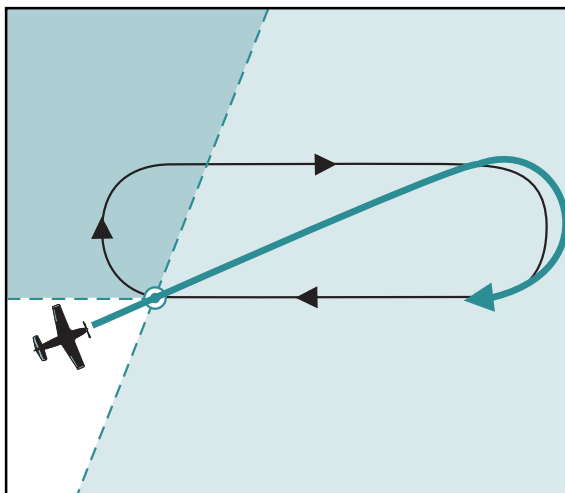


Figure 7

Sound complicated? Most pilots think so. Luckily, a simple direct entry is the most common entry type, since a controller will usually tell you to hold as you approach an intersection along your route of flight. Practicing holds is a great way to exercise your instrument flying skills, and should the day come when a controller tells you to hold, you'll know what to do.

Now, let's practice holding patterns and VOR approaches. Go fly **Instrument Lesson 1** and **Instrument Lesson 2**.

Tutorial 15: Flying an ILS Approach

Are you ready to rock and roll? If you thought VOR approaches were fun, wait till you get hooked on flying the *instrument landing system* (ILS) approach. It's perhaps one of aviation's most challenging, yet satisfying, aerial activities.

Don't forget to do the homework—the last homework of our class. Gets you a little teary-eyed, doesn't it?

An ILS approach consists of a descent to a runway with both vertical and horizontal electronic guidance. It's accomplished by following two needles (Figure 1) located in the ILS display (which is the same instrument as the VOR 1 indicator) on your instrument panel. Unlike other instrument approaches, this one takes you down to a height known as *decision height* (DH), also referred to as *decision altitude* (DA). DH is approximately 200 feet above the runway elevation as shown in Figure 2.

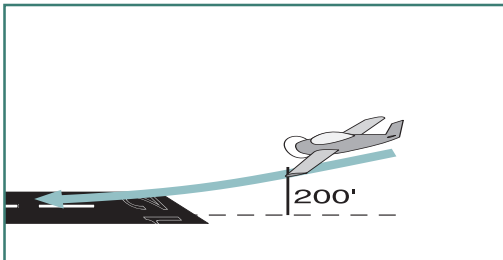


Figure 2

Two Beam or not Two Beam

The ILS consists of two electronic beams. One beam is angled outward and one is angled upward from the runway complex as shown in Figure 3. The outward (horizontal) beam is called the *localizer*. It helps align your airplane with the runway. You track the localizer by following the needle shown in Figure 1 (position A). If the needle is to the right, you go to the right; if the needle is to the left, you go to the left. A needle that remains centered means your

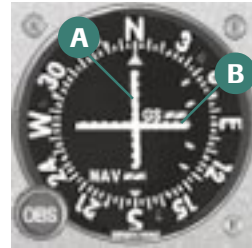


Figure 1

From this not-too-lofty perch, you can take a peek outside and decide if you can see the runway well enough to land. If unacceptable runway visibility prevents a safe landing, you apply power, climb, and head off to someplace else with better weather. Let's take a closer look at how the ILS approach is constructed.

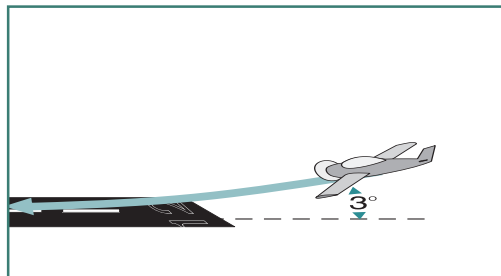


Figure 3

airplane is tracking the runway centerline. Under no-wind conditions, you just need to fly the runway heading to keep the localizer needle centered. If there's wind, you need to make small corrections to compensate for wind drift. Sounds easy, but it does take practice to perfect this skill.

The *glideslope* is an electronic beam that's tilted upward at approximately a 3-degree angle (Figure 3). By centering the glideslope needle, shown in Figure 1 (position B), you're flying an obstruction-free path down towards the runway, like going down a nice, shallow slide at a playground. How do you keep the glideslope needle centered? Fly towards it just like a localizer needle. If the needle swings upward, then fly upward; if it swings downward, then fly downward. The objective is to maintain the specific rate of descent which allows the airplane to track the glideslope down to DH.

Radial Scanning Primary Instruments

How do you maintain that descent rate? You must use the vertical speed indicator (VSI). In addition, flying an ILS approach requires that you maintain a specific airspeed and heading. Therefore, you must also scan the airspeed indicator and heading indicator. As you can see, this isn't the place to catch a little shuteye. Following the ILS needles to decision height is a demanding task. That's why you never leave Step two of the three-step instrument scan. In other words, you spend almost all of your time radial scanning these three important primary instruments. Figure 4 shows the primary instruments for an ILS approach.

The VSI is primary for *pitch*; the HI is primary for *bank* and the airspeed indicator (ASI) is primary for *power*. These instruments are radial scanned along with the ILS display (you don't, however, need to radial scan the

airspeed indicator that often). Therefore, three instruments are continuously radial scanned when flying an ILS, with other instruments occasionally included. Things are far too busy to perform the monitor scan found in the final step of the three-step scan. Now that you know what to look at, what descent rate and airspeed do you fly to stay on the glideslope?



Figure 4

The Constant-rate Descent

For a typical ILS approach flown at 90 knots, a 500-foot-per-minute (FPM) descent rate is required to remain on glideslope. Of course, if you fly the approach at a faster speed, you must increase your descent rate. Glideslope angle and wind are two factors that affect the precise descent rate required to center a glideslope needle. But we'll use a ballpark descent rate of 500 FPM for our example.

Okay, enough talk. Time for a little action, Jackson. Let's practice flying a descent at this rate.

Shucks, you probably thought I was going to let you off without doing another one of those experiments, didn't you? That's not going to happen as long as I'm your instructor. Fortunately, this experiment is fun.

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 15, Situation 1**.

The autopilot's altitude hold is off and the airplane is paused in level flight at an airspeed of 90 knots. I've also hidden the heading indicator, altimeter and turn coordinator for this lesson to help you focus on the appropriate instruments for a constant-rate descent.

Here's what I want you to do. Fly a descent at a constant rate of 500 FPM at 90 knots. Do this by radial scanning the VSI and airspeed indicator, starting with the attitude indicator. You'll do this by reducing power from its present setting to a little less than 10 inches of MP and letting the nose naturally pitch down slightly. Adjust the pitch as necessary to maintain a descent rate of 500 FPM and adjust the power to maintain 90 knots of airspeed. Yes, this is a reversal of the control functions we used in Tutorial 7. Using the controls in this manner allows you to maintain precise control of the descent rate required for an ILS approach. Give it a try.

1. Press **P** to activate the simulation.
2. Adjust power to maintain 90 knots in level flight (approximately 14 inches of MP as shown in Figure 5). Notice that 90 knots requires a pitch attitude of approximately 5 or 6 degrees nose-up pitch.
3. Reduce power to a little less than 10 inches of MP, let the nose pitch forward naturally, and adjust the pitch to maintain a 500 FPM descent rate. This requires approximately 1 degree of nose-up pitch on the attitude indicator (AI).
4. Trim to maintain the attitude for this descent rate.
5. Make small adjustments in pitch to maintain 500 FPM and a small adjustment in power to maintain 90 knots. (Airplanes have inertia so it may take a few seconds to change speed when moving the throttle. Be patient.)
6. Once you're established at this rate, press **P** to pause the simulation.



Figure 5

Believe it or not, you've just learned what to do when intercepting the glideslope. Since glideslopes are normally intercepted from below, you'll fly level at 90 knots until the needle lowers to a center



Figure 6

position in the ILS display (Figure 6). Once centered, you'll reduce power to a little less than 10 inches of MP, adjust the pitch and trim the airplane for a 500 FPM descent rate, all the while maintaining 90 knots. Assuming you're in perfect harmony with the universe, the airplane will remain on glideslope all the way to DH. But you know how easy it is to get a kink in your chakra, so you can't count on your karma being perfect. Therefore, you'll need to make slight variations in descent rate to keep the glideslope needle centered.

Let's assume that you're above the glideslope and must increase your rate of descent to capture it. Increasing the rate from 500 to 700 FPM should do it. Let's try this.

Making Changes in Descent Rate

1. Press **P** to reactivate the simulation.
2. Change the descent rate from 500 to 700 FPM by placing the airplane in a slightly lower nose-down pitch attitude (perhaps 0 degrees) as shown in Figure 7.

You'll also need to reduce power to keep the airspeed at 90 knots since you've pitched down slightly.

- The secret to maintaining a specific rate is not to chase the VSI needle. Simply place the airplane at the precise attitude on the AI, then make small pressure changes on the joystick to adjust the rate of descent.
- Let's assume you've captured the glideslope.

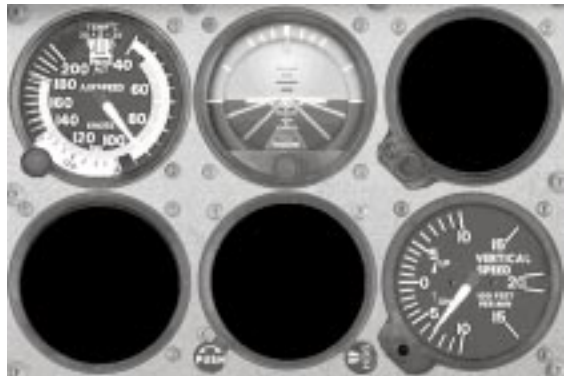


Figure 7

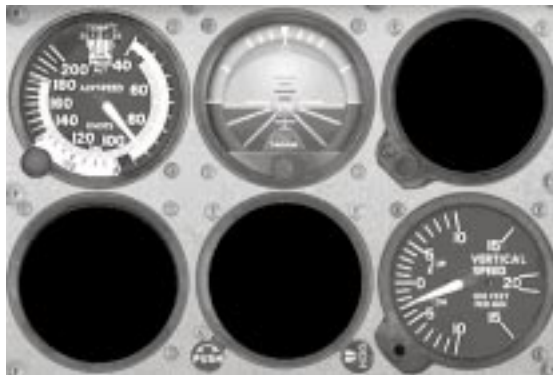


Figure 8

3. Return to a descent rate of 500 FPM by increasing the pitch back to the previous setting known to give you this descent rate (approximately 1 degree of nose-up pitch). Increase the power as required to maintain 90 knots.

From now on, don't worry about specific power settings. Just move the throttle to give you the speed desired.

Now assume you're below the glideslope and must decrease your descent rate to capture it.

4. Change the descent rate from 500 to 300 FPM by placing the nose in a 3-degree nose-up pitch attitude as shown in Figure 8. Increase the power a little (a bit over 14 inches of MP) to maintain 90 knots.

Remember, don't chase the VSI needle. Make pitch changes on the AI, followed by small pressure adjustments on the joystick to fine-tune the VSI's indication.

5. Practice alternating between a 300 and 700 FPM descent rate while maintaining 90 knots. (I've placed you at 5,000 feet above sea level, so it's best to reset the simulation occasionally by pressing **Ctrl+;**, otherwise you'll eventually conk some fish on the head.)
6. When you've developed some proficiency at this, press **P** to pause the simulation and read on.

Okay, you're ready for the real thing. Let's see what an actual ILS approach looks like.



Figure 9



Figure 10



Figure 11

From the **Flights** menu, click **Select Flight**, and choose **Tutorial 15, Situation 2**.

The radio stack is visible in the upper-right corner of your screen for this exercise.

The ILS frequency for Oakland's ILS approach is 108.7 MHz and I've set it into the number one navigation radio (Figure 9). The ILS display is shown in Figure 10. AN ILS doesn't have radials, but I've set the localizer direction of 294 degrees (this is the precise runway centerline direction) as a reference with the OBS. Additionally, the autopilot's *heading hold* and *altitude hold* features are activated. If you look closely at the ILS display (Figure 10), you'll see that you're about ready to capture the glideslope needle from below at 2,500 feet. Here's what you'll do.

Watch the autopilot fly this ILS. Then you can fly one by yourself later.

1. Press **P** to activate the simulation. Make sure power is adjusted to maintain 90 knots in level flight (about 14 Inches of MP).
2. Let the airplane fly straight ahead until the glideslope needle centers as shown in Figure 11.
3. In the autopilot box (at the bottom of the radio



Figure 12

stack), click the **ALT** button and **HDG** button to turn the altitude and heading hold off, and click **APR** (for approach mode) as shown in Figure 12.

4. Establish an airspeed of 90 knots by reducing power to a little less than 10 inches of MP.
5. Observe the descent rate required to fly the glideslope under these conditions (no wind is present) and notice how the localizer needle stays centered when you maintain a heading of 294 degrees.

You may need to reduce power a little during the approach to maintain 90 knots (descending into the denser air at lower altitudes tends to increase engine power).

6. Continue down to 205 feet, the decision height for this approach, then press **P** to pause the simulation.

What do you think? Neat, eh? Autopilots do a great job of flying the ILS because they make small changes in heading and descent rate (if and when this is necessary). A constant heading of 294 degrees and a descent rate of a little less than 500 FPM keeps the ILS needles centered. Figure 13 shows the descent rates vs. different ground speeds required to fly the glideslope on this approach. At 90 knots, for this 3-degree glideslope, a 485 FPM descent rate should keep you right on target.

RATE OF DESCENT											
ANGLE OF DESCENT (degrees and tenths)	GROUND SPEED (knots)										
	30	45	60	75	90	105	120	135	150	165	180
3.0	160	240	320	395	485	555	635	715	795	875	955
3.5	185	280	370	465	555	650	740	835	925	1020	1110
4.0	210	315	425	530	635	740	845	955	1060	1165	1270

Figure 13

Now it's your turn.

Okay, now fly this ILS approach by yourself. As soon as the simulation begins, click off the **ALT** and **HDG** autopilot modes. Intercept the glideslope and commence your descent. You're on your own. If you find yourself having difficulty, click the **APR** button and the autopilot will return you to the ILS.

Just make sure to adjust the throttle to a little less than 10 inches of MP for a 90 knot descent. Once established, click off **APR** and fly it yourself. Using the autopilot this way is like having me on board (in electronic spirit, that is). Here you go.

1. Click **Ctrl+;** to reset the simulation.
2. Press **P** to activate the simulation.
3. Readjust power to 14 inches of MP until intercepting the glideslope.
4. Click the autopilot's **ALT** and **HDG** modes to turn them off.
5. Fly the ILS.

If you're having trouble tracking the localizer, look at the runway ahead of you and visually align yourself with it. Observe how easy it is to fly a constant heading when looking at an actual runway. Why is it easier? Because you get pitch, bank and alignment information in one "over-the-nose" picture. When you can't look outside, it takes a developed instrument scan to acquire the same information from three different instruments: the AI, the HI, and the ILS display, respectively.

6. Click **Ctrl+;** and fly the approach over and over as many times as you desire.

I know this is fun, but you must remember to stop on occasion and consume nourishment. Also, remember if you have a family, they need your attention, too. If a moving van pulls up in front of your house, it's an early warning sign that you're spending too much time flying ILS approaches.

Perhaps you're wondering what it's like to fly an ILS in the clouds? From the **Flights** menu, click **Select Flight**, and choose **Tutorial 15, Situation 3**. This approach takes you down to decision height in heavy clouds under reduced visibility. Give it a try.

What is it like to fly a similar approach under moderate wind conditions? From the **Flights** menu, click **Select Flight**, and choose **Tutorial 15, Situation 4**. This approach takes you down to decision height in heavy clouds under reduced visibility in moderate wind conditions. You'll need to apply a wind correction angle to track the localizer. Remember, if you have difficulty, simply click on the autopilot's APR mode and it will re-establish you on the approach. Give it a try.

ILS Approaches with Charts

What makes the ILS approach more useful than a VOR approach is that it takes you directly to the runway and sets you up for a landing from a comfortably low altitude. The VOR (and other approaches) just takes you over the airport, sometimes at hundreds of feet above the runway. This, of course, makes it more difficult to transition from the instrument approach to the actual landing. The localizer portion of the ILS is much more sensitive than the VOR course. By sensitive I don't mean it

will cry if you yell at it. I mean that the needle response to course deviation is quicker than that of a VOR. This makes it a little more challenging to keep the needle centered in the display. (The glideslope needle is also quite sensitive, so don't yell at it, either.)

Figure 14 shows the ILS Runway 28R approach chart for Portland International Airport (position A). The localizer frequency is 111.3 MHz (position B). Tuning this frequency in your number one navigation receiver programs the VOR display to track *one* and *only one* specific course, which is precisely aligned with the runway (just in case you forgot, NAV 1 is the top receiver in the stack of two). This specific course is called the *localizer course* and, in the case of Portland, it's aligned in a direction of 279 degrees (position C).

Once the localizer frequency is selected, you can set the OBS to the inbound course for a heading reference. (We set this value in the OBS as a memory aid. The OBS is nonfunctional because the VOR receiver is now tuned specifically for the localizer course only.)

Let's assume that you're at 3,000 feet (the glideslope intercept altitude) at position D. You're flying a heading of 279 degrees and the glideslope needle located within the VOR display is above the center position. This means you're below glideslope. As you maintain 3,000 feet, the glideslope needle will eventually center (meaning you've intercepted it). Now you can begin your constant-rate descent as we've previously discussed.

