FLY! II USER MANUAL

Hello—and welcome to Fly! version II. This electronic manual, the "Fly! version II User Guide," is one of two electronic manuals you'll receive, either on the distribution CDs for your copy of Fly! II or from the Fly! II website at www.iflytri.com. Providing these manuals electronically, rather than on paper, lets us keep them constantly up to date for the most current version of Fly! II. However, since they're in the popular Adobe Acrobat format, feel free to print them out if you want a paper copy of your own. (You can download the latest version of the Acrobat reader/printer program for free from www.adobe.com.)

Why two separate manuals? Because we really need to cover two completely different areas of subject matter. In this User Guide, I'll detail how to operate the Fly! II simulation software package itself, but I'll provide only minimal information about actually flying any of the aircraft. In the other manual, "How to Fly!," I'll hardly discuss the simulator at all, except to mention occasional handy key combinations. Why? Because Fly! II is so realistic, with every real-world control visible *and operable* on our super photorealistic panels, that it's far easier and more appropriate to write just as if I were teaching in the actual aircraft, rather than in a simulator (as, in fact, I do in real life). Thus, if I write something like "set the Comm 1 radio to the tower frequency" or "use the prop control to reduce RPM," I'll assume that you'll either simply "grab" the onscreen control with your mouse, use appropriately configured switches or buttons on your control stick or yoke (we'll go over how to set those up shortly), or use the appropriate keyboard shortcuts. We'll include a complete list of those in this first manual—just remember that real aircraft aren't flown from keyboards, and it's the realism of onscreen control that's part of what makes Fly! II so realistic overall.

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Keystroke conventions:

Any time I call out a keystroke or key combination in either manual, it'll be enclosed in brackets. For example, you can apply wheel brakes by tapping the [B] key. Key combinations, indicating that two or more keys should be pushed at the same time, use the plus sign; for example, you can set the *parking* brake by hitting [Shift+M]. Letter keys are *not* case sensitive.

Now let's start exploring the fascinating and exciting world of Fly! II!

Installation:

You've probably already installed Fly! II using the concise printed Fly! II Startup Manual provided with the software. Even so, it's worth going over a few points in detail (the entire text of the printed manual is included in this section):

BEFORE YOU START:

Fly! II is a large and very sophisticated simulation package—indeed, it provides performance and capabilities far beyond those of airline and military flight simulators that ran on mainframe computers only a few years ago! As such, it is configured to make the best possible use of all your computer's resources. It's well worth your time to make sure everything is set up properly; a good "clean install" will provide major benefits in performance.

WHAT YOU'LL NEED:

The *minimum* system requirements for Fly! II are as follows:

MAC

- Mac OS 8.6 or later (Mac OS X TBD)
- 1.2 GB available hard disk space (1.7 GB full install)
- 128 MB of physical RAM (256 or more recommended)
- 4X CD ROM (24X or faster if loading scenery from CD)
- PowerPC G3 350 (PowerPC G4 recommended)
- 16MB Hardware Acceleration required (32 MB recommended)

PC

- Windows 95/98/ME/2000
- 1.2 GB available hard disk space (1.7 GB full install)
- 64 MB of physical RAM (256 or more recommended)
- 4X CD ROM (24X or faster if loading scenery from CD)
- Pentium II 333 (Pentium III 450 or more recommended)
- 16MB Hardware Acceleration required (32 MB recommended)

The simulator will function very significantly better, however, if your system meets these levels of performance:

1.75 GB of free uncompressed disk space for a full install
128 MB of RAM or more
32X or greater CD-ROM drive
Pentium III 500 or higher

Hardware Accelerated Video card with 32MB of RAM or more
DirectX 8a

Note that processor speed, minimum RAM, and video accelerator card capabilities are “non-negotiable.” If Fly! II is installed on a system that doesn’t meet the minimum requirements, it won’t run badly…it won’t run at all! Obviously, the faster a processor, the more RAM, and the more sophisticated a video card you have, the better. The one area in which compromises are acceptable is hard disk space: while an absolute minimum of 1.3 GB of free uncompressed hard disk space 95/98/ME on the CD)

is required to install and store program and aircraft files, you may choose to leave some or all of the (fairly large) scenery and map files on the distribution CDs. We’ll cover how to do that in a moment.

INPUT DEVICES:

While Fly! II can be run solely from the keyboard, you’d probably find doing so an exercise in frustration. All the real-world airplanes on which the airplanes in Fly! II are based have control yokes (those things that look like sawed-off steering wheels), but they can be flown just as well with a joystick. The real-world Bell 407 helicopter is flown with a stick (as are, of course, all helicopters).

If you're going to use a single input device for all aircraft, we'd recommend a good-quality joystick. Fly! II can easily be set up to take advantage of any extra switches or buttons so you can control many additional functions without having to go to the keyboard or mouse, and we'll discuss that when we're examining the appropriate onscreen menu.

The firms that manufacture joysticks also make control yokes; using one makes the experience of flying the airplanes in Fly! II that much more realistic. The next step would be to add a set of rudder pedals; these are particularly important for the multiengine airplanes and for helicopters. Finally, you may want to add a separate single or dual throttle control. While dual throttles are nice, Fly! II makes it easy to handle both engines of the multiengine airplanes, either together or individually, with a single throttle control. Moreover, Fly! II supports multiple input devices, so it's very easy to switch between a stick and a yoke when changing aircraft.

Fly! II assumes you have, and use, a mouse. Unlike many other simulators, which display switches and other controls onscreen but which require complex keystroke sequences to actuate them, Fly! II allows you to "grab" any control visible onscreen with the mouse and operate it just as if you are aboard the actual aircraft. (Most controls are also accessible from the keyboard if you wish.)

PREPARING YOUR COMPUTER:

During installation, Fly! II will examine your computer's hardware capabilities (especially its monitor and video card) and will automatically configure itself to make the best use of available resources. Therefore, it's important that you have the video card, as well as at least one of the input devices you plan to use, installed and operating correctly *before you begin to install Fly! II.* If you have any display problems, now is the time to resolve them.

When you're ready to install Fly! II, we suggest that you first restart your computer (to make sure your operating system is in its default state). Then, it's a good idea to shut down any running applications. Close any open windows (don't just minimize them), then look at the applications tray at the lower right of the Windows desktop. Right-click on each application icon and click on "close" or "unload" as appropriate. (The above steps are also a good idea each time you plan to run Fly! II; making the maximum resources available to Fly! II ensures the best performance and frame rate.)

A WORD ABOUT FRAME RATE:

"Frame rate"—the rate at which your computer screen is redrawn, expressed as Frames per Second (FPS), is often considered by users to be a prime measure of a simulation system's performance—the higher the frame rate, the smoother the appearance and operation of a simulator.

For all practical purposes, frame rates higher than 25 to 30 or so are useless—that's the same rate at which movies and television run, and your eyes can't really perceive any difference at frame rates higher than that. Thus, advertisements touting incredible frame rates don't tell the whole story.

Frame rates slower than 15 or so, however, are quite perceptible, and if you find slower frame rates annoying, there are things you can do to improve the situation.

Improving frame rate—hardware:

Fly! II requires a 3D accelerator card to operate. This is "a computer within your computer," complete with its own highly specialized processor and software and its own RAM, and its function is to "offload" a lot of the specialized calculations required to draw onscreen elements, thus leaving the CPU more time and clock cycles to handle the basic (and very extensive) number-crunching required to run the flight model and dynamic simulation software.

The fancier a graphics card you install, and the more RAM it has, the more smoothly Fly! II will run, and the higher a frame rate you'll obtain. Perhaps less obviously, but equally important, the faster your main processor, and the more RAM your computer has, the better your frame rate will be.

Improving frame rate—software:

Of course, all the RAM in the world won't do Fly! II much good if it's tied up running other applications. Leave recalculating that giant spreadsheet for another time! For optimum performance, close (*i.e.,* exit completely, don't just minimize) all other applications *before* starting Fly! II.

A little further on, we'll discuss ways to improve the frame rate from within Fly! II itself. For now, let's review the actual installation process (feel free to skip ahead if you've already installed Fly! II).

START INSTALLING FLY! (Windows):

Put the first of the two distribution CDs into your CD-ROM drive. If "autorun" is enabled on your computer, the first installation screen will appear automatically. If the installation screen doesn't appear automatically, perform the following steps:

1.) Double-click on the "My Computer" icon on your desktop (usually near the upper left).
2.) When the "My Computer" window opens, double-click on the CD-ROM drive icon (often Drive D).
3.) When the CD-ROM drive window opens, double click on the "Fly II" icon.

DIRECT-X 8a INSTALLATION:

Fly! version II requires the Microsoft DirectX 8a graphics drivers to be installed *before* installing the program itself. If you are sure you already have DirectX 8 installed, you can proceed to install Fly! II by flipping the "Install Fly! II" switch now. If you don't have DirectX 8a (or if you're just not sure), go ahead and flip the "Install DirectX 8 switch," wait until DirectX 8a has completed its installation process, then proceed to install Fly! II. (You may need to reboot your computer after DirectX 8a installation.)

THE CHOICE IS YOURS:

Now, you'll see a screen offering you three different installation choices.

Minimum:

This installation takes up the smallest amount of space 1.2 GB on your hard drive. Basic program and aircraft files are copied to your hard disk but not the Sectional Aero Chart files. Fly! will run just fine, but will not show any maps if you open the map window.

Typical:

This installation, which is recommended for most users, requires 1.75GB of hard drive space. It includes all required program files, basic scenery (elevation and topographic detail data), and all of the FAA Sectional Aeronautical Charts as you'd use in actual aircraft for some of the more populated cities in the United States

Custom:

This option allows you to select which maps will be installed to the hard drive. The Primary Maps are for only very large cities, with the Extra Maps being other less populated areas.

CONTINUE INSTALLATION:

Now you'll be prompted for the location where the Fly! IIfiles will be installed. For most users, the default location (C:\Program Files\Terminal Reality\Fly! II) will work fine. If you prefer to change the location (for example, if you have more space on a different hard drive), you can press "Browse…" to choose a different location, or simply type in the new path.

The program will now begin copying files to your hard drive; depending on the speed of your CD and hard drives, this may take several minutes. Just pour a cup of coffee and enjoy the soothing music and nifty screen shots.

IF YOU CHANGE YOUR MIND…

To remove Fly! II from your system, click on the "Settings" item on your Windows start menu, then choose "Control Panel." When the control panel appears, click on "Add/Remove Programs," scroll down the list of programs, and click on Fly II.

To reinstall the program, simply re-insert the Fly! II CD and repeat the installation procedure as described above.

INSTALLING FLY! (Macintosh)

Minimum and recommended system requirements for Fly! version II (Macintosh) are:

- Mac OS 8.6 or later (Mac OS X TBD)
- 1.2 GB available hard disk space (1.75 GB full install)
- 128 MB of physical RAM (256 or more recommended)
- 4X CD ROM (24X or faster if loading scenery from CD)
- PowerPC G3 350 (PowerPC G4 recommended)
- 16MB Hardware Acceleration required (32 MB recommended)

Put the Fly! II CD's into your CD-ROM drive. If the window does not open automatically, double-click on the CD-ROM drive icon. When the window opens, double-click on the Install Fly II! icon and the installation will begin. If the window doesn't open automatically when the CD is inserted, wait for the CD icon to appear, then double-click on it to open it; then double-click on the Install Fly II! icon. Read the onscreen installation instructions and, if you wish, click on the appropriate button to print or save them. Then press Continue to proceed.

As the installation continues, you can select several options, including which files to install and where they'll appear on your Macintosh.

By default, Fly! II will be installed onto your hard drive's "root" folder. If you wish, you can install it to a different device, or "nest" it into another folder (for example, if you have one called "Flight Simulators").

FINISHING INSTALLATION AND RUNNING FLY!

The last step in the installation asks if you want to launch Fly! now. If you don't, you have more discipline than the rest of us...but you can launch the simulator at any time in the future simply by clicking the Fly! icon on your desktop.

We'll assume, however, that you can't wait, so go ahead and click on the "Launch Fly! now" box, then click "Finish."

After an impressive view of the Flyhawk (and that's not a scanned photo—it's actually being generated "on the Fly!") while the initial program modules load, the first thing you'll see is Fly!'s "Startup Options" screen:

This screen normally appears every time you start Fly!, but don't worry—you only have to select your startup options once.

The most important option to choose is the "renderer," the set of software drivers that makes the most efficient use of the capabilities of your computer and its graphics card. Click on the down-pointing arrow at the right end of the "renderer" bar; you'll be presented with a list of DirectX driver versions. (Macintosh users will see only the OpenGL driver).

The system may show more options than your computer will support, but there's an easy way to find out: any supported DirectX driver will also show the name and type of your video card on the menu bar below the renderer choices. If you select a DirectX driver that's not supported, the video card bar will be blank (and Fly! will not run properly, and may lock up your computer, if you select it). Chose a driver supported by your video card. If in doubt, DirectX 8 is a good first choice.

We'd suggest, at least for the first time you run Fly!, that you leave the resolution and bit depth at the suggested settings. Finally, pull down the menu to set Fly! for the amount of video RAM on your video card. (If you don't know how much you have, watch closely the next time you start or reboot your computer. Typically, the amount of video RAM will be shown at the top left of your screen as your computer turns on. Watch fast! It won't be displayed for long...and be sure to turn your monitor on first, otherwise the message may have come and gone before the screen has warmed up enough to show anything.)

While many of Fly!'s operating parameters can be changed "on the Fly!" from within the simulator, these basic startup options are "locked in" for each Fly! session—the only way to change them is to exit the simulator and restart it.

Another **word about frame rate:**

This is the second-to-last point at which you can make adjustments that will improve your frame rate.

Obviously, the more things your computer needs to draw for each frame, the longer it'll take. Each tiny dot on your screen, called a *pixel* (for "picture element") represents a whole string of numbers—some to determine exactly which pixel it is, and more to determine both its brightness and color. The higher you set your screen resolution on the startup menu, the more pixels the system has to draw. (For example, at a resolution of 640 x 480, there are 307200 separate dots onscreen; at 800 x 600, 480000, or almost half a million; and at 1024 x 768, there are 786432. Each pixel requires 8 bits of information just to determine its location. Then, depending on whether you've selected 16-bit or 32-bit color depth (in other words, how many different shades of color can be displayed—at 32 bits, there are *millions)*, each pixel requires another 16 or 32 bits. If you want to run the system at 1024 x 768 x 32 bits, each individual tiny dot requires no less than *25,165,824 calculations* to be performed up to 30 times a second, so it's inevitable that frame rates will suffer on all but the most powerful systems.

A matter of choice:

If you want to show your friends how fabulous the airplanes, scenery, and weather look, by all means select the highest resolutions and color depths. You may find actually flying Fly! II more rewarding, however, if you're willing to make a few minor compromises.

For example, it's very hard to tell the difference between 16-bit and 32-bit color depth just by looking. Moreover, while it's tempting to run at the highest possible resolution (since you can then see more of the instrument panel on one screen), the individual controls and instruments you see will be proportionally smaller. Most users find 800 x 600 to be about the practical limit for a 17-inch monitor; if you're lucky enough to have a 19-inch screen, try 1024 x 768, but that resolution doesn't really come into its own until you have a 20-inch or 21-inch monitor.

Let's Fly!

From here on, you're probably eager to jump into the action. We're going to work through all simulator controls and features methodically, in the same order you'll encounter them in the actual program.

With everything configured, click on the "Start Fly! II" bar. (All the settings you've chosen will be stored, so next time you start Fly! this is all you need to do). You'll see a rather boring black and white view of our pride and joy, the new Bell 407 helicopter, as well as a picture of a fuel gauge (the actual one from this helicopter, as a matter of fact!). As the simulator loads, the gauge will gradually fill up, while the screen begins to fill with color from the center outward.

Once it's loaded, we'll circle around San Francisco International Airport, then zoom in on the "default" aircraft (as the program is shipped, the Flyhawk trainer—you can change both the startup airplane and airport later).

Welcome screen:

You have three options: Quick Flight, which takes you right into the cockpit; Adventures, which accesses stored flights (either your own, or many that have been stored by Terminal Reality), and an extremely powerful and versatile Flight Planner. For the moment, just click Quick Flight and we'll start examining Fly! II's features.

This takes you right into the cockpit—into what we can call the "home screen" for most other functions. You'll see a menu bar across the top of your screen, and we'll get into all of its many functions, from left to right and from top to bottom, shortly. For the moment, let's just look around and get the feel of the controls. In fact, you can make the menu bar disappear by tapping the [space] bar; another tap on [space] brings it back. Try it! You can use the [space] bar to access all the menu functions from within any of Fly! II's many possible views.

Looking around:

In this Cockpit view, you have two ways to look around: inside the aircraft (*i.e.,* looking at different parts of the cockpit), and outside the aircraft (*i.e.,* looking out of the side or rear windows).

Looking around inside:

You have two ways of changing your inside view of the cockpit: with the mouse, and with the Control [Ctrl] and/or [Shift] keys, plus the four directional arrow keys.

Looking around the main instrument panel:

Because of the huge amount of panel detail presented in Fly!, you usually can't see the entire instrument panel within any single view. Simply move the mouse to the edge of the screen, and your view will "pan" in that direction: a new area of the instrument panel will slide into view. Moving the mouse to the top or bottom of the screen is the equivalent of looking up or down—as you move up, for example, you'll see less of the panel and more out the bottom of the windshield. Anything you see on the panel in these views is "active:" you can grab and manipulate switches and controls with the mouse. You can use the shift key and the four directional arrows—for example, [Shift+left arrow]—to do the same thing.

Other areas inside and outside your airplane:

There are additional areas inside your airplane that aren't on the main instrument panel but that you need to see from time to time. Even in the simple "Flyhawk" trainer, you'll need to see items on the control pedestal, down near the floor, while advanced turbine airplanes like the Pilatus, the King Air, and the Hawker 800 jet have cockpits crammed with switches and controls everywhere, including on the left and right sidewalls, the big control pedestal that runs back between the crew seats, and even in the ceiling! To see these areas, hold down the [Ctrl] key; you'll see flashing yellow arrowheads appear at the edges of the screen to show you any direction in which an additional view is available. While still holding the Ctrl key, just hit the desired arrow. Once again, if any interior view is larger than your screen, [Shift+arrow] or the mouse will move you around within that view. To return to the main view, either press Ctrl+arrow as required, or Shift+Home.

Finally, if you want to "disappear" the entire cockpit (in fact, to disappear your entire aircraft--so that the entire screen is the view out the windshield or side windows), just press [Shift+C]. Another [Shift+C] will bring it back

Pressing the control [Ctrl] key at the same time you press one of the left or right arrow keys is the same as "turning your head" in the indicated direction; each successive press turns you another 45 degrees (including straight back in "Linda Blair" mode). When you press the control key, flashing yellow arrows indicate directions in which additional views are available. Any time you're in any interior view of your aircraft and need to return to the master cockpit view and look out the windshield again, just hit [Shift+Home].

Details, details...

As long as we're looking at the instrument panel, here are a couple more neat features to check out:

Whazzat?

Unfamiliar with some kind of gadget you see on the instrument panel? Or is its legend just a little too hard to read at your chosen screen resolution? Just hold the mouse pointer over it for a second, and a little label will pop up, telling you what it is. Try it on a few switches, controls, and instruments.

Whazzit say?

You probably noticed that when you held the mouse pointer over an object, the pop-up label often has not only a name legend, but a value as well. For movable controls, it'll tell you in percent (%) at what point that control is set in its range; for aircraft instruments (airspeed indicator, altimeter, etc.), it'll tell you the actual value displayed on the instrument. This is particularly handy for smaller instruments, which can be hard to read at high screen resolutions.

What can I do?

You may also have noticed that the mouse pointer itself changes shape, depending on where it's positioned on the panel.

Toggle switches:

If it's on a simple on/off toggle switch, the pointer will be an upward or downward arrow, depending on whether it's just above or below the switch lever itself. Clicking when the arrow points up turns the switch on, clicking when it points down turns it off.

Push-pull controls:

When the mouse pointer is over movable controls (such as throttle, propeller RPM, mixture, etc.) that can operate over a wide range, it changes into a "perspective" arrow (one that looks as if it's pointing into or out of your screen).

Here, you can use it two ways. As with switches, if you move the pointer just above or below the control and click once, you can move the control a small amount in the desired direction with each click.

More intuitively, however, when you see the perspective arrow pointer, you can click *and hold* to "drag" the control steplessly to the desired position. (Note that if you try this on a throttle when you already have an external throttle on your yoke or joystick, it'll "snap back" to the position of the external control as soon as you let go.)

Two-position push-pull controls:

Minor "auxiliary" push-pull controls have only two positions in the simulator (full off and full on...for example, the cabin heater or the parking brake).

Putting the mouse pointer over a control of this type changes it into the familiar Windows "grabber hand." Each successive click toggles the control from one position to the other.

Knobs:

Putting the mouse pointer over a rotatable knob once again changes it into the “grabber hand,” but this time *both* mouse buttons can be used. Clicking or holding the *right* mouse button turns the knob clockwise; clicking or holding the usual *left* button turns the knob counterclockwise.

<u>A note for Macintosh users:</u>

If you have the standard Macintosh single-button mouse, clicking or holding its button is the same as the left button on PCs. To access right button functions, hold down the [Ctrl] key while clicking the mouse button.

“I’m on the outside, looking in...”

Unlike full-scale airline or military flight simulators, Fly! II offers you the option—in fact, a whole range of options!—of seeing your own or other airplanes from the outside. These different views are called "cameras," and you can select them at any time with successive taps on the [C] key. Starting from the home, or cockpit, view, let's take them in the order that they appear (each time you tap [C] you'll cycle to the next view until you're back where you started). Each time you move to a new camera, its name will be briefly displayed at the lower left corner of your screen.

Spot Camera:

This camera always points toward the plane and acts as if it were rigidly attached to it by a long pole—in other words, it's always in the same position relative to your airplane, and moves with it as the airplane turns left or right or pitches up and down.

Holding the [Ctrl] key while pressing any of the four directional arrow keys moves the camera around your plane. The plus and minus keys at the top of your keyboard (*not* the ones on the numerical keypad) zoom the camera closer or farther from your plane at a moderate rate. [Shift+plus] and [Shift+minus] zoom in and out faster, and over a larger range, while [Ctrl+plus] and [Ctrl+minus] zoom in and out more slowly to let you "fine tune" your view just the way you want it.

Hint: If you're ever lost on a big airport, switch to the Spot Camera, hold [Ctrl+up arrow] until you're vertically above your plane (the so-called "God's-eye view"), then hold [Shift+minus] until you're high enough above the scene to see where you are among all the runways and taxiways.

Control check:

As long as we're still using the Spot Camera, let's check the controls (and show off how cool Fly! II's graphics are!). Zoom in (using the [plus] key at the top of the keyboard) until you're close enough to the airplane to see details like the lines of rivets on the wing.

Now slowly move your control yoke or stick from side to side. You'll see the ailerons (the small flaps near the wingtips) move up and down. Move the yoke or stick forward and back, and you'll see the elevator (the large flap on the horizontal tail) move in sync with it. If you have rudder pedals or a stick with a "twist" rudder axis, you'll see the rudder (the flap at the rear of the vertical tail) moving as well.

Control axis indicator:

While we're looking at the controls, let's check out another feature, the control axis indicator. Tap the [X] key on your keyboard.

The little window that pops up shows the position of the three major flight controls (ailerons, elevator, and rudder) and the trim setting for each (trim is covered in detail in "How to Fly!"). Move the controls again, and you'll see the pointers in the axis indicator move with them.

This window is available in *any* of the camera views (including inside the cockpit), and is a very handy way to see if you're doing what you think you are with the flight controls. Like every other window in Fly! II, it can be moved anywhere on the screen that you like; just drag it by its top title bar. Clicking the "X" at the top right corner of the window closes it.

Chase Camera:

Tap [C] and we'll move on to the next view, the Chase Camera. This camera behaves as if it were in another, similar, aircraft flying formation on you, and it's similarly affected by flight dynamics. When you maneuver, it'll tend to "float" around your aircraft, gradually returning to its starting position when you level out. You can set the starting position using the same Control, arrow, and plus and minus keys as above. When you switch to a Chase view of a stationary airplane on the ground, the camera will tend to bob around a bit as it's affected by the continual recalculation of flight dynamics...even though your airplane isn't moving yet!

Observer Camera:

This camera is similar to the Spot camera in that it always points toward your plane, but it's fixed at a given distance and direction in three-dimensional space from your airplane, no matter which way your airplane may be pointed. For example, if it's positioned 300 feet north of your airplane, that's where it'll stay. If you fly east, the view will be of the left side of your plane; if you turn north, you'll be coming at the camera head-on, etc. The same control, shift, and arrow keys apply to this camera.

Fly-by Camera:

This camera is fixed in space about ½ mile ahead of your airplane, and pans to follow you as you fly past. Then the camera jumps ahead to a new position to watch you fly by again, etc. Since the camera is fixed in space, the arrow keys don't do anything; you can still use [plus] and [minus], at the top of your keyboard, to zoom in and out, but the [Shift] and [Ctrl] functions, to zoom faster or slower, don't work in this view.

Tower Camera:

Like the fly-by camera, but this one is permanently fixed at a given location. (usually at the control tower of the airport you took off from). Your airplane is always in the center of the screen, and the zoom-in and zoom-out controls work...but fly too far away and you simply disappear. As with the Fly-By camera, the [Shift] and [Ctrl] zoom speed functions aren't used in this view.

GENERAL SIMULATOR CONTROLS

The next few controls we'll examine are used for general control of the simulator. Many of these can be accessed from the menu bar at the top of the screen (tap [Space] to toggle it on and off) as well as directly from the keyboard.

Gettin' around...

We'll discuss how to get from point A to point B by actually flying the aircraft in Fly! II in our "How to Fly!" manual. In the meantime, since *this* particular manual is about how to run the simulator, rather than how to Fly!, we'll look at one of its special functions: Slewing.

Tap the [S] key to activate Slew mode; it'll be displayed at the lower right of your screen. Now you can *reposition* your aircraft to any point in Fly! II's virtual world. The four directional arrow keys move your aircraft left, right, forward, and backward (*not* up and down). To move up and down, use the [Q] and [A] keys, respectively. Successive taps on each key move the aircraft in the desired direction, faster and faster; to slow down, tap the opposite key. To stop slewing altogether and freeze at your current location while remaining in slew mode, tap the [5] at the center of the *numerical keypad,* not at the top of the keyboard.

You can slew your aircraft's *attitude* as well as its position, using the six keys just above the four directional arrows on your keyboard. [Insert] and [Delete] pitch up and down, [Home] and [Pg Up] bank left and right, and [End] and [Pg Dn] turn the aircraft counterclockwise and clockwise. These keys work slightly differently from the arrow keys: slewing motion halts as soon as you release them.

Flight dynamics simulation is effectively paused when you enter Slew mode, but resumes the instant you leave it. For example, if you slew a parked airplane (with its engine stopped) straight up into the air a few thousand feet, then exit slew mode, it'll behave just as if it had been hoisted up there with a crane, then had the cable cut: it'll start falling straight down, its "tailfeathers" will initially point it straight at the ground, then it'll level out as it gets some speed and wallow along as a glider until it flies into something solid (or until you start flying it properly!).

Gettin' around, part two:

You can also reposition an aircraft to any geographic location, without having to slew it there; that's covered below, when we discuss the "teleport" modes of the flight planner and aircraft menus.

Freeze!

The entire simulation can be paused, or "frozen," at any time by tapping [P]. Subsequent taps toggle the pause mode on and off.

Quiet, please:

Successive [Ctrl+M] keypresses mute and un-mute all Fly! II audio, including engine and aircraft sounds, radio communications, etc.

It's a small, small world...

On long cross-country flights, you can shorten the boring straight and level cruise section by using Distance Compression. [D] turns it on and steps it to higher and higher levels, while [Shift+D] steps it to lower levels and ultimately turns it off.

This is a way to "shrink the world" without affecting flight dynamics—in other words, if you're flying at an indicated 100 mph, the airspeed won't change when distance compression is used. Instead, each successive tap on [D] shrinks the world by a factor of two (x2, x4, x8, x16 etc.) to a maximum of x64; each successive tap on [Shift+D] backs out of compression by the same factor of two. Compression level is annunciated at the bottom left of the screen.

Information, please (about the world):

The mouse cursor is normally a small white crosshair (unless it's over an active cockpit control). Tapping [/] (the forward slash) toggles a handy rangefinder function usable in any outside view; you can tell it's active because the crosshair turns to a little "gunsight" box.

Placing the box anywhere over the ground brings up a readout of how far away it's located. If it's over a structure in Fly! II's database, it'll also read out how tall it is, and how much clearance you have over it. If it's over a radionavigation aid, it'll read out its identifier and frequency. Double-clicking when the "gunsight" is over any airport or navaid brings up a complete data box for that facility.

Information, please (about the simulator):

Tapping [TAB] brings up a couple of different displays that can be very helpful. The first tap generates the simulator's current position (latitude, longitude, and altitude) at the top left and the type of aircraft, date, and time, at the top right. The large center block of information is of information only to software engineers. What's handy for us, however, is the bottom line of information, showing the present visual zoom level at the left and the all-important frame rate at the bottom center.

Tapping [TAB] a second time brings up a narrow information strip showing your aircraft's speed, altitude, vertical speed, engine RPM, and magnetic heading. In effect, this is a highly condensed instrument panel, and it's very handy to have this information onscreen if you've chosen a view that doesn't show the main instruments (including outside views of your own aircraft).

A third tap on [TAB] clears the information displays.

Simulator menu items and functions:

Now, let's go through the simulator's many menu items and functions in detail.

Menu Bar:

If you don't see a menu bar at the top of your screen, tap [SPACE]. Successive taps on [SPACE] toggle the menu bar on and off in any view.

We'll work our way through all the menus, moving from left to right.

File menu:

Load Scenario:

Brings up a list of scenarios (complete simulation situations, with all parameters including aircraft selected, weather, flight plan, etc.) you have saved. Use the bar at the top of the window to choose a different directory if desired. Click on any scenario to load it.

Save Scenario:

Saves the current simulation to a file name of your choice. An excellent way to save an entire session so that you can return to it later. Use the bar at the top of the window to choose a different directory if desired.

Save Scenario As…

Allows you to save an opened scenario under a different name. This is an excellent way to save multiple copies of a scenario with individual changes…for example, if you want to make the same flight in a different aircraft.

Exit

Quits Fly! II.

Options menu:

Sound…options:

Allows you to choose how simulation sounds are presented, select which sounds you'll hear, set sound volume, or mute sound altogether.
Keyboard shortcut: [Ctrl+M] mutes and unmutes all simulation sounds.

Date and Time…options:

Allows you to set the simulator's date and time (the latter in either UTC, or "Zulu time," or local time). The positions of the sun, moon, stars and constellations are accurately depicted based on date, time, and location.

Keyboard shortcut: each tap of [T] shifts time forward 30 minutes; each tap of [Shift+T] shifts time backward 30 minutes. Try this while looking at an external view of your aircraft sitting on the ground, and you'll see its shadow move correctly.

Keys and Buttons…options:

This is a very powerful series of nested menus that lets you set up Fly! II and customize it just the way you want it. There are a number of lists for key and button functions, chosen using the bar at the top left of the window.

To set any key or button, select the desired in the window, then press the corresponding key (or button on your yoke or joystick) to assign that function to it. To clear a key or button, select the desired item, then click on "Clear Key" or "Clear Button" as applicable. You can pre-assign the most common keys and buttons by clicking "Default Keys" or "Default Buttons," but *any and all* keys and buttons can be changed as desired.

Here are the categories of control you can assign:

Menu keys:

Allows you to access a wide range of menu headings with single keys, key combinations, or buttons. You may also combine keys and buttons (for example, [Ctrl]+a joystick button.

Global Keys:

Here, you can assign keys or buttons to individual simulator functions, including ATC (air traffic control) responses. The default buttons you'll see the first time you access this window provide a complete listing of Fly! II's "standard" keyboard shortcuts. Once again, you can change any or all of them to suit your individual preferences.

Camera Keys:

Allows to to predefine virtually any desired camera view (camera, position, zoom level, etc.) and link it to a single key or button.
Hint: it's very handy to link the basic forward cockpit view ([Ctrl+1] default keyboard shortcut] to a joystick or yoke button to allow you to instantly "snap back into the cockpt" from any other view.

Airplane Keys:

This is one of the most important submenus to let you customize the way you like to fly any aircraft. It allows you to assign or reassign any aircraft functions (see the online key list for the default choices) to any key, keystroke combination, or control button.

It's a good idea to make a note of the keys you've selected (or just print your screen if your computer is capable of doing so). If you lose track, you can always click on "Default Keys" and "Default Buttons" to get back to a well-defined starting point (and one that corresponds with the online key list).

Helicopter Keys:

This provides the same functionality as "Airplane Keys," but is modified for the particular requirements of helicopter controls.

Ground Vehicle Keys:

Allows you to choose keys and buttons for moving ground vehicles in the simulation.

Slew Keys:

Allows you to assign or reassign keys and buttons to control the Slew functions described above.

Setup Axis… options:

This menu is where you can configure the actual control axes of your joystick or yoke (as opposed to its buttons and switches). Use the bar at the top left to choose whether these axes apply to an airplane, a helicopter, or a ground vehicle.

Clicking on "Show All Axes" displays all available input channels (for example, individual engines for multiengine aircraft. Clicking on "Test Controller" brings up a window allowing you to test all axes and buttons on your chosen control input device.

Test Controls…

Brings up exactly the same window as "Test Controller" described above. Clicking on "lock controls" at the upper right allows you to test the controls without affecting simulator operation. Each control axis has a "Swap" box; when checked, this reverses the action of that axis only. An example of where you might want to use this would be in a helicopter, in which the collective pitch control (normally linked to a throttle, either on your joystick or a separate unit) is pulled *back toward the pilot* to increase power.

Cockpit… options:

These options allow you to control the appearance of your main cockpit display. The "mouse scrolling" box, when checked, allows you to use the mouse to look around inside cockpit views that are larger than what fits on one screen (see "Looking Around Inside, above). "Stretch Main Window" and/or "Force Full Width" let you expand the cockpit display to fill your entire monitor screen (if it doesn't anyway; these options aren't usually necessary with most graphics cards).

Startup…options:

Let you set how Fly! II "wakes up" when first started: you can see the default startup screen, or jump directly into the cockpit of an aircraft, into a pre-stored adventure, or into the flight planner.

Realism…

This window, with its series of tabs, lets you set how realistic various aspects of the simulation will be. In general, if you're not an experienced pilot, more realistic = more difficult!

Let's run briefly through the tabs; functions available under each are detailed onscreen:

Basic tab:

Lets you choose whether the aircraft can be damaged or is "invincible;" sets whether engine startup **(Keyboard shortcut: [E])** follows realistic steps, or whether the engine just springs instantly to life; determines whether you burn fuel or have an "everlasting" supply, etc.

Advanced tab:

Sets further functions, including how the aircraft responds to different runway surfaces, whether gyro instruments in older aircraft types drift (requiring pilot correction from time to time), how realistically your aircraft (especially single-engine ones) react to prop torque effects (described in the “How to Fly!” manual), and whether fuel mixture in piston engines must be manually controlled.

Helicopter tab:

Sets some even more advanced aerodynamic functions in the unique helicopter flight model. See the “How to Fly!” manual for a more complete discussion of these factors.

Damage tab:

If any of these boxes is checked, the simulator will advise you (and react accordingly) if limits are exceeded. Dive an airplane too fast, pull it up too hard, and a wing will very likely be damaged…and if it comes off, you’ll have a hard time controlling the airplane for the remainder of the (mercifully brief!) flight.

Icing tab:

No, this isn’t the sugary stuff on top of a cake. Checking any box will ensure that the aircraft will react accordingly if flown in conditions of adverse air temperature and humidity that can result in ice forming on its structure. Pick up enough ice without doing something about it, and your troubles will soon be over just as if you’d pulled a wing off!

Scenery options:

This window lets you choose how scenery outside the airplane will appear, and it’s an important one in terms of frame rate. The more complex your scenery settings are, the more shadows you display, and the farther away you can see, the more processing your computer has to perform…and hence, the slower the frame rate may become. Note the warning in this window!

In particular, “Maximum Visibility” sets how far away scenery will be displayed if ou’ve set basic visibility (under the Weather menu, discussed below) at its maximum. “High Resolution Radius” is available only with some high-end graphics cards (grayed out for others), and sets how far away scenery will be displayed in maximum resolution; “Medium Resolution Radius” does the same for virtually any graphics system. Higher numbers = fancier display and lower frame rate.

Finally, “Computer Controlled Aircraft” sets how many other aircraft, controlled by Fly! II, may be sharing your airspace. Again, the more airplanes the simulator has to fly, the less resources it may have to deliver maximum frame rate to your own cockpit.

Pause:

Freezes the simulator; the next selection unfreezes it. **Keyboard shortcut: [P]**

Mute:

Mutes all simulator sounds. **Keyboard shortcut: [Ctrl+M]**

QuickFlight Menu:

QuickFlight… options:

This window lets you choose the options that will apply next time you choose a QuickFlight. You may specify which aircraft to fly, whether or not its engine will already be running when you get into the cockpit, and the airport at which it will be positioned.

Clicking on "Start Now" will immediately start a QuickFlight from this window.

Adventures… options:

From this window, you can choose stored flight adventures. A number are supplied with Fly! II, and others are available from Terminal Reality's Fly! II website (www.iflytri.com).

Flight Plan menu:

This menu gives you access to one of Fly! II's most powerful and versatile features: a flight planner on which you can not only plan a flight (whether around the airport or across a continent), but also define the weather conditions you'll encounter along the way. Because the flight planner can do so many things, it's a fairly complex series of interlocking functions and menus.

Flight Planner…

Accesses the master flight planning map. This is a very versatile and fairly complex feature; for complete information, refer to the online "Fly! II Flight Planner Tutorial."

Current Waypoint…

Displays information about the current flight plan waypoint, the last waypoint behind, or any other waypoint you select. Clicking on "Other Waypoint" takes you to the Directory screen, described below:

Directory…:

From this screen, you can select any airport, navigation aid, or waypoint in the vast Fly! II database. Use the bar at top left to select the desired waypoint type (airports, navaids, or other waypoints), then type in either the common name or the FAA or ICAO identifier in the appropriate box. There's no need to hit [Enter]; as soon as the system finds a match, its name will be displayed. In the event of multiple matches, each will be displayed on a new line.

Once you've chosen a waypoint (clicking on it to select it if multiple choices are displayed), you can do two things:

Clicking on "details" will open another window showing the waypoint's geographic position and elevation. If it's an airport, subwindows (with scroll bars if necessary) provide complete information on all frequencies and runway; if it's a navaid, you'll get location, frequency, and the option to tune your aircraft's nav radio to it by clicking on the "Tune" button. Other waypoints (airway intersections, etc.) will display latitude and longitude.

Clicking on "teleport" will instantly move your airplane to the chosen location.

Navigation Log…:

This window displays all the waypoints in your current flight plan, with distance, heading, magnetic variation, speed, and altitude for each leg. Clicking on "Details" provides an expanded information display for the selected waypoint.

Check list…:

This window is available in either large or small format (toggled by clicking on the plus sign at upper right). It's a reminder of the steps you should follow before starting each flight.

Once you've completed all the steps, you can start your flight by clicking on the "Start Flight Plan" at the bottom of the window.

Log Book…:

This is an electronic version of the traditional paper pilot log. You can record details of each flight, including takeoff and destination points, duration, etc., and add comments if desired. The "Options" submenu in this window lets you add new logbooks and/or new pilots.

Aircraft menu:

Here's where you'll select the aircraft you want to fly, as well as controlling many functions for that particular aircraft.

Select Aircraft…

You can group aircraft (both those shipped with Fly! II, and others you'll find on the Internet) by types, then select among those types by using the menu bar at the upper left. To make sure you see all the aircraft available, set this bar to "All Types."

A thumbnail etch of each aircraft will appear next to its name. To select an aircraft, either click on it (either the thumbnail or the name is fine), then click on "Switch Aircraft" at the bottom of the window; or simply double-click on the aircraft.

Damage Report…:

Select this window to see how badly you've damaged your aircraft after one of those less-than-perfect flights. Then just click on "Repair All" and it'll be as good as new for your next one!

Weight and Balance…:

This is an important part of each flight; if your aircraft is improperly loaded, it may not handle correctly (and if it's overloaded, it might not get off the ground at all!). In this window, we'll load everything except fuel. Click on each station in the left window to select it, then drag the slider in the right window to adjust the weight for that station. To see where the airplane's center of gravity is located at any time, click on the "Show CG" button. A summary panel just below it shows the airplane's current weight buildup.

Fuel Loadout…:

This is the other half of the weight and balance process. In this window, you can see and set the type and amount of fuel aboard your aircraft. The basic window shows total fuel; clicking on "Details" lets you see and adjust the amount of fuel in each individual tank. Again, clicking on "Show CG" lets you see the center of gravity of the airplane as a whole. Don't forget to choose the proper fuel grade using the bar at the right of the window, since each different grade weighs a different amount per gallon.

Tune Radios…

Using this window and the keyboard and mouse, you can tune your aircraft's communication, navigation, and identification radios. (The normal method is to simply tune them from the instrument panel; use this one, for example, if you don't want to leave an outside view.)

CG Indicator…:

Displays the same Center of Gravity indicator seen in the Weight and Balance or Fuel Loadout windows.

Options…:

This window lets you adjust the rate at which the aircraft responds to both its primary (yoke or joystick) and secondary (trim) controls—in other words, it sets handling and control "feel." Note that these settings are specific to whatever aircraft is active at the time, rather than affecting Fly! II as a whole. The trim settings in this window affect the keyboard only (not any trim functions you may have assigned to a yoke or joystick button).

Teleport…:

When initially selected, this window lets you "teleport" your aircraft directly to any latitude or longitude in the world. When first opened, it'll display your current latitude and longitude. Clicking on "Directory" opens the Directory window described above.

Slew…:

Toggles the simulator in and out of the Slew mode described above under "Getting Around." **Keyboard shortcut: [S].**

Weather menu:

This set of functions lets you set the weather at your current location or anywhere along your flight plan (it also interacts with the flight planner). You can set cloud layers, winds at the surface and aloft, precipitation, and general weather. You can also have Fly! II download real-world weather from the Internet and apply it to your current flight.

Overview…:

This window provides an overall view of the weather for your current flight. The “Change” buttons for each panel allow you to enter detailed weather, just as you can by using the next individual weather items:

Clouds…:

In this window, you can enter clouds for up to three separate layers. For each layer, you can select the level of cloud cover (Few, Scattered, Broken, or Overcast), the altitude at which the layer begins, and its thickness.

Few clouds = clouds covering about a quarter of the sky
Scattered clouds = cloud cover from a quarter to half the sky
Broken clouds = clouds cover more than half the sky, but with some breaks
Overcast = the sky is completely covered with clouds.

Winds…:

This window lets you set the winds at the surface and aloft (using the standard layers you'll find in FAA weather briefings). Use the slider to choose the altitude at which you wish to set the winds, then enter direction and wind speed.

If you click on "Set Shear Layer," Fly! II will generate a wind shear (a sudden change in wind speed and direction) for the chosen layer. Otherwise, winds will vary smoothly from one layer to the next.

Load Metar…:

If you've downloaded a METAR file from the Internet, you can select it here. Fly! II will load actual weather for all stations along your route of flight.

Multiplayer Menu:

Through this window, the Internet, and the special Fly! II server at Terminal Reality, you can connect with other pilots to fly together (in formation or separately), share adventures, etc. *You must have an Internet connection up and running to utilize the features in this menu.*

Connect…:

Connects your simulator with the Fly! II multiplayer server.

Disconnect…:

Ends your multiplayer session and disconnects from the server.

Chat Window…:

Opens a chat window to allow you to type messages to other pilots. Their replies will appear in a chat window on your screen.

Find Pilot…:

Checks the server to find other pilots available for multiplayer sessions.

Show MOTD…:

This shows you the message of the day.

Sysop…:

This is an option for on line Sysop's only, so no need to worry about this item unless you have been designated a Sysop by Terminal Reality.

Windows Menu:

This menu lets you access Fly! II's advanced vector and raster maps, see an enlarged version of the KLN-89 GPS, and view instant replays of your flights.

GPS Window:

This is an enlarged view of the KLN-90 GPS on the panel of the Flyhawk, the Sahara, the Kodiak, and the Pilatus airplanes, as well as the Bell 407 helicopter. It performs exactly the same functions, and has exactly the same displays—it's just bigger and easier to see. Any changes made in this window show up instantly on the panel, and vice versa. **Keyboard shortcut: [N]**

Map Window:

This window shows raster charts, i.e., scanned versions of standard FAA paper aeronautical maps. They are always depicted with north at the top, and the window can be moved anywhere on your screen and resized at any time. **Keyboard shortcut: [M]**

The map window has two submenus of its own:

View submenu:

Select map…:

This submenu lets you select both what type of maps you wish to use (menu bar at the bottom of the window), and which map within a given type you wish to view. As shipped, Fly! II includes only Sectional Charts; others will be available in the future from the Fly! II website. To view all maps available, select "show all maps" on the lower menu bar. (See also "auto select" under map options.)

