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Flight Simulator Navigation



Courtesy Roland Zuiderveld, [Click for larger view.](#)

What a beautiful sight—a DC-3 coming in for a landing.

Welcome to this navigation tutorial devoted to Flight Simulator enthusiasts. This opening picture attests to my not-well-hidden love affair with the DC-3. You'll see more DC-3 pictures as you progress through this site, but not exclusively.

Navigation is quite easy to learn and understand. Thousands of aviation students throughout the world are doing that right now either in aviation ground schools, at home

with video-taped lessons, or with self-study books. Understanding and using basic navigation concepts is important to fully enjoy flight simulators, too.

But, darn, I found no single site on the web for flight-sim enthusiasts that addresses everything from basic navigation, to low frequency navigation using the NDB (Non Directional Beacon), to VOR navigation, and the full range of instrument approaches. So this is my attempt to fill that void.

And we're very proud to have received CompuFlight's **Select Site Award**.

You'll do plenty of flying as you venture through the various subjects that follow, plus have the dubious honor of meeting the irrepressible Mr. Benjamin Counter. Counter, a captain of industry, is your best charter customer. There's never a dull moment when he schedules your services. He is, of course, a totally fictitious character. That's good because he gets into more situations than any mortal I've ever met. His Modus Operandi is "I need to fly now." He arrives in the "Plot a Course" section.

I've also included some historical notes on early navigation systems. You'll discover how far we've come and what pioneers the early pilots were.

This tutorial contains so many graphics that you may have to click your browser's reload button to bring up all of the images the first time that you visit each page. As a minimum, you must be patient while they load. Didn't want to cheat you out of the details.

To the best of my knowledge and ability, the stuff posted on these pages is accurate. Here follows the regrettable legal mumbo jumbo that we car- and home-owners feel obliged to post on websites these days.



For any wounded souls who may have imagined that this website in any way degraded them or their computer, understand that, like life itself, there are no warranties expressed or implied. This website is for entertainment only. Also, in no way is it meant to substitute for a full-fledged ground school course if you are a candidate for a "real" pilot's license.

Enjoy and learn ... it will enhance your flight simming experience.

And finally, the talented efforts of many people are liberally sprinkled throughout these webpages. To the last they were generous in granting permission to use their designs or photographs or artwork and descriptions. Please click on the *credits* button below to learn of their contributions. And then get Navigating!

Charles Wood



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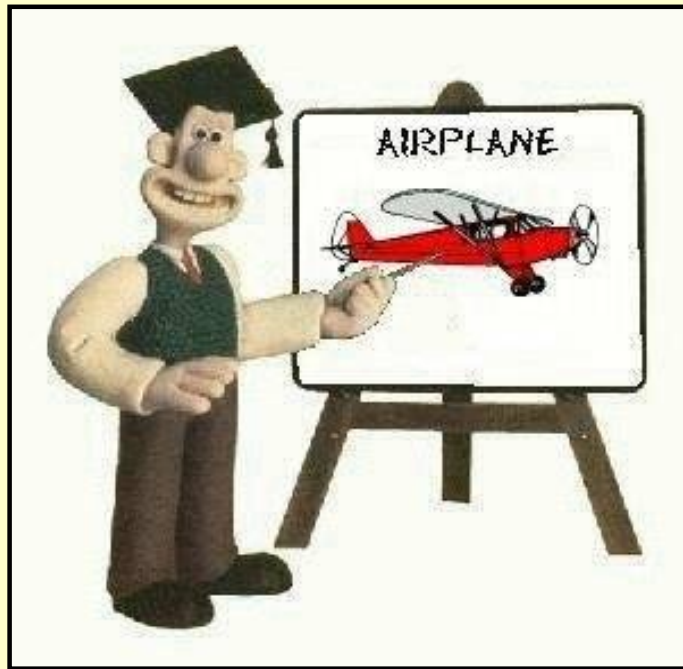
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Some Basics



Wallace over there by the whiteboard really got carried away when he overheard the word "Basics." I think we'll risk skipping his first lecture.

We all intuitively know what Aviation Navigation means—it means knowing where you are, where you want to go, and having a good idea of how much time and fuel it will take to get there. Navigation means finding your way.

The two most fundamental methods of finding your way in an airplane are *pilotage*—the identification of present position and direction of

flight by seeing features on the ground, and *Dead Reckoning*.

Dead Reckoning—an intriguing title. I was once told that the name stems from "You're Dead if you don't Reckon properly," but I think they were pulling my leg.

Dead reckoning is the navigation procedure to plot and fly (in this case) a course based solely on mathematical calculations.

UPDATE! UPDATE! Many Flight Simmers took pity on my pathetic lack of knowledge and patiently explained to me the origins of "Dead Reckoning." Here is one:

"I have spent many (more than I care to count) years navigating sailboats all over the place. In the books that I learned from, it was referred to as 'ded. reckoning,' which stands for deduced reckoning as opposed to using true fixes."... thanks, dg.

Dead Reckoning and Pilotage are so interdependent, though, that they are essentially one method. Ask a pilot how he intends to navigate to his destination, and if he says "by Dead Reckoning," one knows that he also intends to look out the window at the ground features to check his progress.

No assistance from electronic aids to navigation here, thank you very much. If the weather is good, and it's daytime, and you can see the ground at all times, DR can be very satisfactory. After all, both Charles Lindbergh and Amelia Earhart soloed across the Atlantic navigating in this manner. But change any one of those variables and the excitement level can quickly escalate beyond what a mortal cares to handle.

Three properly-performed actions are necessary for dead reckoning navigation to get you to your destination, at the estimated time of arrival:

1. The pilot must properly calculate the course and fuel consumption.
2. The pilot must accurately fly the aircraft
3. The weather service must correctly predict the winds-aloft.

Omitted is "Put enough fuel in the tanks for the journey, and then some." That slight oversight has ruined more than one perfectly-navigated flight. Few will argue that if the aircraft is running low on fuel, the fuel indicator becomes the most fascinating gauge on the panel. Yes, indeed, it does.

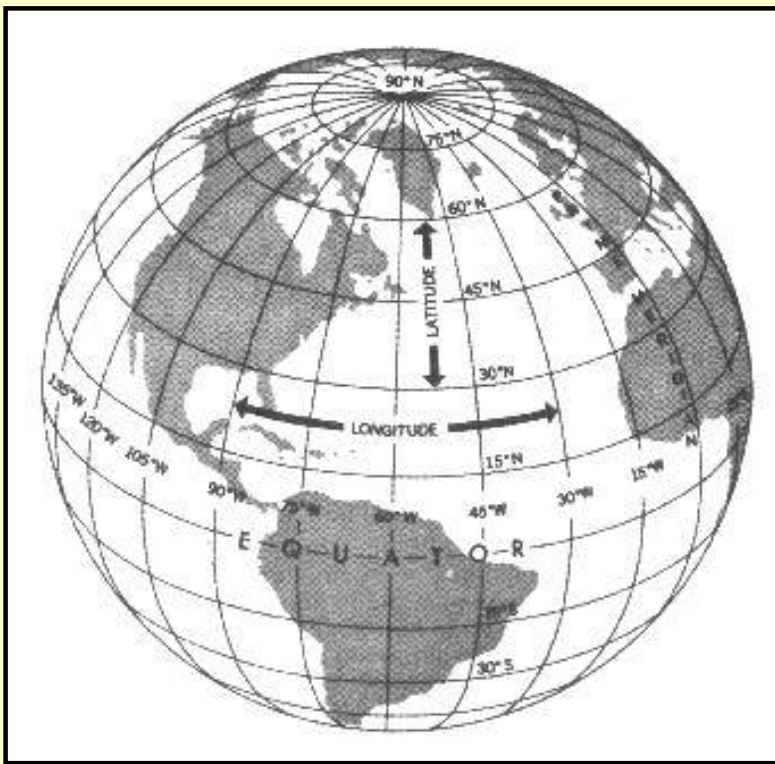
The first two items in the list are under the pilot's control and most pilots have the good sense to do them right. The third criteria is the one that notches up the interest level. Winds-aloft predictions are seldom accurate, and may never be. Sometimes the miss is huge. No big deal, though, if you can see the ground, have chart in hand, and it is properly oriented to follow your flight. You simply adjust for the wind based on landmarks spotted below.

Assume that your estimated course was to take you directly over the power company with its 100-ft. tall smoke stacks. But there it is a mile or so to your left, its plume of white smoke laying down horizontally blowing towards you. Obviously, you must turn left some few degrees to get back on course plus make a heading correction once back on course to accommodate those strong winds.

After returning to course you check the next landmark to see how good your heading correction was, and so on for each landmark, until you reach your destination. Very simple in theory.

There is nothing inherently inaccurate about dead reckoning; it is limited only by the information provided. Dead reckoning is, in fact, the basis of all navigation.

Longitude and Latitude



The equator is an imaginary circle equidistant from the poles of the earth. Circles parallel to the equator (lines running east and west) are *parallels of latitude*. They are used to measure degrees of latitude north or south of the equator. The angular distance from the equator to the pole is one-fourth of a circle, or 90° . Thus latitude would run from 90° North to 90° South of the equator.

Meridians of longitude are drawn from the North Pole to the South Pole and are at right angles to the equator. The "Prime Meridian"

which passes through Greenwich, England, is used as the zero line from which measurements are made in degrees east and west to 180° .

Any specific geographical point can thus be located by reference to its longitude and latitude.

From the earliest days, determining latitude was relatively simple; measure the height of the sun with a sextant. Longitude was a different matter. Greenwich Observatory was set up by King Charles II in 1675 to study means of fixing longitude, and the observatory became the acknowledged world authority on the subject. The telescopes and other instruments there determined the exact position of the meridian, and in 1884 an international conference in Washington agreed that Greenwich should be sited at zero longitude.

By using meridians, direction from one point to another can be measured in degrees, in a clockwise direction from true north. Draw a course line on a chart and measure the angle which this line forms with a meridian.

When moving north or south by one degree of latitude, the distance remains approximately the same whether the observer is at the equator or in London, New York, Tokyo, or Sydney. That number would be unchanged vs. latitude if the earth were a perfect sphere, which it isn't. The earth is somewhat flattened at the poles.

The distance situation is quite different when moving east or west.

Note the convergence of the meridian lines at the poles. Thus moving east one degree at the equator is a greater distance in feet or meters than moving one degree east in London, New York, Tokyo, or Sydney.

Nautical Miles and Knots

The circumference of the earth is divided into 360° . Each degree is further divided into

60 minutes. If you move one minute east or west on the equator, you have gone one nautical mile. Thus a nautical mile is the circumference of the earth divided by 360, giving the distance in one degree, and that is further divided by sixty for the distance in one minute of arc.

Earliest estimates of the earth's diameter was 18,000 statute miles. As methods of measurement improved over the years, the earth's circumference "increased" to 24,901.55 statute miles. Hence the distance of a nautical mile similarly increased with time, too. What a nightmare that must have been for cartographers and navigators.

Regardless of calculations of the earth's circumference, the nautical mile has been standardized at 6076.113 feet, plus another gazillion decimals. One nm = 1.15 statute miles for the purposes of estimating. Again, there are a gazillion decimals in the actual conversion. Using 1.15 will not fly you into a mountain.

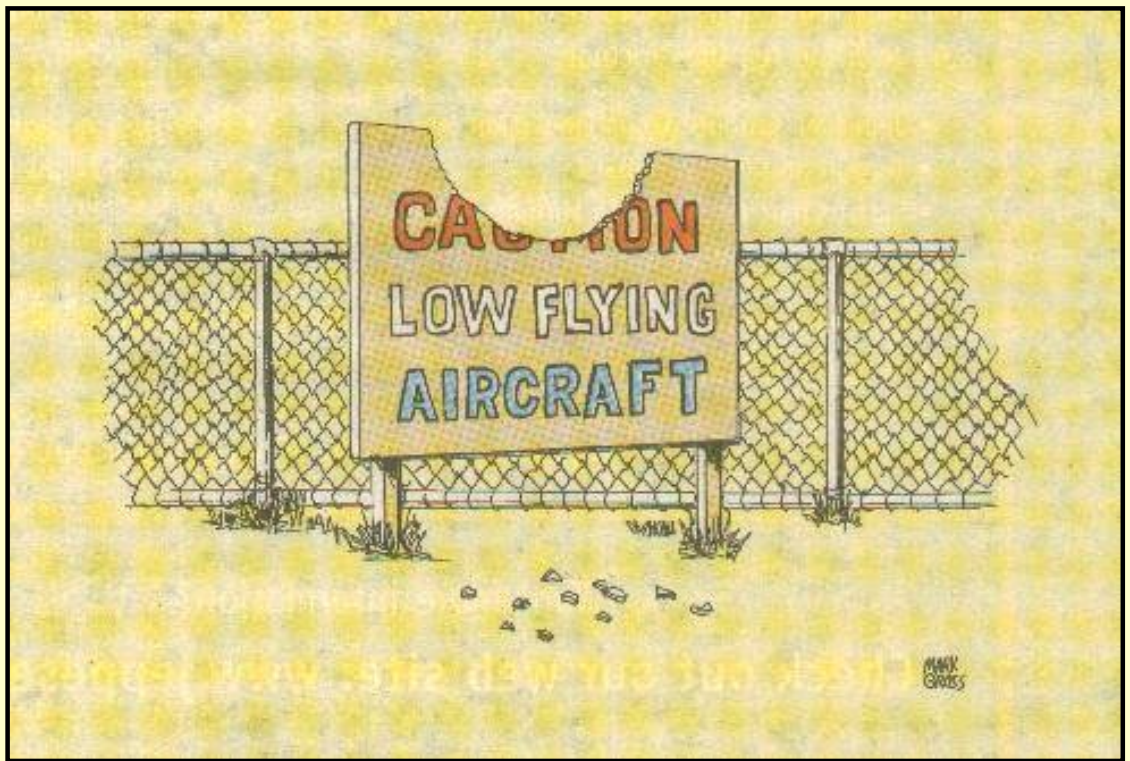
There is a lot of lore behind the knot ... tying knots into lines and clocking the time for each to pass a sailing ship, etc. Suffice it to say that a knot is one nautical mile per hour and hence is 1.15 statute miles per hour.

Two further subjects should be understood before going on to charts.

VFR vs. IFR

The first is VFR weather vs. IFR weather. If the weather is "good," which the FAA defines as a visibility of at least three statute miles and that you can maintain at least 500 ft. clearance from the clouds above you, then you may fly by Visual Flight Rules. Flying at VFR minimums is not very comfortable and you better know where those 1000 ft. TV towers are, because you'll never see them in time to avoid them. They are marked on your charts.

In practical terms, VFR is 3 miles visibility and 1000 ft. ceiling, because the minimum altitude one can fly in an uncongested area is 500 ft. above the surface. But that minimum altitude increases to 1000 ft. **above obstacles** near cities. So, if you depart VFR from Podunk Hollow Airport, with reported ceilings of 1200 ft., you're not going to be legal with that ceiling flying above New York City with all of its skyscrapers reaching for your landing gear.



**VFR flight requires more than just staying clear of the clouds by 500 ft.
Courtesy of and copyright Mark Gross and *Trade-A-Plane*, Crossville, TN.**

Pilots must fly by Instrument Flight Rules, or IFR, if the weather is below VFR minimums, or if they are in Class A airspace, which is anything above 18,000 ft. MSL. A pilot must be instrument rated to fly IFR, which requires passing a written test plus demonstrating the ability to safely fly and land the aircraft solely by reference to the instruments.

Before an IFR flight, an IFR flight plan must be filed with Air Traffic Control (ATC) **and it must be approved**. Normally ATC personnel read back the approved flight-plan shortly before departure. It can be brief and pleasant, such as "Approved as Filed," or, still brief, but less pleasant such as "Approved as Filed with the following changes ..." and then they completely modify your routing.

Pilots may file an IFR flight plan no matter what the weather. There are times when it is prudent to file IFR even in VFR weather. For instance, it might be wise to file IFR if one were to fly a small, single-engine plane over a large body of water after dark when the horizon is difficult to discern. Not supposed to file IFR though if you're not IFR rated.

All U.S. commercial airliners file IFR for every flight.

Flight Altitudes

The second subject worth mentioning is flight altitude. A pilot doesn't hob-nob about in airspace at whatever altitude most eases his lumbago. The FAA has a set of rules for flight altitude. And, wouldn't you know, there is one set of rules for VFR flight and a slightly different set of rules for IFR flight. So here goes. In a moment you'll learn an easy way to remember these rules.

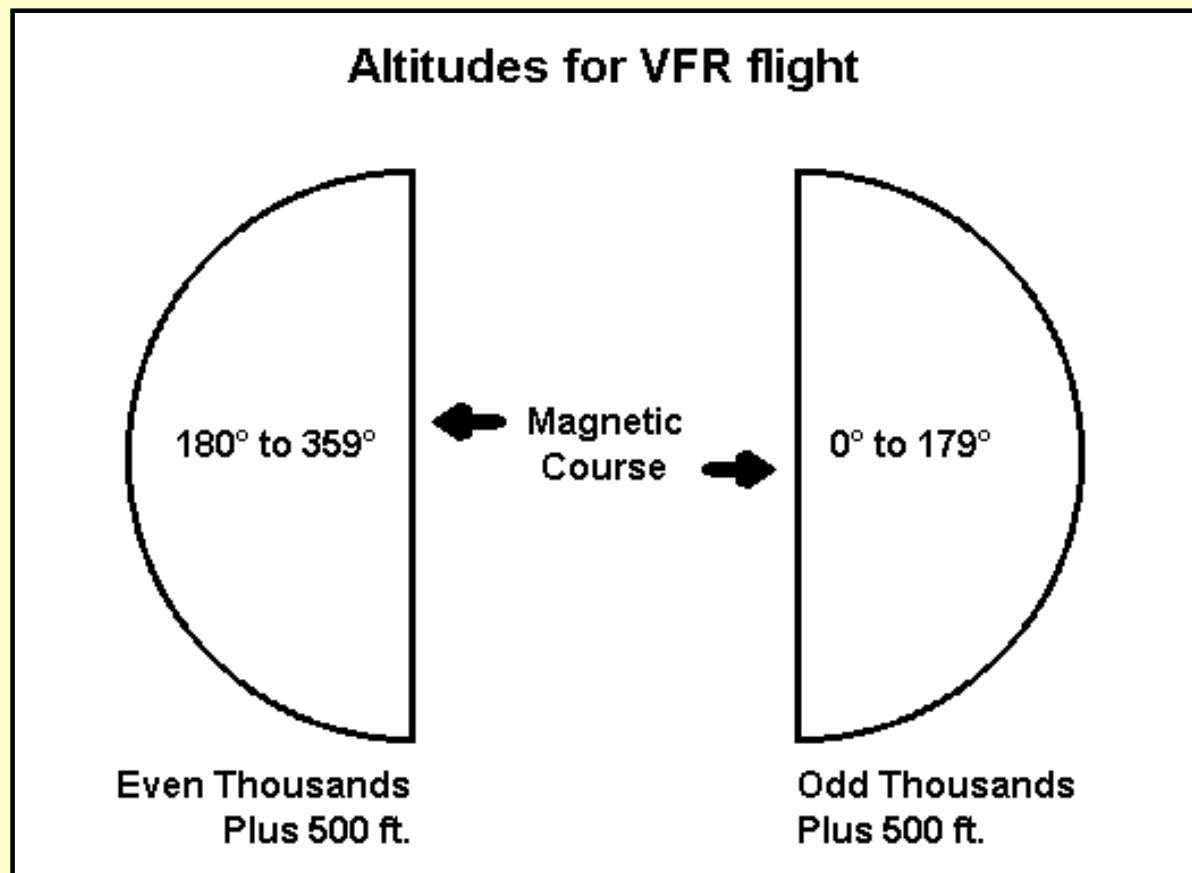
If your VFR flight is above 3000 ft. AGL (Above Ground Level) when flying a magnetic course of 0° to 179° fly at ODD thousands of feet plus 500 feet. In non-gov't. language, fly at 3500 ft. or 5500 ft., or 7500 ft. and so forth if your magnetic course is from 0° to 179° .

And of course, from 180° to 359° magnetic course, your altitude should be EVEN thousands plus 500 ft.—like 4500 ft., 6500 ft., 8500 ft., etc.

How does one remember that rule? It's easy. "Easterners are Odd" will do it. If your VFR course is easterly, i.e., from 0° to 179° fly at odd thousands plus 500 ft.

If one leg of your flight is easterly and you are at 5500 ft., and the next leg is to the northwest, need you change your altitude to adhere to the rule? You sure do.

Notice that the term "magnetic course" has been carefully used throughout this altitude discussion. With a crosswind, the aircraft's magnetic heading will differ from the planned magnetic course.



VFR flight altitudes vs. magnetic course, above 3000 ft.

For example, suppose your planned magnetic course home from a weekend at the racetrack is 005° . But a strong crosswind forces you to steer 355° . Your altitude will be determined by the magnetic course of 005° , i.e., follow the easterly rule to choose your altitude.

How does IFR differ? Forget the "plus 500 ft" adder. So from 180° to 359° on your IFR flight, fly at 4000 ft., 6000 ft., 8000 ft., etc. All of this is a moot point on IFR, though, because ATC assigns your altitude, at which you are obligated to fly even if it violates this

altitude rule.

Not to worry, though, ATC won't assign your Cessna 172 to 17,000 feet. The IFR flight plan that you filed includes your aircraft type, and since computers never make mistakes ...

The pilot must set the aircraft's altimeter to the local barometric pressure or else it will not show the correct altitude, which is vital to know when near the ground.

Rules, Rules and more Rules. To further complicate the airspace issue, in the U.S. the FAA has designated six classes of airspace; Class A, B, C, D, E, and G. A chapter would be required to explain each class, and will not be attempted here. It's enough to remember that a pilot must be in contact with ATC to fly in Class A, B, C, or D airspace.

Sectional charts show the location of each type of airspace and the altitude limits for each class. For those interested in more information, borrow an Aeronautical Information Manual (AIM) from your local library.

At 18,000 feet and above, pilots no longer need worry about local barometric pressures. They uniformly set their altimeters to 29.92 in. Hg. and adhere to the altimeter reading regardless of the actual barometric pressure.

Also, from 18,000 feet and above, the term Flight Level is used, rather than actual altitude. Drop the last two zeros of the altitude for the Flight Level. Thus, 24,000 feet becomes Flight Level 240, written FL240, and spoken Flight Level Two-Four-Zero.

Compass Errors

A compass is one of the pilot's dearest friends, if not always one of his or her "truest" friends. There are times when a pilot must wonder whether a compass is working for him or against him.

The wily compass can find so many ways to lie to a pilot. It's readings will be wrong, if:

1. the aircraft is turning—it can even swing in the opposite direction of the turn!
2. the aircraft is climbing or descending.
3. the aircraft is accelerating or decelerating.
4. the aircraft is flying through rough air.
5. there are metallic objects near the compass.
6. the radios are turned on vs. turned off.

The bottom line is that a pilot can only rely on the compass when the aircraft is in smooth air and flying straight and level. Due to its potential for errors, the magnetic compass is normally used as a backup source of heading information.

The Directional Gyro, more frequently called the DG, provides reliable heading information even in the event of the first four conditions in the list above. For this reason pilots use it as their primary heading indicator. A DG may be electrical-powered or vacuum-powered. In either case, loss of its source of power results in a non-operating DG.

Some call the DG a gyro-stabilized compass. It isn't. It's not a compass at all. It is a gyro-stabilized heading indicator. Before a flight, the pilot must set the DG heading to match the aircraft's compass reading.

The DG does not display accurate heading information for a limitless period of time. Because of "precession," the DG should be checked against the compass about once every fifteen minutes, and its heading indicator reset if necessary.

A compass correction card is the solution for the last two items in the list. A technician manually calibrates the aircraft compass in 30° increments around a circle. He then enters the corrected compass headings on a compass correction card which is then mounted on the aircraft's panel.

FOR (MH)	0°	30°	60°	90°	120°	150°
STEER(CH)	359°	30°	60°	88°	120°	152°
FOR (MH)	180°	210°	240°	270°	300°	330°
STEER (CH)	183°	212°	240°	268°	300°	329°

Typical Compass Correction Card.

This compass requires the greatest correction when the aircraft is on a southerly heading. To track the 180° magnetic course, the pilot must steer a 183° compass heading.

Existing versions of Flight Simulator have no provision to incorporate this correction, since their compasses do not have this sort of error in them. Future versions may, though, in their quest to be "as real as it gets."

Magnetic Variation

The most significant "compass error" is variation. The magnetic north pole and the true north pole are at different locations on earth. Variation is the angle between true north and magnetic north. Therefore, a correction must be made to the compass heading to track a true course, or one based on true north. This correction is called variation.

Variation is discussed in the later section, "Plot a Course."

Miscellaneous Stuff

... that didn't seem to fit anywhere else.

- All headings in aviation are given in three digits. So a heading of 15° is referred to as 015°. In communications each digit is always pronounced separately, so this would be zero-one-five degrees.

- Runway headings are always magnetic.
- To determine runway numbers, divide direction of runway by ten and round off. Thus a runway with a 253° orientation would be runway 25; if the orientation were 257° , it would be runway 26.
- Add or subtract 18 from the runway number to get the runway number in the other direction or to determine the downwind leg.
- A due-north heading in aviation is 360° , not 0° , hence the runway 36 at airports.
- When turning right, either the aircraft or plotting a course, add numbers. For example, heading is 083° , turn right 30° , the new heading will be $083^\circ + 30^\circ$, or 113° .

Navigation procedures aren't useful if you can't fly

When I first started with Flight Simulator, my most common complaint was "I can't trim this aircraft to maintain altitude." Well, as usual, I was my own worst enemy. It was so much fun flying so many different types of aircraft that I never learned anyone of them very well. Once I decided to concentrate on a single aircraft, the MFI-17, and decided to learn its "numbers," flying became more accurate and enjoyable.

So start out by selecting an aircraft to fly and stick with it. I recommend the Saab MFI-17, just mentioned, that can be downloaded from this site. It is a fixed gear, fixed pitch prop plane that can cruise at a pretty decent speed, but is nice and simple to fly when you are learning the fundamentals of navigation.

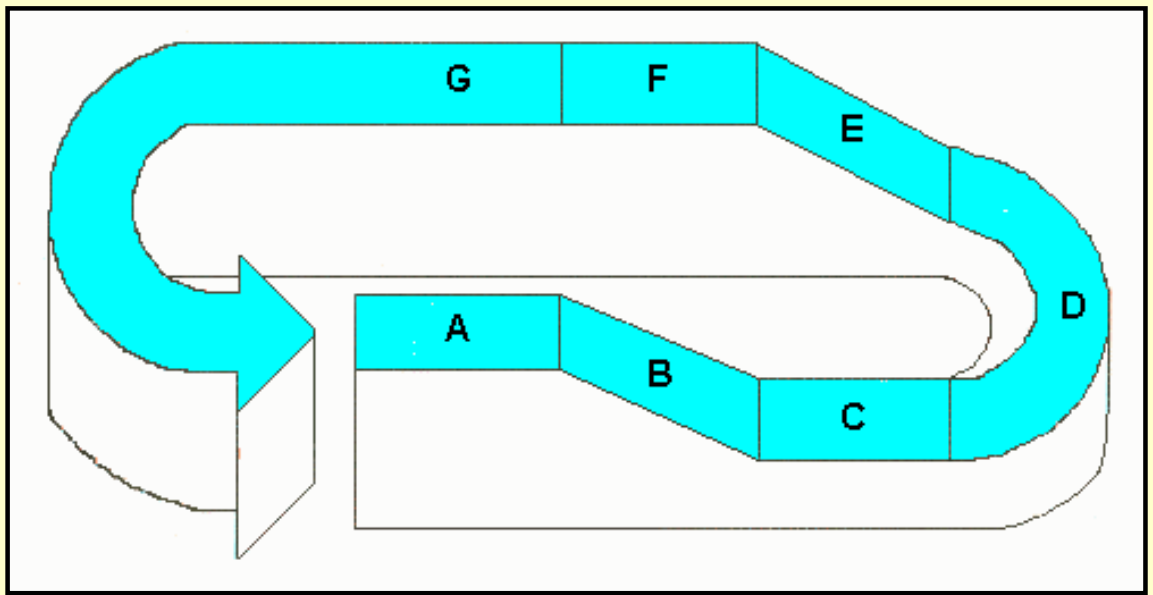
Then take out pencil and paper and write down the power settings for the following configurations:

- Straight and level cruise at 125 kts.
- Descend at 500 fpm, 125 kts.
- Climb at 500 fpm, 100 kts.

Keep the paper nearby with these reference power settings written on it and refer to it whenever you change configuration.

Practice, Practice, Practice

This is a simple practice session incorporating airspeed control, level turns, descents and climbs. Fly the practice pattern with the FS-98 visibility and ceiling set to minimums so that you have only the instruments for reference. All later flight maneuvers will be simple once you have mastered this pattern.



Seven minutes is all it takes to fly this practice pattern.

It's easiest to fly this practice pattern if you first [click here to download the picture and flight instructions](#).

Begin the flight at 1000 ft AGL, then:

- A. Slow to approach airspeed, and fly straight and level for one minute.
- B. Begin a descent for one minute at approach airspeed and a 500-fpm rate of descent.
- C. Level off at 500 ft, and fly one minute at approach airspeed.
- D. Make a level, standard-rate turn. Remember that a standard-rate turn is 3 degrees per second. Make this turn for one minute, which should result in a turn of 180 degrees.
- E. Climb for one minute at climb airspeed and a 500-fpm rate of climb.
- F. Here you should be at your initial 1000 ft altitude. At this point, accelerate to cruise airspeed and cruise power.
- G. Make a standard-rate level turn for one minute, rolling out on your initial heading.

When you fly this pattern the second time, make the turns in the opposite direction, and alternate the directions of the turns from then on.

Although the MFI-17 is a fixed-gear plane, the description below mentions gear settings so that it can be followed when you transition to a high-performance aircraft. Ignore those references with the Saab.

During the descent segment—B—you should use as many different aircraft configurations as you can. In other words, make one simulated approach in the clean configuration, using only power to adjust the rate of descent. Then, make a descent by lowering the gear, adjusting power as necessary to maintain a 500-fpm descent. Finally, use various flap settings, with and without the gear, paying attention to the specific pitch attitude and the approximate power setting needed for each type of descent. This sounds complicated, but the variations are only for one segment, B.

Next, fly the level turn segment—D—with the gear down and the flaps in the clean and the

proper maneuvering position. No matter what configuration you are using in segment D, you have to remember to clean up the aircraft—raise the flaps and gear—when you begin the climb in segment E.

Learn the Saab MFI-17 thoroughly. Practice this pattern once a day until controlling the aircraft becomes second nature, which will happen sooner than you think.

Practice until:

- You can change the gear and flap configurations without gaining or losing any altitude.
- The airspeed remains nailed where you want it.
- One minute of descent results in a loss of exactly 500 feet, one minute of climb results in a gain of exactly 500 feet, and the one-minute turns come out to exactly 180 degrees.

That's plenty of background with an excellent practice flight session. With all of this that as a background, let's move on to charts. The VFR chart will be first. Get to its description by clicking on the *VFR Charts* button below.



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Site best viewed at 600 × 800 resolution.

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VFR Charts



Courtesy Mike Genovese, [Click for larger view.](#)

It is impossible to navigate without a chart.

In the first days of air transportation, airways only connected major cities. In the daytime pilots navigated along these airways with dead reckoning and after dark followed a series of flashing beacons spaced about ten miles apart.

The first aviation charts were strip charts, and displayed an 80-mile

wide corridor about these established airways. Adequate if one remained on the airways, pilots reached for a road map if they had to deviate from their course because of storms, or needed to fly to a destination not on a primary route. Or if they got lost.

In 1930, area charts were developed to provide coverage for the entire United States. These charts divided the now lower 48 states into 87 sections. They have since been reprinted on two-sides and now 37 sectional charts cover the same area.

The Sectional Chart

The Sectional Chart is for VFR flight only. Canadians have their VNC, the VFR Navigation Chart.

Each Sectional Aeronautical Chart carries the name of a principal city within its coverage area. Hence the New York Sectional, or the Miami Sectional, or the Chicago Sectional, etc.

Here are the available U.S. sectionals for the "lower 48" and their coverage area. Note that the New York sectional coverage area is grayed out. Each chart grays-out its own coverage area so that the user can quickly identify that coverage area.



**Coverage chart of available sectionals taken from New York Sectional.
Click image for larger view.**

Notice the shaded rectangles in the illustration that are within some of the coverage areas. They designate Terminal Area Charts, large scale charts for major, congested cities. Features on these charts are the same as on a sectional chart.

Flight-simmers would do well to purchase a sectional chart for the area where they live or an area where they want to "fly." Also buy a Terminal Area Chart if you live near one of those large cities. Both are available at your local airport, or through the Internet (enter "pilot supplies" into your search engine.) Spend some time learning what's on them. It will help you better understand navigation and if you're a flight-sim enthusiast, you'll find them fascinating.

Before delving inside a sectional to begin your flight planning note two things on the chart's front panel: the date of issue and the highest terrain figure.

Sectionals expire six months after their date of issue. Sometimes the changes are small, others are significant like a change in VOR or control tower frequencies. Perhaps a 1000 ft. TV tower was erected near the approach path to your destination airport. Charts are inexpensive, keep them current. The scheduled issue date of the next edition is printed on the front panel of the sectional.

The highest terrain point on a sectional is noted on the front panel of the chart, too, along with its location. Miami sectional's 305 feet is not much of a factor, but you may want to ponder the 6288 feet for the New York sectional.

Sectionals contain a wealth of information. Far too much to fully describe here. The correct time to study a chart in depth is during flight planning, not after the aircraft is in the air. Accident reports indicate that this common-sense rule has not always been followed.

Remember, sectionals are for VFR flight only and so they feature landmarks that are visible from the air: railroads, lakes and rivers, especially prominent buildings, cities, power lines, and towers and other obstructions.

Ground elevations are shown, with the color code for different terrain levels depicted on the front panel.

Naturally, all airports appear on the sectionals. Their symbol color is red if an uncontrolled field (no control tower) or blue if a controlled field. The airport symbols show the runway layouts, too.

The sectionals present an amazing amount of airport information, including the availability of ATIS.

ATIS, Automatic Terminal Information Service, is a recorded announcement broadcast 24 hours a day. This announcement gives the current weather and surface winds, the altimeter setting, active runway in use, frequencies for initial contact with the airport and other advisories, such as if a runway is closed—or the airport is closed! The broadcast information is updated hourly, unless local conditions warrant more frequent updates. Each update is given a letter, and the voice announcement might end with "inform approach control that you have Information Delta."

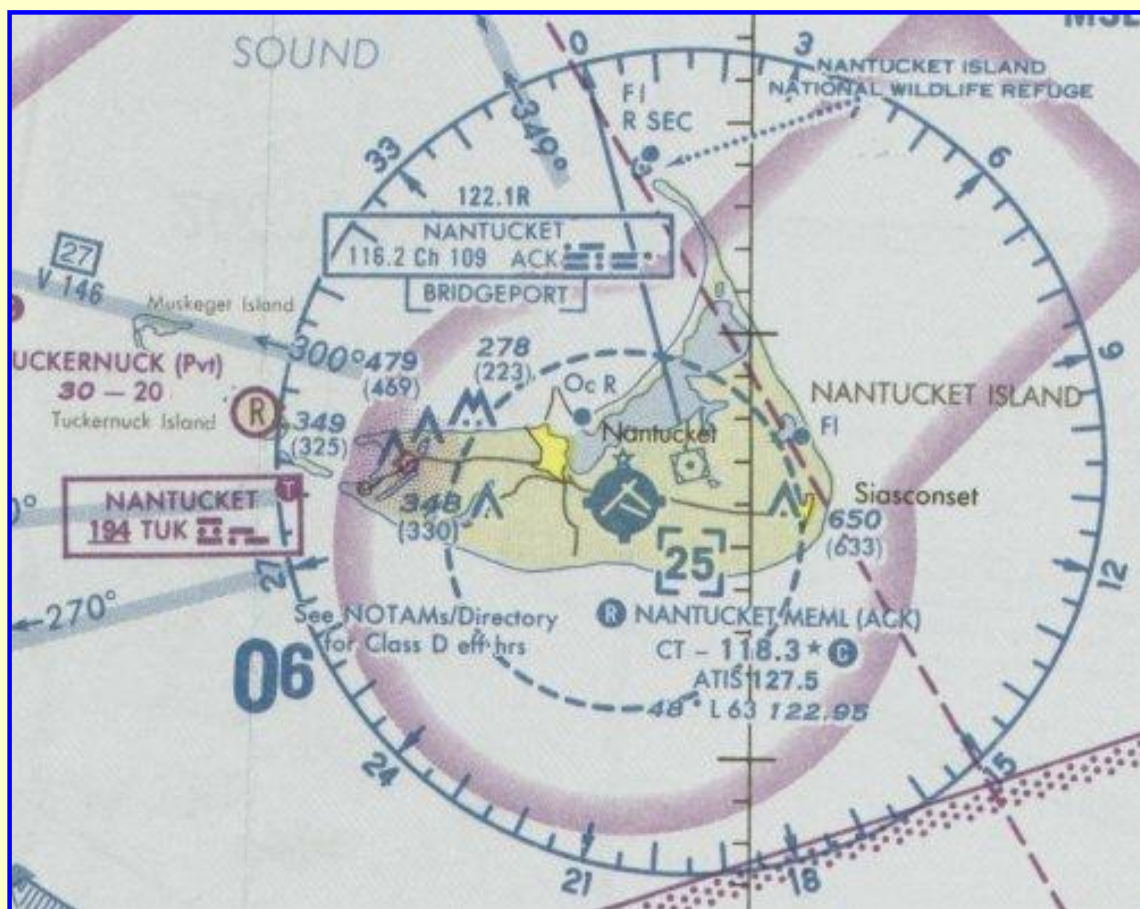
A portion of the pilot's initial contact with approach control could be "Nantucket, this is Barn-Burner 3343-Alpha (type aircraft and registration number), with Delta."

Normally, that would end the reference to ATIS. On occasion, though, approach control might respond, "Roger 3343-Alpha, radar contact ... Echo is current," lightly slapping the pilot on the wrist for last tuning in ATIS too long prior to initial contact.

Oddly, though, I've never heard approach control utter those words of remonstrance when Air Force One initially reports in.

The sectional shows the established airways, called Victor airways, as well as all nav-aids.

Below is an excerpt from the New York sectional centered about the Nantucket, Massachusetts airport. The paragraphs following the image describe many of the features on the chart. I recommend that you click on the image below to print the sectional excerpt (its not color), a pdf file, to use while following the descriptions. If you don't have Adobe's Acrobat Reader, a free program needed to read pdf files, then [click here to get that](#).



An excerpt of the New York Sectional near the Nantucket, Massachusetts Airport.
Click image to download and print the pdf file, then continue below.

Focus on the Nantucket Memorial Airport. The airport symbol is blue, so it's a controlled field. The symbol also shows the orientation of the three runways. The star above the airport symbol indicates that a rotating beacon is present.

Notice the dashed blue circle surrounding the airport symbol. This circle defines the Class D airspace. All aircraft in Nantucket's Class D airspace, which is the surface to 2500 ft. MSL (learned from the "25" in the dashed box), are required to be in radio contact with the tower.

The white "R" in the red circle before the airport name, Nantucket Memorial, denotes that radar is available.

CT – 118.3 identifies the Control Tower frequency as 118.3 MHz.

ATIS 127.5 is next, which signifies that Automatic Terminal Information Service is available on the field, and at Nantucket it broadcasts on 127.5 MHz.

A number-chain near each airport symbol designates the field elevation, whether runway lighting is available and the length in hundreds of feet of the longest runway.

Nantucket's number chain is 48*L63. The field elevation is 48 feet, it has lighted runways, and the longest runway is 6300 feet. The "star" before the "L" means "some lighting limitations exist—refer to the airport/facility directory." Yep, that's another publication a

pilot must buy and keep current—see later for more info.

VORs and NDBs are both shown on a sectional chart. The large compass rose with an arrow pointing towards magnetic north identifies a VOR. A red circle filled with dots portrays an NDB. In this case, both the VOR and the NDB are appropriately named Nantucket.

The navigation box near the top shows Nantucket's VOR frequency is 116.2 MHz. Its identifier is ACK. The Morse code for ACK also appears in this box.

CH 109 is channel 109. Sometime one or two centuries ago, a higher power decided that aviators couldn't handle such complexity as 116.2 MHz. So channel numbers were assigned to the frequencies, thus CH 109 is 116.2 MHz. Surely there is some sort of prize available for the first person to find an aircraft with a Nav receiver that requires channel number settings. If I'm way out in left field on this one, please e-mail me and set me straight. Meanwhile, channel numbers continue to clutter up VOR navigation boxes on charts.

The navigation box to the left, half-way down, identifies the NDB. Its frequency is 194 kHz and the three-letter identifier is TUK. Again the Morse-code is shown. The underline on the frequency means that no voice transmissions are available.

All Victor Airways are marked on sectionals. These are airways defined by VORs, hence the beginning letter of V. Aviation communication extensively uses the phonetic code, so airway V 146 on the 300° radial of the "ACK" VOR would be identified as Victor 146.

The "boxed" 27 above the letters V 146 indicates 27 nautical miles from the "ACK" VOR to the next VOR on the airway.

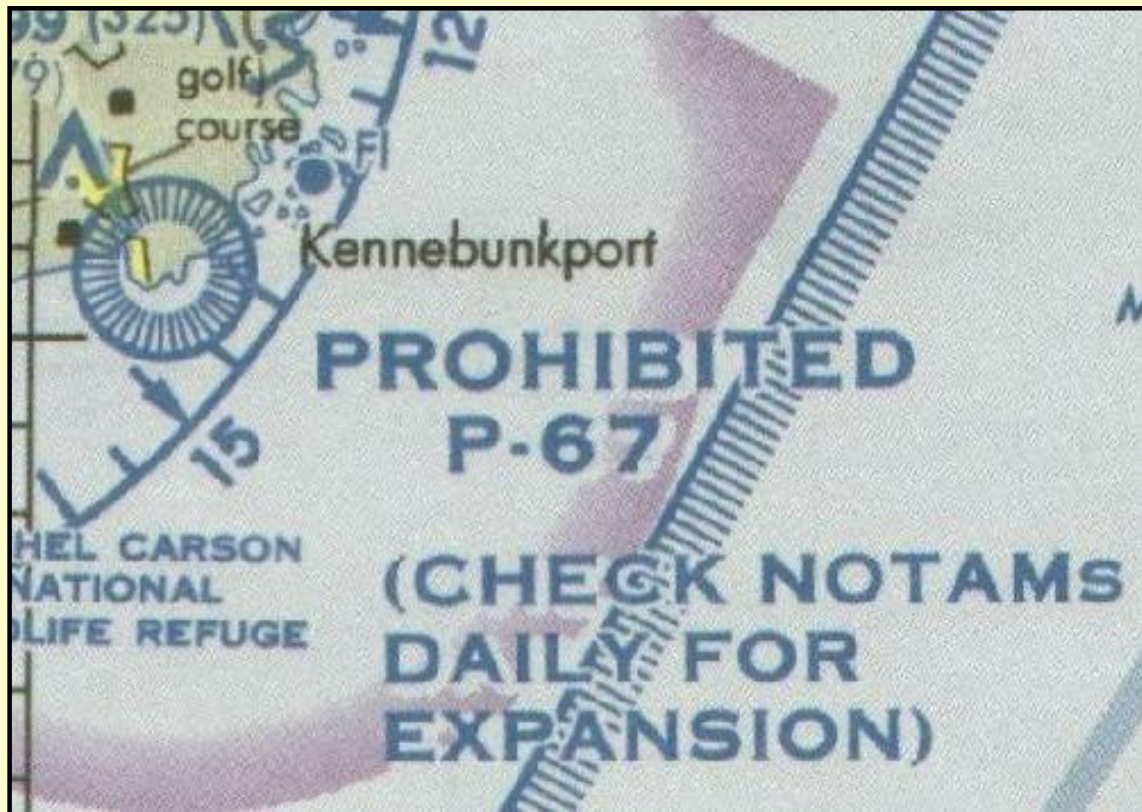
The bold "06" in the lower left of the illustration is the Maximum Elevation Figure for that grid-square. The large digit(s) on the left, here a zero, is the thousands of feet above MSL and the digit on the right is the hundreds of feet above MSL. For this grid the highest elevation of anything, terrain, obstructions, towers, antennas, etc., is 600 feet MSL. Every grid square on a sectional chart has such a notation.

The inverted "Vs" near the airport symbol are obstructions, usually towers. Two numbers are printed next to these obstructions: its height above sea level, and its actual height in parenthesis. You will note a popular obstruction location is near airports.

Don't bother trying to memorize all these symbols and notations. The ones that you frequently use you will learn quickly enough. You can look the others up on the legend panels of the sectional chart.

Each sectional also shows and lists areas of restricted flight. For example, flight is prohibited over the U.S. Capitol or the White House or the Washington Monument. Surface-to-Air Missiles probably don't await you if you violate that airspace, though. It's the bevy of fast-approaching F-16's flown by pilots who, for the moment, have lost their sense of humor that should cause concern. German pilot Matthias Rust ruined it all in 1987 when he flew his Cessna 172 from Germany to Moscow and landed on the grounds of the Kremlin, undetected by the vaunted Soviet air defense.

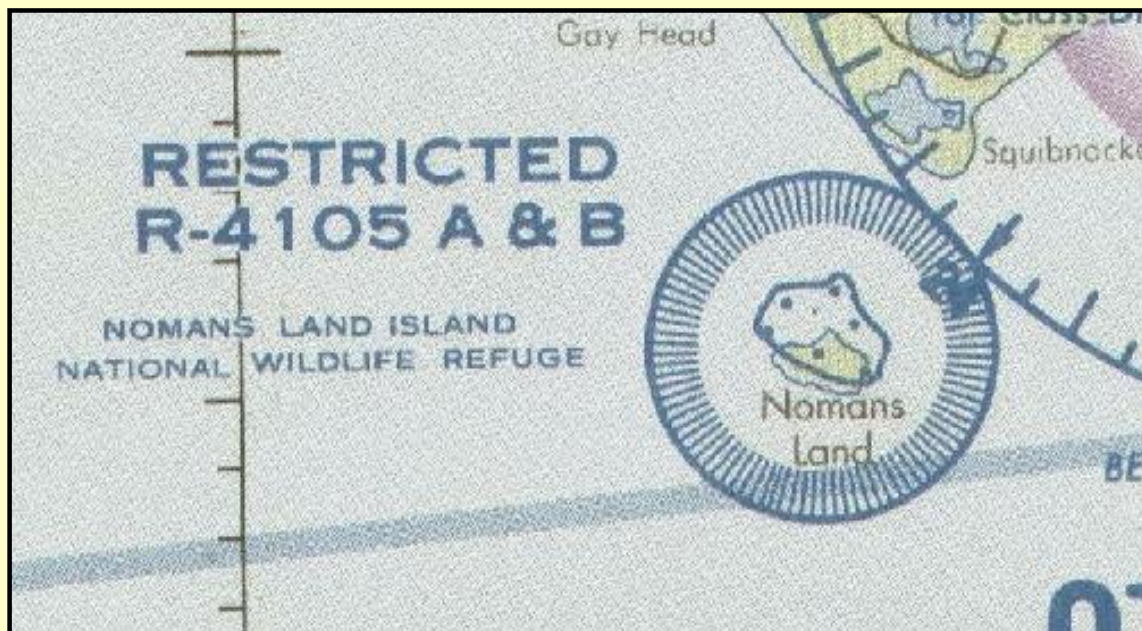
The next illustration shows prohibited area P-67, here a circle with inward radial lines.



P-67 normally prohibits flight from the surface up to 1000 ft. AGL, unless a certain very important visitor is present.

A pilot should contact a Flight Service Station (FSS) for the latest NOTAMS (Notices To Airmen) if he will be venturing near P-67. It's coverage could greatly expand, and ignorance of that fact is no excuse for being in it.

Next is a Restricted area, R-4105, also enclosed with blue hatched lines.



R-4105 protects a national wildlife refuge. This coverage area extends from the surface up to, but not including 18,000 ft.

To overfly R-4105 permission must be requested 48 hours in advance—unless you're at FL180 or above. Just because permission can be requested to overfly a Restricted area doesn't mean it will automatically be granted. The pilot needs a rather compelling reason.

Pilots should also be aware of any Warning Areas in their path of flight. These are identified in the same manner as a prohibited area or a restricted area, with a blue border with hatched lines extending inward.

The notation for Warning Area W-104B should be enough to keep you out:

Warning, National Defense Operating Area. Operations hazardous to the flight of aircraft conducted within this area.

The sectional-chart scale is 1:500,000. That means lay a one-foot ruler on the chart and you will have to pace off 500,000 feet of real ground—almost 95 statute miles—to cover the same distance.

It's only important to know this number because the scale of a Terminal area chart is 1:250,000, and the scale of a World Aeronautical Chart is 1:1,000,000. When flight planning, use the proper scale on your plotter when measuring distances. Oh yes, and the sectional-chart scale question has been on the private-pilot written exam for decades.

Terminal Area Charts

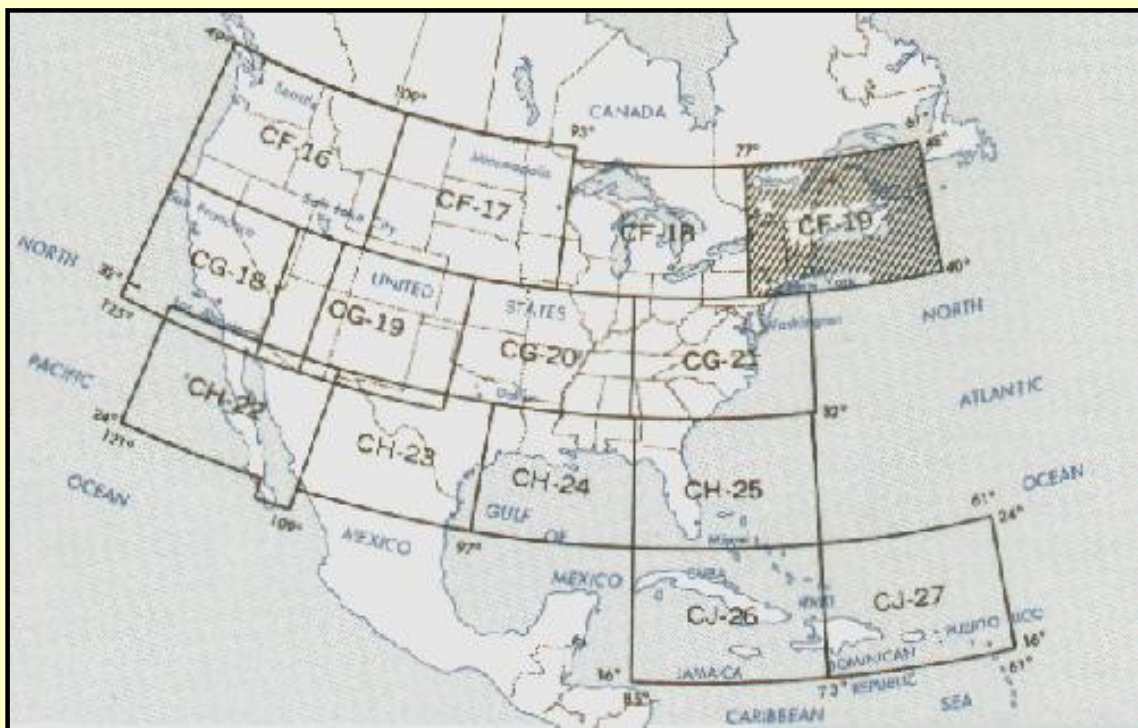
Terminal area charts support Sectionals in the same manner that city street maps support state road maps. The Terminal chart is an expanded view of the terrain and aeronautical features in the vicinity of a major city.

Terminal Area Charts usually carry the same name as the sectional. Sometimes a terminal area chart is available for a second city within a sectional chart, such as the Boston Terminal Area Chart in the New York sectional. Terminal area charts are valid for 196 days (someone must have won the lottery on that number).

As already mentioned, a Terminal Area Chart's features are identical with a sectional chart except that they are one-half the scale to show details more clearly.

World Aeronautical Charts

World Aeronautical Charts—WACs—as the name implies, are available for coverage areas extending beyond the U.S. and Canada. You can get them for the U.S. and Canada, too. Again, buy them at your local airport or through the Internet.



World Aeronautical Chart coverage for the United States.

WAC titles are based on the latitude band they are in. Each WAC coverage is nominally an eight-degree latitude band. As you can see, the CJ series is from 16° to 24°, while to the north, the CF series covers 40° to 48°. As in the sectional chart, the area of coverage of each WAC is grayed out on the front panel for quick reference.

WAC features are identical to sectionals, with two exceptions. The scale is one half, already mentioned, and the validity period differs. World Aeronautical Charts are valid for one year. The date the next edition is scheduled is printed on the front panel.

Airport – Facilities Directory

The Airport – Facility Directory is a comprehensive descriptive listing of every airport, heliport, and seaplane base in the U.S. that is open to the public. It is published every 56 days by the National Ocean Service (NOS). There is so much information in these documents that seven regional volumes are required to cover the lower 48 states. It's indexed by state then city.

The illustration below is part of the header in the Directory for the Nantucket, Mass. Memorial Airport. Everything you ever wanted to know about an airport is contained in this publication: airport sketches, Navaids, communications data, weather data sources, airspace, special notices, and operational procedures. It includes data that cannot be readily depicted in graphic form: e.g., airport hours of operation, types of fuel available, runway data, lighting codes, etc.

It also provides a means for pilots to update visual navigation charts between editions dates; i.e., the Airport/Facility Directory is published every 56 days while the VFR Sectional and Terminal Area Charts are generally revised each six months. This is an inexpensive publication, like charts, and is worth purchasing.

NANTUCKET MEM	(ACK)	3 SE	UTC--5(- 4DT)
48	B	S4	FUEL 100LL, JET A ARFF Index A

This is a portion of the Nantucket Memorial header in the Airport Directory.

The narrative for the first line is, Airport name, three-letter airport designator, airport is 3 nm. south-east of Nantucket city center, and the local time is five-hours earlier than UTC (four hours earlier when daylight savings is in effect). Not shown, but farther to the right on the first line is the longitude and latitude of the airport and the identifying numbers for the sectional chart, the low-altitude IFR chart, and the high-altitude enroute chart that contains Nantucket.

The second line: the airport elevation is 48 ft. above MSL, B means a rotating beacon is present, S4 is the level of aircraft maintenance available (nice to know in case the rubber bands break under the cowling), 100 Low Lead gasoline available, Jet A kerosene fuel available, and ARFF index A indicates the level of fire-fighting and rescue equipment that is available.

Then follows nearly a full page of additional information. [Click here](#) to download the full description for Nantucket plus the directory legend explaining the header data.

An unofficial version of the airport/facilities directory is available online. I'm not certain if it's suitable for "real" navigation, but it's great for flight-simmers. The website is at www.airnav.com.

IFR charts are the next topic. Use the IFR Enroute Low Altitude Chart for IFR flight below 18,000 feet (same title in Canada) and the high altitude enroute chart above that. Click on the *IFR Charts* button below to move on.



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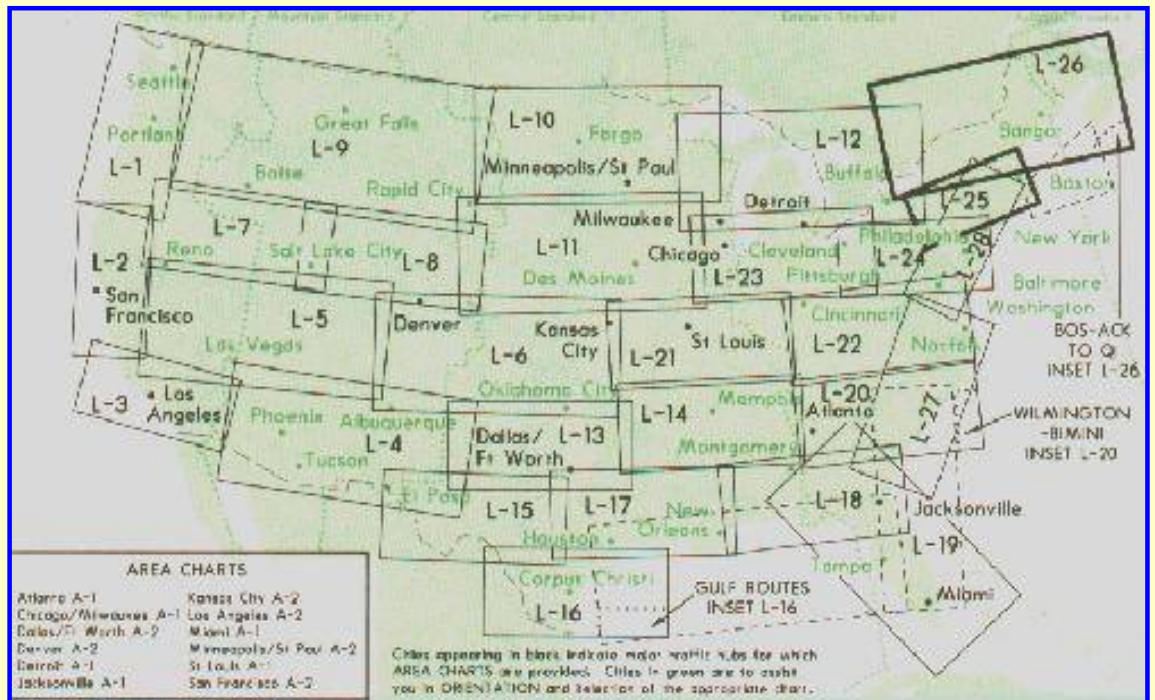
IFR Charts



Courtesy Chris Sheldon, Click for larger view.

As might be expected, IFR Enroute Low Altitude charts differ significantly from their VFR counterparts. Since an aircraft on an IFR flight plan is likely to be touting about in the soup, terrain features are not too important. A quick glance at an IFR chart verifies this. Lakes and rivers are vaguely visible; essentially no other terrain features are shown.

The IFR chart and the VFR chart differ to the degree that one could almost believe that the two issuing departments don't speak to each other. Start with the coverage map on the front panel.



Coverage of Low Altitude Enroute Charts. Click image for larger view.

To begin, gone are the symmetrical areas covered by sectional charts. Some charts cover very large areas, such as L-9, while others cover a small area, see L-3. No grayed-out areas to indicate which chart is in hand, either—been replaced with a heavy border.

Note that low-altitude chart titles begin with the letter "L," and of course the high-altitude

chart titles start with the letter "H." Forget about a cool name to help understand the coverage area, too. Just numbers.

Maybe not so surprisingly, IFR Area Charts are also available. The note below explains: (More easily understood viewing the larger image of the chart coverage.)

Cities appearing in black indicate major traffic hubs for which AREA CHARTS are provided. Cities in green are to assist you in ORIENTATION and selection of the appropriate chart.

This note is on the lower left of the coverage chart.

Looking at the expanded view of the coverage, note that twelve area charts are available. Surprisingly, there isn't one for the New York area. Presumably all traffic is under such rigid ATC control there that an area chart would only be an amusement.

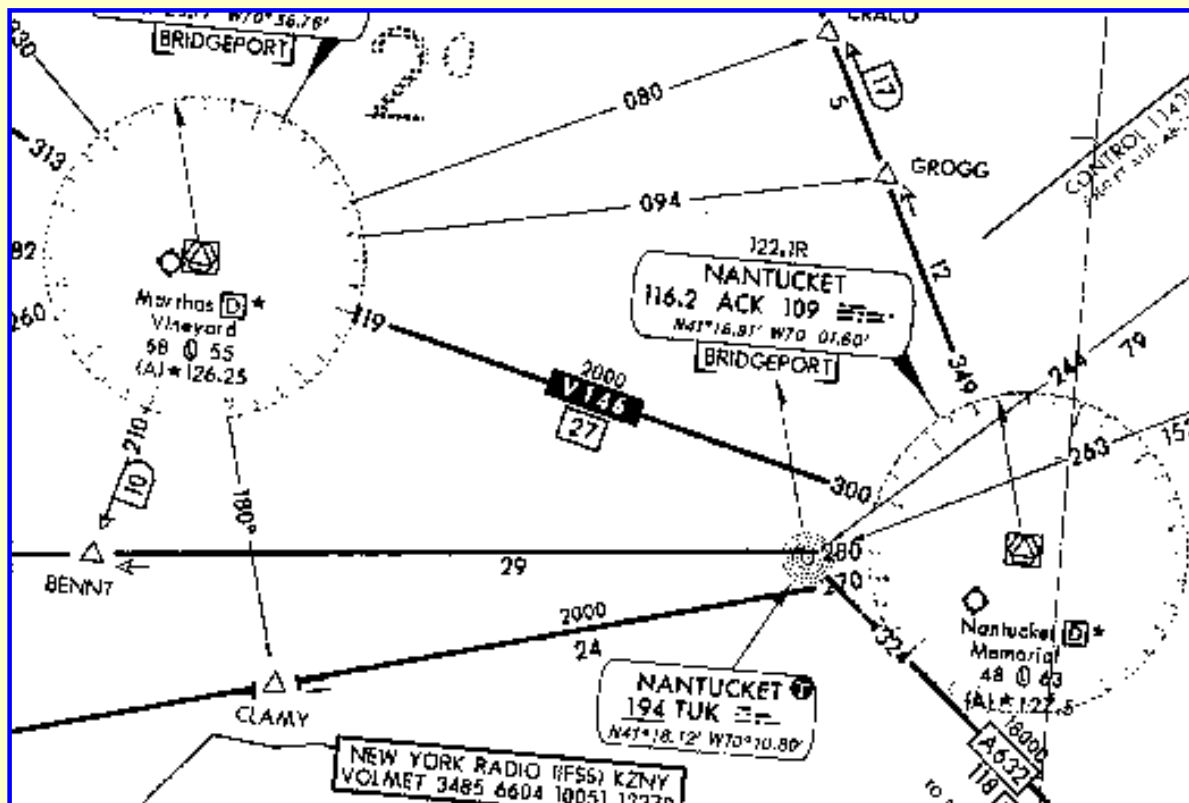
One very important point before moving to the inside. The scale of IFR charts. No more 1:500,000, etc. L-25 is one-inch equals eight nautical miles. At last, distances that can be measured with a common ruler. But wait. L-26, which is on the reverse side of the chart, has a scale of one-inch equals sixteen miles.

L-26 has a Boston – Nantucket – Yarmouth inset with a scale of one-inch equals 40 nm.

Not to worry, though. All pertinent distances (in nm) are printed on an IFR chart. Just be careful when "eyeballing" distances because of the way the scale bounces around from chart to chart.

On to the inside. Like the sectional, IFR charts are printed on both sides, but with a difference. One "L" chart is on one side, and another "L" chart is on the other side. Unlike the sectional chart, which one flips vertically when navigating from the front of the chart to the rear, one flips an IFR chart horizontally. Flip it vertically and you'll be reading it upside down. Well, maybe "reading" is too strong of a word. Cussing may fit better if you fly both VFR and IFR. Apparently what's good for the goose is not good for the gander.

Let's stay near the Nantucket airport.



IFR Chart excerpt near Nantucket. Click on image to download and print high-resolution pdf file.

Many of the features on the IFR chart are similar to those found on the sectional chart. Compass roses are shown for VORs and the NDB symbol remains unchanged, also.

The navigation boxes for ACK VOR and TUK NDB are very similar to sectional chart notation, but with one addition. The longitude and latitude of these nav-aids are listed so that pilots may enter that data into their GPS receivers.

The information adjacent to the Nantucket Airport is in slightly different format, but still easily deciphered: name, Nantucket Memorial, it's in Class D airspace, 48 ft. field elevation, lighted runways, longest runway 6300 ft., ATIS available on 127.5 MHz.

Restricted area R-4105A,B is shown southwest of Martha's Vineyard.

The Bold 20 NE of Martha's Vineyard is the obstruction clearance altitude for that grid on the chart.

The Victor airways are identified. Note V 146. Still shows the 27 nm. from ACK to MVY. The 2000 above the V 146 is the minimum altitude on that airway to guarantee obstacle clearance and reception of signals.

The triangle along V 46, the 270° radial from ACK VOR is an intersection. It is named "CLAMY" and is defined by the 180° radial from MVY. It is 24 nm. from ACK.

The next feature is not seen often. Move to just west of the ACK VOR, to the TUK NDB. Note the airway inbound to the NDB with a 324° bearing. It is named A632. That is a Low

Frequency Navaid airway. In this case, an oceanic airway. Minimum reception altitude is 18,000 feet and it is 195 nm. to the SLATIN intersection.

Move to the 349° radial of ACK. Note the GROGG intersection on that radial, 12 nm. out from ACK. CRACO is the next intersection on the same radial, another 5 nm. out from the VOR. The distance of the two segments, 12 nm. to GROGG and 5 nm. to CRACO is 17 nm. CRACO intersection can be established two ways: the intersection of the 080° radial from MVY with the 349° radial from ACK, or the 17 DME point from ACK. The 17 enclosed in the box as shown near CRACO denotes a DME fix.

Any intersection with an arrow adjacent to it can also be established by the DME mileage from the VOR.

It's time to plot a course and do some flying! Click on the *Plot a Course* button below to move on.



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Plot a Course



I don't see his charts anywhere.

me over, reeling the fuel hose from the truck.

"The Boss told me you should see him the moment you landed," he shouted.

I thanked him and groaned inwardly. The Boss missed his calling—should have been a drill sergeant. He was strictly a "type-A" guy ... "Those who agree with me say I, those who disagree, say I resign." Some call his management style "My Way or the Highway."

"Expected you earlier," was his greeting as I walked into his office. I sat down without responding. As chief pilot of this all-charter operation, I knew that silence in these situations was the only thing that kept me employed.

"As soon as your ship is fueled, I want you to pick up a Mr. Benjamin Counter at New Bedford and fly him to Fishers Island. He's the CEO for an airline here in New England and is a workaholic. He's looking for some property for a second office, to get away for some undisturbed weekends. Supposedly does his best work then—no phones or people to disturb him. Difficult guy to work for, I heard. It'll be just him and an administrative assistant to help with whatever duties may arise."

"He could be a good customer for us if we treat him right," he commanded. "Apparently three other charter outfits didn't because he fired them all. Keep him happy." On that optimistic note he dismissed me with a wave and returned to his mound of paperwork.

I'm not lost, I'm just uncertain of my position.

Not a good feeling. Good preflight planning helps keep that sinking feeling from your stomach.