Instead of making the step-like descents as you did with the VOR approach, the ILS allows you to follow an electronic beam down to the missed approach point while avoiding all obstructions in your path. (This is assuming you don't go below the glideslope and start knocking birds out of trees and chimneys off buildings.)

As you begin your descent on the glideslope, you'll fly over the *outer marker*, shown by the feathered vertical area in the profile (position E). This activates a blue *marker beacon* light in the cockpit (and an alarm that sounds just like the beeper that goes off when the fries are done at the burger joint). The outer marker notifies you that you're at a specific point along your descent (5.2 miles from the runway, as shown in the profile view at position F).

How low can you go on the ILS? All the way down to *DA*, which is 280 feet as shown at position G in the minima section. If you don't have the runway in sight by this point (as well as $\frac{1}{2}$ mile visibility), you must execute a missed approach. Yes, I know there is an "M" shown at the beginning of the runway (position H).

ILS without a Glideslope

Sometimes pilots elect to fly this approach without using the glideslope. They do so because they don't have a glideslope receiver or the glideslope isn't working at the airport (someone may have yelled at it, hurt its feelings, and now it refuses to work). Therefore, the dashed line (position I) in the profile view shows the MDA for the localizer approach, just like the stepdown altitudes you saw on

SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.

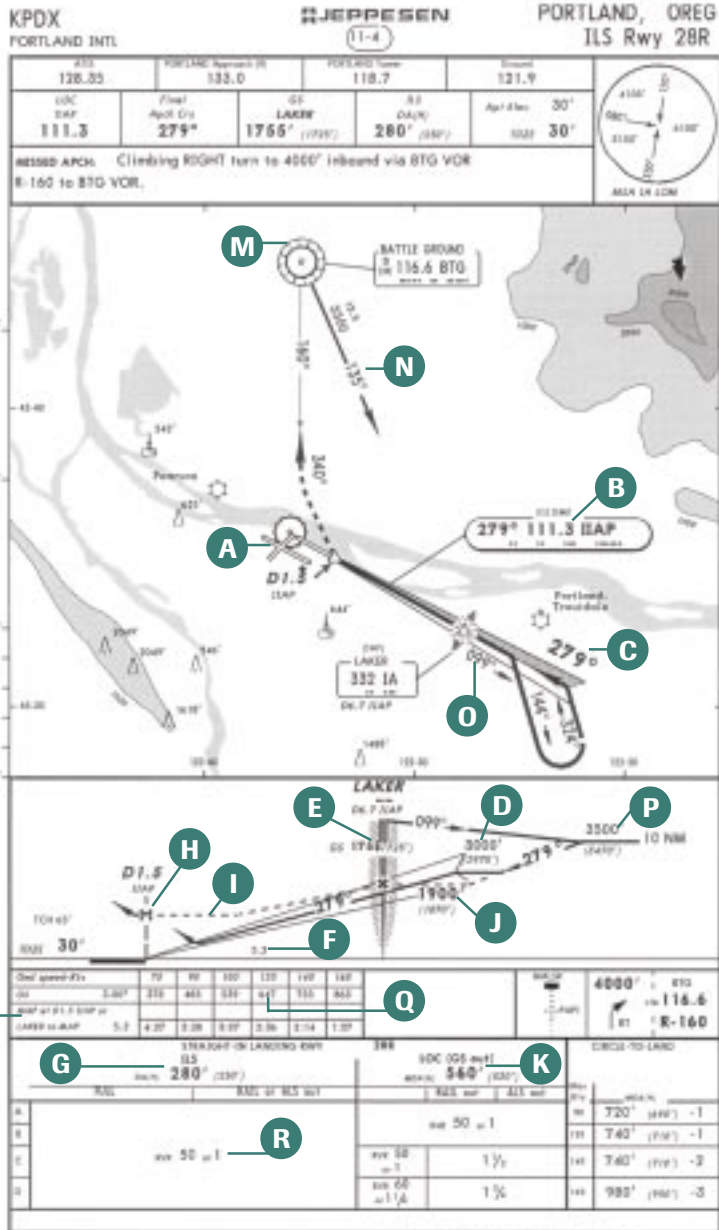


Figure 14

the VOR approach. If I were cleared for a localizer approach, I'd cross the outer marker at 1,900 feet (position J) then descend to 560 feet (position K) and fly to the MAP. The MAP is identified by time (based on a specific ground speed from the outer marker) or by DME on the localizer as shown by position L.

Most everything else about this approach chart should now be familiar to you. For example, suppose you're over Battle Ground VOR (position M) and ATC clears you for the approach. The feeder route from BTG to the ILS is the 135-degree radial (position N). Set your VOR to track outbound on this radial until you intercept the localizer. How will you know that you've intercepted the localizer? You can set one navigation radio (the bottom one) to navigate from BTG VOR and the other navigation radio (the top one) to receive the localizer. As you track from BTG VOR, you'll know you're over the localizer when the localizer needle centers. The outer marker beacon display will also activate in the cockpit as an additional clue since the 135-degree course takes you to LAKER intersection (located on the localizer).

At LAKER, fly 099 degrees (position O), descend to 3,500 feet (position P) and make a procedure turn within 10 nm of LAKER. There is one important item you must know about localizers. Because the localizer is a single electronic beam, tracking opposite its inbound direction results in the needle appearing to read in reverse. In other words, when you are flying outbound from the localizer, if the localizer needle moves in one direction (right or left) you must fly in the opposite direction (left or right, respectively) to center it. This is known as *reverse sensing*. Therefore, as you prepare to fly the procedure turn by tracking *outbound* on the localizer, you'll have to fly opposite the direction of needle swing to keep it centered.

Once you've completed the procedure turn and are inbound headed 279 degrees, the needle will indicate normally. You may descend to 3,000 feet (the glideslope intercept altitude) once established inbound on the localizer after making the procedure turn. Track the localizer and fly the glideslope down to DA.

Why don't you give this approach a try? Choose **Tutorial 15, Situation 5**.

The simulation places you at 3,000 feet on the localizer approximately 17.8 miles from the airport. Assume that ATC has cleared you for the approach. This means you should track the localizer and, when the glideslope needle centers, reduce power and begin a descent at 100 knots at approximately 539 feet per minute. You can do it.

Press **P** to begin the simulation and **P** again to pause the simulation after you've landed. Of course if you land too hard, the runway will pause the simulation for you, so be careful. And, if you want to try one under actual instrument conditions with ½ mile visibility, choose **Tutorial 15, Situation 6**.

I think you should also try an approach from over Battle Ground VOR: choose **Tutorial 15, Situation 7**. The simulation places you at Battle Ground VOR, heading 135 degrees at 4,500 feet. Your NAV 1 radio is tuned to the localizer frequency (111.3 MHz) and NAV 2 is tuned to BTG VOR (116.6 MHz).

Here's the sequence you should use:

1. Track on the 135-degree course from BTG until over LAKER intersection (you'll know you're over LAKER when the blue marker beacon light illuminates and you hear the beeping (fries are done) sound).
2. Turn to a heading of 99 degrees, then make an additional turn to center the localizer needle if required (remember, you'll experience reverse sensing here).
3. Descend to 3,500 feet and fly for two minutes past LAKER intersection (this should keep you within 10 nm of LAKER).
4. After two minutes, turn right to a heading of 144 degrees for one minute, then left to 324 degrees to intercept the localizer inbound.
5. Once you're inbound on the localizer, descend to 3,000 feet and intercept the glideslope (remember, at 120 knots groundspeed, you'll need to descend at a rate of 647 feet per minute (FPM) to remain on this glideslope as shown by the rate vs. groundspeed table in position Q). Your decision altitude is 280 feet and the minimum visibility required to land is one mile (position R).
6. Press **P** to pause the simulation at decision altitude.

When you're finished flying this approach, select **Tutorial 15, Situation 8**. This one is done in the clouds with ½ mile visibility.

Wind Correction on the Localizer

As a teenager I recall the first time I told my dad that I needed some space. He locked me out of the house and said, "Now you've got all the space you need." At that precise moment I understood the power of feedback. Feedback changed my behavior as I know it will change yours, especially in reference to flying the localizer.

When you first begin flying the ILS, head the airplane in the direction of the localizer. In the case of Portland, the localizer direction is 279 degrees. Fly 279 degrees and watch the needle's movement. You want feedback in the form of localizer needle movement. In particular you want to know which way and how much the needle moves as you hold 279 degrees.

The movement of the localizer needle tells you two things: wind direction and wind speed (determined by how fast the needle moves). Once the needle moves from its center position (use a one-dot horizontal deflection), re-center it with a 5 to 10 degree intercept angle (IA). The smaller the intercept angle, the less likely it is that you'll overcorrect. Of course, if you use a 10-degree intercept angle and the needle doesn't move back to center or moves farther from center, then a larger intercept angle is necessary. You also know that you'll need at least a 10-degree wind correction angle once you're re-established on the localizer.

Once the localizer needle is centered, apply a small correction for wind. Try a 1-, 5-, or 10-degree wind correction angle (WCA) based on your best estimate of the winds. With the WCA established, watch the localizer needle. If it returns to center you know that the best WCA is some angle between the current WCA and the localizer direction.

For instance, upon intercepting the localizer at Portland, you fly 279 degrees. In a few seconds, the localizer needle begins moving to the left. You fly a heading 10 degrees to the left of 279 degrees (an IA of 269 degrees) to reintercept the needle. When the needle re-centers, you apply a 5-degree WCA to the left of 279 degrees (274 degrees). If this WCA works, the needle will stay centered. If not, repeat the process using smaller heading changes to re-center the needle. This technique is called bracketing, and it's the technique all professional pilots use (with slight modification) to center VOR and localizer needles.



Practicing this technique is sure to save you embarrassment during later flights. The last thing you want is the localizer needle banging against the instrument case. That's when the passengers start asking those annoying little questions like, "Hey, what's that clicking noise? You got your blinker on, Bud? Is that a time bomb, or what?"

A Few Important Secrets

Now you have the basic idea about how ILS approaches are flown. So here's what the pros know. First, the most important instruments to radial scan are the HI and the VSI. It's not necessary to radial scan the airspeed indicator and the ILS display every time. In fact, you might limit your radial scan of the airspeed indicator to, perhaps, once for every 10 radial scans of HI and VSI. You can also reduce your radial scan of the ILS display to once every three scans of the HI and VSI. Of course, you want to take in the altimeter, MP gauge, and other assorted instruments on occasion, as time permits. Once you've found a heading and a descent rate that allows you to track the ILS, you must fly those values *precisely* until you have a reason to change them. I do mean precisely. Good instrument pilots can hold a heading to a single degree and a descent rate to within plus or minus 25 FPM. Honest! But this does take a lot of practice.

In turbulence, it's easy to have your heading and VSI indication bouncing all around. In these situations, it's best to fly averages. Do this by relying more on the AI for pitch and bank control. Find the pitch that allows for the approximate desired descent rate. Fly this pitch and keep the wings level on the AI.

Additionally, it's sometimes necessary to make small but jerky motions on the joystick when flying a simulator. Unlike the actual airplane, you can't sense a change in pressure on the flight controls. This prevents you from anticipating a change in attitude. Additionally, airplanes have rudders that help fine-tune the airplane's directional control. If you don't have rudder pedals or a joystick with rudder control, small jerky motions on the joystick are sometimes necessary to keep the airplane at precise attitudes.

Well, it's graduation day. If you've completed all these tutorials you've impressed me in several ways. First, you showed tremendous motivation, which I liken to Captain Ahab going after Moby Dick and taking the tartar sauce along. Ahab was motivated, just like you. While many of your brother and sister Flight Sim users were out buzzing bridges and skidding off aircraft carriers you were studying. Additionally, you've delayed your gratification and have earned basic flight skills as a result. I'm impressed.

Now you're ready to take the online **Instrument Lessons 3 and 4**, in preparation for your Flight Simulator **Instrument Rating Checkride!**

Remember, this is only the beginning. Consider taking a flight lesson in the actual airplane. Do it for no other reason than to see how much you really learned. Who knows? In a few years, it may be you taking me for a ride in your airliner.

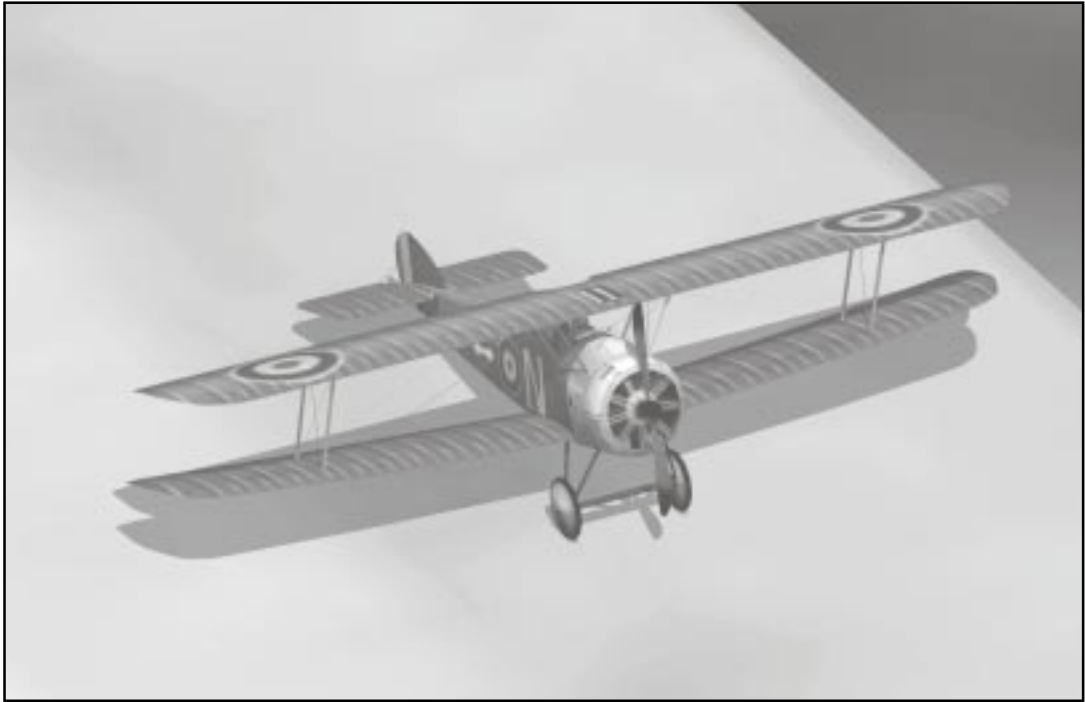
Bon Voyage!

A handwritten signature in blue ink that reads "Rod Machado". The signature is stylized and cursive, with the first name "Rod" and last name "Machado" clearly legible.



The Fleet

chapter eight



Sopwith F.1 Camel Specifications

Specifications	U.S.	Metric
Max Speed	99 kts 114 mph	183 kmh
Engine (two options)	110 hp Le Rhone 130 hp Clerget 9b rotary	
Maximum Range	300 mi	483 km
Service Ceiling	19,000 ft	5,791 m
Empty Weight	956 lb	433 kg
Gross Weight	1,523 lb	690 kg
Length	18.5 ft	5.64 m
Wingspan	26.9 ft	8.20 m
Height	9.083 ft	2.77 m
Seating	1	

Sopwith Aviation Company

Born to privilege, Thomas Octave Murdoch Sopwith could have spent his life playing polo and sailing his 166-ton schooner “Neva”—interests that preceded his passion for aviation. But his intelligence, energy, and curiosity combined well with his engineering education to steer him into pursuits that matched a bounding ambition. In 1910, Sopwith earned British Pilot Certificate no. 31, and before the year was out, he was competing for and setting British aviation records. Shortly after the New Year, he landed a Howard Wright biplane on the grounds of Windsor Castle at the invitation of King George V.

Within two years of earning his pilot certificate, Sopwith was designing his own aircraft and ascending rapidly in the ranks of British aviation. In early 1914, First Lord of the Admiralty, Winston Churchill, took his first ride in a Sopwith airplane. By then, Sopwith aircraft were already entering the service of the Royal Flying Corps, which was fortunate: on August 14th of that year, Britain declared war on Germany.

Among the thousands of airplanes built by Sopwith Aviation Company, Ltd. during World War I were such models as the Tabloid, the Strutter, and the Schneider and Baby floatplanes. More famous were the Pup, the Sopwith Triplane, and the most successful fighter of the war, the Sopwith F.1 Camel.

The rugged design and construction of the planes was frequently demonstrated in combat. One pilot had his Strutter set ablaze by anti-aircraft fire. He was able to put the flames out by ripping strips of burning fabric off the plane. He was then attacked by enemy planes and a severed fuel line forced a landing. The plane was up and flying again the next morning.

After the war, military order cancellations led to the dissolution of the Sopwith Aviation Company. Tom Sopwith became Chairman of Hawker Engineering, which absorbed the Sopwith patents. Following a 1935 merger with Siddeley Armstrong, the company became Hawker Siddeley Aircraft Company.

With war clouds gathering once again, Hawker Siddeley joined in the defense of the realm during the Second World War with the Hawker Hurricane (which can be flown in Microsoft® Combat Flight Simulator), the Typhoon, and the Tempest. From 1939 to 1941 the Hurricane was Britain’s front-line fighter. Though the Supermarine Spitfire won more acclaim in the history books, the Hurricane shot down more enemy planes in the Battle of Britain. More than 14,000 were built.

In 1953, Tom Sopwith became Sir Thomas Sopwith, in recognition of his contributions to aviation.