The second line on this menu displays the name of the currently selected map.

Options submenu:

This submenu allows you to configure further options for the raster map window:

Auto-Select:

When checked, this function automatically selects the correct map (within a chosen map type) to correspond with your aircraft's position.

Auto-Center:

When checked, this function automatically centers the map on your aircraft's current position.

Show user aircraft:

When checked, displays an icon on the map to show the position of your aircraft.

Show computer aircraft:

When checked, displays icons on the map to show the position of other aircraft generated by Fly! II.

25%, 50%, 75%, 100%:

Chooses the scale at which maps are displayed. Higher percentages show the map in a larger scale, but show a smaller area of the map.

Vector Window:

KEYBOARD SHORTCUT:[Shift+M]

While it doesn't display terrain, the vector map in Fly! II is quite a bit more versatile than the raster maps (scanned paper maps). Since it's drawn dynamically from the system database, it can be scaled seamlessly (out to a maximum of about 150 nm from your airplane). In addition, you can choose what information you want displayed, and how it'll be presented.

You can set the vector map to any size you want—from a little thumbnail to the full size of your screen—by dragging its horizontal and vertical borders. Three menus at the top of the vector map control its functions.

Airports menu:

This menu has three items, any or all of which can be active. Active items are checked.

Show airports:

Airports will be displayed either as icons or as yellow dots, depending on your choice in the Options menu.

Show names:

Airport names will be displayed. If the ID option is selected, the ID will also be displayed (in parentheses).

Show IDs:

Airport IDs will be displayed.

Navaids menu:

The functions of this menu are very similar to those of the Airports menu. You can choose which types of navaid are displayed (VOR and/or NDB), and whether they're shown with their names, their identifiers, or both. In addition, you may choose to have VOR frequencies displayed adjacent to the stations.

“Point and click:”

Whether or not names or IDs are displayed, placing the mouse pointer on an airport or navaid will bring up a red animated dotted-line box around it. (If a name or ID is displayed, it will be enlarged in this box). Double-clicking when this box is present will open a details window for the airport or navaid. including runways (if applicable) and frequencies. Clicking the “tune” button in the detail box will autotune the applicable aircraft radio to the selected frequency.

Options menu:

This menu is the "master control" for many of the vector map's functions.

Show Labels:

This selection toggles *all* labels (airports, navaids, names, frequencies, etc.) on and off. Note that even if labels are turned off, you can get complete information on any onscreen object by double-clicking on it.

Use Icons:

When selected, this option displays standard icons for all airports and navaids, and all text labels are white. When deselected, airports (and their labels) are yellow, all VORs and their labels are green, and all NDBs and their labels are red.

Secret tip: when icons are deselected, zooming in to close range and selecting airport names or IDs on and off will bring up an accurate display of runway and taxiway diagrams! Toggling names or IDs must be repeated every time you zoom out beyond the range at which the runways appear.

Show Zoom Buttons, Show Rose Buttons:

These two options select whether the compass rose buttons (at the lower left of the map) and zoom buttons (at the lower right of the map) are displayed or not. Note that these are the only way you have to control these functions, so you'll need them onscreen when you want to access them.

Transparent:

An *extremely* useful option! When selected, it makes the map's black background transparent, without affecting any other display selections. You can put this transparent map up in your windshield, or over some little-used part of the instrument panel, and have it ready for instant access without blocking your view.

Compass Rose:

This option, when selected, draws a standard magnetic compass rose around all VOR stations visible in your current view of the vector map. When the compass roses are visible, you can use the two Compass buttons at the bottom left of the vector map to make them larger or smaller (and thus declutter the screen). NOTE—at maximum map range, the size of the compass roses is fixed.

Two digital boxes are displayed on the periphery of each visible compass rose. The box bordered in red is the bearing from your aircraft *to* that station; the box bordered in blue is your radial *from* the station.

Compass Fade:

Another very handy way to "declutter" the vector map and prevent it from becoming jammed up with overlapping compass roses: when enabled, this option "fades out" all compass roses when the map is zoomed out to greater ranges, then "fades them back in" when the map is zoomed to closer ranges.

Instant Replay window

When you select Instant Replay **(Keyboard shortcut: [I])**, the current simulation "freezes" and the Instant replay window appears.

You can replay the most recent segment of your flight (its duration depends on available memory and frame rate) forward or backward. Each successive tap on the forward or reverse play arrow speeds up the rate of replay. To return to real-time replay, tap the stop key, then resume forward or reverse play.

You can use any view during Instant Replay, or change from one view to another. The "Movie" buttons let you record your Instant Reply and save it as a file as long as you have Quicktime 4.0 or greater installed.

Since the simulation freezes during Instant Replay, then resumes as soon as you exit Instant Replay mode, it's a great way to "back out" of a tough situation or recover from a crash. Simply select Instant Replay, run it backward until you have the aircraft in a situation from which you hope you can recover, then tap [I] and resume the flight—hopefully with better luck than last time. It's too bad we don't have a similar "backspace key" for real-world aircraft!

Aircraft controls:

Now that we've covered the controls for Fly! II as a *simulator*, let's run briefly through the controls for actual *aircraft* functions. Remember that almost all of these are accessible directly from the fully-interactive instrument panels in Fly!II—but for you diehards who don't want to give up your keyboard shortcuts, here they are!

Flight controls:

Elevator up	down arrow
Elevator down	up arrow
Aileron right	right arrow
Aileron left	left arrow
Rudder left	numerical keypad [0]
Rudder right	keypad [.] (period)
Center all flight controls	keypad [5]

NOTE—for helicopters, elevator and aileron correspond to cyclic forward/backward and left/right, respectively; rudder corresponds to antitorque rotor pedals; throttle corresponds to collective pitch control.

Trim nose up	keypad [1]
Trim nose down	keypad [7]
Mixture rich	[Ctrl+9]
Mixture lean	[Ctrl+3]
Increase throttle	keypad [9]
Maximum throttle	[Shift+9]
Decrease throttle	keypad [3]
Minimum throttle (idle)	[Shift+3]
Reverse thrust (toggle) (Note—if using a separate throttle control, select reverse, then increase power. If using the keyboard, select reverse, then use the appropriate key.)	[R]
Propeller pitch increase	[ctrl+7]
Propeller pitch decrease	[Ctrl+1]
Brakes	[B]
Parking brake	[Shift+B]
Left brake	[,] (comma)
Right brake	[.] (period)
Extend flaps (one increment)	[F]
Retract flaps (one increment)	[Shift+F]

Landing gear (toggle)	[G]
Landing gear down (forced)	[Shift+G]

Aircraft lighting:

Panel lights	[L]
Note—panel light dimmers on instrument panel are operational and can be set as desired.	

Navigation, Strobe, and Beacon lights	[Ctrl+L]
Landing and Taxi lights	[Shift+L]

Autopilot:

Note—this function will engage a very basic "software autopilot" even for aircraft not equipped with an autopilot. If the aircraft is equipped with an autopilot, this function will engage it, and its basic mode will be annunciated. Additional modes must be selected from the autopilot panel or control head in the aircraft.

Autopilot on/off toggle	[A]

Miscellaneous:

"Easy" engine start/shutdown	[E]

Note—if "realistic" engine start/shutdown has been selected from the Options menu, the simulator will "walk through" all checklist steps. Boxes and arrows onscreen will describe each step in sequence.

Carburetor heat	[H]
Pitot heat	[Shift+H]

Remember that there are many other functions for which no keyboard shortcuts have been programmed. You can examine these functions—and assign your own keyboard shortcuts or control device buttons if you wish—by accessing the "Keys and Buttons..." submenu of the Options menu.

Air Traffic Control (ATC):

Fly! II allows you to communicate realistically with Air Traffic Control (ATC), both on the ground and throughout your flight.

However, just as in the real world, you can't communicate unless you have tuned your comm radio to the appropriate frequency. One way to do so, of course, would be to look up the frequency on a map, then tune the radio from the front panel.

However, Fly! II also offers you various shortcuts. Double-clicking on any airport on the Vector Map, or on any airport in your flight plan, or even on any airport you can see out the window when using the rangefinder **(Keyboard shortcut: [/])**, will open a "Details..." window that includes all relevant communications frequencies for that facility. Select the desired frequency, then click on "Tune" and your comm radio will be automatically tuned to that frequency.

Tuning a comm radio to an appropriate frequency enables ATC communications. To activate them, tap [`]—that's the "backward apostrophe" at the top left of most keyboards, just to the left of the numeral one / exclamation point key.

To initiate communications, simply tap the number key (on the main keyboard, not the numerical keypad) corresponding to the request you wish to make. (Note that ATIS is a recorded weather broadcast and doesn't require any transmission on your part.)

You'll see a "communications bar" appear at the top of the screen. The active comm frequency is displayed at its left side, and the communications text—both your transmission and ATC's response—will scroll across the bar. If you have a sound card in your computer and have enabled ATC audio from the Options/Sound menu, you'll also hear both sides of the communication from your speakers.

As your flight progresses, other communications opportunities will become available. Simply tap the number key for the transmission or response that best fits the situation.

CHAPTER 2: 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.

THE WING'S THE THING

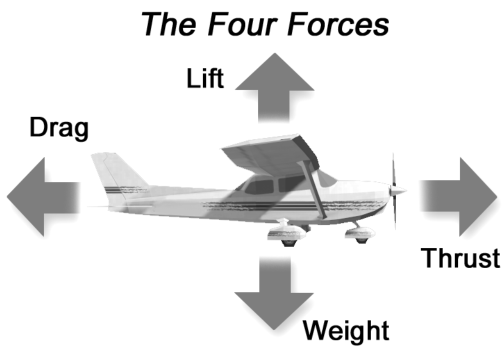
All of the aircraft presented in this release of Fly! II have something in common: they're heavier-than-air craft (*i.e.,* not balloons or dirigibles), and are thus supported by some form of *wing,* either stationary (airplanes) or rotating (the helicopter).   We could say that the wing is really the 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

Most aeronautics texts teach that there are four forces that act on an aircraft (or, considered separately, its wing) 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 aircraft 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 wing 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! II.)

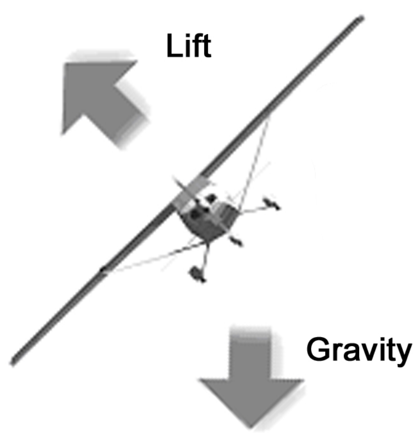
For the moment, in the interest of simplicity, let’s consider only fixed-wing aircraft--airplanes whose wings remain stationary, without the unseemly flailing about we find in helicopters. The aerodynamics of helicopters are sufficiently weird and wonderful that they merit a chapter of their own, which you’ll find further on in this manual.



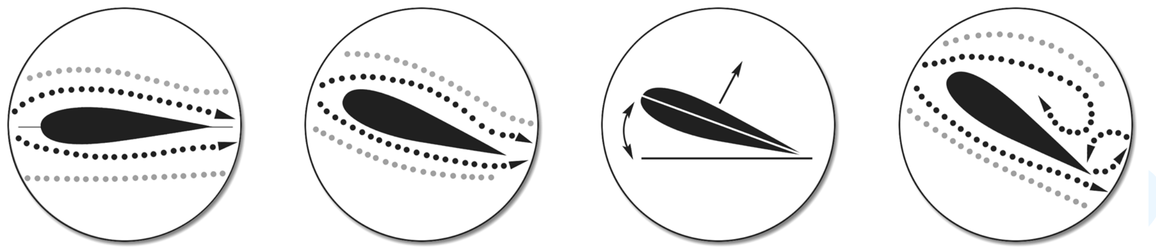
As long as we're flying along straight and level, and at a constant speed, all four of these forces are in balance. The weight of the airplane is exactly counteracted by the lift of the wing, so it goes neither up nor down. Its drag, caused partly by the wing's efforts to keep everything aloft and partly 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.

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

The aerodynamic force produced by a wing 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:



Normal Lift   Increasing Angle of Attack   Chord Line runs thru center of wing   Stalling

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.

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 or *relative wind*—explained in more detail in just a moment--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.

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 Flyhawk trainer.

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.

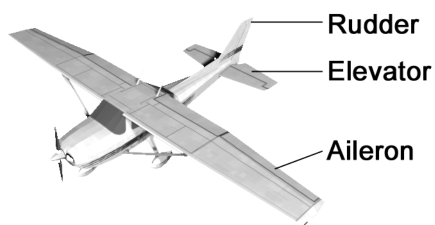
You may be using a joystick or a yoke with Fly! II, and you may or may not have rudder pedals, but the basic principle of all these controls is the same: you're going to use them to point the airplane in the desired direction, then use the lift forces generated by the wing to actually determine where 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 real-world airplanes currently simulated in Fly! II).

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! II; 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 Peregrine in Fly!, are flown "feet on the floor" except during takeoff, landing, or engine failures.

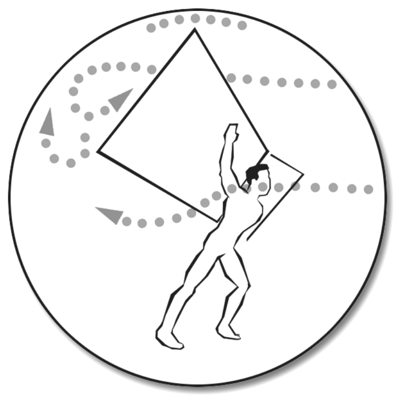
SLIGHTLY MORE ADVANCED AERONAUTICS: A CLOSER LOOK AT LIFT

Earlier in 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 aircraft simulated in Fly! II.

IT'S ALL IN THE CURVES:

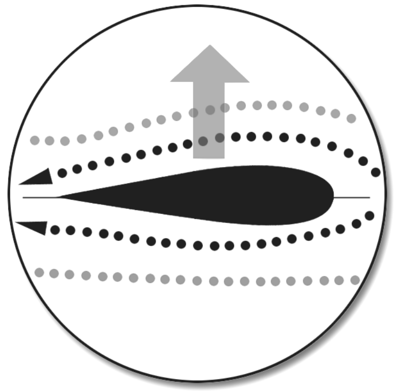
We've already learned that to hold the airplane up, the wing has to push down against the air with a force equal to its weight...but if we look closely, it's not really "pushing." In fact, that's the error made by the first would-be flyers, who tried to use simple flat surfaces--boards!--as wings. It 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.



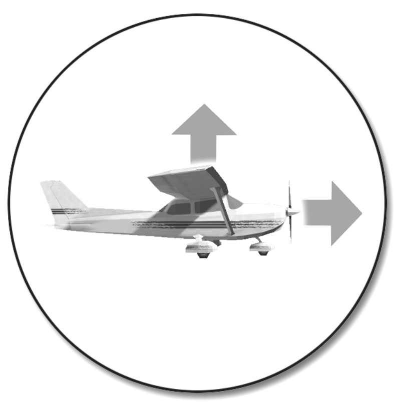
A wing works the same way: it's not so much "pushing" down the air below it as it's "pulling" on the air *above* its upper surface. This is why its curved surface is so important. The distance from the front of the wing to the rear (from its *leading edge* to its *trailing edge*) is longer around the 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*.)

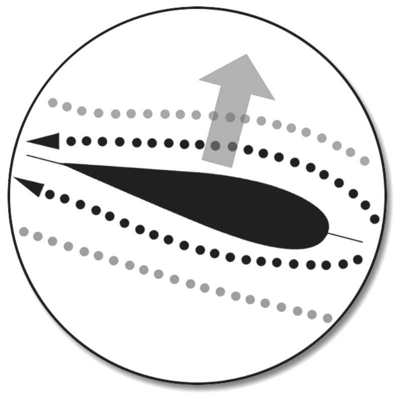


In the second picture, we're looking at a cross-section of a typical wing, or *airfoil*. Because of its curved surface, the air can flow smoothly over the top surface. This is where most of the lift is produced. Notice, too, that we've drawn a line from the center of the leading edge to the trailing edge. Aeronautical engineers call this the *chord line* of the wing...and what's important about it is that the aerodynamic force produced by the wing will always act *exactly at right angles to the chord line*. This total force can be "dissected" into two separate components. *Lift* is produced at right angles to the *relative* wind—the direction from which air seems to be moving over the wing. (Note that this is exactly *opposite* the direction in which the wing is moving through the air—for example, if the airplane is sinking slightly, the relative wind comes from slightly below, as well as from ahead.) The other component is *drag,* and it appears exactly parallel to the relative wind.

This means that if the relative wind is coming from straight ahead, as it would be in level powered flight, the lift components of the total aerodynamic force points very slightly backward. If it weren't for the thrust of the engine, the airplane would slow down.



On the other hand, if the relative wind is coming from slightly below, as it would be during a descent, its lift points slightly forward, pulling the airplane along. 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.



The *amount* of lift a wing can produce depends on three 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.)

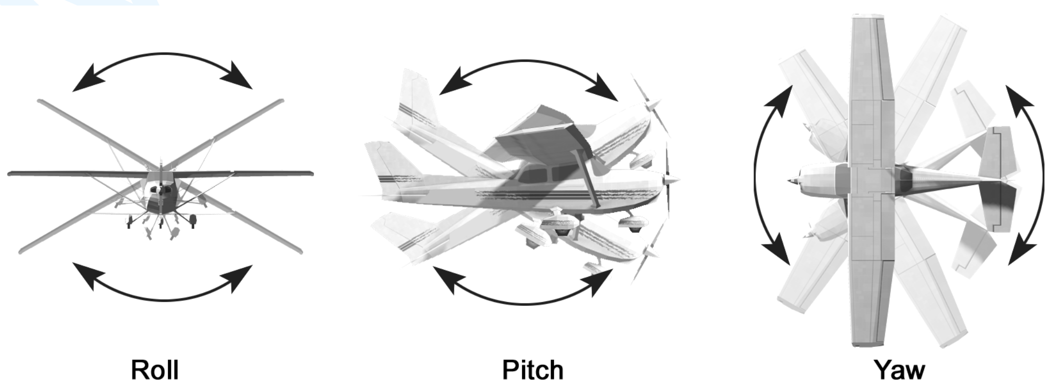
WHAT'S YOUR ANGLE?

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 relative wind. At high speed, it only takes a small 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 large 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:

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 attack 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. Notice how similar this is to the flat plate we looked at earlier? 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 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, a quarter of an inch!



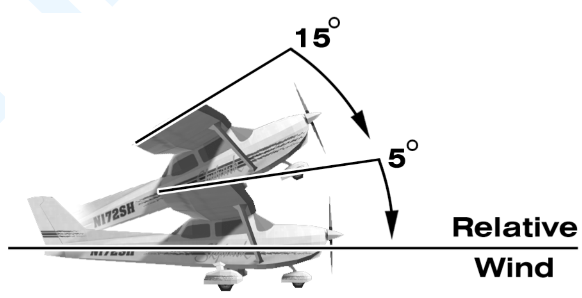
IT'S *ALL* IN THE ANGLE:

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--after all, even gliders can stall with no engines at all!--nor with the small enclosures used to confine farm animals.



Not to scale

"RADIO FLYER" Part 1

This section is an introduction to basic aircraft radios and indicators.

Please note the material in Part 1 covers the radio installations in the Flyhawk, Sahara, Pilatus, Kodiak, and the 407 helicopter. The Aurora and Peregrine have their own radio sections

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 multiengine 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 ¼ inches wide, so they'll fit in the standard radio "stack" in the center of the panel. All the piston-powered aircraft in Fly! II, as well as the Pilatus PC-XII turboprop and the Bell 407 helicopter, use the excellent radios from the erstwhile Bendix-King division of Honeywell, and they all have the same basic installation, even if some use different indicators. In addition, the Flyhawk and the helicopter accommodate their entire complement of radios in a single tall "stack," while those in the Sahara, Kodiak, and Pilatus 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-of which more in a moment-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.

Remember: to quickly find and tune frequencies for any airport or navaid, call up its details (either from the Directory... menu or by simply double-clicking on it on either the vector map or by using the "rangefinder" tool in any windshield or external view), then click the "Tune" button. The frequency will automatically be transferred to the active side of the appropriate nav or comm radio.

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 conjuction with a separate nav indicator in the panel, it can also display navigation information directly.

We’ll cover instrument flying and radio navigation techniques in more detail as we work with individual airplanes, but here’s a simplified overview: The nav receiver receives two different types of signal from ground stations: VOR (Very High Frequency Omnidirectional Range), for enroute navigation from place to place and for non-precision approaches, and ILS (Instrument Landing System), for precision approaches to appropriately equipped airports.

You can imagine that a VOR station sends out 360 separate course signals, one for each degree, like the spokes on a bicycle wheel. Look over at the instrument panel and you’ll see an indicator like this:

This is the VOR indicator, and at the moment we’re interested in three of its components: the ring around the outside, calibrated in degrees, called the Omni Bearing Selector, or OBS; the vertical needle, called the Course Deviation Indicator (CDI); and, just below the CDI, the “flag” indicator. This can show either an upward-pointing arrowhead, indicating that you’re working with a bearing from you “TO” the ground station; a downward-pointing arrowhead, indicating a *radial* “FROM” the ground station to you; or a striped “barber pole” marker, indicating that you’re not receiving valid navigation information from the station.

To use the system for navigation, determine the frequency of the ground station you want to use (by checking it on a map), then tune it on the nav side of the radio using the same standby and active frequency technique as you used on the comm side. Assuming the station is within range, the CDI needle will deflect left or right of center and the flag will show a "TO" or "FROM" indication.

To fly directly toward the station, turn the OBS knob at the 7-o'clock position of the VOR indicator until the CDI needle centers *with the flag showing a "TO" arrow (arrowhead pointed upward).* Note the number of degrees showing above the index at the top of the OBS ring. Now turn the airplane until you're flying at that heading-you *did* remember to check your directional gyro recently, didn't you?-and you'll track straight toward the station, subject only to the effects of any crosswinds that may be blowing. If the CDI needle deflects one way or the other, make a small heading adjustment-say, ten degrees-in that direction, then hold that heading until the needle re-centers, then take out about half the correction and continue to monitor the situation. Each dot represents about a mile off course if you're 30 miles from the station, becoming progressively more sensitive as you get closer.

To fly along a particular radial directly *away* from a VOR station, use the same procedure, but when you initially center your needle, make sure the downward-pointing "FROM" arrowhead is the one you see. The most common mistake made by beginning VOR users is using "FROM" when they should be using "TO" and vice versa. Note, also, that the VOR receiver and indicator show *where you are,* but *not* which way you're heading (*i.e.,* which way the nose is pointed); if you're far enough away from a station, you can fly complete circles and the CDI will never budge.

ILS (Instrument Landing System)

The same indicator is used for flying instrument approaches using the Instrument Landing System (ILS). If you're near an airport equipped with ILS, and have tuned the appropriate frequency, the system will automatically switch to ILS mode.

A full ILS has two primary components: the localizer, which provides left-right guidance to the runway using the vertical needle in the CDI; and a glideslope, for all practical purposes "a localizer lying on its side," which provides vertical guidance down the final approach segment using the horizontal needle that completes the "crosshair" indication on the instrument. The localizer is considerably more sensitive than a VOR signal. Unlike the VOR, however, with its 360-degree coverage selected by the OBS, the localizer radiates along the runway centerline only; turning the OBS will have no effect whatsoever-try it! (However, it's good practice to set the OBS to the final approach course just as a reminder.) Similarly, in localizer operation, there's no "TO" or "FROM" arrowhead; the flag will simply be blank if you're receiving a valid signal, or show the "barber pole" if there's a signal reception problem. A similar flag is provided for the glideslope.

Interpretation of the display is the same as for VOR navigation: fly the published final approach heading, using the left-right deflection of the vertical needle to make *small* heading corrections as required. When you start the final approach, use an appropriate rate of descent as published on the approach chart, then make *small* corrections in the rate of descent to keep the glideslope needle centered.

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.

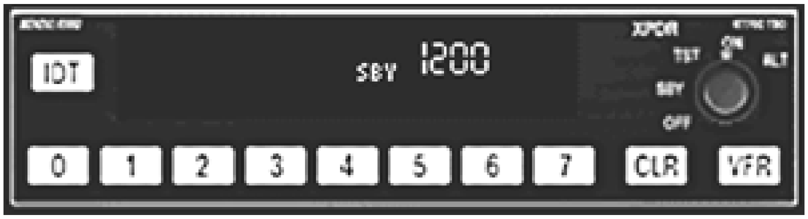
Want to know your bearing "TO" the VOR station without all that laborious OBS-knob twiddling? Push the mode button again, and the standby frequency display will change to your current bearing, complete with the word "TO." Another push and the same thing happens, except now you see the *radial,* and, 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. The big knob selects minutes, the small one selects tens of seconds when pushed in and single seconds when pulled out. 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").

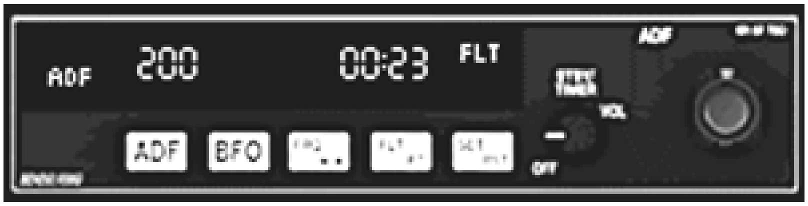
Finally, there's the big mode selector switch on the right side of the unit. The "OFF" position-surprise, surprise!-turns the whole thing off altogether. "SBY" is a standby mode, in which the unit is powered up but not responding to interrogations. It's considered good form to "squawk standby" when on 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 on one 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. 7700 is the emergency code, 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. (Just goes to show you that we can have archaic and still eat it.) 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.



Nonetheless, 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! II*** 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! II***-the "lowly" Flyhawk-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.

Not all of the system's features are implemented in Fly! II; if they were, we'd have to reproduce the actual Honeywell pilot's manual, which is about the size of a thick paperback thriller. 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! II-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 [M] 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! II, the flight plans you set up in the simulator's preflight planning page 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. You can also use this function to show you the nearest special-use airspaces (restricted areas, etc.), which you might want to avoid.

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.

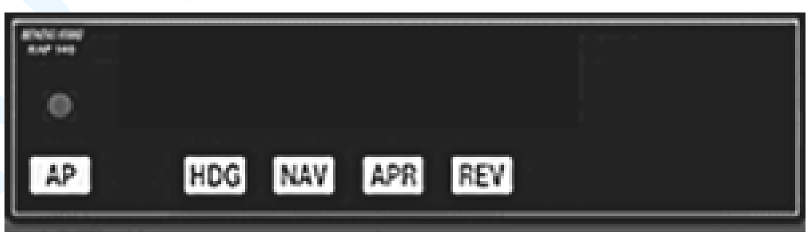
The name of the master page, and number of the sub-page (for example, "NAV 3") are always displayed on the left side of the display.

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 theGPS will request that you enter a waypoint (often your destination airport). Once it's entered 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.

AUTOPILOTS, or, "Let George do it…"



It's another sign of the times that even an airplane as basic as the Flyhawk has an autopilot-as do all of the fixed-wing airplanes in Fly! II.

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 Flyhawk'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 Sahara, Kodiak, and Pilatus can control altitude as well, and even execute creditable ILS approaches, while the top-line systems in the Beech King Air and especially the Peregrine can literally fly the airplane from takeoff to just a few feet from 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 Flyhawk, 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 Flyhawk, 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 (HIS); 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 Flyhawk, 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 "APPR," 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 "APPR," 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 Flyhawk 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 "APPR" 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 "APPR 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; in the Sahara, Kodiak, or Pilatus, 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 jet, "magic brain" can take you all the way to touchdown.

ALL THESE RADIOS…

With this much equipment even in a "simple" Flyhawk, 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. Since you have the cockpit all to yourself, some of the intercom functions aren't implemented in Fly! II. What *is* implemented, however, is the marker beacon receiver: 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! II**,** 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! II, only the C1 and C2 (comm 1 and comm 2) positions are active.

RADIO FLYER - PART 2

The Sahara, Kodiak, Pilatus, and Bell 407 all use the same excellent Honeywell equipment as the Flyhawk. 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 the time), 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. If there's a failure in this part of the system, an orange HDG flag will appear at the top of the instrument.

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.

In airplanes equipped with GPS, appropriate switches and indicators are provided to display GPS information on the HSI.

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 Flyhawk, 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 navaids) 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.

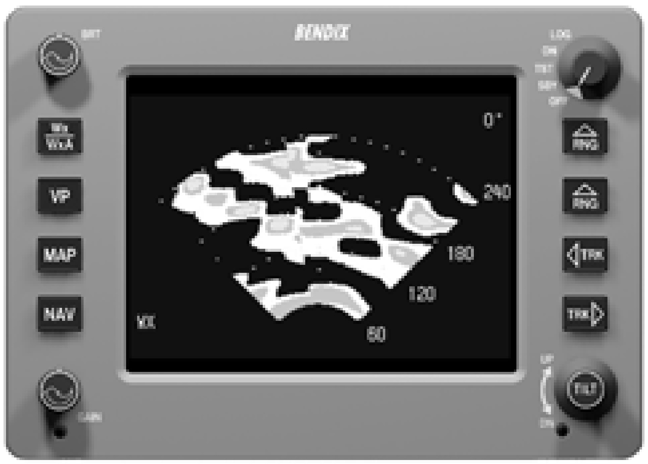
It does this by emitting a pulse of radio energy. The DME ground station receives this pulse and replies to it. By timing how long it takes to get an answer and calculating in the speed of light (186,286 miles per second-"it's not just a good idea, it's the *law!"*), the system determines the range to 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 he 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 by bouncing radio signals back and forth, 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=6080 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 the 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, 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 Sahara, Kodiak, and Pilatus 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 Sahara and Kodiak are very similar in basic operation to that in the Flyhawk, 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, hold down the PITCH SYNC button on the yoke, manually fly the airplane to the new desired pitch attitude, and release the button.

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 descent 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.

The autopilots in the Pilatus and the Peregrine jet have similar capabilities, although their control heads appear slightly different. On these, the buttons for each mode illuminate when that mode is selected. In addition, active modes are indicated on the EFIS (Electronic Flight Instrument System) displays.

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 when the human pilot would like to "stay in the loop." For this, there's the flight director function. Engaging it, by pressing the FD switch., causes a pair of "command bars" to appear in the artificial horizon (more correctly called, at this point, an 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." You should also turn it off anytime you're adjusting the rudder trim, especially in single-engine situations in the Kodiak.

_Aircraft Radio Navigation Techniques

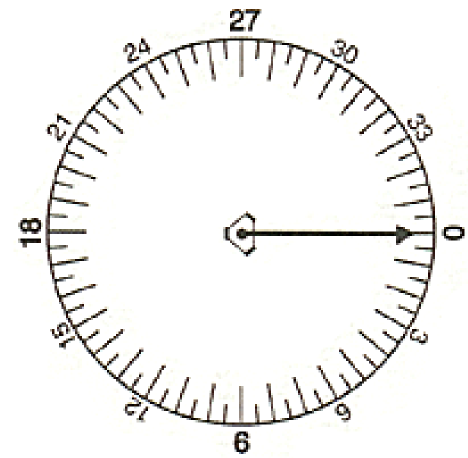
VOR, , ILS, NDB, GPS

All the aircraft in Fly! II 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

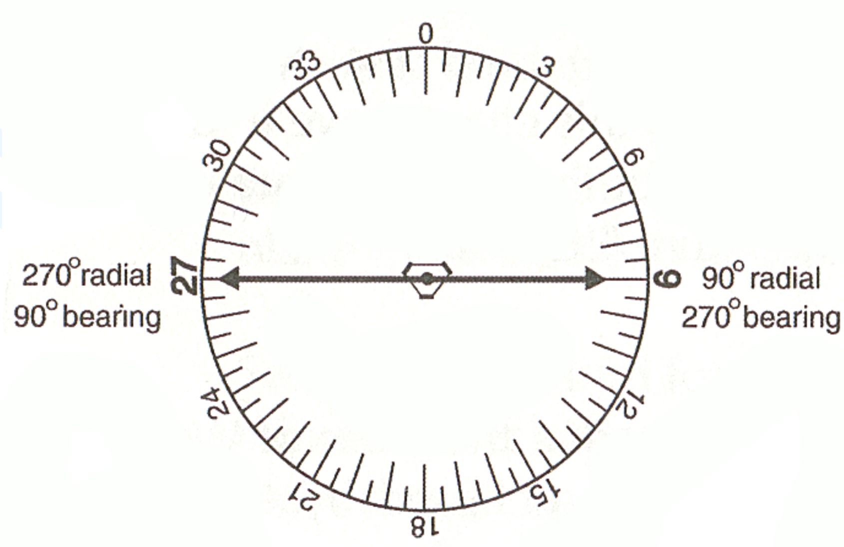
The VOR system was developed at the close of World War II. While at present it's rapidly being eclipsed by GPS, for the moment it's still the primary means of aircraft navigation in most developed countries. VOR provides the pilot with both directional, or bearing, information ("where am I in relation 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



In this example, the 90-degree radial *from* the station is also the 270-degree bearing *to* the station.

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).

TO, FROM, and the VOR INDICATOR

Let's look at a typical VOR indicator.

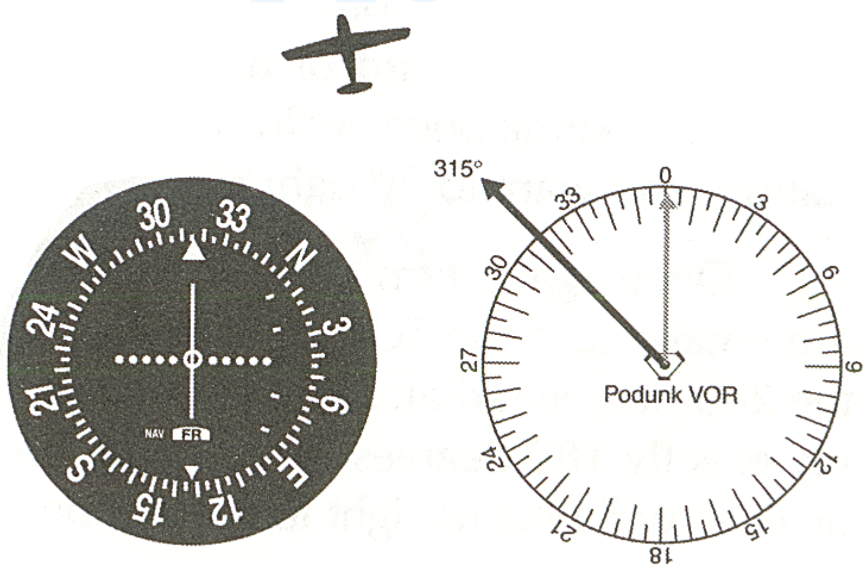
You'll notice an outer ring with degree markings, an adjusting knob at the lower left, and a needle with a center "target" and five dots on each side.

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.

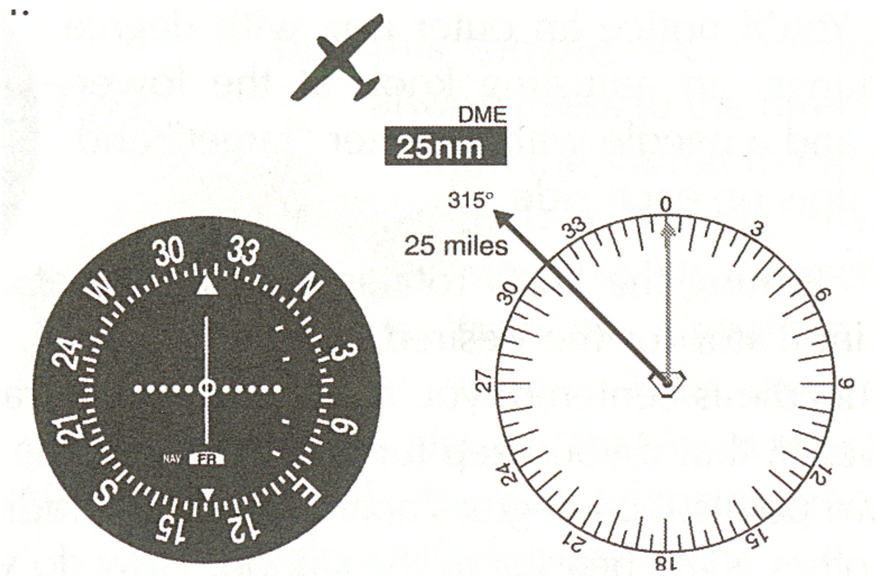
POSITION FINDING AND TRACKING:

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.

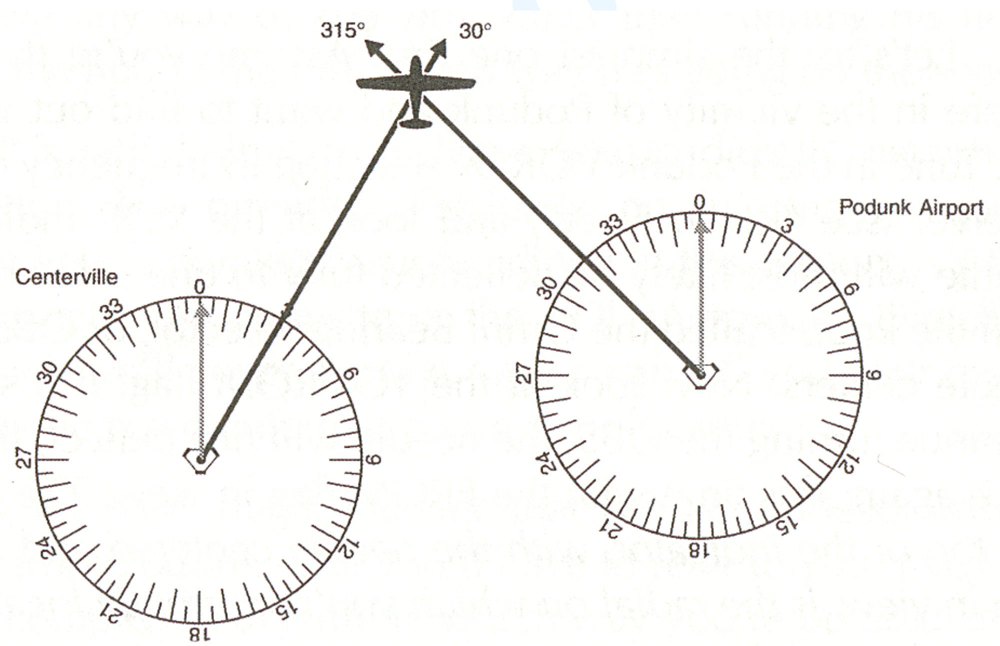
Let's try the simplest one first. Assume you're flying somewhere in the vicinity of Podunk and want to find out where you are. Tune in the Pondunk VOR by selecting its frequency on the nav receiver and look at the VOR indicator. The needle will most likely be deflected fully to one side or the other. 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.

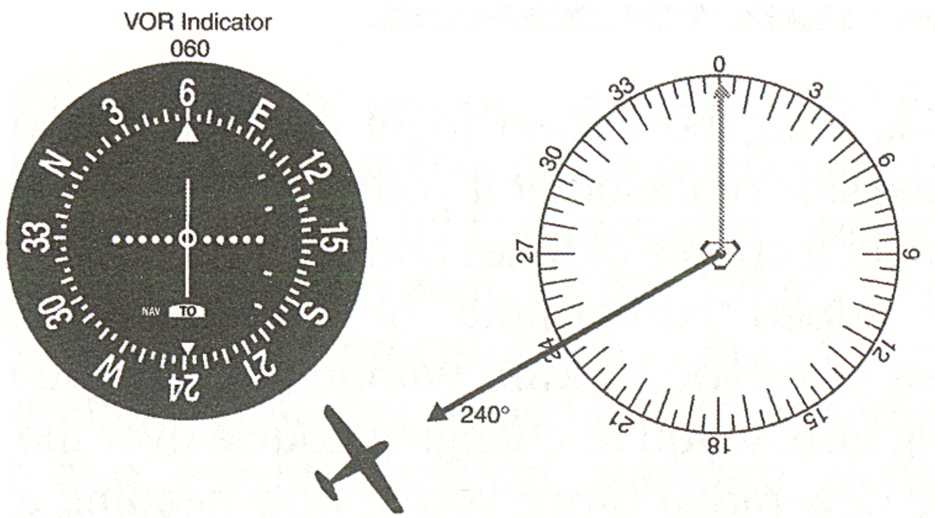


Alternately, you could take a cross-bearing from another VOR station. Let's say that Centerville VOR is somewhere southwest of Podunk. Tune your nav receiver to the Centerville frequency and, once again, center the needle with a FROM flag in view. In this illustration, you're on the 030 radial from Centerville;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



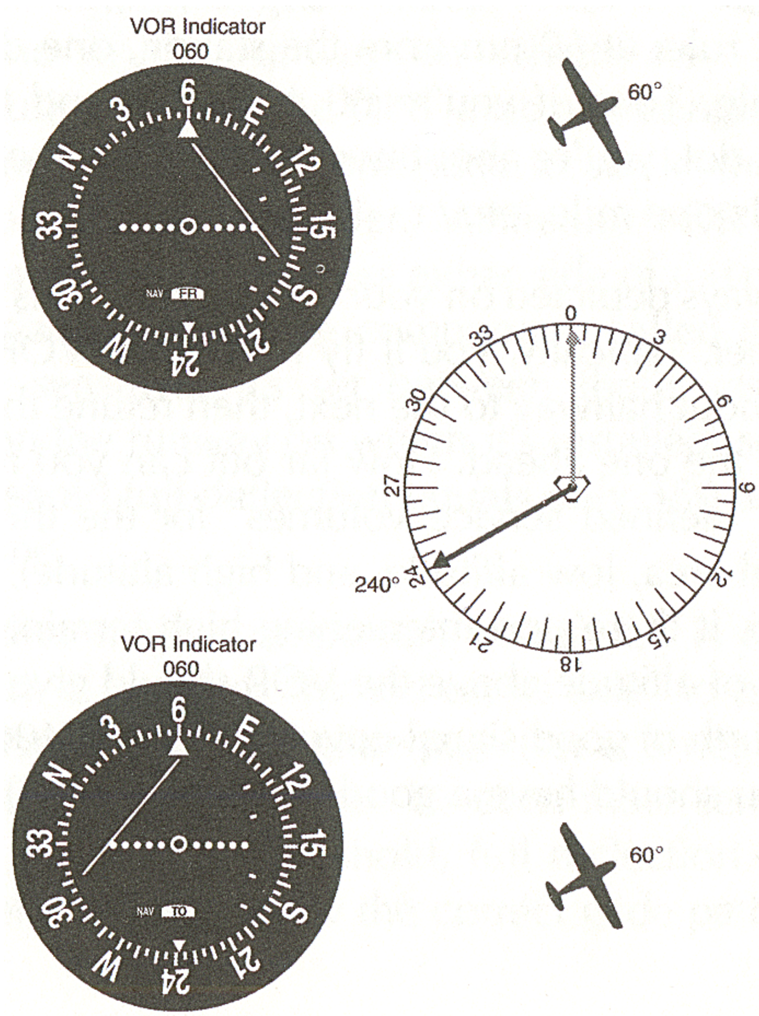
The more common use of VOR, however, is *tracking,* using it to fly directly toward or away from a station. Let's stick with good old Podunk once again. We're somewhere to the west of the station, and want to fly right toward it.

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* <u>*heading*</u> *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.

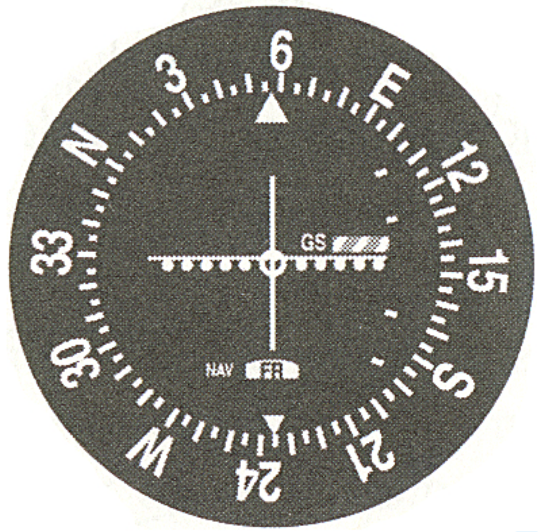
*Remember: with the needle centered and the TO flag in view, the bearing **to** the station is at the top of the indicator and the radial **from** the station is at the bottom. With the FROM flag in view, the radial from the station is at the top and the bearing **to** the station is at the top.*

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.