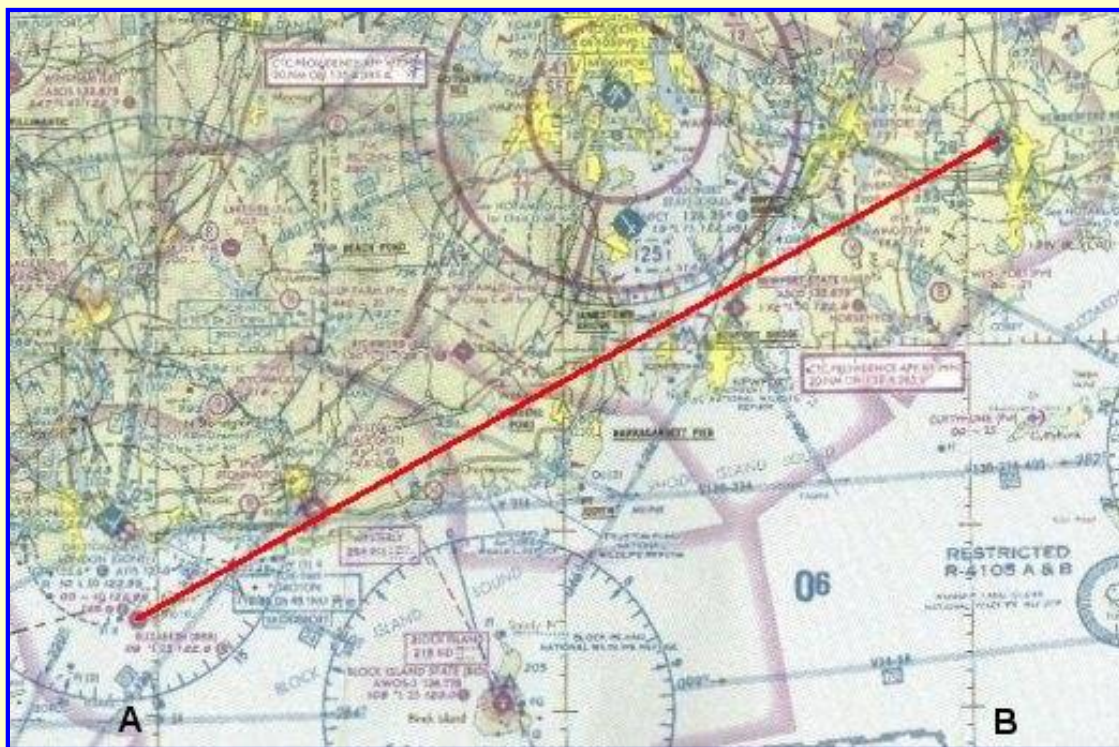
In this section, you'll learn the basics of plotting a course. Two routes are proposed, one in a no-wind situation and the other with a serious wind. After plotting each and calculating the various factors, you'll fly the respective course.

Once you learn the basics, you can download (Downloads section) the software that will flight-plan for you.

Enter Mr. Benjamin Counter

The line boy pulled the fuel truck alongside as I cut the Saab's engine. I had just taxied in after a flight to Boston to pick up some badly-needed spares for our charter aircraft fleet. I was looking forward to relaxing with a Coke in the Pilot's lounge when the line boy waved

So there it was; a flight from New Bedford, Massachusetts to Elizabeth Field, on Fishers Island, just south of New London, Connecticut—your first opportunity to plot a course and test your skills by flying it. The figure below shows the flight path.



**Portion of New York sectional used for first flights. Don't have that sectional?
Click on the image to download the gif file—without the course plotted.**

If you don't have a New York sectional, click the image to download a gif file—zipped—of the portion of the chart needed for this flight. It was scanned at 300 dpi, and is 7.0 in. by 9.5 in. Most likely you will need to resize it before you can use it. Here's how to do that.

Print the gif file at 100 pct size. For the scale to exactly match a sectional's, the distance between the two vertical grid lines, marked A and B, should be 167 mm, or 6-9/16 inch.

Now, suppose the distance on your printout between those grid lines is 164 mm. You must resize the picture to make it larger ... $167 \text{ mm} / 164 \text{ mm} = 1.018$. Resize the image by that factor and print it out again. It should be right on the money.

Flight Planning Worksheet

Use a Flight Planning Worksheet to organize all of the pertinent flight information. Print out the blank forms [by clicking here](#). Acrobat will pop-up with the form, then open it, click on "File," then "Print."

The first entry on the form is at the top-right. Put the aircraft's True Air Speed here. For the trainer in the downloads section, that will be 130 kts. Note that all speeds are in knots. Then fill in the date, the Departure Airport (New Bedford), and the Destination Airport (Elizabeth Field).

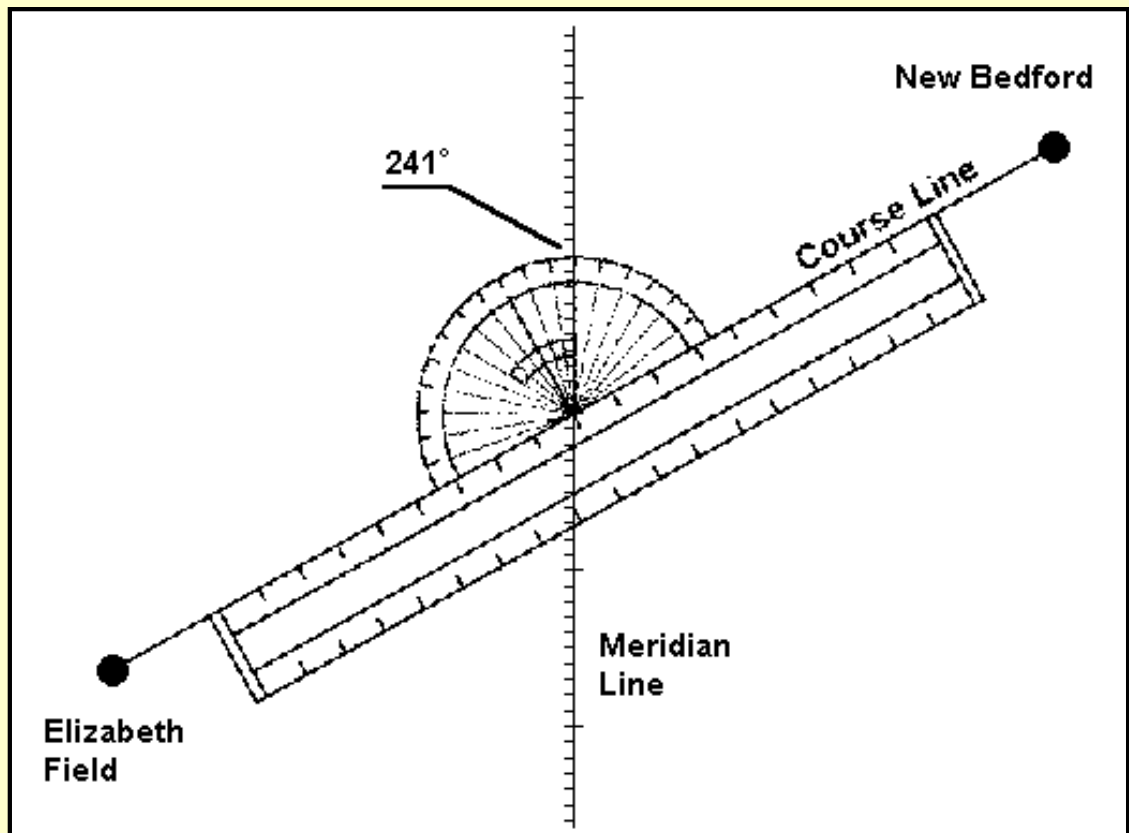
Lastly, enter the destination airport information on the bottom of the form. You don't want to be searching for this information while flying, as you are setting up for the approach. Go to www.ainav.com for the Elizabeth Field info. Retrieve the three-letter airport designator (0B8), the field elevation (9 ft), and the runway information (Rwy 7-25, 1792 ft. and Rwy 12-30, 2328 ft.).

Record this information on the bottom of the worksheet.

[Click here](#) to view the worksheet with the preliminary information filled in.

Let's plot the course and continue filling in the Flight Planning Worksheet.

1. Draw a course line on the chart from New Bedford Airport to Elizabeth Field. Run this line through the center of the two airport symbols. Use a soft black pencil for good visibility of the course line and so that you can easily erase the line when ready to plot another flight.
2. Measure the distance along the course-line between the centers of the airport symbols. Be certain that the nautical-mile side of the plotter is up.
3. The distance should be 54.5 nm. Record this as leg 1 on your flight log.
4. Position the top edge of the plotter, where the mile marks are, along your course line of flight. Move the plotter left or right along the course line until the center-point of the protractor lays exactly on a meridian line. A meridian line is one of the north-south grid lines. The center-point of the protractor is the zero-miles point on the distance scale, in the middle of the ruler. Then read the angle from the outer scale of the protractor where it overlays the meridian line. Use some thought in interpreting this number. See the figure below.
5. For our flight, the meridian line is under the 241° point. This is the TRUE course of our flight. Record it on the worksheet under the heading "TC."
6. For flights that are too northerly or southerly for the protractor to fall on a meridian line, read the angle from the smaller protractor inside the main protractor. Again, position the plotter on the course line. Move it left or right until the center point of the protractor exactly falls on a HORIZONTAL grid line. Then read the angle from the small protractor that overlays the horizontal grid line.
7. The main protractor is marked E-W, meaning use it for flights that are generally easterly or westerly. The inner protractor is marked N-S meaning use it for flights that are mainly northerly or southerly. Keep your wits about you though, and think about the protractor reading to be generally satisfied that you have the correct number.



Measuring the true course, New Bedford to Elizabeth Field.

There now are two more data points for the worksheet: the distance, 54.5 nm. and the true course, 241° .

Determining the effects of the wind on the course would normally be the next calculation, but this first flight is in calm air. So put dashes in the wind speed and direction columns, as well as in the wind-correction-angle column, "WCA." The next flight will consider these factors.

With no wind to contend with, there is no wind-correction angle, and the True Heading (TH) is the same as the True Course (TC) or 241° .

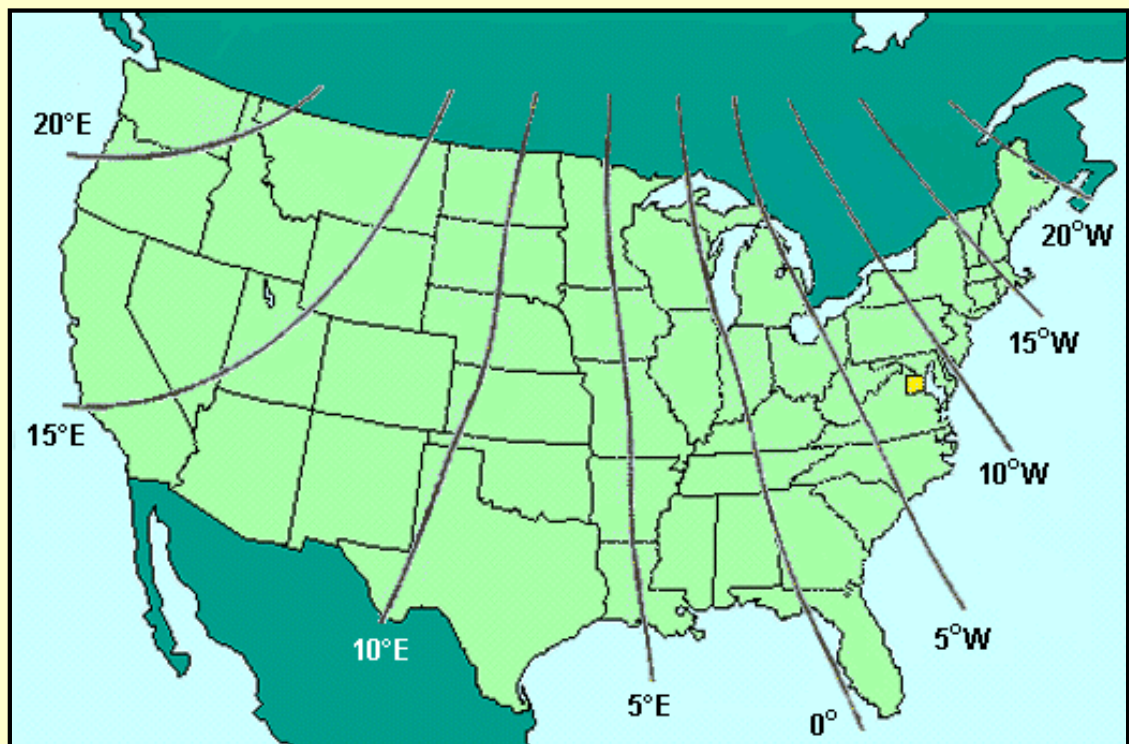
Similarly, since there is no wind, the Ground Speed (GS) will be the same as the TAS, or 130 kts.

Let's take a look at how the worksheet looks up to this point. We'll use Adobe's Acrobat Reader to view the progression of the worksheet. [by clicking here](#).

Magnetic Variation

As most will recall, either from the old days in school, or more recently, the Magnetic north pole on earth is not the same place as the True north pole. Since we fly by the compass, which points to Magnetic north, we have to adjust the aircraft heading, which is based on the compass reading—the Compass Heading—to be on the correct True Heading.

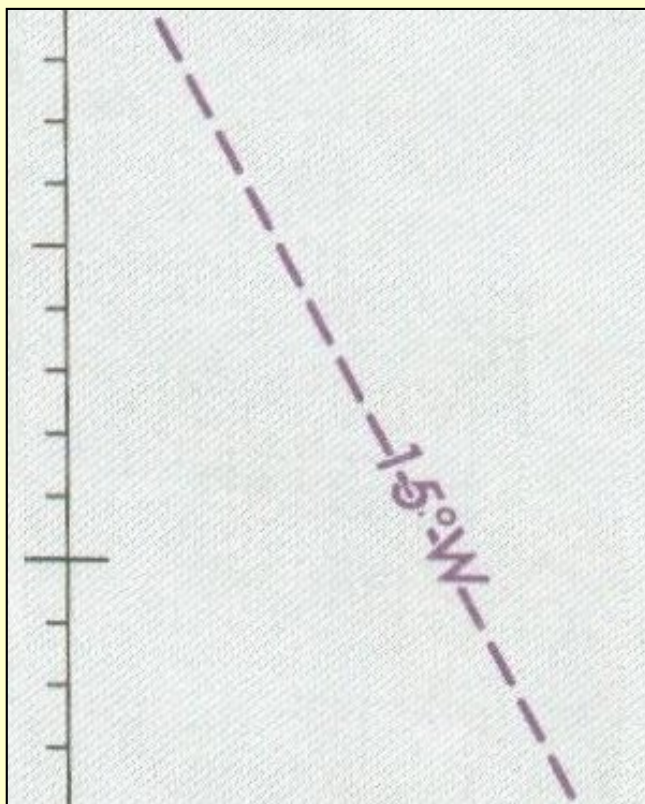
The map below shows the variation in the U.S. between a compass reading and true north.



Magnetic Variation, isogonic lines, across the U.S.—Westerly variation means that the compass points west of true north.

Sectional charts show isogonic lines for every one degree of magnetic variation. An isogonic line is a

line drawn through points of equal magnetic variation. On the New York Sectional an isogonic line passes through Block Island Airport.



The magnetic variation for an isogonic line is written along the line, as this illustration shows, and is normally positioned near the bottom of the chart.

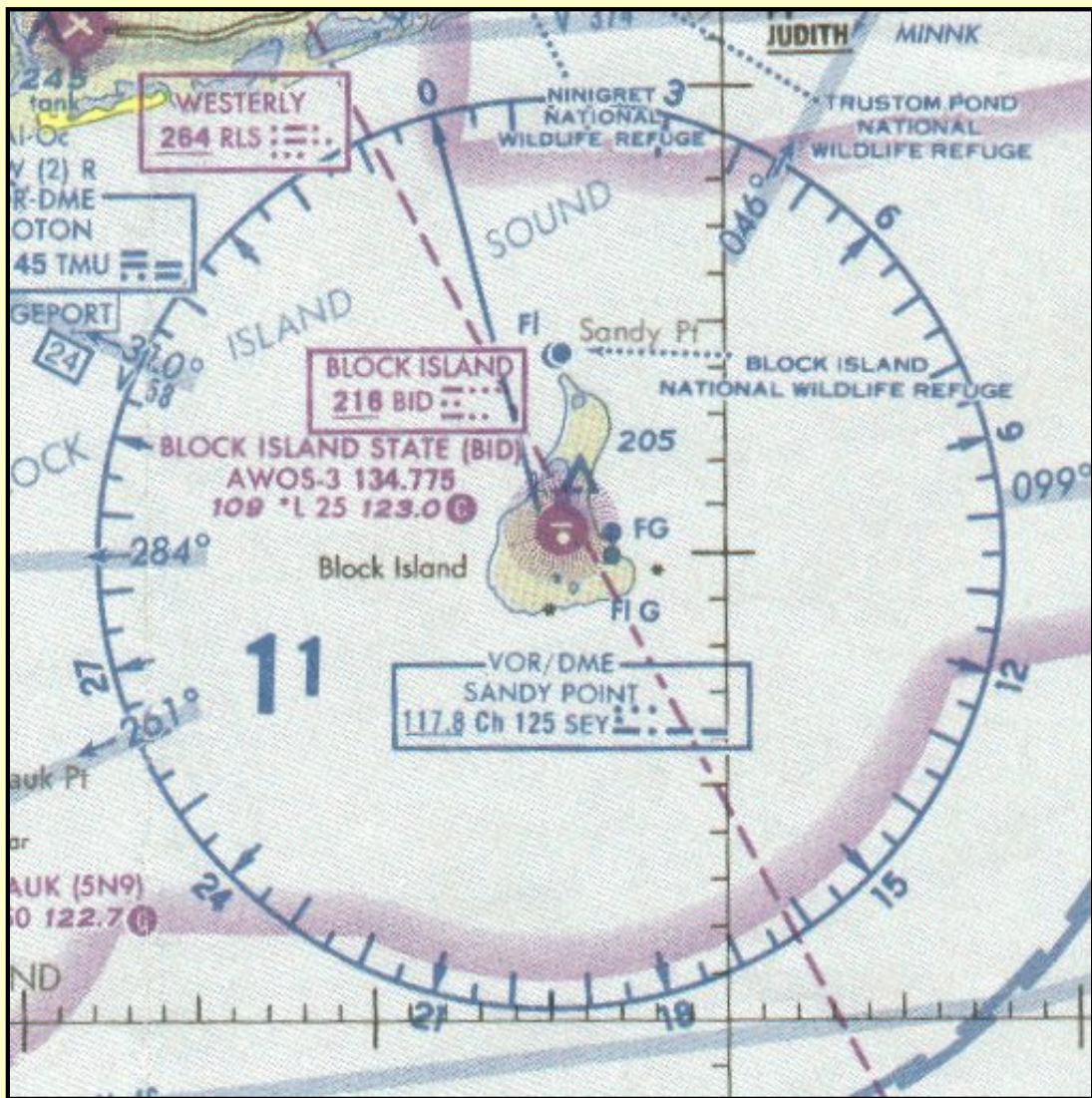
The isogonic line shown also is the one that crosses our flight path from New Bedford to Elizabeth Field. So we have to factor this into the aircraft compass heading to track the true 241° course plotted from the chart.

The question is, add the magnetic variation to the compass heading, or subtract it? Well, there is a rule for that, and another memory aid. But there is an easier way to decide. The clue lays right in front of you, on the sectional chart.

Recall in the sectional chart discussion in a previous section the mention that the symbol for a VOR was a compass rose with an arrow pointing towards magnetic north. A glance at

a VOR near our flight path will give us the add or subtract answer.

Note the Sandy Point VOR in the illustration at Block Island. The isogonic line passing right over the airport is 15° west. Since it is a west variation, magnetic north points west of true north, and that is evident in the illustration.



Sandy Point VOR compass rose, Block Island airport. The VOR 0° radial always points to magnetic north.

Assume your aircraft is flying over Block Island airport along the 0° VOR radial, which is magnetic north. True north is indicated by the meridian line just east of the airport. For the aircraft to head true north, it must turn right to parallel the meridian line. Right turns always adds numbers, so the 15° that the aircraft had to turn is added to its true heading. In this case the compass will show 15° when the aircraft is flying true north.

Just look at a VOR, decide whether to turn right or left from the 0° radial to head true north, then add the magnetic variation if it's a right turn or subtract if it's a left turn.

The easily-remembered memory aid is "East is Least," meaning if the variation is East, subtract the variation from the true course to get compass heading.

The compass heading from New Bedford to Elizabeth Field will then be 256°, or 241° true course plus 15° magnetic variation west.

Choose an altitude. If the flight is long, consider the effect of the winds aloft when choosing an altitude. For the moment, we'll ignore them and just choose the altitude based on magnetic heading, westerly. The flight is brief and VFR, so fly at 4500 ft.

Estimated Time En Route

The final steps in the flight plan is to calculate the Estimated Time En Route, ETE, and fuel used.

$$\text{Estimated Time En Route [Minutes]} = \frac{\text{Distance [nm.]} \times 60}{\text{Ground Speed [kts.]}}$$

First, the data needed:

- First leg distance: 54.5 nm.
- First leg true heading: 241°.
- Cruise altitude: 4500 ft.
- True Air Speed at 4500 ft.: 130 kts.
- Climb speed, 105 kts.
- Rate of climb: 700 fpm.
- Descend airspeed: 120 kts.
- Descend rate: 500 fpm.
- Fuel consumption, cruise, 20 gallons per hour.
- New Bedford field elevation: 80 ft.
- Elizabeth Field elevation: 9 ft.

There are two methods of calculating ETE. The first method is for the purists, or for those who have pulled their 747 out of the garage for a weekend flight and will be cruising at FL390.

1. Calculate the time to climb to cruise altitude.
2. Calculate the time to descend to the destination runway.
3. Calculate time for the remainder of the flight at the cruise altitude.
4. Add the three time calculations for ETE.

Since this first flight is assumed in a zero-wind situation, the ground speed will be the same as the air speed, and the course heading is not a factor in the ground speed. Also, since the departure and destination field elevations are less than 100 ft., they will be ignored for ETE calculations, too.

Time to climb to cruise altitude = 4500 ft. / 700 fpm = 6.4 minutes or 0.11 hrs.

Distance covered during climb = 0.11 hrs. × 105 kts. = 11 nm.

Time to descend = 4500 ft. / 500 fpm = 9 minutes or 0.15 hrs.

Distance covered during descent = 0.15 hrs. × 120 kts. descent = 18 nm.

Balance of flight at cruise altitude = 54.5 nm. minus (11 nm. climb, + 18 nm. descent), = 25.5 nm. at cruise altitude.

Time at cruise altitude = 25.5 nm./130 kts. = 0.20 hrs., or 12 minutes.

Therefore, the ETE is:

Time to climb	6 minutes
---------------	-----------

Time to descend	9 minutes
Time at cruise altitude	12 minutes
ETE	27 minutes

Second method to calculate ETE: calculate the time to fly entire distance at cruise speed.

$$= 54.5 \text{ nm.} / 130 \text{ kts.} = 0.42 \text{ hrs. or 25 minutes.}$$

Add 5 minutes for climb and descend. With this method, the calculated ETE is 30 minutes; 3 minutes longer than the "precise" calculation. For longer flights, this second method of calculation becomes more accurate.

At low cruising altitudes in VFR weather, the second method is very acceptable for calculating ETE.

The final calculation is the fuel consumption. The second method of calculating ETE will suffice for the time aloft to calculate fuel consumption. If you're piloting an airliner flying at high altitudes, as all airliners do, the fuel consumption should be calculated for climb in addition to cruise, as the climb fuel consumption rate is much higher than the cruise consumption rate.

$$\text{ETE} = (54.5 \text{ nm} / 130 \text{ kts}) + 0.083 \text{ (5 min. for climb and descent)} = 0.50 \text{ hrs.}$$

$$20 \text{ gph} \times 0.50 \text{ hrs} = 10.0 \text{ gallons of fuel used for the flight.}$$

Now [click here](#) to see the completed Flight Planning Worksheet for the first flight, New Bedford to Elizabeth Field.

Flight Planning Summary

1. Enter route information on planning sheet.
2. Enter destination airport information on planning sheet.
3. Plot the true course on the sectional.
4. Measure the distance in nautical miles from the departure airport to the destination airport. (Or between checkpoints.)
5. Determine the true course heading with a plotter.
6. Select the cruising altitude (based on magnetic course).
7. Determine the Wind Correction Angle (WCA) and then the True Heading (TH).
8. Add or subtract the magnetic variation (VAR) to determine the Compass Heading (CH).
9. Calculate the ETE—Estimated Time En Route.
10. Calculate the amount of fuel used.

Follow those ten steps for each leg of a flight.

Now let's fly the course!

Start the panel-mounted timer as you lift off from New Bedford's Runway 23 and stop it as you touchdown on Elizabeth Field's Runway 25. Compare your actual flight time against your

calculations. You'll enjoy flying this aircraft with the oversize gauges.

Well, that was an interesting flight and mathematical exercise, but hardly one shrouded in realism. It was, though, a good stepping stone to handle the real-world issues of winds aloft, and their affect on navigating from point A to pont B.

Winds aloft affect both the ground speed of the aircraft, and the heading that the aircraft must fly to stay on the desired true course.

Time to Debunk Another Myth

Some pilots contend that a strong headwind is not a concern because the lost time will be gained on the return journey, when benefitting from the tailwind. The truth is, for a constant wind situation, the effects of a headwind cannot be reversed by the tailwind on the return trip. A simple calculation will end the discussion on this subject.

For illustration, assume a 180 nm. journey, a 60 kt. headwind, and an aircraft that cruises at 150 kts TAS.

The ground speed into the headwind will be 150 kts. minus 60 kts. wind or 90 kts. Time to fly the 180 nm. will be $180 \text{ nm.} / 90 \text{ kts. ground speed}$, or 2.0 hrs.

For the return trip, ground speed will be 150 kts. plus 60 kts. tailwind, or 210 kts. Time to fly the return trip will be $180 \text{ nm.} / 210 \text{ kts.}$, or 0.86 hrs.

Total flight time with this wind situation = 2.0 hrs. + 0.86 hrs. = 2.86 hrs.

Now consider the no-wind journey. Still 180 nm. each way, total 360 nm. TAS of aircraft is 150 kts. Therefore total round-trip time, with no wind, will be $360 \text{ nm.} / 150 \text{ kts. TAS}$, or 2.4 hours—0.46 hrs. shorter than flying with the headwind and tailwind.

Try the calculation for any distances, any TAS, and any wind speed. The results remain the same. The effects of a headwind can not be overcome by the same tailwind.

The Second Flight and more of Mr. Benjamin Counter

"What did you do to Mr. Counter?" the Boss shouted. "He gave me an earful about your violent antics while landing at Fishers Island. Said your jerky maneuvers almost threw him out of the plane."

'Violent antics?' If I knew it would come to this I'd have barrel-rolled out.

"The deer that ran onto the runway as I was about to flare out left me with two choices," I replied, evenly. "It was either venison steaks à la propeller blades at the expense of your sparkling-new MFI-17, or go around from a near-stall and put up with Counter's complaints—tough decision, but I chose the latter."

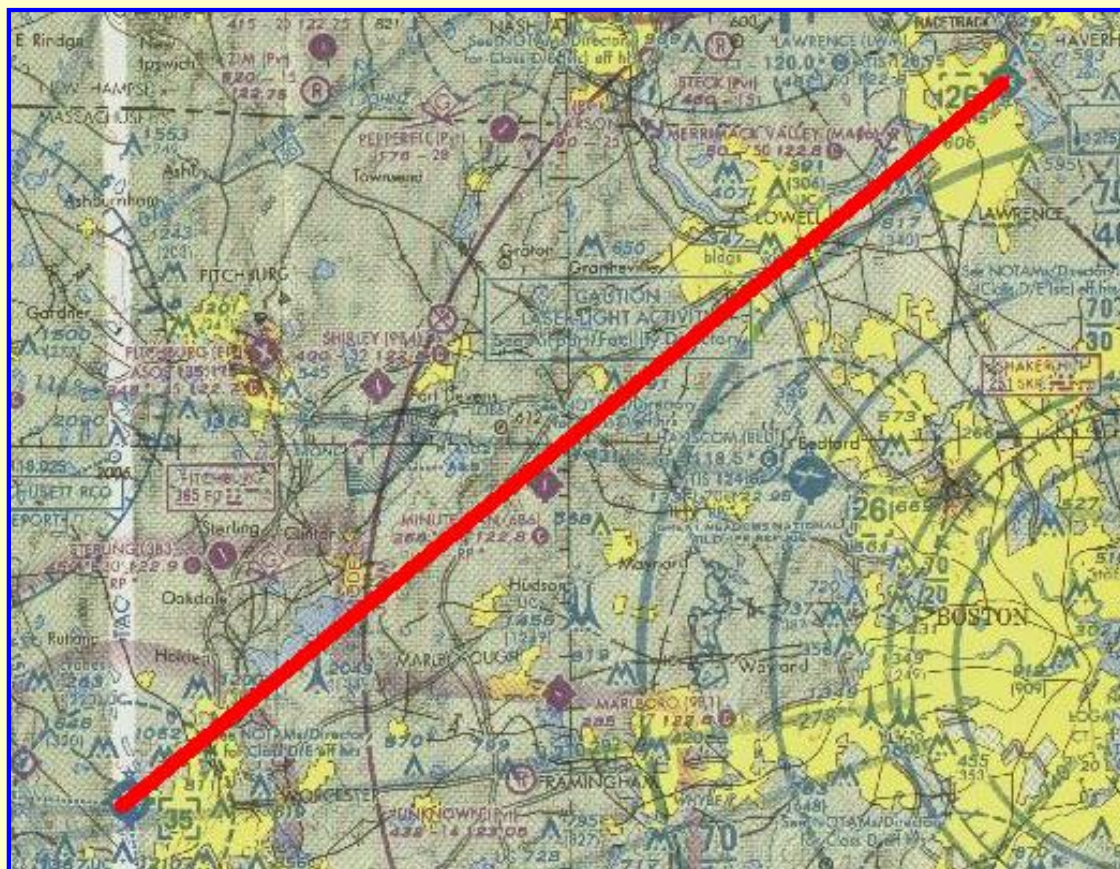
"He didn't mention a deer. Anyway, he's giving us, you, one more chance, so don't botch it. He needs to get from Lawrence Airport to Worcester—this afternoon. His stock broker is in the Worcester office with a hot trade recommendation, but Counter wants to talk to him about it in person before the market closes.

"So give Counter a nice smooth flight and we might keep him as a customer," the Boss finished.

A nice smooth flight? A strong cold front had just raced through early this morning leaving very brisk north-westerly winds in its wake. Flying low and slow will be very bumpy.

Can't worry about that now. The flight originates at Lawrence, Mass., airport ID LWM, then southwest to Worcester, airport ID KORH. Time to plot it and move on.

The figure below shows the route of flight, which is still wholly contained on the New York sectional chart. A click on the image will download a zipped file of the same portion of this sectional for those without the chart. Go to the Downloads Section if you have a color printer.



Second flight, Lawrence, Mass. to Worcester, Mass. Click the image for the GIF file, without the course plotted, if you don't have the New York sectional.

Again, check the print-out of the sectional for faithfulness in size. The distance across two grid-squares should be 166 mm.

Print and begin a new Flight Planning Worksheet for this second flight. On the sectional plot the true course from Lawrence, Mass., KLWM, to Worcester, Mass., KORH.

Enter that information, along with the Worcester Airport, KORH. data onto the worksheet.

The winds aloft are 315° at 40 kts. That goes on the worksheet, too. Note, winds aloft commonly vary depending on altitude, but for this example they are considered constant regardless of altitude.

Now [click here](#) to see the Worksheet containing this initial data. If your results differ, recalculate or remeasure to find the problem. If your work is OK, and I messed up, please e-mail me and I'll correct whatever is wrong.

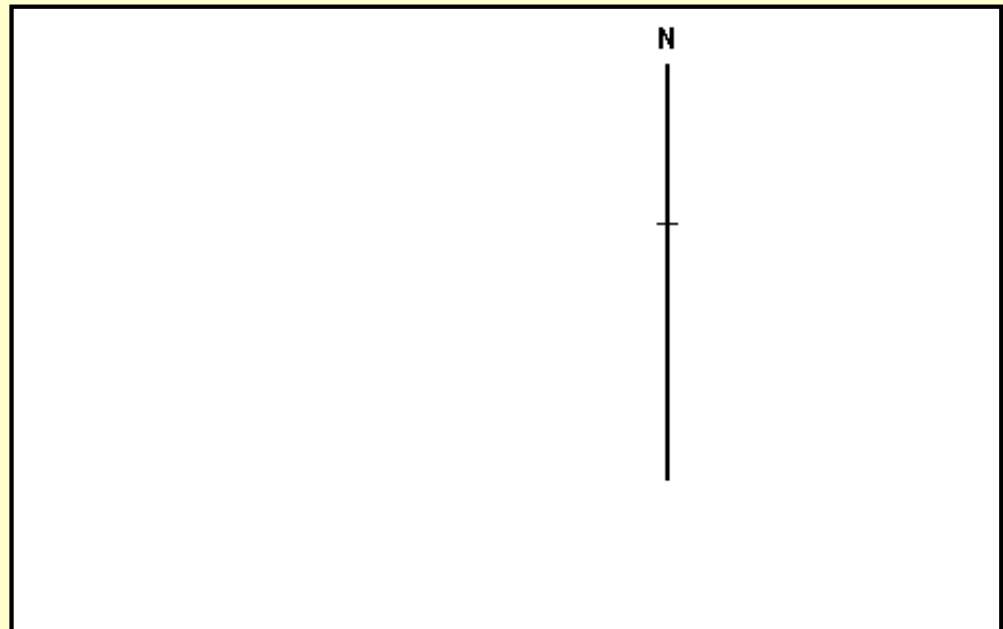
The Famous Wind Triangle

We draw a triangle on a sheet of paper to determine the wind correction angle (WCA) and ground speed (GS). It is a simple, six-step process that takes less time to do than to describe. Best of all, it's an approach that works whether the flight is simple or complex.

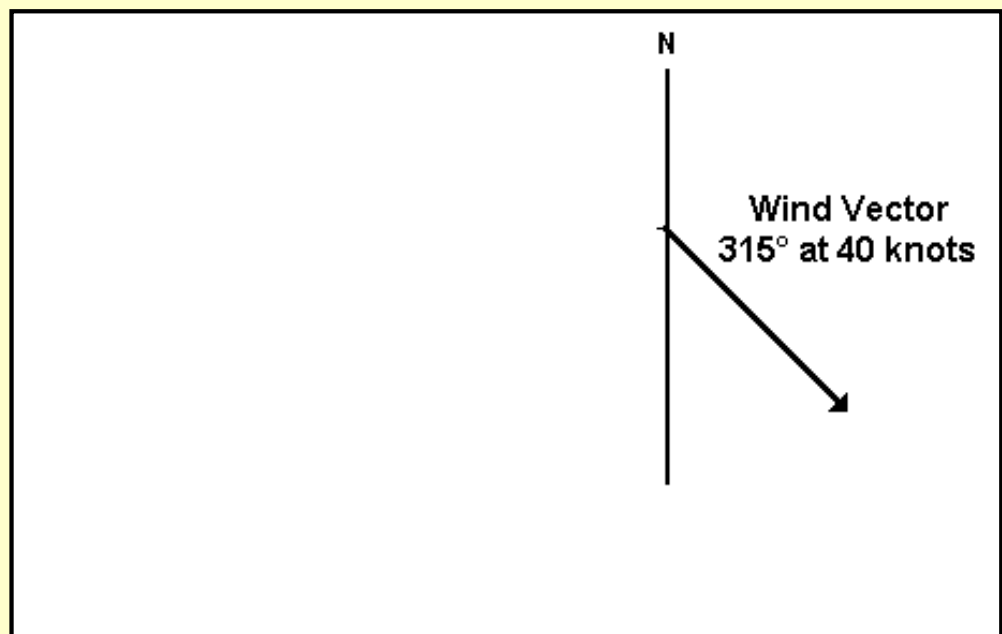
Begin by orienting the paper in the direction of the flight. For an east or west flight, the long side of the paper should be horizontal. For a north or south flight, turn the long side vertically. Use a separate sheet for each leg of the flight.

A conventional ruler or scale and a protractor will work fine for this work.

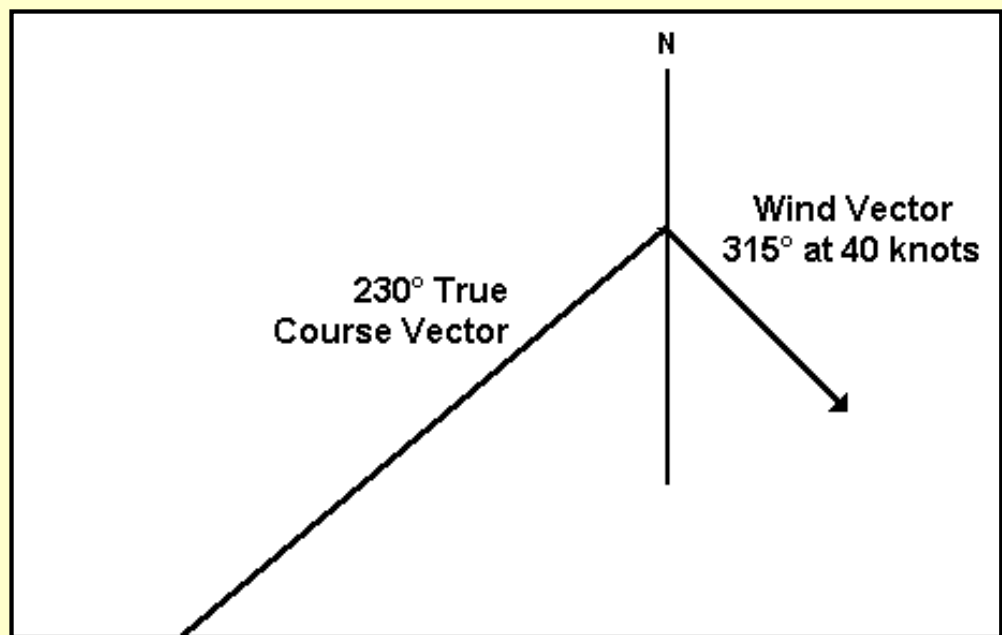
Now the steps of the wind triangle.



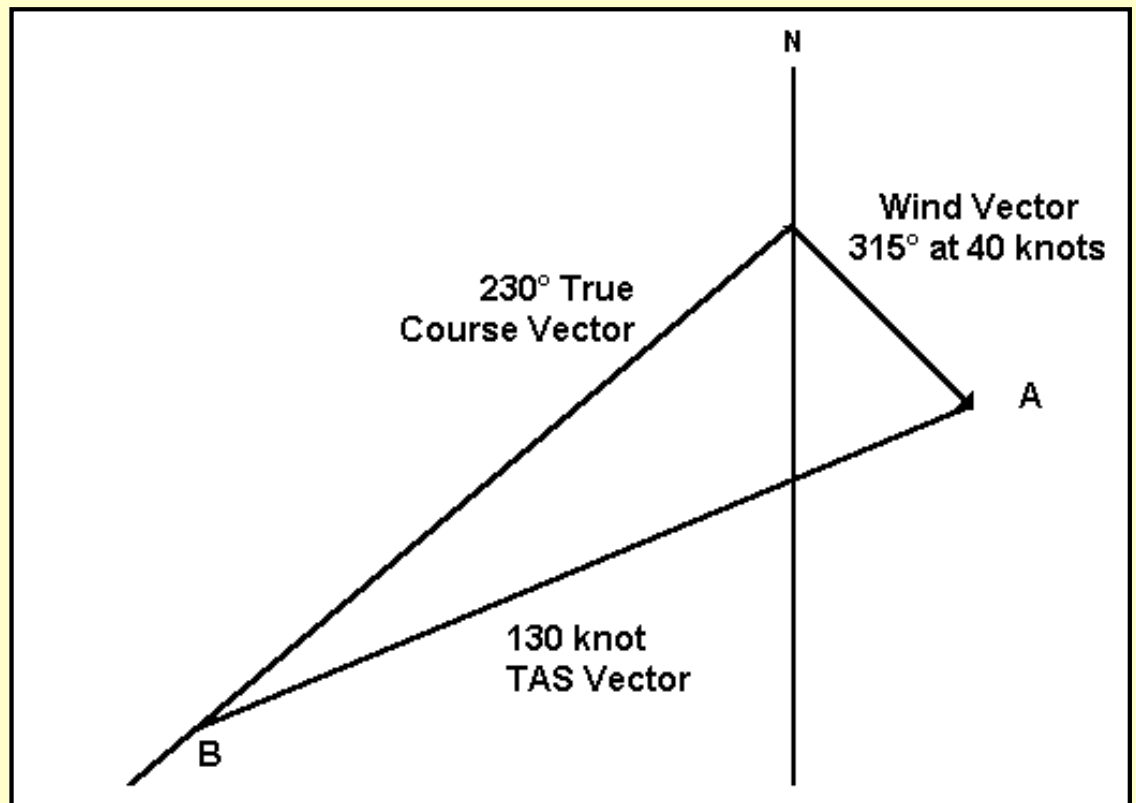
- 1. Draw a vertical line representing a meridian line. In this instance, the line is to the right of the paper and to the top since the aircraft's true course on the first leg is south-westerly. Want to leave room on the page for plotting.**



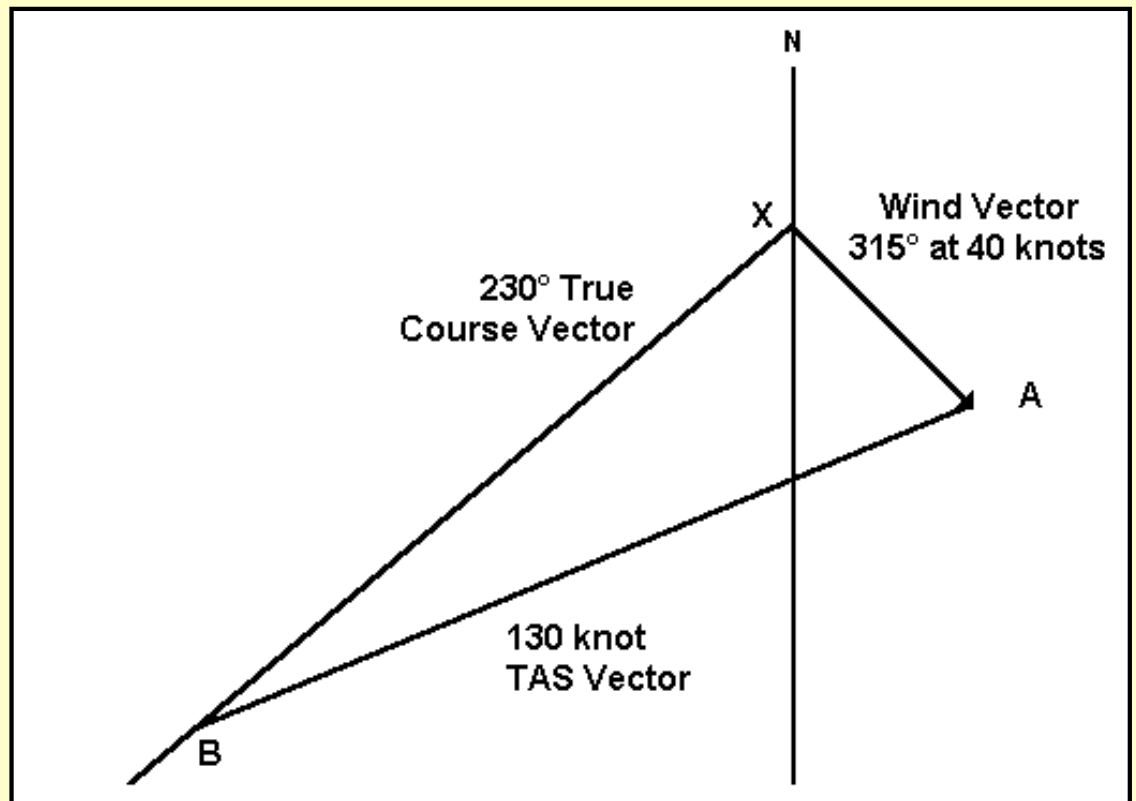
2. Next draw the vector for the wind. Use any scale, but keep it consistent for all vectors. I find 1 mm = 1 kt a workable scale. Wind FROM the north-west, 315°, is wind going TO the south-east. Measure all angles carefully.



3. Draw the vector for the True Course. Here it is 230°. The line should be "long" as the pertinent length will not be known until the third side of the triangle is entered, on the next step.

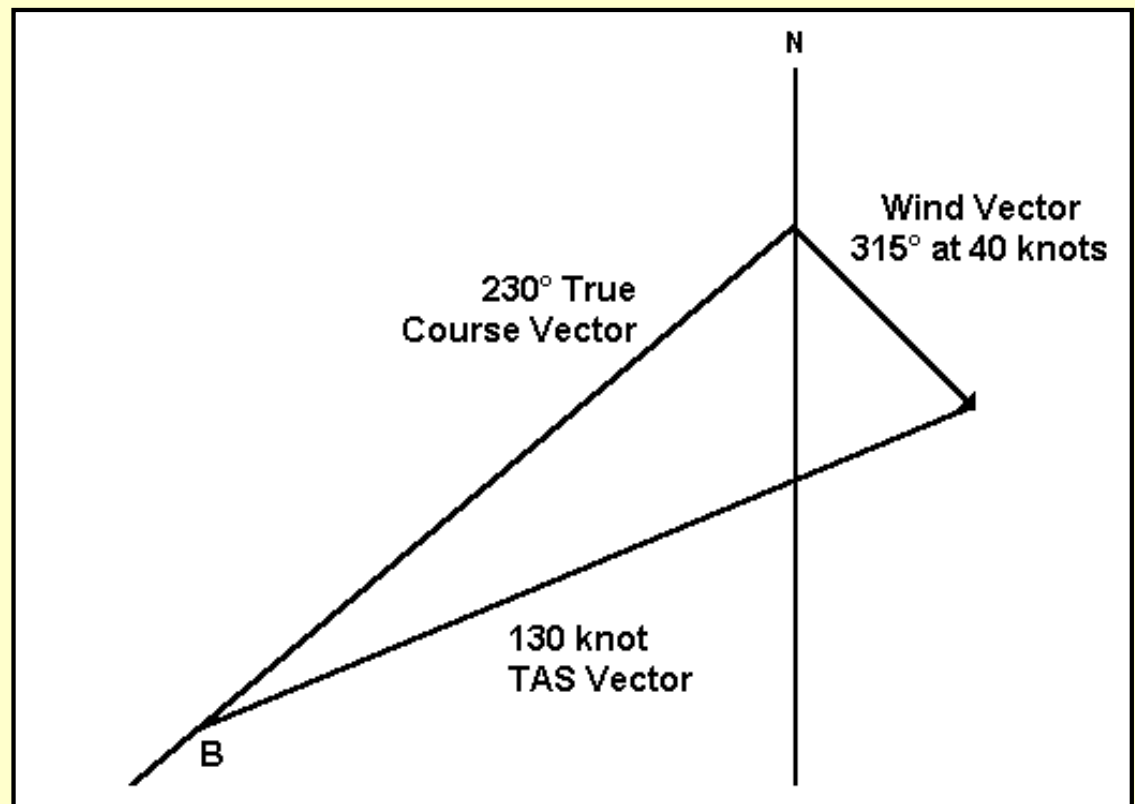


4. Put in the TAS vector. In this example, it is 130 units long for 130 kts. Hold the "zero" of the ruler at point A and rotate the ruler until the 130-unit mark intersects the True-Course vector, here at B. Draw the line from A to B. The triangle construction is now complete.



5. Measure the distance along the True-Course vector, from point X, the origin, to point B, where the TAS vector intersects. This distance is the aircraft's Ground Speed. In this

case, it is 94 knots.



6. To determine the Wind Correction Angle measure the inside angle at B, between the True-Course Vector and the TAS vector. Here the angle is 18°. If the wind is from the right of the aircraft, add the WCA; if from the left, subtract the WCA. In this case, the wind is from the right, so the WCA is plus.

In summary, here are the steps to build a wind-triangle and then determine the aircraft's Ground Speed and Wind Correction Angle:

1. Draw a vertical line on a sheet of paper to represent a meridian line.
2. Draw the wind vector, faithfully reproducing its velocity and wind direction. Remember that winds are reported "from" a compass heading and 180° must be added to that when drawing the vector.
3. Draw the True-Course vector from the point of origin between the meridian line and wind vector.
4. Draw the TAS vector with its origin at the end of the Wind vector. The ruler should be rotated about that point until the no of units of TAS intersects the True-Course Vector.
5. Measure the distance along the True-Course vector between the two points of intersection. That will be the Ground Speed.
6. Measure the angle inside the point where the TAS vector intersects with the True-Course vector.

After you've drawn two or three wind triangles, you'll find you can complete the process in about 3 minutes.

Download the completed worksheet, [flightplan-lwm1.pdf](#), from the Downloads Section.

Microsoft Complicates the Flight-Planning

Normally, at this point you should be ready to enter the winds into the MS Flight Simulator and start the flight. But recall that the weather dept. reports Winds Aloft in true direction, so that we can flight plan using true course, and reports surface winds in magnetic direction, since runway headings are magnetic.

Flight Simulator specifies ALL winds in magnetic, so an additional calculation is needed before the flight plan is completed.

We must convert the Winds Aloft to their equivalent Magnetic direction to properly set up Flight Simulator.

Add the Magnetic Variation to the Winds Aloft True direction if the variation is West, as it is here, or Subtract the Magnetic Variation from the Winds Aloft True direction if the variation is East.

For this flight, the wind's magnetic direction = $315^\circ \text{ true} + 15^\circ \text{ variation} = 330^\circ$. So, to properly set up Flight Simulator, enter a wind of 40 kts from 330° .

Now climb into your Saab MFI-17, with the FS-98/FS-2000 weather set for a wind of 40 kts from 330° , note the headings, etc., in your Flight Planning Worksheet, and be on your way. Start the panel stopwatch as you roll down Lawrence Airport's Runway 33 and stop it after touchdown at Worcester. Compare your flight time with the predicted flight time.

Be sure to use the proper runway at Worcester. Land on Runway 33, not Runway 29. With this very strong wind, you could not keep the aircraft on the runway using any runway except 33.

And enjoy the flight. Give Counter a nice ride.

The Great Microsoft Flight-Sim Wind Software Bug

Unfortunately, you can't simply set the wind speed and direction of the wind in FS-98, then take off from the airport. In FS-98, because of a serious software bug, an aircraft on the ground will rotate to point into the wind, or "weathervane." Makes no difference whether the engine is on or off or the brakes are set or not. In this example, with a wind of 40 kts. from 270° the nose of the aircraft will slide around until the compass shows a heading near 270° . Sometimes you will be lucky and that heading is approximately aligned with the runway. Other times, it could be 90° to the runway.

The solution? There are two, neither good.

- Take off regardless of the alignment of the aircraft with the runway. Shortly after the aircraft is airborne, turn to the runway heading, correcting for the effects of the crosswind. I use this method, and have mostly avoided crashing into terminal buildings, other parked aircraft, or mountains.
- If you have a strong desire to taxi the plane to the runway, the method above will not work. It is practically impossible to adequately control the direction of the aircraft while taxiing with any level of wind. So turn off the wind, take off, then turn the wind back on shortly after take-off.

Some aircraft don't exhibit this property, in which case you can do everything "right."

FS2000 was just released a few days ago and I haven't heard yet whether this bug has been corrected.

Alternatives to the Wind Triangle

While pencil, paper, ruler and protractor offer a simple, accurate, and quick method to calculate Ground Speed and Wind Correction Angles, more convenient devices have evolved over the years. Probably the most well known is the Dalton E6-B flight computer. The E6-B is basically a circular sliderule with a sliding tab for wind calculations. With practice, it can be manipulated with one hand, certainly a consideration when piloting an aircraft faced with an unplanned change of route.



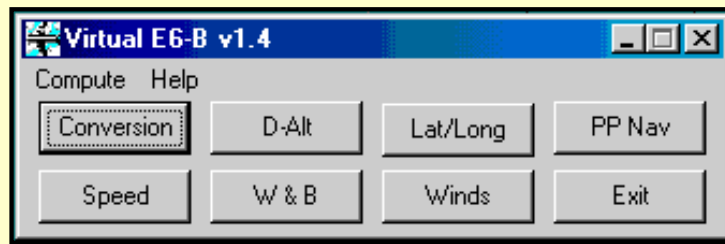
Millions of pilots have trained on the E6-B flight computer.

The E6-B has been around a long time. Philip Dalton invented it in the early 1930s. During WWII, it was engraved brass, later plastic. Today, one can purchase aluminum, plastic, or cardboard models. Buy one if you are into realism and nostalgia. Try eBay and other auctions for better quality units at decent prices.

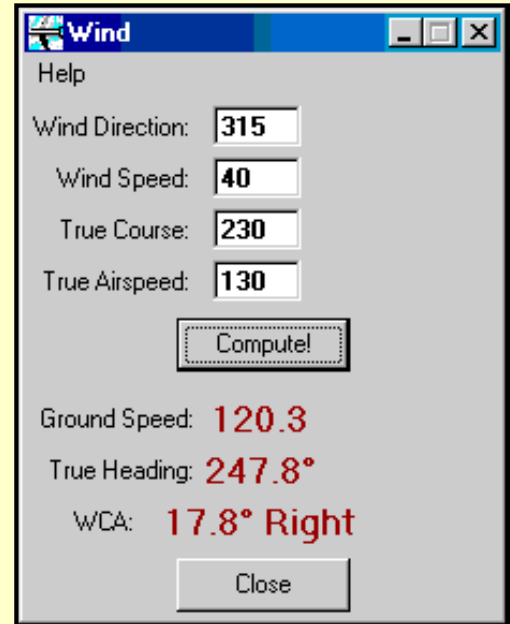
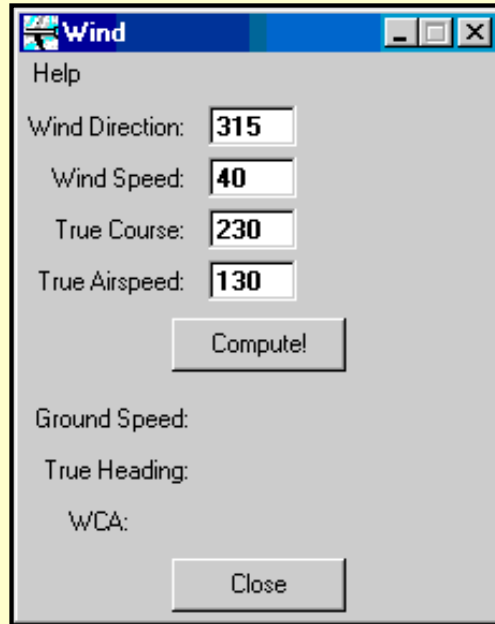
The Virtual E6-B

For ease, simplicity, accuracy, and speed, the flight-simmer should try the virtual E6-B. It is a freeware software program that calculates the Wind Correction Angle, Ground Speed, and a host of other things. See the illustrations below for the calculations just performed using the wind triangle.

[Click here](#) to download this handy utility.



The opening panel of the Virtual E6-B shows the many options available.



On the left, input numbers have been entered. On the right, results computed.

With the basics of plotting and flying VFR courses behind us, the next step is instrument work. We'll begin with the Non Directional Beacon, NDB, because once you have mastered that work, you can handle all of the other IFR work with ease.

Handy Sheet 3.0

Before going to the next section, there is one last nugget to pass along. It's Wagner B. Beskow's Handy Sheet 3.0, <http://www.geocities.com/CapeCanaveral/Hall/7704/>

Here is what's on this one-page reference guide for all your simulated flights:

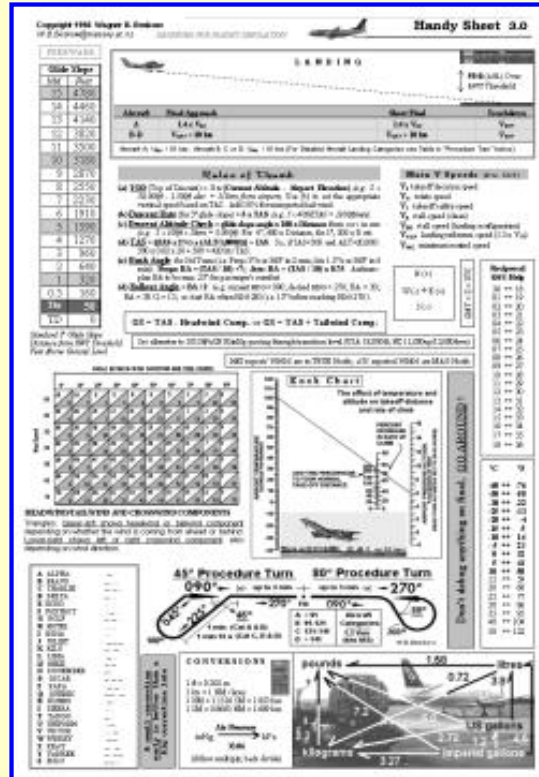
Main Features

Diagrams

- Approach and Landing Speeds
- 45° and 80° Procedure Turns
- Koch Chart (effect of temperature and altitude on takeoff distance and rate of climb)
- Fuel, Air Pressure and Distance Conversions
- Wind Components (obtain head/tailwind and crosswind components)

Tables

- Approach and Landing Speeds;
- Glide Slope;
- Phonetic Alphabet;
- Reciprocal Runways;
- Temperature Conversions and
- RULES OF THUMB on how to quickly obtain:
 - TOD (top of descent)
 - Descent Rate
 - Descent Altitude check
 - TAS (True Airspeed)
 - Bank Angle and
 - Rollout Angle



All that plus a few extras on a single A4 page to eliminate cockpit clutter and pilot distraction. Applicable to any aircraft.

Click on the image for expanded view.

Download the Handy Sheet, [MS Word 97 version](#) here.

Don't have MS Word 97? Link to Microsoft's free Word Viewer, [wd97vwr32.htm](#).

A bitmap version of the Handy Sheet is also available, but at lower resolution. [Click here for the bmp version](#).

Course vs. Track

Before moving on, it's worth reinforcing the difference between Course and Track. Your course is the path of flight that you have plotted on a chart. Your track is the actual route that your aircraft covers when flying from point A. to Point B. Because of wind, or drift for other reasons, your track can differ considerably from your course.

Simply remember that course vs. track is intention vs. reality.

The Earliest Navigation Aids

NDB navigation is the next topic. It was a major breakthrough for airlines and enabled them to meet schedules almost without regard to weather. But there were aids to navigation before the proliferation of NDBs. Read how it all began in the next section. Learn about the early progression of navigation aids. I think you'll find it fascinating and you'll marvel at how well the early pilots did with these systems. Pioneering will have a new meaning.

Click on *How it Began* below to move on.



Click here to comment.

Site best viewed at 600×800 resolution.

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G-AMPZ of Atlantic Airways, at Manchester, England, Airport. Courtesy of and thanks to Chris Sheldon, fwog@mindless.com.

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VOR Approaches

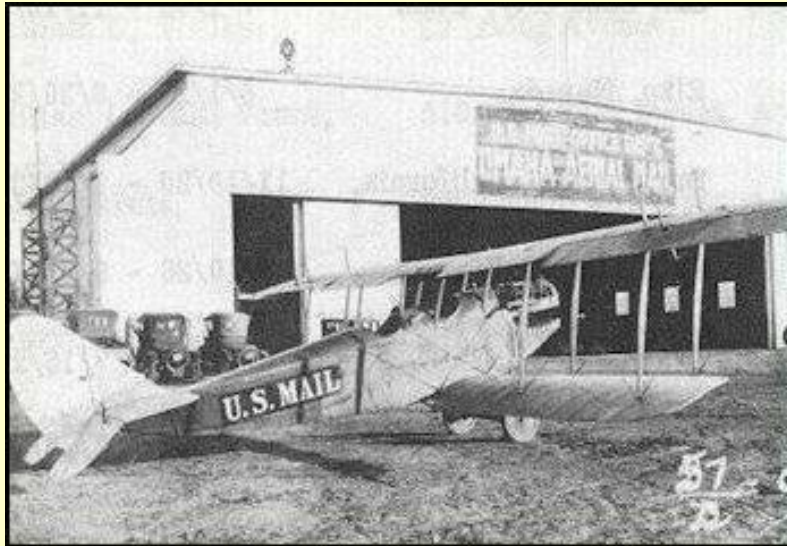
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How it Began



A Curtiss "Jenny" flew the first Airmail in 1918.

Flashback to May 15, 1918, to Washington, DC. It's early Wednesday morning, a blustery day. President and Mrs. Woodrow Wilson are in the grandstand. So is Assistant Navy Secretary Franklin D. Roosevelt. The Postmaster and second assistant Postmaster wouldn't have missed this day for anything. Members of Congress arose early to be there, too, pondering whether to allocate additional funds for this new service.

Lt. Boyle has just mounted his Curtiss Jenny biplane, four sacks of mail weighing 150 lbs secured in the front cockpit. All eyes are on the frail World-War-One aircraft in Washington's Polo Grounds, anticipating the great event.

Airmail service will be inaugurated on this day. And the Army and Post Office Dept. have been jointly charged to provide that service.

In only moments flights will simultaneously disembark from Washington and New York's Belmont Park Race Track. Each will stop at Philadelphia to deliver and pick up mail, refuel, change pilots, and then continue on to the other destination. A large crowd mills about at Philadelphia's Bustleton field, too, excited to be part of this highly-publicized history-in-the-making.

In Washington, mechanics hover near Boyle's aircraft, ready on the signal to "prop" the plane, to bring the engine to life. Boyle gives the thumbs-up, shouts "Clear," then "Contact!" The mechanics take their cue with a swift pull on the prop ... nothing. They try again ... still no roar of the engine. Repeatedly they try, without success. The honored guests in the grandstand become restless.

A holler comes from the side "Check the fuel!"

The mechanics do and, embarrassed, find the tanks dry. Quickly filling the tanks, they again prop the plane. The engine's roar reaches the grandstand. A cloud of blue smoke envelops all standing nearby. Worried frowns by those from the Post Office Dept. turn into broad grins.

Army personnel reappear from behind the grandstand. Everybody is friends again.

In but moments, the Jenny leaves the ground, struggling for altitude, anxious to clear the trees that rim the sports park. News reporters and photographers race back to their offices to begin work on the front-page coverage planned for the afternoon editions.

Less than twenty minutes into the air on his way to Philadelphia, Boyle gets lost, lands in a farmer's field, and severely damages the plane's prop. The Army rushes a new prop to the site. But the airmail will not go through that day. It is returned to Washington.



N.Y. Times, May 16, 1918.

The press is generous with its praise of the newly-inaugurated service. It dismisses the crash in a single sentence—"With the exception of an accident to one of the airplanes between Washington and Philadelphia, it was a complete success." That Boyle took off in the wrong direction and crashed south of Washington apparently was considered un-newsworthy.

The south-bound aircraft had left Belmont Park as scheduled, and flew uneventfully to Philadelphia. Six minutes were consumed there transferring mail, refueling, and changing pilots and then the Jenny successfully continued its journey to Washington, to little publicity, other than a small headline.

Three months after the inauguration of service the Post Office was delegated full responsibility for Airmail service.

The Transcontinental Route

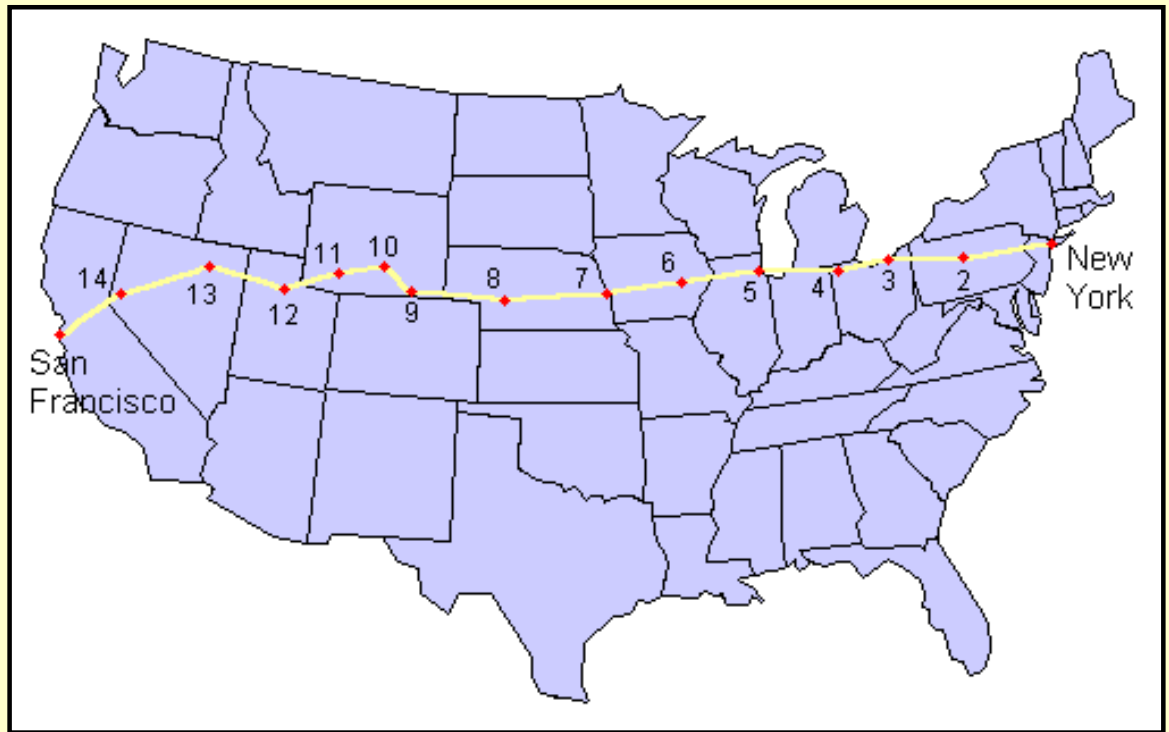
The Washington to New York route proved a commercial failure.

Once the novelty wore off of posting an airmail letter from Washington to New York or back business dropped drastically. The distance covered, 218 miles, was too short to permit any substantial time saving over existing surface transportation. Twenty-four cents was a hefty

price to pay for a few hours saved in mail delivery time.

