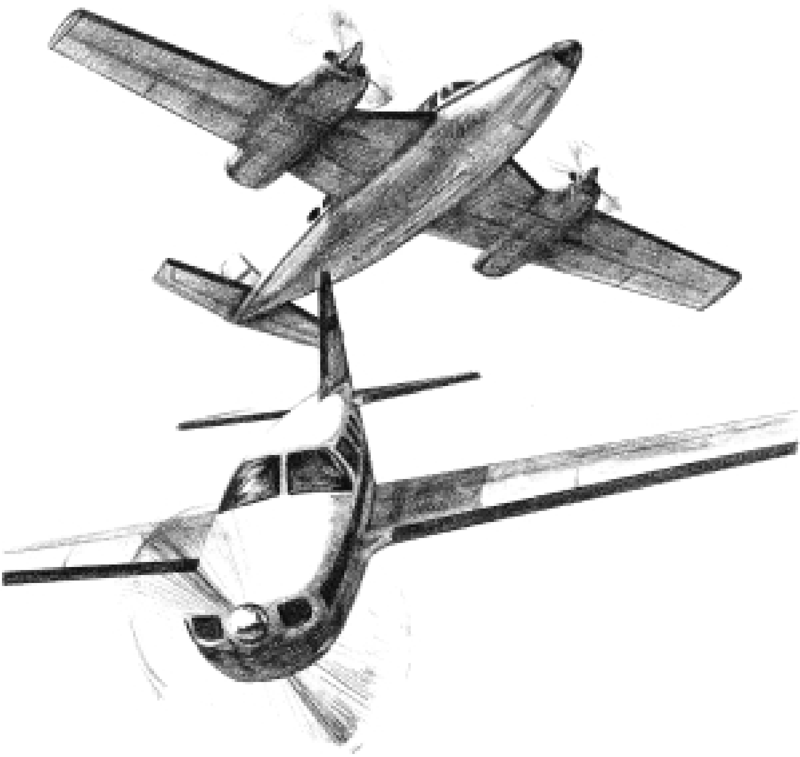

Fly!

Pilot Handbook

Written by
Peter Lert

Original Illustrations by
Peter Carpenter

Technical Documentation by
Greg Kramer

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Edwin E. Steussy, Publisher.
Amy Yancey, Coordinator.

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Dedicated to Captain Daniel A. Combs, retired USAir.

In Loving Memory of Vernon Temple, who was a source of strength, humor and faith to all of us fortunate enough to have known him.

Quick Start Reference

Everyone loves to jump right into the pilot's chair and try a quick flight before changing any options or settings. Still, even the most experienced user will need to tend to a few details before giving into their enthusiasm. If you read nothing else, follow the steps here before continuing.

All Pilots

- Configure your graphics options (p. 10).
- Setup your sound options (p.12).
- Choose and configure your controls (p. 14).
- Establish your Auto-Save options (p. 18).
- Select Realism elements (p. 19).

Novice Pilots

- Once you have done all of the above, proceed to the Fly New view and pick a pre-set scenario (p. 31).

Experienced and Advanced Pilots

- Since you will probably want to tinker with the simulation's more advanced options, give some attention to these items.
- Confirm your Cockpit Options (p. 16).
- Tune your Radios (optional — p. 17).
- Choose your Logbook Options (optional - p. 19).
- Tweak your Airplane Options (see Airplane, p. 21).
- Jump into your Flight Planner (p. 32)

Simulation Interface

Welcome to the most realistic general aviation flight simulator ever developed for the personal computer. No need, however, to crow too much about the things that make Fly! special — since you are reading this manual, you've already been convinced!

This reference guide is divided into two primary sections. The first section covers the configuration and user interface issues underlying this simulation: menus, options, and simulation controls. The second section - Flight Instruction - leaves these nuts-and-bolts procedures behind and immerses you entirely in the flight simulation aspects of Fly! The information detailed in both of these sections are equally essential to your enjoyment of this product, but are outlined separately to reinforce the central premise in Fly! — once you are in the virtual cockpit, you are in a plane and every effort is made to then free you of thoughts of video card configurations and key definitions.

Fly! can be played on computers running either Microsoft Windows or Apple's MacOS. Throughout this manual, most statements will refer to both versions. In the rare occasions when your choice of operating system requires specific attention, however, we will refer to the appropriate information for both platforms.

Finally, we realize that not every virtual pilot wants the same level of simulation. Some will want to spend time tinkering with every control, lever, and option, getting every ounce out of Fly!'s realism. Others, however, will not want to quibble with fuel mixture, load, or wing icing, rather craving the thrill of flight and the beauty of the scenery. No matter which kind of pilot you are (or even if you're somewhere in between), you will find your desired experience in Fly! with only a few changes to some essential options.

Starting the Simulation

Once installed, locate and open Fly!'s folder and double-click on Fly!'s icon ("FLY.EXE" in Windows or "FLY!" in MacOS) to launch the program. The first time you run the program, you will be taken directly to the Intro Screen and primary menu bar. Many users will be content to start Fly! through this welcome screen, but it is possible to customize which of the interface screens will greet you when you launch the program in the future (see Graphics Options, p.10).

Interface

Once you have completed setup and configuration of your video card, sound card, and input devices, you can proceed to Fly Now! or the Flight Planner views to prepare a flight. Once you select and begin a flight, the simulation will start and you can begin interacting with the plane and your environment.

There are some basic interface items to be aware of while in simulation mode.

The mouse is "active" at all times, but will automatically hide itself after 5 seconds of inactivity. Whenever you wish to manipulate a cockpit item, or use the mouse to control a window or other feature, simply move the mouse and the cursor will appear. To hide the cursor, simply stop using the mouse and it will disappear after 5 seconds.

Any windows you open will operate like normal windows in your other applications. You can click in a window to activate it, click at the top of the window or in its title bar to drag and move the window, click in the lower right corner to resize the window (if it has a size box), and click in the upper corner to close the window (if it has a close box.) The "main" visual area is also treated as a window – although you will not see a "border" or title bar, you can still click on the sides or bottom right corner to click and resize the main area. Clicking on the top will allow you to drag the main window to a new location. The cursor will change to indicate when moving or resizing is a valid option.

All windows remember the last location, size, and state they were in when you exit and re-enter the simulation. You can re-arrange the size and location of the primary "window" and any secondary windows, and they will automatically return to those positions the next time you use Fly!

If you are running Fly! in full screen mode, you can press the **Space Bar** to access the primary menu bar. The primary menu bar will give you access to all available settings dialogs and secondary windows (see Primary Menu Bar, p. 9)

To exit the simulation and return to the primary Fly! interface screens, press the **Escape** key.

Intro Screen

Fly Now!

Links to the Fly Now View (p. 31). This is the quick and easy way to get right into the air and is ideal for novice or inexperienced pilots.

Flight Planner

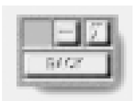
Links to the Flight Planner View (p. 32). The starting point for more experienced and expert pilots, this option allows the pilot to establish a customized flight plan, choose and configure any available aircraft, and modify the weather environment for the flight plan.

Multi-player

Links to Fly!'s multi-player system. Consult the separate Multi-Player Guide for details.

Support

If you have access to the Internet, this links to the web site for Fly! support. This page also provides news and updates for Fly!, as well as links to other Fly! and Terminal Reality related web sites.



Navigation Icon Bar

The Navigation Icon Bar appears on all pre-flight views in Fly! Each button allows you to get where you want to go quickly and easily.

– (Microsoft Windows only) Minimizes Fly! from view allowing you to access your operating system's Desktop.

X (Microsoft Windows only) Quits Fly! Note that unless you activate the "Ask Before Exiting" option in Options - Auto-Save, hitting this button will quit Fly! without asking you to confirm your choice.

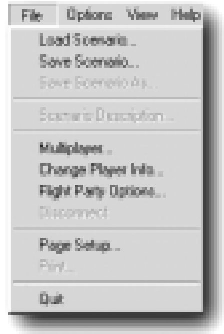
Back (All Platforms) Takes you to the previous screen. Note that pressing Back does not erase any changes you made before pressing Back.

Primary Menu Bar

The primary menu bar appears at the top of the screen, sporting an array of drop-down menus. Some Menu Bar selections and even some menus will not be available at all times; if an item is faded, or "grayed-out," it is currently unavailable. The simulation's menus are: Apple (MacOS only), File, Options, View, Windows and Help.

File Menu

File Menu



Load Scenario

Brings up a file box for loading predefined or favorite scenarios and resuming saved flights. Available pre-flight and during simulation.

Save Scenario

You can save your flights at any time. This comes in handy if you want to preserve a flight in progress to resume at a later time. Save Scenario will replace the contents of the last saved scenario of the same name – if you do not wish to lose your previous saved scenario, use the Save Scenario As function to select a new name.

Save Scenario As

Allows you to save your scenario under another name. This is otherwise functionally identical to Save Scenario.

Scenario Description

Read a scenario's description if the author (you or someone else) entered one when they saved their scenario.

Page Setup

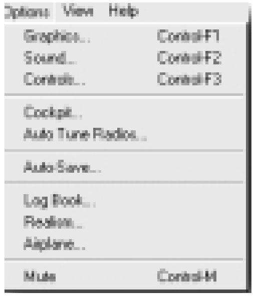
This menu selection, as it does normally in your operating system, allows you to configure your printer before printing.

Print

The Flight Planner view allows optional printed output of flight plan related information. This menu selection sends output to the printer.

Exit (Microsoft Windows) / Quit (MacOS)

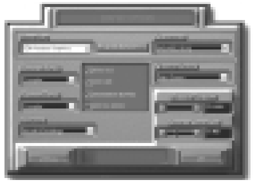
Options



While it is important to understand these various options (especially if you are getting unsatisfactory performance), you can jump right into the sky with the default options. We do not, however, recommend it.

Quick starters can simply head for their plane once they have defined their Graphics, Sound, and Control options, but all pilots will benefit from understanding the following information.

Graphics



These options tell Fly! which graphic effects to generate, as well as what video hardware is installed in your machine. Whether you have 3D hardware installed or not, you will want to review the options in this box before you step into the cockpit for the first time. The performance and frame rates of Fly! can be impacted most significantly by manipulating selections in this dialog.

Video Card

Use this pop-up menu to identify the brand and type of video card you have installed in your computer. Fly! will automatically configure visual effects based on the published capabilities of the video card. If you do not have a 3D accelerator card installed, select Software Only. If you have a 3D accelerator installed but it is not listed here, you can select DirectX5 Compatible, DirectX6 Compatible, or 3Dfx Glide Compatible for defaults.

Startup Screen

This pop-up menu allows you to pick what screen you will see by default when launching Fly! in the future. You may choose between the Intro, Fly Now, Flight Planner, or Multi-Player Views. If you always go to one of these areas when launching Fly!, you will find it convenient to save your favorite as the simulation's start-up screen.

Scenery Detail

Increases or decreases the amount of graphic detail in Fly!'s 3D scenery. The levels of detail are: None, Sparse (includes only major buildings), Normal (shows secondary landmarks, and well known Points Of Interest), and Complex (displays all of the above plus generic buildings for added realism). Lower this detail to increase system performance.

Airport Detail

Increases or decreases the level of graphic detail in Fly!'s airport runways. Lower this detail to increase system performance.

Shadows

Specify which objects cast shadows onto the ground scenery. The available selections are: None, Aircraft Only, and Aircraft and Buildings. Turning off building shadows by selecting Aircraft Only can significantly improve frame rates in areas of high building concentration.

Checkboxes

Detail Tiles: Check this box to experience enhanced ground detail around major airports. This requires considerable processor power and video RAM. Turn off this feature to increase system performance.

Lens Flare: Check this box to enable colorful lens flare effects projected from the sun. Turn off this feature to increase system performance.

Environment Mapping: This feature maps reflections of the sky, clouds and ground onto the exterior of your aircraft resulting in a more life-like look. Turn off this feature to increase system performance.

Auto Full Screen: If selected, this feature causes the simulation to open in full-screen mode by default. If unchecked, the simulation will open in a window. Note that any 3D accelerator hardware you have installed will ***not*** be used unless you are running in full screen mode. By activating Auto Full Screen, you ensure your hardware will always be used by default. Running in software only modes will result in significantly slower performance.

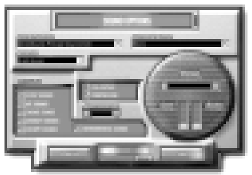
Terrain Visibility

This slider alters the maximum distance you can see from your aircraft. Beyond this maximum distance, terrain will be shrouded by haze. The setting ranges from 10 to 20 miles. Note that this setting limits the Visibility setting in Environment—no matter how high you set that slider, you will not be able to see beyond the distance specified here.

Texture Cache Size

Slider changes the size of the simulation's Texture Cache. This cache blocks off a chunk of your available RAM for pre-loading of textures to speed rendering. The larger you set this cache, the fewer "pauses" you will experience due to disk accesses during flight. You are limited in this setting by the amount of available RAM in your computer. Values range from 8MB to 32MB. You should be careful not to set this value too high if your machine has a too little RAM installed.

Sound



These options allow you to define the sound hardware and specifications for your system. Sound is a significant element in an effective simulation, so the higher you can move these settings, the deeper your immersion in the flight experience. Keep in mind that higher sound settings will slow system performance, so be prepared to lower them to remedy any stuttering or slow frame rates.

Sound Device

This pop-up menu allows you to select which sound hardware will be used to produce Fly!'s sound effects.

Quality

Quality settings range from 8-bit to 16-bit on this pop-up menu. Reduce this setting to improve system performance.

Speaker Setup

Pop-up menu establishes whether your system supports Mono, Stereo, or Surround sound.

Checkboxes

These options allow you to adjust the kinds of sound effects you will hear. Using these options can impact sound card and system performance. Deactivate some or all of these checkboxes to increase system performance.

Setup Sounds: Mood-setting background sounds that play while in the simulation's set-up menus. Click this box to activate or deactivate these sounds.

ATC Sounds: Air Traffic Controller chatter plays while you are seated in your cockpit. Click this box to activate or deactivate these sounds. Turning off this option will not disable the scrolling ATC text displays, allowing you to still receive critical ATC information without audio output.

Engine Sounds: While in flight, your engine emits the satisfying, familiar hum of a plane in flight. Click this box to activate or deactivate engine startup, idle, propeller, or shutdown sounds.

Aircraft Sounds: Besides engine sounds, each aircraft also produces a range of other sound effects, including flaps, tire noise, stall horn, and gear horn. Check this item to enable or disable these sounds.

Cockpit Sounds: While in the cockpit view, a variety of sound effects are used to reproduce in-cockpit atmosphere. Effects include switches, marker beacon signals, ground noise, gyroscopes, and audible alarms. Check this item to enable or disable these sounds.

Environmental Sounds: This check box controls the audio for wind, rain, and thunder. Enable or disable as desired.

Volume Control

With this slider, you can increase or reduce the relative volume of all sound effects. The Left and Right indicators show the sound output levels of each speaker attached to your system.

Radio

The Radio related checkboxes control the use of LiveMic™, a feature that allows you to use voice communication with other players when participating in multiplayer over the Internet. You must have a microphone attached to your computer, as well as a sound card that supports microphone input.

Full Duplex: Allows you to talk and listen simultaneously when using two-way radio transmission. Requires a full duplex-capable sound card (see your sound card's manual to find out if yours is full duplex-compatible).

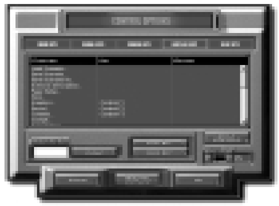
Compression: Toggles Radio compression on and off. Use compression if attempting to use two-way radio transmission over dial-up Internet connections. If you are playing over a LAN, you probably don't need to turn compression on; sound quality will be clearer without compression.

Amplification: Amplifies incoming two-way microphone audio.

Mute

Negates all volume controls.

Controls



This dialog may be used to customize the simulation's default keyboard and button assignments to suit your personal style and preference.

The key list shows the name of the simulation function in the left column, the currently defined keystroke in the center column, and the currently defined joystick or controller button assignment in the right column. Any listed function can be assigned to a keyboard shortcut, or to a button on a joystick or other input device.

Key Assignments

The various keyboard and button commands are divided into sets for greater organization. Select from each of the following to find the commands you wish to customize (For more information on all these controls and their default key assignments, Controls & Shortcuts, p. 41)

Menu Keys: Controls for the simulation's general interface and menus.
Global Keys: Universal keys available regardless of aircraft being used.
Camera Keys: Controls for the movement and placement of cameras.
Airplane Keys: Controls for movement of your airplane and systems.
Slew Keys: Controls for placement of aircraft in Slew Mode. (p. 50).

Redefine Key

When you click on an item in the Assignments list, its currently assigned key appears in this text entry box. If you want to change the key assignment, input it here. Be sure, however, not to use a key already assigned to another function. To assign a button to a function, simply select the function in the Key Assignments list, then press the button on your controller.

Clear: Pressing this button clears the assigned keyboard shortcut and controller button.

Load Set/Save Set

User-defined key configuration sets can be saved for later use by pressing Save Set and can be recalled with the Load Set button. Fly! ships with a collection of pre-configured key configuration sets that match other competing flight products, to allow easier learning for users already familiar with these products.

Restore Defaults

Resets all keyboard/button assignments to their original defaults.

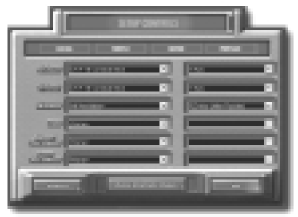
Null Zone

This slider allows you to increase the realism of the simulation by creating a "null zone" on your input device. This zone, a percentage of your device's range of motion, creates a region around the controller's central point in which it will not respond. The higher the percentage, the farther the device must be used before the aircraft will respond. Null zone has no effect if you are using the keyboard or a gamepad as your primary input device.

Setup Controls

Click this button to open the Setup Controls dialog, which is used to select which joystick or input devices should control the various axes for the aircraft.

- For Microsoft Windows users:



This dialog box allows you to define what, if any, input devices you intend to use with Fly! Input is divided between General controls, Throttle, Mixture and Propeller. Click the area you wish to edit, which will then display the available axis inputs.

For each axis listed, choose the input device you want to control that axis from the appropriate combo box. Once the input device is selected, you can choose which axis on that device is used to control the aricraft axis. Make this selection from the appropriate combo box on the right. This allows complete customization of the input controls for FLY!

X-Axis: Select which input device will control the X-axis of the aircraft. The X-axis controls left-to-right banking of the aircraft through the ailerons.

Y Axis: Select which input device will control the Y-axis of the aircraft. The Y-axis controls the nose up-nose down pitch of the aircraft through the elevator.

Rudder: Select which input device will control the Rudder of the aircraft. The rudder controls left-to-right yaw.

Throttle: Select which input device will control the Throttle of the aircraft.

Left Toe Brake: Select which input device will control the left toe brake in the aircraft. Certain rudder pedal input devices may not support this functionality.

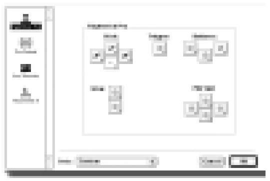
Right Toe Brake: Select which input device will control the right toe brake in the aircraft. Certain rudder pedal input devices may not support this functionality.

Trim: Select which input device controls the aircraft's Elevator Trim.

Open Control Panel: Clicking this button opens the Microsoft Windows joystick control panel to test and calibrate your input devices.

Engine Controls: Clicking the Throttle, Mixture and Propeller buttons allows selection of input devices for each of these functions. You can assign the same input axis to control multiple engines, or specify separate input axes for each engine.

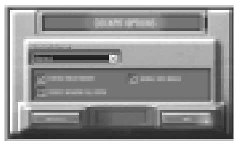
- For Apple MacOS users:



This dialog box allows you to define what, if any, input devices you intend to use with Fly! This is the standard MacOS InputSprocket configuration dialog, allowing you to configure and assign functionality to each input device.

Click on an input device listed in the left column to display the programmable functions for that device. Click on the icons to open a pop-up menu allowing you to choose which function that axis should map to. You should only use this dialog to assign device axis input for Fly! For buttons and point of view configuration, use the Controls dialog to establish button assignments as desired.

Cockpit Options



These options dictate how the cockpit view and gauge detail will be presented in the simulation.

Gauge Detail

Dictates the level of detail (frames of animation on needles, compasses, etc.) presented on the cockpits' array of dials and indicators. Normal, coarse, and minimal. Lower this setting to increase system performance, particularly if you are running short of RAM.

Stretch Main Window

When active, this feature creates a realistic change of perspective when you scroll around the cockpit—the landscape seen through your window will stretch as your perspective changes. You may see a small performance increase when this feature is on.

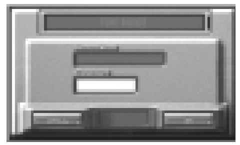
Cockpit Window Full Width

Normally, if you resize your window while using a camera other than cockpit, you will see the same resizing when you return to your cockpit. When you activate this feature, your cockpit will always be full-screen width.

Scroll with Mouse

Allows you to scan your instruments by moving your mouse pointer to the edges of the screen. If you choose to disable this option, you must use the Shift + Arrow Keys to look around your cockpit (p. 41).

Tune Radios



Your radios are your navigational and communications lifeline when you are high in the sky. Use this dialog to select a radio and tune by keyboard. The frequency you enter will always be set as the "active" frequency for the selected radio. You always have the option of tuning the radios directly in-flight by directly manipulating the radio with the mouse from the cockpit view. For more on using your radios, see Radios, p. 44.

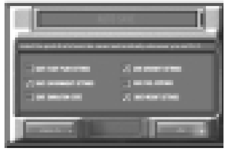
Select Radio

Pop-up menu allows you to choose from the available radios installed in the currently selected airplane. Radios differ across different aircraft, so carefully browse this list to find the exact component you are wanting to tune.

Frequencies

Enter the frequency to set as the active frequency for the selected radio. Fractional frequencies may be entered, but if a frequency is entered that is outside the tuning range of the selected radio, the change will have no effect.

Auto Save



This set of options allows you to define which of your settings will be automatically saved between sessions. The next time you launch Fly! these settings will load by default, speeding your return to flight. Each of these checkboxes can be toggled to indicate which data you want saved automatically when you exit Fly!.

Flight Plan

Preserves departure and arrival airports and times, user-defined waypoints, and flight paths.

Environment

Saves all environmental settings for clouds, wind, weather, visibility, etc.

Simulation State

Saves the state of the simulation when you exit. You can resume your flights in progress without saving manually.

Aircraft

Remembers the last selected aircraft.

Fuel

Preserves settings for fuel loadout for each fuel tank. Only active if Aircraft has been selected.

Weight

Saves preferences for weight loadout for each passenger, pilot, and cargo slot. Only active if Aircraft has been selected.

Ask Before Exiting

Select this check box if you want to be prompted before exiting Fly!

Logbook

Real-world pilots log every hour they spend in the air or on simulators to demonstrate how much in-flight experience they have. The same mechanism is available in Fly! Every moment in flight can be recorded so you can trace your history and impress your friends.

Flight Entries

This list contains a history of each flight you have taken in Fly! Each entry displays the date and time of flight, the aircraft in use, and the flight duration.

New Log Book

Create a new log book. You will be asked to specify a location on your hard disk to save the new log book file.

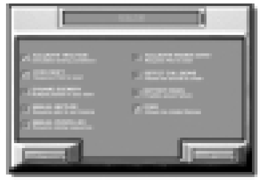
Open Log Book

Opens an existing log book. The last log book you open before leaving this dialog will be considered the “active” log book.

Details

Click the Details button to see complete details of the flight entry currently selected in the Flight Entries list.

Realism



Fly! offers unprecedented realism in a flight simulator, but many beginning pilots may find these features cumbersome when learning to fly. Review the following realism elements to decide what level of realism you expect from the simulation.

Detect Collisions

Activating this option makes all structures (i.e. buildings, bridges, towers, and other aircraft) solid. With the feature enabled, these structures can be hit by your plane. Deactivating it allows you to pass through these structures.

Battery Drain

Normally, your battery is drained by the use of electronic devices, reducing your power levels over time. When you turn off this feature, your battery will have an infinite charge.

Dynamic Scenery

Turning this feature on allows the simulation to create computer controlled aircraft in the world around you. Turning this feature off can provide performance boost, but will also simplify the situation somewhat—if there are other planes in the air, you must be mindful of their locations and co-exist with them during take-offs and landings.

Simulation

Icing

Cold weather and high moisture levels can cause ice to form on your wings, a runway, and aircraft parts, reducing airplane performance. Turning off this feature eliminates the possibility of ice forming. When active, you will experience the effects of icing when conditions are present, but there is no visual indication of ice on the aircraft or outside surfaces.

Accurate Ground Traction

Rain or ice can cause runways to become slick, making takeoffs and landings difficult. Turning this feature off eliminates this hazard and preserves dry-weather conditions regardless of actual weather.

Gyro Drift

Gyroscopic instruments have a tendency to lose accuracy after extended use. Experienced pilots know how to adjust for this “drift,” but it can be confusing to novices. You can disable this if desired.

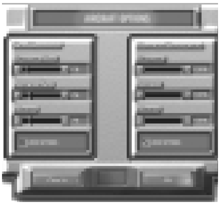
Accurate Engine Start

The procedure to set-up and start engines is a lengthy and complicated one. When this option is enabled, pressing the Easy Engine Start key will allow the plane to methodically turn on and activate each aircraft system in order. This can be helpful when learning the startup sequences for each aircraft. When disabled, pressing the Easy Engine Start key will immediately start the aircraft with minimal delay.

Manual Propeller

Pilots often need to adjust propeller RPM, but you can let the computer make these changes if you deselect this feature.

Airplane



These options encompass the fine tuning necessary to ready a plane for flight. Be sure to adjust these before flight, or leave them at their default settings if you are unsure how to adjust them. Note that these changes only affect the currently selected aircraft, and do not affect all other aircraft. This allows for distinct input tuning for each aircraft individually.

Trim Sensitivity

Moving this slider makes any adjustments to trim (in other words, each press of the key controlling that adjustment) less significant. As a result, pressing the Elevator Trim Up key would have less effect if Trim Sensitivity is adjusted to the left. If you wish your adjustments to have a more dramatic effect, move this slider to the right. To tie Elevator, Aileron and Rudder Trims together, click the **Lock Settings** checkbox.

Control Exponential

This factor dictates how much effect holding the following controls will have. In other words, the longer you hold the adjustment, the faster it adjusts. Moving the slider to the left causes controls to accelerate at a slower rate, moving it to the right causes acceleration to increase. To tie all three settings together, click the **Lock Settings** checkbox.

Mute

Mutes all sound. This can also be activated by pressing Control-M in Windows or Command-M in MacOS. Selecting Mute again restores volume to previous levels.

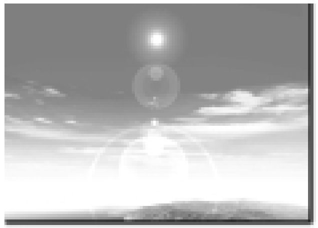
View Menu

Cockpit Camera

For most pilots, this will be their primary view of the world. From this view, you can look around your cockpit as freely as if you were there (especially if you have mouse scrolling activated, see Scroll with Mouse, p. 15).

Spot (Chase) Plane Camera

This is a free-motion camera. Activating it immediately transports you outside your plane to watch it in flight. Use the camera control keys to zoom and pan around until you find the view that suits your needs. You can even save your favorite positions to a hot key.

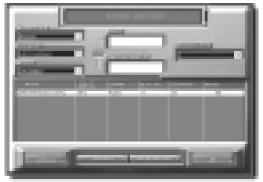


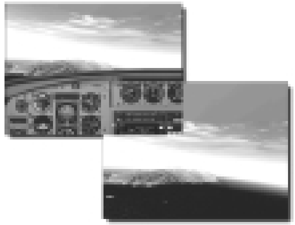
Fly By Camera

This is a stationary camera that observes your plane's approach, pass-by, and departure. When you go out of range of the camera, it assumes a new position and starts its pan again.

Directory

Use this tool to jump to any geographical point (airport, nav-point, etc.). The directory is a stripped-down version of the Departure/Arrival Dialog Box (see Flight Planner, p. 32).





Toggle cockpit

When in Cockpit view, use this feature to hide your entire instrument panel from view. When the panel is turned off, you will have a full-screen view of the landscape in front of your aircraft. To maintain your essential controls, you might want to bring up your Mini-Cockpit Window (p. 30).

Intro Screen

Links to the Intro Screen View, (p. 8).

Fly Now!

Links to the Fly Now! View, (p. 31).

Flight Planner

Links to the Flight Planner, (p. 32).

Setup Aircraft

Links to the Setup Aircraft View, (p. 36).

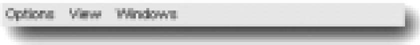
Environment

Links to the Environment View, (p. 38).

Toggle Full Screen

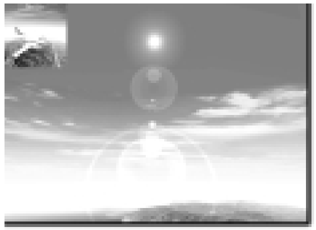
Switches between full-screen, zoomed in-window and desktop in-window modes. Keep in mind that 3D hardware acceleration will not be used when running in windowed modes, resulting in lower frame rates.

Windows



This menu contains all of the simulation's special Windows. These alternative views provide powerful and flexible tools that every pilot should learn to use. For example, you can bring up a sectional map of your current location to find out where you. Or, you can call up a miniature version of your cockpit so you can control your plane while using an external camera. These Windows are:

Secondary Camera Window



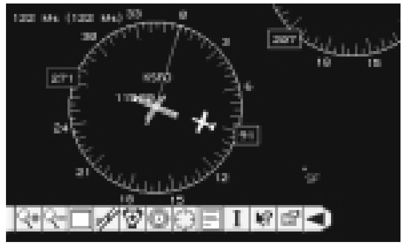
This window displays any of the external camera views. For example, if you want to be seated in the pilot's seat, but still want to watch your plane from the outside, you can bring up this window to view the Spot Plane Camera. You can scroll through the available camera views as normal by pressing **C**. When the Secondary Camera Window is the active window, it receives all camera keystrokes. Some 3D accelerator cards do not support this feature.

Map Window

Opens a window displaying your plane centered over a sectional map of your immediate area. With this tool, you can immediately confirm your location or locate nearby navaids, airports, or major terrain features. Fly! ships with sectional charts covering the continental United States.

You can scroll around the window by holding the Shift Key (turning your mouse pointer into a grabbing hand) and clicking to grab and drag the map. You may also use the camera control keys (i.e. Control + Right Arrow). Double click anywhere on the map to re-center the map on your plane. Finally, you can click and drag to see distance measurements.

Vector Map Window



The Vector Map is a graphic display that illustrates nearby airports, VORs, and NDBs in vector format. The Vector Map is a resizable window that allows viewing up to 150 nautical miles in radius from the airplane's position. In the event that you have no visible navigation aids from the airplane's view, use the Vector Map to quickly find a reference navaid to guide you on your way. Highlight a navaid in the Vector Map by moving the mouse over the navaid. Double-click on a highlighted navaid to open an information window about the corresponding navaid. The Vector Window is one of FLY!'s most flexible tools. Explore the array of features, buttons, and aids freely and frequently.

Control Bar

The Control Bar provides a method to quickly modify the visible navaids in the Vector Map. The Control Bar is located at the bottom-left of the vector map. The Control Bar can be opened or closed. When the Control Bar is closed (collapsed) it displays an arrow pointing to the right. Click on the right arrow to open (extend) the Control Bar. The Control Bar in the open position displays an assortment of buttons. The arrow previously pointing to the right now points to the left. Click on the left arrow to close the Control Bar. The arrow previously pointing to the left now points to the right. The button functions are described below from left to right:

Zoom-In:

Click the Zoom-In button to increase the amount of visible area in the Vector Map while increasing the size of the items visible. Click and hold the Zoom-In button to zoom at an increasing rate. When the Vector Map is at maximum zoom, the Zoom-In button becomes disabled.

Zoom-Out: Click the Zoom-Out button to decrease the amount of visible area in the Vector Map while decreasing the size of the items visible. Click and hold the Zoom-Out button to zoom at an increasing rate. When the Vector Map is at minimum zoom, the Zoom-Out button becomes disabled. The maximum zoom out allows a 150 nautical mile visible radius from the airplane.

Maximize/Restore: Click the Maximize/Restore button to quickly maximize the Vector Map to full size of the screen or restore it to its previous size. Click the button to maximize the window. Click the button again to restores the window to its previous size.

Airport: Click the Airport button to enable or disable the display of Airport navaids in the Vector Map. The Airport appears as a yellow vector Airport when in colored graphic mode, or as the appropriate Airport icon when in icon graphic mode. As the Vector Map is zoomed in, the Airport (in colored graphic mode) displays runways. When the Vector Map is close to maximum Zoom-In, runway identifiers are displayed at the ends of the runways, helping you to find the appropriate runway when attempting to land. Double-click an airport to open an Airport Information Window about the corresponding airport.

VOR: Click the VOR button to enable or disable the display of VOR navaids in the Vector Map. The VOR appears as a green vector VOR when in colored graphic mode, or as the appropriate VOR icon when in icon graphic mode. The display of compass plates is disabled when VOR navaids are disabled. Double-click a VOR to open a Navaid Information Window about the corresponding VOR.

NDB: Click the NDB button to enable or disable the display of NDB navaids in the Vector Map. The NDB appears as a red vector NDB when in colored graphic mode, or as the appropriate NDB icon when in icon graphic mode. Double-click a NDB to open a Navaid Information Window about the corresponding NDB.

Compass Plate: Click the Compass Plate button to enable or disable the display of compass plates on all VOR navaids. The compass plate is displayed as a green circle with a radius between one and five nautical miles. The compass plate circle is scaled appropriately when the Vector Map is zoomed. A solid green line points from the middle of the circle to magnetic north. Along the perimeter of the circle are marks at intervals of 30º, 10º and 5º. The Bearing To and Radial From are displayed on the perimeter of the circle. Flying the Bearing To directs your plane to the compass plate along an imaginary line from your airplane to the center of the circle. If you get lost while flying, find a nearby compass plate and fly at the Bearing To to resume your flight plan.

Text Labels: Click the Text Labels button to enable or disable navaid labels. The amount of information in the text label of each navaid type can be set in the Options Screen.

Graphics Mode: Click the Graphic Mode button to toggle the display of icons or colors for navaids. When displaying icons for navaids, an icon appears in the Vector Map corresponding to the type of navaid. The icons are the same icons found in the Flight Planner, for more information, see Map Icons p.34. When displaying colors for navaids, airports are yellow, VOR navaids are green, and NDB navaids are red.

Cursor Info: Click the Cursor Information button to display the specified information near the mouse cursor. The exact information displayed near the mouse cursor is set in the Options Screen. The settings include the distance from the airplane to the mouse cursor, the radial from the airplane to the mouse cursor, and the bearing to the mouse cursor from the airplane. All the information is calculated from the center of the airplane to the tip of the mouse cursor. Click the Cursor Information button again to disable the option.

Options: Click the Options button to display the Options Screen. The options screen allows you to specify the visuals in the Vector Map. The Vector Map Window resizes to accommodate the Options Screen. The options are described in more detail in Vector Map Options, p.28. Click the Options button again to close the Options Screen and restore the Vector Map Window to its previous size.

On-Window Text

The Options Screen allows you to selectively display information about your flight. The information is displayed at the top of the Vector Map and is divided into 3 sections. The sections include the top-left, top-middle, and top-right of the Vector Map.

The date and time, air speed and true air speed, altitude and elevation are found in the top-left section of the Vector Map. The time is displayed in UTC (Coordinated Universal Time - Zulu). The air speed is the speed of the airplane without the effects of nature. The true air speed combines the speed of the airplane with the forces of nature (i.e. wind, gravity, etc.) acting on the airplane. The altitude is the height of the airplane relative to sea level. The elevation is the height of the airplane relative to the ground directly beneath it.

The distance of the view area is displayed in the middle section of the Vector Map. The distance is measured from the airplane to the left edge of the Vector Map followed by the distance of the airplane to the top edge of the Vector Map (i.e. 150 nm x 150 nm). For instance, zooming into the Vector Map increases the scale of the Vector Map which decreases the viewable distance.

The longitude and latitude of the airplane is displayed in the top-right section of the Vector Map.

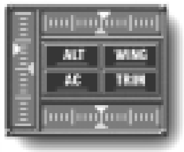
Vector Map Options

Click the Options button on the control bar to display to Vector Map Options Screen. The Options Screen allows you to configure the Vector Map to your taste. All option states are saved when modified. When you return to your Vector Map from session to session, it appears as you left it. The following describes each option found in the Vector Map Options Screen:

Airport:	Toggles the airport visual on and off.
Airport Name:	Toggles the airport name label on and off.
Airport Identifier:	Toggles the airport identifier label on and off.
VOR:	Toggles the VOR visual on and off.
VOR Name:	Toggles the VOR name label on and off.
VOR Identifier:	Toggles the VOR identifier label on and off.
VOR Frequency:	Toggles the VOR frequency label on and off.
NDB:	Toggles the NDB visual on and off.
NDB Name:	Toggles the NDB name on and off.
NDB Identifier:	Toggles the NDB identifier on and off.
NDB Frequency:	Toggles the NDB frequency on and off.

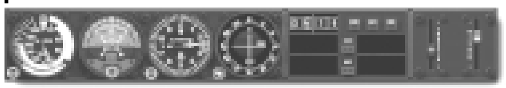
Text Labels:	Toggles the display of text labels on and off.
Compass Plate:	Toggles the display of compass plates on VOR navaids.
Cursor Info:	Toggles the display of information near the mouse cursor.
Cursor Distance:	Toggles the display of the distance from the airplane to the mouse cursor. The information is displayed near the mouse cursor.
Cursor Bearing To:	Toggles the display of the bearing from the airplane to the mouse cursor. The information is displayed near the mouse cursor.
Cursor Radial From:	Toggles the display of the radial from the airplane to the mouse cursor. The information is displayed near the mouse cursor.
Time:	Toggles the display of the time.
Date:	Toggles the display of the date.
Speed:	Toggles the display of the indicated and true air speed of the airplane.
Altitude:	Toggles the display of the altitude of the airplane.
View Distance:	Toggles the display of the visible distance.
Lat/Lon:	Toggles the display of the latitude/longitude of the airplane.
Graphics:	Toggles the display of the navaids to either colors or icons.
Cursor Distance Measurement:	Toggles the distance measurement used in all dist--ances displayed in the Vector Map. These distances include the cursor distance and visible distance of the Vector Map. The measurements are as follows: Feet (ft), Meter (m), Kilometer (km), Statute Mile (mi), Nautical Mile (nm).
Compass Plate Size:	The plus and minus buttons increase and decrease the size of the compass plate respectively. The maximum compass plate size is 5.0 nm. The minimum compass plate size is 1.0 nm.

Axis Window



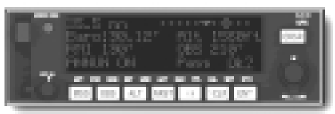
Brings up a visual representation of your axis readings and trim tab settings. This window will stay on screen even if you switch to another view. The window has three sets of indicators: the vertical bar represents your elevators, the top your ailerons, and bottom your rudder. White arrows show current position of control input (either keyboard or joystick) and orange arrows show current trim settings. The ALT button (on the Axis Window, not on your keyboard) activates Altitude Hold, an autopilot-like setting that maintains your current rate of Altitude change (not your current altitude). The WING button activates the Wing Leveler. AC activates the Auto Coordination (keeps aileron and rudder turns coordinated)—recommended for keyboard users. Finally, TRIM activates auto-trim for the aircraft. However, since this feature will attempt to auto-trim the plane in all circumstances, only turn on when necessary.

Mini Cockpit Window



Whether you want to have access to your controls even when using an external camera or you simply don't want a full instrument panel blocking your view, you can bring up this window. It contains six essential controls (Airspeed Indicator, Altitude Indicator, Attitude Indicator, CDI, Compass, NAV/COM Radio, Throttle Lever, Propeller Lever, and Mixture Lever) at the bottom of the screen. This window will stay on screen even if you switch to another view.

GPS Window



Brings up a full scale view of the Bendix/King KLN89 GPS radio (when applicable). This allows for easier direct input using the mouse, and also allows for GPS access when not using the cockpit view. You can optionally open this window by double clicking inside the faceplate of the GPS on the primary cockpit panel.

Help

This help menu links users with Internet connections directly to a variety of Web Sites which can assist you with troubleshooting and updating Fly! Windows users will also see the "About Fly" menu in this location. Look to these sites for assistance.

- Fly! Support Page
- Terminal Reality Inc. Home Page
- Gathering of Developers Home Page

Fly Now

Fly Now is primarily for novice pilots, allowing them to jump right into the aircraft without having to establish a flight plan, but it is also for the veteran who just wants a quick fix of flight. Whatever the reason, this is the fastest way to get yourself into the air.

Scenario

The scenarios in Fly Now are all predefined, meaning that your plane, weather and load considerations are already established. All you need to do is pick which scenario you desire and take off. Scan this list for the plane and location you wish to fly and click once to highlight it.

Category

The category pop-up menu is used to help classify scenarios for easy location. This feature is intended for third-party add-on product expansion. By default, leave the pop-up selected to "<All Scenarios>" or "FLY! Defaults" to view FLY! original scenarios.

Details

This button accesses a description of the scenario.

FLY

Transfers you to the cockpit of your plane to fly the selected scenario—be sure you have chosen the correct scenario before you press this button. Many of the scenarios that ship with Fly! begin with the plane in the air, but some start on the ground, requiring you to take off but allowing you to bypass the engine start-up procedures.

Flight Planner

The Flight Planner is the interface for more advanced pilots who want to define many of the aspects of their flying experience: route, plane, load, weather, etc. Beginning a flight this way requires substantial experience and knowledge (consult this manual liberally if you have any doubts), but many options can simply be left in their default position.

- **Departing From/Arriving At**

Click on these buttons to define your departure airport and time and arrival airport. Note that these dialog boxes are essentially the same with differences noted below.

Search For

Choose the type of facility you wish to search for. When accessing this dialog from the Flight Planner, only Airports can be searched.

Country

Select which country you would like to depart from. Making this choice will bring up a list of available airports in the Airport Detail chart below. Most of the world's countries are included on this list.

State

If you chose "United States" from the Country pop-up menu, you will next be able to choose your state of departure. This pop-up menu will be unavailable if you have chosen any other country.

Name

If you know the name of your desired airport, you can simply enter it in this text box. If no keystrokes are entered within a second, the search will automatically be executed.

FAA or ICAO ID

If you don't know the name of your chosen airport, but do know its FAA or ICAO identification code, you may enter that code here. If no keystrokes are entered within a second, the search will automatically be executed.

Favorites

This section allows you to save any search result for quick selection or airport lookup in the future.

Search Sets: Click on this pop-up menu to chose from all favorite sets you have already defined. When you chose an airport on the list, it will appear in the Airport Detail Chart below.

Add Set: This button adds an airport displayed in the Airport Detail Chart to your Favorites list.

Remove Set: This button removes the last selected set (shown in the popup-menu) from your Favorites list.

- **Airport Detail**

This chart displays the currently selected airport and many of its details.

Name: Name of the airport.

FAA or ICAO ID: Airport identification code.

Usage: Whether the airport is public or private.

Elev.: Elevation of the airport above or below sea level.

Country: Country in which the airport is located.

State: State in which the airport is located.

- **Runway**

This box lists the available runways at the selected airport. The line drawing to the right represents the runways and their configuration.

ID

Lists the identification number for each of the selected airport's runways. As you highlight a runway in this box, the line drawing to the right illuminates to indicate the runway you have chosen.

Size

Indicates the size of each runway in feet.

Details Button

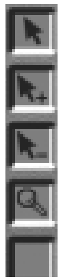
Calls up information on a selected airport including com frequency, name, location, elevation.

Departure Time

Specify your desired departure time here in Departing From dialog box. This time should be entered in Coordinated Universal Time (UTC), or Zulu time.

- **Pointers**

These tools located in a vertical stack along the left side of the screen allow you make changes to your flight plan within the map window.



Arrow A pointer for use within the map box. Used to select or view details of items on the map.

Arrow + This tool enables you to add elements to your route. Click on the navigational aids you would like to add to incorporate into your plan.

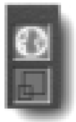
Arrow – This tool removes elements from flight plan. To use, click on the element you wish to remove.

Magnifying Glass Allows you to magnify an area of the map by clicking on it. To zoom out, Control+Click with the mouse. The behavior of this tool depends on whether you are looking at a vector display or a map: in map mode, zooming will select the next most detailed map (i.e. clicking on North America on the world map will jump to the map of North America). Note that the “next most detailed map” may not necessarily be a higher scale than the previous map, it may simply cover a smaller area. Use the Detail Map Overlay to see where maps intersect.

Map Icons

The two icons in the lower left corner of the screen indicates which maps you will see in the map window.

Map Overlay: Pressing this button toggles the topographical map on and off.



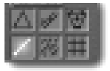
Detail Map Overlay: Pressing this button toggles a map overlay that indicates the location of detail maps. If an area is shaded in blue, there is a map available for that region.

Current Map: Indicates which map is currently open.

Detail Map: Pop-up menu to choose a different map.

Overlays

These map overlays provide useful navigational information by plotting various elements onto the map window. Click on each overlay button to toggle the switch on (illuminated) or off (shaded).



Latitude Longitude Guide: Overlays longitude and latitude lines on topographical maps only.

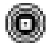
Weather: Displays temperature, wind speed, and wind direction. Only functions if METAR data has been imported from the Environment screen.

Route Chosen: Overlays your flight route.

Waypoints: Overlays all available waypoints as locations on the map. Represented as triangles.

Airports: Overlays all available airports as locations on the map. Represented as crossed runways or as FAA-defined representation of the runway layout.

Navaids: Overlays all available Navigation Aids (or “NAVAIDS”) as locations on the map. Navaids come in five varieties. The symbol in the left column represents the symbols as they are shown on standard aviation maps and the symbols in the right column are their interface equivalents. The latter are designed to be as similar as possible to their actual counterparts, but there are some small differences:

 NDB-Concentric circles

 NDB with DME-Circles with blue square center

 VOR-Hexagon with blue center

 VOR with DME-Hexagon with square center

 VOR with Vortac-Hexagon with bold edges

Detail Options

Allows you to filter out many of the details brought up by activating the overlays. The number of airports, navaids, etc. can be a bit overwhelming, so this feature can help clear up the clutter of the map view.

_____ Detail

This button changes depending on what kind of symbol is most recently clicked upon in the map window. Airports, Navaids, Waypoints, and flight segments can contain details of each specific item which are accessed via this button.

Edit Route

Pressing this button brings up a box listing all airports and waypoints on your route from point A to point B. From here you can select each point individually to change them as you deem fit.

Generate Route

Automatically generate routes by simply specifying the Departure and Arrival Airports. Using this tool, however, overrides any other flight plan information.

Setup Aircraft and Environment

Links to appropriate section (p.36 and 38).

FLY

Initiates the flight plan you have prepared and transports you to the cockpit of your plane to begin startup procedures. Be sure that all of your flight plan settings, including Environment and Setup Aircraft settings are established before pressing this button.

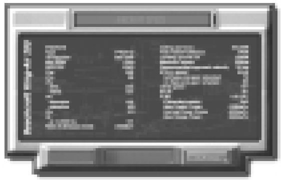
Setup Aircraft

To choose and configure an aircraft for flight, you must first select the aircraft you wish to fly and then access the aircraft fuel and weight options from this screen.

Types to Display

All aircraft shipped with Fly! are categorized by their engine configurations. This pop-up menu allows you to see all of the available planes ("All Aircraft") or only aircraft of a specific type (Single-Engine, Multi-Engine, Single-Engine Turbo-Prop, Multi-Engine Turbo-Prop, and Jet).

Details



Once you have selected an aircraft, its image appears in the right hand window. Click on the Details button to view selected performance information for the aircraft.

Load Out

Load Out is the weight load and distribution of all things carried by the aircraft including, for example, cargo, pilots, passengers, and fuel. All of these elements can be customized and placed by use of the two Load-Out screens: Fuel and Weight.

Fuel: Fuel Load Out allows you to specify the amount and placement of fuel in your aircraft.

Center of Gravity: These indicators display the balance of the aircraft both front-to-back ("Fore and Aft") and side-to-side ("Left and Right"). The placement of fuel and weight (see Weight Load Out below) impacts these readings. Ideally, you want to keep the aircraft balance within the green area of the indicator, as close to center as possible. If weight is not evenly distributed, it will impact the aircraft's flight stability. The dial shows red to indicate serious weight or balance problems.

Fuel Tank Icons: Each aircraft has a number of fuel tanks located around the plane, represented in this screen by ovals with a red fuel symbol. The level of fuel in the tank is indicated by the gold coloring that rises or drops as fuel level is changed.

Uniform Fill-On/Off: Activating this feature allows you to fill all tanks in the order they should be filled with one adjustment (on by default) and assures that any changes in fuel level will affect the weight distribution of the craft evenly. If, however, you wish to offset a weight imbalance due to cargo or passenger load, you may do so by turning Uniform Fill off and specifying different fuel levels to offset the weight. When you turn off Uniform Fill, individual fuel level sliders will appear below each tank allowing you to make adjustments independently.

Total Fuel Level: This slider allows you to fill all tanks when Uniform Fill (see above) is on. When Uniform Fill is off, you may not use this slider to fill the tanks, but it will rise and drop as you add fuel to the individual tanks to indicate changes to the aircraft's total fuel level.

Total Fuel/Max Fuel: Numerically indicates the total fuel loaded onto the aircraft and the maximum amount the plane can hold. Keep in mind that the amount of fuel you can carry is limited not only by these numbers, but by the total weight capacity of your aircraft - it is possible to exceed weight capacity while having less than maximum fuel loaded.

Setup Aircraft: Returns to Setup Aircraft (see above).

Load Out Weight: Links to Load Out Weight (see below).

Weight

Center of Gravity: These indicators display the balance of the aircraft both front-to-back ("Fore and Aft") and side-to-side ("Left and Right"). The placement of fuel and weight (see Fuel Load Out above) impacts these readings. Ideally, you want to keep the aircraft balance within the green area of the indicator, as close to center as possible. If weight is not evenly distributed, it will impact the aircraft's flight stability. The dial shows red to indicate serious weight or balance problems.

Pilot, Passenger, and Cargo Icons: You can distribute weight in your plane graphically by clicking on pilot seats, passenger seats, or cargo bays to add or remove occupants of those sections. For example, you can click on a chair to add a passenger. Watch the effect placing and removing objects has on the Center of Gravity indicator above and the Total Weight indicator below. Please note that although you may add and remove passengers from the plane, you will only see a single occupant in the 3D aircraft when flying the simulator.

Name, Type, Weight: These fields act as both an alternative way to insert people and cargo into your plane and as a means of modifying items already placed. To place a new object, choose its Name (i.e. Co-Pilot, Left Rear Passenger) and Type (Pilot, Passenger, Cargo or none) and specify its weight. To change an already placed object, select its position from the Name pop-up menu or highlight it by pointing at it and make any changes in these boxes. Most often, you will want to raise or lower the weight of objects to balance out the weight load. Keep in mind that the pilot (you) cannot be removed from the plane.

Total Weight/Max Weight: Numerically indicates the total weight currently loaded on your aircraft (including fuel) and the maximum weight your aircraft can carry. Note that you cannot exceed the maximum amount and that heavier loads will affect airplane performance. The dial shows red to indicate serious weight or balance problems

Setup Aircraft: Returns to Setup Aircraft (see above).

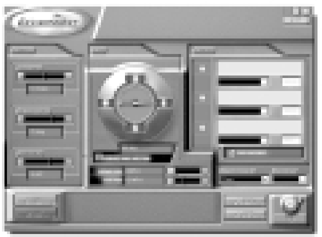
Load Out Fuel: Links to Load Out Fuel (see above).

Flight Planner: Links to Flight Planner (p. 32).

Environment: Links to Environment View (p.38).

FLY: Takes you to the cockpit of your plane. Be sure all settings in this section as well as Environment and Flight Planner are to your liking before embarking on your journey.

Environment



Ever wanted to control the weather? With the Environment interface, you can. Keep in mind that these settings will be established worldwide and will not change no matter how long or where you fly. For greater realism, however, you can allow Environmental settings to be established with real weather data by activating the METAR feature, described below.

Options

These sliders allow you to alter various weather attributes, each of which can dramatically impact on aircraft performance.

Visibility: Visibility is the distance the pilot can see from the cockpit - the higher the visibility, the farther the pilot can see. As visibility decreases, objects in the distance will be shrouded in haze if they are beyond your maximum visibility range. Visibility settings range from 0 to 20 miles. This setting can affect system performance but will have no effect on aircraft performance. Note that this setting is limited by the Maximum Visibility setting in the Graphics Options dialog (p. 11).

Temperature: External temperature can have profound effects on your airplane. Cold temperatures increase the chance of icing. Hot temperatures, on the other hand, render the air less dense and less able to support a plane in flight. Temperatures range from -50°F to 120°F.

Pressure: Indicates the outside barometric pressure at sea level. Pressure can impact the accuracy of altitude readings - if pressure is high, actual altitude will be lower than is shown on instruments. If, for example, you land at an airport that is at a different elevation than your airport of origin, you will have to adjust the Kollsman window on altimeter from the primary cockpit panel. This is particularly important in IFR (Instrument Flight Rules) flight. Pressure settings range from 28.0 Hg to 31.0 Hg.

Wind

Few things have more impact on flying than wind. Wind affects speed adjustments, fuel efficiency, and take off and landing directions. You can manually set the direction of the wind by clicking on any point within the compass.

Variable Wind Direction: Click in this box to randomize the direction of the wind for greater realism. Activating this feature overrides any settings made on the Wind Direction dial. The dial sets the predominant wind direction. Selecting variable winds allows the wind to “blow” from more than one direction but it still maintains the predominant direction.

Average Speed: Slider establishes the average wind speed in the simulation. Wind will change speed constantly, occasionally rising above or below this average, but this figure represents the general steady airspeed. Speeds range from 0 MPH to 50 MPH.

Gust Speed: You can set the peak level for wind gusts with this slider, establishing the maximum spikes for wind effect.

Clouds

You can set the cloud count at three layers of atmosphere with these text boxes and pop-up menus. Cloud layers can be set to your preference (in feet) and cloud density can range from Few to Scattered to Broken to Overcast. To activate these features, first click on the Sun icon to the left of each layer to activate clouds at that level. You may then set cloud density and altitude manually in the pop-up menu and text box respectively.

Show Backdrop

Activating this checkbox will introduce a photographic background of distant clouds and horizon into the simulation. This alone has no effect on weather conditions, but is simply a visual option to enhance the “out the window” view.

Precipitation

Use the Precipitation pop-up menu to select the type of precipitation you desire: Clear (or None), Rain, or Snow. Precipitation can obscure vision, alter airplane performance, and increase take off and landing hazards.

Intensity

Precipitation intensity can be defined using this pop-up menu and can be set to Light, Medium, or Heavy. The more intense the precipitation, the greater the impact on the simulation. As a note, to introduce Thunderstorms into the environment, set Rain as the precipitation type and Heavy as the intensity.

Import METAR

To create more realistic weather conditions, you can add real-world weather by importing weather reports based on the the National Weather Service “METAR” files. Each METAR file describes latest weather observations from one of thousands of reporting stations around the world.

When you fly within 140 miles of one of these stations, the weather will change to reflect the actual weather in that region and if you are within the range of more than one station, the weather will be interpolated from all nearby stations. If, finally, you fly out of range of any stations, the weather settings will revert to your manually defined Environmental settings.

Pressing the Import METAR button brings up a file box allowing you to choose which METAR files to import. Locate and open the METAR file you wish to import. Once you import a new METAR file, and previously imported METAR data will be lost.

METAR files can be obtained from a number of sources. A few come installed with your copy of Fly!. If you desire other files, they can also be obtained from various sites on the Internet including those of NOAA (the National Oceanographic and Aeronautics Administration) and many popular flight simulation Web sites.

Clear METAR

Clears METAR settings and reverts to your manually defined Environmental settings.

You may also link to **Setup Aircraft**, **Flight Planner** and **FLY**.

Keyboard Controls & Shortcuts

System Controls

Pause	P
Access Menu Bar	Space Bar
Toggle Full Screen Mode	Control + Enter
Exit to User Interface	Escape
Mute	Windows: Control + M
	MacOS: Command + M
Graphic Options Dialog	Control + F2
Sound Options Dialog	Control + F3
Control Options Dialog	Control + F4
Saving Screen Shots	Control + Tab
Displaying frame rate and status information	Tab

Cockpit Controls

Scrolling Cockpit Views

If you have Scroll with Mouse selected in Options - Cockpit, you may simply move the mouse pointer to the edges of the screen to scroll in the desired direction. Or you may use any of the following keyboard commands.

Scroll Cockpit Up	Shift + Up Arrow
Scroll Cockpit Down	Shift + Down Arrow
Scroll Cockpit Right	Shift + Right Arrow
Scroll Cockpit Left	Shift + Left Arrow
Head Pitch/Seat Adjust Down	]
Head Pitch/Seat Adjust Up	Shift +]
Home Cockpit	Shift + Home

Manipulating Cockpit Instruments

You can adjust any of the usable cockpit instruments with your mouse pointer. Note that Radios have special mouse interaction features (p. 44).