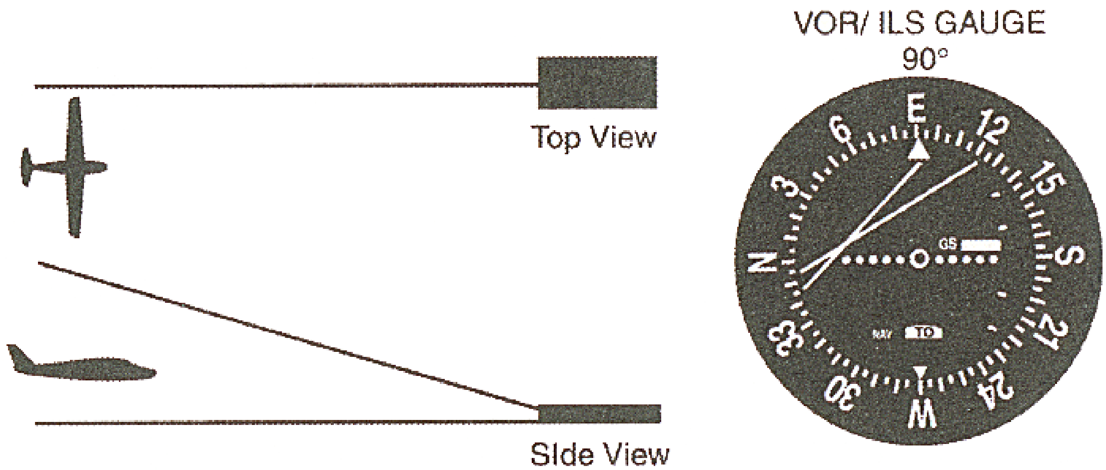


While ILS uses the same indicator as VOR, what goes on "behind the scenes" is quite different (the nav receiver switches modes automatically when an ILS frequency is tuned). While a VOR station provides radials in a full 360-degree circle around it, the ILS provides only a single course, aligned *exactly* with the centerline of the runway on which it's installed. (During ILS use, the OBS knob and compass ring aren't 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.

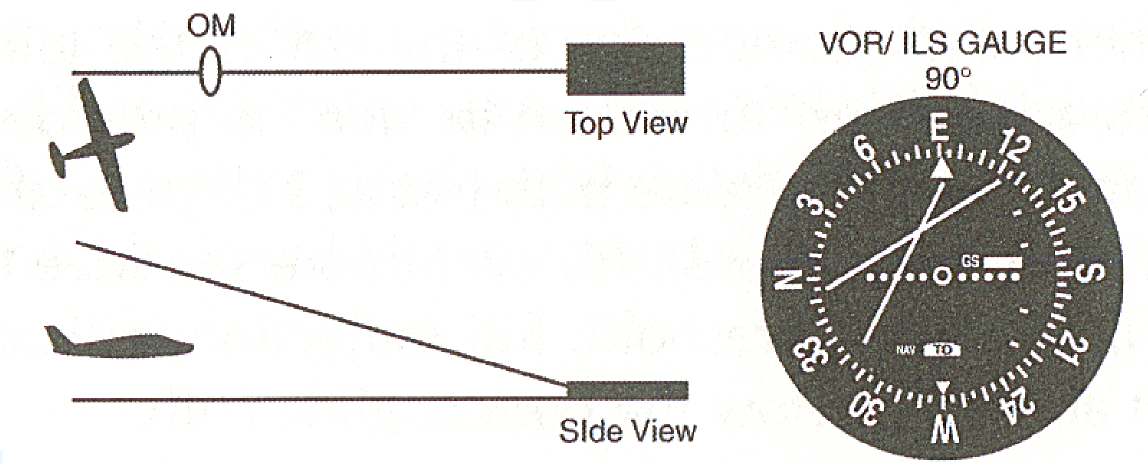
The other major component of the ILS is the *glideslope*. Essentially, it's a localizer "turned on its side" to provide precise vertical guidance down the glide path (set at 3 degrees below the horizontal at most installations). It's even more sensitive than the localizer; at the runway threshold, full 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 higher-pitched "dit-daahhh, dit-daahhh" signal in sync with an amber panel light.

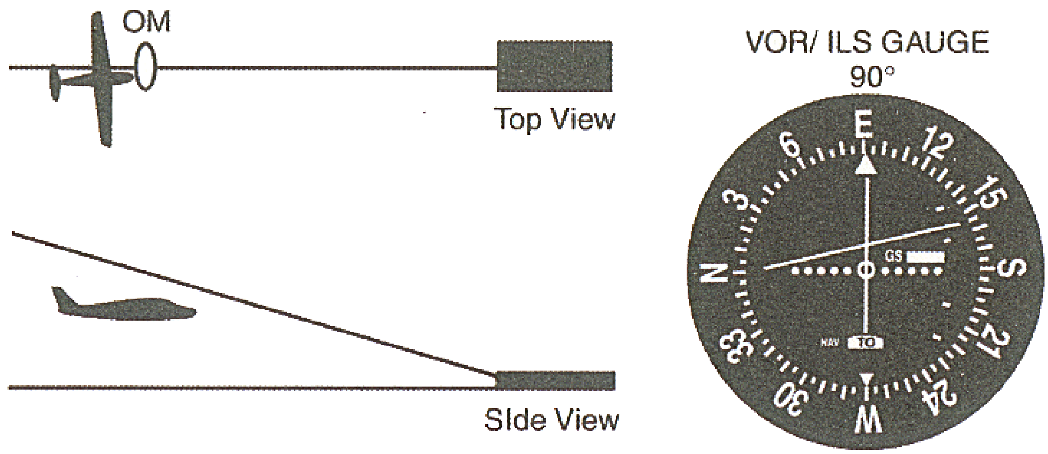
The skills you'll use to fly an ILS are essentially the same as those for a VOR, except that now you have to do them in three dimensions (and quite a bit more precisely). Where, before, you simply watched the "fly left" or "fly right" indications of the VOR needle, now you also have to follow the "fly 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.



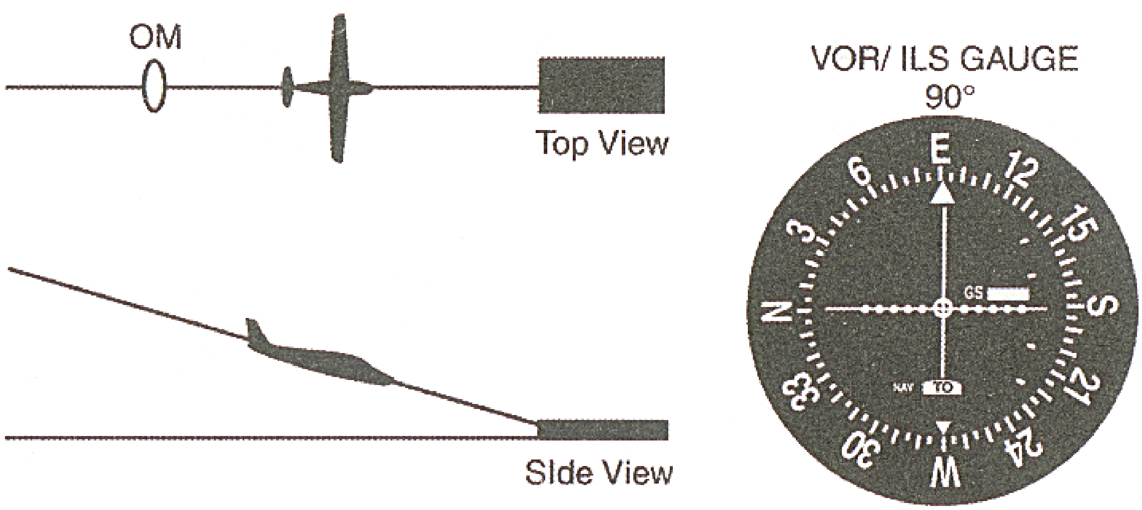
Once again, we're at Podunk—in this case, on the ILS for runway 09 at Podunk Municipal. Approach control is vectoring us onto the final approach course from the southwest, and we're at an altitude of 1500 feet. Since we're well to the right of the localizer, the needles are telling us "fly left," and 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

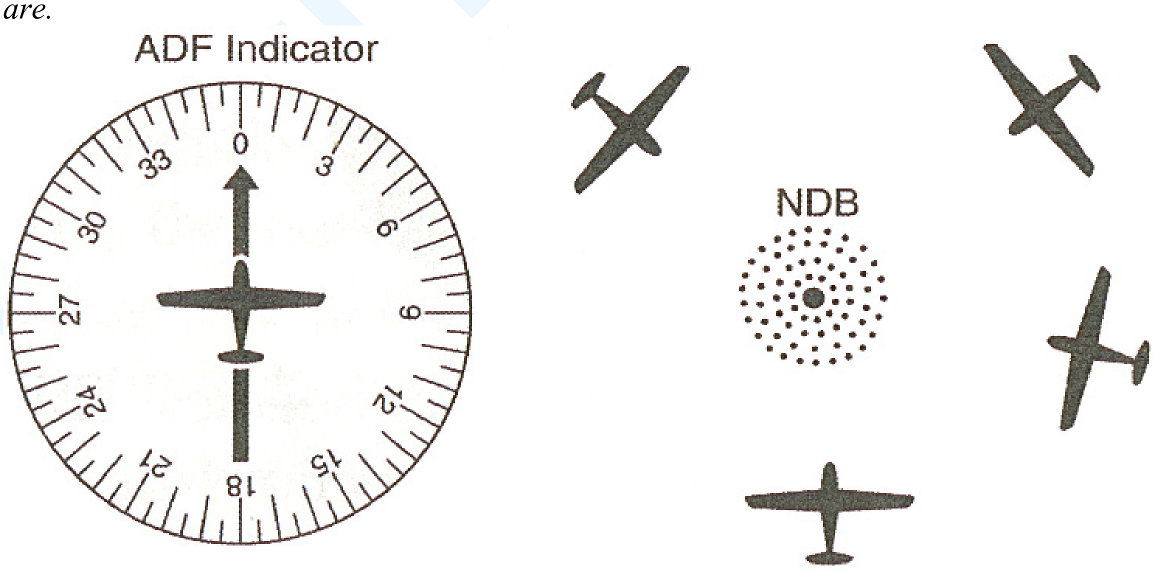
The localizer and glideslope are exactly aligned for use with only a single runway. At some airports, however, the localizer's "back course" can be used for a *nonprecision* approach to the *other end of the same runway, landing in the opposite direction.* There are only two significant things to remember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

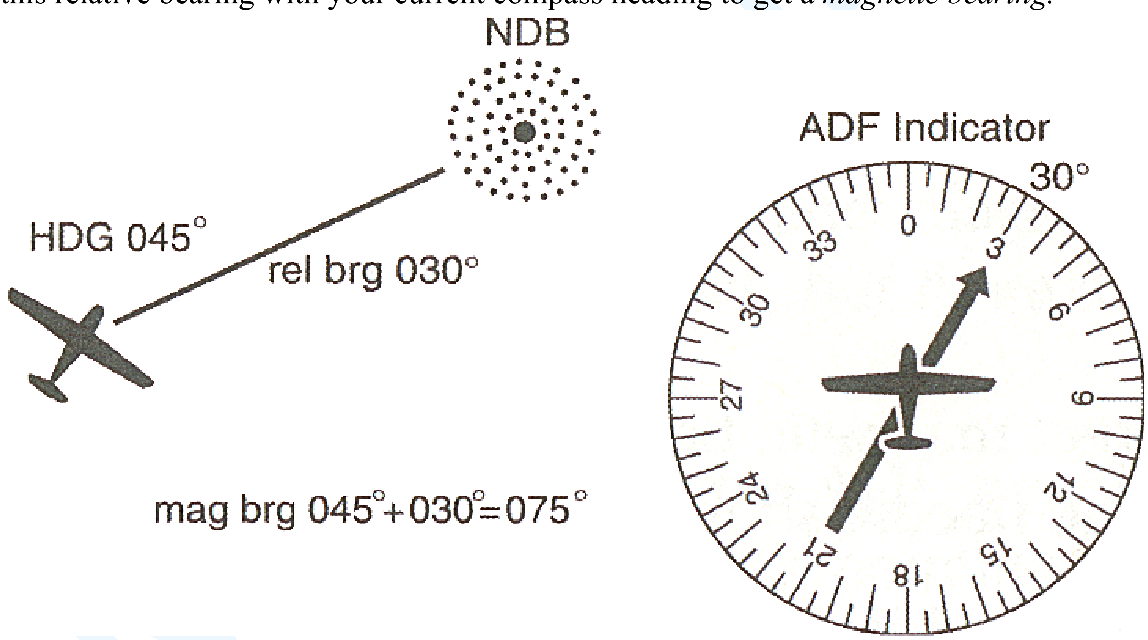


Note, in this illustration, that each of these airplanes is in a different location—but the ADF indicator would appear as it is shown in all of them.

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.*

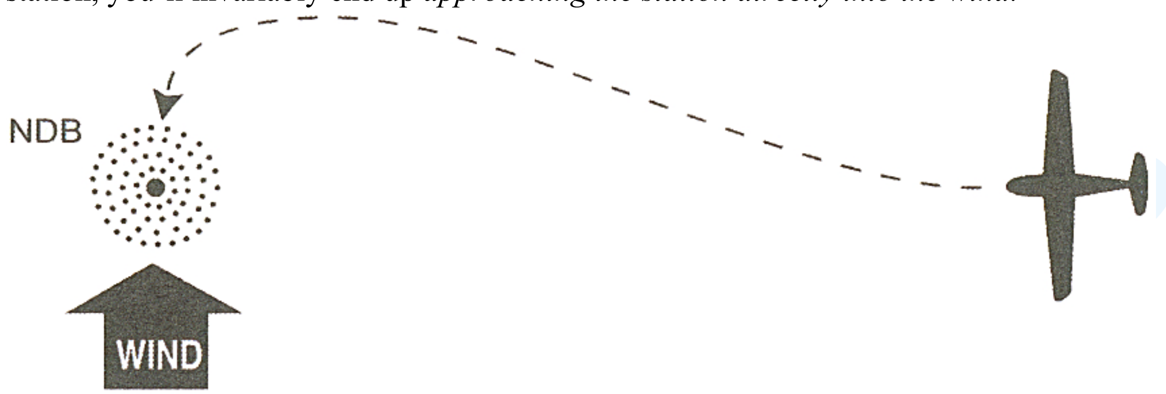


For example, in this illustration our heading is 045 degrees magnetic. The relative bearing is 030 (the station is 30 degrees right of the nose), so its magnetic bearing is 075 degrees—our heading plus the relative bearing. That's the heading we'd have to turn to if we wanted to fly right over the NDB.

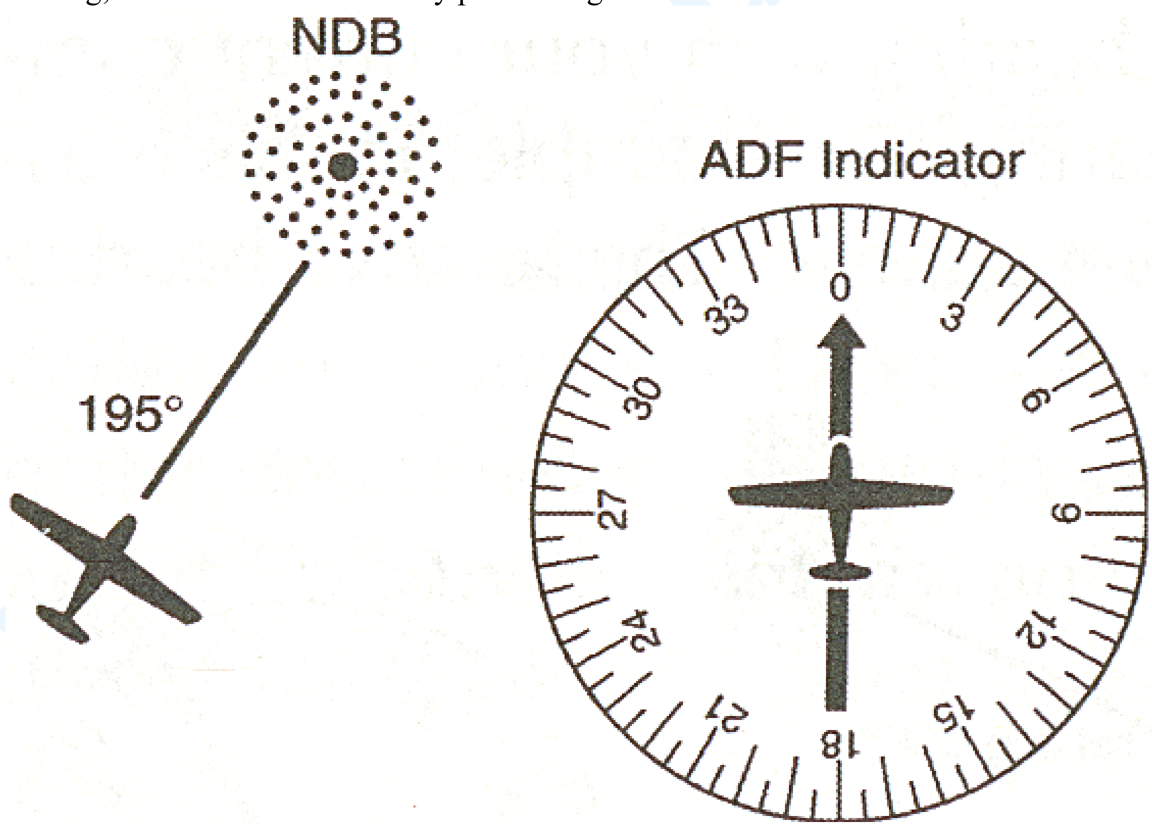
HOMING AND TRACKING:

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.

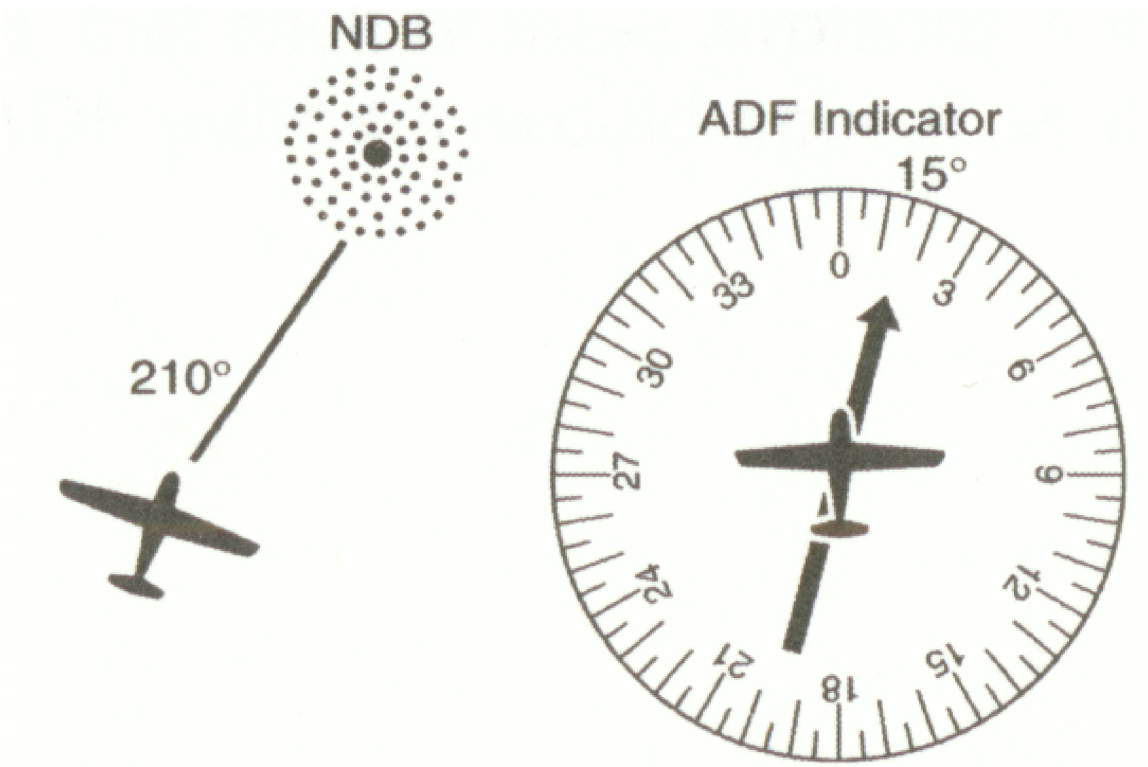
Unfortunately, this won't give you a straight track across the ground. Instead, the wind will push you one way or the other. As you keep turning to keep the station straight ahead, your heading will change. If you started at any significant distance from the station, you'll invariably end up *approaching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



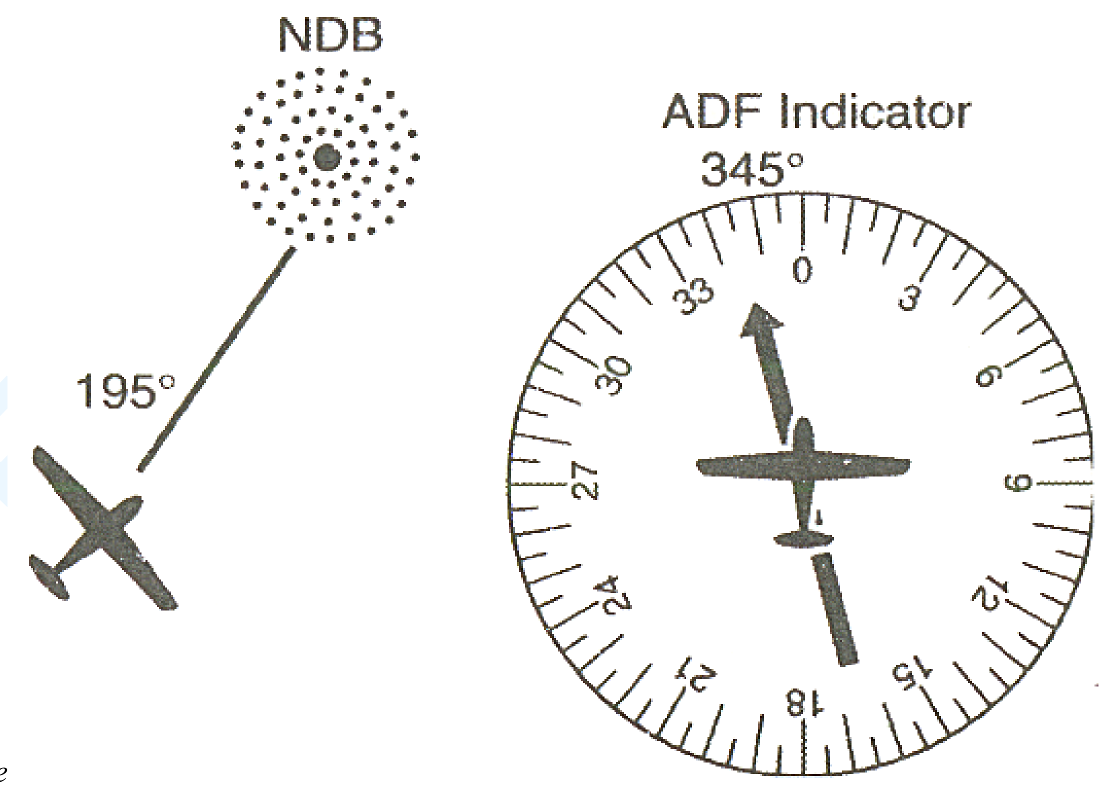
Instead, determine the magnetic bearing to the station by adding the relative bearing to your compass heading. (If the result exceeds 360 degrees, just subtract 360—for example, if you're heading 345 and the relative bearing is 030 for a total of 375, subtract 360 to get the correct magnetic bearing 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 Sahara, the Kodiak, and King Air B200 in Fly! II), have an instrument called a Radio Magnetic Indicator, or RMI, that does all the work for you. Described in greater detail in the online manual for avionics, 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.

FLIGHT PLANNER USER INSTRUCTIONS AND WALK-THROUGH

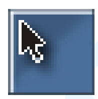
The first, and most important, item on the Flight Plan menu is the Flight Planner itself. Think of it as a master control center from which you can access a host of other functions.

Perhaps the simplest way to explain many of these functions is to "walk through" a typical flight planning process. Let's start out from San Francisco International Airport. If your aircraft isn't already located there, don't worry-we'll be able to "teleport" to that location as soon as we start the flight planning process. Click on Flight Plan on the menu bar, then on Flight Planner on the drop-down menu.

What'll appear (assuming you haven't changed the flight planner's default options yet) is a full color world map, with an airplane symbol showing your current location. As with other windows, you can drag this one to any location on your screen; you can also resize it by dragging its horizontal or vertical borders.

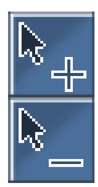
You'll also see a couple of "palettes," or toolbars. The smaller one, with eight items, is what you'll use to actually generate and modify your flight plan and all its parameters; the larger one, with twelve items, controls what you'll actually see on the map. In fact, since these palettes are so important to the use of the flight planner, let's examine them in detail now:

This is the "editing" palette, and it offers you eight different tools:



At the upper left is the "select" tool. This is a general-purpose tool that allows you to select individual items on the map for various purposes, which we'll cover in a moment.

Click on this tool, and you'll see it become brighter, or "highlighted." (It may already be highlighted; try clicking on a different tool for a moment to see the difference.) Only one tool at a time can be highlighted on this palette.



The next tool down, marked by a + sign, is the insert tool. This is used to insert waypoints on your flight plan. Immediately below it is a similar tool, marked by a - sign, to delete waypoints.

Click on the insert tool, then move it back over the flight planner map for a moment. Notice how the mouse pointer changes to indicate the active tool whenever it's within the flight planner map area.

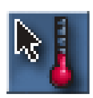
The edit/select tool can be temporarily changed to either the insert or delete tools, respectively, by holding [Alt] or [Ctrl] while clicking. The mouse pointer will change *accordingly as long as the keys are held.*

Next in line is the magnifier, or zoom, tool. Click on it and move it over the map; notice how the mouse pointer becomes a magnifying glass with a + sign. Click anywhere on the map, and your view will zoom in. Now hold the [Shift] key, and notice that the mouse pointer changes to a magnifier with a - sign. [Shift+click] zooms the view back out.

The tool at the top right allows you to add areas of precipitation (rain) along the flight plan. Move it over the map and click it where you want an area of precipitation. [Shift+click] to remove precipitation you've inserted.

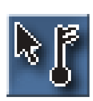
Like all the weather tools on this palette, this tool has a more precise mode, available by holding the [Alt] key. With the tool somewhere on the map, [Alt+click] now. A window will open in which you can chose the type of precipitation (rain or snow), its intensity, and the range around the mouse pointer at which it will be generated.

The clouds tool works exactly the same way the precipitation tool does, including a more detailed [Alt+click] function. You can use the default cloud types and layers, or specify up to three layers of your choice. [Shift+click] to remove clouds.



The temperature tool lets you specify a range of air temperatures (they change automatically with altitude) for any location; the [Alt+click] function allows to to choose more specific temperatures and geographic ranges. These changes will affect aircraft performance as well as weather; high temperatures are often associated with turbulence.

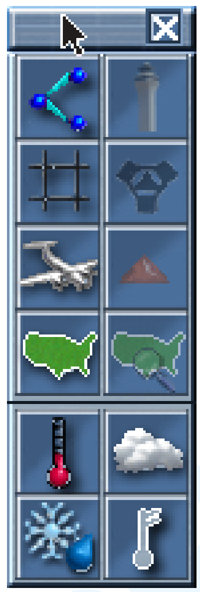
[Shift+click] to reset temperatures you've changed to default values.



The winds tool lets you specify either default or specific [Alt+click] winds for any location. [Shift+click] to reset winds you've changed to default values.

All eight of the options on this palette are also available via the "Mode" menu at the top of the flight planner map. Clicking on any desired item on the menu has exactly the sam effect as selecting that tool on the editing palette.

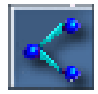
Now, let's move to the second palette:



This palette controls what you'll see on the flight plan map. Depending on how much you've been playing with the weather tools on the editing palette, the map may be looking a bit cluttered by now so let's simplify things a bit:

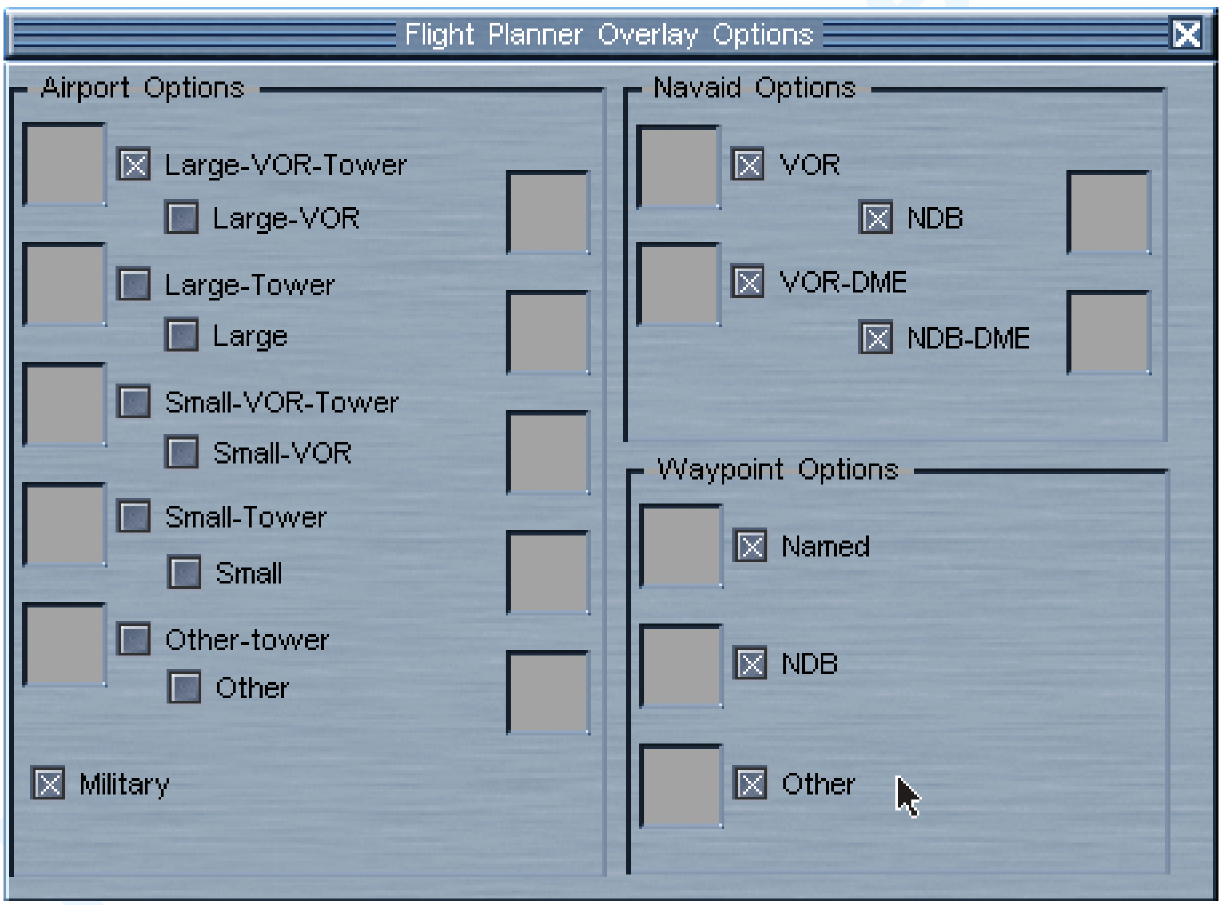
These four buttons at the bottom of the overlay palette match the weather editing tools on the editing palette, and they're automatically turned on any time you insert the corresponding type of weather. Notice that on this palette, any number of buttons can be active at the same time.

Click on each of these buttons now to turn them off. Notice that they become dimmer, and that the corresponding weather icons are removed from the flight planning map.

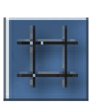


This button toggles the display of your planned flight route on and off. Since we haven't planned a route yet, it should have no effect. Click it now to highlight it, since we'll want to see the route we'll be planning.

Thus button toggles the display of airports on and off. Exactly *which* airports will be displayed depends on what you choose using the Flight Planner Overlay Options menu (click on Options at the top of the map, then click on Overlay Options).



Using this window you can choose whether to display large or small airports, different types of navaids, etc. You may want to change these options to "declutter" the map as you zoom in and out.



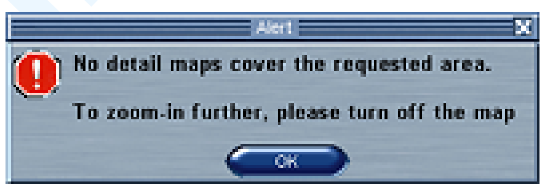
This button toggles the latitude/longitude grid on and off.

This button toggles display of navigational aids on and off. Like the airport button, this is affected by your choices on the Flight Planner Overlay Options menu.

This button toggles the symbol showing the present position of your aircraft. It's a great way to get an overview of where you are on a particular flight plan.

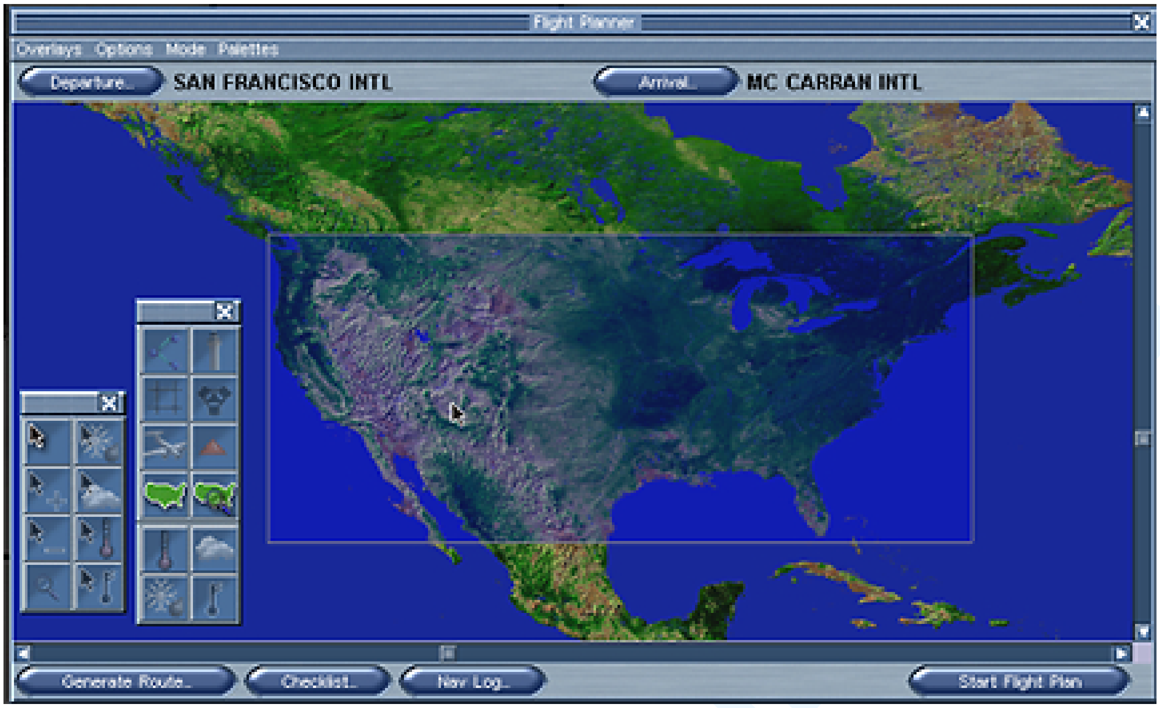
This button toggles display of waypoints that are neither airports nor navaids. These can include airway "intersections" defined by the FAA, as well as waypoints you've created for yourself.

This button toggles the display of the large-scale world terrain map. Note that this map is only available at larger scales of view. If you attempt to zoom in to a view not supported by a terrain map (whether the large-scale or detailed maps), you'll get a message like this:



In this case, simply click on the map button to turn the map off. You can still see all relevant airports, navaids, and other waypoints.

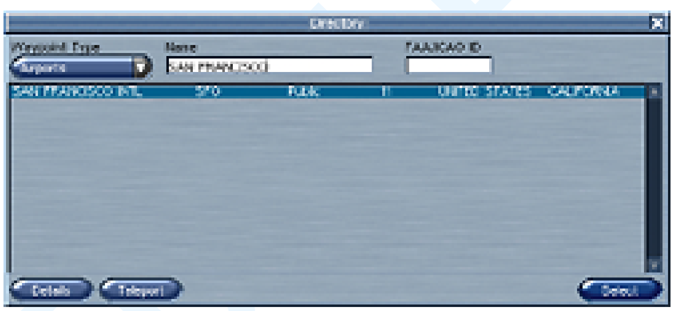
As shipped, Fly! II has areas of much more detailed terrain map coverage, with more available from the Internet in the future. This button toggles a display of areas covered by these higher-resolution maps.



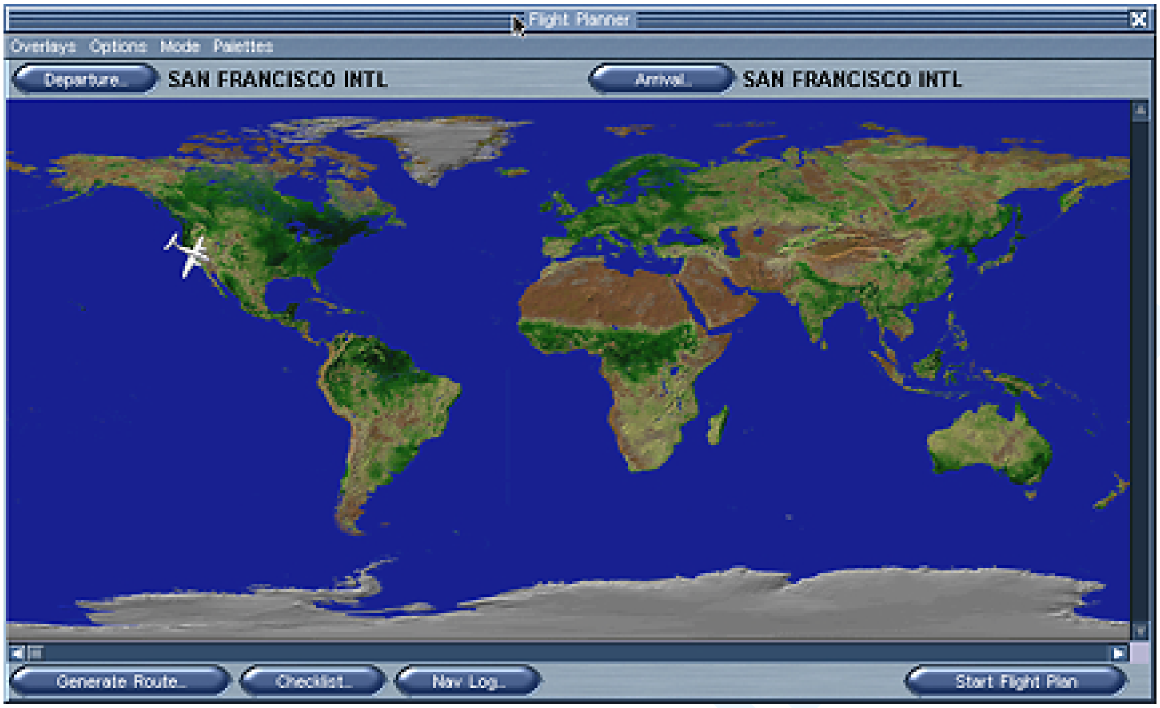
As with the editing palette, all the functions on this palette can also be accessed from the "Overlays" menu at the top of the flight planner map.

Now let's go ahead and generate a sample (and simple) flight plan!

To begin, click on the "Departure" bar at the top left of the flight planner map.



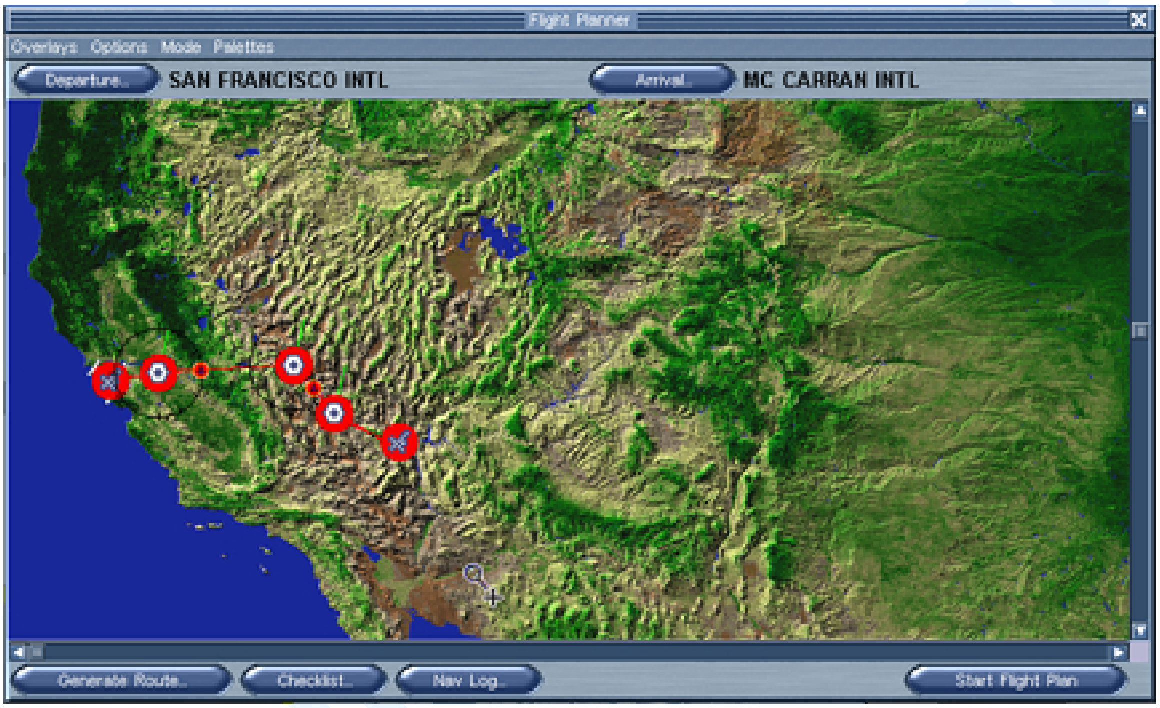
Does this look familiar? It's our old friend, the Directory window. If you're not already there, click on "Teleport." Then, click on "Select." (You may have to click on "departure" again if teleporting returns you to the main flight planner map.)



For the moment, the flight planner has inserted San Francisco as both the departure and arrival, but let's fly to Las Vegas. Using the same technique, click on "Arrival…" and choose Las Vegas.

You can see that the flight planner has drawn a direct line between the departure and destination. It will also display all flight plan waypoints whether their type is selected (on the overlay palette or menu) or not. Try it by toggling a couple of different overlay items on and off now.

Nowadays, with most aircraft equipped with GPS, direct routings like the one shown here are becoming more and more common. Unfortunately, regardless of how well your airplane might be equipped, the Air Force owns big chunks of restricted airspace in southern Nevada and eastern California, and we'll have to fly around them. Later, we'll see how to choose exactly the flight plan we want…but Fly! II can do a remarkably good job on its own! Click on "Generate Route…" at the bottom left of the flight planner now.



As you can see, the system has generated a new route via three VORs and three airway intersection waypoints.