On average mail planes were carrying only seven pounds of special airmail per trip; the rest was selected first class. The Post Office lowered the postage to 16 cents. Still expensive, business only increased slightly.

The Post Office Dept realized that Air Mail's value lay in cross-country delivery where significant time could be saved. The New York to San Francisco route was chosen to test transcontinental Airmail service. By 1920 fifteen fields spaced approximately 200 miles apart over a 2680-mile route made up the airway.



The transcontinental airmail route ran from New York to San Francisco. Intermediate stops were: 2) Bellefonte, 3) Cleveland, 4) Bryan, 5) Chicago, 6) Iowa City, 7) Omaha, 8) North Platte, 9) Cheyenne, 10) Rawlins, 11) Rock Springs, 12) Salt Lake City, 13) Elko, and, 14) Reno.

Air Mail Service pilots were the unsung heroes of early aviation. In their frail biplanes, they battled wind, snow and sleet to pioneer round-the-clock airmail service along the world's longest air route, the U.S. transcontinental. In the process, thirty-four pilots lost their lives.

Since September 1920, the Post Office Dept. had flown the mail from New York to San Francisco, but during daytime only, transferring it to trains at night. As a result, elapsed time was 72 hours at best, or a mere 36-hour saving over the fastest all-rail trip.

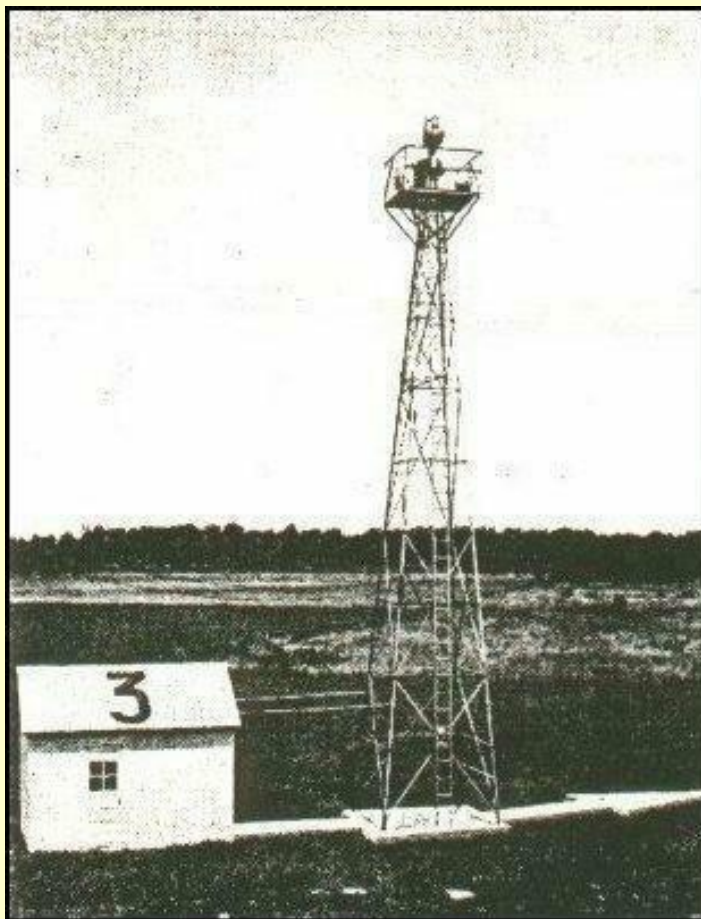
Flying the mail was risky business. During the nine years the Post Office Department operated the Airmail Service, there were over 6,500 forced landings. On the average, airmail pilots had a life span of only about 900 flying hours.

The Post Office Dept. increased the pressure on its pilots by announcing that the air mail flights could be conducted on a schedule 93% of the time.

Flying in open-cockpit biplanes, exposed to the bitterly cold air and harsh weather conditions, the pilots often became so numbed and exhausted that they couldn't think clearly or make decisions quickly. Not publicized by the Post Office Dept. was the fact that in order to fight the cold and the constant pressure of deadlines, with on-time delivery expected under even the worst of flying conditions, many of the pilots carried bottles of liquor along when they flew.

Carrying the mail was not the only business of aviation. In 1914 the world's first regularly scheduled air-passenger service opened up along a 22-mile route from Tampa to St. Petersburg, Florida. The service could carry only one passenger at a time and cost \$5 for the 23-minute flight. It was a financial failure and lasted only a short time.

These early days of aviation presented a unique set of problems and the inability of aircraft to navigate in rough weather and darkness topped the list. The government became involved in 1926.



Beacon site at intermediate landing field, Cleveland-Albany route. The "3" on shed roof signifies beacon 3 of 10 in this sector.

highways for the airman.

The first navigation-aid system consisted of flashing beacons. These high-intensity lights, located along popularly-flown airways, literally shone into the air like a connect-the-dot puzzle, winking and blinking a friendly invitation to come ahead.

The beacons, of course, did not flash, but rotated through a complete circle giving the impression of flashing.

In October 1931, D. C. Young of the Airways Lighting Sub-Committee recapped the progress of lighted airways at a lighting conference in Pittsburgh, Pa.

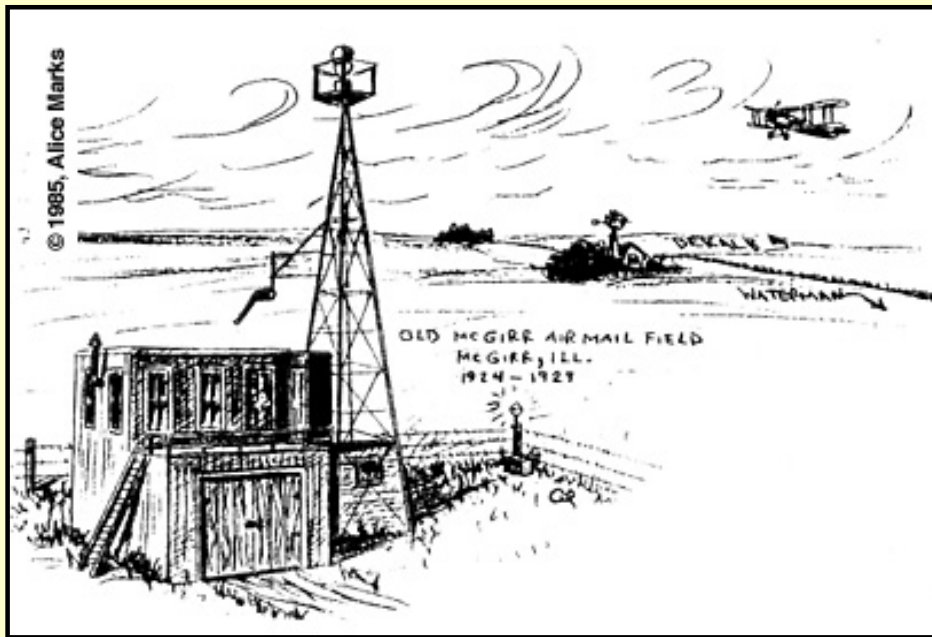
"Ten years ago, a scheduled night flight by airplane across the United States was only a dream. Now, such flights occur nightly, and on scheduled time. The converting of this hazardous journey into one of comparative safety ... is the achievement of constructing aerial

If air travel were confined to daylight hours only, the speed and directness of route would give the airplane little or no advantage over fast trains operating on 24-hour schedules. The Post Office Dept. realized this in 1922 when it was transporting the mail by air. So it

established facilities for the airmail pilot to follow at night and succeeded in showing a remarkable improvement in speed on the coast-to-coast route.

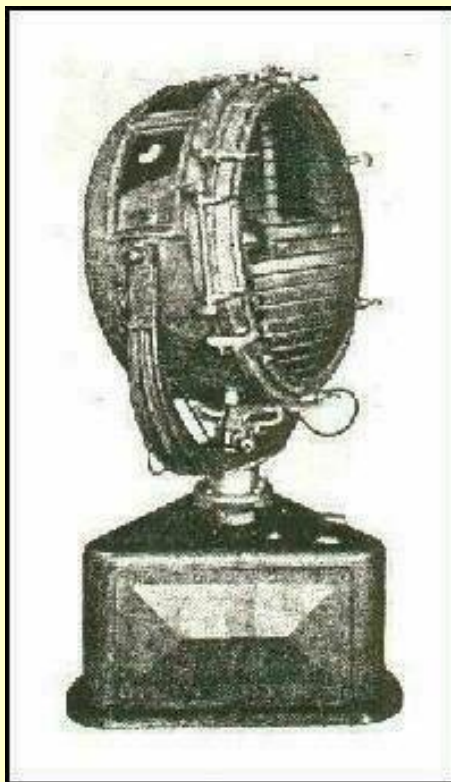
In the four years since 1926 when the government took over the airways 14,500 miles of lighted highways had been created for the airmen.

High-intensity beacons are established approximately 10 miles apart along these civil airways . The beacon consists of a 24-inch parabolic mirror and a 110-volt, 1000 watt lamp. The beacons, which rotate at 6 rpm, show a one-million candlepower flash every 10 seconds for 1/10th second duration.



Pilots often stopped at McGirr Field, on the Omaha–Chicago route, when they had an "emergency," knowing that the food was excellent and that they would be well cared for.

Intermediate landing fields are provided every 30 miles along these routes, in the absence of suitable commercial or municipal fields, and each is equipped with beacon, boundary, approach, obstruction, and wind-cone lights.



1000 watt Airway Beacon

The beam from the airways beacon is a high-intensity pencil of light of about 5-degree beam width visible 20 to 40 miles in clear weather. The beam is aimed 1.5° above the horizon. A small percentage of the beacon's light is reflected upward to provide close-range visibility.

Two course lights are mounted on the tower just below each searchlight; one points forward along the airway and the other points backward. These 500-watt searchlights give a 15 degree horizontal beam width.

The course lights are fitted with either red or green lenses. Every third beacon has green course lights signifying that it is on an intermediate landing field. Thus the pilot knows at a long range the availability of landing fields. (This is the forerunner of today's airport rotating beacons which alternately flash green and white.)

All other beacons had red course lights.

As the mechanism revolved and the clear flash of the beacon passed from the pilot's vision, the red or green flash of the course light came into view. Course lights flashed coded dot-dash signals to indicate the beacon's position on the airway. Code signals ran from 0 to 9; thus, if a pilot received a signal for the number 4, he knew he was flying over the fourth beacon of a particular 100-mile stretch of airway. But he could not determine his precise position merely by receiving a course-light signal if he did not know independently over which 100-mile stretch he was flying.



Letters designated the airways, the first letters of their terminal cities. The order of the letters was established as south to north and west to east. Thus Omaha to Chicago was Airway O-C. LA-SF defined the Los Angeles to San Francisco airway, and so forth.

Regular maintenance of the airway beacons and intermediate fields was crucial. This duty was entrusted to Airway Caretakers. Daily they climbed the 51-ft. steel towers to check every beacon within their territory, cleaned dirty lenses, replaced burned-out bulbs, etc. Repair problems requiring more expertise or equipment and tools not locally available were referred to "mechanicians," who serviced a 175-mile route with a half-ton pickup truck.

Caretakers at intermediate fields were on duty from 6:00 pm to 6:00 am. If a pilot "dropped" in to one of these emergency fields, caretakers were expected to provide transportation to and from town, furnish them with meals, and assist in repairing their aircraft.

To "Plane Post" a letter cost 24 cents an ounce in 1918, which included special delivery.

With airways on the transcontinental route now lighted, airmail could be delivered in one-third the time of a train.

Click on the *On the Beam* button to learn how radio navaids further simplified the pilot's navigation chores.



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Site best viewed at 600 × 800 resolution.

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On the Beam



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The old-timer sat in the pilot's lounge with his coffee, listening to the student pilots discussing their navigation assignment. Like dolphins bounding to the water's surface, keywords occasionally reached his ears: "Waypoints," "VORs," "GPS," "Radials" "OBS," "Compass locators," "DME," "Victor-Airways."

He shook his head smiling wistfully and stared at his coffee. So much has changed, he thought. Student

pilots don't even get sent to the hangar for a bucket of prop wash anymore.

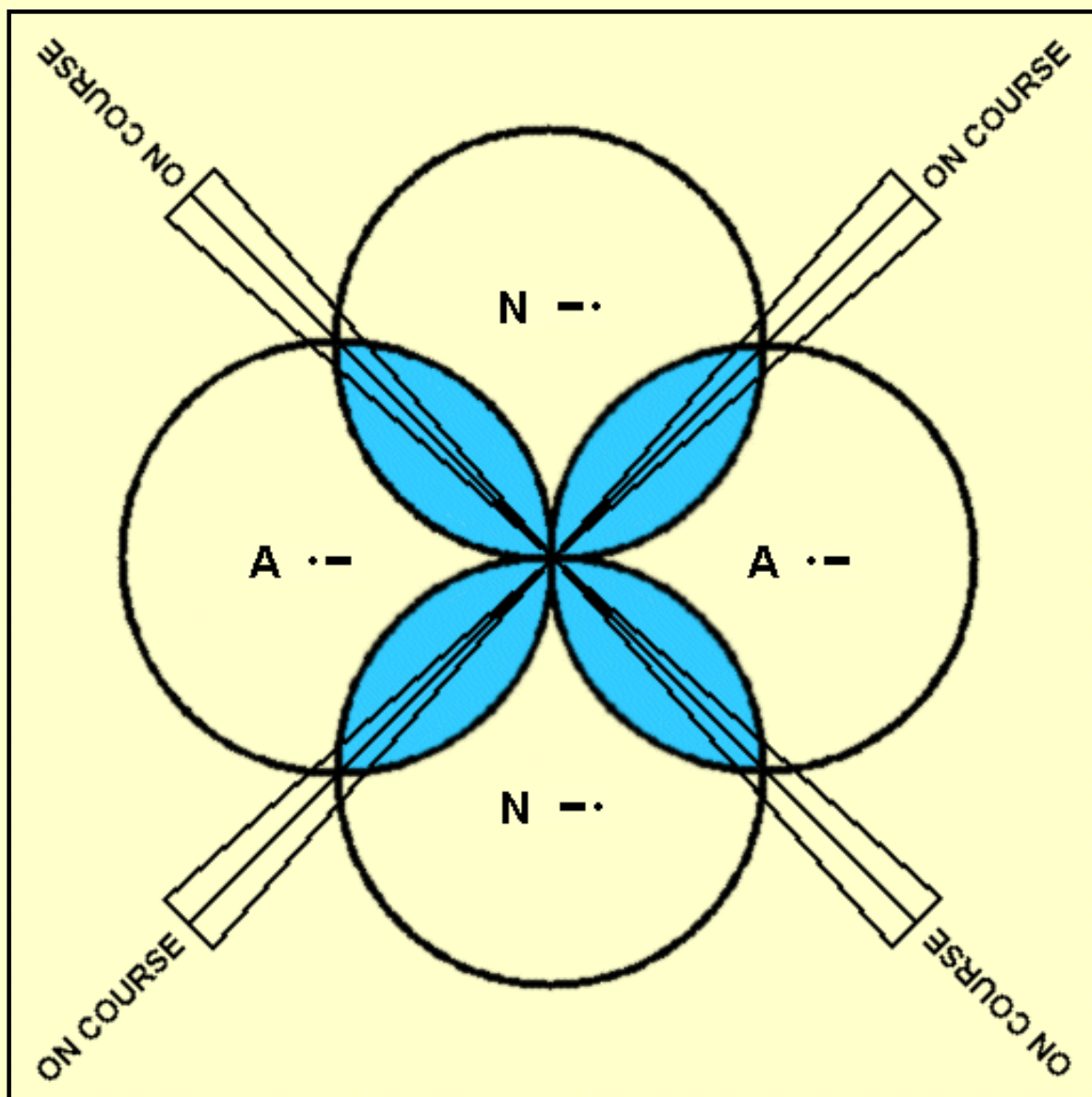
The old-timer's mind drifted back to the '40s, when he was a young airline pilot. Radio navigation was so different then. "A" and "N," which side on this leg?

While early flashing beacons were economical and a great aid for night-time navigation in clear weather, they were of no value in overcast conditions, or during the day when they weren't even turned on. And they were sometimes difficult to locate in the distracting light of urban sprawl. These handicaps hastened the development of the LF navigation system.

Radio beacons in the 190 to 535 kHz radio band had formed the earliest LF navigation system. These powerful, 1500-watt beacons were spaced about 200 miles apart and defined electronic airways. A pilot flew for 100 miles guided by the beacon behind him and then tuned in the beacon ahead for the next 100 miles. The beam width was about 3° so it was important that the pilot promptly tune in the station in front. At 100 miles and a 3° beam width, the aircraft was "on course" if it were within ± 2.6 miles of the airway centerline.

The beacons transmitted two Morse-code signals: the letter "A," • – , and its opposite, the letter "N," – • . When the aircraft was centered on the airway, or electrical beam, these two opposite Morse-code signals merged into a steady, monotonous, hypnotizing tone. Broadcast of the beacon's Morse-code identification interrupted these tones twice a minute.

If the aircraft drifted off course to one side, the Morse code for the letter "A" could be faintly heard. The greater the drift, the stronger the "A" Morse code signal. Straying to the opposite side produced the "N" Morse code signal.



The four-course radio range. One antenna's figure-eight pattern transmits Morse-code "A," and the other antenna's figure-eight pattern transmits Morse-code "N." The "On-Course" signal develops where the two figure eight-patterns overlap (shaded) and the two Morse-code signals interleave to provide a constant tone.

The illustration shows the beacon's two figure-eight transmission patterns. Where they overlapped was "the beam." One can see that technically, beams weren't actually transmitted. But the term "on the beam" was so entrenched with pilots that it became common usage.

Because of the dual loop-antenna system used, each beacon defined four airways, and hence this system was named the four-course radio range. With the letter "A" to the aircraft's left heading towards the beacon on two of the courses, and to its right on the other two courses complicated navigation. Worse, the letters didn't stay put. When the aircraft passed over the beacon, from inbound to outbound, the letters switched from one side of the airway to the other.

Station passage was marked by a "cone of silence," where the aural tone briefly disappeared as the aircraft flew directly overhead.

When possible, radio-range stations were located near an airport, and situated so that one of

the four beams lined up with the principal runway, "thus facilitating radio approach landings under conditions of low visibility."

While not pin-point accurate, the radio-range system was a great leap forward over simple dead-reckoning navigation or flashing beacons.

Pilots became very skilled at flying the four-course radio range. As mentioned, a station identified itself every half-minute. It first broadcast its call letters in the "N" quadrant and then in the "A" quadrant. Pilots could hear both broadcasts. If the two signals were equal volume, a pilot knew that he was "on course." But, for example, if the call sign from the "N" side was louder, he knew that his aircraft was off center and he should adjust his heading towards the other side of the airway. Many pilots found it easier to stay on course by monitoring the call-sign transmissions than by listening to the steady tone.

In fact, a pilot was encouraged to fly off-center from a radio-range beam, to fly the right-hand edge of the beam. This reduced the possibility of encountering an aircraft coming from the opposite direction, particularly when flying IFR in the days before ATC assigned altitudes.

Eighteen months after the four-course radio range system was launched it was deemed essential to aviation. This navigation system revolutionized airline transportation as much as the introduction of the DC-3. For the first time, scheduled air service meant just that. Only infrequently did poor weather or low ceilings or limited visibilities cancel a flight.

When flying through mountain passes in IFR weather or on a dark night, the pilots paid close attention to the tones in their headphones. Palms became moist in the cockpit when static from electrical storms interfered with the reception of those crucial signals—or when beacon signals bounced off the canyon walls and gave false information.

Radio Direction Finding



Lear Radio Compass. Sorry about the poor quality—will rescan when new software arrives.

There are several types of equipment under this general head. In each case, however, use is made of the directional characteristics of a loop antenna. The loop may be either fixed or rotatable.

The LF radio-range system had two principal drawbacks: it provided no information on the aircraft's position nor whether it was flying to or from a beacon. If a pilot were flying along a *known* airway he could extrapolate the to/from situation with a drift off course slightly to pickup the "A" or "N," then deduce from the charts whether the beacon was in front or behind him.

A number of maneuvers were available to a pilot to eliminate the ambiguity of which direction the beacon was relative to his heading, or to determine which quadrant of the radio range he was within, or identify which beam of the range he was intercepting. These maneuvers had names such as the 90° turn method and the parallel method. Useful as they were, they each required a significant deviation from the aircraft's intended course, sometimes even a 180° turn away from the station.

The installation of marker-beacons every 20 to 30 miles along the airway partially informed the pilot of his position. Each beacon transmitted a distinct identification signal and so on passage a pilot could mark his progress to the next four-course station.

The old-timer shook his head again, his thoughts deep into the past.

The Radio Compass was the first glimmer of hope in determining bearings to a radio station, of filling the information void of the four course radio range. It added a fixed loop antenna and visual indicator to the receiver system. With this system, as long as the aircraft was headed directly toward a radio station the needle of the indicator remained centered; headings to the right or left of the station resulted in a corresponding deflection of the needle.

The radio compass was chiefly used as a "homing" device, and bearings of radio stations off the line of flight could be obtained only by turning the aircraft toward the station and noting the magnetic compass heading when the needle was centered.

Replacing the fixed loop antenna with a rotatable loop eliminated this cumbersome maneuver. This system was called a Radio Direction Finder. With the rotatable loop,

bearings could now be obtained without turning the airplane itself. The pilot or navigator would rotate the loop, usually mounted on the fuselage below the cockpit, to the position of minimum signal strength, or "null." The bearing to the radio station was then read from a graduated, mechanical dial.

By repeating this procedure with a second beacon an aircraft's position could be determined by triangulation after locating the two stations on the flight chart.



The ADF antenna is below the cockpit. (Click image for full size.)

The Automatic Direction Finder, a marvelous invention, followed the RDF. Finally, a self-contained apparatus for aircraft navigation was available. Gone were rotatable loop antennas and guess-work readings from mechanical azimuth dials. The ADF indicator needle *always* points directly towards the beacon, which now could be a Non Directional Beacon—NDB. Rick Covington's photograph of a Piedmont DC-3 shows the ADF antenna mounted below the cockpit.

The NDB provides good, basic navigation capabilities. An aircraft can follow the ADF needle to home to the station, although this is poor navigation practice—see later. The aircraft can track a specific NDB radio radial—electronic highway—to fly a specific course to or from the NDB station. The pilot

can use two crossing radials to triangulate a position for a navigational fix. With a timer, it's even possible to determine time and/or distance to and/or from an NDB station.

In addition, and probably the most prominent use of the NDB, it can provide an instrument approach procedure for landing. A pilot could now locate a runway without actually seeing it, to descend through overcast and/or low visibility conditions and land the aircraft by reference to the ADF indicator, the compass and the clock or a timer.

Yep, mused the old-timer, as he refilled his coffee, the ADF sure simplified navigation.

Click on the *ADF Basics* button to see what the old-timer meant.



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Navigating with the ADF



The LF navigation system was so durable that for twenty years it had no competition. It was widely used long after VOR installations began to sprout up throughout the country. It has the major advantage over a VOR in that reception is not limited to line of sight distances. The LF signals follow the curvature of the earth, and thus the maximum distance that an ADF is usable depends only on the power of the beacon.

Additionally, the ADF indicator provides more information than the VOR indicator. Here it shows that the aircraft is on a 345° heading and that the magnetic bearing to the NDB is 060°.

The ADF Indicator.

When I was doing my Instrument Flight training many students dreaded NDB procedures. They hoped that the FAA examiner would "forget" to test those skills. To my knowledge they never "forgot." Currently, it is mandatory to successfully demonstrate an NDB approach on the instrument flight test.

On reflection, one wonders why emotions ran—and run!—so negatively towards ADF procedures. In some aspects it is simpler to track to or from an NDB than to or from a VOR. The VOR, of course, offers the advantage that one can set in the desired radial with the OBS, leaving little doubt that the track to or from the station is correct.

Six ADF navigation procedures will be reviewed here.

- ADF Time- and Distance-to-Station checks.
- Intercepting a bearing.
- Homing.
- Tracking inbound to an NDB.
- Tracking outbound from an NDB.
- NDB Approaches.

On first reading the descriptions, ADF procedures could appear difficult. With modest practice on FS-98, though, they become routine. They even make sense! The key to successful ADF navigation is to know where you are at all times. Visualization is a must to make the right moves.

Four types of ADF Indicators are in use. *In every case, the needle points to the navigation beacon.*

- Fixed Compass Card.
- Rotatable Compass Card.
- Single-needle Radio Magnetic Indicator.
- Dual-needle Radio Magnetic Indicator.

Fixed Compass Card



The Fixed Indicator's compass card is exactly as the name says. It is fixed to the face of the instrument and cannot rotate; 0° is always straight up—the nose of the aircraft. Visualizing the situation with this type of indicator can be daunting.

Consider the present situation. Remember, all numbers are *relative* to the aircraft's magnetic heading. From before, the aircraft is heading 345°. The ADF indicator shows the beacon 75° relative to the aircraft's heading. Since the beacon is to the right, add numbers: 345 plus 75 equal 420. Subtract 360 and the magnetic bearing to the beacon is 060°. It's enough of a mental calculation sitting at a desk; in a pitching aircraft glooping about in the soup, the math can seem impossible. Some consider using this type of ADF Indicator as cruel and unusual punishment: great as an emergency backup, very unsatisfactory for every-day use.

The fixed-indicator can still be found on many aircraft panels, but not in many planes where the pilot actually uses the ADF.

Rotatable Compass Card



The Rotatable Compass Card Indicator was a big step over the fixed-card indicator. The pilot can rotate the compass card with the heading knob to display the aircraft's magnetic heading "straight up." Then the ADF needle will directly indicate the magnetic bearing to the NDB. For example, again the aircraft is on a 345° heading. The pilot manually rotates the ADF card to show a 345° heading as shown here. The magnetic bearing to the beacon now correctly shows as 060°. Now, to track to the beacon simply turn the aircraft to a heading of 060°—ignoring any wind correction requirements for the moment ... just remember to rotate

the compass card to the new aircraft heading of 060° after the turn.

Single-needle Radio Magnetic Indicator



The Single-Needle Radio Magnetic Indicator is the best of all worlds. The Radio Magnetic Indicator, as its name implies, is an instrument that combines radio and magnetic information to provide continuous heading, bearing, and radial information. It is an extremely simple indicator.

The Indicator's compass card is a directional gyro and so it rotates automatically as the aircraft turns. Thus it always accurately indicates the magnetic heading of the aircraft as well as the magnetic bearing to the beacon. Although it's a "hands-off" instrument, its compass card should be checked against the magnetic compass every fifteen minutes or so and adjusted with the heading knob to correct for any precession errors common to directional gyros. The face of the single-needle RMI is similar to that of the rotatable card ADF just shown.

The ADF gauge on the MFI-17 "training" panel is a single-needle Radio Magnetic Indicator. The illustration here includes the digital display added to the RMI which indicates the bearing to the station. The digital display is not a standard feature on an RMI. It was included here because precisely reading the RMI is such an integral part of the practice flights.

Dual-needle Radio Magnetic Indicator



The dual-needle RMI is similar to the single-needle RMI except that it has a second needle. The instrument here presents the same information as the two previous instances: aircraft heading is 345°, and the magnetic bearing to the NDB is 060°—the yellow needle. The second needle, green here, typically points to a VOR station tuned in on the Navigation Receiver—in this case, fly 303° to get to the VOR. The dual-needle indicator is particularly useful in fixing the location of an aircraft. The two lines of position appear right on the face of the gauge.

Sophisticated RMIs show magnetic bearing to any two nav stations chosen by the pilot: ADF and VOR#1, ADF and VOR#2, or VOR#1 and VOR#2. Military pilots routinely navigate with an RMI and wonder why the rest of us fool around with a standard VOR indicator.

Characteristics of ADF Navigation

Please note, that from here on, all ADF discussions and mathematics is limited to navigation using a single-needle RMI.

The most important concept in ADF navigation is that the needle *always* points to the station. There are three implications to this.

- First, when tuned to an ADF station for homing, tracking, intersections, holding or an approach, you never have to touch the system. Unlike the VOR, there's no OBS to think about, no need to "twist" anything in station passage or at any other time. This makes the ADF much simpler to use.
- Second, with an ADF you always know where you are in relation to the station. There is no TO-FROM to interpret, no confusion about radials and bearings, no way to set the wrong OBS numbers.
- Third, ADF orientation is much simpler than VOR orientation. With an RMI the head of the ADF needle *always* indicates the bearing to the station. Simply turn to the heading under the arrow head to fly towards the beacon.

Low frequency beacons can sometimes be received at great distances. It is very important to verify the Morse-code identifier of the station to be certain you are navigating from the proper beacon—even in FS-98.

ADF Time and Distance Checks

For all flights in this section, select the "Saab-ADF" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ILS-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel. The proper aircraft installation provides six choices of Saab aircraft, each with a different panel.

Good exercises to develop NDB awareness are the ADF Time and Distance Checks. Tune in an NDB station, verify its Morse identifier, (Click left portion of radio face) and then position the aircraft so that the needle points directly to the left or right, indicating that the station is directly off the aircraft's wing.

Note the bearing to the station and also the time, or set the timer. Then fly a constant heading until the bearing changes 10°. Note the number of seconds it takes for the bearing to change this 10°. Then simply divide that elapsed time by ten to determine the time to station in minutes.

$$\text{Minutes to station} = \frac{\text{Time in seconds}}{(\text{Degrees of bearing change})}$$

You can then estimate the distance to the station:

$$\text{Nautical Miles to station} = \frac{\text{TAS [kts]} \times \text{Minutes flown}}{(\text{Degrees of bearing change})}$$

A Time and Distance Example



- You're en route from New Bedford, Mass. to Manchester, N.H., tracking the 005° bearing to the Haget beacon. Company-President Mr. Benjamin Counter is your sole passenger. Part-way into the flight Mr. Counter decides that a face-to-face meeting would be appropriate with the principal-stockholder, Mr. Well Thee. Mr. Thee is vacationing in Provincetown, on Cape Cod, with his administrative assistant. This working arrangement was mentioned in the Route-selection section.
- For the Time and Distance to Provincetown, tune in and verify the Provincetown beacon. Then—in this case—turn to a 025° heading to put Provincetown's beacon directly off your right wing. The ADF indicator shows a 115° bearing to the beacon. Start the timer.
- Maintain a 025° heading. When the ADF needle has shifted ten degrees, to a 125° bearing to the station, note the time—three minutes and forty seconds, or 220 seconds.

Plugging the numbers into the formulas above:

The time to station is:

$$\frac{220 \text{ seconds}}{10 \text{ degrees}} = 22 \text{ minutes to station.}$$

You can then estimate the distance to the station:

With Mr. Counter on board—"Bean" Counter to all who are out of his hearing range, the aircraft is cruising at a very economical 120 kts. The distance to Provincetown's beacon is then:

$$\frac{120 \text{ kts} \times 3\text{-}2\text{/}3 \text{ (3 min 40 sec., 220 sec.)}}{10 \text{ degrees}} = 44 \text{ nautical miles to station.}$$

One can only hope that Mr. Counter is not inspired to again change your destination before reaching Provincetown.

As seen, the calculations for time and distance to station are quite simple. What's even easier is to read those numbers from a table. The Saab MFI-17 is recommended for this navigation tutorial. Knowing that it cruises at 125 kts True Air Speed, a table can be prepared with a spreadsheet showing both time to station and distance to station for any value of time to cross 10°. The table below is for 20-second increments of time to cross 10° but it is just as easy to use your spreadsheet and prepare it for 10 or 15 second increments, interpreting for the in-between values.

If your aircraft differs from the MFI-17, just redo the table for the appropriate cruise speed. The Time to Station column is independent of speed.

Time and Distance to Station vs. Time to cross 10° for 125 kts TAS

Time to cross 10° (Seconds)	Time to Station (minutes)	Distance to Station (nm)	Time to cross 10° (Seconds)	Time to Station (minutes)	Distance to Station (nm)
20	2	4	180	18	38
40	4	8	200	20	42
60	6	13	220	22	46
80	8	17	240	24	50
100	10	21	260	26	54
120	12	25	280	28	58
140	14	29	300	30	63
160	16	33	320	32	67

Intercepting a Bearing

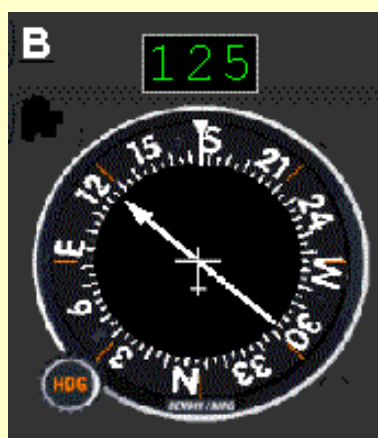
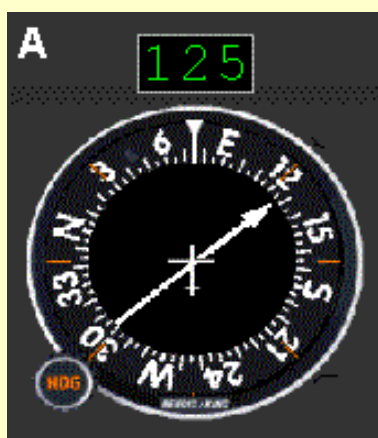


Probably the most common ADF navigation procedure is intercepting a specific bearing of a Non Directional Beacon. The technique is similar whether intercepting an inbound bearing or an outbound bearing.

Until this easily-understood maneuver is learned, VFR approaches to an airport will be sloppy, and all but impossible in IFR conditions. This procedure becomes second nature after a few FS-98 practice sessions.

The illustration above shows the aircraft nicely tracking inbound—no wind—on the 075° magnetic bearing to the

Provincetown—PVC—beacon. Three simple flight maneuvers, as shown in the illustrations below, will accurately put you on any inbound or outbound NDB bearing. Here, the desired bearing is 075° to the PVC beacon to line up with Provincetown's Runway 7.



- A. Turn to the desired bearing (075°), and note the number of degrees of needle deflection to the left or right—in this case it's 50° (125° bearing minus 075° heading). Then *double* this amount to determine the interception angle (100°).
- B. Turn toward the needle the number of degrees determined above (100°). Adding that to the desired bearing—right turns, add numbers; left turns, subtract numbers—gives an intercept heading of 175°.
- C. Maintain the new intercept heading (175°) until the needle points to the desired bearing (075°). Then turn to the (075°) bearing. Of course, the turn should be started shortly before the desired bearing is reached so as to roll out on the correct heading without any overshoot.

With no wind you need only continue on the 075° inbound heading to Provincetown. But there is *always* wind. The next chapter provides you with the techniques to correct for the effects of the wind.

But first, open up your flight simulator and randomly select an NDB. Then choose a bearing to that NDB and practice intercepting it from several positions around the NDB. Do this for several other randomly chosen NDBs until you can comfortably and accurately intercept any bearing to an NDB no matter where you are or your direction of flight in relation to the NDB.

And Finally



No usable ADF signal.

Now, click on the *Tracking* button to learn how to get to and from an NDB as easily as if it were a VOR station.

Nothing is quite so important as recognizing when your RMI cannot receive signals. The situations that create that dilemma are:

1. The ADF Receiver is turned off.
2. The ADF Receiver is not tuned to the station.
3. The NDB is too distant to provide a reliable signal.
4. The aircraft's altitude is too low (reception is generally reliable at and above 1000 ft AGL).

When "Off," or receiving no usable signal, the RMI needle points directly to the right, 90° away from vertical. In addition to that, the digital bearing indicator on the training panel also displays three dots as shown in the image.



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ADF Tracking



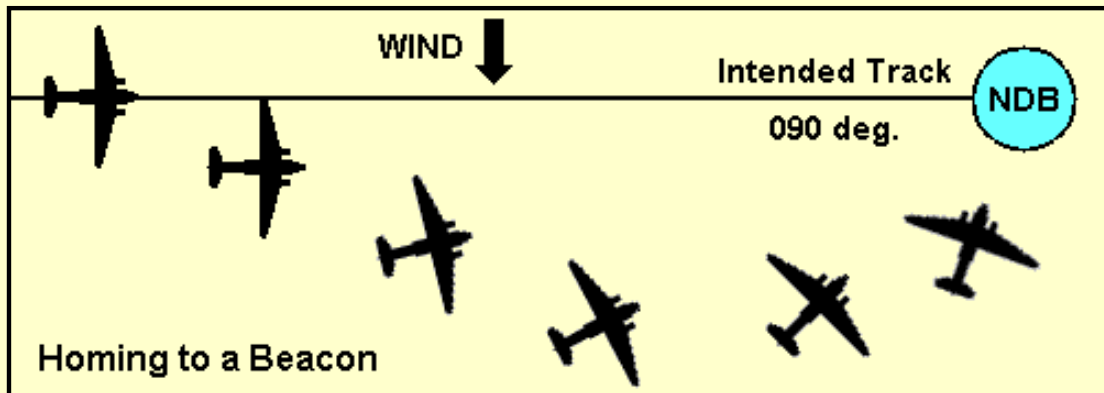
See that critter to the left? That's a homing pigeon. They're also bred and trained for racing. For him, homing is good. For an aircraft, homing is not good. Let's take that procedure off the table right now.

Homing is *Unacceptable*

Homing is easy and instinctive, but it is also inefficient and potentially dangerous. Homing to a station simply means pointing the aircraft in the direction of the station. The easiest way to do this is to turn the aircraft in the direction of the needle until the needle points to the top of the indicator.

The pilot compensates for the wind by keeping the needle centered with heading adjustments. With the wind constantly pushing from one side, the pilot has to constantly change the heading as he proceeds toward the station to keep the needle on the nose. With homing the crosswind pushes the aircraft away from the direct course and the resulting path to the station will be curved.

The series of illustrations below graphically show why homing is undesirable. To the left the aircraft begins homing to the 090° NDB bearing with a 090° heading. The crosswind from the north blows the aircraft off course, to the south. The following images of the aircraft show how it's heading has to be adjusted to maintain the needle on the nose as the wind blows from the North. As it nears the NDB the wind has blown the airplane so far off the inbound bearing that, to keep the needle on the nose, it must fly a heading of 020° instead of the desired 090°.



With a crosswind, homing results in a curved flight path to the NDB.

Homing is unacceptable for IFR navigation because the aircraft strays too far from the intended

course. The wide, looping course shown in this illustration could take it into a hill, a radio tower, or other obstruction at the minimum altitudes of an NDB approach.

Turning towards the wind to keep the needle centered as the aircraft approaches the beacon is sometimes called "Birdogging," i.e., when windy, ADFs gradually drift you toward the wind direction as you approach them.

Tracking



The only way to fly a straight course to a station is to *track* to the station. Tracking means to establish a wind-correction angle that negates the drift caused by the crosswind.

Again, rely on the rule to turn *toward* the pointer to intercept any course being paralleled. This rule applies whether flying inbound or outbound.

Once you have intercepted the desired bearing, hold that heading and see what effect the wind has. Let's continue with the previous example, intercepting and tracking the 075° bearing to Provincetown's Runway 7—and see what happens.

The ADF gauge above shows that a crosswind from the left has blown our aircraft off course. Our heading is still 075°, but the airplane has drifted off the bearing by 10°. The bearing to the PVC beacon is now 065°—needle points to 065°. A turn to the left, towards the needle, is necessary to return to the desired 075° bearing. But how much correction is needed to stay on course?



- To get back on course, double the drift first noted and turn toward the needle by that amount, in this case 20° relative, or to a 055° heading. You are reintercepting the bearing.
- Hold the intercept heading of 055° until the needle returns to 075°, the desired bearing to the station. Now reduce the correction by half—10° in this case—to a heading of 065° to compensate for the wind. You should also lead the turn back on track by two to five degrees, depending on how far you are from the station.
- This method of correcting for wind drift is called bracketing. You may have to "bracket" several times to establish a reference heading that keeps you on the desired bearing, especially if a long distance from the station. The initial wind correction may be too large or too small to stay on the bearing. If so, adjust the correction. In example C, if the 10° correction (065° heading) proves too much, reintercept the bearing and try a 5° correction with a 070° heading.

Chasing the needle is a common mistake in ADF intercepts, tracking and bracketing. It is so tempting to follow that moving needle. *Resist that temptation!* Hold the heading steady until the

needle reaches the relative bearing that you want, then make the turn.

Near the station the ADF needle will become "nervous," start wiggling and become more sensitive. Again, don't chase the needle, just fly the reference heading. The needle will start to swing to the left or right on passing over a station.

Wait until the needle has definitely swung around to verify station passage—at least five to ten seconds past the ADF station. Then turn to the outbound magnetic heading to determine which side of the bearing you are now situated and how much you will have to correct.

Practice flights, tracking inbound

Tracking inbound really is a simple procedure as you have just read. The two flights next described will polish up your inbound tracking skills. Complete the Flight Planning Worksheet before beginning each flight.

For all flights in this section, select the "Saab-ADF" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ILS-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel. The proper aircraft installation provides six choices of Saab aircraft, each with a different panel.

Long Island to Meriden, Connecticut



© Barry Thomas, Silversmith
Derbyshire, U.K.
See Credits Section.

"What's going on in Long Island?" I asked the Boss. His message on my pager said to call, urgent.

"It's Counter, again," he replied. "Seems his Administrative Assistant is threatening to quit. His A.A. has a passion for hand-made silver and so Counter wants to fly to Meriden this afternoon."

"Meriden?"

"Yeah," the boss interrupted. "It earned the title of 'Silver City of the World' for the great hand-made stuff there. Counter figures if he can get there fast enough and buy something really cool, his A.A. won't quit. I don't understand the big deal, I mean, isn't the A.A. a clerk, a dime a dozen?"

"I think Counter's A.A. has more talents than that," I suggested. I had seen her and she was a knockout. Scuttlebutt had it that she had been a finalist in a local beauty-queen pageant a year or so back.

"Yeah, you're probably right. They get to know the inner workings of the company—that increases their value."

I didn't see the need to bring him up to speed. "The weather on the Sound isn't looking too good ... overcast and lousy visibility."

"Counter said he'd pay a bonus if you get him there and back today," the Boss offered, sensing my reluctance.

I hung up and headed for the airport. It seemed like I was now Mr. Benjamin Counter's private airline.

1. Today's weather is poor. Set in 1500 ft. overcast with a visibility of 3 miles. Start the timer at the beginning of the takeoff roll. Depart from The Francis Gabreski airport on Long Island, New York, using runway 33. Your destination is Meriden, Connecticut, field elevation 99 ft. Tune in the Meriden beacon—"MMK"—on 238 kHz. On departure turn right and intercept the 001° bearing to MMK, 41 nm. distant, 21 minutes flying time at 125 kts. cruise. Ten minutes into the flight begin a 500 fpm descent. Slow to approach speed and descend to 1000 ft., 500 ft. below the overcast. Continue tracking inbound on the 001° bearing until spotting the runway then execute a visual landing.
2. Same route, same weather, but the wind has picked up. Set in a 30 kt wind from 310°. Note: prior to departure the airspeed indicator will read about 28 kts. That is from the strong surface wind which will considerably shorten the takeoff run. Continue as before.

[Click here](#) to print the information for these two flights.

These flights will be pretty well under control after you fly each of them two or three times. You will be a busy pilot en route, too.

It is extremely important that you listen to the Morse-code identifier for any beacon that you are tracking to or from and verify that it is the proper NDB. Since NDBs operate in the LF band they can have great range. Click the left side of the face of the radio for the ident function. A second click discontinues the ident.

The words GUESS and KNOW when used in flying may produce entirely opposite results.

Outbound Bearings from the NDB



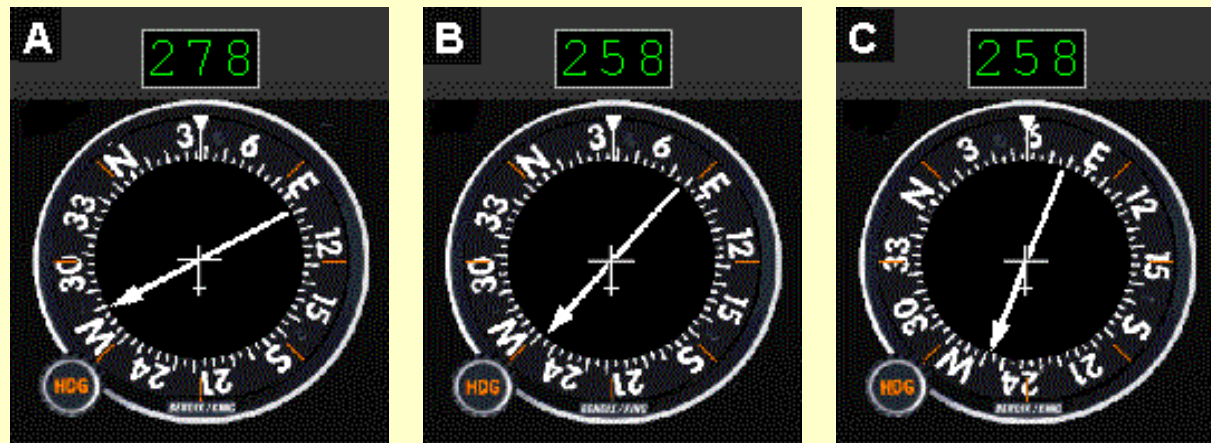
The procedures to intercept, track, and bracket outbound NDB bearings are very similar to those used on inbound bearings. The difference is that we work with *reciprocals* of the headings.

Limit outbound maneuvers to course corrections to compensate for crosswinds. It's not smart to intercept an outbound bearing en route because no information exists on where you are ... one nm. from the beacon or 30 nm. from the beacon? One traditionally enters an outbound leg at station passage, i.e., from a known position.

Assume that the last leg of your flight tracks outbound on the 078° bearing from the FFF beacon to Provincetown's Runway 7. The bearing from your aircraft to the beacon will be the reciprocal, or 258°, which is where the ADF pointer should be. Here the ADF indicator shows the aircraft's heading is 078°. But the ADF needle, pointing behind you to the FFF beacon, isn't on 258°. It's on 278°—you've drifted 20° off course.

Point number one. Just as tracking *inbound* to a beacon, if you are paralleling the desired path outbound, the pointer arrow shows you which way to turn to get back on course. Here the arrow points to the left so turn the aircraft to the left

Follow the same procedure as when intercepting an inbound bearing, Double your 20° error and turn *towards the POINTER* of the ADF needle, to the left by 40°.



- With a 40° turn to the left for intercept, the aircraft heading will be 078°–040° or 038°. Notice that the pointer has swung farther away from the tail of the plane. That confirms that your turn was in the correct direction when flying outbound.
- Maintain a 038° heading until the ADF needle nearly reaches the desired 258° bearing from the aircraft to the beacon.
- Turn right to 058°, one-half of the initial correction angle, and track outbound with the pointer on 258° to the station. If you continue to drift off course, repeat the bracketing steps until the track is correct. Bracket outbound the same as on an inbound leg, except determine the wind correction necessary using reciprocals.

In actual practice, one would not drift so far off course as this example, to require a 40° intercept angle. Large numbers were used here so that the procedures would be clearly visible on the ADF indicator. Run through these procedures two or three times on FS-98 to make everything click together.

Remember that the needle always points to the station. *Never* put the needle on the tail by changing the heading. This will cause you to miss the bearing completely and, as you will see during an NDB approach, if you lose that outbound bearing, you miss the airport.

Schenectady, N.Y. to Pittsfield, Mass.



I was in the pilot's lounge relaxing after a tough IFR flight. We had been in the soup the whole time. I lapsed into a day-dream about my last CAVU flight—Ceilings and Visibility Unlimited—when our receptionist tapped me on the shoulder. I looked up and she nodded in the direction of the Boss's office. Without a word I got up and walked over.

"Is your aircraft fueled?" he asked before I could sit down.

"Yep, topped up, oil checked and windscreen polished," I replied, lowering myself into a battered chair.

"Good," he responded. "because I just got off the phone with Mr. Airline-CEO Counter. He missed his flight to Providence this morning, and there won't be another until tomorrow morning, which would be embarrassing."

I contemplated that for a moment but nothing came to mind that would embarrass Counter.

The Boss went on, "Counter is the scheduled Commencement speaker tonight at his alma mater, Downhome University of Hillsdale. They requested him to speak because of his rise in industry and his insistence that business success is directly tied to punctuality. It will not send a good message if he misses that commitment because he over-slept his flight. He requested your services because you can keep your mouth shut, whatever on earth that's all about."

A picture of his administrative assistant flashed across my mind and some of the destinations where the two had met for "business" purposes.

"So leave for Block Island as soon as you can get the engine cranked up and get him to Providence. There's a bonus for both of us if you can make it look like the charter was planned from the start," the Boss said with finality.

I rose to leave when the Boss added, "And it doesn't help his humor or increase his desire to charter our services if you remind him of his alma mater's initials."

Downhome University of Hillsdale. What could I say?

Practice flights, tracking outbound

Two practice flights are listed below that will sharpen your skills at intercepting and tracking an outbound radial using the ADF. Although the routes are the same, the flights differ. Try to fly each flight once a day until you have nailed the procedures. That will happen very quickly.

Concentrate on staying on the 026° outbound bearing. In case your calculator is broken, the reciprocal of 026° is 206° . A one-degree deviation puts you off course by 0.5 nm. at the end of the 34 nm. flight. This is a long distance to track outbound, especially to arrive at a runway. That's why these are such good practice flights.

Enjoy the flights. It will be a busy 20 minutes.

1. Depart from Block Island, R.I. using runway 10. Wind is calm. Your destination is Green Airport, Providence, R.I., field elevation 52 ft. Track the 026° radial outbound from Block Island Beacon—BID, 216 kHz. Distance is 34 nm, altitude, 5000 ft., landing Providence runway 5, and ETE is 20 minutes. Start the timer at the beginning of the takeoff roll. Begin your 500 fpm descent ten minutes into the flight. You won't be long at your cruising altitude.
2. Same route, except depart from runway 28 and make a climbing left turn, circling over the airport to intercept the 026° outbound radial. Add some complexity to this flight and reduce the visibility to 3 miles and the cloud cover to overcast, base at 1100 ft. Set in a brisk wind of 35 kts from 280°.

[Click here](#) to print the information for these three flights.

After successful completion of these three flights, you'll easily master the next piece, NDB approaches.

NDB Approaches

There are two types of NDB approaches: an inbound approach, if the station is on the field; and an outbound approach if the station is some distance from the field. The next section discusses each of these approaches in detail.

Holding Patterns

Holding patterns, you may remember, was not among the navigation procedures listed earlier that would be reviewed. In the late 1940s they were important and frequently used. Circumstances still exist today when they are required. But holding patterns are not covered here because they usually are in response to an ATC instruction or, in the event of a missed approach, while awaiting an ATC instruction. Since voice communication is not a standard Flight Simulator 98 component, holding procedures, the response to an ATC instruction, will not be reviewed.

Click on the *NDB Approaches* button for your first instrument approaches.



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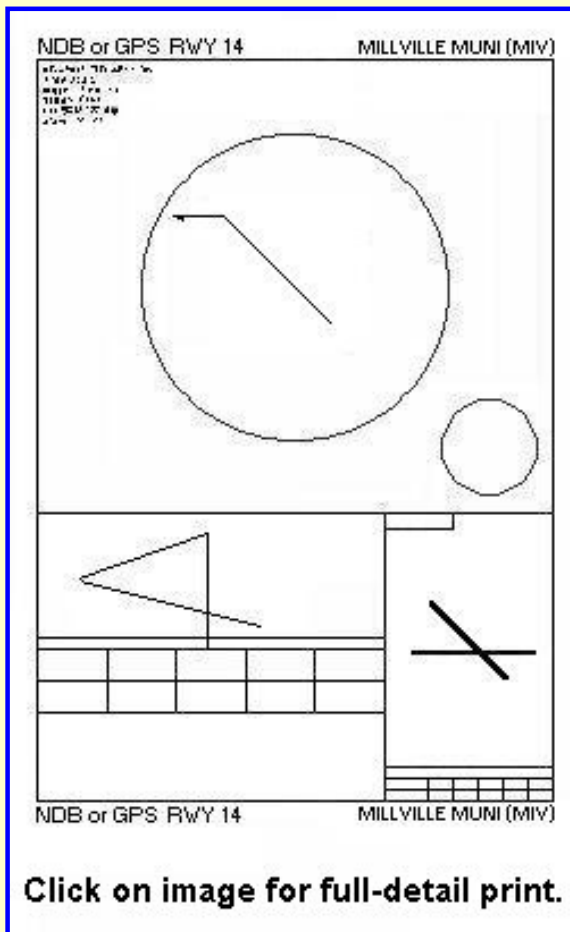
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Instrument Approach Plates



The ADF is King!

What an incredible advance the NDB and ADF brought to instrument flying. Their capability went vastly beyond that of the four-course radio range. For the first time, an aircraft could now approach an airfield that it could not see, to a runway that it could not see until very near, and safely land. What a boost that gave to airline on-time performance.

Using the ADF with the NDB, flights can routinely land in prevailing weather of 600 ft ceiling, or less, and only one-mile visibility. Compare that with the nominal 1000 ft ceiling and three-mile visibility requirement of a VFR flight.

The FAA publishes approved instrument approaches for U.S. airports. Aircraft performing instrument approaches must conform to these published procedures. Instrument Approach Plates, as these charts

were once officially called, are published for and named after the Navaid used for the approach. This could be an NDB, VOR, ILS, LOC, RNAV, or GPS. Some approaches also require DME or availability of airport radar.

Only NDB approaches will be discussed here. Master them and all of the other approaches follow easily.

Note that the entire discussion pertains to approaches to airports in instrument conditions. Nowhere is the word "landing" used. That is the pilot's decision within the limits of each published approach procedure.

Yes, despite the emphasis that follows on IFR approaches, aircraft do take off in IFR conditions, too. In the absence of countermanding limits at specific airports, a one or two engine aircraft must have at least one-mile visibility to take off. Aircraft with more than two engines require only a half-mile visibility. In neither case are ceilings specified. Individual airports may have minimum ceiling requirements, with 300 ft. being very common.

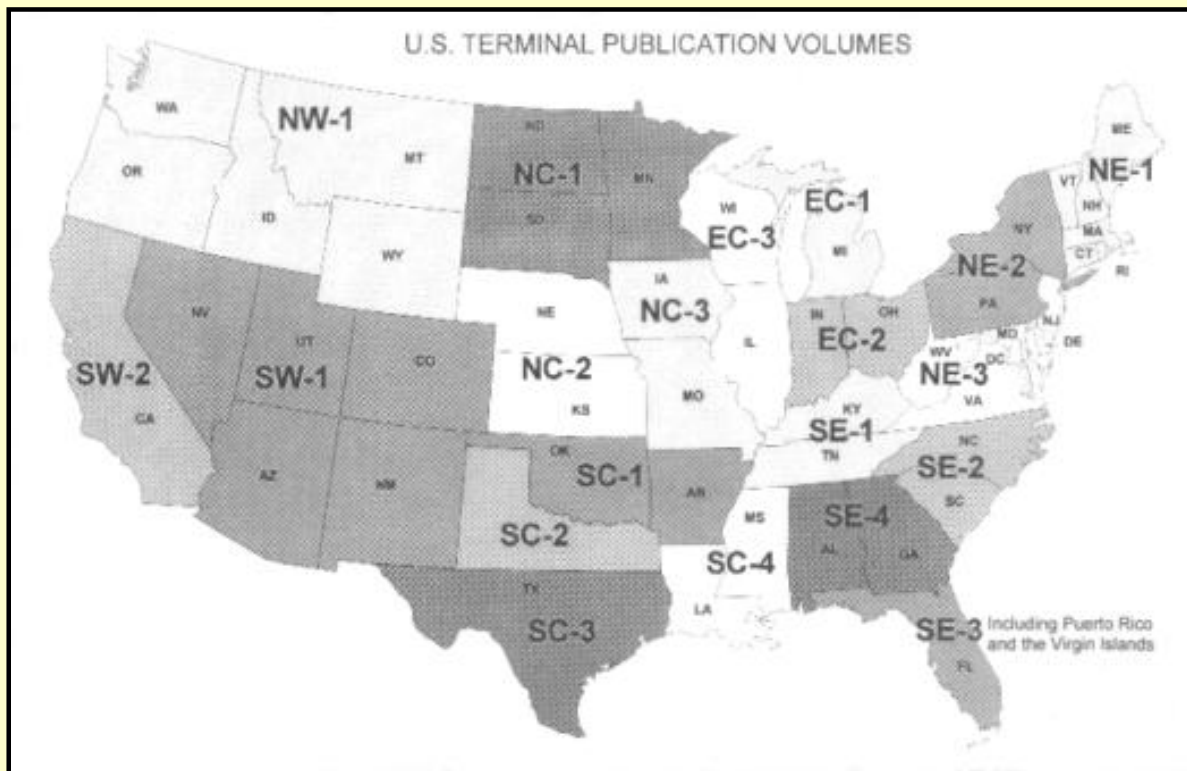
A pilot is advised to carefully consider whether to takeoff at these minimums. If the minimum conditions for takeoff are 300 ft. and one-mile, but the only IFR approach procedure requires 500 ft and one-mile, a return to the airport for whatever reason would not

be possible.

The Approach Plate

The arrangement and location of content of all approach plates is identical. To assist in learning the approach plates and NDB approaches, I recommend that you buy one volume of the FAA publication *U.S. Terminal Procedures*. The FAA divided the U.S. into twenty regions, as shown, and the publication price for any one region is only \$3.00. In the meantime, click on the Millville NDB approach plate at the top of this section for a full-detailed print.

Here is the coverage chart for Terminal Publication Volumes:



Twenty volumes of Terminal Procedures cover the contiguous 48 states.

One brief note on the ILS, the granddaddy of all of the instrument landing systems, before moving on. The ILS, or Instrument Landing System, is a precision approach system. It provides glide-path information in addition to a localizer signal to guide the aircraft to the runway. None of the other approach procedures provide glide-path information and hence are called non-precision approaches. ILS landing minimums are lower than all of the other approach procedures.

Approach Plate Features

The most efficient way to explain the features of an approach plate is to work from top to bottom. Following the explanations will be easier, though, if you first print Millville's NDB Runway 14 approach plate by clicking on the image at the top of this section.

Header



NDB or GPS RWY 14

The left header identifies the type of Navaid used for the approach and the corresponding runway. This Instrument Approach Plate (IAP) describes the procedure for either an NDB or GPS approach to Runway 14.

In some cases, a runway is not listed in the header, for example, VOR–A. That means that the published approach path is not aligned within 30° of any runway heading. The aircraft must "circle" the airport once it is in sight to line up with a runway.




MILLVILLE MUNI (MIV)
MILLVILLE, NEW JERSEY

The right header is the airport name, Millville Municipal, followed by its three or four letter airport designator, MIV. Below that is the airport's location, Millville, New Jersey. The airport name information is important for cities with several airports. Be certain you've got the right plate in front of you.

Plan View Panel

Communications Information—Uncontrolled Field

ATLANTIC CITY APP CON
124.6 263.6
MILLVILLE RADIO
123.65 (CTAF)
UNICOM 123.0 
ASOS 128.125

<http://www.navfltsm.addr.com/ndb-appr.htm> (4 of 12) [18-Nov-01 12:17:45 PM]

frequency is approach control. It lists Atlantic City App Con so we know that the radar is not at Millville. That's the first clue that Millville Municipal Airport is not a controlled field. Approach Control's frequency is 124.6 MHz or 263.6 MHz for military aircraft.

Millville Radio is next on the list, and is the Flight Service Station, which is on the field at Millville. It is not a control tower, but rather a source of flight information. Pilots can get the latest weather information from them, file flight plans, learn of advisories, etc. Millville's frequency is 123.65. CTAF following the frequency signifies the Common Traffic Advisory Frequency for Millville. Pilots announce their intentions over this frequency, much as with Unicom, but know that the specific coverage is for the Millville Airport only. CTAF is only available at fields without a control tower, to increase safety while in or near the traffic pattern.

UNICOM, a channel also for pilots to announce their intentions at an uncontrolled field, is on 123.0 MHz. The "L" in the dark circle following the Unicom frequency indicates the availability of Pilot Controlled Lighting. By rapidly keying his Microphone on Unicom the pilot can turn on the runway lights. he pilot can control up to three different intensity levels of lighting depending on the particular microphone keying used.

ASOS is Automated Surface Observation System, which continuously measures and broadcasts, minute by minute, the surface weather conditions at an airport. The Millville information is available on 128.125 MHz. When installations are complete, this system will be on 1700 airports. The Airport/Facilities Directory includes ASOS information, including broadcast frequencies and telephone numbers for phone-line connections to the broadcasts. Check www.airnav.com for ASOS and weather information for an airport near you.

Communications Information—Controlled Field

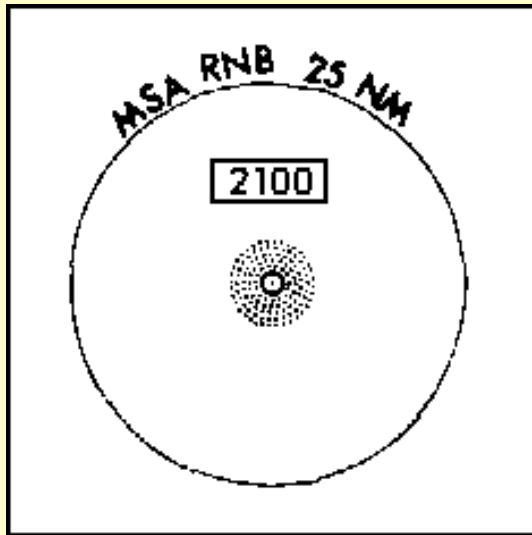


**ATIS 119.55
MANCHESTER APP CON
124.9 305.4
MANCHESTER TOWER
121.3 (CTAF) 324.3
GND CON
121.9
CLNC DEL
135.9
ASOS**

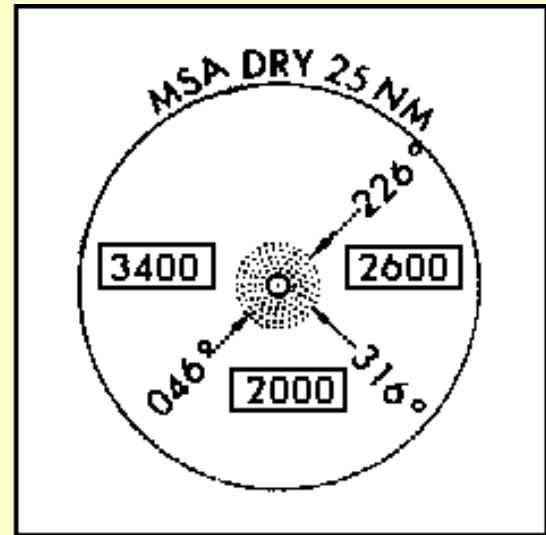
Here is the communication information for the Manchester, New Hampshire airport. Again, the frequencies are listed in the order that a pilot would access them, beginning with ATIS.

The ASOS listed without a frequency means that the service is available, however, the information can only be obtained over the telephone. With ATIS on the field and Approach Control reporting current conditions if they differ from ATIS, it's not necessary to also broadcast the ASOS information.

Minimum Safe Altitude—MSA



Millville MSA



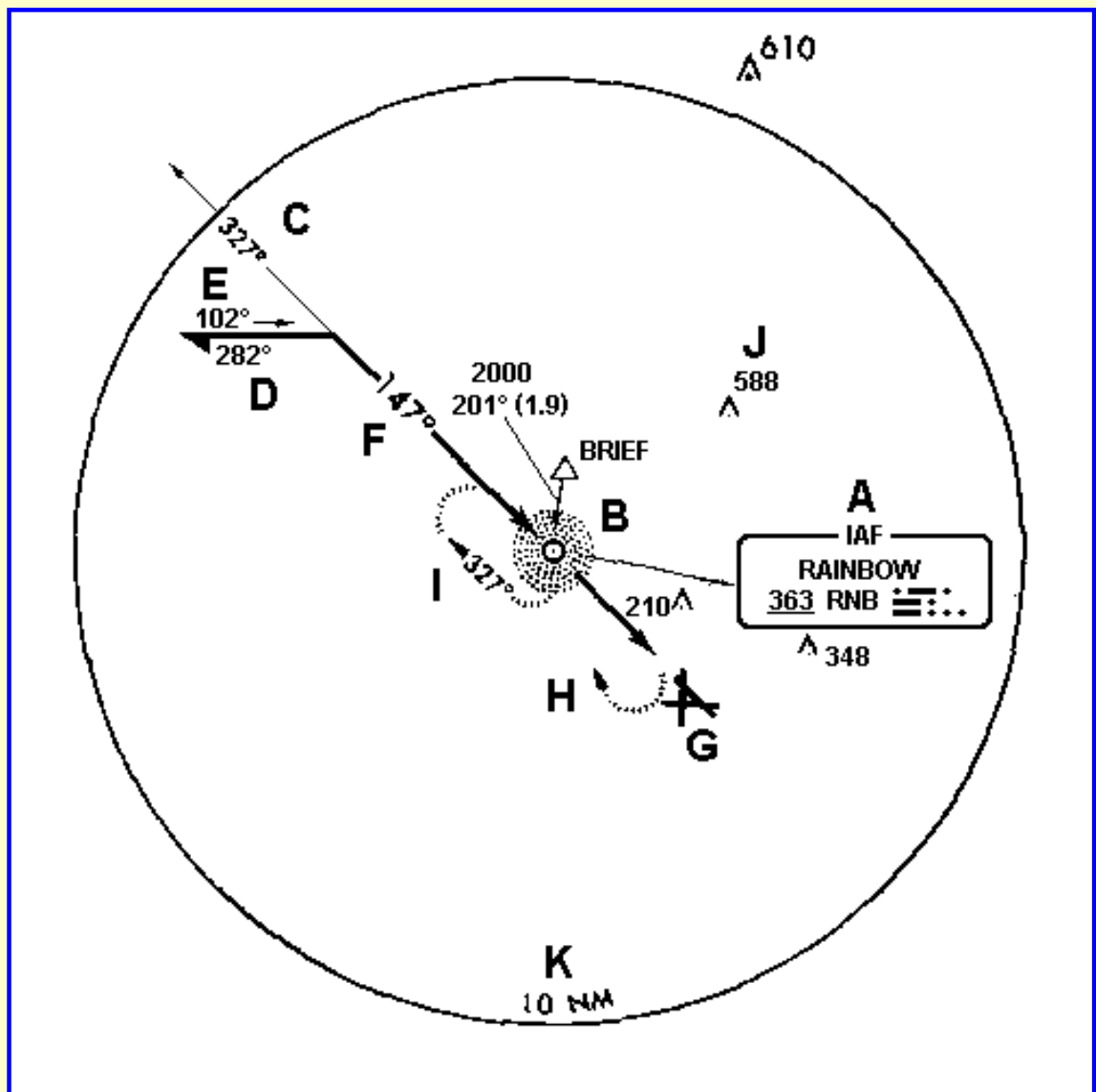
Manchester MSA

The minimum safe altitude—MSA—within 25 nm is shown inside a circle on the plan view. MSA provides 1000 ft. of clearance from all terrain and known obstructions. The 25 nm radius circle is centered on the Navaid used for the approach, in the case of the examples above, an NDB. RNB and DRY are the three-letter designators for the respective NDBs.