In more recent years, Hawker has produced business, military, and transport aircraft. They developed the widely respected Hawker 125 business jet, which today is owned and built by Raytheon Aircraft. Among the most famous Hawkers is the AV8-B Harrier “jump jet,” the world’s first vertical takeoff and landing attack aircraft.

In 1977, Hawker Siddeley merged with the British Aircraft Corporation to form British Aerospace (BAE). Employing over 43,000 people, BAE is one of the largest aerospace and defense contractors in Europe and is part of the combined effort to develop the future Eurofighter aircraft.

Sopwith 2F.1 Camel

In July, 1917, the Sopwith Camel entered the fray of World War I aerial combat. Developed by the British as a replacement for the Sopwith Pup, the Camel was an extremely agile and maneuverable airplane. With its two Vickers machine guns, it outgunned the Pup and provided a measure of insurance against losing a fight due to a jammed gun. The humped fairing that covered the machine guns gave the Camel its name. In less than two years' service, the Camel finished the war with 1,294 victories on its tally sheet.

The Camel was the deadliest Allied airplane of World War I—for enemy and Allied pilots alike. 413 Allied pilots suffered combat-related deaths and 385 died from non-combat-related causes in the Camel. Aces loved it but, it was not a plane for beginners. British Major W. G. Moore explained that “being totally unstable in all directions and very sensitive fore and aft, and much influenced by engine torque, [it] was a deathtrap for the inexperienced pilot. A skilled pilot could not wish for a better mount.”

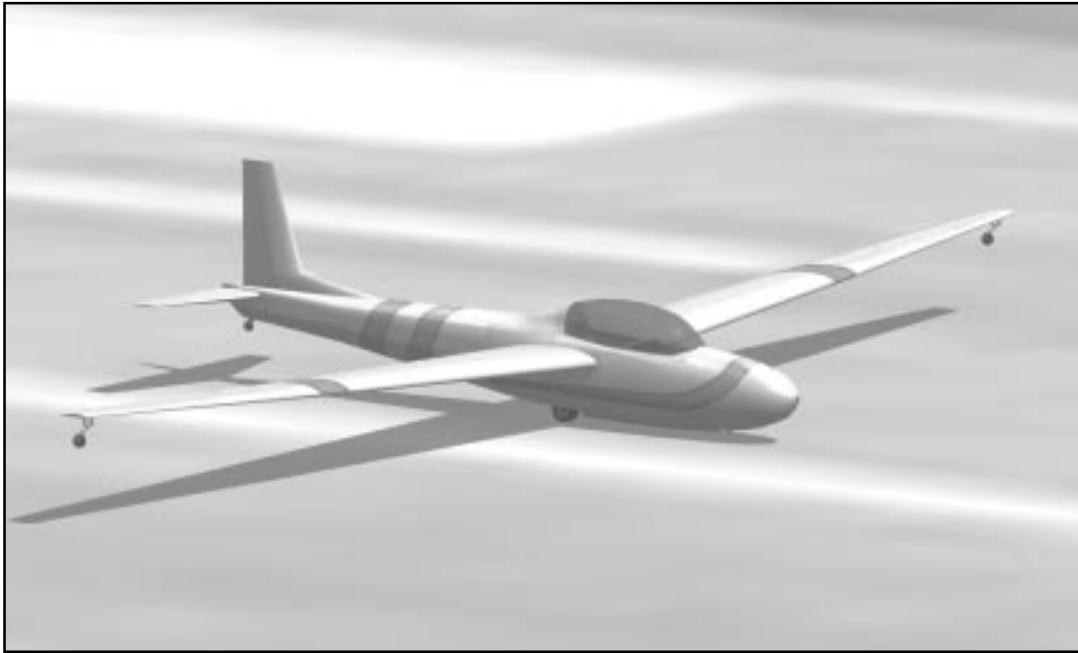
What made the Camel tricky to handle is that much of its mass was concentrated in the front seven feet of the airplane. While having incredible turn performance, the forward center of gravity combined with high torque forces from its big rotary engine meant that the plane could easily out-maneuver its unwary pilot. Sudden forward stick movements (which pitch the aircraft's nose down) could actually catapult the pilot out of his seat if he wasn't strapped in. The plane was also prone to deadly unintentional spins, of which little was understood at the time (proper Camel spin-recovery techniques not yet having been developed).

Though capable of flying higher, the Camel was most effective at around 12,000 feet (3,658 m), where its maneuverability had an advantage over German fighters. In his open cockpit at those altitudes, the pilot would be exposed to bitter cold. A pilot remembered, “I flew in a wool-lined leather coat, a red knitted scarf—important to keep out the draught—mask, goggles and mittens, plus long sheepskin thigh boots.”

The names of a number of World War I aces are inseparably linked to the Camel. Tradition holds that Canadian Sopwith Camel ace Roy Brown shot down the dreaded German flyer, Manfred von Richtofen (the Red Baron), although it is now generally believed that von Richtofen was downed by ground fire. Canadian Donald MacLaren scored 54 victories in the Camel. And, when famed cartoonist Charles Schulz chose to send his hero Snoopy up against the Red Baron, Snoopy's steed of choice was, of course, the Sopwith Camel.

For details on flying this aircraft, see the **Aircraft Information** section of Help.

As with all taildraggers, takeoffs, landings and taxiing can be tricky in the Sopwith. Carefully monitor your directional control.



Schweizer 2-32 Specifications

Specifications	U.S.		Metric
Maximum Speed	137 kts	158 mph	254 kmh
Engine	none		
Glide Ratio	34 to 1		
Empty Weight	850 lb		386 kg
Length	26.75 ft		8.15 m
Wingspan	57 ft		17.4 m
Wing area	180 sq ft		19.37 m ²
Aspect Ratio	18.05		
Maximum L/D (calculated)	~57 kts	~66 mph	~106 kmh
Minimum Sink (calculated)	~47 kts	~54 mph	~87 kmh
Seating	2		
Useful Load	580 lb		263 kg

Schweizer Aircraft Company

The love of soaring: that's the motivation that kept the Schweizer brothers building sailplanes through many years of less-than-soaring sales volume. Although the company's success was largely from manufacturing other products, they maintained a tradition of building some of the world's best sailplanes, even when it didn't always make the best business sense.

As teenaged boys, Ernest, Paul, and William assembled their first glider at home in a barn in 1930. The model 1-1 was launched by manpower (unlike modern gliders, which are towed aloft by powered aircraft, winches, or automobiles), and flown successfully by all members of the local soaring club. It was an auspicious beginning.

It wasn't long before the brothers formed the Schweizer Aircraft Company (SAC). Though they became widely respected for their designs and manufacturing acumen, it would be many years before a substantial enough market emerged to support large-scale production of sailplanes for private individuals. However, even during the lean years, soaring records were set and soaring events were won by pilots flying Schweizer sailplanes. Schweizer aircraft became the standard by which to measure sailplane performance.

With the advent of World War II, nearly every company having anything to do with aviation got into defense work. The Schweizer Aircraft Company built parts for many famous aircraft, including the P-40 and P-47 fighters and the C-46 transport, and they built gliders for the Army Air Corps to use in pilot training programs.

After the war, there were thousands of surplus gliders to be had cheaply, which dampened the commercial sailplane market. SAC, based in Elmira, New York, won a lucrative contract to build the welded fuselage for a neighboring company's new machine: the Bell 47 helicopter. SAC eventually built more than 1000 Bell 47 bodies. The company continued to be called upon by the government and other aircraft manufacturers as an important subcontractor of defense and civilian aircraft projects.

The first truly successful Schweizer glider (in terms of numbers built) was the SGS 1-26. It could be factory assembled or purchased as a kit for assembly by the owner. Over a 25-year production run, 700 of these planes were built. In 1962 SAC introduced the classic SGS 2-32, still considered to be one of the finest sailplanes ever designed.

For nearly 40 years the company built the Ag Cat, a radial-engine biplane used for spraying crops. They also went into the helicopter business, and today build three models in that line: the 300C, 300CB, and the 330SP. Still an active defense contractor, their products include the Schweizer SA 2-37A and RU-38 surveillance planes.

Sons of the three Schweizer brothers now run the company. With the passing of the company's command to the next generation, Schweizer Aircraft Corporation is one of the few remaining family-owned aircraft manufacturers in the United States.

Schweizer SGS 2-32

Through the late 1960s and much of the 1970s, one aircraft stood apart as the world's highest performance multi-seat sailplane: the Schweizer SGS 2-32. Many world soaring records were set in 2-32s in both men's and women's categories, including a distance run of 505 miles.

In the early 1960s, it was apparent that European manufacturers were beginning to cut into SAC's position as the premier builder of high-performance sailplanes. The European companies could build quality aircraft at 50% of the labor costs of the U.S. manufacturer, and deliver them to U.S. shores at a price that Schweizer couldn't match. In order to compete, Schweizer had to produce a superior aircraft.

Be patient and gentle. The sailplane's long wings don't move very quickly, so you may have to wait a moment to see a response after moving the stick.

In 1962 SAC began development of the 2-32. This aircraft took twice as many hours to design, tool, and build as previous Schweizer sailplanes. Initially priced at \$8000, the production and development costs of the meticulously designed aircraft eventually pushed the price tag up considerably.

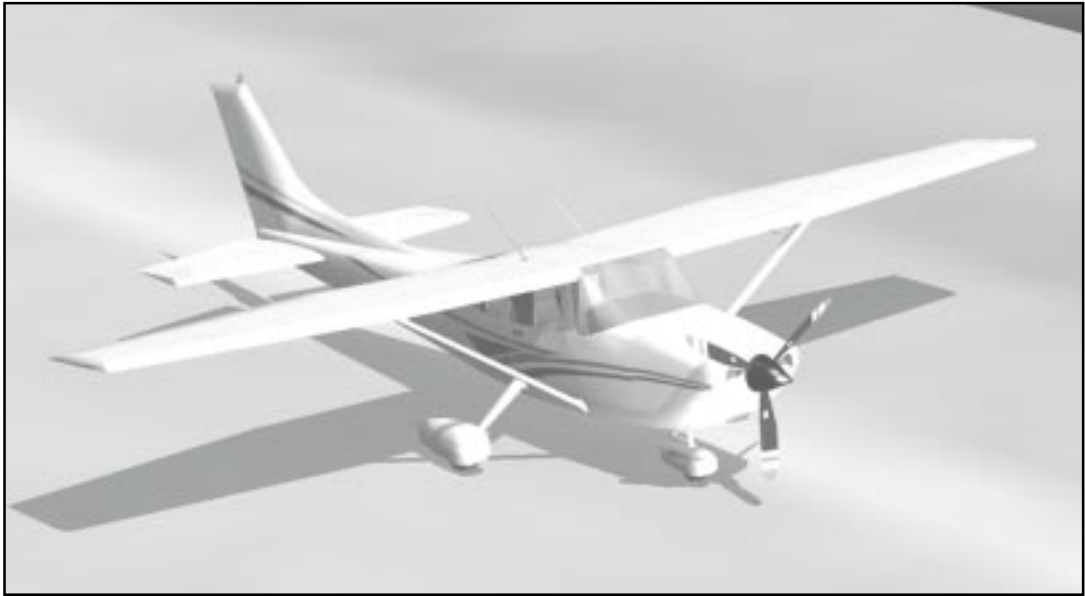
The 2-32's 57-foot wingspan provided a glide ratio of 34 to 1, which meant that at an altitude of 1 mile, the plane could glide a distance of 34 miles. The interior was luxurious and comfortable for a sailplane. It had dual flight controls, and though technically a two-seater, it could actually carry two people in the rear in addition to a pilot in the front. A large bubble canopy provided excellent visibility.

The highly efficient wing and aerodynamically clean fuselage of the 2-32 made it a candidate for an early attempt at non-stop flight around the world. Although that record was not set for many years (in 1986 by the Burt Rutan designed Voyager), a modified 2-32, sporting a small engine, did set a non-stop distance record of 8,974 miles (14,442 km) in 1969.

When the 1,000th Schweizer sailplane (a 2-32) was built, SAC held 57% of the sailplane business in the United States. But this was not to last. The all-metal SAC planes last indefinitely, and by the mid 1970s they had nearly saturated the market. Sleek new European fiberglass sailplanes had lower prices and carried a certain cachet that domestic sailplanes did not. SAC eventually ceased production of their sailplane line.

When manufacture of the 2-32 ended in 1976, a total of only 87 had been delivered. Nevertheless, the 2-32 had already earned a permanent place in soaring history, and remarkably, a 2-32 in good condition today can fetch as much as \$50,000. The model is still a popular choice for commercial soaring rides, and if you go to a local soaring center to take a ride, you may find yourself in a Schweizer 2-32.

For details on flying this aircraft, see the **Aircraft Information** section of Help.



Cessna 182S Specifications

Specifications	U.S.		Metric
Maximum Speed	145 kts	167 mph	269 kmh
Cruise Speed	140 kts	161 mph	259 kmh
Engine	Textron Lycoming IO-540-AB1A5 230 hp		
Propeller	McCauley 3-bladed constant speed		
Maximum Range	820 nm	944 mi	1519 km
Service Ceiling	18,100 ft		5,517 m
Fuel Capacity	88 U.S. gal		333 l
Empty Weight	1882 lb		854 kg
Maximum Gross Weight	3,110 lb		1,411 kg
Length	29 ft		8.84 m
Wingspan	36 ft		11 m
Height	9 ft		2.74 m
Seating	4		
Useful Load	1,228 lb		557 kg



Cessna 182 RG Specifications

Specifications	U.S.		Metric
Maximum Speed	160 kts	184 mph	296 kmh
Cruise Speed	156 kts	180 mph	289 kmh
Engine	Textron Lycoming O-540-J3C5D 235 hp		
Propeller	McCauley 2-bladed constant speed		
Maximum Range	1,135 nm	1306 mi	2,102 km
Service Ceiling	14,300 ft		4,359 m
Fuel Capacity	92 U.S. gal		348 l
Empty Weight	1,784 lb		809 kg
Maximum Gross Weight	3,100 lb		1,406 kg
Length	28.625 ft		8.72 m
Wingspan	36 ft		11 m
Height	8.75 ft		2.67 m
Seating	4		
Useful Load	1,328 lb		602 kg

Cessna Aircraft Company

His name is synonymous with light aircraft. Clyde Cessna, one of aviation's adventurous pioneers, started flying in 1911 and began building planes soon after. The first was a tiny monoplane that he named "Silver Wings." Throughout the early teens he built and crashed a number of aircraft which were either modifications of other designs or designs of his own. He had minor success during this time as a manufacturer and as a pilot, putting on demonstrations at public gatherings for fifty cents a head.

Cessna went back to farming for several years but in the mid-twenties was enticed to join in an aviation venture with Walter Beech and others. Soon he struck out on his own again, determined to build the first airship with a full-cantilever wing, the Cessna Phantom. The Cessna Aircraft Company was soon building the A-series planes, which were successfully employed in commercial and racing ventures.

Success led to expanded production facilities and development of the DC series. The DC-6A and DC-6B were officially certified on October 29, 1929—the day of the stock market crash, harbinger of the Great Depression. Despite valiant attempts to keep the company alive, the plant doors were closed. Cessna privately continued developing and racing planes with his son until his dear friend Roy Liggett was killed in a plane designed and built by Clyde during a race at which he was a spectator.

Though Clyde's enthusiasm for flying was dampened, that of his nephews was not. After assisting in the resurrection of the company, Clyde relinquished the company helm to his nephew Dwayne Wallace, who would lead Cessna Aircraft

Corporation for nearly 40 years. Throughout his tenure Wallace was a popular figure at Cessna who in the early days wasn't above sweeping floors, living on nickel hamburgers, and flying races to win payroll money.

The company served during World War II by producing Bobcat trainers and parts for B-29 bombers, and was a pioneer in the employment of women in factory jobs. Postwar prosperity and demand for private planes launched Cessna into the role for which it is best known today, as a producer of personal and business aircraft. In addition to creating the Air Force's first jet trainer (the T-37) and business-class twins, Cessna began production of the single-engine line, which to most people defines "Cessna." Starting with the Cessna 120 and moving up through successive models, the Cessna singles are the world's best-selling airplanes.

You'll find that the Cessna maintains straight-and-level flight very well once you trim the aircraft. Trim it and fly it "hands off." When you're flying the RG, be sure to put your landing gear down on approach or in the traffic pattern.

Although downturns during the 1980s halted the production of piston-powered Cessnas, the company is back to building a new generation of its famous singles. Cessna also builds six business jet models including the world's fastest, the

Citation X. After many decades of success, it seems Cessna will continue its eminent role in general aviation well into the future.

Cessna 182S Skylane and Skylane RG

When Cessna saw how well their Model 180 was selling, they looked for a way to make it an even bigger success; the answer was the Model 182. The 182 first flew in 1956 and its big advancement was the patented Land-O-Matic tricycle landing gear (weren't the fifties grand?), which make landing and ground handling easier, attracting would-be pilots who didn't want to fly taildraggers. During the model's lifespan it has been beefed up, modified, and released in retractable-gear (RG) and turbocharged (T) versions. Like all the Cessna piston aircraft, production of the 182 was halted in 1986 due to market forces and the high price of product liability insurance premiums. Now, the 182 is back in a new incarnation.

The Cessna 182 Skylane feels and acts like a heavier, more powerful version of its sibling, the 172 Skyhawk. While there is nothing tricky about flying the 182, pilots shouldn't underestimate it; the Skylane doesn't tolerate indifferent pilot technique.

The airplane is a workhorse and a very stable platform for flying on instruments. Even with a full tank, the 182 carries a family-size useful load and performs admirably as an aerial sport utility vehicle.