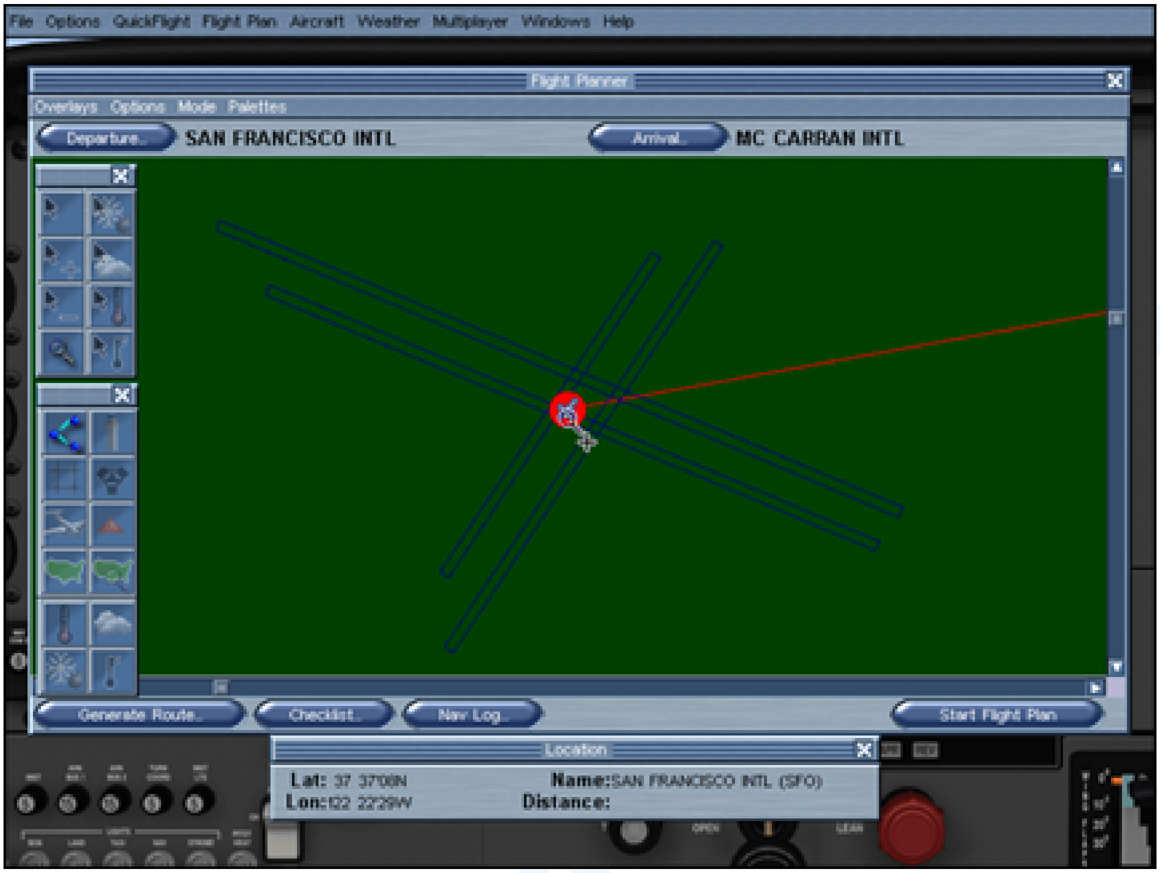
Looks pretty complex, doesn't it? But Fly! II offers you several different ways to find out details about your flight plan. Let's start with one of the simplest: click on the "Palettes" menu at the top of the map, then click on "Location."

A new window opens on your screen, showing the latitude and longitude of the current position of the mouse pointer. If the pointer is placed on any waypoint visible on your screen (whether or not it's part of your flight plan), its name will also be displayed.

You can obtain even more information about any onscreen waypoint, whether or not it's part of your flight plan, by using the edit tool and double-clicking on the desired waypoint. Try this first on some waypoint that's not in your flight plan…

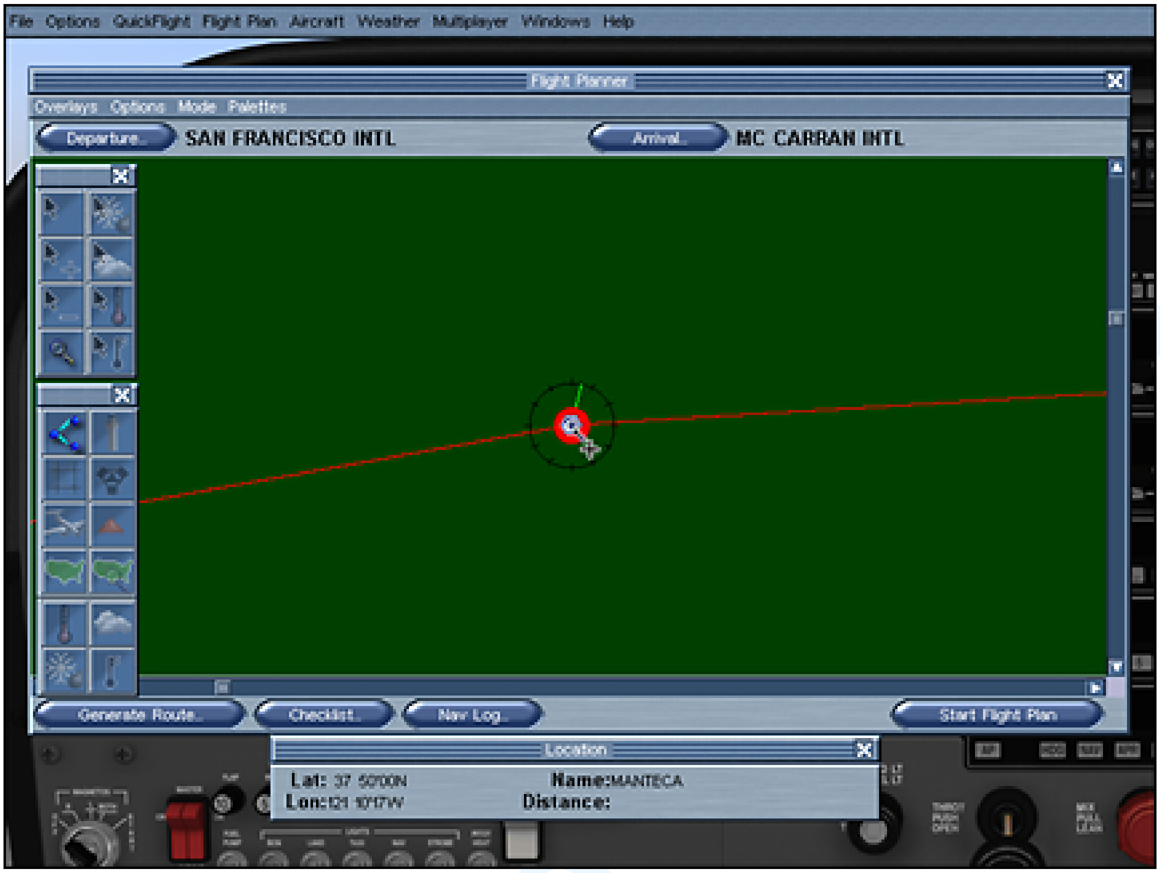
You'll notice that if you've clicked on an airport, you get frequency and runway information. If you click on a navaid, you not only get frequency information, but can automatically tune your aircraft's nav radio to that frequency by simply clicking on the "tune" button.

Now try clicking on a waypoint in your flight plan. Let's try San Francisco Airport first.



You can see that you get quite a bit more information here. In addition to the airport's frequency and runway information, you see a runway diagram and info blocks below showing your prior and next flight plan waypoints (in this case, there's no prior waypoint since SFO is the beginning of your flight plan).

Now try clicking on the first navaid on the flight plan.



Here, you get information on the navaid in use (and can autotune it if you wish), as well as information on your prior and subsequent waypoints.

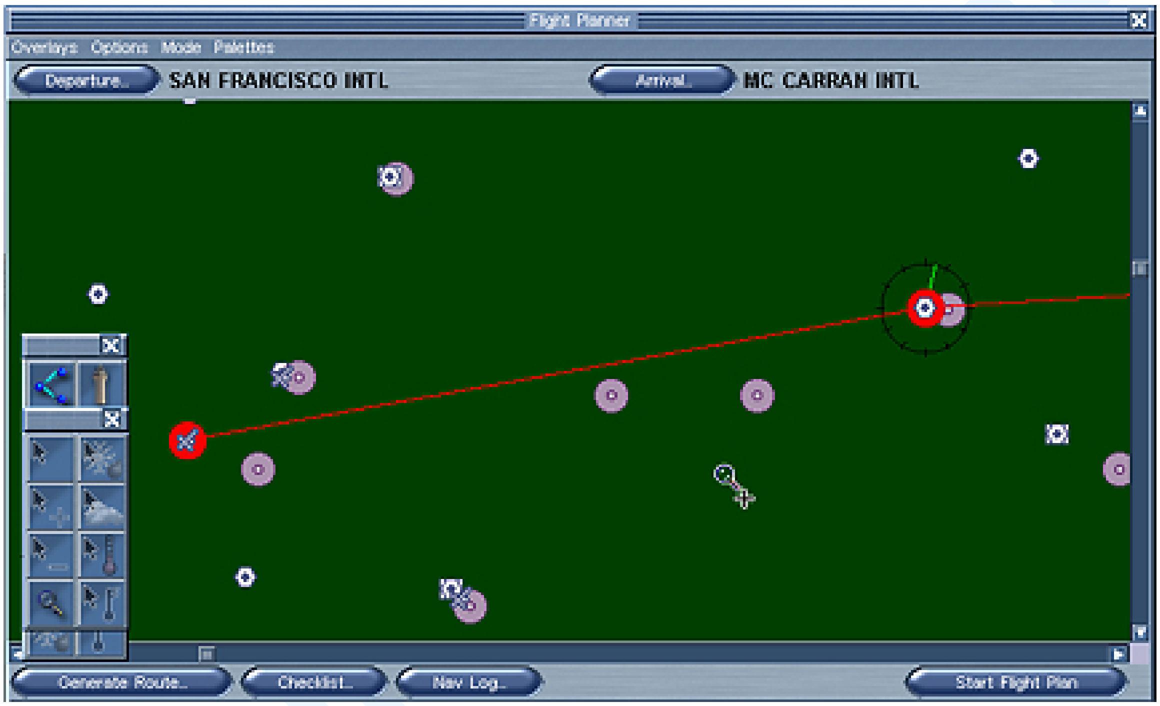
"But wait!," as they say on TV, "there's more!" Click on "Nav Log…" at the bottom of the flight plan map.

The Nav Log window displays a great deal of information, and allows you to modify the flight plan from this window if desired. From left to right, you'll see the waypoint name (with an X if you've already passed it), its identifier, distance and bearing to the next waypoint, local magnetic variation, etc.

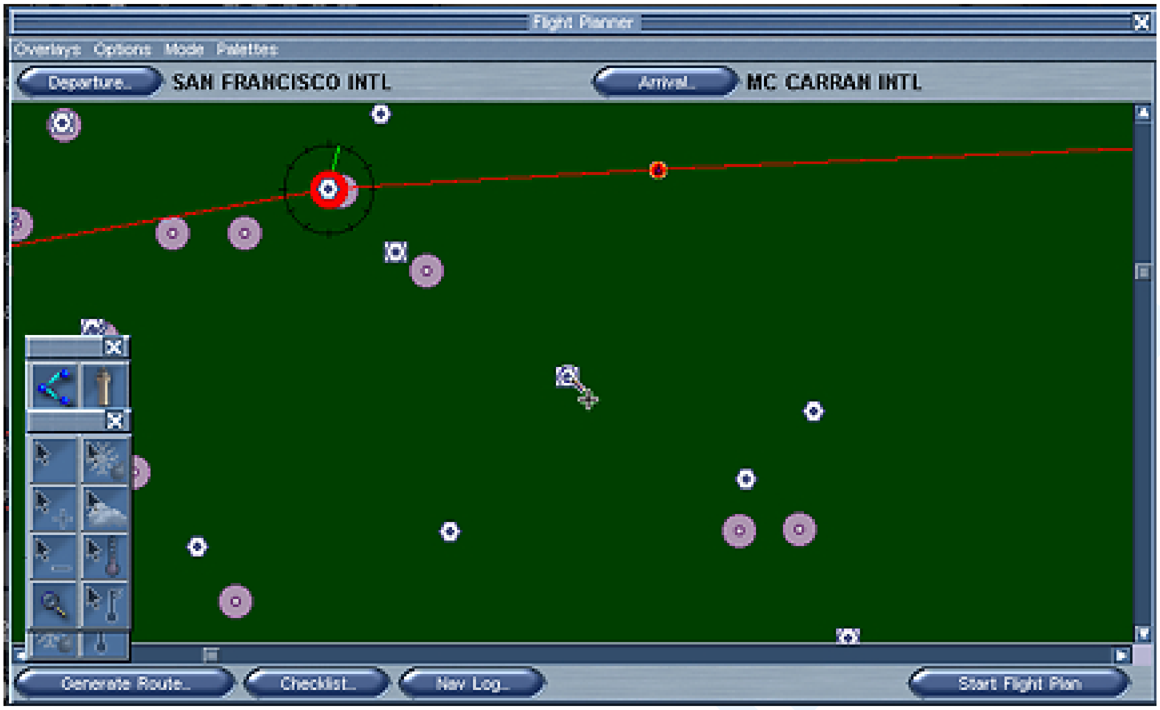
Double-clicking on any waypoint (or single-clicking, then selecting "Details…") will provide data on that waypoint, including arrival and departure times. You can also add a new waypoint immediately after the one that's highlighted, delete the highlighted waypoint, or change the order of waypoints by highlighting one, then moving it up and down the list with the arrow buttons just to the right of the list.

Now let's look at the more advanced features of manual flight planning.

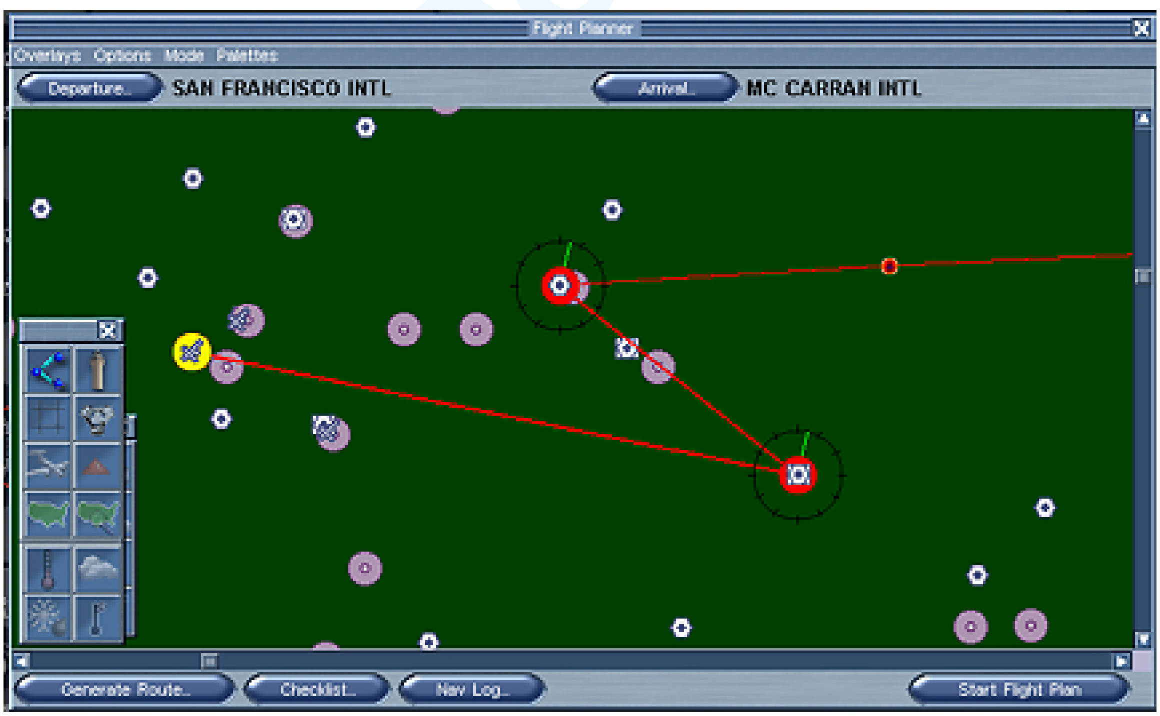
We'll use the same flight plan, but let's use the magnifier tool to zoom in on the area right around San Francisco. To reduce clutter and let us zoom in closer, turn the terrain map overlay off. Turn on the airport and navaid overlays so that you see a fair number of them displayed on the map.



Let's say that instead of flying over the Manteca VOR (ECA), we want to fly via El Nido (HYP), somewhat to the south. The flight planner map doesn't show navaid or airport identifiers, but we can use the location palette to find it. Turn it on now using the Palettes menu, then move around among the nearby VORs until you find El Nido.



Now that we know where it is, we can add it to our flight plan, but first we need to choose where it will go. In this case, we can first click on San Francisco, our departure (which will then turn yellow), then select the “add waypoint” tool, and finally click it on El Nido.

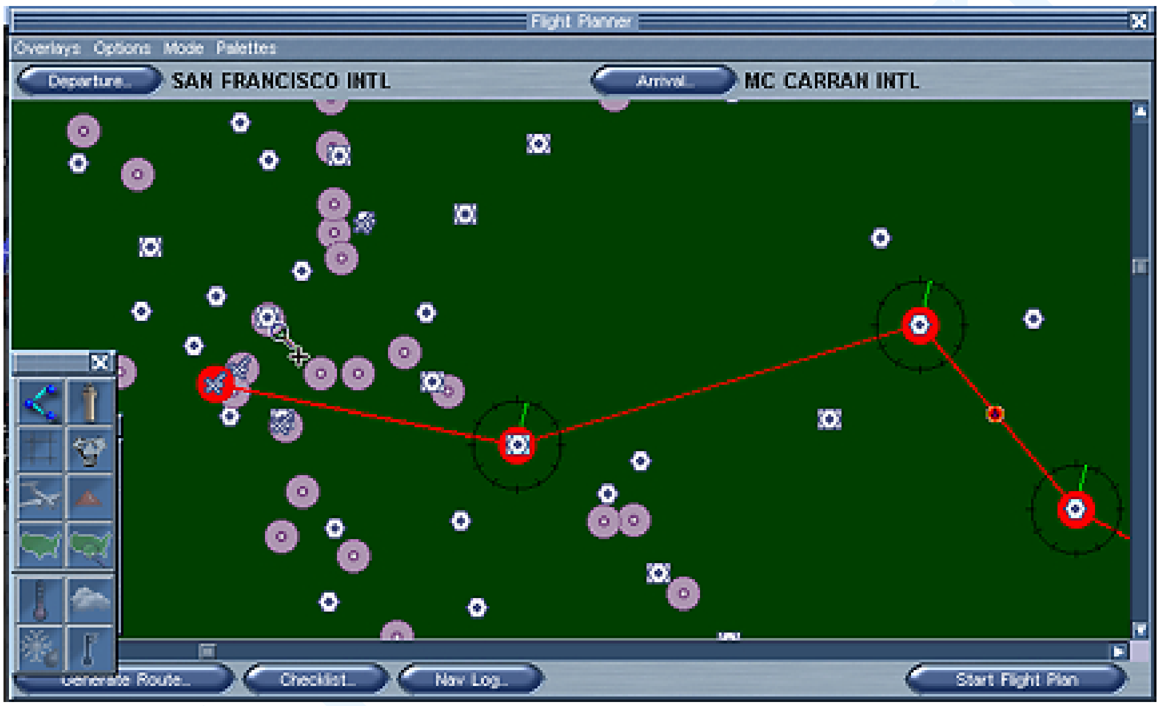


We’ve added El Nido; all that’s left is to delete Manteca by clicking it with the "delete waypoint" tool.

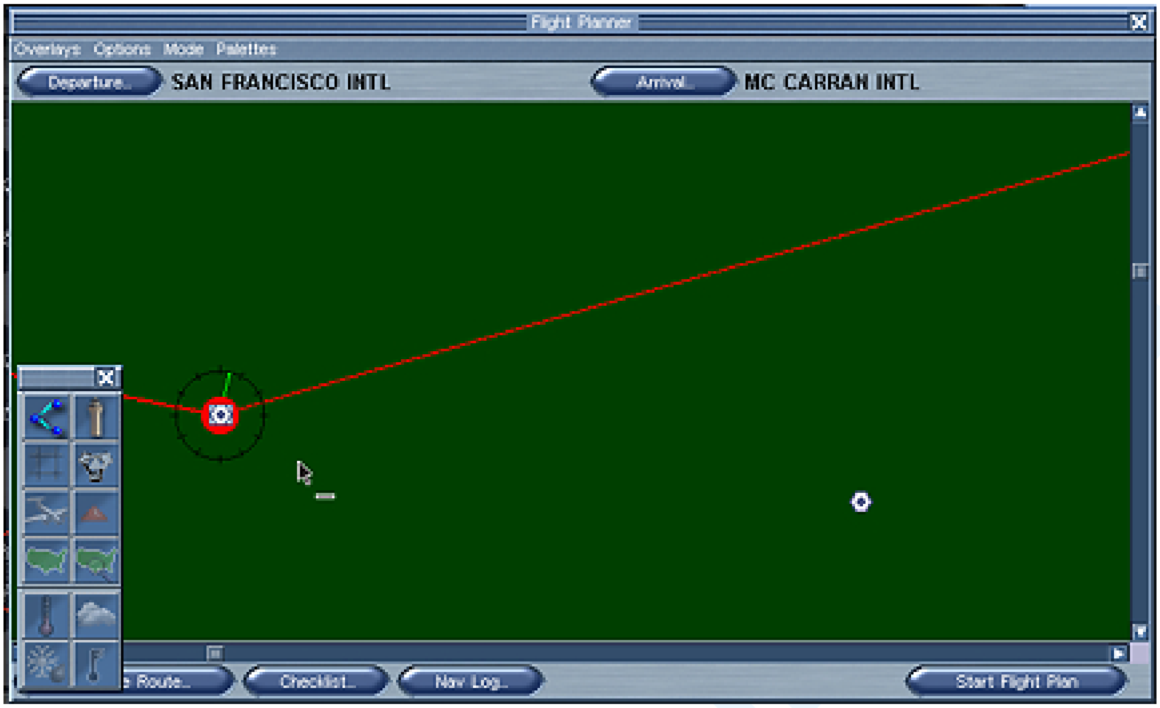
Thus, we've seen that there are two ways to add, delete, or change flight plan waypoints: directly from the map, or via the Nav Log screen.

Finally, using the map screen, you can add waypoints of your own that aren't in the database. Let's say we want to delete DUCKE intersection (the waypoint right after El Nido), and instead fly over the Yosemite Valley, which is about 10 miles north of the Friant (FRA) VOR. That's the VOR straight east from El Nido.

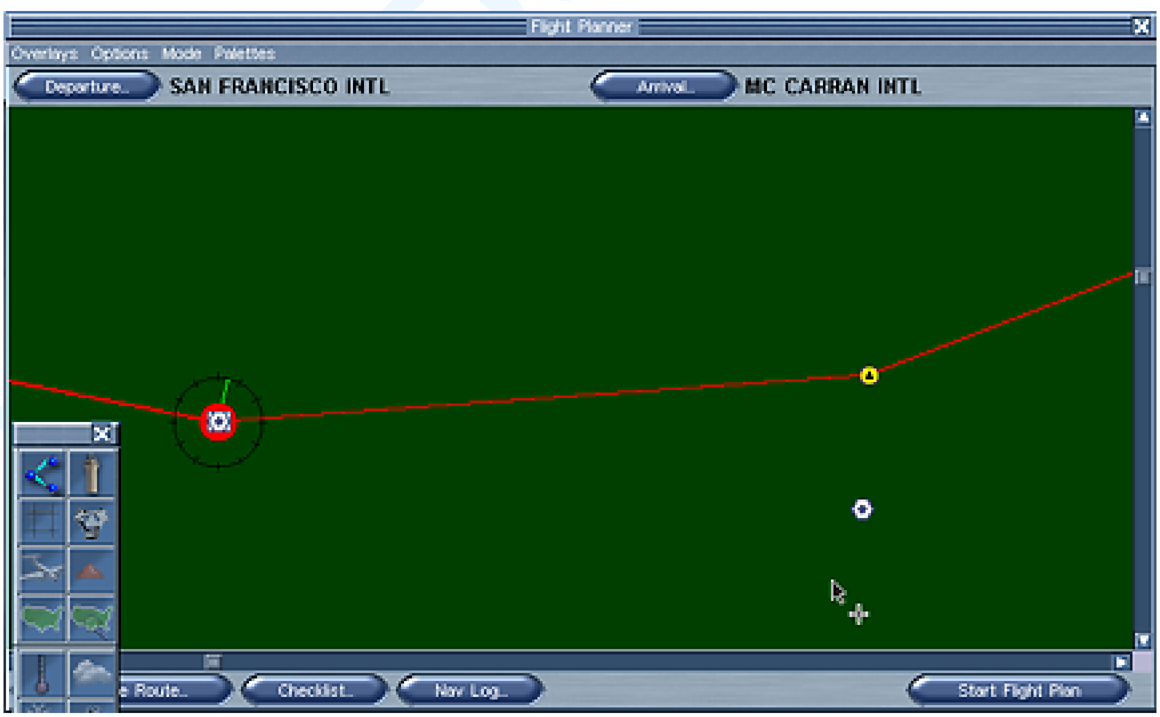
First, delete DUCKE from the flight plan using either method.



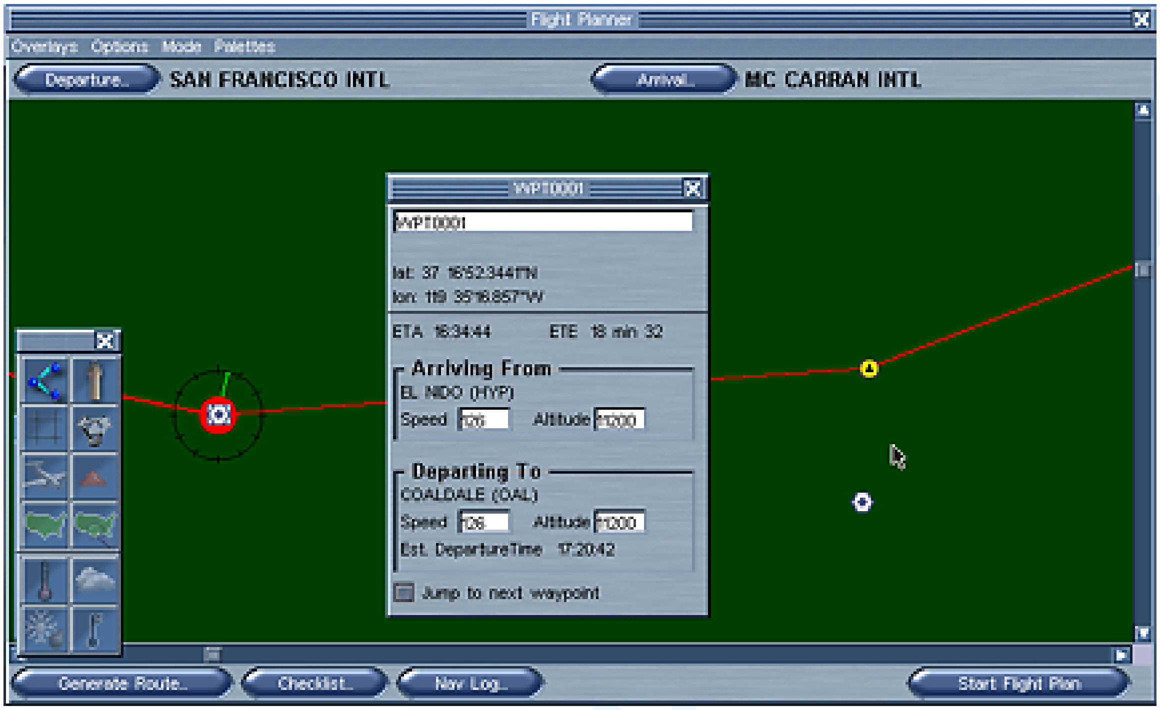
Now let's zoom in a bit closer on the area we're interested in, by clicking the magnifying tool near the El Nido VOR.



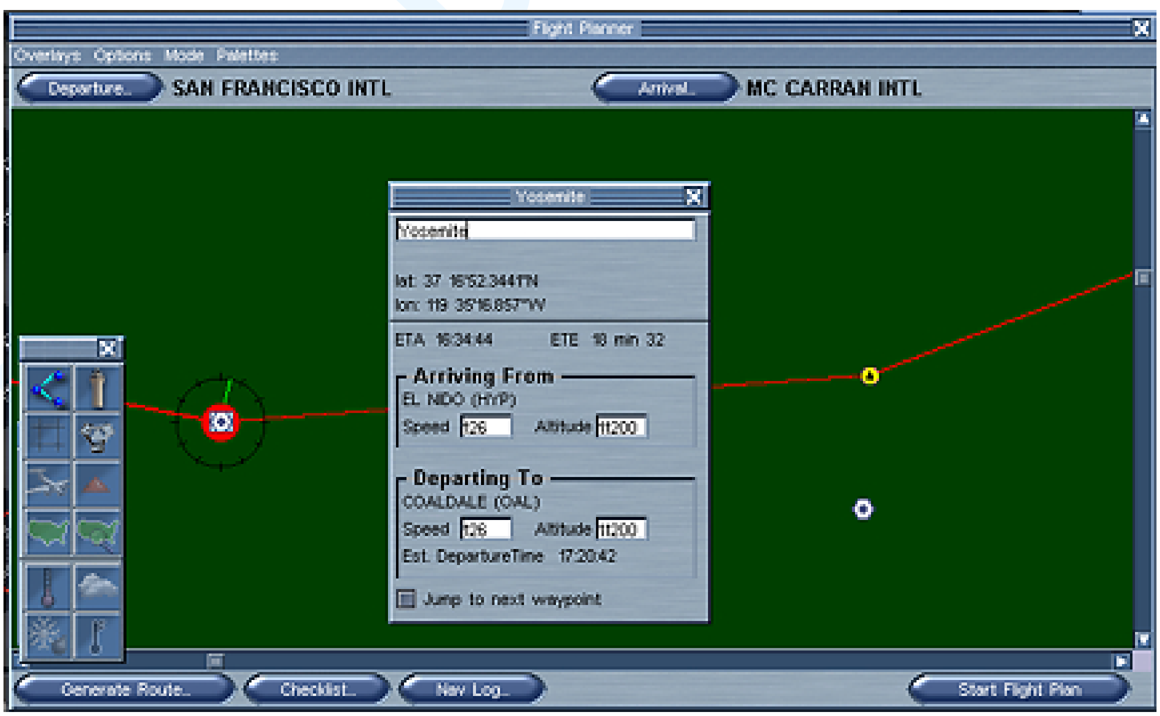
Yosemite is about 10 miles north of the FRI VOR; that's about the diameter of the compass rose Fly! II draws around active flight plan VORs, so first choose the select tool and click on HYP (since that's the waypoint just prior to the one we want to add); then choose the Add Waypoint tool and click it about halfway between Friant and the existing red course line.



You might want to save this waypoint for future use, so let's give it a name. Using the select tool, double-click on the waypoint you just created.



The detail screen that pops up shows the waypoint's location, together with a system-assigned number. You can change the number to any number or name you like by clicking your mouse in the name field, then typing in the new name.



As you can see, the Fly! II flight planner is an extremely versatile, powerful, and sophisticated tool. As you use it, you'll become comfortable with the way in which it "interlocks" with other menu functions such as the weather menu.

A final note: flight plans generated with the Fly! II flight planners are automatically transferred into the appropriate pages of the KLN-89 GPS or the Flight Management System (FMS) in the Hawker/Peregrine jet. To save a flight plan, simply save the flight for which it was prepared.

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. This is the unit installed in a number of aircraft in Fly! II: the Flyhawk trainer, the Sahara piston single, the Kodiak piston twin, the Pilatus PC-XII turbine single, and the Bell 407 helicopter. 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 Flyhawk has enough capabilities and functions to meet the needs of a helicopter, 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 Flyhawk, the HSI in the other aircraft) and autopilots (all the 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 rest of the screen includes the waypoint identifier, in which case you'll 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 via the two knobs at the right of the unit and the CRSR (cursor) key just above them.

Turning the outer knob moves you between the main pages, annunciated both on the lower left line of the display and by a small glowing bar above the legends along the bottom of the screen. (For example, in this illustration, we're on the page for the currently active flight plan, so the little bar is above FPL and the lower left line of the screen shows FPL 0.) The smaller inner knob moves you among the individual sub-pages; in this example, turning it would get you to FPL 1, FPL 2, FPL 3, etc. Often, each sub-page is too large to fit on a single screen. In this case, you'll see a plus sign. For example, if you're 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 function of the two knobs changes when you need to make a data entry. This is when you'll use the cursor, which you make active by pressing the CRSR key just above the knobs. (On many occasions, the system will turn the cursor on automatically when necessary). Any time the cursor is active, the word CRSR replaces the page name and number in the bottom left line. Now, turning the large outer knob selects the cursor's location on the right side of the screen. If the cursor is merely going to be used to select among existing information, its location is marked by an underline, and the relevant information flashes. If you're actually going to enter letters or figures, the cursor location will "reverse out" (*i.e.,* change from orange-on-black to black-on-orange) and begin to flash. Now you can use the inner knob to scroll in the desired character, then use the outer knob to move the cursor to the next space, and so on.

As soon as you begin a data entry, the word ENT will begin to flash on the left side of the display. This indicates that the entry won't be completed until you press the ENT key just to the left of the knobs. Thus, all the functions for page selection and data entry are grouped around the knobs at the right side of the unit.

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 an external lamp in some installations). If there's more than one message, they're displayed in chronological order. A further push on the MSG key returns you to normal operation.

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 360; you can set this "electronic OBS" by turning the small inner knob. 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, and nearest special-use airspace, if you're trying to figure out where you *shouldn't* be. The "direct-to" key-the D transfixed by an arrow, like this, ~~D~~->, is one of the functions you'll use most often. Press this key, which turns on the cursor, then scroll in the identifier of a desired waypoint, hit ENT, and the system will immediately switch to the NAV 1 page and begin to navigate from your present position to that waypoint.

CYCLIC FIELDS and the >CLR KEY:

The >CLR key has a couple of different functions. In it's simplest, it's like the backspace key on a typewriter: use it to get rid of mistakes. Each successive press moves it one space further to the left.

However, in some pages, such as NAV 1, you'll notice that several fields have the left-bracket "hairpin" symbol. This means that they're "cyclic" fields: the system has several different bits of information available to display at that location on the screen. With the cursor active and positioned on a cyclic field, successive pushes on the >CLR key will "cycle through" the available choices. This allows you to customize the screens to your own taste and requirements. When you've cycled to the display you want, you can lock it in, either by pressing ENT or simply by turning the cursor back off by pressing CRSR.

The ENT key is your way of telling the system, "I'm satisfied with the data I've entered or chosen, go ahead and execute the command." It retains this function for all screens.

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 and time should be correct, and the latitude and longitude should be at or near your current position. 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.

Verify that all the info is correct. If not (for example, if you've flown the airplane a significant distance with the GPS turned off), use the cursor and inner and outer knobs to enter correct information. When you're satisfied, make sure the cursor is on the flashing "OK?" and press ENT.

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! II isn't configured for nonprecision 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 (we 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.

WAYPOINT PAGES: APT, VOR, NDB, INT, USER, ACT

APT

The APT (airport) pages contain information about airports stored in the database.

APT 1

This page displays the identifier, altitude, airport name, city, and state of a given airport. Note that the name and city are often different-for example, "John F. Kennedy" and "New York, NY." If you're unsure of the identifier of an airport, just enter its proper or city name.

APT 2

This page displays the identifier, latitude and longitude, and state of the airport; it'll also note if the location is private, military, or a heliport. The bottom line gives range and bearing from your present position to that airport; a cyclic field allows you to switch between bearing (TO) and radial (FROM).

APT 3

This shows the identifier; any special-use airspace associated with the airport; the difference between its local time zone and UTC (with daylight saving time in parentheses), what types of fuel are available; and what instrument approaches are available.

APT 4

This page is likely to have the "+" sign indicating that there are several such pages available for an airport. Each subpage shows 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 descending order of length.

APT 5

Another page likely to have the "+" sign: this one 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, INT, 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.

The INT (intersection) pages provide name, location, and range and bearing. The second page provides the navaid, range, and bearing used to define the intersection on aeronautical charts.

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, INT, 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.

NAV Pages:

These are the pages you’ll be using most often-the ones via which the system “talks to you” and 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 along 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. Since 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 groundspeed.

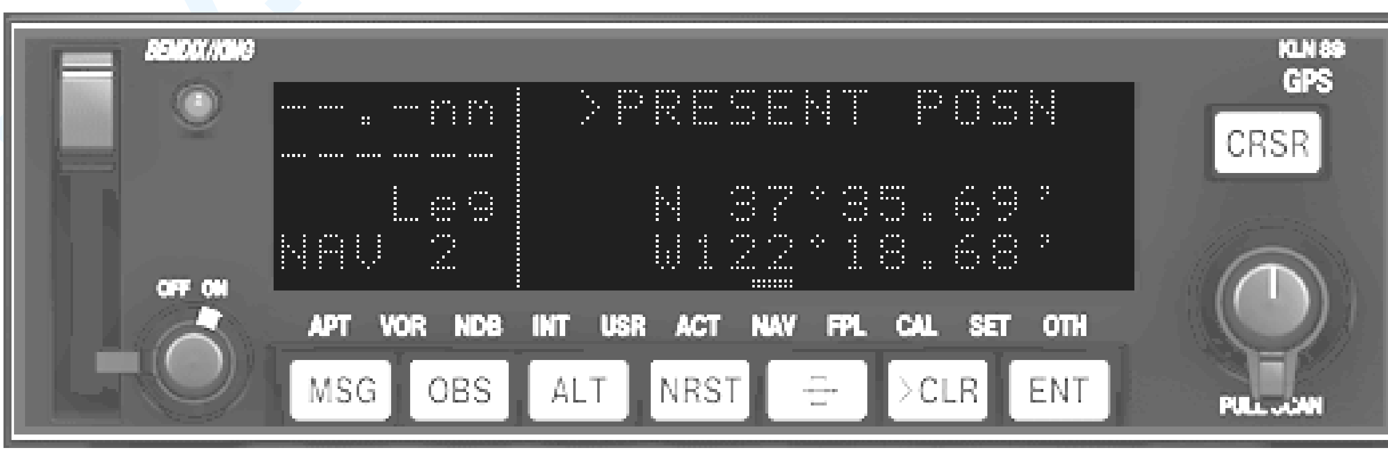
The second line can be cyclically selected to show either a graphic CDI or a numeric display that's very useful if you're more than five miles off course

A third push on the >CLR key shows you the CDI scale (sensitivity) currently in use, and allows you to change it (values are +/- 5, 1.25, or 0.3 nm) if desired.

The third line shows the desired track (DTK) and your actual track made good over the ground (TRK). 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.

NAV2 PAGE

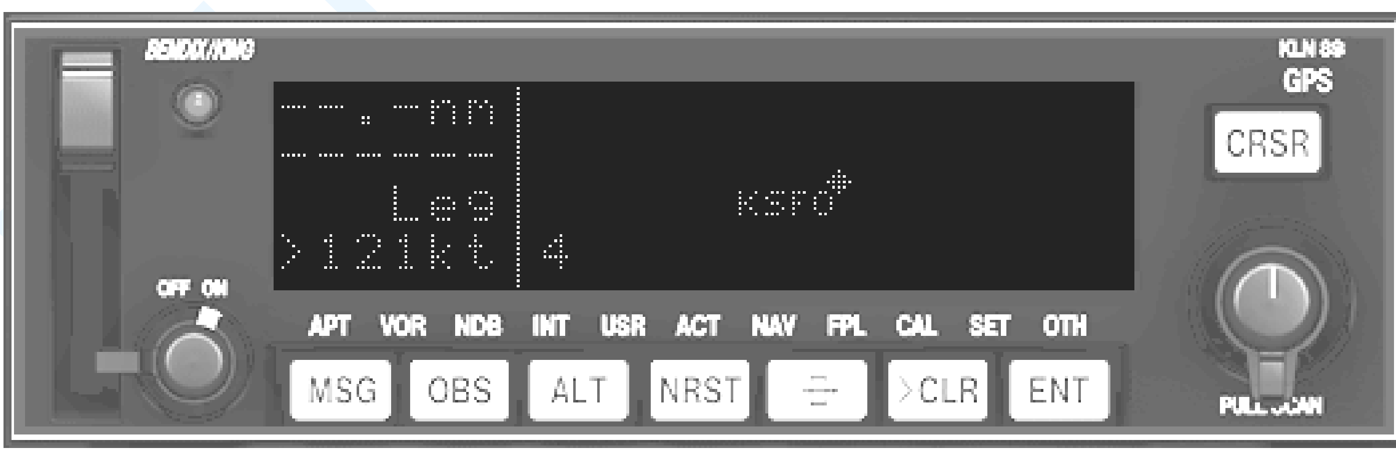


This is the "present position" page, and it's very handy when ATC requests a position report. The default display gives range and bearing from a nearby VOR, but you can use the cursor to insert any reference you want. (ATC, however, will not be pleased if you give your position over Oklahoma in terms of, say, range and bearing from Beijing.) The second page gives 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 groundspeed first exceeded 30 knots); your ETA at the final destination of your flight plan; and how long you've been flying.

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 groundspeed, 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, turn on the cursor, then use the small inner knob to set 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.

Turning the outer knob with the cursor on puts it over the MENU? field and pops up a menu of additional choices. This allows you to choose how the map is oriented and what will be displayed. SUAs (special use airspaces), 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.

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! II, 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.

CAL 1

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. In WPT mode, use the two cyclic fields at upper right to enter the desired waypoints. Distance and ESA will appear on the third line.

Entering your anticipated groundspeed at the left end of the fourth line will bring up estimated time enroute at the right end of the same line.

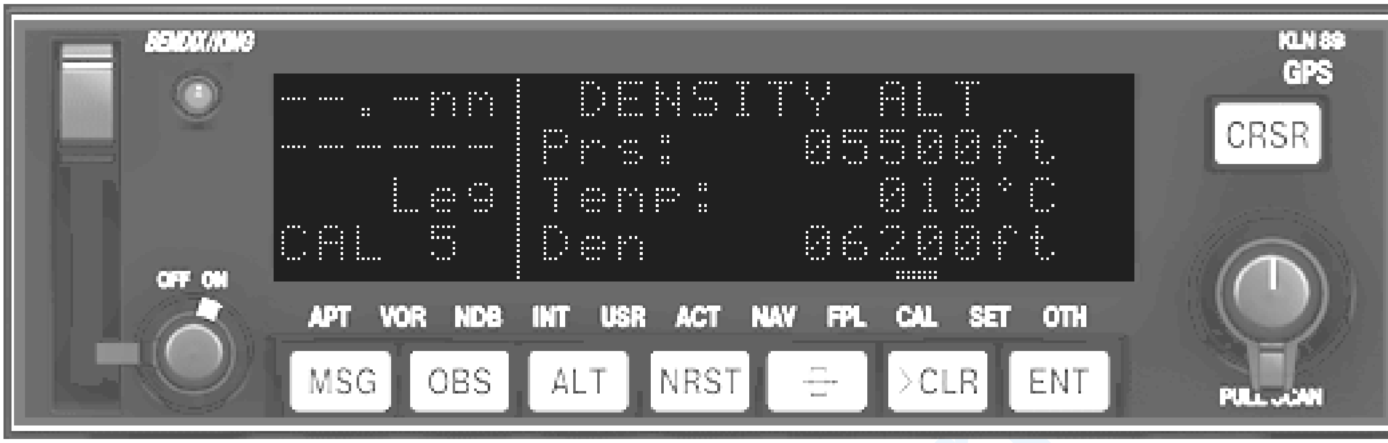
CAL 2

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; then enter your anticipated fuel flow and the amount of reserve you want aboard when you land. The system will use the groundspeed you entered on the CAL 1 page and return the amount of fuel you should have onboard when you take off.

CAL3

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 beep to alert you when the magic moment arrives.

CAL 4, CAL 5



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. 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.

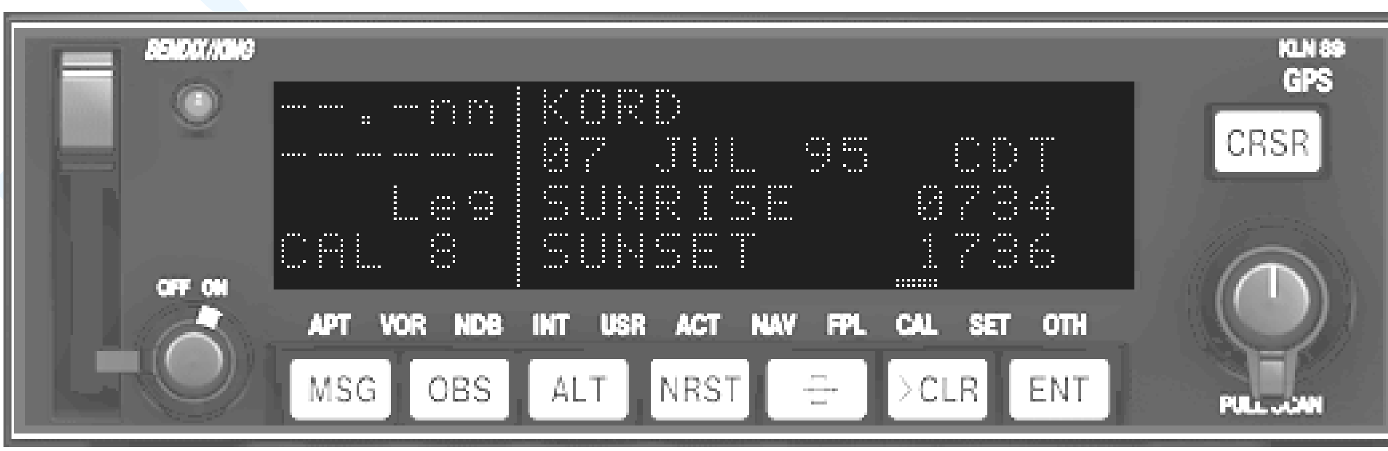
CAL 6

This page will figure out your true airspeed for you. Enter indicated (calibrated) airspeed at CAS. 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).