If the Navaid were a VOR, the center symbol would be the familiar VOR symbol found on sectional charts. The center symbol corresponds to the Navaid used for the approach, or will be a waypoint symbol if flying a GPS approach.

More than one MSA can be designated for any given approach Navaid, as the two diagrams above show.

Approach—Plan View



Click the image to print this plate imprinted with the identifying letters.

Centered in the plan view are the "horizontal" details of the instrument approach. Horizontal details mean that no altitude information can be obtained from this portion of the plate. That information appears in the profile view, in the next-described panel.

The plan-view features are explained below in the order that a pilot confronts them. Letters "A" through "K" defines this sequence. Click on the image above to print the approach plate imprinted with these identifying letters to follow the explanation.

- A. Identify the NDB—be certain that you are approaching the correct beacon. Frequency indication on the receiver is not sufficient because LF beacons can have great range. Listen for the ident Morse code as shown in the Navigation box. The IAF at the top of the box means that this Navaid is the Initial Approach Fix for this instrument approach. All approaches start somewhere, and that place is the IAF.
- B. The Navaid here is Rainbow NDB, ident RNB. Approach the airfield by tracking to the NDB.
- C. On reaching the IAF, turn OUTBOUND from the airport. In this case, the track (compensating for wind) should be 327°.
- D. Track outbound from the IAF for two minutes, then start the procedure turn. Here it is

- a left turn to 282° . Note that the line with a half-arrow head indicates that a procedure turn is a mandatory part of the approach procedure.
- E. Proceed on the 282° heading for a minute or so, then turn AWAY from the airport to the reciprocal heading of 102° to return back to the approach course to the field.
 - F. As the ADF indicator nears the 147° bearing to the NDB, turn inbound, right in this case, and track to the NDB on that bearing.
 - G. Continue inbound until the field and runway 14 is in sight. The miniature airport plan "G" accurately portrays the runway layout in relation to your inbound track.
 - H. If the runway is not in sight when it should be, a missed approach is mandatory. "H" shows that a right turn is required to perform a missed approach.
 - I. The missed approach procedure generally sends the aircraft to the Navaid and into a holding pattern to await further instructions from ATC. "I" shows the holding pattern and the proper headings. It also shows, in this case, that the holding pattern requires right turns.
 - J. Before beginning the approach, take note of the obstructions. By now you are aware that antenna towers seem to cluster near airports. Know generally where they are and their height.
 - K. The circle surrounding the plan view of the approach procedure is 10 nm in radius, centered on the Navaid. You are expected to remain within this 10 nm. distance from the beacon while performing the approach. i.e., don't fly a 20 nm outbound leg, or 15 nm after turning into the procedure turn. You only own the airspace within the 10 nm radius circle.

OK, I give up—what's a procedure turn?

Looking again at the approach plate, your flight path brings you to the beacon, RNB, then you fly outbound from the beacon, away from the airport and runway. Obviously you have to get turned around to return to the airport, and the procedure turn is a standardized way of doing that.

It's common to execute the procedure turn about two minutes out from the beacon. That time is flexible, but too little rushes you too much on the return to the beacon and too long may take you outside the mandatory 10 nm. radius that you must remain within.

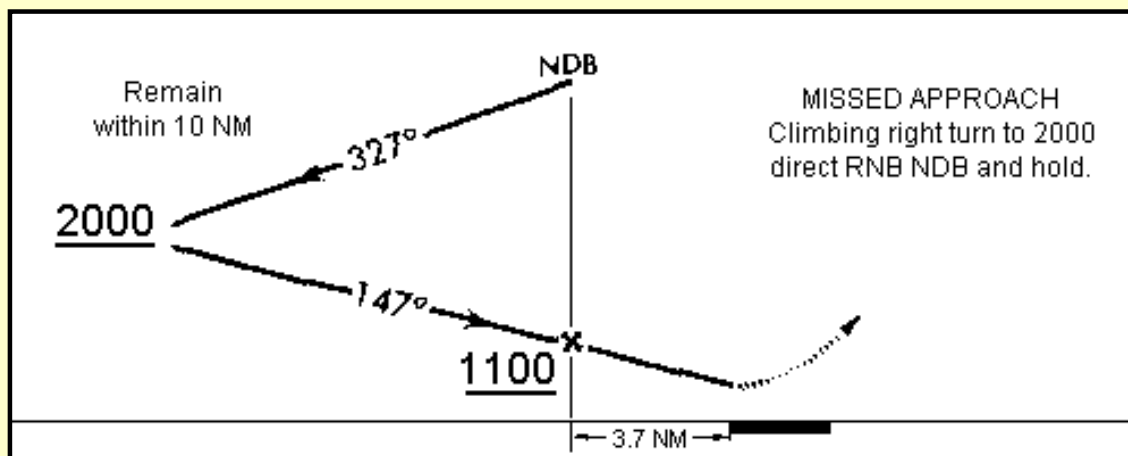
There's an unpublicized hazard, too, with a procedure turn that begins a looooong way out from the beacon. That's the bevy of pilots of high-performance aircraft asking to see you, the ones that you delayed while you moseyed that long distance back to the beacon at a nice leisurely pace.

The procedure turn begins with a 45° turn away from the outbound track. Fly that heading for a minute or so, nothing hard and fast about that time, then execute a 180° turn *away* from the airport to return to the desired bearing to the beacon.

When you intercept the desired inbound bearing to the beacon, actually just shortly before that point, you make another 45° turn, this time toward the airport, nicely rolling out on the specified track back to the beacon.

The approach plate defines the direction of the procedure turn from the outbound track. There is no freedom in that: what the chart shows is mandatory.

Approach—Profile



As just seen, the plan view on the approach plate gives no altitude information. That information is on the profile view.

Considering the approach again, the aircraft flies outbound, tracking 327° from the NDB. Notice the underlined 2000 in the profile view. That indicates that the aircraft may not descend lower than 2000 ft MSL while outbound and in the procedure turn.

Once the aircraft is inbound, tracking 147° to the beacon, it may descend further, but no lower than 1100 ft. until it reaches the beacon, also referred to as the FAF or Final Approach Fix. From that point it may begin its descent to the MDA, or Minimum Descent Altitude, which is discussed on the next part of the approach plate.

The heavy line to the right of the beacon signifies the runway. Here, it is 3.7 nm from the beacon, a crucial number to know in a non-precision approach, where distance is gauged by time.

How low can you go? What are the minimum visibility requirements? Read on.

Minimums

CATEGORY	A	B	C	D
S-14	520-1 438 (500-1)		520-1¼ 438 (500-1¼)	520-1½ 438 (500-1½)
CIRCLING	520-1 437 (500-1)	540-1 457 (500-1)	540-1½ 457 (500-1½)	640-2 557 (600-2)

The minimums table is immediately below the profile view.

Landing minima are established for six categories of aircraft; ABCDE and COPTER. An aircraft fits into one category or another based on its maneuvering speed. Maneuvering speed is defined as 1.3 times the stall speed at maximum gross weight in the landing configuration.

The table below identifies the Category vs. Maneuvering Speed.

Approach Category	A	B	C	D	E
Speed (Knots)	0–90	91–120	121–140	141–165	Abv 165

Note that approach plate lists only the first four categories.

The next two rows list the minima for the two possible types of landing with this procedure: Straight in to runway 14 (S–14), or Circling to land at any of the other available runways. A Straight landing is defined as one where the approach course is aligned within 30° of the runway heading.

The straight-in landing minima at Millville for runway 14 is 520 ft. Minimum Descent Altitude (MDA) and one statute mile reported visibility for Categories A and B aircraft. The MDA remains the same for C and D, but the visibility minimums increase to 1¼ and 1½ statute miles respectively.

MDA is exactly as the words say. The aircraft may not descend below the Minimum Descent Altitude during an approach unless the approach-end of the runway is firmly in sight, and a safe, normal visual landing can be made. No diving to the runway hoping to touchdown on the last quarter of its length.

Ignore the numbers in the parenthesis; they apply to military aircraft only. The small numbers just before the parenthesis is the actual height of the MDA above the airport. This may not be the mathematical subtraction of ceiling and field elevation, because field elevation and airport height can differ by several feet.

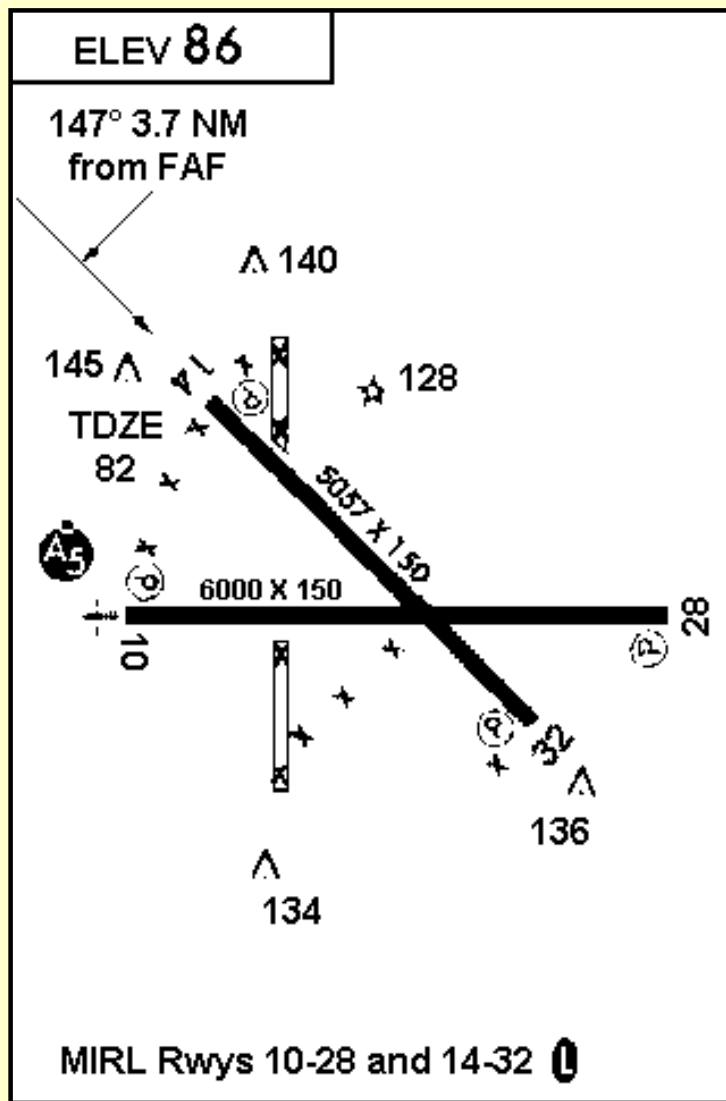
Note that the landing minima for a circling approach are generally higher than for a straight-in approach.

The white "T" in the black triangle below the table indicates either that the takeoff minimums are non-standard or that there is a published departure procedure, or both. This information will be in the front of the approach chart booklet.

At Millville, the take-off minimum is 300–1 for all categories of aircraft. A published departure procedure also exists, named LEEAH TWO. The text description of this departure, when take-off is from Runway 10 or 14:

Climb to 400 ft. Turn left heading 100° and intercept SIE R–333 (SIE VOR, 333° radial) to LEEAH INT, then via ... Maintain 2500 ft., expect filed altitude 10 minutes after departure.

Airport Plan View



The plan view of the airport is an important feature of the approach plate. The field elevation is noted in the upper left-hand corner of this view. Millville's elevation is 86 ft.

This view gives the pertinent details of the runways; their length and width, and the runway numbers. Note the "TDZE 82" for Runway 14. That is the Touch Down Zone Elevation for Runway 14. Recall in the minimums table that for the S-14 approach with an MDA of 520 ft, the height above the airport was shown as 438 ft? That was obtained by subtracting the 82 ft TDZE from 520 ft MDA.

Recall also on the plan view of the approach, that three runways were in the little diagram at the end of the approach arrow? The airport plan view shows that runways 10-28 and 14-32 are available. A third N-S runway is

shown as closed—denoted by an "X" at either end.

The airport plan view also reminds the pilot that Rwy 14 is 3.7 nm from the FAF, Final Approach Fix, which is the NDB, and that the approach course is 147°.

At the bottom of the view is the runway lighting information. Here MIRL, Medium Intensity Runway Lights, are available on both runways and are pilot controlled.

The Black circle with a white "5" inside of it near Rwy 10 indicates the type of lighting. A white letter in a black circle denotes that the lights are pilot controlled. The dot at the top of that black circle indicates sequenced flashing approach lights—called "the rabbit" by pilots because they chase it down to the end of the runway.

If the airport is large, its plan view occupies an entire page of the approach plate booklet.

Time from FAF to MAP

FAF to MAP 3.7 NM					
Knots	60	90	120	150	180

Min: Sec	3:42	2:28	1:51	1:29	1:14
----------	------	------	------	------	------

Distances in a non-precision approach are gauged by measuring time. The critical time of a non-precision approach is from the FAF, or Final Approach Fix (the NDB) to the MAP, Missed Approach Point, or touch down zone of the runway. The times to cover this distance, 3.7 nm here, are calculated and entered into a table located below the airport plan view.

It would be nice if our aircraft, considering any wind component, approached the MAP at a speed exactly listed in the table. Seldom happens, so interpolation is needed. Assume you approach in your Barn Burner at 75 knots, midway between two entries in the table. Recalculate for your 75 kt approach speed, 2 min., 58 sec., and jot that time down on your clipboard so that it will be available when you run the approach. Don't want to be doing those calculations at the final moments of the approach.

It's time to fly the approach. Click on the *NDB off Airport* button to get into the soup and see if you can find the runway.



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Atlantic City, New Jersey

Some people get all the tough jobs. The Boss said to fly Mr. Counter to Atlantic City, New Jersey, in time for the *Miss America Pageant*, and then stick around until it's over because who knows where he will want to go to next, and when.

Wow! Atlantic City entertains like no other destination in the country. Why couldn't the Pageant last all year? This place has thirteen casinos offering 24-hour non-stop action, world-class headline entertainers, bright sandy beaches, a 4½ mile amusement-filled Boardwalk, and championship golf courses.

But after three days Mr. Counter's phone call last night awoke me from a sound sleep. He said to be ready first thing in the morning to fly him and a guest to Millville to recuperate from all of the noise and excitement of Atlantic City. While there, he also wants to explore the natural attractions.

The weather is lousy today ... 600 ft and one mile visibility. Maybe Mr. Counter will change his mind. If the weather gets any lower, Millville will be socked in.

The sound of a car-door slamming turns my head. No, Mr. Counter won't cancel his plans. Here he comes now, struggling with two suitcases under one arm. The other arm is around Miss Natural Attractions' waist.

The Flight

Time to go to work. Yep, we'll use the same Millville approach plate that we just discussed in the previous section. Since you're now very familiar with its features, it makes sense to fly that particular approach.

For all flights in this section, select the "Saab-ADF" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel.


The first approach will be in a no-wind situation, just to get the feel of it. Use whatever aircraft you're most comfortable with, but flying the Saab MFI-17 keeps things to the basics. We're going into a small field, no 747's behind us to irritate if we slow up a little way out.

Print the approach plate again, if necessary, [by clicking here](#) then we can begin.

Approach Worksheet

Review the information for the approach. I recommend using the Approach Worksheet to get all of the numbers in front of you for quick, easy reference. [Click here](#) to print it. Two approaches can be figured with one printout. The worksheet lists information in the order that it is needed.

Lets get the FAF to MAP approach time calculation out of the way first. Assume an 80 kt maneuvering speed for the MFI-17. For 3.7 nm, that time would be 2 min., 47 sec. Jot that at the bottom of the Worksheet.

Approach Worksheet		Date: 9/20	
Airport	<u>MILLVILLE</u>	Type Appr	<u>NDB</u>
Field Elevation	<u>86</u>	Runway	<u>14</u>
NAVAID	<u>RBN</u>	Freq	<u>363</u>
HDG to NAVAID	<u>288°</u>	Altitude	<u>4000</u>
Outbound Hdg	<u>327°</u>	Altitude	<u>2000</u>
PT  R out	<u>282°</u>	return	<u>102°</u>
Inbound Hdg	<u>147°</u>	Altitude	<u>1100</u>
FAF to MAP	<u>2 : 47</u>	MDA	<u>520</u>
Remarks			

Millville Airport Approach Worksheet

Set the weather on your flight simulator to one mile visibility and cloud cover to 600 ft. MSL "overcast." Set the wind speed to zero knots.

Now fill in the rest of the data on the worksheet. The completed worksheet is shown in the illustration. PT is the Procedure turn information, Left or Right, and the heading away from the outbound course and the return heading after the 180° turn.

This first flight will originate from Bader Field, Atlantic City, New Jersey, where I took my PP check ride a few decades ago. Tune the ADF receiver to 363 KHz, and verify its Morse code identifier (Click left-portion of radio face). The distance to the Rainbow beacon is 31.5 nm. Calculate the ETE for your aircraft, or, for the MFI-17, plan a cruise speed of 120 kts for the calculation. Reset the panel timer to zero.

Leave the aircraft's autopilot in the off position. We're going to fly this route.

You may want to refamiliarize yourself on how to intercept an NDB bearing, both inbound and outbound. If so, [click here now](#) to go to that explanation in the NDB navigation section.

Take-off from Runway 29 and start the panel timer. Jog slightly left to intercept the 288° radial from the RNB beacon at Millville. Climb to 4000 ft.

A few minutes before your anticipated arrival at the RNB NDB, begin your descent to 2000 feet. Plan on a standard 500 fpm descent. You'll be busy enough during the actual approach that it will be good to get this behind you now.

As the needle begins to swing, announcing arrival at the RNB Beacon, turn right and intercept the 327° outbound bearing. Reset and restart the panel timer. Maintain the 2000 ft. altitude.

When the timer reads two minutes turn left to a heading of 282° for the procedure turn. Reset and restart the timer. Maintain your altitude on the turn. All turns should be a standard-rate, two minutes for 360°.

When the timer again reads two minutes, turn right to 102° to return to the inbound track to the beacon. Reset the panel timer, but don't restart it until intercept of the inbound bearing is complete.

Intercept the 147° bearing with a right turn. Restart the timer after stabilizing your inbound heading. It will be slightly longer inbound to the beacon from the procedure turn, than it was outbound because the procedure turn was away from the airport.

Descend to 1100 ft altitude at 500 fpm. Transition to landing configuration: proper flap setting, gear down if retractable, propeller full rpm if constant speed prop. Slow to approach speed, for the MFI-17, 80 kts. and one notch of flaps. Once you reach the FAF, RNB NDB inbound, only one task should remain to occupy your attention: descend to the MDA and fly to the MAP and land.

It's important here to establish the concept of a stabilized approach. The aircraft's configuration should be stabilized before reaching the FAF, i.e., speed reduced to the desired approach speed and flaps properly set. Again, for the MFI-17, we'll use 80 kts. and one notch of flaps.

As the needle swings on beacon passage inbound, reset and restart the panel timer. Immediately descend to the 520 ft MDA for this approach. At 500 fpm that will eat up about 1:10 of your inbound 2:47 to the MAP. Don't drop one foot below 520. Keep heading and speed constant as you track outbound from the beacon to the runway.

Don't chase the needle if it starts to move. Make small corrections in heading to stop the needle movement and then stay on that heading. Pay close attention to the timer. If everything is OK, continue to the MAP. If you're not happy with the approach, execute the missed approach with a climbing right turn to 2000 ft and return to the beacon. Fly outbound and restart the approach again.

Arriving at the MAP

The minimum visibility for this straight-in approach is one mile. That means that you should clearly spot either the end of the runway or the runway lights about one-mile before reaching the runway. Once they are clearly in view, transition to a normal VFR, straight in landing.

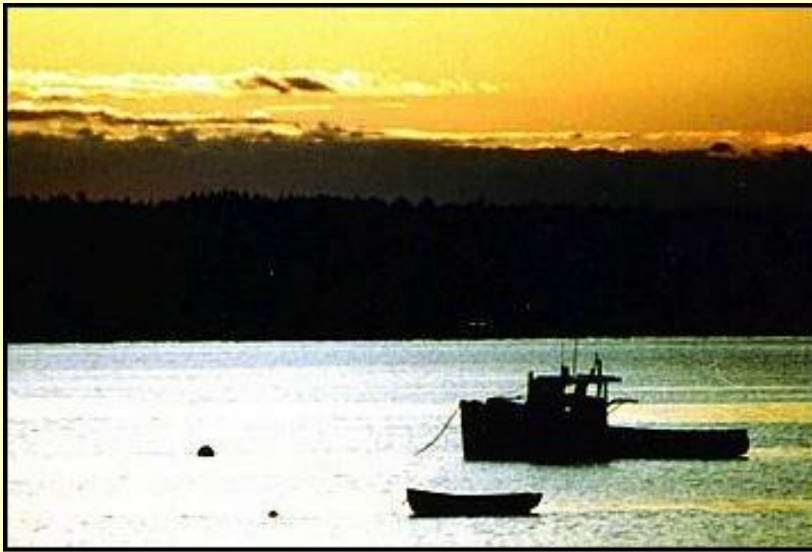
Be aware that the runway threshold, when it appears, may be a few degrees off from straight ahead on your approach. Some wiggling may be necessary to line up to land. Don't lose the ship now.

Also, be advised that if you first spot the runway threshold only a few seconds before the time to MAP has elapsed that you will be 438 feet above the runway. If the runway is 10,000 feet long, not a problem. If it's 3000 feet long, you probably cannot lose that altitude and still have enough runway in front of you to land.

Don't point the nose down and figure "you can make it." More than one captain of a propliner thought the same, ended up folding up the nose gear on touchdown, as well as his career. Go around and try again.

With these thoughts in mind, your landing should be safe and comfortable. Taxi to the gate and buy yourself a well-deserved cup of coffee. Presumably Mr. Counter and Miss Natural Attractions can take care of themselves.

The Teardrop Turn



Penobscot Bay, Belfast, Maine

Not every instrument approach begins with a nice convenient arrival at the airport as the one just flown. You arrived at the RNB beacon and then made an easy 40° right turn to begin the outbound leg of the approach procedure.

This next flight presents a different challenge.

**Belfast, Maine to
Pittsfield, Maine**

I still can't believe it. The Boss had sent me to Belfast, Maine to ferry back a nearly-new MFI-17. But it wouldn't be ready for a week and he had told me to take some vacation while waiting for it.

It was a great week in the heart of coastal Maine. I mingled with seafarers, back-to-the-landers, and always-on-the-landers. The high point was visiting the Penobscot Marine Museum, Maine's oldest maritime museum, and famous for its breadth of exhibits

But the week was up, the fun time was over. The Boss had asked me to check in before I left, that he might have a charter for me. It was with foreboding that I lifted the phone. We hadn't heard from Benjamin Counter for some time, now.

"You must have done something right," the Boss said. "Counter recommended us to their principal stockholder, a Mr. Well Thee. Thee needs a hop from Pittsfield, Maine down to Gloucester, Mass. in time to catch the Casino Cruise. Not to worry, I told him. It's only an hour and a half flight—you'd easily have him there before sailing time."

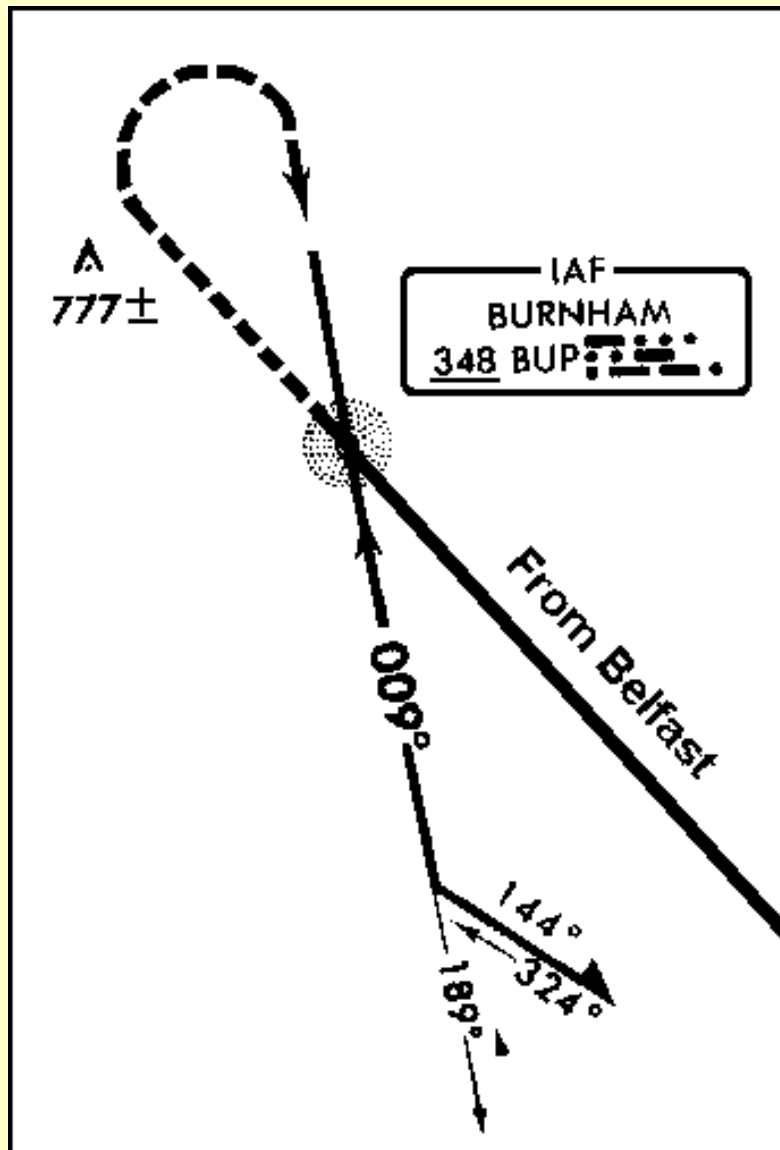
"Thee must be a workaholic, too," the Boss continued. "because, like Benjamin Counter, his administrative assistant will join him to help with the workload when the gaming tables are closed. Beats me how anyone can do any work on a cruise ship with live entertainment that's a floating casino to boot. All I can figure is that those uppity-up people just can't ever get their mind off of business."

The Boss hung up before I could explain that business.

The Flight

[Click here to print](#) the NDB approach plate for Pittsfield Muni airport.

Take-off from Runway 33 at Belfast Municipal airport and pick up the Burnham Beacon (348 KHz, BUP) 23 nm distant. Track inbound on the 338° bearing. You'll notice that your initial arrival at the IAF is broadly inbound to the airport, the opposite direction to begin the approach procedure.



Teardrop turn, from Belfast

Then track to the bearing and you're in great shape to start the approach on station passage because the aircraft heading is already correct.

The teardrop turn is helpful in another way, too. You can determine the wind-correction angle needed on the way to the beacon, and have that under control, too, as you pass the station.

The teardrop turn was invented for just this situation.


Fill out the Approach Worksheet for Pittsfield. Just writing the numbers on the form will enhance your memory of them later.

Proceed over the NDB on the 338° track established from Belfast. Altitude should be at or above the 2600 ft. listed for the outbound course of the approach. Note the 777 ft. obstruction very near the flight path. Not a good time to get sloppy on altitude. Drop one notch of flaps and slow to 80 kts.

Don't start the turn back to the NDB so early that you swing too wide. Best to go out a little farther than you think necessary, start the turn, and continue around, intercepting the 189° bearing from the beacon in the conventional manner.

Approach Worksheet

Date: 9/26

Airport	<u>PITTSFIELD</u>	Type Appr	<u>NDB</u>
Field Elevation	<u>198</u>	Runway	<u>1</u>
NAVAID	<u>BUP</u>	Freq	<u>348</u>
HDG to NAVAID	<u>338°</u>	Altitude	<u>4000</u>
Outbound Hdg	<u>189°</u>	Altitude	<u>2600</u>
PT  R out	<u>144°</u>	return	<u>324°</u>
Inbound Hdg	<u>009°</u>	Altitude	<u>1400</u>
FAF to MAP	<u>3 : 00</u>	MDA	<u>780</u>

Remarks

RWY 1 TDZE 195 ft

Pittsfield Muni Airport Approach Worksheet

The flight from Belfast to Pittsfield is very short, so fly that route and approach several times until it is under control and you're satisfied with the results.

The Circling Approach

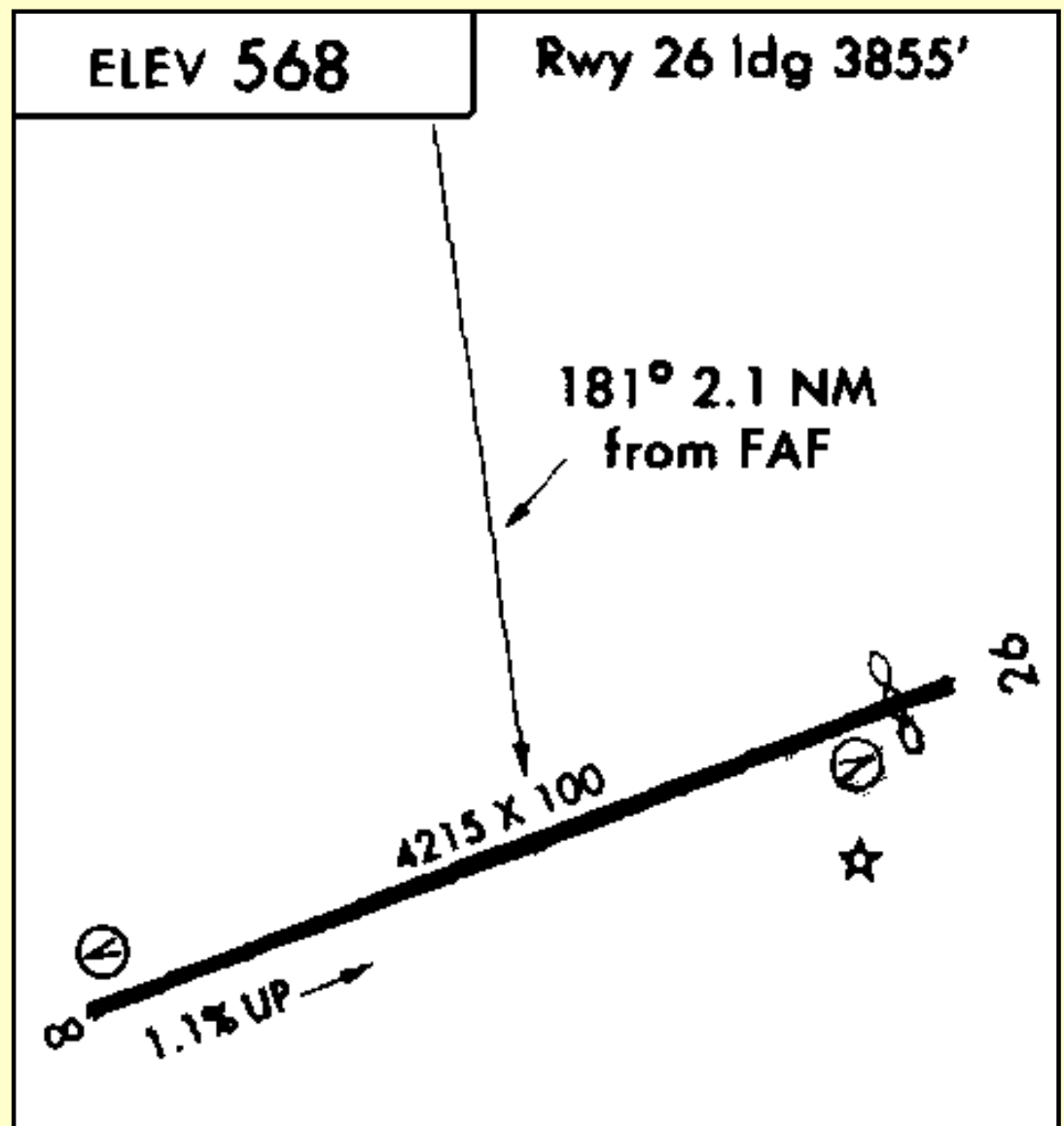


"Perkasie?" I mumbled. Again a ringing telephone had awakened me from a sound sleep.

"Yeah, the place where they reenact Washington's crossing every year. I watched it once when I was a kid."

This time it was the Boss. He wanted me in Perkasie ASAP, 30 miles north of Philadelphia, to collect Mr. Counter, to save his bacon. Seems like Counter had to

beat a hasty retreat from Millville. As mentally stimulating as Miss Natural Attractions was, she was not totally forthcoming. It turned out that the "Miss" part, although technically correct, was substantively inaccurate. Her Significant Other, a professional wrestler and small at only 287 lbs, was at that very moment looking for "that creep who stole my gurl."



A circling approach is the only option for Pennridge Airport.

So here I was, at Philadelphia Int'l. airport, as close as I could get to Perkasio, waiting for the weather over there to lift. It was less than 30 miles from here to the Pennridge airport. I reviewed their approach plate again and sighed when I glanced at the airport plan view. The approach was broadside to the runway and a circling approach would be necessary.

Three situations can create the need for a circling approach.

- If the instrument approach is not aligned within 30° of the runway heading, as the case in Perkasio.
- If the surface winds make it unsafe to land on the runway that the approach procedure is aligned with.
- If the straight-in approach procedure forces a dangerously high rate of descent, usually a factor of the terrain.

Although the MDA for a circling approach brings the aircraft into the vicinity of the field below normal traffic-pattern altitude, it guarantees 300 ft vertical clearance from all obstacles in the circling area.

Why Perkasio's approach is nearly perpendicular to their only runway is unknown to me. But we have to deal with it.

Print the Pennridge/Perkasio approach plate [by clicking here](#) then we can begin.

Since the wind is calm, we'll chose to land on Runway 8.

- It provides the full 4215 ft. to land on. If we were to land on Runway 26, only 3855 ft. is available because of the displaced threshold.
- The traffic pattern is standard left turns, and the approach is better aligned for a left-hand pattern into Runway 8 than flying completely around the airport to enter the left-traffic pattern from the other side.
- Runway 8 has a 1.1% upgrade, which will more rapidly slow the aircraft than the downgrade of Runway 26.


Set the weather on your flight simulator to one mile visibility, wind, calm and the ceiling at 1240 ft, "overcast." The NDB is very close to the field, 2.1 nm, so calculate the time to the MAP at 80 kts (1 min., 35 secs.).

Just received ATC clearance to leave for Pennridge. Depart Philadelphia Int'l., Rwy 35, climb to 4000, direct to UKT, cleared for the approach, Pennridge Airport.

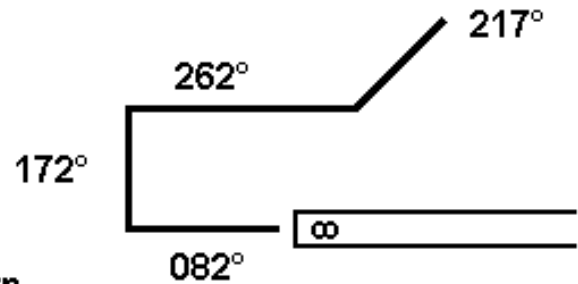
The pertinent information is filled in the worksheet in the illustration.

Approach Worksheet

Date: 9/30

Airport	<u>PENNRIDGE</u>	Type Appr	<u>NDB</u>
Field Elevation	<u>568</u>	Runway	<u>8</u>
NAVAID	<u>UKT</u>	Freq	<u>208</u>
HDG to NAVAID	<u>007°</u>	Altitude	<u>4000</u>
Outbound Hdg	<u>001°</u>	Altitude	<u>2500</u>
PT L  out	<u>046°</u>	return	<u>226°</u>
Inbound Hdg	<u>181°</u>	Altitude	<u>1800</u>
FAF to MAP	<u>1 : 34</u>	MDA	<u>1240</u>

Remarks

Rwy 8
Traffic Pattern**Pennridge Airport Approach Worksheet**

Fly to UKT and start the approach. There is nothing unusual about the approach up to arriving at the FAF inbound. Then things get very busy, very fast.

*It is in thick, not in clear weather,
that airmanship is proved.*

Reset the panel timer, and start it at the FAF. Begin your descent immediately to 1240 ft. MDA. That is a 560 ft change in altitude, and the time from the FAF to the MAP is 1 min., 24 secs., so this is not the time to casually reduce altitude.

Keep the traffic pattern in mind as you head towards the runway. On sighting the runway, turn right to 217° to the traffic-pattern entry heading. From this point on, fly a conventional left-traffic pattern and land on Rwy 8, which slopes slightly upgrade.

If you lose sight of the field once you start circling for the desired runway you are required to immediately execute a missed approach.

You may not descend below the MDA while circling until you are in the actual landing phase, i.e., on base leg or final.

You should have fun flying these approaches. You'll become proficient at them much more quickly than you realize which will greatly improve your flying in general. VOR approaches are very similar to NDB approaches, except for the indicator and some fiddling that you have to do with the OBS knob. You'll find the transition quite easy.

When the NDB is on the field, rather than located some distance away as they were here, the approach procedure is significantly different because there is no FAF. Press the *NDB on the Field* button below to learn the differences in that sort of approach procedure.



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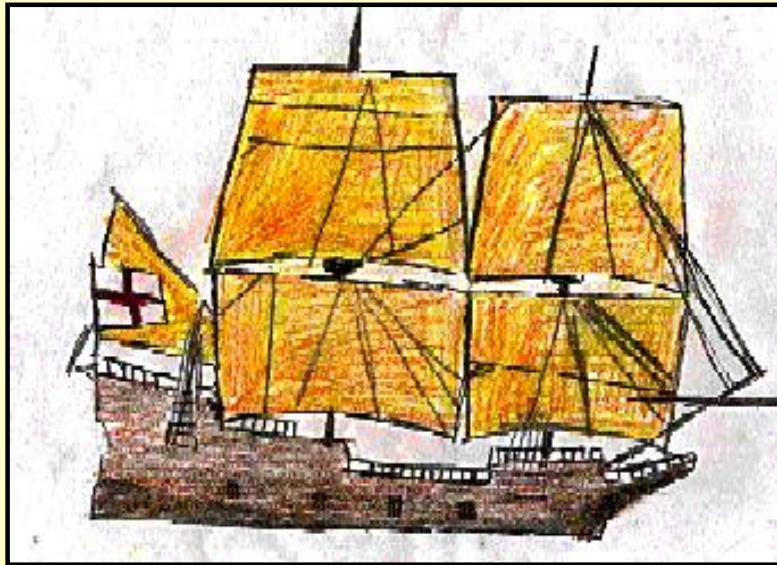
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NDB On Field



Mr. Counter skipped the Boss this time—called me directly, at home. Said he was turning over a new leaf. Wanted to sop up some history.

He called from Plymouth, Mass., from the plantation where the Pilgrims landed and settled. Said that the Pilgrims spelled it Plimoth, and who had the nerve to change the spelling?

I had no answer to that.

Worse, he went on, the Mayflower first landed at Provincetown, on Cape Cod, four weeks before it came to Plimoth. How come he never learned that in school?

I didn't have an answer for that either. Well, I did, but it would probably have cost me the charter.

They had some good history stuff in the museums over there in P'town, he went on. He wanted me to fly him over there in the morning. He had heard about the sailors on the Mayflower. They had cursed the Pilgrims all the way across the Atlantic for praying so much.

His kind of people, those sailors, Counter said. He wanted to learn more about those sailors. Never could understand how this country got started with people working the farms that wore tall black hats and big shiny buckles. Some of those sailors must have stayed behind.

"Hey," he finished, "any town that is so bad that the Pilgrims had to leave it? I gotta be there."

I was ready to hang up ... "One more thing," he hollered. "Don't get here too early. I'm helping a Holyoke student with her studies tonight—she's home alone for the weekend."

So much for the new leaf. I wanted to tell him that the professional wrestler's convention was in P'town this weekend, and they'd all be there. But it wasn't true.

I reached for my charts in the flight bag.

The Flight

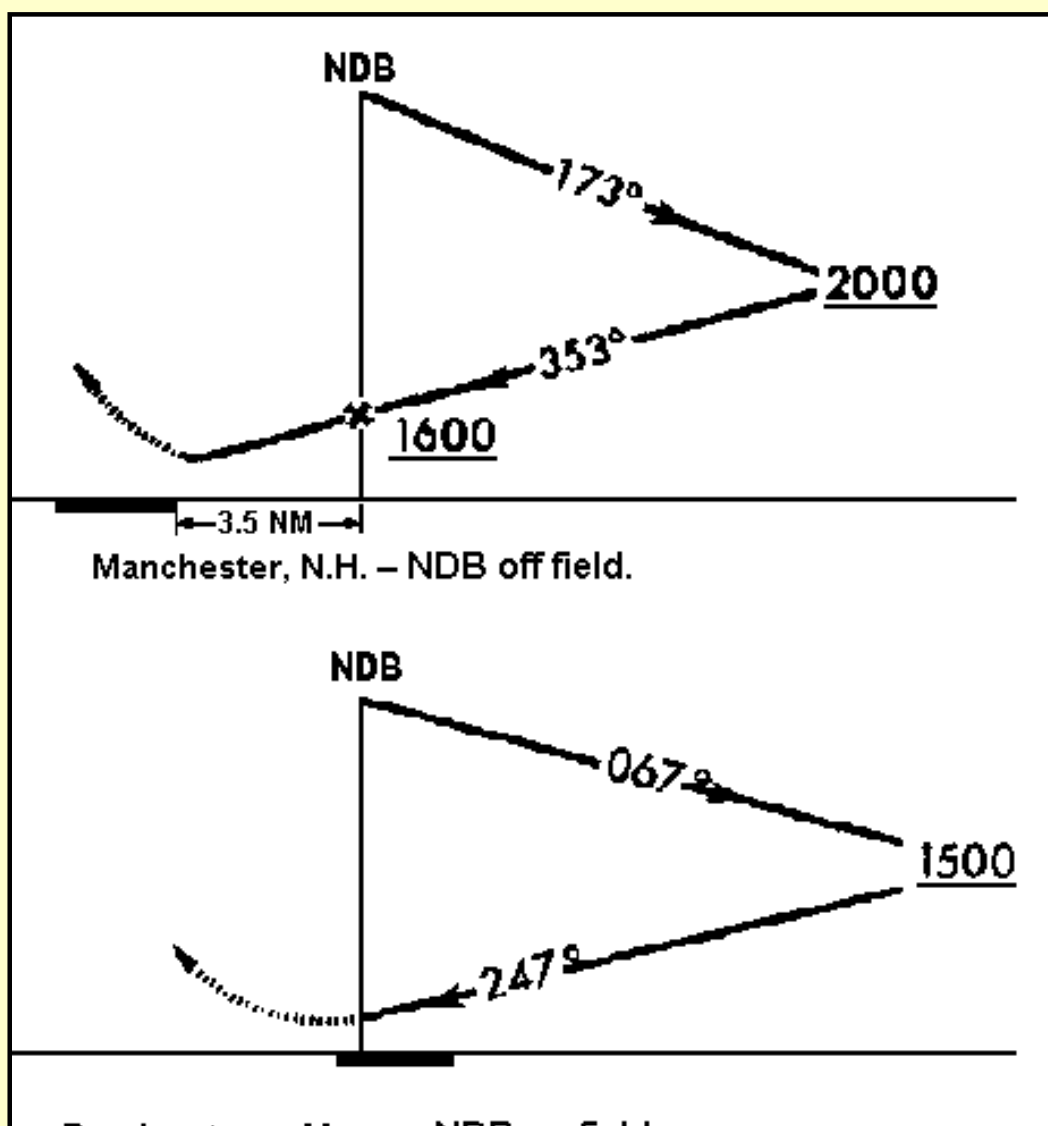
It's a brief flight from Plymouth Municipal Airport to Provincetown: 13 to 15 minutes to the PVC beacon, the IAF. Smart to fly ... an hour and a half or so to drive out around the hooked arm of Cape Cod.

For all flights in this section, select the "Saab-ADF" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel.

Print Provincetown's approach plate [by clicking here](#).

Two significant differences are notable on Provincetown's approach plate vs. the ones used up 'til now. There is no FAF, and the table of times from FAF to the MAP is blank. Since the NDB is on the field, it can't be the Final Approach Fix, hence there can be no times for FAF to the MAP.

The next two figures compare the Manchester, N.H. approach plate (beacon off the field) with Provincetown's. The differences are immediately apparent. The Maltese Cross on Manchester's profile signifies the FAF—the Final Approach Fix, the last electronic fix before beginning the descent to MDA and the point that you should start timing for the missed approach point. There is no corresponding symbol on the Provincetown approach profile.



Provincetown, Mass. – NDB on field.

The Maltese Cross on the Manchester approach (top) signifies the FAF. Provincetown has no Maltese Cross, no FAF. The beacon is on the field.

FAF to MAP 3.5 NM					
Knots	60	90	120	150	180
Min:Sec	3:30	2:20	1:45	1:24	1:10
MANCHESTER, NEW HAMPSHIRE					
Knots	60	90	120	150	180
Min:Sec					
PROVINCETOWN, MASSACHUSETTS					


**Manchester, its beacon off the field, has an FAF, and FAF to MAP times.
Provincetown's beacon is on the field, no FAF, and no FAF to MAP times.**

Despite Mr. Counter's plea not to depart early, we're ready to go at 8:00 a.m. Provincetown has some low-lying fog and calm winds. We'll take-off from Plymouth's runway 6 and have been approved for an NDB approach to Provincetown's runway 25. For this very short flight we've been assigned to 3000 ft. cruise altitude.

Begin, as usual, by completing the approach worksheet.

Approach Worksheet

Date: 10/16

Airport	<u>Provincetown</u>	Type Appr	<u>NDB</u>
Field Elevation	<u>8</u>	Runway	<u>25</u>
NAVAID	<u>PVC</u>	Freq	<u>389</u>
HDG to NAVAID	<u>083°</u>	Altitude	<u>3000</u>
Outbound Hdg	<u>067°</u>	Altitude	<u>1500</u>
PT  R out	<u>022°</u>	return	<u>202°</u>
Inbound Hdg	<u>247°</u>	Altitude	<u>520</u>
FAF to MAP	<u>N/A</u>	MDA	<u>520</u>

Remarks

Beacon on field**Provincetown Airport Approach Worksheet**

Descend to 1500 ft. approaching the PVC beacon. Cross the beacon, start the panel timer and intercept the 067° outbound bearing. Maintain this track for two minutes, adjusting the heading as necessary for any wind. At the two-minute point, make the 45° left procedure turn, to a heading of 022°.

It's your choice whether to reset the timer or not at this time. Continue on the procedure-turn heading for one to two minutes, then reverse back to 202° with a right turn. The aircraft should be in the landing configuration at this point. Slow to 80 kts., and drop one notch of flaps.

Intercept the inbound bearing of 247° , reset the panel timer, and immediately descend to the MDA of 520 ft. Although there is no FAF to MAP time, the timer will generally keep you apprised of your distance from the airport. You flew outbound for two minutes plus made a procedure turn away from the airport, so inbound time will be on the order of two and a half minutes.

At this point you have only three tasks: fly the aircraft at the MDA, sight the runway, and land. Don't clutter your mind with other things.

With no FAF to fly from, your only option is to forge ahead until the runway is sighted or until the ADF needle indicates station passage. This is not all bad because you are flying inbound to the beacon, to an increasingly accurate signal. Mind your heading and don't chase the needle.

The MAP is unmistakably clear: station passage.

Without a clear timing fix inbound, the non-FAF procedure has a built-in trap in that the outbound leg (on the way to the procedure turn) usually starts over the airport, not over a beacon a mile or three from the runway. Pilots who fly a normal two-minute outbound leg may wind up still letting down to MDA when they roar across the airport or else descending at a very rapid, unsafe rate when the problem is recognized.

The solution is simple: extend your outbound leg to three minutes so you'll have room to descend on the way back to the airport. As soon as it's legal, i.e., on course, inbound, head for the MDA; don't hesitate. Grinding along at MDA for an extra half-minute or so is not sinful; besides it gives you better odds on breaking out of the clouds and more time in level flight to look for the airport and make a rational decision about when to start down for the landing.

One final matter. On a non-FAF approach, the runway heading will never coincide with your inbound heading. Since the beacon is located on the field, it must be located to the side of a runway, not right in front of it where it would be a hazard. So there will be some last-minute jockeying in position to properly align the aircraft with the runway heading.

Fly this route several times until you're satisfied with the results. It's really a fairly simple approach.

Next, crank in a stiff crosswind of 20 kts. from 170° . This will shorten the flight across Cape Cod Bay and give you a serious crosswind to contend with during the approach. Enjoy the challenge.

This ends the NDB work. The next subjects are VOR navigation and VOR approaches. Press the *VOR Navigation* button below to move along.



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VOR Navigation

Part I



Douglas's forgotten DC-5, four of twelve built went to KLM, as did this one here. Click image for full size.

The VHF Omnidirectional Range navigation system, VOR, was probably the most significant aviation invention other than the jet engine. With it, a pilot can simply, accurately, and without ambiguity navigate from Point A to Point B.

The widespread introduction of VORs began in the early 1950s and nearly 50 years later it remains the primary navigation system in the overwhelming majority of aircraft.

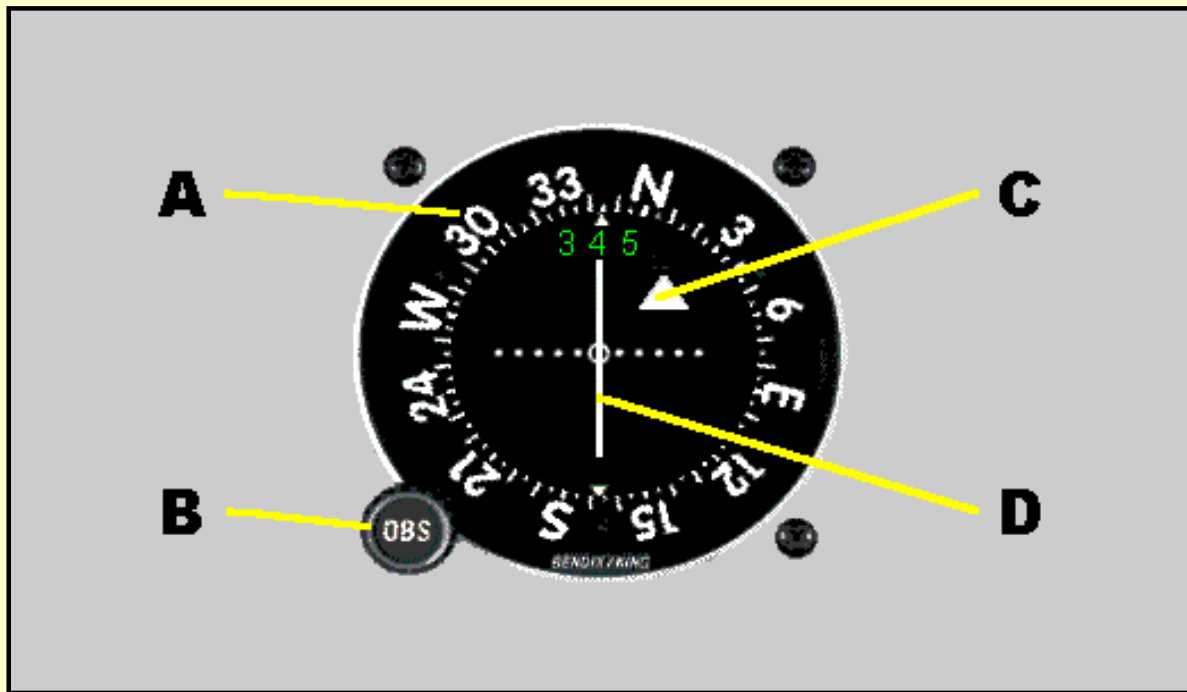
If you jumped to this point of the website without proceeding through the earlier sections, I strongly recommend that you return to the [Air Navigation](#) section and review the sections on VFR Sectional Charts, IFR enroute low altitude charts, and the basics of plotting a course. Further, you should go to the [NDB Approaches/Approach Plates](#) section and read the basics of Instrument Approach Plates, now called Terminal Procedures.

The basic principle of operation of the VOR is very simple: the VOR facility transmits two signals at the same time. One signal is constant in all directions, while the other is rotated about the station. The airborne equipment receives both signals, looks (electronically) at the difference between the two signals, and interprets the result as a *radial* from the station.

The GPS, Global Positioning System, is making inroads onto the navigation scene and offers a flexibility unavailable with either NDB or VOR systems. However, it is supplementing these systems, not replacing them.

The RMI indicator used in the NDB navigation exercises is as close to a "hands-off" indicator as you will find. In an aircraft the RMI compass card must initially be aligned with the compass before a flight begins and then rechecked every fifteen minutes or so, and that's it.

With VOR, however, course information must be manually entered into the indicator. The VOR indicator below shows an aircraft heading toward, "TO," the Omni station on the 345° radial. This aircraft is south of the station. That will become clear why in a moment.

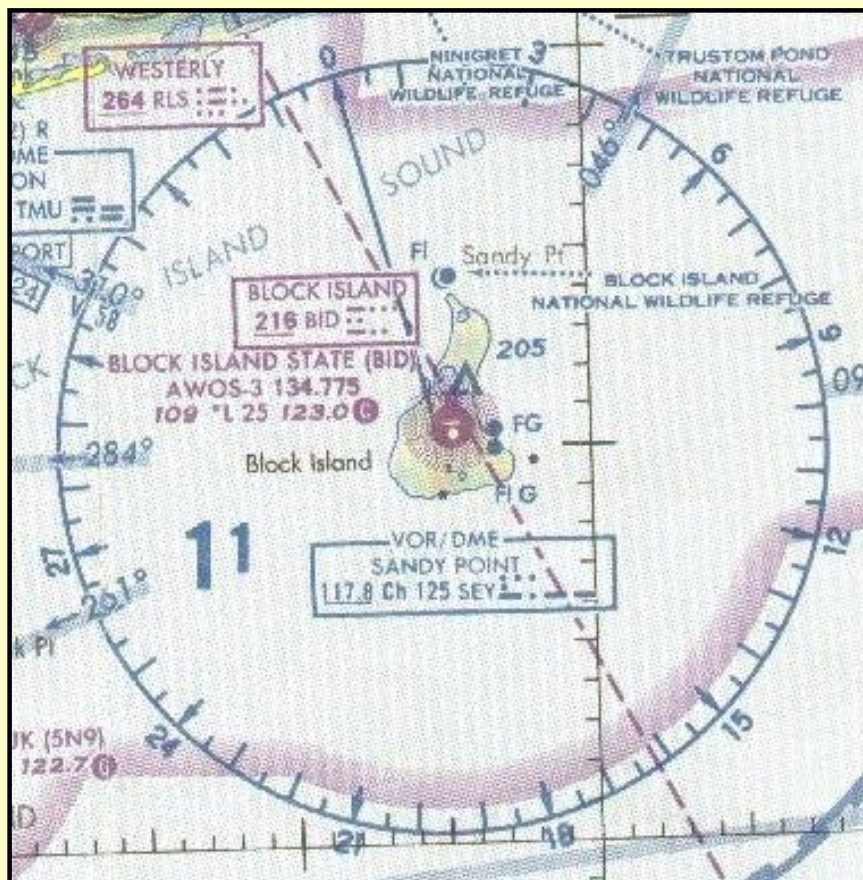


The four components of the VOR Indicator. See text for details.

The VOR display has four elements:

- A. A Rotating Course Card, calibrated from 0 to 360°, which indicates the VOR bearing chosen as the reference to fly TO or FROM. Here, the 345° radial has been set into the display. This VOR gauge also digitally displays the VOR bearing, which simplifies setting the desired navigation track.
- B. The Omni Bearing Selector, or OBS knob, used to manually rotate the course card.
- C. The TO-FROM indicator. This arrow will point up, or towards the nose of the aircraft, when flying TO the VOR station. The arrow reverses direction, points downward, when flying away FROM the VOR station. A red flag replaces these TO-FROM arrows when the VOR is beyond reception range, has not been properly tuned in, or the VOR receiver is turned off. Similarly, the flag appears if the VOR station itself is inoperative, or down for maintenance. Here, the aircraft is flying TO the station.
- D. The CDI, or Course Deviation Indicator. This needle swings left or right indicating the direction to turn to return to course. When the needle is to the left, turn left and when the needle is to the right, turn right. When centered, the aircraft is on course. Each dot in the arc under the needle represents a 2° deviation from the desired course. This needle is more-frequently called the left-right needle, with the CDI term quickly forgotten after taking the FAA written exams. Here, the pilot is doing well, and is dead-on course—or maybe lazy and with the autopilot activated in the "NAV" mode.

Radials, Radials, Radials



To grasp the VOR system you must understand that it is entirely based on **radials away from the station**.

In the Sandy Point VOR to the left, note first that the arrow on the 0° radial points away from the center of the compass rose. You'll remember that this radial points to the west of true north because of the west magnetic variation. North on a VOR is Magnetic North. So, if you overflow this VOR on the 0° radial, you would be flying

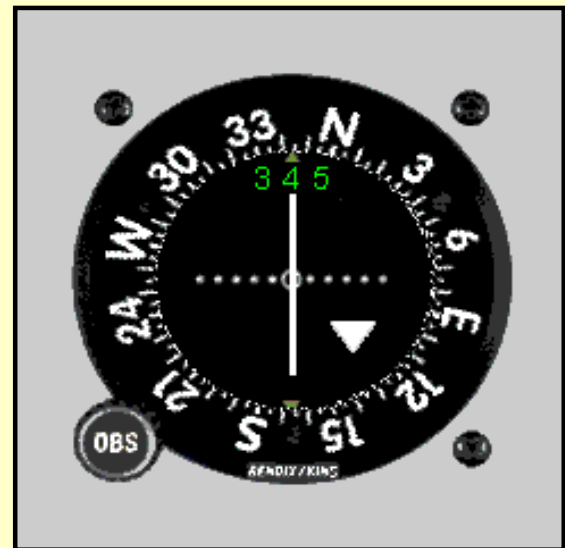
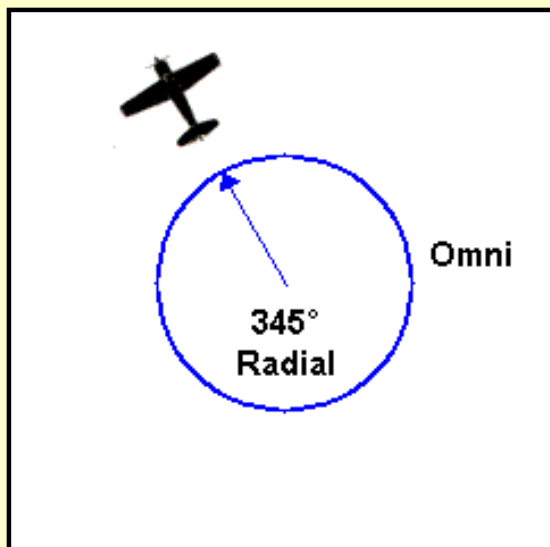
away from the VOR.

Similarly, note the arrows by the 30°, 60°, 90° marks and the rest of the way around the compass rose. They all point away from the station. Radials are *always* away from the station.

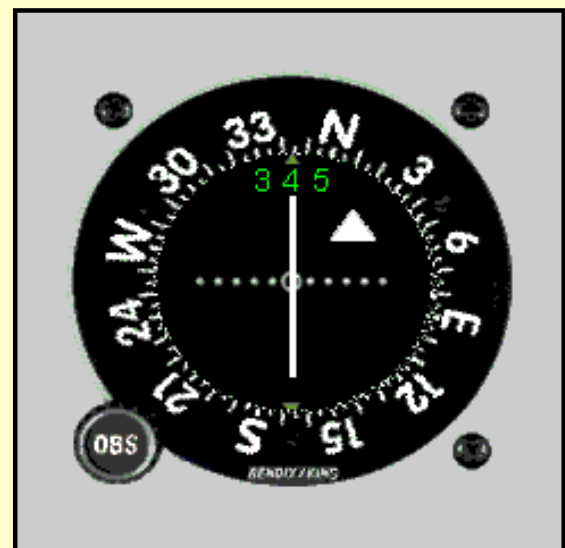
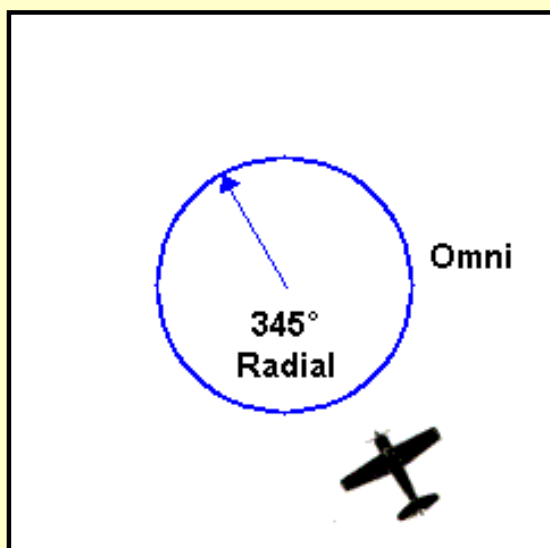
There is only *one* line on the chart for each numbered radial for a particular VOR station. Whether you are flying it outbound or inbound, or crossing it, a radial is always in the same place.

The only possible complication lies in the reciprocity of the numbers. Whenever you are proceeding outbound, your magnetic course (and heading when there is no wind) will be the same number as the radial. Turn around and fly inbound you must mentally reverse the numbers and physically reverse the OBS setting so that your course is now the reciprocal of the radial. But the radial you are flying on hasn't changed.

Some examples will cement this in your mind.



This aircraft is north of the Omni station, flying on the 345° radial away FROM the station. The left-right needle shows the aircraft on course and the FROM flag is present, pointing down, toward the station behind.



This aircraft is south of the Omni station. Its magnetic course is 345°. Walk through the steps below to understand the VOR reading.

1. The aircraft isn't on the 345° radial because that radial extends from the Omni to the northwest as shown by the arrow.
2. The aircraft is actually on the reciprocal radial, the radial pointing towards the plane. That reciprocal radial is 165°, away from the station like all radials.
3. If the 165° radial were set into the VOR, the FROM flag would properly show, because the aircraft is away from the Omni on that radial.
4. Here is the important point. If the OBS is rotated until the needle centers and the FROM flag shows, it will *always* show the correct radial from the Omni that the aircraft is on **regardless of the aircraft heading**.
5. To eliminate the confusion of location relative to an Omni, the magnetic course of the aircraft and the radial setting on the VOR should be the same.
6. Presumably the aircraft is flying in the desired course direction, so its heading will be approximately the same as the VOR setting, i.e., the magnetic course. The heading may differ slightly from the VOR because of the correction needed to correct for wind

drift.

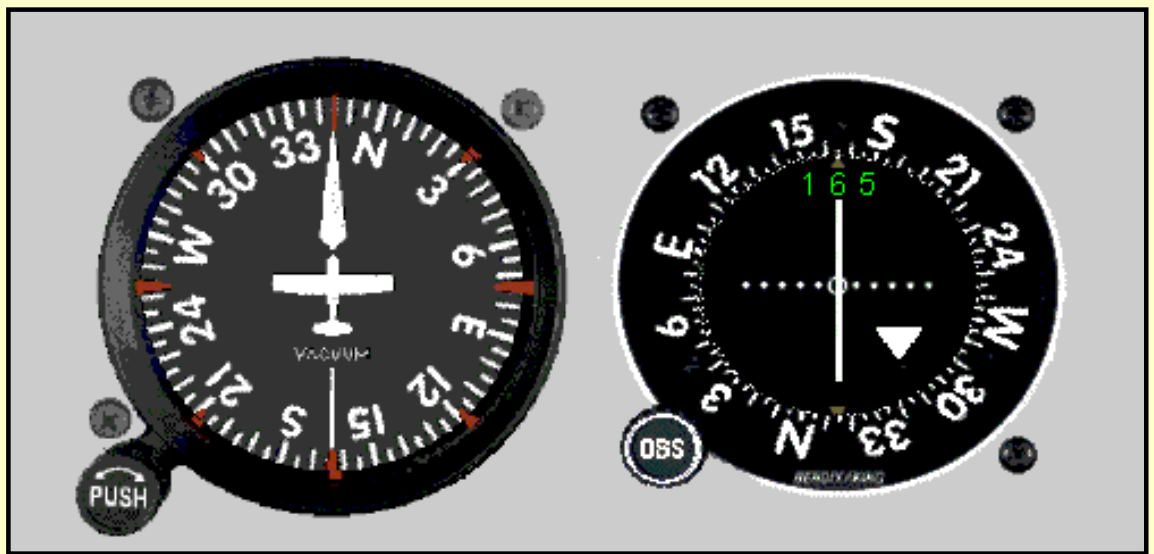
7. Thus, with the OBS set to 345° the left-right needle shows the aircraft on course and the TO flag is showing, pointing up, toward the station ahead.

Experiment with this on your FS98 or FS2K to see the effects of the OBS setting on the TO-FROM flag. Select any Omni, position the aircraft to be flying TO it, then rotate the OBS so that its reading centers the needle and the TO flag appears.

Next, rotate the OBS to the reciprocal of the course. The needle will again center, but the FROM flag will appear.

A one-line recap: to know whether you are flying TO or FROM an Omni, the OBS setting must be approximately the same as the aircraft heading.

Where am I?



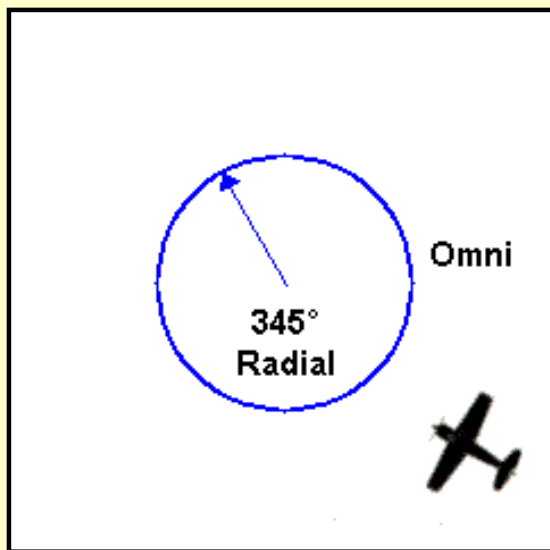
This illustration shows the confusion that can result, yes, that the VOR indicator can actually provide **wrong** information if the OBS isn't set properly.