Buttons: Buttons are pressed by clicking on them.

Levers: Levers are pulled by grabbing them with a click-and-hold followed by movement in the direction of your choice.

Dials: Dials are turned to the left by Left-Clicking in Windows and Single-Clicking in MacOS and turned to the right by Right-Clicking in Windows and Control-Clicking in MacOS.

Pedals: Cannot be manipulated with mouse.

Popup Gauge Information: Point at any usable gauge on your control panel to get not only the identity of the gauge, but also the current reading for that gauge. Gauge labels will automatically appear after holding the mouse over the gauge for one second.

Airplane Controls

The following keyboard controls are used to pilot your aircraft in the simulation. Keep in mind that many of these controls can also be affected by input devices (i.e. Joysticks or Flight Yokes) or manual adjustment of cockpit controls (see Cockpit Controls, above).

Ailerons

Aileron Right . . . . Right Arrow
Aileron Left . . . . Left Arrow

Auto-Landing Feature

Land at the most suitable runway at nearest airport. Takes over all functions and performs landing with no input from the pilot.

Auto-Land . . . . Z
Auto-Land Abort . . . . Z + Shift

Brakes

Ground Brakes . . . . B
Parking Brakes . . . . Shift + B

Center Controls

Center Aileron & Rudder . . . . Num 5
Center Ailerons, Elevator, & Rudder. . . . . Shift + Num 5

Elevator

Elevator Up . . . . Down Arrow
Elevator Down . . . . Up Arrow
Elevator Trim Up . . . . Num 1
Elevator Trim Down. . . . . Num 7

Engines

Using this feature will automatically perform system and engine startup. If you have turned on “Accurate Engine Start” in Realism (p. 20), you will have to wait while the computer performs each of the startup steps in sequence. If not, the engine will start up instantly.

Easy Engine Start . . . . E

Flaps

Retract Flaps . . . . Shift + F
Extend Flaps . . . . F

Fuel

Mixture Down . . . . Control + Num 3
Mixture Up . . . . Control + Num 9

Gear

Up/Down . . . . G
Force Down . . . . Shift + G

Heat

Carburetor Heat On/Off . . . . H
Pitot Heat On/Off . . . . Shift + H

Miscellaneous Controls

IFR Hood On/Off . . . . Shift + I

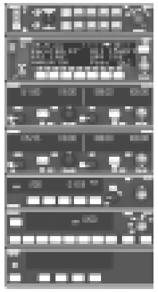
Only available in the cockpit view. Turns off all 3D drawing outside window. Essentially, allows for blind flying under IFR (Instrument Flight Rules) by pulling a blinding hood over the cockpit window.

Prop Pitch Decrease. Control + Num 1
Prop Pitch Increase . . . . Control + Num 7
Rudder Right . . . . Num . (period)
Rudder Left . . . . Num 0
Throttle Maximum . . . . Shift + Num 9
Throttle Minimum . . . . Shift + Num 3
Throttle Up . . . . Num 9
Throttle Down. . . . . Num 3

Simulation

Avionics Controls

Radios



A number of radios are available to assist you in navigation and communication, including ADF, COM, NAV, GPS, and transponder radios. For details on the operation of these devices, see Radio Flyer in the Flight Instruction section.

Tuning: As with all cockpit dials, you can point at the dials with your mouse pointer and turn them left and right with a Left-Click and Right-Click (Windows) or a Click and Control-Click (MacOS). You can also click directly on the LED numbers on the radio to tune them up and down.

Autopilot: Autopilot allows you to relinquish the controls to the tender mercies of your aircraft's automated piloting system. Engage this system by toggling it on (disengage with the same button). Once the system is engaged, you can instruct the Autopilot to maintain either your altitude rate-of-change, your heading, or both. Note that this is not a "real-world" autopilot (that system is covered in the Pilot's Manual) and is available on all planes, regardless of whether the actual plane is equipped with an autopilot.

Autopilot Toggle . . . . A
Autopilot Altitude Hold . . . . Control + A
Autopilot Heading Hold . . . . Shift + A

Lights

Navigation Lights, Strobe, and Beacon Lights. . . . . . Control + L
Landing and Taxi Lights . . . . Shift + L
Panel Lights L

Turns on and off the instrument panel lights in planes where illumination is not automatic. The default aircraft in Fly! all have full-time running instrument panel lights that do not have to be manually turned on (though primary aircraft power must be on). You cannot turn lights off in these aircraft, but you can adjust them through the various cockpit light controls available in the cockpit panels.

Simulation Controls

Cameras

Real-world pilots are only able to see from one vantage point, their seat. While the main point of this simulation is to put you in that position, you have even more power with Fly's alternate camera views. These cameras (including your cockpit view) offer almost infinite control over your viewing position. Experiment with these cameras and use them in conjunction with windows (see below) to find precisely the view and layout that pleases you.

General Camera Control

Cycle Thru Cameras (i.e., Cockpit, Spot, Fly By, etc.) C
Cockpit Toggle . . . . Shift + C

Moving the Camera

Some of the cameras can be moved and zoomed as you see fit.

Zoom Camera In . . . . Control + =
Zoom Camera In Fast . . . . Shift + =
Zoom Camera Out . . . . Control + -
Zoom Camera Out Fast . . . . Shift + -
Pan Camera Left . . . . Control + Left Arrow
Pan Camera Right. . . . . Control + Right Arrow
Pan Camera Up. . . . . Control + Up Arrow
Pan Camera Down . . . . Control + Down Arrow

Camera Hot Key Definition

If you are particularly fond of a certain camera angle, you can save it to a hot key for instant access. Simply establish the camera position you want and define the position by pressing Shift and any of F1 through F8. You can then press only the recall key (F1 through F8) to instantly jump to that position.

Define Camera 1. . . . . Shift + F1
Define Camera 2. . . . . Shift + F2
Define Camera 3. . . . . Shift + F3
Define Camera 4. . . . . Shift + F4
Define Camera 5. . . . . Shift + F5
Define Camera 6. . . . . Shift + F6
Define Camera 7. . . . . Shift + F7
Define Camera 8. . . . . Shift + F8

Recall Hot Key

Activate Defined Camera 1. . . . . F1
Activate Defined Camera 2. . . . . F2
Activate Defined Camera 3. . . . . F3
Activate Defined Camera 4. . . . . F4
Activate Defined Camera 5. . . . . F5
Activate Defined Camera 6. . . . . F6
Activate Defined Camera 7. . . . . F7
Activate Defined Camera 8. . . . . F8

Window Controls

This collection of mini-windows is among your most useful tools. Use them in conjunction with any of the simulation's cameras to get the complete picture of your plane and the world around you. Note that these windows can be resized and persist in both size and position even between sessions.

> **Basic Operation**: Generally, windows operate like any other window in your operating system. Open with the keystrokes listed below, move around by grabbing the top or title bar of the window, and close with either a click to the appropriate corner or a key combination.

Secondary Camera View. . . . . W
Map View . . . . M
Vector Window . . . . Shift + M
Axis Window. X
Mini Cockpit Window. . . . . Shift + X
GPS Window . . . . N

Air Traffic Control

In the real world, Air Traffic Control (ATC) is available (and sometimes mandatory) to pilots when flying in and around major air traffic areas, and when outside weather conditions prevent flying by visual reference (Visual Flight Rules, or 'VFR' flight). ATC assumes many responsibilities, the most important is to maintain a safe level of separation between a plane and any surrounding planes or terrain. When flying in Instrument Flight Rule ('IFR') conditions where visibility may be restricted, it is mandatory that the pilot be in constant communication with ATC.

Fly! offers you the ability to participate with ATC as you choose. This is considered an advanced feature, and may be skipped by beginning pilots if desired. Fly! supports the primary centers of control for ATC: Clearance Delivery, Ground Control, Tower, Departure Control, Arrival Control, and Center. Each of these centers is responsible for a specific area of control for aircraft operations. In addition to establishing and maintaining communications with ATC throughout your flight, you may also hear other computer controlled planes as they interact with ATC. This can occur at any time if a computer aircraft is using an ATC service on the same radio frequency as you.

ATC services are not available at all airports. In some cases, you may only have a subset of the ATC services available. In these cases, it is normal for smaller airports to offer multiple ATC services through the same controller. For example, some airports may have a dedicated frequency and controller for Clearance Delivery, and one for Ground Control. Another airport may have a single frequency that covers Clearance, Ground, and Tower. Regardless of this, Fly! will allow you to choose the "service" you want, even if these are tied to the same frequency. If an airport only offers Unicom (which only provides basic airport information), then you will not see any ATC services listed for the airport, and IFR approaches and departures will not be possible from the airport.

You may activate ATC at any time, regardless of whether you created a flight plan or if you started the simulation from the Fly Now view. To communicate with ATC, press the ATC key (`). You will be prompted with a list of ATC services to communicate with. If your COM radio is already tuned to a valid ATC service, Fly! will bypass this selection window and proceed to your request.

Once you select the ATC service to communicate with, a window will appear with the available requests or responses you can make to ATC. If your COM radio was not already tuned to the ATC service, it will be auto-tuned for you. Press the ‘1’ through ‘0’ key to select the request or response you wish to make. The ATC system will react as appropriate, and will give you verbal instructions on how to proceed.

All ATC communications are echoed to a scrolling text display at the top of your screen. If you have multiple radios tuned to multiple services, you will see a separate text display for each ATC communication you receive. You can turn off the audio portion of ATC communications through the Sound options dialog (see p. 12)

Remember that your radio is your “life-line” to ATC. If you tune your radio away from ATC, or turn off the COM radio audio through the audio panel of the aircraft, you will be blissfully unaware of any demands ATC is making of you. In real life, this could result in serious fines or suspension of your license! Fortunately in Fly! you can choose to ignore ATC if you wish – just remember that there are other planes in the air that are assuming you will follow ATC’s instructions.

The normal “steps” of participating with ATC are as follows:

Tune your COM radio to the ATIS frequency for the airport you are departing. The ATIS frequency is shown on the sectional map, and can also be obtained by double-clicking the airport in the Vector Map window or by using the “Range Finder” feature (see p. 52). ATIS is an automated weather observation system, and you will be required to have this information before contacting Clearance Delivery.

Contact Clearance Delivery. If you created a flight plan in the Flight Planner, you will open your flight plan with Clearance Delivery at this time. Clearance Delivery will also verify that you have the latest ATIS information.

Contact Ground Control to receive permission to taxi, as well as directions to the active runway.

Once you reach the active runway for take-off, you will transition to Tower to receive permission to enter the active runway and take off. Once you have taken off, Tower will pass you to Departure Control to vector out of the airport’s airspace safely.

Once out of the airport airspace, Departure Control will have you contact Center to track and assist your flight enroute. If you are travelling across large geographic distances, you may be asked to tune to other Center controllers along the way. Once you near your final destination, Center will hand you off to Approach Control to begin your final descent and entry into the arrival airport’s airspace.

Approach Control will give you “vectors” for your final approach, which are a series of heading changes to safely route you into the traffic pattern and prepare you for landing. Once the active runway is clear, and you are the next aircraft in line to land, Approach Control will pass you to Tower for final clearance to land.

Once Tower is contacted, you will be given final clearance and can make your approach. Once you land, you should clear the active runway as soon as safely possible.

Once you are safely on the ground and at a full stop, you will contact Ground Control to help guide you back to the terminal area of the airport. Once you have reached your destination and have engines off, you can contact Clearance Delivery to close your flight plan.

ATC On/Off Toggle	Shift + `
ATC Menu	`
ATC Response #1	1
ATC Response #2	2
ATC Response #3	3
ATC Response #4	4
ATC Response #5	5
ATC Response #6	6
ATC Response #7	7
ATC Response #8	8
ATC Response #9	9
ATC Response #10	0

Slew Controls

Slew Mode allows you to suspend the simulation and manually place the aircraft anywhere and in any position you like. To activate Slew Mode, press **S**. Once in Slew Mode, the keys listed below will control the position of the aircraft. Movement in Slew Mode is continuous and cumulative, meaning that the longer you hold a Slew directional key, the faster your craft will move. When you reach the position you want, press Slew Stop to freeze.

Slew Mode . . . . S
Slew Stop . . . . Num 5
Slew Up . . . . Q
Slew Down . . . . A
Slew Left . . . . Left Arrow
Slew Right . . . . Right Arrow
Slew Backward . . . . Down Arrow
Slew Forward . . . . Up Arrow
Pitch Up . . . . Insert
Pitch Down . . . . Delete
Bank Left . . . . Home
Bank Right . . . . PgUp
Rotate Left . . . . End
Rotate Right . . . . PgDn

Changing Time of Day

You may freely change the time of day in Fly! while in-flight. Using these keys adjust the time forward or backward by 30 minutes at a time. Note that this does not affect the simulation – your plane will move at its current speed and continue to fly as expected. Fly! accurately computes the position of the sun, moon (including moon phases) and stars based on the exact month, day, year, and time you have selected and your location on the Earth. Changing time of day will also affect the position and perspective of any ground shadows being cast by aircraft or ground structures.

Time Forward . . . . T
Time Backward . . . . Shift + T

Distance Compression

You can shorten long flights by activating the Distance Compression feature. When this feature is armed, it effectively shrinks the ground distance between where you are and where you want to go allowing you to cover more ground in the same amount of time. Here's what distance compression does not do: it does not speed up time, it does not change the control of your plane or the physics acting upon it. Effectively, it shrinks the world.

Each increase in Distance Compression halves the normal distance. This continues exponentially up to a factor of 1/64th. Distance can not be expanded beyond a 1:1 ratio.

Increase Distance Compression . . . . D
Decrease Distance Compression . . . . Shift + D

Instant Replay

Any time you wish to review your most recent actions in flight, bring up the Instant Replay tool. Doing so will pause the simulation and open a window containing a strip of buttons like the controls on a VCR. You can Play, Rewind, Fast Forward, or Reverse Play through the last few minutes of flight (based on your frame rate and available memory).

If you press the Play or Reverse Play buttons repeatedly, the rate of play is doubled (up to 8x) each time you press the button. You can slow the replay back to normal speed by pressing stop and hitting play once.

A NOTE and a WARNING: Instant Replay is not only a VCR, it's a time machine. When you go back in time through its recording of your flight, you are actually transporting the simulation back to that point in time (though any on-screen time display will not change). In other words, were you to run the instant replay back one minute and then deactivate instant replay, you would regain control of your aircraft at that point. This can be useful to re-attempt a failed or missed approach. If you wish to resume your flight from where you were, be sure to fast forward to the latest end of Instant Replay and then exit.

Exiting the Instant Replay window resets the replay buffer and begins a new recording.

Activate Instant Replay I

Range Finder Feature

While in any camera mode, you can use the Range Finder Feature to identify important structures and landmarks within your field of view.

Once you activate the Range finder, you may point at any object you see on the ground, the sky, or in the air and you will see a label identifying the object and calculating the distance to it.

You can point to almost anything with this tool. Pointing at a building or structure will display the height of the structure, your current clearance over the structure (to make sure you can clear it from a distance), and the range to the structure. Pointing at an airport or VOR will show you their name and range. You can double-click on an airport to receive an Airport Information window, which displays runway, localizer, and ATC frequency information. You can double-click on a VOR to receive information about its operating range and frequency. If you are feeling really adventurous, you can find the range to the sun and the moon, or the catalog names of stars in the sky!

Activate Range Finder . . . . /

Web Sites of Interest

http://www.iflytri.com

http://www.terminalreality.com

http://www.godgames.com

Airplane Manufacturers

Cessna C172R:

http://www.cessna.textron.com/

Piper Malibu Mirage and Navajo:

http://www.newpiper.com/

Raytheon Beech Super King Air B200 and Hawker 800XP:

http://www.raytheon.com/rac/

Flight Instruction

To Dianne - I'm really married to you, not this manual.

Author Bio

Peter Lert started flying in sailplanes while a high school student in Switzerland. In the subsequent 35 years, he's amassed some 15,000 flight hours as well as obtaining Airline Transport Pilot and Certified Flight Instructor licenses for aircraft ranging from balloons to jets.

He has worked as an experimental test pilot, aviation journalist, and was Senior Scriptwriter for the Interactive Systems Division of FlightSafety International, the world's largest private provider of full-scale flight simulator training. At present, he lives in the mountains of southwest Colorado and is chief pilot of two multi-engine flight operations (one corporate, one charter).

INTRODUCTION

Welcome to the start of what we're sure will be an exciting, entertaining, and instructive experience. FLY! has been designed to replicate the sights and sounds of flying some of general aviation's best-known aircraft with unparalleled realism. It goes much farther than that, however. The handling and aerodynamic responses of all the airplanes available have been mathematically duplicated, or "modeled," with a level of accuracy that approaches (and, in many cases, surpasses) that of full-scale airline and military flight simulation systems. Extremely detailed terrain rendering, based on actual satellite imagery and topographic data, makes the outside view as realistic as possible, while the combination of photorealistic instrument panels and actual working panel controls (i.e., you can simply "grab" the appropriate switch or knob with your mouse) completes the picture and puts you right in the pilot's seat. (After all - how many real airplanes are controlled from keyboards?)

Want even more realism? FLY! has a very sophisticated weather "engine" to provide weather effects from innocuous fair-weather clouds to blinding fog, or the firehose rain of a thunderstorm.

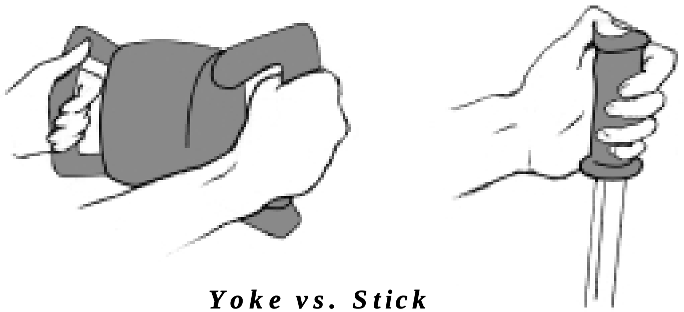
Those features, though, aren't what we'll address in this manual. With an interface as realistic as FLY!'s, you don't need "yet another computer manual" (and, for those of you who want to learn about keyboard shortcuts and other "simulator only" features, ~~those total nerds~~ my esteemed colleagues over at the computer side of the house have provided an excellent one). Instead, what you're holding is almost entirely a flight manual, written as though I were actually instructing you in the airplane (as I do in real life). In fact, I'll make almost no mention of keyboard or even mouse commands unless absolutely necessary; since operation of the program is so simple and instinctive, I'll just say something like "use the prop control to increase the RPM" or "tune the nav radio to 118.5 mHz," with the assumption that you'll simply reach out and do it.

This means that it's very worthwhile for you to take a look through the Simulation Interface (see page 4) now to make sure you're up to speed on the basic techniques. They're all simple and self-consistent: you use the same moves to "grab" and operate any switch, knob, or handle on the panel, regardless of its function (or, for that matter, in which airplane it's installed). Again, this is merely realism - in the real airplane, your hand would work the same way all the time.

A MATTER OF CONTROL:

FLY! supports just about any input device currently available, including both conventional and force-feedback joysticks. That being said, however, I'd personally suggest that you'll get the most out of FLY! if you use a control yoke: all five of the airplanes modeled in this release have yokes, rather than sticks, in their actual cockpits. Similarly, for single-engine airplanes, a simple throttle (or the one provided on most yokes) will suffice; those fancy multi-function ones, studded with so many buttons and switches they look like a chunk sawed out of a bassoon, are more suited to military flight simulations, and have no counterpart in civil aircraft at this time. (For multi-engine airplanes you'll most likely be grabbing the screen throttles with your mouse.) Rudder pedals are an excellent idea, particularly if you're planning serious engine-failure work in the multiengine birds.

Flight Instruction



Yoke vs. Stick

TAKING IT IN SEQUENCE:

We've laid this flight manual out in a logical sequence to fit the needs of just about anyone, whether you're a first-time novice or an experienced pilot (of either flight simulation programs or actual airplanes). If you're starting from scratch, you'll find your enjoyment of the program greatly enhanced if you take the time to read the chapters on fundamentals of flight and cockpit basics - it'll make your subsequent flights much easier. If you have any experience, either real-world or simulated in any of the planes presented, by all means jump right in. Indeed, there's no reason you shouldn't try your hand at, say, the Hawker 800XP jet, even if all you've ever flown has been a single-engine trainer - just don't expect to do any better than you would in a similar real-life situation! Sure, you may survive and even have fun - but you'll be using FLY! more as a game than as the extremely sophisticated flight simulation system it really is. (Of course, all of us like to just play sometimes…and there's nothing wrong with that.)

The airplanes we've chosen are presented in the same progression you'd encounter if you were actually learning to fly and starting a career that could culminate in the airlines or at the pinnacle of corporate aviation. We'll start out with a basic light single, the Cessna 172R Skyhawk - the airplane, in fact, in which tens of thousands of Americans have earned their Private Pilot license. From there, we'll move on to the Piper Malibu Mirage, a heavy single (or what the FAA calls a "complex high-performance aircraft"). With its pressurized cabin, turbocharged engine, and advanced avionics, the Mirage is one of the most sophisticated piston-powered single-engine airplanes ever manufactured. If the Skyhawk is "the Plymouth of general aviation," the Mirage is its Lexus or Mercedes Benz.

From there, we'll move on into the fascinating world of multiengine airplanes. We'll start with a medium piston-powered twin, the Piper Navajo Chieftain. For years a mainstay of both corporate and, in particular, commuter flying, the old "NavaHog" is the airplane on which many of the current generation of airline pilots got their "heavy iron" start. Next will come the classic Beech Super King Air 200 - the epitome of the corporate turboprop, and one that remains not only in production, but in service in both executive and commuter versions worldwide.

Finally, we'll come to a classic midsize business jet: the Raytheon Hawker 800XP. Based on one of the earliest business jet designs, this enduring classic has developed to a luxurious modern corporate cruiser with transcontinental (or even transoceanic) capabilities and a thoroughly up-to-date suite of avionics, including the latest electronic cockpit displays. It's in this aircraft that you'll be introduced to the special worlds of swept-wing aerodynamics and high-speed, high-altitude flight.

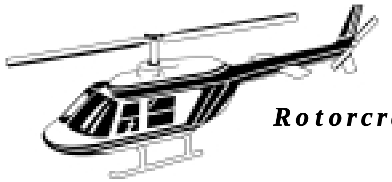
Here, then, is FLY! We're sure it'll provide you with hours of far more than just entertainment…and now, if you'll grab your flight cases and move into the classroom at the back of the hangar, we'll begin our preflight briefing…

Hawker 800XP

Flight Instruction

FUNDAMENTALS OF AERODYNAMICS

There are a number of different ways to go about learning to fly. One - we might call it “the old school”—is to just sit down in an airplane with an instructor and start flying. Another, however, can make the whole experience much more rewarding: learning a little, before you start flying, about what’s really going on, what really makes your aircraft fly and behave the way it does. That’s the way I try to start out my real-life flying students; and that’s what we’re going to do here.



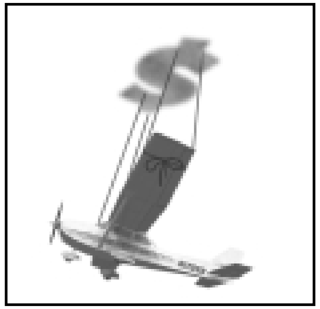
Rotorcraft

THE WING’S THE THING

All five of the aircraft presented in this release of FLY! have something in common: they’re all fixed-wing airplanes. By this, I don’t mean that they’ve been broken and repaired, but rather that their wings stay decently in one place, rather than the unseemly flailing about we see in rotorcraft. We could say that the wing is really the most important part of any airplane; all the other bits, like powerplants and control surfaces, are really there to aid the wing in fulfilling its purpose: providing lift.

What’s lift? It’s simply the force generated by the wing as it deflects the air through which it’s moving.

THE BALANCE OF FORCES

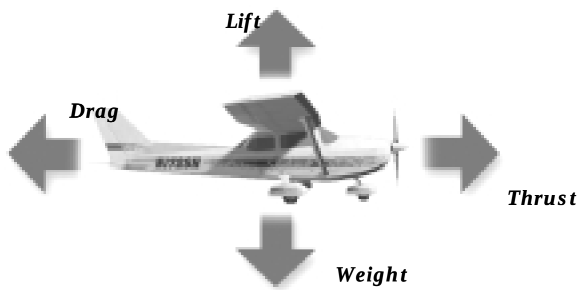


Force of Money

Most aeronautics texts teach that there are four forces that act on an airplane in flight, and that they show up in two opposing pairs. One pair is weight, which is pretty obvious, and lift, the force exerted by the wings in holding the airplane up in the air (you’ll find out in a moment that lift does a lot more than that). The other pair is thrust, the force that pulls or pushes the airplane forward through the air, and which is usually provided by some kind of engine (but not always - look at gliders!), and drag, the opposing force that tries to hold it back. (Actually, all aircraft are supported by a fifth force, invisible but all-pervasive, called money - and that’s the reason we need flight simulators like FLY!)

As long as we’re flying along straight and level, and at a constant speed, all four of these forces are in balance. The weight of the airplane is exactly counteracted by the lift of the wing, so it goes neither up nor down. Its drag, caused partly by the wing’s efforts to keep everything aloft and partly by the effort needed to push the whole airplane forward through the air, is exactly counteracted by the thrust of the powerplant, so it neither speeds up nor slows down. As soon as we try anything even the slightest bit fancy, though - say, a turn, climb, or descent, or, worse yet, some combination of these - things start getting a bit more complex.

The Four Forces



Flight Instruction

LIFT IS WHERE YOU ~~FIND~~ POINT IT:

The lift a wing produces is, for all practical purposes, at right angles to its surface. Bank the airplane into a turn, for example, and the lift banks with it; instead of lifting straight up, the wing is now also pulling the airplane toward the inside of the turn. (In fact, that's what makes the airplane turn in the first place.) Of course, this also means that there's less lift available to counteract the pull of gravity, so unless we take appropriate measures, the airplane will tend to sink a bit when it's turning.

IT'S ALL IN THE ANGLES:

To deal with this, as well as with many other situations in flight, we have to control the amount of lift the wing produces. In a turn, for example, we have to increase the amount of lift so there's enough available both to hold the airplane up and to pull it into the turn. To do this, we'll increase something called angle of attack, and this is a concept important enough to merit a few paragraphs in its own right.

Normal Lift

The amount of lift produced by any wing is dependent on two major factors: the speed at which it moves through the air, and the angle between the airflow and the wing's chord line, an imaginary line between the centers of its leading and trailing edges. We've probably all performed (and been yelled at for) the classic basic experiment of aerodynamics: sticking our hands out of the window of a moving car. Tilt the front of your hand up (increasing the angle of attack), and your arm rises; tilt it down, and it sinks. This can occupy simple minds for many miles.

Increasing Angle of Attack

Chord Line runs thru center of wing

What may have been a bit less obvious was that it took a lot more tilt to hold the weight of your arm at lower speeds than at high ones. Indeed, once the speed got low enough - usually right before you got dropped off at school - no amount of tilting would be sufficient, and your arm would drop painfully onto the doorframe. You'd reached the stalling speed of your wing - er, arm. We'll discuss stalls in considerably more detail when we start flying the Cessna 172.

Stalling

A MATTER OF CONTROL:

The lift produced by an airplane's wing does a lot more than just hold it up in the air. A car is steered by the side forces generated by its tires against the pavement. The airplane, though, has nothing to push against but air, and nothing to push with but its wing. To get the airplane to move in the direction you want - and that includes up and down as well as to the side in turns - you have to direct the wing's lift in the desired direction and/or change its amount. This is where the flight controls come in.

You may be using a joystick or a yoke with FLY!, and you may or may not have rudder pedals, but the basic principle of all these controls is the same: you're going to use them to point the airplane in the desired direction, then use the lift forces generated by the wing to actually determine where you go. As long as the air isn't too bumpy, just about any airplane will fly along quite nicely, continuing in whatever direction it's pointed without much attention required from the pilot, as long as all the controls are centered. (A well-aligned car on a straight road is in a similar situation.) Where the difference between airplanes and cars becomes clear, however, is how the controls are used when you want to make a change.

If you want to turn a car - say, to follow a curve in the road - you'd turn the steering wheel until the car was turning at the rate you wanted, then hold it in that position until you'd completed the turn. In the airplane, it's quite different. To start a turn, you'll move your yoke or joystick to start banking in the desired direction - but as long as you hold the controls in that direction, the airplane will continue to increase its bank angle, steeper and steeper. (In fact, if you held the controls into a turn long enough, the airplane would perform a complete roll, something not recommended in any of the five real-world airplanes currently simulated in FLY!).

Instead, move your controls only until you've reached the desired bank angle, then return them to the center. The airplane will tend to hold that bank angle and continue around the turn, pretty much on its own. When you want to roll out to level flight, you'll actually have to move the controls the other way until the wings are level once again. Similarly, if you want to climb, pull the stick or yoke back gently until the nose rises to the angle you want; then return it to, or near, the center to hold that position. To level off from a climb, ease the controls gently forward until the nose is back down where you want it, then re-center them once again.

WHAT DO THE CONTROLS DO?

All fixed-wing airplanes have three primary flight controls: ailerons, elevator, and rudder.

The ailerons are what make the airplane bank left and right. They're small flaps hinged to the rear of the wing, near the tips (in fact, their name means "little wings" in French), and they work in opposition: when one goes up, the other goes down. They're connected to the cockpit controls so that they're operated by sideways (left-right) movement of the stick or yoke.

The elevator is the movable portion of the horizontal tail, and its name is something of a misnomer: although it indirectly can affect the altitude at which an airplane flies, what it controls directly (and very effectively) is nothing more than our old friend angle of attack. It's operated by forward-backward movement of the stick or yoke: pull the control back toward you, and angle of attack increases; push it away, and angle of attack decreases.

Note that I purposely haven't said "the nose goes up," "the airplane gets slower," or anything similar, since that depends entirely on the initial position, or attitude, of the airplane. For example, in the unlikely event of your being upside down, pulling the controls would bring the nose down toward the ground while increasing the airspeed alarmingly. A considerably more common situation would be a steeply-banked turn; pulling the stick or yoke would tighten the turn, but wouldn't have much direct effect on your altitude or speed (at least at first).

Finally, the rudder is the movable portion of the vertical tail. A common misconception is that this is what turns the airplane. In fact, it's the lift from the banked wing that makes the turn; the function of the rudder is mainly to ensure that the airplane is pointed the same way it's going, rather like the feathers on an arrow. In an actual airplane, it's controlled by the foot pedals. Don't worry too much if you don't have a set of rudder pedals for FLY!; the program can be configured to handle rudder chores automatically. In fast, high-performance airplanes, the rudder isn't as important as in slower ones. Most jets, such as the Hawker 800XP in FLY!, are flown "feet on the floor" except during takeoff, landing, or engine failures.

ADVANCED AERONAUTICS: A CLOSER LOOK AT LIFT

In the main part of this chapter, we've explained that lift not only supports, but also steers, an airplane. A little more detail about how lift is produced (and what happens if and when that production quits!) can be very valuable - and it'll increase your understanding of all the airplanes simulated in FLY!

IT'S ALL IN THE CURVES:

We've already learned that to hold the airplane up, the wing has to push down against the air with an equal force...but if we look closely, it's not really "pushing." In fact, that's the error made by the first would-be flyers, who tried to use simple flat surfaces - boards!—as wings. It wasn't until pioneers like Lilienthal and the Wright brothers examined the wings of birds that they realized that the secret was in their curved shapes. Actually, Leonardo da Vinci had figured that one out four hundred years earlier...but he was a theorist rather than an experimenter.

It wasn't long after da Vinci that another European, Daniel Bernoulli, discovered that the faster a fluid moves (whether it's air or water), the lower its pressure will be. Here's a simple experiment: take a sheet of typing paper and hold it, by its two top corners, just below your mouth. Now blow gently over the top of the paper. You'll notice that it floats up to the horizontal, even though you're blowing across the top rather than underneath it. Why? Because the fast-moving air over the top of the paper is at low pressure compared to the air underneath.

A wing works the same way: it's not so much "pushing" down the air below it as it's "pulling" on the air above its upper surface. This is why its curved surface is so important. The distance from the front of the wing to the rear (from its leading edge to its trailing edge) is longer around the curved top than along the relatively straight bottom. Air flowing around the wing has to speed up over the top, thus creating lower pressure and generating lift.

There's another reason the curve is important as well. Look at these two pictures. The first (fig. 1) shows a flat surface angled to the air, as tried by the first (unsuccessful) experimenters. You'll see that it produces a very limited amount of lift from the "push" on its bottom surface...but the airflow over the top "trips," or separates, as soon as it gets past the sharp leading edge, and rather than speeding up over the top it just swirls in useless turbulence. Not only does it not create any lift, it also causes a great deal of drag.

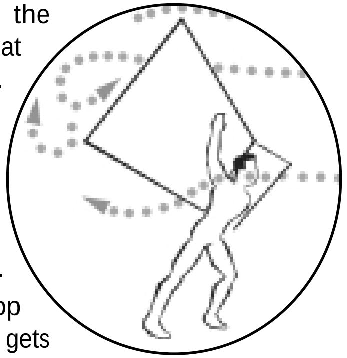


Figure 1

In the second picture (fig. 2), we're looking at a cross-section of a typical wing, or airfoil. Because of its curved surface, the air can flow smoothly over the top surface. This is where most of the lift is produced. Notice, too, that we've drawn a line from the center of the leading edge to the trailing edge. Aeronautical engineers call this the chord line of the wing...and what's important about it is that any aerodynamic force the wing produces will always act exactly at right angles to the chord line. This means that if the wing is tilted up (as it is even in level flight, if only by a small amount), its lift points very slightly backward. If it weren't for the thrust of the engine, the airplane would slow down (fig. 3).

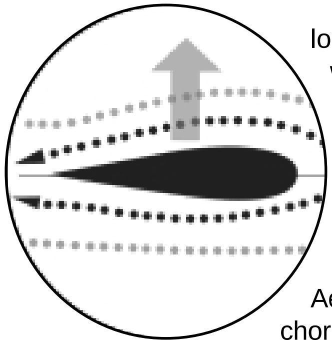


Figure 2

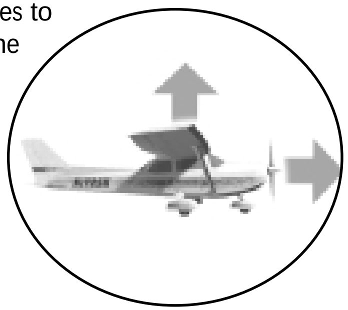


Figure 3

On the other hand, if it's pointed even slightly downward, as it would be during a descent, its aero force points slightly forward, pulling the airplane along (fig. 4). This is how gliders (sailplanes) can keep moving, even though they don't have engines: they're always descending through the air. How do they stay up all day? By finding areas where the air is rising faster than the glider descends... just like when you used to get yelled at for playing on the escalators at the mall.

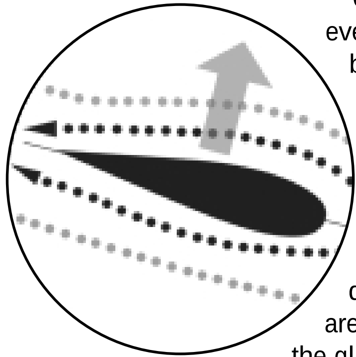


Figure 4

The amount of lift a wing can produce depends on four things. One is more or less constant: the design of the wing and its airfoil. Generally, a thick, highly curved wing produces lots of lift at low speeds, making it ideal for slow, light aircraft. A thin wing produces less lift, but is more efficient at high speeds; you'll find it on jets. (How do jets manage to take off and land at reasonably low speeds? By changing the shape of their wings with various flaps, slats, and similar movable bits and pieces.)

WHAT'S YOUR ANGLE?

Two more variables can change the amount of lift a wing produces: the speed at which the wing is moving through the air, and its angle of attack - the angle between the wing's chord line and the oncoming air (also called the relative wind). At high speed, it only takes a little angle of attack to generate enough lift to support the airplane. The slower we fly, the more angle of attack is necessary to generate the same amount of lift. Next time you're near an airport, watch the airliners coming in. Even though they're descending as they near the runway, they're flying along slightly nose-high - at their low approach speeds, it takes a lot of angle of attack to provide enough lift. As they descend the last few feet, their noses rise even more. This maneuver is called the landing flare. The pilot is trying to make the touchdown as soft as possible. As speed bleeds off over the runway, it takes even more angle of attack to reduce the rate of descent and avoid one of those "take that, La Guardia" arrivals.

TOO MUCH OF A GOOD THING:

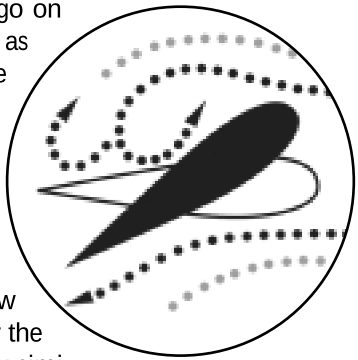


Figure 5

Unfortunately, we can't just go on increasing angle of attack forever as speed bleeds off to zero; if we could, we'd have no need for helicopters. Instead, once the angle of attach reaches a certain point (called critical angle of attack), the air can no longer make the curve around the leading edge and over the top of the wing. Instead, the flow separates, becoming turbulent over the top of the wing (fig. 5). Notice how similar this is to the flat plate in figure 1? That's right: when this happens, most of the lift disappears, and the wing is stalled. At this point the wing has, for all practical purposes, "quit flying;" gravity reasserts itself, and the airplane begins to drop.

Sounds serious, doesn't it? It is, of course...but hardly fatal. All that's necessary to recover from the stall is to reduce the angle of attack below the critical level by easing forward on the controls. The airflow promptly reattaches itself, and the wing resumes its job of producing lift. You'll practice stalls, and stall recoveries, in all the airplanes in FLY! A stall isn't even a particularly dangerous or unusual situation. Until the last years of World War II, almost all airplanes were "taildraggers," with two large main landing gear and a small caster under the tail. These airplanes sit on the ground right at the critical angle of attack, and thus have to be fully stalled for a "three point" landing. In fact, a perfect landing in a taildragger is actually a complete stall followed by an uncontrolled crash...from an altitude of, say, half an inch!

Axes of Movement in an Airplane

Roll *Pitch* *Yaw*

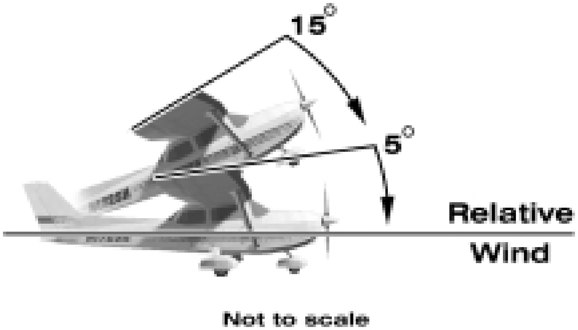
IT'S *ALL* IN THE ANGLE:

There are two vital things to remember about stalls:

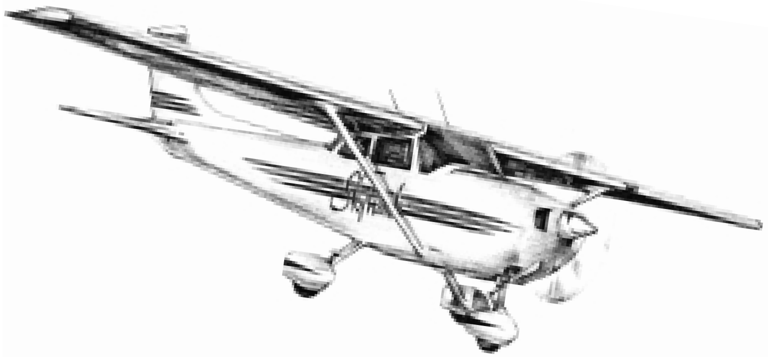
The most important one is that, while we may often talk about an airplane's "stalling speed," that can be misleading. Whether or not a wing will stall depends only on its angle of attack - and the stall can and will occur at any speed if the critical angle of attack is exceeded. Wrap an airplane up into a steep turn, so that centrifugal force adds to its apparent weight, and you'll have to increase the angle of attack to compensate. At some point, you'll have pulled all the way to the critical angle of attack, and the wing will stall even though you're flying well above the published stall speed. Don't worry - these high-speed, or accelerated, stalls are no more fearsome than the regular kind, and we'll practice them together.

The "stall speed" published in an airplane's specs only applies to a stall entered gently from straight and level flight. Most airplane handbooks include a table that shows vividly how the stall speed goes up at increasing angles of bank.

The other thing to remember is that, in aviation, the word "stall" means only one thing: the condition in which the airflow over the wing has separated, and lift has been impaired. It has nothing to do with the engine quitting (nor, for that matter, with the small enclosures used to confine farm animals). After all, even gliders can stall with no engines at all!



Angles of Attack



Cessna's Skyhawk
"The Plymouth of the Skies"

Cessna 172R – Introduction and Tour

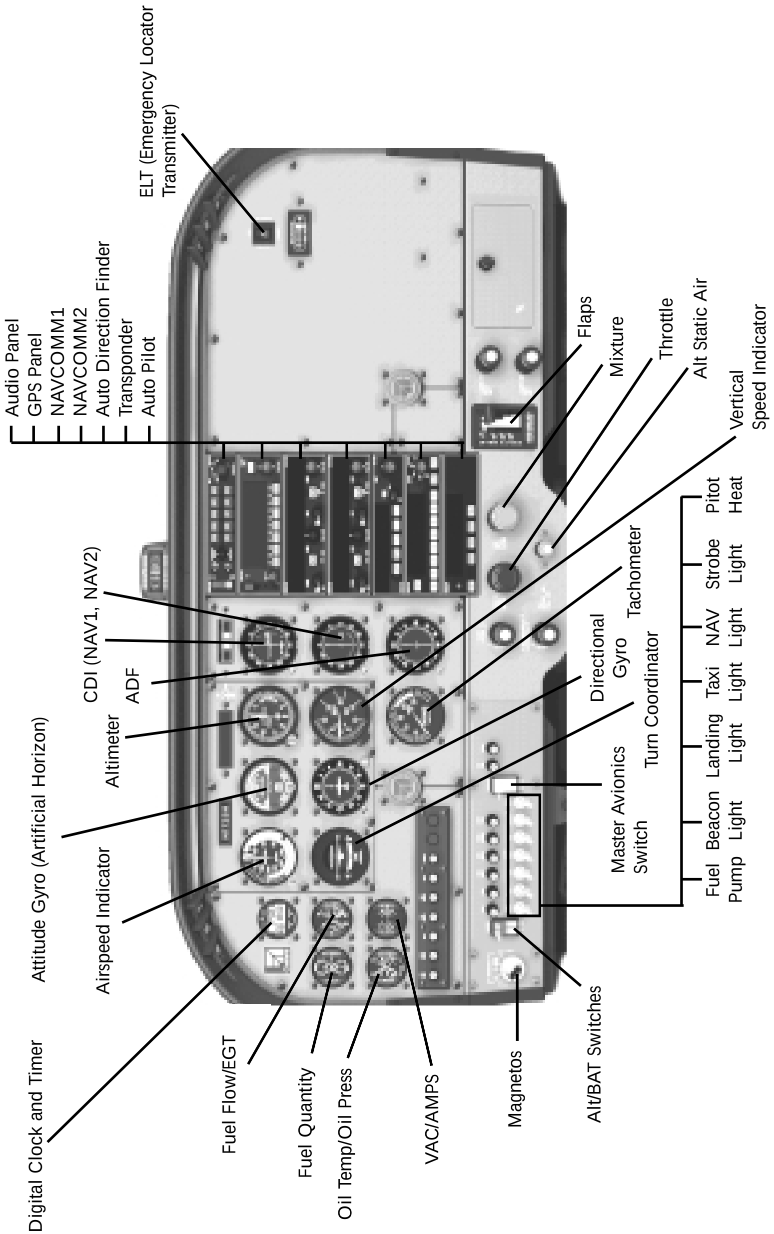
We've spent enough time looking at theory in the last couple of chapters. Let's start flying - and our steed for these first introductory lessons will be the same airplane that's probably taught more Americans to fly than any other: Cessna's immortal 172.

A LITTLE HISTORY

If the Douglas DC-3 is sometimes characterized as "the plane that taught the world to fly," then the Cessna 172 would have to be "the plane that made Americans pilots." First introduced in 1956 (when it sold for all of $8750 brand new), it was aimed squarely at the prosperous postwar middle class. As such, it was designed to be uniquely easy to fly, featuring "Land-o-Matic" tricycle gear (no, really - advertising copywriters in the '50s were something else), "Para-Lift" flaps, and car-like doors on each side. Contemporary ads featured all-American families flying off for wholesome vacations; the dads almost invariably decked out in Ward Cleaver-style fedoras.

"But wait - there's more!" Two years ago, the 172 went back into production at Cessna's brand-new single-engine plant at Independence, Kansas. By now it may well be the most produced plane in history, eclipsing even Germany's Me-109 fighter and Russia's IL-2 Shturmovik attack plane. It's a little hard to be exact - record keeping got a little spotty in the final months of World War II! With its fuel-injected engine and fancy instrumentation, the new 172R (the model included in FLY!) may seem a far cry from that first 1956 model...but it's still essentially the same benign and efficient "Plymouth of the skies," and its handling and performance are still as amiable as ever. Alas, a new one, well equipped, may leave you just enough for an airport cheeseburger...from a $150,000 check.

Cessna 172R Cockpit



A COCKPIT TOUR

Let's settle into the left seat and take a look around. You'll notice right away that just about everything is grouped on the left or pilot's side of the panel; unless the airplane has a lot of optional equipment installed, the copilot's side is mostly blank.

Directly in front of the pilot, at the top of the panel, are the six primary flight instruments, arranged in two rows of three. These are sometimes called "the sacred six," and we'll examine them in more detail in just a moment. They're mounted on a separate section of the panel, which is shock-mounted - i.e. it "floats" in rubber mounts - primarily to protect the delicate gyro instruments from vibration.

To the left of the flight instrument panel, a cluster of four smaller gauges monitors the health of the engine and aircraft systems; the single one above them is a digital clock. Just below the bottom right of the six primary instruments is another full-size gauge; this is the tachometer, and in this airplane, it's the primary reference instrument for setting power.

To the right of the main flight instrument panel, three full-size instruments in a vertical row display navigational information. To the right of these, stacked vertically, are the airplane's communication and navigation radios.

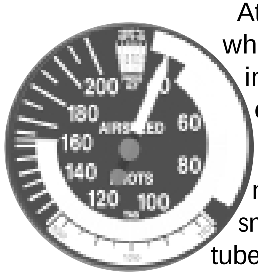
There's some important stuff along the bottom of the panel, too. At the lower left are the ignition key - we won't get very far without that one - and switches for the airplane's electrical system and accessories such as internal and external lights. At bottom center are the plunger-style throttle and fuel mixture controls; to the right of them, the appropriately flap-shaped handle for the wing flaps.

Finally, the vertical part of the panel, going down to the floor, has some important controls of its own. At its left, you'll see a large, vertically mounted knurled wheel. This is the airplane's trim control, and you'll find yourself using it often. Below that is a red fuel shutoff knob, which would normally be pulled only in case of fire or fuel leak. Further down, just above the floor, is the fuel selector which governs whether fuel will be drawn from the left wing, the right wing...or both at once, the position in which it's usually kept.

INSTRUMENTS: THE "SACRED SIX"

Since you'll be spending most of your time looking at the six main flight instruments, we'll cover each in detail. By the way, this particular arrangement of them - two rows of three, with a specific location for each - is standard worldwide. You'll find the same arrangement in all the airplanes in FLY! that have conventional round instruments - and even the Hawker Jet, with its all-electronic display, presents its information in a similar order. The information presented here is equally valid for all the rest of the airplanes in FLY!, so feel free to refer back here if you have questions later on in your FLYing career.

THE AIRSPEED INDICATOR



At the top left of the flight instrument group is what's probably the single most important dial in the whole airplane: the airspeed indicator, often abbreviated ASI.

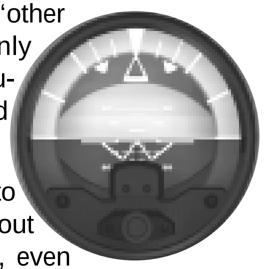
Functionally, it's very simple: nothing more than a pressure gauge, connected to a small tube (the pitot - pronounced pee-toe - tube) that's mounted on the outside of the airplane, with its open end facing forward. The faster you fly, the more air pressure is rammed into the pitot tube and indicated on the ASI - which of course is calibrated, not in pounds per square inch, but in knots. A knot is one nautical mile per hour, or 1.15 mph. We'll discuss later why we use knots instead of miles per hour - but since a knot already means "one nautical mile an hour," you'll mark yourself as a dweeb if you ever say "knots per hour."

Strictly speaking, the ASI is accurate only at sea level and at a standard temperature (15 deg. C/59 deg. F, if you're interested). At any higher altitude or temperature, the speed you see on the ASI (called indicated airspeed, and abbreviated IAS) is somewhat lower than how fast you're actually going (called true airspeed, abbreviated TAS). This information can be useful for navigation, but what does it have to do with how you actually fly the airplane? Nothing. The same factors that affect the ASI also affect the air moving over the wings and propeller. The airplane "doesn't know" the difference between IAS and TAS: you'll lift off, maneuver, and land your airplane at the same indicated airspeeds whether you're flying from Miami, at sea level, or Leadville, Colorado, at almost 10,000 feet.

You'll notice some colored markings on the ASI. The green arc is the normal operating range; its lower edge is the speed at which the airplane will stall with flaps retracted. The beginning of the white arc, at a somewhat lower speed, is where the airplane will stall with its flaps extended all the way; the top of the white arc is the fastest you're allowed to fly with them extended (anything faster will put too much stress on them). The yellow arc, which begins at the top end of the green one, is a caution range - it's okay to fly there if the air is smooth, but if it's bumpy, you risk over-stressing the airplane. (In the 172, about the only way you'll even get into the yellow is if you're coming downhill with a fair amount of power on.)

Finally, at the top of the yellow arc, there's a redline, called the "never-exceed speed." That's exactly what they mean: fly faster than that, and you're a test pilot. Make an abrupt control movement above redline, or hit a good solid gust, and you could find yourself literally "walking on air."

THE ATTITUDE GYRO



At the center of the top row is the "other single most important instrument," certainly the most important if you're flying on instruments: the attitude gyro, often also called the "artificial horizon."

This is the instrument you'll use to control the airplane when you can't see out the windshield. Without gyro instruments, even the most skilled pilot can't tell if the airplane is flying straight or turning, flying level, climbing, or descending, unless he or she can see the real horizon out in front.

At the center of the attitude gyro is a little symbolic airplane, which always remains in a fixed position. The rest of the instrument moves behind it. The blue portion represents the sky, the black or brown portion the ground, with the division between them showing the horizon. Thus, as you maneuver the actual airplane, you'll see the horizon in the instrument move to show your attitude, your position in space.

The scale at the top of the instrument reads actual bank angle, with small marks every ten degrees up to 30 degrees, then two more marks at 60 and 90 degrees.

THE ALTIMETER

The third instrument in the top row on the right is the altimeter. Basically a glorified barometer, this utilizes air pressure to read the airplane's altitude above sea level - not above the ground. In other words, you could be flying along near Denver with the altimeter reading a comfortable 6000 feet...but you'd be only about 700 feet above the ground (or well below it once you got a few miles west).

There are three clock-like hands. The big one reads hundreds of feet; the small one, thousands, so if the altimeter were reading "half past three" you'd be at 3500 feet above sea level. The smallest hand - the one that looks like a little triangle at the outer edge of the scale - reads tens of thousands; with the 172's modest ceiling, you're unlikely to see it much beyond "half past one."

Finally, there's a little setting window at the 3 o'clock position, controlled by a small knob at the 7 o'clock point. This is called the Kollsman window, because the first altimeters to have it were made by that firm; it's become a generic term, like Kleenex or Ductape. Since the altimeter measures barometric pressure, which changes with the weather, the Kollsman window is used to compensate for those changes by setting in the local barometric pressure; otherwise, the altimeter could be in error by several hundred feet. This can be embarrassing when you're depending on it to keep you clear of the ground during an instrument approach.

THE TURN COORDINATOR

At the left of the lower row is another gyro instrument, called a "turn coordinator." Where the attitude gyro directly indicates angle of bank, the turn coordinator does so indirectly, indicating instead whether the airplane is actually turning - changing its direction - to the left or right. It doesn't show any pitch information, and is labeled to warn you of that shortcoming.

In return for that seeming failure, though, it has a lot going for it. First of all, it's a lot simpler and more rugged than the gyro horizon, and thus less prone to failure. Second, the gyro horizon and the directional gyro (which is explained next) are powered pneumatically, using vacuum pumps on the engine; the turn coordinator is electric. Vacuum pumps are notoriously unreliable, which is why the 172R has two of them - but even then an air leak could leave the gyro horizon unusable. This way, you have two different types of gyro instruments, powered by completely different systems, in the hope that no combination of malfunctions would deprive you of everything at once.

At the bottom of the turn coordinator is a curved glass tube with a metal ball, damped by liquid, sliding back and forth inside. This so-called "skid and slip" ball indicates whether you have the right bank angle for the rate at which you're turning (or, conversely, that you're turning at the right rate for the bank angle you're using). You'll control it with the rudder pedals, if you have them; if not, FLY! can be configured to take care of that for you automatically. The skid ball neither has, nor needs, any type of airplane power at all.

THE DIRECTIONAL GYRO

Next in line, in the center and directly below the attitude gyro, we find the other air-driven gyro instrument, the directional gyro or gyrocompass.

Here, too, we find advantages and shortcomings. The DG's advantage, compared to a traditional magnetic compass, is that it's much steadier and easier to read. In rough air, a regular compass swings back and forth all the time. Even in smooth air, it's only accurate in straight flight. The earth's magnetic field has a vertical component as well as the obvious horizontal one, and since airplanes bank when they turn, the old-fashioned compass will lag way behind for part of the turn, then rush ahead, then lag again - it's only accurate (and not very, then) when you're passing right through due east or west. The DG, on the other hand, neither knows nor cares about magnetic north; it simply tries to hold a rigid position in space, so its indication is smooth and constant.

And therein lies its disadvantage, too: since it doesn't know where north is, it also doesn't know if it's accurate or not. Even the best gyros drift a bit with time (and even a theoretical "driftless" gyro, rigid in space, would appear to do a slow flip every 24 hours as the world turned beneath it). That's why the 172's directional gyro has to be cross-checked every ten minutes or so against the old-fashioned magnetic compass in the middle of the windshield, and reset as necessary using the knob at the 7 o'clock position. And, as with the gyro horizon, if both vacuum pumps fail, all bets are off...

If you're new to this, you'll notice that neither the DG nor the "whiskey" compass in the windshield (so called because its damping fluid is mostly alcohol) are marked off in the traditional N, S, E, and W. Instead, we use degrees, with 0 for north, 90 for east, 180 for south, and 270 for west. In aircraft instruments, they're called out every 30 degrees, with the last zero left off - thus, "9" is east, "24" would be southwesterly at 240 degrees, and so on.

THE VERTICAL SPEED INDICATOR

Finally, at the bottom right of the "sacred six," we find the vertical speed indicator (VSI). This is a very simple unpowered instrument which simply reads whether the airplane is climbing or descending, and how fast (up to 2000 feet per minute either way). Unless in a very strong thermal or mountain wave, no 172 has ever climbed at 2000 fpm except in the dreams of the Cessna marketing department, but a 2000-fpm descent, while ear-popping, is not unheard-of. Something to remember about the VSI is that its indications lag behind what's really happening by up to 10 seconds.

POWERPLANT INSTRUMENTS

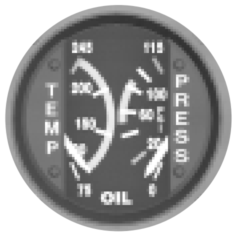
Tachometer

The most important engine instrument - and one you'll refer to quite frequently when setting power - is the tachometer, located just below the VSI. Airplane engines turn a lot slower than their automotive counterparts; you'll notice that this one is redlined at only 2400 rpm.

Engine RPM is controlled directly by the throttle - but in an airplane like the 172, with its simple fixed-pitch propeller, it's also controlled indirectly by airplane speed. It's rather like driving a car with only one gear. Shove the throttle in all the way with the airplane at a standstill on the ground, and it'll only turn up around 2100 rpm - but as its speed increases in a climb, it'll pick up a bit more. Level off in cruise, let the airplane accelerate, and it'll nudge redline. That's a perfectly acceptable way to operate, as long as you don't exceed 2400 rpm - but if you start a descent without reducing power, the engine will overspeed very readily. Just pay attention to the tach and you won't have a problem.

The other engine instruments, which monitor its "health," are the smaller ones to the left of the main flight instrument panel. At the bottom left is a dual indicator showing both oil pressure and oil temperature - the latter important since in an air-cooled engine like this one, the oil plays an important role in cooling as well as lubrication. To its right, another dual indicator monitors how much vacuum the dual air pumps are producing to run the gyro instruments (warning lights elsewhere will show if either pump fails), and whether the electrical system is charging or discharging the battery.