CAL 7

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. 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.

CAL 8



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!

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 Special Use Airspace, 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 ENT.

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.

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! II the criteria are set automatically based on aircraft type.

Similarly, if you're concerned about staying out of special use airspace, select NRST SUA**.** You'll get distance and bearing to the nearest point of the SUA, as well as the altitudes in which it applies. Turning the small knob clockwise one click will show you if radio communications are required**;** if they are, press >CLR to get a list of the appropriate frequencies.

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 (not shown)

The SET pages are used to control various system setup functions. In Fly! II, these are determined automatically by the simulator program.

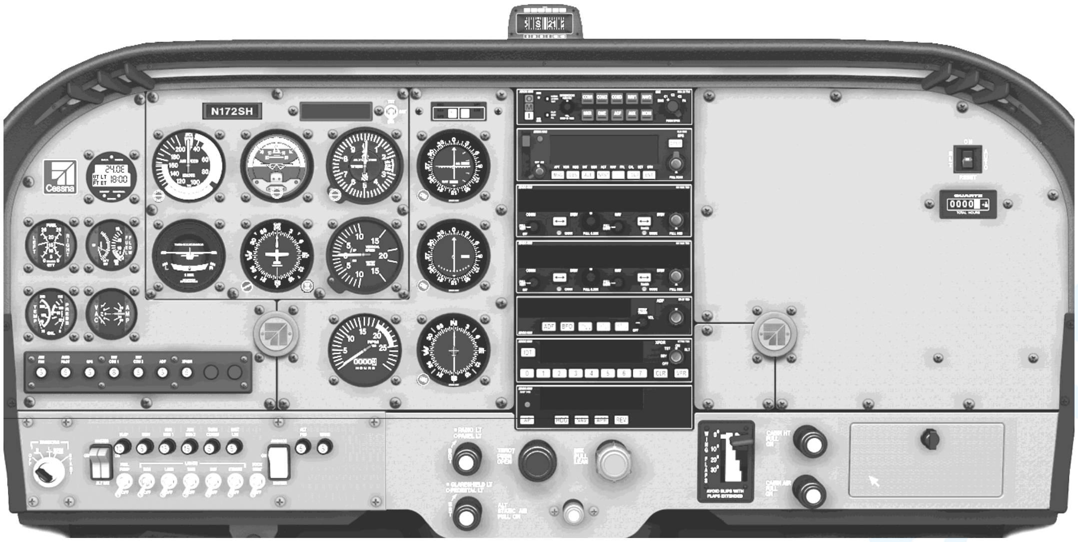
The OTH pages are used primarily to monitor the status of the GPS satellite signals. Information is available to show which satellites are in use, their position in the sky, and whether they are functioning properly.

FLYHAWK TRAINER

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 docile, yet responsive, Flyhawk trainer. Similar to a very popular light airplane that's been in production for the last 40-odd years, the Flyhawk is easy to fly—yet not *too* easy, so that there's little chance you won't learn what you need.

At the same time, the airplane is sufficiently well-equipped for you to learn everything you need for the instrument rating—and it has sufficient performance and load-carrying capability so you can use it for a lot more than just local training flights.

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 (pilot's) side of the panel; unless the airplane has a lot of optional equipment installed, the copilot's side is mostly blank.

Right 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 a further 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 left.

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! II** that have conventional round instruments--and even the Citation X, 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! II**, so feel free to refer back here if you have questions later on in your **FLY**ing career.

THE AIRSPEED INDICATOR

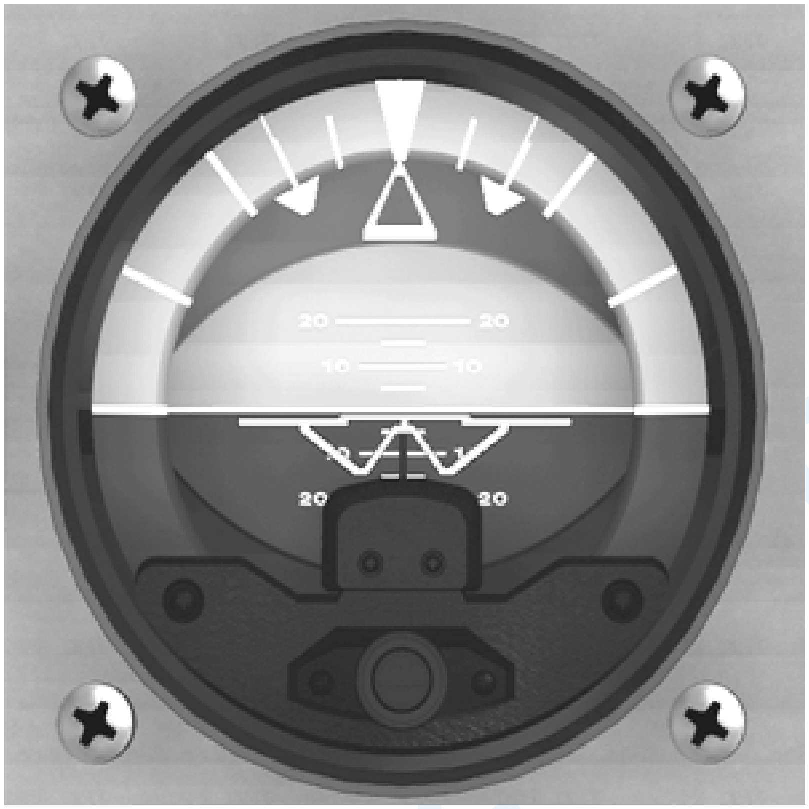
At the top left of the flight instrument group is what's probably the single most important dial in the whole airplane: the airspeed indicator, often abbreviated ASI.

Functionally, it's very simple: nothing more than a pressure gauge, connected to a small tube (the *pitot 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 OK to fly there if the air is smooth, but if it’s bumpy you risk overstressing the airplane. (In the Flyhawk, 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 "gyro 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 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 clocklike 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 Flyhawk'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 embarassing 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 comes next) are powered pneumatically, using vacuum pumps on the engine; the turn coordinator is electric. Vacuum pumps are notoriously unreliable, which is why the Flyhawk 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 instrument, 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! II** 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, 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 Flyhawk'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...

By the way, 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.

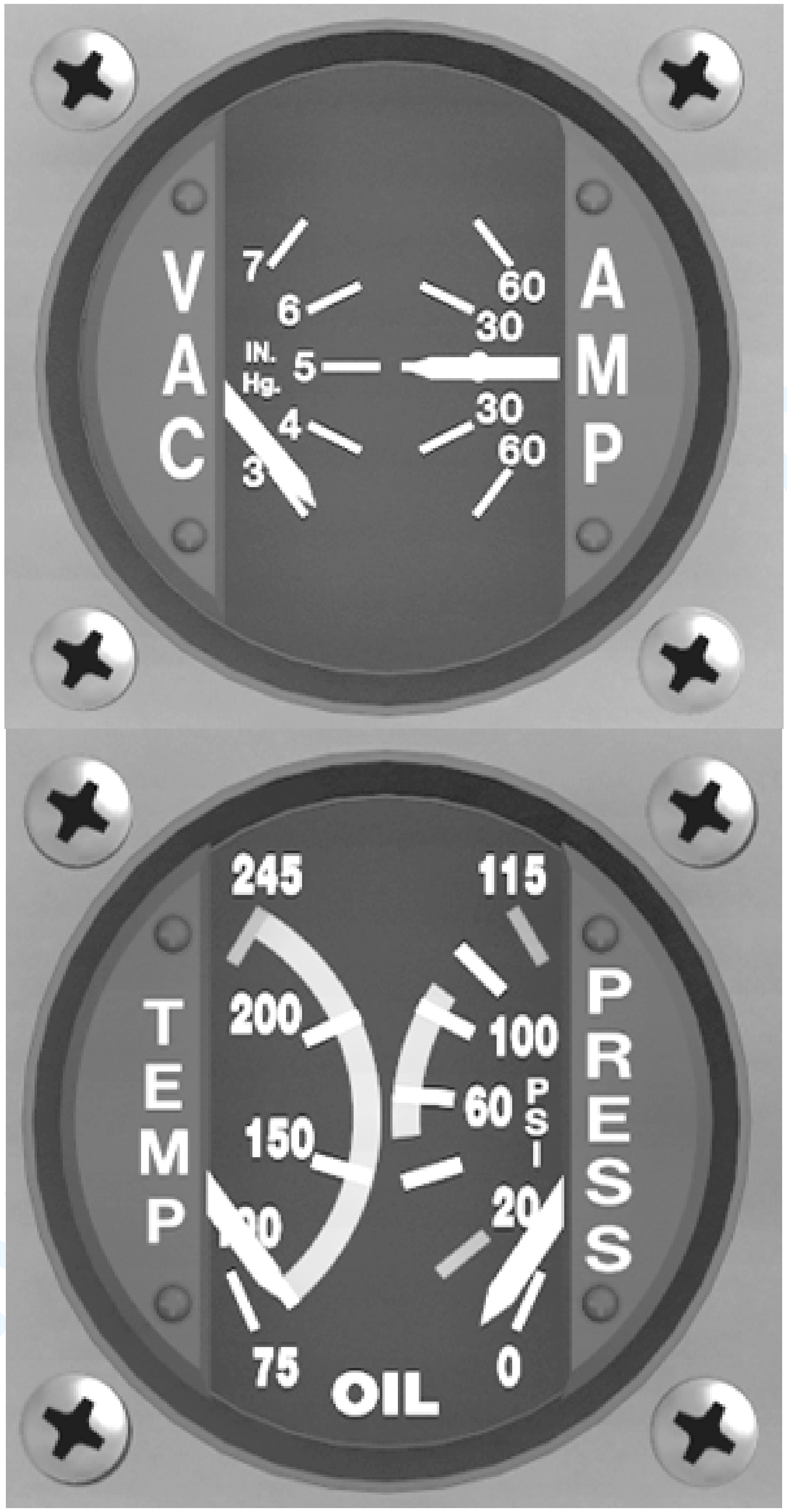
THE VERTICAL SPEED INDICATOR

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 Flyhawk has ever climbed at 2000 fpm except in the dreams of pilots, but a 2000-fpm descent, while ear-popping, is not unheard-of. Something to remember about the VSI is that its indications lag what's really happening by up to 10 seconds.

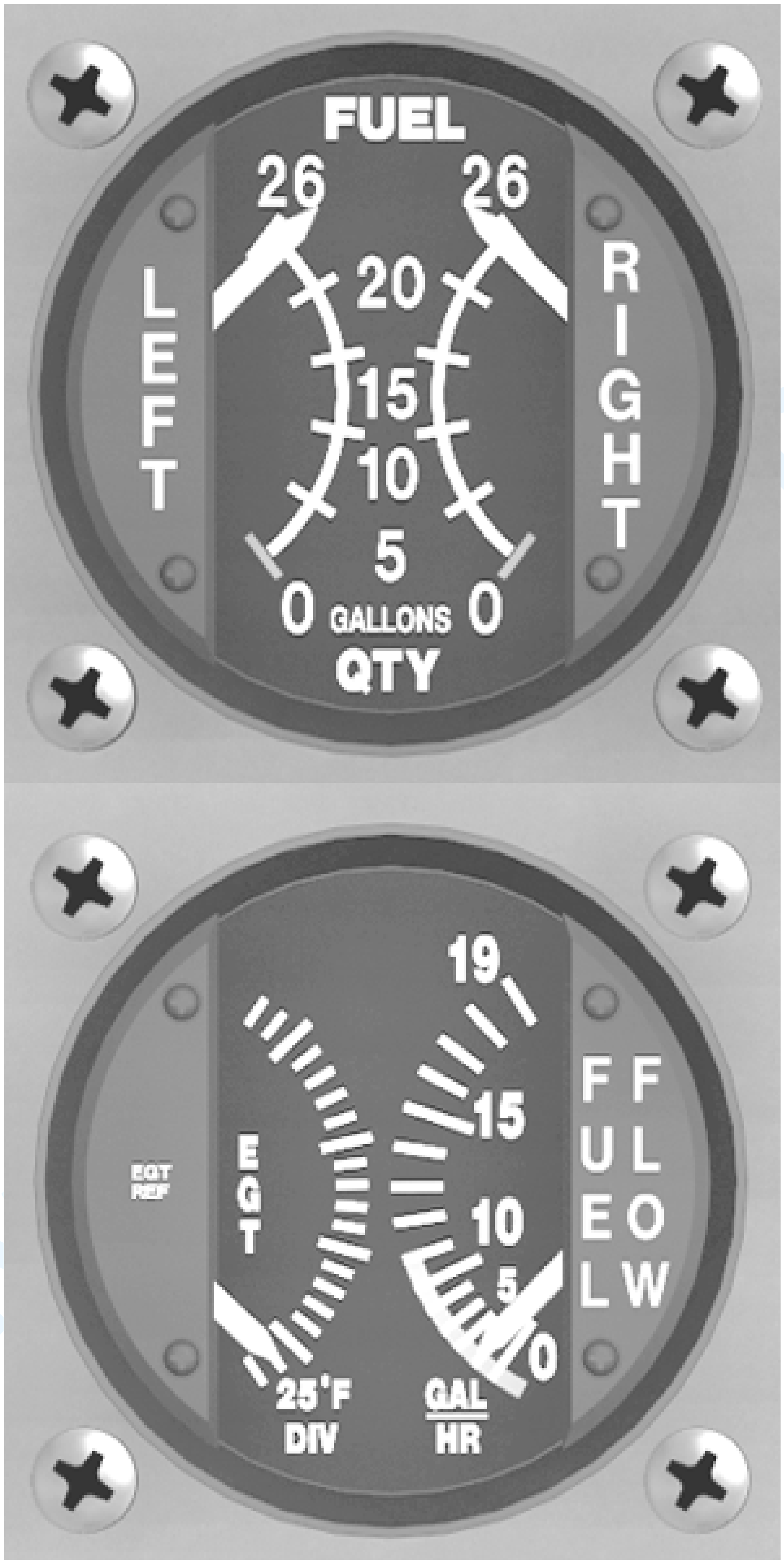
POWERPLANT INSTRUMENTS

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 throtte--but in an airplane like the Flyhawk, 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 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.


FUEL
26
26
LEFT
RIGHT
20
15
10
5
0
GALLONS
0
QTY
19
15
10
5
0
EGT
FUEL FLOW
25°F DIV
GAL HR

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! On the right, two more pointers are controlled by the red fuel mixture knob to the right of the throttle. 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 Flyhawk'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.)

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 enrichen 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!

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! II* 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 Flyhawk 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! II* 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," and you'll know them because they'll appear in this rather nerdy-looking typeface.

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 different-sized pilots all have the same eye position).

In *FLY! II*, 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.) Tape a piece of thin string across the face of your monitor, lined up with the top of the instrument panel.

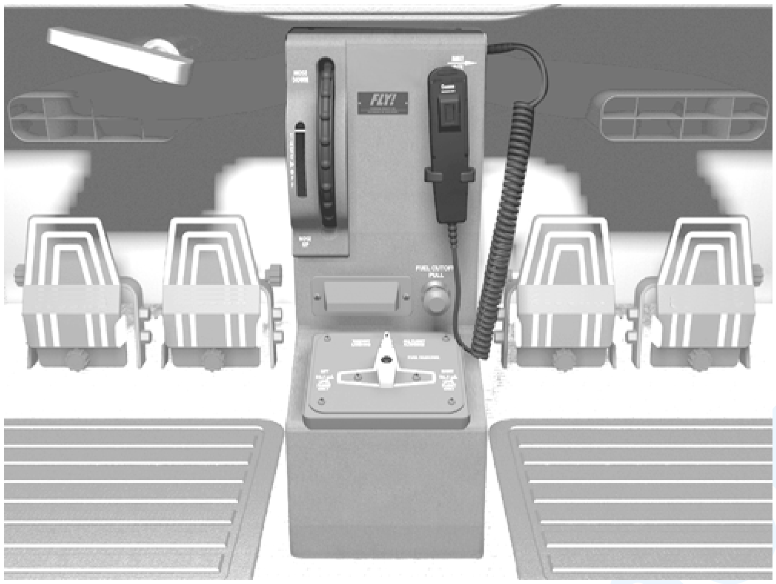
You can use this to get back to the right spot when you've moved around the panel. It's also your reference point if you choose a full-screen outside view, but still need to know your pitch attitude relative to the horizon.

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! II*'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.

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's something of a pain 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! II

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:

The Flyhawk 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.

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 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. If you have 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 FlyhawkR is reproduced in the appendix. However, you can cover just about any airplane using simple mnemonics. Different ones 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: CIGAR.

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. 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" 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" 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 pushed all the way in. We'll leave the auxiliary pump off for the moment.

"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.

Finally, "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 labelled "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 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 OK, then switch on the aux pump just as a backup for takeoffs and landings.

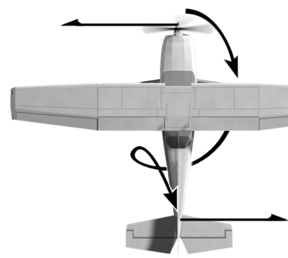
TAKEOFF! (finally!)

The big moment has arrived. Before we start to move, notice how far below the horizon the top of the instrument panel is; that's about what you'll see in level flight. 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! II* 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."

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. Lower the nose until it's about the same distance below the horizon as it was when we were on the ground, still keeping the wings level. 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.

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, and 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 Flyhawk 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.

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.

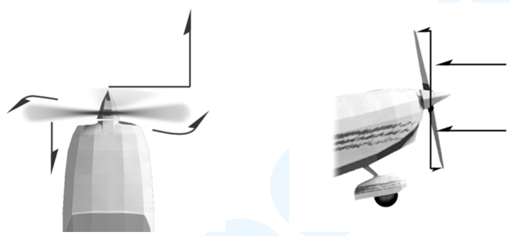
There are two ways to make the airplane go up and down, and they can be used together or separately. Changing the pitch attitude (within reason, of course), simply makes the airplane go "uphill" or "downhill." If you leave the power alone during such changes, you'll see the same reaction as if you were 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 Flyhawk) and adjust the power to get the rate of climb you want. (In a real-world Flyhawk, particularly if you have a couple of buddies along on a warm day, you'll typically use full throttle and accept whatever underwhelming 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 contines to play a role, there's another force: the notorious "P-factor." (Not to be confused with the distress pilots feel when they've been flying for several hours after drinking too much coffee before takeoff.)



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 thus 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.

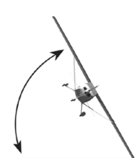
You'll notice that the airplane tends to hold whatever bank it has with the yoke centered. As you rolled into the turn, it started turning (changing its heading) to the right. With the yoke centered to maintain the 30-degree bank angle, it continues turning right. As you approach your planned new heading, 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: a roll-in to the desired bank angle, re-centering the controls (with minor adjustments as necessary) to keep the turn going without letting it get either shallower or steeper; then an opposite roll-out to return to level flight, and 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.

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 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 on the airplane; all of a sudden, that poor little Lycoming has two whole Flyhawk's bolted onto it! That rustling noise you hear behind you is the passengers getting those little waxed paper backs out of the seatback pockets…

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.

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

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 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 NumLock 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 exit the simulator and we'll pick up on our next lesson!

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 Flyhawk, 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 preposition 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 making this noise(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, you can check it, during preflight inspection and if you're tall, 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…

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 Flyhawk 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 unstall the airplane, but you'll also plaster your passengers onto the ceiling and lose a lot of unnecessary altitude.

Just lower the nose to 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 Flyhawk 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 hav 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 Flyhawk 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, while the air flowing through the slot between the wing and the flap helps keep the overall flow attached at very high angles of attack. At full deflection, they also create a great deal of drag. The Flyhawk'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.

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 Flyhawk 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 Flyhawk 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 at which you started.

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…

OK. 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 as a tendency to "dig in" if we don't pay attention to angle of attack, and slow itself even further.

OK—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—this 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:

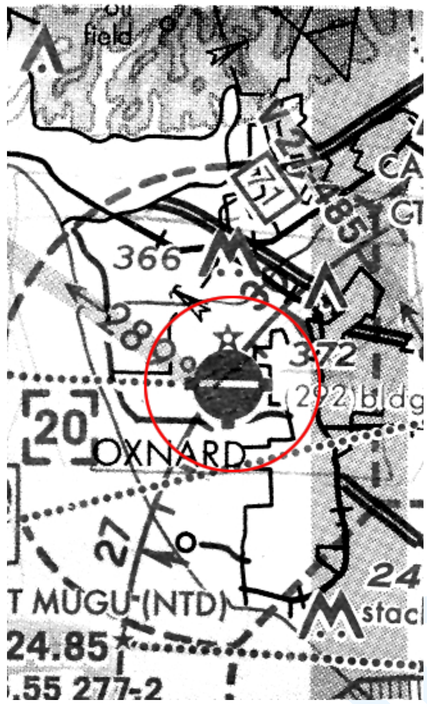
At this point, you've been exposed to all the maneuvers and skills you need to land the airplane, so let's try one. We'll be using our "four fundamentals" to fly a series of turns and descents around the airport, culminating in a descent to the runway and an approach to a stall just above it. How far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

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

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

For the moment, we won't worry about radio communications or other traffic, but we *do* need to know the airport's elevation above 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.

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.



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.

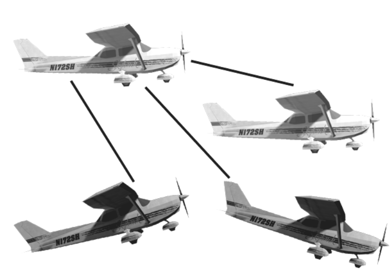
As the runway moves back to the 10 o'clock position, start another smooth 90-degree left turn. As you roll out, the runway should be straight ahead; if you plan to use the rest of the flaps (there's no law that says you have to—in fact, the airplane lands just great with no flaps at all), this is a good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

The hardest thing for early students to judge is the correct angle of descent, but many 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 Flyhawk, 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.



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!

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 Flyhawk? In the case of spins, it's simple: among all the airplanes in this release of *FLY! II*, this is the only one in which spins are authorized. (In fact, in the real world, none others were even intentionally spun during certification flight tests—so, to some extent, whether or not the Sahara, the Kodiak, or King Air would recover from a spin is a matter of conjecture; and it's a fair bet that the jet, with its swept wings, would have an unrecoverable spin.)

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 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 Flyhawk.) 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.) Slow the airplane to minimum "mushing" speed and trim for it.
3.) Ensure shoulder harness is fastened.
4.) At about 100 feet above your best estimate of the terrain altitude, turn on the landing light.
5.) 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.

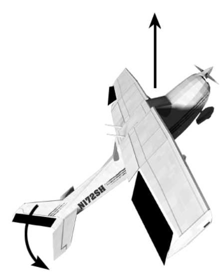
Roll into a steep turn, either way, and once you get the turn established, with enough back pressure to keep the nose at the right height below the horizon, add even *more* back pressure—and pull it in pretty briskly. Surprise! You'll hear the stall warning horn and, if you keep pulling, the airplane 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.

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 foot-full 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.

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 recommends against slips if the flaps are extended more than 20 degrees, since the displaced airflow produces an uncomfortable "buffeting" of the elevators which you'll feel through the yoke.)

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 Flyhawk 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 Flyhawk 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 unstall 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. 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.

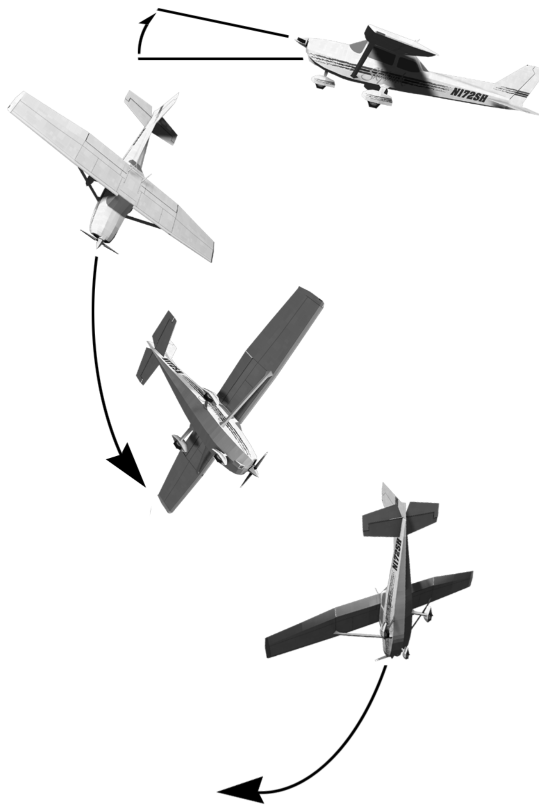
You’ll have a very impressive straight-down view out the windshield, and the ground will be rotating. Pick some prominent object—a road or coastline is good—to keep track of the turns. After a turn and a half, start the recovery.

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.



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 Flyhawk 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 Flyhawk, this varies from 81 knots at light weight to 99 knots at gross weight. We'll use 90 knots for this demonstration.

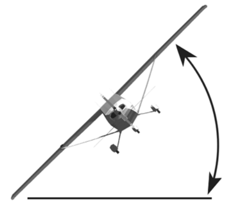
Now, without slowing any further, briskly apply full up elevator. You might get a very brief shriek from the stall warning horn; what *will* happen is that the airplane will pitch up, hard, and snap a wing down equally hard (most likely to the left). Basically, you've "snapped" it into a spin—but since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

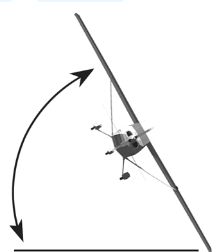
Back in the days before gyro instruments, airplanes that flew into even innocuous, non-turbulent clouds often came out in pieces. Those pilots who survived ("I always use Maxwell House parachutes…they're good to the last drop!) reported being unable to tell whether they were flying straight or in a turn, 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.

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 up," so increasing it does a lot more to tighten then 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:

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 takeoff 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 OK. (If not, of course, you can make an approach, since anyone who gets an instrument rating is trained and tested to the full requirements.)

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! II***,** it's much simpler: just set your view so the instrument panel comes all the way up to the top of the screen.

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." Altitude control may seem a little more touchy than when you can 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. 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 so 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!

<u>Before descending into the clouds:</u>

1.) If you have a gyro compass, turn the heading 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:

…and this will be the hardest part…

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! II* 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! II*

Sahara

INTRODUCTION

If you're coming into the Sahara right out of the Flyhawk, 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 Sahara, which replicates one of the most advanced and complex single-engine civil aircraft in current production, and arguably the most advanced in its class ever built. The Sahara every bit as sophisticated, in terms of systems, equipment, and capability, as business turboprops.

For all that, though, the Sahara 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 Flyhawk are entirely applicable to this airplane as well. Even the operating speeds aren't all that different, particularly in the landing pattern. True, the Sahara 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 Sahara 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 section on avionics systems in this manual.

FOLDING ROLLERS:

Obviously, one of the main differences between the Sahara and the Flyhawk is that the Sahara 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! II 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 than that: 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 it; 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 Sahara 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 Sahara 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!

What if it's a real problem? Still "no biggie:" the gear handle will already be down, so just go over to the left-side circuit breaker panel and pull the 25-amp "HYDRAULIC PUMP POWER" circuit breaker (second row down, third from the front). 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.

You can practice this procedure, by the way; just pull the hydraulic pump c/b *before* you put the (normal) gear handle down; then use the emergency control to lower the gear. To restore the system to normal operation, push the emergency control back in, reset the circuit breaker, 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 Sahara 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 Sahara and the Flyhawk, 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 Flyhawk, the Sahara has an Avco-Lycoming engine, and there's a family resemblance among all the "Lycs." The Flyhawk's 160-hp four-cylinder engine is an IO-360, meaning that it's fuel-**I**njected, its cylinders are horizontally **O**pposed, and it has a displacement of 360 cubic inches. Using the same notation, the Sahara's 350-hp six-cylinder TSIO-540 is **T**urbo**S**upercharged, fuel-**I**njected, horizontally-**O**pposed, and has a displacement of 540 cubic inches. Notice the relationship in displacement? Just about every cylinder Lycoming has ever built since, roughly, 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 Sahara 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 Sahara'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, while it, and the airplane attached to it, are slipping rapidly through "thin" high-altitude air. A side benefit, in the case of the Sahara, is that the turbos give us a supply of sea-level air for cabin pressurization.

You may have noticed, flying the Flyhawk, 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 relatively anemic Flyhawk at full throttle, and accept whatever performance they can get!) This is the case with any non-turbocharged, or *normally-aspirated,* aircraft. The Sahara, 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 Flyhawk, that any time you changed your airspeed, the engine would speed up or slow down without your touching the throttle.

This is because the Flyhawk 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 Sahara, 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 levelled 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 Sahara 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 "**Prop**ping 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 Flyhawk 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 Sahara's sophisticated engine is crude, yet primitive--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 help you set the correct fuel mixture in the Sahara: the fuel-flow indicator, the exhaust-gas temperature indicator (EGT), and, to a lesser extent, the cylinder-head temperature indicator (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 EGT. 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 EGT 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 levelled off and trimmed correctly for cruise; set cruise power; wait a moment, for engine temperatures to stabilize; then slowly start leaning the mixture while watching the EGT. 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 Flyhawk, the Sahara'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.

Now that you have a pretty good idea of what's going on "under the hood," let's climb aboard and start flying the Sahara:

COCKPIT TOUR:

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 Flyhawk. Sure, there *is* more, but 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 Flyhawk (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 advanced avionics chapter in the online manual. Another additional instrument, the Radio Magnetic Indicator (RMI) is also described in that section.

WHAT'S UP:

One thing you'll notice in the Sahara 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!

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 a chore, it has rudder, as well as elevator, trim; both trim wheels are on the center console.

DUAL SYSTEMS:

While the Sahara 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 Sahara 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 on the right wing).

ENGINE INSTRUMENTS:

The Sahara 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 desired 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 pre-programmed with the amount of fuel onboard before takeoff. In Fly! II**,** 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 Flyhawk, the Sahara 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 Sahara doesn't just want it to be a far-weather friend. Unlike most other singles (even most high-performance ones), the Sahara 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 next to their switch. The windshield heat has HI and LO settings; if it overheats, you'll get the WINDSHIELD HT FAIL annunciator light. 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 ¼ to ½ 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 ¼ inch of ice, you might just "puff up" the ice to the point where the boots cycle uselessly underneath it. More than ½ 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 single, fairly lengthy, checkout flight in the Sahara-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, one flown by the autopilot and one by you.

STARTUP:

The engine starts a bit differently from that of the Flyhawk. Check that the fuel selector is in the L or R tank position. When you turn on the master (battery) switch, you may hear the faint hum of a 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 and turn off the emergency pump. You've now primed the engine. Check that both magneto switches are ON and hit the starter. The STARTER ENGAGED light will illuminate on theannunciator panel and the engine will crank. As it fires, move the mixture control fully forward, release the starter, and verify that the STARTER ENGAGED light is out. Does this all sound too complicated? Just crack the throttle, set the mixture fully forward, hit E on your keyboard, and Fly! II will take care of all the details.

RUNUP:

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

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

I, as before, is for **I**nstruments: 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 artifical horizon erect and steady.

G, as before, is for **G**as-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 **A**vionics-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 **R**unup, but this time it's more of a general reminder to do one; we're actually going to to it in a bit more detail a couple of letters further in our mnemonic.

T stands for **T**rim. 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.

Now we'll get to the actual runup. I stands for **I**gnition. 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.

Finally, P stands for **P**ropeller. 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 Sahara 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 Flyhawk; 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 Flyhawk, 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 Sahara 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 Flyhawk, you may think that the Sahara 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. If you didn't start this flight at San Francisco International, use the "Teleport" function of the "Flight Plan" menu to get you near there now.

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 south 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 on about the 120-degree radial from SFO).

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 glides-lope 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.

SIM TIP

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 a dot or two above center 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 second dot above center, 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 half 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.

Sahara Engine Run-up and

Final 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

Kodiak

Multi-engine flying principles, airplane and cockpit description, flight maneuvers.

MOVING UP TO A TWIN:

Welcome to the world of multiengine 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 Kodiak, and this is a pretty significant airplane in a couple of different ways. Modeled closely after a modified version of a very common medium piston twin, the Kodiak 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.) 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 twin on which the Kodiak is based. IT'S EASIER THAN YOU THINK:

If you've been flying a heavy piston single, such as the Sahara, you should have no trouble transitioning into the Kodiak (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 Kodiak, 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 Sahara, you're on familiar territory: the Kodiak uses almost exactly the same 350-hp turbocharged Lycoming engine, so you can just consider that you're flying two Saharas in close formation.

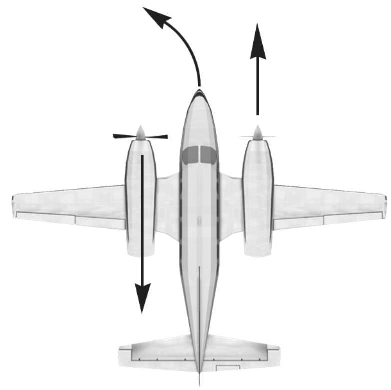
By the same token, the special skills you have to learn to be a safe multiengine pilot are, in fact, *single-engine* techniques. The twin flies just like a single as long as both engines are running; it's when one of them becomes uninterested in further toil that things become, to say the least, interesting.

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.

OK, 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. *(Notice-no animals were actually harmed in the preparation of this manual.)*

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.



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.

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 Fly! II, 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 your feathering a prop automatically). 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.

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 onto an airport as soon as possible.

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 VMC, 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 multiengine airplanes, with a big red radial line. The warning is simple: if you're flying below VMC, 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!

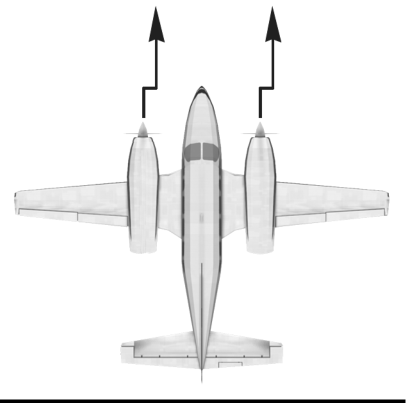
Bear in mind, too, that losing 50% of your power will cost you a lot more than 50% of your performance. Flying on one engine, the airplane requires big, “draggy” control surface deflections to keep in control; and even, the fuselage is still getting dragged along perceptibly sideways. It’s not very efficient. 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.)



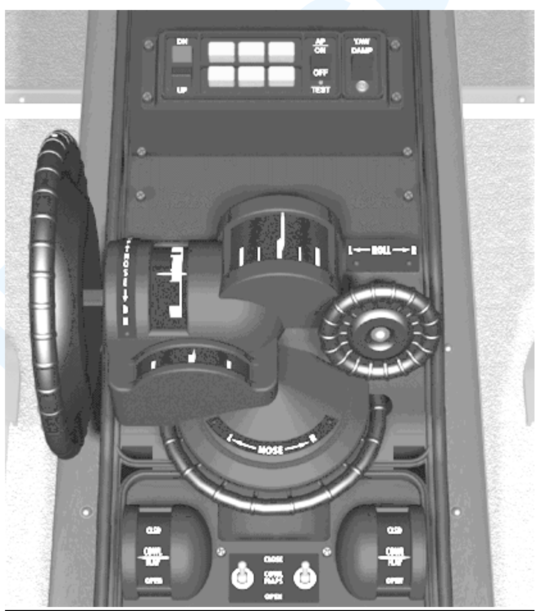
BACKWARDS IS GOOD:

"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 was done on the airplane on which our Kodiak is based, although it took some persuading to get Lycoming and the prop manufacturers to build them. The Kodiak 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!

KODIAK COCKPIT TOUR:

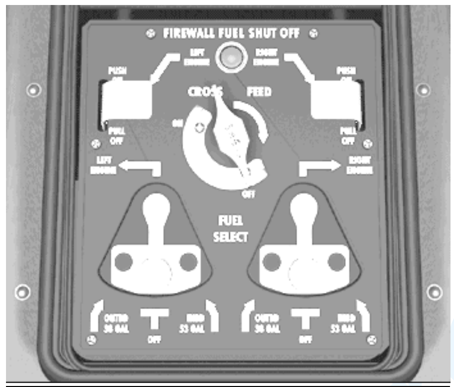
By now, you should be pretty familiar with the way aircraft cockpits are laid out. Sure enough, there are the usual "sacred six" flight instruments right in front of the captain (with an additional set over on the copilot side). The dual-width radio stack, replete with bells and whistles, is in the center panel. Above them, the engine instruments are laid out with, from left to right, manifold pressure, RPM, TIT, 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, labeled L and R, 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.

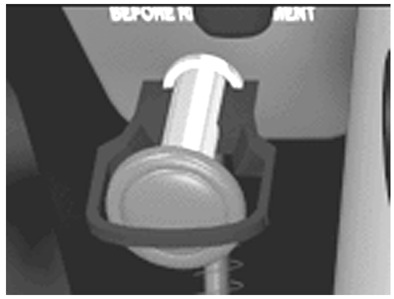
Finally, at the bottom of the console, a bunch of techy-looking levers control the fuel system. Each wing has inboard and outboard tanks. In normal operation, each engine draws fuel from the tank(s) on its side of the airplane; the outboard ones are considered auxiliary tanks, and are approved for use in level flight only. The two rearmost levers are the fuel selectors for their respective engines, and have inboard, outboard, and OFF positions.



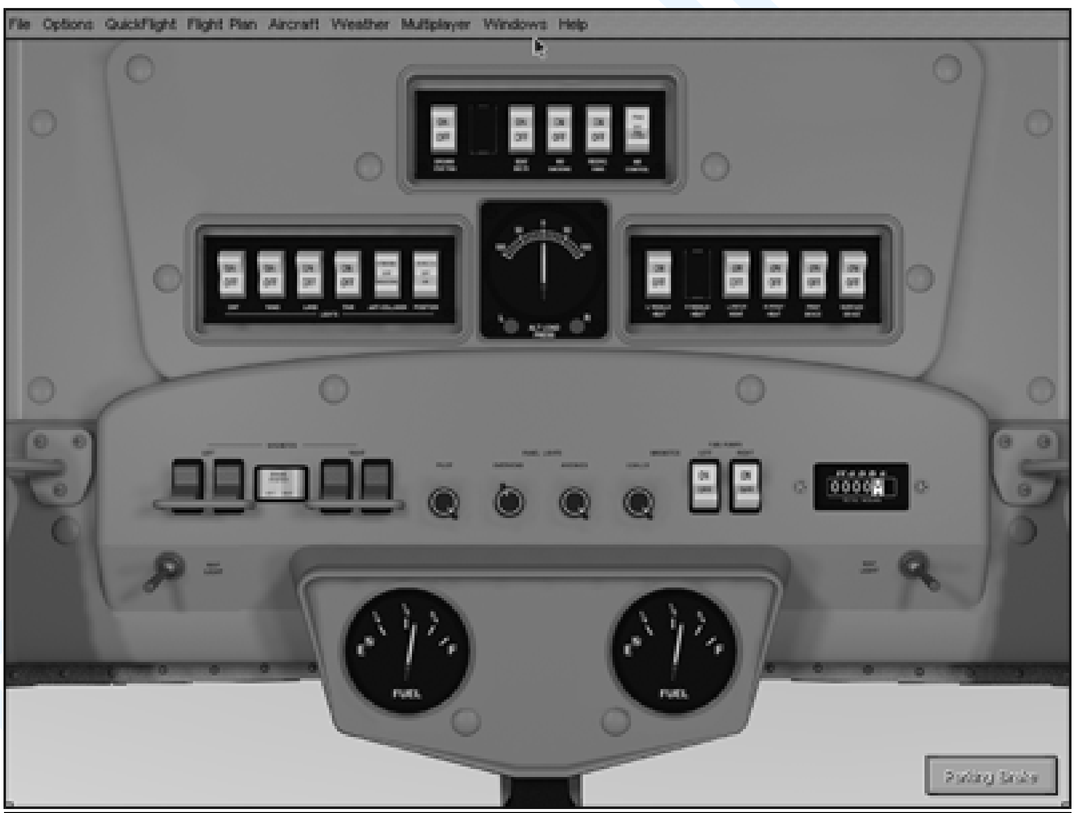
In the center of the fuel panel is a single lever controlling fuel crossfeed. This is provided for emergency use-for example, if an engine fails, crossfeed can be used to let the remaining engine utilize fuel from the failed-engine side. For example, if the right engine has failed and you want to use 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 and pull the boost pump circuit breaker on that side. 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.

As long as we're looking down, let's take a glance at the floor just aft of the center console. See that little hatch? It conceals the handle for the emergency hydraulic hand pump. In the unlikely event that both engine-driven pumps fail, or dump their fluid supply overboard, opening the hatch, pulling out the red pump handle and pumping it through 50 body-building strokes will extend the gear. (The flaps are electric-and if they fail, just find an airport with a decent-size runway and land without them.)

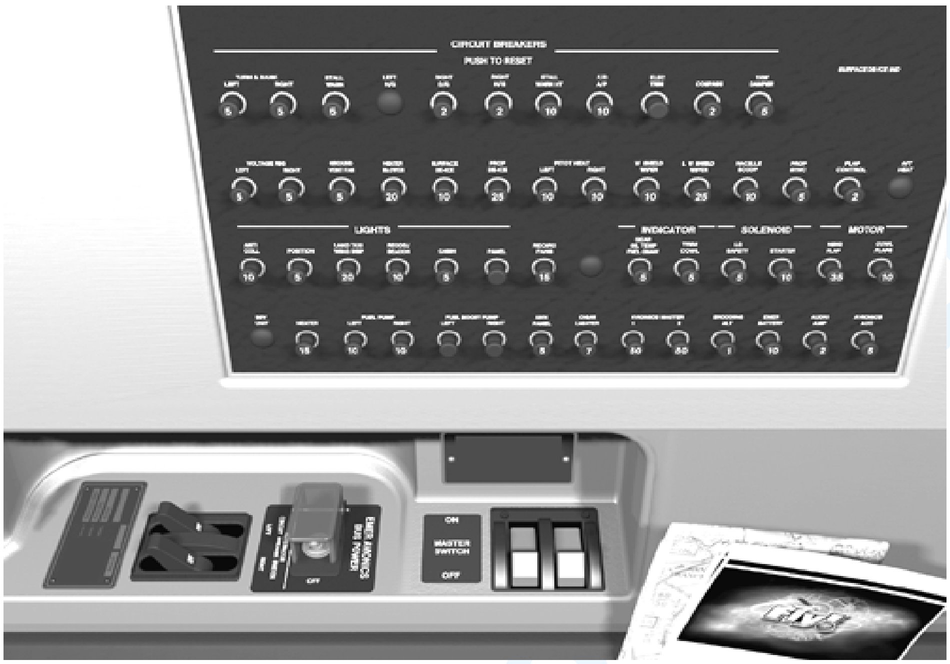


Now let’s look up above the windshield. Wow! Even more switches than in the Sahara, and a few dials besides! Actually, two of those dials-the left and right fuel gauges-represent one of Piper’s few design errors in the Kodiak. Four tanks, two gauges: how does that work? It’s simple-each gauge indicates 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”…



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. A similar circuit breaker panel on the right side of the cockpit is dedicated to avionics systems.



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!

You can use the same technique you learned to start the Sahara-after all, the engines are almost identical. While some twins have their battery located much closer to one engine than the other, suggesting that that one should be started first, the Kodiak's battery is in the nose, so you can start whichever you like. 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 2300 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 Sahara, 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 43 in. Hg. and a rather noisy 2575 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 (VMC) 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). As you reduce power, you can synchronize the engines for quieter operation. If there's any difference in RPM between the two engines, you'll hear a fluctuation in the engine noise:
mmmMMMmmmMMMmmmMMMmmmMMMmmm...
The greater the RPM difference, the faster the noise will fluctuate. Slowly move one prop control forward and the other backward; if the fluctuation gets faster, move them the other way. When the engines are exactly in synch, you'll hear a steady, reassuring drone.