One of the improvements in the new 182s is that they now have a wet wing (the fuel is stored

directly inside the wing). Older models had a rubber fuel bladder in the wing that could wrinkle as it aged, creating nice little pockets in which water could accumulate. Water and avgas don't make for a good fuel mix.

Also new is the choice of the Textron Lycoming IO-540-AB1A5 engine (Textron owns Cessna) producing 230 hp at 2,400 rpm. This makes the Skylane a fuel-injected airplane for the first time, eliminating the threat of carburetor icing. The three-bladed McCauley prop helps complete the grown-up appearance of the new Skylane.

What isn't new for the Skylane is a retractable-gear version. The RG included in Microsoft Flight Simulator is based on earlier models, since Cessna is currently producing only the fixed-gear Skylane. The RG makes a nice transition for pilots desiring a more complex airplane that will get you where you're going 15 knots (28 kmh) faster than the fixed-gear model at top speed.

Over the years, the empty weight and useful load of the Skylane have decreased through successive models. Since it has retained the same power plant output, it has slightly higher maximum and cruise speeds. Range has been extended in all models with larger fuel capacity.

It's easy to see why Microsoft has offered the versatile and time-tested 182 in every version of Flight Simulator since its introduction. It's an aviation legend: in the realm of flight simulation and in the real world.

For details on flying this aircraft, see the **Aircraft Information** section of Help.



Extra 300s Specifications

Specifications	U.S.		Metric
Maximum Speed	200 kts	230 mph	370 kmh
Cruise Speed	178 kts	205 mph	330 kmh
Engine	Textron Lycoming AEIO-540 L1B5		300 hp
Propeller	3-bladed constant speed		
Maximum Range	415 nm	478 mi	769 km
Service Ceiling	16,000 ft		4,877 m
Fuel Capacity	42.3 U.S. gal		160 l
Empty Weight	1,470 lb		667 kg
Maximum Gross Weight	2,095 lb		950 kg
Length	23.36 ft		7.12 m
Wingspan	26.25 ft		8 m
Height	8.6 ft		2.62 m
FAA Certified Load Factor	+/- 10 g		
Seating	1		
Useful Load	625 lb		283.5 kg

Extra Flugzeugbau

Walter Extra is well on his way towards being added to the long list of legends that populate German design and engineering circles. A mechanical engineer whose avocation was aerobatic competition, he won several German National Championships and competed internationally. After flying a modified Pitts Special in the 1982 World Aerobatic Championship, Extra decided to design his own high performance monoplane. His Extra 230 was in the air the next year.

In 1984, Walter flew the 230 in the World Aerobatic Championship, which focused attention on the new design and sparked orders from other pilots: Extra Flugzeugbau (Aircraft Construction) was born. Aerobatic champion Clint McHenry purchased an Extra 230 and flew it to win the U.S. National Aerobatic Championship in 1986 and 1987. Pete Anderson won the 1990 Championship in his 230. A total of 19 Extra 230s were built, and a number of U.S. Aerobatic Team members flew them at World Aerobatic Championships.

The Extra 260 prototype flew in 1987 with a larger engine than the 230 and a new three-bladed prop. This model incorporated a larger wood wing in addition to carbon-fiber composite tail surfaces and landing gear. Patty Wagstaff won the World Aerobatic Championship flying her 260 three years in a row ('91, '92, '93). Her Extra 260 now resides in the National Air and Space Museum in Washington, D.C.

The prototype 300 model was completed in 1988 and 300s were flown by three different competitors at the World Aerobatic Championship that year. The 300 horsepower Extra was taken through full German and U.S. certification. The

FAA certified the 300 with an unprecedented +/- 10G rating—more Gs than most humans can withstand and remain conscious. More improvements to the Unlimited class 300 were introduced with the single-seat 300S.

Walter Extra builds his planes to be flown by recreational as well as competitive pilots, and all of the Extras have been designed with that vision. With the introduction of the 300L in 1993, Extra took a further step in that direction with a two-place version of the 300 that is often equipped with full IFR panels and autopilots. To date this is Extra Flugzeugbau's best seller. And it's still a stellar aerobatic performer, even with two souls on board.

The slightly smaller and lower-powered Extra 200 is designed for the introductory aerobatic market. It has lower initial acquisition costs and lower operating costs and is a perfect choice for the fixed-base operator (FBO) who wants to offer basic aerobatic courses.

Extra Flugzeugbau entered into a new market in 1999 with the Extra 400. The model 400 is a six-place, pressurized, cabin-class plane built for a niche between the recreational and corporate light-business aircraft markets. Over 90% of the 400 is constructed of carbon-fiber composites, giving it exceptional strength and light weight.

The Extra experience can be summed up in the following words: light weight, high thrust, and performance, performance, performance. While broadening the base of their product line, Extra Flugzeugbau will remain one of the top competitors in the construction of world-class aerobatic aircraft.

Extra 300S

If airplanes were horses, the Extra 300S would be a champion thoroughbred. It is, in fact, designed to be a champion in Unlimited class aerobatic competitions. The 300S combines light weight, a 300 horsepower engine, and exquisite control harmony in an aircraft that has won several World Aerobatic Championships.

A derivative of the two-place model 300, the wing of the single-place 300S was lowered eight inches to provide better ground visibility and improve the general appearance of the aircraft. After this anxiously awaited model was introduced in March of 1992, three of the four existing production aircraft were flown in the World Championship that July.

The Extra 300S has an incredible roll-rate: 400 degrees per second. Just as impressive is how precisely maneuvers can be executed in the hands of an expert pilot like Patty Wagstaff. Attend one of her airshows and you'll see a 300S carve paths through the sky like it's on a rail.

Most aircraft require the pilot to drive downhill a bit to gather enough momentum for a loop. With the Extra 300S, just pull the stick back in level flight at high cruise power and it leaps through the vertical, headed for the opposite horizon. This airplane is at home in a roll, loop, tail slide, hammerhead, Cuban Eight, or any other extreme attitude you want to put it into.

A hint of the control sensitivity of the 300S comes with the first movement of the stick. There is no slack or resistance in the control circuit. When you move the controls, the airplane follows instantly. Long ailerons provide the aerial equivalent of power-assisted rack-and-pinion steering, and fingertip control is all that's needed. Even at steep bank angles, the controls are surprisingly light. Electrically adjustable rudder pedals customize the plane's fit to any pilot, and the bubble canopy provides a roomy, panoramic view of the world whether right-side up or upside down.

As with many taildragger aircraft, visibility over the nose of the 300S is not terrific when on the ground. The standard technique while taxiing is to perform S-turns to see where you're going. But when you apply the power for the takeoff run, the tail comes up very quickly followed by the rest of the plane shortly thereafter.

Most 300Ss are purchased by pilots who just want a fast, sporty plane that they can turn upside down on occasion. The rest go to buyers who employ them in competition or for entertaining the crowds at airshows. Whatever motivates them to buy it, owners of the Extra 300S love this high-spirited and well-mannered stallion for its legendary performance.

For details on flying this aircraft, see the **Aircraft Information** section of Help.

You'll find that the Extra requires only fingertip control to move it around the sky. Climb above 3,000 ft AGL to perform aerobatics, and use a light touch on the stick. You can't easily break this bird, so feel free to put it through its paces.



Learjet 45 Specifications

Specifications	U.S.		Metric	
Cruise Speed	Mach 0.81	464 kts	859 kmh	
Engines	Allied Signal TFE731-20	3,500 lb thrust		
Maximum Range	2,200 nm	2,532 mi	4,074 km	
Service Ceiling	51,000 ft		15,545 m	
Fuel Capacity	6,000 lb	882 U.S. gal	2,722 kg	3,338 l
Maximum Gross Weight	20,450 lb		9,276 kg	
Maximum Takeoff Weight - HGW	20,200 lb		9,163 kg	
Length	58.4 ft		17.8 m	
Wingspan	47.8 ft		14.6 m	
Height	14.3 ft		4.3 m	
Seating	Up to 9 passengers			
Useful Load	2,650 lb		1,202 kg	

Learjet

When most people think of business jets, they think Learjet. For more than three decades, through a number of corporate changes, Learjet has produced some of the finest aircraft in the world.

William Powell Lear was a 61 year old millionaire entrepreneur when he began work on development of the Learjet. Dissatisfied with the speed of the propeller-driven craft available to business travelers in the 1950s, he decided to build a corporate-class jet. He wasn't the first to develop a "biz-jet," but he may have been the most audacious.

The first designs were influenced by a Swiss fighter, the P16. Lear hired the Swiss design team but soon discovered that the pace of life and business in Switzerland wasn't up to his traditional rapid-fire way of getting things done. He moved the project to Wichita, Kansas, and with a new American design team set about attempting the impossible. Pundits in the aviation business estimated it would take ten years and \$100 million dollars to accomplish what Lear wanted. He would prove them wrong.

Lear did realize, however, that with the financial resources at hand, traditional development processes would not work. He decided that they would not build a prototype, and the very first Learjet would be built with the production tooling—a risky method that could not tolerate a major design error. But it worked. On September 15, 1963, only nine months after the move to Wichita, Learjet 001 was rolled out. Just ten months later the Learjet was granted a Type Certificate by the FAA.

Learjets have always been designed with performance in mind. Every effort was expended to squeeze more speed and less drag out of the airframe. It sprinted past the competition at 0.82 Mach with a 41,000 ft (12,497 m) service ceiling and 1,500 nm (2,778 km) range for five to seven passengers, and did it with a smaller price tag.

After selling the company in 1967, Bill Lear went on to other pursuits including the unfinished Learliner and Learfan aircraft projects. With over 100 inventions to his credit (including the eight-track stereo) he left a rich legacy and an enduring mark on aviation.

The next milestone, with the company now under the Gates Learjet banner, was the introduction of the 30 series. For the United States Bicentennial, the company repeated the 1966 round-the-world flight of a Learjet 24 with a Learjet 36. The new efficient turbofan model bested the old time by 1.5 hours and used nearly 3,000 gallons (11,353 l) less fuel. Learjet got a jet certified to fly at 51,000 feet (15,545 m), an altitude that would allow later models to take advantage of weather, wind, and fuel efficiency up high. The Concorde was the only other civil aircraft certified to such heights.

Today, as a division of Bombardier Aerospace, the company's stars are the Learjet 31A, Learjet 45, and Learjet 60. They are still among the most popular aircraft in their class, and their beautiful, sleek lines are instantly recognizable. Want testimony to the enduring quality of the Learjet name? Point to any business jet and ask the average person what it is. They'll likely say, "It's a Learjet."

Learjet 45

The Model 45 is Learjet's first all-new aircraft since Bill Lear's first Model 23. Although it looks like a Learjet, it has only half the parts of a Model 35, reflecting a significant design progression. The parameters set down for the 45 called for it to have the performance of the Learjet 35, the handling of the Learjet 31A, and greater cabin space than the competition.

This is Learjet's first paperless airplane, designed entirely on a computer screen. In some cases the computer design files are loaded directly into production milling machines, which allows for an exceptional degree of precision in manufacturing (especially important when major parts that have to fit together are made on different continents!). This reduces not only time in construction but also the rate of rejection of parts (inherent in any manufacturing process).

Like so many ventures today, building Learjets is a cooperative arrangement of various entities. The Model 45 is a prime example. Learjet was responsible for systems and final assembly in the United States, the fuselage was built by Shorts in Ireland, and the wing design and construction was done by de Havilland in Canada (all Bombardier subsidiaries).

Ease of operation was a key design goal with the new Learjet. In addition to fewer parts, the craft has a maintenance tracking system built in. A technician can plug a laptop computer into a panel and download a fault list from all of the avionics, engines, and other systems.

The 45's glass cockpit makes for simplified in-flight system management. The Primus 1000 integrated avionics system and engine instru-

ment/crew advisory system (EICAS) has a page for monitoring every major system, as well as displaying primary flight instruments.

Power management usually creates a high workload when flying jets, requiring new power settings with changes in weight and ambient conditions. The Learjet 45 takes much of power management off the pilots' hands by computing it for them. For takeoff, advance the thrust levers three clicks to the takeoff position, feet off the brakes, and you're out of here. During the climb, ease the levers back a notch to the max continuous thrust (MCT) position and let the digital electronic engine computer (DEEC) worry about the rest.

At 45,000 ft (13,716 m) and at a weight of 17,000 pounds (7,711 kg), the high-speed cruise number is 445 knots (824 kmh) with a fuel flow of about 1,062 pounds per hour (pph)(482 kgh). Back the power down to a long-range cruise setting and the speed decreases to 408 knots (756 kmh), while fuel burn slows to 987 pph (448 kgh). The 45 has a maximum IFR range of about 1,800 nm (3,334 km). With a maximum operating altitude of 51,000 feet, the 45 easily reaches and cruises at 45,000 feet, unlike some lighter jets that are certified to 45,000 feet but rarely are used at that altitude.

Learjet has shown once again its ability to adapt to the market and produce what the customer wants. In the Model 45 the company has crafted a machine that gets the customer there on time and in comfort while keeping the pilots and the corporate flight office happy.

For details on flying this aircraft, see the **Aircraft Information** section of Help.



Boeing 737-400 Specifications

Specifications	U.S.	Metric
Cruise Speed	Mach 0.74 477 kts	883 kmh
Engines	CFM56-3C1	
Maximum Range	2,059 nm 2,370mi	3,813 km
Service Ceiling	36,089 ft	11,000 m
Fuel Capacity	5,311 U.S. gal	20,098 l
Empty Weight - Standard	76,180 lb	34,555 kg
Maximum Takeoff Weight	138,500 lb	62,823 kg
Length	120 ft	37 m
Wingspan	85 ft	25.9 m
Height	36.5 ft	11.13 m
Seating	147 to 168	
Cargo Capacity	1,373 ft ³	38.9 m ³



Boeing 777-300 Specifications

Specifications	U.S.	Metric
Cruise Speed	Mach 0.84 482 kts	893 kmh
Engines (three options)	P&W 4000 GE 90 RR Trent 800	
Maximum Range	5,600 nm 6,444 mi	10,371 km
Service Ceiling	36,400 ft	11,095 m
Fuel Capacity	45,200 U.S. gal	171,050 l
Maximum Takeoff Weight - Basic	580,000 lb	263,084 kg
Maximum Takeoff Weight - HGW	648,000 lb	293,928 kg
Length	242.33 ft	73.9 m
Wingspan	199.91 ft	60.9 m
Height	60.66 ft	18.5 m
Seating	368 to 550	
Configurations	Seating ranges from 6 to 10 abreast with two aisles	
Cargo Capacity	7,552 ft ³	214 m ³

Boeing Company

In 1903, the same year that the Wright brothers made their revolutionary flight, a young man named William Boeing left Yale engineering school for the West Coast. He made his fortune trading timberlands, moved to Seattle, Washington, and soon became interested in the new field of aviation.

After learning to fly with aviation legend Glenn Martin in 1915, Boeing and a partner decided they could build a better flying machine. On the morning of the first test flight of their B&W floatplane, Boeing became impatient waiting for his pilot and took the controls, piloting the first flight of a Boeing aircraft himself.

World War I inaugurated the first production orders for Boeing aircraft. By the end of 1918, 337 people were on the Boeing payroll (a number that would one day swell into the tens of thousands). Fighter pursuit planes were built for the Army Air Service, and the Navy bought 71 NB trainers during this time. With the Model 15 and the P-12/F4B series, Boeing became the leading producer of fighters for the next decade.

Bill Boeing and pilot Eddie Hubbard flew a Boeing C-700 to make the first international airmail delivery in 1919. By 1929 the three-engine, twelve-passenger Model 80, Boeing's first model built specifically for passenger transport, was in the air. Boeing was now one of the largest aircraft manufacturers in the country. Fueled by further expansion, the company's interests soon included several airlines, among them the future United Airlines.

An antitrust breakup of the company in 1934 left Bill Boeing disheartened, and he left the aviation business to raise horses. The company leadership

kept the company name and the Boeing vision for the future: a focus on large airliners and bombers.

Boeing's contribution to the war effort during World War II included the construction of thousands of the legendary B-17 Flying Fortress and B-29 Superfortress bombers. Once the war was over, the company turned its attention back to civilian as well as military development and production. Along with the Stratocruiser (the last propeller-driven plane Boeing would build), the company produced America's first swept-wing jet bomber, the B-47, and the giant B-52 bomber (still on the front lines today, though production ceased more than three decades ago).

The demands of the flying public in the post-war world made it clear that jet transports were necessary to haul more people longer distances at faster speeds. Boeing was able to make significant inroads into this market by putting the 707 jetliner into service before Douglas Aircraft Company (later McDonnell Douglas and now part of Boeing) launched their DC-8. Using about one-tenth the fuel of an ocean liner, the \$5 million 707 could carry as many transatlantic passengers a year as the \$30 million Queen Mary.

Boeing has continued as a leader in airliner innovation and military/aerospace technology. The company ushered in the jumbo era in the early 1970s with the 747 and continued to develop short-haul airliners—including the world's most successful jetliner, the Boeing 737. Military and aerospace projects have included work on NASA space programs, the cruise missile, and the B-2 bomber. Boeing aircraft have been the presidential choice for Air Force One for 40 years.

More than 80% of the world's jetliners are Boeing aircraft. The company's commercial, military,

space, and communications businesses combine to make it the world's largest aerospace manufacturer and the leading exporter of goods from the United States.

Boeing 737-400

One should hardly be surprised that the world's most prolific manufacturer of commercial aircraft is also the producer of the world's most popular jetliner. The 737 became the best-selling commercial jetliner world-wide when orders for it hit 1,831 in June of 1987 (surpassing Boeing's own 727 as the previous champ). It wasn't always that way; in the first few years of production, there were so few orders that Boeing considered canceling the program. They didn't, and the airplane has more than proven itself in over three decades of service.