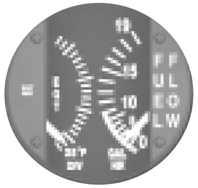
Oil Temperature & Pressure Gauge



Vacuum Gauge & Amperage

Above these are two more gauges, both quite important. On the left, two pointers show how much fuel remains in the left and right wing tanks - always nice to know! To the right of the throttle, two more pointers are controlled by the red fuel mixture knob. Since airplanes operate over a much wider altitude range than cars, it's necessary for the pilot to adjust the ratio of fuel and air entering the engine. Modern cars do this automatically, with fancy computers and oxygen sensors...but modern cars can also pull over to the side of the road if they quit. The 172's constant-flow mechanical fuel injection system is stone-age technology by comparison...but it requires no electrical power whatsoever and has only one moving part.

Fuel Gauges

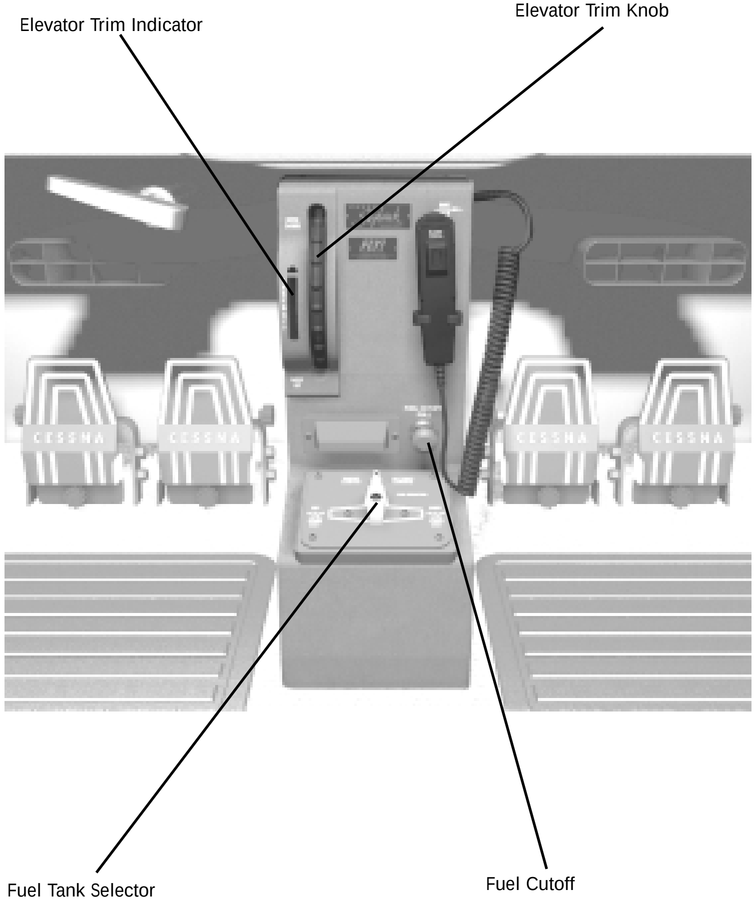


The right needle in this dual gauge shows, in gallons per hour, how much fuel the engine is using. This is not only useful information to have in general ("if I have 30 gallons on board and I'm using ten gallons per hour, it's gonna get awful quiet around here in three hours or so"), but can provide a quick way of setting the mixture ("at 8000 feet and 2300 rpm, I should be burning about eight and a quarter gallons an hour").

The left needle provides an even more precise way of setting mixture. It measures exhaust gas temperature (EGT). For any given power setting, the highest possible EGT occurs when the fuel/air ratio is exactly correct. Often, however, operating at peak EGT is hard on the engine. In many cases, you'll lean the engine (by slowly and carefully easing back on the mixture control) until EGT peaks, then enrich by a set number of degrees for best power or economy.

The vertical row of instruments to the right of the main flight group, and the stack of radios to the right of them, will come into play when we start looking at navigation and instrument flight. For the moment, though, we've been on the ground long enough. Let's start flying!

Cessna Floor Panel



Cessna 172R – Basics

INTRODUCTION

In this chapter, we're going to use the tried and true Cessna 172R Skyhawk for quite a bit of basic flight instruction. If you're starting from scratch, by the time you've worked through this material, you'll have a thorough grounding in techniques that will apply equally to all the aircraft in FLY! If you're an experienced pilot (either real-world or simulators), you can use this chapter as a reference for basic techniques - or for information on the Skyhawk and its procedures in particular. With so much ground to cover, this chapter will be longer than most - it gives you all the basics, while those on other airplanes will be devoted more to the individual idiosyncrasies of those types.

Because FLY! is so realistic, I'll generally write as if we were in the real airplane. However, now and then I'll need to make allowances or suggestions for the simulator environment. I'll call these "SimTips." Here's one now:

> **SimTip**
>
> In real airplanes, it's important to have the seat adjusted properly to get the same perspective out the windshield every time you fly. (In fact, many jets have a little optical sight gadget on the windshield center post to assure that all pilots, regardless of size, have the same eye position).
>
> In FLY!, you'll be using your mouse to look around the instrument panel. Just as in the real airplane, the outside perspective will change as you do this. To be sure you always return to the proper perspective, select the "home" instrument panel view by pressing **Shift** + **Home**. (Or select the panel view that you prefer to use most of the time.) Use **Shift** + **F1** through **F8** to "remember" an eye location, then use **F1** through **F8** to return to that spot.

First Lesson: The Four Fundamentals

A typical first flight lesson will cover the "four fundamentals" of flight. Actually, there might be five, since the first of them is "straight and level" flight - and on a number of occasions, when I've asked a student to demonstrate straight and level flight, they'll say something like, "sure!…which one first?" It's not as funny as it sounds; just to cruise along, straight and level, requires attention to several things at once.

The four fundamentals, then, are straight and level flight; turns; climbs; and descents. You can see that these can be combined to form any maneuver necessary. When you get in an airliner to fly from Los Angeles to New York, the pilot will perform a climb, mixed with turns as necessary, to get away from the airport and up to cruise altitude; straight and level flight, mixed with turns as necessary, to get from LA to NY ("fly east until you get to the first ocean, then turn left"); and, finally, a descent, mixed with turns as necessary, to land at JFK.

If you're in a hurry to get into the air, you can pick one of FLY!'s scenarios that start out with the airplane already in flight. In the real world, however, even your very first flight lesson must, of necessity, begin with engine start, taxi, and takeoff, so that's what we'll cover here.

BEFORE TAKEOFF CHECKLIST

You'll already have done the internal and external preflight inspection of the airplane. Now it's time to get all our ducks in a row to get started up.

Look down at the bottom of the center pedestal and make sure that the fuel selector is in the "both" position. Just above it, the red fuel shutoff knob should be pushed all the way in. Now look a bit higher up and check that the trim indicator is at or near the "takeoff" mark.

Flight Instruction

SimTip: Pitch Trim

You'll be using the pitch trim wheel a great deal in this, and most other, airplanes. In the real airplane, you'll be able to reach for it without looking, and you'll feel its effects directly, as pressures in the control yoke. In the simulator, it can be tedious to have to change your panel view every time you need to make a trim change.

I suggest you either configure the switches on your control yoke (preferred) or stick to provide pitch trim; or use the keyboard shortcuts (keypad 1 for nose up, keypad 7 for nose down). If you have a force-feedback stick, you should be able to feel the pressures changing. Otherwise, you'll have to gradually release elevator pressure until the airplane holds the pitch attitude you want "hands-off."

LET'S FLY!

Return to a normal cockpit view and turn on the master switch. Some of the annunciators at the top of the panel will light up (they'll blink for ten seconds, then stay on) and the small engine gauges at the lower left of the panel will come to life. Check the left and right fuel gauges to be sure they indicate the amount of fuel you have on board.

ENGINE START

If you're in a hurry, hit "E" on the keyboard and the airplane will magically spring to life. You're missing all the fun, though; here's the way the airplane is actually started:

Unlike earlier models of the 172, the current "R" model has a fuel-injected engine which requires "priming" before startup - especially if it's cold. Check that the mixture control is in its idle cutoff position (pulled all the way out); now "crack" the throttle, i.e., pull it all the way back, then push it in about half an inch. Note: if you have Auto Mixture activated, you cannot manually alter mixture.

Now turn on the auxiliary fuel pump, and, while watching the fuel flow gauge (lower left), push the mixture control in until you see about 3 to 5 gallons per hour of fuel flow, then pull it back out.

SimTip

To get an accurate readout of any instrument panel gauge, position the mouse pointer over it. A window will pop up with a digital readout of the current value.

Turn the ignition key all the way to the right, to the "start" position. The engine will crank. When it fires, smoothly push the mixture control all the way in. As soon as the engine starts, check the oil pressure gauge. If it doesn't start to rise within about 15 seconds, kill the engine by pulling the mixture control all the way out.

Once the engine has started, turn the auxiliary fuel pump back off and verify that the ignition key is at the "BOTH" position. You'll see the annunciators go out, and as the vacuum pumps come online, the artificial horizon will go through a few gyrations, then settle down to a straight-and-level indication. Turn on any exterior lights you'll need. Although we won't be using the radio on this first lesson, turn on the avionics master switch and watch all the radios come to life.

HEY, TAXI!

Now we need to get out to the active runway. (If the simulator has already positioned you on a runway, we'll just taxi around on it for a few moments to get the feel of things).

On the ground, the airplane is steered, not by the control yoke, but by the rudder pedals. It's very common, on a student's first flight, to find them twisting frantically on the yoke while the airplane continues inexorably toward some obstacle! Make sure the parking brake is released, add just a little power to get rolling, and try steering the airplane in gentle left and right turns using the rudder pedals (or the "twist" axis if you have a three-axis control stick).

SimTip

If you don't have rudder pedals or a three-axis stick, use the bottom two keys (0 and .) on the numerical keypad for rudder control. Keypad 5 centers the rudder.

Tapping the brakes will slow you down. For some active rudder pedals, the top of each pedal actuates the wheel brake on that side only, so you have to squeeze them equally. You can use individual brakes to tighten up your turn radius on the ground.

Finish up your taxiing by lining the airplane up with the centerline of the runway, retarding the throttle to idle, and braking to a stop.

BEFORE TAKEOFF

Every airplane has its own pre-takeoff checklist, and the one for the 172R is reproduced in the appendix. However, you can cover just about any airplane using simple mnemonics. Different mnemonics are used in different countries and for different airplanes (for example, RAF fighter pilots say "TAFFIOHHH"), but the one we'll use here is simple: CIGARS.

C

We'll start with "C" for "CONTROLS." Roll the yoke all the way to the left; while holding it all the way over, pull it all the way back; while holding it back, roll it all the way to the right; while holding it to the right, push it all the way forward. You can confirm the control surface movement by switching to an external camera. This is also called "boxing" the controls. What you've done here has simultaneously proved that the ailerons and elevator move through their entire range, and that they don't interfere with one another (for example, by the mysterious workings of the yoke snagging a hanging wire somewhere behind the panel) anywhere in that range. Note that merely rolling the yoke from side to side at one particular elevator deflection, or pulling the yoke all the way back and forth with the ailerons neutral, doesn't necessarily eliminate any possible interference; you need to "box" the controls as just described. Finish by moving the rudder pedals all the way back and forth.

I

"I" stands for "INSTRUMENTS." Take a general look across the panel and verify that everything is reading about what it should be; in particular, the engine instruments should show correct oil pressure, with both oil and cylinder head temperatures starting to come up; the ammeter should show a slight charge. Now check the flight instruments. The airspeed indicator should be at zero, the artificial horizon should show wings level and either neutral pitch attitude or barely above the horizon (depending mostly on how much air you have in the nosewheel strut!). The altimeter should show field elevation above sea level. If it doesn't, use the knob at its 7 o'clock position to adjust it. The turn coordinator should show a wings-level indication, with its ball centered.

The directional gyro should agree with the "whiskey compass" atop the instrument panel; it, too, has an adjustment knob at 7 o'clock. Finally, the vertical speed indicator should indicate zero - its needle should point to the 9 o'clock position.

G

"G" stands for "GAS." Check the left and right fuel gauges for adequate fuel onboard, verify that the fuel selector is on "both" and the fuel shutoff is pushed all the way in. We'll leave the auxiliary pump off for the moment.

A

"A" stand for "ATTITUDE." For once, this doesn't mean how you feel, or if you intend to get in my face later on; it's your cue to check pitch attitude, or, in this case, to verify that you have the pitch trim set properly for takeoff. If it were mis-set, you'd either have to exert a mighty heave to get the airplane off the ground; or you might find the airplane leaping into the air before it, or you, were really ready to fly.

R

"R" stands for "RUNUP," and since there are several steps to this, we'll take them one at a time:

- Hold the brakes, or set the parking brake. Now, gradually increase the throttle until you reach 1800 rpm.
- What we're going to do now is check the engine's two completely independent ignition systems. Each cylinder has not one, but two spark plugs, and they're fired by separate magnetos (often simply called "mags"). What's a magneto? It's very similar to the ignition system of a car, and even includes a distributor - but instead of having points and an external coil (or, in modern cars, an electronic ignition system), the magneto generates its sparks internally, using a rotating permanent magnet (hence the name). This makes it entirely independent of the airplane's electrical system - the mags, and the engine, will continue to run even if the airplane system fails altogether. (In fact, old-fashioned airplanes don't even have electrical systems, which is why they have to be started by the "Hemingway" method of swinging the prop by hand - as in *A Farewell to Arms*.)

- Move down to the ignition switch. While watching the tachometer, move the switch two "clicks" to the left, paradoxically labeled "R." What you've just done is switched off one of the engine's two magnetos - in this case, the left one. The engine should continue to run, but since it's not quite as efficient with only a single spark to ignite the fuel/air mixture in the cylinders, its RPM should drop slightly (50 to 100 RPM).
- Now switch back to BOTH, verify that the RPM comes back up to 1800, then switch only one click to the left, to "L." Once again, the RPM will drop slightly. What you want to see here is (a) that the drop is no more than 150 RPM on either mag, and (b) that the difference between the two mag drops is no more than 50 RPM. Make sure you finish by switching back to BOTH once again.
- The final runup item in Cessna's checklist is to check the vacuum gauge in the green arc. You might also glance at the annunciator panel to ensure that it's dark.

Thoughts differ as to how to handle the auxiliary fuel pump on injected Lycoming engines like this one. The fact that the engine performed normally during runup indicates that the engine-driven fuel pump is working properly, so we should be able to count on it from here on. On Lycomings, however, you can also run the aux pump with no adverse effects (unlike on Continentals, the other major brand, in which running the aux pump along with the engine-driven one will flood out the engine and kill it). If the engine-driven pump should fail right after takeoff, the engine will quit, leaving you with a busy situation at low altitude - so in Lyc-powered airplanes, my personal practice is to verify during runup that the engine-driven pump is okay, then switch on the aux pump just as a backup for takeoffs and landings.

S

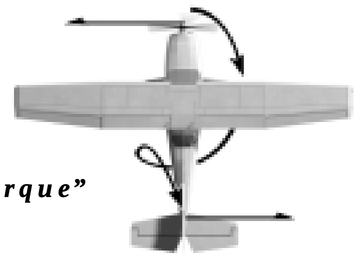
"S" is for "SAFETY"! Seatbelts on, doors latched, objects stored, etc.

TAKEOFF! (finally!)

The big moment has arrived. Crosscheck that with the artificial horizon; the miniature airplane should be just about on the horizon bar.

Make sure the brakes are released, then smoothly apply full power. The airplane will start to roll ahead. If you have FLY! set for realistic flight modeling (and I strongly recommend that you do - we worked very hard on its accuracy!), you'll notice that the airplane will also try to veer off to the left.

This is not due to politics. Rather, it's the combination of a number of aerodynamic and physical effects, often grouped under the (mostly incorrect) label of "torque."



"Torque"

In fact, in this situation (airplane on the ground), torque per se - the tendency of the engine to roll the whole airplane opposite the direction of propeller rotation - plays a relatively minor role. Far more significant, during the takeoff roll, is the fact that the air moving back from the propeller does so not in a straight line, but with a spiral motion imparted to it by the propeller's rotation (clockwise as seen from behind). Thus, there's a good deal of force pushing against the left side of the vertical fin, thus shoving it to the right and pushing the nose to the left.

Just keep your eyes out the windshield, applying rudder as necessary to keep the airplane tracking the runway centerline. Glance at the airspeed indicator from time to time. As the speed approaches 55 knots, apply gentle back pressure to raise the nose to just barely below the horizon. The airplane will lift off - don't let it settle back to the runway. Let it accelerate to a climb speed of 70 to 80 knots - remember, lowering the nose will let it speed up, raising the nose will slow it. Now start breathing again.

We've moved right from takeoff into one of the four fundamentals: climb. At the same time, we're going to try to keep going straight ahead. To maintain a straight course, simply keep the wings level (either with the real horizon if you can see it, or with the artificial one). To control your climb airspeed, maintain the correct pitch attitude - and, at this point, if you can't see the horizon over the instrument panel, I'd suggest altering your cockpit view until you can.

Keep climbing until you get to around 3000 feet. Now we'll level the airplane off and set cruise power to start working on straight and level flight. The airplane will start to speed up. When it gets to around 100 knots, reduce power to about 2100 RPM. It'll continue accelerating, although less strongly now, and the RPM will creep up again toward 2200.

Why does the RPM change all by itself? Because this airplane has a fixed-pitch propeller. Think of the blade like the thread of a screw, pulling the airplane through the air. Obviously, since the air has some "give" to it, the relationship between airspeed and RPM isn't totally locked in, but there's still a very close correlation - it's as if we were driving a car that was always in the same gear. We'll play with this relationship a little more in just a few moments.

STRAIGHT, LEVEL, STABILITY, AND TRIM

Sooner or later, everything should settle down: the airplane will be flying straight ahead (wings level), neither climbing nor descending (nose at the right distance below the horizon), and the RPM and airspeed have stabilized around 2200 RPM and 105 to 110 knots. You'll most likely find, however, that you have to hold steady elevator pressure (most likely forward) to keep the situation stable.

This is where the trim control comes in. Slowly actuate it in the same direction you're holding pressure until you can release the pressure on the yoke or stick without the pitch attitude changing. The airplane is now "in trim," and barring air turbulence, it should fly straight and level with little or no input on your part.

While it's doing this, let's take a moment to look at why it can remain so stable on its own. (If it's not quite doing that, go ahead and pause the simulation).

Any certificated civil airplane has a fairly high level of pitch stability. That is, when it's trimmed for a certain speed (as we did just now), it'll tend to hold that speed even if displaced from it. Let's take a look at how this works.

You'll see that the airplane is like a teeter-totter, balanced on the point at which the wing exerts its lift (called, appropriately enough, the center of lift). While a good deal of the airplane's useful load (people, luggage, and fuel) is arranged near the center of lift (either in front of it or behind it), there's a significant chunk of iron stashed away just about as far forward as you can get: the engine.

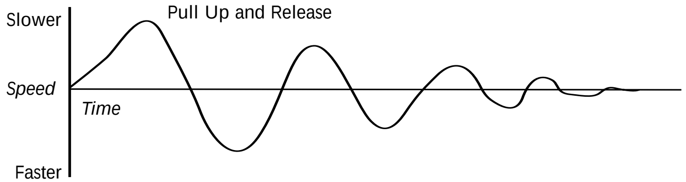
Tail Airfoil

This means that the airplane's natural tendency would be to drop its nose. To counteract this, the horizontal tail has an airfoil similar to that of the wing - but upside down! Thus, it's actually pushing downward, and thus balancing the airplane and keeping the nose up where it belongs.

Now, you'll recall from the introduction - you did read it, didn't you?—that the amount of lift an airfoil produces is in proportion to its airspeed. Let's say, for example, that we hit a gust that drops the nose of the airplane a bit. Since it's now going downhill, it'll speed up - and as it does, the downforce generated by the tail increases, thus bringing the airplane's nose back up toward level flight. Similarly, if something displaces the airplane's nose upward, it loses speed; the downforce created by the tail decreases, allowing the weight of the engine in the nose to bring the nose back down.

The process isn't instantaneous. Let's get back into the cockpit for a demonstration. Once you have the airplane trimmed out for level flight, pull the nose up until the airspeed has dropped to 85 or 90 knots, then let go of the controls. (You can continue to nudge them from side to side to keep the wings level, but don't make any pitch inputs or corrections. Or, since the 172 autopilot doesn't control any pitch functions, just turn it on and it'll keep the wings level for you.)

As soon as you turn the controls loose, the airplane will try to return to its trim speed. In fact, since it's now flying so slowly, it doesn't even have enough "tail power" to keep the nose up to the normal level flight attitude; the nose will gently drop to somewhere below level flight attitude, and the airplane will speed up. As it approaches its trim speed, the nose will start to come up again…and, since we've now exceeded our trim speed in a gentle dive, it'll rise a bit above level flight once again, then go back down, come back up, etc.—a little less each time , until it's settled back down at its trim speed.



Stable Pitch Damping

Basically, then, the trim speed, at which the airplane is stable, could be considered a "zero point." All the trim control does is to set at what airspeed that zero point occurs, so you can fly the airplane at any speed you want without constantly having to hold pressure against the controls.

Before we leave the trim control, let's look at the other major factor that affects airplane trim: power. With the airplane trimmed up straight and level once again, and without touching the controls (except, as before, use the autopilot or little sideways nudges to keep the wings level), pull the throttle back to around 1900 RPM.

You'd expect the airplane to slow down, wouldn't you? Surprise! Its initial reaction is to drop its nose and even speed up a bit!

Why? Because the horizontal tail is right behind the propeller - so the airspeed it "sees" is a combination of the airplane's actual forward speed and the thrust produced by the engine. Reduce power, and there's less air passing over the tail; thus, it produces less downforce, and the nose comes down.

Now shove the throttle wide open. The nose comes up - and while the airplane will ultimately settle down near its formerly trimmed speed, it'll first go a bit below it, for the same reason.

What if the tail weren't right behind the propeller(s)? Sure enough: airplanes with T-tails have much less trim response to power changes.

CLIMBS AND DESCENTS

These little trim exercises lead logically into the next two fundamentals: climbs and descents.

There are two ways to make the airplane go up and down, and they can be used together or separately. Changing the pitch attitude (within reason, of course), simply makes the airplane go "uphill" or "downhill." If you leave the power alone during such changes, you'll see the same reaction as if you were to drive a car on a hilly road with the gas pedal locked in one position: it'll slow up going uphill, and go faster on the downhill stretches. Try it!

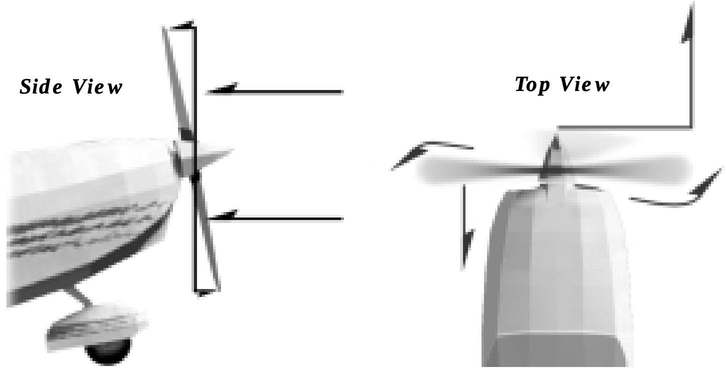
You can also adjust the power, as we did in the last trim exercise. If you leave the pitch trim alone, and don't use any control pressures, the results are also predictable: reduce power, and the airplane will go downhill (possibly speeding up a bit as well); add power, and it'll climb, possibly slowing.

In the real world, of course, you use both controls at once. To climb, raise the nose to get the airplane to an efficient climb speed (70 to 80 knots works well in the 172) and adjust the power to get the rate of climb you want. In a real-world 172, particularly if you have a couple of buddies along on a warm day, you'll typically use full throttle and accept whatever rate of climb you can achieve—"She's givin' ye all she's got, cap'n!" To descend, set your pitch attitude for the desired airspeed (typically cruise speed or a bit more), then set power to achieve the desired rate of descent without exceeding the redline RPM.

Here's a fine point: just as on takeoff, you'll notice that as you add power and pull the nose up for a climb, the airplane wants to veer to the left.

This time, while the spiraling propeller slipstream continues to play a role, there's another force: the notorious "P-factor." This is not to be confused with the distress pilots feel when they've been flying for several hours after drinking too much coffee before takeoff.

P-Factor



Downgoing blade takes bigger bite.

Center of effort is displaced to the right.

Take a look at this sketch to see what's happening. When the nose of the airplane is pointed up, the propeller isn't just spinning in a vertical plane. The downgoing blade (the right one for American engines) is also moving forward, in the direction of flight, while the upgoing (left) one is moving backward. Thus, the right blade "sees" a higher airspeed, and takes a bigger "bite" out of the air, than the left one.

This, in turn, means that the right side of the propeller is doing more work, pulling harder, so its center of effort - the apparent point at which it's pulling - is no longer in line with the propeller hub. Instead, it's displaced some distance to the right (typically, up to half the blade length), thus pulling the nose of the airplane off to the left. In a steep, low-speed, high-power climb, you'll have to hold a good deal of right rudder pressure to keep the airplane straight.

By the way, as you might expect, all Russian and many other European engines turn the other way - and, sure enough, you need a heavy left foot in their airplanes.

ONE GOOD TURN DESERVES ANOTHER

Let's return, once again, to trimmed straight-and-level flight.

Now we're going to try some turns to either side - first gentle ones, then steeper. Remember, turns in an airplane are made by directing part of the lift in the desired direction, and we do this by banking.

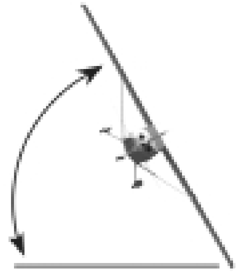
Let's try one to the right. Note the heading shown at the top of the directional gyro - that's the direction we're headed right now - and the direction at the 3 o'clock position, 90 degrees away, which is where we want our turn to finish up. Got it? Fine…now start applying gentle pressure to the right on the yoke while looking out forward at the horizon. The airplane will start to bank to the right. Glance at the artificial horizon. When the bank has reached 30 degrees, the first large mark (past the two smaller ones) at the top of the instrument, roll the yoke back to the center.

You'll notice that the airplane tends to hold whatever bank it has with the yoke centered. As you rolled into the turn, it started turning (changing its heading) to the right. With the yoke centered to maintain the 30-degree bank angle, it continues turning right. As you approach your planned new heading, you'll do just the opposite: roll the yoke to the left to bring the wings back level, then center it once again to keep them there.

Thus, you see that a turn in an airplane is actually requires four separate control movements:

1. a roll-in to the desired bank angle.
2. re-centering the controls (with minor adjustments as necessary) to keep the turn going without letting it get either shallower or steeper.
3. then an opposite roll-out to return to level flight.
4. another re-centering of the controls after that.

Pretty cool, huh? Except that chances are, now that you're back in level flight, that we've lost some altitude. Why? Because any lift that we use to make us turn (by banking) is that much lift taken away from the basic task of keeping the airplane up in the air. Let's turn to the left, back to our original heading - but this time, look out the front and pay close attention to what the nose is doing relative to the horizon.



60 Degree Bank

As we start the turn, it'll try to drop a bit - that's because the airplane is sinking a little, and its natural stability (as discussed earlier) wants to point the nose down to compensate. What do we do? Simple - we add just a bit of back pressure during the turn. If you note exactly how far below the horizon line is before you start a turn, then add back pressure as necessary while turning, the turn should come out level.

Now let's try a real steep turn - we'll start this one to the left. Roll the airplane into a 60-degree bank - that's the second large mark at the top of the artificial horizon.

You'll notice a couple of things right away. One is that the airplane turns a lot faster; the other is that it will take lots more back pressure to keep the nose up. You'll also notice that a lot of airspeed will get scrubbed away: to maintain altitude in a 60-degree bank requires so much back pressure that you're putting a constant load of 2 G's (a "G" is equal to the normal force of gravity) on the airplane; all of a sudden, that poor little Lycoming has two whole 172's bolted onto it! That rustling noise you hear behind you is the passengers getting those little waxed paper bags out of the seatback pockets…

> **SimTip**
>
> You'll need some form of rudder control (either pedals or the keypad 0 and period) for these next maneuvers.

TURN COORDINATION

Something else you may have noticed, especially during the steep turns, is that the ball in the turn coordinator instrument might have been doing some weird things.

This is because the airplane doesn't always want to go where it's pointed (or, conversely, point where it's going).

First, let's try something weird: rather than using the yoke, try to make a turn simply by applying full rudder in the direction you want to go.

The airplane will, in fact, try feebly to turn; it will even drop the appropriate wing a little. Mostly, though, it'll just sort of slither along sideways, going more or less the way it was to begin with, and with the ball in the turn coordinator all the way to the outside of the turn.

What's happening? This is a great illustration of how lift, aimed by banking, rather than the rudder, is what actually turns the airplane. All you've managed to do is point the nose a bit to the inside of the turn (and, given enough time, the change in engine thrust direction will, in fact, change your direction altogether); but it's pretty ineffective, and also uncomfortable as centrifugal force slings you, your passengers, and the skid-indicating ball to the outside of the sloppy turn.

Now let's try the other extreme: rack the airplane over into a steep turn, using the yoke only, without any rudder pressure. The ball will drop to the inside of the turn. The nose, however, may not point all the way into the turn; indeed, as you start the turn, it'll momentarily slew in the opposite (outward) direction, since the aileron on the raised wing produces more drag than that on the lowered one (a phenomenon called "adverse yaw").

The function of the rudder is to balance out these forces. In a properly executed ("coordinated") turn, the ball will remain centered throughout, and passengers should not feel "the leans" in either direction - in fact, if they can't see out, they shouldn't even know you're turning. The ball will always move away from the side with excessive rudder pressure, so if in doubt, the rule is simple: "step on the ball," adjusting rudder pressure until it's in the middle between the index lines.

THE EASY WAY OUT

We've done a lot of work for a first lesson. If you're feeling feisty, you can try to get the airplane back onto an airport by hitting the **M** key to bring up a local map, turning the airplane until you're headed for a blue or magenta airport symbol, then using your own combination of turns, descents, and power adjustments to get down onto the end of a runway. In a real airplane, your instructor would take you home at this point - if you're ready for a break, just hit the **Z** key to activate Auto Land.

Cessna 172R - Intermediate

THE DREADED STALL

In this lesson, we'll begin by looking at what some students consider a stressful maneuver - at least (and probably only!) the first time around. This is the stall: the condition in which the airplane is maneuvered to, and past, the critical angle of attack, at which the airflow separates from the wings and the production of lift effectively ceases.

Notice that at no point have I said "stalling speed," and that's entirely intentional. I'm trying to underscore, here, that a stall is solely the result of exceeding the critical angle of attack. True, in many flight regimes, this exceedance often comes at low airspeeds - but it's important to remember that, with a hard enough pull on the yoke, it can come at any speed. We'll look at some of these "accelerated stalls" as we go along.

Let's begin by getting the airplane up to a safe altitude for stall practice. This means at least 3500 feet AGL; I'm even happier at 5000 feet. Not that it takes nearly that much altitude to recover from a stall, of course; in fact, later on, we'll practice recovering with minimum loss of altitude. On the other hand, a botched recovery can eat up quite a bit of altitude, particularly if you let it develop into a full-blown spin. And since the 172R, when operated in utility category (no more than two folks, half fuel, and no baggage), is signed off for spins…yes, we'll do those, too (urp!).

If you want more practice in engine start, taxi, and takeoff, by all means use the opportunity. On the other hand, if you don't want to take the roughly ten minutes we'll need to get off the ground and up to 5000 feet, just pre-position the simulator to an appropriate location and altitude.

LOOK OUT BELOW!

The first thing we'll do before any stalls is a couple of steep turns, one in each direction. These are called clearing turns, and they serve two purposes. Not only do they loosen you up a bit, and let you get the airplane "in hand;" if they're steep enough (let's use 45 degrees), they also give you a chance to look out the side windows and make sure there's no one flying right below us, in the airspace we'll descend into during the stalls.

THE EASY ONE FIRST

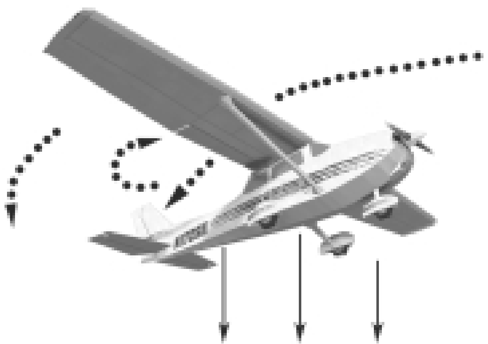
Get the airplane trimmed up for a normal cruise and make your clearing turns. When you're recovered to straight and level flight, ease the power back to idle. The nose will try to drop, but don't let it. Instead, bring it up above the horizon about ten degrees; what we're looking for is a gradual and constant slowing, with the airspeed ideally reducing by one knot per second.

You'll notice that as the airplane slows, it takes more and more back pressure to hold the pitch attitude. Glance at the airspeed indicator. As it reaches a point 5 to 8 knots above the bottom of the green arc (the flaps-up level stalling speed at maximum weight), you'll start to hear a mournful whine.

This isn't your passengers (actually, it might be). Built into the root of the left wing is a little air horn, plumbed to an opening in the wing's leading edge. In normal flight, the opening senses normal, or even higher than normal, air pressure. As the angle of attack increases, however, the stagnation point - the point on the leading edge at which the air splits to go above and below the wing - moves downward. Just before stalling angle of attack, it's moved far enough that the opening is now on the upper, or low-pressure, side of the stagnation point. Air is sucked out through the horn, and that's the stall warning sound you hear. It's a simple, reliable system, requiring no electricity or moving parts.

In fact, if you're tall, you can check it during preflight inspection by placing your mouth over the opening and sucking gently; you'll hear the horn. An instructor of my acquaintance used to suck so hard that he'd damage the horns until a mechanic prepared an airplane with a few squirts of Tabasco just inside the opening…

Full Stall



Meanwhile, back in the air: keep increasing back pressure as the airspeed decreases. Right around the bottom of the green arc, depending on how you have the airplane loaded, one of two things will happen:

1. The airplane will give a little shudder and its nose will drop a foot or so; a wing may drop a bit as well. You'll feel a definite "sinking sensation."
2. (More likely): You'll "run out of stick"—you'll have the yoke as back as far as it will go. The airplane will sort of tiredly ease its nose back down to the horizon, possibly with a bit of shuddering and shaking, and the VSI will show a rapid descent.

Either way, you've "stalled" according to the FAA. In the first case, there's been an actual separation of the airflow over the wings, and the airplane has started to drop. In the second case, you've run out of elevator control; the airflow is at least partly separated, and you're not producing enough lift to hold the airplane up (hence the rapid rate of descent). In addition, in either case, you'll have noticed that the airspeed has rapidly decreased quite a bit more: as the airflow begins to separate, drag increases radically.

NOW WHAT?!

At least you've noticed that the airplane merely sinks - it doesn't "plummet" (at least the very docile 172 won't). Still, if this sinking isn't arrested before you reach the ground, it'll be unfortunate. To recover, all we have to do is to reduce the angle of attack so the airflow reattaches to the wing, and we do that by reducing back pressure. Notice that unless you're in an extreme situation, you don't need to shove the yoke all the way forward; if you do, you'll certainly un-stall the airplane, but you'll also plaster your passengers onto the ceiling and lose a lot of unnecessary altitude.

Just lower the nose a bit below the horizon; at the same time, open the throttle all the way. Hold the nose on the horizon as the airplane flies out of the stall. Don't try to pull up again; you're still at a low speed and high angle of attack, so a secondary stall isn't far away.

Practice this several times. What you're working toward is a recovery with minimum loss of altitude once the stall "breaks."

DEPARTURE STALL

To the extent that the 172 can be goaded into a full stall at all, the ones we just did were the easiest and most docile. Now let's look at another type: the departure stall, in which we simulate someone trying to climb too steeply after takeoff.

In level flight, after making your clearing turns, pull the throttle back to or near idle, holding your altitude and letting the airplane decelerate to near its normal takeoff speed of around 60 knots. Trim as necessary, or just set the trim at the takeoff mark.

As you reach 60 knots, apply full power, pull the nose up to and beyond a normal climb attitude, and let the speed start bleeding off. One thing you'll notice right away will be that it'll take a lot of right rudder to keep the airplane headed straight with the skid ball in the middle of its tube.

Since you're now carrying part of the airplane's weight with power, the airspeed indicator will go perceptibly below the green arc before the stall actually "breaks." You'll still get 5 to 8 knots advance notice from the stall warning horn. The pitch attitude before the break will be quite a bit steeper, and the break will be sharper, with the airplane possibly getting further nose-down than in the first stall series. If you didn't have the rudders just right, there's also a good chance that a wing will drop - most likely the left one.

You're already at full power, so the object now is to recover with as little altitude loss as possible. Relax just enough back pressure to get the airplane flying again, then bring the nose up near the horizon to arrest the sink rate, but don't pull so hard you stall again. As the airplane picks up speed, you can reduce power to a normal cruise setting.

SLOW FLIGHT AND APPROACH TO LANDING STALLS

Now we're going to explore the effect of the flaps on the airplane. The big "barn door" flaps on the 172 move backward, as well as downward, as they extend. This makes them very effective for increasing lift: not only do they increase the curvature of the wing by lowering its trailing edge, but they increase its area as well.

At full deflection, they also create a great deal of drag. The 172's flaps can be set at any position between full up and full down, but pilots typically use the three "notches" in the flap control. The first notch, at 10 degrees, produces much more lift than it does drag; it can also be extended at speeds up to 110 knots. Full flaps, at 30 degrees, create much more drag than lift; you have to be below the top of the white arc, at 85 knots, to lower them. The 20 degree notch "splits the difference" between lift and drag, but is subject to the same 85-knot speed limitation. (Older 172's had a final notch at 40 degrees that let them come down like parachutes - but left you so little energy for a soft landing that you really had to know what you were doing!)

The air flowing through the slot between the wing and the flap helps keep the overall flow attached at very high angles of attack .

Set the airplane up in level cruise flight and engage the autopilot so you don't have to worry about keeping the wings level (remember, the autopilot in the 172 has no control over the pitch axis). Make sure the airspeed is below 110 knots. Now lower the first notch of flaps.

You'll notice an impressive pitch-up and "ballooning"—the airplane will gain a couple of hundred feet of altitude. This is because you've created a major increase in the wing's lift without changing the amount created by the tail. Wait until the airspeed settles down again and note its new value. It'll be lower than it was before, the airplane will be at a slightly lower nose attitude, and it'll be descending slightly.

At this point, we've added more lift than drag. Many pilots will blithely say "the 172 has a big nose-up trim change when you extend the flaps," and in a sense, they're right: it does, at least at first. However, until your use of trim is completely instinctive, rather than trimming madly nose-down, then having to trim back nose-up as the airspeed dissipates, just sit tight for a moment and you'll find the trim change wasn't nearly so large as you thought.

With all these ruminations, we're probably down below 110 knots now, so run out the second notch of flaps. Again, there's a nose-up trim change and a bit of ballooning, but less than the first time. This is due partly because we have less airspeed, and thus less energy, starting out, and partly because the flaps are now transitioning from "pure lift" to a more balanced "lift and drag" regime. Again, wait until the airplane has settled down. Again, we've shed some airspeed; the nose is down further yet; and we're descending a bit faster.

Finally, since we're now well within the white arc, extend the flaps all the way. The "balloon" will be very slight, but even more speed will dissipate, the nose will go down further yet, and the sink rate will increase. Throughout this evolution, we've touched neither the yoke, the throttle, nor the trim.

All right - now, in one swell foop, bring the flaps all the way up. The airplane will drop its nose and sink like a rock, at least for a moment - but as it accelerates, the nose will come back up, and if you've really been honest about not touching pitch, power, or trim, sooner or later (after a few mild "dipsy doodles") you'll be back at trimmed level speed.

What you've experienced here is that the flaps can be used, not only to configure the airplane for slow flight, but for control. Particularly as you start flying on instruments, when you'll have to keep track of a whole lot of things at once, you'll find it a mark of professionalism to control the airplane not only with pitch and power, but also (and in some cases primarily) with configuration changes. This will become even more important as you move into higher-performance aircraft.

"THE BACK OF THE CURVE"

Now for a rather interesting exercise. Start out with the airplane in trimmed level flight, then gradually reduce power to about 1750 RPM and re-trim until you're flying just below the top of the white arc. Next, extend the flaps to the second notch, wait for the "balloon" to run its course, and trim once again for level flight. The airspeed should settle around 70 to 80 knots.

Notice what your tachometer is indicating - due to the fixed-pitch prop, it'll have changed a bit as we slowed. Now, using elevator and trim, slow the airplane by ten knots; then, holding it at that airspeed, adjust the throttle until we're neither climbing or descending. Look at the tach again, and you'll see that we've reduced power a bit more. Stands to reason, doesn't it? To go slower, use less power…

Okay. Now reduce the airspeed another ten knots - carefully, we're pretty close to the stall, and you may hear the horn intermittently - and, once again, adjust power to maintain altitude. Guess what? It takes more power this time! We're flying slower, but it takes more power to do it.

We've entered what's known as the "region of reversed command," also called "the back side of the power curve." Down to a certain speed, the airplane seems to be following the rules - more power, more speed. Below that, however, everything seems backward.

What's happening here is that as we approach the critical (stalling) angle of attack, any small increase in angle of attack causes drag to build up even faster than lift. This is why we have to be so cautious as we approach a stall - as we get close, the airplane has a tendency to "dig in," if we don't pay attention to angle of attack, and slow itself even further.

Okay - as long as we're down here, somewhere below the bottom of the green arc, let's try some gentle turns. This is called "maneuvering at minimum controllable airspeed," or simply "slow flight," and it's an excellent exercise. Remember, stall speed goes up with increasing bank angles (we'll explore that more in a bit), so make all your turns very gentle.

Finally, let's reduce the power to or near idle, and let the airplane start descending so that it maintains airspeed. After we have things stabilized, extend the final notch of flaps, continuing the descent. To make things even more interesting, start a gentle turn in either direction.

What we're about to do is called an "approach to landing stall." We have the airplane configured as if we were going to land, and we're descending as we would in the landing pattern. Pick an altitude a couple hundred feet below where we are now, and when you reach it, apply back pressure to try to level off without adding power.

You'll notice it won't take much back pressure to stop the descent - indeed, you'll be able to do so with the nose still perceptibly below the horizon. Moreover, with all the drag of the flaps, speed will bleed off pretty quickly.

By now, we're well below the bottom of the green arc - the speed at which the airplane would stall with the flaps up - and, as we approach the bottom of the white arc, with the horn moaning away, the airplane will stall. Considering how much lift we've been trying to produce, and how quickly it goes away, the "break" may be surprisingly brisk, and it will most likely be accompanied by a pretty quick wing drop (usually to the inside of the turn unless you're a real lead foot on the outside rudder).

How to recover? As always, by relaxing back pressure, adding full power, then gently starting to bring the nose back up to minimize the loss of altitude. Use rudder as well as (or even more than) aileron to help raise the lower wing. As soon as you start the recovery, you can bring the flaps back up to the first notch to help acceleration - but don't bring them all the way up until the airplane is both accelerating and climbing, because there'll be some settling as they come up the last ten degrees.

What are we trying to show here? Among other things, that the nose doesn't have to be above the horizon for the airplane to stall - his time, it let go with the nose down. Also, this maneuver shows that the flaps-down stall can be fairly brisk, and that it can take a good deal of altitude to recover…and since the real-world scenario for this type of stall is in the landing pattern, at less than 1000 feet above the ground, this is a type of stall that should be avoided at all costs.

LET'S HEAD FOR THE BARN

At this point, you've been exposed to all the maneuvers and skills you need to land the airplane, so let's try one. We'll be using our "four fundamentals" to fly a series of turns and descents around the airport, culminating in a descent to the runway and an approach to a stall just above it. How far above it, in case the airplane actually stalls? Oh, six inches or so…

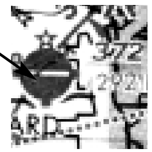
First, of course, we have to find the airport.

For the moment, we won't worry about radio communications or other traffic, but we do need to know the airport's elevation above or below sea level. If you're using one of the San Francisco Bay area scenarios, any of the major airports right around the bay are near enough to zero not to matter. We're going to use a pattern altitude of 1000 feet above the airport, so check its elevation (printed below the airport symbol), then start a gentle descent to an altitude 1000 feet higher. We'll also assume, for the moment, that there's no wind, so it doesn't matter which runway we choose; in the real world, of course, we'll always choose the runway most nearly aligned into the wind.

> **SimTip**
>
> *Hit the **M** key to turn on the map display, then turn the airplane until it's pointed at one of the blue airport symbols.*

Take another look at the airport symbol, which will have at least one runway depicted as a light-colored line. If there are several, pick the one most nearly aligned with the direction from which we're approaching. Even though there's no wind, we're not going to land straight in, but rather fly a standard pattern. This is partly to develop good habits, but even more because the pattern offers you a lot more opportunities to judge distance, altitude, and descent rate.

Airport Symbol



As we get closer to the airport, level off at pattern altitude and set power for around 90 to 100 knots. Don't fly straight at the middle of the airport; instead, aim a bit to the right. We want to start the first, or downwind, leg of the landing pattern at 1000 feet above the ground and about a mile to the right of the runway, so that you'll be able to see it out the left side of the airplane.

Before we go any further, set your directional gyro (which has probably drifted during our earlier flights) to match the magnetic compass on top of the panel. As you get close enough to the airport, you'll see the big numbers painted on the ends of the runways. These represent the magnetic heading of the runway, minus the final zero - for example, 9 would be a heading of 90 degrees, 24 would be 240 degrees, etc. Obviously, each runway has two numbers, 180 degrees apart, painted on each end: the other end of runway 9 is runway 27, the other end of runway 24 is runway 6, etc.

Pick the runway you're going to use, note its number, and turn the airplane so you're flying 180 degrees opposite that direction (called the reciprocal heading). If you don't feel like the mental math, just turn to parallel the runway, with the reciprocal heading at the top of the directional gyro and the direction in which you'll be landing at the bottom.

About halfway along the runway, extend the first notch of flaps and trim, if necessary, to maintain level flight. Keep an eye, not just straight ahead, but out to the left. When your planned touchdown point is below the left wingtip, reduce power a couple of hundred RPM and begin a gentle descent - no more than 500 feet per minute.

Keep looking to your left as well as checking forward. When the end of the runway has moved back to about the 8 o'clock position, you'll start your base leg by making a smooth 90-degree turn to the left. Roll out of the turn, and the runway should be at about the 11 o'clock position. This is a good time to extend the second notch of flaps, adjusting trim and power as necessary to maintain a smooth descent at 70 to 80 knots.

As the runway moves back to the 10 o'clock position, start another smooth 90-degree left turn. As you roll out, the runway should be straight ahead; if you plan to use the rest of the flaps (there's no law that says you have to - in fact, the airplane lands just great with no flaps at all), this is a good time for them.

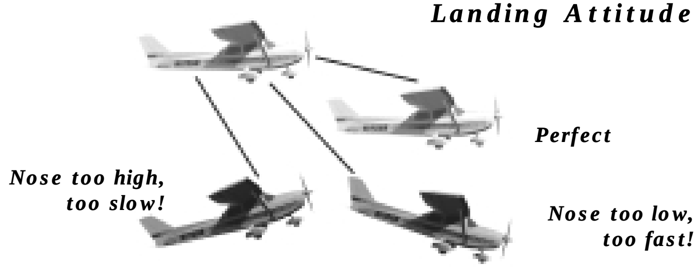
The hardest thing for early students to judge is the correct angle of descent, but most larger airports will help you out. Depending on where you are, you'll either see a pair of light bars on the left side of the runway (the Visual Approach Slope Indicator, or VASI), or a single line of four lights (the Precision Approach Path Indicator, or PAPI).

They work in a very similar fashion. Using VASI, if you see two white light bars, you're above the optimum glide path; if the further bar is red and the nearer one is white, you're right where you should be; and if they're both red, you're too low, and should add power right away.

With PAPI, the resolution is even more precise. Four white lights mean you're quite a bit too high; three whites and one red, still high, but not as much; two white and two red, just right; one white and three red, you're low; and four reds, you're really low - again, add power and climb back up to the correct glide path.

Either way, keep your wings level, making small corrections to stay lined up with the runway centerline; use elevator, and trim if necessary, to control your airspeed; and make judicious power adjustments to control altitude and glide path. As you get right over the end of the runway, don't look at the ground right ahead, but at the far end of the runway. In the 172, if you simply raise the nose until the top of the instrument panel is just about on the horizon, then gently wipe the power all the way off while holding the nose in that position - remember, it'll try to drop as you remove the power, so be ready to add a little more back pressure - you're almost guaranteed a creditable landing.

Landing Attitude



Squeech! Congratulations! We're on the ground, but you can't relax quite yet—"the airplane isn't done flying until it's tied down." Carefully apply the brakes to slow down, and remember that once on the ground the airplane steers with the rudders, not with the yoke - I've had otherwise excellent students "grease on" their first landing, then sit there twisting the yoke as the airplane sashays toward the edge of the runway…

…but you're too sharp for that, aren't you? Welcome to the world of fliers…and, since it's traditional to cut off a student's shirttail to commemorate his or her first solo, I hope you were wearing an old one today!

Flight Instruction

Cessna 172R
Before Takeoff Checklist*

1. Flight controls . . . . .FREE & CORRECT
2. Flight instruments (DG/Altimeter) . . .CHECK AND SET
3. Fuel quantity . . . . .CHECK
4. Mixture . . . . .RICH
(or as required for high altitude takeoffs)
5. Fuel selector valve . . . . .RECHECK BOTH
6. Elevator trim . . . . .SET for takeoff
7. Runup: . . . . Throttle 1800 RPM
8. Magnetos . . . . .CHECK
9. Suction gauge . . . . .CHECK
10. Engine instruments .CHECK
11. Annunciator panel .CHECK
(none illuminated)
12. Strobe lights . . . . .AS DESIRED
13. Radios and avionics . . . . .SET
14. Autopilot . . . . .OFF
15. Wing flaps . . . . .SET for takeoff
(0-10 deg.)
16. Brakes . . . . .RELEASE

**Note that all Final Checklists assume that you are at the end of the runway with the engine(s) running, with the sole exception of the Malibu Mirage.*

Cessna 172R - Advanced

ONWARD AND UPWARD

In this section, we're going to try a few more advanced flight maneuvers, including a potentially life-saving emergency procedure and a couple of spins; and we'll take our first, very basic, look at the arcane techniques of instrument flying.

Why do we choose to do these in the 172? In the case of spins, it's simple: of the airplanes in this release of FLY!, this is the only one in which spins are authorized. In fact, in the real world, none of the others were even intentionally spun during certification flight tests - so, to some extent, whether or not the Malibu, Navajo, or King Air would recover from a spin is a matter of conjecture; and it's a fair bet that the Hawker 800XP jet wouldn't.

As far as instrument flying is concerned, we'll cover only the very basics that a private pilot needs to know: essentially, if you fly into a cloud and lose visual reference, how to either fly out the other side or turn around without wrapping the airplane up into a spiral. We'll leave radio navigation and instrument flying for later on and bigger planes; not only are they more stable, but they have more sophisticated instrumentation that'll make your job easier.

LET'S DO THE "MUSH"

No, it's not the latest dance craze - it's a confidence builder, as well as being a good way to use up excess altitude on practice flights. As usual, we'll start out at a normal cruise; any altitude above about 2000 feet will be fine.

What would you do if you had an engine failure? You'd just pick someplace and land - after all, the airplane glides just fine, and you typically have the power all the way back at idle during the last few moments of every landing anyway.

But what about at night, or in bad weather, when you can't see the ground? Let's try a "mush," not unrelated to "flight at minimum controllable airspeed," but without power. Slow the airplane from cruise, pull the throttle to idle, and, as we get down into the white arc, extend your flaps all the way.

Now, using back pressure and trim, see how slowly you can fly. Depending on loading, you'll probably get down below 50 knots, with a rate of descent not much more than 1000 fpm.

What's important about this? Well, if you can hold this attitude and speed all the way to the ground, and as long as you have your shoulder harness fastened, the ensuing impact, even if you can't see the ground to make a more normal emergency landing, will certainly be survivable - and one you may very likely walk away from, if a bit banged up. (Unfortunately, this technique doesn't work nearly so well in airplanes bigger and faster than the 172.) Sure, the airplane will be a write-off; but, as they used to teach in the RAF, "If a prang appears inevitable, strive to strike the cheapest, softest object in the vicinity, as gently as possible." Thus, in case of an engine failure at night, we can develop the following checklist:

1. Extend full flaps.
2. Confirm fuel supply (you may just be out of fuel in one tank).
3. Slow the airplane to minimum "mushing" speed and trim for it.
4. Ensure shoulder harness is fastened.
5. Pull Fuel Cutoff knob to reduce risk of fire upon landing.
6. At about 100 feet above your best estimate of the terrain altitude, turn on the landing light.
7. If the terrain visible in front of the airplane appears unsuitable for landing - turn the landing light back off!

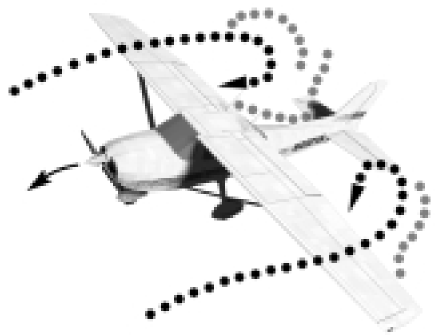
BANKING AND YANKING

We're going to take a final look at a few specialized stalls, so let's start out with the airplane cruising at a reasonable altitude - say, 5000 feet. Get it trimmed out for a gentle cruise at around 100 knots.

Roll into a steep turn, either way, and once you get the turn established, with enough back pressure to keep the nose at the right height below the horizon, add even more back pressure - and pull it in pretty briskly. Surprise! You'll hear the stall warning horn and, if you keep pulling, the airplane will let go in a fairly sharp "stall break." As it does, glance at the airspeed indicator: you're still well up into the green arc, many knots above what you've come to think of as "stall speed." Go ahead and recover to level flight.

What you've just experienced is an "accelerated stall," and what you're learning here is, once again, that the airplane doesn't have to be flying slowly to stall - it's a matter of angle of attack, not speed. Where might you run into this situation? Perhaps if you're maneuvering hard to avoid another airplane - or, in a higher-performance airplane, if you come steaming into the traffic pattern at some impressive speed, then realize you're going to have to turn hard to avoid overshooting your desired downwind leg.

Accelerated Stall in a Bank



Flight Instruction

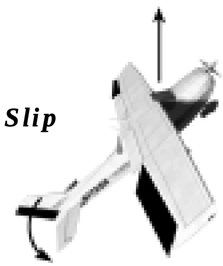
ALL CROSSED UP

Next, let's look at something that'll seem counterintuitive at first: intentionally un-coordinated flight. Thus far, we've been using the rudder to keep the skid ball centered. Now, however, we're going to use aileron one way and rudder the other to perform a sideslip.

Start a normal turn in either direction - but once it's established, feed in a footful of outside rudder. The skid ball will drop toward the inside of the turn - and, on a larger scale, so will the airplane altogether. Take a look at the VSI, and you'll see an impressive rate of descent. This is a "slipping turn," and while it feels uncomfortable - in the real airplane you'd feel yourself leaning to the inside - its' a very handy way of losing altitude.

Even more precise is a forward slip. First, let's return to level flight. Now, gently lower either wing, as if you were starting a turn - but, at the same time, feed in just enough opposite rudder so the airplane keeps going straight ahead. Actually, while it'll maintain the same track across the ground, the nose will move toward your "heavy foot," and if you could see the airplane from above, you'd see that it would be moving crabwise.

Forward Slip



This is actually a very useful maneuver in a couple of different landing situations. First of all, if you've botched your landing pattern and find yourself way high on final approach, a forward slip like this is a great way to get rid of excess altitude without building up excessive airspeed. (Be aware, however, that Cessna recommends against slips if the flaps are extended more than 20 degrees, since the displaced airflow produces an uncomfortable "buffeting" of the elevators.)

A forward slip is even more useful if you have to land in a crosswind - sooner or later you'll find an airport where none of the runways lines up with the wind! If you point the nose right at the end of the runway on final approach, you'll find yourself drifting to one side or the other. Simply making a slight turn into the wind could stop the drift - but now you're approaching the runway slightly sidewise, and touchdown in this "crabbed" position would be hard on the landing gear.

Instead, you can use a forward slip. If you like, you can start it well out on final, lowering the upwind wing enough to stop the drift and adding enough opposite rudder to keep the nose pointed right at the end of the runway. Alternatively, you can fly your final approach in a crab, then, as you cross the end of the runway, lower the upwind wing and use opposite rudder to line the nose up with the centerline (called "kicking out the crab"). Either way, just before touchdown you'll have the upwind wing lowered a bit and plenty of downwind rudder - and, if it's done right, the airplane will touch down one wheel at a time. Want to try it? Just set up the simulator environment for a brisk crosswind at the airport you're using and give it a whirl!