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 me 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 in addition to your yoke, or a joystick with a "twist" rudder axis control.

IT'S QUIET OUT THERE…TOO QUIET…

OK, 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? OK, 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.

OK: you've identified the dead engine by noting which foot you don't have to use (and 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** 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, and pull the FUEL BOOST circuit breaker for that side. 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 OK 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! II?

This is a time when you may run out of hands, so if you have a friend around to kill an engine for you from the keyboard, so much the better. Alternatively, you may configure the simulator to do it automatically.

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 Kodiak 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 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.*

OK, 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!

PILATUS PC-XII: INTRODUCTION TO ADVANCED SYSTEMS AND AVIONICS

Welcome to the remarkable Pilatus PC-XII—arguably the most advanced single-engine civilian aircraft in production. This sophisticated airplane offers cabin size and all-weather performance virtually identical to that of the Aurora, but with the efficiency, reduced operating costs, flexibility, and superior short-field capability of a single.

It's also a much more recent design than the Aurora. This allows it to take advantage, not only of improved aerodynamics and construction techniques, but, especially, to recent advances in avionics. It's not an exaggeration to say that the systems installed in most PC-XIIs rival those found in the latest airliners. Combine that with an airplane that can go virtually anywhere, and one that's built with Swiss craftsmanship and attention to detail, and you have a combination that's hard to surpass.

A LITTLE HISTORY:

The Swiss firm of Pilatus has been in existence since well before World War II. After the war, their production moved in two directions: rugged trainers for the Swiss Air Force, and a series of extremely successful single-engine bushplanes called "Pilatus Porters." Capable of hauling astonishing loads in and out of even more astonishingly small and primitive airstrips, Porters found employment all over the world, from the heights of the Himalayas to the jungles of Southeast Asia.

Between the ever-increasing load-hauling requirements and the fact that aviation gasoline is often impossible to obtain in the Third World, it was natural that Pilatus would turn to light, powerful gas turbine engines, and the Turbo Porter was born. Some years later, a new air force requirement (as well as the increasing cost of military jet pilot training worldwide) led them to re-engine their successful P-3 Swiss Air Force trainer and create the PC-7. A follow-on version, the PC-9, proved such an excellent airplane that it's been selected for construction in the US as the Raytheon Texan II, and it'll be the new primary trainer for both the USAF and the US Navy in the 21st century.

During all this development, it became evident to Pilatus that gas turbine engines in general, and the Pratt & Whitney PT-6 in particular, had reached a level of reliability that would make a multipurpose single-engine civilian airplane a very attractive possibility. Indeed, statistics showed that most single-engine mechanically-caused mishaps, even in piston-powered airplanes, were the result of failures in auxiliary systems, rather than in the powerplant itself. Their goal was to build an aircraft that could combine the performance and cabin size of a turboprop twin with the clean wing, rugged landing gear, and short/rough field capability of a back-country single, while still offering a comparable level of dispatch reliability. The result, with a single engine but with virtually all other essential systems duplicated, is the PC-XII.

EASY TO FLY

In fact, with its high level of automation, duplicated systems, and simple power management, the PC-XII is probably easier to fly, overall, than the Sahara described elsewhere in this manual—and with its huge power reserve, it can go anywhere the little Sahara can go. Therefore, in this manual chapter, we'll touch only lightly on the "how to fly" aspects of the PC-XII; if you're competent in the Sahara, you'll have an even easier time in the PC-XII. Instead, we'll devote much of our attention to its airline-style "big airplane" systems and avionics, particularly its Electronic Flight Instrument System (EFIS).

SYSTEM REDUNDANCY AND FAULT TOLERANCE: "TWO IS BETTER THAN ONE:"

Pilatus's basic design philosophy for the PC-XII's systems, and the way they're operated, reflects current airline standards. As far as systems are concerned, the idea is that no single failure can place the aircraft in a critical or dangerous situation (with the very unlikely exception of a complete engine failure). In other words, any system or device on the airplane either has to have an adequate backup, or be sufficiently "noncritical" that its failure isn't immediately dangerous.

An example of the former idea is the electrical system: while there is only one engine, it drives two completely separate DC generators, each of which powers its own set of busbars in the electrical system. If the secondary generator fails, the primary generator is still capable of handling the airplane's complete electrical load. If the primary generator fails, the (somewhat smaller) secondary generator can handle all the really essential items—and to prevent overloading it, nonessential items are automatically shut down (called *automatic load shedding*). Similarly, the Electronic Flight Instrument System (EFIS), even if it's installed only on the pilot's side of the airplane, has backup switching so that if either display tube, or its electronic signal generator, fails, the system can be switched to a backup "composite" display in which all information is presented on the single remaining tube. (In Fly! II's PC-XII, there's even more redundancy here, as there's a complete EFIS installation on the first officer's side of the airplane as well.

In terms of less critical, or "fail soft," systems, let's look at a couple: the flaps and landing gear.

The flaps are electrically driven, and powered from the BATTERY bus—which means that if *any* electrical power is available on the airplane, they'll run. If they develop a mechanical problem and begin to move asymmetrically, an electronic monitor will halt further motion—but, given the airplane's already low landing speeds, a no-flap landing is an annoyance, rather than a critical condition. Even on relatively short fields, the combination of powerful brakes and even more powerful reverse thrust will bring the PC-XII to a halt with reduced, or even no, flaps.

Landing gear, of course, is somewhat more critical, but here there are two separate backups. The gear is normally cycled hydraulically, with the hydraulic system powered by an electrical (rather than engine-driven) pump. However, there's a very simple and reliable gravity backup system, making backup gear extension so reliable that the electric controls for the primary system aren't even considered essential (and therefore are on the non-essential electrical bus, the one that's automatically load-shed if the main generator goes down.

All you need to do for a "no-hydraulics" gear extension—I hesitate to call it an "emergency"—is to put the gear handle down, just as you would any other time. Moving the handle releases the hydraulic pressure that holds the gear up, and it simply extends by gravity. Want a backup for the backup? If for some reason the gear doesn't lock down on an emergency extension, there's a hand pump in the center console; about 80 strokes will do the job.

Even the engine's hydropneumatic fuel control has a backup. Studies of those few actual failures that have occurred with Pratt & Whitney PT-6 engines indicate that the most common (and even that one is rare) isn't an outright failure, but something called a "Py rollback." In order to operate smoothly, the engine's hydropneumatic fuel controller bases its internal settings on the pressure of air sampled from the engine compressor. This is called "Py air," and it gets to the fuel controller via a long tube on the outside of the engine. If this tube should break, leak, or become clogged, there's a chance the engine will "roll back" to idle power (it won't quit; it'll just idle very happily, and won't respond to the power lever). That's not a problem in the PC-XII—just move the main power lever to maximum (there'll be no response from the engine), then use the Manual Override (MOR) lever next to it to regain control of the engine. It'll be somewhat "touchier" than the normal power control lever, and reverse thrust won't be available after landing...but response and performance are still entirely adequate to let you complete your flight.

The other way in which the PC-XII reflects modern airliner-style design is in the arrangement of its cockpit and the operation of many of its systems. Current airline philosophy is for what's called a "dark, quiet" cockpit, meaning that in normal operation all warning lights are extinguished, and all audio warnings are silenced. The PC-XII has an extensive caution and warning light panel just ahead of its power control levers, called the CAWS (Central Advisory and Warning System). In normal flight operation (and when not in icing conditions), this panel will show only a single green light, indicating that pitot and angle of attack probe heat is operational. Occasional other green lights (for fuel pumps, etc.) or blue lights (autopilot autotrim, air conditioner compressor operation) may illuminate momentarily to show the pilot that "normal" operations are going on, but generally the panel will be dark.

If any serious (warning) or somewhat less serious (caution) conditions occur, however, the corresponding light will illuminate. At the same time, a flashing red (master warning) or yellow (master caution) on the main instrument panel will get the crew's attention, and a warning tone will sound. The master lights can be canceled by pushing on them; the caution lights will remain illuminated.

In keeping with modern systems design philosophy, as much as possible has been automated to reduce crew workload; many switches, rather than having "off" and "on" positions, are marked "auto" and "on." For example, the two electric fuel boost pumps (one in each wing) aren't required for normal engine operation, since motive fuel flow from the engine itself runs venturi-type jet pumps in the wings. They are required, however, for starting—so, with their switches in "auto," they'll run automatically during the start sequence, then shut down once there's sufficient motive fuel flow. The only other time they'd run would be in case of fuel imbalance (more fuel being used from one wing than from the other)—but they're also tied in to the left and right fuel gauges, so they'll run automatically as required to keep the airplane in balance.

The electrical system is another good example of systems automation. In normal operation, two separate generators power the system, each feeding its own busbar to provide power to its "customers." As long as both generators are operating, the two systems are "separate but equal." Should either generator fail, however, the systems are automatically tied together to allow the remaining generator to power all essential circuits. In addition, if generator 1 fails, leaving only generator 2 (which has a smaller capacity), the nonessential bus is automatically shed to ensure adequate power for critical items. (The pilot can override this if it's necessary to use certain items powered by the nonessential bus.)

Overall, this design philosophy, as well as the airplane's extremely benign handling and excellent power-to-weight ratio, make it a pleasure to fly. Let's climb up the steps in the big airstair door, step into the cockpit, and look around.

The PC-XII panel represents a very interesting hybrid of "big jet" and "light aircraft" avionics. Until quite recently, almost all turbine aircraft used heavy, remote-mounted avionics, with only control heads on the instrument panel (look at the panels of the Aurora twin turboprop or the Peregrine jet as examples). In the last few years, however, panel-mounted avionics have been developed that offer not only the same level of performance, but the same level of reliability as well. The cost and weight savings are obvious: consider the difference between a remote-mounted comm radio about half the size of a shoebox, plus an interconnect cable with dozens of wires, plus the panel-mounted control head, and a single unit about the size of a paperback book, mounted entirely in the panel. In fact, an argument can be made that with the deletion of the interconnect harness and its multipin connectors, the panel-mounted unit is *more* reliable than remote equipment.

(In terms of redundancy, some PC-XII operators—particularly those in remote areas—often carry a couple of extra radios along with them as loose equipment, something reasonably feasible in terms of weight and cost. In the event that an installed unit fails, it can be swapped out—even inflight if necessary—in just a few moments.)

In the PC-XII, some units which come from the "big airplane" end of the business are available only in remote-mounted form. These include the signal generators and computers for the EFIS displays and the remote Attitude and Heading Reference System (AHRS) that provides them with attitude and heading data. Just about everything else, however, is panel-mounted: the same excellent Honeywell Silver Crown equipment we're familiar with in every airplane from the Flyhawk on up.

The main instrument panel is laid out in the familiar "sacred six" arrangement. If the airplane is already powered up the first time you see it, you'll see that the more common artificial horizon and HSI have been replaced by a couple of screens. These are called, respectively, the Electronic Attitude Director Indicator (EADI) and Electronic Horizontal Situation Indicator. They provide the same information as the mechanical indicators they replace—and a whole lot more, which we'll cover in a few moments.

In addition, on the left side, there's a backup electromechanical artificial horizon. This has its own battery pack, and will keep running (and stay lighted) for about half an hour even if the entire electrical system is shut down.

You'll also notice a small red light in the flap indicator. This will illuminate (accompanied by a warning tone) if you attempt to extend the flaps at too high an airspeed (or fly too fast once they're extended). It has two settings: 165 knots for the first 15 degrees of flap extension, and 130 knots for the rest.

Let's take a closer look at the center instrument panel. At the top, in the glareshield, are two small panels. On the left is the control for the autopilot and flight director, which we'll discuss together with the EFIS; on the right, the audio selector panel, exactly the same unit you've seen in the Flyhawk, Sahara, or Kodiak.

Further down, on the left side, is the GPS; below it, the electronic engine and systems display, or EIS, which warrants a short discussion of its own.

More than just an electronic version of the traditional engine instruments, the EIS incorporates both engine and systems monitoring functions. Across the top are the three primary power instruments (torque, temperature, and Ng, or gas generator RPM); they display their readings in both graphic and digital form. Vertically below the RPM dial are the dual fuel gauges (left and right wing) and a dual gauge for oil temperature and pressure. Oil temperature and pressure are also displayed digitally in the windows to the left of the gauges, as well as Np (propeller RPM), outside air temperature, and the voltage and amperage of both generators as well as the battery.

Another window displays fuel parameters. In addition to displaying the total fuel on board, it shows current rate of consumption (fl/h), and total remaining endurance (endur) at the current power setting. These figures are based on initial fuel onboard, which is retained in memory even when the airplane is shut down. Since the wing fuel tank gauges are extremely accurate, there's no need to manually “scroll in” added fuel after refueling the airplane; simply press the “fuel reset” button at the bottom of the EIS and the value will be updated automatically.

Gauges showing engine parameters will flash slowly (40 flashes/min) when their individual limits are approaches, and rapidly (80 flashes/min) if they're exceeded. The electrical system digits will flash to warn of over- or under-voltage, excessive battery drain, or excessive load on either generator. The outside air temperature digits will flash if the temperature is less than 4 degrees C and the pitot/angle of attack probe heat switch is off.

Notice that there's no indication of prop RPM other than the small digits. This underscores the simplicity of flying the PC-XII: there's only a single power lever for the engine (rather than a power lever and separate prop control, as in the Aurora), and when it's above idle range the prop always turns at the same speed (1700 RPM). Thus, the prop RPM indicator's function is more advisory than controlling.

Overall, you can see that the EIS is a “nerve center” to monitor virtually all critical powerplant and systems parameters. Once you've set things up for cruise, there's hardly even any need to look at it; it'll flash if it needs your attention.

All the important switches except those for the electrical system are grouped on the lower left panel. At the left are the engine starter, fuel pump switches, and environmental controls, as well as a couple of avionics switches. Take particular note of the one labeled “EFIS,” with “norm” and “cmpst” positions; we’ll come back to those later. On the right, the upper row controls lighting; the lower controls ice protection systems.

A large center pedestal runs back between the crew seats. At the front is the big caution and warning system (CAWS) annunciator panel. Again, in keeping with airliner philosophy, there’s not much need to keep an eye on it; if it needs your attention it’ll flash the master caution or master warning light, right above the EADI where you can’t miss it (and in case you’re really zoned out it’ll sound a warning tone as well).

Just below the CAWS are the controls for the pilot’s side EFIS, the multifunction display mounted in the center panel, and the weather radar. We’ll examine those in conjunction with the EFIS.

Further aft is the triple trim position indicator. In the airplane, elevator and aileron trim are controlled by buttons on the yokes, while rudder trim is controlled by a switch on the power lever. Notice that the elevator and rudder trim indicators include small green lights; these illuminate when either axis is being retrimmed by the autopilot.

Next come trim and flap interrupt switches (to halt either system in case of uncommanded motion) and an alternate flap switch.

When you examine the power quadrant, you’ll notice something missing compared to other turboprops: there’s no prop control. That’s because the PC-XII runs its prop at a single constant speed (1700RPM). Instead, there’s just the power control lever (PCL), which covers the range from reverse to full forward thrust, and a condition lever which has three positions: all the way aft, which cuts off fuel and feathers the propeller; ground idle, which runs the engine at a relatively low speed for taxi; and flight idle, the position for all inflight operations.

On the other hand, there's also an extra lever, just to the left of the PCL. This is the manual override lever (MOR) for the engine fuel control. As discussed earlier, it provides a backup means of engine control in case of a Py rollback. The PCL must be moved fully forward before the MOR is used.

Finally, aft of the power controls, we find the switches and dimmers for all cockpit and cabin lighting grouped together. On the aft face of the center pedestals are two manual shutoff levers. One controls engine bleed air to the airplane's environmental control system (cabin pressurization, heat, and cooling); the other is the firewall fuel shutoff. Between them, the large red knob is the extendable handle for the hydraulic system hand pump (used only for emergency landing gear extension).

ELECTRONIC FLIGHT INSTRUMENT SYSTEM:

The heart of the PC-XII cockpit is the Electronic Flight Instrument System (EFIS). If it's not already powered up, just hit [E] for the moment to start up the entire airplane; we can go through a more detailed start sequence later.

The EADI presents all the information you'd see on an artificial horizon, and a lot more. Notice that your heading is displayed along the horizon line. The two flight director bars allow you to use the autopilot computer's functions while still flying the airplane yourself; as long as you keep the symbolic airplane tucked into the bars, you are satisfying the demands of the autopilot guidance computer. In a sense, your muscles have replaced the autopilot's control servos.

The vertical scale at the left displays angle of attack, and is particularly useful during approaches, while the one on the right shows raw glideslope data on an ILS. Raw localizer data appears across the bottom of the display, just above the turn needle. Finally, the rising runway symbol will appear when the radar altimeter reaches 200 feet AGL, and will increase in size until touchdown.

The EHSI is even more versatile. In its basic mode, shown here, it's little more than an electronic picture of a conventional HSI. One or two bearing pointers can be superimposed, so the instrument simultaneously acts as an HSI and an RMI (note that the PC-XII also has a conventional RMI just to the left of the HSI).

The key to the EHSI's versatility is this control panel, just below the CAWS on the center pedestal. We suggest that you have the instrument panel available and powered up in Fly! II for the next few paragraphs so you can try out all the functions as they're described.

We'll work from left to right, and from top to bottom. The knob labeled DH controls the decision height setting of the radio altimeter; the setting is visible on the EADI, and a yellow DG legend will illuminate upon reaching the appropriate altitude. The button marked SYS REF is used both to self-test the displays, and to choose what information will be displayed when the EHSI is in its GPS map mode (flight plan waypoints, navaids, or airports. The brightness control has two concentric knobs; one sets the brightness of the EHSI, the other that of the EADI.

The first two buttons in the top row set the basic display mode of the EHSI. Pressing HSI provides a full 360-degree HSI compass rose, while pressing ARC changes the display to a partial arc (85 degrees) in front of the airplane. All other display components (course arrow, deviation bar, bearing pointers) remain the same. If any of them are “off screen” in ARC mode, appropriately colored numbers near the sides of the arc indicate their current position.

The NAV button, on successive presses (clicks), cycles through the available sensors for the primary nav display (the EHSI deviation bar). In the PC-XII, these are VOR/ILS, GPS, and ADF. When GPS mode is selected, successive clicks on the HSI or ARC button turn on and off a nav data overlay including waypoints and courselines. The RNG^ button, and the RNGv button just below it, adjust the scale of nav map or radar information displayed on the EHSI.

In the lower row, the CRS knob sets the EHSI’s course arrow. It’s much easier to reach this knob than it would be to reach around the yoke (not depicted in Fly! II) to get at the EADI on the panel—and if you’re flying with a copilot, he or she can set courses for you without having to reach across. Momentarily pulling the CRS knob automatically sets the course arrow to the direct course to the currently active waypoint or navaid. At the opposite end of the bottom row, the heading knob works the same way—a momentary pull (click) syncs the heading bug with your current heading.

The two bearing pointer buttons (single arrow for #1, double arrow for #2) cycle through selections for the #1 and #2 pointers: VOR (1 or 2 as applicable), GPS, and ADF. When a pointer is onscreen, its sensor and distance (if available) is annunciated at the bottom left or right corner of the EADI. Finally, the 1-2 button chooses between the system (VOR/LOC 1 or 2) displayed on the main course arrow (if that sensor is in use).

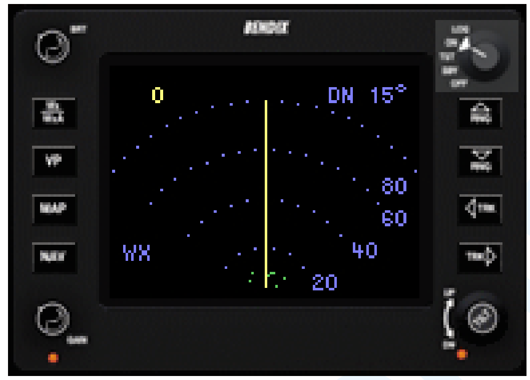
The EFIS system has an additional display in the center panel. This multifunction display can perform a number of functions, controlled by the MFD panel just below the EFIS panel. As before, we suggest you have Fly! II up and running to explore these options.

Many of the buttons on this panel have the same functions as those on the EFIS panel just above (although, of course, they affect the multifunction display rather than the EADI). The ARC mode has an additional selection in which all nav information is suppressed, and the display shows only weather radar information. Radar can also be superimposed over nav displays if desired.

Normally, the MFD's course arrow duplicates the setting on the pilot's EADI. However, when the button next to the CRS knob is pushed, it becomes active for the MFD only. The TCAS ONLY button clears the display of all but TCAS (Transponder Collision Avoidance System) data. At the other end of the panel, the CHK LIST button allows you to display pre-programmed checklists on the MFD.

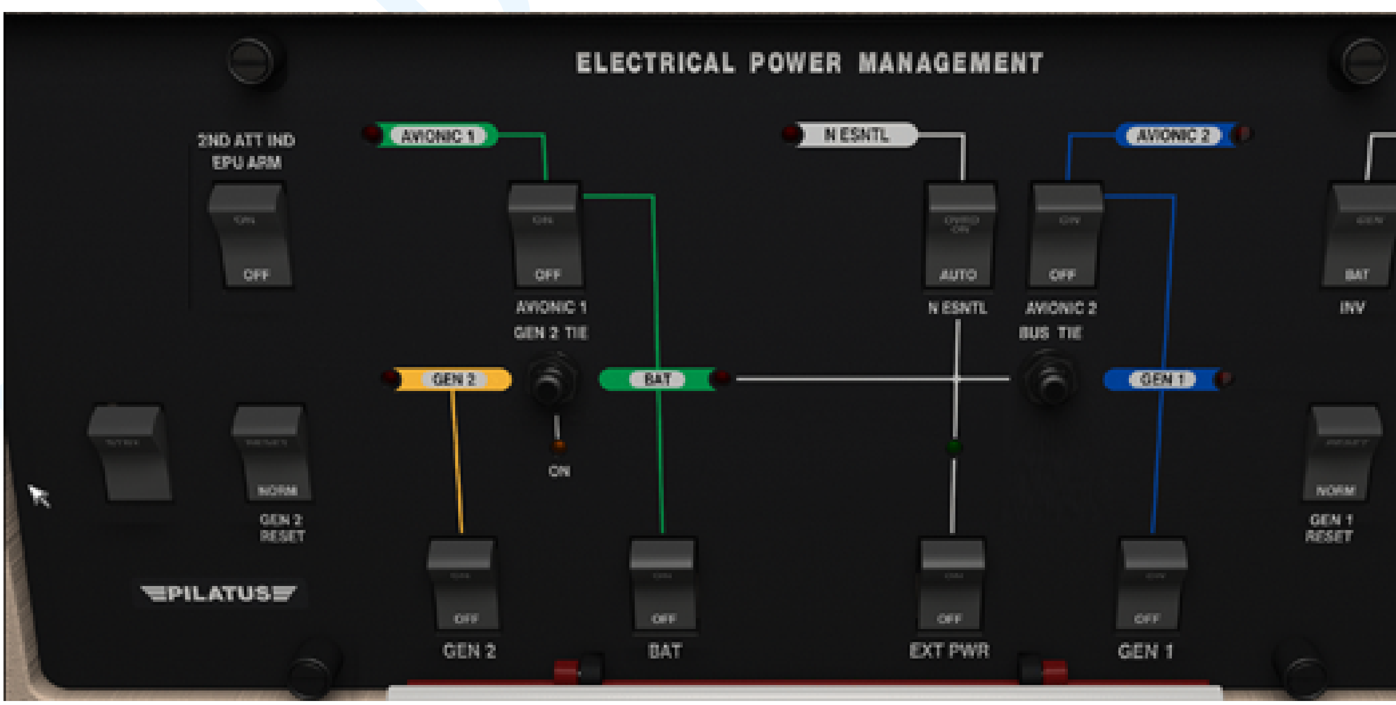
Perhaps the most interesting feature of the MFD control head is the little joystick at the center. Let's say you see a storm cell sitting right over your next flight plan waypoint. If you're displaying your GPS flight plan on the MFD, the first movement of the joystick will create a new waypoint, just in front of your aircraft. Now, using the joystick, you can position this waypoint to a location that'll take you around the storm;

then pressing the ENT button just above the joystick will insert that waypoint into your flight plan.



The lowest control panel in this group is for the weather radar (with an engine and prop in the nose, the radar scanner itself is mounted in a radome at the tip of the right wing). In addition to standard radar modes, positioning the yellow “track” line on a target of interest (by using the <TRK and TRK> buttons), then clicking on VP, changes the radar to a vertical scan at that location, allowing you to see a vertical profile of weather ahead.

You’ll have plenty of opportunity to explore the avionics system’s capability on future flights. For the moment, let’s make a short hop to familiarize you with the airplane’s handling and the basic modes of the autopilot. If everything is running now, hit [E] to shut it down, and we’ll run through a standard startup and takeoff.



We'll begin on the overhead panel, which controls the electrical system. Before we start, notice the hinged red bar at the bottom of the panel. This is called the "gang bar." In an emergency, flipping this bar up will remove all power from the airplane. Turn the BATT switch on now; you'll notice some warning lights, indicating that the associated busses are unpowered. You can also switch the SBY GYRO EPU switch to ARM. This arms the backup battery pack for the standby gyro horizon; it must be switched off when you shut the airplane down, or the emergency battery would come online (and, after half an hour, run down) when you turned off the rest of the airplane electrical system. Now click [Ctrl+down arrow] twice to get down to the center pedestal, and verify that the PCL is at ground idle and the condition lever is at OFF.

Hit [Ctrl+up arrow] to return to the main instrument panel. Click on "fuel reset" at the bottom of the EIS to set the digital display to your actual onboard fuel. If you like, click and hold "test" on the EIS to verify that it's functioning correctly and that all gauge segments illuminate.

Click on the starter switch, at the lower left of the main instrument panel. On the EIS, you'll see Ng (the rightmost upper gauge) start to increase. When it stabilizes, go down to the power controls and move the condition lever to GND IDLE. Return to the main instrument panel and you'll see fuel flow and ITT increase smoothly. The prop will unfeather and accelerate to about 1000 RPM.

Return to the overhead panel and turn on both generators and both avionics busses; the little "bus out" lights will extinguish. Return to the main panel and you'll see that the avionics have come to life and most of the legends on the CAWS have extinguished. On the lower right group of switches, turn on probe heat and any exterior lights you want, and check that the probe warning light on the CAWS has extinguished. The autopilot won't engage until it's run through its preflight test, so go to the controller (in the panel glareshield) and click on TEST now. Several autopilot lights will blink on and off.

Set the flaps to the first notch (15 degrees) by tapping [F]. Check that rudder and elevator trim are in the green range and set them if necessary. Taxi out to the runway, line up, and we're almost ready to go.

THE JOYS OF FLAT RATING:

One of the nicest things about the PC-XII is that its engine is flat-rated. This means that the installed engine can actually put out a lot more power than its rated 1200 hp (takeoff) or 1000 hp (continuous) at lower altitudes, allowing it to maintain takeoff power to very high altitudes. Unless you're taking off from someplace like La Paz, Bolivia (13,000 feet above sea level), on a warm day, the engine will almost invariably reach its torque limit long before it reaches its temperature limit. It also has an automatic torque limiting system, so power management for a normal takeoff is very simple: just shove the PCL forward until you just reach limiting torque, and go.

Let's do that now. The airplane will accelerate very briskly, and since you don't have to worry about minimum control speed, as you would in a twin, you can rotate at what would seem a ridiculously low speed: 75 to 85 KIAS. Retract the gear ([G]) when you have a positive rate of climb, but leave the flaps at 15 degrees until passing 100 KIAS, then retract them by tapping [Shift+F]. Best rate of climb is at 120 knots, but at a very steep deck angle; 160 knots will get you upstairs almost as fast, but with greater passenger comfort and a better view over the nose.

As we're climbing out, let's explore some of the labor-saving features. On the EFIS control panel, click once on the center of the HDG knob. Notice that the heading bug in the EADI and EHSI are now synchronized with our current heading. Now, on the autopilot control panel, click on HDG. Notice that the flight director bars appear on the HSI. Now click on AP. The autopilot will engage and hold our current heading and pitch angle.

Let's plan to level off at 15,000 feet. On the altitude preselector (just above the altimeter), dial in 15,000, then click on ARM. That's all there is to it! The airplane will climb to 15,000 feet, then engage the autopilot's altitude hold and level off automatically. The other autopilot and flight director modes are the same as those for the Sahara; the control head just looks slightly different. Notice, too, that current autopilot modes are annunciated on the EADI.

Let's try a couple of stalls. Like larger jets, the PC-XII has a "synthetic" stall to protect you from the somewhat more significant real one. Reduce power and begin to bleed off the airspeed. As you approach the stall, you'll first feel a synthetic buffet from a stick shaker (you'll just hear it in Fly! II); then, as speed decreases further, a 65-pound force will push the stick forward, dropping the nose.

To conclude this brief introduction to the PC-XII, we'll return to the airport and land. Assuming you haven't changed the heading, it should be straight behind us a few miles, so just use the HDG control knob on the EFIS panel to change your heading by 180 degrees; the airplane will docilely turn around. Then disengage the autopilot (click on AP).

Unlike the high-strung piston engine in the Sahara or Kodiak, the mighty PT-6 in the PC-XII isn't bothered by inflight reduction to flight idle if necessary, so ease the power lever back, lower the nose, and line up on the runway. The landing gear can go down at 177 KIAS (once it's down you can go all the way back up to redline if necessary), the first notch of flaps at 165 KIAS, and the rest at 130 KIAS. On final, the PC-XII feels like a much larger, more stable airplane than you'd expect. With the big, sophisticated cockpit, you feel like you're in an airliner...until you notice the low final approach speed, a mere 80 knots even at maximum gross weight! No wonder this "airliner" can operate out of short grass or gravel landing strips if you want it to.

We've just scratched the surface of what the PC-XII and its avionics can do; now it's your turn to explore them. In general, just use Sahara airspeeds, and you'll do fine—just don't be surprised that performance is better and pilot workload much lower.

AURORA

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:

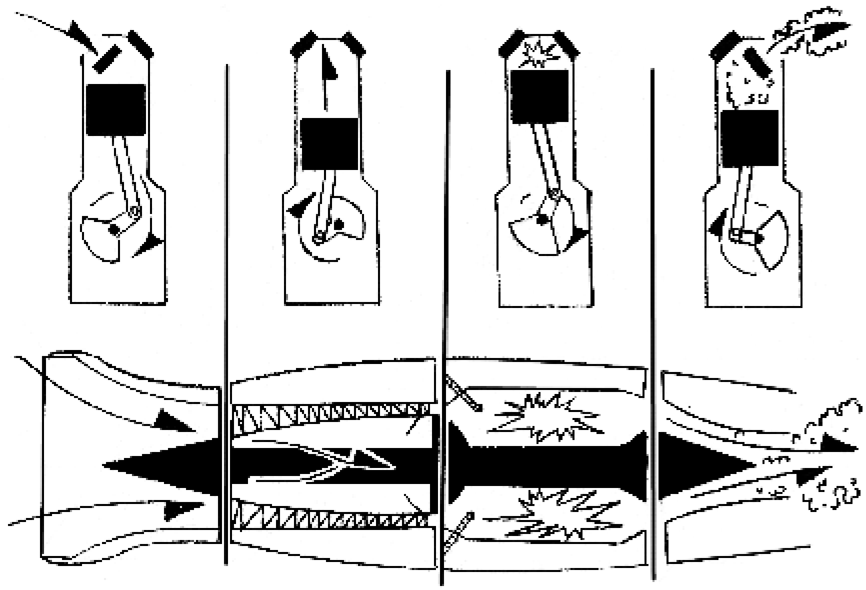
For all their power and seeming complexity, gas turbine engines are actually much simpler than their piston powerplants. They come in three basic styles: turboshafts, which provide output power via a high-RPM shaft and are found only in helicopters; turboprops, in which most of the output power still 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.

Why is this the case? And, for that matter, if turbines are so simple, why do they cost so much? Because their internal parts operate in a very demanding thermal environment, often requiring the use of exotic and expensive alloys ("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.

AIRCRAFT AND COCKPIT TOUR:

As you approach the Aurora, 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.

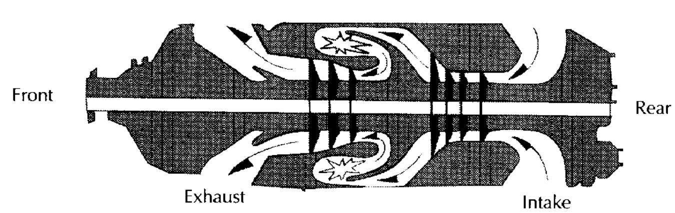
What strikes everyone at first glance is that big T-tail. Why have the horizontal stabilizer and elevator all the way up there? For a couple of reasons. The most obvious is that this location gets them up out of the downwash of the wing and the propeller slipstream; thus, the trim changes with power 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.

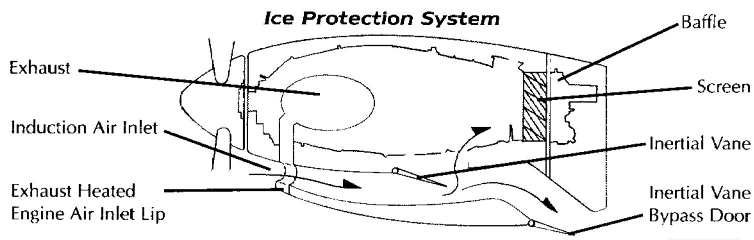
A look at the engines and their nacelles tells the educated eye at a glance that this is a PT6-A powered airplane. There are two clues. The most obvious is that, at rest, the propeller blades are feathered. This is because the PT6-A is what's called a *free turbine* engine. (Unfortunately, this proves 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 Aurora (and every other airplane except the Beech Starship or Piaggio Avanti, which have "pusher" props), 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 40,00 RPM, the engine is vulnerable to damage if it ingests any ice. On the Aurora, 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.



IN THE COCKPIT:

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 Auroras 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.

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 N_G, 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 *percent 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 N_G 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.

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.

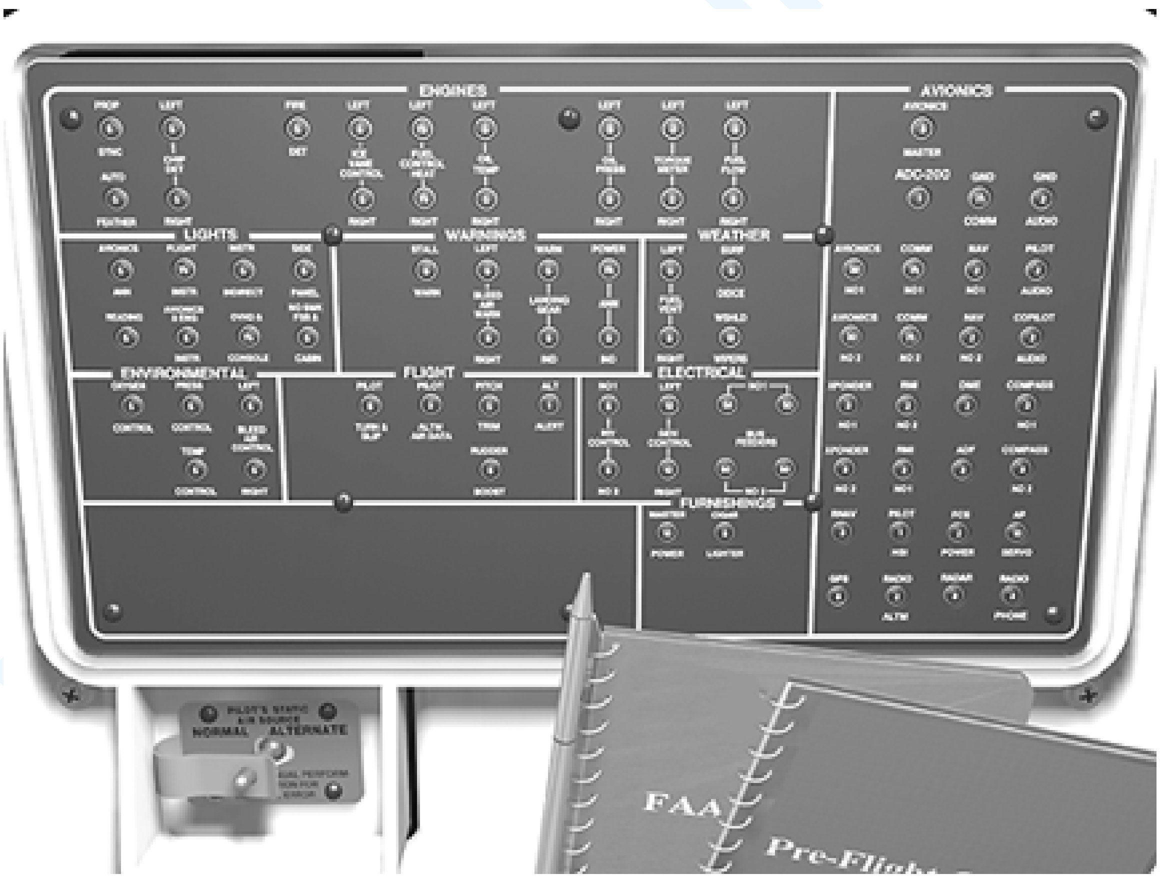
In the center of the subpanel is a group of annunciators which are considered less urgent than those in the glareshield. All the glareshield annunciators are red, and will illuminate the red MASTER CAUTION flasher. Those in this panel are either amber, and will illuminate the amber MASTER WARNING flasher, or green, indicating simple advisories only. Green lights do not illuminate either warning flasher. 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.

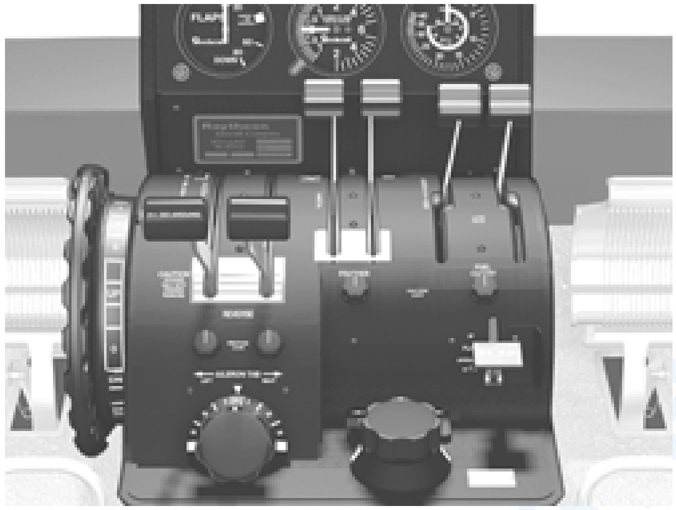
Almost all of the switches on the subpanel are actually "switch/breakers," combining the functions of a switch and a circuit breaker. An overload on any of these circuits will cause its switch to click back to the OFF position.

SIDE PANELS:

Circuits not controlled by switch/breakers have their own pop-out type circuit breakers on the left and right cockpit sidewalls. The left side panel also 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.



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; you've also got electric trim via thumb switches on the outboard horn of the yoke. 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 Auroras 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 "autofeather." When it's armed (normally only for takeoffs and landings), it monitors the torquemeters of both engines. If either engine loses power, the autofeather 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 autofeather, 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. Normally, it's not armed until just before takeoff, to prevent running the igniters unnecessarily at low engine power settings on the ground (they wear out, just like spark plugs—but they cost a lot more!).

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 Aurora 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 many of the later Auroras, 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 N_G 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 N_G 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, and 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 N_G continues to accelerate. At 50% N_G 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 N_G 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 N_G 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 u 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—while the engines make that characteristic mmmmMMMRRAAOOWWwww noise that turboprop pilots like so much.

The prop governors normally limit maximum RPM to 2000, and have a secondary limiter to prevent propeller overspeeds if there's a mechanical problem. Normally, this is set at 2080 RPM, which is higher than we can ever achieve in normal operation. However, there's a test switch, on the lower left subpanel, that resets this function to around 1850 RPM. With both engines at idle, make sure both prop controls are all the way forward. We'll check the rudder boost system at the same time, so make sure the RUDDER BOOST switch on the center pedestal is ON.

Hold the test switch to the PROP GOV position and slowly advance one power lever until RPM stabilizes between 1830 and 1910 RPM. Did the rudder pedal on that side move forward by itself? If not, continue to hold the switch, cautiously advancing the power lever, until you can verify rudder pedal response: power lever forward, rudder pedal forward. Return the power lever to IDLE and repeat the test for the other engine.

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 autofeather system. Hold the autofeather switch to the TEST position and advance both power levers together until you reach about 500 ft/lbs of torque. The L and R AUTOFEATHER ARM lights will come on. Now, slowly bring one power lever back. As torque passes through about 400 ft/lbs, the *opposite* AUTOFEATHER 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 an Aurora 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 Aurora than in the Kodiak.

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 autofeather 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 Flyhawk's normally-aspirated engine doesn't have enough grunt to hurt itself in the first place, and those of the Sahara and Kodiak 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 AUTOFEATHER 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 autofeather 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. (This, incidentally, 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 autofeather 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 Aurora 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 autofeather 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 Kodiak! As the swerve begins, you'll feel the right rudder pedal move forward, and it won't take as much leg pressure to hold the Aurora straight as it did the Kodiak. Moreover, 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 AUTOFEATHER 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_{YSE} 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 Kodiak 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 bit 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...

PEREGRINE 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 Kodiak, 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 Aurora). Unfortunately, the most significant labor-saving device in the Peregrine (or any other jet except the Cessna Citation) is not implemented in Fly! II.

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. Only the little Cessna Citation, which has very simple systems, a flight deck specifically designed for single-pilot operation, and cruise speeds low enough that it's sometimes laughingly referred to as the "Nearjet," is exempt, at least at the time this manual was written, from the two-pilot requirement.

Thus, if you sometimes feel a bit frustrated at the complexity of the Peregrine, 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 we'll cut you all the slack we can. Don't forget, too, that if you start feeling rushed, Fly! II has a capability not yet available in even the most sophisticated jets: just hit [P] to pause the simulation and take a breather!

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.

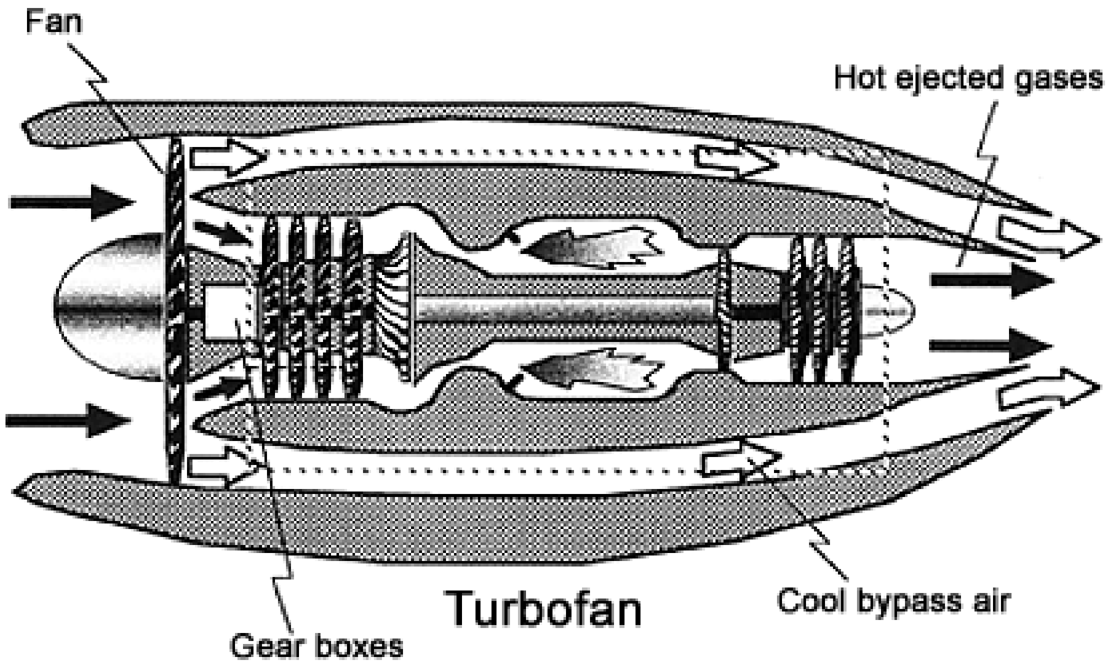
What makes a real difference is how *much* air gets shoved aft: you can either shove a lot of air slowly (a propeller) or a little air fast (a jet). The problem is that shoving air really fast is wasteful—there's no point in putting it out the back much faster than the airplane is moving forward. The 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 "frying air" crackle of an old "straight pipe" 20-series Learjet, Saberliner, or Jetstar taking off.