If you bounce the -400 on landing, don't continue to pull the stick back to flare. That will cause you to strike the ground with the rear fuselage before the main gear touch again. Instead push the nose slightly forward and add a little power.

The reason for the 737's great success is its design flexibility. It lends itself well to modifications that fit the market needs of its customers, and currently seven variants are available. The ability to order different versions of the same plane allows an airline to fit the airplane to a particular route and passenger load while maintaining a smaller inventory of support and service equipment for its fleet. And, like all of the planes in this family, the 737-400 has crew

commonality with its siblings—a pilot qualified to fly one is qualified to fly all of them.

The short-haul 737s have ranges from 2,300 mi (4,180 km) to 3,800 mi (6,110 km). And, speaking of short, the first model's length was only 8 inches greater than its wingspan, giving the airplane a compact look that led to its nickname: Fat Albert.

Derivative models of this line were on the drawing boards before the first 737-100 ever flew. The -200 grew in length over the -100 and was fitted with progressively more powerful engines, eventually allowing the maximum takeoff weight to increase by nearly 32,000 pounds (14,515 kg). The most important advancement with the next size, the -300, was the use of a new type of engine. The General Electric/Snecma CFM56 produces more power than the old JT8Ds of earlier models, while producing far less noise and providing better fuel economy.

The -400 sits at the upper end of the 737 lineup (the -500, -600, and -700 are smaller but faster). While the 737-300 allowed up to 126 passengers to be seated in its lengthened cabin, Boeing put it on the rack again, this time stretching it another 10 feet (3.05 m) to a total of 119 feet 7 inches (36.45 m). This longer airplane became the -400, which first flew in February 1988 and seats 147 to 168.

All variants of the 737 will continue to fly for many years to come. From its short and stubby origins to its more elegant stretched versions, the 737 has always been beautiful in the eyes of airline bean counters. Its position in the travel marketplace and in aviation history is assured.

For details on flying this aircraft, see the **Aircraft Information** section of Help.

Boeing 777-300

On the outside it may resemble the jetliners you've seen for years. Inside it's a whole new type of bird. The newest plane in the long and proud Boeing family line is the 777, commonly referred to as the "triple 7." This long range, fuel-efficient twinjet was first delivered in May of 1995 to fill a gap in the market between the 747 and 767. It is capable of seating 305 to 479 passengers and the longer-range 777-200 version can carry them 8,860 miles.

The genesis of the 777 was unique in Boeing history. From the outset it was designed with cooperation and input from its future customers. Boeing actually had engineering staff from the airlines working with Boeing engineers at the factory. And the 777 is the first airliner ever completely designed on computers. Using Computer Aided Three-dimensional Interactive Applications (CATIA), every system and piece of the plane was created and fitted together on computers before production began. It worked so well that Boeing didn't need to create a full-scale physical mock-up of the airplane. The result was that after laser-aligning the major sections and wings of the real airplane, the port wingtip was a mere 0.001 inch (.0025 cm) out of alignment. The fuselage was out of alignment by only 0.023 inch (.058 cm).

One of the distinguishing features of the 777 is its perfectly round fuselage cross-section, as opposed to the more ovoid shape of previous Boeings. This gives structural strength and simplicity to the fuselage, making it less prone to fatigue. It is 22 inches (55.88 cm) wider than the competition, allowing provision of one extra seat

per row than the Airbus A330/340 (and to an airline, seats are revenue). The plane has an enormous below-deck cargo capacity, even greater than the 747-400 (by weight, not volume).

A striking external feature of this wide-body is the main gear. Larger than that of any other airliner, each main gear of the 777 has six wheels—giving the same pavement loading as a jumbo DC10-30 but with half the parts and less complexity. The left axle of each main can actually be steered up to eight degrees to aid nose-gear steering.

The in-flight entertainment system is like nothing any airliner has ever had. It's the most complex system of its kind ever developed, and with an estimated 250,000 lines of dedicated software code it's as sophisticated as some airplanes' avionics systems. Each passenger has a choice of up to 12 video channels and 48 audio channels. Each seat has a phone that doubles as a game controller, credit card reader, and modem link. At 9,000 pounds (4,082 kg) for a typical installation, this is some heavyweight entertainment!

Key to the present and future success of the 777 is its flexibility. Designed to be stretched, shortened and modified in many ways to suit its customers' needs, it can even be ordered with folding wingtips to allow parking at gates designed for smaller planes. From the extremely powerful new engines to the all-glass cockpit, this airplane has the technology to carry it far into the 21st century.

For details on flying this aircraft, see the **Aircraft Information** section of Help.



Concorde Specifications

Specifications	U.S.	Metric
Max Speed	Mach 2.04	
Cruise Speed	Mach 2 1,164 kts 1,340 mph	2,156 kmh
Engines	Rolls-Royce/Snecma Olympus 593 Mark 610 Turbo jet	
Max Thrust	38,050 lb with afterburner	
Maximum Range	3,371 mi	6,115.3 km
Service Ceiling	FL600 60,000 ft	18,288 m
Max Fuel Capacity	26,400 lb	11,975 kg
Fuel Consumption	22.6 tonnes/h	
Max Takeoff Weight	408,000 lb	185,070 kg
Max Landing Weight	203,000 lb	92,079 kg
Length	202.33 ft	61.66 m
Wingspan	83.83 ft	25.6 m
Height	40 ft	12.2 m
Seating	128 (British Airways Concorde seat 100)	
Max Payload	29,000 lb	13,150 kg

Concorde History

Concorde was not built by one company; in fact, it was not even built by one country. Great Britain had decided by 1961 that it was both desirable and technologically feasible to build a supersonic transport (SST) with transatlantic range. The enormous cost and risk required that the project be undertaken with a partner. American companies were also looking at SST development, but their ideas did not mesh well with the design and technological parameters that the British had already decided on. Turning to the only European nation in the 1960s with the ability to undertake such a program, Great Britain chose France to join in what was at that time a unique (and very complicated) collaboration to build Concorde.

The agreement, signed at The Hague in 1962 divided responsibilities, risk, cost, and rewards equally between the two nations. The target date for the prototype's first flight was 1966, with the first production flight in 1968. These targets were missed, and the flights were made in 1969 and 1975 respectively. The original cost projections of between 150 and 170 million pounds sterling were widely short of the mark as well.

The challenges were as extreme as the high altitude environment the aircraft would be flying in, and compromises had to be found all along the way. Making the aircraft too strong would render it too heavy. Making it too efficient at one speed might make it impossible to fly at another. The builders had to gamble on achieving a high number of Atlantic crossings by this craft to offset its predicted low payload capacity (only 128

seats). Even the air safety regulations were inadequate to cover all the contingencies of operating a supersonic passenger transport.

Just under six years of testing presented a number of political, environmental, technical, and economic obstacles that—though difficult—were ultimately overcome by the Concorde team, producing one of the world's great aircraft. New technology was developed that had an impact in other industries. You can thank Concorde for such innovations as the anti-lock braking system on your car (which is also used on many other aircraft).



With a few very short-lived exceptions, Concorde has flown only in British Airways and Air France livery, and all 13 to come off the assembly line still serve those two airlines. A recent study by Britain and France concluded that no market currently exists that would justify the expense of developing a new version of the supersonic airliner. Another study in the United States involving Boeing and NASA concluded virtually the same thing. Concorde was clearly an idea well ahead of its time.

Concorde

Concorde is on its way down from cruising at Mach 2 (1,340 mph), twice the speed of sound, towards a landing speed of 163 knots (301.8 kmh). As it decelerates, passengers sit in air-conditioned comfort while Concorde is shrinking: yes, shrinking. There is a slight scent of ozone in the air.

This is a normal flight for an airplane that is unique among airliners.

Temperatures upwards of 117C° (243F°) can be reached on Concorde's skin from friction when flying at supersonic speeds. This heating actually causes the aircraft to grow by several inches. As it decelerates towards subsonic speeds, the heat radiating from the windows and fuselage skin begins to subside and Concorde contracts towards its subsonic length. By design, engine air is bled off into the cabin air system. In normal descent and deceleration from 60,000 ft (18,288 m) through ozone rich altitudes, the lower heat of reduced power settings does not convert all the ozone entering the engine compressors into oxygen.

Concorde's powerful Rolls-Royce Bristol/Snecma Olympus engines are highly efficient at supersonic speeds but highly inefficient and noisy at low speeds such as during takeoff and landing. Engine noise, coupled with the potential for sonic booms near cities, presented Concorde with an uphill battle for approval to fly into American airports. Transatlantic crossings were the reason Concorde was built, and approval to land at American airports was crucial to the airplane's success. Approval eventually came, but to enter and exit New York airspace requires a complicated set of maneuvers involving power changes

When the Flight Simulator 2000 realism setting is at the highest level, you will have to monitor the center of gravity (CG) and move fuel between tanks manually. Otherwise, movement of the fuel to maintain the proper CG is done automatically.

and specific crossover points to avoid committing noise violations.

Concorde is a machine designed to get you to your destination quickly regardless of the cost. From London to New York in only 3½ hours is considered by some travelers to be worth paying the nearly \$10,000 US for a round trip. With only one cabin class on Concorde, you can be assured of a bit of pampering and a decent meal.

And this is the only commercial transatlantic flight that can make you younger. If you take off from London at 12:01 a.m. on January 1st you will land in New York at about 10:30 p.m. on December 31st the day (and year!) before you took off.

The Concorde has a remarkable safety record and has made many technological advancements available to the aviation industry worldwide. Though there are no second generation supersonic airliners on the drawing boards in Europe or elsewhere, British Airways and Air France expect their fleets to be flying until at least 2015.

For details on flying this aircraft, see the **Aircraft Information** section of Help.



Bell 206B JetRanger III Specifications

Specifications	U.S.	Metric
Cruise Speed	115 kts 132 mph	213 kmh
Engine	Allison 250-C20J 420 shp	
Maximum Range	435 nm 500 m	805 km
Service Ceiling	20,000 ft	6,096 m
Hovering Ceiling	19,600 ft	5,974 m
Fuel Capacity	91 U.S. gal	344 l
Empty Weight	1,640 lb	744 kg
Maximum Gross Weight	3,200 lb	1,451 kg
Maximum Gross Weight External Loading	3,350 lb	1,519 kg
Hook Load Limit	1,500 lb	680 kg
Length	31.2 ft	9.51 m
Rotor Span	33.3 ft	10.15 m
Height	11.7 ft	3.57 m
Seating	Up to 5	
Useful Load	1498 lb	679 kg

Bell Helicopter

It is fitting that the permanent collection of the Museum of Modern Art in New York City contains a Bell-47 helicopter, an object whose beauty is inseparable from its efficiency. The genius of Leonardo Da Vinci produced the idea of vertical flight; centuries later it would take another brilliant innovator, philosopher, and artist to bring the concept to commercial reality. His name was Arthur Young.

Young came to Larry Bell's attention in 1941 after Young had been working on helicopter design for over a decade. Bell was an entrepreneur and successful manufacturer of military aircraft like the Airacobra P-39. A demonstration of Young's working model convinced Bell of the design's importance. He set Young's research group up in their own facility in Gardenville, New York, and let them go to work. Thirteen days later, Pearl Harbor was attacked, initiating United States involvement in World War II.

During the war, Young's small team worked hard on developing the helicopter while the rest of the company constructed war machines. Two dramatic unplanned mercy flights in 1945 presaged the helicopter's future role as a medical evacuation ("medevac") vehicle. On March 8, 1946, the Bell Model 47 was awarded the world's first commercial helicopter license, and the U.S. Army took delivery of production models the same year. Model 47s saw medevac service in the Korean conflict. The Bell-47 had a long production life and hundreds are still in service around the world.

Textron Corporation acquired Bell in 1960, and by 1976 it was Textron's largest division. Among its most successful developments was the UH-1

"Huey," the workhorse of the Vietnam War. Variants of the Huey were used as troop transports, gun ships, and air-ambulances. They also see service today as corporate shuttles and medical transports. The AH-1 Cobra attack helicopter, H-40 Iroquois, OH-580 Kiowa Warrior, TH-67 Creek trainer, and CH-146 Griffon also join the ranks that make Bell the largest supplier of helicopters to the U.S. armed forces. Bell is also teamed with Boeing to produce the V-22 Osprey tilt-rotor aircraft for the United States Marine Corps.

Perhaps the most recognizable Bell is the 206B JetRanger. The highly regarded 206 is employed around the world in military service, as a corporate transport, as a rescue service/medevac vehicle, as a police unit, and in television reporting.

With more than 35,000 aircraft delivered in more than 120 countries, Bell notes that their helicopters around the world accumulate fleet flight time at more than 10 hours per minute. That gives a whole new meaning to the old adage, "Helicopters don't fly, they beat the air into submission."

When at the controls of the JetRanger, imagine you're trying to balance one ball on top of another. Make small, smooth control movements or you'll likely put the aircraft into unrecoverable oscillations.

Bell 206B JetRanger III

The Bell 206 series has accumulated an astounding array of impressive statistics. More than 6,000 JetRangers are flying worldwide in roles as diverse as corporate transportation, police surveillance, and United States Army Aviation training. The series has flown over 26 million flight hours, and a few JetRangers are flying with more than 30,000 hours on their airframes.

The JetRanger design derived from a Light Observation Helicopter (LOH) proposal Bell submitted to the United States Army in the 1960s. Though it lost out to a Hughes Aircraft Company design, Bell decided to develop the model as the 206 for the civilian market.

Despite Bell's best efforts, the original LOH design was found unsuitable for conversion to civilian use, primarily because of its limited carrying capacity. Engineers started over with an entirely new fuselage, resulting in an elegant teardrop-shaped aircraft that would seat five and carry their baggage.

Due to rising costs of the Hughes helicopter, the LOH competition was reopened in 1967 and Bell's 206 won this round. The 206 was purchased by the Army and put to work under the designation OH-58A. JetRangers are still serving in the armed forces. The newest model in uniform is the TH-67 Creek primary trainer. The United States Army credits a rise in student grades and a drop in course failures to the use of the Creek in training programs.

But it's as a civilian that the JetRanger has seen its biggest success. The original 206 has evolved into the JetRanger II and the JetRanger III, both incorporating major upgrades to more powerful engines.

According to the National Transportation Safety Board, the Bell 206 has the best safety record of all single-engine aircraft. Reinforcing its safety record, the Bell 206B JetRanger III is the only helicopter in its class to offer rupture-resistant fuel cells and shoulder harnesses as standard equipment.

Although helicopters are inherently unstable and difficult to fly, testimony to the JetRanger's ease of handling is the fact that it can be certified for single-pilot IFR operation. In 1994, Texas businessman Ron Bower flew a Bell 206B JetRanger III solo around the world. Bower navigated across 21 countries and 24 time zones in 24 days. By the end of the journey, he'd flown over 23,000 miles (37,015 km) and had broken the previous around-the-world helicopter speed record by nearly five days.

The JetRanger III costs less to operate and maintain than any other craft in its class and has the highest resale value of any light helicopter. A winning formula for safety and value has made the JetRanger the world's most popular helicopter series.

For details on flying this aircraft, see the **Aircraft Information** section of Help.

Appendices

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appendices

Elrey Borge Jeppesen

At the age of 14, Elrey Borge Jeppesen took a ride with a barnstormer and decided that flying was definitely for him. At 20, “Jepp” earned his pilot’s license, which was signed by Orville Wright.

Jepp flew challenging air-mail routes in the Western United States during the 1930s. Dangerous flying conditions were compounded by the fact that pilots had no aeronautical charts to use; they used road maps, if anything at all. Bad weather often kept a pilot on the ground, or forced an early landing. And, sadly, many pilots were lost in these dangerous conditions.

Jepp began keeping notes in a 10-cent notebook, drawing his own maps, and noting which routes were better in inclement weather. He also included drawings that profiled terrain and airport layouts, and noted phone numbers of local farmers who could provide weather reports. Soon, his notes and maps were in great demand by other pilots.

When radio emerged as the newest technology for navigation, Jepp developed ways to use the technology for improving point-to-point navigation. He also began designing instrument approach procedures, which he documented on his instrument approach charts—the only source in the country for that type of material.

Jepp went on to fly for United Airlines, where he met his wife, Nadine, one of the first flight attendants. When their chart business took off, Jepp left United to form the Jeppesen Company.

Charts

This appendix contains charts supplied by the Jeppesen Sanderson Company (“Jeppesen”), the world leader in aviation charts, for use in Microsoft® Flight Simulator 2000. Charts are included for some of the most interesting areas you can visit in Flight Simulator and for airports you will visit in the Lessons and Adventures.

If you’re unfamiliar with using charts for navigation, go through the Tutorials on basic navigation found in Chapter 7, “Learning to Fly with Rod Machado.” You’ll find additional instructions for using the charts in the Preflight Briefings for each Lesson and Adventure.

Most of the charts provided in this appendix are *instrument approach charts*, which guide pilots as they approach an airport for landing. Others are Standard Terminal Arrival (STAR) and Standard Instrument Departure (SID) charts that simplify navigating to and from an airport area. Pilots also use *VFR sectional charts* and *IFR en route charts* for cross-country navigation.

To see the kind of information provided in sectional and en route charts, use the Map View feature in Flight Simulator. For more information about Map View, choose **Simulator Help** from the **Help** menu.