THE "DREADED TAILSPIN!"

That's what they used to call it in the old flying movies. Actually, a spin involves the whole airplane, not just the tail; and, unless you're a member of the Rastafarian Air Force, it doesn't have to be "dreaded" at all!

What happens in a spin? It's a stalled condition, with the airplane subject as much to gravity as to aerodynamics; but, because the stall was entered asymmetrically (in other words, the airplane wasn't flying quite straight ahead at the stall "break"), one wing isn't "quite as stalled" as the other, and is still developing some lift - not enough to keep the airplane in the air, but enough to make it rotate.

Don't panic! The docile 172 has to be prodded pretty hard to even start a spin; and, once one develops, it takes a determined effort to hold it into the stalled and spinning condition. We'll try a couple of spins, making a positive recovery from the first one - but for the second, we'll just turn the controls loose and let it recover all by itself.

In fact, the 172 is so reluctant to spin, and so eager to get itself out of the situation, that you probably can't hold it into a spin for more than 4 to 6 turns before it'll have picked up enough speed to un-stall itself and transition into a steep spiral despite your best efforts to keep spinning.

We'll want plenty of altitude for this maneuver, so let's climb (or slew the simulator, if you're impatient) up to 8000 feet. Once a spin is fully developed, the airplane will come down relatively slowly - like a sycamore seed! - but altitude loss during the entry and recovery are faster. Cessna notes that entry, a one-turn spin, and recovery can take up to 1000 feet - but a 6-turn spin, if you can get the bird to keep spinning that long, takes less than 3000.

We'll start in level cruise, with the airplane trimmed to 100-110 knots. Even though this means you'll have to pull pretty hard to get the initial stall, this trim setting will make the recovery easier. Do a couple of really solid clearing turns, because it's all downhill from here!

The airplane spins a bit better to the left than the right, because even at idle there's still some spiraling propeller slipstream. We'll do the first one that way. Ease the power back to idle and pull the nose a good 15 degrees above the horizon; we want a good, crisp stall "break" to start things off.

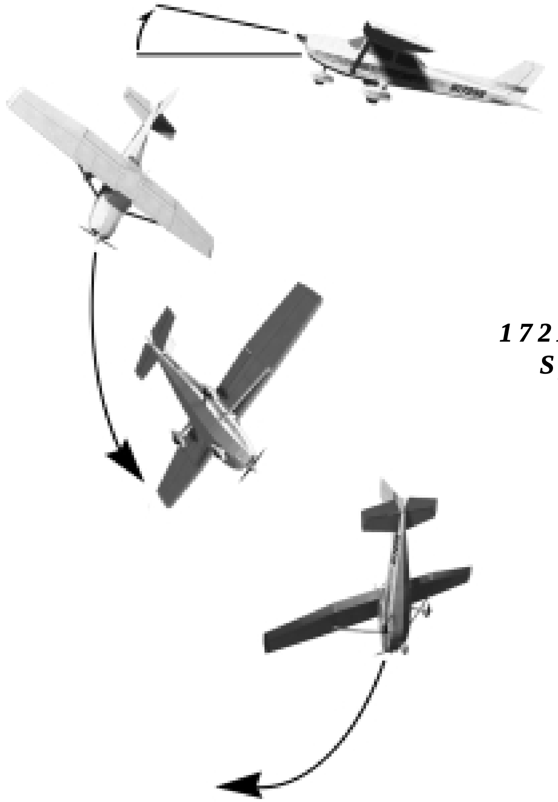
Just before the break, pull the yoke all the way back and hold it there, and smoothly apply full left rudder. Time it so that you reach full rudder just as the yoke hits the "up" stop.

As Jackie Gleason used to put it, "Awaaaay we go!" The airplane will drop its left wing hard - in fact, during the entry it won't feel like it's spinning, but rather as if it's rolling over onto its back. The bank angle may, indeed, go well beyond 90 degrees. Keep holding the yoke all the way back and keep the left rudder pedal to the floor.

You'll have a very impressive straight-down view out the windshield, and the ground will be rotating. Pick some prominent object - a road or coastline is good - to keep track of the turns. After a turn and a half, start the recovery.

The recovery is a one-two-three process:

ONE:	Smoothly apply full rudder opposite the spin.
TWO:	As the rudder reaches the stop, briskly move the yoke or stick forward until the airplane stops rotating. Airspeed will begin to increase.
THREE:	Smoothly return the rudder to center and gently recover from the dive in which you'll find yourself. Don't add power until the nose is at least back on the horizon.



172R in a Spin

Exciting, isn't it? But not really that scary. Climb back up to altitude and try another. This time, things won't seem to be happening quite so fast. You'll have time to look at the airspeed indicator; notice that it stays pretty low during the whole spin, and doesn't jump off its peg and start indicating again until you're into the recovery. Take a quick look at the turn coordinator, too: if you ever enter a spin at night, or in cloudy conditions, and don't know which way you're turning, it'll always tell you.

Let's try another confidence builder: climb back up to altitude, make a clearing turn or two, make sure the airplane is trimmed for 100 to 110 knots level cruise, and start another spin, this time to the right. At the end of a couple of turns, simply let go of all the controls, and take your feet off the rudders.

The recovery will be a lot sloppier; it'll take longer, use more altitude, and probably leave you more nose-down, with airspeed building up rapidly. But notice that the airplane managed to recover all by itself - something to keep in mind if you ever lose control at night or in the clouds and aren't sure what to do.

BANKING AND YANKING, PART 2

We've entered our spins via a gradual deceleration - but we've also learned that an airplane can be stalled at any speed. Is the same true of spins?

Yes, it is - and although the 172 isn't cleared for aerobatics, there's at least one situation that approximates the entry into an aerobatic maneuver called a "snap roll." For those of you who are flying in the real world, I should point out that this is very hard on the airplane - so, for once, "Kids: go ahead and try this at home…but not out in the real world."

Every airplane has, published among its limitations, something called "maneuvering speed." This speed changes with aircraft gross weight, and is the maximum speed at which you can "make full or abrupt control movement." Unlike stall speeds, maneuvering speeds are higher when the airplane is heavier, and there's a relationship here: the maneuvering speed is set such that if you apply full pitch control at or below the maneuvering speed appropriate for your weight, the airplane will stall (and hence unload itself structurally) before it can pull enough "G" force for permanent damage. This also means that it can hit the maximum probable gust without any structural damage.

Let's demonstrate this, once again at altitude: slow the airplane to a maneuvering speed appropriate for its weight; in the 172, this varies from 81 knots at light weight to 99 knots at gross weight. We'll use 90 knots for this demonstration.

Now, without slowing any further, briskly apply full up elevator. You might get a very brief shriek from the stall warning horn; what will happen is that the airplane will pitch up, hard, and snap a wing down equally hard (most likely to the left). Basically, you've "snapped" it into a spin - but since it still has significant forward speed, the spin goes forward instead of down.

Hold the controls fully back long enough, reduce power, and the initial snap will progress into a normal spin. Neutralize the controls, and the airplane will recover - but as to its attitude, your guess is as good as mine. Figure out which way is up, roll in that direction…

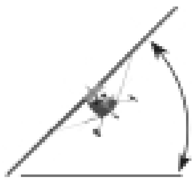
BANKING AND YANKING, PART 3

…and that brings us to the final "hairy" maneuver for the course. It's another one with a colorful name from the 1920s: "The Graveyard Spiral." (Ominous music, please…)

Back in the days before gyro instruments, airplanes that flew into even innocuous, non-turbulent clouds often came out in pieces. Those pilots who survived ("I always use Maxwell House parachutes…they're good to the last drop!") reported being unable to tell whether they were flying straight or in a turn, then losing control of the airplane. The airspeed would build up to awful values (often "off the dial,") then they'd feel huge forces pinning them into their seats until the hapless airplane started shedding its wings…

A quick demonstration will explain. As usual, get the airplane set up in cruise at a reasonable altitude. Start a reasonably steep turn, either way, but keep it less than 45 degrees. With the turn established, add more back pressure and watch the airspeed indicator, altimeter, and VSI: airspeed will decrease, altitude will increase, and the VSI will show a climb.

Level out, and roll into a turn the other way - but this time let it get steeper than 45 degrees - in fact, up to 60 degrees if you want. Again, add back pressure and watch the gauges. This time, the rate of turn increases - but airspeed either stays where it is or increases, too, while the altimeter and VSI show a rapid descent.

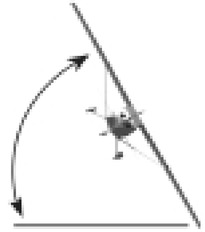


45° bank

A glance at this diagram shows what's happening: Remember, the lift produced by the wing is used both to support the airplane, and to make it turn. As long as the bank angle is 45 degrees or less, the lift is pointed "more up than sideways," so increasing angle of attack, while it may make the turn tighter, also makes the airplane climb and slow down.

At angles of bank of more than 45 degrees, however, the lift is pointed "more sideways than down," so increasing it does a lot more to tighten the turn than to make the airplane climb. Moreover, once in a steep bank, an airplane will tend to steepen the bank even further. Those old pilots, not knowing "which way was up," would instinctively pull to reduce airspeed - but, instead, they'd just wrap the turn up, tighter and tighter, until something broke (or they spiraled down into the ground).

The moral to this story? If you ever find yourself in a spiral, with the airspeed increasing and the altimeter unwinding at an alarming rate, there's a definite one-two-three sequence to recovery, just like for a spin. This works equally well whether you can see out or not:



60° bank

ONE:	Reduce power!
TWO:	Get the wings level. If you can see the real horizon, great. If not, use the artificial one - or if you don't have that, the turn coordinator. If the airplane isn't turning (little airplane in the turn coordinator level), the wings must be at or near level.
THREE:	Now - and only now - use back pressure to reduce the airspeed.

Where might this come in handy? Well, we found ourselves in spiral dives at the end of our spin recoveries a little while ago…but a more likely scenario for a spiral would be if you "let the airplane get away from you" while flying on instruments.

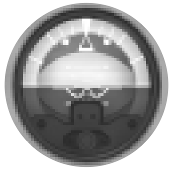
"OH, SAY, CAN YOU SEE?" or "Well, no, actually, I can't…"

Typically, you'll rack up a hundred hours or so of flying time before you start considering serious instrument flying. In the long run, you'll probably find the sought-after Instrument Rating your real "ticket to fly," since without it even the best airplane is a fair-weather friend at best. Moreover, for most private pilots, their instrument flying is what we could call "soft," or "easy," IFR. For example, a couple of minutes of instrument flying right after take-off can have you up in the sun, above the clouds and on your way, while your non-rated brethren wait hours for the clouds to burn off - and, chances are, by the time you get to your destination, the weather there will be okay. If not, of course, you can make an approach, since anyone who gets an instrument rating is trained and tested to the full requirements.

Flight Instruction

For the moment, though, we'll just look at the very basics: flying the "four fundamentals" without visual reference.

Let's start out, as usual, with the airplane in normal cruise at 5000 feet. In actual flight training, instrument students wear a gadget called a "hood," or special glasses called "foggles," that have the effect of blocking the outside view while still letting them see the instrument panel. In FLY!, it's much simpler: just hit **Shift** + **I** to activate the IFR hood.



Artificial Horizon

Your primary instrument for aircraft control is the artificial horizon, with its miniature airplane. The little airplane's wings should be exactly on the horizon when the airplane is in level cruise. If they're not, use the knob at the bottom of the instrument to adjust them. You should find straight and level flight pretty easy: just hold the "picture." Attitude control may seem a little more touchy when you can't see over the nose, but that's an illusion: nothing has changed outside the airplane.

It's when you start to make a turn that it gets more interesting: you'll find that many of the things you've been doing instinctively, like holding a little back pressure in a turn, now require conscious thought and correction. Continue to pay attention to the artificial horizon, but not exclusively. "Locking in" on one instrument is a sure way to let the others start wandering off. Instead, develop a "scan," always returning to the artificial horizon, but checking the airspeed, altimeter, turn coordinator, VSI, and gyro compass as well.

The most useful maneuver if you inadvertently fly into "instrument meteorological conditions" (IMC) is a quick 180 to get back out of them. No, make that a gentle 180 - one of the fastest ways to get into trouble is to try rapid maneuvers on the gauges. First, note your current heading on the directional gyro. Watching the artificial horizon, bank gently in the direction you want to go - 15 or 20 degrees should be plenty. Don't blindly add back pressure, but keep an eye on the altimeter (which reacts quicker than the VSI). If it starts to go down, add just a little back pressure as the turn progresses. If the little airplane in the turn coordinator - not the artificial horizon - moves its wingtip past the white index mark, you're turning too fast; reduce your angle of bank a little.

Keep checking back to the gyro horizon to monitor your bank and pitch attitude, but cross-check the directional gyro. As you approach your reciprocal heading (or as your original heading gets down to the 6 o'clock position), gently roll wings level. Your altitude and airspeed will probably have wandered off a bit; this is a good time to correct them.

Let's try a gentle descent. At this stage of the game, you might want to consider making as few changes at a time as possible, so if you only need to go down a few hundred feet, just apply gentle forward pressure until you get there, accepting the minor increase in airspeed; then level off and let the airplane find its way back to trim speed in its own time.

Let's say, however, that you find yourself trapped on top of an overcast; you've confessed your plight to a Flight Service Station, and they've informed you that if you descend on a given heading, you'll have visual conditions beneath the clouds.

Get the airplane stabilized, in cruise, on the desired heading. Now, simply reduce power a couple of hundred RPM; the airplane will start a gentle descent without your having to fiddle with the trim. About 100 feet or so above the altitude at which you want to level off, gently bring the power back up to its original setting. Let the airplane level off and find its own trim speed once again, then make small corrections as necessary.

As you become more proficient, you can start combining climbs and descents with gentle turns. We'll leave more advanced procedures for future lessons.

THE TECHNIQUE OF LAST RESORT

"A little knowledge is a dangerous thing." Many non-instrument rated pilots who've come to grief have done so because they've tried to do too much and "gotten in over their heads." Although it's not taught all that often anymore, here's a technique for a letdown through the clouds to better weather below. Ideally, of course, you'll have a full panel of instruments…but the beauty of this technique is that it's simple enough for a non-instrument pilot to accomplish with nothing more than a turn coordinator. In fact, if the air's not too rough, you can do a creditable job with nothing more than the magnetic compass!

Before descending into the clouds

1. If you have a gyro compass, turn to the desired heading. If not (magnetic compass only), turn directly East or West to minimize the compass's errors and swinging tendencies.

2. Extend flaps to the first notch; this will make the airplane more stable in airspeed.

3. Set power and trim for a descent of 500 feet per minute. Check the trim to ensure that the airplane maintains it "hands off."

Upon entering the clouds

4. Let go of the controls and fold your hands in your lap! That's right - at this point, chances are you'd do more harm than good, possibly wrapping yourself into a spiral, if you try to fly the airplane. Instead,

5. Use gentle rudder pressure only to maintain heading. Don't try to "nail" it, either; it's better to let it get off 5 or even 10 degrees than to overcontrol. Just try to even out the swings. Remember: be gentle!

When you regain visual contact with the ground, wait a few moments to make sure you're out of the clouds; then take over and fly normally. This technique works in just about any general-aviation airplane; over the years, it's saved quite a few lives. Many pilots are skeptical about it; FLY! gives you the ideal chance to try it out and prove that it works.

Not that you'll need it, of course. With the material in these lessons, you have a solid grounding in basic techniques that'll see you through the rest of your career - and the rest of the airplanes in FLY!

Radionavigation Made Simple

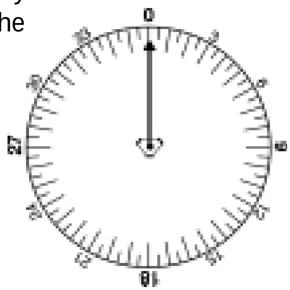
All the aircraft in this version of FLY! are equipped to utilize four forms of radionavigation: Very High Frequency Omnidirectional Range (VOR), the Instrument Landing System (ILS), Nondirectional Beacons (NDB), and the satellite-based Global Positioning System (GPS). In this chapter, we'll look at the techniques for using the first three of these; a separate chapter is provided for "the wave of the future," GPS.

VOR

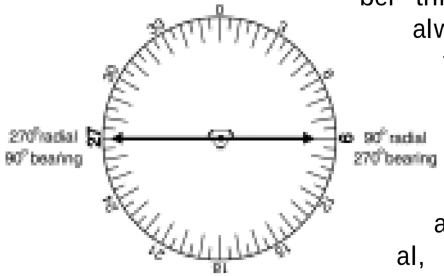
The VOR system was developed at the close of World War II. While at present it's rapidly being eclipsed by GPS, for the moment it's still the primary means of aircraft navigation in most developed countries. VOR provides the pilot with both directional, or bearing, information ("where am I in relation to the VOR ground station") and left-right guidance along courses directly toward or away from the station. A military version of VOR, called Tacan (for Tactical Air Navigation) provides distance information in addition to the directional data. In the USA, many such stations are co-located with VORs and called VORTACs; their distance information is also available to civilian users. Other stations, called VORDMEs, provide similar capabilities without the military system. In use, there's no difference to a civil user between a VORTAC and a VORDME.

RADIALS AND BEARINGS

To visualize the function of a VOR, imagine a big bicycle wheel, with 360 spokes, laid horizontally on the ground. Its hub corresponds to the location of the VOR station; the spokes, since they radiate away from the hub, are called *radials*.



As we continue to discuss aircraft radionavigation, that term, as well as its companion, bearing, will come up frequently, usually associated with a specific degree value (for example, “the 315-degree radial from Podunk VOR”). It’s important to remember this simple fact: a radial always refers to the direction from the station to the aircraft; a bearing always refers to the direction from the aircraft to the station. Thus, we can also say that for every radial, there’s a corresponding bearing 180 degrees away.



WHAT ABOUT HEADING?

Let’s go back to our bicycle wheel analogy for a moment. Imagine that each spoke has, engraved in the metal every few inches, its radial value in degrees, starting with 0 at the north. Let’s also imagine a literate ant, crawling along and among the spokes. He can read which spoke he’s on at any given moment - but he doesn’t have any way of knowing, other than running his head into either the hub or the rim, which way he’s going on the spoke.

VOR is rather similar: it allows you to directly determine your location, but provides absolutely no information about which way you’re pointed (your heading). In this respect, it’s like GPS, but exactly the opposite of the ADF (Automatic Direction Finder, which we’ll cover shortly), which can tell you your heading, but has no direct information on your location.

Thus, the VOR might indicate that you are, indeed, on the 315 radial from Podunk - but you’ll have to refer to your magnetic or gyro compass to determine which way you’re pointed (and, at least in the short term, which way you’re going). VOR stations are aligned to magnetic north, so when you look at them referenced on a sectional chart they may be rotated so that their 0 radial is rotated towards the Earth’s magnetic pole. Keep this in mind during flight, since true north does not equal magnetic north in most cases!

TO, FROM, and the VOR INDICATOR

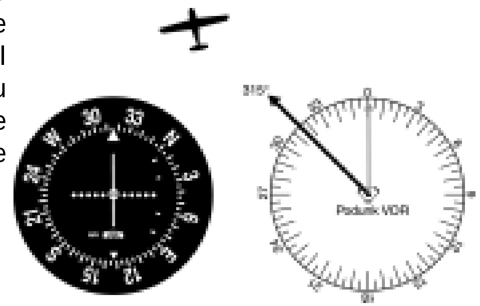
Let’s look at a typical VOR indicator (discussed in more detail in the Radio Flyer chapter). You’ll notice an outer ring with degree markings, an adjusting knob at the lower left, and a needle with a center “target” and five dots on each side.

Turning the knob rotates the ring to set the indicator for the desired bearing or radial. If the needle is centered, you’re exactly on that radial. You’ll notice, however, that if you keep turning the knob, the needle will center at two points, 180 degrees apart. One is the radial from the station, the other is the bearing to the station. How do you know which is which? By checking the indicator’s TO and FROM flags, which appear as a white arrowhead pointing up or down, respectively.

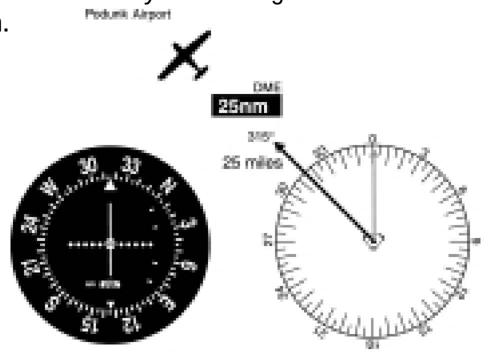
POSITION FINDING AND TRACKING:

You can use the VOR two ways: simply to locate your position (often in conjunction with Distance Measuring Equipment, or DME), or to follow an exact course directly to or from the station: tracking.

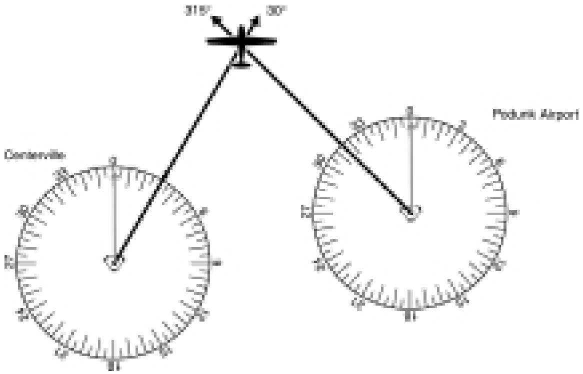
Let’s try the simplest one first. Assume you’re flying somewhere in the vicinity of Podunk and want to find out where you are. Tune in the Podunk VOR by selecting its frequency on the nav receiver (see “Radio Flyer”) and look at the VOR indicator. The needle will most likely be deflected fully to one side or the other. Turn the knob (called the Omni Bearing Selector, or OBS) until the needle centers. Now look at the TO/FROM flag. If it shows TO, continue turning the OBS; the needle will first deflect, then center once again, this time with the FROM flag in view. *The number at the top of the indicator, with the needle centered and the FROM flag in view, is the radial on which you’re currently located.* In this illustration, we’ve once again used the example of the 315 degree radial from Podunk, so you know you’re somewhere to the northwest of the station.



If you merely want to determine your exact position, there are a couple of ways to go about it. If you have DME, just make sure it's set to the nav receiver you're using and read off the distance to the station.

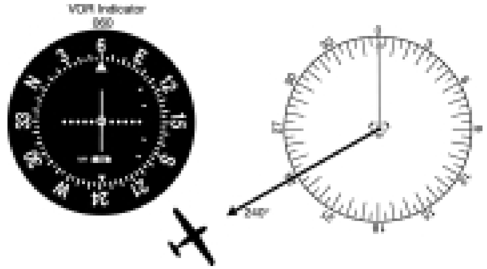


Alternately, you could take a cross-bearing from another VOR station. Let's say that Centerville VOR is somewhere southwest of Podunk. Tune your nav receiver to the Centerville frequency and, once again, center the needle with a FROM flag in view. In this illustration, you're on the 030 radial from Centerville; where it crosses the Podunk 315 radial is your exact position.

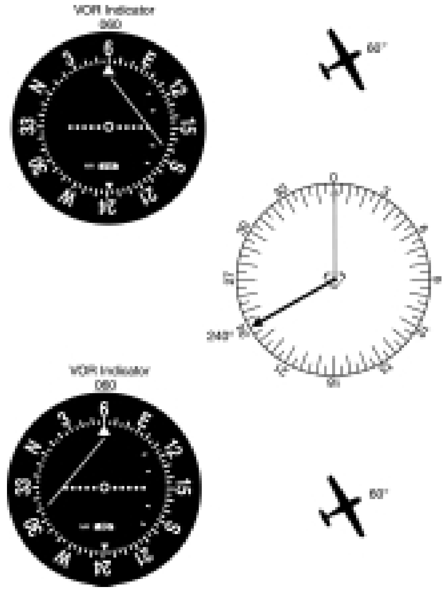


The more common use of VOR, however, is tracking, using it to fly directly toward or away from a station. Let's stick with good old Podunk once again. We're somewhere to the west of the station, and want to fly right toward it.

Once again, turn the OBS until the needle centers, but this time make sure the TO flag is in view. In this example, we're on the 240-degree radial. Since each radial is associated with a bearing exactly 180 degrees away, flying on an initial heading of 060 degrees will take us right to the station.



Why "initial" heading? Because, except in the rare case when the wind is right on our nose (or the even rarer one when it's right on our tail), if we simply hold our 060 heading, sooner or later we'll be blown off course to the left or right. In either case, the needle will deflect in the opposite direction, as seen here. The rule for VOR tracking is simple: when the needle deflects, make a small heading correction in that direction ("fly to the needle"); once it re-centers, take out about half the correction, hold the new heading, and watch the situation for a while. *Don't "chase the needle;" make a small heading correction, hold the new heading, and wait for the needle to respond.*



STATION PASSAGE

As you pass the station (right overhead if you're good or lucky, to one side or the other if you're like the rest of us), the needle will quiver a couple of times and the flag will change from TO, through its striped "barber pole" or OFF indication, to FROM. If your course takes you onward without a turn, you don't have to do anything else. If you're changing course over the VOR, set the OBS to the new radial (since you're now heading away from the VOR) and continue using the same heading correction technique.

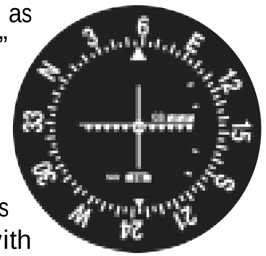
Remember: with the needle centered and the TO flag in view, the bearing to the station is at the top of the indicator and the radial from the station is at the bottom. With the FROM flag in view, the radial from the station is at the top and the bearing to the station is at the bottom.

Each dot of deflection indicates a deviation of two degrees. How much is that in the real world? It depends on how far you are from the station - after all, the "spokes" are a lot closer together near the "hub." Remember your high school trig? The sine of one degree is about 1/60 (actually, for those of you working for extra credit, it's 0.01745240643728), which gives us the useful "one in sixty" rule: at 60 nm from the station, one degree equals about one mile. Thus, if you're 60 miles out and the needle is deflected one dot, you're about two miles off course; at 30 miles, one dot equals one mile, etc.

The airways depicted on your navigation charts run from one VOR to another. Typically, you'll fly FROM the VOR behind you until you're about halfway to the next, then retune the nav receiver and fly TO the one ahead. How far out can you receive them? The FAA has "defined service volumes" for the three classes of VOR (terminal area, low altitude, and high altitude), but a simple rule of thumb, if there's no intervening high terrain, is that every thousand feet of altitude above the VOR should give you ten nautical miles' worth of good signal coverage (i.e., at 4000 feet above the station you should have a good signal at least 40 miles out).

ILS

VOR is used both for enroute navigation and for so-called "nonprecision" instrument approaches to smaller airports. At larger airports, however, you'll find a precision approach system called Instrument Landing System, or ILS. What's the difference between precision and nonprecision? Not only is ILS significantly more accurate than VOR, but in addition to providing left-right guidance, it also provides vertical guidance along the final approach glide path. As a result, ILS approaches can be made to lower weather minimums than nonprecision types - as low as a ceiling of only 200 feet and visibility of only half a mile, even for lightplanes, and all the way to touchdown for the latest jets with fully automatic landing systems.

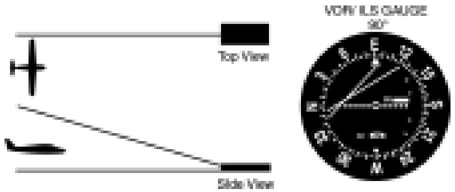


While ILS uses the same indicator as VOR, what goes on "behind the scenes" is quite different (the nav receiver switches modes automatically when an ILS frequency is tuned). While a VOR station provides radials in a full 360-degree circle around it, the ILS provides only a single course, aligned exactly with the centerline of the runway on which it's installed. (During ILS use, the OBS knob and compass ring are not functional; however, it's a good idea to set in the inbound ILS course just as a handy reminder.) While the VOR indicator's full deflection represents 10 degrees either side of the desired course, the ILS's horizontal guidance component, called the localizer, is much more sensitive: it's set between three and six degrees, depending on the runway on which it's installed, such that at the runway threshold full deflection equals only 350 feet off the runway centerline.

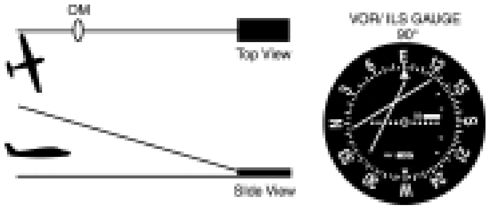
The other major component of the ILS is the glideslope. Essentially, it's a localizer "turned on its side" to provide precise vertical guidance down the glide path (set at 3 degrees above the horizontal at most installations). It's even more sensitive than the localizer; at the runway threshold, full deflection indicates only about 50 feet above or below the correct glide path.

Finally, most ILSs have a couple of *marker beacons*. These are very small transmitters that send a short-range signal straight up to activate both audio tones and colored indicator lights on your instrument panel. The outer marker is generally about five miles from the threshold. As you cross over it, you'll see a blinking blue light in sync with a low-pitched "boop, boop, boop" tone. The middle marker is about half a mile from the threshold, and it emits a "dit-daahhh, dit-daahhh" signal in sync with an amber panel light.

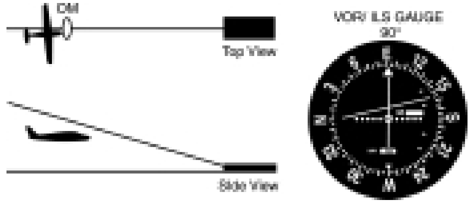
The skills you'll use to fly an ILS are essentially the same as those for a VOR, except that now you have to do them in three dimensions (and quite a bit more precisely). Where, before, you simply watched the "fly left" or "fly right" indications of the VOR needle, now you also have to follow the "fly up" and "fly down" (or, more accurately, "descend shallower" or "descend steeper") indications of the glideslope needle. Let's work our way through a typical ILS final approach.



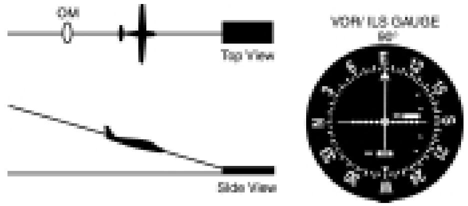
Once again, we're at Podunk - in this case, on the ILS for runway 09 at Podunk Municipal. Approach control is vectoring us onto the final approach course from the southwest, and we're at an altitude of 1500 feet. Since we're well to the right of the localizer, the needles are telling us "fly left," and since we're well below the glideslope, they're also telling us "fly up." We'll just continue to hold our assigned heading of 045 degrees and our assigned altitude of 1500 feet.



Now we're beginning to intercept the localizer and we've been cleared for the approach. As the localizer needle "unpegs," we'll turn to the inbound heading of 090 degrees, making small heading corrections as necessary to center the needle and keep it there. Here, even more importantly than with VOR, it's vital *to fly heading, rather than chasing the needle.*



At the outer marker, the glideslope is about 1500 feet AGL, so as we approach the marker the glideslope needle will start creeping down from its full "fly up" indication. As it nears the center, we'll adjust aircraft configuration and power to start following it down. Just as it's important to fly headings, and not chase the localizer needle, it's important to establish a stable rate of descent on the vertical speed indicator, correcting as necessary with small changes in power and pitch attitude, rather than "chasing the glideslope."



As we continue down the approach, the needles will become more and more sensitive - make your corrections smaller and smaller to keep pace. At the middle marker, the glideslope is about 200 feet above the ground - right at minimums, so if you don't see the runway at this point, initiate the missed-approach procedure. A common error, with the runway in sight, is to "duck under" the final segment of the glideslope. Don't do it! Just "hold what you've got," and you'll touch down about 1000 feet in from the threshold with plenty of runway left on which to decelerate and stop.

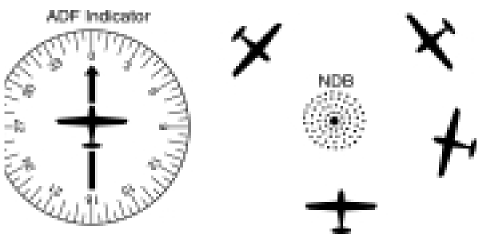
THE BACK COURSE

The localizer and glideslope are exactly aligned for use with only a single runway. At some airports, however, the localizer's "back course" can be used for a nonprecision approach to the other end of the same runway, landing in the opposite direction. There are only two significant things to remember about such a back-course approach:

1. Since the OBS is not functional and the localizer provides only a single course signal, you can't set the indicator to "work the other way" as you could on a VOR. Thus, when on the back course, you must make your corrections by turning away from the needle rather than toward it. (If you're lucky enough to have an HSI - see "Radio Flyer" - you can fly normally as long as you keep its course arrow set to the front course value.)
2. The back course approach provides no vertical guidance. Although the glideslope needle may deflect due to local reflections, these are false signals and must be ignored.

NDBs and the ADF

Your airplane is equipped with a further navigation radio, called an Automatic Direction Finder (ADF). Actually, this unit is better described by its old-fashioned name of "Radio Compass." Just as a magnetic compass points toward magnetic north, the needle of the ADF will point toward simple ground stations called Nondirectional Beacons, or NDBs. Thus, unlike a VOR, the ADF can tell you your heading with regard to the station, but not necessarily where you are.

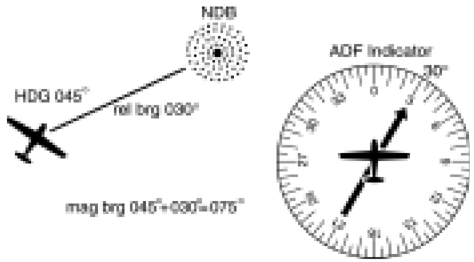


Note, in this illustration, that each of these airplanes is in a different location - but the ADF indicator would appear as it is shown in all of them.

In addition to this ambiguity, the ADF is inherently less accurate than a VOR. In recent years it's fallen into disrepute, supplanted largely by GPS. In fact, it probably would have disappeared entirely in the USA were it not for its one redeeming feature: in addition to the low-frequency NDBs, it can also receive (and, for that matter, point at) commercial AM broadcast stations - a feature much appreciated on long, boring flights, particularly during the World Series or NFL playoffs! It's also still a primary basis for navigation in the developing world, largely because an NDB ground station is orders of magnitude simpler, easier to maintain, and cheaper than a VOR.

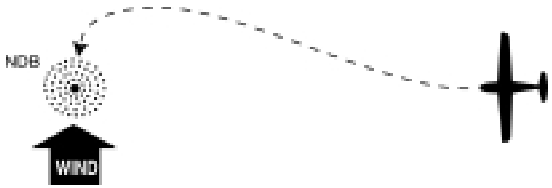
IT'S ALL RELATIVE

Absent any other information, the only thing you can tell from the ADF is the relative bearing to a station - starting at 0 if it's right in front of you, going to 90 if it's at your 3 o'clock position, 180 if it's right behind you, etc. To determine where you are in relation to the station, and which way you have to fly to get to it, you need to combine this relative bearing with your current compass heading to get a magnetic bearing. For example, in this illustration our heading is 045 degrees magnetic. The relative bearing is 030 (the station is 30 degrees right of the nose), so its magnetic bearing is 075 degrees - our heading plus the relative bearing. That's the heading we'd have to turn to if we wanted to fly right over the NDB.

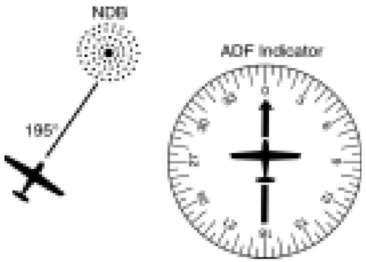


HOMING AND TRACKING:

The easiest way to get to an NDB is simply to “home” on it: just turn the airplane until the needle points straight ahead, and keep it there.

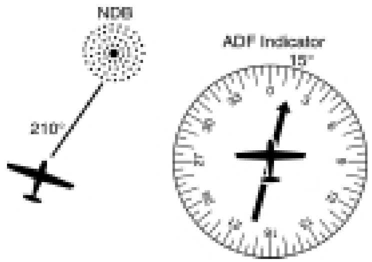


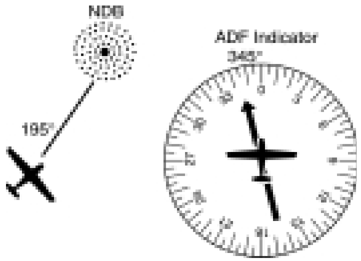
Unfortunately, this won’t give you a straight track across the ground. Instead, the wind will push you one way or the other. As you keep turning to keep the station straight ahead, your heading will change. If you started at any significant distance from the station, you’ll invariably end up approaching the station directly into the wind.



Instead, determine the magnetic bearing to the station by adding the relative bearing to your compass heading. (If the result exceeds 360 degrees, just subtract 360 - for example, if you’re heading 345 and the relative bearing is 030 for a total of 375, subtract 360 to get the correct magnetic bearing of 015.) Now turn to the magnetic bearing; the needle should initially point straight ahead.

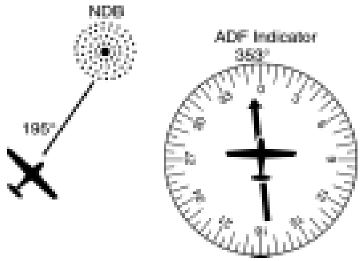
Next, hold that heading, and watch the needle. Unless you’re very lucky, it’ll gradually start to drift to one side or the other, indicating that you’re being blown off course.





If you were to just turn until you were pointed right at the station again, you’d merely be homing again. Instead, turn until the needle is as far on the opposite side of the zero index as it has drifted. This should gradually bring you back to the correct course, at which point the needle will have moved even farther to the opposite side.

Now take out about half the correction. Continue to fly this new heading, making further refinements as necessary.



DON’T LIKE ARITHMETIC?

The constant mental calculation of relative and magnetic bearings has been the bane of ADF flyers for years, but there are some ways around it.

Perhaps the simplest is to just visualize the ADF needle superimposed on your directional gyro (DG). If it’s pointing 45 degrees right, for example, just look at your DG and note the number under the 45-degree “tick mark;” that’s the magnetic bearing to the station.

A small step up in complexity are more modern ADF indicators with a movable, rather than fixed, compass rose. Just twiddle the little adjusting knob to set your current magnetic heading at the top of the instrument, and read the magnetic bearing to the station directly from the needle. (You can also read your radial from the station under the tail of the needle.)

Finally, fancier airplanes (including the Malibu Mirage, Navajo Chieftain, and King Air B200 in this release of FLY!), have an instrument called a Radio Magnetic Indicator, or RMI, that does all the work for you. Described in greater detail in the "Radio Flyer" chapters, it has a compass card that's automatically synchronized with the airplane's gyrocompass. VOR signals can also be displayed on the RMI; thus, at a glance you can see your current bearing to, and radial from, either VOR or NDB stations.

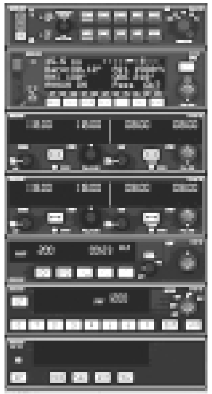
Radio Flyer
Part 1

Glance around the cockpit of just about any modern general-aviation aircraft, and the first impression is "there are sure a lot of knobs and dials." As you get around to flying the aircraft, you'll soon find that there are relatively few instruments you'll focus on for guidance in actually maneuvering the machine. Many of the other instruments, and a lot of the remaining panel "real estate," is taken up with the ship's radio installation - the electronics you'll be using both to communicate with ground controllers and other airplanes, and to locate your position and find your way through the sky.

Indeed, it's modern radio equipment that has made even light general aviation aircraft so useful and practical. Originally, the radio equipment required for instrument navigation - i.e., finding your way by some means other than looking out the window at the ground - was so large, heavy, and expensive that only airliners and the largest multi-engine corporate aircraft could use it. Now, with lightweight, transistorized equipment that can be mounted right in the instrument panel (instead of in big remote equipment racks), even the lightest single can have navigation and communication capabilities surpassing those of airliners of just a few years ago.

Much of today's radio equipment is somewhat standardized; while the appearance and some features of different manufacturers' radios may differ slightly, just about all general aviation radios are 6 $^{1}/_{4}$ inches wide, so they'll fit in the standard radio "stack" in the center of the panel. All the piston-powered aircraft in this version of FLY! use the excellent radios from the Bendix-King division of AlliedSignal, and they all have the same basic installation, even if some use different indicators. In addition, the Cessna 172R has room for its entire complement of radios in a single tall "stack," while those in the Malibu and Navajo Chieftain are divided into two shorter ones.

COMMUNICATIONS



Your airplane is equipped with two KX-155A “nav-comm” radios. The name indicates that each radio incorporates both navigation and communications functions; in fact, for all practical purposes each of these units comprises two completely separate systems, one for navigation and one for communications.

The left side of the radio is the “comm” side. It displays two frequencies: the “active,” the one actually in use, at the extreme left side of the unit, and the “standby,” or preselected frequency, to its right. In normal use, frequency selection affects only the standby frequency; the outer knob changes whole megahertz (mHz), while the inner knob changes the figure to the right of the decimal in steps of .05 mHz. If you need to tune one of the more recent “split” frequencies, in steps of .025 mHz, pull the inner knob out, then turn it.

To make your new setting the active frequency, push briefly on the double-headed arrow button to the left of the tuning knob. The standby and active frequencies will “flip-flop;” thus, the former active frequency is now maintained on the standby side in case you need to change back to it quickly. It’ll be overwritten next time you make a frequency input.

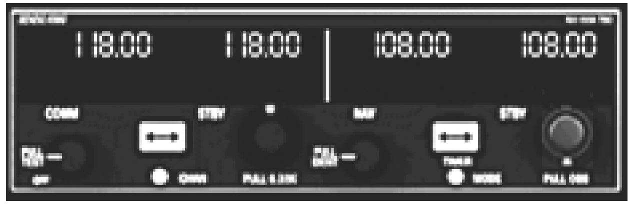
ADVANCED OPERATION

The comm radio can be preset to store often-used frequencies in a series of preset “channels.” To program these, press and hold the small white “chan” button for two seconds. The unit will now display a flashing channel number, indicating that the channel can be programmed.

Select which channel number you want to enter by turning the inner knob. Then press the double-arrow transfer button; the standby frequency will flash, and can be changed by using the inner and outer knobs in the usual fashion. Press the transfer button again to store the frequency and, if you wish, select another channel to program. When you’re done programming, press the “chan” button again to return to normal operation and save all the channels you’ve loaded.

To use your prestored channels, press briefly on the “chan” button. The inner tuning knob will now scroll through the preset channels, displaying them in the standby frequency window. When you reach the one you want, press the double-arrow transfer button to make it active.

VOR NAVIGATION



The right side of each KX-155 is the “nav” side, and while it operates in conjunction with a separate nav indicator in the panel, it can also display navigation information directly.

ADVANCED OPERATION

Like the comm side, the nav side of the KX-155 has some nifty extra features, accessible via the little white “mode” button below the frequency display.

Don’t want to use the VOR indicator (or, perhaps, it’s in use by another unit like the GPS receiver, of which more later)? Push the mode button once, and the standby side of the nav frequency display changes to an electronic OBS which can be set by pulling out the inner nav frequency knob, while an electronic version of the left-right CDI needle appears below it.

You can still change back and forth between the active and “blind” standby frequency using the double-arrow transfer switch; and as long as the inner knob is pushed back in, you can tune the active frequency directly. Tune a localizer frequency, and the letters LOC appear in the OBS area. If the received frequency for either VOR or a localizer is too weak, the word “FLAG” will appear and the “needle” of the electronic CDI will disappear.

Want to know your bearing "TO" the VOR station without all that laborious OBS-knob twiddling? Push the mode button again, and the standby frequency display will change to your current bearing, complete with the word "TO." Another push and the same thing happens, except now you see the radial, and, appropriately enough, the word "FROM." In either of these modes, if the signal is too weak, the display changes to a line of dashes.

Another push of the mode button gets you a very fancy stopwatch, which starts counting up as soon as you enter this mode. To stop it and reset it to zero, hold the frequency transfer button for a couple of seconds. Subsequent pushes on the transfer button start and stop the stopwatch.

But wait! There's more! When you've reset the stopwatch to zero, you can use the frequency knobs to preset times and use it as a countdown timer, very handy for instrument approaches. Left/Right click the knob to change minutes. Double click the knob to toggle minutes and seconds. Left/Right click the knob to change seconds. Now, pushing the frequency transfer button will start the timer counting down from the preset value.

A final push of the mode button gets you back to the basic frequency-select mode. The stopwatch, if running, will keep on doing so; you can refer back to it any time with four quick pushes on the mode button. Since both the #1 and #2 nav-comm radios have this feature, you have two separate stopwatches at your disposal - for example, one might be monitoring how long it's been since you took off, while the other might be counting down to remind you to switch fuel tanks later on.

TRANSPONDER

While the transponder doesn't tell you a whole lot, it tells the world around you - specifically, air traffic controllers - some things it's very important for them to know.

Specifically, it tells the rest of the world two things: who you are, by the numerical code you set into it; and, since ATC's radars see in only two dimensions, how high you are, by electronic information it gets from your altimeter and transmits to the ground radars every time they sweep past you (and "interrogate" your transponder, if you want a fancy technical buzzword).

Its controls are very simple. Transponder codes consist of four digits, from 0000 (which is never used) to 7777 (also never used); the archaic computer brains of the FAA can't recognize any digit larger than 7. When you're assigned a specific code by ATC (typically, as part of an instrument clearance or during a conversation with a controller when you want to enter controlled airspace), just punch it in using the buttons. The "CLR" key can be considered a "backspace" if you make a mistake.

Of course, often you'll be flying in visual conditions without talking to any controllers at all. There's a standard VFR transponder code for this, 1200 - and rather than having to punch it in every time, just hit the "VFR" button and it'll be set automatically. Often, the first time you talk to a controller, you'll be using this code, and to help pick you out from all the other VFR traffic, he or she will ask you to "squawk ident." This makes your blip light up specially on the screen; to do it, just hit the "IDT" button (which, despite what your instructor may say, does not stand for "idiot").

Finally, there's the big mode selector switch on the right side of the unit. The "OFF" position - surprise, surprise! - turns the whole thing off altogether. "SBY" is a standby mode, in which the unit is powered up but not responding to interrogations. It's considered good form to "squawk standby" when on the ground, supposedly to prevent cluttering up controllers' scopes around the airport; but in the real world, their equipment automatically "disappears" any targets moving at less than flying speed anyway, so you might as well ignore it. "TST" tests all the functions of the equipment and lights up all the segments and legends on the display.

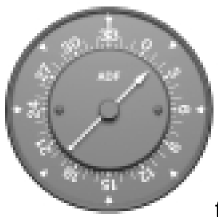
"ON" is what you'd expect to be the normal mode, but they've pulled a fast one on you here: since current regulations require all aircraft to have not only the transponder but the altitude reporting equipment as well, your normal operating mode will be "ALT." In this mode, the "raw altitude," or flight level, being reported to the ground stations will be displayed on the left of the transponder.

Note that this will not necessarily correspond to your altimeter reading unless the local pressure is 29.92 in. Hg. and you've set the altimeter accordingly; it could be a couple of hundred feet off either way if the local altimeter setting is particularly high or low. (ATC's computers automatically take this into account). More likely, the only time you might use the "ON" position is if your altitude encoding system is way off, in which case the controller will tell you to "stop altitude squawk."

You might want to remember a couple of specific squawk codes, too. The emergency code is 7700, one to punch in anytime you're in real trouble (for example, an engine failure or other inflight emergency). Somewhat less frantic is 7600, the code to use when you've lost radio communications but are otherwise OK. If you can still receive but not transmit, controllers will often transmit to you "blind," asking you to acknowledge by pressing your "ident" button.

Finally, and relatively unlikely considering that this is a simulator, 7500 is the international code indicating "I've been hijacked, but don't really want to talk about it right now because someone is shoving the nasty end of an AK-47 into my ear."

ADF (Automatic Direction Finder)



Although the Bendix-King one installed in our airplanes is a very nice modern unit, the ADF overall is actually a pretty archaic piece of equipment, dating from the 1930s. Also called a "radio compass," the ADF can point its needle at any low-frequency station it can receive. In a sense, it's exactly the opposite of the VOR: while the VOR can show you where you are, but not which way you're pointing, the ADF can show you which way you're pointing, but not necessarily where you are. The ADF indicator has a movable compass card, which can be set by the knob at the 7 o'clock position. If you set your actual heading at the top of the dial, the head of the needle indicates the present bearing from you to the station, while the tail of the needle shows the radial from the station to you…but if you want it to read correctly, you'll have to reset it every time you change your heading.

None the less, it has its uses. As you get deeper into the arcana of instrument flying, you'll find approaches based on non-directional beacons (NDBs), and unless you have an approach-qualified GPS receiver and an appropriately published "GPS overlay" approach chart, you'll need the ADF. Moreover, should you ever lose the services of your directional gyro (due perhaps to a vacuum failure, or one of the instrument itself), the ADF can provide a heading reference that's much more stable in rough air than the "whiskey compass" up in the windshield.

Last but far from least, among the stations that fall within the tuning range of the ADF are regular AM broadcast outlets. Not only does this provide a very simple way of navigating if your destination is a town large enough to have a halfway powerful AM station - you can also listen to it! Many ADFs in high-performance airplanes gather dust except during the World Series playoffs or the Superbowl.

The Bendix-King ADF used in FLY! has standby and active frequencies that work exactly the same way as for the nav and comm radios. It also has a stopwatch that works the same way as the ones in the KX-155s, so now you have three timers at your disposal - say, one to show how soon you'll reach the next checkpoint, one to show when to switch fuel tanks, and one to remind you when to open your brown bag flight lunch. In fact, you really have four, since the ADF also has a flight timer that starts when you turn on the radio power (in fixed-gear airplanes) or when you lift off and retract the gear in folding-roller ones. The FLT/ET button switches back and forth between the two timers; in ET mode (it stands for "elapsed time," not the little leathery guy who was always trying to phone home), the SET/RST button starts and stops the timer or, when held in, lets you preset it for count-down use, just like the ones in the comm radios.

GLOBAL POSITIONING SYSTEM (GPS)

It's really a sign of the times that even the most basic airplane in FLY! - the "lowly" Cessna 172R - now comes with a GPS as standard equipment. Only a few years ago, GPS was considered a highly exotic (and extremely expensive) system for worldwide navigation, suitable only for the heaviest bizjets. Now that you can buy a basic handheld version at Wally World for a couple of hundred bucks, it's also become the de facto navigation standard for new light aircraft.

There are some very neat things about GPS: since it's based on satellites, rather than ground stations, it works anywhere in the world. And since it's digital, its remarkable accuracy - within 300 feet at worst, and generally much better - remains the same anywhere you use it. In normal mode, one dot of deviation (either on the GPS's own display or on a CDI connected to it) represents one mile off course, whether you're a thousand miles from the waypoint or right on top of it.

FLY's airplanes use the Bendix-King KLN-89 GPS. With the exception of the 89B extensions, almost all of the system's features are implemented in FLY! The displays you'll find yourself using most often (and which are implemented here) are the four "NAV" pages. The first gives you the name of the waypoint you're flying to, an electronic CDI, numeric displays of both the desired track or DTK - the course you should be flying to get to the waypoint - and the actual track, the course over ground that you actually are flying at any given time, groundspeed, and time remaining until you get to the waypoint.

The second nav page shows your present position, both in latitude/longitude and as radial and distance from a nearby navaid (usually a VOR or airport). The third page shows present time, the time you took off, the time you'll arrive at your final destination, and how long you've been flying. The fourth page is a very simple schematic moving map. In FLY! - alas, not in real airplanes - you can also "pop up" an actual FAA Sectional Aeronautical Chart, complete with a symbol showing your position, by hitting the "NumLock" key.

There are a few other GPS functions of which you should be aware. You needn't bother with the GPS's flight plan pages, on which you can enter up to 25 different pre-stored flight plans with departure, intermediate, and destination waypoints; in FLY!, the flight plans you set up in the simulator's Flight Planner are automatically transferred to the GPS. On the other hand, if you ever get in trouble on a flight and want to get down fast, hitting the GPS's "NRST" key will bring up a display of distances and bearings to the nearest airports.

Overall, the system's functions are easy and interesting to explore, and use the same conventions for input and output from one page to another. To move from one page - which you might consider like a chapter in a book - to another, turn the large outer knob. A little "dash" at the bottom of the display will indicate which page you're in at any time. Within each page are sub-pages, accessed by turning the small inner knob. The name of the master page, and number of the sub-page (for example, "NAV 3") are always displayed on the left side of the display.

If you need to enter data, hit the "CRSR" key to turn on the cursor; the affected field will "reverse out," showing black characters on an orange background instead of vice versa. Now the large outer knob moves the blinking cursor to the position of any character you want to change, while the small inner knob scrolls through the available characters. When you've input the correct information, hit the "ENT" key to enter it. If you make an error, the key marked ">CLR" works like a backspace.

One area where you'll often be entering data is in conjunction with the "direct to" key - the one that has a capital "D" transfixed by an arrow. Hit that key, and the GPS will request that you enter a waypoint (often your destination airport). Once it's entered and and you've confirmed it with the "ENT" key, the unit will automatically switch to "nav" mode and display distance, bearing, and track to that point, whether it's a few miles away or halfway around the world. In addition to being displayed on the GPS itself, the left/right steering portion of the nav display can be switched to show up on the #1 nav indicator, where it can be "seen" by the autopilot as well as by you.

Finally, several of the available pages have so-called "cyclic fields," blocks of data marked with the caret or "hairpin" (>). This indicates that you have a choice of what data to display in this field. To change it, turn on the cursor using the CRSR key, then turn the outer knob until the desired field "reverses out." Now hit the ">CLR" key. The field will change to something else - for example, from GS (groundspeed) to BRG (bearing). Each successive push of the >CLR key will offer another choice until you've seen all that are available. When you've "customized" the display to your liking, push CRSR again to turn off the cursor and store your choice.

Don't panic! There is more detailed information on the GPS later in the GPS Appendix (pg. 265).

AUTOPILOTS, or, "Let George do it…"

It's another sign of the times that even an airplane as basic as the 172R has an autopilot - as do all of the airplanes in this release of FLY! We'll go into more detail about individual autopilots as we work with each airplane, but, again, we can make some general statements here that apply to all the systems.

The 172's simple autopilot is a "single-axis" system. This means it can steer the airplane from side to side (using the ailerons) and even track navigational radios, but control of altitude, climbs, or descents, is always left to the human pilot. The more sophisticated systems in the Malibu Mirage and the Navajo Chieftain can control altitude as well, and even execute creditable ILS approaches, while the top-line systems in the Beech King Air and especially the Hawker can literally fly the airplane from take-off to touchdown, regardless of weather.

All of these systems have "lockout" logic that won't let you engage them unless they've satisfactorily passed their preflight test on the ground. And while they differ widely in capability, their various modes (if available) have the same nomenclature regardless of which airplane you're flying.

The "basic autopilot" mode will hold the airplane's wings level (and, in every airplane larger than the 172, will also attempt to hold the pitch attitude present when the autopilot was engaged). Even this seemingly simple function can be remarkably valuable, especially if you're (a) on instruments and (b) busy - say, trying to look at a map or tune a radio at the same time. The FAA feels so strongly about autopilots that they won't even allow a single pilot to carry passengers for hire in instrument flight conditions unless the airplane has a functioning autopilot - and during his or her semiannual check flights, that pilot has to show the FAA that he or she knows how to use the autopilot in all its modes.

In the 172, the autopilot also provides a valuable backup. Although its more sophisticated modes depend on the directional gyro, it can still provide its basic wing-leveling function if the gyro or its vacuum pumps fail.

In the heading mode, annunciated "HDG," the autopilot will hold an actual heading, preselected by setting the "bug" on the directional gyro to the desired value. On the larger airplanes, the simple directional gyro is replaced by a multifunction instrument called a Horizontal Situation Indicator (HSI); it's described in the next chapter.

In the navigation mode, annunciated "NAV," the autopilot will follow the course set in the navigation indicator - whether the information is coming from a VOR receiver or the GPS. In the 172, the heading "bug" must be set to the same value as the desired course; in the larger airplanes, this value is set by a second knob on the HSI.

Finally, there are a couple of approach modes. The basic mode, annunciated "APR," functions the same way as "NAV," but is more sensitive to allow greater precision as the airplane nears a runway. A modified mode, annunciated either "REV" (for "reverse") or "BC" (for "back course"), is used only on a few special non-precision approaches that use the "wrong side" of an ILS localizer to approach the opposite end of the runway normally used for an ILS. This mode has the same sensitivity as "APR," but reverses its responses to needle displacement since the airplane is flying "the wrong way" on the approach.