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 an awful 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 Peregrine, 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 Peregrine have a *bypass ratio* of almost 4 to 1—*i.e.,* some four times more air goes around the core engine than through it.

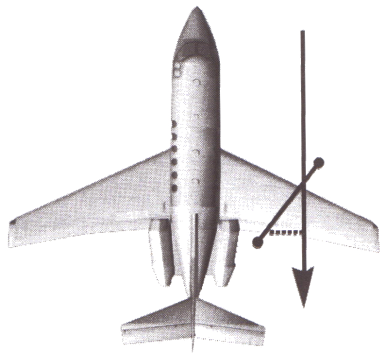


The cool air passing through the bypass duct doesn't get accelerated nearly so much as the hot gases coming out of the turbine, so it propels the airplane much more efficiently. In addition, it provides a "sheath" around the hot jet exhaust, allowing it to mix gradually with outside air, so turbofans 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:

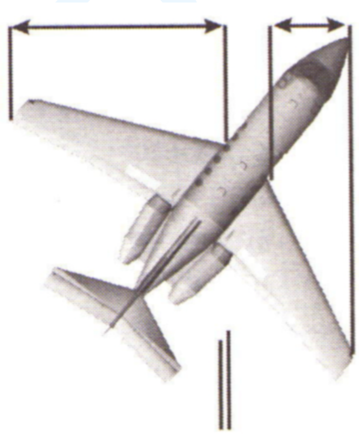
Until now, you've been flying straight-wing airplanes in a relatively low speed range, one in which airspeed was the primary factor. In the jet, however, you'll be flying at a significant fraction of the speed of sound, called *Mach 1* (after Austrian physicist Ernst Mach, who did much of the early research 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.



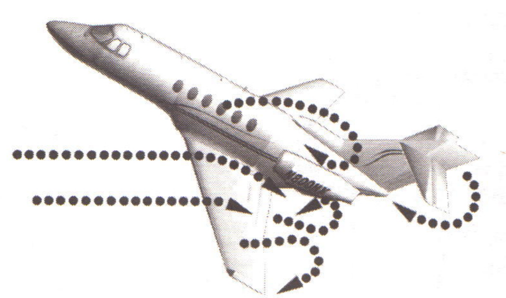
As it does, however, the "tailfeather effect" of the vertical fin, as well as the increased drag of the left wing, try to slew it back around to the left. The right wing starts to come back up, while the yaw switches around the other way. Unfortunately, it's out of phase with the rolling motion, so the 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 Peregrine 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 Peregrine 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:

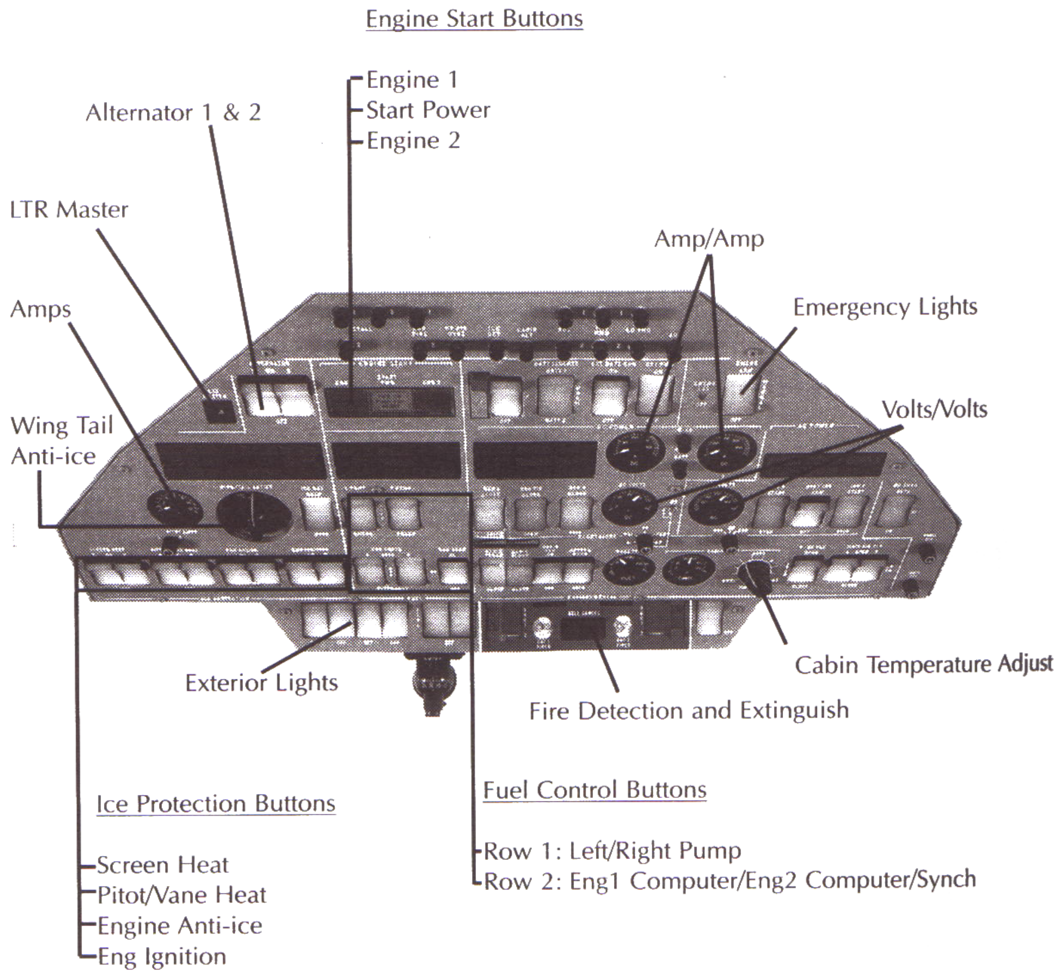
Don't!

Fortunately, the airplane itself has a strong sense of self-preservation in the form of an active stall prevention system. In the Peregrine, 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 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.



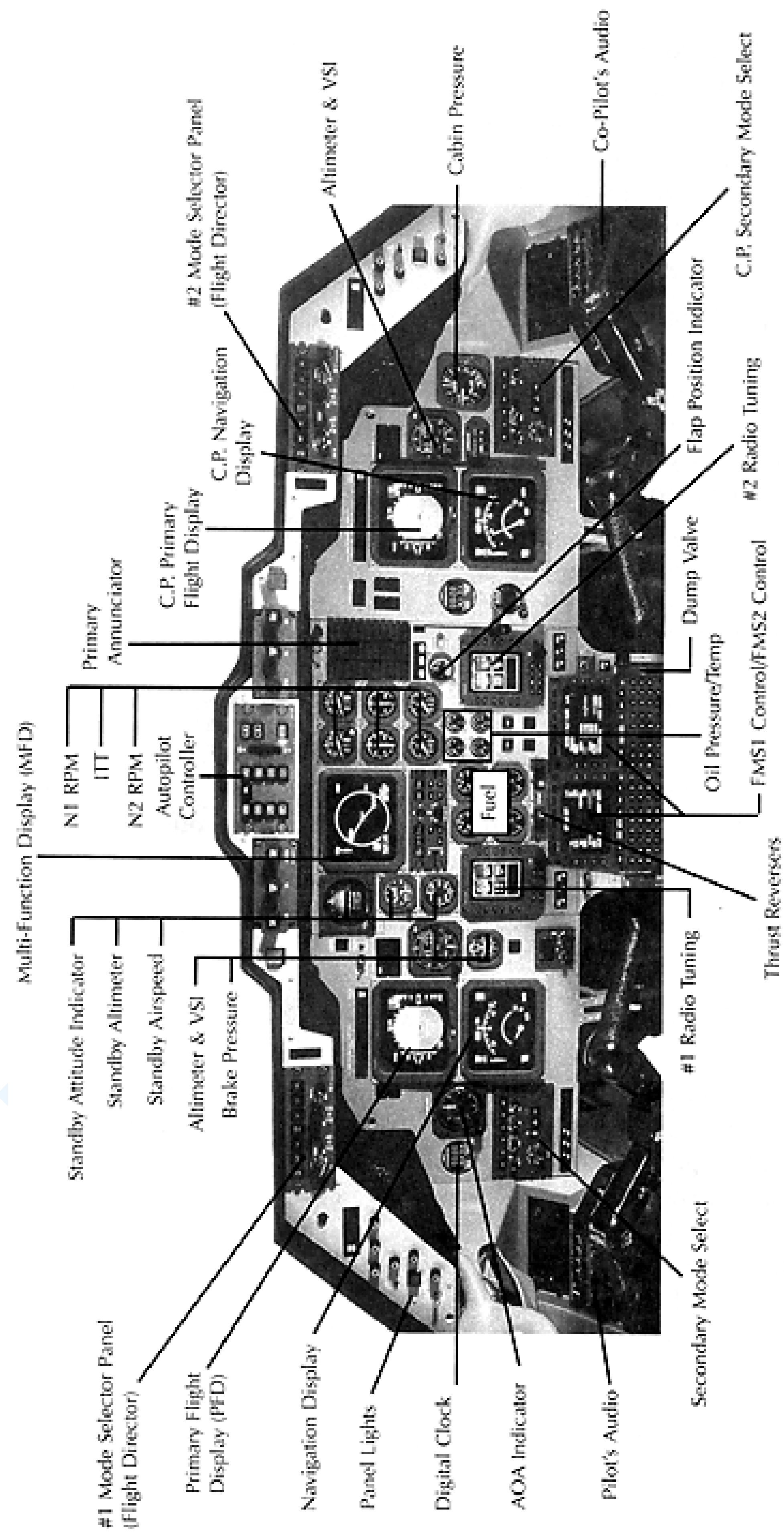
ROOF PANEL:

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.



#1 Mode Selector Panel (Flight Director)
Primary Flight Display (PFD)
Navigation Display
Panel Lights
Digital Clock
AOA Indicator
Pilot's Audio
Secondary Mode Select
Standby Attitude Indicator
Standby Altimeter
Standby Airspeed
Altimeter & VSI
Brake Pressure
Multi-Function Display (MFD)
N1 RPM
ITT
N2 RPM
Autopilot Controller
Primary Annunciator
C.P. Primary Flight Display
C.P. Navigation Display
#2 Mode Selector Panel (Flight Director)
Altimeter & VSI
Cabin Pressure
Co-Pilot's Audio
C.P. Secondary Mode Select
Flap Position Indicator
#2 Radio Tuning
Dump Valve
Oil Pressure/Temp
FMS1 Control/FMS2 Control
Thrust Reversers
#1 Radio Tuning
Fuel

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 at 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. The must be OFF for takeoff and landing to ensure full engine performance, but you should turn the ON as soon after takeoff as possible. Savvy Peregrine 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. Let's start with the glare shield, and we'll work outward symmetrically from the center. Right in the middle, where either you or your nonexistent copilot can get at it easily, is the altitude alerter/preselector. 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).

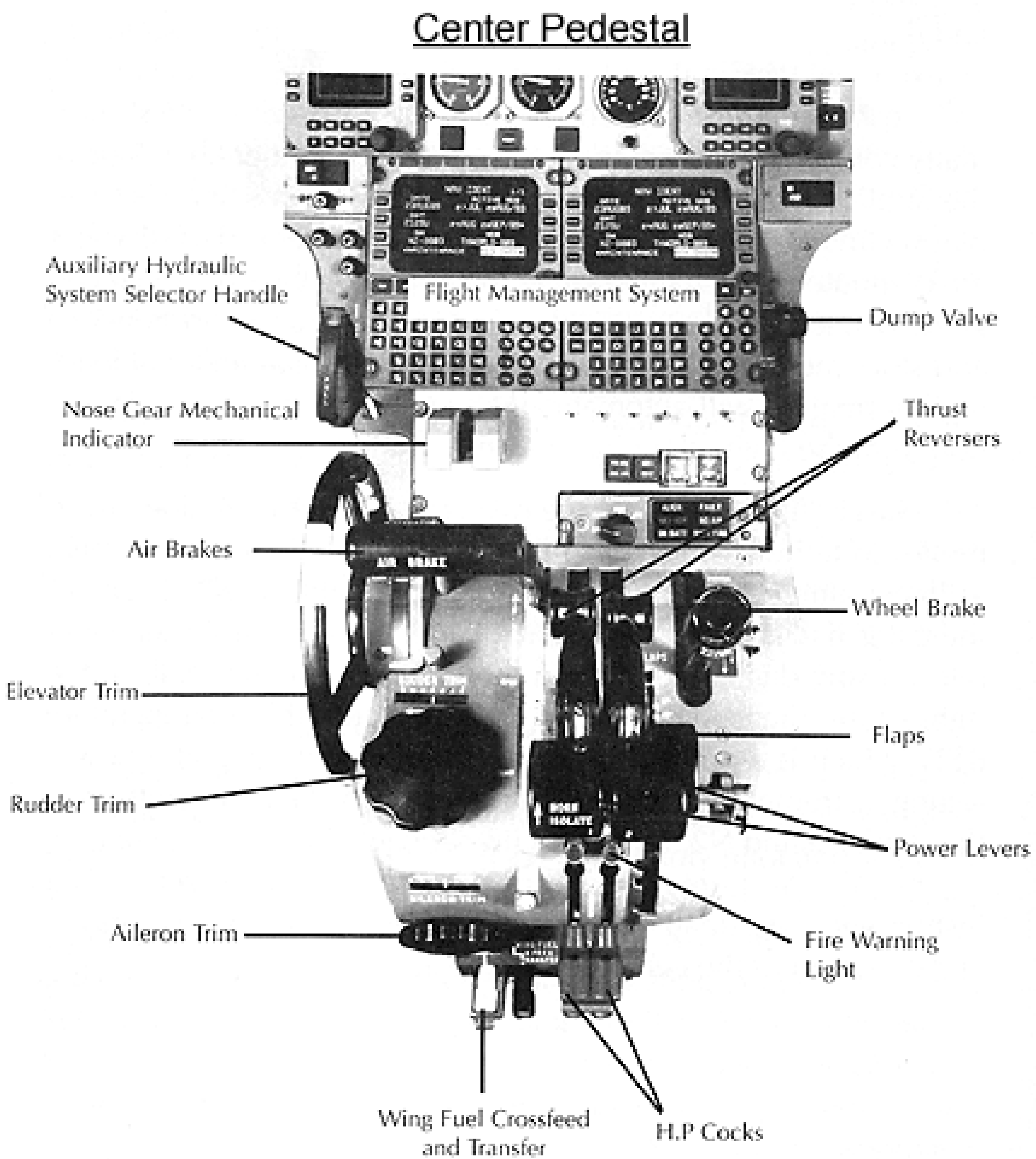
The "conventional" instruments—airspeed indicator, altimeter, VSI, etc.—aren't as conventional as meets the eye, either. Because of the wide range of speeds and altitudes at which a jet operates, they'd have very serious errors if the used only pitot and static air pressure inputs. Instead, they're operated 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 altimeter—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 are two standby artificial horizons: a large one just above the standby airspeed and altimeter, with built-in ILS cross-pointers linked to the #1 NAV receiver; and a smaller "peanut" horizon just above the copilot's airspeed indicator.

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, display navigation data, or even show checklists. Above 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. Below and to the left of the MDU is the autopilot and yaw damper control panel. To its right are the control heads for the dual Flight Mangement Systems (FMS). 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! II flight plan and fuel loading information will automatically be transferred into the simulation from the flight planning screens.) The small vertical section below the center of the main panel has the control heads for the nav, comm, and ADF radios and the transponders.

Just right of center are the two vertical rows of engine instruments. Fuel flow indicators are at the top, each incorporating a digital "fuel consumed" counter. In turbofan engines, the primary power setting instrument at lower altitudes is fan speed in per cent, labeled N_1. Each N_1 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.

Next down is N_2, indicating (in per cent) the speed of the core engine; this is primarily a limiting, rather than power setting, instrument. Below this is interstage turbine temperature (ITT), which is a limiting instrument at low altitude and a power setting instrument in high-altitude cruise. 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.



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; if the airplane has thrust reversers, their "piggyback" levers are on the front of the power levers. 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 Aurora'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!II to allow easy use on standard keyboard and joystick configurations.

Like most larger jets, the Peregrine 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. To start the APU, the airplane battery and start switches must be on. Once it's running (its start sequence is entirely automatic after pushing the START switch), its generator and bleed air supply can turned on to provide aircraft services including ground air conditioning and main engine starting.

ELECTRONIC FLIGHT INSTRUMENT SYSTEM (EFIS)

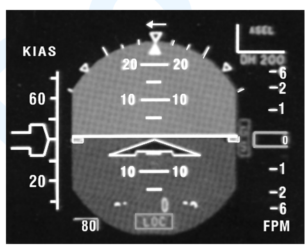
One of the most significant advances in cockpit instrumentation in recent years has been the development of electronic cockpit instruments, commonly referred to as EFIS. The installation in the Peregrine , while not as all-encompassing as the "all glass cockpit" or "Atari Ferrari" systems found in the 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 of 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—but to use it only that way would be to waste most of its capabilities.

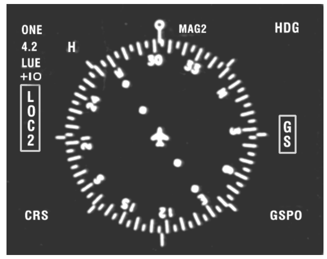
Finally, EFIS offers the capability of reversionary modes. If your ADI fails with a conventional system, you're "Sierra Oscar Lima." With EFIS, you can just switch it to the lower display. Still want both ADI and HSI information? Just select a composite mode that displays both on one screen. Signal generator failure? Just push a button and you can display the output from the one on the copilot's side on your instruments—or, for that matter, you can "borrow" the one from the center multifunction display to run everything!

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 (either the delta-wing "V-bar" or crosshairs, whichever you prefer—try *that* with a mechanical instrument!); 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 upper half of the HSI superimposed below the horizon.



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 at your option you can show *two* course arrows, each with its to/from flag and course deviation indicator, so you can monitor two nav sources at once. 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, VOR stations, course lines, etc.) and/or weather radar returns on this display. For instance, you could see at a glance what your position is relative to the desired course, and that there's bad weather over your next waypoint—time to call ATC and get a course change!

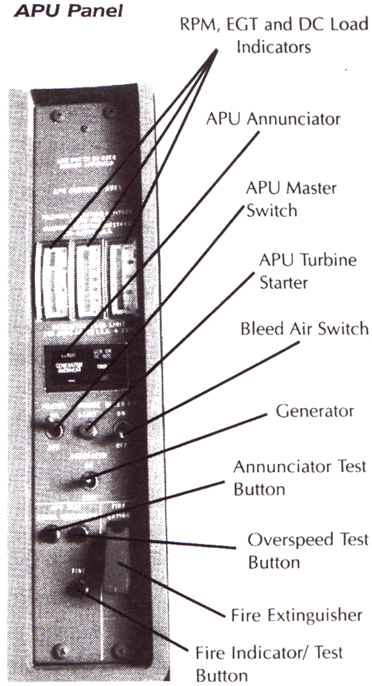


A complete description of the EFIS system fills up a full-size three-ring binder! In ***Fly!***, I suggest you simply play with it, using the display selector panel at the bottom of the instrument panel and the bearing selector panel at the top of the glareshield, to explore its capabilities. You can't 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.

APU Panel



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.

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 crossfeed/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 N_2 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, N_1, and N_2 should all be climbing. Maximum allowable temperature during start is 974 deg. C for not more than 10 seconds.

At 46% N_2, 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 takeoffs and landings are made with precalculated performance figures. The actual tables for the Peregrine fill a big book all by themselves. We'll provide a simplified version: enter the graph with your aircraft weight and altitude (we'll ignore temperature, but it's important in the real world), 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 takeoff, 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 attempt to justify their miserable existence.

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.

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! II 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.

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 according to the performance table 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) with his/her right hand while making the final throttle adjustment with his left. Then he’ll tap the back of your hand and say “power is set;” you’ll respond with “my throttles.” 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 should now take your right hand off the power levers and put it on the yoke. 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 #1 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 Peregrine 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.

With its generous wing area, the Peregrine's best rate of climb comes at relatively low indicated airspeeds around 200 KIAS or less. Many operators elect, instead, to hold a pitch attitude of no more than 15 degrees, accepting a minor decrease in efficiency in return for greater cabin comfort. Pitch angles greater than 15 degrees may feel quite uncomfortable for passengers, particularly those seated in aft-facing seats.

As you climb at a constant pitch attitude, you'll notice your indicated airspeed decreasing slowly. At the same time, however, your indicated Mach number (IMN), which you can see on your primary flight display, will be *increasing* as you gain altitude.

As you climb past 35,000 feet, you can improve fuel economy by setting the #1 and #1 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.) This is also a good time, if you haven't done it already, to 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).

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 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 our maximum altitude of 41,000 feet. Assume we're cruising at a fast M0.78. If the temperature is standard, that works out to a *true* airspeed of 447 knots. *Indicated* airspeed, however, will be only 230 knots.

At the other end of the equation, 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 particuarly 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 "low-speed buffet boundary." Entering the one for the Peregrine at 41000 feet and, say, 25,000 lbs gross weight, we find the allowable range between the low-speed and high-speed buffet boundary ranges from M0.64 to M0.70. At standard air temperatures, that's the equivalent of 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 Peregrine 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 V_{MO} or M_{MO}? 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 Peregrine 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, and

Step 5 (this is the one that floats people out of their seats): shove the nose down to either M_{MO} or $V_{MO,}$ 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 JFK controller ask an inbound Concorde, "...uh, Speedbird 5, could you descend 18,000 feet in the next 11 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 before you reach 10,000 feet; 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 V_{REF}. 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, bleeding off to Vref itself as you cross the threshold. 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. Bear in mind, however, that the airplane's landing runway length numbers are predicated on being exactly at Vref over the threshold. It's also a good idea to calculate a V_2 for your landing weight, just in case you have to go around and have the bad luck to lose an engine while doing so.

TOUCHDOWN:

Unlike in a lightplane, 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 have thrust reverse, wait until the nosewheel is on the ground, and you or the copilot are holding it there with forward pressure, before you pull up and back on the power lever "piggyback handles." *(To apply reverse thrust in Fly! II, hit [R] on the keyboard, then move the throttle forward.)*

CROSSWINDS:

SimTip

Toggle between forward and reverse thrust modes by pressing the R key.

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!

WINDSHEAR! WINDSHEAR!

One of the most dangerous conditions, and one which affects jets worse than some other aircraft, is wind shear—a sudden change in the wind's speed, direction, or both near the surface. A *positive* windshear means that your airspeed suddenly increases;

a *negative* one, which is usually more dangerous, that it decreases. Larger airports, as well as most modern jets, have systems to warn the pilot that this is occurring.

In either case, your best action is to get the (expletive, deleted) out of there. Even a positive windshear will, at best, make your final approach and landing flare unpredictable; and since windshears often come in pairs (all that moving air has to go *somewhere*), a sudden gain in airspeed on final approach may well be the harbinger of an equally sudden decrease a few seconds later. Whether or not you have this kind of warning, a negative windshear—where 15 or 20 knots of airspeed suddenly disappear while the airplane seems to sink out from under you—is a *very* nasty sensation.

Why are jets more vulnerable than smaller planes? Partly because they're heavier (particularly jumbos, of course), and thus it takes them more time to change their velocity in space. The other reason is that jets don't respond to power lever movement nearly so quickly as turboprops or recips: if you have the engines "unspooled" for final approach, it may seem to take forever before they're putting out useful power again.

The current philosophy for a positive windshear encounter is to transition to a missed-approach climb, adjusting power as necessary, and be prepared for a negative shear at any time. A negative windshear encounter, particularly if close to the ground, requires much more decisive action. *Immediately* pitch the airplane up to its normal takeoff attitude, and *immediately* apply *full* power. In fact, if in any doubt whatsoever, don't even glance at the power instruments, but apply "radar power," *i.e.,* shove the power levers forward until the knuckles of your right hand hit the radar screen in the panel! You *may* damage the engines (you probably won't if you get the power back below redline within a few seconds), but you definitely *will* damage them if you add insufficient power and hit the ground as a result!

Don't stop with that, though. As soon as you've pitched up and powered up, check your rate of descent. Still sinking? Then keep pulling, right up to the beginning of the stick shaker if you have to. This will give you the maximum short-term performance to keep from hitting the ground; once things have stabilized, aim for a more reasonable speed. Some modern EFIS systems have a very helpful display in windshear situations: a red line appears on the EADI showing exactly how close you are to stick shaker activation.

A PIECE OF CAKE:

As your final graduation exercise, we're going to lose an engine right at V_1. Taxi back, get the airplane configured for takeoff, and check the tables for the correct V speeds for your current weight. The Peregrine 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 V_1, 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 V_R, 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, would 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, and you're getting help from the rudder boost..

In fact, some jet manuals don't even specify a different set of V speeds for a single-engine approach (although you may fly somewhat faster due to a reduced flap setting). 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 Flyhawk—and about as far as we can teach you with this release of Fly! II. 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 the next add-on to Fly! II.

INTRODUCTION TO ROTARY-WING AERODYNAMICS

You're about to embark on an entirely new area of flight: the helicopter. Although flying a helicopter may not be inherently more difficult than flying a fixed-wing airplane (after all, look at all the high-school grads who learned to fly them very well during the Vietnam era), it can be very different. In fact, it can be so different that, given the choice, many helicopter instructors (including me) find it easier to teach someone to fly a helicopter from scratch than to cross-train a fixed-wing airplane pilot.

That being said, however, there are quite a few parallels—particularly if you look at the helicopter in the most literal interpretation of its generic name: a rotary-*wing* aircraft. Like any other heavier-than-air machine, a helicopter flies because of its wings.

Taken individually, a rotor blade is nothing more than a skinny wing flying at a very high airspeed; and, taken individually, it obeys *exactly* the same aerodynamic rules and principles as any other wing. Like any other wing, it can glide without power if necessary; like any other wing, it can be stalled.

It's when we examine this wing in the context of a helicopter, on which it's spinning around, that things become a bit more complex; and they become more complex yet when we start looking at the helicopter as a whole, and the way its various dynamic components interact both with the atmosphere and with each other.

A LITTLE HISTORY:

The dream of a heavier-than-air machine capable of hovering motionless in the air has been with us at least since the days of Leonardo da Vinci (if not, indeed, since the first time some caveman watched a hummingbird). With the appearance of the gasoline engine in the late 19^{th} century, a power source was finally available that was both light and strong enough to allow for some serious experimentation. By the time of the First World War, a few experimental test rigs (with rigid rotorlike horizontal propellers) had actually managed to heave themselves a couple of feet off the ground for a few moments at a time. Some could even hover, after a fashion—but, invariably, as soon as they attempted to move horizontally at any kind of speed, they became uncontrollable.

It wasn't until after World War I that a Spaniard, Juan de la Cierva, realized that the blades of any sort of lifting rotor or propeller had to be able to deal with very widely varying airspeeds as the whole assemblage moved through the air. His innovation of a hinge, allowing individual blades to flap up and down while rotating, allowed the construction of aircraft called "autogyros," which flew with a combination of unpowered rotors and airplane propellers. While capable of flying quite slowly, they still could not hover, or take off or land vertically.

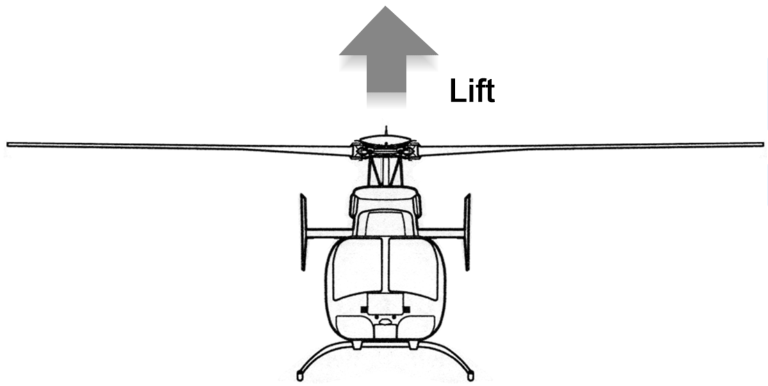
The step to actual helicopters came with the realization that it would be necessary to control each blade individually. Both the US and Germany had workable helicopters by World War II, although their use in combat was negligible, and development of helicopters has continued unchecked since then.

A SPLIT PERSONALITY:

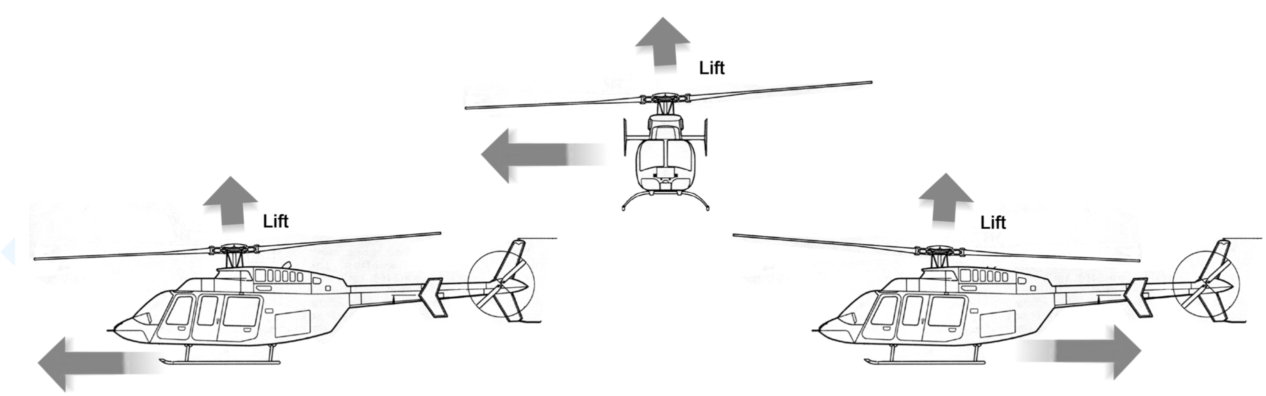
In a sense, a helicopter behaves like two entirely different aircraft, depending on whether it's hovering or flying at appreciable speed (which is called, in helicopterese, *in translation.)* When it's hovering or flying very slowly, you could equate its rotor system to a group of very small airplanes, flying in very tight circles. Once it gets some speed, however, it's more like an airplane suspended beneath a single circular wing (although one with some odd characteristics). Dealing with the change between these modes is one of the challenges of helicopter design and piloting. Let's look at the hovering situation first.

GOING NOWHERE:

The helicopter's rotor system is, indeed, similar to a very large propeller, and it runs at a constant speed. Like a constant-speed propeller on an airplane, the amount of thrust it delivers to the surrounding air is controlled by varying the pitch of its blades, all at the same time. This is called *collective pitch control,* and it's controlled by a cockpit lever called, appropriately enough, the *collective.* It's mounted along the left side of each pilot seat, somewhat like a handbrake lever; pulling it upward increases blade pitch.



Of course, if this rotor were just spinning in a rigid horizontal plane atop the aircraft, and doing nothing more than supporting its weight, the helicopter would be completely at the mercy of any movement of the air around it—it would drift about uncontrollably, like a balloon (as, in fact, you'll probably find it doing on your first attempts at hovering)! What's necessary is some way to tilt the rotor disc slightly, so that a small component of its lift can be directed in any desired direction, whether to keep the helicopter in one place (hovering), or to accelerate it in a desired direction (forward, backward, or sideward flight).

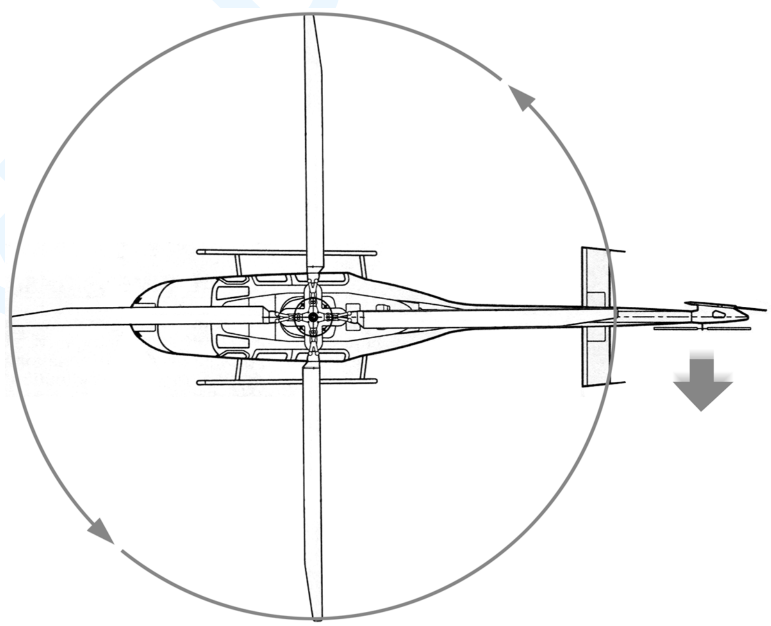


This is achieved by changing the pitch of each rotor blade, *one at a time,* as it sweeps through the applicable part of the circle. (For example, to fly forward, we'd want to tilt the rotor disc in that direction, so we'd want to decrease the pitch of each blade as it sweeps through the forward part of the circle, and increase it as it sweeps through the rear part.) Since this pitch change occurs once per circle, or cycle, for each blade, it's called *cyclic pitch control,* and the cockpit control that affects it is called the *cyclic* (pronounced either "sigh-click" or "sick-lick"—take your choice!) and mounted vertically in front of the pilot. (Actually, since the whole rotor system acts like a big gyroscope, the desired pitch change is applied 90 degrees before the point at which it finally occurs.)

The way this is done is by means of a device called a *swashplate.* We don't need to go into too much detail here; suffice it to say that it's a device on the rotor mast to which the pitch control links of each individual blade are attached. Moving the cyclic in the cockpit tilts the swashplate in the required direction, changing the pitch of each blade in turn, while moving the collective moves the entire swashplate up and down, changing the pitch of all the blades at once. Do you start to understand why a rotor hub looks so mechanically complex?

LET'S (NOT) TWIST AGAIN...

Of course, keeping the rotor turning means that the powerplant is putting out a lot of work—and since the helicopter isn't attached to anything, Newton's Third Law tells us that the engine is working just as hard to turn the rest of the helicopter the other way! Why doesn't the whole thing just spin round and round? (Early ones did, until they figured this part out!) Because of the efforts of the *antitorque rotor*¸ located at the tail of the helicopter and often called the "tail rotor." This closely resembles an airplane propeller, and works exactly the same way, producing thrust to offset the torque that's constantly trying to spin the helicopter around. Like the main rotor, it runs at constant speed (in fact, it's geared to it mechanically), so thrust is controlled by varying its pitch. The cockpit control for this is the pair of *antitorque pedals.*



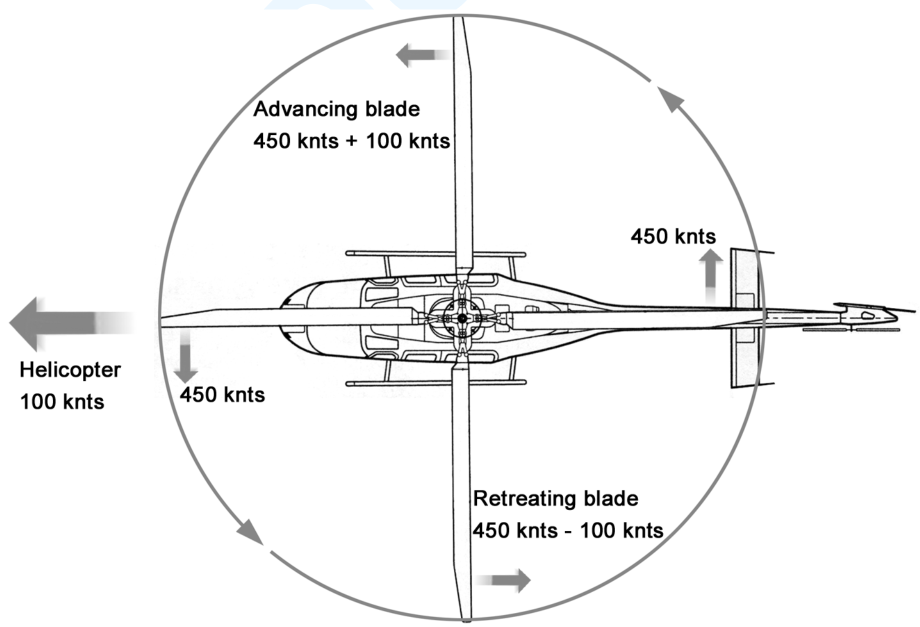
ONE GOOD TURN DESERVES ANOTHER...

Just to keep things interesting, the amount of power (and hence engine torque) required by the main rotor system varies constantly. If you want to climb, for instance, you'll pull in more collective. This applies more power to the rotor system and, in turn, increases the torque that's trying to turn the helicopter the other way. Thus, in an American helicopter, *an increase in power (collective setting) also requires an increase in left pedal deflection, and vice versa.* (Many European and Russian helicopters turn their main rotor the other way, so they'd require *right* pedal with a power increase. There's no particular advantage to one way or the other—it's just one of those weird things, like driving on the right in England.)

MOVING OUT:

Things become even more complex when we start to fly the helicopter in any particular direction at a speed faster than, say, a brisk jog. Let's say we're flying forward (the most common direction, after all) at 100 knots.

Now, even in a hover, the helicopter's little "wings" are clipping along at quite an airspeed. In the Bell 407, for example, at normal RPM the airspeed at the tips of the blades is almost 450 knots! When we're moving forward, though, the forward-going blades on the right side of the helicopter "see" a higher airspeed (550 knots at the tip), while the aft-going blades on the left side "see" a correspondingly lower airspeed (350 knots at the tip).



Obviously, the side with the forward-going blades is going to produce a lot more lift than the one with aft-going blades—and this is why the first attempts at helicopters would invariably fall over (to the aft-going side) as soon as they moved off from a hover. It wasn't until Cierva's flapping hinge that rotor systems could accommodate this *asymmetric lift.*

But wait...there's more...

Once a helicopter is moving at decent speed, its motion through the air produces additional lift over most of the rotor disc as a whole. This is called *translational lift,* and it's why it takes much less power to support a helicopter in forward flight than in a hover. Where you'll feel this is on both takeoffs and landings. As you lift into a hover, then gradually begin to gain speed, you'll feel the helicopter suddenly "come to life" and gain performance as it moves into translational lift. Similarly, as you begin slowing up toward a hover during a landing approach, you'll find yourself needing to add quite a bit of power as the helicopter begins to settle out beneath you. (If this proves to be more power than you have available at some particular combination of altitude and temperature, you're in trouble.) Don't forget, too, that every power change requires its corresponding change on the antitorque pedals.

DON'T FLY TOO FAST:

The faster you fly forward, the greater this dissymmetry of lift becomes, and the more cyclic pressure you'll need (to the right on American helicopters) to counteract it. Before you'd run out of control, however, something even more significant starts to occur at excessive speed. Remember, our forward speed is added to the rotor speed on the forward-going side, subtracted from it on the aft-going side. At some speed, we'll reach the point at which so much speed is being subtracted from the aft-going blades that they begin to stall.

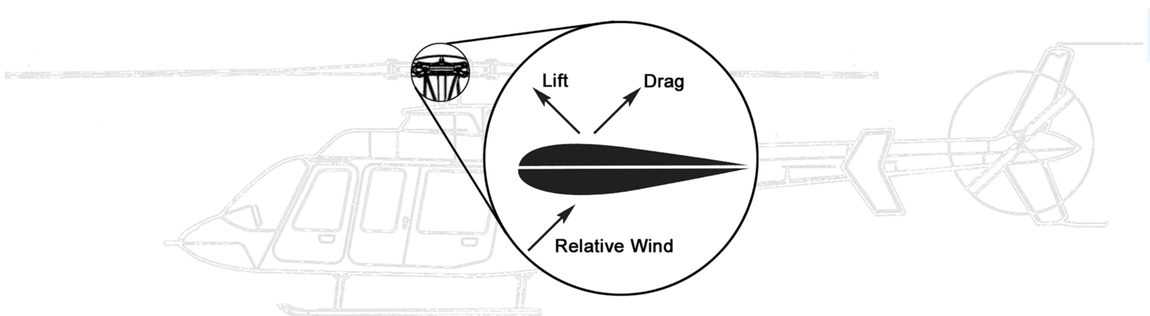
This is called *retreating blade stall,* and it's what sets the absolute upper speed limit for just about any helicopter (other factors may set lower limits). If you ever are so foolhardy as to seek it out, the first signs will be *very* heavy vibration, followed by a tendency to roll toward the stalling side (left in American helicopters).

Since the air is thinner at high altitudes, a higher blade angle of attack (more collective) is required to produce the same amount of rotor thrust. This reduces stall margins, which is why most helicopters (including the 407) have restricted high speed ranges depending on altitude.

WHAT IF IT QUITS?

This is the question that's almost invariably asked by the uninitiated—and their expectation is that if the engine fails, the helicopter will drop like a stone.

Luckily for us, it won't. Remember, the total aerodynamic force produced by *any* wing, whether fixed or rotary, is composed of both a lift and a drag component—and remember that if the relative wind is coming from below the chord line, the lift component is directed at least slightly forward. That's how a fixed-wing airplane glides—and if you think of rotor blades as little airplanes flying in a tight circle, there's no reason they can't glide in a circle, either!



What's critical, in an airplane as well as in a helicopter, is to reduce the angle of attack to prevent the wing (or blade) from stalling. In an airplane, that would mean lowering the nose; in a helicopter, it means to *immediately* reduce the collective all the way to the bottom of its range. Sure, the helicopter will descend—but it won't "fall out of the sky," but descend relatively gently. During this descent, the air flowing upward through the center part of the rotor, where blade speeds are relatively low, drives the blades and keeps them turning (while still contributing its share of lift). Out near the tips, where blade speeds are higher, even more lift is produced, although the blades themselves are also producing drag. This situation is called *autorotation,* partly because the blades are "turning themselves" and partly because, as old instructors like to say, they "ought'a rotate if you do everything right." The inner part of the blade is now considered the *driving portion,* while the outer part is considered the *driven portion.*

We'll cover autorotations in much more detail once we've gained a little experience with the helicopter. For the moment, let's get into the cockpit and start looking around.

COCKPIT TOUR:

Right off the bat, you'll notice something different. All the airplanes you've flown have been commanded from the left seat. The Bell 407, like most helicopters, is flown from the right.

This is, at least partly, a hangover from the bad old days when helicopters were even more unstable than they are now. You'll notice that I didn't say "less stable;" even the nicest current light helicopters are, at best, neutrally stable. Where an airplane, if disturbed from trimmed flight, will attempt to return to the trimmed condition, a helicopter will just go off in the new direction after the disturbance. Most helicopters are, in fact, *un*stable—they don't even need a disturbance to want to go off in a new direction, but are constantly trying to do so on their own.

What this means is that they *have to be flown every second*. For all practical purposes, *you can never let go of the cyclic stick*, which you hold in your right hand. The collective, on (and in!) the other hand, is a bit less critical—when you're not actively maneuvering, you can let go of it for a few seconds at a time. Therefore, it makes sense to put the pilot all the way over on the right, so that he or she can get to necessary controls with the left hand. Not that you want to stay away from the collective all that long, either—in the event of an engine failure, you need to lower the collective *right now* to avoid excessive loss of rotor RPM.

CONTROLS:

As mentioned before, your primary flight control is the cyclic, which isn't depicted in Fly! II, the antitorque pedals, and the collective. The latter two are visible in the view below the main instrument panel, which you can see by tapping [Ctrl+down arrow].

WHAT ABOUT POWER?

If you have your right hand on the cyclic, your left hand on the collective, and your feet on the antitorque pedals, how are you going to control the throttle?

Well, in a modern turbine helicopter like the 407, the answer is simple: you don't!

This wasn't the case in older piston-powered helicopters such as the 407's ancestor, the Bell 47 (the "mosquito carrying a flashlight bulb" you see in the opening credits for M*A*S*H, for example). In those machines, the throttle was controlled by a motorcycle-style twist grip on the collective, which is why such helicopters (as well as the iron men and women who flew them) were called "throttle twisters." Helicopters of this era had mechanical linkages between the collective itself and the throttle, called "correlators," whose purpose was to minimize the amount of throttle-twisting required; depending on the model of helicopter, the flight conditions (altitude, temperature, gross weight, etc.) these worked after a fashion—but there was still plenty of throttle twisting required.

With the advent of gas turbine power, the helicopter pilot's workload was suddenly reduced: these engines have automatic governors or regulators, and when working properly throttle management becomes almost a "set it and forget it" evolution. In extreme conditions, however, or when maneuvering hard, it's still possible to "get ahead" of these governors, leading to engine overtemperatures or RPM "sags."