Same example as before. The aircraft is south of the Omni, on the 165° radial. It is flying northwest. Observe the DG. The aircraft is heading 345° as desired. But the OBS was improperly set to 165° and the VOR is falsely informing the pilot, with a nicely centered needle, that he/she is flying away FROM the Omni. The aircraft, of course, is flying TO the Omni.

Hate to beat a dead horse, but again, the TO-FROM confusion disappears if the aircraft heading and the OBS setting are approximately the same which they weren't here. Pay attention to this and you will stay out of trouble.

This sort of error usually happens when the pilot rotates the OBS, watching only for a centered needle, not also paying attention that the setting should approximate the magnetic course, or aircraft heading.

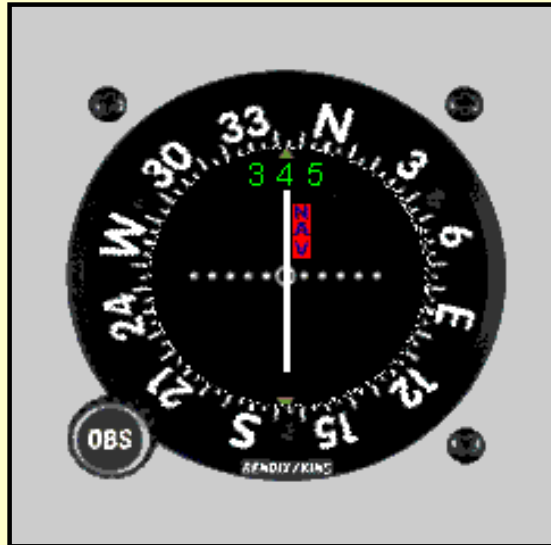
Wandering off course?



This aircraft has drifted off the desired course, to the right. Not paying attention to a crosswind (what other kind is there?), or simply letting the heading wander could do it. In any event, the VOR needle has swung to the left, indicating that the aircraft must turn left to return to course. Like the RMI, with the VOR a pilot *always* turns towards the needle to return to course, assuming that the OBS setting approximates the aircraft heading.

This aircraft is 4° off course. Each dot of the arc under the needle is a 2° deviation from the desired course.

"The needle is centered, my flying is perfect"



Nice thought, but not necessarily. The VOR system operates in the VHF frequency band, from 108.0 to 117.95 MHz. Reception of VHF signals is a line-of-sight situation. Nominally, you must be 1000 ft AGL to pick up an Omni within its maximum low-altitude service range.

The VOR indicator is smart enough to know when a usable signal has not been received and displays an "OFF" flag, a red "NAV" flag in the gauge in this illustration. So when you are flying to or from an Omni station and you're quite content at how stable the CDI needle has been, it's worth taking another glance at the gauge to see if the OFF flag is staring back at

you.

The OFF flag also displays if the Nav receiver is tuned to the wrong frequency or, blush, if it's properly tuned but you neglected to turn on the power switch. If you're taking your check ride with an FAA examiner for a real license, that oversight is likely to get you a quick return to terra firma. And, there's also the possibility of a popped circuit breaker interrupting power to the Nav receiver, a connector jiggled loose, etc.

VOR Range

Ah, the oft asked and seldom answered question: how far away can I pick up a reliable signal from the Omni and what altitude need I be at? The FAA neatly skirts the answer by classifying Omnis by an altitude code, with the ranges vs. altitudes as shown in the table below.

Reception Range vs. Altitude of VORs

VOR Class	Range nm	within Altitude feet
Terminal (T)	25	1000 – 12,000
Low Altitude (L)	40	1000 – 18,000
High Altitude (H)	40	1000 – 14,500
	100	14,500 – 60,000,
	130	18,000 – 45,000

Data is from the *Aeronautical Information Manual*, AIM.

These ranges assume, please contain your laughter, that terrain plays no part in VOR ranges of reception. But terrain, of course, can greatly impact the reliable range of an Omni.

Consider the Bangor VOR, BGR, at Bangor (Maine) Int'l. Airport. Here are the comments in the *Airport/Facility Directory*:

"VOR unusable 342°—063° below 2500 ft."

Pretty significant terrain impact, wouldn't you say? So think of the FAA data in the table as a starting point that may be modified by terrain.

Checking VOR accuracy

The VOR is the most common navigation instrument presently on aircraft panels. We rely on it to accurately track VOR radials, whether flying between Omni stations, or locating intersections, or arriving and departing from airports. We accept at face value that what it displays is accurate. Well, on FS98 and FS2000 it is always accurate. But in the real world, not only can the gauge be wrong, but the FAA requires that a pilot check the VOR for accuracy within 30 days of an IFR flight. Even if a pilot never flies IFR, it is prudent to regularly check the VOR for accuracy.

One acceptable way to formally check VOR accuracy is with a VOR Test Facility, more commonly called a VOT. A VOT is a low-power Omni station located on many of the mid-to-large size airports. A VOT differs from a standard Omni in that it transmits only a single radial, the 360° radial.

To calibrate a VOR, the pilot tunes in the VOT frequency while on the ground (in rare instances this check is performed in the air). Refer to the back of the *Airport/Facility*

Directory for frequencies and whether it is a ground check (G) or an airborne check (A). See the Connecticut illustration below.

CONNECTICUT VOR TEST FACILITIES (VOT)

Facility (Arpt Name)	Freq.	Type VOT	Remarks
Bradley Int'l	111.4	G	
Bridgeport (Sikorsky Mem)	109.25	G	
Groton (Groton–New London)	110.25	G	
Hartford (Hartford–Brainard)	108.2	A	3 nm Radius 1200–5000 ft.

Data is from the Airport/Facility Directory.

Next, rotate the OBS until the to-from needle centers. Read the number from the Omni Bearing Indicator ring or digital display. To be legal, the gauge must be within 4° of either 180° with the TO flag showing or of 0° with the FROM flag showing.

Make note in the illustration above that the VOT at Bradley Int'l. airport is on 111.4 MHz. That information is important later while performing one of the VOR approach practice flights.

It's time to fly—All flights will be on the New York Sectional Chart.

For all flights in this section, select the "Saab-VOR" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ILS-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel. The proper aircraft installation provides six choices of Saab aircraft, each with a different panel.

For VOR work, a Nav-2 and VOR-2 are on the panel as the primary system rather than a Nav-1 and VOR-1. For VOR work I preferred a gauge without a glideslope needle.



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Part II



As a pilot, there are better ways to find the airport.

(Click left-portion of radio face), rotate the OBS until the left-right needle is centered and the TO-FROM flag shows TO. The number that now appears under the OBS index is your course to the station (inbound). It will always be the *reciprocal* of the radial you are on.

Now turn to and fly that heading, applying drift correction as necessary to keep the needle centered, and that's all there is to it.

For all flights in this section, select the "Saab-VOR" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ILS-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel. The proper aircraft installation provides six choices of Saab aircraft, each with a different panel.

Setting the Nav Receiver and VOR

The proper time to tune your Nav receivers is while the aircraft is on the ground. Don't need to be fumbling about after take-off, looking at the Nav receiver or VOR indicator, when you should be concentrating on your climb-out and your turn to the outbound heading. So include tuning the Nav receivers, along with the ADF, in your pre-take-off checklist. That includes setting the OBS to the desired radial.

I've set the Nav Radios, but the TO-FROM flag is still off. What's wrong?

Well, nothing is wrong, actually.

You will encounter five basic problems in the routine use of the VOR:

- Determining a course to take you direct to a VOR.
- Intercepting and tracking radials inbound and outbound from a VOR.
- Identifying an intersection.
- Determining the Wind Correction Angle that will keep you on course.
- Where on earth am I?

You normally will encounter the first case immediately after takeoff. The procedure is simple. After tuning and identifying the station

Microsoft, in their "as real as it gets" approach, doesn't allow a VOR to indicate until the aircraft is 1000 ft or so above the ground, unless the VOR station is located at the departure airport. VORs operate in the VHF band, "line of sight," and therefore their signals can not be received until attaining a certain altitude above the ground.

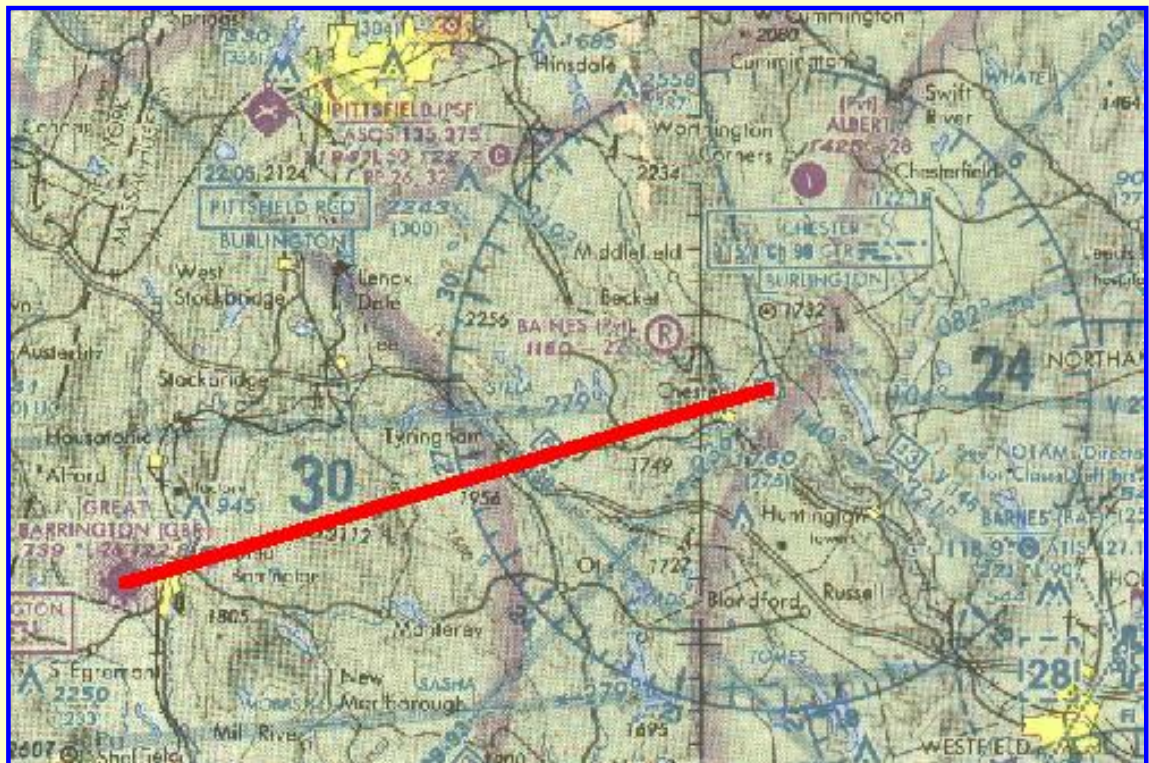
The solution is to turn on the "ident" feature of your Nav receiver, so that you will be able to hear the VOR's Morse-code identification. Take off with everything properly set, and when you hear the Morse ident, or shortly afterward, you have gained sufficient altitude for reliable reception. The VOR's To-From flag should appear. Then, verify by its code that the proper station is tuned, and turn off the ident.

Take note, though, of the published range of the VOR, which FSNavigator displays when the cursor is placed on the VOR. If you're out of range, you won't pick up the VOR signals, and the To-From flags will not appear.

You may also have noted that while on the ground the ADF indicator usually jumps to life when that radio is tuned to the correct frequency, even if the NDB is 25 NM away. That, too, is proper, because the LF radio waves of an NDB propagate differently than VHF, and can be received while the aircraft is on the ground.

Great Barrington Airport to Chester VOR

The first flight will be from Great Barrington, Mass. to the Chester VOR, 21.2 nm distant. Chester VOR is 115.10 MHz. Tune the Nav receiver to the CTR VOR before takeoff and turn on the ident switch to permit hearing the Morse code identifier when the Omni is received (Click left-portion of radio face). Depart from Runway 11 and climb to 5500 ft. After receiving and verifying the ident signal (Click left-portion of radio face) rotate the OBS until the needle centers and the TO-FROM flag is in the TO position. The flag may not appear until a few seconds after hearing the ident.



Great Barrington Airport to Chester VOR. Click image for full size.

Turn to the heading shown on the VOR index card and fly to the station, keeping the needle centered with only an occasional correction of heading, if needed. Don't chase the needle! Monitor the Saab's digital heading readout at the top of the instrument panel to more accurately set and track the radial.

As the aircraft nears the Chester VOR the needle will become more sensitive and may swing farther off center. Continue to resist the urge to chase the needle. Maintain the correct heading until station passage, indicated by the TO-FROM flag switching to the FROM position.

Repeat this flight once more, then reverse to runway 29 for another two flights. Fly this route twice more from Rwy 29, but set in a 24 kt wind from 005° to practice tracking a radial with a crosswind. Follow the same technique of "bracketing" that you used for NDB flights.

Recall that FS98 aircraft "weather-vane" on the runway in the presence of a crosswind, i.e., turn and point into the wind. Either let it happen and takeoff with whatever heading the wind has forced and return to the runway heading immediately on lifting off, or disable the crosswind until the early climb-out and then turn it on.

Cortland County – Chase Field to V423 Outbound from Ithaca VOR

This flight originates at Cortland County – Chase Field, New York. The flight plan requires intercepting the V423 airway outbound from the Ithaca VOR and then continue en route to Syracuse.

If you are unfamiliar with the location of any U.S. airports or navaids, go to www.airnav.com for their coordinates. When at that website select either the "Airports" button or the "Navaids" button at the top of the page and then enter the requested information.



Cortland County Airport to Ithaca VOR, V423 outbound. Click for full size.

For example, Cortland County – Chase Field's coordinates are 42° 36"N and 76° 13"W (rounded). Once you have located the airport, you know that the Navaid will be nearby. But, if you can't find that, either, go again to www.airnav.com for its coordinates.

V423 is an FAA-designated airway. The "V" preceding the airway number signifies that it is a VOR airway connecting two or more Omni stations. Examine the chart and note that V423 is 026° outbound from the Ithaca VOR. If you had the actual N.Y. Sectional chart you would note that this segment of V423 runs 41 nm from the Ithaca VOR Northeast to the Syracuse VOR.

Might as well finish up the real flight planning of this route segment. Let's check the Ithaca VOR for any limitations. Again, go to www.airnav.com, select the "Nav aids" button at the top, and enter ITH into the blank box. Scroll down the next page until the Remarks section appears.

Woah! Here we go again. Another VOR with terrain problems. The remarks state:

VOR portion unusable 360-059 BYD 10 nm BLO 3800'; 060-080 BYD 28 nm BLO 2500'; 081-150 BYD 10 nm BLO 3800'.

That shorthand is pretty easy, but here it is in plain English:

VOR is unusable from 360°–059° beyond 10 nm below 3800 ft.; from 060°–080° beyond 28 nm below 2500 ft.; and from 081°–150° beyond 10 nm below 3800 ft..

You will also note that limitations exist on the DME (Distance Measuring Equipment)

performance.

The significant piece of information for us in the remarks section of the Ithaca VOR is that the VOR is unusable from 360°–059° beyond 10 nm below 3800 ft. That segment exactly overlays our intended flight path to intercept V423. Not a problem as long as we are aware of it.

The procedure to intercept an *outbound* radial is:

1. Before takeoff, set the Nav receiver to the appropriate VOR frequency.
2. Similarly while still on the ground, set the OBS to the radial intended to intercept.
3. On takeoff, turn to the heading set into the VOR. Since we are intercepting an outbound radial, the heading and the OBS setting should match.
4. The TO-FROM indicator should settle on FROM. If it doesn't then continue on the OBS heading until the FROM flag appears. Be aware that the TO-FROM flags won't appear until reaching the minimum reception altitude.
5. Where are you in relation to the desired intercept radial? The CDI, left-right needle, will tell you. If the needle is centered, with a FROM flag, you are already dead-center on course. Rather unlikely, though.
6. If the needle is to the left, turn left to intercept the radial. The amount of turn depends on how much needle deflection is showing. A large needle deflection warrants a large intercept angle, perhaps 30°. A small needle deflection requires a more modest interception angle.
7. A needle deflection to the right requires right turns to intercept.
8. Once intercepting the radial, return to the OBS heading and check for any wind correction needed to properly track the radial outbound.

This flight departs from Cortland County Chase Field, Runway 24. Set the Nav receiver to the Ithaca VOR, 111.80 MHz., and the OBS to 026°.

Cortland County uses a left traffic pattern. Intercept V423 outbound—the 026° radial—from the Ithaca VOR. Remember that although you receive apparently normal VOR signals and the FROM flag appears normal, the readings cannot be judged reliable until at an altitude of 3800 ft. or above.

After intercepting V423 continue en route for at least ten minutes confident that you are properly maintaining track. With the northeasterly heading, the flight altitude should be 5500 ft.

If desired, fly to and land at the Syracuse Hancock Int'l airport. As you near the Syracuse VOR, change the Nav receiver frequency to 117.0 MHz. and track inbound, remaining on V423. Hancock's Rwy 14 is 5.2 nm from the SYR VOR on the 136° outbound radial. Field elevation is 421 ft. Syracuse is a controlled field and you will be cleared for a straight-in approach to Rwy 14.

Repeat this outbound intercept flight two more times.

Then fly the route another two times after setting in an 18 kt. wind from 090°.

Enjoy the flights.

Harriman and West Airport to Albany VOR, 097° inbound

This flight will intercept and track a VOR radial inbound to station. The procedure is nearly identical to intercepting and tracking a radial outbound from a VOR. The difference lies in some quick preliminary mathematics.

When you are tracking a radial inbound to a station, you are actually flying in the opposite direction of the radial. Remember, all radials are outbound from a VOR. Suppose that you must track inbound on the 073° radial of the Busybody VOR. Since the 073° radial is outbound from the station and you are flying inbound, you must determine the reciprocal of the radial to properly set the OBS on the VOR indicator.

The reciprocal, of course, differs from the radial by 180°. Don't reach for your calculator to determine a reciprocal. Use the 200–20 method. With this method, you'll accurately determine the radial in less time than it takes to pick up your calculator and turn it on.

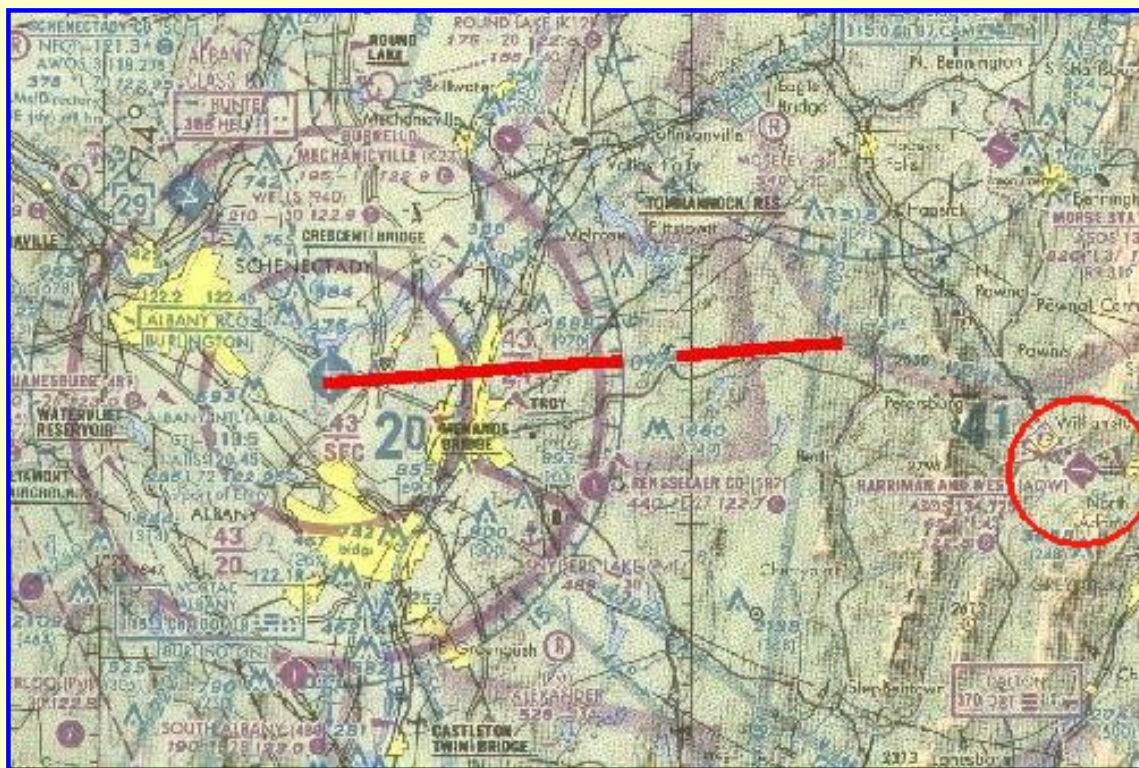
You either add 200 then subtract 20 or subtract 200 then add 20. Two examples will show you how easy this is.

Let's go back to tracking inbound to the Busybody VOR on the 073° radial. Add 200, we have 273°. Subtract 20 we have 253°—which is the reciprocal.

In that case we added 200 then subtracted 20. It can't be the other way around, subtract 200 and add 20, because the answer is impossible. Consider: subtract 200 from 073°, we have –127°. Add 20 brings this to –107°, an impossible answer since it's negative.

The second example, track inbound on the 345° radial. First, subtract 200 which gives 145°, then add 20 which gives 165°—the reciprocal, fast and accurate.

Now the flight.



Harriman and West Airport to Albany VOR, 097° inbound. Click for full size.

The flight begins on Rwy 29 of Harriman and West airport in North Adams, Mass. After takeoff, exit the left traffic pattern and intercept the 097° radial of the Albany VOR. Track inbound to Albany Int'l airport and land on Rwy 28.

Go to www.airnav.com to see if there is anything that we should be aware of regarding the Harriman airport, Albany Int'l, or the Albany VOR.

The remarks for the Harriman airport warn us of mountain ranges nearby:

Mountain ranges 9100 ft. north at elev. 1894 ft.; 4300 ft. north at elev. 2254 ft.; 10,800 ft. south at elev. 2951 ft., and 12,800 ft. south at elev. 2690 ft.

Well, that's certainly worth knowing. We better not stray too far north or south of Harriman until we gain some altitude. Harriman's field elevation is 654 ft.

Information on Albany Int'l airport is also interesting. Besides obtaining the field elevation of 285 ft., we learn that deer and birds can either be on or in the vicinity of the field. We'll have to keep a watch out for that when landing.

From the same website we learn that the Albany VOR suffers usability limitations for many segments. The one that concerns us most is:

... from 100° – 135° beyond 8 nm below 10,000 ft.

Well, we will be tracking inbound on the 097° radial, only 3° removed from the segment that is unusable beyond 8 nm below 10,000 ft. Best that we pay attention to our track since we won't be at 10,000 ft. altitude. We infer from that that there is a mountain range 8 nm distant

from the VOR in that segment.

Armed with this information, we're ready to start our flight from Harriman and West airport. Set the Nav receiver to 115.3 MHz. and rotate the OBS to 277° , the reciprocal of the 097° radial. Start the takeoff roll and remain vigilant of the surrounding mountain ranges while climbing out after lift off.

Intercept Albany's 097° radial using the same techniques as intercepting an outbound radial except for the presence of the TO flag. The westbound flight will be at 6,500 ft. You will be cleared for a straight-in approach to Albany's runway 28. Enjoy a cup of coffee in the pilot's lounge on the completion of the flight.

Repeat this flight one more time, then fly it again with a 33 kt. wind from 350° .

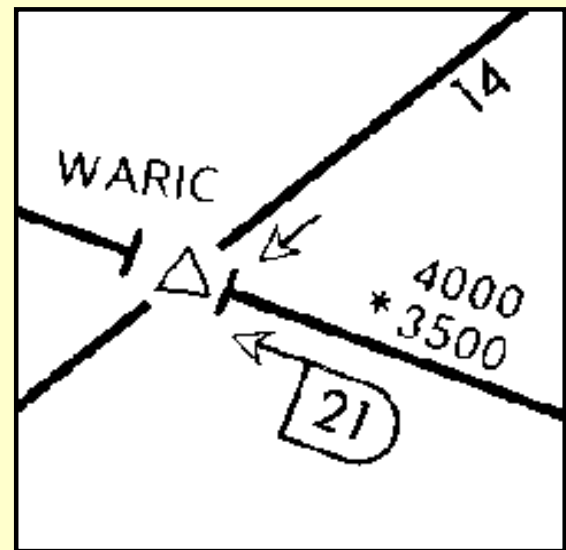
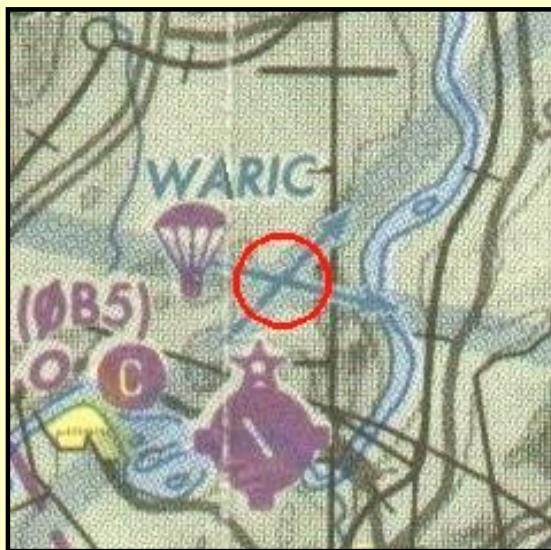
Reporting an Intersection

An intersection is the point where two or more designated VOR radials cross. Sometimes the combination of a VOR radial and a specified distance along that radial defines an intersection. There is no ambiguity on an intersection location. Intersections are often named, but not always.

Performing some action at an intersection is a commonplace piloting event. It may be a shift in course along a Victor airway, a point of departure to begin an instrument approach, or it could simply be a required or requested position to report to ATC.

Intersections are identified on both Sectional charts and IFR enroute charts. The illustration below shows the difference in presentation of intersections on those charts, with WARIC intersection the example.

The intersection of the 298° radial from the Gardner VOR and the 238° radial from the Keene VOR defines the WARIC intersection.



Named intersections, for example WARIC in the left illustration, are identified on Sectional charts by two (or more) crossed arrows pointing *towards* the VORs that form the reference

for that intersection. The parachute symbol here has nothing to do with the intersection; it pertains to nearby Turners Falls airport and cautions of that activity in the area.

The right-hand illustration shows the format for an intersection on an IFR enroute chart. A triangle denotes an intersection. Note also that the two arrows point *away* from the VORs. The "21" in the box is the distance, in nm., from the Gardner VOR. That box signifies that the intersection may also be established by the 238° radial from the VOR plus a DME (Distance Measuring Equipment) fix at 21 nm.

The "14" in the upper right designates the 14 nm. distance between WARIC and the Keene VOR. The *3500 denotes the minimum obstruction clearance altitude, MOCA, and the 4000 denotes the minimum en route altitude, MEA.

Assume that you are flying outbound from Gardner VOR on the 298° radial. ATC has requested that you report arrival at the WARIC intersection for further clearance. If your aircraft has two Nav receivers, tune Nav-1 to Gardner VOR, 110.6 MHz. Set the OBS to 298°. Tune Nav-2 to the Keene VOR, 109.4 MHz., and set that OBS to 238°.

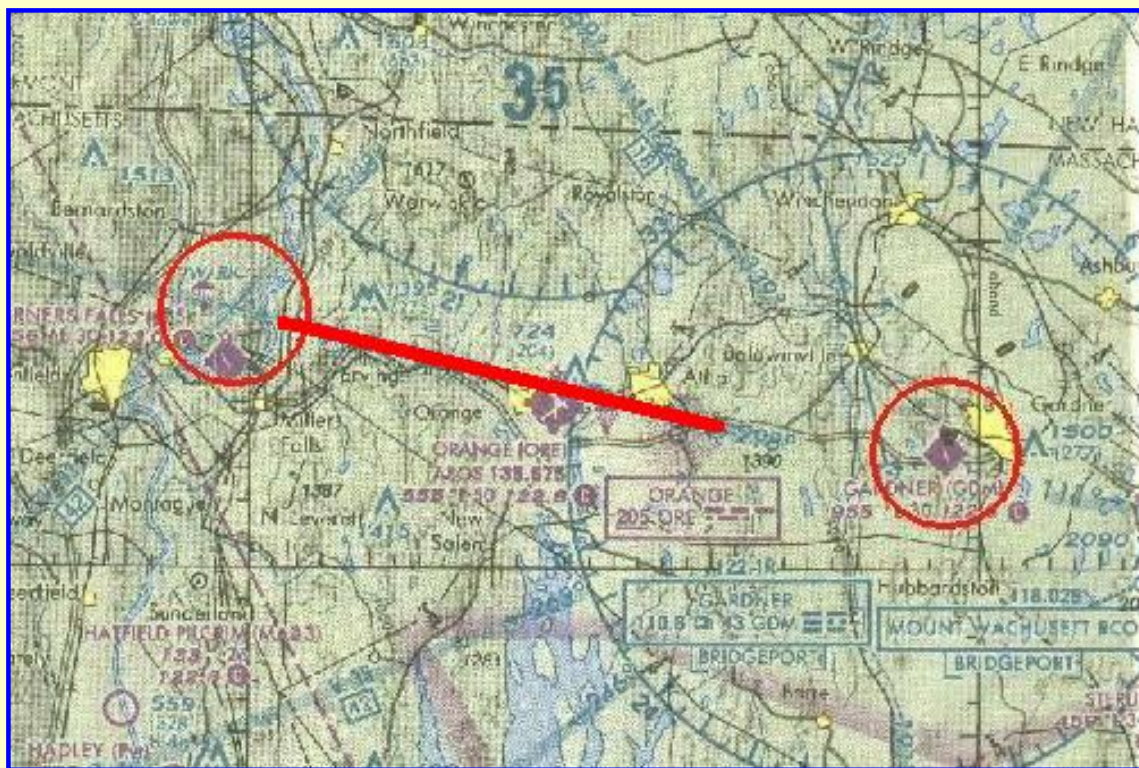
Flying outbound from Gardner, heading 298°; when the needle on Nav-2 centers, you have arrived at the WARIC intersection. Both VOR indicators will display FROM flags.

How do you know whether you have passed an intersection before you set up the two Navs? It's easy. When the "side" radial is set in the OBS, you have not arrived at the intersection as long as the needle is deflected *toward the station*, or to the right in this case.

If you had tuned in Keene VOR, set the OBS to 238° and the needle deflected left, you've already passed WARIC, and you better let ATC know it fast.

Only have one Nav receiver? All of the above still works, just takes a little more fiddling. After you are outbound from Gardner and are comfortable that you are accurately tracking the 298° radial, switch on the autopilot and activate the heading hold function. Now retune the Nav for the Keene VOR, reset the OBS to 238°, and monitor the CDI needle. It's worth a quick look back to the Gardner VOR on occasion to be certain that you are accurately tracking outbound on the 298° radial. Don't dwell there else you may pass the intersection.

Now the flight



Gardner Muni Airport to WARIC Intersection. Click for full size.

You have been cleared to depart Gardner, Mass. Muni Airport, Runway 18. Intercept V2 westbound, the 298° radial of Gardner VOR. Report WARIC intersection for further clearance.

Before departure, set Nav-1 to Gardner VOR, 110.6 MHz., and set the OBS to 298°. This will be a single-receiver navigation problem. WARIC intersection is the 238° radial of Keene VOR, 109.4 MHz.

Gardner field elevation is 955 ft., left traffic. ATC has cleared you to 6000 ft.

Repeat the flight with a Runway 36 departure from Gardner. On reaching WARIC intersection you are cleared to intercept V93 inbound to the Keene VOR on the 238° radial. Reduce altitude to 5000 feet for the leg to Keene. Continue and land at Dillant-Hopkins Airport, Keene, N.H., elev. 485 ft. You are cleared for a straight-in approach on Runway 2, 5.3 nm. from Keene VOR on the 022° radial outbound.

Determining the Wind Correction Angle that will keep you on course

This section will be a review for those who diligently worked the NDB portion of this tutorial. This is the situation that you will use most frequently if you set a wind in your flight simulator for your flying challenges: figuring out the proper Wind Correction Angle, WCA, or "bracketing the course."

If you always take immediate corrective action when you notice the left-right needle drifting off center, you'll never get off course far enough to need bracketing; but a sharp turn over the VOR or vectors to a new radial where the wind effect is unknown, may find you chasing a CDI that's off scale.

The first thing to do is to turn 30° towards the radial and wait for the needle to center. For example, in the last flight with a runway 36 departure from Gardner Muni Airport, turn left after exiting the traffic pattern to intercept the 298° radial. Since we want to intercept quickly, establish a 30° intercept angle with a heading of 268° and then track the 298° radial when the needle centers. With a crosswind, you'll soon notice that the CDI is drifting off center.

Assume the wind has blown you to the left of course—the needle is to the right of center. Here is the procedure for the example flight from Gardner to determine the Wind Correction Angle to accurately track the 0298° radial.

1. Begin the bracketing procedure with a turn to 328° , which is the 298° desired track plus a 30° first-try bracket correction.
2. This should move the needle back to center. Since it moved the CDI back to center, you now know the WCA bracket: 30° is too much and 0° is not enough.
3. Try something in between, so with the needle centered, cut the wind correction in half—to 15° . Your heading should now be $298^\circ + 15^\circ$, or 313° .
4. Evaluate the effect of the 15° WCA. Depending on whether the plane still drifts away from the radial, add more correction; if it drifts toward the radial, decrease the WCA.
5. Continue this cut-and-try process until the CDI stays nailed dead-on in the center.
6. The procedure sounds complicated, but is very intuitive. Do it a few times and it becomes second nature.

Click on the *VOR Navigation - Part III* button for more VOR procedures.



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Part III

Benjamin Counter returns



Franklin Pierce
14th U.S. President

I was enjoying a fine meal at *Ashford by the Sea* in Hampton, N.H. The Boss had told me to have a good dinner during my layover in coastal New Hampshire. "The tab's on me," he said.

My cellphone rumbled. I glanced about at the nearby diners all of whom had grown silent at the sight of my cellphone. "Yes?" I whispered into the mouthpiece.

"I want to get to Concord first thing in the morning," the voice boomed from the other end. It was Counter.

In the past he called the Boss when he wanted to charter. Then he got my home-phone number and called me direct. The Boss had told me to accommodate Counter whenever it was feasible. He'd bill him later. Now Counter had my cell number. What was next?

"Concord?" I asked rather foolishly.

"Yeah, I'm at Pease Int'l. Tradeport in Portsmouth and saw your plane parked by the General Aviation terminal. I have to get to Concord to thank President Franklin Pierce," he answered.

That really set me back. Pierce, our 14th President, had died in 1869. "I don't believe he'll be able to see you," I wise-cracked.

"Don't be funny," Counter rejoined. "Eight-A.M. at the airport," and he hung up.

What did Counter have in common with Pierce, I wondered? A quick look on the Internet later was of little help. A Democrat and our most obscure President, Pierce was from Concord, N.H. Did Counter hate lawyers? Pierce was oft quoted from his inaugural speech, "In a body [like Congress] where there are more than one hundred talking lawyers, you can make no calculation upon the termination of any debate."

No, there had to be something more. Then it started to come to me. Pierce was a 'Northerner with Southern principles.' He favored slavery which so angered his followers that many broke away and formed the Republican Party. Counter wanted to thank him for his contribution to the formation of the Republican Party.

Pierce's popularity wasn't helped by the Whig opposition's campaign rhetoric: "Hero of many a well-fought *bottle*."

I set my alarm and went to bed.

The Flight

For all flights in this section, select the "Saab-VOR" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ILS-ADF" does not appear on your aircraft list, return to the "[What you need/Aircraft](#)" section to download and install the Saab MFI-17 file with the modified panel. The proper aircraft installation provides six choices of Saab aircraft, each with a different panel.

Your flight is from Pease Int'l Tradeport, Portsmouth, N.H. to Concord (N.H.) Muni Airport. A strong cold front came through a few hours ago, leaving crystal-clear skies and a very strong wind of 28 kts. from 350°. You will depart from Runway 34, intercept the Concord 119° radial and land at Concord on Runway 35. The distance between the two cities is 31 nm. Pease field elev. is 98 ft., and Concord is at 344 ft. Cruise at 4500 ft.

Before departure, set your Nav receiver to 112.90 MHz, and the OBS to 299°—the reciprocal of Concord's 119° radial.



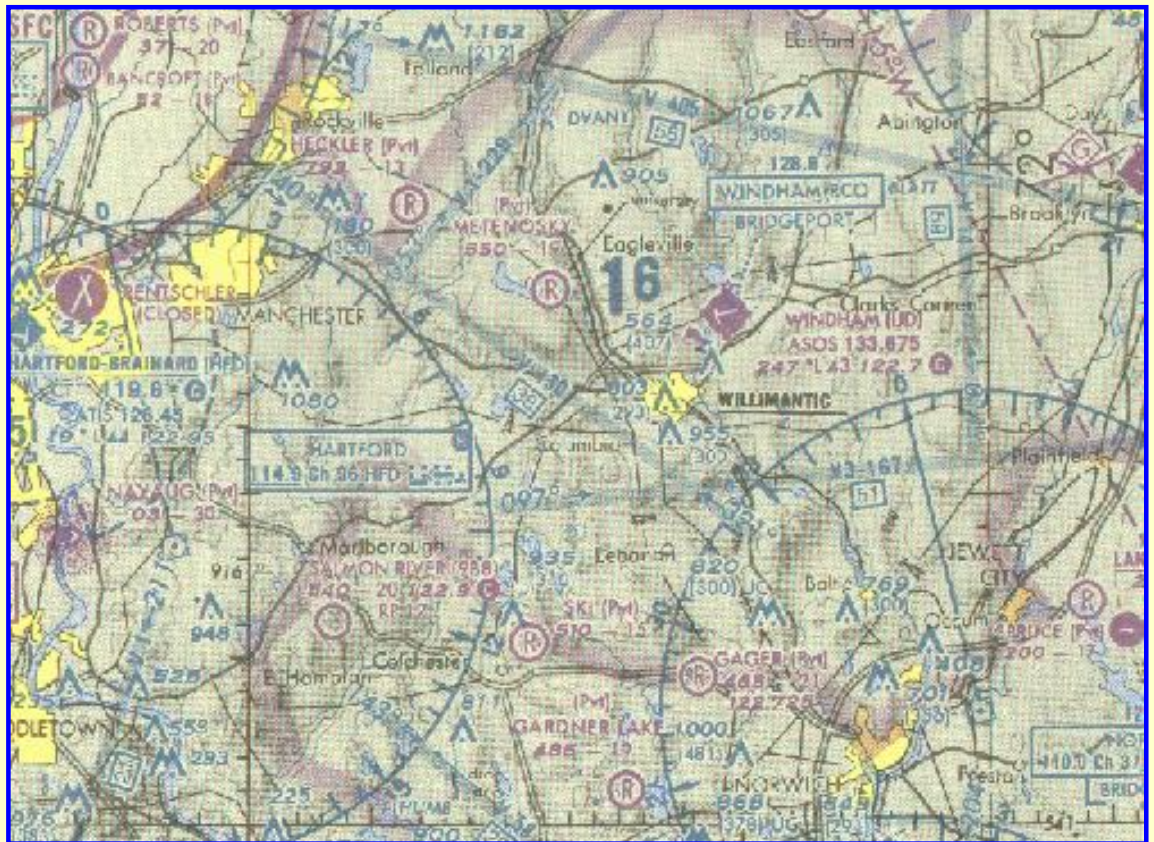
Pease to Concord. Click image for full size.

Where am I?

With the plethora of Nav aids dotting the landscape these days, it's getting harder and harder

to get lost. But we pilots are an ingenious lot. No matter how closely the FAA, or its equivalent in other countries, spaces Navaids to protect us against ourselves, we continue to outwit them. We don't get lost, of course. Pilots simply don't get lost—it's just that none of the landmarks within the range of our vision happen to be on our chart. We certainly intend to talk to the authorities about these poorly-marked charts once we land, that is if we can find the correct airport—or any airport.

There is hope. With a VOR receiver fixing one's location takes only moments.



We're somewhere on this section of the chart. Click image for full size.

We locate our position by triangulation. We'll use the Hartford, HFD, 114.9 MHz VOR to the west and the Norwich, ORW, 110.0 MHz VOR to the east as our reference points.

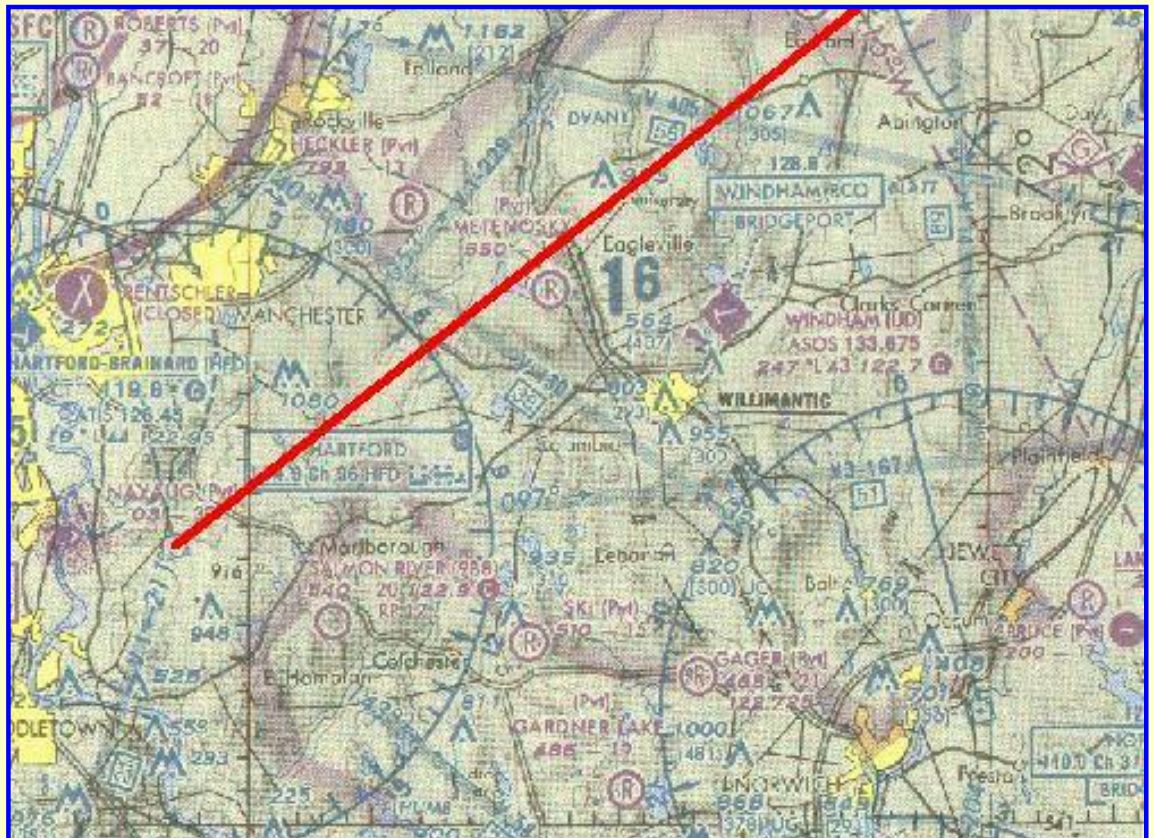
Select either HFD or ORW as your first reference, it makes no difference. We'll use Hartford.



The Nav receiver is set to the HFD VOR, 114.9 MHz, the ident switch is on (Click left-portion of radio face), and we've rotated the OBS until the needle is centered with the FROM flag showing. The index card shows that we are on the 065° radial from HFD. Remember, the aircraft heading does not affect determining the radial from a VOR if you center the needle with the FROM flag showing.

You can prove this to yourself on FS98 or FS2000. Position your aircraft within receiving range of any VOR, but not too close, then determine the radial from the VOR by centering the needle with the FROM flag showing, and then fly the aircraft in any heading, observing that the needle doesn't significantly change other than the normal movement from crossing radials.

With this information, we'll draw the 065° radial from HFD on the chart.



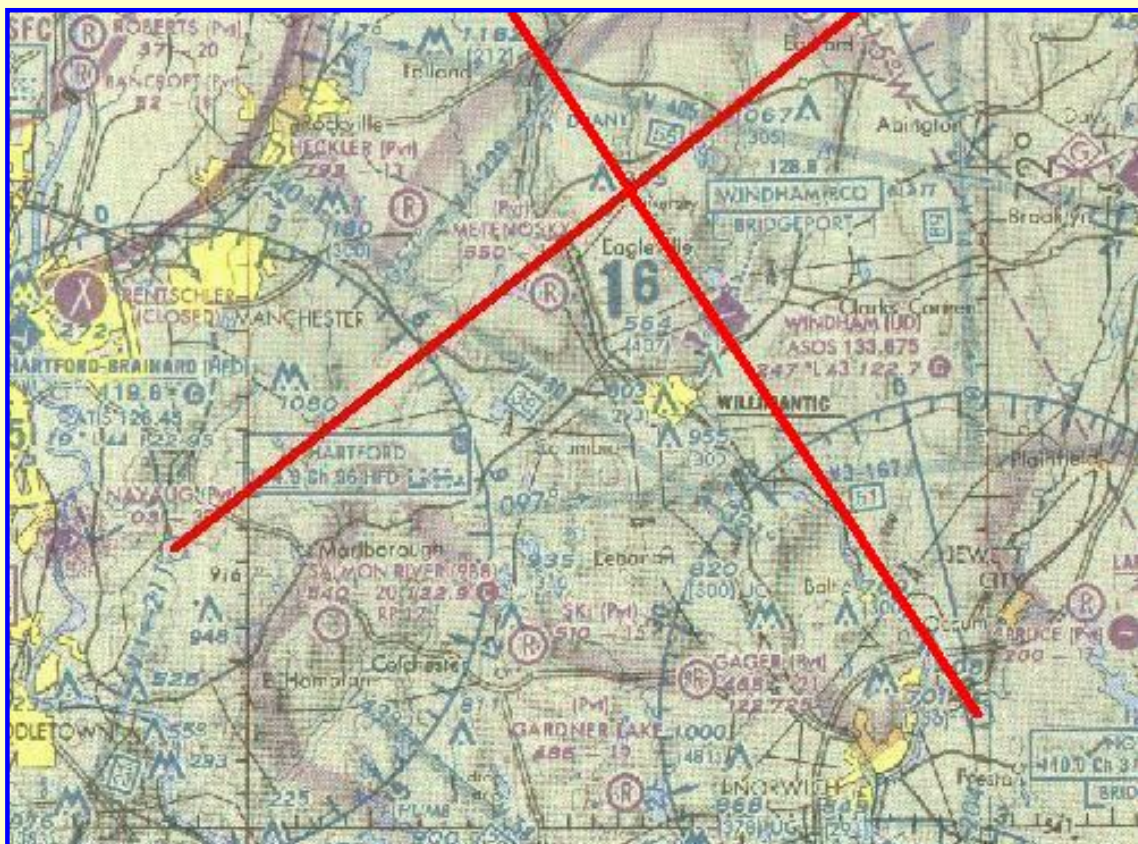
We're somewhere on the 065° radial of HFD. Click image for full size.

Now repeat the procedure using the Norwich VOR.



The Nav receiver is set to the ORW VOR, 110.0 MHz, the ident switch is on (Click left-portion of radio face), and we've rotated the OBS until the needle is centered with the FROM flag showing. The index card shows that we are on the 340° radial from ORW.

With this information, we'll draw the 340° radial from ORW on the chart.

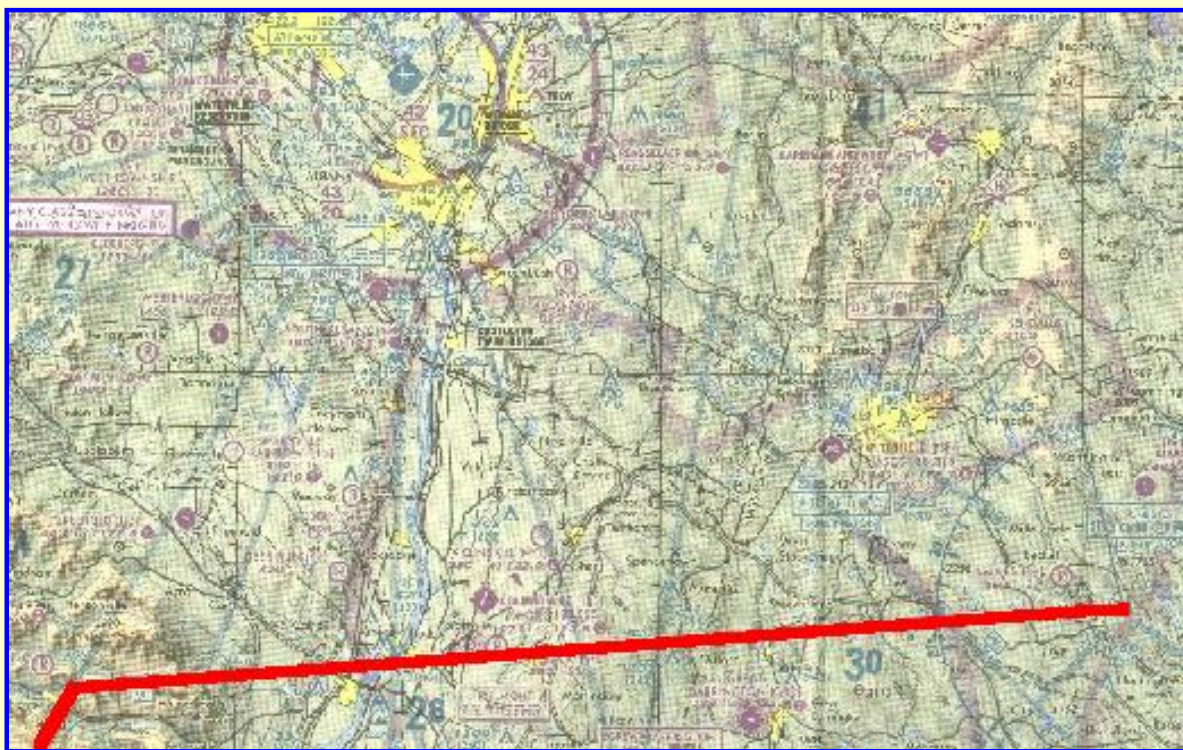


See, Pilots don't get lost—we're at the intersection of the two radials.
Click on the image for full size.

Important Note: One obtains the greatest position accuracy when the angle between the two reference VORs is 90° . In this case, the angle is 085° ($065^\circ - 340^\circ$ which becomes $065^\circ + 20^\circ$).

Where am I on the Airway?

The procedures just described are useful if a pilot becomes disoriented or lost, but hopefully that is a very infrequent experience. A much more common situation is the desire to locate your position along a Victor airway when it is a long distance between VORs or to an intersection. This is especially true when flying IFR and ground features are not visible.

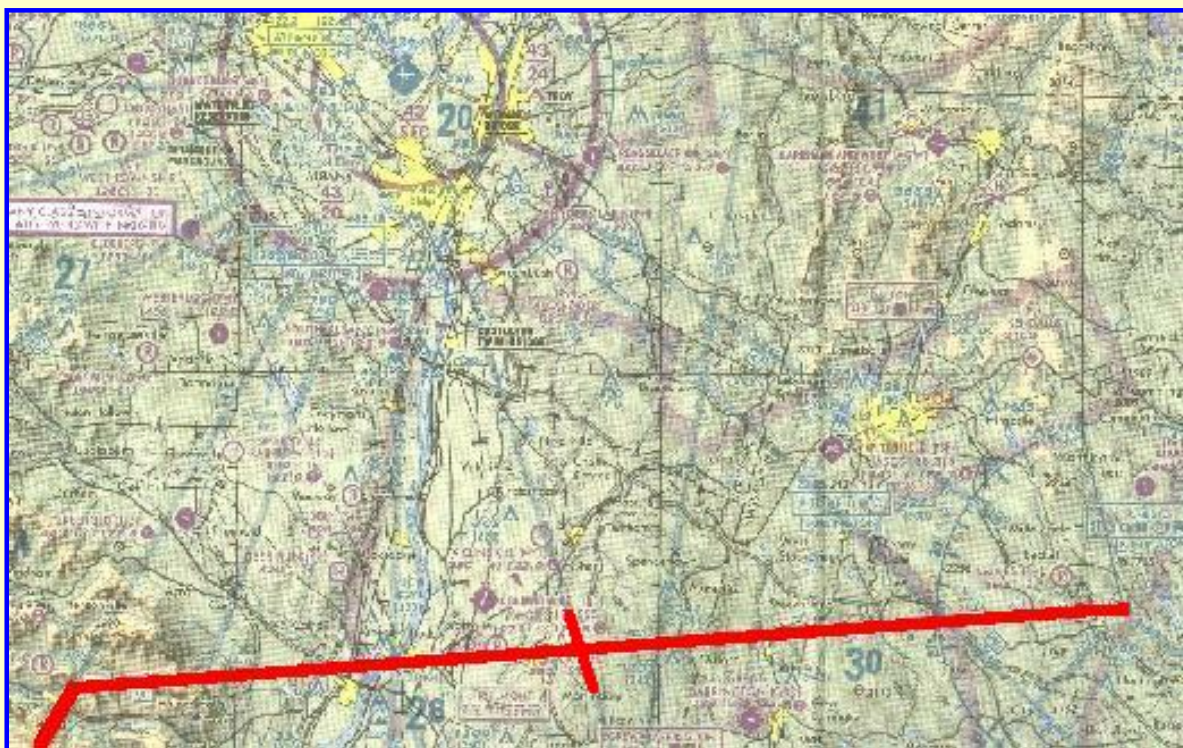


Route of flight, V270 to V489. Click image for full size.

Assume that your route of flight takes you westward from Chester VOR (279° , CTR, 115.1) via V270 to AGNEZ intersection (222° , ALB, 115.3) where you turn south on V489. It is 56 nm from Chester to AGNEZ. Flying time in the MFI-17 with a 125 kt cruise is about 27 minutes from station passage to that intersection. Monitoring progress along a long, straight flight path provides an excellent opportunity to determine your ground speed and the head- or tail-wind component.



The Nav receiver is tuned to Albany VOR, 115.3, ident switch is on (Click left-portion of radio face), and the needle has been centered on the 175° radial from ALB. Since we are flying on V270 we needn't draw the full radial down from Albany VOR—just a tick mark where it crosses our flight path will show where we are.



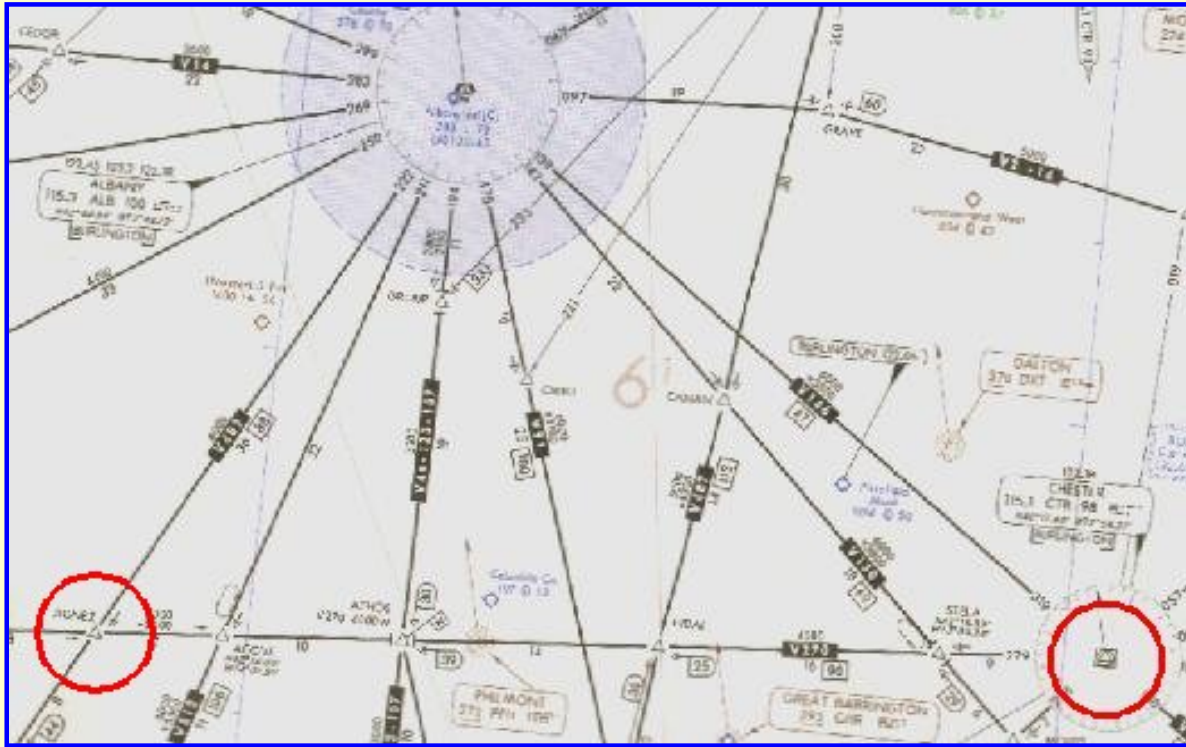
There we are, at the intersection of the two radials. Click image for full size.

IFR charts are useful for more than just IFR flights. Consider the Chester to AGNEZ route via V270 on chart L-25. Notice how many intersections there are along the route. These are convenient checkpoints during a flight. The radials are already printed on the chart, it's simply a matter of tuning in Albany VOR on 115.3 MHz, and setting the OBS for the appropriate radial, making certain that the FROM flag is showing. Then you can map your progress along V270 from Chester to AGNEZ intersection, at which point the flight plan requires a left turn to intercept V489.

There's even an NDB immediately on the flight path so that's one more checkpoint of your

progress. Just tune the ADF to 272 KHz, Philmont, PFH and note station passage.

Your next flight will be Chester to AGNEZ. For simplicity, fly it with the IFR chart. [Click here](#) to download the 300 dpi file of the section of the IFR chart needed for the flight. Unzip it and print it full size with the minimum margins that your printer allows.



IFR chart showing V270, Chester to AGNEZ. Click image for full size.

The flight will begin at Barnes Muni Airport in Westfield, Mass., 13 nm southeast of Chester VOR. Intersections will be from Albany VOR, 115.3 MHz.

1. Set wind into FS98/FS2K of 30 kts from 150°.
2. Using electronic E6-B, calculate WCA for this wind, cruise at 125 kts, course; 279°.
3. Tune Nav to Chester VOR, 115.1 MHz.
4. Take-off will be from Runway 15, left turn, direct to Chester VOR. Reset timer.
5. Climb to 6000 ft.
6. At Chester, intercept V270 westbound. Start Timer.
7. Apply calculated Wind Correction Angle.
8. Cruise at 125 kts IAS.
9. Log the time when passing the following intersections:
 - o STELA
 - o ATHOS
 - o ACOVE
 - o AGNEZ
10. Terminate flight after passing AGNEZ—Stop Timer.
11. Calculate Average Ground Speed from Chester VOR to AGNEZ Int. (56 nm)

Benjamin Counter's unlikely friend



**Biltmore Hotel,
Providence, R.I.**

This was the highlight of the year, the annual convention of the New England chapter of the Charter Pilots of America. It was at the Biltmore, Providence, Rhode Island's grand dame of hotels. The Boss grudgingly gave me the time off—not because he wanted to, but to keep his pilots current on the latest regulations and procedures emanating from Washington.

The convention was nearing its end after two days of updates and seminars on issues affecting charter pilots. Tonight's formal dinner-dance nicely capped everything off. I was in my hotel room struggling with my bow tie—real, not clip-on, when a knock sounded on the door. I glanced at my watch, congratulating myself on knowing the perfect corsage arrangement to compliment my companion's gown.

I called to the delivery person to bring in the flowers and froze when an all-too familiar voice boomed

"Good evening!"

It was Counter.

"I see we're just in time," he went on before I could utter a word.

"We are?" I said in amazement.

"Yes," Counter replied, a broad grin on his face. "You won't need the bow tie or the monkey suit—we have to leave in forty-five minutes to get to the meeting on time."

"I have other plans tonight," I said, returning to the task of tying my bow tie.

"The Boss said you might say some nonsense like that—told me to tell you to call him if you had any problem doing the charter. Said something about seminars being a waste of time and money, anyway" Counter finished.

"Where we going?"

"Worcester—they're doin a special memorial on a classmate of mine—Abbie Hoffman."

I was stunned. "*The* Abbie Hoffman," I asked, "of the Chicago Seven?"

"Yes, of course," Counter replied, confused that I would ask. "Is there another?"

I looked at Counter again. Yeah, he was about the right age.

Abbie Hoffman, the leader of the Yippies, Youth International Party, organized the nation's youth through media stunts. He had been in Chicago to disrupt the 1968 Democratic

Convention in protest of the Vietnam War. Among other things, he had pledged to spike the entire city's water supply with LSD. It was technically an impossible feat, but nonetheless the city surrounded the reservoir with armed guards.

The anti-war demonstrations became violent and Hoffman, with other leaders, was arrested, leading to the famous Chicago Seven trial. He went underground but ultimately was imprisoned. Following his release he became increasingly unstable and committed suicide in 1989.

I looked at Counter again, wondering what this business leader could have in common with Abbie Hoffman. Because of all of the acid and drugs that had been done during those years the Hippies' famous underground slogan came back to me:

*If you can remember the 60's,
you weren't really there!*

I glanced at my watch again. Leaving now, I could still be back in time for dessert and the dance. "I have a phone call to make and we'll go," I said, reaching for the phone.

The Flight

This flight, from Quonset State Airport in North Kingstown, R.I. to Worcester, Mass., puts everything together learned so far on VOR navigation. Your cruise speed will be 125 kts, and climb and descend at 90 kts. Total distance is 55 nm. It's a fun flight because you stay busy. Here are the details:



Quonset to Worcester (chart is turned 90°). Click image for full size.

[Click here](#) to download the 300 dpi file of that part of the IFR chart needed for the flight. Unzip it and print it with one-inch (2.54 cm) printer margins.

1. Departure is from Rwy 34, Quonset State Airport, just south of Providence.
2. Fly inbound to PVD, 115.6 MHz, climbing to 4000 ft.
Distance = 7 nm.
3. At PVD intercept V146 NW, fly the 321° radial inbound to PUT, 117.4 MHz.
Distance = 23 nm.
4. At PUT turn NE, fly the 029° radial outbound, to the GOZZR Intersection.
Distance = 19 nm.
5. During the PUT to GOZZR leg, descend to 3000 ft, but no lower.
6. Turn left at GOZZR intersection and intercept the Rwy 29 localizer, 110.9 MHz, to Worcester Regional Airport. When tuned to a localizer frequency the left-right needle is four times as sensitive as when tracking a VOR, i.e., 0.5° per dot.
7. Also note that when tuned to a localizer, the OBS is inoperative. Smart pilots rotate the OBS to the localizer heading (in this case 289°) as a visual reminder of their magnetic course after intercepting the localizer. This makes them aware of the intercept angle and how early to begin the turn towards the final heading.
8. Track the localizer inbound, descending and landing on Rwy 29. Be alert, Worcester field elevation is 1009 ft.
Distance = 6 nm.

Flight Log

From this flight on, you should complete a Flight Log prior to starting any flight. It requires that you first complete the worksheet described earlier in the "Plotting a Course" section under Air Navigation.

Calculate the Ground Speed and time en route for each leg of this flight. For this first flight, there is no wind, so the Ground Speed will be the same as the TAS, True Air Speed.

Then complete the Flight Log. [Click here](#) to view and print blank flightlog sheets.

[Click here](#) to view and print (if desired) a partially completed flightlog sheet for this flight, with a 30 kt wind from 290° , which you will set in for the next flight.

After flying the route, set a 30 kt wind from 290° into your Flight Simulator. Recalculate the Ground Speed, the Wind Correction Angle and the time en route for each leg. Use the virtual E6-B for these calculations.

Note that the magnetic course is already determined for this flight because it is the to or from radial of the respective VOR. To convert this to True Course, subtract the 14° westerly variation from the magnetic courses.

Now re-fly the course. Do it without using the autopilot and enjoy the challenge.

Click on the *VOR Approaches* button to get into the soup and see if you can find the runway at your destination.



[Click here to comment.](#)

Site best viewed at 600 × 800 resolution.

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VOR Approaches

Part I



In aviation, a lack of planning can often result in undesirable consequences.

As the name implies, VOR approaches are approach procedures which use VORs as the primary navigational aid. This section is the first of two that describes VOR instrument approaches. First will be approaches where the VOR is located away from the airport and Part II covers approaches where the VOR is located on the field. This is the same classification system that was used with the NDB approaches that you studied earlier.

Variations of each fundamental type of VOR approach are described and you will fly them all. Seven practice flights cover the most commonly encountered VOR approaches.

A flight-information package is associated with each flight. It is a zip file containing the text description of the flight, a GIF file of the appropriate portion of the IFR chart, and a GIF file of the approach plate for the designated runway at the destination airport. Simply click on the image showing the route of flight to download the information file.

Both the IFR charts and the approach plates were scanned at 300 dpi, so keep that in mind when sizing them to print. In general, you won't go far wrong with one-inch (2.54 cm) left and right margins.

Before you fly the flights study the text descriptions, the approach plates and the IFR charts that you downloaded. By doing this you will find that the procedures fall right into place. Keep the information packages near your computer when you fly the flights, too, so that you can easily refer to them for specific details. After you print the information packages file them in a three-ring binder, otherwise clutter can build fast.

VOR approach procedures are nearly identical to the NDB approaches discussed earlier. If you progressed through those sections then transitioning to VOR approaches will be simple. The VOR gauge indications will differ from the RMI, of course, and some fiddling of the OBS will be necessary, except when on a Localizer approach.

This section concentrates on VOR approaches where the VOR is located off the field.

If you jumped to this point of the website without proceeding through the earlier sections, I strongly recommend that you return to the [Air Navigation](#) section and review the sections on VFR Sectional Charts, IFR enroute low altitude charts, and the basics of plotting a course. Further, you should go to the [NDB Approaches/Approach Plates](#) section and read the basics of Instrument Approach Plates, now called Terminal Procedures.

Don't chase the needle!