Important: The charts contained in this *Pilot's Handbook* are intended for use with Flight Simulator only. They are not intended for use in actual aviation navigation. Charts for use in the real world are updated frequently, and although

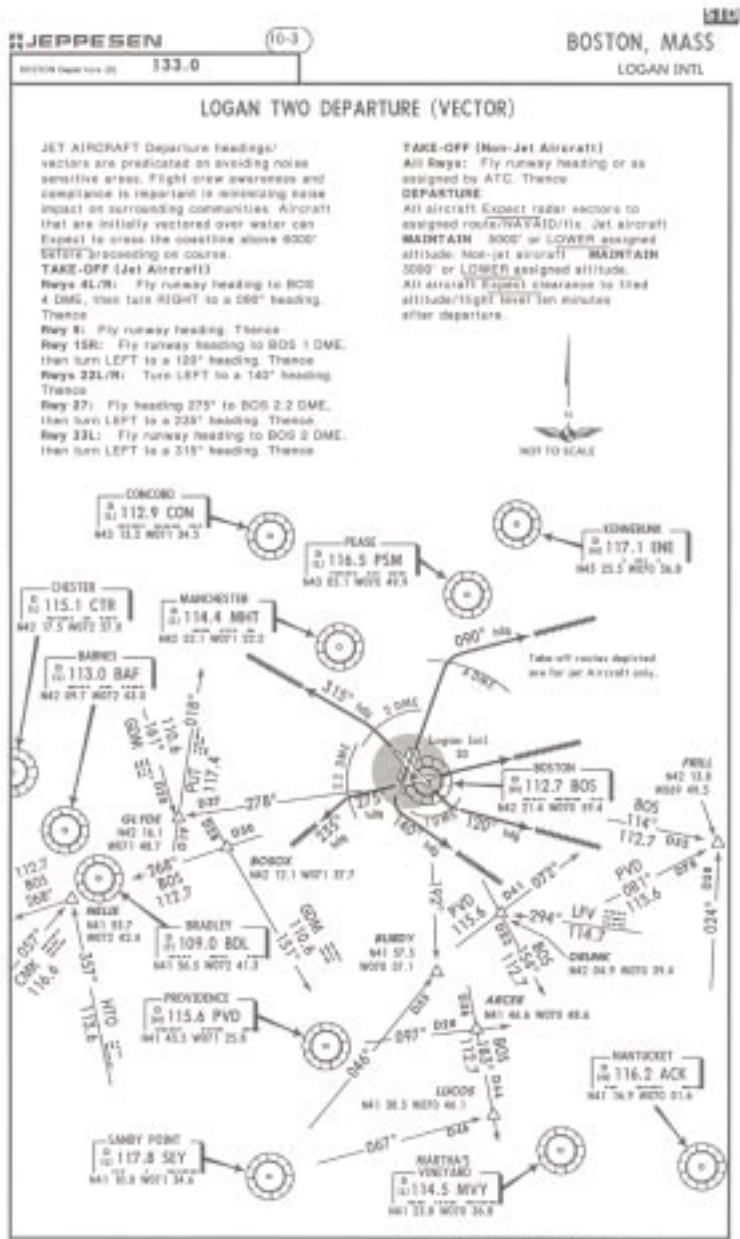
the charts in this handbook are real-world charts, they will not be updated.

This appendix contains the following charts.

Area	Airport name	Chart name
Boston, MA	Logan International	Logan Two Departure ILS Rwy 33L
Chicago, IL	O'Hare International	O'Hare One Departure
Islip, NY	Long Island Mac Arthur	ILS Rwy 06
London, UK	Heathrow	Compton SIDs ILS DME Rwy 09R ILS DME Rwy 09L ILS DME Rwy 27L ILS DME Rwy 27R
Minneapolis, MN	Flying Cloud	VOR or GPS Rwy 9R
New York, NY	John F. Kennedy International	VOR or GPS Rwy 4L/R
Paris, France	Charles de Gaulle	ILS Rwy 27
San Francisco, CA	San Francisco International	Quiet Two Departure ILS Rwy 28R
Seattle, WA	Seattle-Tacoma International	Olympia Two Arrival ILS 16R ILS DME 34R
	King County International/Boeing Field	Ephrata Four Arrival ILS 13R approach
Titusville, FL	Space Center Regional	ILS Rwy 36
Tokyo, Japan	Narita	Libra North & South Arrivals Comet & Cosmo North Arrivals ILS Rwy 16 ILS Rwy 34

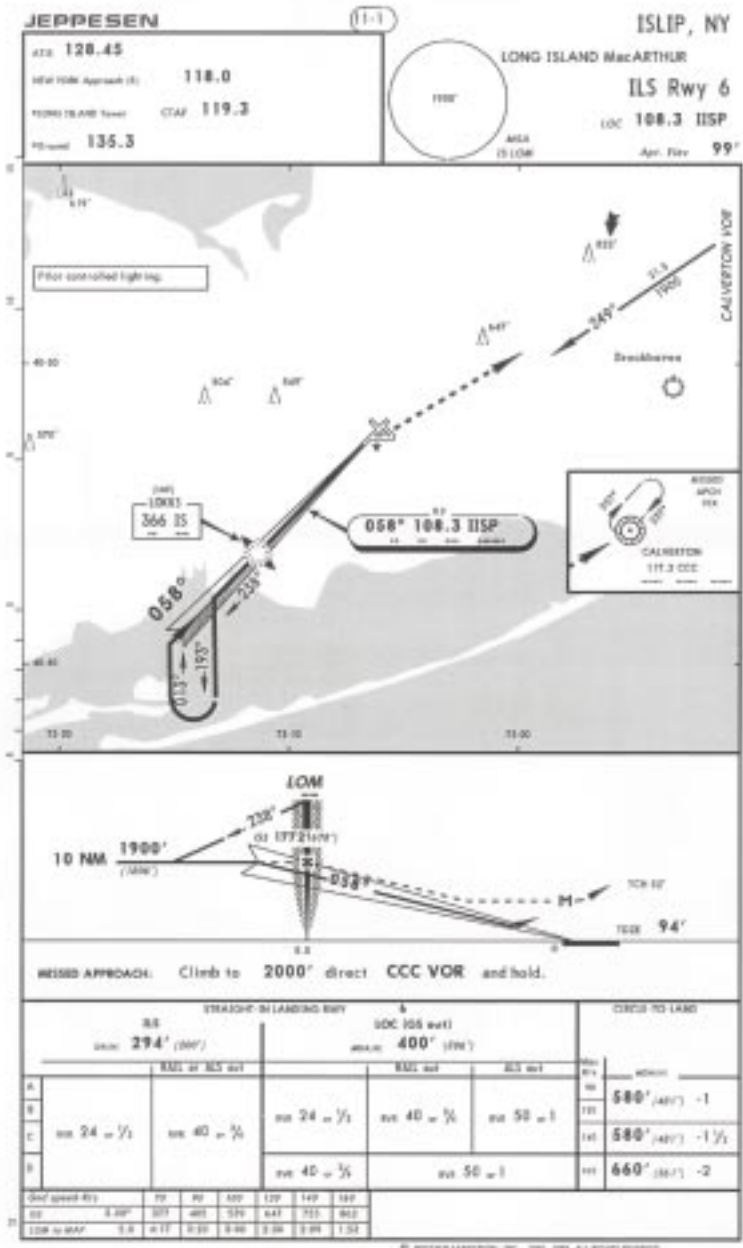
SIMCharts by Jeppesen

This abbreviated chart is intended for flight simulation use ONLY and will vary from actual navigational charts.



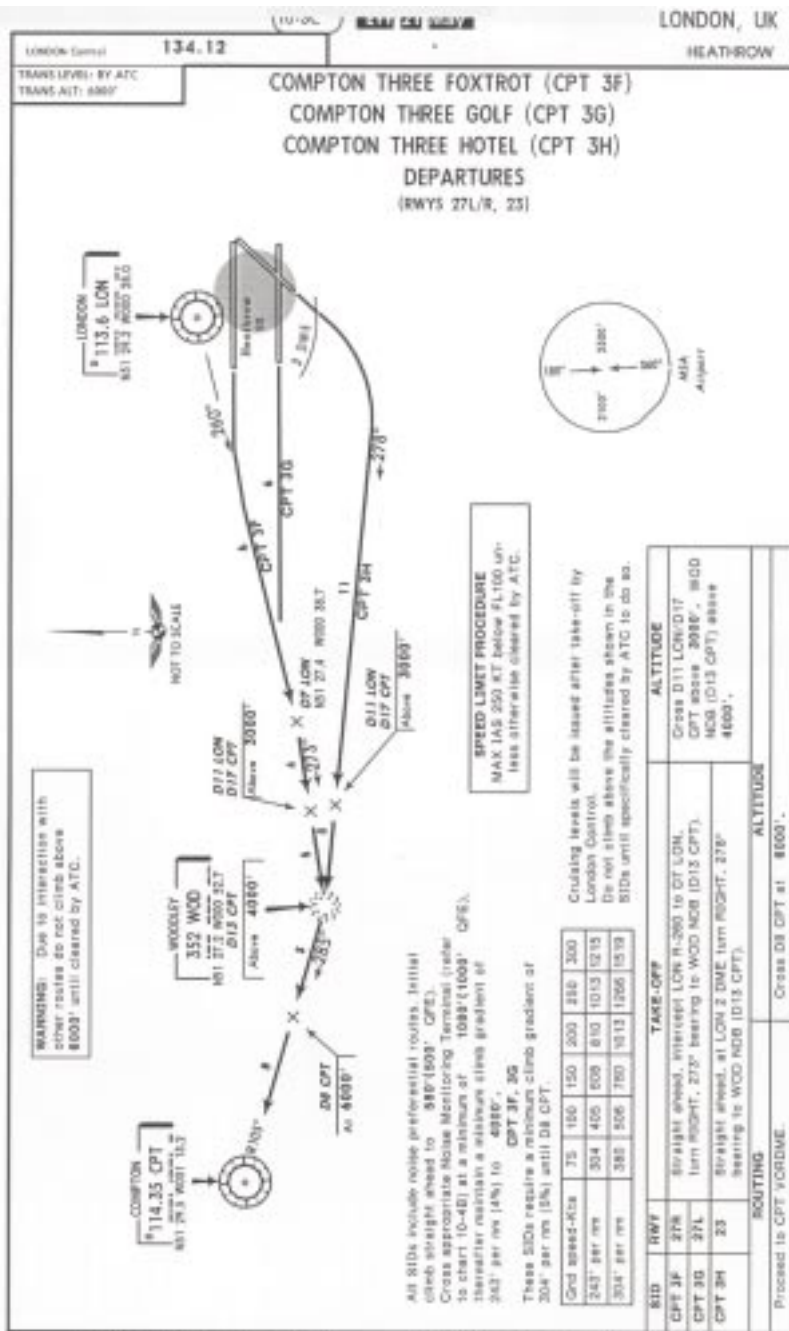
SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.



SIMCharts by Jeppesen

This procedural chart is intended for flight simulation use ONLY and will vary from actual navigational charts.



SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.



SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.

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LONDON, UK
● ILS DME Rwy 27L



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SIMCharts by Jeppesen.

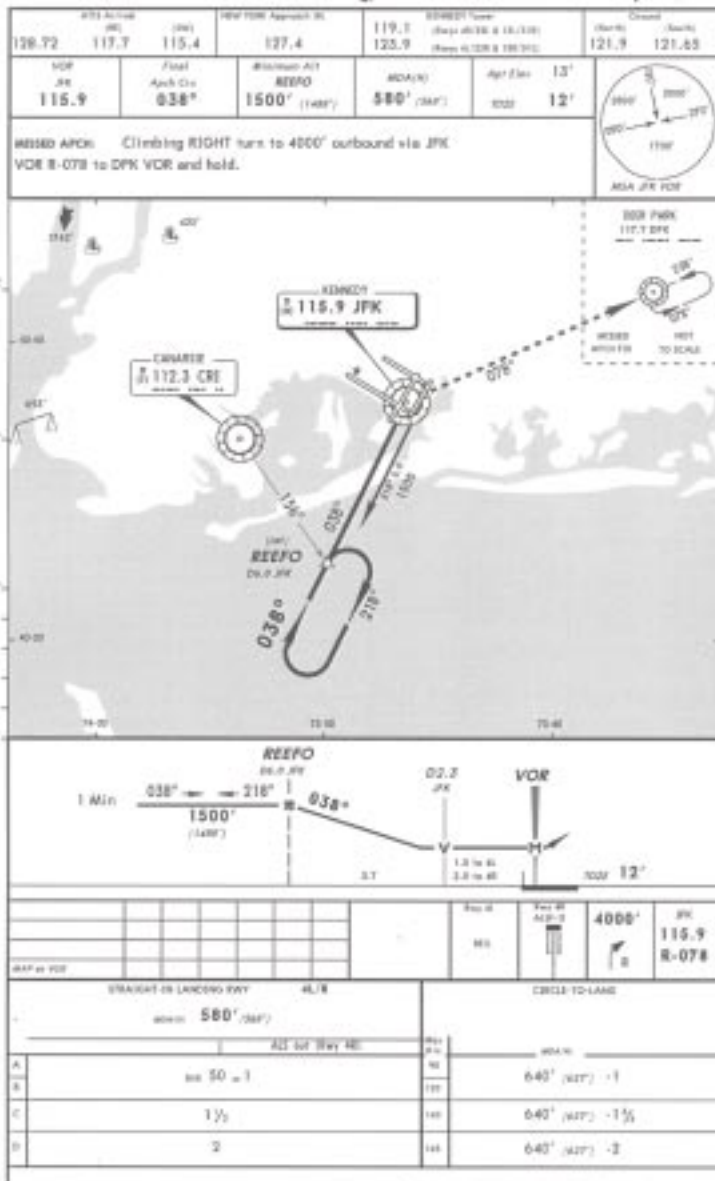
This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.



SIMCharts by Jeppesen

This aeronautical chart is intended for flight simulation use ONLY and will vary from actual navigational charts.