The latest technology, which is installed on the 407, is FADEC—Full Authority Digital Engine Control. When this is operating correctly, there's no direct mechanical connection between the collective and its twist grip throttle and the engine. Instead, an electronic computer (the Electronic Control Unit, or ECU) measures a whole raft of parameters including engine and rotor RPM, temperature, altitude, collective position, etc. and provides not only virtually instantaneous power response with no overshoots, but protection against overtemperature or overspeed. It also makes engine startup a fully automatic sequence.

In normal flight, the twist-grip throttle is simply positioned to its "FLY" detent and left there. In case of FADEC failure, the system reverts to manual mode and the engine can be controlled by the twist throttle.

Let's take a quick look at the overhead panel, which controls some important functions, and then move on to the main instrument panel. Tap on [Ctrl+up arrow] to see the overhead panel.

That big red handle at the aft end is the rotor brake, which is used *only* during engine shutdown, and then only after the rotor has slowed down below 40% RPM. Make sure it's released before engine start—and when you shut the helicopter down, make sure the blades are parked at a 45-degree angle to the fuselage. This is to avoid heat damage to the fiberglass blade if it were parked right above the hot exhaust duct.

Circuit breakers protect all the helicopter's electrical services. Notice the two small toggle switches at the front of the circuit breaker panel. These control a couple of fuel pumps, and the left one is hot-wired to the helicopter battery. This means that if you don't make a point of shutting it off during your shutdown procedure, you'll come back to a dead batter next time.

NOTE—in the actual helicopter, the overhead panel is mounted in the ceiling, and all switches are moved forward to turn them on. When viewed on your computer screen, this means that switch handles move DOWN to turn on, UP to turn off. This applies only to the overhead panel; switches on the main panel or control pedestal move in the normal "UP=ON" direction.

Ahead of the circuit breaker area is the main switch panel, and the most important switches are in the forward (bottom) row. From left to right, they control the hydraulic control boost ("power steering," if you like), the anticollision light, the inertial particle separator if installed (this keeps foreign matter, such as snow, dust, or loose grass out of the engine intake, but costs a bit of power), the generator, and the battery master. The battery switch is turned on before startup, and turned off last after *shutdown; turn it off prematurely, and you'll lose such things as all the engine instruments while the engine is still winding down.*

Now hit [Ctrl+down arrow] and we'll look around the main instrument panel.

MAIN INSTRUMENT PANEL

Across the top of the panel are three rows of caution and warning lights. Most of the yellow ones are of the "land as soon as practical" variety, although "fuel low" and any of the engine or transmission chip lights (meaning that metal chips have been detected in the oil) qualify for the more immediate "land as soon as possible." So do the red lights; obviously, if you get the "engine out" light, you don't have much choice. The one you really don't want to see is the red RPM light, meaning that rotor RPM is dangerously low, and you're approaching blade stall, and this light is reinforced by a loud horn. Your reaction should be to get the collective down now¸ and establish a steady autorotation; then, and only then, sort out the problem if there's sufficient time and altitude.

The large push-button to the right of the caution and warning lights tests them all simultaneously.

The main instrument panel itself has three rows of large flight instruments at the right, and two rows of smaller engine instruments at the left. The first two instruments down from the top in the leftmost row of large instruments are the two most important ones for flight.

FLIGHT INSTRUMENTS

Right at the top, in the center of the panel, is the airspeed indicator. You'll notice that it reads quite a bit lower than those you'd find in an airplane. It also has not one, but two redlines. The highest, at 140 KIAS, is the absolute limit for the helicopter, but it only applies at low altitudes. At higher altitudes and/or temperatures, lower maximum speed limits apply; they're placarded in the cockpit.

The other (striped) redline, at 100 knots, is applicable under a number of conditions, including flight with any (or all) cabin doors removed, flight at high gross weights, and autorotations. If the placard maximum speed for a given altitude is lower than 100 KIAS, the lower speed applies.

Not shown is another limitation. Due to the possibility of interference between the antitorque rotor and the tail boom if full left pedal is applied at high forward speeds, an automatic device restricts pedal travel at higher airspeeds. If this system is disabled, maximum speed is restricted to 60 KIAS.

Just below the airspeed indicator is an even more important instrument: the dual tachometer. Remember, what's most important in a helicopter is the airspeed over the blades; obviously, that's directly related to their RPM. On the dual tachometer, the inner needle, labeled Np (for Powerplant) shows the RPM of the engine's output shaft; the outer needle, labeled Nr (for Rotor) shows the RPM of the main rotor. Both are expressed in percent of maximum; at 100%, the rotor is turning at 413 RPM (and the engine output shaft at just over 6000).

In normal operation, the two needles will be "married" at 100% RPM. In fact, you'll notice that the allowable range for Np is extremely narrow—basically, 100% RPM, period.

The allowable range for the rotor is somewhat wide (from 85% to 107% RPM), but you'll see that only under very abnormal circumstances, and only when the transmission and rotor system are decoupled from the engine for some reason (for example, if the engine has failed). In this case, you'll see split needles on the tach.

To the right of these instruments are standard flight instruments (artificial horizon, HSI, altimeter, and VSI). For our purposes, we can consider these relatively unimportant: since the 407 is not certificated for instrument flight, and since it's typically flown at low altitudes, it's generally operated primarily by the time-honored practice of looking out the windows. In fact, helicopters in general, and light ones like the 407 in particular, are one of the last bastions of true "seat of the pants" VFR flying. Below the flight instruments is the indicator for the ADF. You can select navigation information from either the GPS or the VOR receiver to be displayed on the HSI by using the push-button switch at the right edge of the instrument panel.

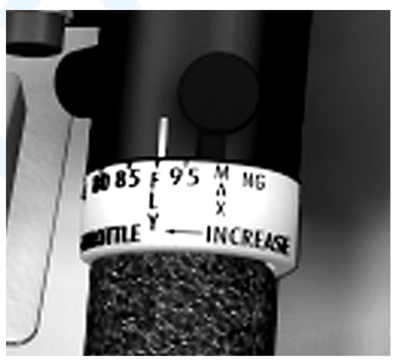
ENGINE INSTRUMENTS

The engine instruments are arranged in two vertical rows just to the left of the flight instruments, with the three most important ones right next to the airspeed indicator and dual tachometer.

At the top is the torquemeter, which indicates directly how much power is being supplied to the rotor. This is your primary power setting instrument, and is affected directly by movement of the collective.

Next down is MGT, which stands for Measured Gas Temperature—the temperature of the stream of hot gas in the engine. While the torquemeter is your power setting instrument, MGT is your power limiting instrument: at higher temperatures and/or altitudes, you may reach limiting engine temperature before you have obtained all the torque you might like. In this case, you'll just have to be content with what power (torque) you can obtain. You'll notice a couple of red markings beyond the redline. The first, at 843 degrees, is a start limit; you should abort an engine start if MGT goes above this mark for more than a couple of seconds. The second, at 905 degrees, is an absolute limit beyond which any engine operation will be recorded immediately as an exceedance.

Below this, and the third of the "really important engine instruments," is Ng—the RPM of the gas generator portion of the engine. Like rotor RPM, this is calibrated in per cent (if for no other reason than that the actual number—over 50,000 RPM at high power—would make the gauge pretty crowded). In normal operation, with the FADEC operating properly, this can be pretty well ignored. If FADEC fails, however, you should match the setting on the twist-grip throttle to the indicated Ng; markings are engraved on its bezel ring for the purpose.



All three of these instruments have LCD displays for highly exact readings. In addition, all of them constantly monitor their values. If any value is exceeded, it will begin to flash as a warning to the pilot to reduce power immediately; the "check instr" light at the top of the panel will also flash. After a few seconds of flashing (it varies depending on the parameter), flashing will cease and the date, duration, and value of the exceedance will be recorded. The digital display in the instrument will display the letter "E" and the value of the exceedance for 11 seconds. The "check instr" annunciator will remain on until you push the "instr chk" button just below it.

You can tell that there's been an exceedance (which, in the real world, would be reported to maintenance) when you first apply electrical power before startup: the affected gauge will once again display the E and exceedance value, and won't indicate correctly until you acknowledge it by pressing the "instr chk" button. In the real world, this information remains stored in the helicopter, and displayed every time it's powered up, until cleared by maintenance using a laptop computer.

The remaining engine instruments monitor parameters such as oil pressure and temperature for both the engine and transmission, fuel quantity and pressure, and generator output. The top left instrument is a digital clock, which also displays outside air temperature and system voltage (selected by the red button at the top). Don't try a battery start unless you see at least 24 volts, or a hot start is likely.

There are also a few important switches and buttons on the main panel. At the bottom right, with a red guard to secure it in the ON position inflight, is the master fuel valve. Normally, it's turned off after shutdown (which also cuts the left and right fuel pumps), but in an emergency (such as complete loss of engine control), it provides a last-ditch way to shut down the engine. To its left is the FADEC switch; successive pushes change from FADEC to manual mode, annunciated on the switch. This is normally used only to deal with FADEC malfunctions. At the extreme right edge are two more switch/annunciators; one, mentioned above, switches the HSI display from the Nav 1 receiver to the GPS; the other overrides the high-airspeed left antitorque pedal block (for example, to restore full pedal travel at low speeds if the block fails to disengage). At the top, just below the red RPM warning light, is a button to mute the various warning horns.

Finally, tap once again on [Ctrl+down arrow] to take a closer look at the collective. You'll notice the twist-grip throttle, with its calibrations for approximate Ng when operating in manual (non-FADEC) mode. Next to these markings is a small, round silver button. This is the idle stop release. Once the engine is running, the twist grip can't be rolled off to the "stop engine" position unless this button is pushed and held.

There are two switches on the head of the collective lever. The left one allows you to turn the landing lights on and off without moving your hand away from the collective. The right one, spring-loaded to its center OFF position, controls the starter. For a normal FADEC start, it only has to be held momentarily to the START position; the starter will then remain engaged, shutting off automatically at the conclusion of the start sequence. To manually disengage the starter, hold the switch briefly in the DISENGAGE position.

LET'S FLY!

Control issues:

It's very difficult to fly the Bell 407 without some form of tail rotor control (either a "twist" yaw axis on your joystick, or (much better) separate pedals. If you don't have either of these, the default keys for tail rotor control are [ins] and [delete] for left and right, respectively. If your keyboard is laid out with these keys above and below each other, rather than left and right, you may want to reconfigure them using the Options-->Keys and buttons-->Helicopter keys menus.

In its default configuration, Fly! II assigns the collective pitch lever to the throttle on your joystick (or a separate throttle if you're using one). In an actual helicopter, you add power by pulling up on the collective. Therefore, for maximum realism, you may want to use the Options-->Setup Axes... menu to "swap" the throttle's direction of motion, so that full forward is idle and fully back is maximum power.

STARTUP AND RUNUP:

Bell's startup checklist "flow" goes from a brief visit to the collective, up to the electrical switches in the ceiling, then down to the panel. Tap [Ctrl+down arrow] to see the collective. Check that you can move the twist-grip throttle all the way from OFF through FLY and back to OFF. (Keyboard shortcuts: [Ctrl+pg dn] for OFF, [Ctrl+pg up] for FLY. While you have the collective in view, check that the landing lights switch is OFF, so that full battery power will be available to the starter.

Now tap [Ctrl+up arrow] twice to move to the overhead panel. All switches should be OFF except HYD (hydraulic control boost) and the anti-collision light. Check that the rotor brake is released (handle up against the ceiling) and all circuit breakers are in. Now turn the BATT switch ON.

Tap [Ctrl+down arrow] to return to the main instrument panel, where all sorts of things should be happening. You should hear the low rotor RPM warning horn (cancel it if you like by pushing the horn mute button below the RPM warning light, which will be on). Within 3 seconds, a number of engine and FADEC caution lights will illuminate, and you'll hear the (different) engine out warning tone for a moment. A few seconds later, you'll hear it again, and the ENG OUT caution light will come on. Mute the horn once again.

If you haven't wasted any time getting down to this panel, you may also see the engine instruments sweep to the tops of their displays, then back down, while illuminating all segments in their LCD readouts, as part of their power-up self test. During this test, the Nr indicator (rotor needle in the dual tach) will go to 107%, and the Np (powerplant needle) will go to 100%. If you want to run this test later (with the engine running), just hold the LCD TEST button.

Now it's time to start the engine, which is much easier with FADEC than in past helicopters. In those, you had to hold a starter button, then manually twist the throttle open until the engine fires up, then carefully modulate it to keep the RPM accelerating while avoiding overtemperatures. In fact, that's still the way you'd start the 407 if you had a FADEC autostart failure. (If the FADEC fails altogether before takeoff, rather than just in its start mode, it's a no-fly item...so "fuhgeddaboutit".

With FADEC, it's a lot easier. Make sure the collective is all the way down, and move the cyclic until the CYCLIC CENTERING caution light extinguishes. Go briefly to the overhead panel and turn on the two boost pump switches at the lower left of the circuit breaker panel; return to the main panel, check that the red-guarded fuel valve switch at the lower right is on, then verify that fuel pressure is showing (leftmost row of instruments, second one down, left display). As long as you're over on that side, verify that the FADEC is in AUTO mode, and press-to-test the rudder stop—it should go to the ENGAGED mode as long as you're holding the button.

Here we go, and the order is just the opposite from a manual start. First, rotate the throttle twist grip to IDLE. Then, momentarily move the starter switch on the collective head to the START position. (You have to do this within 60 seconds of moving the throttle to idle, or the system "times out." If it does, just roll the throttle to OFF, then back to IDLE, to reset the timer.)

From here on, the start cycle is automatic. Monitor the engine instruments as the engine spools up. If it goes over the first triangular red mark beyond the redline, or if the main rotor hasn't started to turn by the time you get to 25% Ng RPM, abort the start by rolling the throttle back to OFF.

In a normal start, however, things will spool up very nicely without further attention. At 50% Ng, the starter will disengage, and the START light will go out; at 60%, the ignition is no longer needed, and the AUTO RELIGHT light will go out. The engine should settle down at 63% Ng. Now you can go back to the overhead panel and turn on the flight instrument switches and the avionics master switch.

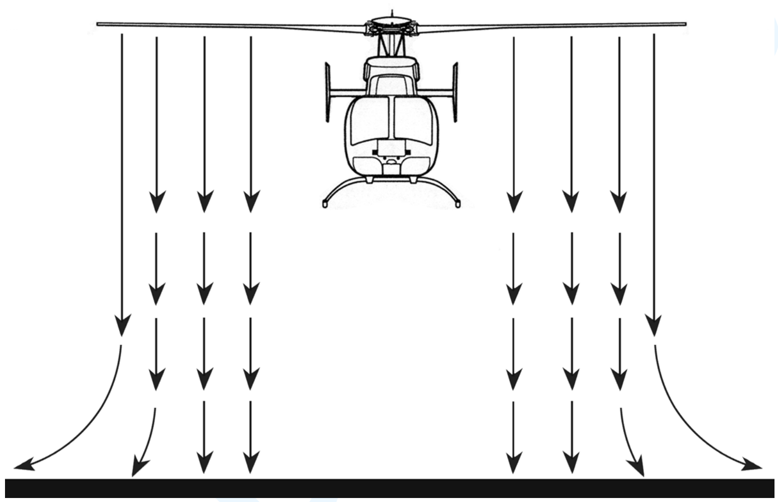
Since we don't have control feel in Fly! II, we can't really check what the helicopter feels like with the hydraulic control boost switched off, but we can still do the preliminary check and, later, verify that it still responds to the controls. Turn the HYD switch off and verify that the HYDRAULIC SYSTEM caution light illuminates; then turn it back on and verify that the light extinguishes. More important is the FADEC manual mode check: push the FADEC switch on the panel, verify that the MANUAL mode light illuminates, then make a slight adjustment to the throttle twist grip (use the mouse) and verify that the engine follows you. Return the throttle to idle and re-engage the automatic FADEC mode.

Almost ready to fly! Roll the throttle up to its FLY detent and wait for both Np and Nr to stabilize at 100%. Turn the HYD switch off and make some gentle control inputs on all three controls to verify that there's no uncommanded movement, and that you have control. (In Fly! II, you can see the edge of the rotor disk move in the forward view as you do this.) Turn the HYD switch back on.

LIFTOFF TO A HOVER

The first thing we're going to do is simply lift off to a normal hover (with the skids 4 to 6 feet off the ground.) Look straight ahead out the windshield (not at the ground right in front of you) and slowly start raising the collective. You'll see the torque begin to increase.

Before the helicopter even begins to lift off, it'll get light on its skids, and it may begin to turn to the right. Gently feed in left pedal until it stops trying to turn; then, as you gradually continue to add collective, add left pedal at the same rate. When you've reached sufficient power, the helicopter will lift off. Immediately "freeze" the collective; the helicopter will probably rise to just about the right hover height pretty much by itself.



HOVER EFFECTS:

Why does it do this? Because when it's hovering near the ground (called in ground effect), the helicopter in effect "stuffs" a cushion of air between itself and the surface; this effect is perceptible up to about half the rotor span above the ground. It would take much more power to hover out of ground effect, which is why helicopter performance charts include both "hover in ground effect" (HIGE) and "hover out of ground effect" (HOGE) listings. You'll notice that for a given temperature and gross weight, the helicopter can HIGE at much higher altitudes than it can HOGE (or, for the same altitude, it can HIGE on a much warmer day than it can HOGE). On this particular liftoff, by time you've pulled in enough collective to lift off, you probably have enough to hover a couple of feet off the ground, so the helicopter can seek its own balance between available power and the effect of the ground cushion.

If you've set the various helicopter effects to "realistic" in the Options-->Realism-

->Helicopter... menu, you'll probably also notice that you're drifting to the right, and that it takes a little left cyclic pressure to stay over one spot.

This is an effect of the antitorque rotor. Remember, as the rotor turns to the left (from your cockpit viewpoint), the whole helicopter is trying to turn to the right; that's why you added left pedal as you pulled collective. The tail rotor is pushing the tail to the right to counteract this—but in doing that, it tends to push the whole helicopter to the right as well. Watch an American helicopter in the hover, and you'll notice that its roll attitude is very slightly left-skid-down. In the 407 this effect is quite small, since the rotor mast is installed with a slight built-in left tilt, but it's still perceptible.

Try to be as gentle as possible on the controls—a helicopter (particularly one with hydraulic control boost like the 407) is flown with pressures, not movements. In the real helicopter, you should hardly see the cyclic move at all. In fact, if you watch a good, smooth helicopter pilot at work, it doesn't look as he or she is flying at all, but rather very slowly and gently playing some sort of exotic musical instrument.

For the moment, just try to stay at least near, if over, one particular spot. A stable hover is probably the most difficult thing to learn at first; it can be taught to some extent, but then it has to be practiced. The trick is to make, and then remove, very small, smooth corrections; about half a second before you realize that you need them! (A good exercise is the old trick of trying to balance a broom vertically above your hand.) It is also helpful, as mentioned above, not to look at the ground right in front of the helicopter, but rather out toward the horizon.

It can be frustrating, but also very gratifying. It's very common for the final leap to competence to come very suddenly—you'll spend hours thrashing around, with sweat pouring down your face (and remember, you can't let go of the controls to wipe your eyes!)—then, from one moment to the next, "the nickel will drop" and the helicopter will suddenly become stable.

PEDAL TURNS:

Once you have the helicopter reined into a stable hover, try a couple of pedal turns: apply a small amount of pedal in the desired direction to slowly turn the helicopter. You may notice that a left pedal turn makes the helicopter sink just a bit, while a right one may make it rise. This is because a left turn requires more blade pitch from the tail rotor, and hence more power, which it takes away from the main rotor; a right one requires less. With practice, you'll make the almost infinitesimal collective correction without even thinking about it.

In fact, not thinking is the key to successful hovering (and, to a lesser extent, helicopter flying altogether). Not that I'm suggesting that you "dumb down." It's just that will all the controls affecting not only the helicopter, but each other, and all the sensory cues coming in at once, no one can think fast enough to handle it all. You need to practice until you make and remove the myriad control corrections on a subconscious level—sort of like rubbing your belly and patting your head, writ large. It may be that the reason it's easier to hover while looking at the horizon is that you get your visual cues from peripheral vision, which is processed subconsciously, rather than staring directly at a target and thinking about it.

HOVER TAXI:

Now let's try moving slowly around the immediate area—and by that, I mean not much more than walking speed. Why do I emphasize slowness?

Because we still want to make this a hovering maneuver, which means we don't want to "fall off" the invisible ground cushion. Move a bit too fast, and the downwash of air through the rotor can't replenish the cushion fast enough. Move faster yet, and we'll start encountering translational lift before we're quite ready.

To start moving, apply very gentle pressure to the cyclic in the desired direction; as soon as the helicopter starts to move, take out at least half of what you just put in. To slow down, use gentle cyclic pressure opposite the direction of movement.

Moving forward is easy. Moving sideways is a bit less so; because it has "tailfeathers," the helicopter will want to point its nose in the direction it's moving, so you'll need just a bit of opposite pedal. Moving backward is hardest, because the tailfeathers want to spin the helicopter around; you'll need to pay close attention, using either pedal as necessary. Real-world helicopter students spend hours hovering along taxiway lines and airport markings for practice.

SETTING DOWN:

Let's end this segment by setting the helicopter back on the ground. Get back to a stationary hover (or as close to one as you can manage), pick an object out ahead to look at, and begin slowly lowering the collective. Remember, as you reduce power, you'll have to apply right pedal to keep the helicopter pointed in the same direction. If you're moving over the ground at all, make sure it's forward: the helicopter can actually "run on" to its skids quite nicely, but is likely to fall over if there's any sideways component.

This is a great way to demonstrate the ground cushion, too. If you start from, say, a 6-foot hover, then make only a tiny collective reduction, the helicopter will just settle a couple of feet, then stop descending—you've gotten down to where the ground cushion is thicker. It'll actually take a very slow, but continuous, downward motion of the collective to land the helicopter—the feeling is almost that you're pushing it onto the ground. Once the skids touch, smoothly lower the collective all the way to the bottom.

THE HOVERING AUTOROTATION:

It may seem paradoxical to introduce an autorotation this early in your learning process, but there are some good reasons. One, of course, is that the helicopter doesn't know or care how much or little experience you have; it may choose to shut down, for its own reasons, anytime. Another is that a hovering autorotation is pretty easy, at least compared to some others you'll encounter.

A final one goes back to my own training, these many years ago. In those days, my instructor had found a loophole in the FAA regs stating that a student pilot could fly a helicopter alone, even before any official endorsement for solo, as long as the aircraft was "tethered to the ground." The local FAA office's interpretation of "tether" was any physical connection, no matter how flimsy, between the helicopter and the ground, so once I'd mastered (or, more accurately, managed) a halfway decent hover and could perform "safe, if not elegant" hovering autorotations, my little piston-powered helicopter was equipped with an old Dodge brake drum, tied to one skid by a 10-foot length of parachute cord. "As long as you don't pick up that brake drum, you're legal," I was told, "now get out there and practice." I spent hours practicing hover maneuvers and chugging along the taxiways of our big old WWII training field in the midwest; by the time my instructors decided it was time to continue my training, that brake drum was worn down to a thin, gleaming crescent. It's still a great way to practice.

Let's try a couple. This is a good time to enlist the help of a friend, since you'll "run out of hands" otherwise. Lift off into a normal hover, and when everything is stable, have your friend cut the engine, either by turning off the fuel valve or by hitting [Ctrl+pg dn].

Two things will happen: the helicopter will settle, and it'll yaw—fairly hard—to the left. Why the yaw? Because the tail rotor is still trying to compensate for all the torque that's suddenly not there anymore. Smoothly apply right pedal to stop the rotation and simultaneously smoothly raise the collective to cushion the touchdown.

A WORD ABOUT ROTOR ENERGY:

Obviously, as soon as the engine quit, the main rotor started to slow down (although you were probably too busy to watch the tach). How fast it slows down depends on a number of factors, but a significant one is how much energy is stored in the rotor system as inertia.

A high-inertia rotor system is one that's quite heavy, often with long blades—in fact, in some helicopters, additional weight in the form of chunks of depleted uranium is added to the blade tips. High-inertia rotors tend to maintain their speed longer after an engine failure. The 407's predecessor, the LongRanger, had a fairly high-inertia rotor; in a hovering autorotation from a skid height of a couple of feet, if you just chopped the throttle, kept the helicopter straight with the pedals, and did nothing at all with the collective, it would sit down pretty firmly...but not hard enough to break anything. The JetRanger's big brother, the Huey, had an even higher-inertia rotor system. I've seen experienced military pilots do a complete autorotation from a couple of thousand feet in the air, set the helicopter down gently, then pick it up again and do a pedal turn¸ before those big blades finally ran out of oomph.

The downsides of high-inertia rotor systems is that they're less responsive in the air, and they're heavy—weight that might otherwise go to payload.

Low-inertia rotor systems, on the other hand, are light, responsive, and efficient. They offer crisp handling and excellent control—but require a bit more proficiency on the part of their pilots. Specifically, they'll "lose turns" faster after an engine failure (although, as we'll see shortly, they can also regain them faster). The 407's four-blade composite rotor is classed as a low-inertia system.

UP, UP, AND AWAY...

With the beginnings of a handle on the hover, let's finally get the 407 up into the air and going somewhere. Lift off into a normal hover as before, and turn the helicopter in the direction in which you want to depart.

Now, apply gentle cyclic pressure to start moving in that direction. As you get to about 15 knots, you'll feel the helicopter settle a bit—you've "flown off the ground cushion." Depending on your hover height when you started, you may need to add a little collective; don't forget to coordinate with the pedals.

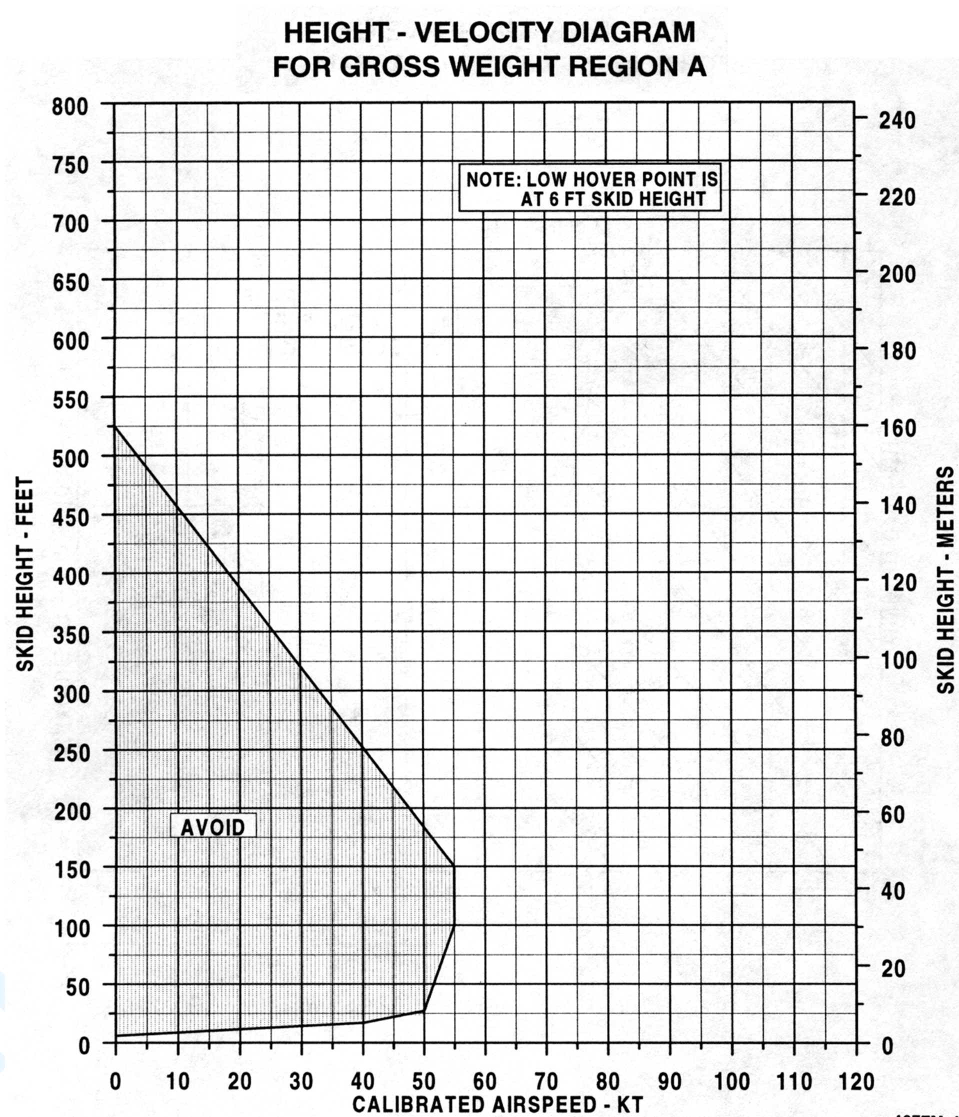
At around 20 to 25 knots, you'll feel something different. The helicopter will feel like it wants to climb (it does!), and it'll also feel as if it wants to roll to the left (it does!).

You've entered translational lift, the condition in which the rotor blades are affected not only by their rotation, but by the forward speed of the helicopter as a whole. As we discussed earlier, the forward-going (or advancing) blades are exposed to a higher airspeed than the aft-going (or retreating) blades. The faster you fly, the more right cyclic pressure it'll take.

In forward flight, you'll find the helicopter much more stable than in the hover; in fact, it behaves more like an airplane. Use left and right cyclic pressure to roll in and out of banked turns, just like an airplane; use forward and aft pressure to control your speed. To climb or descend, adjust the collective (and, of course, the pedals). As in an airplane, for a given power setting you can fly level at one particular airspeed, descend at a higher one, or climb at a lower one, so once again the cyclic and collective have to be used interactively.

GETTING BACK DOWN

Sooner or later we'll have to get the helicopter back onto the ground. A normal approach is nothing more than a gradual descent, gradually transitioning into a hover. First, however, we should get acquainted with something colorfully called the "dead man's curve." No, it's not that nasty switchback where someone went through the guardrail—it's more accurately called the "height-velocity diagram."



Here's a typical H-V envelope; it reads in skid height above ground from bottom to top, and airspeed from left to right.

We'll get into energy management in more detail when we discuss autorotations further. For the moment, it's enough to know that as long as you operate the helicopter in the unshaded area of the chart, you should be able to make a safe autorotation (with average pilot technique) if the engine fails. If you're in the shaded area (for example, 100 feet off the ground at 20 knots), you can't make a safe autorotation no matter how good a pilot you might be.

This isn't to say, of course, that helicopters are never operated in the "avoid" region; many types of operation (for example, takeoffs and landings from buildings or elevated platforms, or "external load" work like setting powerline pylons) require extended stays "on the wrong side of the curve." It's simply a matter of acceptable risk—as long as the engine is running, you're fine, so it's just a matter of your faith in Bell, Allison/Rolls Royce, and the deity of your choice!

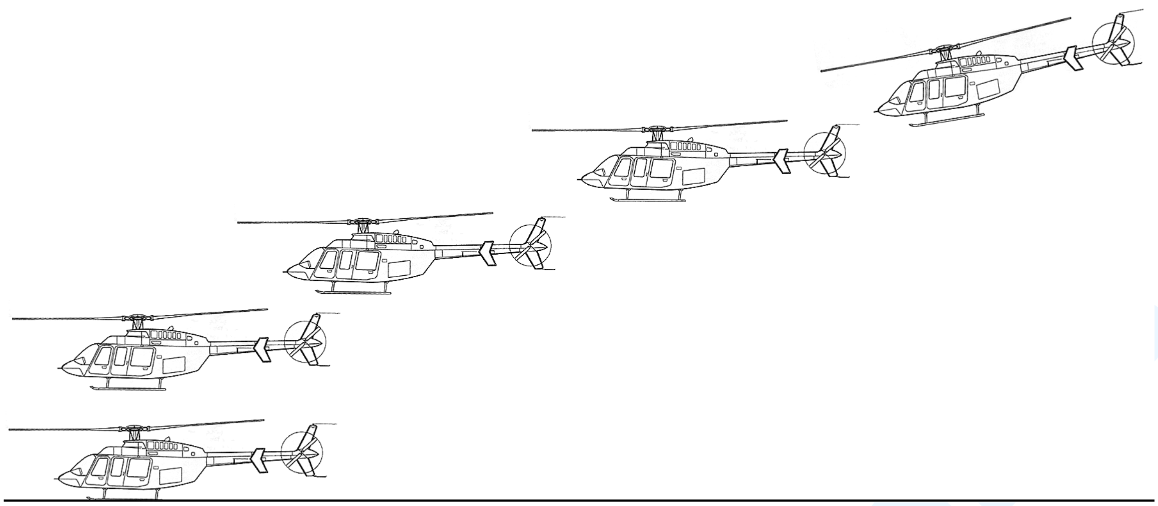
What it means for normal approaches, however, is that you should plan them to avoid the shaded area.
Take a closer look. You can see that on a takeoff, you should stay below 25 feet until you reach a speed of 50 knots. Similarly, on an approach, it would be best not to decelerate below 50 knots until you were down to 25 feet skid height or lower. In the real world, that's probably pretty hard to manage unless your landing spot has very wide, clear approaches (like an airport). Still, you can try to minimize your exposure to the "avoid" area.

60 knots is a good speed with which to start a landing approach, since at that speed you're well outside the curve. Line up your landing spot and, holding 60 knots at first, adjust the collective to give you the desired rate of descent—the chosen spot should neither move up or down in the windshield.

As you get closer, begin slowing by slight aft cyclic pressure. This will initially take a further collective reduction to avoid rising above your desired glide path. As you decelerate below about 30 knots, however, you'll feel the helicopter begin to settle—you're starting to lose the effects of translational lift. It'll also want to roll to the right, requiring a slight cyclic correction.

Once you're below translational lift speeds, you'll have to start pulling collective back in. If you're approaching your landing spot too fast, you may have to apply even more aft cyclic pressure to reduce speed. Make sure you don't do this too close to the ground, as you risk striking the tail rotor if the helicopter is pitched up too high.

Finally, as you settle toward your desired hover height, you'll need to add more collective (and left rudder) to establish a hover. Don't expect everything to come out right the first time; typically, a student will end up in a hover some distance away from the desired spot, then hover over to it.



Once over the desired spot, lower the collective to set down as we did before.

STEEP DESCENTS

Now, as we gain experience, we'll add another maneuver: a steep descent. This is what you'd use if you had to land in a confined area with tall obstacles. Lift off, climb out, and establish level flight at 500 feet above the ground and 60 knots.

On our last approach, we made a slight collective reduction to start a very gentle descent. This time, make a considerably greater reduction (don't forget the pedals!) to descend more steeply, still maintaining 60 knots. When you reach 200 feet, smoothly pull the collective back up to maintain level flight at 60 knots, then add power and climb back up to 500 feet. Try this several times, making the descent steeper each time.

SPLITTING THE NEEDLES:

There's no hard and fast dividing line between normal and steep descents, but as you get into the steeper ones, you may notice something interesting: the rotor and engine tach needles may "split" on the dual tachometer (this is less likely to happen with FADEC in automatic mode, you may want to try manual just for this demonstration). What's happened here is that during the descent, you demand so little power that the rotor system "decouples" from the engine, activating a clutchlike device installed between the engine and transmission. You can force this condition (starting at a safe altitude) by using the mouse to roll the throttle below the FLY detent to split the needles, simultaneously lowering the collective to maintain rotor RPM. Roll the throttle back up to FLY before you raise the collective to arrest the descent.

Remember: in low-power (or no-power) situations, rotor speed is controlled by the collective. Raising the collective reduces rotor speed; lowering it increases rotor speed.

QUICK STOPS

Now we'll try another maneuver, one that most students find a lot of fun: the quick stop. Let's say we're zipping along a taxiway at low altitude and high speed when a jet pulls out in front of us. We want to slow down fast, but we don't want to climb.

Establish flight at about 25 feet along an easily-followed reference—a road, taxiway, or runway. Now, to stop in as short a distance as possible, smoothly and simultaneously lower the collective to the bottom and apply just enough back pressure on the cyclic to maintain your altitude, neither climbing nor sinking. You may notice the dual tach needles splitting during this maneuver; Np will remain at 100%, but Nr may climb briefly toward 105% or so. As the helicopter declerates and starts to settle, use forward cyclic pressure to bring it back to a level attitude, and collective as necessary to hold altitude. Fun, isn't it? Practice it until you're proficient at stopping the helicopter in minimum distance without losing altitude.

PUTTING IT ALL TOGETHER:

There's a reason we've practiced these particular maneuvers in this particular order: you've been gaining the skills you need to perform a safe autorotation!

We'll start by doing a few practice autorotations to what's called a "power recovery"—i.e., rather than landing, we'll terminate the maneuver in a hover. Begin at 500 feet, flying at 100 knots.

Now we're going to simulate an engine failure by smoothly but rapidly lowering the collective all the way to the bottom (or reducing throttle to minimum on your joystick). In addition to various horns and warning lights, which are the least of our concerns for the moment, you'll notice a few things: the helicopter will yaw to the left (as in a hovering autorotation), it'll tend to drop its nose, and it'll start a pretty rapid descent.

We're already at the maximum authorized speed for autorotation, and we want to get slower—the speed for maximum glide distance over the ground is 80 KIAS, and that speed for minimum descent rate is 55 KIAS. We'll use 80, so apply aft cyclic pressure to decelerate to that speed. The helicopter will just about hold altitude while you're decelerating (which won't take long), then resume it's descent. Take a look at the dual tach; Nr will probably be higher than 100%. As long as it's below 107%, it's fine for the moment. Now hit [P] to pause the simulator while we discuss autorotations.

AUTOROTATIONS AND BANK ACCOUNTS:

I'm indebted to the remarkable Frank Robinson, of Robinson Helicopters, for this method of explanation. In addition to being a brilliant designer and a very savvy businessman, Frank is probably the best helicopter instructor I've ever encountered.

To keep a helicopter's rotor turning, and to keep it supporting the helicopter, requires energy. In normal flight, that energy comes from the powerplant. Where does it come from during an autorotation?

Actually, it can come from three different sources, and you can compare them to bank accounts, with the energy taking the place of money. Think of the rotor's energy needs as a mortgage—you gotta pay it, and keep paying it, or you're in trouble. To draw the analogy even farther, you can transfer "funds" between these "accounts" without any additional charges—although if you make the wrong choice at low altitude, at the end of an autorotation, "there may be a substantial penalty for early withdrawal."
Let's label the accounts "altitude," "forward speed," and "rotor energy." In steady forward flight, with the engine running, the balance in all three accounts remains the same, with constant deposits from the engine matching the constant withdrawals through the rotor.

Now the engine quits—no more deposits. As in real life, however, the skinflints at the Rotor Mortgage Company insist that their payments continue (and we sure don't want to be foreclosed at this point!), so we'll need to transfer funds from other accounts.

We have a few bucks saved up in our rotor energy account, but in a low-inertia ship like the 407, it's not much—just enough to keep us afloat while we figure out which funds to transfer. Since we're at altitude, the altitude account is flush...so let's start "transferring funds" to the rotor by descending. This is what's happening when we bottom the collective—we're transferring energy from the altitude account into the rotor energy account to balance the constant drain from the rotor. If we keep the rotor speed up, we're keeping its energy account up, as well as replacing any losses we may have incurred right after the engine failure.

Obviously, we can't keep this up forever—sooner or later, we'll reach the ground. At this point, our altitude account is pretty well tapped out...but we still haven't touched our reserve in the forward speed account. Oh, well...there went the kids' trip to an Ivy League college...By reducing our forward speed, we can start transferring energy from that account into the voracious mortgage...er, rotor. In fact, with a low-inertia rotor system like the 407s, this speed-reducing maneuver, called a "flare," will actually increase rotor speed, so we're building up a little cushion in the rotor energy account.

By the time the flare is complete, we're within a few feet of the ground (which means the altitude account is tapped out), and we've either slowed to minimal forward speed, or stopped altogether (which means the forward speed account is broke, too). But the repo man isn't here yet—we still have a decent balance in our rotor energy account. Now is when we can spend it by raising the collective to cushion the touchdown. With no deposits, that account will dwindle the instant we start to raise the collective (particularly since we're now adding rotor pitch, an expensive luxury)...but before we're completely bankrupt, we'll have the helicopter on the ground.

SAVE AND SPEND WISELY

We can actually manage these accounts during an autorotation, and adjust our spending plan to best deal with the situation.

For example, if we have a nearby landing spot made (which means you can just about see it between your feet through the chin bubble), we may want to come down as slowly as possible. This would dictate a forward airspeed of only 55 knots, so we might not have as much energy in our "speed" account to transfer to our "rotor" account during the flare. On the other hand, we can keep the rotor account as high as possible by leaving the collective all the way down, and maintaining 107% rotor RPM.

On the other hand, if the only available landing spot is farther away, we may want to fly at "best glide" speed of 80 knots. Our sink rate will be significantly higher—but we'll be coming into the "flare" transaction with a full "speed" account. This means we'll have plenty of energy to transfer into the rotor account at that time, so we might consider reducing our rate of descent a bit by pulling on just a bit of collective to bring rotor speed back to 100%--possibly even a bit lower. You'll notice that the green arc on the dual tach goes all the way down to 85%...but that doesn't leave you much for those "unexpected last-minute expenses!" Bell recommends no less than 90% for training autorotations (and remember that the low RPM warning light and horn come on at 95%). During the flare, we may actually want to lower the collective again to build rotor speed as high as possible.

TOO MUCH OF A GOOD THING

What we want to avoid is over-flaring. Not only does this risk leaving us up higher than we want to be with rapidly dwindling rotor energy reserves, but if we're low enough it puts the tail rotor awfully close to the ground. As long as the surface is reasonably smooth, you'll get a perfectly good autorotative landing by running the skids on at 10 to 15 knots, and you'll have much more time to "play" the final collective pull and touchdown.

AUTOROTATION AND POWER RECOVERY

Now do you see why we've introduced maneuvers in the particular order we chose? Seen alone, an autorotation looks difficult and scary...but if you think of it as nothing more than "a steep descent followed by a quick stop followed by a hovering autorotation," you can see that it's just a series of maneuvers in which you're already proficient.

We'll do a few for practice first, leaving off the touchdown at the end. Ready?

Tap [P] to resume the simulation—we're in a steep unpowered descent, with the engine running at 100% RPM but the collective bottomed all the way.

Hold 80 knots. The helicopter will certainly seem to be swooping down at an impressive rate, but it's equally certain that it's not "falling out of the sky." At about 50 feet, apply smooth, but fairly decisive, back pressure on the cyclic to flare. The nose will come way up, the rate of descent will slow...and you'll see and hear the rotor speed up to near its 107% redline (the needles will split for a moment). As the descent stops, apply forward pressure to level the fuselage, and as the helicopter settles, smoothly raise the collective again to transition to a hover. Of course, all these large collective movements will require corresponding pedal inputs. Don't worry about getting the helicopter to stop dead—anything below translational lift speed is OK. Do enough of these until you're comfortable. Then do a couple of hovering autorotations, just as a refresher.

IT'S THE REAL THING

Now you're ready for this series of lessons' "graduation exercise:" an actual autorotation to touchdown. Let's start at 800 feet and 100 knots, just to give you a little more room. Ready? Take a deep breath and hit [Ctrl+pg dn] to shut down the engine.

The needles will split right away, and you'll get the "engine out" light. Simultaneously apply back cyclic pressure to start the speed toward 80 knots, and smoothly lower the collective. If your reactions are reasonably fast, you probably won't get the low RPM light or horn.

Once the descent has stabilized, you can experiment with rotor speed control. A slight pull on the collective will bring Nr back toward 100%. Ease the collective back down to build rotor speed back up; you'll notice that the sink rate increases as you do so.

At about 50 feet, smoothly and firmly apply back pressure to the cyclic to arrest the descent and reduce your forward speed. Nr should be right at its maximum. As the helicopter levels out, you should be down to around 15 to 20 feet. Make a definite forward cyclic correction to level the skids ("rocking the ship forward" is a good image). As it begins to settle, smoothly pull in more and more collective to cushion the touchdown.

It's important to keep the helicopter coming down (although not too fast) all the way through the final settle-and-touchdown phase. Pull too much collective too early, and you'll run out of blade energy and fall the last few feet—that's the "early withdrawal penalty" I mentioned earlier. In a really hard touchdown, it's not unusual for the main rotor blades to flex down far enough to chop off the tailboom. It's much better to settle on gently, even if you're still moving forward at 10 or 15 knots.

Congratulations! You've mastered the most critical maneuver in helicopter landings. It's often said that "A good landing is one you can walk away from; a great one is one after which the aircraft is still flyable." There's no reason you shouldn't make great landings in the 407, power on or power off, from here on.

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Fly! II

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