Oh, are you going to grow to hate that expression. It was used often in the NDB sections, and you will see it used frequently through-out the VOR sections, too.

What does "Don't chase the needle mean?" Well, consider Roger Rudder's piloting technique. He's tracking the VOR and the needle drifts a dot to the right. Ole eagle-eye Roger notices, and following the maxim "always steer towards the needle" slams the stick to the right. The sound of breaking glass comes from the passenger cabin as beverage glasses fly everywhere. But Roger has done very well because the needle has nicely, and very quickly, returned to center.

But, wait! How'd that needle get a dot to the left, now? Doesn't matter. Dauntless Roger has the situation well under control, and in a superb example of mind over matter, slams the stick to the left, up against the stop, to get that frigging needle centered again, where it belongs! His technique was better, because this time fewer beverage glasses were heard breaking from the rear cabin.

But the needle is determined to prove who the boss is and it again drifts to the right. Never can it be said that Roger Rudder doesn't understand how to correct the aircraft's heading when off course. With the supreme confidence that only piloting can bring, Roger again slams the stick to the right, with only a brief mutter heard from under his breath.

Children watching from the ground giggle and point in awe at the near-perfect S-curves that Roger's plane is carving in the sky.

Well, you get the picture. Fearless Roger Rudder was chasing the needle with the stick (yoke) in a vain attempt to master the heading situation, rather than properly correcting his heading.

In the dark ages, an instructor would shout a cliché if he thought Roger Rudder had slid behind the controls. "Change heading the same way that you approach a woman—slowly, with forethought, and then stop a bit to see what effect you've had before you do anything else!" Of

course, he threw in a few expletives, too, just to make sure that you both were on the same wavelength.

Well, an instructor wouldn't survive long today with a sexist attitude like that. Pretty good aviation technique, though.

The most important first step to correct a heading with a drifting VOR (or ADF) needle is to stop the movement of the needle. Don't panic and immediately try to recenter the needle. Get the needle stopped! Once you've stopped the drift of the needle and noted the heading required to do that, it's then a simple jog to get the needle back on center again.

Take Roger Rudder's situation again. The VOR needle has drifted one dot to the right. You would briefly consider how rapidly the one-dot drift occurred, then make a small heading adjustment to the right, and watch what happens. If the needle continues to move to the right, make another small heading adjustment to the right, and again stop to see the effect.

Of course, if the first heading adjustment not only stopped the needle, but started it moving toward the left, you would make an even smaller heading adjustment to the left to stop the needle from drifting.

If the gods are smiling on you, the first heading adjustment will stop the needle. Usually not, though, and some bracketing will be necessary.

Once the needle is frozen to the face of the gauge, note your heading, then turn the aircraft towards the needle to center the needle. With the needle centered, return to the heading that froze the needle to the gauge face, and track dead-on all the way in to the runway.

It's an extraordinarily easy technique to master and it consistently works. The giggling children will have to find something else to amuse them.

* * *

The Boss was having difficulty holding his temper. I was having difficulty not smiling.

"The only service we provide is the best charter flight you can buy," The Boss said with resignation. He was using his speaker phone, and for a change, it was he and not me who was having the difficult conversation with Mr. Benjamin Counter.

"Don't tell me that!" Counter snapped back. "You fly into New Hampshire all the time, so you certainly had to know. What I can not understand is why you and your pilots refused to divulge the information to me."

"I'm sorry you're upset, Mr. Counter, but asking our pilots to competently and safely fly our aircraft is quite enough," The Boss said while rolling his eyes to the ceiling. "To also expect them to be Certified Financial Advisors doling out advice during a trip is unreasonable. When our pilots are in the air we expect their mental arithmetic to pertain to course headings, ground speeds, procedure turns, and the like, not to interest rates, stock market indices, or commissions."

"Hogwash on the Certified Financial Planner stuff," Counter bellowed out. "Do your pilots know that there is no income tax in New Hampshire?"

"Of course they do, Mr. Count..."

"And do they also know that there is no sales tax in New Hampshire?" Counter continued.

"Well, yes, I suppose that they do," The Boss said, beginning to show little affection to *The Customer is always right* motto affixed to the wall behind his desk. "After all, Massachusetts' people frequently flock to New Hampshire to avoid sales taxes on big-ticket purchases."

"Well, then, why did I have to learn those facts just yesterday from the celery and lettuce man in the grocery store?" Counter shouted.

The Boss wisely chose a different path. "Now that you know the situation, what would you like from us?"

"I'm in Concord and want a flight to Manchester. I understand that good-value property is still available there and that it's the cultural hub of New Hampshire. I may want to set up a new residence in the vicinity, and avoid those vindictive taxes. I also heard that not long back *Money Magazine* named Manchester the #1 Best Small City in the Northeast."

"OK," The Boss said, "We'll fly you ... "

"One thing worries me about New Hampshire, though," Counter interrupted. "Looks like there's a lot of muddled thinking there."

"Muddled thinking?" The Boss and I repeated in unison.

"Yeah," Counter answered. "Less than 40% of the state voters are Republican; the rest are Democrats or Undeclared." A click and dial-tone followed as Counter hung up.

"I guess he wouldn't have cared to know that New Hampshire planted the first potato in the U.S. in 1719," I said, walking for the door.

The Flight



Concord to Manchester. Flight path shown is to MHT VOR, the beginning of the VOR approach. Click image to access complete flight-info package.

For all flights in this section, select the "Saab-VOR" aircraft from the Aircraft menu in FS98 or FS2000. If "Saab-ILS-ADF" does not appear on your aircraft list, return to the [What you need/Aircraft](#) section to download and install the Saab MFI-17 file with the modified panel. The proper aircraft installation provides six choices of Saab aircraft, each with a different panel.

The flight begins at Concord Municipal airport, Concord, New Hampshire with Manchester, N.H. the destination. Click on the image to the left to download the flight-information package, con-mht.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 35 at Manchester, and this text description of the flight.

This flight ends with the simplest VOR approach. You will fly to the VOR,

proceed outbound from the VOR, away from the field, make a procedure turn to the left, and return to the VOR, finally descending to the runway.

Do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 900 ft overcast, cloud tops at 10,000 ft., and one-half mile visibility. The wind is calm.
- Move the aircraft to Concord's Runway 35, and retract the flaps to 0°.
- Tune the Nav. receiver to the Manchester VOR, 114.4 MHz., ident MHT.
- Set the OBS to 172°. Reset the timer to zero.
- Takeoff from Runway 35 with a climbing left turn to the southwest. ATC has cleared you to 4000 ft.
- Intercept V141 south-bound, indicated by the VOR needle centering and a TO flag showing. Cruise at 120 kts.
- Track inbound to the MHT VOR. Heading will be 172° with no wind.
- On station passage, when the FROM flag appears, turn left to 155° and set the OBS to the same number.
- Start the timer, and track outbound for two minutes.
- During the outbound leg from the VOR, descend to 2000 ft. You probably will have to continue your descent into the procedure turn since you have 2000 ft. to lose.
- After two minutes outbound from the VOR, turn left to the procedure turn heading of 110°. Reset and restart the timer.
- Fly the 110° heading for one minute then make a 180° turn to the right to 290°.
- Set the OBS to 335° the inbound heading to the VOR and to Manchester's Runway 35 and reset the timer, but do not start it yet.

- Intercept the MHT 335° radial with a right turn, and start the timer.
- Descend to 1600 ft., drop one notch of flaps and slow to 80 kts.
- Shortly after two minutes on the timer you will reach station passage at the MHT VOR, indicated by the TO-FROM flag switching to FROM.
- Maintain your heading; don't worry on station passage if the needle slides off the side of the gauge. If you're tracking well it will return to center shortly after station passage.

The purpose of everything that you have done so far is to stabilize the approach *before* arriving at the FAF, Final Approach Fix. By stabilizing the approach only power adjustments will be necessary to descend or maintain level flight. If you don't stabilize the approach before arriving at the FAF, it's not likely to be satisfactory.

- If there is a crosswind, which is common, the inbound leg from the procedure turn to the FAF is the place to establish the correct WCA, not after passing the FAF.
- On station passage at MHT, when the FROM flag appears, reset and restart the timer, and reduce power to descend to the MDA, Minimum Descent Altitude, of 860 ft.
- Don't chase the needle on station passage. Maintain 80 kts. and proceed outbound from the VOR on the 335° radial towards the runway, remaining level at 860 ft.
- The distance from the station to the runway is 4.3 nm. At 80 kts 3 min., 14 secs. will elapse to cover this distance.
- With one-half mile visibility you should sight the runway or approach lights at about 2 min, 51 secs. after station passage. Although the runway will lie dead ahead if you have tracked from the VOR well, it is angled 17° to the right. Runway 35's heading is 352° so be prepared to turn to it when you sight it.
- On seeing the runway, further slow the aircraft and configure it for landing. Field elevation is 234 ft so you will have a little over 600 ft to descend to land.

Repeat the flight with the same conditions, but add a crosswind of 010° at 26 kts. Enjoy the challenge and satisfaction of flying it well.

Note: the winds in FS98 and FS2000 are Magnetic Direction, not True Direction, so enter your Magnetic Course into the Virtual E6-B Computer instead of True Course when calculating Wind Correction Angles, WCA, and Ground speeds.

* * *



Mt. Monadnock, the second most climbed mountain in the world.

At last, a tranquil flight. Counter had neither reached me on my pager nor through The Boss. I was on my way out of the pilot's lounge at the Gardner, Massachusetts municipal airport, headed to my MFI-17 to perform the usual early-morning thorough preflight. The jaunty gait to my step pronounced to all my good humor and optimism. I stopped to let the fuel truck pass on its way to a plane that had just taxied in.

When the way became clear again, I couldn't move. Counter was standing beside my plane, a broad grin on his face. At his feet was a mountain of gear, the specifics of it indiscernible from the distance.

"Good Morning!" he shouted.

I responded in kind, if not quite with the same enthusiasm.

"You don't have to deadhead back after all. I have a long weekend free, and want to go to Keene, N.H. then scale Mt. Monadnock," he said as I drew nearer. He spread his hands at the stack of mountaineering equipment at his feet for emphasis.

Even though Mt. Monadnock is the second most-climbed mountain in the world, behind only Mt. Fuji in Japan, the level of difficulty is not high. It peaks at 3165 feet, 1800 feet above the parking lot, with five major, well-cleared and well-marked trails to guide the trekkers. A fit person can make it to the top in under three hours including rest stops.

I looked at Counter's equipment in awe: four stacks lay at his feet:

Clothing

- Two hats, a sun hat and warm hat
- Wind parka w/hood
- Mittens, Camp
- Mittens, Climbing
- Over Mittens
- Wind pants
- Gaiters
- Overboots
- Polarguard jacket and pants

Camping Gear

- A tent
- Sleeping bag and booties
- Thermarest pad
- Bic lighters
- Bowl, cup, spoon
- Tea strainer
- Food
- Alarm wrist watch
- Swiss Army knife
- Tooth brush/Tooth powder
- Hand lotion, Chapstick
- Miniature TV set

Climbing Gear

- Ice ax
- Ice tool w/hammerhead
- Crampons
- Ropes (2 9x50m)
- Prusiks
- Pulleys
- Harness (seat and chest)
- Belay/Rappel device
- Carabiners
- 5 Pickets
- 4 Ice Screws
- Tools for bindings and crampons
- First-aid kit
- Aspirin

Day Gear

- Water Bottles w/insulated cover
- Sun screen
- Sun glasses, Sun hat (baseball)
- Ski goggles

- Camera/Film
- Compass, Maps

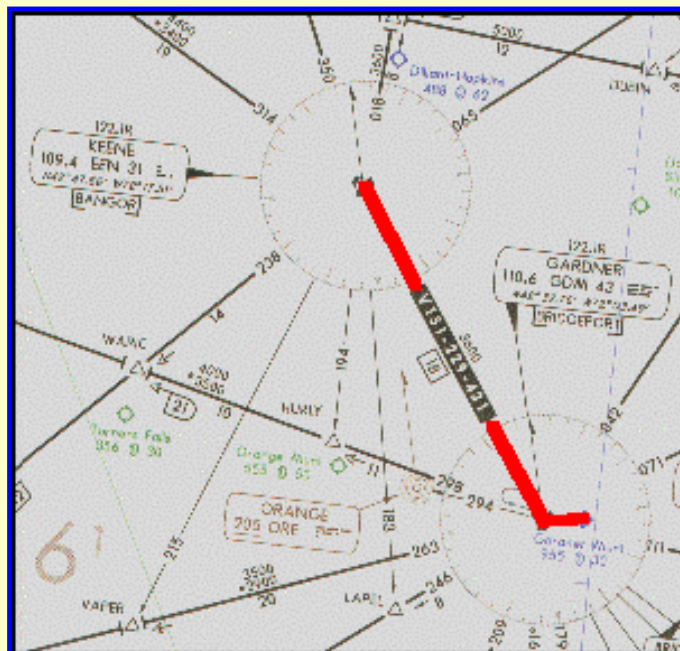
Had Counter confused Mt. Monadnock with the 12,380 ft. Mt. Fuji?

One thing about Counter, he never did anything very ordinary. I knew Keene well, with relatives living there. It's the geographic center of New England. The view from Mt. Monadnock's summit is magnificent. On a clear day all six New England states can be seen.

If it had been Halloween, Counter could have participated in another Guinness *Book of World Records* event: For five straight years more pumpkins were carried into Keene and put on display than anywhere else in the world. Over 17,000 last year.

Counter didn't do his homework well: Keene and Cheshire County are enclaves with the highest density of Democrats in all of New Hampshire. Clinton visited there six times, twice after being elected President. The local organizing committee issued a special button for one of Clinton's appearances: *Keene on Hilary*. Clinton quipped that he had one of those buttons on his desk in the Oval Office, although it's unclear whether he uttered those words before or after the Monica mess.

The Flight



Gardner to Keene. Flight path shown is to EEN VOR, the FAF of the VOR Rwy 2 approach. Click image to access the complete flight-info package.

The flight begins at Gardner Municipal airport, Gardner, Mass. with Keene, N.H. the destination. Click on the image to the left to download the flight-information package, gdm-een.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 2 at Dillant-Hopkins airport in Keene, and this text description of the flight.

This flight is unusual in that a procedure turn is not required for our route of flight. We proceed from the GDM VOR to EEN VOR and straight in to Runway 2 at Dillant-Hopkins.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your

mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 1700 ft overcast, cloud tops at 10,000 ft., and one and one-half mile visibility. The wind is calm.
- Move the aircraft to Gardner's Runway 36, and retract the flaps to 0°.

- Tune the Nav. receiver to the Gardner VOR, 110.6 MHz., ident GDM.
- Set the OBS to 323°. Reset the timer to zero.
- Takeoff from Runway 36 with a climbing right turn to 280°. ATC has cleared you to 4000 ft.
- Intercept Gardner's 323° radial north-bound, indicated by the VOR needle centering. Cruise at 120 kts.
- Track outbound from the GDM VOR. Your heading will be 323° with no wind.
- Activate the HDG control of the Autopilot to maintain the 323° outbound track from GDM.
- Retune the VOR to 109.4 MHz., Keene VOR, ident EEN.
- Set the OBS to 024°, the inbound track to Keene VOR and Dillant-Hopkins' Runway 2.
- Intercept the 024° radial with a right turn and descend to 2600 ft.
- Slow to 80 kts and drop one notch of flaps. Track inbound to the VOR.

At this point your approach should be stabilized.

- On station passage, when the FROM flag appears, start the timer, and descend to 1600 ft.
- Don't chase the needle on station passage. Maintain your heading and don't worry if the needle slides off the side of the gauge. If you're tracking well it will return to center shortly after station passage.
- Runway 2 is 5.7 nm from the FAF, EEN VOR. Elapsed time to cover that distance at 80 kts will be 4 min., 17 secs.
- With one and one-half mile visibility, the runway threshold or approach lights should become visible 1 min., 08 secs. before arrival at 80 kts, or 3 min., 09 secs. after station passage.
- On sighting the runway, configure the aircraft for landing and make a normal landing. Field elevation is 488 feet so slightly more than 1100 ft must be lost for touchdown from the MDA.
- Runway 2's heading is 019° so a 5° turn to the left to it will be necessary after sighting it.

* * *



Littlebrook Air Park—Your destination.

"I know your family has planned the reunion for two years," The Boss said, handing me a sheet of paper. "But this is right on your way—should only take a couple of hours."

I was in The Boss's office and quickly read the document; an e-mail from Mr. Benjamin Counter. It repeated what The Boss had already told me over the phone. Counter had recently learned of a distant relative that had died in an Indian ambush in the late 17th century, and he wanted to get to the site to learn more.

Counter had joined the information age by sending an e-mail. A spark of hope rose in me that he would continue to progress and learn how to plan in the future, rather than "Right now will be OK," when asked 'when did he want to leave?'

Counter's e-mail detailed what little he knew. The time was July 4, 1697 and his relative was in a party of settlers returning home from the Parish of Unity in S. Berwick, Maine. Major Charles Frost was among the group, the apparent target of the ambush. Frost was Military Governor of the Province of Maine, before it broke away from Massachusetts. In a battle during the King William War, Frost and his troops captured 600 Indians, selling some of them in the West Indies as slaves. Others were killed.

The Indians retaliated—and it was successful. Frost was killed, along with two settlers who happened to be in the wrong place at the wrong time.

Counter's goal is Littlebrook Air Park, in Eliot, Maine, a five minute drive to "Ambush Rock," where the incident took place. It all happened over 120 years before Maine became the 23rd state. And Counter had to be there "right now!"

"Pick up Counter at Portland's G-A terminal," The Boss said with finality.

I left, wondering what logic made a flight north to Portland then back south with Counter to Eliot "right on my way."

The Flight



Portland to Eliot. Flight path shown is to PSM VOR, the FAF of the VOR-A circling approach. Click image to access complete flight-info package.

The flight begins at Portland International airport, Portland, Maine, with Littlebrook Air Park in Eliot, Maine the destination. Click on the image to the left to download the flight-information package, pwm-eliot.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 2 at Littlebrook airport in Eliot, and this text description of the flight.

This flight requires a circling approach to Littlebrook's Runway 30, and includes a wind condition to keep the challenge up. There is also a VOR intersection to contend with. The flight proceeds from Sanford to the Pease VOR, PSM, a left procedure turn, return to PSM and track outbound to Littlebrook with a circling approach into the left traffic pattern for Runway 30.

A longer flight was allotted than previous flights to provide time to stabilize the Wind

Correction Angles.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts.

- Set the flight simulator weather conditions to 750 ft overcast, cloud tops at 10,000 ft., and one mile visibility. Set the wind at 29 kts., from 300°.
- Recall that winds in FS98 and FS2000 are Magnetic Direction, not True Direction, so enter your Magnetic Course into the Virtual E6-B Computer instead of True Course when calculating Wind Correction Angles, WCA, and Ground speeds.
- Move the aircraft to Portland's Runway 29, and retract the flaps to 0°.
- Tune the Nav. receiver to the Kennebunk VOR, 117.1 MHz., ident ENE.
- Set the OBS to 242°. Reset the timer to zero.
- Takeoff from Runway 29 with a climbing left turn to intercept V93, the 242° radial to ENE VOR.
- Climb at 90 kts. to your cruise altitude of 6000 ft. The WCA will be 16° Right for climb.
- Plan a 120 kt. cruise speed. With a 29 kt. wind from 300° the WCA will be 12° Right for cruise.
- Set the proper Wind Correction Angle based on air speed, then activate the autopilot heading control for that heading.
- On station passage of ENE, when the FROM flag appears, tune the Nav. receiver to the Pease VOR, 116.5 MHz., ident PSM. Set the OBS to 200°. The airway becomes V106.
- Intercept YUKES intersection of V106 and V3, indicated by centering of the VOR needle with a TO flag showing.

How do you know whether you have passed an intersection? It's easy. When the needle is on the same side of the gauge as the station is to the aircraft, you have not arrived at the intersection.

But remember, intersections are determined by FROM radials. The radial FROM PSM to establish YUKES intersection is 020°. With the VOR tuned to PSM, and with the OBS set to 020° we have not reached the intersection as long as the needle is deflected to the left, which is the side of the aircraft that the station is on.

But we have set the OBS for PSM to 200°, the reciprocal of the radial, the TO direction because we are going to intercept that radial and fly to the station. Setting the OBS to the reciprocal of the radial, and with the TO flag showing, reverses the rule. We have not reached the intersection as long as the needle is deflected *away* from the side of the aircraft that the station is located, or to the right in this case.

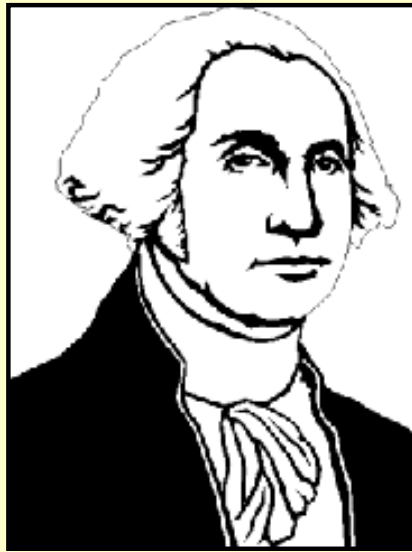
- Turn left at YUKES and track inbound to the VOR, magnetic course of 200°. The Wind Correction Angle will be 14° Right. Set the autopilot heading control on if desired.
- Descend to 3000 ft. during this leg.
- At station passage of PSM, when the FROM flag appears, turn right to 232°, set the OBS to this number, start the timer and fly outbound for two minutes. The WCA will be 13° Right.
- At two minutes, turn left to 187° into the procedure turn. Reset and restart the timer. The WCA will be 13° Right.
- At one minute turn right to 007° The WCA should be 13° Left. Set the OBS to 052° the inbound heading to the VOR and to Littlebrook's Runway 30.
- On intercepting the 052° radial turn right to track to the station. Start the timer and descend to 1500 ft.
- After two minutes or so expect station passage. The WCA inbound will be 13° Left at 120 kts.
- Slow to 80 kts, and drop one notch of flaps. Readjust the WCA to 20° Left at 80 kts. to keep the needle centered at this reduced speed. Use the autopilot heading hold, if desired, inbound to the VOR, but at station passage switch the autopilot off and manually fly the remaining portion of the approach and landing.

At this point your approach should be stabilized, especially your compensation for the strong wind from the left.

- At station passage, when the FROM flag appears, reset and restart the timer and descend to the MDA of 720 ft. Your ground speed will be 86 kts. Time to cover the 4.3 nm to the field at 86 kts. will be 3 min., 00 secs.
- With one-mile visibility, expect to sight the field at 2 min., 18 secs. after station passage. Field elevation is 130 ft.
- On spotting the field, enter a left downwind leg of 120°. The left base leg will be 030° with a WCA of 21° Left. Be aware that your ground speed on final approach will only be 51 kts. into the teeth of the wind, so moderate your rate of descent to avoid an embarrassing last-minute burst of speed to prevent an early landing.
- Note that The landing threshold of Runway 30 is displaced 86 ft. Don't touchdown early.

After the flight reward yourself with a cup of coffee for a job well done. Instrument approaches don't get much tougher than this one

* * *



I love the morning and arrived at the airport early, as usual, before anyone else. Started the coffee and relaxed in the pilot's lounge.

The phone rang in the outer office. Still by myself I went out and picked it up.

"Charter Service," I answered.

"Good morning," a beautiful female voice began. "Am I speaking with the Executive Charter Pilot?"

With that voice, I was willing to be anything she wanted. "Yes, Ma'am," I answered in my sunniest voice.

"Good, I'm Cheryl, Mr. Counter's Administrative Assistant. He's on Block Island and asked me to contact you about a flight to North Kingstown, Rhode Island. He was feeling very nostalgic last night about what drive's him, about what gives him the motivation to arise each morning and fight off the swarming alligators." After a pause, she said rather apologetically, "His words."

"Of course we can help," I responded. "What time this morning does Mr. Counter want to be there?" I asked trying very hard to keep the sarcasm from my voice.

"He said it didn't matter," She answered. "Anytime between 9:00 AM and 10:00 AM would be OK."

"Must be pretty important," I said, shaking my head sadly.

"Oh, it is," she responded quickly. "Mr. Counter wants to visit the birthplace of Gilbert Stuart, the man whose work so inspired him."

The name meant nothing to me. "Is Mr. Stuart famous?" I asked.

"Oh, yes," Cheryl enthused. "He's the famous artist that painted George Washington's portrait that you see hanging everywhere. And he painted the portraits of four other presidents, too, plus British Kings George III and George IV."

"I'm sure Stuart's work is awesome, but I'm missing the connection with the motivation that drives Mr. Counter," I said rather puzzled.

"Oh, Silly," Cheryl said with a laugh, "Stuart did the portrait that's on every one-dollar bill."

The Flight



Block Island to Quonset State. Click image for complete flight-info package.

The flight begins at Block Island State airport, Block Island, Rhode Island, with Quonset State airport in North Kingstown, Rhode Island the destination. Click on the image to the left to download the flight-information package, sey-oqu.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 34 at Quonset State airport in North Kingstown, and this text description of the flight.

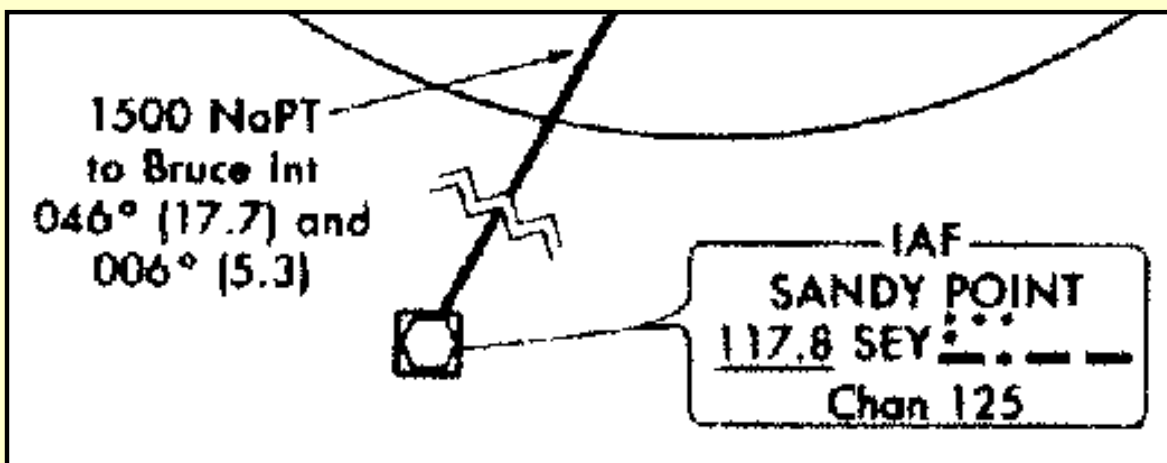
You wanted a VOR approach where the Omni was off the field? Well, not only is this VOR some 8 nm. off the field, but it is *past* the field. This approach introduces the concept of an FAF identified by the intersection of two VOR radials. A procedure-turn is not required for our route of flight and entry into the approach.

The flight proceeds from the 046° radial of Sandy Point VOR, SEY, at Block Island, intercepts the 186° radial of Providence, PVD, then straight in to Quonset's Runway 34.

You'll be a little busy on this approach, but it's a piece of cake compared to the last one.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts.

- Set the flight simulator weather conditions to 700 ft overcast, cloud tops at 10,000 ft., and one mile visibility. The wind is calm.
- Move the aircraft to Block Island's Runway 28, and retract the flaps to 0°.
- Tune the Nav. receiver to the Sandy Point VOR, 117.8 MHz., ident SEY.
- Set the OBS to 046°. Reset the timer to zero.



This note on the approach plate explains that if you fly the SEY 046° radial at an altitude of 1500 ft and intercept the PVD 006° radial TO the station, you may enter the approach procedure without having to perform a procedure turn.

- Takeoff from Runway 28 with a climbing right turn and intercept V268, the 046° radial from SEY VOR. The SEY VOR is the IAF, Initial Approach Fix, for the approach.
- For such a short flight you'll cruise at the 1500 ft. initial approach altitude for Quonset State. Climb at 90 kts.
- When you are satisfied with the VOR outbound track, activate the autopilot heading control to maintain the magnetic course of 046°.
- Retune the Nav. receiver to 115.6 MHz., Providence VOR, ident PVD. Set the OBS to 006°, the inbound course to the VOR and Runway 34 at Quonset State airport.
- When the needle centers, indicating an intercept of the 006° radial TO PVD, turn left to that heading.
- When properly tracking inbound on the 006° radial, reactivate the autopilot to maintain the heading.
- Retune the Nav. receiver to 110.0 MHz., the Norwich VOR, ident ORW. Set the OBS to 110° to identify BRUCE intersection when the needle centers and a FROM flag is showing.
- Reduce your speed to 80 kts., and drop one notch of flaps.

At this point your approach should be stabilized.

- Fly to the BRUCE intersection. Remember, with the needle on the same side of the gauge as the station is to the aircraft—to the left in this case—you have not yet arrived at the intersection.
- BRUCE intersection is the FAF for the approach to Runway 34. When the VOR needle centers, you're there. Start the timer.
- Retune the Nav. receiver to the PVD VOR, 115.6 MHz.
- Return the OBS to 006° and keep the needle centered.
- Descend to 660 ft.
- Time to fly the 5.1 nm. from the FAF to the MAP at 80 kts. is 3 min., 50 secs.
- With one-mile visibility you should spot the approach lights or Runway 34 threshold in 3 min., 05 secs.
- Be alert because you have significant altitude to lose. Field elevation is 19 ft. so you will have to bleed off 641 ft. Best to do this by dropping full flaps and chopping the power, slowing the aircraft to 70-75 kts. or so.

You should refly this particular VOR approach when you are again in an aircraft with a full

panel, i.e., two VORs and a DME. It is a very easy instrument approach under that situation.

That concludes the session on VOR approaches for the situation where the VOR is located some distance from the field.

Fly each approach a second time, to hone the techniques, before moving to the next section.

Click on the *Approaches—VOR on the Field* button to move to the next type of VOR instrument approaches, where the VOR station is on the field.



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Site best viewed at 600 × 800 resolution.

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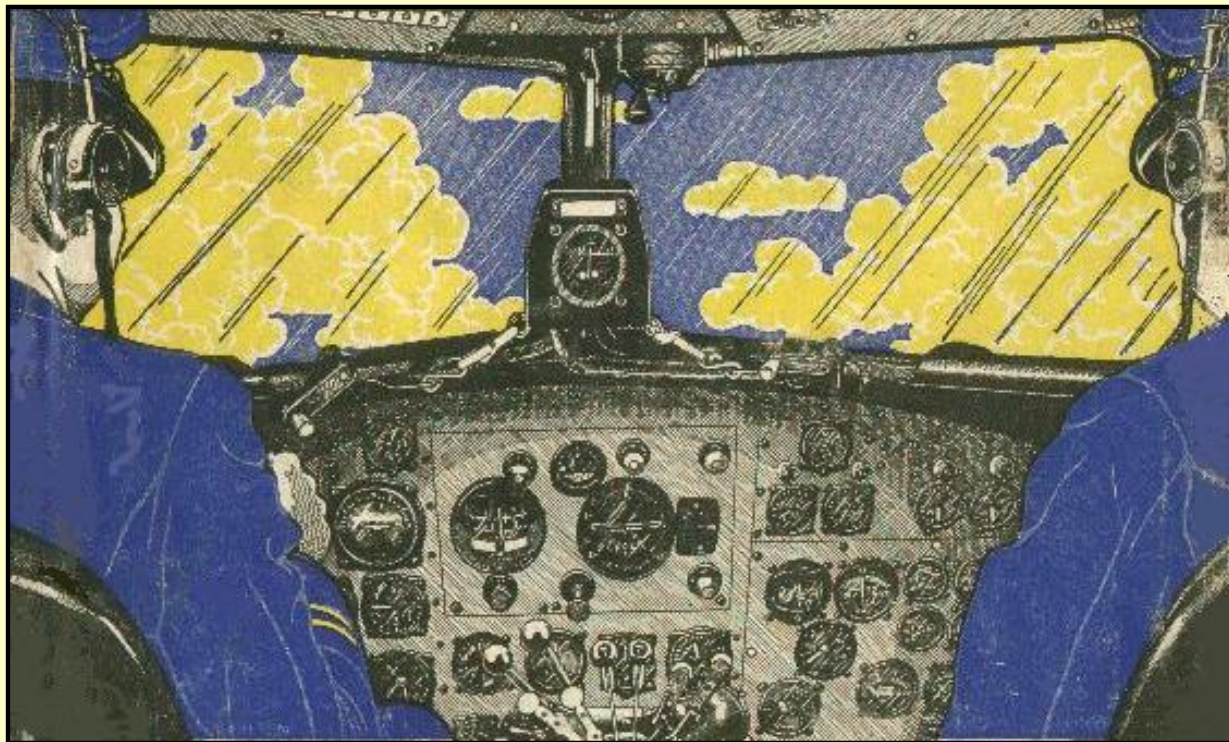
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VOR Approaches

Part II



Piloting a DC-3 in IFR weather, 1942.

VOR approaches with the station off the field have the advantage that an electronic fix, the Final Approach Fix, is available to provide exact time and distance information to the airport. For this reason, some pilots prefer that type of VOR approach over one where the VOR is on the field, where precise time and distance information to the field is not available.

Of course, if the Omni station has DME capability and a DME is available in the aircraft, then time and distance information to the station, or the field, would be available.

The approach procedures described here assume no DME capability.

VOR approaches flown when the station is on the field have two advantages over the others, though. First, the VOR sensitivity increases as one nears the VOR, or field. This should place the aircraft nearer to the desired final approach position.

Second, there is no ambiguity on the MAP, Missed Approach Point. When the VOR is off the field, the pilot must determine the MAP point by measuring time from the FAF. In the case of the VOR on the field, the TO-FROM flag will switch from the TO position to the FROM position. At that point if the runway is not in sight, the pilot must execute a Missed Approach Procedure.

With the flight experience obtained from the previous practice sessions, these approach procedures

will be easy.

Runway Visibility Range

A number of years ago, the FAA decided that visibility figures didn't accurately report how far down a runway a pilot could see from a moving aircraft. They developed a new criteria which better specified the visibility down a runway; called Runway Visibility Range, or RVR. In many instances approach plates now report visibility minimums in RVR.

Look at the table of minimums on a Martha's Vineyard approach plate.

Minimums, Martha's Vineyard VOR RWY 24 approach.

CATEGORY	A	B	C	D
S-24	540/24 477(500-1½)		540/40 477 (500-¾)	540/50 477 (500-1)
CIRCLING	540-1 472 (500-1)		540-1½ 472 (500-1½)	620-2 552 (600-2)

Notice the first entry under Category A and B for the S-24 approach, the straight-in to Runway 24 at Martha's Vineyard airport. It is "540/24." The 540, of course, is the Minimum Descent Altitude, MDA. Can't go below that altitude unless the runway or approach lights are in sight and a normal landing can be made.

A "24" appears after the slash indicating that a minimum of 2400 feet RVR is required to land for S-24. The RVR is specified on an approach plate in hundreds of feet. If you were flying a Category-C aircraft, your RVR requirement is 4000 ft., and 5000 ft. for Category D.

Well, all that is nice to know. When you look at the minimums on your approach plates, you'll now understand that sometimes statute miles visibility requirements are specified and at other times the RVR requirements are shown, and you'll recognize each.

Unfortunately, that's as far as Microsoft lets you go, is to understand the information. FS98 and FS2000 only let you select visibility in statute miles. Maybe patch two will fix that.

There are two ways to convert the RVR to statute miles to enter the proper information into the flight simulator: First, you could divide the RVR by the 5280 ft. in one mile. For a 2400 ft. RVR, that would give you 0.45 mi. which you would round up to 0.5 mi.

The second, and simpler way, is to look at the military numbers on the approach plate. Jump to the second set of numbers, specifically those enclosed by parenthesis. Again for Categories A and B, the military numbers are "(500-½)." The military requirement is 500 ft. ceiling with one-half mile visibility. From this you now know to enter one-half mile visibility into your flight simulator for these two categories. Category C would be ¾ mile visibility and Category D would be 1 mile visibility.

A 2400 ft. RVR is so common that you will quickly learn to enter one-half mile visibility into your flight simulator for that situation.

The visibility minimums for the circling approach are always given in miles.

* * *



Gay Head Lighthouse, Martha's Vineyard.

I was on short final to Nantucket's Runway 24. The weather was at minimums for the VOR approach; 420 ft. ceiling, solid overcast, heavy fog with a 2400 ft. runway-visibility-range. Now at the MDA, my canopy was brushing at the clouds while I mucked about in and out of the scud, trying to keep on course.

What lousy weather, even the birds must be walking.

I nearly jumped out of my skin when an alarm sounded in the cabin. Quickly glancing around, I searched for the

source of trouble. Then the racket stopped. Returning my gaze to the gauges, the aircraft was still doing well; heading right on the money and altitude on the MDA. MAP was in forty-five seconds. If the approach lights didn't show soon, it was going to be a Go-Around.

The alarm sounded again, more insistent. I cursed to myself. It was my cellphone in my flight bag. I had forgotten to turn it off. If I had the time and altitude, I'd have opened the canopy and sent that phone sailing into Buzzards Bay. There was nothing I could do now but put up with it. It was a distraction I didn't need as it continued to ring.

Then the runway appeared and I greased on a landing. As I turned off the runway, the ringing stopped.

The caller caught up to me as I was asking the line-boy to fuel the aircraft. I dug into my flight bag, retrieved the phone, and answered it. Counter was on the other end.

"Good Day to you," he boomed, as if sunning himself on the Riviera. "How convenient that you're at Nantucket. I'm here, too."

"And where might that be," I asked, trudging to the terminal, the mist seeping through my clothes.

"A cab's bringing me out now. Your boss said I could catch you there, that you wouldn't mind a short hop to Martha's Vineyard."

"What's going on in the Vineyard," I asked, glancing above at the darkening skies.

"The lighthouses, of course. It's the lighthouses," Counter replied. "I watched *A Stolen Life* on The Late Movie last night. Great Bette Davis movie! Great special effects! The story was around a Martha's Vineyard lighthouse. Martha's Vineyard has five of 'em, you know. And the best, I hear, is Gay Head.

"The weather's not looking good," I tried.

"Nonsense! I'm packed, checked out of the hotel, got my bag with me, and everything." He responded. "I'm almost there. What better time to look at lighthouses and listen to fog horns than on a foggy day?" he asked.

"I don't think there have been any fog horns working for years," I said, with a glimmer of hope.

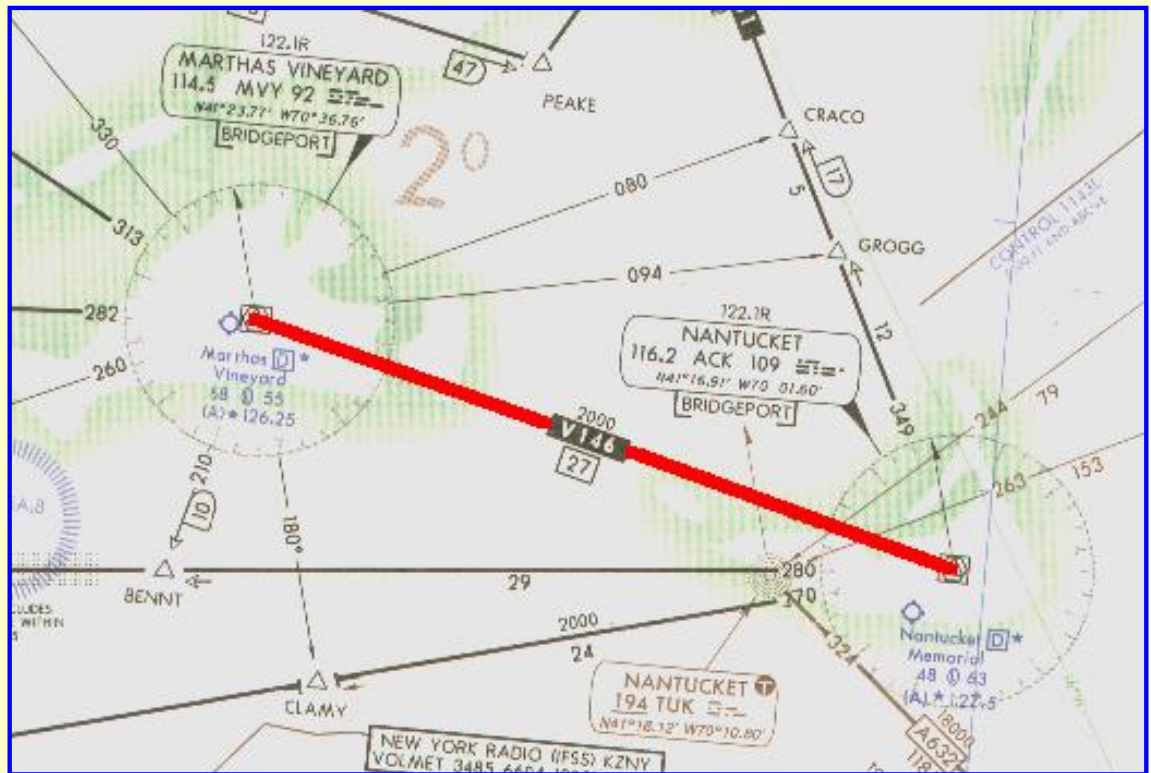
"Doesn't matter. That Gay Head light is one important light. It sits 170 feet above the sea on clay bluffs on the Western side of Martha's Vineyard. That's where the Devil's Bridge rocks threaten the entrance to Vineyard Sound, the main route to Boston Harbor from the south.

"Did you know that a lighthouse could be too high?" Counter went on. "Yep, he replied," before I could get a word in. "Gay Head was so high at first that it shone above the fog. Didn't help the ships very much. It's been up and down like an elevator ever since, designers trying to find the best height."

"There was a big shipwreck nearby in 1884. I heard 120 people drowned. I want to go there and learn more," Counter ended.

"Let me check the weather on the Vineyard, see if it's as bad as it is here," I said.

Nantucket, Massachusetts to Martha's Vineyard, Massachusetts.



Nantucket to Martha's Vineyard with a VOR Rwy 24 approach.

Click on image for flight-information package.

You've done enough single VOR gauge work, now. From this point on, if two VORs are part of an approach, you'll use a Saab panel with two VORs on it. Just watch the flight instructions for which panel to select from the Aircraft menu in FS98 or FS2000.

As a status checkpoint, if the "Saab-ILS-DME" does not appear on your aircraft list, return to the

"[What you need/Aircraft](#)" section to download and install the most current Saab MFI-17 file with the modified panel. The proper aircraft installation provides seven choices of Saab aircraft, each with a different panel.

The flight begins at Nantucket Memorial airport, Nantucket, Mass. with Martha's Vineyard, Mass. the destination. Click on the image above to download the flight-information package, ack-mvy.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 24 at Martha's Vineyard airport in Vineyard Haven, and this text description of the flight.

This is a straight-forward flight ending with an instrument approach at Martha's Vineyard, where the VOR is on the field. We proceed from Nantucket to the MVY VOR, fly outbound, execute a procedure turn, and return to MVY and Runway 24 at Martha's Vineyard.

There is a very difficult 129° right turn at MVY VOR when arriving from Nantucket to intersect the 068° radial to start the approach. We convert this into a simple maneuver with a left teardrop turn at MVY, coming back around to intercept the 068° radial.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 700 ft overcast, cloud tops at 10,000 ft., and three-quarter mile visibility. The wind is calm.
- Select aircraft Saab-VOR.
- Move the aircraft to Nantucket's Runway 24, airport ack, and retract the flaps to 0°.
- Tune the Nav. receiver to Martha's Vineyard VOR, 114.5 MHz., ident MVY.
- Set the OBS to 299°. Reset the timer to zero.
- Takeoff from Runway 24 with a climbing right turn to 345°. ATC has cleared you to 4000 ft.
- Intercept Martha Vineyard's 299° radial northwest-bound, indicated by the VOR needle centering. Cruise at 120 kts.
- Track inbound 299° to the MVY VOR.
- As the needle centers and the FROM flag appears indicating station passage, start the timer and *maintain your 299° heading* for one minute. Change the OBS setting to 068°.
- Don't worry if the needle slides off the gauge on station passage, and don't chase it by altering your heading. Stay on course and the needle will return to dead center in a moment.
- At one minute after station passage turn left and come back around to intersect the 068° radial inbound to MVY VOR. The TO flag should be showing when the needle again centers.
- Stop and reset the timer on the return leg to MVY, but don't start it.
- At station passage, when the FROM flag appears, start the timer and fly outbound for three minutes descending to 1500 ft.
- Drop one notch of flaps and slow to 80 kts. while on the outbound leg.

It's vital to stabilize the approach well before beginning descent to the MDA.

- At three minutes, or slightly longer if you wish to be at 1500 ft. when beginning the procedure turn, turn right to 113°. If the outbound leg is more than three minutes, mentally note the time when starting the procedure turn. Be aware that you must remain within 10 nm. of the VOR during the approach procedure, which is only five minutes flying radius from the VOR at 120 kts. Time and distance allowances must be included for the procedure turn to stay within the 10 nm.
- Reset and restart the timer. Fly the 113° heading for one minute. Set the OBS to 248°, the

inbound track to the VOR and to Runway 24.

- After one minute into the procedure turn, turn left to 293° to return to intercept the 248° inbound radial to the station.
- Reset but do not restart the timer.
- When the VOR needle centers, turn left and track inbound on the 248° radial.
- Start the timer, and descend to 540 ft., the MDA. Since you flew outbound for three minutes, expect station passage after three and a half minutes, or so, inbound. If the outbound leg was different than three minutes, add about a half-minute for the inbound leg to station passage. This will not be exact, but will provide a far better gauge of distance to the VOR than guessing.
- Keep the VOR needle centered with minor heading adjustments, but don't chase the needle.
- Be alert on this approach. With only a three-quarter-mile visibility, you will sight the approach end of the runway only 45 secs. before arrival at the threshold. The runway will be a bit off to the left because of the location of the VOR on the field.
- If the TO-FROM flag switches to FROM before or just as you sight the runway, immediately execute the Missed Approach Procedure shown on the approach plate— it's too late to land.
- Field elevation is 68 ft., hence you must descend 472 ft. after sighting the field. Chopping the power and dropping full flaps should put you in a good approach attitude, as well as allowing you to slow the aircraft even more. Do not point the nose of the aircraft down and dive for the field. A crash may result or the speed will be so high that you will float past the end of the runway. Flare normally and touchdown.
- Time: 30 minutes.

* * *



Louis Bleriot, in his Monoplane X1, was the first to fly across the English Channel.

"Flying is too easy, today," Counter said, as I was gathering the items for our flight. He had out-done himself and scheduled this flight two days in advance. "Push a few buttons, and electronics take you from Point A to Point B," he went on. "As far as I can see, even a child could do it."

"Nothing to it," I replied, not looking for a debate. "It's so simple, sometimes I wonder why I even come along."

"You don't even look like a pilot," Counter said, moving in a

different direction. "No scarf, no goggles, no helmet, no leather jacket."

"The Boss doesn't pay me enough to buy upscale stuff like that," I said, with a sigh.

"I may have to talk to him about that, he charges me big money. Let's get going—I can't wait to learn about some real pilots and the airplanes that they flew," Counter said walking out the door towards the aircraft.

"Well, you'll see plenty at *The New England Air Museum* at Bradley," I answered, catching up to

him. "They have over 70 aircraft on display."

"I'm only interested in one plane and one pilot, actually—Louis Bleriot of France. He was the first to fly solo across the English Channel, from France to England. Did it in 1909," Counter said, his enthusiasm building. "In the Bleriot Monoplane X1."

"Yeah, he sure earned a reputation," I said.

"You bet he did. Taught himself how to fly, invented his own plane, and a monoplane instead of the biplanes that everyone else was fooling around with." Counter was getting excited. "Imagine, he won the £1000 prize from the London newspaper, the *Daily Mail*, for a 24 mile, 40 minute flight. That was \$5000, had to be a good pilot."

"Worth about \$100,000 today. He had his problems, though. Crashed his plane 51 times before the flight across the Channel," I added. "He even had a cast on his leg when he set the record with his famous flight."

"Yeah? Where'd you learn that? All I read was that his engine quit over the English Channel because it had overheated. Then a lucky rainstorm came up and cooled off the engine enough to restart and get him over the White Cliffs of Dover," Counter finished proudly.

"Well, you do know that he crashed when he landed on English soil?" I asked.

"Of course," Counter said, a bit defensively. "All the old pictures show that."

"That was crash number 52. That nameless soul had to have had Bleriot in mind when he coined the famous expression." I said, holding back a smile.

"What expression was that?" Counter asked suspiciously.

"Any landing that you can walk away from is a good landing."

Meriden, Connecticut to Hartford, Connecticut.



Meriden to Bradley Int'l with a circling VOR Rwy 33 approach to Rwy 15. Click on image for complete flight-information package.

The flight begins at Meriden Markham Municipal airport in Meriden, Connecticut, with Bradley Int'l. airport in Windsor Locks, Connecticut the destination. Click on the image to the left to download the flight-information package, mmk-bdl.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 33 at Bradley Int'l., and this text description of the flight.

This is another VOR approach not requiring a procedure turn. And, while the VOR for this approach is on the field, the Final Approach Fix is a VOR intersection providing the same valuable time and distance information to the field as if the VOR were off the field. It's sort of the best of both worlds.

To add to the challenge, this is a circling approach with a serious wind component. You will land at BDL's

Runway 15, but use the approach procedure for Runway 33 and circle to land at Runway 15. You'll be busy.

Actually, it's a pretty straight-forward flight ending with a circling instrument approach at Bradley Int'l. where the VOR is on the field. We proceed from Meriden to the Hartford VOR, then to the CLEFF intersection, inbound to the WISOK intersection, the FAF, and then to the airport, circling around to land on Runway 15.

Note: A discrepancy exists between the FAA information for the Bradley VOR frequency and that on FS98 and FS2000. The FAA data lists 109.0 MHz. while the simulators incorrectly list 111.4 MHz. Obviously you must tune 111.4 MHz for the practice flights but the charts will show 109.0 MHz.

The 111.4 MHz. is the VOT frequency, not the VOR. Recall the VOT discussion in the "VOR/Basic Navigation" section. Microsoft got it wrong.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 850 ft overcast, cloud tops at 10,000 ft., and two miles visibility. Set the wind to 20 kts. from 175°.
- Select the Saab-Loc aircraft.
- Move the aircraft to Meriden's Runway 18, airport mmk, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Bradley VOR, 111.4 MHz., ident BDL.
- Set the Primary OBS to 329°.

- Tune the Secondary Nav. receiver to Hartford VOR, 114.9 MHz., ident HFD. Fly the first leg with Nav-2.
- Set the Secondary OBS to 070°. Reset the timer to zero.
- Fly Nav-2. Takeoff from Runway 18 with a climbing left turn to track 070° to HFD. ATC has cleared you to 5000 ft.
- Climb at 90 kts. While climbing, the WCA will be 12° to the Right.
- At 120 kts. cruise, the WCA is 9° to the Right.
- On station passage at HFD, when the FROM flag appears, turn left to magnetic course 021° and set the Secondary OBS to this number. The WCA will be about 4° to the Right.
- Descend to 3000 ft.
- Fly Nav-1. When the Primary Nav needle centers, you are at CLEFF intersection, 10.2 nm. from the field.
- Turn left to the 329° magnetic course heading inbound to the VOR and start the timer. You will have an 18 kt. tailwind and need a 6° WCA to the Left at 80 kts.
- Descend to 1900 ft. Drop one notch of flaps and slow to 80 kts.

It's vital to stabilize the approach well before beginning your descent to the MDA.

- Change the Secondary VOR OBS to 004°.
- When the needle again centers, in about 3 min., 07 secs., you are at WISOK intersection, the FAF, 5.1 nm to the station and field.
- Reset and restart the timer, and descend to 680 ft.
- With the 18 kt. tailwind your ground speed will be 98 kts. It is 3 min., 07 secs. to the threshold of Runway 33.
- With two-miles visibility, you should spot the runway in 1 min., 53 secs. This is the opposite end of your landing runway.
- On sighting Runway 33, directly enter the 330° left downwind leg for Runway 15.
- Do not drift into the clouds. If you do, you must immediately execute a missed approach.
- The Left base leg is 240° with a 13° Left WCA. Turn final approach and land normally after configuring the aircraft for landing. Your ground speed on final will be 62 kts.
- Time: 24 minutes.

When you are in an aircraft with a full panel, i.e., two VORs and a DME, you should refly this VOR approach . It is very easy under that situation.

* * *

The Boss had a good year last year—business was up strongly. He was even considering hiring another pilot and leasing another Saab MFI-17.

It must have been a good year, because I was on my way to Bridgeport to pick up new electronics for the fleet. We were going all digital. I think Mr. Counter had something to do with that. He talked about other charter companies being more modern and maybe that's where his business belonged.

That got The Boss's attention real fast. One final leg and I'd be in Bridgeport. The weather wasn't cooperating well, but at least it was above minimums, if only barely.

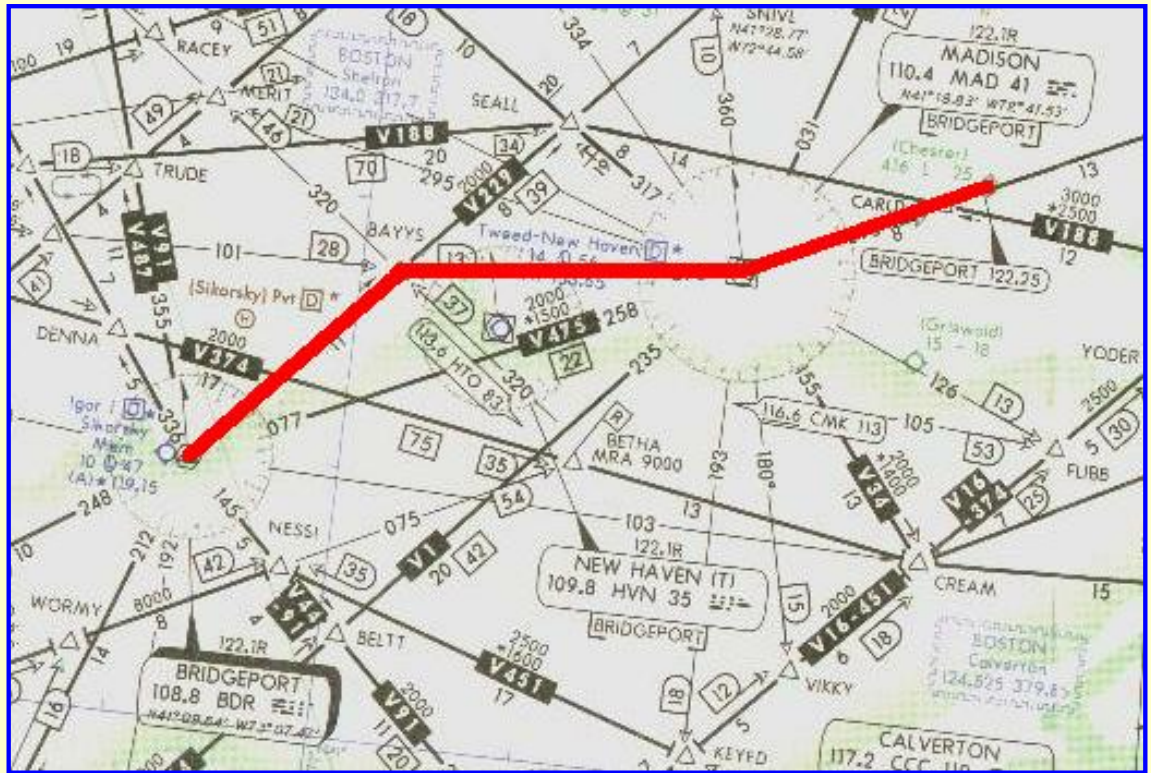
What made this flight particularly enjoyable was that I had left my pager and cellphone back home. It would be almost impossible to interrupt my schedule.

I finished the flight planning, had gotten the weather, filed an IFR flight plan for Bridgeport, and pre-flighted the aircraft. I was ready to go. The engine came up smoothly when I started it, and the

gauges all looked good. Chester is not a controlled field, so I dialed up UNICOM to announce my intentions to depart.

As I was taxiing out to the runway, UNICOM called back and asked if I could take a message from a Mr. Benjamin Counter. I reported that their transmission was breaking up, must be a bad mic., but I would check back when airborne. I opened the throttle and was quickly in the air.

Chester, Connecticut to Bridgeport, Connecticut.



Chester to Bridgeport with a VOR Rwy 24 approach.
Click on image for flight-information package.

This third flight will be easy. You've been through a host of new procedures up to this point and it's time for a VOR approach that's "fun." The flight begins at Chester airport in Chester, Connecticut with a destination of Igor Sikorsky Memorial airport in Bridgeport, Connecticut. The approach will be to Runway 24. Click on the image above to download the flight-information package, chstr-bdr.zip.

The zip-file includes the IFR chart, the approach plate for VOR Rwy 24 at Bridgeport, and this text description of the flight.

This is another VOR approach not requiring a procedure turn and also one where the FAF is a VOR intersection. We proceed from Chester airport to the Madison VOR, then to the BAYYS intersection, inbound to the MILUM intersection, the FAF, and then to the airport with a straight-in landing to Runway 24.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 600 ft overcast, cloud tops at 10,000 ft., and one mile visibility. The wind is calm.
- Select the Saab-Loc aircraft.
- Move the aircraft to Chester's Runway 17, airport 3B9, and retract the flaps to 0°.
- Tune the primary Nav. receiver to 108.8 MHz., the Bridgeport VOR, ident BDR.
- Set the primary VOR OBS to 234° for the BAYYS intersection.
- Tune the secondary Nav. receiver to Madison VOR, 110.4 MHz., ident MAD. Fly the first leg with Nav-2.
- Set the OBS to 258°. Reset the timer to zero.
- Fly Nav-2. Takeoff from Runway 17 with a climbing left turn over the airport to intercept and track 258° to MAD. ATC has cleared you to 4000 ft.
- Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- On station passage at MAD, when the FROM flag appears, turn right to magnetic course 276° and set the OBS to this number. MAD is the Initial Approach Fix, IAF, for this approach.
- Descend to 3000 ft.
- Fly Nav-1. When the primary VOR needle centers at BAYYS, turn left and track TO the VOR on the 234° heading.
- Descend to 1800 ft.
- Tune the secondary Nav. receiver to 116.6 MHz., the Carmel VOR, ident CMK.
- Set the secondary OBS to 110° for the MILUM intersection, the FAF for the VOR approach to Runway 24.
- Drop one notch of flaps and slow to 80 kts.

It's vital to stabilize the approach well before beginning your descent to the MDA.

- When the needle centers indicating MILUM intersection, the FAF, start the timer and descend to 460 ft.
- Continue tracking inbound TO the Bridgeport VOR and Runway 24.
- At 80 kts., 3 min., 08 secs. will elapse to fly the 4.7 nm. to the MAP or Runway 24 threshold.
- With one-mile visibility, Runway 24's threshold or approach lights should become visible in 2 min., 28 secs.
- Bridgeport's field elevation is 10 ft., so you will have 40 seconds to descend 450 ft. for touchdown. Slow the aircraft for a normal landing by reducing power and further lowering the flaps.
- Flight time: about 20 minutes.

* * *

This ends the VOR approaches. The next section introduces the Instrument Landing System.

Before moving on to the ILS, though, fly each approach above a second time to hone the techniques.

Click on the *ILS Basics* button to learn about the Instrument Landing System.



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What you need

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Localizer Appr.

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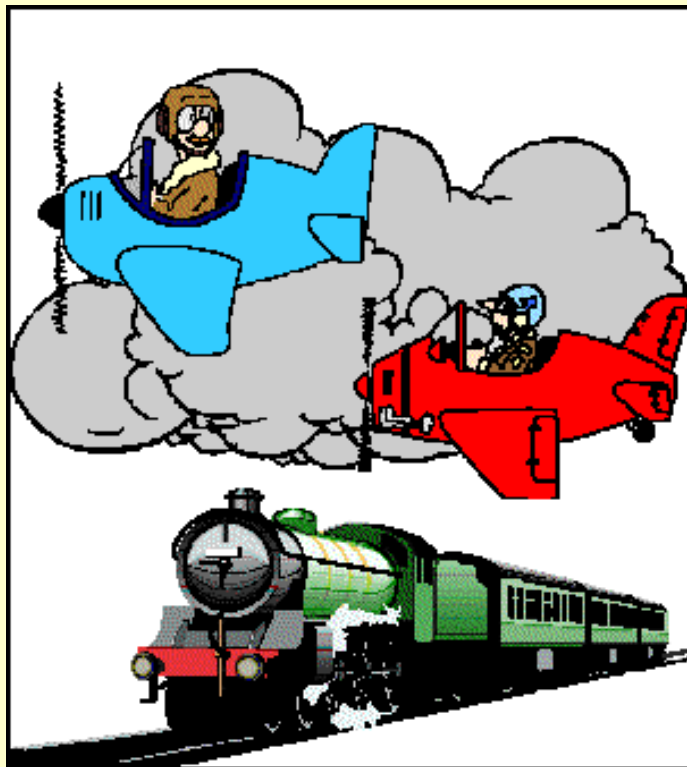
ILS Approach

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The Instrument Landing System



**Johnson, IFR does not mean
"I Follow Railroads!"**

the most sophisticated equipment it can guide you right down to the runway—zero Decision-Height and zero visibility.

If you jumped to this point of the website without proceeding through the earlier sections, I strongly recommend that you return to the [Air Navigation](#) section and review the sections on VFR Sectional Charts, IFR enroute low altitude charts, and the basics of plotting a course. Further, you should go to the [NDB Approaches/Approach Plates](#) section and read the basics of Instrument Approach Plates, now called Terminal Procedures.

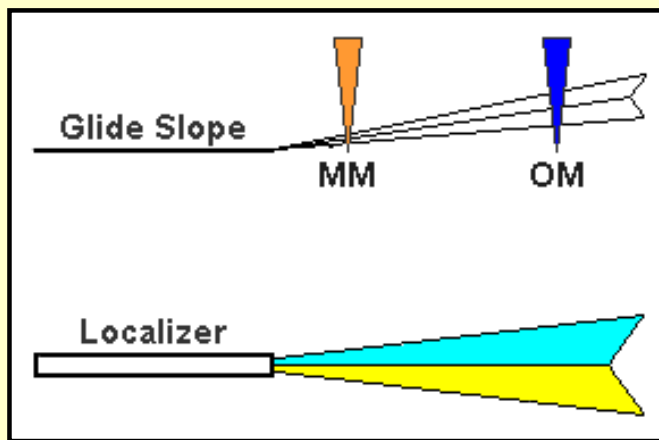
The ILS Components

When you fly the ILS, you're really following two signals: a localizer for lateral guidance (VHF); and a glide slope for vertical guidance (UHF). When you tune your Nav. receiver to a localizer frequency a second receiver, the glide-slope receiver, is automatically tuned to its proper frequency. The pairing is automatic.

Up to now, your instrument approach experience has allowed you to land in weather conditions as adverse as an overcast ceiling of 400 ft. and visibility as low as one-half mile.

NDB and VOR approaches, with their lateral guidance to the runway, greatly improve the reliability of flight schedules. But without the capability to provide vertical guidance to the runway they are limited in utility. No vertical guidance classes them as non-precision approaches.

The Instrument Landing System adds glide-slope, or elevation information. Commonly called the ILS, it is the granddaddy of them all when it comes to getting down close to the ground. In every sense it is a precision approach system and with

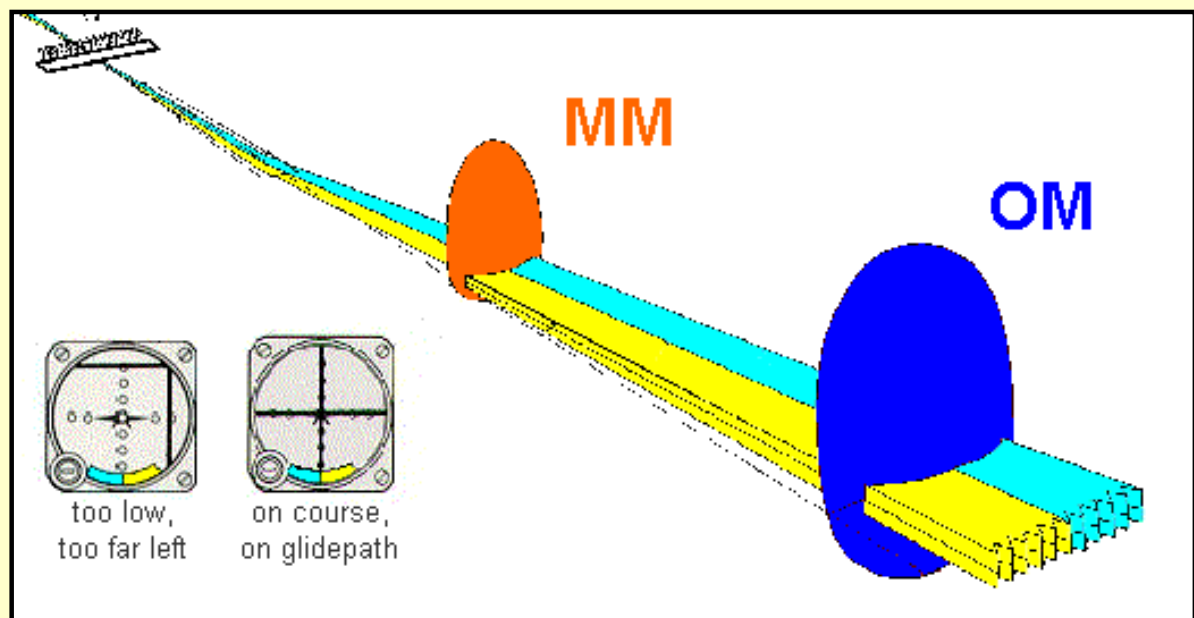


runway lights.

There's more to an ILS than the localizer and glide slope signals. The FAA categorizes the components this way:

- **Guidance information:** the localizer and glide slope.
- **Range information:** the outer marker (OM) and the middle marker (MM) beacons.
- **Visual information:** approach lights, touchdown and centerline lights,

Descriptions of the ILS components



Three-dimensional depiction of the Instrument Landing System. Early VOR indicators had the yellow and blue-colored arc as shown here, but it was later phased out because it provided no useful information. Localizer antennas shown at far end of runway.