All of these are "lateral modes," in which the autopilot guides the airplane from side to side. The airplanes larger than the 172 have autopilots that also incorporate "vertical modes." The simplest, already mentioned, simply holds whatever pitch attitude existed when the autopilot was first engaged. Altitude hold, annunciated "ALT," will hold the aircraft at a specific altitude above sea level - the altitude at which the "ALT" feature was engaged on the more basic units, while the more sophisticated autopilots will allow you to preset the desired altitude on an external dial, and can control the airplane to climb or descend, then level off automatically at the desired altitude.

Last, but sometimes far from least at the end of a long day in nasty weather, these autopilots, when in "APR" mode on an ILS, can capture and follow the ILS glideslope on final approach. Fly up to the final approach fix at the right altitude and with the airplane configured for the descent, and when the "APR CAPTURE" and "GS CAPTURE" lights come on, just extend the gear, reduce power if necessary, and wait for the runway to show up in the windshield; even in the Malibu Mirage or Navajo Chieftain, the autopilot should be able to get you down as close as 200 feet above the ground, and within half a mile of the runway threshold, before you have to take over and land visually. In the Hawker, the "magic brain" can take you all the way to touchdown.

ALL THESE RADIOS...

With this much equipment even in a “simple” 172, you need some way to select which of the many radios you’ll listen to and talk over. The gadget that allows you to do this is at the top of the radio stack, and is called an “audio selector panel.”

Compared to most of the other gear, it’s pretty simple. The marker beacon receive is particularly important; most ILSs, and a few other airways and approaches, use very simple low-powered radio transmitters, pointing straight up, to advise pilots when they’ve passed a given point. These signals not only produce audio tones, but light up the blue outer (O), orange middle (M), and white inner (I) marker lights on the audio panel.

The double row of ten switches selects which of the various receivers you’ll hear in the headphones or, in FLY!, the cabin speaker (always selected in the simulator). Pushing any of these switches so that its little green indicator bar lights up selects that source to be heard; note that you can listen to as many receivers at once as you care to. The selector at the right of the panel chooses which transmitter you’ll speak over. In the airplanes in FLY!, only the COM1 and COM2 positions are active for transmission. NAV1 and NAV2 can be used to listen to morse code ID of tuned Navaid and MKR can be used to turn on/off the marker beacon audible signal.

The Mirage: "Every bit as sophisticated... as business turboprops."

Piper Malibu Mirage

INTRODUCTION

If you're coming into the Malibu Mirage right out of the Cessna 172R, you've covered the entire range of current single-engine airplanes in one grand leap. You've gone from one of the simplest and most basic of all airplanes to the Malibu Mirage: certainly the most advanced and complex single-engine civil aircraft in current production, and arguably the most advanced in its class ever built. The Malibu Mirage is every bit as sophisticated, in terms of systems, equipment, and capability, as business turboprops. Indeed, while we're concerned here with the piston-powered version, you can even buy a turboprop Malibu Mirage--either the new "Meridian," right from Piper, or a conversion package for existing Malibu Mirage airframes.

For all that, though, the Malibu Mirage is still a single-engine airplane (albeit, in the eyes of the FAA, both a "complex" and a "high performance" one); the basic skills you learned in the 172 are entirely applicable to this airplane as well. Even the operating speeds aren't all that different, particularly in the landing pattern. True, the Malibu Mirage can cruise at well over 200 knots--but it's optimized to do so at high altitude, where the indicated airspeeds may be only around 135 knots (this is the reason for its relatively long, narrow, sailplanelike wings). There are, however, a number of additional systems to learn about; those, and their management inflight, are some of the main subject material in this chapter. In addition, we'll use the Malibu Mirage as our platform for further exploration of the arcane world of instrument flying; and some of its more sophisticated navigational instruments are described in the second "Radio Flyer" section of this manual.

FOLDING ROLLERS

Obviously, one of the main differences between the Mirage and the 172 is that the Malibu Mirage has retractable landing gear. For many pilots, their first flight in a retractable-gear airplane is a real milestone, their first move into the world of complex and high-performance machines. Insurance companies, too, seem to take retractable gear very seriously, at least in terms of how much experience they want you to have before they'll turn you loose in a retractable airplane without adult supervision.

That being said, however, there's nothing particularly magic about retractable gear. If you were to forget to retract the wheels after takeoff, the airplane would fail to realize much of its normal performance, but there would be no damage to anything but the pilot's ego. Forget to extend them before you land, however, and the results will be considerably more impressive. It's been said that there are only two kinds of pilots: those who will someday make a gear-up landing, and those who have already. It's also said that if you're not sure you've landed gear-up (and this may be more applicable to FLY! than in the real world), a sure clue is that it will take much more power than usual to taxi.

Basic operation of the gear is about as simple as you can imagine: retract it after you take off and please, please, extend it before you land! There are a few fine points, however.

WHEN TO RETRACT

The airplane will climb a lot better once the gear is "in the wells," but if there's any chance of its settling back to the ground - for example, a premature heavyweight takeoff on a hot day - it's awfully nice to have those wheels down there! Airline procedure is for the captain to call for gear retraction as soon as the copilot verifies, from the altimeter and VSI, that the airplane is climbing strongly and calls out "positive rate." Lacking a copilot, we can use a much simpler criterion, and one particularly useful in case of an engine failure in this single-engine airplane: leave the gear down until there's no longer enough runway ahead to land on, then retract it. **Do not exceed** 126 knots airspeed until the gear has been retracted.

When you move the landing gear handle to the "up" position, a number of things happen. The electrically-powered hydraulic pump runs, and the amber "HYD PUMP" indicator on the annunciator panel illuminates. The three green "down and locked" lights next to the gear handle go out as each wheel unlocks and begins to retract, and the red "GEAR WARN" annunciator light illuminates. When the gear is completely retracted, both GEAR WARN and HYD PUMP lights will extinguish. There are no mechanical uplocks; inflight, the gear is held in the retracted position by hydraulic pressure trapped in the system. In the event a hydraulic leak or failure allows one or more of the gears to "bleed down," the red GEAR WARN light will illuminate.

WHEN TO EXTEND

The simplistic answer, of course, is "before you land, dummy!" But there's more to it. In addition to its primary function, the gear serves a very valuable secondary one: allowing you to control descents with airplane configuration and drag, rather than only by power reduction. As we'll see when we start examining the engine in detail, rapid, large power reductions are very hard on the engine; in many cases, it's better to make only a small power reduction, achieving the additional required descent rate by adding landing gear, flaps, or both.

This can also simplify instrument flying. On a typical approach using the instrument landing system (ILS), for example, you'll be flying level to the final approach fix, then descending along the glideslope. If you have power set for level flight at a reasonable approach speed with gear up and approach flaps extended, dropping the wheels at the final approach fix will give you just about the right rate of descent with no additional power reduction--one less task at a time you're already pretty busy!

You can also use the gear for drag if you need to get down from high altitude in a hurry--for example, if you have a cabin pressurization problem while cruising up in the 20,000-feet-and-up range. (Bear in mind that the airplane's oxygen system is only good for 15 minutes of use.) You can extend the gear at any speed up to 165 knots; but once it's down and locked, you can go right up to 195 knots, only 3 knots shy of the airplane's 198-knot redline. At that speed, with the gear down, the Mirage will come down like the proverbial greased piano.

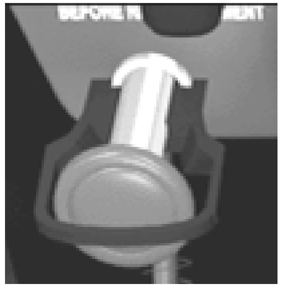
When you select "down" on the gear handle, what happens is essentially the reverse of the retraction sequence: the HYD PUMP and GEAR WARN lights come on, and remain on until all three green lights have illuminated to indicate that their respective gears are down and locked (the downlocks are integral parts of each wheel's hydraulic actuator).

LANDING GEAR WARNINGS

The red GEAR WARN light will also illuminate, accompanied by an annoying horn, to warn the pilot under certain circumstances: any time all three wheels aren't down and locked and either (a) the throttle is retarded below about 1/3 power, or (b) the flaps are extended beyond 10 degrees.

LANDING GEAR MALFUNCTIONS

If you ever lower the gear and don't see the reassuring glow of "three greens," don't panic. In fact, as any experienced Piper pilot will tell you, the first thing to check isn't even part of the gear system as such: it's the panel light dimmer switches, below the control yoke. If the DAY/NIGHT switch happens to be in the NIGHT position, the lights will be on--but so dim you can't see them!



Emergency Landing Gear Handle

What if it's a real problem? Still "no biggie:" the gear handle will already be down. Slow the airplane to 90 knots or less (to make it easier for the nose gear to extend against the slipstream), then pull the red emergency gear extension knob just below and to the left of the normal gear handle. Don't be shy--it takes about a 25-pound pull. This will dump the hydraulic pressure holding the gear up, and all three units will extend by gravity (assisted by springs). Yaw the airplane from side to side a couple of times to help the main gear extend and lock. To restore the system to normal operation, push the emergency control back in, and the gear can be retracted normally.

PRESSURIZED CABIN

As you've seen, the landing gear system is as close to a "no-brainer" as you'll find on this airplane. The pressurization system runs a close second. Although the idea of a pressurized cabin may seem to be pretty heady stuff, it's nowhere near as complex as it was in the days of the great piston-powered airliners like the Constellation, Stratocruiser, or DC-7.

Basically, high-pressure air supplied by the engine's turbochargers is first cooled, then fed into the cabin. The pressurization system has no control (other than on and off) over the rate at which this air enters the cabin; instead, it controls pressurization and cabin altitude by regulating the rate at which the air flows back out, through a pair of pneumatically controlled outflow valves at the back of the cabin.

Most of the time, you'll use only one control: the pressurization controller on the instrument panel. Its outer ring of numbers indicates the altitude, in thousands of feet, at which the system will attempt to maintain the cabin; the inner ring indicates the highest airplane altitude at which the system can maintain that cabin altitude. The knob at the lower left controls the rate at which the cabin altitude climbs and descends; leaving it at about the 9 o'clock position will provide your passengers with comfortable rates (no "ear popping").

For a normal flight, set the cabin altitude at 500 to 1000 feet above your takeoff altitude before departure. Once you have things squared away for your climb, set the controller to 500 to 1000 feet above your landing altitude, or to your cruise altitude plus 1000 feet on the inner ring of numbers, whichever is higher. If you've had to use this latter technique, reset the controller to 500 to 1000 feet above your landing altitude as you start your descent.

Just below the controller is a triple indicator showing cabin altitude, cabin rate of climb or descent, and differential pressure - the difference, in pounds per square inch, between the air inside and outside the cabin. A glance at this will reveal how carefully the structure of a pressurized airplane must be designed. For example, assuming that each cabin window has an area around one square foot, at the maximum normal differential pressure of 4.5 psi, it has to withstand a force of some 650 pounds. Each half of the windshield has to withstand close to a ton!

PRESSURIZATION SYSTEM FAILURES

There are only two ways the pressurization system can fail: "not enough" or "too much."

In the first case, you'll notice a higher cabin altitude than what you've selected; if the cabin gets much above 10,000 feet, the CABIN ALT annunciator will illuminate. Check that the controller is set properly, the pressurized air dump valve control is pushed all the way in, and the PRESSURIZE/DEPRESSURIZE switch is in the PRESSURIZE position; if that doesn't cure the problem, you have no choice but to descend, donning your oxygen mask if the situation warrants.

The "too much" situation is somewhat more insidious, since there's no warning light--and how many of us spend a lot of time looking at cabin pressure in cruise? It's also highly unlikely, since even if the pressurization system loses control over the outflow valves due to some malfunction, the valves themselves will passively vent overpressure at 5.6 psi. Still, a significant overpressure could pose a real hazard, since it could cause structural failure of the fuselage.

The cure is easy: pull the pressurized air control to its RAM position, flip the pressurization switch to DEPRESS--and hang on to your ears! At this point, the airplane will depressurize very rapidly–as before, descend, donning your mask if necessary.

EMERGENCY DESCENT

As we'll cover when we look at the engine, a rapid major power reduction is hard on the engine--but when you need to get down, fast, to avoid losing consciousness, it's no time to scruple. It's highly unlikely that the Mirage will be cruising at an indicated airspeed higher than 165 knots--so pull the power to idle, drop the gear, and stuff the nose down until you approach 195 knots. The airplane will come down like a rock; once you've gotten the descent going, you need to fiddle a bit with the fuel mixture to keep the engine running smoothly. When you get to a "breathable" altitude, level off, retract the gear, and set an appropriate cruise power.

THE POWERPLANT

Perhaps the most significant difference between the Mirage and the 172, and certainly the most significant in terms of how you'll operate and fly it, is its magnificent turbocharged, intercooled engine and its constant-speed propeller. We'll address them first separately, then together:

THE ENGINE

Like the 172, the Mirage has an Avco-Lycoming engine, and there's a family resemblance among all the "Lycs." The 172's 160-hp four-cylinder engine is an IO-360, meaning that it's fuel-Injected, its cylinders are horizontally Opposed, and it has a displacement of 360 cubic inches. Using the same notation, the Mirage's 350-hp six-cylinder TSIO-540 is TurboSupercharged, fuel-Injected, horizontally-Opposed, and has a displacement of 540 cubic inches. Notice the relationship in displacement? Just about every cylinder Lycoming has ever built since the fall of Carthage has had a displacement of 90 cubic inches. While there are differences in detail design, the Lyc boys basically put together engines by adding more and more 90-cu.-in. cylinders, all the way up to a monster eight-cylinder IO-720.

In this era, when products from computers to hair dryers have "turbo" modes, it's worthwhile to take a moment to describe a real "turbo." It's short for "turbosupercharger;" the Mirage engine has two of them, one for each bank of three cylinders (primarily because two little ones fit better into the cowling than one big one).

Each turbo consists of a turbine and a centrifugal air compressor, linked on a common shaft. The turbine is driven by exhaust gases, thus powering the compressor to compress the engine's induction air, the air supply that will be mixed with fuel and burned in the cylinders. It's almost "something for nothing," which is why the first turbochargers, in World War II, were sometimes called "bootstrap turbines," after the legendary Baron Munchhausen, who claimed to be able to fly simply by pulling himself up by his own bootstraps.

One reason turbos didn't appear until World War II is that they had to wait for the development of sufficiently advanced alloys. If you could see under the Mirage's cowling at cruise power and altitude, you'd find the whole exhaust system, and both turbos, glowing anywhere from cherry red to a cheerful orange. Even the compressor side gets pretty warm, which is why a large intercooler is installed to reduce the temperature of the induction air before it's ducted to the cylinders.

Why go to all this trouble? Because, as we gain altitude, the air gets thinner and thinner; by 18,000 feet, the atmospheric pressure is only half of what it is at sea level. This is both good and bad: if the air is thinner, airplanes can slip through it with much less resistance; but there's also a lot less air for engines to "breathe," so they lose power.

With a turbo, however, we can feed the engine "thick" sea-level air, by way of compression, while the airplane slips rapidly through "thin" high-altitude air. A side benefit, in the case of the Mirage, is that the turbos give us a supply of sea-level air for cabin pressurization.

You may have noticed flying the 172 that it took more and more throttle to maintain a desired RPM and airspeed as altitude increased. I say "may" because most pilots climb the 172 at full throttle. This is the case with any non-turbocharged, or normally-aspirated, aircraft. The Mirage, however, has an automatic controller that regulates how much exhaust flows through the turbos to spin them; thus, once you've set the throttle for the desired power setting, there's no need for further adjustment as you climb or descend.

THE PROPELLER

You'll also have noticed, in the 172, that any time you changed your airspeed, the engine would speed up or slow down without your touching the throttle. This is because the 172 has a simple fixed-pitch propeller. It's like driving a car with a manual transmission that's locked in one gear: the engine speed has a direct relationship with how fast you're going down the road.

The Mirage, however, like other high-performance airplanes, has a variable-pitch constant-speed propeller, which is much more like an automatic transmission. It allows the engine to turn at the most efficient or appropriate speed for a given flight condition, regardless of the airplane's airspeed at the time. For example, for takeoff, it's desirable to run the engine at as high an RPM as possible. This allows the maximum amount of air and fuel to run through it over time, so maximum power is available.

For climb, a somewhat lower RPM is appropriate. Once leveled off in cruise, the lowest possible RPM that allows the engine to produce the required level of power is desirable--primarily because engines and propellers are most efficient (in terms of miles per gallon, rather than maximum power) at lower RPMs, and secondarily to reduce both inside and outside noise.

Thus, the Mirage has two main power controls, and two main power instruments: the throttle, which controls how much fuel/air mixture gets into the cylinders (and which is set by reference to the Manifold Pressure Gauge, of which more in a moment), and the propeller control, which controls the RPM at which the engine operates, and which is set by reference to the tachometer.

It does this by varying the pitch, the angle at which the propeller blades meet the oncoming air. They're like the threads on a screw: in the low pitch, or "high RPM" position, each turn of the propeller moves the airplane only a little way forward, as if the "screw" had very fine threads. In high pitch, the "low RPM" position of the propeller control, the blades take a bigger "bite" of air with each turn, and move the airplane forward faster; the "screw" is a very coarse-threaded one. I know that the relationship between high pitch/low RPM and vice versa is confusing at first; the Brits describe it much more rationally, as "coarse" and "fine" pitch.

Let's stick with the image of a wood screw a moment longer. Imagine you're driving two screws, a coarse one and a fine one, into the same seasoned block of oak. It'll take a lot more force to twist the screwdriver when you're driving the coarse one; the fine one will drive a lot more easily, although it will take many more turns to get it screwed in the same distance.

It's the same in the air. When you set the prop control (the blue handle on the power quadrant) for a desired RPM, you're actually setting a hydraulic governor on the engine that, in turn, meters oil to the propeller hub to set the blades at the correct angle. If you increase either airspeed or engine power, the propeller will try to speed up; the governor will automatically adjust the blades to a coarser pitch, making the propeller "more difficult to turn," to maintain RPM. Similarly, if you slow up or reduce power, the governor will sense the RPM beginning to decrease and will "fine off" the blades to maintain the correct value. The governor also has minimum and maximum set points. With the prop control all the way forward, the engine will run at its 2500 RPM redline if there's enough power available; if not (for example, at low power on the ground), the blades will go to the fully-fine position and will act as a fixed-pitch propeller. The minimum set point corresponds with the bottom of the green arc on the tachometer.

ENGINE OPERATING TECHNIQUE, PART 1: Power Settings and Changes

Power setting for high-performance piston airplanes are almost always expressed in terms of a pair of numbers: the manifold pressure, or throttle setting, and the RPM, or propeller setting--for example, "35 in. Hg./2500 RPM." What's an "in. Hg.?" It's an inch of mercury, an ancient measure of air pressure dating from the days when pressure gauges were vertical glass tubes full of quicksilver. (Does the measurement seem familiar? It's the same unit, at least in the USA, that you'll find for altimeter settings; normal sea-level pressure is around 30 in. Hg.)

The rule of thumb to avoid overstressing an engine (rather like the "lugging" you feel if you try to drive up a steep hill by flooring your car in too high a gear) is that when making a power increase, you increase the RPM first, then the manifold pressure. Power decreases go exactly the other way: manifold pressure first, then throttle. As a reminder, you can use the mental image of "Propping something UP" and "Throttling something DOWN." (For small power changes within the cruise regime, you may often find yourself changing only one control without moving the other at all.)

ENGINE OPERATING TECHNIQUE, PART 2: Mixture Control

There's a third handle on the power quadrant, with a red knob. (The 172 has a similar control.) This is the fuel mixture control, which sets the ratio of fuel and air flowing into the cylinders.

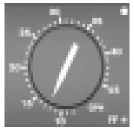
How come cars don't have one? Three reasons: one is that unless you're driving in the Andes or the Himalayas, cars operate over a fairly limited altitude range. Even then, you'll notice a significant loss of performance driving in the mountains; and, if you're going to confine all your driving to higher altitudes, you can have your car's carburetor set for a leaner mixture by changing fuel jets.

Another is that modern cars have electronic fuel injection systems. Somewhere in the bowels of such systems are hundreds of angels, dancing on the head of a pin to set the fuel mixture exactly right for the right altitude. But those angels need electricity, and sometimes they get tired, or confused, and you have to pull over to the side of the road. That's harder in an airplane. The manually-controlled Bendix continuous-flow fuel injection system used even on the Mirage's sophisticated engine is crude--but, barring contaminated fuel (or the problem, common to all airplanes, of their inability to manufacture more fuel inflight when needed for longer-than-planned flights), there's almost nothing that'll make it quit working.

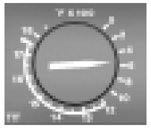
Finally, most light aircraft engines are called "air-cooled," and, indeed, they are--at cruise power. If, however, their cowlings and cooling fins were big enough to handle their cooling needs at takeoff and cruise power, the hapless pilot would have a hard time seeing past them. Not that it would be much of a problem, since there'd be so much drag the airplane couldn't fly, anyway.

Instead, at high power settings, aircraft engines are run at much richer fuel mixtures than optimum, allowing the excess unburned fuel to carry away the additional heat. (Pollution? Don't even ask...) At high power, they're not just air-cooled; they're fuel-cooled as well. Car engines, by contrast, can run at much higher internal temperatures, because they have heavy water-cooling systems to carry off the excess heat.

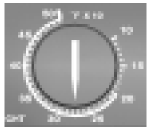
You have three instruments to set the correct fuel mixture in the Mirage: the fuel-flow indicator, the turbine inlet temperature indicator (TIT), and, to a lesser extent, the cylinder-head temperature indicator (CHT).



Fuel Flow



TIT



CHT

Takeoff and initial full-power climb are always performed with the mixture control in its forwardmost full rich position. Typically, for a cruise climb, the throttle and prop control are set for the desired power setting and the mixture is pulled back until the fuel flow indicator shows the correct value as set out in the pilot's operating handbook (for example, 35 in.Hg./2500 RPM/32 gallons per hour).

You can use a similar technique for cruise power setting, but the handbook values are, of necessity, very conservative. Once at cruise power, you can set the mixture more accurately by referring to TIT. It will reach its maximum, or "peak," when the ratio of fuel and air is exactly optimized. Piper's operating handbook authorizes operation at peak TIT for all cruise power settings up to a limit of 32 in. Hg/2500 RPM. How much more efficient is this than setting by fuel flow? Well, although we've only reduced power 3 in. Hg. from the climb setting, fuel flow has dropped to 20 gph--more than a third! Another reason that these lean fuel flows are authorized for cruise, rather than for climb, is that now airspeed is higher, so more air flows through the cowl to cool the engine.

How do you set it? Get the airplane leveled off and trimmed correctly for cruise, set cruise power, wait for engine temperatures to stabilize and then slowly start leaning the mixture while watching the TIT. It will rise to a peak, then begin to drop off again. Note the peak, and when it starts dropping, enrich the mixture until it's back at the peak value.

ENGINE OPERATING TECHNIQUE, PART 3: "Take care of your engine, and it'll take care of you."

Compared to the "bulletproof" normally-aspirated engine on the 172, the Mirage's TSIO-540 is a high-strung thoroughbred--after all, its displacement is only 50% bigger, but it produces more than twice as much power under very demanding circumstances.

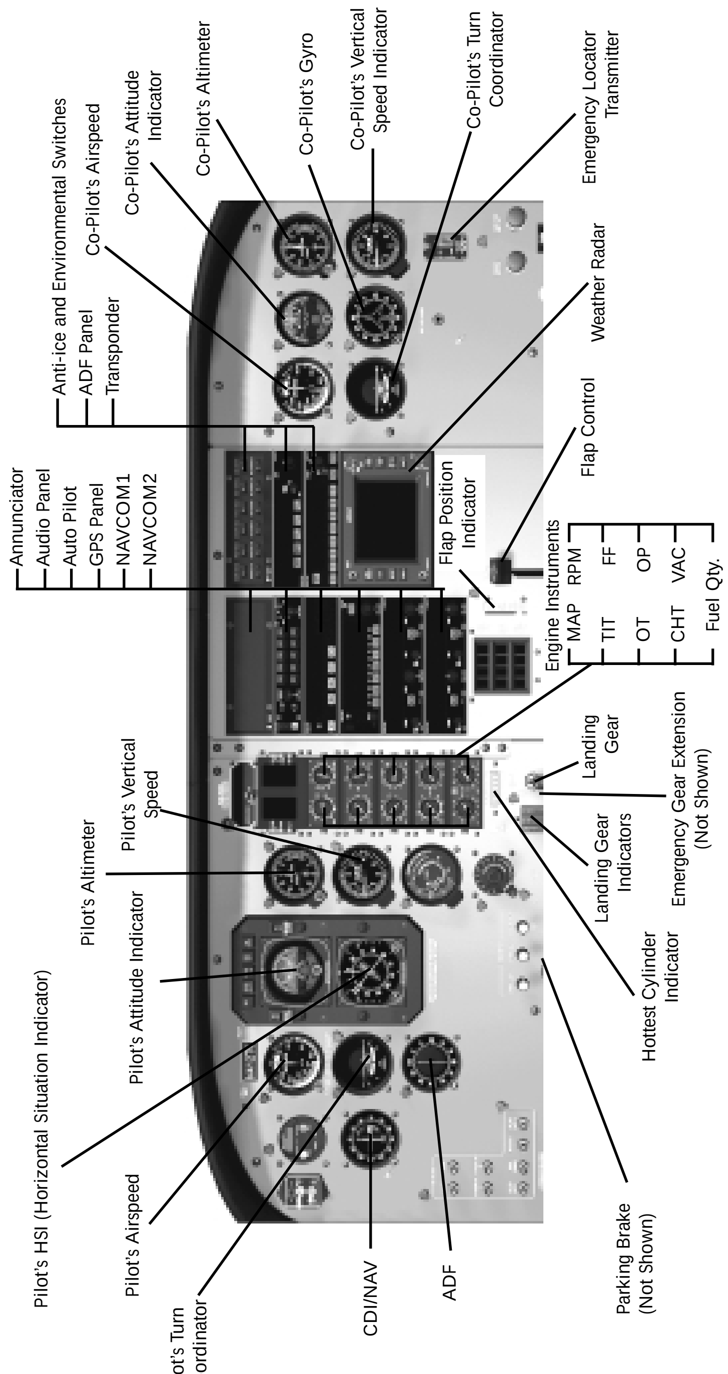
You'd think the enemy of such an engine is heat, but that's only part of the problem. The real culprit is temperature change, especially if it's rapid--and a lot more aircraft engines are damaged (cylinder head cracking, etc.) by cooling them off too fast than by overheating them.

This usually occurs during descents: you've reduced power, so the engine isn't developing as much heat as it was, while at the same time your airspeed has increased, so that more cooling air is moving through the cowling. There are, however, several easy steps you can take to minimize the ill effects.

One, as mentioned before, is to use aircraft configuration and add drag for descent, rather than simply pulling off the power and stuffing the nose down at "Warp speed." It may look weird to extend the landing gear at 20,000 feet (admittedly, a severe case), but no one is watching anyway.

Another, and perhaps the most important, is to reduce power slowly. A pretty good rule of thumb is "don't pull off more than one in. Hg. of manifold pressure per minute," although in a pinch--say, if ATC wants you to get down "right now"--you can pull off two inches, then wait two minutes. Try to adhere to this rule until you get down to about 55% power or less--and keep an eye on your CHT gauge, striving to keep it at least above the bottom of the green arc.

Finally--and this is the one that most pilots seem to ignore, especially when they're new to high-performance flying--don't be in any big hurry to enrich the mixture as you descend, particularly in turbocharged airplanes. If your fuel injection system is working right, the mixture you've used for any cruise power setting will be adequately rich for that or any lower power setting. There's no reason to enrich it, which wastes fuel as well as overcooling the engine, until you're down near the ground, where you might need a richer mixture for a go-around or missed approach...and by that time, you should be configured for approach and slowed up so there isn't as much of that nasty cool air blowing over the cylinders.



Mirage Cockpit

Flying the Malibu Mirage

Welcome aboard the Malibu Mirage! Settle down in the cockpit and look around, and it'll seem at first as though there's a lot more going on than in the 172. Sure, there is more, but not all that much...and, as you start to glance around, you'll see some familiar old friends.

SAME OLD "SACRED SIX"

The primary flight instruments are almost exactly the same as they are in the 172 (in fact, over on the copilot side of the panel, they are exactly the same). The only difference on the captain's side is that the directional gyro has been replaced by an extremely handy device called a Horizontal Situation Indicator (HSI). For a more detailed description, check the Radio Flyer Part 2. Another additional instrument, the Radio Magnetic Indicator (RMI) is also described in that section.

WHAT'S UP

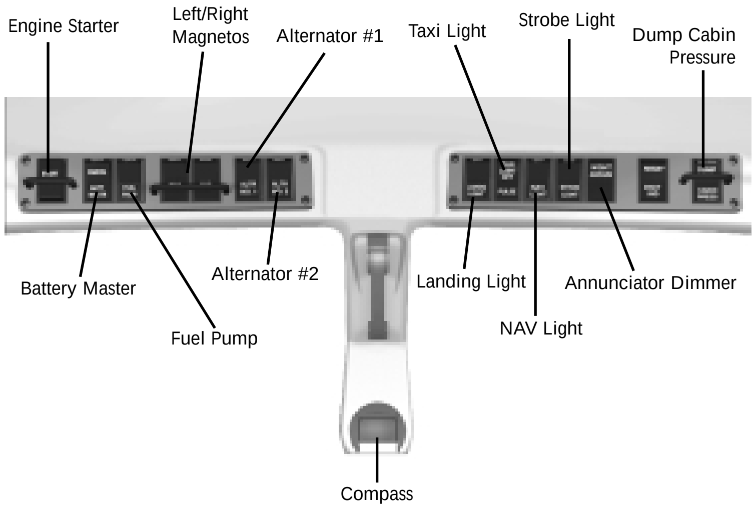
One thing you'll notice in the Mirage is that some of its most important electrical switches, including the battery master and the magnetos, are arranged across the top of the windshield. This is partly an effort to save instrument panel "real estate," and partly an effort to give it a "big airplane" feel, like the overhead panels you'll find in an airliner. Even low-time pilots hear the refrain from "The High and the Mighty" and see those four imaginary gold rings on their sleeves when they have to fiddle with stuff in the roof...never mind that by the time a real airline pilot has reached the eminence where he's flying something big enough to have a complex overhead panel, he's probably so old he needs special trifocals, with an additional near-vision segment at the top, to make sense of it!

SimTip

Use **Ctrl** and the arrow keys to look around inside the cockpits.

Malibu Overhead Switches

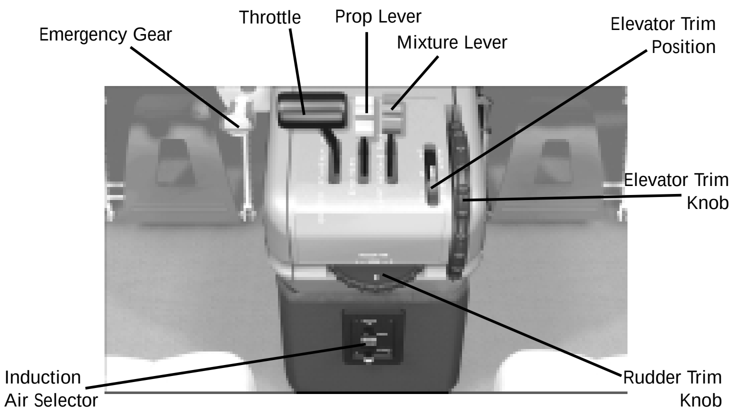
(use* Ctrl *+ Up Arrow to see overhead)



Another big-airplane touch is the power controls: hefty multi-engine style levers in a center console, rather than little plungers sticking out of the instrument panel. Since this airplane has enough power to make holding right rudder in a prolonged climb tiresome, it has rudder, as well as elevator, trim; both trim wheels are on the center console.

Malibu Floor Panel

(use* Ctrl *+ Down Arrow to see floor panel)

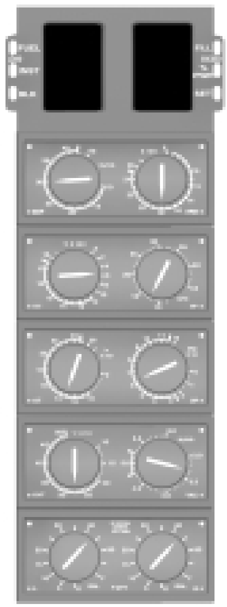


DUAL SYSTEMS

While the Mirage has a single engine, it's a very reliable one; and if you analyze the history of problems encountered by single-engine airplanes, it's often the failure of some ancillary system, rather than the engine itself, that caused the difficulty. Thus, the Mirage not only has dual vacuum pumps, it also has a multi-engine style "split" electrical system, with two completely separate belt-driven alternators on the engine. Circuit breakers are on the left and right sidewalls, while digital ammeters for each alternator, and a single voltmeter, are on the lower center panel. Above it, there's a dual-width avionics stack with room for everything up to, and including, weather radar (its antenna is carried in a bomblike pod under the right wing).

ENGINE INSTRUMENTS

The Mirage uses state-of-the-art electronically-driven engine instruments, arranged in two vertical rows just to the right of the primary flight instruments. These instruments are somewhat smaller than standard ones, but since they're operated electronically, they're linked with a digital readout to allow extremely exact readings. Red lights next to each indicator will illuminate if critical operating limitations are exceeded, and the extent and duration of each limitation is recorded and stored.



The digital readout display is at the top of the engine instrument stack and has left and right windows, each showing two lines of data. When the system is first powered up, the top lines of the left and right windows show TIT and fuel flow. The two lower lines show manifold pressure and RPM.

The top two circular instruments, reading from left to right, are the manifold pressure and tachometer. This is logical, since they're arranged the same way the power levers are. Also, since these are the two engine instruments that you'll be using most, the lower two digital display windows, directly above these two vital gauges, are permanently dedicated to them. High-resolution digital readouts of any of the other gauges can be obtained by pushing the button next to the gauge. The readout will appear in the top window of the appropriate side, while a green light next to the gauge will indicate which one is being displayed digitally.

The two gauges in the second row are both affected by the mixture control. From left to right, they are Turbine Inlet Temperature (TIT) and fuel flow. Pushing the button to the left of the TIT gauge brings up its fine-resolution digital display in the top of the left window at the extreme top of the stack. The digital display for fuel flow is a bit more sophisticated. Pushing the button to the right of the fuel flow gauge brings a digital readout, in gallons and tenths per hour, into the top right window.

However, pushing the "FUEL" button at the top of the stack will bring up, on successive pushes, how much fuel is aboard; how long, in hours and tenths of hours, that fuel will last at the present rate of consumption; and how much fuel has been consumed since takeoff. In the actual airplane, this unit can be preprogrammed with the amount of fuel onboard before takeoff. In FLY!, the amount is automatically transferred from the fuel loadout you enter on the aircraft setup screen. The other function available in the top digital display is a readout of outside air temperature (OAT), brought up by pushing the lower button next to the right window. Accurate knowledge of OAT is important when calculating true airspeed and correct power settings.

The third row contains the oil pressure and oil temperature gauges; the fourth, cylinder head temperature (CHT) and the vacuum system gauge. The CHT normally indicates the hottest of the six cylinders, annunciating which one it is by illuminating one of a row of six lights just below the engine instrument stack. A switch marked CHT CYCLE below these lights lets you "step" through the cylinders manually. The vacuum gauge indicates vacuum in the system as a whole; if either of the two vacuum pumps fails, automatic valves keep the system running while a legend in the annunciator panel lets you know which pump has become disinterested in further toil.

Finally, the bottom row has gauges for the left and right fuel tanks (60 gallons each). Unlike the Cessna, the Mirage doesn't have a BOTH position on its fuel selector (located at the bottom of the instrument panel); it's up to the pilot to switch back and forth between the tanks. Maximum permissible imbalance is 10 gallons (60 lbs); if it's exceeded, the FUEL IMBALANCE light will come on in the annunciator panel as a reminder to switch tanks. An easy way to run the fuel system, assuming you're starting out with a balanced fuel load, is to take off and climb on the left tank, keeping track of fuel consumed, then switch to the right one after you've burned 10 gallons (or as soon as the FUEL IMBALANCE light comes on). This should be right around the time you level off at cruise altitude; and since the airplane burns about 20 gph at cruise, you can now just switch tanks every hour and know that the two tanks will always be within 10 gal or less of each other.

ICE PROTECTION SYSTEMS

Anyone who's spent the big bucks for an airplane like the Mirage - a new one will set you back somewhere slightly on the wrong side of three quarters of a megabuck! - doesn't just want it to be a fair-weather friend. Unlike most other singles (even most high-performance ones), the Mirage can be equipped so it can be flown legally in known icing conditions. Controls for the ice protection systems are at the top of the right-hand radio stack.

There are four separate systems. Three of them, operated electrically, can be used as de-icers (i.e., to get rid of ice once it's formed), but are better employed as anti-icers, to prevent it from forming in the first place! The propeller blades are heated electrically, turning on and off on a 90-second cycle; you can monitor them on the small ammeter marked PROP AMPS. The windshield heat has HI and LO settings. Two further switches provide heat to the pitot tube and the stall warning vane on the left wing.

The other system, providing ice protection for the wings and tail, has to be operated as a de-icing device, i.e., it can't prevent ice from forming, but can get rid of it once it has. This surface de-ice system has rubber "boots" along the leading edges of the wings and tail surfaces. Once 1/4 to 1/2 inch of ice has formed, pushing the SURF DEICE switch will cause these boots to be sequentially inflated with air from the output side of the vacuum pumps, thus cracking the ice off.

Note that if you cycle the boots with less than 1/4 inch of ice, you might just "puff up" the ice to the point where the boots cycle uselessly underneath it. More than 1/2 inch, and the ice might be too tough to crack off, so you need to keep an eye on it. At night, the switch marked ICE LIGHT turns on a light on the left side of the fuselage to light up the left wing leading edge for you. If you ever notice an inexplicable loss of performance, and you're flying in a cloud at any temperature from freezing down to about –20 deg. C, check to see if some of the cloud is sticking to your airplane! (At lower temperatures, any moisture in the air is usually already frozen before you get there.)

LET'S FLY!

We're going to make a single, fairly lengthy, checkout flight in the Mirage - about the same kind of thing you'd get if you were an experienced pilot being exposed to the airplane for the first time. Assuming you have little or no retractable-gear or constant-speed prop experience, we'll devote a little extra attention to that; and we'll finish up with a couple of ILS approaches at San Francisco International (SFO), one flown by the autopilot and one by you.

STARTUP

The engine starts a bit differently from that of the Cessna. Check that the fuel selector is in the L or R tank position. When you turn on the master (battery) switch, you will activate the fuel booster pump in the selected tank. There's no separate switch for these pumps; they're turned on automatically by the fuel selector.

Crack the throttle about half an inch. Check that the mixture is pulled all the way aft (idle cutoff); now turn on the emergency fuel pump. Push the mixture in for about three seconds if the engine is cold, one second if it's warm; now pull it back to ICO (Idle Cutoff) and turn off the emergency pump.

What you've just done is primed the engine, allowing a small amount of fuel to collect in the intake manifold. Now set the parking brake, check that both magnetos are turned on, and press the starter. As the engine cranks, the STARTER ENGERGIZED annunciator will come on. As the engine starts, check that the light goes out and that the oil pressure starts rising. The gyro instruments will dance around as they come up to speed. Check that both ammeters indicate a charge and that no abnormal annunciators are illuminated. Turn on the avionics master.

Flight Instruction

Once you've taxied to the active runway, we'll do a slightly more complicated pre-takeoff check than we did in the Cessna. Remember our CIGARS mnemonic? Now we have a similar, but new, one: CIGAR-TIP.

C, as before, is Controls. Check for freedom and correct movement.

I, as before, is for Instruments: engine instruments reading properly, with manifold pressure, RPM, TIT, and fuel flow showing in the top digital display; altimeter set; HSI showing the correct heading; and artificial horizon erect and steady.

G, as before, is for Gas - correct amount onboard, fuel gauges verified, fuel selector on the fuller tank, and, for the moment, emergency pump OFF. (We'll use it as a backup for takeoff and landing, but let's leave it off during the runup as a check that the mechanical one is working properly.)

A now stands for Avionics - considering that this is a complex airplane that will probably often fly in an instrument environment, let's make sure our nav and comm radios are properly set before takeoff. For this flight, since we'll be practicing ILS approaches, tune to the ILS at the airport you're using. In addition, the autopilot won't engage until it's run through its self-test cycle once, so hit its test switch now.

R stands for Runup, but this time it's more of a general reminder to do one; we're actually going to do it in a bit more detail a couple of letters further in our mnemonic.

T stands for Trim. This time there are two to check - both pitch (at the takeoff mark) and rudder (at its takeoff mark, or a bit right of neutral). If you have electric pitch trim enabled on your yoke or joystick, this is a good time to check that, too.

I stands for Ignition. Set the brakes, and advance the throttle to 2000 RPM. Check the magnetos one at a time. Maximum allowable drop is 175 RPM, with maximum differential 50 RPM between the two. Make sure both are turned back on.

P stands for Propeller. With the engine still at 2000 RPM, pull the blue prop control back until it drops to about 1500 RPM, then return it full forward. On a cold day, you might want to repeat this (called "exercising the prop") a couple of times to get warm oil into its hub.

TAKEOFF AND CLIMBOUT

Taxi into position and line up on the runway. Normal takeoffs in the Mirage are made with flaps retracted. On a very short field, however, the first notch of flaps will get you off the ground a bit quicker; we'll practice that one on our next takeoff.

Make sure that the prop and mixture controls are all the way forward and turn on the emergency fuel pump. Now, smoothly bring the throttle up to a manifold pressure of 42 in. Hg. If everything is working properly, that will correspond with the full forward position of the throttle. When the engine is cold, however, manifold pressure may "overshoot" slightly, requiring a small adjustment.

Let the airplane accelerate and begin the rotation to takeoff attitude at 80 to 85 knots. As the airplane leaves the ground, wait until there's no longer enough runway to land on, or until you see a definite climb indicated on the VSI and altimeter; then tap the brakes and retract the landing gear. Airspeed and rate of climb will begin to increase at once. Aim for 91 knots until all obstacles are cleared, then continue to accelerate to 125 knots for a normal cruise climb. Check that the HYDRAULIC PUMP light has gone out after the gear has completed retraction.

While the airplane can be climbed indefinitely at full takeoff power, it's wasteful and noisy. Instead, let's set cruise climb power: we'll gently reduce the throttle to 35 in. Hg., then slowly bring the mixture back until fuel flow indicates 32 gph. Leave the prop at 2500 RPM for the moment. Once we're at a safe altitude - say, 1000 feet AGL - relax, take a deep breath, and turn off the emergency fuel pump. Is the airplane in trim? Is the skid ball in the center? Adjust the trim wheels as necessary.

Let's level off at 5000 feet for some preliminary airwork. As the airplane accelerates, set up an economical cruise power of 30 in. Hg. and 2400 RPM. Remember, the throttle is reduced first, then the RPM. Set the mixture for a fuel flow of about 18-19 gph.

Now try a couple of steep turns. You'll notice that the airplane isn't quite as "nimble" as the 172; control pressures are higher, and the roll rate is slower. Try to get a feel for the amount of back pressure required. Let's consider these clearing turns, as well, and we'll try a couple of stalls.

Bring the prop back up to 2500 RPM, enrich the mixture to about 22 gph, reduce the throttle to around 20-25 in. Hg., and pull up into a gentle straight-ahead stall. You'll find the "break" a bit sharper than in the 172, but there's plenty of warning from the stall horn. As you release back pressure to start the recovery, smoothly bring the throttle up to 35 in. Hg. (that's why we advanced the prop and mixture before starting the stall series). You'll notice that even with good technique, the Mirage will probably lose a bit more altitude during the stall and recovery; that's typical for higher-performance airplanes. Notice, too, that as you bring in the power, it might take quite a bootful of right rudder to keep the ball centered.

Here's an excellent exercise to develop both a good instrument scan, and an awareness of how changes in aircraft configuration affect its performance. It's called "the FAA Weave," as it often shows up during check rides.

Begin by setting the airplane up in normal cruise, trimmed out to hold altitude "hands-off." Set the course arrow at your current course, and the heading bug sixty degrees to one side-let's say the left. What we're going to do is make steady turns back and forth between the course arrow and the heading bug, holding our current altitude, while changing aircraft configuration and power setting as required. Roll into a standard-rate turn to the left (i.e., turn at a rate so the little airplane in the turn coordinator points its wingtip at an index mark). When you have the turn established, extend the first (approach) notch of flaps. Maintain altitude and allow the airspeed to stabilize.

As you approach the heading bug, roll back into a right turn and extend the landing gear. Continue to maintain altitude; you'll notice that the airplane will slow quite dramatically. Add power, if necessary, to maintain 100 knots.

By now, you should be approaching the course arrow once again. Roll back into a second left turn and extend the second notch of flaps, still maintaining altitude. Adjust power to maintain 90 knots. As you approach the heading bug, roll back into a right turn, extend the last of the flaps, and-this is the tricky one-adjust power to maintain 75 knots, while still maintaining altitude.

As you approach the course arrow this time, start reversing the entire sequence. On your first left turn, retract one notch of flaps and accelerate to 90 knots, without losing any altitude; on the second turn, bring up the next notch and accelerate to 100 knots; on the third, retract the gear; and, on the fourth, retract the final notch of flaps and accelerate to cruise speed once again. Not easy, is it? In one exercise, you've practiced just about all the basic airplane-handling skills you'd need to fly an instrument approach.

UP, UP, AND AWAY

Before we do that, however, let's make a brief excursion to altitude to get a look at cruise power setting and mixture control. Set cruise climb power of 35 in. Hg., 2500 RPM, and 32 gph fuel flow, and trim the airplane for 125 knots. Note the rate of climb-this thing is quite a performer. However, we're going all the way up to our maximum authorized altitude of 25,000 feet, so once you've seen enough of how it handles in climb, go ahead and use the simulator's "slew" function to run up to 24,000 feet. Then return to normal operation so we can make the last 1000 feet of the climb, and the subsequent level-off, manually.

As we get to about 24,500 feet, bring the nose down just a bit, so that we climb the last 500 feet at about 500 fpm on the VSI. As we reach exactly 25,000 feet, ease the nose down until the altimeter stops moving and the VSI zeros out. Stay ahead of the trim as the airplane accelerates; it'll keep on doing so for some time. Finally, bring the throttle back to 32 in. Hg. and the prop back to 2400 RPM. (If the engine can't hold 32 in. Hg. at this RPM, as might happen on a warm day, increase the RPM, using the prop control, until it can.)

Let's use the autopilot for a moment so we can concentrate on leaning the mixture. Adjust the heading bug to line up right under the lubber line at the top of the HSI, engage the autopilot, and hit the HDG and ALT buttons so the airplane maintains its current heading and altitude. Check the fuel gauges, too-this might be the right time to switch tanks. If you haven't changed the rudder trim since leveling off, the ball is probably displaced a bit to the left, so dial in just enough left rudder trim to recenter it.

The airspeed will ultimately stabilize somewhere around 145-150 knots, depending on air temperature. That may not seem all that fast for this airplane, but remember-that's indicated airspeed. At this altitude, true airspeed should be around 220 knots; that's better than 250 mph!

Note, however, that the fuel flow is still pretty high; if you punch up the "hours remaining" display, you'll notice that we don't have much time to enjoy our high speed. This is where leaning the mixture helps a great deal. We're probably starting out with a fuel flow close to 30 gph. You can bring the mixture control back smoothly, but fairly quickly, until we get down to about 22 gph.

From here on, however, you'll need to continue to lean slowly and carefully, while watching TIT closely (make sure you have it showing in the upper left digital display, if necessary by pushing the button next to the TIT gauge). The system needs some time to respond. As you continue to lean, the TIT will increase, then start back down. This is the "peak," and as it starts down you're on the lean side, which is not authorized for continuous operation. Slowly re-enrich the mixture until it's once again reached its peak value-in fact, you may want to continue until it just barely begins to decrease again, just to be sure you're back on the rich side.

Now look at the fuel flow. It should be down around 18 gph. That's a 40% reduction in fuel flow-or a 40% increase in range. Looked at differently: the range figures in the pilot's handbook are based on proper leaning procedure. If you've planned and fueled for a 1000-mile flight, and forget to lean, somewhere around 600 miles it's going to get awfully quiet up there...

Before we head back down, let's disengage the autopilot and hand-fly for a moment. Compared to the 172, you may think that the Mirage is sensitive in pitch: it'll seem quite difficult to hold altitude smoothly. Actually, it's fairly heavy and stable in pitch. What you're seeing, instead, is the result of its significantly higher cruising speed: it takes much less of a pitch change at these speeds to cause a significant rate of climb or descent. The little dot at the center of the artificial horizon is the same size as the horizon line on the instrument. You may find that your corrections are limited to half, or even one quarter, the diameter of that dot.

LET'S GET DOWN

We'll head back for the airport for a couple of practice ILS approaches. On the first one, we'll let the autopilot handle the chores so you have a chance to see what's going on; on the second, you'll do the flying. If you like, you can set the simulator for moderately unpleasant weather-let's say a ceiling of 500 feet and a mile visibility.

We'll start a descent manually, so you can get used to reducing power, then slew the simulator so we don't waste too much time. Disengage the autopilot, then bring the throttle back just a bit, reducing power by only one in. Hg, to 31 inches. Check your watch, or start one of the stopwatches in the nav receivers or the ADF: it's a good rule of thumb, on these highly-tuned turbocharged engines, to reduce power at a rate of no more than one in. Hg. per minute until getting well below the cruising range. This avoids overly rapid cooling of the engine. What if ATC needs you to descend quickly? Drop the gear and/or the flaps!

In this case, though, we won't worry about cracking the simulator's electronic cylinder heads; pull the power back to about 25 in. Hg., get the airplane trimmed for a descent, and put the simulator in slew mode to get us down to, say, 2000 feet. Place us about 15 miles from the airport, near but not right on the reciprocal of the active ILS runway (i.e., if we're going to land on runway 28R, we should be southeast of the airport on about the 120-degree radial).

As you exit slew mode and regain control of the aircraft, set up a low cruise (24 in. Hg./2200 RPM) and engage the autopilot in HDG and ALT modes. Fly a heading of about 315 degrees. Set the course arrow in the HSI to 280 degrees and tune the #1 nav receiver to 111.7 mHz. The center of the course arrow will deflect to the right, indicating that we're left of the final approach course, and the glideslope needle will deflect upward, showing that the glideslope is still somewhere above us.

Now press the APPR button. The autopilot will annunciate APPR ARM, indicating that this mode is "armed," but it'll continue to follow the heading bug for the moment. Keep an eye on the HSI. As the needle "unpins" from its full deflection, extend the first notch of flaps. As long as we're going to let the autopilot fly the approach, this is all we need to use.

As the needle moves closer to the center of the instrument, you'll notice that the autopilot annunciations change: HDG disappears, and APPR ARM changes to APPR CPLD: the system has "coupled" to the localizer, the left-right signal of the ILS. Notice, too, that the airplane has turned so the course arrow is now straight up and down: we're flying right at the runway. Depending on the model autopilot installed, we may also see a GS ARM annunciator.

By now, the airplane should be stabilized at around 100 knots; adjust power as necessary if it isn't. Now watch the glideslope needle, which will eventually "unpin" from its position at the top of the indicator. As it gets within about a dot above the center index, lower the gear. By the time it's down, the needle should be centered. The ALT annunciator will go out, the GS (or GS CPLD) annunciator will illuminate, and the airplane will start down the glideslope.

At this point, we're about five miles from the end of the runway. Speed will have stabilized around 90 knots-the gear added quite a bit of drag, but we're also going downhill now! Turn on the emergency fuel pump. In about two and a half minutes, you should see the approach and runway lights appearing out of the gloom ahead. As you approach the threshold, you'll hear the "dit-dah, dit-dah" of the middle marker. Disengage the autopilot, and as the end of the runway passes under the nose, ease the throttle to idle, raise the nose to the horizon, and wait for the chirp of rubber on concrete.

SimTip

To cheat by "slewing" the simulation, press the **S** key on your keyboard while using the directional keys to control the aircraft that you are flying. The longer you hold the arrow key the quicker you will skew in that direction. **Q** slews up. **A** slews down. Numpad **5** stops the slew motion. Press **S** again to exit slew and return to flight.

ONE MORE TIME

Taxi back for takeoff. This time, we're going to fly the approach by hand. Leave the #1 nav radio set to the ILS, and the course arrow set to the inbound course.

Let's try a short-field takeoff, too. Extend the flaps to the first notch and line up on the runway. Check that the emergency pump is on and apply full power.

This time, start to raise the nose at 70 knots. You may note that the left-swinging tendency is stronger at this low speed. As the airplane lifts off, accelerate to 80 knots and maintain this, while retracting the gear, until all local obstacles are cleared. Now continue the acceleration; bring the flaps up as the speed passes through 90 knots; you may have to make a slight pitch change and trim adjustment. Accelerate to 125 knots and set climb power of 35 in. Hg/2500 RPM/32 gph.

At 1000 feet, start a right turn to the reciprocal heading of the ILS, and continue about 15 degrees beyond it. Notice that the HSI gives you an "at a glance" overhead view of the navigation picture: you're off to the side of the ILS (with the center of the course arrow deflected to your right), closing in on it at a shallow angle. The head of the course arrow is pointing toward the bottom of the instrument, so you can continue to "fly toward the needle" even though you're heading away from the airport, "backwards" to the ILS. As the needle begins to center, turn left until the course arrow is pointed straight down. For a very smooth intercept, just keep the end of the deflected needle on the bottom of the lubber line, and you'll automatically make a gentle turn until everything is centered.

Level off at 1500 feet and set cruise power. We're now headed outbound on the ILS, and to reverse our course, we're going to perform a maneuver called a "procedure turn." To ensure doing it far enough away from the airport, wait until the glideslope pointer has risen all the way to the top of the instrument before starting it.

While tracking outbound on the ILS, set the orange heading bug 45 degrees to your left. As the glideslope needle reaches the top of the scale, begin a standard-rate left turn until you've lined up on the heading bug. As you roll wings level at the end of this turn, start a stopwatch.

At the end of 45 seconds, start a standard-rate turn to the right. Continue the turn for one minute, or until the head of the course arrow is 45 degrees to your right (there's a handy index mark on the HSI at that position). Your position, if you need to report it to ATC, is now "procedure turn inbound."

You can set the heading bug to your new heading as a reminder. This is a good time to start slowing the airplane for the approach by extending the first notch of flaps. Continue to maintain 1500 feet and watch the left-right needle of the HSI (the center portion of the course arrow).

When it unpins, just keep its upper end under the lubber line and you'll find yourself turning smoothly to the inbound final approach course. Once you're established, try to avoid "chasing the needle." Instead, if the needle deflects to one side or the other, make a small heading correction in that direction, then hold it until the needle recenters; then remove half of that correction and wait to see what happens, repeating the process as necessary. Continue to scan all the instruments, returning often to the artificial horizon. As the glideslope needle starts down from the top of the instrument, get ready to lower the landing gear; do so when the glideslope is about a dot above the center.

Just as you fly a heading, using the HSI needle for corrections, once you start the descent, fly a steady vertical speed (around 600-700 fpm down, depending on your airspeed), using the glideslope needle to tell you when to make very small pitch corrections. The division between earth and sky on the artificial horizon is called the "horizon bar," and we're talking here in terms of no more than one bar width-often less than that.

Adjust power and/or add more flap as necessary to maintain your desired airspeed and rate of descent on the glideslope. As before, when the runway becomes visible, continue to "hold what you've got" until the end passes beneath the nose, then smoothly reduce power, raise the nose to the horizon, and touch down.

Piper Malibu Engine Run-up and Before Takeoff Checklist

1. Parking brake . . . . .SET
2. Propeller control . . . . .FULL INCREASE
3. Throttle . . . . .2000 RPM
4. Magnetos . . . . .CHECK
   (max drop 175 RPM, max difference 50 RPM)
5. Gyro suction . . . . .CHECK 4.8 to 5.2 in. Hg.
6. Ice protection eqpt . . . . .CHECK as required
7. Voltmeter . . . . .CHECK
8. Ammeters . . . . .CHECK
9. Oil temperature . . . . .CHECK
10. Oil pressure . . . . .CHECK
11. Propeller control . . . . .EXERCISE, then FULL INCREASE
12. Fuel flow . . . . .CHECK
13. Throttle . . . . .RETARD
14. Annunciator panel . . . . .PRESS TO TEST
15. EMERG fuel pump . . . . .ON
16. Alternators . . . . .ON
    (check ammeters)
17. Flight instruments . . . . .CHECK
18. Engine gauges . . . . .CHECK
19. Pressurization controls . . . . .SET
20. Fuel selector . . . . .FULLER TANK
21. Induction air . . . . .PRIMARY
22. Ice protection eqpt . . . . .AS REQUIRED
23. Mixture . . . . .FULL RICH
24. Propeller control . . . . .RECHECK FULL INCREASE
25. Flaps . . . . .SET FOR TAKEOFF
26. Trim . . . . .SET
27. Controls . . . . .FREE
28. Air conditioner . . . . .OFF
29. Parking brake . . . . .RELEASED

Radio Flyer
Part 2

The Malibu Mirage and the Navajo Chieftain both use the same excellent AlliedSignal - Bendix/King radio equipment as the Cessna 172R. Operation of basic nav, comm, transponder, and ADF equipment is exactly the same, but the nav displays use more sophisticated instruments. In addition, depending on airplane, some additional equipment and capabilities have been added.