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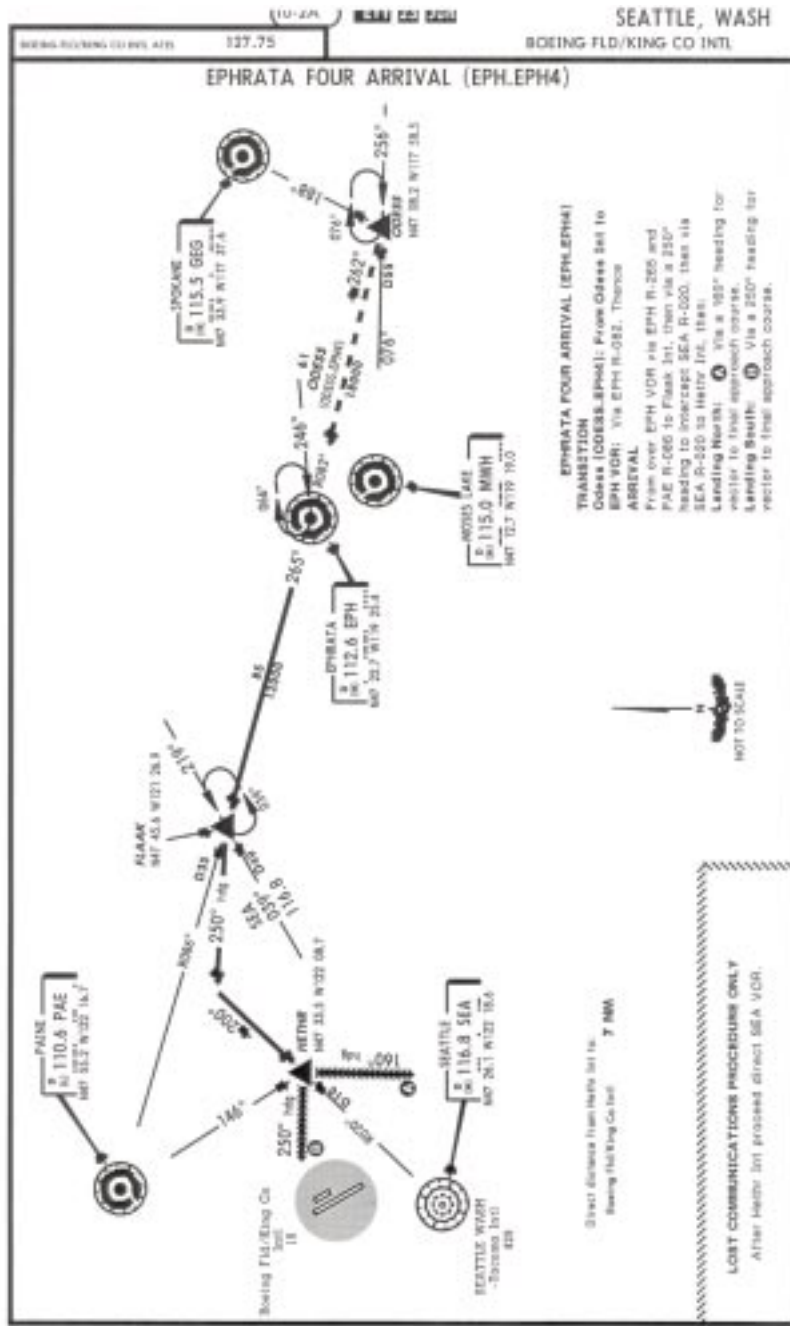
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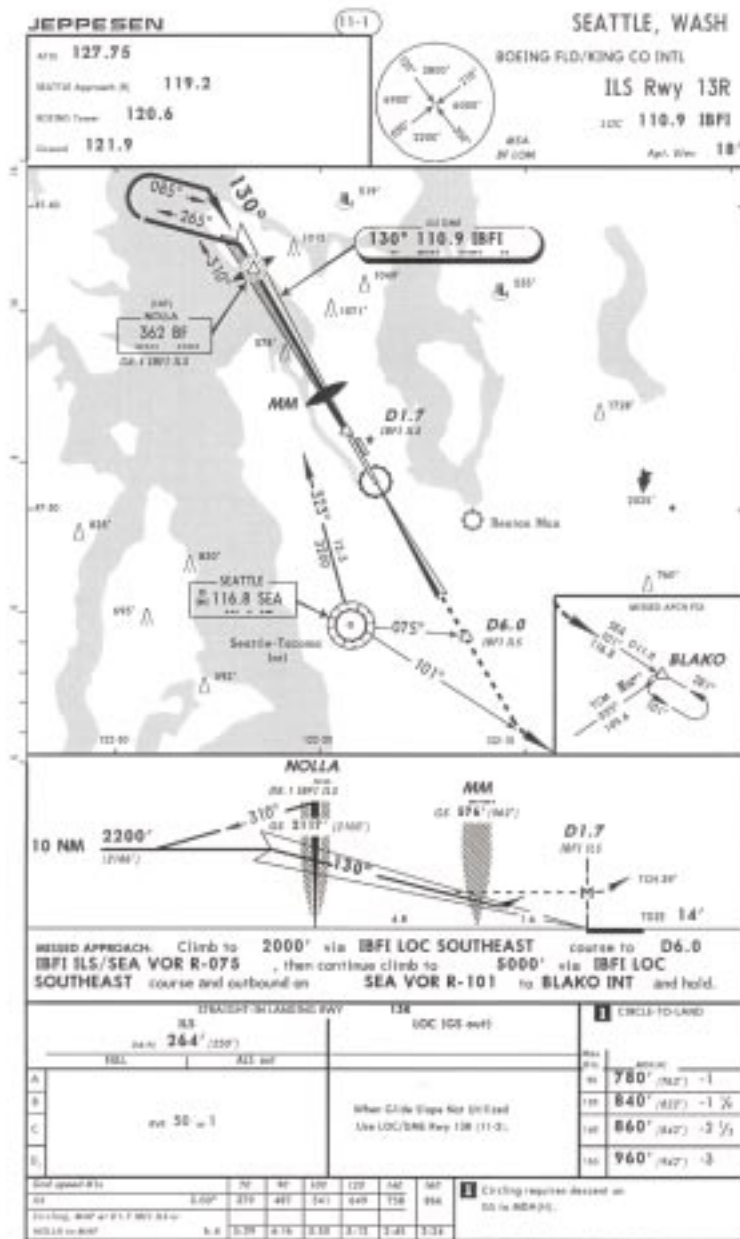
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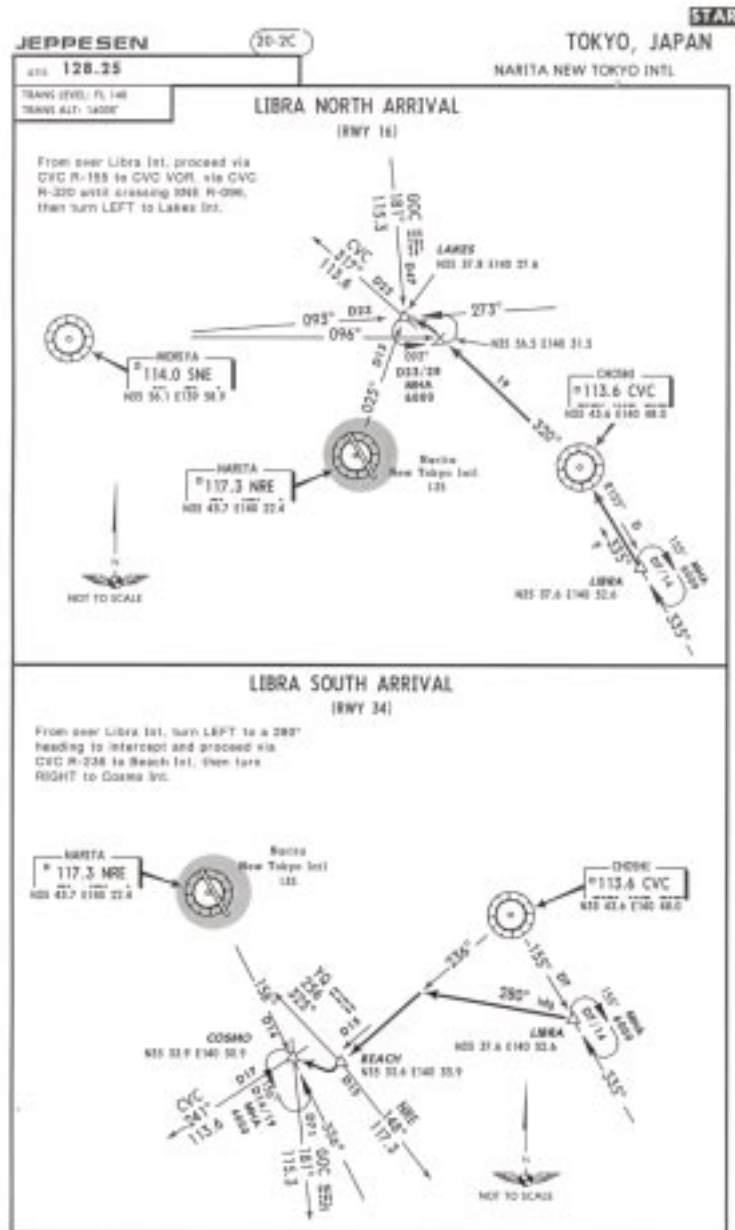
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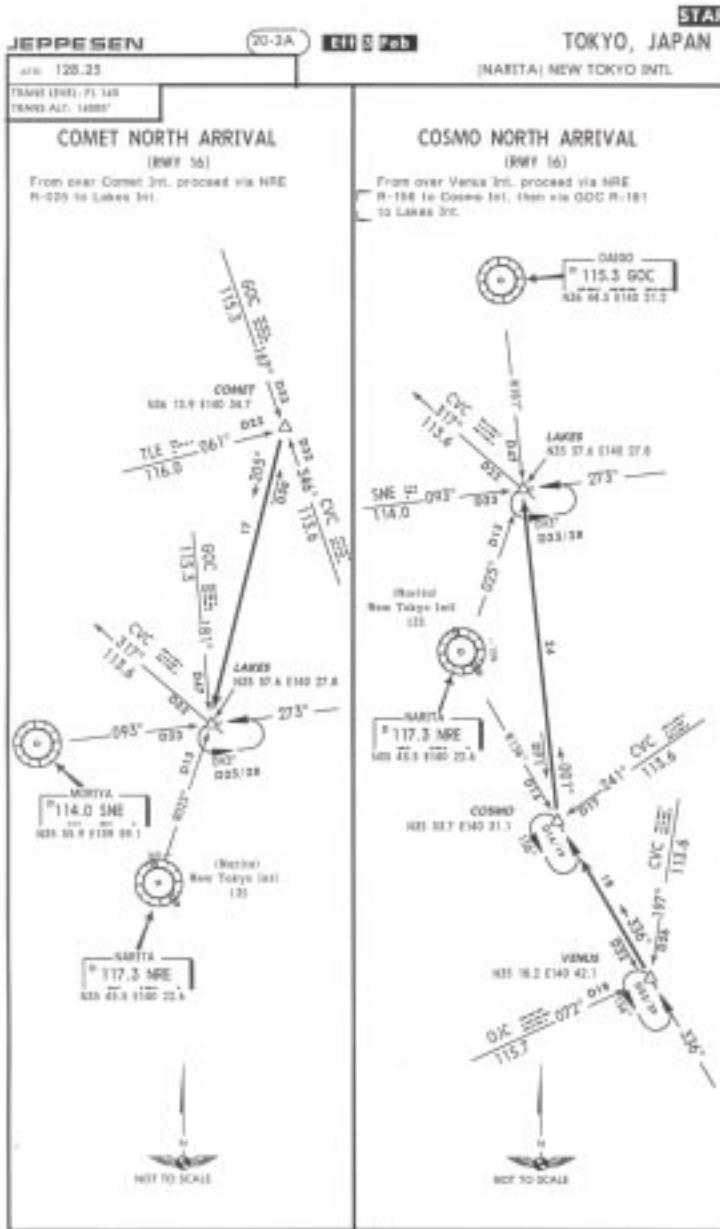
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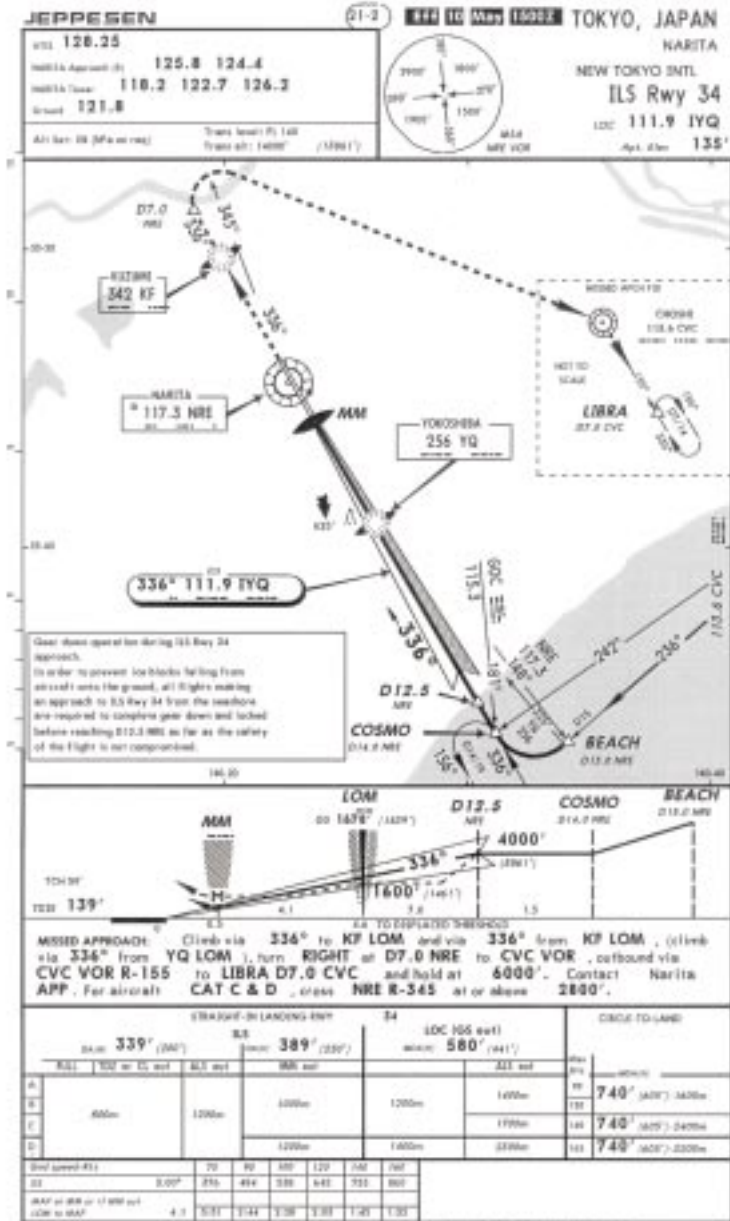
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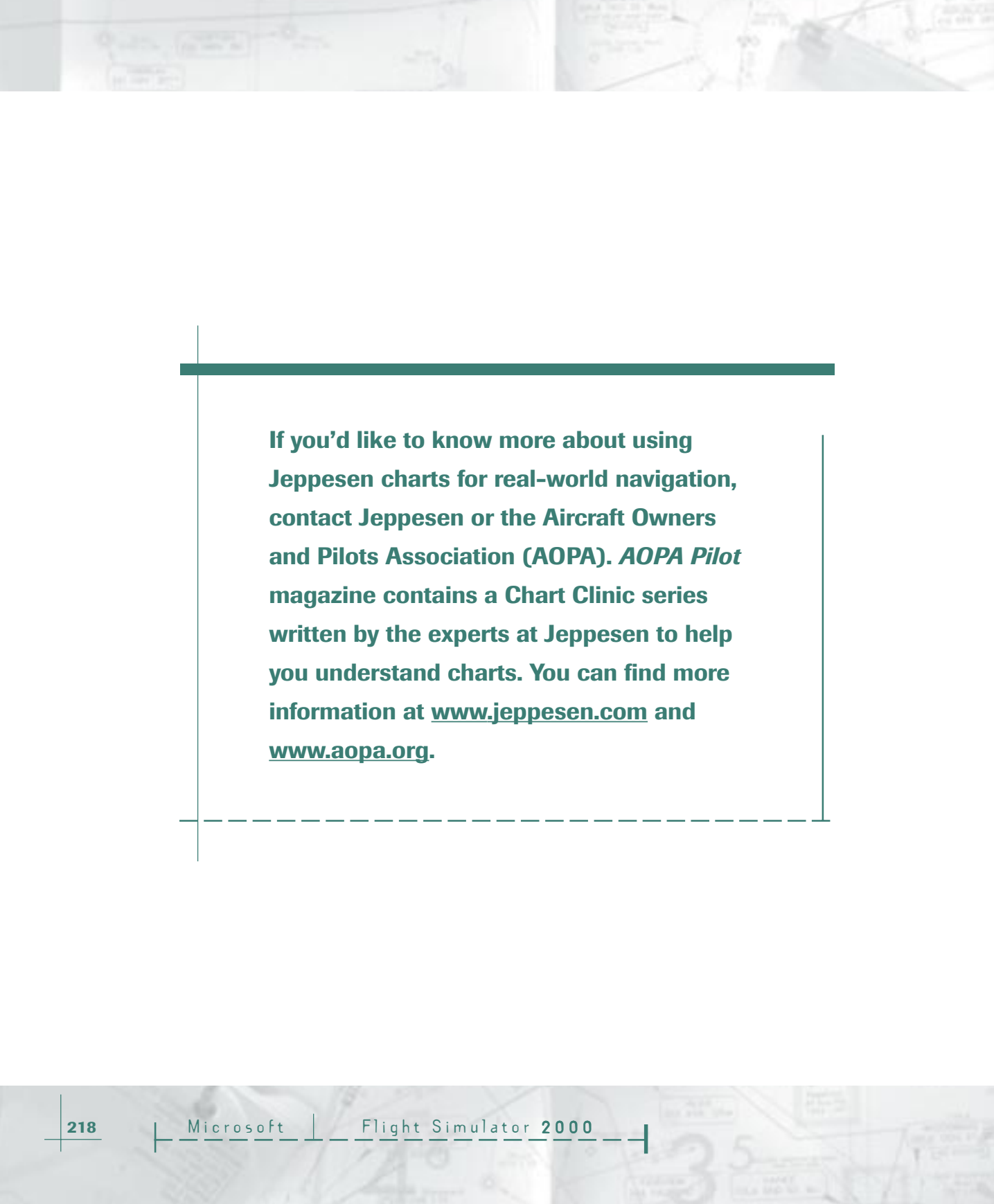
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The background of the page is a faded, light-colored image of Jeppesen navigation charts, showing various symbols, lines, and text typical of aviation charts. The text is centered within a white rectangular area defined by a solid dark green top border, a solid dark green right border, and a dashed dark green bottom border. A solid dark green horizontal bar is positioned above the text area.

If you'd like to know more about using Jeppesen charts for real-world navigation, contact Jeppesen or the Aircraft Owners and Pilots Association (AOPA). *AOPA Pilot* magazine contains a Chart Clinic series written by the experts at Jeppesen to help you understand charts. You can find more information at www.jeppesen.com and www.aopa.org.

Glossary

This is a brief glossary of some of the terms that appear in this *Pilot's Handbook*. For extended definitions and hundreds more terms, see the **Glossary** section of the onscreen Help.

aerobatics

Precision maneuvers such as barrel rolls and loops, and other similar maneuvers not necessary for normal flight.

aileron

Movable control surfaces, usually located near the wing tips, that control the rolling motion of an aircraft. The ailerons move simultaneously in opposite directions.

air traffic control (ATC)

A network of control towers, approach and departure controls, and en route control centers designed to ensure the safe and efficient flow of air traffic. ATC's primary responsibility is to maintain separation between aircraft operating under Instrument Flight Rules (IFR), but ATC also provides services to aircraft operating under Visual Flight Rules (VFR).

airspeed

The rate at which an aircraft moves through the surrounding air. Pilots use several types of airspeed during flight. For example, indicated airspeed (IAS) is the speed shown on the airspeed indicator (usually in knots). Calibrated airspeed (CAS) is IAS corrected for instrument and installation error. True airspeed (TAS) is IAS corrected for changes in atmospheric temperature and pressure.

The aircraft's speed over the ground—groundspeed—is TAS corrected for the effect of a headwind or tailwind.

altimeter

Cockpit instrument that displays changes in barometric pressure as changes in the height of the aircraft relative to sea level.

altitude

Height of the aircraft above a reference level. Altitude above ground level (AGL) is the absolute height above the earth. Altitude above mean sea level (MSL) is the height above the average level of the earth's oceans.

angle of attack (AOA)

The angle between the wing and the oncoming airflow—the relative wind. The angle of attack is related to the direction in which the aircraft is moving, not to the angle the wing makes with the horizon.

attitude

The orientation of the aircraft's axes relative to the horizon.

automatic pilot (autopilot)

A device that automatically controls an aircraft. Similar in concept to the cruise control feature of an automobile, simple autopilots keep an airplane's wings level. More sophisticated autopilots can fly an airplane from immediately after takeoff all the way to its destination and then make an automatic landing.

avionics

Derived from "aviation electronics," this term most commonly refers to the electronic communication, navigation, and flight-control equipment onboard an aircraft.

bank

The angle of an airplane's wings with respect to horizon; rotation about an aircraft's longitudinal axis.

center of gravity (CG)

The point at which an airplane would balance if it were suspended by a cable. The CG is also the point at which the aircraft's three axes—longitudinal, lateral, and vertical—intersect and the point at which the four fundamental forces of flight—lift, weight, thrust, and drag—are assumed to act.

checklist

A procedure list used by pilots to systematically check and set an aircraft's systems prior to takeoff and landing, and during emergencies.

checkride

A flight administered by an examiner from a country's aviation authority to test an individual before issuing a pilot certificate to that individual.

class (aircraft)

With respect to the certification of aircraft, a broad grouping of aircraft with similar characteristics of propulsion, flight, or landing.

class (pilot rating)

A classification of aircraft used on pilot certificates and ratings. In this respect, "class" means aircraft with similar operating characteristics; for example, single engine, multi-engine, land, water, helicopter, and so forth.

drag

The resistance of the aircraft to movement through the air. Drag is one of the four fundamental forces in flight; it opposes thrust.

dual

The number of sets of controls in the plane (i.e., two), or the fact that a pilot is flying under the supervision of an instructor. See also **solo**.

elevator

A movable control surface located on the horizontal stabilizer of an aircraft's empennage (tail). Although its name implies that the elevator makes the airplane climb or descend, it actually controls only the aircraft's pitch attitude—the angle of the nose above or below the horizon.