The Localizer

The localizer signal provides azimuth, or lateral, information to guide the aircraft to the centerline of the runway. It is similar to a VOR signal except that it provides radial information for only a single course; the runway heading. Localizer information is displayed on the same indicator as your VOR information.

When tracking the localizer the pilot turns towards the needle in the same manner as with VOR navigation.



Familiar looking gauge, isn't it? Tracking inbound on the Localizer to Runway 5R, Green airport, Providence, R.I. From left to right, the aircraft is 1° Right of course, two dots (turn left to return), On course, and 1° Left of course (turn right to return). Note the absence of a TO-FROM flag.

The localizer indicator reacts differently from a VOR in several ways.

1. The localizer consists of only a single course.
2. The localizer course needle is four times as sensitive as a VOR needle. Heading adjustments must be much smaller because of the increased sensitivity of the indicator. For VOR work, each dot under the needle represents 2° deviation from course while for the localizer each dot under the needle represents 0.5° deviation from course.
3. Because the localizer provides information for only one radial, the runway heading, the Nav. receiver automatically cuts out the OBS, the Omni Bearing Selector knob. Rotating the OBS still rotates the course ring on the instrument, but has no effect on the needle.



In all three cases here, the aircraft is tracking the Localizer inbound to Providence's Runway 5R, heading 047°. Notice that the OBS is set at three different positions with no effect on the needle centering. That is a characteristic of the Localizer indicator.

Smart pilots rotate the OBS to the desired localizer heading as a reminder of where they are going, as in the first image to the left, above.

How sensitive is the Localizer? Near the Outer Marker, a one-dot deviation puts you about 500 ft. from the centerline. Near the Middle Marker, one dot means you're off course by 150 ft.

Specifics of the Localizer

1. The localizer antenna is located at the far end of the runway.
2. The approach course of the localizer is called the front course.
3. The course line in the opposite direction to the front course is called the back course.
4. The localizer signal is normally usable 18 NM from the field.
5. The Morse code Identification of the localizer consists of a three-letter identifier preceded by the letter I. Here is the localizer identifier for Providence's Runway 5R.

I-PVD



No, this is not Providence. It's the localizer antenna at Charlotte's (N.C.) Douglas Int'l airport on a murky, about-to-snow day.

The Glide Slope

The Glide Slope is the signal that provides vertical guidance to the aircraft during the ILS approach. The standard glide-slope path is 3° downhill to the end of the runway. Follow it faithfully and your altitude will be precisely correct when you reach the touchdown zone of the runway.

Think of the glide slope as a localizer laying on its side, squirting a signal 3° up into the air, and you'll have it just about right.

Tracking the glide slope is identical to tracking a localizer. If the glide-slope needle swings away from center—up or down—maneuver the aircraft towards the needle by adjusting the engine's power. Don't point the aircraft's nose up or down.



Inbound to Runway 5R, Green airport, Providence, R.I. From left to right, the aircraft is Above the glide path, On the glide path, and Below the glide path.

Remember the stable approach that we worked so diligently to obtain for NDB and VOR approaches? It's every bit as important when tracking the glide slope. Pointing the aircraft's nose up or down disturbs that stability. Changing the power doesn't.

The glide path projection angle is normally adjusted to 3 degrees above horizontal so that it intersects the MM at about 200 feet and the OM at about 1,400 feet above the runway elevation. The glide slope is normally usable to a distance of 10 NM.

How sensitive is the glide slope? It's much more sensitive than the localizer. At the Outer Marker, each dot of glide slope deviation equals about a 50-foot excursion from the prescribed glidepath. At the Middle Marker, the sensitivity is an astounding eight feet per dot.

Marker Beacons

Marker beacons are used to alert the pilot that an action (e.g., altitude check) is needed. This information is presented to the pilot by audio and visual cues. The ILS may contain three marker beacons: inner, middle and outer. The inner marker is used only for Category II operations. The marker beacons are located at specified intervals along the ILS approach and are identified by discrete audio and visual characteristics (see the table below). All marker beacons operate on a frequency of 75 MHz.

Indications a pilot receives when passing over a marker beacon.

MARKER	CODE	LIGHT	SOUND
OM	---	BLUE	400 Hz two dashes/second
MM	.-.-.	AMBER	1300 Hz Alternate dot and dash
IM	WHITE	3000 Hz
BC	WHITE	

Notice above that the sound gets "quicker" and the tone "higher" as the aircraft moves towards the airport—first dashes, then dots and dashes, finally just dots.



The Saab panel displays both the color and first letter of the marker beacon.
Click the beacon indicators to hear their tones.

The OM, 4 to 7 NM from the runway threshold, normally indicates where an aircraft intercepts the glide path when at the published altitude.

The MM, 3500 feet from the runway threshold, is the Decision Height point for a normal ILS approach. On glide path at the MM an aircraft will be approximately 200 feet above the runway.

The IM. 1000 feet from the runway threshold, is the Decision Height point for a Category II approach. See later for description of categories of ILS approaches.

BC ... Most, but not all, airports with an ILS also offer guidance on the back course. The BC marker identifies the FAF for the back course. A Back-Course approach is non-precision since there is no glide path associated with it.

The majority of problems in locating marker beacons are the availability of real estate and access to utilities.

Decision Height?

The ILS brings in a brand new term, Decision Height, or DH as you will always hear it from here on. Thus far, the altitude published in the minimums section of the approach plates that you have used has been the MDA, or Minimum Descent Altitude. When flying a non-precision approach, you are not authorized to descend below the MDA unless you can see the runway and make a normal landing.

DH has a similar meaning. The DH for an ILS approach is a point on the glide slope *determined by the altimeter* where a decision must be made to either continue the landing or execute a missed approach. That's pretty simple.

Consider the minimums, below, for Runway 5R at Green airport in Providence, R.I.

Approach minimums, Runway 5R, Green airport, Providence, R.I.

CATEGORY	A	B	C	D
S-ILS 5R	253/18			
S-LOC 5R	720/24		720/60	720 - 1½
CIRCLING	720 - 1		720 - 1¾	720 - 2

Note: For this example, the military minimums data has been omitted.

Here is the interpretation of the minimums data from the table above, for any Category A or B aircraft, i.e., $1.3 \times \text{Stall Speed}$ equals or is less than 120 kts.

- The minimums for a straight-in ILS approach to runway 5R are 253 ft. DH and 1800 ft. RVR. As you descend down the glide slope, when your altimeter reads 253 ft., you must make a decision whether to continue the descent and approach, or to execute a missed approach.
- If the Glide Slope is unavailable for whatever reason, one could fly a Localizer approach straight in to Runway 5R. In that case, with no glide slope, the approach is no longer a precision approach because no vertical guidance information is being provided. The 720 ft. on the chart is now the MDA, not the DH, and the minimum RVR has increased to 2400 ft. Here, like the VOR and NDB approaches that you have already flown, you may descend to the MDA as soon as you pass the FAF.
- The circling approach, of course, is also a non-precision approach. Its MDA is 720 ft and the minimum visibility is one mile. Notice that RVR is not used here. RVR is strictly for visibility down a runway. In a circling approach, the pilot's concern is his or her ability to keep the airport in sight while maneuvering for a runway which differs from the approach course.

Many airline carriers require Category D minimums for a circling approach even if the aircraft falls in the Category A or B range. The circling approach is difficult and raising the minimums relieves some of the stress.

Sad to say that there are air carrier pilots who refuse to accept anything other than an ILS approach due to their lack of experience with the other procedures. They would prefer to encounter a runway with unfavorable winds. Nor do they trust their "black boxes" without any experience with them on alternate approaches.

ILS Categories

For the longest time, the minimums for an ILS approach were one-half mile visibility and a 200 ft. ceiling. Then things began to change, principally the reliability, accuracy, and capability of the autopilot. RVR, a more reliable measurement of visibility, began to appear on approach plates, too.

As these changes evolved, the FAA designated three categories of ILS approaches, with successively lower minimums. Later, they decided that three categories didn't fit all of the desired situations and further expanded it. The next table shows the full range of ILS approaches.

Categories of ILS Approaches.

Category	DH	RVR	Remarks
I	200 feet	2400 feet	
I	200 feet	1800 feet	With touchdown zone and runway centerline lighting .
II	100 feet	1200 feet	Half the minimums of a standard Cat I approach

IIIa	below 100 feet	700 feet	
IIIb	below 50 feet	less than 700 feet but not less than 150 feet	
IIIc	No DH	No RVR limitation	Pray that your electronics and autopilot are reliable.

Data from Aeronautical Information Manual, *AIM*.

You'll notice that the Cat. IIIc approach is a zero-zero approach.

The autopilot is in full control of the aircraft for any approach below Cat. I. And you can't initiate a Cat. II or Cat. III approach at just any airport simply because the weather minimums require it. Those approaches, like all the others, must be approved and published.

Does lower-minimum ILS capability really buy us anything?

Good question. I suppose that the FAA keeps a myriad of statistics on aircraft landings throughout the U.S. I don't know whether that data includes statistics on the category of an ILS landing, but wouldn't it be interesting to know what percent of commercial-airliner landings are Cat. II or lower? Or even legit Cat. I? Maybe a senior captain of a major airline can write-in and tell us of his or her experience.

Of interest, though, is the progressive lowering of minimums for each type of approach for a real situation. Take a look at the next table which compares the DH/MDA and RVR for each type of approach at Green Airport in Providence, R.I.

Straight-in approach minimums for Runway 5R, Green airport, Providence, R.I. Field elevation is 55 ft.

Type Approach	DH/MDA ft.	RVR ft.
NDB	740	4000
VOR	720	2400
LOC	720	2400
ILS	252	1800*
ILS Cat. II	153	1200

* Touchdown zone identification lights and runway centerline lights are available.

The "LOC" approach is a Localizer approach which utilizes only the localizer component of an ILS. It is thus a non-precision approach with higher minimums. Localizer approaches are the first subject covered in the next chapter.

Compass Locators



Thought you'd seen the last of the RMI? Not so. Airline captains use them more frequently than you'd guess, even if seldom for an NDB approach.

It has become increasingly common to collocate a compass locator transmitter with the Outer Marker beacon. Some airports also have them with the Middle Marker and Inner Marker beacons, too. These LF NDBs serve the dual function of keeping pilots apprised of their position relative to the marker beacons and also can be navigation aids in their own right.

Compass-locator NDBs usually have a power of less than 25 watts, with a range of at least 15 miles and operate between 190 and 535 KHz. At some locations, higher powered radio beacons, up to 400 watts, are used as OM compass locators. These generally carry Transcribed Weather Broadcast information (TWEB).

Compass locators transmit two-letter identification groups. The outer locator transmits the first two letters of the localizer ident Morse code, and the middle locator transmits the last two letters of the localizer ident code. In both cases, the ident begins with the letter "I." For example, at Providence, Runway 5R:

Localizer Ident: I-PVD

OM Ident: I-PV

MM Ident: I-VD

Distance Measuring Equipment (DME)



This is a nice DME, other than the fact that I couldn't read the digits until I repainted them white.

The controls and readouts are about as evident as you'll find. Across the top is distance in NM (5.1), *ground* speed in kts (80) and the time to station in

minutes (4). This model lets you select which VOR the DME is measuring distance from—the one tuned with Nav receiver #1 (N1) as in this case, or Nav receiver #2 (N2).

The only small issue is a reminder that the distance indicated on the panel of a DME is *slant* range, not distance along the ground. The aircraft is in the air and the distance measured is from up there to the station, like the hypotenuse of a triangle, if that doesn't bring back too many bad memories. So you'll always be somewhat closer to the station than indicated by the DME.

The error is greater for short distances than large distances. For example, if you were cruising at 5000 ft. and the DME indicated 5.1 NM as in the illustration, your ground distance to the station is about 4.9 NM, a 3% error. If your DME reports 30 miles, still at 5000 ft, ground

distance now is 70 ft shorter than the slant range, an insignificant error.

Distance Measuring Equipment can be a crucial part of an ILS installation. Not only does it assist with the approach, but it can be a necessary component to guide you to the FAF to begin the approach. You'll get a chance to do some DME work in the final section of the ILS approaches.

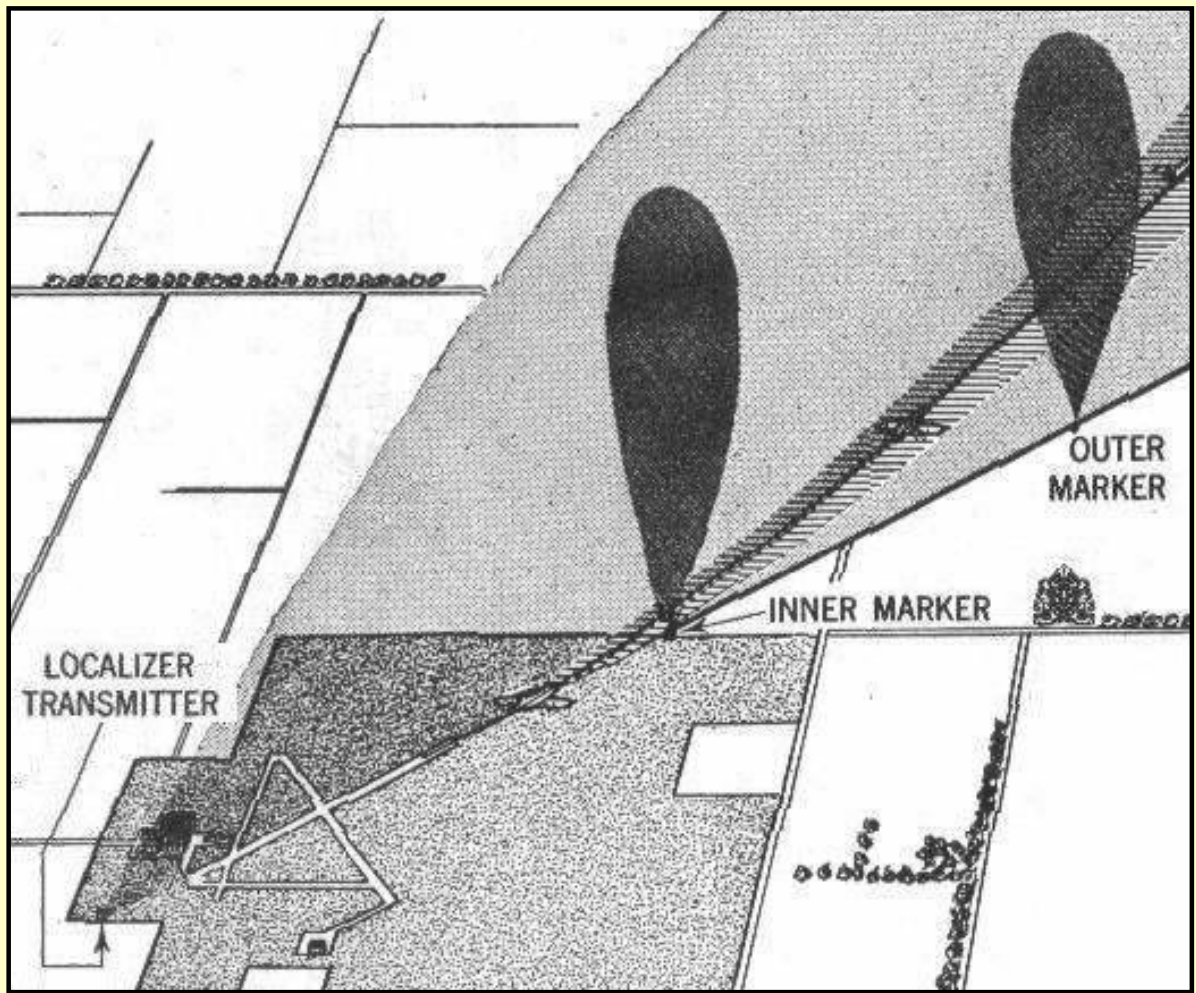
Functions of the DME in an approach:

1. When installed with the ILS and specified in the approach procedure, DME may be used:
 - a. In lieu of the OM,
 - b. As a back course (BC) final approach fix (FAF), and
 - c. To establish other fixes on the localizer course.
2. In some cases, DME from a separate facility may be used:
 - a. To provide initial approach segments,
 - b. As a FAF for BC approaches, and
 - c. As a substitute for the OM.

Early ILS

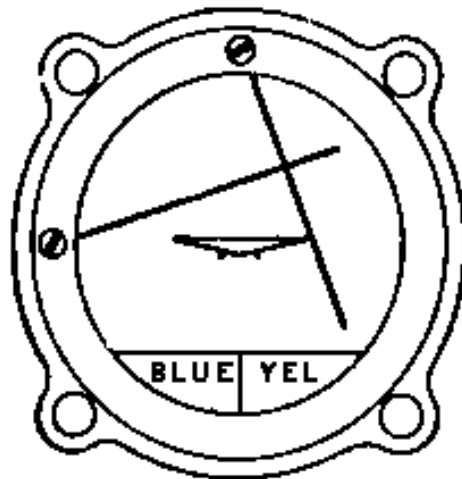
You might be surprised to learn that the Instrument Landing System pre-dated the invention and deployment of the VOR system. Test installations of VOR systems in the late 1940s quickly showed their usefulness and by the early 1950s wide-spread installation of these systems was a high priority for the FAA, then known as the CAA.

Experimental work on instrument approach and landing systems, however, had been well under way since 1928. The first ILS was installed for service tests at the Indianapolis airport in 1940.

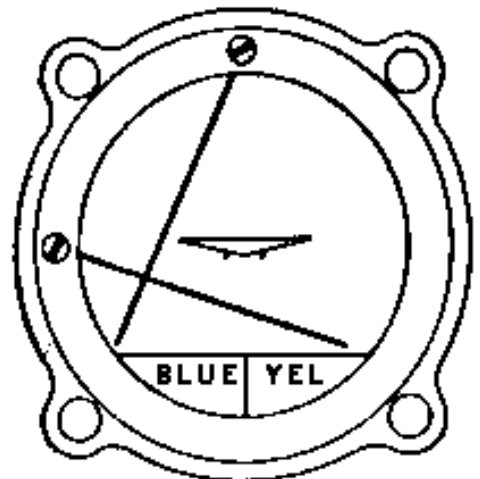


The first Instrument Landing System, Indianapolis (Ind.) Municipal airport, 1940. The only noted difference: their Inner Marker is now the Middle Marker.

Indianapolis was not chosen by accident. The CAA had consolidated its technical development facilities there in 1939, adjacent to the municipal airport. That site was the center for developing air navigation aids until 1958 when it moved to Atlantic City, N.J.



**Left of Course
Below Glide Path**



**Right of Course
Above Glide Path**

The 1940 gauges don't look much different than ours, 60 years later.

Enough, already. It's time to fly. Click on the *Localizer Approaches* button to learn about instrument approaches using the ILS Localizer signal.



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Localizer Approaches



1939. Doesn't this remind you of a simpler time? No instrument approach needed here. Sorry, no prizes for guessing the type aircraft.

You've had plenty to read so far, so we'll get right into some flights. All flights in this section end with Localizer Approaches, with no vertical guidance information provided. Thus they all are non-precision approaches, and Minimum Descent Altitudes, MDAs, will apply.

Some pilots call non-precision approaches "Dive and Drive"—"Dive" to the MDA and then you're so low that you feel you could almost "Drive" to the runway.

Five practice flights provide lots of variety on types of Localizer approaches. But it became obvious while choosing flights that the panels available up to now were too limiting on choices of Localizer and ILS approaches. So ...

You folks will be happy to learn that I have come to my senses, and added a second VOR to both the Saab-LOC and the Saab-ILS panels. I have also added two more selectable panels that include an ADF on the Localizer and ILS panels. All of these mods replace the standard compass, which no one paid any attention to anyway. No new gauges are needed; they're already in the gauge package that you downloaded with the Saab file.

If you installed any version of the Saab training panel **BEFORE** 02-Feb-00, then download and reinstall the updated trainer by clicking on "[saabmfi-mod.zip](#)". You may also access that file through the Downloads Section.

* * *

Flying the Localizer

Most of the skills learned when flying VOR approaches are applicable to Localizer approaches.

- Turn towards the needle to correct for drift—except for a Back Course approach when you do the opposite and turn *away* from the needle to correct for drift.
- Don't chase the needle.
- Establish the proper Wind Correction Angle very early in the approach.
- Stabilize the approach so that only power changes are needed for altitude changes.

The biggest difference, of course, is the four-times increase in sensitivity when tracking a localizer. Off course by one degree is a two-dot deflection on the Indicator gauge. A half-degree misalignment is one dot.

How do you correct a heading that is misaligned by one-half degree? You "kick it over." Yes, that means rudder pedals. And you kick the pedal on the side that you want to turn. Right turn. Right pedal. You simply don't bank a plane when you want to make a 1° heading adjustment.

One of the joys of flying the MS flight simulators are that the aircraft are generally very stable on heading. It's too bad the same can't be said for altitude stability. So once you have established your heading, your aircraft is likely to stay where you want it all the way down the pipe to the runway.

A joystick is the least satisfactory control when flying a localizer or ILS. It is very difficult to make small changes with a joystick. They are super in combat situations when you want to roll out of a tough situation, but not ideal for holding the localizer.

A yoke is the next step up from a joystick. It's easier to make small heading corrections with it than a joystick. The realism is more satisfying, too.

And, as mentioned, rudder pedals with a yoke is the best possible choice. Now you have the same control over your flight that a pilot flying the big iron has (and the same control as one who flies the small iron, too).

Something to think about when your tax refund arrives and you're puzzled about how to spend it.

* * *

The first flight is from Newburgh, N.Y. to the Essex Co. airport in Caldwell, N.J.

Select the "Saab-LOC" aircraft from the Aircraft menu in FS98 or FS2000 for the first three flights in this section. The instructions for the last two flights in this section include which panel to select.

You will notice on the Localizer panel that the "Primary" VOR is the single needle indicator, while the "Secondary" VOR has both Localizer and Glide Slope needles. This may seem backward, but I wanted the dots under the CDI needle to be visible. The horizontal Glide Slope needle would obscure them. In the ILS panel the dual-needle indicator is properly the Primary VOR.

Localizer approaches are very similar to VOR approaches with a few slight differences. The most noticeable will be the increased sensitivity of the needle on the localizer indicator. As already mentioned, it is four times as sensitive as when the Nav receiver is tuned to a VOR signal.

Also recall that the OBS setting has no impact on the needle. So get into the habit of setting the OBS to the localizer approach course as a reminder of where you are going. It will be one less thing to write

down or remember and it is always in front of you.

* * *

Stewart Int'l airport, Newburgh, N.Y. to Essex Co. airport, Caldwell, N.J.



Stewart Int'l., Newburgh, NY., to Caldwell, N.J. with localizer approach to Runway 22. Click the image to access the complete flight-information package.

This first flight is easy and enjoyable. The flight begins at Stewart Int'l airport in Newburgh, N.Y. with a destination of Essex Co. airport in Caldwell, N.J. The localizer approach is to Runway 22. Click on the image above to download the flight-information package, swf-cdw.zip.

The zip-file includes the IFR chart, the approach plate for LOC Rwy 22 at Caldwell, and this text description of the flight.

We proceed south-bound from Stewart, tracking to the Teterboro VOR, but intersect the localizer to Caldwell's Runway 22., before reaching Teterboro. We turn right to track inbound to Caldwell with a straight-in landing to Runway 22. We must pass a VOR intersection after the FAF before descending below 800 ft.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.



Essex County airport.

- Select the Saab-LOC aircraft from the flight-simulator aircraft list. You want two VORs for this flight.
- Set the flight simulator weather conditions to 1000 ft overcast, cloud tops at 10,000 ft., and one mile visibility. The wind is calm.
- Move the aircraft to Stewart's Runway 16, airport KSWF, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Caldwell's localizer, 109.35 MHz., ident I-CDW.
- Set the Primary VOR OBS to 223°, the localizer track to the runway.
- Tune the Secondary Nav. receiver to the Teterboro VOR, 108.4 MHz., ident TEB.
- Set the Secondary VOR OBS to the

vicinity of 190°. You will center the needle with the OBS after takeoff and track that radial until intercepting Caldwell's localizer. Fly the first leg with Nav-2.

- Reset the timer to zero.
- Takeoff from Runway 16, climbing out with a modest right turn 190°.
- Fly Nav-2. When your Secondary VOR comes alive, and warning flags disappear, readjust the OBS as necessary to center the needle. Observe that a TO flag is showing and then ident the VOR, TEB.
- Track that radial to Teterboro. ATC has cleared you to 6000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- You will intercept Caldwell's Runway 22 localizer before reaching the Teterboro VOR, about 14 min. into the flight.
- Begin your descent to 2000 ft. when the Localizer needle comes alive, i.e., when you can see movement towards the center of the gauge. Descent rate should be no more than 500 to 700 fpm.
- Note from the diagram on the approach plate that the 25 NM MSA is 3000 ft. You will intercept the localizer at about 10 NM from the field, putting you well within the 10 NM safe radius for the ILS approach. Observe that the safe radius centers on the FAF, some 5 NM before the field. Therefore you can go immediately to the altitudes shown for the approach, which is 2000 ft, until reaching the FAF.
- Ident the localizer before committing to the right turn, I-CDW.

- Fly Nav-1. Turn right to heading 223° on intercept to track in bound to Runway 22.
- Continue your descent to 2000 ft.
- Slow to 80 kts. and drop one notch of flaps.

It's vital to stabilize the approach well before beginning your descent to the MDA.

- Readjust the Secondary Nav. VOR OBS to 323°—a FROM flag should appear. When that needle centers you are at the FAF for the Runway 22 approach. Monitor its progress to keep appraised of your relative distance to the FAF.
- Maintain 2000 ft. until the FAF.
- The Outer Marker beacon will sound out dashes at the FAF, and the Blue OM light will appear on the marker beacon receiver's indicator.
- At the OM, start your timer and start your descent to the 860 ft. MDA.
- Readjust the Secondary VOR's OBS to 303°. You may not descend below 800 ft before passing this intersection, even if you have the field firmly in sight.
- Hold your rate of descent between 500 fpm and 700 fpm. Passengers in unpressurized aircraft unaccustomed to flight will be uncomfortable with higher rates of descent.
- Don't chase the needle; it will be very sensitive as you near the runway. Just try to keep it from moving.
- At 80 kts., 3 min., 59 secs. will elapse to fly the 5.3 nm. to the MAP or Runway 22 threshold.
- With one-mile visibility, Runway 22's threshold or approach lights should become visible in 3 min., 14 secs.
- Caldwell's field elevation is 173 ft., so you will have 45 seconds to descend 687 ft. for touchdown. Slow the aircraft for a normal landing by reducing power and further lowering the flaps.
- Good job; have a cup of coffee. The Boss said he'd pay for it.
- Flight time: About 25 minutes.

* * *

Manchester, N.H. to Beverly, Mass.



Manchester, N.H. to Beverly, Mass. with localizer approach to Runway 16. Click the image to access the complete flight-information package.

This flight is somewhat shorter than the first flight but a little busier during the final approach. The flight begins at Manchester airport in Manchester, N.H. with a destination of Beverly, Massachusetts. The localizer approach is to Runway 16. Click on the image above to download the flight-information package, mht-bvy.zip.

The zip-file includes the IFR chart, the approach plate for LOC Rwy 16 at Beverly, and this text description of the flight.

We proceed south-east bound from Manchester to the Lawrence VOR, then intersect the localizer to Beverly's Runway 16., making a right turn to track inbound to the airport with a straight-in landing to Runway 16. A VOR intersection is the FAF for this approach.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Select the Saab-LOC aircraft from the flight-simulator aircraft list. You want two VORs for this flight.
- Set the flight simulator weather conditions to 700 ft overcast, cloud tops at 10,000 ft., and one mile visibility. The wind is calm.
- Move the aircraft to Manchester's Runway 17, airport KMHT, and retract the flaps to 0°.

- Tune the Primary Nav. receiver to Beverly's localizer, 110.5 MHz., ident I-BVY.
- Set the Primary VOR OBS to 157°, the localizer track to the runway.
- Tune the Secondary Nav. receiver to the Lawrence VOR, 112.5 MHz., ident LWM.
- Set the Secondary VOR OBS to 145°. Fly the first leg with Nav-2.
- Reset the timer to zero.
- Fly Nav-2. Takeoff from Runway 17, climbing out with a modest left turn to intercept LWMs 145° radial. A TO flag should appear. Ident the VOR.
- ATC has cleared you to 3000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Be alert for station passage at LWM as things will get busy.
- On station passage at LWM, when the FROM flag appears, continue on your 145° heading.
- Begin your descent to 1800 ft.
- Fly Nav-1. Turn right to 157° as you intercept the Runway 16 localizer.
- Slow to 80 kts. and drop one notch of flaps.

It's vital to stabilize the approach well before beginning your descent to the MDA.

- Tune the Secondary Nav. receiver to the Boston VOR, 112.7 MHz., ident BOS.
- Set the Secondary VOR OBS to 015°. A FROM flag should appear. When that needle centers you will be at the FAF for the Runway 16 approach.
- Maintain 1800 ft. until the FAF.
- When the Secondary Nav. needle centers, from the BOS VOR, start your timer and start your descent to the 580 ft. MDA.
- Hold your rate of descent between 500 fpm and 700 fpm.
- Don't chase the needle; it will be very sensitive as you near the runway. Just try to keep it from moving.
- At 80 kts., 3 min., 45 secs. will elapse to fly the 5.0 nm. to the MAP or Runway 16 threshold.
- With one-mile visibility, Runway 16's threshold or approach lights should become visible in exactly 3 min.
- Beverly's field elevation is 108 ft., so you will have 45 seconds to descend 472 ft. for touchdown. Slow the aircraft for a normal landing by reducing power and further lowering the flaps.
- Safe landing, the runway will be wet.
- Flight time: About 19 minutes.

* * *

LDA Approach vs. Localizer Approach ... Is there any difference?

Not much, actually. If you've thumbed your way through an FAA volume of instrument approach plates you'll have noticed an occasional heading such as LDA Rwy 2, and the like. Although they're not common, you may encounter a Localizer-type Directional Aid in your FS98/FS2000 travels.

If you stay on course with a conventional localizer approach it will roll you down the centerline of the runway. That's why Cat II and Cat III ILS approaches are possible.

The LDA is the same as a localizer, but off-set from the runway heading. It provides course guidance down to a point from which you can proceed to the airport by visual references. Terrain features generally force the installation of an LDA approach system; it's the skyscraper, or 1000-ft. TV tower, or granite hill on the normal approach path that prevents using the conventional localizer.

Chester, Connecticut to Hartford, Connecticut



Chester, Conn. to Hartford, Conn. with LDA approach to Runway 2. Click the image to access the complete flight-information package.

This next flight culminates with an LDA approach. Think of it as one more way to keep final approaches from becoming too boring. It's very short and begins at the Chester, Connecticut, airport where you earlier began a flight leading to a VOR approach. We're heading in a different direction this time, to the Hartford-Brainard airport in Hartford, Connecticut.

The LDA approach at Brainard is to Runway 2. Click on the image above to download the flight-information package, chstr-hfd.zip. The zip-file includes the IFR chart, the approach plate for LDA Rwy 2 at Hartford-Brainard, and this text description of the flight.

The flight could hardly be simpler. We proceed northwest, make an easy intercept of the Runway 2 localizer into Brainard. After the FAF we cannot descend below the MDA until passing the Danns intersection, even if the field is in sight. Assume that this flight is under radar control, allowing the direct route to an intercept of the localizer.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

Remember, this is an LDA approach, Localizer-type Directional Aid, and the approach path is *not* lined up with the runway. A right turn is necessary upon reaching the runway to land. Going straight, without the turn, will bring you down onto the taxiway and into the control tower, a rather

unsatisfactory ending to a good IFR approach.

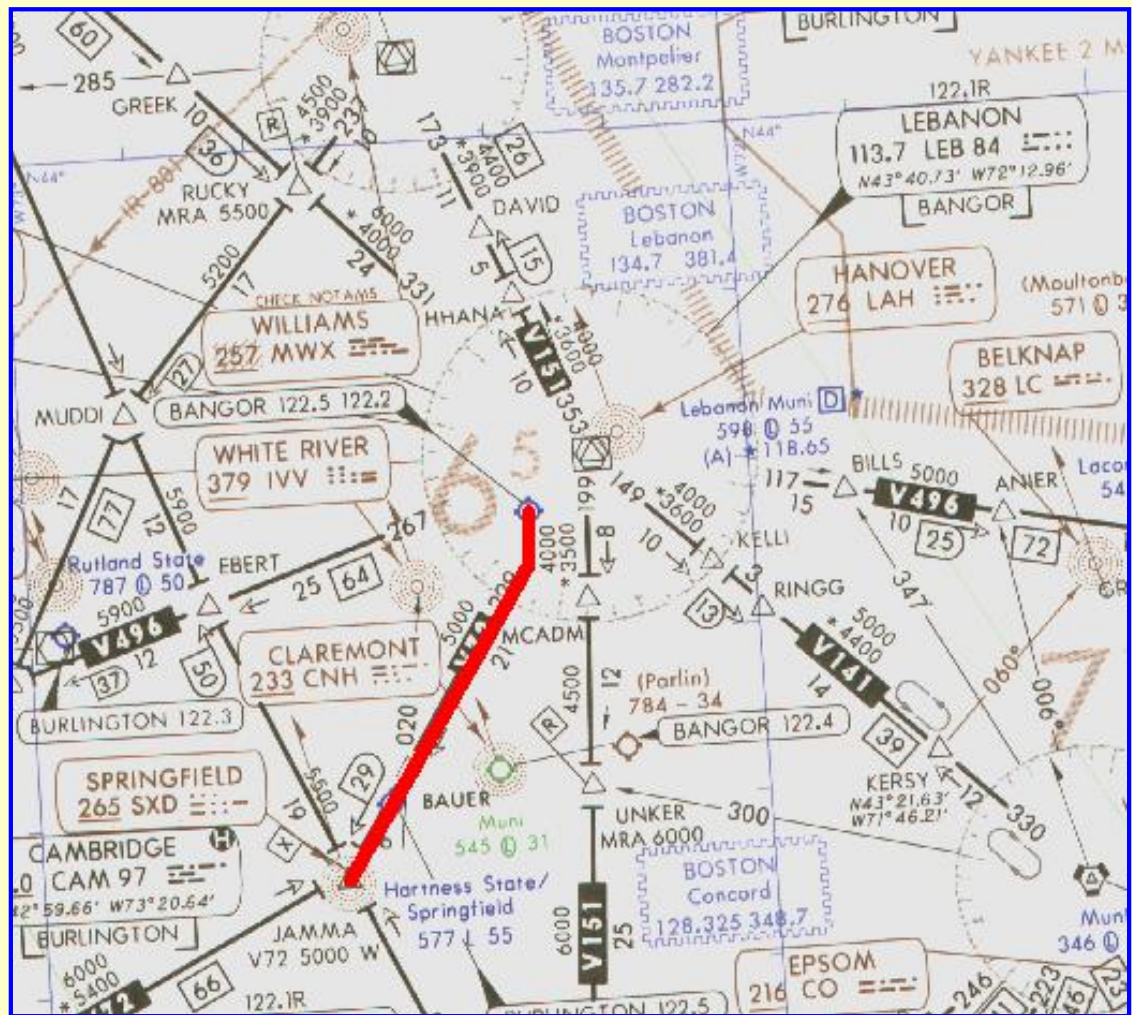
- Select the Saab-LOC aircraft from the flight-simulator aircraft list. You want two VORs for this flight.
- Set the flight simulator weather conditions to 750 ft overcast, cloud tops at 10,000 ft., and one mile visibility. The wind is calm.
- Move the aircraft to Chester's Runway 35, airport 3b9, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Brainard's Runway 2 Localizer, 109.7 MHz., ident I-HFD.
- Set the Primary VOR OBS to 002°. The Runway 2 heading is 23°, so anticipate a 21° right turn on arrival.
- Tune the Secondary Nav. receiver to the Hartford VOR, 114.9 MHz., ident HFD.
- Set the Secondary VOR OBS to 278°.
- Reset the timer to zero.
- Fly Nav-1. Takeoff from Runway 35, climbing out with a modest 10° left turn to a 345° heading to insure intercepting the localizer at a comfortable distance from the FAF.
- ATC has cleared you to 3000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Ident both the localizer, I-HFD, and the VOR, HFD. A FROM flag should be showing on the HFD VOR.
- On intercept of the localizer, turn right to 002° to track it inbound.
- Descend to 2200 ft.
- Slow to 80 kts. and drop one notch of flaps.

It's vital to stabilize the approach well before beginning your descent to the MDA.

- Watch the progress of the needle on the Secondary VOR. When it centers you will be at the FAF.
- Reset the Primary VOR OBS to 023° the runway heading. Maintain 2200 ft. until the FAF.
- When the Outer Marker sounds, and the Blue marker light appears, with the Secondary Nav. needle centered from the HFD VOR, start your timer and start your descent to the 640 ft. MDA.
- Hold your rate of descent between 500 fpm and 700 fpm.
- Reset the Secondary VOR OBS to 323°, the Danns Intersection.
- Don't chase the needle; it will be very sensitive as you near the runway. Just try to keep it from moving.
- Include the Secondary VOR in your instrument scan; you cannot descend below the MDA until passing Danns Intersection, when this needle centers.
- At 80 kts., 4 min., 03 secs. will elapse to fly the 5.4 nm. to the MAP or Runway 2 threshold.
- With one-mile visibility, Runway 2's threshold or approach lights should become visible in 3 min., 18 secs.
- One more time, this is an LDA approach. Anticipate a 21° right turn to land after sighting the runway.
- Brainard's field elevation is 19 ft., so you will have 45 seconds to descend 621 ft. for touchdown.
- Slow the aircraft for a normal landing by reducing power and further lowering the flaps.
- The Runway 2 landing threshold is displaced 410 ft. Don't touchdown early.
- Pray that, before your next arrival here, a bulldozer removes what ever terrain features prevented this from being a standard localizer approach.
- Flight time: About 15 minutes.

* * *

Lebanon, New Hampshire to Springfield, Vermont



Lebanon Muni airport, Lebanon, N.H. to Springfield, Vt. with a Localizer circling approach to Runway 23. Click the image to access the complete flight-information package.

It's time to notch up the excitement a little. This flight has several new aspects: the FAF is an NDB, the Localizer back course must be flown to set up the approach, a procedure turn is needed to get turned around, and it all ends with a localizer approach to Runway 5, then circling around to land on Runway 23.

The flight begins at Lebanon Muni airport, Lebanon, New Hampshire, with a destination of Hartness State airport, Springfield, Vermont. A localizer approach to Runway 5 and circling to land at Runway 23 ends it all. Click on the image above to download the flight-information package, leb-vsff.zip.

The zip-file includes the IFR chart, the approach plate for LOC-A at Springfield, and this text description of the flight.

Recall that if an approach plate name ends in a letter, like LOC-A, rather than a runway number, then a circling approach is required. Looking at Springfield's LOC-A approach plate, you will notice that the localizer takes you right down the throat of Runway 5; a 050° localizer course to Runway 5 which is aligned to 050°. So what's the problem with a straight-in approach to Runway 5?

Your elevation above the runway threshold is the problem. The field elevation is 577 ft. and the MDA is 1660 ft., nearly 1100 ft. above the end of the runway. That's too high to safely descend and land, thus a circling approach is called for.

We proceed south-bound from Lebanon Muni, intercept the 228° radial from Lebanon VOR, intercept Springfield's Localizer and pass over the Springfield airport. We fly outbound on the localizer and enter a standard left procedure turn two minutes after passing the SXD NDB. We return to the airport on the localizer, with SXD NDB the FAF for the approach. Descend to the MDA, circle the airport on sighting it, and land on Runway 23.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Select the Saab-LOC-ADF aircraft from your Flight-Simulator's aircraft list. This flight requires both a localizer and an ADF.
- Set the flight simulator weather conditions to 1800 ft overcast, cloud tops at 10,000 ft., and 1½ mile visibility. The wind is calm.
- Move the aircraft to Lebanon's Runway 18, airport KLEB, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to the Lebanon VOR, 113.7 MHz., ident LEB.
- Set the Primary VOR OBS to 228°, the Lebanon radial to Springfield airport.
- Tune the ADF to the Springfield NDB, 265 KHz., ident SXD.
- Reset the timer to zero.
- Takeoff from Runway 18, climbing out with a modest right turn to 190°.
- ATC has cleared you to 6000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Intercept the Lebanon 228° radial with a right turn. Observe that a FROM flag is showing and then ident the VOR, LEB.
- Track the 228° radial to Springfield. When your track and heading is firmly established, retune the Primary VOR to Springfield's Localizer, 111.3 MHz, ident I-VSF.

When your Nav. receiver picks up the Springfield Localizer you will be flying on the back course. This localizer is set up to guide you on a 050° heading to the vicinity of Runway 5 for the approach. But you will be tracking the localizer in the opposite direction, on a 230° heading. THE LOCALIZER NEEDLE OPERATES IN THE REVERSE DIRECTION WHEN YOU FLY THE BACK COURSE OF A LOCALIZER.

Instead of turning toward the needle if you drift off course, on the back course you must turn *away* from the needle.

- Adjust your heading to intercept the back course of the localizer. With no wind it should be 230°. Ident the localizer, I-VSF.
- Note the ADF needle. It should be on 230° and pointing towards the nose of the aircraft. Ident the NDB; SXD.
- Begin your descent to 4500 ft.
- Fly over the airport and continue outbound. At station passage of the NDB, when the ADF needle swings and points to your tail, start the timer.
- Fly outbound for two minutes. Continue to be aware of the reverse sensing of the needle. Reduce your speed to 80 kts.
- At two minutes enter the left procedure turn, heading 185°
- Reset and restart the timer.
- Reset the OBS to 050° the localizer heading.
- After one minute in the procedure turn, turn right 180° to 005° and return to the localizer course.
- Reset the timer.
- As the needle centers turn right to 050° to intercept and track the localizer inbound. From here in you turn towards the needle to correct for drift, being on the front course of

the localizer.

- Again, with no wind, the ADF needle should be pointing to 050° right on the nose of the aircraft.
- Drop one notch of flaps. Descend to 3500 ft.
- Keep the localizer needle centered without chasing the needle.
- At the FAF, station passage of the NDB when the ADF needle swings and points to your tail, start the timer and begin your descent to 1660 ft.
- At 80 kts., 3 min., 45 secs. will elapse to cover the 5.0 NM from the FAF to the airport.
- You should spot Runway 5 after 2 min. 38 secs. with 1½ mile visibility.
- On sighting the field, which will be nearly 1100 ft. below you, jog to the right and enter the left downwind leg to land on Runway 23.
- Descend to the 1400 ft pattern altitude then execute a normal left turn approach to Runway 23.
- Left base leg will be 320°. Land normally, being aware of the 100-ft. trees on either side of the runway.
- Give yourself a well-deserved pat on the back.
- Flight time: about 30 minutes.

Before moving to the next flight, refly this flight. It contains just about every procedure that you will encounter in a localizer approach: a back course, a front course, NDB FAF, procedure turn, and a circling approach.

* * *

The Localizer Back Course

The localizer antenna array is located at the far end of the runway, away from the approaching aircraft. Its antennas are arranged and manufactured in such a way to transmit a narrow signal on the runway approach path. That localizer signal is so accurate that with its guidance, along with the glide slope signal, an aircraft can safely land when the visibility is zero and when the ceiling is zero.

However, the Localizer antenna array also radiates a narrow signal beam in the opposite direction of the approach path. That signal is called the Localizer Back Course.

A prime advantage of the Back Course is that you get it for free. It need only be tested and certified to become available to pilots "coming in from the other direction." It is an excellent alternative to a circling approach. As you will see in the next flight, approach plates are published specifically for the localizer back course.

Too many pilots shy away from a back course approach because of the reverse sensing of the needle. On the back course, one must correct drift with a turn *away* from the needle. Keep your wits about you, though, and you will quickly master the reverse sensing needle.

The Back Course localizer approach is a non-precision approach. There is no glide-path guidance with it. Glide-path signals from the front course may be received while on the back course, but you should ignore them.



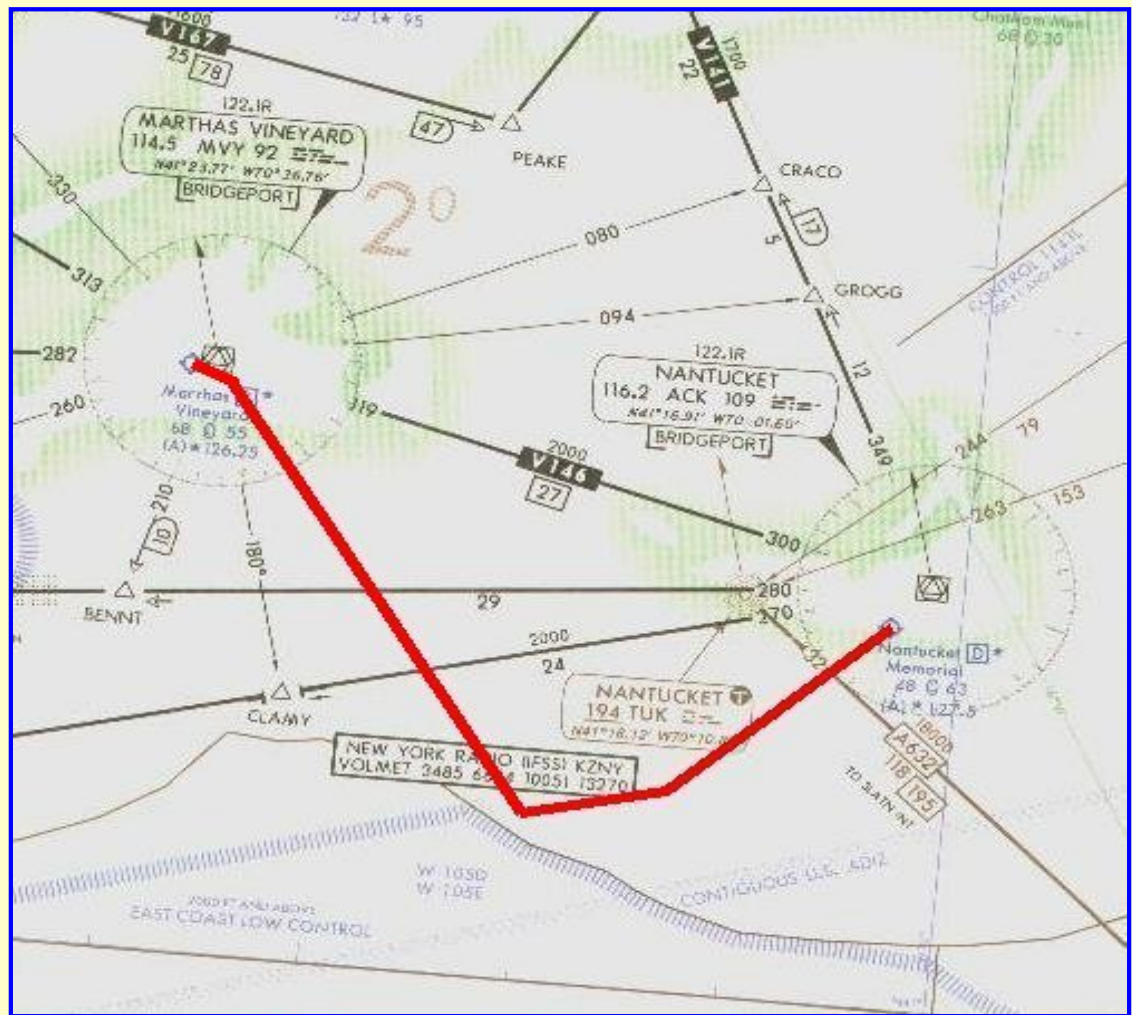
You can engage most autopilots for a Back Course approach by pressing the BC switch. That switch reverses the sensing of the autopilot so that it turns the aircraft away from the needle to correct for drift.

Although a back course localizer approach is similar to a VOR approach, it has several advantages over a VOR approach.

- It is four times as accurate as a VOR approach.
- It can provide lateral guidance precisely on heading with the runway since the localizer antennas are in front of the runway, not offset to the side like an Omni antenna must be.
- It provides a signal for a single radial, the runway heading. Hence, no OBS settings are needed nor can they be set wrong.
- When used in lieu of a circling approach, the airport minimums are lower and the approach is simpler.

You'll enjoy the variety of a Back Course approach.

Marthas Vineyard, Massachusetts to Nantucket, Massachusetts



Marthas Vineyard airport, Vineyard Haven, Mass. to Nantucket Memorial airport, Nantucket, Mass. with a Back Course Localizer approach to Runway 6. Click the image to access the complete flight-information package.

The flight route looks weird, doesn't it? Well, it was chosen for a reason. You just completed a flight with a procedure turn followed by the usual 45° intercept of the localizer inbound. As you have undoubtedly discovered by now, a 45° intercept is not all that simple. One either overshoots or undershoots when turning back onto final course, interspersed with the occasional nice roll-out on final to keep you trying harder. The only person who consistently does well intercepting at 45° is called an autopilot.

Your performance substantially improves, though, as the intercept angle is made smaller. It's amazing how much better an intercept is at 30° , for example, than 45° . ATC knows this as well as pilots, which is why they vector aircraft under radar control to a position for a 30° localizer intercept.

That is the intent of this unusual route from Martha's Vineyard to Nantucket, to put you on a flight path for a 30° localizer intercept, as if under radar control.

This final flight in the Localizer section is a nice relief from the previous flight. It is a simple departure from Martha's Vineyard, with a turn at an intersection to put us on course to intercept the back-course localizer to Nantucket's Runway 6. Click on the image above to download the flight-information package, mvny-ack.zip.

The zip-file includes the IFR chart, the approach plate for LOC BC Rwy 6 at Nantucket, and

this text description of the flight.

We proceed south-bound from Marthas Vineyard airport after intercepting the 159° radial from Martha Vineyard's VOR. Fly 21 NM to an intersection, turn left to 091° to intercept Nantucket's Back-Course localizer to Runway 6, and land. That's it! Of course, we have to be constantly aware that we are flying the back course localizer and that the needle senses in the reverse: one must turn *away* from the needle to return to course.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Select the Saab-LOC aircraft from the flight-simulator aircraft list. You want two VORs for this flight.
- Set the flight simulator weather conditions to 450 ft overcast, cloud tops at 10,000 ft., and one mile visibility. The wind is calm.
- Move the aircraft to Marthas Vineyard's Runway 15, airport MVY, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Marthas Vineyard VOR, 114.5 MHz., ident MVY.
- Set the Primary VOR OBS to 159°.
- Tune the Secondary Nav. receiver to the Nantucket VOR, 116.2 MHz., ident ACK.
- Set the Secondary VOR OBS to 249°.
- Reset the timer to zero.
- Fly Nav-1. Takeoff from Runway 15, climbing out on a 135° heading. Be prepared to intercept the very near 159° radial of MVY.
- Intercept and track the MVY 159° radial southbound. The Primary VOR should show a FROM flag. Ident MVY.
- ATC has cleared you to 5000 ft. Climb at 90 kts. and cruise at 120 kts.
- After the "off" flags disappear from the Secondary VOR, ident the VOR, ACK.
- Fly Nav-2. Keep the Secondary VOR in your scan. When that needle centers, turn left to a 091° heading.
- Begin your descent to 1700 ft.
- Slow to 80 kts.
- Retune your Primary Nav. Radio to Nantucket's Localizer, 109.1 MHz.,
- Ident the Localizer, I-ACK.
- Retune your Secondary Nav. Radio to Marthas Vineyard VOR, 114.5 MHz., ident MVY.
- Keep track of the Primary VOR for an intercept of Marthas Vineyard Localizer when the needle centers.
- Fly Nav-1. On intercept of the localizer, turn left to 061°.
- Drop one notch of flaps. You should be level at 1700 ft.

It's vital to stabilize the approach well before beginning your descent to the MDA.

- Stay on course with minor heading adjustments away from the needle. You are on the localizer Back Course.
- When the Secondary VOR needle centers, at the FAF, descend to 380 ft.
- At 80 kts., 3 min., 22 secs. will elapse to cover the 4.5 NM from the FAF to the MAP.
- You should spot Runway 6 after 2 min. 38 secs. with 1 mile visibility.
- Continue your approach to Runway 6 and land normally.
- Not so bad, was it? It will probably be your best landing after doing the others. A back-course approach is a nice alternative to what might otherwise be a circling approach, nobody's favorite.

- Flight time: About 22 minutes.

Refly this short flight to hone the back-course skills further.

* * *

This is the end of the localizer approaches. You've flown five of them and your last ones should have been pretty good. With this experience behind you, go back and fly the five approaches one more time. You'll be pleased at how well you do.

The next piece in the ILS approach is flying the Glide Slope. Click the *Flying the Glide Slope* button below to get started.



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Flying the Glide Slope



Wouldn't it be great to be in this front office?

The five Localizer approaches in the previous section were an excellent beginning to mastering the ILS. That experience, especially if you flew each approach twice, greatly reduces the distraction of tracking the localizer while learning full ILS approaches.

However, you must proficiently accomplish one remaining task before you're ready to fix your eyes on the glide slope needle and descend the slippery slope to the runway.

The standard glide slope for an ILS approach is 3° . To maintain that 3° descent you must know the rate of descent needed for any ground speed, otherwise your ILS approaches will be very unsatisfactory.

Knowing the descent numbers is not enough. You must also be able to accurately maintain the desired rate of descent.

Stay with us and we'll resolve both problems.

First, here are the rates of descent for various ground speeds for a 3° glide slope.

Rates of descent for 3° glide path vs. Ground Speed.

kts	55	60	65	70	75	80
fpm	292	318	345	371	398	424
est.	275	300	325	350	375	400

Note first: the higher the ground speed, the higher the descent rate to stay on the 3° profile.

The fpm row, feet per minute, shows the actual rates of descent needed for various ground speeds appropriate for the Saab MFI-17. For example, at 80 kts. ground speed, your Saab must descend at 424 fpm to remain perfectly aligned with a 3° glide slope.

Well, the 424 fpm number, along with the other rates of descent in that row, show that calculators are alive and well. But few mortals could memorize that row of numbers, let alone recall them when mucking about in the soup just prior to an approach.

It's time for another rule of thumb: Multiply the ground speed, in knots, by five and you will have a usable number for the correct rate of descent, in feet per minute.

Note the row in the table labeled "est." That is the ground speed multiplied by five. Those numbers are a little lower than the actual fpm's needed, but are within about five percent so only a little tweaking will be needed to stay on the glide slope. Furthermore, those numbers keep you on the "high" side of the glide slope, a better place to err than the "low" side.

And that is the key to a good ILS approach: "only a little tweaking is needed."

We've beaten around the bush on this Ground Speed thing. The air speed is not what's of interest in this calculation, it's the ground speed that counts. So if the TAS is 80 kts as it should be for the Saab on approach, and your headwind component is 15 kts., then ground speed is 80–15 or 65 kts., times five would be a rate of descent of 325 fpm.

Sorry, a lot of words to say that rate of descent equals five times the ground speed.

Practice, Practice, Boring, Boring

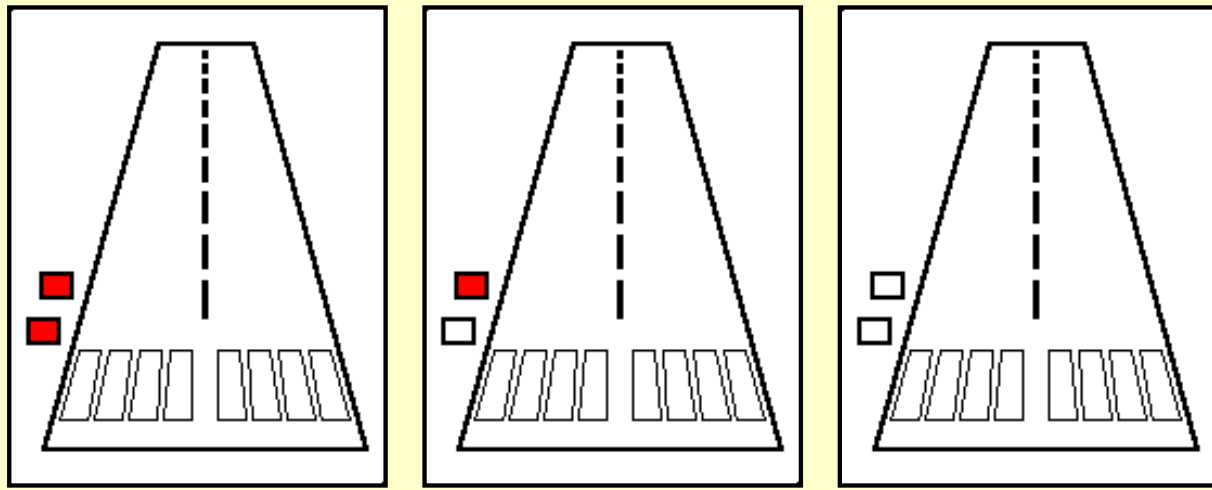
Not today. We're going to practice setting and maintaining the proper glide-slope rate of descent by flying the VASI in brilliantly clear VFR weather—at six different airports with only a few keystrokes to move from one airport to another. You jet jockeys flying the big iron can even participate if you promise to keep your fingers, err, ah, mouse, away from the autopilot.

VASI System

Most runways with a published IFR approach are equipped with lights that help pilots determine if they're on the proper descent path during the final stages of approach and landing. The most common system is the VASI, or Visual Approach Slope Indicator.

VASIs come in several varieties, but a typical system includes two sets of light bars placed on the left side of the runway, one nearer the landing threshold than the other. Lenses split the light into red and white beams.

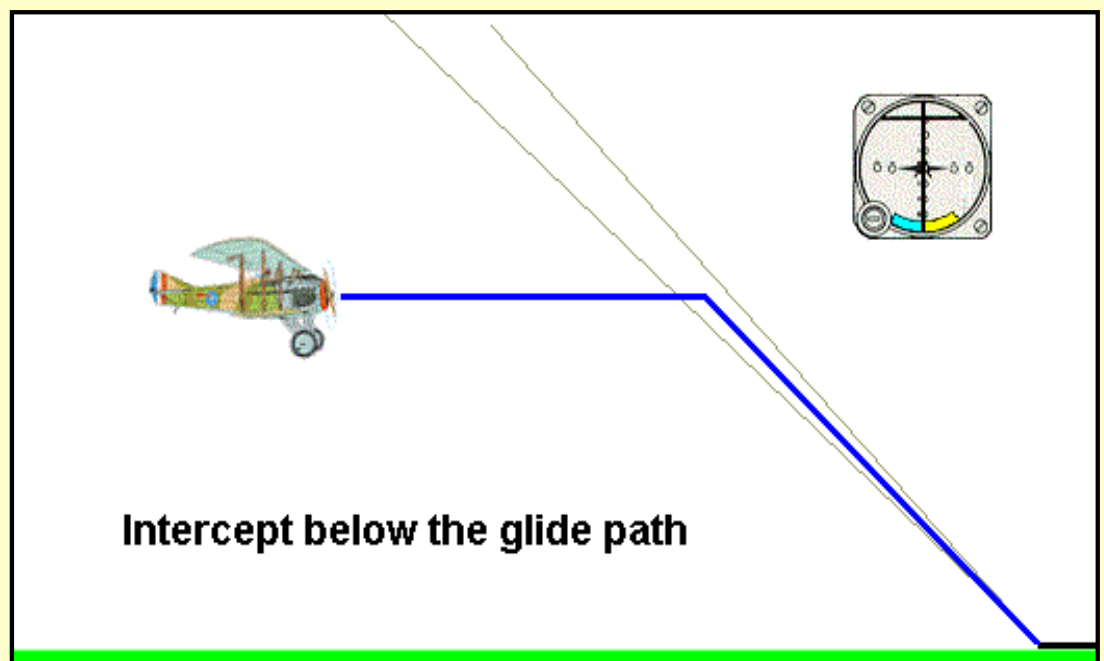
Three combinations of lights exist with this arrangement. If you're approaching the runway on the proper glide path, usually a three-degree slope, you'll see a red light above a white light.



Left, "Red over red, you're dead," approach is low. Center, "Red over white, you're all right," approach is perfect. Right, "White over white, you'll fly all night," approach is high.

Intuitively, of course, one understands that red-red is "danger," or low, and then the others take care of themselves.

Intercepting the Glide Path



The preferred method to intercept a glide path, whether the ILS Glide Slope or the VASI lights, is from below. Two reasons for this.

Intercepting a glide slope from above involves shifting from the rate of descent used to intercept to the rate of descent to maintain the glide slope. For most that is a more difficult maneuver than flying level and beginning a descent when intercepting the glide slope. Why complicate your life when all you need do otherwise is concentrate your attention on a proper ILS approach?

The glide-slope beam "thickness" is 1.4° but false lobes can exist above the glide path. An aircraft might intercept one of these erroneous signals when intercepting from above, leading it to the runway

on an improper glide path.

So do it the easy, error-free way. Fly level, intercept the glide path, then begin and stabilize the rate of descent.

Aiming Point

While VASI lights are a useful aid for controlling the slope to the runway, you must also have an aiming point. The aiming point is the point where the airplane would impact the runway if you don't initiate a flare.

Flight-simmers love the long, straight-in approach. It seems so much simpler than the standard entry into a downwind leg where it's necessary to keep the runway in sight during the turn onto base leg and the turn onto final.

The straight-in approach also eliminates the needless bother of determining entry, downwind and base-leg headings, of determining wind correction angles for each of those headings, and of determining which approach is standard for the desired runway, left-hand or right-hand turns. Gone, too, is the worry of how far away from the runway to fly the downwind leg and when to turn base-leg.

In fact, standard procedure landings, with turns onto base leg and final, are easier than long approaches because everything happens so much closer to the airport where you can see and judge better. It's unfortunate that FS98/FS2000 visibility limitations discourage pilots from becoming proficient in those fun-type landings.

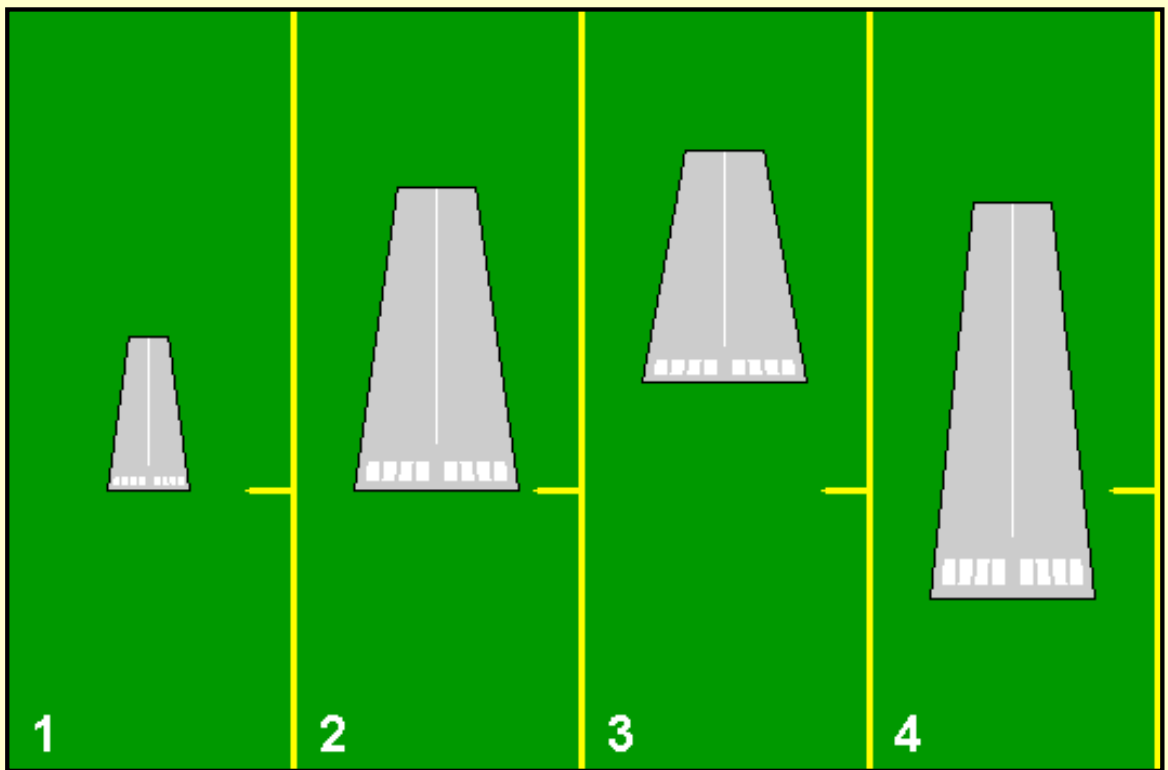
All of that aside, most IFR landings follow a long, straight-in instrument approach. The aiming-point technique will improve all of your landings, whether long, straight-in approaches, or the standard procedure landings. Once the landing becomes visual it will accurately get you to the threshold of the runway.

Begin by focusing your attention on the threshold end of the runway, an easily discernible point in FS98/FS2000. The object is to adjust your rate of descent so that the aiming point does not move during your entire approach to land. It only gets bigger as you get closer.

A china marker pencil will be useful until you have a few landings under your belt using this technique. You'll practice this in the VFR landings with the VASI, but in actual IFR approaches you'll use this technique as soon as the runway becomes visible.

After you begin your descent down the glide-path and everything is fairly stable, pause your FS and mark a line on the monitor beside the approach end of the runway, to emphasize your aiming point. Then continue your approach. The end of the runway must not stray from the line you drew on the screen.

If you have set your rate of descent precisely correct, it will be as if you're suspended in air; there will be no movement of the runway as you approach. It will almost be eerie. Any movement of the approach end of the runway signifies that the point of your actual landing will differ from your point of intended landing. Here are the possibilities:



1. Aiming point established at yellow mark.
2. No movement of the runway threshold as you near the airport. The rate of descent is perfect.
3. The runway threshold is creeping up the screen as you approach. The landing will be short, the rate of descent is too high. Pray that there are no schools or hospitals below.
4. The runway threshold is creeping down as you approach. The landing will be long, the rate of descent is too low. Pray that no 20-story condos are at the end of the runway.

Once you alert your senses to be aware of any movement of the runway threshold, this becomes a very natural technique to use when landing.