HORIZONTAL SITUATION INDICATOR (HSI)

This may well be the coolest single instrument you'll encounter. First developed in the 1960s (and called a Pictorial Navigational Indicator at first), the HSI combines the functions of a gyrocompass and a nav indicator (with OBS, CDI, and flags built right in) to give you a "God's-eye-view" that lets you see and interpret your whole navigation, or horizontal situation at a single glance.

Here's how it works. The outer ring, calibrated in degrees, is a gyrocompass. As with the conventional directional gyro, it rotates as the airplane turns, with your heading always shown under the line (called the "lubber line," a throwback to the days of iron men in wooden ships). Compared to the standard gyro, however, it has an added feature: you don't have to set it every ten minutes or so to compensate for instrument drift. Instead, a small magnetic sensor mounted elsewhere in the airplane (usually in a wingtip or in the tail to get it away from all the steel in the engine) constantly corrects the system for drift, so it points accurately to magnetic north at all times.

In the center of the instrument you see a large arrow called, appropriately enough, the "course arrow." This is analogous to the OBS on a conventional VOR indicator. Like an OBS, it can be set to the desired course using the knob with the arrow symbol at the 7 o'clock position. You'll notice that the whole course arrow turns to indicate the course you've set against the degrees on the compass ring. If the airplane turns, the course arrow moves with the compass ring. Thus, as you look at the instrument, you can see both the desired course and your present heading in relation to the miniature airplane portrayed at the center of the dial.

The center section of the course arrow can deflect left and right, and this is analogous to the left-right CDI needle in a standard VOR indicator. Next to it, a large arrowhead points forward or backward; this is the TO/FROM indicator. Inadequate nav signals are indicated by the orange NAV flag at the top of the instrument.

If you're right on course, the center of the arrow will be lined up with its head and tail, and will pass under the little airplane. If you're off, the needle will move to one side or the other, so you instantly see where you are in relation to where you should be, as if you were looking down upon the airplane and your desired course from a great height.

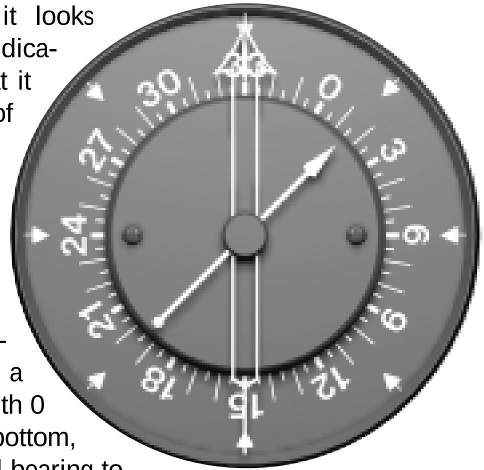
The knob at the 5 o'clock position sets the orange heading "bug," the V-shaped index that can move around the outside of the compass ring. You can use it as a handy reminder of the heading you should hold - and the autopilot will do the same thing in its HDG mode. To fly a desired heading, just set the bug, engage the autopilot, hit HDG, and the airplane will turn to and hold that heading.

Whether you or the autopilot (in NAV) mode is watching the course arrow to keep it centered, you'll often notice that it doesn't point straight up and down, but slightly off to one side or the other. This indicates that you (or the autopilot) are correcting for a crosswind. The difference between the tip of the course arrow and your actual heading, indicated under the lubber line at the top of the instrument, shows your wind drift correction at a glance, so you see intuitively which way the crosswind is blowing. Are you starting to realize how cool the HSI is?

Finally, it has one "non-horizontal" mode: when you've tuned the nav receiver to an ILS, you can see a glideslope pointer at the side of the instrument. Thus, you have the complete navigation picture in one place, simplifying your instrument scan.

RADIO MAGNETIC INDICATOR (RMI)

The RMI is the predecessor of the HSI, but it remains a very handy instrument to have.



You'll notice that it looks very much like the ADF indicator in the 172, except that it has two needles (one of which has double parallel lines, just so you can tell the two apart). In fact, it is an ADF indicator, among other things, but with an important additional feature. Originally, old-fashioned ADF indicators had a fixed background card, with 0 at the top and 180 at the bottom, so figuring out your actual bearing to a station required considerable mental arithmetic. Later ones, as in the Cessna, have a movable card, but it must still be set manually to correspond with your airplane's heading, and changed manually every time you make a turn.

The RMI's compass card, however, is hooked up to the same remote slaved gyro system that runs the HSI. Thus, the ADF (single) needle not only shows you where the station is relative to the nose of the airplane; you can also read off bearing to the station directly under the head of the arrow, or your radial from the station directly under the arrow's tail.

The double-needle arrow does the same thing, but it's hooked up to a VOR receiver. You'll recall that the old-fashioned ADF indicator could show you which way to head to the station, but not where you were; the standard VOR indicator shows you where you are with respect to a ground station, but not which way you're headed. The RMI gives you both vital pieces of information, regardless of whether you're using VOR or ADF signals for guidance.

Some GPS-equipped airplanes have the capability to display the direction to the next GPS waypoint on the RMI; look for an appropriately-labeled switch.

DISTANCE MEASURING EQUIPMENT (DME)

Although it's gradually being eclipsed (like most other ground-based nav aids) by GPS, DME remains a vital part of the navigational picture. Developed in the 1960s from a military system (still in use) called TACAN, DME provides the "missing piece" of navigation information not supplied by VOR or ADF: distance from the station.

It does this by emitting a pulse of radio energy. The DME ground station receives this pulse and replies to it. By timing how long it takes to get an answer and calculating in the speed of light (186,300 miles per second - "it's not just a good idea, it's the law!"), the system determines the range to the station and displays it in nautical miles and tenths. Almost all DME stations are co-located with VORs, so by tuning in a single station you can fix your position. (Otherwise, you'd have to tune in two different VORs and plot where the radials crossed.) In fact, the DME has no separate tuning controls; there's a pre-programmed relationship between VOR and DME frequencies, so if you tune your VOR to a given station, the DME will automatically tune to it as well.

The small knob in the DME indicator selects which of the two VOR receivers will command its tuning. A center "hold" position locks the DME onto its current frequency. This can be very handy if, for example, you're shooting an ILS ("they shoot ILSs, don't they?") to an airport that also has a VOR located on the field: first, tune in the VOR so the DME locks in on its signal. Now, put the DME in "HOLD" mode; then tune the VOR to the appropriate ILS frequency. You now have left-right and up-down ILS data displayed on your nav indicator or HSI, while the DME reads distance to the airport. (At some larger airports, the ILS has its own DME facility, making the hold procedure unnecessary.)

A couple of cautions: since the DME reads actual distance to the station, what it displays is slant range. Unless you're flying at recklessly low altitudes, it'll never read zero, even if you pass right over the station; it'll show your altitude, in nautical miles (1 nm=6078 feet). If you're close to the station, but at high altitude, "your mileage may vary."

The DME also displays both groundspeed, in knots, and time, in minutes, until you'll pass over the station. Bear in mind, however, that these figures are only accurate if you're heading directly toward or away from the station, as you would be when flying on an airway. If you're flying some random course, the groundspeed and time-to-station displays will be inaccurate. In the extreme case, if the station is directly off a wingtip, groundspeed would be zero and time to the station infinite, regardless of how fast you're actually flying.

WEATHER RADAR

I've often overheard passengers, as they board an airplane and see the radar screen on the panel, saying, "Oh, we've got weather radar, so we can fly through thunderstorms." Nothing could be further from the truth: the whole reason for weather radar is not to fly through thunderstorms or other severe weather.

In operation, a modern weather radar is very simple. Our airplane is depicted at the bottom of the screen; the radar scans a pie-shaped slice of sky, with its outer edge at the range selected by the pilot. Intermediate range rings and azimuth marks on the screen help you "eyeball" the position of storms and figure out how to fly between or around - not through! - them.

All the radar can see is water, in the form of raindrops. It cannot see clouds as such, and its performance spotting frozen water (snow or hail) is very poor. Depending on the density of rain that it sees, it depicts, or "paints," weather cells in green, yellow, or red. The assumption, generally a good one, is "the heavier the rain, the rougher the ride."

We can also make a couple of fine distinctions. The gradient between levels of rain is important, i.e., a red area surrounded by wide areas of yellow and green may not be as rough as one where the surrounding bands are narrow. You can also sometimes get information about the extent of a storm by using the radar's tilt control, which lets it look at weather above or below your cruise altitude as well as straight in front of you. Tilt too far down, and the screen will light up with smeary returns from the ground, rather than from weather. On larger, fancier airplanes, the radar is stabilized in both tilt and roll with signals from the autopilot gyros. On smaller ones, you'll have to adjust the tilt manually if you change pitch attitude for a climb or letdown; and during turns, one whole side of the screen will light up as the beam scans down onto the ground on the inside of the turn.

The radars on the Malibu Mirage and the Navajo Chieftain have an extra feature called "Vertical Profile." It's activated by the "track" arrows and the VP button on the face of the radar. Here's how it works:

Select a weather cell you wish to examine and press the left or right "track" arrow. A yellow line will appear on the screen. Use the arrows to point it at (and through) the center of the weather cell. Now press the VP button. The radar will stop sweeping back and forth. Instead, it will remain pointed at the selected cell, and will scan up and down. The screen presentation will change to show the airplane at the left and a vertical cross-section of the weather; the numbers at the top and bottom of the screen indicate heights in thousands of feet above and below your present flight altitude, not above sea level.

THREE-AXIS AUTOPILOT

The autopilots in the Malibu Mirage and Navajo Chieftain are very similar in basic operation to that in the Cessna 172, but - once again - they offer additional features and capabilities.

The most significant of these is that they can control the elevator as well as the ailerons. There are three pitch modes. When the autopilot is first turned on, it will capture and hold whatever pitch attitude exists at that time. You can change its pitch attitude using two methods: either hold the pitch control switch on the autopilot controller in the up or down position, which will change pitch attitude at around one degree per second or push the pitch sync switch on the yoke (if you have it enabled), fly the airplane to a new attitude and release the switch.

Pressing the ALT button will "capture" the altitude at that moment. The airplane will level off and continue to hold that altitude. Fine corrections (for example, when you receive a new altimeter setting and change the altimeter) can be made using the up/down switch; the airplane will climb or descend at around 500 fpm as long as the switch is held, and will capture the altitude at which the switch is released.

You also have a very useful device called an altitude alerter/preselector. Set a desired altitude into it, using the inner and outer knobs, and as you climb or descend to within 700 feet of that altitude, it'll alert you with a chime. Once you've leveled off at the desired altitude, the unit will chime again to warn you if you stray off altitude by 300 feet in either direction.

If you're climbing or descending with the autopilot engaged, pressing the ALT ARM button on the alerter/preselector will have no immediate effect, but as you reach the desired altitude the autopilot will automatically switch from pitch hold to ALT HOLD mode, and the airplane will level off, untouched by human hands.

Finally, if you're flying an ILS, the autopilot can follow the glideslope. Put the system in APPR mode to arm this feature. As the glideslope needle nears the center of the scale (usually, you'll approach it from below by flying level in ALT mode), the system will capture it and control the airplane to the required descent rate.

Flight Instruction

AUTOMATIC TRIM

In order to control the elevator without its servos constantly holding excessive pressure, the autopilot system includes an electric motor to operate the trim wheel. In addition, when the autopilot isn't engaged, a switch on the control yoke allows you to adjust the trim without letting go of the controls. If the autopilot is engaged, pressing the trim switch will disengage it.

FLIGHT DIRECTOR

There are times when it would be nice to utilize the capabilities of the autopilot's computer for things like ILS guidance or interception of desired courses, but keeping the human pilot "in the loop." For this, there's the flight director function. Engage it by pressing the FD switch and a pair of "command bars" appear in the artificial horizon (now called the Attitude Director Indicator, or ADI). Now, selecting any of the autopilot's guidance modes, but without engaging it, will cause these bars to move.

As long as you, the human pilot, keep the miniature airplane in the ADI "tucked in" to the bars, you're satisfying the computer's commands. It's the same computer that would otherwise run the autopilot; the only difference is that its output signals are going to the command bars, rather than the control servos, and you're providing the muscle to move the controls instead.

Even with the autopilot engaged, the command bars provide a useful reference and confirmation that it's doing what it's supposed to. Whether you or the servos are flying the airplane, remember that satisfying the command bars doesn't necessarily mean that you're on course - but if you're not, you're doing what you're supposed to in order to return there.

YAW DAMPER

While the autopilot doesn't need to use the rudder to control airplane direction (aileron control alone is more than sufficient), it incorporates a third axis, called the yaw damper, simply to keep things coordinated and the ball in the center. This provides a significant increase in passenger comfort, particularly in long-body airplanes. The yaw damper is typically turned on just after takeoff, and off just before landing. This is particularly important if you're landing in a crosswind; otherwise the yaw damper will "fight" your pedal inputs as you level the wings and "kick out the crab." Turn it off anytime you're adjusting the rudder trim, especially in single-engine situations in the Navajo Chieftain.

Piper's Navajo Chieftain

Piper Navajo Chieftain

MOVING UP TO A TWIN

Welcome to the world of multi-engine flying! In a sense, you're already getting a head start: most students start out either in one of the very light ("lite?") twins like the Beech Duchess or Piper Seminole or, if they're lucky, a slightly larger traditional light twin like the Cessna 310 (remember Sky King's "Songbird?"), Beech Baron, or Piper Aztec.

You, however, are privileged to jump right into the Piper Navajo Chieftain, and this is a pretty significant airplane in a couple of different ways. Not only is it a prime example of the “medium piston twin” that’s become a mainstay of corporate and light commuter aviation; it’s also the first “truly professional” airplane for many pilots, a springboard to an airline career. Piston-powered it may be, but the Chieftain is a good-sized airplane, carrying up to nine passengers plus the pilot. (That’s the most the FAA allows without a two-pilot crew.)

Flying a Chieftain is a great way to gain real-world experience, the kind that looks good in your logbook. Ask in the cockpit of any airline jet nowadays, and chances are good that at least one of the pilots will have served his or her apprenticeship in the trusty “Navahog.” The airplane remains an essential air service provider even today. As regional airlines move into turboprops and even smaller jets, they can’t afford to keep serving the smallest communities. For those markets, particularly in outlying or sparsely populated regions, the Chieftain remains a real lifeline.

IT’S EASIER THAN YOU THINK

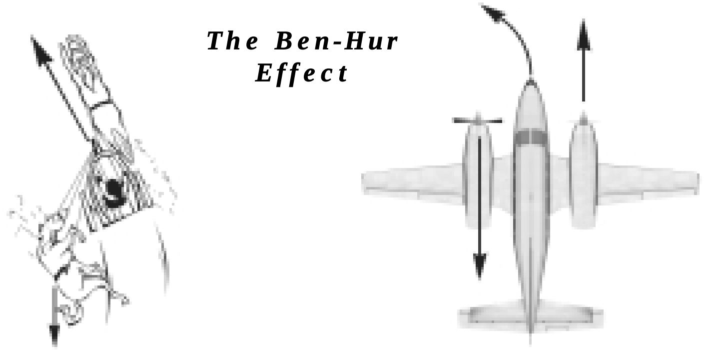
If you’ve been flying a heavy piston single, such as the Malibu Mirage provided in this release of FLY!, you should have no trouble transitioning into the Chieftain (or any other light or medium piston twin). I’m going to let you in on a big secret: as long as both engines are running, there’s absolutely no difference between flying a twin and a heavy complex single. (Actually, in the case of the Chieftain, it’s even easier, as you’ll find out a bit later when we discuss the concept of critical engines.) If you’re coming from the Mirage, you’re on familiar territory: the Chieftain uses almost exactly the same 350-hp turbocharged Lycoming engine, so you can just consider that you’re flying two Mirages in close formation.

By the same token, the special skills you have to learn to be a safe multi-engine pilot are, in fact, single-engine techniques. The twin flies just like a single as long as both engines are running; it’s when one of them becomes uninterested in further toil that things become, to say the least, interesting.

THE BEN-HUR EFFECT

A simple way to understand this is to imagine that you’re driving a Roman chariot. If you want to feel like Charlton Heston, go right ahead - but since we’re discussing an airplane with only two engines, we’ll trade in the fancy 4-horsepower Formula IV version he drove in the movie for a simpler 2-hp sports model.

Okay, so you’re thundering along when one of the horses - let’s say, the left one - stumbles and goes down. “Whoa, Dobbin!” you cry, but the right horse keeps charging along while the left one, still in harness, gets dragged along on his butt. As you can see from the accompanying illustration the combination of thrust on the right side and drag on the left side makes the whole assemblage want to turn left*. The same effect occurs in an airplane: the engine that’s producing thrust pulls its side of the airplane forward, while the engine that’s stopped does not.



The Ben-Hur Effect

FEATHERS IN THE WIND

In fact, if an engine does quit, the initial effect is even worse than we’ve shown above, with one engine running and one stopped. As you’ve noticed flying singles, when you close the throttle, the engine doesn’t quit turning; if you’ve been brave (or foolhardy) enough to either cut the mixture or shut down the ignition inflight, the engine still turns, or “windmills,” at a pretty fair fraction of its former operating speed.

* Notice: No animals were actually harmed in the preparation of this manual.

Unfortunately, this requires a fair bit of work, in its purest physical sense. If you've ever tried to hand-start an airplane (Kids: don't try this at home without getting thorough instruction, unless you want to end up with a nickname like "Lefty"), you'll know that it takes a real heave. This is because any piston engine is, in effect, an air pump - and for a propeller to windmill, it has to turn the attached engine over each piston's compression stroke. Although it's hard to believe, at typical speeds the drag of a windmilling propeller is very close to that of a solid disk of the same diameter!

The only way a twin can keep flying on one engine is to get the failed unit to stop windmilling as soon as possible. To do this, the blades on the constant-speed propellers used on twins are capable of feathering, or turning completely edge-on to the wind. Once this has been done, they're no longer trying to turn a dead engine, and they come to a stop with an immediate (and very welcome) reduction in drag.

This is so important that in the days of the great piston airliners, if an engine failed and its prop would not feather, the standard procedure was to shut off its oil supply in the hope that the engine would either seize or break its propeller shaft off outright. It's a dangerous procedure, with a high risk of structural failure or fire - but the drag of a windmilling prop is so great, it was considered worth the risk.

To feather a failed engine in the airplanes in this version of FLY!, the procedure is very simple: simply pull the affected prop control all the way back. In the actual airplanes, it has to be pushed sideways, lifted over a gate, or pulled past extra resistance to avoid feathering a propeller inadvertently. This opens a valve in the prop governor that dumps all the oil pressure from the hub, allowing springs and the blades' centrifugal forces to swivel them to the feathered position, if the engine is at lower power or off.

Some light twins used primarily for training have unfeathering accumulators that allow you to get a prop back into its operating range simply by pushing the control back forward; otherwise, you have to attempt to restart the engine to get oil pressure back to the prop. In the real world, of course, any problem serious enough to warrant feathering in the first place generally means you should leave well enough alone and get to an airport as soon as possible.

> Incidentally: how come the props don't feather when you shut down the engine? Because starting an engine with a feathered prop puts a huge load on it, so there are anti-feather locks that are engaged centrifugally at and below about 700 RPM as the engine stops. In a windmilling situation, it'll be turning faster than that, so it can feather. On single-engine airplanes, the locks are simple fixed pins, since there's no need to feather - once an engine quits, you're on your way to a prompt landing, period! And on some types of turbine, which start quite differently, the props do feather when you shut them down. Got all that? There'll be a short quiz later on…

THE NEED FOR SPEED

How can we counteract this severe yaw and turning tendency when an engine fails? By the use of rudder - often just about full rudder - against the turn. Look at most twins, and you'll see that they have pretty large vertical tails - significantly larger than those of singles of similar size and weight. Why? To provide enough "tail power" to overcome the asymmetric thrust of a single-engine situation.

And how do they do this? Obviously, by deflecting the air flowing over them. The faster we fly, the more effective the tail becomes, so it's the designer's task to size the tail and rudder for the worst-case situation: with the airplane flying at minimum speed with one engine windmilling and the other at full takeoff power.

Obviously, there isn't much point in providing a fin and rudder big enough to keep the airplane straight at speeds below the stall, since at that point it won't be flying anymore; instead, the speed that's set is called V_{MC}, or minimum control speed. It's defined by the FAA as the speed at which the airplane can be controlled (its heading held constant) with one engine (the "critical" one, which we'll discuss in a moment) windmilling, the other one at maximum power, and the airplane in takeoff configuration. They don't necessarily say it has to be easy to hold, either - in fact, they assume maximum rudder deflection, and allow an untrimmed rudder pedal force of up to 150 lbs!

This speed is so important that it's marked, on the airspeed indicator of multi-engine airplanes, with a big red radial line. The warning is simple: if you're flying below V_{MC}, and an engine quits, you will not be able to control the heading of the airplane unless you reduce power on the operating engine, give up some altitude to gain more flying speed, or both. Obviously, if this happens only a few feet above the ground on takeoff, your options are quite limited!

Bear in mind, too, that losing 50% of your power will cost you a lot more than 50% of your performance. Flying on one engine, the airplane requires big, draggy control surface deflections to keep in control; and even then, the fuselage is still getting dragged along perceptibly sideways. It's not very efficient. The published figures for single-engine ceiling rate of climb for light and medium piston twins assume that the dead engine has been feathered, gear and flaps retracted, and the failed-engine wing raised up to five degrees to get a little help from the bank angle - and even then they're pretty underwhelming. Yes, the old pilot's joke that "the remaining engine is just enough to get you to the scene of the crash" is an exaggeration…but not all that much of one!

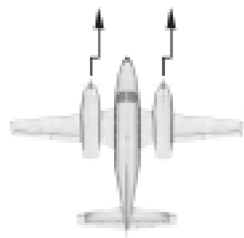
LET'S GET CRITICAL

But wait - it gets worse!

You'll recall, from our earlier discussion on P-factor, that at low airspeeds and high power settings, such as in a climb, the propeller's center of effort moves out from the center along the downgoing blade. (Class? Class?! Why do I always see the same hands up?)

Now consider the same situation in a twin. If it has conventional engines (turning clockwise as seen from behind), this displacement of thrust is inward, toward the fuselage (and hence the center of gravity, as well as the rudder) on the left engine; but outward, even further from the fuselage, on the right engine. Thus, if the left engine quits, the airplane will try harder to turn to the left than it will to the right if the right engine quits. Losing the left engine puts you in more trouble than losing the right one - so the left engine is the "critical" one. On British and other European twins, with motors that run the other way, the right engine is critical.

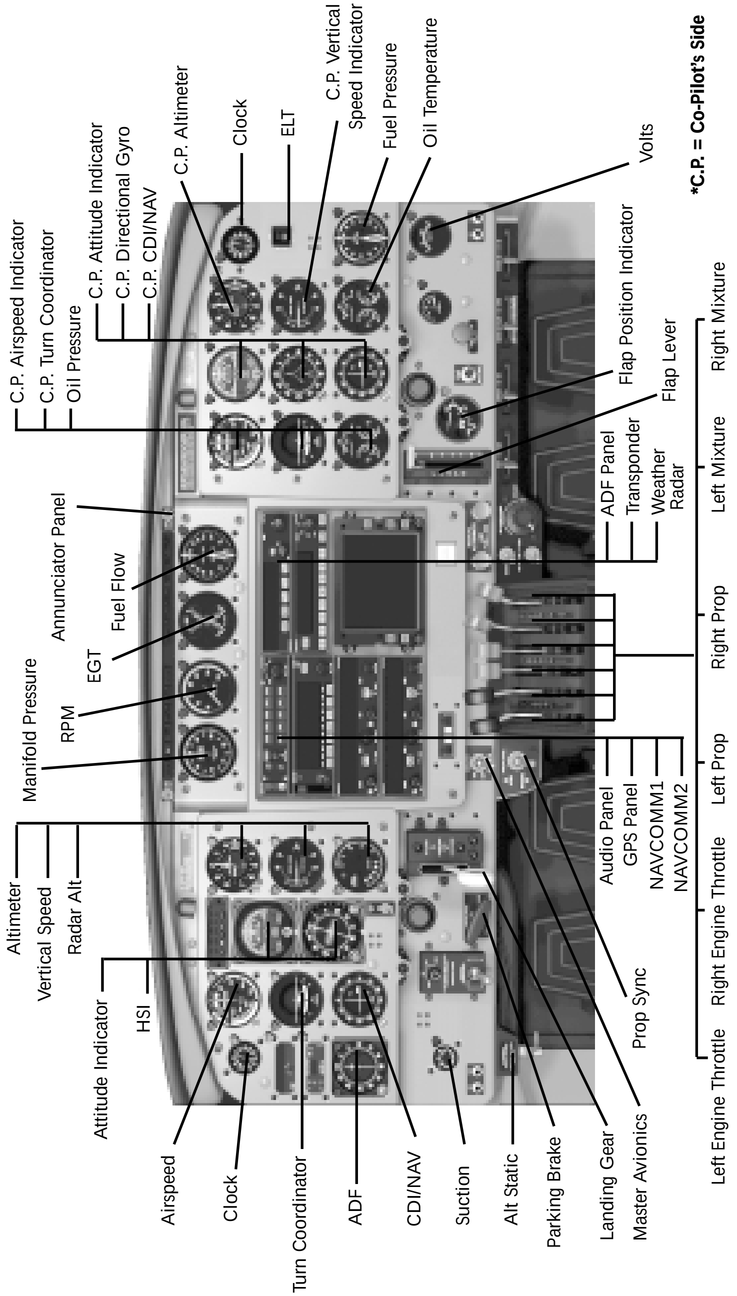
The engines pull to the right.



BACKWARDS IS GOOD

"In that case, why not just install engines and propellers that turn in opposite directions?" I hear you cry. Why not indeed? In fact, that's just what Piper did on the Chieftain, although it took some persuading to get Lycoming and the prop manufacturers to build them. The Chieftain doesn't have a critical engine - its single-engine performance, such as it is, will be the same regardless of which engine has failed. There's another benefit, too: assuming you have the rudder trim centered, you've lined up correctly with the runway centerline, and both engines are performing properly and equally, you can take off and fly around all day with your feet flat on the floor!

Navajo Cockpit



CHIEFTAIN COCKPIT TOUR

By now, you should be pretty familiar with the way aircraft cockpits are laid out. Sure enough, there are the usual "sacred six" flight instruments right in front of the captain (with an additional set over on the copilot side). The dual-width radio stack, replete with bells and whistles, is in the center panel. Above them, the engine instruments are laid out with, from left to right, manifold pressure, RPM, EGT and fuel flow, corresponding to the positions of the paired black throttles, blue prop controls, and red mixture controls on the center console. Each instrument has two needles, color coded for the corresponding engine.

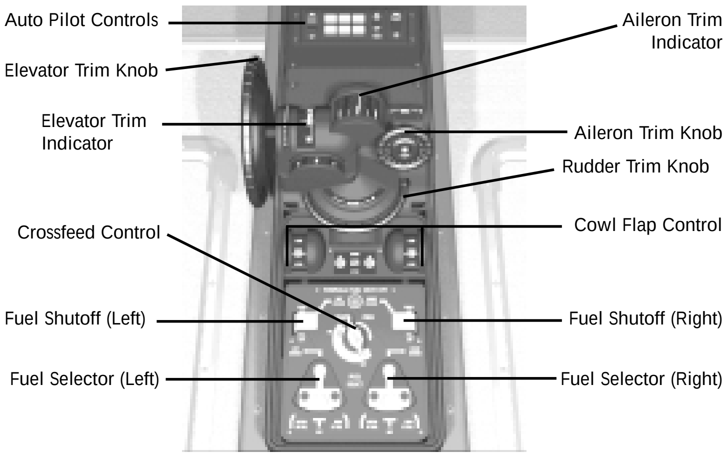
It's below and above the instrument panel that things get perceptibly busier than in a single. Just aft of the engine-control levers is the control panel for the autopilot and flight director. There are no less than three trim wheels, each with its own indicator: the big elevator trim, on the left side of the console; the equally large rudder trim wheel, which will become vital in single-engine work, sitting horizontally; and a somewhat smaller knurled knob for aileron trim. Below these are a pair of switches and indicators to control the cowl flaps, one for each engine. These are adjustable flaps on the bottom of each cowling which can be adjusted to control the rate of cooling airflow through the cowling. Close them too tight, and you can overheat an engine; leave them open too far, and you'll be causing needless drag. In particular, in a single-engine situation, you'll want to close the ones for the failed engine all the way to minimize drag - and, depending on how much power you need from the good engine, you may have to crack its cowl flaps a bit.

Finally, at the bottom of the console, a bunch of techy-looking levers control the fuel system. Each wing has inboard and outboard tanks. In normal operation, each engine draws fuel from the tank(s) on its side of the airplane; the outboard ones are considered auxiliary tanks, and are approved for use in level flight only. The two rearmost levers are the fuel selectors for their respective engines, and have inboard, outboard, and OFF positions.

In the center of the fuel panel is a single lever controlling fuel crossfeed. This is provided for emergency use if an engine fails, crossfeed can be used to let the remaining engine utilize fuel from the failed-engine side. For example, if the right engine has failed and you want to use fuel from that side, begin by turning on both emergency fuel pumps (we'll cover them in more detail when we're flying). Next, select the tank you wish to use on the failed-engine side. Now, open the crossfeed valve; then, holding your breath, turn the fuel selector for the operating engine to OFF. When you've verified that the engine continues to run, turn the operating engine's emergency pump OFF. Oh, yeah - you can exhale now. The boost and emergency pumps on the failed-engine side are handling the load of transferring fuel across the airplane. To resume normal operation, reverse the sequence.

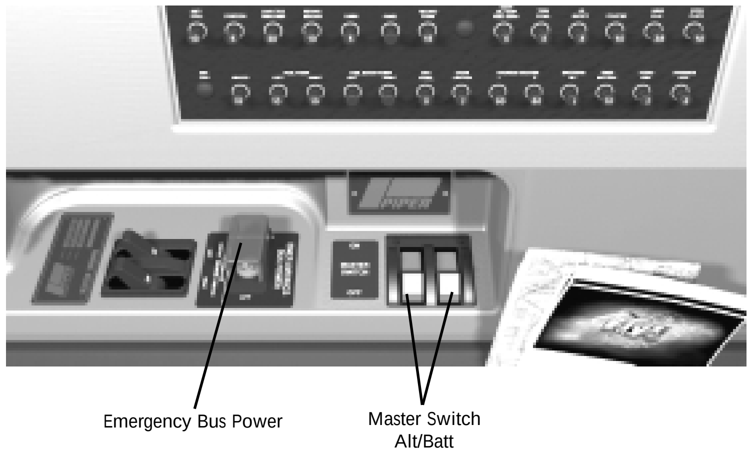
There are also a couple of red tabs, one for each engine, at the front of the fuel selector panel. These are the firewall shutoff valves; normally, you'd only pull them after an actual engine failure or in case of fire.

Navajo Floor Panel



Now let's look up above the windshield. Wow! Even more switches than in the Mirage, and a few dials besides! Actually, two of those dials - the left and right fuel gauges - represent one of Piper's few design errors in the Chieftain. Four tanks, two gauges: how does that work? It's simple - each gauge indicates the quantity in the tank currently selected on the fuel controls at the bottom of the console. It's a logical system - but if you're getting near the end of the outboard tanks before switching back to the inboards, the prominent location of the gauges can lead to a bit of that old "OhMyGawd, we're outta gas, we're all gonna die!" paranoia among the passengers that can't help noticing them pointing at "E"…

Navajo Pilot Side Panel



The other dial is the ammeter, for the electrical system. The bottom row of switches includes the left and right magnetos for each engine, with the starter between them, and the left and right emergency fuel pump switches. The top row includes all the lighting, ice protection systems, etc.

That's about it except for the battery and alternator master switches, cleverly hidden down by your left knee at the bottom of the left-side circuit breaker panel. Just behind them, the two big handles that look like old-fashioned light switches are the circuit breakers for the left and right alternators.

LET'S FLY!

Get set to enjoy the performance of a multi-engine takeoff and climb…because that's about the last time you'll be allowed to have both engines running during this lesson!

Use the same technique you learned to start the Mirage - after all, the engines are almost identical. The Chieftan's battery is in the nose, so you can start whichever you like first, unlike many other twins. In fact, it's a good idea to alternate which engine you start first, since it provides a quick check of the vacuum and hydraulic pumps on that side. Shut the same one down first after landing, and you can check the pumps on the other side.

With both engines running smoothly and the avionics powered up, we can taxi for takeoff. Normally, a twin is steered the same way as anything else, via the rudder pedals. If you really need to tighten up a turn, however, you can also use differential power, adding a bit of throttle on the outside while retarding it on the inside. See how well that works? Does this tell you anything about how the airplane may handle with an engine out in the air?

Once you've gained a little experience, you may choose to run up both engines together, but for the moment we'll check them one at a time. First, advance the throttle to 1500 RPM. When the speed stabilizes, move the blue prop control all the way aft; the RPM will start to drop quite rapidly, proving that the propeller is beginning to feather. Return the prop control full forward before it's dropped more than 500 RPM and verify that it comes all the way back up to 1500 RPM. Now advance the throttle to 2400 RPM and check the magnetos. Verify that the engine instruments are all "in the green," retard the throttle to an idle of about 1000 RPM, and repeat the process for the other engine.

TAKEOFF AND CLIMB

This airplane is larger and heavier than the Mirage, so standard takeoffs are made with the flaps extended to 15 degrees. Verify that the left and right fuel selectors are in the inboard position, the crossfeed is closed, and both emergency fuel pump switches are on. Line up on the runway, making sure that the rudder trim is centered, and smoothly advance both throttles all the way. On a standard day, this should give you 40 in. Hg. and a rather noisy 2400 RPM. Since the turbo controllers on this engine measure air density, rather than just pressure, you may see up to 49 in. Hg. on a very hot day or at high takeoff altitudes.

The minimum control speed (V_{MC}) is 76 knots, but the airplane will lift off much more smoothly if you wait for about 80 to 85 knots to start raising the nose. When the altimeter and VSI show a solid climb, retract the gear (it should be up before you hit 128 knots), and continue to accelerate; at 100 knots, retract the flaps, compensating for the slight pitch change. Set climb power of 38 in. Hg. and 2400 RPM, at which point things will get much quieter; remember, when reducing power, the throttles come back first, then the props (just the opposite of when you increase power). You're allowed to lean the mixture to a fuel flow of 27 gph per engine, but you must also keep the cylinder head temperatures at or below 475 deg. F (cooler is better for longer engine life). On all but the hottest days, a climb speed of around 120 knots will get you upstairs at a reasonable rate while letting you close the cowl flaps about half way for better performance - just keep an eye on those CHTs.

AND NOW FOR A LITTLE AIRWORK

You know how to do steep turns and stalls by now, so have at 'em - you don't need me to coach you through them anymore! You'll notice that the airplane has a much heavier feel and control response than what you've been flying until now; how do you think it got the "NavaHog" nickname? Once you're used to making smooth, but decisive, inputs, though, you'll find it quite responsive, while its heavier feel makes it nice and stable in turbulence. As you'll find out later, it's also a great instrument platform. This would be a great time to execute a few "FAA weaves," too, both to get more feel for the airplane and to keep your instrument scan up to snuff.

Overall, you'll notice that it doesn't fly any differently from a single, just heavier. In fact, if anything, it's easier: it goes right where you point it, it's less bothered by turbulence, and with those neat counterrotating engines, you shouldn't have to make any rudder trim changes as you add or reduce power or change airspeed.

> Note: the rest of this lesson requires either rudder pedals or rudder control on your joystick.

IT'S QUIET OUT THERE...TOO QUIET...

Okay, fun's over (or, depending on your outlook, about to start):

Our first exercise will be a relatively innocuous engine failure, at altitude and in cruise configuration. Climb the airplane (or slew the simulator) up to 5000 feet or so, set up a medium cruise condition at around 30 in. Hg/2300 RPM, and get the airplane trimmed up. Satisfied? Okay, pull the right mixture control all the way back to idle cutoff.

The airplane will immediately yaw and roll to the right, so get on the controls and get it leveled out again. You'll find yourself holding considerable left aileron and rudder pressure, and that rudder pressure is the key way to determine which engine has failed: "Dead Foot, Dead Engine." In other words, at this point, you could take your right foot off the rudders and the situation wouldn't get any worse - but relax your left foot, and the airplane will yaw to the right.

This is the first item in the classic engine-failure check, which in its entirety is "Identify; Verify; Feather; Configure; Secure." Actually, some pilots have come to grief by getting fixated on any of these steps; a more correct checklist would read, "FLY THE AIRPLANE; Identify; FLY THE AIRPLANE; Verify; FLY THE AIRPLANE; Feather; FLY THE AIRPLANE; Configure; FLY THE AIRPLANE; Secure; and, last but far from least, FLY THE AIRPLANE." All the skill in the world at figuring out which engine has failed and getting it shut down will be of little avail if, in the meantime, you let the airplane get away from you.

Okay, you've identified the dead engine by noting which foot you don't have to use. Be aware that this check is only valid if you have the airplane reasonably straight and level, so - at the risk of repeating myself--FLY THE AIRPLANE. The next step is to verify that you have, indeed, chosen the right engine, since feathering an engine is pretty irrevocable (at least in the short term). Feathering the one good engine you have left is not conducive to prolonged flight. How do we verify? By closing the throttle on what we think is the dead engine. If, indeed, it's dead, things won't get any worse. If it's the good engine, you'll know right away! If this had happened "for real" near the ground, you'd also want to verify that you had every available pony working for you, so you'd move all the power levers all the way forward.

In many light airplanes, the quick way to do this is to put the flat of your hand across the back of all six and just shove Up here in cruise, we don't have to do that - but it's a good habit pattern to have when the chips are down.

Now we can go ahead and feather the engine. Take a good long look at the power levers to make sure you've grabbed the correct one, and bring the prop lever briskly all the way back. The engine will twirl to a halt, often with a bit of shuddering and shaking - but the airplane will seem to come back to life with the elimination of all that drag.

Next, we'll configure the airplane for continued single-engine flight. This means that we'll get rid of all excess drag, first of all by retracting the landing gear and flaps. "But they're already up," I hear you cry. True enough, up here at cruise - but making these "cleanup" items part of your automatic response to an engine failure means they'll be there when you need them (and you will in just a few more minutes!). Configuring also means dialing in enough rudder trim to relieve the load on your "live" leg, which might be getting pretty tired by now. It also helps to bank into the good engine - "raise the dead" - by about five degrees; the skid ball should be about halfway out of its little cage in the turn coordinator. Use all three trim wheels until the airplane flies straight and level, hands off, on one engine.

Finally, we'll secure the dead engine - i.e, set things up for a prolonged shutdown. Close its cowl flaps all the way - after all, it's not putting out any heat! Turn off its emergency fuel pump, then its magnetos. Set its fuel selector to the center OFF position. Finally, check the CHT on the good engine, and adjust its cowl flaps if necessary. Take your time through all of these steps - after all, the airplane is flying okay by now - and be sure you're doing them to the correct engine.

SINGLE-ENGINE APPROACH AND LANDING

Normally, this would come a bit later in the syllabus - but since we already have an engine shut down, let's head back toward the airport (fly or slew the simulator as you prefer) and we'll examine the prospect of a single-engine landing.

It's no big deal as long as you remember one all-important factor: The airplane will maintain altitude on one engine, as long as it doesn't have too much drag. Once you extend more than the first notch of flaps, however, and particularly when you extend the landing gear, it's going to come downhill.

This, in turn, means two things. One is that you'll hold off adding drag until landing is assured - until you know you've got the runway made. The other is that once you've added drag and are below, say, 600 feet AGL, you are committed to land. If you had to go around on one engine, you'd have to give up altitude while you got the airplane cleaned up again (and even after that, its climb rate would be miserable). If a truck pulls out on the runway in front of you, too bad - just move over to the side and land on the taxiway, or even in the grass!

Fly your normal landing pattern, but keep the speed above the blue radial line on the airspeed indicator - we'll make a much closer acquaintance with that line in a minute - and leave the landing gear and flaps up (or, if necessary, extend the flaps to no more than the first notch). Some people like to fly their final approach a bit higher than usual, but don't overdo it or you may find yourself running out of runway later. As you turn on final approach, it's a good idea to dial the rudder trim back toward neutral: even though this means you'll be holding rudder pressure on final, you won't be faced with a sudden trim reversal as you pull the power off the good engine to land. Try to minimize your power changes, and make those that are necessary slow and gentle.

When you're sure you can make the runway at your present power setting, extend the landing gear; at this point you can also use more flap if necessary, but be sure you realize that you are now committed to land, no matter what. As you come in over the threshold, ease the throttle back to idle.

You may be surprised to find that the airplane "floats" further than it does on a normal landing, and that its directional trim feels a bit strange. Remember: you no longer have the usual drag of a windmilling engine on the feathered side.

THE WORST OF THE WORST

What's the worst thing that can happen to you in a twin? Most pilots agree that it's an engine failure right at liftoff. In fact, there are those who say that this situation is worse in a twin than in a single: at least in the single you don't have to worry about options, and since the airplane is smaller and lighter, it'll probably crash pretty gently (in fact, at a big airport, you may still have plenty of runway to land on).

The twin, on the other hand, can stay in the air if you do everything right, and right away. If not, it, too, will crash - but it's a lot heavier, and is going a lot faster, so it'll hit hard. Over the last 20 years or so, the engine-failure accident rate for singles has been higher - but the engine-failure accident fatality rate is higher in twins, pointing up the need for correct pilot technique.

Training in light twins in the real world, no sane instructor is going to chop an engine on you near the ground; it's just too risky. That's one of the reasons to train in a simulator - aren't you glad you have FLY!?

THE NEED FOR SPEED, PART DEUX

Take another look at your airspeed indicator and note the blue radial line at 106 knots. Here, again, is a speed so important it merits a special marking: best single-engine rate of climb speed, or VYSE. Actually, and with no aspersions cast on the builders of piston-powered light and medium twins, it might better be called "least-worst" single-engine rate of climb speed, as you're about to find out!) This is the speed at which the airplane will get away from the ground fastest on a single engine. (It is not, however, the speed at which it will climb steepest; that one, best single-engine angle of climb speed or VXSE, is unmarked at 92 knots, and is what you'd use if you needed to clear an obstacle immediately ahead.

VYSE is colloquially called "blueline" speed, and close to the ground it could just as well be called "lifeline." Any faster, and the airplane won't climb as well; any slower, and while it may climb a bit steeper, it won't be gaining altitude as rapidly. Moreover, if you ever let the airspeed get below blueline, the only way you can get your speed back will be by descending unless the Chieftain is loaded very lightly. On a normal takeoff, you'll want to get above blueline as soon as possible, so that if an engine does fail your airspeed will be trending toward it, rather than away from it. We'll even be a little easy on you this time around: we'll let you get 110 knots before you lose an engine. (In the real world, if you lose an engine below blueline, your best course of action will most likely be to put the airplane back on the ground: it's far better to go off the end of a runway on the ground, slowly and under control, than to come back down to the ground as a falling object at high speed!)

Here we go (gulp!). Get the airplane configured for a normal takeoff, start the takeoff roll, lift off, accelerate to 110 knots, and before you retract the gear or flaps, fail the left engine by pulling its mixture all the way back (or have a buddy do it for you).

You'll be very impressed at how much harder the airplane tries to yaw and roll than it did when you lost an engine at cruise. Why? Two reasons: one is that this time the good engine is at absolute maximum power, rather than at a cruise setting; the other is that you're now at a much lower airspeed, so the controls are less effective. You'll need to make a determined effort to get the wings level and nail the heading; it'll probably take full rudder. At the same time, watch the airspeed: don't let it continue to accelerate, but at all costs don't let it get below blueline.

Okay, we don't have much time to lose: Identify ("Dead foot, dead engine"), Verify (close the throttle of the dead engine), and feather it. You'll be able to reduce the rudder deflection right away, and the airplane will fly straighter - but it still won't be going uphill at any particularly satisfying rate. What's next? Configure. If you're not actually settling back toward the ground, go ahead and get the gear up to get rid of its drag, but be prepared for a sickening momentary sagging feeling as the inner gear doors open (they'll close again in a second). If the airplane does seem to be settling (or, in any case, if there's enough runway remaining ahead), just go ahead and land and we'll try again.

This time, though, we're still hanging in the air. Continue configuring by bringing the flaps up - and it's a good idea to "milk" them up bit by bit, rather than retracting them all at once. Continue to pay close attention to the airspeed, keeping it nailed on that blue line.

Whew! The airplane should now be climbing - and it'll even improve a bit once you've banked 5 degrees into the good engine ("raising the dead") and closed the cowl flaps on the dead one. How fast will it climb? Fast?! If you've done everything right, and you've started out from sea level on a standard day, with the airplane loaded to its authorized gross weight, you'll be rocketing upward like a homesick anvil - at all of 230 feet per minute! And that's in straight flight, too - any turns will eat up most, if not all, of that paltry climb rate.

Let's put that in perspective. Say we want 1000 feet AGL to feel safe making turns to return to the airport for a single-engine landing. It's going to take a bit over 4 minutes to climb that high on one engine, during which time we'll cover almost nine (statute) miles of landscape! Does your favorite airport have that much clear terrain off the end of the runway? What if your takeoff altitude is higher than sea level, or the temperatures are warmer than standard?

Sobering, isn't it? I'm not trying to denigrate the performance of piston twins (once you get into a turboprop, things aren't quite as bad). I am trying to point out, however, that there's little or no margin for error, particularly near the ground.

What about up at altitude? Is blueline important up there? It depends how high you are, and if you need to stay up there. Up to the airplane's single-engine service ceiling (13,700 feet at maximum weight on a standard day), it will at least hold altitude if flown at blueline. Above that, blueline is still important: it'll minimize the rate at which you lose altitude (called "drift-down").

Practice your single-engine techniques - and once you have them really solid in nice weather, try them on instruments. When you've mastered them, you'll know that you have what it takes to be a professional pilot. And here's a secret about turboprops and jets: with their additional performance, as you're about to find out, it only gets easier from here on!

Navajo Chieftain Before Takeoff Checklist

1. Parking brake . . . . .SET
2. Mixtures . . . . .RICH
3. Prop controls . . . . .FORWARD
4. Cowl flaps . . . . .OPEN
5. Engine instruments . . . . .CHECKED
6. Throttles . . . . .1500 RPM
7. Prop controls .CHECK FEATHERING (max drop 500 RPM)
8. Gyro pressure . . . . .CHECK 4-6 in. Hg.
9. Alternator output . . . . .CHECK
10. Alternator INOP lights . . . . .OUT
11. Annunciator panel lights . . . . .OUT
12. Throttles . . . . .2300 RPM
13. Magnetos . . . . .CHECK (max drop 175 RPM, max diff 50 RPM)
14. Prop Controls . . . . .EXERCISE (max drop 300 RPM), then FULL INCREASE)
15. Throttles . . . . .IDLE 600-650 RPM
16. Throttles . . . . .1000 RPM
17. Friction lock . . . . .SET
18. Seat belts/No smoking sign . . . . .ON
19. Fuel selectors . . . . .INBOARD
20. Fuel Quantity . . . . .CHECK
21. Mixtures and prop controls . . . . .FULL FORWARD
22. Flaps . . . . .SET (0 deg. for normal takeoff, 15 deg. for short field takeoff)
23. Autopilot . . . . .OFF
24. Trim . . . . .SET (3)
25. Surface de-ice . . . . .OFF
26. Pitot, prop, windshield heat . . . . .AS REQUIRED
27. Avionics . . . . .AS REQUIRED
28. Direction indicator . . . . .SET
29. Radar . . . . .AS REQUIRED
30. Transponder . . . . .AS REQUIRED
31. Controls . . . . .FREE
32. EMERG fuel pumps . . . . .ON
33. Air conditioner . . . . .OFF
34. Prop sync . . . . .OFF
35. Parking brake . . . . .RELEASE

King Air B200 — The pleasure of flying a turbine.

Beech King Air B200

INTRODUCTION

Welcome to the wonderful world of turbine-powered flying. Those who aspire to a professional piloting career will assure you that this is “where it’s at;” and once you’ve had the pleasure of flying a turbine, you’ll find it hard to go back to pistons.

This is not merely, or even primarily, because the turbine powerplant, whether turboprop or jet, is easier to manage (although it is). Nor is it because these airplanes have all kinds of labor-saving devices to make your job easier (although they do). As much as anything, it’s because the turbine is inherently much smoother and more comfortable than a piston engine, with all those parts busily bashing back and forth. Add to that the fact that both turboprops and, especially, jets have so much reserve performance that, for the first time, a single-engine situation is more an annoyance than a life-or-death situation, and you’re getting close to a pilot’s ideal.

A TURBINE ENGINE PRIMER

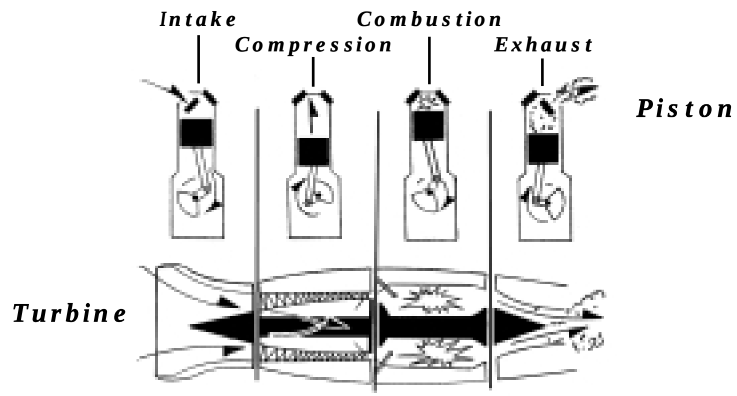
For all their power and seeming complexity, gas turbine engines are actually much simpler than their piston powerplants. They come in three basic styles: turboshafts, which provide output power via a high-RPM shaft and are found only in helicopters; turboprops, in which most of the output power still appears at a shaft, but one that turns at the much lower speeds at which propellers operate efficiently (1500-2000 RPM); and "pure jets," either turbojets or turbofans (we'll get to those in the next chapter), whose output power appears solely as jet thrust.

All of these types, however, share the same core technology - and, while they may have only one major moving part, you'll be surprised to find out that they operate on the same four-stroke internal-combustion "Otto" cycle as the piston engines found in airplanes and cars. Although there are fancy names for each stage in this cycle, we can summarize them as "Suck, Squeeze, Burn, and Blow."

Let's look at a piston engine first (those of you who passed Auto Shop in high school are excused). During the intake stroke ("suck"), the piston moves down, the intake valve is open, and the fuel-air mixture is sucked into the engine. During the compression stroke ("squeeze"), the valves are closed, the piston moves back up, and the mixture is compressed. During the combustion stroke ("burn") the mixture is ignited, and as it burns and expands it forces the piston back down. Finally, during the exhaust stroke ("blow"), the exhaust valve is open, the piston moves back up, and the burned gases move out the exhaust pipe.

The only time the piston is actually moved by the gases in the cylinder, or extracts power from them, is during the combustion stroke; during all three other strokes, it's moved by the crankshaft (powered either by other pistons if there are several cylinders, or by a heavy flywheel if it's a single-cylinder engine). Considering that the whole evolution proceeds by fits and starts, it seems remarkable that piston engines run at all, much less as efficiently as they do!

Now let's look at a gas turbine doing the same job. In the accompanying illustration, the appropriate stages of each engine are portrayed directly beneath each other.



Air flows into the engine's intake ("suck"). Here, it meets a series of whirling compressor blades - often several stages, one after the other ("squeeze"). The compressed air is fed into a combustion chamber and mixed with fuel. There's already a fire burning in there ("burn" - turbines need ignition only during startup). As the heated air expands, it flows out through the exhaust ("blow"). There will always be at least one turbine wheel installed at this point. If the engine is a pure jet, the turbine will extract just enough energy from the stream of hot gases to power the compressor (sort of like lifting yourself by your own bootstraps), while the rest of the energy rushes out the back to provide thrust. If it's a turboprop, additional turbine stages will extract as much energy from the stream of gas as possible, directing it to a gearbox and, ultimately, to the propeller shaft. There will still be a bit of residual thrust, and plenty of heat, in the exhaust gases (holding your hand over the exhaust of a turboprop would qualify as Not A Good Thing To Do), but most of the energy will have gone to the propeller.

There are a few differences between the way turbines and piston engines are operated. Startup procedures are quite different, and will be covered in considerable detail. In general, while turbines are much simpler to operate than piston engines, they require more care - not because a mistake could cause you to fall from the sky, but rather because only a moment's inattention might result in extremely expensive turbine section damage.

Flight Instruction

Why is this the case? And, for that matter, if turbines are so simple, why do they cost so much (over $250,000 each on the Super King Air)? Because their internal parts operate in a very demanding thermal environment, often requiring the use of exotic and expensive alloys (that we'll dub "unobtainium"). True, the temperatures and pressures in a piston engine are similar to those in a turbine - but they occur only during the combustion ("burn") stroke, allowing the relatively massive components to cool off during the other three strokes. By contrast, the little turbine blades - they're each smaller than a postage stamp - are continually immersed in the stream of hot gas, with no chance for a rest.

THE SUPER KING AIR AND ITS ENGINES - A BIT OF HISTORY

Turboprops - generally pretty large ones - started appearing on airliners in the 1950s, as the airlines' demands for higher performance, less maintenance, and more economical operation outstripped the capabilities of the big radial piston engines available until then. Initially, however, there were no small engines and no small business turboprop airplanes. The smallest turboprop airplane in general use, starting in 1958, was the admittedly magnificent Grumman Gulfstream, powered by a pair of 1019-hp Rolls Royce Dart airline turboprops - but with a seating capacity of up to 21 and a gross weight of up to 36,000 lbs, it was out of reach of all but the largest corporations.

Meanwhile, however, north of the border, the engineers at United Aircraft of Canada, Ltd., were developing a very versatile compact gas turbine for both aviation and industrial purposes. Their PT6 series has found its way into everything from firefighting pumps to Andy Granatelli's Indy car (which had such fabulous performance it was subsequently disqualified). More importantly, the availability of the aviation version of the PT6 prompted Beech Aircraft to develop an appropriate airframe to go with it. The first King Air 90, which appeared in 1965, was developed from an earlier piston-powered model (the Queen Air 88) and sported a pair of PT6-A-6's cranking out 500 hp each. It became the archetypal small to medium business and corporate turboprop, a position it continues to occupy.

Over the years, both the King Air and PT6 families developed ever bigger and stronger members, but the family resemblances are strong. The Super King Air B200 featured in this release of FLY! is a far cry from the old "straight 90," but its heritage is evident at a glance; and its mighty 850-hp PT6-A-42s are similarly close to their original 500-hp ancestor. In fact, the PT6-A series is the most widely distributed light turboprop engine in aviation history, with tens of thousands of units in the field…not to mention quite a few more turboshaft versions in helicopters. While it's still built in Canada, the program now is owned by Pratt & Whitney.

AIRCRAFT AND COCKPIT TOUR

As you approach the Super King Air, you'll see that it's still, basically, "just an airplane." It may, however, be a bigger one than any you've flown thus far; we'll discuss some of its features on a quick walkaround, then move into the cockpit.

What strikes everyone at first glance is that big T-tail. Why have the horizontal stabilizer and elevator all the way up there? For a couple of reasons. The most obvious is that this location gets them up out of the downwash of the wing and the propeller slipstream; thus, the trim changes with power or aircraft configuration (landing gear and flaps) are minimized.

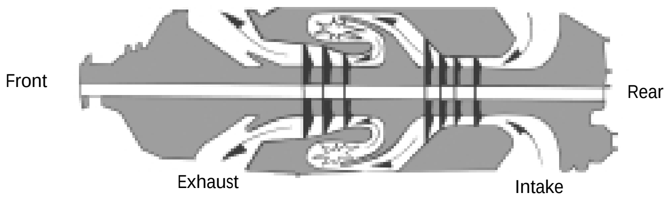
A secondary reason is that this location allows the horizontal surfaces to act as an "endplate" for the vertical fin and rudder, making these more effective and thus allowing them to be smaller. They're still pretty good-sized, of course; they need to be able to handle a potential situation with a windmilling prop on one side and 850 feisty ponies on the other! Without the horizontal up there, however, the vertical fin and rudder would have to be quite a bit taller - to the point that getting the airplane into some typical corporate hangars could be problem.

A look at the engines and their nacelles tells the educated eye at a glance that this is a PT6-A powered airplane. There are two clues. The most obvious is that, at rest, the propeller blades are feathered. This is because the PT6-A is what's called a free turbine engine. (Unfortunately, this proves to be an oxymoron at maintenance or overhaul time.) What it means is that the turbine stages that drive the gearbox and propeller are not connected mechanically to those that drive the engine's compressor section. When the engine is started, its core section (called the gas generator) can come up to speed right away, without being affected by propeller loads.

The other turbine (called the power turbine) and propeller can spin up to idle RPM at their own speed; as they do, oil pressure from the gas generator section will unfeather the blades.