Federal Aviation Administration (FAA)

In the United States, the federal government agency responsible for the regulation and promotion of aviation.

flaps

A hinged portion of an airplane's wing, generally on the trailing edge, that can be lowered during takeoff and landing to increase the wing's lift and drag.

frame rate

In computer simulations, the speed at which successive frames of the simulation display on the screen. This is similar to the frames of a movie passing through the light source of a movie projector.

general aviation (GA)

In the United States, a term applied to all aviation not related to the military or scheduled airline service. It includes flight training, charter flights, flying for pleasure, and business-related aviation. The term is also used to describe a broad class of aircraft not used by the military or scheduled airlines.

glass cockpit

Refers to the replacement of conventional cockpit gauges with computerized cathode ray tubes (CRTs) or liquid crystal displays (LCDs). A number of gauges are combined into the displays, and the pilot can often flip to different “pages” to see navigation or aircraft system information.

Gs

A measurement of the load factor, or apparent gravity, experienced by an aircraft during flight. One G represents the force of gravity exerted on a body at rest. When an aircraft climbs, turns, or accelerates, positive G-forces act upon it. When it descends or decelerates, negative G-forces act upon it.

heading

The direction in which the aircraft is pointed, usually referenced to magnetic north.

horizontal stabilizer

The horizontal surface of the empennage (tail). The horizontal stabilizer is an airfoil that creates a downward force on the tail to balance the upward force generated by the wing. It also incorporates the elevator; on some airplanes, the entire horizontal stabilizer acts as an elevator.

instrument flight rules (IFR)

In the United States, regulations that apply to pilots, aircraft, and aircraft operations when weather conditions do not meet the criteria for visual flight, when aircraft are operated in Class A airspace—that is, at altitudes at and above 18,000 ft (5,486 m)—, or when pilots choose to operate in controlled airspace under those rules regardless of the prevailing weather.

instrument landing system (ILS)

A system of navigation aids and approach lights that provide both horizontal and vertical guidance to aircraft approaching a runway.

instrument meteorological conditions (IMC)

Weather conditions that require flight under instrument flight rules (IFR). In controlled airspace in the United States, IMC conditions generally mean that the ceiling is less than 1,000 ft (305 m) and flight visibility is less than 3 mi (5 km).

instrument rating

A rating added to a pilot certificate that allows a pilot to act as pilot in command of an aircraft solely by reference to flight instruments.

joystick

Name sometimes given to the stick used to control the ailerons and elevators in some aircraft.

In Flight Simulator, “joystick” means an input device connected to a computer’s game port and used to control the ailerons and elevator. A joystick may also incorporate buttons and switches to control the throttle, landing gear, flaps, and other functions.

kneeboard

A clipboard used in the cockpit to hold charts and other things the pilot needs to have at hand. Kneeboards are sometimes but not always strapped to the pilot’s knee.

In Flight Simulator 2000, the kneeboard contains checklists and other helpful reference information. Press **F10** to access the kneeboard.

knots

See **nautical mile**.

landing gear

The wheels, struts, and other equipment that an aircraft uses to land or maneuver on the ground.

lift

The upward force produced by an airfoil, such as a wing, interacting with the air. Lift acts at right angles to the relative wind or the aircraft's flight path. One of the four fundamental forces in flight, lift is opposed by weight.

Mach number

The ratio of an aircraft's speed to the speed of sound.

manifold pressure gauge

An instrument that measures the air pressure in the intake manifold of a piston engine. Usually calibrated in inches of mercury, this instrument (really a barometer) is used in combination with the tachometer to set engine power. Most small training aircraft have only a tachometer. Aircraft with larger engines and aircraft with constant-speed propellers usually have manifold pressure gauges.

nautical mile (nm)

A distance of about 6,076 ft (1,852 m). The nautical mile is based on the length of one minute of longitude at the equator. In aviation, distances and speeds are measured in nautical miles (nm) and nautical miles per hour (knots).

panel

The surface on which the aircraft's instruments and radios are installed (similar to an automobile's dashboard). Larger aircraft often have multiple panels, sometimes on the sides or ceiling of the cockpit.

pitch

Movement of an aircraft about its lateral axis (nose up or nose down), or the angle of an airplane's nose above or below the horizon.

primary flight instruments

The six instruments displayed on the standard instrument cluster: airspeed indicator, attitude indicator, altimeter, turn coordinator, heading indicator, and vertical speed indicator.

rating

In the United States, an endorsement added to a pilot certificate that specifies the classes of aircraft (single-engine land, multi-engine land, helicopter, and so forth) that a pilot may fly and whether the pilot is allowed to act as pilot in command when the weather does not meet the minimums specified for flight under visual flight rules (VFR).

roll

Rotation about an aircraft's longitudinal axis. A roll is also an aerobatic maneuver in which an airplane rotates completely around its longitudinal axis.

rudder

A movable control surface usually mounted on the vertical stabilizer of the tail. The rudder moves the aircraft about its vertical (yaw) axis. It does not, however, turn the airplane. It is used primarily to balance forces in turns and to counteract yawing motions induced by the propeller during flight.

sailplane

A highly efficient unpowered aircraft that can maintain or gain altitude by riding thermals or other rising air.

screen resolution

The level of graphics detail displayed on a computer screen.

slow flight

Flight at an aircraft's minimum controllable airspeed.

solo

Flight during which only one pilot is flying the aircraft. See also **dual**.

spot plane

A view in Flight Simulator that allows you to see the airplane you are flying as though viewing it from another plane flying alongside.

stall

A sudden loss of lift caused by a disruption of the normal smooth flow of air over the upper surface of a wing. A stall is an aerodynamic phenomenon and has nothing to do with the engine. A stall occurs when a wing's angle of attack reaches a specific value, called the *critical angle of attack*.

standard rate turn

A turn of either 3 degrees or 1.5 degrees per second. Small aircraft typically use the 3 degrees/second rate, which results in a 360-degree turn after 2 minutes. Large, fast aircraft typically use the slower rate, which results in a 360-degree turn in 4 minutes. Pilots use the standard rate turn while flying under Instrument Flight Rules (IFR). It provides a steady, predictable, and easy-to-control rate of turn.

stick

A tubular control in some aircraft, usually between the pilot's knees, used to control the aircraft about its roll and pitch axis (the same function as a yoke).

straight-and-level flight

Like a balancing act, straight-and-level flight requires that you make smooth, small corrections to keep from wobbling all over the sky. To master straight-and-level flight, you must hold a constant altitude and a constant heading.

supersonic

Speed that exceeds the speed of sound; Mach 1 or greater.

tachometer

The instrument that shows the speed of rotation of the engine. It is marked in revolutions per minute (rpm).

throttle

The cockpit control that most directly determines the power output of the engine.

thrust

The forward force generated by a propeller or jet engine that moves the aircraft forward through the air. One of the four major forces, thrust is opposed by drag.

traffic pattern

The traffic flow prescribed for aircraft landing and takeoff from an airport.

trim

To adjust a movable tab on a control surface, usually the elevator, to relieve pressure on the flight controls. Trim is necessary because as an aircraft changes speed, the amount of air flowing over the control surfaces varies. Without trim, a pilot would have to hold forward- or back-pressure on the yoke or column to maintain a specific airspeed or pitch attitude. Larger aircraft also have aileron and rudder trim.

vertical stabilizer

The vertical tail surface on an aircraft; sometimes called a "fin." The vertical stabilizer is fixed on most aircraft. With the attached rudder, the vertical stabilizer provides directional stability by controlling movement about the vertical (yaw) axis.

very high frequency omnidirectional radio range (VOR)

A ground-based radio transmitter that sends signals in 360 radials. Some of these radials define airways, but pilots can track any radial to fly a specific path over the ground.

visual flight rules (VFR)

The “rules of the road” that govern flight when the visibility and ceiling allow pilots to navigate and avoid obstacles and other aircraft by visual reference.

visual meteorological conditions (VMC)

Weather conditions that permit flight under visual flight rules (VFR).

weight

One of the four basic forces at work on an aircraft in flight. Lift opposes weight (more accurately, the sum of all downward forces), which always acts directly toward the center of the earth.

yaw

Movement of an aircraft about its vertical axis, as when the nose turns left or right. Along with roll and pitch, yaw is one of an airplane’s three basic movements. The vertical stabilizer and rudder are designed to control yaw.

yoke

Steering wheel-like device that projects from the panel or is mounted on a column in front of the pilot. Allows the pilot to control the aircraft around the pitch and roll axis (the same function as a stick).

To see extended definitions for these terms, and to get definitions for hundreds of other aviation and simulator terms, in Microsoft® Flight Simulator 2000 click the **Help** menu and then click **Glossary**.

Recommended Reading

The following works are highly recommended by the Microsoft® Flight Simulator 2000 team for any aviation enthusiast.

Ackerman, Diane. *On Extended Wings*. New York: Charles Scribner's Sons, 1987.

Poet Diane Ackerman struggles with a macho instructor and her own self-doubt in this beautiful, moving book about learning to fly.

Bach, Richard. *A Gift of Wings*. New York: Delacorte Press, 1974.

A collection of short stories and essays by the world's best-known pilot-philosopher. Bach's other aviation classics include *Stranger to the Ground*, *Biplane*, and *Nothing By Chance*. Must-reads for anyone passionate about flying.

Buck, Rinker. *Flight of Passage*. New York: Hyperion, 1997.

Two teenage brothers refurbish a Piper Cub and set out to fly across the country in the 1960s.

Coyle, Shawn. *The Art and Science of Flying Helicopters*. Ames, Iowa: Iowa State University Press, 1996.

Filled with diagrams and graphs, Coyle's book explains clearly both the art and the science of rotary-wing flight.

Gann, Ernest K. *Fate Is the Hunter*. New York: Simon and Schuster, 1986.

Gann was an early airline pilot and a Military Air Transport Service pilot during World War II. He tells wonderful tales about the days when being an airline pilot was considered to be something between foolish and completely idiotic.

Gosnell, Mariana. *Zero 3 Bravo: Solo across America in a small plane*. New York: Knopf, 1993.

A young woman flies her Luscombe across the United States and back, seeing America from 1,500 feet.

Kisor, Henry. *Flight of the Gin Fizz: Midlife at 4,500 feet*. New York: Basic Books, 1997.

A deaf pilot sets out to recreate a flight across America by a deaf pilot who accomplished the feat in 1911.

Langewiesche, Wolfgang. *Stick and Rudder*. New York: McGraw-Hill Book Company, 1972.

Written in 1944, *Stick and Rudder* is still thought of as one of the best books for understanding how planes fly and how to fly better. This is a timeless classic every pilot should read.

Machado, Rod. *Rod Machado's Instrument Pilot's Survival Manual*. San Clemente, CA: The Aviation Speakers Bureau, 1991.

There have been many good books written about instrument flying—this one focuses on the topics that keep instrument pilots up at night scratching their heads. With his usual humor, Machado reveals connections and relationships that most instrument pilots discover only after thousands of hours in the cockpit.

Machado, Rod. *Rod Machado's Private Pilot Handbook*. San Clemente, CA: The Aviation Speakers Bureau, 1996.

Ground school has never been so much fun! Easy-to-understand explanations, helpful diagrams, and a humorous style make Machado's *Handbook* one of the most unique aviation books on the shelves.

Markham, Beryl. *West With the Night*. Norwalk, CT: Easton Press, 1989.

Markham was an African bush pilot in the 1930s. She became the first person to fly solo across the Atlantic from east to west. A beautifully written, poetic autobiography, *West With the Night* is considered by many to be one of the greatest works of non-fiction in the 20th century.

Padfield, R. Randall. *Learning to Fly Helicopters*. Blue Ridge Summit, PA: Tab Books, 1992.

Ever wonder what it's like to learn to fly a helicopter? In this conversational book Padfield dispels the myths, then walks you through the training step-by-step. A great overview of a helicopter pilot's world.

Saint-Exupéry, Antoine de. *Airman's Odyssey*. San Diego, CA: Harcourt Brace Jovanovich, 1984.

Best known for his children's classic *The Little Prince*, Antoine de Saint-Exupéry also wrote more explicitly of his experiences as a pilot. *Airman's Odyssey* is a collection of three of his best works. Blending adventure and philosophy, these stories strap you into the cockpit and take you deep into the mind of one of history's most eloquent aviators. It is poignant to note that Saint-Exupéry disappeared in the Sahara while on a military flight—a scenario similar to the story he penned in *The Little Prince*.

Microsoft Product Support Services

Help is available from many different sources. Please take the time to read the following so we may direct you to the most appropriate help source for you.

The services and prices listed here are available in the United States and Canada only. Support outside the United States and Canada may vary. Microsoft's support services are subject to Microsoft's then-current prices, terms, and conditions, which are subject to change without notice. For information about support outside the United States and Canada, see Flight Simulator Help.

Self Help

Help yourself with Microsoft® Personal Online Support—designed specifically for home users and individuals! Go online and get the most up-to-date answers swiftly and easily. You can use simple self-help tools or search a wide variety of technical information. If you still need help, Personal Online Support provides an easy way to submit support incidents directly to Microsoft via the Web.

Connect to Online Support at:
<http://www.microsoft.com/support>

Assisted Support

No-Charge Assisted Personal Support

If you acquired this product as a stand-alone retail product, you are eligible for unlimited no-charge assisted Personal Support during regular business hours. You can receive no-charge Personal support via the Web or the telephone. When submitting incidents, please be prepared to provide your Product ID (“PID”) number.

The PID is a 20-digit number that you can find by clicking **About Flight Simulator** in the **Help** menu.

When you contact Product Support Services, you should be at your computer and have the following information at hand:

- The version of Flight Simulator
- The type of hardware, including network hardware, if applicable
- The operating system (e.g., MS-DOS®, Windows® 95, Windows NT®, and so on)
- The exact wording of any informational or error messages that appeared on your screen
- A description of what happened and what you were doing when the problem occurred
- A description of how you tried to solve the problem

Paid Assisted Personal Support

If you need help after hours, or if you have used up or are not eligible for no-charge Personal Support, you can use Pay-Per-Incident Support via Microsoft Personal Online Support or via the telephone. Support fees are billed to your VISA, MasterCard, or American Express card. In the U.S.: \$35 U.S. per incident. In Canada: \$45 CDN + tax per incident. Both are available 24 hours a day, 7 days a week, including holidays.

Note: If your Microsoft product was preinstalled or distributed with your personal computer or dedicated system (Windows CE-based device), or provided by an Internet Service Provider (ISP), and your Product ID (PID) contains the letters "OEM" after the first five digits, you are welcome to use the many online no-charge self-help or paid assisted support offerings provided by Microsoft. No-charge assisted support for OEM licenses is not provided by Microsoft. Please contact the personal computer manufacturer, device/system manufacturer, or ISP directly for more information regarding their no-charge and paid offerings for support of your product. Please check the documentation that came with your personal computer or check our list of manufacturer phone numbers at: <http://support.microsoft.com/support/webresponse/pid/oem.asp>

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Getting Assisted Support

Via the Web

Web-based support on Microsoft's Personal Online Support is available 24 hours a day, 7 days a week. Any time day or night you can submit via the Web a no-charge or paid incident to a Microsoft Support Professional. You will receive notification from Microsoft that your solution is available and your answers are ready during regular business. Connect to Online Support at: <http://www.microsoft.com/support>

Via the Phone

In the United States:

No-charge assisted support: (425) 637-9308

Note: This number is based in Redmond, Washington, so your phone company may charge you for your call. Contact your long distance provider for rate information.

Regular business hours for no-charge assisted Personal Support are 5AM to 9PM Pacific Time Monday through Friday, and 9AM to 3PM Pacific Time Saturdays, excluding holidays.

Paid assisted support: (800) 936-5700

Available 24 hours a day, 7 days a week, including holidays.

In Canada:

No-charge assisted support: (905) 568-3503

Note: This number is based in Mississauga, Ontario, so your phone company may charge you for your call. Contact your long distance provider for rate information.

Regular business hours for no-charge assisted support are 8AM to 8PM Eastern Time Monday through Friday, excluding holidays.

Paid assisted support: (800) 668-7975

Available 24 hours a day, 7 days a week, including holidays.



A front-facing view of a large commercial airplane on a runway. The aircraft is highly reflective, showing clear reflections of the sky and the ground. The nose, cockpit windows, and the main cabin door are prominent. The landing gear is visible, and the wings extend to the right. The background is a bright, hazy sky. The word "Index" is overlaid in a dark green, sans-serif font on the right side of the image.

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