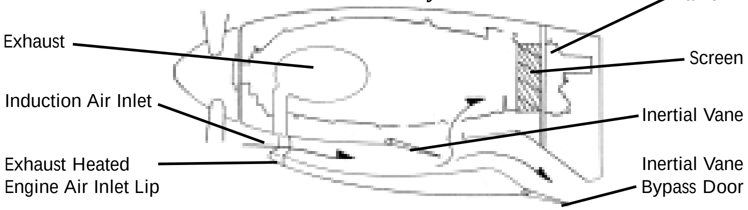
The other clue is that where you'd expect a big jet exhaust at the back of the engine nacelle, there's either nothing or an optional baggage locker! Instead, there are two big exhaust pipes at the front of the engine, right behind the propeller. This is because in the King Air (and every other airplane except those with "pusher props" such as the Piaggio Avanti), the PT6-A is a reverse flow engine. It's actually mounted backward in the cowling, with its intake at the rear. Air entering through the scoop just below the prop flows aft through the cowling and makes a U-turn to enter the engine. Then it works its way forward through the compressors, combustion chamber, and turbines before making another U-turn in the exhaust stacks. It's a very handy arrangement: the shaft from the gas generator turbine goes aft into the engine to spin the compressor, while the one from the power turbine goes forward to the gearbox and propeller.

PT6-A Reverse Flow Engine



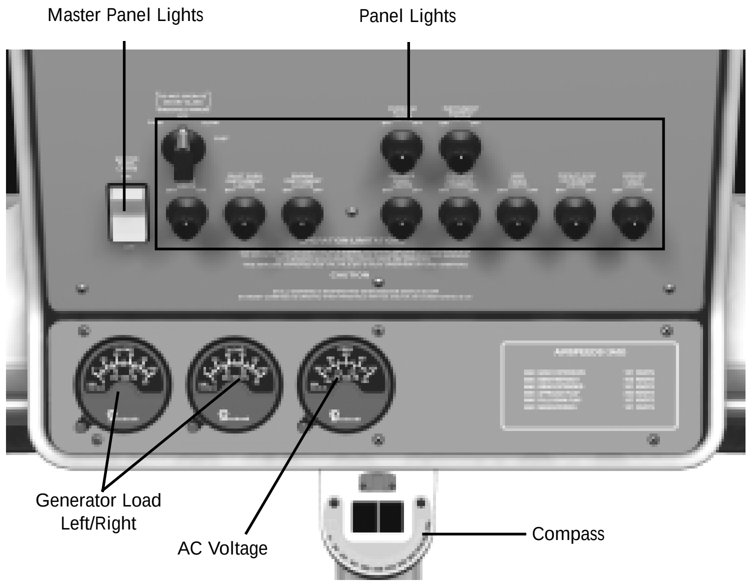
There's an additional benefit to this arrangement: engine ice protection. With its fragile compressor blades spinning at close to 40,000 RPM, the engine is vulnerable to damage if it ingests any ice. On the Super King Air, the inlet lip is heated with exhaust gas. In normal operation, air flows straight back into the cowling and enters the engine. In icing conditions, however, doors and vanes are deployed to form an inertial separator. The air must make a sharp turn to enter the engine. Ice particles, however, are too heavy to do so, so they "skid out" of the turn and are dumped overboard through the open bypass door at the rear of the cowling.

Ice Protection System



IN THE COCKPIT

King Air Upper Panel

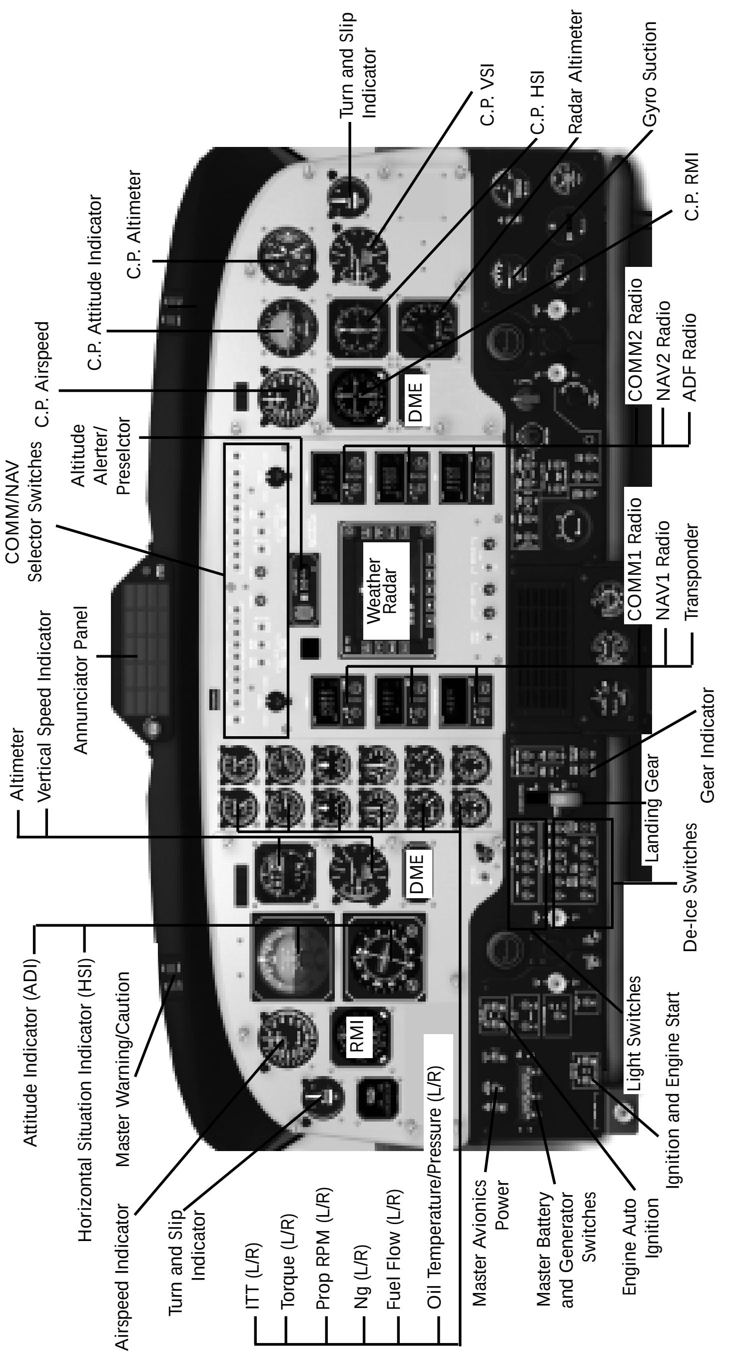


OK, walk up through the roomy cabin and settle into the pilot's seat. It may take a bit of gymnastics to do so, since many King Airs are equipped with a double-width center pedestal, between the seats, to accommodate optional equipment. Take a look around. At first, it may seem there are an awful lot of switches, dials, and gadgets; but they're very logically grouped, and you'll soon find your way around easily among them.

Let's start at the very top. A row of knobs in the ceiling controls the brightness of various groups of instrument and panel lights, but you only have to set them once; just to their left, a single switch turns them all on and off together. Just above it is a knob for the windshield wipers.

Just above the top of the windshield are three meters to monitor the electrical system. The left two are for the starter-generators on each engine (on most turbines, a single unit serves both functions - run DC back into a generator, and it becomes an electric motor!). Each reads the output of its unit in amps; to read volts, push the button at the 7 o'clock position. The other meter, to the right, monitors the 400-Hz AC supply used by some instruments and avionics, indicating voltage in its normal mode (should be 115 volts) and frequency when its button is pushed.

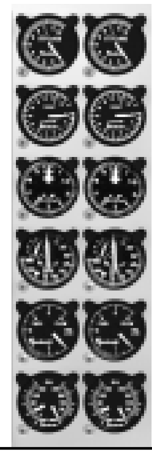
King Air Main Panel



Before we get into the main instrument panel, take a quick look at the edge of the glare shield running across its top. Directly in front of each pilot are two lights: a red one, labeled MASTER WARNING, and an amber one labeled MASTER CAUTION. Each of these lights will flash to alert the crew of a situation that needs their attention on either the warning annunciator panel, located at the center of the glare shield, or the caution/advisory annunciator panel located at the bottom center of the instrument panel, just forward of the power levers. Either flashing master warning or caution light can be extinguished by pressing on it, but the associated warning or caution annunciator itself will stay on. The master lights will flash again each time a new annunciator illuminates. Inboard of the master lights on each side of the glare shield are the guarded buttons to activate the engine fire extinguisher bottle for that side. A “D” in the bottom half of each switch indicates that its bottle has been discharged; the “OK” indicator illuminates during system test.

On to the main panel itself: Flight instruments are arranged in the usual “sacred six” in front of each pilot (the turn and slip indicators may be displaced to make room for an RMI). You’ll notice that the Attitude Director Indicator (ADI) and Horizontal Situation Indicator (HSI) are bigger than in the airplanes you’ve been flying up to now. This is because they use larger and more accurate remote gyros, mounted in the avionics compartment in the nose. In case of failure (annunciated by ATT or HDG flags in the instruments), you can switch to the conventional panel-mounted gyros on the copilot’s side of the panel.

ENGINE INSTRUMENTS



The engine instruments are stacked, two across for the left and right engines, to the right of the captain’s flight instrument panel. They’re somewhat different from what you’ve become used to flying piston-powered airplanes.

At the top of the stack is Interstage Turbine Temperature (ITT). This measures the temperature of the hot gases between the gas generator turbine and power turbine. Strictly speaking, it’s not a power-setting instrument, but rather a limiting one: it’s the instrument you’ll monitor, especially at higher altitudes, to avoid exceeding engine limitations.

Next down is the torquemeter. This indicates, directly, how hard the engine is turning the propeller shaft, and is your primary power setting instrument. Like the ITT, it has a redline which must not be exceeded.

Next comes the tachometer. To allow very accurate setting of RPM, it works like a miniature altimeter: the big hand indicates hundreds of RPM, the small hand indicates thousands. Takeoff RPM is 2000; you'll cruise between 1600 and 1800 RPM.

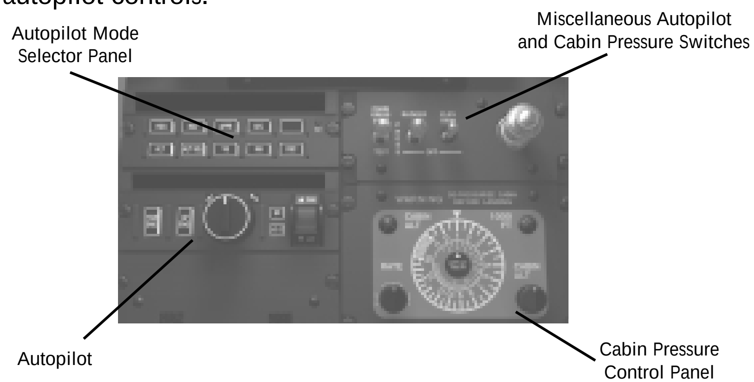
The next indicator is one you'll find only on a turbine airplane: it's marked NG, meaning gas generator RPM, and indicates how fast the core engine (not the propeller) is turning. Because the numbers can be so high, it doesn't read them directly; instead, it's calibrated in per cent RPM, with a redline at 101.5%. To make it easier to read, there's a small inset needle that reads in 1% increments; it'll make ten turns between zero and redline NG RPM.

Below this is fuel flow, calibrated in hundreds of pounds per hour. Traditionally, turbine fuel quantities are measured in units of weight (pounds) rather than volume (gallons). This is partly because turbine fuel changes its volume with temperature more than gasoline does - a gallon weighs 6.7 lbs on a standard day, less on a warm one, and more on a cold one - and partly to allow the pilot to know at all times what the actual gross weight of the airplane is. (In aircraft of this class, we'll use that weight for accurate calculation of takeoff and approach speeds).

Finally, at the bottom of the stack, a pair of dual indicators displays oil pressure and temperature for each engine.

FLOOR PANEL

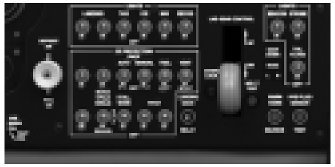
The floor panel is where you will find the cabin pressure and autopilot controls.



CENTER PANEL

The center panel is devoted to the avionics installation. The only significant difference from what you're used to is that these are airline-style remote radios: since these high-performance units are too large to fit into the instrument panel, the actual radios are mounted in the nose, while only the remote "control heads" are on the panel. Functions are basically the same as for the smaller radios; only the nav radios' "digital RMI" functions have been deleted, in the assumption that any airplane in this class will have at least one actual RMI in the panel. The switches across the top of the avionics panel control which radios you'll hear, and on which ones you'll transmit; there are two completely separate audio switch panels, allowing the captain to communicate on comm radio while the copilot uses the other one.

SUBPANEL



Running all the way across the airplane below the instrument panel is a big subpanel that at first glance appears to be a forest of switches. They're logically groupled, however: at the extreme left, above the captain's left knee, are the master electrical switches (battery and generators) and those devoted to engine functions, including starting, ignition, and ice protection. Above the captain's right knee, the top row of switches controls exterior lighting; the lower two rows control airframe, rather than engine, ice protection functions. To the right of these is the big landing gear handle.

In the center of the subpanel is a group of annunciators which are considered less urgent than those in the glareshield. All the glareshield annunciators are red, and will illuminate the red MASTER CAUTION flasher. Those in this panel are either amber, and will illuminate the amber MASTER WARNING flasher, or green, indicating simple advisories only. Below the annunciator are the flap position indicator, cabin rate of climb indicator, and cabin altimeter/differential pressure gauge.

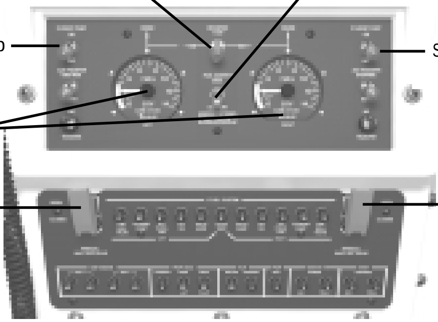
The right subpanel is concerned primarily with passenger comfort items: cabin lights and all the controls for the environmental system (heating and air conditioning). Finally, at the extreme right are a few small gauges for such things as pneumatic pressure, vacuum for the copilot's gyro horizon, cabin air temperature, oxygen cylinder pressure, and the airplane's hour meter.

Almost all of the switches on the subpanel are actually "switch/breakers," combining the functions of a switch and a circuit breaker. An overload on any of these circuits will cause its switch to click back to the OFF position.

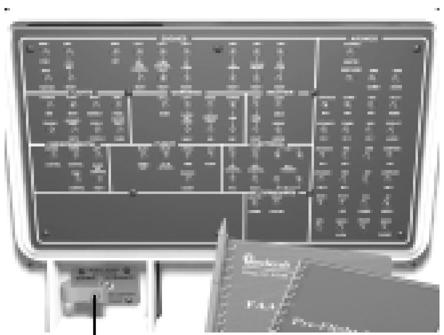
SIDE PANELS

The left side panel contains switches and indicators for the airplane's fuel system. Be aware that some fuel system functions, including various remotely-operated valves and the standby pumps (all protected by, and labeled on, the top left row of circuit breakers) are connected to a "hot" battery busbar, one that's energized even when the aircraft master switch is off. Be sure that the fuel crossfeed and standby pump switches are in the OFF position before leaving the airplane - or you'll come back to a dead battery. The right side has the alternate/static air switch.

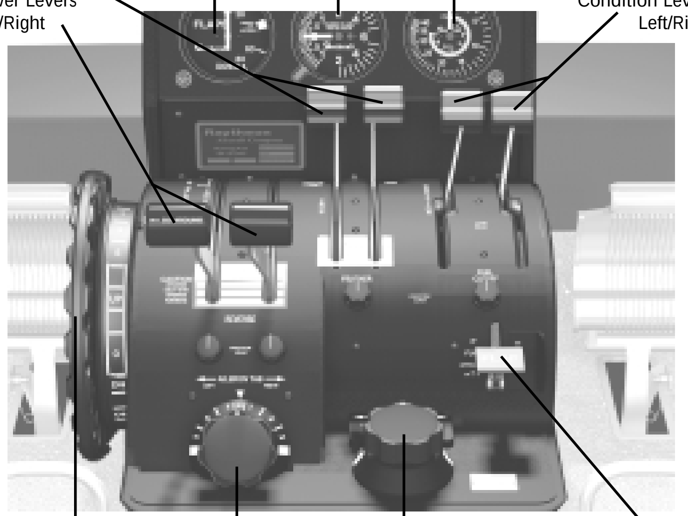
Pilot Side Panel



Co-Pilot Side Panel



CENTER PEDESTAL



The center pedestal, between the crew seats, is dominated by the engine controls. Each engine has a power lever (analogous to the throttle on a piston engine), a prop control that works exactly the same way as it does in any other airplane, and the red-knobbed condition lever, which is used primarily during engine startup and shutdown. Consider it a fuel control: when it's all the way back, fuel to the engine is cut off, and when it's moved forward, the fuel is turned on. Its secondary function is to set the speed at which the engine idles (when the power lever is in the flight or ground idle position). Low idle is quieter, and provides less residual thrust during the landing flare, while high idle provides a more rapid transition into reverse thrust after landing.

To the left of the power levers is the big manual elevator trim wheel, with its indicator. Aileron and rudder trim knobs and indicators are on the console below and behind the engine control levers. At the right side is the flap control, which has only three positions: UP, APPCH (which can also be used for short-field takeoffs), and DOWN.

Behind this, the pedestal accommodates the autopilot/flight director controller, the cabin altitude selector and pressurization controller, and a short row of switches controlling pressure dumping, power to the elevator trim system, a rudder boost function that we'll explain shortly, and the yaw damper unless it's part of the autopilot.

Most recent Super King Airs have enough optional equipment (long range navigation systems, remote course arrow and heading bug selectors, etc.) to warrant making this section of the pedestal "double width" to accommodate two rows of standard-size accessories.

LABOR-SAVING DEVICES

Remember that I said that this airplane is easier to fly than a piston-powered twin? That's partly because it has several features that take care of some tasks for you in critical situations.

One of these is "auto-feather." When it's armed (normally only for takeoffs and landings), it monitors the torquemeters of both engines. If either engine loses power, the auto-feather will automatically feather that propeller, at the same time disarming itself on the other side of the airplane to avoid the risk of feathering both engines. Thus, if you lose an engine on takeoff, while you should still have the old "Identify, Verify, Feather" litany in mind, you're more likely to see an initial hard swerve toward the failed side followed by a reduction in pedal pressure as that engine feathers automatically.

Another system, working in parallel with auto-feather, is rudder boost. A certain amount of air is bled from the compressor of each engine, primarily for pressurization and environmental purposes. Some of this bleed air is directed to a pair of pneumatic servos attached to the rudder. If the system detects a large discrepancy in bleed air pressure, as would occur during an engine failure, pressure from the operating engine is directed to the appropriate servo to assist the pilot in maintaining rudder pressure on the operating-engine side.

Finally, there's auto-ignition. Remember, once "the fire is lit" in a turbine, there's no further need for ignition. However, it's possible for the fire to blow out, for example if an engine ingests a big slug of water when the airplane rips through a deep puddle on takeoff. If either engine drops below 400 ft/lbs of torque, the auto-ignition system will actuate the igniters on that side to help prevent a flameout.

STARTUP

A gas turbine is particularly vulnerable to damage during startup, when there's a risk of getting a big, hot fuel fire going before there's enough airflow through the engine to handle its internal cooling needs. When you crank up a piston engine, you can let go of the starter button or key as soon as the engine fires. A turbine, on the other hand, needs the help of the starter to accelerate all the way up to idle speed (a much larger fraction of normal operating speed than with a piston engine). If you quit cranking too soon, you're likely to experience what's called a "hot start," in which the turbine exceeds its ITT limitations. Pratt & Whitney cut you a little slack here: while maximum ITT is 800 deg. C for takeoff and 770 for high cruise, you're allowed to go up to 1000 deg. C during startup - for all of five seconds! In the real world, however, you can consider that there are no numbers on the ITT gauge beyond 850 - from there out, it's nothing but dollar signs!

I suggest that you go over the starting sequence, step by step, and get it firmly in mind before we actually try it. Once things start happening, even on a normal start, there's no time to look at a checklist - and, without trying to scare you, I should warn you that a badly botched start could cause up to $100,000 in engine damage in just a few seconds.

Check that the power levers are at idle, the prop controls fully forward, and the condition levers fully aft, in the cutoff position. If you wish, you can check operation of the standby fuel pumps before turning on the battery master switch by turning each of them on momentarily and listening for operation. Now turn the battery switch on and check that the L and R FUEL PRESS annunciators are off; then turn the standby pumps OFF and check that the L and R FUEL PRESS annunciators illuminate. Briefly press the MASTER WARN and MASTER CAUTION flashers to reset them.

Before initiating a start, it's a good idea to press the voltmeter button on either of the ammeters above the windshield and verify that you see at least 24 volts. If not, you're just about guaranteed to get a hot start; call for an external power unit.

Conventional King Air wisdom suggests starting the right engine first, since the battery is in the right wing root and the cable run to the right starter/generator is shorter. Actually, on most later

King Airs, the big junction box with the start switching relays is in the middle of the airplane anyway, so it doesn't make much difference, but tradition dies hard. Move the right ignition/engine start switch up to the ignition/engine start position. The R FUEL PRESS annunciator should extinguish right away, and the right NG tach will start to wind up. The green R IGNITION annunciator should also be on at this time.

Now take a quick glance to see if the right oil pressure is at least beginning to stir off its peg. Wait for NG to stabilize above 12% - the higher, the better - but don't waste any time once it does.

Now is when things are going to start happening faster. Move the right condition lever to the LO IDLE position, and keep your hand on it in case you have to abort the start. You'll see a momentary "kick" of the right fuel flow gauge, indicating that jet fuel is being sprayed into the combustion chamber. Within no more than 10 seconds (generally a lot less), you should hear the "Whoompf!" of lightoff, and the ITT gauge should come to life.

Watch it like a hawk! It'll rise rapidly at first, then hesitate, then start rising again as the secondary fuel flow nozzles kick in. By the time it gets to about 700 degrees, the rate of rise should be slowing perceptibly. If it's still zipping on up, I'd suggest aborting the start by pulling the condition lever back to idle. Don't de-energize the starter - even after the fire has gone out, you still need to keep plenty of air moving through the engine to cool it back down.

In a normal start, of course, that won't be necessary; just keep an eye on ITT as the NG continues to accelerate. At 50% NG RPM, you can move the ignition/engine start switch back to the center OFF position. At this point, you can relax: the engine is self-sustaining, and the start is complete.

CROSS-START

If you have an unusually strong battery, or if you're running on external power, you can go ahead and start the other engine the same way. In the real world, however, most batteries only have enough energy for one nice, cool start; we'll give both our battery and the second engine a little help.

Begin by moving the condition lever on the engine you've just started (the right engine) to the HI IDLE position. Now, on the left subpanel, hold the R GEN switch in the RESET position for at least one second, then move it to ON. You'll see the R GEN FAIL light on the annunciator panel extinguish, and the right ammeter, above the windshield, will show a hefty charge rate. In about six seconds, you'll also see the BATTERY CHARGE annunciator. Go ahead and charge the battery until the loadmeter has dropped back to about the 50% mark.

Now, turn the right generator back OFF. This seems paradoxical, but there's a reason: the starter draws the most current during the first few seconds after you turn it on, when it's accelerating the engine from a standstill; then its current requirements drop off quite steeply. If you suddenly hit the operating generator with a huge load like that (up to 1000 amps!), you're asking for trouble. At best, you'll probably blow a current limiter - a big, very expensive fuse - down under the floor; you can't fly until it's been replaced. At worst, you'll blow a "mechanical fuse": in order to protect the unbelievably expensive gears in the engine, there's an intentional weak point in the only hideously expensive starter-generator driveshaft, which will shear if hit with a sudden load. Either way, you're not going flying until you've called a mechanic...and maybe the bank...

Now move the left ignition/start switch to the ON position, and watch the left NG start to wind up. When it hits 10%, you know you're past the big amperage load, so now go ahead and hold the R GEN switch to RESET for one second, then move it to ON. You'll notice that the left NG will now wind up a lot faster, and stabilize at a higher level, since it has the right generator helping the battery - and as you continue the start, the ITT will peak at a much lower level. Once the left engine is stable, move its ignition/starter switch to OFF, reset and turn ON its generator, and finally bring the right engine's condition lever back to LO IDLE.

PRE-TAKEOFF CHECKS

Turn on the inverters and avionics and taxi to an active runway. With no magnetos to worry about, we won't do an engine "runup" in the traditional sense, but there are still a few items to check. While you're taxiing, you can experiment with the propellers' "beta" range. Rather than riding the brakes to keep taxi speed down, lift up on the power levers and ease them back below IDLE. The L and R BETA lights will illuminate and the airplane will slow up - you're actually sneaking toward reverse thrust.

If you anticipate flight in icing conditions, check the engines' inertial separators. Run both engines up to 1800 RPM, note the torquemeter reading, and move both ice vane switches to EXTEND. The L and R ICE VANE annunciators will illuminate and you should see a slight drop in torque. Return the switches to RETRACT and verify that the annunciators go out and the original torque value is regained. Return the power levers to IDLE.

Finally, we'll check the auto-feather system. Hold the auto-feather switch to the TEST position and advance both power levers together until you reach about 500 ft/lbs of torque. The L and R AUTO-FEATHER ARM lights will come on. Now, slowly bring one power lever back. As torque passes through about 400 ft/lbs, the opposite AUTO-FEATHER ARM light will go out. Keep reducing power; at about 260 ft/lbs, the propeller will start to feather. Because the engine is actually still running, the torque will increase as the prop blades begin to turn sideways, so it'll "cycle" in and out of feather; in an actual engine-failure situation, it would feather all the way. Bring the power back up to 500 ft/lbs and repeat the test on the other engine.

TAKEOFF, CLIMBOUT, AND POWER MANAGEMENT

On the assumption that you know the basic flying moves by now (would they trust you with a Super King Air if you didn't?), I won't go into much detail about how to fly the airplane as such; and if you want to try some instrument work, be my guest, but you don't need me to hold your hand! Instead, we'll just touch on the differences you can expect from piston power, and we'll sample one engine failure on takeoff to show you how much easier it is in the Super King Air than in the Navajo Chieftain.

Line up on the runway, check that the propeller controls are all the way forward. Unless you anticipate a maximum-effort stop or short-field landing, you can leave the condition levers in LO IDLE. Turn ON the auto-feather and auto-ignition systems. The L and R IGNITION lights will come on.

Up to now, the engines you've flown behind have been protected against exceeding their limits. The 172's normally-aspirated engine doesn't have enough grunt to hurt itself in the first place, and those of the Malibu Mirage and Navajo Chieftain have automatic manifold-pressure controllers and limiter valves. There's nothing like that here: if you shove the power levers all the way forward, you can instantly strip out the prop gearbox at low altitude, or Chernobyl the turbine section when you get higher. Instead, for takeoff, carefully advance the power levers until you're about 50 ft/lbs shy of the 2230 ft/lb redline; it'll pick up the rest of the torque as it accelerates on the takeoff roll. Verify that the L and R IGNITION lights have gone out, and the L and R AUTO-FEATHER ARM lights have come on.

Accelerate past the 86-knot V_MC, lift off around 105, start the gear up, and climb at about 130 knots. It gets upstairs a lot faster than the Navajo, doesn't it? For less noise, ease the power levers back to about 1900 ft/lbs and pull the props back to 2000 RPM. As you do, you'll notice the torque come back up, since the props are now taking a bigger bite out of the air. Since this airplane doesn't have counterrotating props, you'll also need some right rudder trim. Once you're well away from the ground, turn the auto-feather system OFF.

You'll notice that, as you climb, the torque drops off. You can regain it by carefully moving the power levers forward - but notice, as you do, that the ITT rises. Sooner or later you'll reach an altitude at which ITT hits 770 deg. C., the maximum recommended for climb or cruise. This is called the crossover point - from now on, ITT, rather than torque, is the limiting factor. Incidentally, this is one reason the airplane performs better on cold days: you can advance the power levers farther before you hit limiting temperature.

NORMAL LANDING

Spend as much time as you want feeling out the airplane; as always, steep turns, stalls, and "FAA Weaves" are an excellent way to do so. When it's time to head back to the field, you'll see another advantage of turboprops: while it's still nice to avoid sudden major temperature changes, if you need to get down fast you can just smoothly pull the power levers all the way back to "idle" and come down like a rock. You'll get a landing-gear warning horn; you can silence it by pushing the button on the left power lever. The system will reset as soon as you bring the power above idle again.

Enter the landing pattern about 1500 feet above the ground and arm the auto-feather system. The first notch of flaps can go down at 200 knots, the gear at 181, and the rest of the flaps at 157, so it's easy to slow down. Plan to slow to 110 to 115 knots on short final, depending on aircraft weight. If you want to make a maximum-effort short-field landing, set the prop controls all the way forward and set the condition levers to HI IDLE. In the real world, however, people who can afford to travel by King Air like their peace and quiet, so leave the props where you had them for cruise. When the gear comes down, you'll get a yellow RVS NOT READY annunciator...just live with it!

As you cross the threshold, ease the power levers back to idle, raise the nose to the horizon, and let the airplane settle onto the main gear. As the nose comes down (lower it gently so it doesn't thump to the runway), briskly move the prop controls all the way forward; then lift the power levers and pull them into reverse. Even without heavy braking, the airplane will slow quickly. Unless you're on a recently-swept hard-surface runway, try to get out of reverse before you're down to 40 knots, or you'll pick up a lot of dirt and gravel and chew up your prop blades.

ENGINE FAILURE ON TAKEOFF

Taxi back for takeoff and get things set up. Since you have all the goodies to help you, we don't want to make things too easy - so we'll do a short-field takeoff, with the flaps set at the first notch. Plan to rotate at 94 knots, and aim for 106 knots as you pass through 50 feet and get the airplane cleaned up.

We're going to "fail" the left engine (the critical one) right at rotation. Since the PT6-A is a free turbine engine, we don't need to shut it down; at idle power, there's no reason not to feather it and just let it run. The prop blades will be paddling around at pretty low RPM, but they won't be producing any thrust, and at idle power the exhaust effects are negligible. Make sure auto-feather is armed and rudder boost is switched on.

OK, here we go! Power levers up, set torque at about 2180 ft/lbs, and accelerate. At 94 knots, rotate, and as soon as the airplane lifts off, yank the left power lever all the way back to idle.

The airplane will certainly check, and swerve to the left - but it won't be nearly so bad as it was in the Chieftain! Out of the corner of your eye, you'll see the left tach unwinding: the left engine has feathered. Check that the L and R AUTO-FEATHER ARM lights have both gone out: the left one because it's done its job, and the right one because the system is preventing "fratricide." As soon as you're sure the airplane is solidly in the air, retract the gear.

The airplane won't have lost much, if any, speed; but you can anticipate that it might "sag" a bit as the flaps come up. Carefully let it accelerate to its best single-engine angle of climb speed, or V_{XSE}, of 115 knots. (Hint: have trouble remembering that V_X speeds mean angles, and V_Y speeds mean rates? There are more angles in the letter X than there are in the letter Y.) Maintain V_{XSE} until you've gained 100 feet.

Now retract the flaps and let the airplane accelerate to V_{YSE}, 121 knots. Trim for that speed and set rudder and aileron trim so it'll hold heading, hands off, with the left wing raised enough to get the skid ball about halfway out of its cage. Now look at the rate of climb. Even with the airplane at maximum gross weight, you should be seeing 740 fpm, not much less than the Chieftain would do at gross weight with both engines running! Service ceiling on one engine is listed as 21,735 feet on a standard day - enough to clear any mountains in North America. Actually, it might even be a bit higher: even if you took off at gross weight, climbed straight to that altitude, and immediately lost an engine, you'd already have burned off about 150 lbs of fuel.

As you can see, there's a bit more to get used to - but there's a lot more there to help you too. Do you agree that flying a turboprop is simpler than flying a piston twin? Want it even easier? Then move on to the next chapter and sample a jet...

Beech King Air B200 Before Takeoff Checklist

1. Avionics and radar . . . . CHECK
2. EFIS . . . . TEST
3. Pressurization. . . . . SET
   (inner scale at planned cruise alt. plus 500 feet)
4. Autopilot . . . . CHECK, then OFF
5. Elevator trim. . . . . CHECK
6. Propeller feathering . . . . CHECK
   (engines will continue to run with props feathered)
7. Vacuum and pneumatic pressure . . . . CHECK
8. Fuel quantity, flight and engine instruments. . . . . . CHECK
9. Propeller levers . . . . FULL FORWARD
10. Flaps . . . . SET
11. Trim . . . . SET (3)
12. Left and right Bleed Air switches. . . . . OPEN
13. Electric heat (if installed) . . . . OFF
14. Annunciators . . . . EXTINGUISHED or CONSIDERED
15. Ice protection . . . . AS REQUIRED
16. External lights . . . . AS REQUIRED
17. Autofeather . . . . ARM
18. Transponder. . . . . ON

The Hawker 800XP Jet –– Co-pilot not included!

Hawker 800XP Jet

INTRODUCTION

Welcome to the world of jet flying. If you've made it this far, you've really "arrived" as a pilot. To many, this is considered the pinnacle of the profession - and while you may think "this is only a little business jet," the fact remains that it's every bit as complicated (and performs just about the same) as any midsize airline twin, such as a Boeing 737 or McDonnell-Douglas (er, Boeing, nowadays...) DC-9.

You're taking on a bit of a task, too. At the end of the chapter on the Navajo Chieftain, I noted that "it would only get easier from here on out." I based this on the fact that turbine aircraft enjoy not only much better performance and powerplants that are simpler to operate, but boast a number of labor-saving devices as well (such as the automatic feathering system on the Beech Super King Air). Unfortunately, the most significant labor-saving device in the Hawker 800XP is not implemented in this release of FLY!

I refer, of course, to a copilot. While jets may be inherently simpler to fly, there's a lot going on, and you're gobbling up both fuel and airspace at an impressive rate of speed. The FAA, in its infinite wisdom, has decreed that any civil airplane powered by jet engines has to have a crew of at least two.

Thus, if you sometimes feel a bit frustrated at the complexity of the Hawker, bear in mind that in the real world, you'd have someone else to help you with system operation, fly the airplane while you delve into checklists, etc. Here at FLY!, we'll cut you all the slack we can. Don't forget, too, that if you start feeling rushed, FLY! has a capability not yet available in even the most sophisticated jets: just hit **P** to pause the simulation and take a breather!

THE HAWKER JET: A Piece of History

Just about everyone - even most pilots - thinks that the Learjet, which first flew in 1963, was the first small corporate jet. By that time, though, in England, the celebrated old firm of de Havilland had already been flying their DH-125 for well over a year.

The airplane was originally conceived as a VIP liaison transport for the RAF, and called the "Dominie." The name means a lower-ranking prelate of the Church of England...go figure. It served very well in that role; in fact, for many years, one was reserved for transporting the "V-est of IPs" in England: H.M. Elizabeth II. At the same time, it gained immediate popularity as a corporate transport. Over subsequent years, the basic design was stretched through –400 and –600 airframe versions, while the thrust of its Rolls Royce Viper turbojets was upped from 3360 to 3750 lbs each.

The biggest change came in 1977, when production, which had briefly wandered as far afield as Beech Aircraft in Wichita, returned to Hawker-Siddeley in the UK. One of the main complaints about the 125 had been its relatively short range, and plans were afoot to retrofit earlier versions with the much more fuel-efficient Garrett TFE-731 turbofan engine, which produced almost the same thrust (3700 lbs) while burning about 40% less fuel (see below). With the –700, the fans went on right at the factory. The –800 version appeared in 1984, with thrust upped to 4300 lbs a side and a sleek curved windscreen replacing the angular flat-paned "wheelhouse" of earlier versions. Most recently, the XP version (for "extended performance") appeared in 1995, with improved avionics and engines uprated to 4660 lbs each for better performance at higher temperatures and altitudes.

You don't have to get very far below the surface, though, to find the original de Havilland 125. The airplane retains its classic layout, with moderately swept wings, a cruciform tail (the horizontal is mounted about two thirds of the way up the vertical fin), and the traditional de Havilland entry door, with its arched top. Systems layout is classically European, and the cockpit retains a "pukka British" look and feel, right down to the somewhat strange-looking "handlebar" control columns (which it shares with the Concorde!). The airplane may not be the fastest in its class, but its cabin is among the roomiest and most luxurious, and the Hawker is built not only with old-world craftsmanship (even if it's now, once again, put together in Wichita), but with staunch British values: "Why use tiresome sheet metal when you can have this lovely forging?"

JETS 101A: Turbojets vs Turbofans

Why are turbofans more economical, so much so that virtually all jets now use them? For that matter, what is a turbofan, anyway?

For the answer, let's look back for a moment at what makes a jet (or, for that matter, any airplane) fly. Right before he got really famous for inventing that fig-filled cookie, Isaac Newton stated that "for every action, there is an equal and opposite reaction." Airplanes stay up in the air by pushing down with a force equal to their weight; and they go forward by pushing back with a force equal to their drag. At slower speeds, they push back with a propeller; at higher speeds, by shoving air out the back of a jet engine.

What makes a real difference is how much air gets shoved aft: you can either shove a lot of air slowly (a propeller) or a little air fast (a jet). The problem is that shoving air really fast is wasteful - there's no point in putting it out the back all that much faster than the airplane is moving forward. The bigger the speed difference, the less efficient the engine. Fast air is noisy, too - and energy wasted in making noise isn't helping move your airplane.

"Pure" jets, then, work well in very fast airplanes - military fighters, for instance. When business jets first appeared, there were no turbofans (and jet fuel cost something like nine cents a gallon), so efficiency wasn't a prime concern. Neither was noise - just listen to the nasty crackle of an old "straight pipe" 20-series Learjet getting underway.

What was needed was something that could move air faster than a propeller, but slower than a pure turbojet, and that's the turbofan. At the core of every turbofan is a straight turbojet - but attached to the front is a big fan (or, if you prefer, a small, shrouded propeller with a whole lot of blades). This fan is driven, like the propeller of a turboprop, by energy extracted from the jet exhaust, using its own set of turbine blades (and, in some engines, including those on the Hawker, a set of reduction gears very similar to those on turboprops).

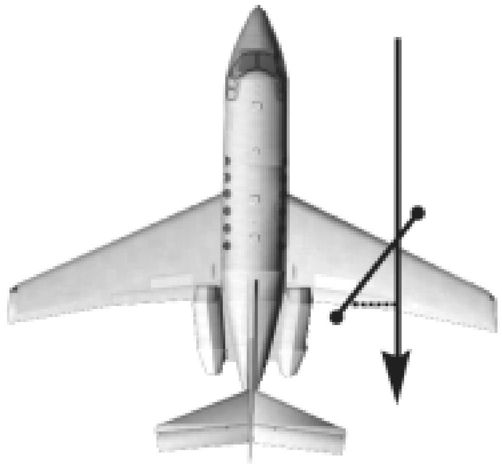
Only the physical arrangement is different, since the fan is an integral part of the engine. Once air has been sucked in by the fan, however, most of it doesn't go through the core turbojet engine; instead, it bypasses it via a circular duct that surrounds the core. The engines in the Hawker have a bypass ratio of almost 4 to 1 - i.e., some four times more air goes around the core engine than through it.

The cool air passing through the bypass duct doesn't get accelerated nearly so much as the hot gases coming out of the turbine, so it propels the airplane much more efficiently. In addition, it provides a "sheath" around the hot jet exhaust, allowing it to mix gradually with outside air, so turbofans are inherently much quieter than pure jets. In fact, old "straight pipe" jets like early Lears are now banned from many airports, especially at night.

JETS 101B:
High-Speed Aerodynamics

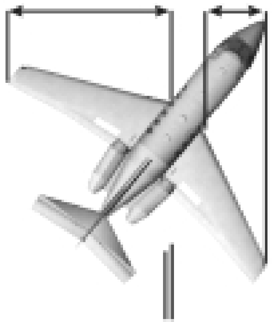
Until now, you've been flying straight-wing airplanes in a relatively low speed range, one in which airspeed was the primary factor. In the jet, however, you'll be flying at a significant fraction of the speed of sound, called Mach 1 (after Austrian physicist Ernst Mach, who did much of the early research into high-speed fluid and gas flow). As you approach Mach 1, the behavior of the air changes: it becomes more like water, an incompressible fluid, than a gas. Since air can't readily move faster than the speed at which sound propagates through it, in a sense it "can't get out of its own way" fast enough. Instead of flowing smoothly over a wing, it "piles up" to form shock waves.

The speed at which this occurs, for a given airfoil, is called its critical Mach number, and it applies to the speed at which the air moves chordwise, straight from the leading to the trailing edge. If the wing is swept, so the air moves over it obliquely, the speed of the chordwise component is reduced, so the airplane as a whole can fly faster without encountering Mach number difficulties.



This brings with it, unfortunately, some other problems. One of the most common is something colloquially called "Dutch Roll." Alas, this isn't something like a Danish pastry; rather, it's a coupling, or relationship, between roll and yaw that can make the airplane difficult to control.

Let's say a swept-wing jet, flying along, yaws slightly to its right. Now the right wing acts as if it were swept even more, thus having less effective span, while the left one acts as if it were swept less, with more effective span. Result? The airplane begins to roll off to the right.



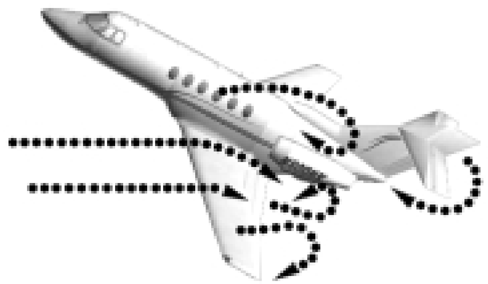
As it does, however, the "tailfeather effect" of the vertical fin, as well as the increased drag of the left wing, try to slew it back around to the left. The right wing starts to come back up, while the yaw switches around the other way. Unfortunately, it's out of phase with the rolling motion, so the airplane starts to wallow back and forth. Depending on the airplane, this reaction can range from mildly uncomfortable, through nauseating, to "divergent" - meaning that each successive swing gets larger until the airplane becomes uncontrollable. Moreover, again depending on the airplane, it will range from counterintuitive, through extremely difficult, to completely impossible for the pilot to regain control.

Most jets are equipped with a device called a yaw damper, which automatically actuates the rudder to eliminate Dutch Roll. The Hawker is actually quite well-behaved in this regard, and can be flown - if you stay on top of it! - without its yaw damper engaged. Normally, however, you'll engage the YD right after takeoff, and disengage it just before landing. If you want to sample the Dutch Roll, disengage the YD at high altitude, make a decisive rudder input, and release all controls; the airplane will start a definite left-right rocking, with the skid ball sliding back and forth. If you're really sharp, you may be able to damp out the motion with ailerons and rudder. You may find it easier, however, to wait until you near the extreme of a swing, then apply a dab of aileron into it to put the airplane into a steady turn, then recover from there.

SWEPT-WING STALLS

Because of their geometry, swept wings tend to stall first at the tips, with the stalled area progressing inboard.

This is unfortunate for at least two reasons. One is that since the ailerons are out near the tips, there's a tendency for roll control to be lost in the stall. Worse, however, is that the wing's sweep puts the tips well aft of the airplane's center of gravity - so as the tips stall, and lose lift, the airplane pitches up, making the stall much worse. Moreover, once a T-tailed jet like the Hawker pitches up into a stall, the horizontal tail will be immersed in the turbulent, separated wake of the wing and engine nacelles. This is called a "deep stall" in this country (the ever-colorful Brits call it a "superstall.") What's particularly un-super about it is that with the horizontal tail blanked out, you have no elevator control. In other words, it's unrecoverable. Repeat after me, class: "Gravity never sleeps...



With this in mind, my advice about stalls in swept-wing jets can be summed up in one word:

DON'T!

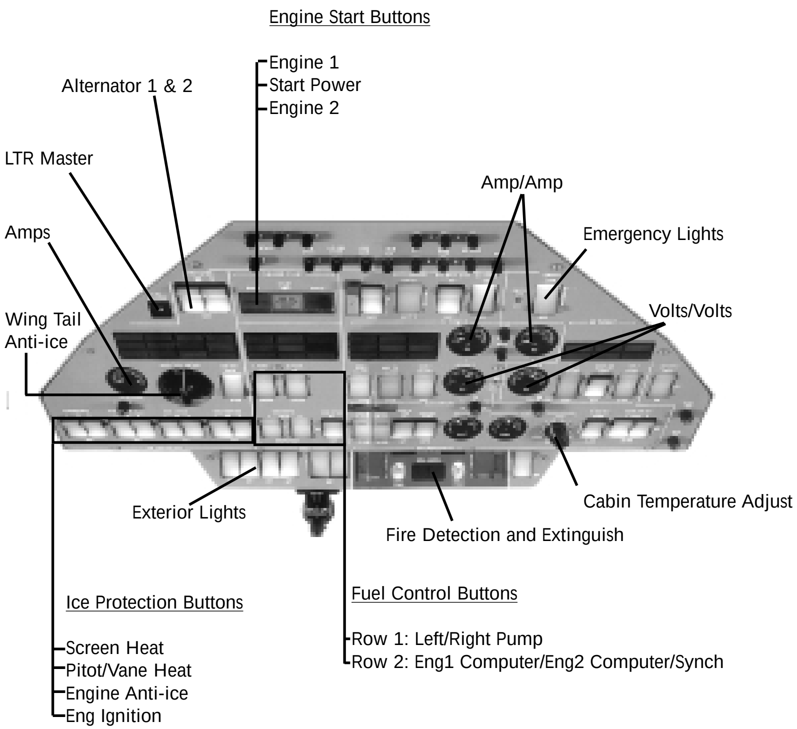
Fortunately, the airplane itself has a strong sense of self-preservation in the form of an active stall prevention system. In the Hawker, it's operated by a pair of angle of attack vanes on the sides of the fuselage and constantly evaluates factors including airspeed, angle of attack, flap position, and pitch rate. If it senses the airplane getting unpleasantly close to a stall, it activates its first "stall warning" phase. Since there's virtually no aerodynamic buffet to warn the crew, it turns on an electric control column shaker, as well as warning lights on the instrument panel. If you have a force feedback joystick or yoke, you'll be able to feel the stick shaker - but it's pretty noisy in any case!

If the pilot is so thick-headed as to ignore this warning, the airplane moves on to the "stall identification" phase, and at this point it doesn't mess around. Somewhere in its little electronic brain, it says, "enough, already," and shoots 2,500 psi of hydraulic pressure to a cylinder attached to the elevator controls: the "stick pusher." The nose drops smartly, just as it would if a conventional airplane were actually stalled. Since the consequences of an actual aerodynamic stall would be so disastrous, the airplane produces a "synthetic" one with sufficient margin for recovery.

COCKPIT TOUR

Let's start looking around the cockpit. If you're coming from smaller airplanes, you'll probably be struck right away at how much stuff there is in the ceiling (or, as the Brits call it, the "roof panel"), so let's look there first. Luckily, the roof panel has white lines dividing it into various functional areas.

Hawker 800XP Ceiling Instrument Panel



ROOF PANEL

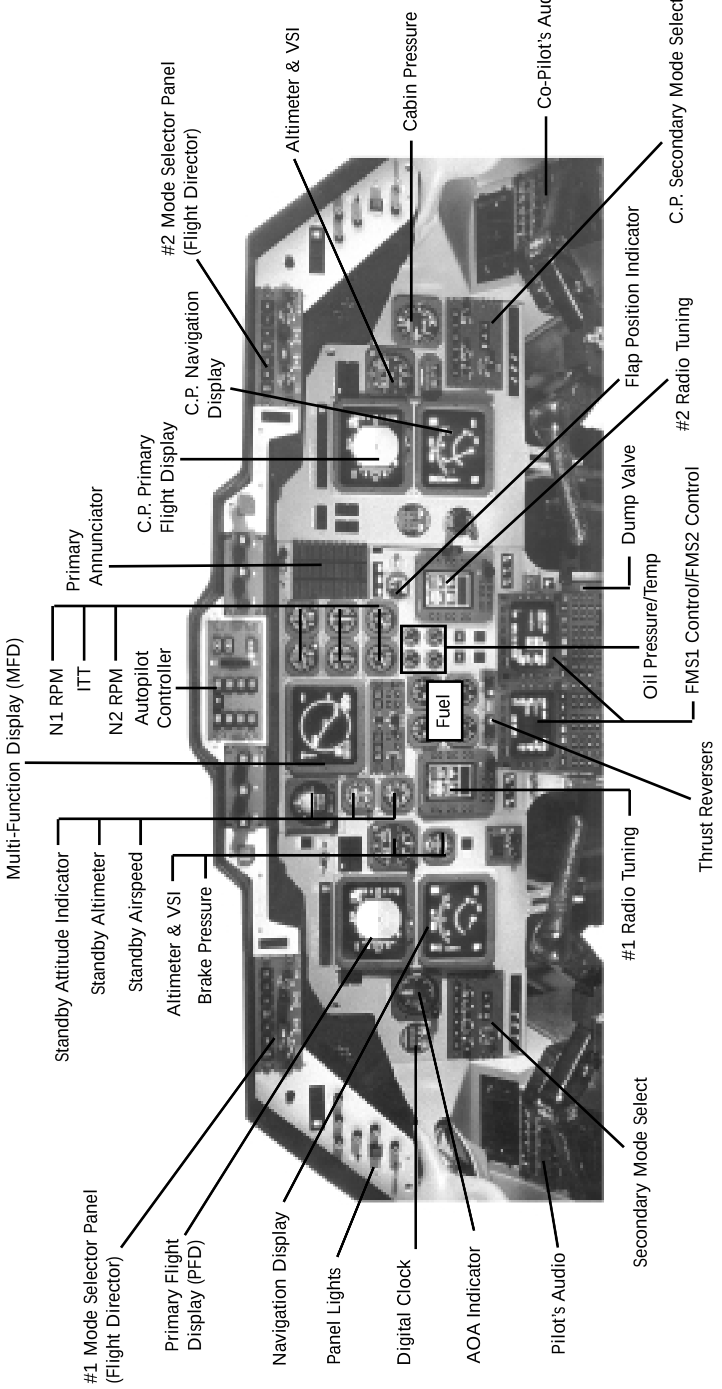
We'll take it from the top down and from left to right. At the very top, the two rows of black pushbuttons test various aircraft systems and warnings. Push any of them, and the respective warning lights (and, where applicable, audio warnings) will be activated.

The leftmost triangular area, with its various switches and warning lights, controls all the ice protection systems. Of particular interest is the large black dial that looks like an egg timer. In fact, it is an egg timer, and even goes "ding" when it runs out! This time, however, it controls operation of a pump that distributes an antifreeze-like fluid through tiny perforations in the leading edges of the wing and horizontal stabilizer. The system is very effective as an anti-ice device, i.e., it can prevent ice from forming, but isn't so good at getting rid of it once it forms; be sure to turn it on before you enter icing conditions. The fluid tank is good for about an hour (there's a gauge for it on the copilot's side panel). In the actual airplane, its filler is inside the main cabin door, so for long flights you can carry a jerrycan of extra fluid and top it up inflight.

The next area, again with switches and warning lights, is devoted to the engines. The switches you'll use often are the three across the top: a master start power switch, which must be turned on before you can use either of the individual starters to its left and right. Below the bank of warning lights are the switches for the left and right fuel boost pumps, which are normally on at all times.

Further to the right, a large area is devoted to the DC and AC electrical systems. At the top are switches for the batteries, and for external power if you have the airplane plugged in to a ground power unit. While there's enough "oomph" in the batteries to start at least one engine, it's hard on both the engine and batteries - it's a much better idea to start up using either external power or the airplane's own Auxiliary Power Unit (APU) which we'll discuss later. If you have a major electrical problem, moving the master battery switch to its EMERG position will keep the most essential systems and instruments alive while you figure out what to do next.

Hawker 800XP Main Instrument Panel



Below the battery switches are the switches and warning lights for the generators; to their right are two ammeters, one for each generator, plus a voltmeter which can be switched to read the voltage on the various electrical system "busses." The items you really don't want to do without are powered by the "essential bus," and will remain available (at least for a while) with both generators offline and the battery switch in EMERG. (In addition, the standby gyro horizon and a couple of key avionics systems have their own little emergency battery packs.) Further right, more switches and another voltmeter keep tabs on the airplane's "tame AC" system, which uses electronic devices called inverters to provide frequency-stable 115-volt 400-Hz AC to the avionics package. Why "tame AC?" Because each engine also has an alternator providing 208-volt "wild AC," whose frequency varies with engine speed; it's used only for windshield and side window anti-ice heat.

Running all the way across the bottom of the right half of the roof panel are the environmental controls. The most important thing to remember about these is the two rightmost switches, which control the flow of bleed air from each engine to the pressurization and air conditioning systems. They must be OFF for takeoff and landing to ensure full engine performance, but you should turn them ON as soon after takeoff as possible. Savvy Hawker drivers turn them on one at a time, with several seconds' pause between them, to minimize "ear bumps" as the pressurization system comes online.

Finally, just above the windshield, a smaller subpanel has all the exterior lights on its left side, while the red-painted right side has the fire extinguisher switches for each engine. There are two "shots" available; each can be used for either engine, and you can use both on one side if you have a persistent fire.

MAIN INSTRUMENT PANEL

There's lots going on here, too. At the same time, however, you may notice that the panel appears a bit "sparse," due to the fact that a number of instruments you'd expect to see are replaced, instead, by the two large CRT screens directly in front of each pilot. The one at the top is called the Primary Flight Display (PFD) and incorporates the functions of the gyro horizon/attitude director indicator (ADI) as well as an airspeed/mach indicator (AMI). The lower screen, the nav display, incorporates the functions of an HSI, but includes many other advanced functions.

Let's start with the glare shield, and we'll work outward symmetrically from the center. At the top center of the glare shield is the Autopilot Control Panel. Flanking it to either side are display selectors for the captain's and copilot's electronic flight instrument systems (EFIS), which we'll cover at length a bit later. These also incorporate the course arrow and heading bug adjusting knob for the captain's and copilot's electronic HSI, allowing either crewmember to adjust either the own unit or the other crewmember's without having to lean across in front of them. Just outboard of these, on each side, are the red MASTER WARNING flashers, which will illuminate any time a red warning light appears on the main annunciator panel. Pressing either of them will extinguish both of them, but the annunciator on the panel will remain lit.

Now the glare shield jogs downward a step, and both the captain and copilot have a mode selector for their (separate) flight directors. The autopilot can follow the commands of either flight director (and is normally switched to the captain's side). The slanting area of each side of the glareshield contains selector switches for that side's EFIS symbology and dimmer knobs for various areas of panel lighting.

On to the main panel itself! As usual, flight instruments are arranged in the "sacred six" in front of each crewmember. Unless you've already powered up the avionics, you'll notice that the Attitude Director Indicator (ADI) and Horizontal Situation Indicator (HSI) are blank. Rather than electromechanical instruments, these are the screens of the Electronic Flight Instrument System (EFIS).

The "conventional" instruments, such as the altimeter, VSI, etc. - aren't as conventional as meets the eye, either. Because of the wide range of speeds and altitudes at which a jet operates, they'd have very serious errors if they used only pitot and static air pressure inputs. Instead, they're operated by an Air Data Computer (ADC) which ensures that their readings are accurate and consistent throughout their entire operating range. What if the ADC quits? Use the copilot's. What if it quits? Use the little standby airspeed indicator and altimeter just to the right of the captain's combined altimeter and VSI - they'll have errors, but they're certainly good enough to get you through an instrument approach and onto an airport.

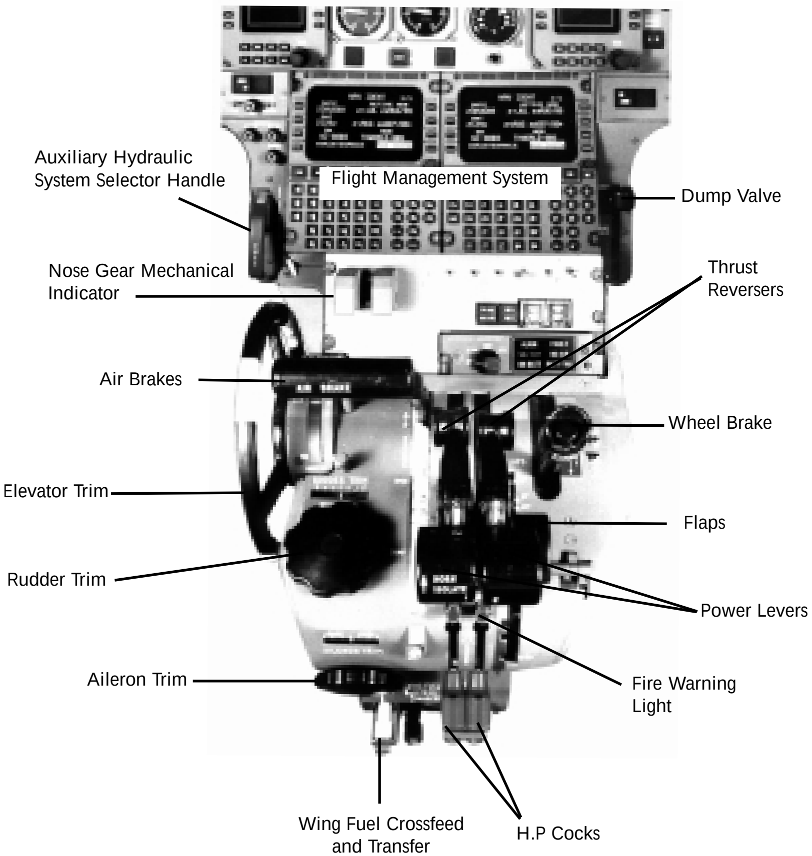
Similarly, if the EFIS system goes out completely, (and it has so many reversionary modes that's highly unlikely), there is a standby artificial horizon: just above the standby airspeed and altimeter, with built-in ILS cross-pointers linked to the #1 NAV receiver.

Just to the right of the standby instruments is what appears to be a radar; in fact, it is, among other things, but it can be much more. This is the Multifunction Display Unit (MDU). In addition to displaying radar data (controlled by the knobs just below the MDU), it can serve as a backup for any failed EFIS indicator or display navigation data. Below the MDU are fuel gauges for the left and right wing systems, and a simple "FULL/EMPTY" indicator for an extra fuel tank in the aft fuselage. Flanking them on either side are the integrated radio tuning units (RTUs). Each of these normally controls the comm, nav, ADF, and transponder on its side of the airplane. The two large panels, with keyboards and CRT displays, control the dual Flight Management Systems (FMSs) These are computers which tie together the airplane's various navigation systems (including a remoted-mounted GPS), and can generate and store multi-leg flight plans. In FLY!, flight plan and fuel loading information will automatically be transferred into the simulation from the flight planning screens.

Just right of center are the two vertical rows of engine instruments. In turbofan engines, the primary power setting instrument at lower altitudes is fan speed in per cent, labeled N1. Each N1 indicator has an orange reference "bug" which can be set accurately, using digits displayed in the indicator, by the knob to the right of the digits. . Below this is interstage turbine temperature (ITT), which is a limiting instrument at low altitude and a power setting instrument in high-altitude cruise. Finally, at the bottom of the stack we find N2, indicating (in per cent) the speed of the core engine; this is primarily a limiting rather than power setting instrument. Very small oil pressure and temperature indicators are at the bottom of the center panel.

To the right of the engine instruments is the main annunciator panel. In addition to its own annunciators (red and yellow ones will also light the MASTER WARNING flashers), it has several "repeater" lights. These are provided to call attention to annunciators in the roof panel; each is labeled with the area of concern (ICE PROT, ELECT, etc.) and an upward-pointing arrow. Below the annunciator panel are the landing gear handle and its associated lights, and the flap position indicator.

Hawker 800XP Center Pedestal



CENTER PEDESTAL

The center pedestal is also pretty busy - and, in the finest British tradition, it's full of big "locomotive style" levers. It's dominated by the two big power levers, each with its smaller "piggyback" lever for thrust reverse. To the right of the power levers is a big brake handle. In its normal (forward) position, it allows braking to be controlled (including antiskid functions) by the captain's and copilot's toe brakes. Pulled halfway back, it activates an emergency brake system, still controlled by the pedals, which has enough capability to handle three landing runs even if the airplane's hydraulic system has failed. Pulled all the way back, it sets the parking brake; this can also be used for an emergency last-ditch stop, but it'll lock up the wheels and blow the tires.

To the left of the power levers is another big handle, and it has two functions. Inflight, with flaps retracted, it operates speed brakes which extend above and below the wings; these are used to increase descent rates when required, or to slow the airplane to allow flaps or landing gear to be extended. The speed brakes can be modulated to any position between fully closed and fully open.

Use of speed brakes when flaps are extended is prohibited inflight, and with good reason. The four-position flap handle is located on the center pedestal behind and to the right of the power levers. When the flaps are extended, if the speed brake handle is lifted over a gate (or, as the British call it, a "baulk"), and pulled further aft, it activates a system called "lift dump." The speed brakes extend, and the flaps move past their normal maximum 45-degree deflection to almost straight down. This is remarkably effective at increasing drag and getting the airplane's weight onto its wheels, since it lives up to its name: it "dumps" virtually all of the wings' lift. Obviously, if you were to try this inflight, gravity would immediately reassert itself with predictably dire results.

The three trim wheels are ranged along the left side of the pedestal, with pitch trim also available via electric switches on the control yoke. Just below and to the left of the flap lever are the left and right "high pressure cocks," which control valves within the engines' fuel controls. These are what you'll use to start and stop the engines, and are the equivalent of the King Air's condition levers. In the event of an engine fire warning, a red light in the affected HP cock will illuminate as a reminder of which one you need to shut down.

Finally, the row of four levers on the back of the center console controls the fuel system. The leftmost turns the transfer of fuel from the aft fuselage tank to the wing tanks and engines ON and OFF. Since the airplane handles better with the aft tank empty, it's normally turned on fairly early in the initial climb, as soon as you think there's enough "headroom" in the main tanks, aided by the engines' fuel burn rate, to accommodate its 233 gallons. The next handle, with the "zigzag" gate, opens a crossfeed valve in its first position, allowing either engine to use fuel from either wing; in its bottom position, fuel is actually transferred from one wing to the other, depending on which has its boost pump switched on. (Fuel flows TO the side with the operating pump.) The two rightmost levers are low-pressure cocks, analogous to firewall shutoff valves although they actually turn off the fuel before it leaves the tanks and their associated plumbing. The left LP cock must be ON if you intend to use the APU.

MISCELLANEOUS CONTROLS

SimTip

Nosewheel steering is done by using the rudder keys or the rudder axis in FLY! to allow easy use on standard keyboard and joystick configurations.

Like most larger jets, the Hawker is steered, on the ground, by a separate nosewheel steering system. Its "tiller" is a large knurled knob on the left cockpit side ledge. On a typical takeoff, the pilot will steer, using the tiller, until sufficient airspeed is reached (around 50-80 knots) for the rudder to become effective.

The control panel for the APU is mounted in the passageway aft of the cockpit, where the copilot can get at it easily. In this release of FLY!, we'll just use keyboard shortcuts to start and stop the APU.

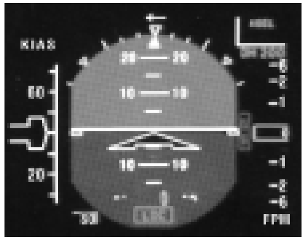
ELECTRONIC FLIGHT INSTRUMENT SYSTEM (EFIS)

One of the most significant advances in cockpit instrumentation in recent years has been the development of electronic cockpit instruments, commonly referred to as EFIS. The installation in the Hawker 800XP, while not as all-encompassing as the "all glass cockpit" or "Atari Ferrari" systems found in the latest airliners, is still a very capable one and represents a mid-level EFIS system.

Why develop EFIS in the first place? One reason is simplicity and reliability: while EFIS, with its CRT displays, signal generators, and control panels, may seem complex, it has no moving parts. By comparison, the electromechanical instruments of earlier systems resemble Swiss watches inside - and are similarly delicate, and need similarly trained people to work on them.

Another is versatility. An electromechanical instrument can display only its built-in function: an attitude gyro, an HSI, etc. The CRT of an EFIS instrument is the equivalent of a blank sheet of paper - the signal generator can "draw" almost anything on it. As you'll soon find out, in its most basic mode, the EFIS simply shows pictures of an entirely conventional ADI and HSI on its two primary screen, plus an airspeed/mach indicator "tape."

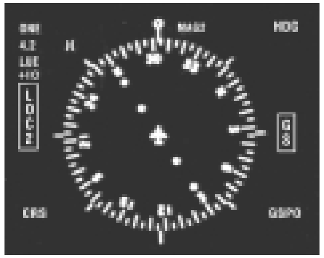
Finally, EFIS offers the capability of reversionary modes. If your ADI fails with a conventional system, you're "Sierra Oscar Lima." With EFIS, you can just switch it to the lower display. Still want both ADI and HSI information? Just select a composite mode that displays both on one screen.



Since the artificial horizon is your most important instrument, the upper EFIS display always shows its basic blue sky and brown earth display. What's handy here is all the additional data that can be called up. This includes the flight director; annunciation of autopilot and flight director modes and flags; and vertical scales at the left and right for speed or angle-of-attack commands and altitude hold, vertical navigation, or glideslope tracking, respectively. Should either of the two display screens fail, the remaining one can be used for a composite display showing the artificial horizon and steering commands with the HSI superimposed.

The other major feature of the primary flight display is its airspeed indicator tape, which tells you a lot more than merely how fast you're flying. The basic display is a vertical airspeed scale which scrolls up and down on the instrument. At its center, in the T-shaped box, your exact airspeed is displayed in digits.

What's particularly helpful is the pair of magenta bars that appears to "grow" up and down to the left of the airspeed digits box. This is a "trend vector," and tells you whether your airspeed is increasing or decreasing, and how fast. The end of the vector indicates what your speed will be about ten seconds from now.



The real star of the system is the EHSI, the lower of the two main instruments. In its "native" mode, it's a standard HSI, but in addition, you can bring up one or two bearing pointers, adding RMI information to the same instrument.

When flying enroute, you may prefer to put the EHSI into its "arc" mode. Now, instead of showing the whole HSI, it shows only an arc ahead of the airplane. What's handy about this is that you can superimpose nav data, waypoints, and VOR stations on this display.

To the right of each nav display is a smaller multifunction display, which you can choose to use either as an HSI or RMI. The large knob at its upper right corner selects the display format, while the two smaller knobs select the source information to drive the pointers.

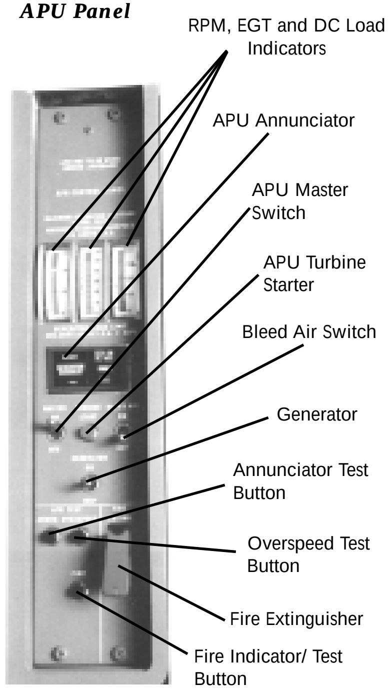
A complete description of the EFIS system fills up a full-size three-ring binder, and has been simplified for easy use in Fly! I suggest you play with it, using the display selector panel to the left of each nav display and the bearing selector panel at the top of the glareshield to explore its capabilities. You can't hurt anything - and if the autopilot is flying the airplane, you'll be changing only displays, not what the system is actually following.

STARTUP

It's very unusual to start a jet of this class entirely from its internal batteries. If external power is available, we can use that. Otherwise, we'll use the batteries to start the Auxiliary Power Unit (APU). Begin by verifying that both LP cocks are ON. Turn the master battery switch, near the top of the roof panel, ON. Set the DC voltmeter selector to B1 or B2 and verify you have 24 volts.

Now bring up the APU control panel. Push the ANNUN button to test that all the warning lights illuminate, then the FIRE button to verify that the fire warning light and bell are working right. We're ready to start the APU, which is an automated process. Turn the APU master switch ON and push the TURBINE START button. Watch the gauges as the top of the panel; you'll see the RPM and EGT wind up. When they're stable, move the APU generator switch to ON; you'll see the ammeter showing a load. If you want to use APU bleed air for cabin heat or air conditioning, turn the bleed air switch ON. Now return to the view of the roof panel.

APU Panel



Watch the gauges at the top of the panel. Switch the voltmeter to PE (the essential bus) and verify that you have 28 volts. The MASTER WARNING flasher will probably be on; push it once to cancel it. There will still be all kinds of lights on both the main warning panel and the roof panel. The avionics should be awake, with all the EFIS displays visible. From here on, we'll be alternating our attention between the roof panel, the engine section of the main instrument panel, and the center pedestal, so there'll be a good deal of switching back and forth. At least, since we have the APU online, we can take our time without worrying about running down our batteries.

In the roof panel, turn both L and R FUEL PUMP switches ON. Verify that FUEL 1 and FUEL 2 LO PRESS lights go out. At the lower right, make sure the L and R MAIN AIR VALVE switches are OFF, and the MAIN AIR VALVE 1 and 2 lights on the lower instrument panel are off. Push the START switches for the #1 and #2 inverters on the AC panel and set the standby inverter to ARM. The AC voltmeter should indicate 115 volts and all the warning lights in that area of the panel should extinguish.

On the center pedestal, check that the power levers are at idle, the L and R HP cocks are OFF, and - at the rear of the pedestal, from left to right - the aft fuel tank transfer and cross-feed/wing transfer levers are OFF and the LP cocks are ON (all four levers at the tops of their slots).

Here we go: in the roof panel, push the switch between the two start buttons; it will light up. Let's start the right engine first: push the right starter button and hold it until it lights up and indicates OPERATING. Now drop down to the center panel and note that N2 is starting to wind up. When it reaches 10%, move the appropriate HP cock to the ON position and look back at the upper left side of the roof panel; the white IGN ON annunciator should be lit. Go back to the center panel; by now, the right ITT, N1, and N2 should all be climbing. Maximum allowable temperature during start is 974 deg. C for not more than 10 seconds.

At 46% N2, the start sequence should terminate automatically: the OPERATING and IGN ON lights will extinguish, the right starter-generator will "switch roles," and the GEN 2 FAIL light will go out. The right ammeter should be showing a load; if it's not, manually turn on the right generator. Now, use the same sequence to start the left engine. When you're done, push the start power switch, between the two start buttons, once again to extinguish it.

Most operators will elect to shut down the APU at this point. Turn the left and right main air valves ON (you'll get warning lights on the main annunciator panel, and a flashing MASTER CAUTION; cancel it). Now, on the APU panel, turn the generator and bleed air switches OFF. Wait two minutes for the unit to cool down, then momentarily press the TURBINE START button; this simulates an overspeed and shuts the unit down, at the same time verifying its automatic protection features. When its tachometer reaches zero, turn the APU master switch OFF.

THE NUMBERS GAME

One of the things that makes jet flying different is that all take-offs and landings are made with precalculated performance figures. The actual tables for the Hawker fill a big book all by themselves. We'll provide a simplified version: enter the graph table with your aircraft weight and altitude (we'll assume standard temperature; in the real world, you'd use the actual value) and you'll get three speeds: V_1, V_R, and V_2. Each of them is significant.

V_1 is called "decision speed," and in the real world it takes takeoff field length into account as well. Its interpretation is simple: if you lose an engine before reaching V_1 you abort the take-off, and if you lose it after V_1 you must press on. Why? because there's no longer enough runway left for you to stop! The full performance tables will tell you not only how much room you need to accelerate from a standstill, lose an engine (no critical ones on jets!) right at V_1, and still take off (to a height of 35 feet); they'll also show how much you need to do the same thing and struggle to a halt. They don't make many allowances, either - you're likely to end up with the nosewheel on the last inches of concrete and the nose itself sticking out into the overrun!

V_R is rotation speed, at which you raise the nose to lift off. In a normal takeoff, it'll come very shortly after V_1 ; if you lose an engine, though, it may take longer, while you grit your teeth and watch the end of the runway coming closer and closer.

Finally, V_2 is "takeoff safety speed." You'll notice that there's no blueline on the jet's airspeed indicator; this is because its weight and performance vary so widely from one takeoff to the next. Instead, you have to calculate all the speeds every time. Making these calculations, and calling off the speeds during the takeoff roll, is one way copilots used to justify their miserable existences. Nowadays, the Flight Management System can calculate these speeds.

Flap setting will depend on field length, ambient conditions, aircraft weight, and what kind of terrain there is surrounding the airport. You'll need less runway if you use more flap, but the airplane won't climb as well once you're off the ground. In many cases - for example, departing a high-altitude field surrounded by mountains, on a warm day - your only recourse is to keep things light, possibly taking off with only enough fuel to get to some nearby airport at a lower elevation. Our simplified takeoff chart is based on 15 degrees of flap.

With speeds calculated, we'll taxi to the active runway and line up. Remember, on the ground at low speed, the airplane steers via the nosewheel tiller. Here's where you're really going to be busy without a copilot (and if you have a buddy who wants to see what FLY! is all about, this is a great time to enlist his or her aid). I'm going to talk you through a normal takeoff as if you had a copilot.

The Numbers Game

Table 1 - Simplified takeoff speeds (standard temperature assumed)

wt->	28000	28000	28000	25000	25000	25000	22000	22000	22000
alt	V_1	V_R	V_2	V_1	V_R	V_2	V_1	V_R	V_2
S.L.	125	133	140	116	124	133	116	116	126
3000	125	133	140	116	124	133	116	116	126
6000	126	133	139	117	124	131	111	116	125

Table 2 - Landing approach speeds (VREF)

Weight (lb x 1000)	17	18	19	20	21	22	23	23.5
VREF (knots)	108	111	114	118	121	123	126	127

TAKEOFF

Taxi onto the runway and get lined up. Verify that you've got the flaps set at 15 degrees and that the trim is set for takeoff; if it's outside the takeoff range you'll see the ELEV/AIL TRIM light on the main annunciator panel. All the annunciators, including those in the roof, should be off at this time; you'll probably still have the main air valves on, so turn them off now.

In the real airplane, you'd grab the nosewheel tiller in your left hand and use your right to set the power levers near takeoff power. As you start to roll, the copilot will hold the yoke forward (for better nosewheel steering). Since the electronic engine computers (EECs) automatically adjust takeoff thrust based on air temperature and altitude, you don't need to make finicky power adjustments-just move the thrust levers smoothly all the way forward. As the ASI stirs from its peg, the copilot will call "airspeed alive." At some predetermined value - often 80 knots - he'll verify that both ASIs are reading the same and say, "80 knots, crosschecked."

By now, if not before, you'll have adequate steering through the rudder pedals. As you let go of the tiller and move your hand to the yoke, you'll call "my yoke" and the copilot will let go of the yoke on his side. At V_1 the copilot will call it out. Since you know you must continue the takeoff from this point, you may elect to take your right hand off the power levers. At the "rotate" callout, raise the nose to about ten degrees.

Typically, it'll take more of a pull to start the nose up than to hold it, so be ready to relax back pressure partway as you near your pitch target. The airplane will trundle along for a couple more seconds before lifting off. As the altimeter and VSI start to show a climb, the copilot will call "positive rate;" your response is "gear up, yaw damper on." Meanwhile, you're adjusting the pitch attitude to accelerate past V_2. The airplane will gain speed quickly; you'll probably need to be pretty active on the trim. As soon as the gear is up, turn on the #1 and #2 MAIN AIR VLV switches, one at a time - if you wait, the airplane will already have climbed a few thousand feet, and there'll be a real "ear bump" as the cabin pressurizes.

CLIMB

Most jets get more and more efficient the faster they go, and the Hawker is no exception - but it runs up against a few FAA rules. At most airports, as long as you're within 2500 feet of the surface, you shouldn't go faster than 200 knots. This shouldn't be too hard to maintain, particularly while you're still retracting the flaps - and by the time a minute or less has gone by, you'll have climbed past 2500 feet anyway. The next restriction is 250 knots, and that one is valid through 10,000 feet.

In the Hawker, with its generous wing area, recommended enroute climb speeds are relatively low, hovering around 200 knots or a bit less. You'll probably find it easier to just hold about a 15 to 20 degree pitch angle, even if that puts you a few knots above the most efficient speeds at light weights; anything steeper than 20 degrees feels pretty uncomfortable, particularly for passengers in aft-facing seats.

As you climb past 35,000 feet, you can improve fuel economy by setting the #1 and #2 MAIN AIR VALVE switches to their center LP ON position. (Just don't forget to set them back to ON before you reduce power for the descent, or you won't have enough airflow to keep the cabin pressurized). As soon as the fuel level in each wing tank has decreased below 3300 lbs you should start transferring fuel forward from the ventral tank; just move the leftmost lever at the back of the pedestal down to the bottom of its slot. Within a moment or two, the little indicator between the two main fuel gauges should change from FULL to a "barber pole" pattern.

Check it from time to time; until it indicates EMPTY, you're restricted to a maximum indicated airspeed of 280 knots, and the airplane must not be landed with fuel in the ventral tank except in an emergency.

THE DREADED "COFFIN CORNER"

And what's the maximum allowable speed once you've emptied the ventral tank? Well, at sea level it would be 335 knots; at altitude, it's either M 0.80 or its equivalent airspeed. Luckily, you don't have to work that out: instead of a single redline, the ASI tape has a "barber pole" that's positioned by the air data computer to indicate the maximum allowable speed. You'll notice that as you've been climbing, the barber pole has been sneaking down toward your current indicated airspeed.

This leads to an interesting discussion. (OK, maybe it's boring - but if you unwittingly violate its rules, you may find the results fascinating!) We're dealing with two limiting airspeeds up here, and they're getting closer and closer together. Remember, as we climb higher and higher, the speed of sound (M 1.0) gets lower and lower (as does our limiting IMN of 0.8). This is reflected by the steady downward sweep of the airspeed-limit "barber pole."

At the same time, as we maintain roughly the same true airspeed, our indicated airspeed is decreasing steadily. Let's look at the situation at an altitude of 41,000 feet. Assume we're cruising at M0.67.

At high altitudes (with their correspondingly lower air densities), an aircraft must be pulled to a higher angle of attack to attain a given G-load than in the dense air of lower altitudes. You don't normally think of a jet making particularly steep turns at altitude; but, since rate of turn depends on true airspeed, you may find that it takes a fairly significant bank angle to achieve a necessary rate of turn, for example if you're making a course change over a VOR. The common convention among jets is to calculate the "buffet boundary" - the point at which the airflow begins to separate from the wings - for a G-load of 1.5, corresponding to a bank angle of about 45 degrees. Every jet's performance manual includes a table called "buffet boundary." Entering the one for the Hawker at 41000 feet and, say, 25,000 lbs gross weight, we find the allowable range between low-speed and high-speed buffet runs from M0.64 to M0.70. Given standard temperatures, that corresponds to only about 35 knots.

In other words, the higher we fly, the narrower is the margin between our maximum and minimum allowable speeds. What happens if we exceed the maximum? Various things could occur, including airframe buffet, aileron "buzz", loss of elevator effectiveness, or a nose-down pitch change or "Mach tuck." All of these are caused as shock waves form or move on the airplane. At the low-speed end, we're effectively encountering the beginnings of a high-altitude stall.

The docile Hawker has a relatively wide range, even at its maximum operating altitude. This hasn't always been the case, even with business jets, and it's still something to watch out for. Imagine, for example, that you're cruising right at the Mach limit. Your attention wanders for a moment, the nose drops just a hair, and the airplane overspeeds - at least into the region of the audible overspeed warning, and perhaps to the point of actual Mach buffet. What's your immediate reaction? To pull back on the stick, of course...but this pull in some G-load, and now you've got the low-speed buffet!...or is it still the Mach buffet? They feel just about the same...

Old-time jet pilots called this region, where the high and low limit speeds come together, the "coffin corner." Modern civil jets are provided with adequate margins, if necessary simply by limiting their maximum permissible altitudes. Probably the worst airplane for a "coffin corner" was the U-2 spyplane: with its straight wings it had a low limiting Mach number, while its very high operating altitudes meant that the low-speed buffet boundary was very high. Above 70,000 feet, its allowable operating range encompassed all of 7 knots, requiring very precise flying indeed!

JET UPSETS AND OTHER FUN STUFF

So what do you do if you inadvertently exceed VMO or MMO? It could occur in severe turbulence, if you're suddenly pitched nose-down. In such a case, it's called an "upset," no doubt because of how it makes you feel.

Actually, the situation isn't quite so dire as you may think. If it happens at relatively low altitude, while the airspeed might be pretty high, the indicated Mach number won't be too bad, and you'll have plenty of margin above a low-speed buffet - just don't pull the wings off! At high altitude, you don't have much margin, so you'll have to be more circumspect...but you have quite a bit more room between you and terra firma in which to sort things out.

You also have some powerful allies in the speed-reducing game. One of the biggest is simple drag: it takes a lot of power to make even a slick airplane like the Hawker 800 go fast (even pointed downhill), and if you reduce power, it'll either slow up, or at least quit accelerating quite so terrifyingly. When in doubt - power levers back!

Your other helper is the speed brakes, which can be extended all the way at any speed. Luckily, they don't cause a significant trim change (unlike the spoilers on old Lears, which caused a nose-down pitch just when you least needed it!). Put out the "boards" at high speed, and it'll feel as if the airplane had run into a wall of feathers.

This is also the technique to use if you need to get down fast with a pressurization malfunction.

Step 1: **Put on your oxygen mask**, since you won't do very well at the subsequent steps if you've passed out in the meantime!
Step 2: **Power levers back!**
Step 3: Roll into about a 30-degree bank to either side. This serves two purposes: it keeps you from descending into somebody underneath if you're on an airway, and it helps keep the folks in back in their seats as you execute.
Step 4: Airbrakes out all the way.
Step 5: (This is the one that floats people out of their seats) Shove the nose down to either MMO or VMO, whichever comes first. Remember that as you descend, the barber pole will creep up, so you can keep on increasing your descent rate until you get down to a breathable atmosphere.

NORMAL DESCENTS

Even normal descents take a bit of planning, since you don't want to arrive in the terminal area high and fast, only to have to execute a "chop, drop, and stop" maneuver - neither the engines nor the CEO in back like it! Not that it doesn't still happen, usually due to poor planning on ATC's part.

I recall flying in the New York area one day and hearing a harried controller ask an inbound Concorde, "...uh, Speedbird 5, could you descend 18,000 feet in the next 20 miles?" There was a moment's stunned silence on the frequency before a very cultured British voice floated down from the heights: "Oh, I daresay I could, old chap...but I'm afraid I couldn't bring the aeroplane with me..."

A rough, but handy, rule of thumb is to allow yourself three nautical miles of flight for every thousand feet of descent. This means that if you're crusing at 41,000 and heading for a sea-level airport, you'd better start down about 120 miles out! As long as you're above 10,000 feet and the air is smooth, there's no point in wasting time: ease the nose down to just short of the barber pole and adjust power to maintain the necessary rate of descent. At about 12,000 feet you'll need to pull off a good deal of power and/or use the airbrakes to slow up to 250 knots; then continue toward the airport, adding drag in the form of flaps as necessary.

LANDINGS

Just as you calculate a speed for takeoff, so must you (or your copilot) figure one out for landing approaches, based on your weight. This is where those fuel counters come in handy, since you know how much less you weigh now than when you took off. The appropriate chart in the flight manual will give you the right speed, called "reference speed" or VREF. This is actually the speed at which you should cross the runway threshold to be guaranteed the right amount of energy in the flare and touchdown; there's no reason, unless you're headed for a very short runway, to fly the approach at less than about "ref plus ten" when maneuvering, and "ref plus five" on short final. Many pilots feel more comfortable adding half the value of any wind gusts if they're less than 15, or full gust value if they're higher, to their final approach speed. It's also a good idea to calculate a V2 for your landing weight, just in case you have to go around and have the bad luck to lose an engine while doing so. If you plan to use thrust reverse, this is a good time to turn on the two power switches and verify that the white OFF lights extinguish.

TOUCHDOWN

Unlike in a light plane, you don't want to hold a jet off the runway until you reach minimum speed. Not only will it float a long way down the runway, but if you get slow enough to fire the stick pusher you'll suddenly find yourself "planted." Instead, when you get down to about 20 or 30 feet (by radio altitude or copilot callout), smoothly pull the power levers all the way to idle and "hold what you've got" in pitch attitude.

The airplane should settle into ground effect and touch down gently. At that point, it's up, over, and back on the airbrake lever to activate "lift dump." If you're going to use thrust reverse, wait until the nosewheel is on the ground, and you or the copilot are holding it there with forward pressure, and verify that the two ARM lights in the glare shield have illuminated, before you pull up and back on the power lever "piggyback handles."

CROSSWINDS

There's another reason not to hold the airplane off until the last minute. Don't forget that the tips of those swept wings are behind the landing gear: the higher you hold the nose, the closer they are to the ground. If you're instinctively holding one wing down into a crosswind, your tip-strike margin is even smaller! Instead, fly final approach, wings level, in a slight crab if necessary. As you're about to touch down, once you're used to the airplane, you can "kick out" the crab without lowering a wing. If in doubt, just touch down slightly crabbed - it's not elegant, but the landing gear is designed to take it - and it's a whole lot more elegant than dragging a wingtip through the runway lights!

SimTip

Toggle between forward and reverse thrust modes by pressing the **R** key.

A PIECE OF CAKE

As your final graduation exercise, we're going to lose an engine right at V1. Taxi back, get the airplane configured for takeoff, and check the tables for the correct V speeds for your current weight. The Hawker has a nifty system called APR (Automatic Performance Reserve); if the power levers are forward for takeoff and the engine speeds split by more than 5%, it'll automatically tweak on a couple of extra per cent on the good engine to help you through those first few anxious moments.

Off we go, using standard takeoff technique and callouts. At V1, go ahead and chop one of the throttles to idle. You'll feel a slight swerve, but you'll also feel the rudder pedal on the operating side go forward all by itself, courtesy of the rudder bias system. This is where it takes discipline: don't haul the airplane into the air, wait for VR, which may seem like it's a long time in coming.

When you reach it, rotate to the normal takeoff altitude; when you're sure you're solidly in the air (by which time you'll most likely be at 35 feet already, with the end of the runway passing beneath you), go ahead and retract the gear. Now you can carefully accelerate to your flap retraction speed and start thinking about returning for landing. Don't bother turning on the bleed air valves; you're not going high enough to need cabin pressurization, and you might as well save all the performance for your remaining engine.

Compared even with a turboprop, you'll most likely be impressed at what a "non-event" this has been. Sure, the airplane isn't climbing as impressively as it normally does; but it'll still be doing as well as most turboprops, and better than most piston twins, with both engines running. Handling will be pretty benign, too: with the engines in close to the center, the asymmetric thrust, while certainly perceptible, is relatively minor. In fact, many jet manuals don't even specify a different set of V speeds for a single-engine approach. Just "do your thing" normally, perhaps paying a bit of extra attention to rudder trim as you pull off the power to touch down, and you should have it made.

CONGRATULATIONS!

You've come a long way from that little Cessna 172 - and about as far as we can teach you with this release of FLY! We hope you've enjoyed it as much as we have...and if you're still ambitious and want to fly something even larger and more sophisticated...say, a jumbo jetliner?...it won't be long until you'll be able to, in a future release of FLY!

Hawker 800XP Before Takeoff Checklist

1. Brakes and brake pressure . . . . .CHECK
2. Instruments . . . . .CHECK
3. Thrust reversers . . . . .ARM
4. ENG CMPTR, RUDDER BIAS, T/R switches and annunciators . . . . .CHECK
5. Flaps . . . . .SET
6. Trims . . . . .SET (3)
7. APU Bleed Air . . . . .OFF
8. APU . . . . .OFF
9. APU Master switch . . . . .OFF after 2 mins
10. BATT AMPS . . . . .check below 20
11. FMS . . . . .CHECK if required
12. Exterior lights . . . . .AS REQUIRED
13. Transponder . . . . .SET and ON
14. Flight controls . . . . .FREE
15. Anti-ice and engine ignition . . . . .AS REQUIRED

Appendices

AlliedSignal KLN-89 GPS

GPS—WAVE OF THE FUTURE

One of the most remarkable developments in avionics during the past decade has been that of the Global Positioning System (GPS). In that short time, it's gone from an exotic system that only the military could use (or afford) to a general utility that's become indispensable to many user communities.

Nowhere has this been more evident than in aviation. For the first time, there was a highly-accurate and dependable navigation sensor that could work in even the smallest aircraft, and would do so worldwide and in any weather. The first unit generally available for lightplane use, which wasn't even a dedicated aviation system, was Trimble's "TrimPack." At about the size and weight of a (hardcover) Tom Clancy novel, and able to store only a relative handful of waypoints, each of which had to be laboriously "scrolled in" by the pilot, the TrimPacks nonetheless went out the door as fast as Trimble could build them, despite a $5000 price tag. Today, you can buy a unit that outperforms the old TrimPack by far, including having every airport and VOR in the entire world pre-stored in its database, for less than a tenth as much...and it'll fit in your shirt pocket!

KLN-89

In this chapter, we're going to concentrate on one particular GPS, the AlliedSignal KLN-89. Why? Because this is the unit installed in three of the airplanes in this release of FLY!: the Cessna 172R, the Piper Malibu Mirage, and the Piper Navajo Chieftain. This also illustrates one of GPS's strong points: a single unit, small, light, and cheap enough to be appropriate for even a fixed-gear single like the 172R, has enough capabilities and functions to meet the needs of a pressurized single or a commuter twin. (Indeed, you'll find quite a few of them in the panels of corporate turboprops and jets, too.)

CONTROLS AND DISPLAYS

For a system with its range of capabilities and features, the KLN-89 is not only remarkably small and light; it's also surprisingly simple to operate. While it also provides left-right guidance to panel displays (the CDI in the Cessna, the HSI in the Pipers) and autopilots (all three airplanes), most of the information it provides to the pilot is presented on its gas-discharge matrix screen.

You'll notice that the screen is divided, by a vertical line about a third of the way in from the left, into two parts. The section to the left of the line always displays the distance to the active waypoint, in enhanced numbers, on its top line. The second line is usually the identifier of the active waypoint (so you always know where you're going, and how far to go, regardless of what you're displaying on the rest of the screen). The exception is if the right of the screen includes the waypoint identifier, in which case you will see groundspeed on the left.

The third line generally displays the system's navigation mode: LEG if it's navigating from one waypoint to another, and a magnetic bearing if the system is in OBS mode (in which case you can dial in the desired course to or from a waypoint, just as if it were a VOR station). It may also flash "M" if the system needs to get your attention to view a message (more on that in a moment), or "ENT" if it's waiting for you to confirm a data entry by pressing the ENT key.

Finally, the fourth line on the left tells you "where you are" in the system. With so much information available, and so many possible inputs, the KLN-89's interface is divided into various "pages." Actually, the master pages are more like categories, or chapters in a book, each divided into individual sub-pages.

CURSES! FOILED AGAIN!

The way you move around among these pages, and enter data into them, is by clicking directly on the highlighted fields, page legends below the screen, buttons below the screen, and the right knob.

To change to a page of the GPS, click on the legends along the bottom of the screen. The current selected page is annunciated on the lower left line of the screen and by a small glowing bar above the corresponding legend. In addition, the buttons below the legends are also clickable. The knob on the right of the GPS will increment or decrement the current sub-page. For instance, if you are on the APT page, clicking left and right on the knob will toggle between the 6 sub-pages of the APT page. Often, each sub-page is too large to fit on a single screen. In this case, you'll see a plus sign beside the page number. For example, if you are looking at an airport's page to determine what runways are available (APT 4) and there are more than the two that'll fit on one screen, you'd see APT+4 to let you know that there's more than one APT 4 page for that airport.

The modifiable fields in the GPS are brighter than the non-modifiable fields. To modify a field, move the mouse cursor over the appropriate field. When the mouse is over a modifiable field, the field will blink and be underlined. Click the left or right mouse button to toggle through the field appropriately. When a field has been clicked, the system will turn the cursor mode on automatically to let you know you are modifying a field. Any time the cursor is active, the word CRSR replaces the page name and number in the bottom left line. Cursor mode will not change the functionality of the GPS knob. The CRSR mode is simply a reference that you are modifying a field on the current page. To turn off the cursor mode, click on the CRSR button or change to a different GPS page.

Most of the GPS fields will automatically accept the changes. If a field needs an acknowledgement of the modification, the word ENT will begin to flash on the left side of the display. This indicates that the entry will not be completed until you press the ENT key at the bottom of the screen, left of the knob.

The remaining controls are the keys along the bottom of the unit. MSG is used to retrieve any messages the system has for the pilot (annunciated by the flashing MSG indicator on the left side of the screen, as well as a remote message annunciator in some installations). If there's more than one message, they're displayed in chronological order. Press the MSG key to display a message. A further push on the MSG key returns you to normal operation or toggles to the next message.

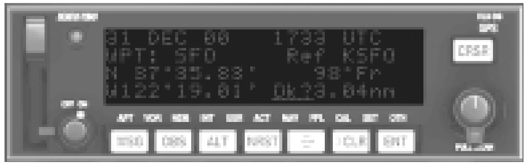
The OBS key is used when you want to fly to or from a waypoint along a specific radial, rather than on the leg from the last waypoint. When it's pressed, the word LEG is replaced by a number from 000 to 359; you can set this "electronic OBS" by clicking directly on the OBS field.

The ALT key accesses altitude-related functions - for example, the system will advise you of the minimum safe altitude at your current location, and, if you're on a flight plan, the highest minimum safe altitude between your current position and the final destination.

The NRST key calls up displays of "nearest things," including nearest airports - great to know if the engine quits! - nearest navaids, if you're trying to figure out where you are on the map.

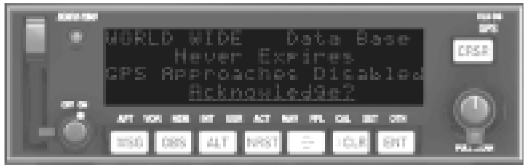
The "direct-to" key - the D transfixed by an arrow, like this, D->, is one of the functions you'll use most often. This page initiates direct navigation from your present position to your destination. Press this key, and input the desired waypoint (if you selected direct-to from another page, it may default this field for you), then click ENT. This will take you to the appropriate page for this waypoint for verification. Click ENT again to accept the waypoint and the system will switch to the NAV 1 page and begin to navigate from your present position to that waypoint.

TURN ON, TUNE IN...



When you power up the system, the KLN-89 will run through a series of self-test screens, culminating in the "initialization page" with the "OK?" flashing, the date, time, latitude, and longitude.

If you're at an airport, its designator (beginning with K, since ICAO designators are used and we're in the United States - go figure!) and your distance and bearing from the center of the airport will also be displayed.



The next page you see will show the expiration date of the installed database.

In FLY!, it's always current; in the real world, it's updated as often as every 28 days by inserting small data cards on the left side of the unit. Since the installation in FLY! isn't configured for non-precision approaches, you'll also see the words "GPS Approaches Disabled" on the third line. The cursor will be active on the word "Acknowledge?" Once again, press ENT.

Finally, the system will show the waypoint page for the waypoint at which the system was last powered down. This will (I hope!) have been an airport, so the KLN-89 will obligingly show you the page with the radio frequencies you'll need to get going again.

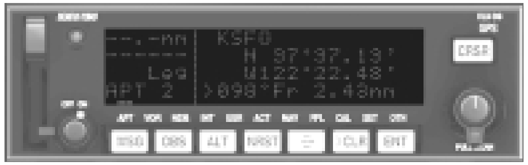
PAGE BY PAGE

We'll examine the various pages individually, beginning with the one you'll most likely see once the system has completed its power-up sequence. Clickable fields are brighter in color than fields that just display information. Click on the knob to the right of the GPS to toggle the sub-pages associated with the current page. A left-click decreases the page number and a right-click increases the page number. As an alternative, click on the sub-page number located to the right of the page name, on the left of the display to increase and decrease the current sub-page.

AIRPORT PAGES

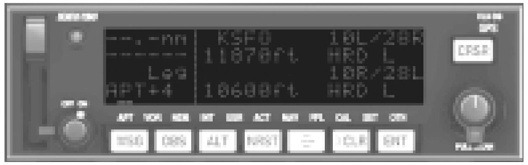
The APT (airport) pages contain information about airports stored in the database.

This page displays the identifier, altitude, name, state, and whether the airport location is private, military, or a heliport. If the airport type is public, then none of the previous airport location identifiers are displayed. You can select an airport by clicking directly in the identifier or name field.



This page displays the identifier, latitude, longitude, range and bearing of the airport. The bottom line gives range and bearing from your present position to that airport; a cyclic field at the bottom of the screen allows you to switch between bearing (TO) and radial (FROM). Click the cyclic field to change between to and from radials.

The APT3 page displays the airport identifier, the difference between its local time zone and Corrdinated Universal Time (with daylight saving time in parentheses), the available fuel types; and available instrument approaches.



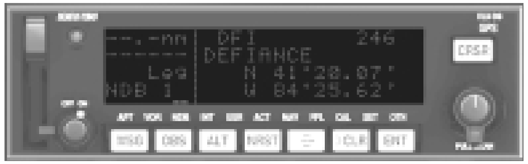
This page page is likely to have the "+" sign (APT+4) indicating that there are several APT4 pages available for an airport. Each subpage displays the orientation, length, surface, and lighting for up to two runways. The system stores up to five runways for each airport. Runways are listed in order of length.

Another page likely to have the "+" sign is the APT5 page. This page displays available radio frequencies for the airport, with abbreviations indicating their purpose. If a frequency has specific requirements (for example, an approach control frequency covering only a given area), this is also displayed.

VOR, NDB, USER, ACT PAGES

Like the APT pages, these provide information on specific types of waypoint. The VOR and NDB pages provide the identifier, name, location, and frequency of the navaid; the second page of each type provides range and bearing, with a cyclic TO and FROM selection. Toggle the TO/FROM radial field by clicking directly on it.

The **USER** pages allow you to enter and store your own waypoints. You can use either location (lat/long) or range and bearing from an existing reference waypoint such as an airport or navaid; you can also "capture" your present position.



The **ACT** page is a simple way to get information on the waypoint toward which you're currently flying. Selecting it brings up the appropriate APT, VOR, NDB, or USER page for that waypoint without the need for you to enter an identifier.

ALT PAGES

The ALT 1 page is used to set the system for current barometric pressure (since it gets its altitude input from your airplane's encoding altimeter, not from GPS). The second and third lines display MSA, the minimum safe altitude between your present position and the waypoint and, if you have a multileg flight plan active, MESA, the highest minimum enroute altitude between your present position and the final destination. These are often different: for example, if you're flying over flat country but there's a range of mountains between you and the destination, you might see something like MSA 3000, MESA 14000.

The ALT 2 page is used to program the system for "advisory vertical navigation." By entering current altitude, desired final altitude, distance prior to (minus) or after (plus) a waypoint, groundspeed, and desired rate of descent, you can receive advisories: the "altitude you should be at" vs your current altitude. This is very useful in descent planning, particularly in high-performance aircraft.

DIRECT TO PAGE

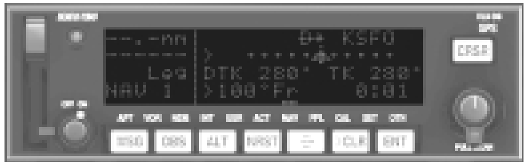
This page allows you to navigate directly from your present position to your destination. and displays the destination identifier. If the GPS is on a waypoint page, the "direct-to" key defaults to the identifier of the waypoint. Otherwise, it defaults to the active waypoint on the NAV1 page. When no waypoint is active, the identifier is blank.

Modify the destination by clicking the the identifier field, then press the ENT key to accept. If your new destination is valid, the GPS will display the waypoint page corresponding to the identifier. Press ENT to accept or CLR to return to the Direct To page. Accepting will send you to the NAV1 page and begins navigation to the designated waypoint. If invalid, the GPS willchange to the USR page and allow you to create the waypoint.

NAV PAGE

These are the pages you'll be using most often - the ones via which the system gives you required navigation information in a concise form.

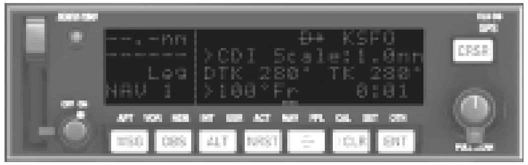
NAV1 PAGE



This is the primary navigation display; it's the page you'll probably use most often, and has just about everything you need on it.

Depending on whether you're flying long a leg from one waypoint to the next, or on a direct-to routing, you'll see either the FROM waypoint or the D-> symbol, plus the TO waypoint, on the first line. The active waypoint is now displayed on the right side of the screen. The space on the left, where it was displayed, now shows your ground speed.

The second line can be cyclically selected to show either a graphic CDI or a numeric display that's very useful if you're more than five miles off course.

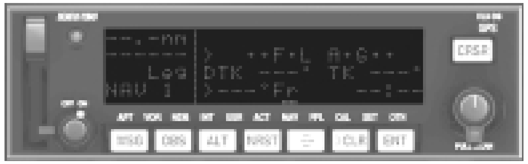


To change the CDI scale (sensitivity) currently in use, toggle the CDI field to the "CDI Scale" display and click the >CLR button. The values allowed are +/- 5, 1.25, or 0.3 nm.

The third line shows the desired track (DTK) and your actual track made good over the ground (TK). As long as you fly the airplane to keep these numbers the same, you're either on course or flying exactly parallel to it.

The fourth line has another cyclic field that can show the TO or FROM bearing, plus time to the waypoint. Click directly on the field to toggle between TO and FROM.

Appendices

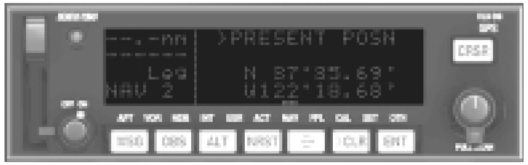


If the GPS does not have an active waypoint, the NAV1 page is in flag mode and is not usable for navigation.

NAV2 PAGE

This is the "present position" page, and it's very handy when ATC requests a position report. The default display gives range and bearing from a nearby VOR, but you can use the cursor to insert any reference you want. (ATC, however, will not be pleased if you give your position over Oklahoma in terms of, say, range and bearing from Beijing.)

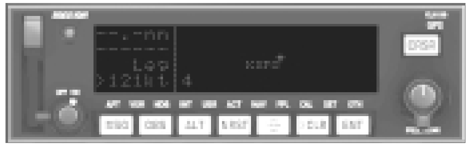
Click in the reference field to modify the reference waypoint. Click in the TO/FROM field to toggle between TO and FROM radials. Click on the PRESENT POSN field to toggle the NAV page 2 between reference waypoint and present position in latitude and longitude.



NAV3 PAGE

This is the "time" page: it gives you the current (very accurate) GPS system time in the time zone you've selected; the time you took off (actually, when your ground speed first exceeded 30 knots); your ETA at the final destination of your flight plan; and how long you've been flying. Click on the time zone field to toggle the reference time zone. The Depart and ETA times will be adjusted accordingly. Click on the flight time field to reset the current time to zero

NAV4 PAGE

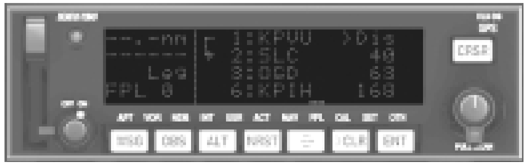


This is one of the coolest pages in the system. In its most basic mode, seen here, it provides a "God's eye view" of your position, track, and flight planned route. The field at lower left can be cycled between ground speed, desired track, time to the next waypoint, or numeric left/right deviation.

All the really interesting stuff, however, happens on the map. At its lower left is a number representing the range from top to bottom. To change the range, click directly on the range field. A left-click decreases the range and a right-click increases the range. If you set the range past the highest or lowest values, you'll see the word AUTO. This range setting lets the system choose; it'll pick the lowest range that'll show the current waypoint plus the next one beyond it.

Clicking the CRSR button will activate the NAV4 menu. After clicking the CRSR button, MENU? appears above the range field. Clicking the MENU? field allows you to choose how the map is oriented and what will be displayed. illo: fig 3-131 Airports, and VORs can all be selected ON or OFF. You may also select whether the map will be displayed with north up, the desired track up, or your actual track-made-good up. At any time when viewing the map, pressing >CLR will "declutter" it of everything but the flight-plan waypoints; a second push will bring them back. Click the CRSR button again to remove the MENU? options.

FLIGHT PLAN (FPL) PAGES



The "master" flight plan page is FPL 0. This is always the flight plan currently in use. The current FROM and TO waypoints are indicated by the arrow symbol at the left. The bottom waypoint displayed is always the last one in the flight plan; the display will scroll automatically based on where you are, or you can scroll it manually.

The figures at the right are a cyclic field. You can select cumulative distance-to-go; estimated time enroute (ETE); estimated time of arrival (ETA); or the desired magnetic track between waypoints. In an actual installation, pages FPL 1 through FPL 25 are used to load and store flightplans. In FLY!, only FPL 0 is active; flight plans are loaded via the simulator's dedicated flight planning screens and saved, if necessary, as "scenarios."

CAL PAGES

These pages access a built-in multifunction calculator that's not only far more accurate, but also much easier to use, than the traditional "prayer wheel" circular slide rules pilots have been using for years.

CAL1 PAGE

The CAL 1 page figures distance, time, and enroute safe altitude for flights either between waypoints (WPT mode) or along your flight plan (FPL mode). Select the mode in the upper left cyclic field by clicking in the WPT/FPL field. In WPT mode, click in the two cyclic fields at upper right to enter the desired waypoints. Bearing appears on the second line. Distance and ESA appears on the third line.

Entering your anticipated ground speed at the left end of the fourth line will bring up estimated time enroute at the right end of the same line. Click in the ground speed field to modify the ground speed.

CAL2 PAGE

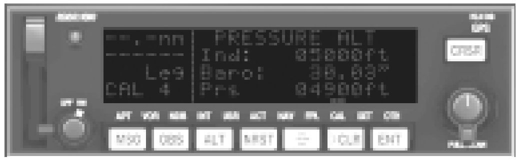
The CAL 2 page does almost the same thing, except for fuel rather than for time. Use FPL or WPT mode, entering the waypoints as necessary by clicking on the fields; then enter your anticipated fuel flow and the amount of reserve you want aboard when you land by clicking in the fields. The system will use the ground speed you entered on the CAL 1 page and return the amount of fuel you should have onboard when you take off.

CAL3 PAGE

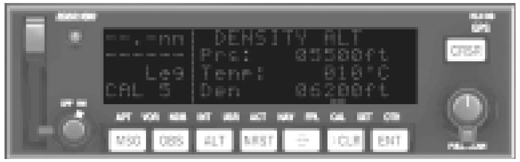
This is probably the most expensive alarm clock/kitchen timer you've ever seen. Enter either a desired elapsed time or desired time of day, and the system will alert you with a message when the magic moment arrives. Click in the time zone field to change time zones. Click in the alarm at or alarm in fields to set the alarm appropriately.

CAL4 AND CAL5 PAGES

Here's a two-step process to determine your density altitude - very handy if you're planning to take off from someplace well above sea level on a warm day!

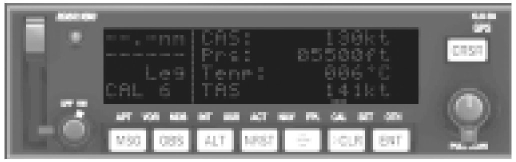


On the CAL 4 page, enter the altitude showing on your altimeter and the barometric pressure you've got set into your Kollsman window by clicking in the corresponding fields. The system will return the pressure altitude (which you could also have obtained by setting your Kollsman window at 29.92 in. Hg).



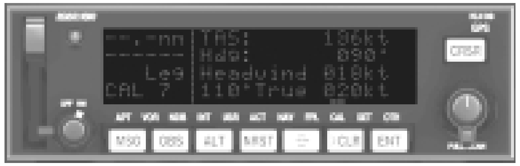
Now go to the CAL 5 page; the pressure altitude will have carried over from CAL 4. Enter the current temperature, and the system will return density altitude - the one that actually affects the performance of your airplane. Click in the pressure altitude or temperature fields to modify the density altitude.

CAL6 PAGE



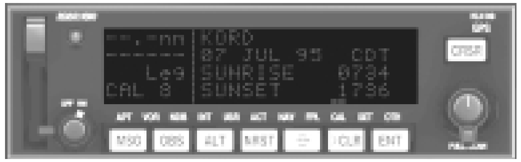
This page will figure out your true airspeed for you. Enter indicated (calibrated) airspeed at CAS by clicking in the corresponding field. If you've used CAL 4 or CAL 5, the pressure altitude and temperature will be carried over from them; otherwise, enter them now. The system will return your true airspeed (TAS).

CAL7 PAGE



We can continue to step through these linked calculator functions; CAL 7 is used inflight to determine actual (as opposed to forecast) winds aloft. If you've used CAL 6 to determine your true airspeed, it'll carry over; otherwise, enter it at TAS by clicking in the corresponding field. Next, enter an accurate heading from your directional gyro (you did check it against the magnetic compass recently, didn't you?). The system will return actual wind, both in terms of headwind or tailwind component and in terms of true (not magnetic!) direction and speed. Why true? Because that's how winds aloft are reported; magnetic directions are used only for airport surface wind reports.

CAL8 PAGE



Finally, this is a handy one if you want to avoid those "fly-by night" operations. Since the GPS system has to maintain an accurate astronomical almanac to know when and where to expect to find its satellites, it didn't take much additional computation power to add the ephemeris figures for the sun.

When you first select this function, it displays predicted sunrise and sunset for the flight-plan destination; based on current date and current system time zone. Any of these values, however, can be changed - for example, try checking it for your next birthday...in Paris! Click in the reference waypoint, date, and time zone fields to get the corresponding sunrise and sunset.

NRST (NEAREST) PAGES

These pages can be accessed at any time by pressing the NRST key. When you first access this function, you're given a list of categories - nearest airport, nearest VOR, nearest CTR, etc. Just in case you're in trouble, the page always comes up with the cursor already sitting on APT, so if you need directions to the nearest airport, fast - say, the engine just quit! - all you need to do is hit NRST and select the desired waypoint type..

This will bring up a page showing the distance and bearing to the nearest airport, as well as its identifier, name, altitude, and the length and surface of its longest runway - all stuff it's nice to know in a hurry. You'll also notice a number 1 next to the identifier, indicating that it's the "first nearest" of nine choices. Turning the small right knob will scroll through the next choices, working from nearer to further.

If you're actually in a bind, as soon as you see an airport you like on the display, just hit D-> and ENT. The system will pop back to the NAV 1 page with the desired airport as the new active waypoint. Similarly, you can use the function to find the nearest VOR and NDB navaids, user waypoints or the Center frequency controlling your present position.

By the way, in the real world you can preset the selection criteria for the nearest airport - for example, if you're in a jet you probably don't want to go to a 1500-foot gravel strip, so you might select 5000 feet of hard surface as a minimum. In FLY! the criteria are set automatically based on aircraft type.

Similarly, you can use the function to find the nearest navaids (VOR, NDB), intersections, or user waypoints, as well as the frequencies for the nearest Flight Service Station (FSS) communications facilities, or the Center frequency controlling your present position.

SET AND OTH PAGES

The SET pages are used to control various system setup functions. In FLY!, these are determined automatically by the simulator program.

The OTH pages are used primarily to monitor the status of the GPS satellite signals. Information is available to show which satellites are in use, their position in the sky, and whether they are functioning properly.

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Terminal Reality Team

Producers

Brett Combs . . . . Co-Producer
Richard Harvey . . . . Co-Producer & Programming Lead

Development Team

Matthew Bogue . . . . Programming
Chuck Carson . . . . Art/3D Modeling
Paul Eckstein . . . . Sound Engineer
Daniel Ellis . . . . Documentation
David Glasscock . . . . Scenery
David Haber . . . . 3D Modeling
Den Johnson . . . . Art/3D Modeling
Scott Johnson . . . . Programming
Rob Minnis . . . . Programming
Paul Nettle . . . . Programming
Mark Randel . . . . Graphics Engine
Kyle Richards . . . . Lead Sound Engineer
Paul Russell . . . . Simulation
Anton Schwing . . . . Test Lead
Terry Simmons . . . . Art Lead/3D Modeling
Jeff Smith . . . . Marketing Director
Brian Stevens . . . . Art/Art Design

Additional Assistance

Allen Bogue . . . . Programming
Fletcher Dunn . . . . Programming
Mike Porter . . . . Art
Mark Randel . . . . Lead Technologist
Greg Seehusen . . . . Programming

Administration

Christie Combs . . . . Accounting
Marilyn Webb . . . . Office Manager

Take 2 Interactive Team

Matt Spall . . . . Head of European Development
Phil Rodkoff . . . . Test Manager
Frazer Nash . . . . Product Manager
Mike Wenn . . . . Producer
Gary Sims . . . . Lead Tester
Lee Brown, Nick Sneddon, Adam Rabin, Ronnie Jackson, Darren Lloyd, Daley Salami, Charlie Johnstone, Chris Lacey, Greg Mathews . . . . Testers

Tarantula Team

Andy Mason . . . . Lead Tester
Jim Collins, Kevin Hobson, Tim Bates, Mark Lloyd, Paul Byers, Charlie Kinloch, James Thompson, Kit Brown, Denby Grace, Lee Johnson, Jim Cree . . . . Testers

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OUR TECHNICAL SUPPORT CONTACT DETAILS

Take 2 Support

PO Box 555

Lincoln

LN1 3YD

Telephone: +44 08700 128129* (weekdays, 9:30am - 5:00pm GMT)

Fax: +44 08700 128130

e-mail: support@flyuk.com

Website: www.flyuk.com

* - 2 Lines

Notes

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Take 2 Interactive
Hogarth House, 29-31 Sheet Street
Windsor, Berkshire SL4 1BY, UK
Attn: Customer Service