Remember to adjust rate of descent with power, not by changing the position of the yoke. Consider this ancient aviation proverb:

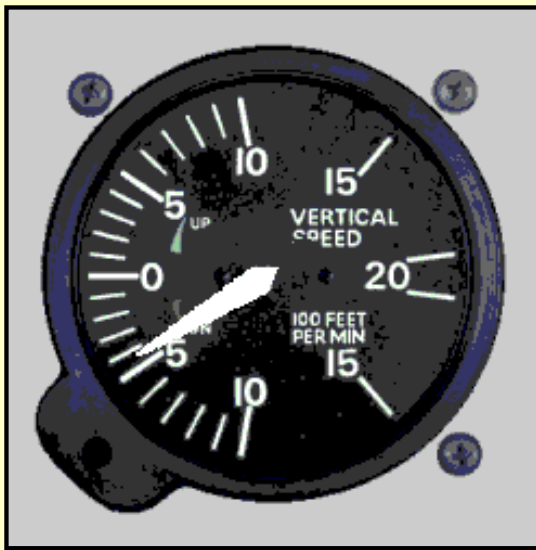
If you want to go up, pull back on the yoke.

If you want to go down, pull back a little more.

If you want to go down real fast and spin around and around and around, just keep pulling back.

Actually, the technique to control rate of descent on the glide slope is controversial. See the discussion on this a little farther down the page.

Why don't I just set the rate of descent with the VSI?



Because the VSI, the Vertical Speed Indicator, *lies* to you. It does a very nice job of telling you what happened the day before yesterday, but is about the least reliable gauge on your panel at telling you what's happening now.

Try this little experiment. Trim your Saab for straight and level flight, about 100 kts. IAS. The VSI should show zero. Now shove the nose down ten degrees, watch the VSI, then pull the nose ten degrees above the horizon. The VSI needle is all over the place.

The VSI does a good job of reporting stable conditions, straight and level flight or a constant, unvarying climb or descent. But it is of little use while

the attitude of the aircraft is changing.

If the VSI has so little value, why put it on the panel?

Didn't say that it was of little value. It is excellent at reporting stable settings, which is what IFR flying is all about. Stable settings.

Holding the Glide Slope—Throttle or Pitch?

Student pilots learn early in their flight training that the throttle controls rate of descent, or climb, while the yoke, or pitch, controls airspeed. Few people argue with that, although there is some interaction between the two controls. But it's a nice simple, nearly fool proof technique.

There are times to do this backwards, though. For example, if one is flying straight and level and the altitude has drifted low by 15 feet, an ease-back on the yoke to regain that small altitude is an appropriate technique.

Midway through this ILS section, I started to get some feedback on holding the glide slope with pitch, or attitude, and airspeed with throttle, rather than the other way around. I went to some experts and the consensus was right down the middle. Half said throttle for rate of descent, the other half said pitch, or yoke.

I got a lot of good information when I posted the question on an aviation newsgroup. Here are my conclusions, taken from many responses.

- Learn the proper power setting to hold the glide slope. The following VASI approaches will help you do just that.
- Intercept and descend down the glide slope, using the throttle to control your rate of descent.
- If you are drifting *above* the glide slope, very slightly reduce the throttle and note the RPMs that most closely keep you on the glide slope.
- If you are drifting below the glide slope, slightly ease back on the yoke to "quickly" return to the glide slope, then slightly increase the RPMs to stay on the glide slope. Allegedly, there is safe altitude below you when descending the glide slope, unless otherwise noted on the approach plate. But, in fact, obstructions below you, such as TV towers or tall buildings, can be frighteningly close. So don't tarry when below the glide slope. Pitch control is a quicker reaction than power control.
- Flying a jet vs. a prop plane makes a big difference. In a jet, many seconds can elapse between

the time that you advance the throttles and a noticeable power increase (or decrease) occurs. A prop plane, on the other hand, responds much more quickly to throttle adjustments. So, when flying a jet, track the glide slope with the yoke, or pitch control, because you want immediate response.

Things happen so much more quickly in a jet. In the early days of jet travel, a jet crashed on an ILS approach. The pilot, with a gazillion hours in propliners, did the natural thing, and advanced the throttles when he started to drift below the glide path. By the time the engines responded, some ten or fifteen seconds later in those days, he was scraping the ground.

- So bottom line:
 - a. In prop planes, throttle to control rate of descent. If high, slightly decrease the throttle.
 - b. When below the glide path, responsively return to the glide path with the yoke, then slightly readjust power to stay there.
 - c. In jets, because events occur so swiftly, pitch control to maintain the glide slope.

VASI Approaches

Let's fly some VASI approaches. Here are six which will help your glide slope work.

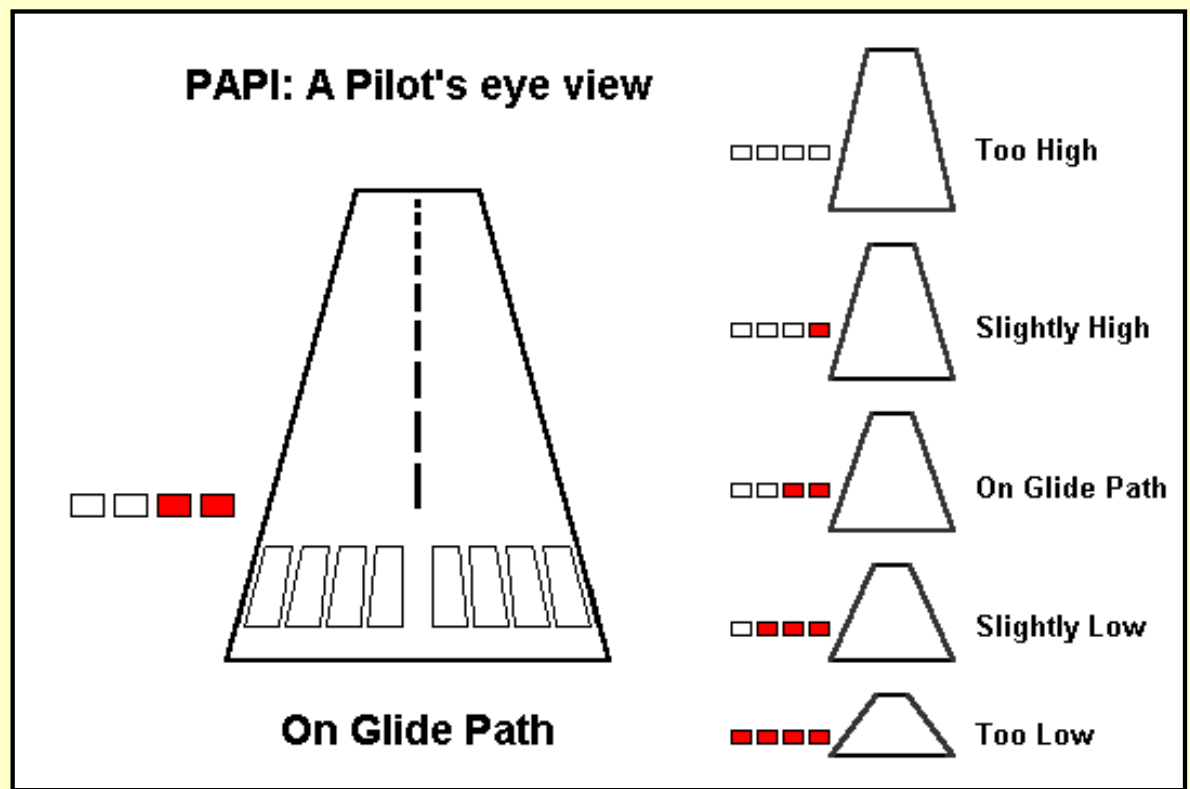
The VASI Approaches—all are 3.0° glide path.

	City	Rwy	Head Wind	Intercept Alt.	Hdg	Loc. MHz.	Type	RPM
1.	Schnectady SCH	4	--	2010	040°	109.7	VASI	
2.	Providence PVD	23L	--	1930	227°	109.3	VASI	
3.	Worcester ORH	29	290° @ 15 kts.	2920	289°	110.9	VASI	
4.	White Plains HPN	16	--	2050	162°	109.7	PAPI	
5.	Boston BOS	4R	--	1720	036°	110.3	PAPI	
6.	Keene EEN	2	020° @ 20 kts.	2590	018°	108.9	PAPI	

Click here to print the full [VASI approach information](#).

PAPI: VASI, but a notch better

Actually, only three of the approaches in front of you rely on the VASI; the other three use the PAPI. PAPI, the Precision Approach Path Indicator, as its name implies, vertically guides you to the runway with a narrower beam of light, thus more precisely. Here is the PAPI in pictorial form.



The familiar red and white lights have the same meaning as with the VASI, but the PAPI places them side-by-side rather than front-to-back.

Since the PAPI system uses a narrower beam of light you must fly the glide path more precisely than the VASI to stay on the beam. You really have to stay on your toes when flying the VASI because there is no indication that you are drifting off the glide path until the lights switch to red-red or white-white. You may find yourself flying an S-slope down to the runway: bump the white-white, descend and bump the red-red, climb and bump the white-white, etc.

The PAPI, with its extra lights, forewarns you when you are drifting from the desired glide path. If you see three reds or three whites, slightly off the glide path, it's time to take the necessary action to stop the drift. Minor power adjustments should do it and knowing the correct RPM for the desired rate of descent puts you a jump ahead of the game, where the lights are determined that you shouldn't stay between them. It's actually rather fun. You feel as if you've beaten the system when you slide all the way down the glide path with the PAPI lights properly remaining white-white-red-red.

The approaches that you will fly begin 4.0 NM before reaching the FAF. This provides 3 minutes to identify the localizer and to stabilize the aircraft in straight and level flight on the localizer heading. All speeds are 80 kts., with one notch of flaps dropped.

The intercept altitudes shown are taken from the approach plates for an ILS approach to the same runway. They are your expected altitudes as you cross the Outer Marker. These altitudes will differ from the approach altitudes shown on your approach plates. The intent here is to descend using the VASI rather than fly a full approach.

Intercept the descent path when the Outer Marker sounds, dashed tones, and a blue indicator light illuminating on the instrument panel. In most instances, the VASI lights will *not be visible* from the Outer Marker on FS98/FS2000. Don't worry, start the planned descent at the Outer Marker. The VASI will pop into view very shortly.

Note the RPM column at the end of the table. Record the engine RPM here for each flight after you have achieved a stabilized descent down the glide path. The point is to learn what engine RPM provides the proper rate of descent for your aircraft in the approach configuration of 80 kts., and one notch of flaps lowered. Then when you fly the full ILS you reduce your engine power to this RPM setting when intercepting the glide path. The RPM numbers are in the vicinity of 1700 for approach and 1350 for 400–450 fpm descent.

Digital Tachometer

I just recently added a digital tachometer readout to the four ILS and LOC panels. This will greatly assist in setting the desired rate of descent for VASI approaches and for flying the ILS. If any of those panels are missing the digital tach readout, either install the patch by clicking [tach.zip](#), or reinstall the entire aircraft if your existing version is older than 01-Feb-00, by clicking [saabmfi-mod.zip](#).

To minimize porpoising, smoothly reduce the RPMs when throttling back to descend. The digital tach readout above the main VOR gauge allows you to precisely set the desired RPMs.

Point of View

FS98/FS2000 has a tab position to change your point of view of what is in front of the windshield. The system defaults at 1.00, but many pilots who fly in "real time" feel that a value of 1.5, which magnifies the view, is more realistic. Their rationale is that it is equivalent to focusing your eyes on a specific target, such as a runway, vs. taking in the broader picture like viewing mountains.

I prefer the 1.5 view, but it is a subjective thing. Try both then, for all flights, stick with the one that you like best. The VASI lights are definitely easier to see in the 1.5 view mode. Alt View/Options then enter zoom.

Here are the steps for the VASI approaches.

- Click here to print the full [VASI approach information](#) for use while flying. The printed version is necessary. In addition to the information in the table above, it contains the FS98/FS2000 setup information for each approach.
- Select the Saab-LOC-ADF aircraft in the FS Aircraft menu. We will fly the localizer by the gauge, but the glide path by the VASI and so don't need the glide-slope needle yet, or even want it visible.
- Turn off Autopilot—this is important. Aircraft may crash trying to return to settings previously saved by the autopilot.
- Set Zoom to 1.50 ... View/Options.
- Go to "World/Weather" to set the weather conditions: visibility to "unlimited," clouds to "haze only," and the wind to "0 knots."
- Get your Saab airborne from any airport, and then trim it out to 80 kts. straight and level, with one notch of flaps set in. Headings and altitudes don't matter now because you will set them in later for each approach.
- Approximate engine settings for 80 kts. with one notch of flaps: 1750 RPM, level flight; 1400 RPM, 400 fpm descent.
- Set the Nav to the localizer frequency shown in the table, and set the OBS to the heading in the table.
- If a head wind is indicated in the table, go to "World/Weather" and set in the appropriate wind numbers.
- Go to "World/Go To/Exact Location" to set in your latitude and longitude, heading and

altitude information for each approach.

- Save the FS Program, marking it as your default so that it will return to these conditions the next time you open FS.
- Start planned descent rate at the OM even if VASI/PAPI lights are not yet visible. Use the digital tach readout above the VOR to set the desired rate of descent.
- Fly and enjoy! Don't let the red-over-white VASI indication slip away.
- Trim for 80 kts., if necessary, with the digital elevator trim.
- Scan all flight instruments during the descent; don't let the airspeed wander from 80 kts.
- Pay close attention to the RPMs, keeping them where they belong.
- Press "Shift-Enter" to raise view of ground, if needed and "Shift-Backspace" to lower view.
- Record the engine RPM in the table for the stabilized descent down the glide path.
- To repeat a flight, press "Ctrl – ;" to return to its beginning point.

Flying the Glide Slope

You're now ready to fly the glide slope. The glide-slope needle flies identically to the localizer needle; no adjustments on the gauge affects the needle position. You fly towards the needle to correct for an off-course indication. The illustrations below show the three possible vertical situations when flying the glide path.



On the left, both needles are centered, aircraft is on glide path and localizer. Center, glide-slope needle is high, you are below the glide-path and must fly *up*, toward the needle to return. Right, glide-slope needle is low, you are above the glide-path and must fly *down*, toward the needle to return.

The deviation of the glide-slope needles is exaggerated in the illustrations. Don't let them get that far off of center. Like the Localizer needle, react promptly when you see needle movement away from center. The object is to stop the needle movement. Don't fret for the moment that you might be a needle-width off of center. Get the needle stopped, by adjusting power. Once you're satisfied that the needle is stopped, then make a tiny power correction to return the needle to center.

Think small when flying the glide slope. All adjustments should be small. Some pilots advocate a jog of the yoke to return the aircraft to the glide slope but this is likely to mess up the stability that you've worked so hard to establish. Try to adjust only with the throttle.

Six Glide Slope flights

Guess what? You're going to repeat the six flights that you just completed with the VASI/PAPI, but flying the glide slope needle.

The table below summarizes these flights and flight conditions.

The Glide Slope Approaches.

	City	Rwy	TDZE	Head Wind	Alt.	Hdg	LOC	Ident	Vis. mi.	Ceiling ft.	DH
1.	Schnectady SCH	4	338	--	2500	040°	109.7	I-SCH	3/4	650	555
2.	Providence PVD	23L	51	--	2100	227°	109.3	I-ARJ	1/2	350	251
3.	Worcester ORH	29	991	290° @ 15 kts.	3000	289°	110.9	I-EKW	3/4	1300	1191
4.	White Plains HPN	16	439	--	2100	162°	109.7	I-HPN	1/2	750	639
5.	Boston BOS	4R	18	--	1800	036°	110.3	I-BOS	3/8	320	218
6.	Keene EEN	2	488	020° @ 20 kts.	2600	018°	108.9	I-EEN	1	920	823

Here are the steps for the Glide Slope approaches.

- Click here to print the full [Glide Slope approach information](#) for use while flying. The printed version is necessary. It contains all of the information in the table above plus the FS setup information needed for each flight.
- Click here to download the zip file with the six approach plates needed for the flights. They are 300 dpi GIF files; print with one-inch margins and the size will be accurate. [Approach Plates for Glide Slope flights](#).
- Select the Saab-ILS aircraft in the FS Aircraft menu.
- Turn off Autopilot—this is important. Aircraft may crash trying to return to settings previously saved by the autopilot.
- Go to "World/Weather" to set the weather conditions to the ceilings and visibilities shown in the table. Set the cloud tops at 10,000 ft. If a head wind is indicated in the table, enter that data while there, too.
- Get your Saab airborne from any airport, and then trim it out to 80 kts. straight and level, with one notch of flaps set in.
- Approximate engine settings for 80 kts. with one notch of flaps: 1750 RPM, level flight; 1400 RPM, 400 fpm descent.
- Set the Nav to the localizer frequency shown in the table, and set the OBS to the heading in the table.
- Go to "World/Go To/Exact Location" to set in your latitude and longitude, heading and altitude information for each approach.
- Save the FS Program, marking it as your default so that it will return to these conditions the next time you open FS.
- Begin your descent when the glide slope needle center. Use the RPMs established from the VASI flights for descent.
- Use the digital tach readout above the VOR to set the RPMs.
- Fly and enjoy! Don't let the glide-slope needle slip away, but don't chase it, either.

- Trim for 80 kts., if necessary, with the digital elevator trim.
- Scan all flight instruments during the descent; don't let the airspeed wander from 80 kts.
- Pay close attention to the RPMs, keeping them where they belong.
- To repeat a flight, press "Ctrl –;" to return to its beginning point.

This is the end of flying the glide slope. We're at the point that most flight-sim pilots were waiting for: the full ILS approaches. Well, all you have to do is click the *ILS Approaches* button below to get there.



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Flying the ILS



Although it looks like a DC-3, it's a DC-2. Douglas Aircraft Company manufactured only 156 DC-2s before introducing the DC-3.

An ILS is an ILS is an ILS.

Well, not exactly. Here follows eight ILS approaches, each differing from the other in some manner. As you fly these approaches, hopefully without benefit of the autopilot, except for the final flight, you can't help but notice that tracking the localizer and glide slope is getting easier and easier. As you come to the end of this section, you might find that keeping the needles centered within half a dot is no longer much challenge.

The only method to achieve that level of flying, is "flying by the numbers." Without consistency little success can be achieved. While flying, keep a chart near at hand that contains the important engine and trim settings. Beauty and perfect geometry is not so important as quick legibility. The next illustration shows my solution.

SAAB					
CONFIG	RPM	FLAPS	TRIM	KTS	FPM
CLIMB	2300	—	200	90	
CRUISE - LVL	2222	—	-12	120	—
CRUISE - DESC.	2060	—	-33	120	500
APPR - LVL	1720	1 NOTCH	260	80	—
APPR - DESC.	1320	1 NOTCH	240	80	500
GLIDE SLOPE	1420	1 NOTCH	220	80	420

Prepare a chart similar to this for each aircraft you fly. Add a Manifold Pressure column if the aircraft has a constant speed prop.

This chart is six columns wide by seven rows high, but modify the layout to suit your needs. Construct such a chart for every aircraft that you fly. A heavy piece of cardboard works best. Layout the grid and enter the information with a felt-tip pen. Keep these charts next to your monitor for easy access.

* * *

The ILS Approaches

Before beginning the ILS approaches, firmly understand the meaning of DH, Decision Height. The DH is the lowest height to which the approach can be conducted by instrument reference alone. From that point on you must be able to see either the runway or the approach lights and be able to execute a safe visual landing. If not, a missed approach is required.

NOTE: YOU WILL GET THE GREATEST BENEFIT FROM THIS SECTION IF YOU FLY EACH APPROACH A SECOND TIME BEFORE MOVING TO THE NEXT FLIGHT. FLYING EACH A THIRD TIME IS EVEN BETTER. ALL FLIGHTS ARE SHORT.

One last time, more features have been added to the Saab, mainly a DME panel. [saabmfi-mod.zip](#) Click that file name to download the plane and panels, even if you had previously downloaded it. You won't be able to fly all of the approaches correctly without the updated panels. If you have

downloaded the saabmfi-mod.zip file after 14 March 2000, you should be current and needn't download it again. I hope.

* * *



"Florida?" I repeated, dumbfounded.

"Yeah," The Boss answered, "Mrs. Grayson wants her ferrets flown down there, to Palatka, to be with her for the winter—wants personal handling, know that they won't be sitting out beside the baggage compartment of some plane in this subfreezing temperature."

It had all happened so fast. Florida looked mighty good now after the fourteen-inch snowfall in New England a few days back. I was ready to go in an hour. Mrs. Grayson's chauffeur had brought the ferrets to the airport with their cage, and I left for Palatka in my MFI-17.

Ferrets delivered, I was now at the motel, pool-side to be exact, enjoying the warm sun and beautiful temperature. Life was good.

"Sir, are you the charter pilot?" The desk clerk had approached with a sheet of paper in his hand. "A fax for you," he said, handing it to me, and left.

"Tried reaching you since early this morning. Please answer your phone. Had to get the motel fax number from your Boss."

"I'll be there in an hour. Need a flight to Gainesville. Want to catch a sunset hot air balloon ride tonight."

It was boldly signed "Counter." Very boldly signed.

The weather was going to change in a few hours, be uncharacteristically overcast. I'd get Counter to Gainesville, but wondered whether he'd be ballooning tonight or not. I grabbed my towel and headed for the room to change. Maybe it would be a bumpy flight.

Kay Larkin airport, Palatka, Florida to Gainesville, Florida.



Kay Larkin airport, Palatka, Fla. to Gainesville, Fla. with ILS approach to Runway 28. Click the image to access the complete flight-information package.

This first flight is easy and enjoyable. The flight begins at Kay Larkin airport in Palatka, Florida with a destination of Gainesville, Fla. The ILS approach is to Runway 28. Click on the image above to download the flight-information package, kayl-gnv.zip.

The zip-file includes the IFR chart, the approach plate for ILS Rwy 28 at Gainesville, and this text description of the flight.

We proceed west from Kay Larkin, tracking to the Gainesville VOR, GNV, but intersect the localizer to Gainesville's Runway 28. before reaching GNV. We turn right to track inbound to Gainesville with a straight-in landing to Runway 28. The flight requires some modest VOR and DME work.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 350 ft overcast, cloud tops at 10,000 ft.,

and one-half mile visibility. The wind is calm.

- Move the aircraft to Kay Larkin's (Palatka, Fla.) Runway 27, airport 28J, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Gainesville's localizer, 111.3 MHz., Ident-GNV.
- Set the Primary VOR OBS to 285°, the localizer track to Runway 28.
- Tune the Secondary Nav. receiver to the Gainesville VOR, 116.2 MHz., ident GNV. Fly the first leg with Nav-2.
- Set the Secondary VOR OBS to the vicinity of 260°. You will center the needle with the OBS after takeoff and track to GNV until intercepting Gainesville's localizer.
- Switch the DME to Nav-2.
- Takeoff from Runway 27, climbing out with a very slight left turn to 260°.
- When your Secondary VOR comes alive, and warning flags disappear, readjust the OBS as necessary to center the needle. Observe that a TO flag is showing and then ident the VOR, GNV.
- Track that Gainesville radial. ATC has cleared you to 4000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- You will intercept Gainesville's Runway 28 localizer at the 24.4 NM DME point., before reaching Gainesville VOR, about 7 min. into the flight.
- Ident the localizer before you turn right to intercept, I-GNV.
- Fly Nav-1. Turn right to heading 285° on intercept to track in bound to Runway 28, keeping the localizer needle centered.
- Begin your descent to 2100 ft. on localizer intercept. Descent rate should be no more than 500 to 700 fpm.
- You are about 14 NM from the FAF when intersecting the localizer.
- Retune Nav-2 to Ocala VOR, 113.7 MHz., OCF.
- Set Nav-2 OBS to 017°, to identify the Dante Intersection.
- At Dante Int., when the Nav-2 needle centers, descend to 1700 ft.
- You are now 6.0 NM from the OM.
- Slow to 80 kts. and drop one notch of flaps.

It's vital to stabilize the approach well before beginning your descent down the ILS.

- Readjust the Secondary Nav. VOR OBS to 006°—a FROM flag should appear. When that needle centers you are at the FAF for the Runway 28 approach. Monitor its progress as a back-up of your relative distance to the FAF, Wynds intersection.
- Maintain 1700 ft. until intercepting the glide slope.
- The Outer Marker beacon will sound out dashes at the FAF, and the Blue OM light will appear on the marker beacon receiver's indicator.
- Stay on the glide slope and localizer until you reach your DH of 322 ft. Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway.
- You've heard this before. Don't chase the needles; they will be very sensitive as you near the runway. Just try to keep them from moving.
- Gainesville's Runway 28 TDZE, Touch Down Zone Elevation, is 122 ft., 200 ft. below you at the DH. It should be an easy coast in from there if you've stayed on top of the needles.
- Remember, on an ILS, the TDZE is the important elevation, not the field elevation. The Runway 28 TDZE at Gainesville is 30 ft. lower than the field elevation, a very significant difference. Take a look at the plan view of the airport on the approach plate to see the difference.

- Nice start on an easy flight, if a little busy.
- Flight time: About 20 minutes.

* * *

Monroe County, Monroeville, Alabama to Pensacola Regional, Florida



Monroe County airport, Monroeville, Ala. to Pensacola Regional airport, Pensacola, Fla. with an ILS approach to Runway 17. Click the image to access the complete flight-information package.

This flight is also easy and enjoyable, with some intersection work thrown in for a change of pace. The flight begins at Monroe County airport, Monroeville, Ala. with a destination of Pensacola Regional airport, Pensacola, Fla. The ILS approach is to Runway 17. Click on the image above to download the flight-information package, mvc-pns.zip.

The zip-file includes the IFR chart, the approach plate for ILS Rwy 17 at Pensacola, and this text description of the flight.

We proceed southeast and then south from Monroe County airport to the PENSI intersection. Then it's a left turn for a straight-in ILS approach to Pensacola's Runway 17. The flight requires some modest VOR/DME work to identify intersections.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 400 ft overcast, cloud tops at 10,000 ft., and one-half mile visibility. The wind is calm.
- Move the aircraft to Monroe County's (Monroeville, Ala.) Runway 21, airport MVC, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Monroeville VOR, 116.8 MHz., Ident-MVC.
- Set the Primary VOR OBS to 160°.
- Tune the Secondary Nav. receiver to the Saufley VOR, 108.8 MHz., ident NUN.
- Set the Secondary VOR OBS to 188°.
- Switch the DME to Nav. 1. This will monitor distance from MVC VOR.
- NOTE: The departure field's elevation, Monroe County, is 419 ft. The overcast is set at 400 ft. Therefore, your departure will be in zero ceiling, with zero visibility. Just point the nose of the aircraft down the runway and lift off at the correct speed.
- Portions of the flight, as in the previous flight, will be flown with VOR-2. If you feel more comfortable flying exclusively with VOR-1, with VOR-2 used only to identify intersections, etc., that's OK, too. It just involves more switching and setting of Nav receivers and indicators.
- Fly Nav-1. Takeoff from Runway 21, climbing out with a left turn to intercept MVC's 160° radial. Intercept with a very shallow angle; you are very close to the VOR.
- ATC has cleared you to 5000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Pay close attention to VOR-2. The OFF flag will be showing because the aircraft is out of range of the NUN Omni (range is 39 NM). Turn on and leave on the VOR-2 ident so that you will hear when it becomes active. Check that the OFF flag is no longer visible before relying on this gauge.
- Fly Nav-2. When the VOR-2 needle centers, turn right to 188° and track that radial southward. The DME will read 23 to 24 NM at the course change.
- After intercepting NUN's 188° radial, retune the primary VOR to Crestview VOR, 115.9 MHz., Ident CEW.
- Set the primary VOR OBS to 263°.
- When both your primary and secondary VOR needles center, you are at PENSI intersection. The DME should read 31 NM from CEW.
- At PENSI intersection immediately turn left to a 166° heading.
- Retune the Primary VOR to 111.1 MHz., Pensacola's localizer frequency for Runway 17, Ident I-PNS.
- Fly Nav-1. Track the localizer inbound.
- The DME will read 19-20 NM, about 13-14 NM to the FAF.
- Descend to 1700 ft. Descent rate should be no more than 500 to 700 fpm.
- Reset Nav-2 OBS to 052°, to identify the Brent Intersection.
- Brent intersection is the FAF for the ILS approach to Runway 17. There is no OM.
- Check that Nav-2 is still tuned to Saufley VOR, 108.8 MHz., Ident NUN.
- Drop one notch of flaps and slow to 80 kts.
- Maintain 1700 ft. until intercept of the glide slope, shortly before arrival at the Brent

intersection.

- The DME will read 5.9 NM at Brent intersection, with both VOR-1 and VOR-2 needles centered.
- Reduce power and descend down the glide slope upon intercept.
- Stay on the glide slope and localizer until you reach your DH of 321 ft. Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway.
- DH is 321 ft. Don't descend below that point if the runway is not in sight. You will reach the DH near the Middle Marker, amber light on the panel, alternating dots and dashes sounding from the speaker.
- Pensacola's Runway 17 TDZE, Touch Down Zone Elevation, is 121 ft., 200 ft. below you at the DH. It should be an easy coast in from there if you've stayed on top of the needles.
- Land and take satisfaction in the challenge of a busy flight.
- Flight time: About 36 minutes.

* * *



My laptop computer was open in front of me. I was at my motel after a charter to bring a WW II history buff to visit the Holocaust Memorial Museum here in St. Petersburg. I spotted The Boss's e-mail message right away. Short and to the point, it read: "Nothing this morning, check back after lunch."

The AOL Instant-Messenger Icon flashed as I was about to disconnect. I clicked on the Icon, but didn't recognize the screen name, "TheWildOne." I opened the message.

It was from Counter.

I read Counter's message, wondering the nature of his present crisis.

"I have to be at McKechnie Field today in time to see the Pittsburgh Pirates play. They head north for the regular season after this game," the e-mail began. "The Buccos have always been my team ... a baseball team with heritage. Can't watch them play in New England since they're in the National League. Only American League sissies up there."

McKechnie Field was in Bradenton, not far south of St. Petersburg, across Tampa Bay, but a long drive around the inlet. McKechnie had been the Pirates' spring-training home for over thirty years. I went back to the e-mail.

"The Pirates will be back in the hunt again for division championship, and maybe more. With their history, it's only a matter of time. Earned their name in 1890 because they 'Pirated' a star player from the Philadelphia A's. So much nostalgia surrounds the Bucs, I gotta be at the game. Hey, what other team can boast all this?

- They played the first World Series game ever in 1903, against the Boston Pilgrims.
- Honus Wagner, Pirate shortstop, was the first player to have his signature branded in a Louisville Slugger. He never batted below .300 for his first 17 years as a big leaguer.
- Honus Wagner was also in the first class to be inducted into the Hall of Fame. Babe Ruth, Ty Cobb, Christy Mathewson and Walter Johnson were the other original members.
- Pirate Bill Mazeroski was the first player to decide a World Series with a home run in the 7th game. It happened against the Yankees and was one of the greatest moments in World Series history.
- The Bucs have the most players with 3000 hits; Honus Wagner, Paul Waner and Roberto Clemente.
- The Pirates have the most batting championships, with twenty-four.
- The Pirates always struggled for attendance. In their first stadium, Recreation Park, one game showed a paid attendance of six, plus eleven hanger-ons, for a total of seventeen in the ball park.
- Forbes Field was home for the Pirates for sixty-one years, from 1909 to 1970. With a twelve-foot brick outfield fence, it was a "Man's" field.
 - Left-center field was so deep, 457 ft., that the batting cage was stored there during ball games.
 - That deep center field allowed a lot of room for triples and inside-the-park home runs. Pirate "Chief" Owen Wilson set the major league record for triples (36) in a single season in this park.
 - The right-field roof was an 86 ft. high target for many Major League sluggers. Ten different players launched eighteen home runs over that roof. Pirate Willie Stargell led the charge with seven round-trippers.
 - Babe Ruth was another legendary long-ball hitter to clear that roof. As he finished his career with the Boston Braves, on May 25, 1935, Ruth hit three home runs against the Bucs. His last four-bagger, number 714, cleared the right field roof. Babe Ruth was the first to launch one over the roof, too.
 - Pitchers had a challenging task in Forbes Field. In its sixty-one year history, there was never a no-hitter thrown.

I thought about Counter's e-mail. He sounded a believer in the Pittsburgh Pirates.

I loved baseball, too, and McKechnie Field was the place to watch it played the way it should be: In the sun and on the grass.

St. Petersburg, Florida to Sarasota/Bradenton, Florida



St. Petersburg Int'l airport, Fla. to Sarasota/Bradenton Int'l airport, Fla. with an ILS approach to Runway 14. Click the image to access the complete flight-information package.

The previous flights were easy, but pretty busy during the ILS approach. This flight is less busy, but with some interesting variations. The flight originates at St. Petersburg Int'l airport, Fla. with a destination of Sarasota/Bradenton Int'l airport, Fla. The ILS approach is to Runway 14. Click on the image above to download the flight-information package, pie-srq.zip.

The zip-file includes the IFR chart, the approach plate for ILS Rwy 14 at Sarasota, and this text description of the flight.

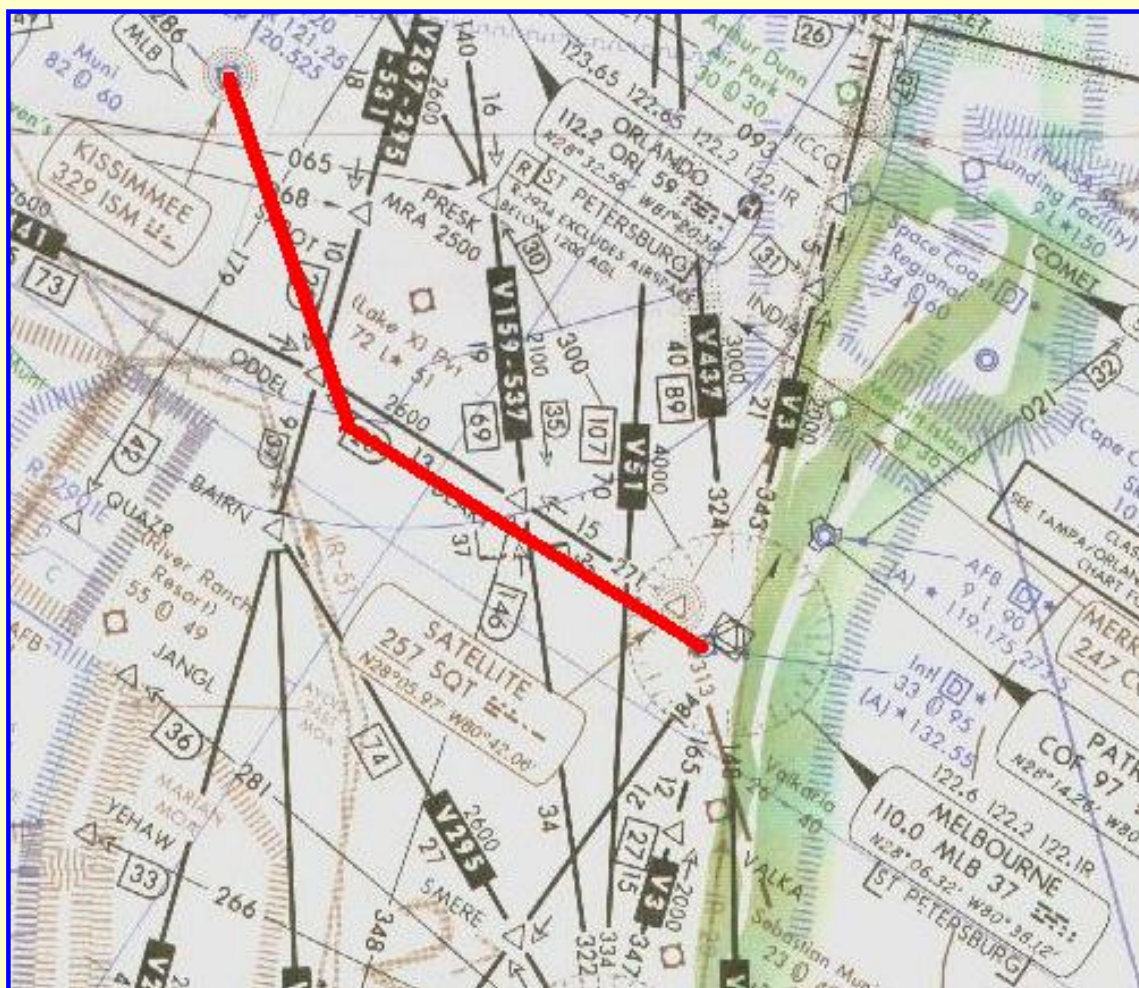
We proceed southwest from St. Petersburg and intercept Sarasota's ILS at a rather sharp angle. Again, no OM, but must rely on a VOR radial and DME distance for the FAF. We have a nice long straight-in ILS approach to Sarasota's Runway 14. The flight requires some modest VOR/DME work to identify intersections. Also, simulated ATC instructions will be given in the form of change of altitude at certain DME distances.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 328 ft overcast (lowest ceiling that FS98 permits, FS2K owners, set it to 300 ft.), cloud tops at 10,000 ft., and one-half mile visibility. The wind is calm.
- Move the aircraft to St. Petersburg's Runway 17L, airport KPIE, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Sarasota's localizer, 111.3 MHz., Ident I-FFV.
- Set the Primary VOR OBS to 136°. as a reminder of runway heading.
- Tune the Secondary Nav. receiver to the St. Petersburg VOR, 116.4 MHz., ident PIE.
- Set the Secondary VOR OBS to 188°. Fly the first leg with Nav-2. .
- Switch the DME to Nav-2. This will monitor the distance from PIE VOR.
- Portions of the flight, as in the previous flights, will be flown with VOR-2. If you feel more comfortable flying exclusively with VOR-1, with VOR-2 used only to identify intersections, etc., that's OK, too. It just involves more switching and setting of Nav receivers and indicators.
- Fly Nav-2. Takeoff from Runway 17L, climbing straight out to intercept PIE's 188° radial.
- NOTE: You may be surprised to see that the VOR-2 needle indicates a left turn to intercept the 188° radial. That is because of the location of the VOR on the field relative to the runway. Ignore that for the moment and climb straight out until intercepting the 188° radial, about 0.6 NM on your DME.
- ATC has cleared you to 4000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- When the DME reads 16.0 NM from PIE, descend to 3000 ft. Before descending verify that the DME is switched to Nav-2.
- Fly Nav-1. On intercept of Sarasota's Localizer for Runway 14, turn left and track inbound at 136°. You are about 13 NM from the field.
- Begin descent to 2000 ft.
- Drop one notch of flaps and slow to 80 kts.
- Retune the Secondary VOR to 115.2 MHz., Sarasota's VOR, Ident SRQ.
- Set VOR-2 OBS to 315°.
- Monitor the DME along with the other flight instruments—there is no OM.
- Maintain 2000 ft. until intercept of the glide slope, shortly before arrival at FRUGL intersection.
- FRUGL intersection is 6.3 NM from SRQ VOR. It is the FAF for the ILS approach to Runway 14.
- Reduce power and descend down the glide slope upon intercept.
- Stay on the glide slope and localizer until you reach your DH of 224 ft. Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway.
- DH is 224 ft. Don't descend below that point if the runway is not in sight. You will reach the DH near the Middle Marker, amber light on the panel, alternating dots and dashes sounding from the speaker.
- Sarasota's Runway 14 TDZE, Touch Down Zone Elevation, is 24 ft., 200 ft. below you at the DH. It should be an easy coast in from there if you've stayed on top of the needles.
- Pat yourself on the back for a good flight.
- Flight time: About 22 minutes.

* * *

Kissimmee, Florida to Melbourne, Florida



Kissimmee Municipal airport, Fla. to Melbourne Int'l airport, Fla. with an ILS approach to Runway 9R. Click the image to access the complete flight-information package.

An ILS approach doesn't get much simpler than this one. The flight originates at Kissimmee Municipal airport, Fla. with a destination of Melbourne Int'l airport, Fla. The ILS approach is to Runway 9R. Click on the image above to download the flight-information package, ism-mlb.zip.

The zip-file includes the IFR chart, the approach plate for ILS Rwy 9R at Melbourne, and this text description of the flight.

We proceed southeast from Kissimmee and intercept Melbourne's Localizer 21 NM from the field providing a nice long straight-in ILS approach to Runway 9R. The previous flights will make this seem very easy. Except that it's time for a real-world cross wind.

By now you should have downloaded and installed the virtual E6-B computer, and placed an icon on the desktop. This marvelous utility calculates Wind Correction Angle—WCA, and Ground Speeds in a matter of seconds. You should use it for every flight where a wind is present. Then you will know in advance what action is necessary to counteract the effects of the wind.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 328 ft overcast (lowest ceiling that FS98 permits, FS2K owners, set it to 300 ft.), cloud tops at 10,000 ft., and one-half mile visibility. Set the wind at 150° at 15 kts.
- Move the aircraft to Kissimmee's Runway 15, airport ISM, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to the Melbourne VOR, 110.0 MHz., ident MLB.
- Set the Primary VOR OBS to 089°.
- Tune the Secondary Nav. receiver to the Vero Beach VOR, 117.3 MHz., Ident VRB. Fly the first leg with Nav-2.
- Set the Secondary VOR OBS to 129°.
- Turn Nav-2 Ident on, and leave it on, to recognize when that VOR becomes "active," which will be about 3000 ft. MSL.
- Switch the DME to Nav-2. This will monitor the distance to VRB VOR.
- Portions of the flight, as in the previous flights, will be flown with VOR-2. If you feel more comfortable flying exclusively with VOR-1, with VOR-2 used only to identify intersections, etc., that's OK, too. It just involves more switching and setting of Nav receivers and indicators.
- Takeoff from Runway 15, climbing out left to 135°
- Fly Nav-2. Intercept VRB's 129° radial when the VOR gauge becomes "active,"—hear ident and OFF flag no longer visible.
- ATC has cleared you to 5000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- The Virtual E6-B calculates 3°R WCA for this cross wind and heading at 120 kts. TAS. The wind is almost directly on the aircraft nose during this first leg, slowing the ground speed to 106 kts.
- At about DME 42 the VOR-1 needle should be nearly centered.
- Near the intercept point of the 089° radial to MLB retune the primary VOR to Melbourne's Localizer, 108.3 MHz., Ident I-MLB.
- Set the VOR-1 OBS to 090° as a reminder of the runway heading.
- Fly Nav-1. Turn left and intercept Melbourne's Localizer for Runway 9R.
- Inbound track is 090° but roll out on 096° heading to compensate for the cross wind
- You are about 17 NM from the FAF.
- Begin descent to 2100 ft.
- Maintain 120 kts. until instructed otherwise.
- Change Nav-2 to the Melbourne VOR, 110.0 MHz., ident MLB.
- Set the VOR-2 OBS to 089°.
- Drop one notch of flaps at DME 13 and slow to 80 kts.
- The Virtual E6-B calculates 9°R WCA for this cross wind and heading at 80 kts. TAS.
- The ground speed will be 72 kts. on final. Use the rule of thumb of five times ground speed for rate of descent on the glide slope, which is 360 fpm, a shallower rate of descent than you are accustomed to. Be attentive to this rate of descent while coming down the glide slope. Less power reduction will be needed than for a no-wind approach.
- The FAF, Outer Marker, is at 7.8 NM on the DME.
- Maintain 2100 ft. until intercept of the glide slope.
- Use this level-flight part of the approach to stabilize the air speed and WCA before

reaching the FAF.

- Reduce power and descend down the glide slope upon intercept.
- Stay on the glide slope and localizer until you reach your DH of 233 ft. Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway.
- DH is 233 ft. Don't descend below that point if the runway is not in sight. You will reach the DH near the Middle Marker, amber light on the panel, alternating dots and dashes sounding from the speaker.
- Remember, your WCA is 9°R. Therefore you must look slightly left to spot the runway since you are crabbing down on the approach.
- Melbourne's Runway 9R TDZE, Touch Down Zone Elevation, is 33 ft., 200 ft. below you at the DH. It should be an easy coast in from there if you've stayed on top of the needles.
- Flight time: About 30 minutes.



Here's what you'd have seen had the flight to Melbourne been VFR.

* * *

Dade County Training Facility to Miami, Florida



Dade County Training Facility to Miami Int'l airport, Fla. with an ILS approach to Runway 9R. Click the image to access the complete flight-information package.

This flight originates at the Dade County Training Facility, 32 NM west of Miami Int'l airport, Fla. The ILS approach is to Runway 9R. Click on the image above to download the flight-information package, [tnt-mia.zip](#). The zip-file includes the IFR chart, the approach plate for ILS Rwy 9R at Miami, and this text description of the flight.

Here you will be introduced to the "Might is Right" rule.

You fly this ILS approach into Miami Int'l, intermingled with the big iron and their 160 kts approach speed, twice that of the Saab. The controller has asked you to maintain 120 kts. until glide slope intercept, a routine type of request at many very-busy airports. You're not obligated to comply, but if you don't the controller may ask you to do a "left 360 for spacing, and report over Atlanta for additional advisories before returning to the final approach course."

You see, the 767 and 747 drivers can get a little testy when asked to line up over Mexico for their turn inbound behind you while you lollygog in at 80 kts. from 20+ NM out.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts. Only by doing this will you both understand the purpose of each step, but you will visualize them in your mind, a critical part of instrument flight.

- Set the flight simulator weather conditions to 328 ft overcast (lowest ceiling that FS98 permits, FS2K owners, set it to 300 ft.), cloud tops at 10,000 ft., and one-half mile

visibility. The wind is calm.

- Move the aircraft to Dade County's Runway 9, airport TNT, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to the Homestead VOR, 108.2 MHz., ident HST.
- Set the Primary VOR OBS to 133°.
- Tune the Secondary Nav. receiver to the Virginia Key VOR, 117.1 MHz., Ident VKZ.
- Set the Secondary VOR OBS to 096°.
- Turn on Nav-1 Ident, and leave it on, to recognize when that VOR becomes "active," which will be about 1500 ft. MSL.
- Fly Nav-1. Takeoff from Runway 9 with a right turn-out to 133°.
- Intercept Homestead's 133° radial when the VOR gauge becomes "active,"—hear ident and OFF flag no longer visible.
- ATC has cleared you to 5000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Fly Nav-2. When VOR-2 centers turn left to track VZK's 096° radial.
- Change Nav-1 to Miami's Runway 9R Localizer, 110.9 MHz., Ident I-BUL.
- Set the VOR-1 OBS to 090° as a reminder of the runway heading.
- Switch the DME to Nav-2.
- Fly Nav-1. When VOR-1 centers turn left to 090° to track the Localizer to Miami's Runway 9R.
- You are about 15 NM from the FAF.
- Begin descent to 3000 ft.
- Maintain 120 kts. and 3000 ft. until glide slope intercept.
- Change Nav-2 to the Dolphin VOR, 113.9 MHz., ident DHP.
- The VOR-2 indications are unimportant. The only interest here is the DME distance to that VOR, so it must be tuned in.
- Drop one notch of flaps at the glide slope intercept and slow to 80 kts.
- Reduce power and stay on the glide slope while bleeding off speed.
- Set nose-up trim to about 260.
- Stay on the glide slope and localizer until you reach your DH of 209 ft. Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway.
- DH is 209 ft. Don't descend below that point if the runway is not in sight. You will reach the DH near the Middle Marker, amber light on the panel, alternating dots and dashes sounding from the speaker.
- Miami's Runway 9R TDZE, Touch Down Zone Elevation, is 9 ft., 200 ft. below you at the DH. It should be an easy coast in from there if you've stayed on top of the needles.
- Flight time: About 21 minutes.

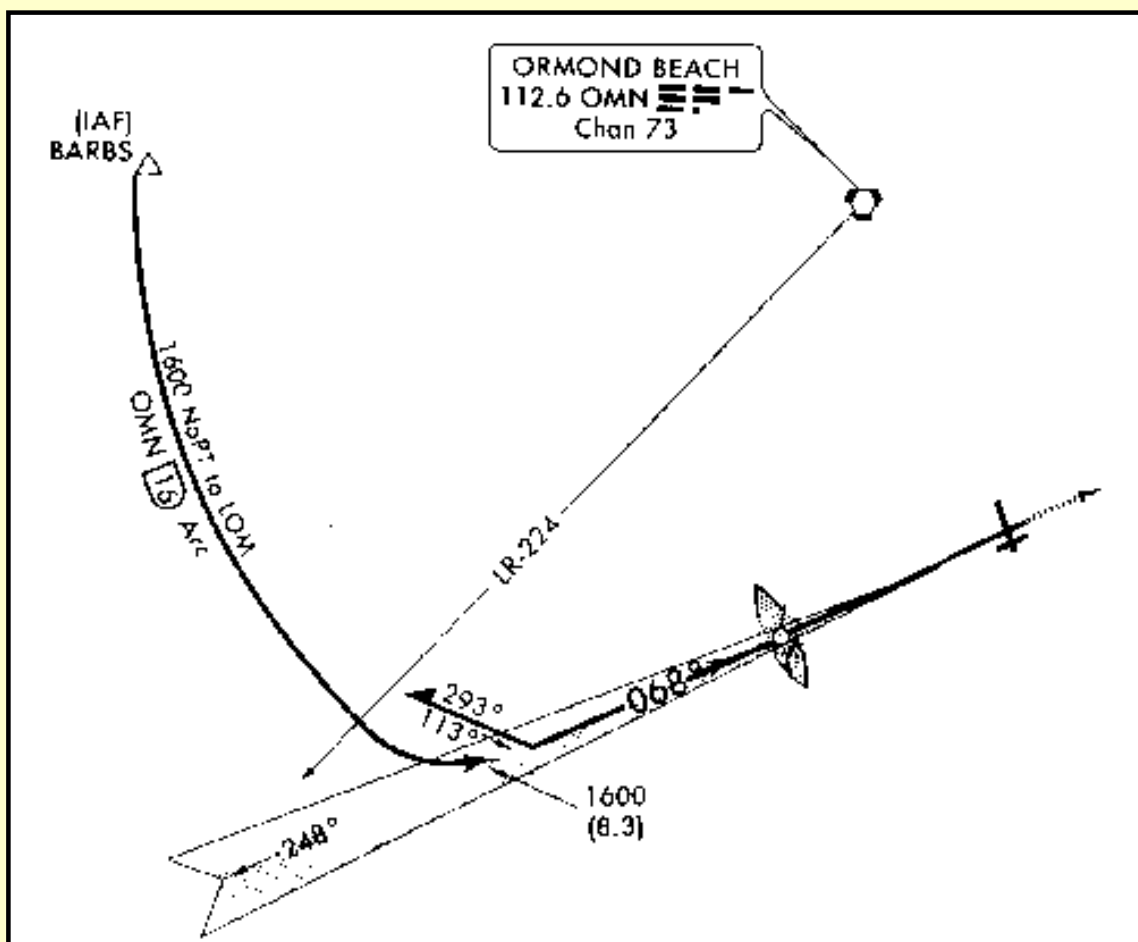
* * *

The DME arc

The next flight introduces the DME arc. A DME arc is a flight path that is flown at a constant distance from a VOR station. In the extreme case, it would be a 360° circle around the VOR. For a 16 NM DME arc the radius of the circle would be 16 NM centered on the VOR. The illustration below shows the 16 NM DME arc from Ormond Beach VOR, OMN, entering from the north to the Runway 7L ILS approach at Daytona Beach, Florida.

A DME-arc approach saves time. The time-consuming procedure turn is eliminated along

with the frustration of flying *away* from the airport to set up the approach.



Daytona Beach International has two DME arc approaches. This is the north-entry 16 NM DME arc.

The pertinent information is written along the DME arc on the approach plate: 16 NM arc from OMN, no procedure turn required (or allowed), fly the route at 1600 ft. altitude. The entry point is BARBS intersection.

The aircraft enters the DME arc at BARBS intersection on V267 and continues around the arc until LR-224, the 224° Lead Radial, which *Leads* you into the ILS. At LR-224 the pilot turns sharply to the left and intercepts the localizer.

To fly a DME arc perfectly accurately the pilot must concentrate solely on the DME, constantly making small heading corrections towards the VOR. This is neither practical nor safe. Other gauges on the panel demand attention and pre-landing duties are usually calling at this time, also.

Flying *straight-line segments* is the key to mastering the DME arc.

The BARBS intersection is on OMN 271°. The Lead Radial is 224°—47° around the arc. We will fly "20° straight-line segments," that is, we will change heading by 20° increments to remain "on the arc."

Upon entering the arc, include the DME in your instrument scan. When the DME increases by 0.1 mi, turn left (in this case) by 20° and be alert again for the next shift of the DME to 16.1 NM and make the next 20° change in heading to the left, and so forth until reaching the 224° deg; Lead Radial. Then make a normal, left turn to intercept the localizer.

* * *

Kay Larkin airport, Palatka, Florida to Daytona Beach, Florida



Kay Larkin airport, Palatka, Fla. to Daytona Beach Int'l airport, Fla. with an ILS approach to Runway 7L. Click the image to access the complete flight-information package.

This flight originates at Kay Larkin airport in Palatka, Florida with a destination of Daytona Beach Int'l airport, Fla. The ILS approach is to Runway 7L. Click on the image above to download the flight-information package, [kayl-dab.zip](#). The zip-file includes the IFR chart, the approach plate for ILS Rwy 7L at Daytona Beach, and this text description of the flight.

We proceed east from Kay Larkin to V267, then southbound to the BARBS intersection, and then follow a 16 NM DME arc around OMN to the ILS to Daytona Beach's Runway 7L.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts.

- Set the flight simulator weather conditions to 330 ft overcast, cloud tops at 10,000 ft., and one-half mile visibility. The wind is calm.
- Move the aircraft to Kay Larkin's Runway 9, airport 28J, and retract the flaps to 0°.

- Tune the Primary Nav. receiver to the Craig VOR, 114.5 MHz., ident CRG.
- Set the Primary VOR OBS to 178°.
- Tune the Secondary Nav. receiver to the Ormond Beach VOR, 112.6 MHz., Ident OMN.
- Set the Secondary VOR OBS to 135°. Fly the first leg with Nav-2.
- Turn on Nav-2 Ident, and leave it on, to recognize when that VOR becomes "active," which will be about 1500 ft. MSL.
- Fly Nav-2. Takeoff from Runway 9 and fly due east, 090°, anticipating intercept of the 135° radial to OMN.
- ATC has cleared you to 5000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Intercept OMN's 135° radial after the VOR gauge becomes "active,"—hear ident and OFF flag no longer visible.
- When VOR-2 centers turn right, intercept, and track OMN's 135° radial south-east bound.
- Fly Nav-1. About 6 NM later, when VOR-1 centers, turn right, intercept, and track CRG's 178° radial south bound.
- Switch the DME to Nav-1.
- Set the VOR-2 OBS to 271° to identify BARBS intersection.
- At DME 48, ROYES intersection, begin descent to 1600 ft.
- Maintain 120 kts. TAS.
- Switch the DME to Nav-2.
- Fly Nav-2. When VOR-2 centers at BARBS, note the DME reading.
- If the DME is less than 16.0 NM, turn right 10 to 30° to enter the DME arc, depending on the distance from the desired arc.
- If the DME is more than 16.0 NM, turn left to 10 to 30° to enter the DME arc, depending on the distance from the desired arc.
- Change the VOR-2 OBS to 224°, the LR-224 radial from OMN.
- Maintain the heading determined above until the DME moves to 16.0 NM. Then return to original 180° heading.
- Change VOR-1 to 109.7 MHz., Runway 7L Localizer, Ident I-DAB.
- Change VOR-1 OBS to 068° as a reminder of the runway heading.
- When the DME shows 16.1 NM turn left 20° and maintain the new heading until the DME again moves to 16.1 NM.
- If the DME keeps increasing, cut another 10° to the left and proceed as before.
- Repeat this procedure around the arc until VOR-2 centers, at LR-224°.
- Fly Nav-1. Turn left to 090° and intercept the localizer to Runway 7L.
- Drop one notch of flaps and slow to 80 kts.
- Intercept the glide slope and descend normally.
- Stay on the glide slope and localizer until you reach your DH of 232 ft. Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway. Don't descend below that point if the runway is not in sight. You will reach the DH near the Middle Marker.
- Daytona Beach's Runway 7L TDZE is 32 ft.
- Flight time: A busy 34 minutes.

* * *



The P-40 was America's foremost fighter in service when WW-II began. P-40s engaged Japanese aircraft during the attack on Pearl Harbor and also were flown in China early in 1942 by the famed Flying Tigers. Courtesy Air Force Museum, wp-afb, Dayton, Ohio.

It was raining like the dickens. I had just taxied in to Ithaca's Tompkins County airport, in New York, on my way back home from Florida, with a detour tomorrow to Albany to pick up a package for The Boss. The rain and low weather hadn't messed up my plans, this was my scheduled stopover for the night anyway.

The receptionist and I were waiting for the line-boy to bring the numbers in for my refuel so I could settle the bill, catch a taxi into town, and get to my motel. The line-boy would need a canoe to make it in with this downpour. It was pitch black outside except for the nearby blue taxiway lights and the reflections off the tarmac from the rain-weakened floodlights.

The telephone rang. The receptionist answered it, said a few words, then turned to me. "Did you just fly in from Florida in a Saab?" she asked.

"Yes," I said, puzzled.

"Lucky," she responded, with a glance out the window at the weather, and handed me the phone.

"Glad I caught you." It was Counter. "The Boss didn't have your motel info so I would have missed you if you weren't at the airport."

I glanced at the weather, too, thinking only of my nice warm motel. "Glad that didn't happen, I answered."

"I need a lift to Elmira in the morning. Want to get over to the Hammondsport, to the Glenn H. Curtiss Museum."

"Albany's the other direction from Elmira," I responded, drily. "And the weather's not looking good, either."

"Albany? Who wants to go to Albany? My father-in-law's brother was a Flying Tiger in World War II. Flew the P-40 Tomahawk. Glen Curtiss invented and built that plane, over 14,000 of them. I want to go see what it looks like and learn more about it. Twelve cylinder, 1400 HP engine pushed that baby along, I know that much."

"Great plane, great pilots you know," Counter went on. "They held back the Japanese planes from attacking the Burma road into China. The Flying Tigers had a thirty to one kill ratio over the Japanese. That ratio's never been equalled since. Just about won the war for us in China, shot down 300 Japanese aircraft. Our guys were there the summer before Pearl Harbor, in 1941."

"Sound's a worthwhile visit," I said.

"You know, Curtiss was a great pilot, too," Counter interrupted. "The government issued him Pilot's License #1. But back to the Tomahawk, I'd sure like to buy one of those P-40s for what Uncle Sam paid."

"How much was that?"

"\$55,000 and change," Counter said with a laugh. "See you in the morning."

Ithaca, New York to Elmira, New York



Tompkins County airport, Ithaca, New York to Elmira/Corning Regional airport, Elmira, New York with an ILS approach to Runway 6. Click the image to access the complete flight-information package.

We're back in the north again. This flight originates at Tompkins County airport in Ithaca, New York with a destination of the Elmira/Corning Regional airport, Elmira, New York. The ILS approach is to Runway 6. Click on the image above to download the flight-information package, ith-elm.zip. The zip-file includes the IFR chart, the approach plate for ILS Rwy 6 at Elmira, and this text description of the flight.

We proceed southwest from Ithaca to the Elmira VOR via V426, execute a tear-drop turn and return to intercept the localizer to Elmira's Runway 6.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts.

- Set the flight simulator weather conditions to 1200 ft overcast, cloud tops at 10,000 ft., and one-half mile visibility. The wind is calm.
- Move the aircraft to Ithaca's Runway 32, airport ITH, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to the Ithaca VOR, 111.8 MHz., ident ITH.
- Set the Primary VOR OBS to 236°.
- Tune the Secondary Nav. receiver to the Elmira VOR, 109.65 MHz., Ident ULW.
- Set the Secondary VOR OBS to 235°.
- Switch the DME to Nav-1.
- Fly Nav-1. Takeoff from Runway 32 with a climbing left turn.
- Intercept and track V428, the 236° radial of ITH.
- ATC has cleared you to 4000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- Fly Nav-2. At 11 DME, VILCU intersection, switch navigation to VOR-2.
- Track the 235° radial to the Elmira VOR, ident ULW.
- Switch the DME to Nav-2.
- Change Nav-1 to Elmira's Runway 6 Localizer, 109.1 MHz., ident I-UEK.
- NOTE: Runway 6 and 24 Localizers are both on 109.1 MHz., but have different idents because each is a front-course approach. If you ident the localizer too early you will hear I-ELM for Runway 24.
- Change VOR-1 OBS to 062° as a reminder of the runway heading.
- Don't chase the VOR-2 needle as you approach ULW, it will be very sensitive and may even drift off scale for a moment.
- At station passage of ULW, turn left to 220°.
- Reset VOR-2 OBS to 220° and track that radial outbound.
- Fly Nav-1. At 7 DME turn right to 040°.
- Descend to 3000 ft.
- Intercept the Runway 6 Localizer.
- After localizer intercept, drop one notch of flaps and slow to 80 kts.
- Intercept the glide slope and descend normally.
- Stay on the glide slope and localizer until you reach your DH of 1144 ft.
- Don't look away from the gauges until very shortly before reaching the DH, about one-half mile from the runway. Don't descend below that point if the runway is not in sight. You will reach the DH near the Middle Marker.
- Elmira's Runway 6 TDZE is 944 ft.

- Flight time: 31 minutes.

* * *



A reminder to the "young-uns" that flavorful, multi-course meals were once served in the "back cabin," and on real china, as seen in this DC-2. Note, too, the absence of over-size luggage in the overhead bins.

* * *

CAT II Approaches

For years, the ILS capability to land with a ceiling as low as 200 ft. and a visibility limited to one-half mile was satisfactory for airline schedule maintenance, if not without a few grumbles. When conditions lower than this extreme exist, it is rarely for long periods of time, i.e., morning fog that will later burn off, or during heavy thunderstorms when no one should be attempting a landing anyway, etc. Most passengers understand that delayed flights due to poor weather are beyond everyone's control.

But the rapidly increasing number of passengers and aircraft showed how much chaos could result if weather shuts down an entire region to air travel, even if briefly. So the FAA went the extra step and developed a working system to allow aircraft to land all the way down to zero ceiling and zero visibility.

As previously discussed, ILS landing conditions were segregated into three Categories, with CAT I being the existing minimums of 200 ft DH and one-half-mile visibility.

A CAT II capability allows landings with seeing conditions as low as a DH of 100 ft. above the TDZE, and 1200 ft. RVR, slightly less than a quarter-mile. In other words, CAT II cuts the CAT I minimums in half.

A pilot doesn't just jump into his favorite aircraft, though, and decide to shoot a CAT II approach because the weather has gone sour. The FAA issues a CAT II authorization after the pilot satisfies certification and currency requirements. In addition, a CAT II approach may only be flown in an aircraft meeting minimum equipment requirements and into fields with approved CAT II approaches.

The pilot must pass both an oral exam and a flight test to be certified. The flight test requires at least two ILS approaches to a DH of 100 ft, one to a full-stop landing and the other to include a missed-approach procedure. The CAT II approaches must be performed with an autopilot (over-simplification, but will do).

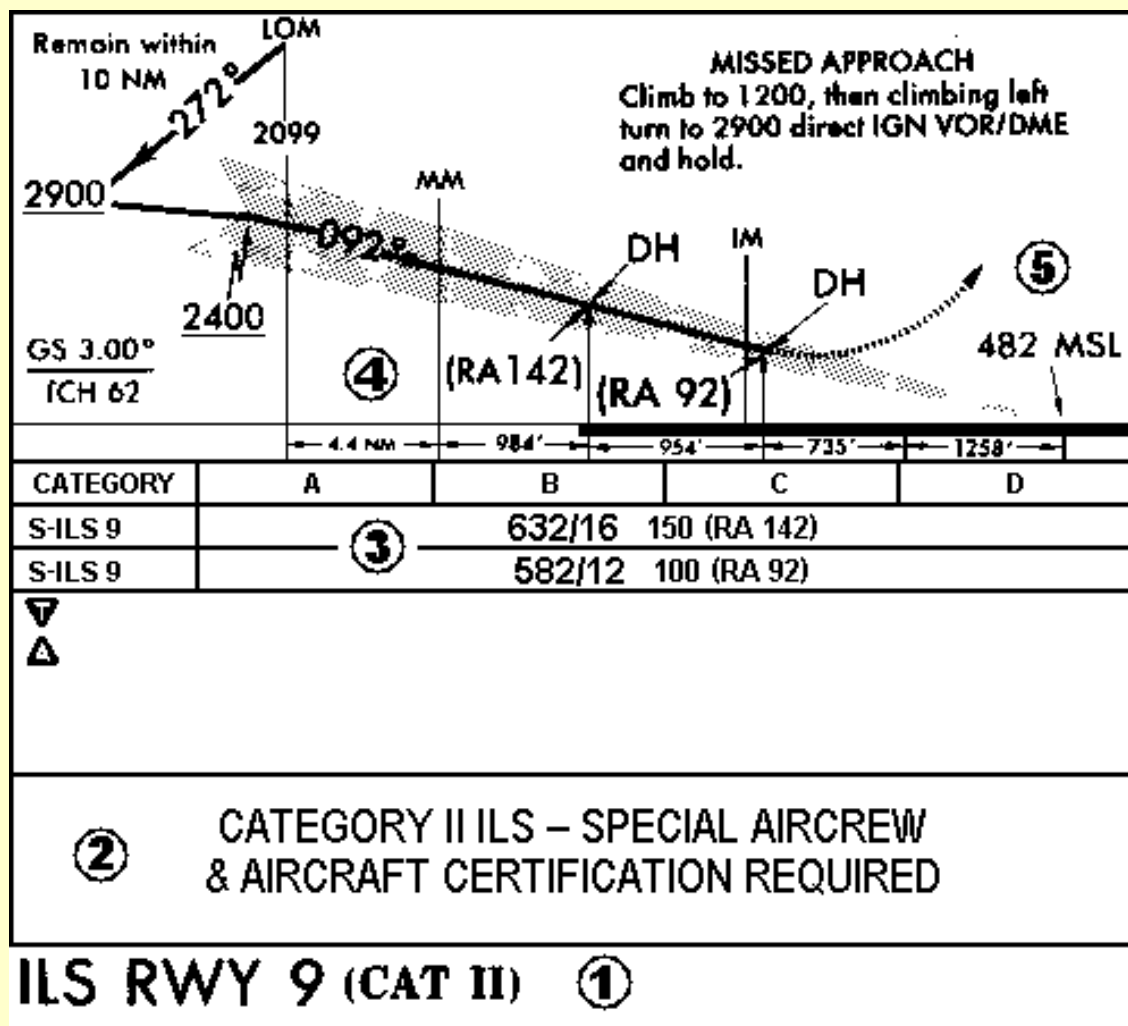
A CAT II authorization is only valid for six months, then another oral exam and flight test must be passed.

For a runway to be certified for a CAT II approach, an Inner Marker beacon, IM, is required in addition to the OM and MM beacons. The IM is located at the DH for a CAT II approach.

The minimum additional aircraft equipment requirements are a marker-beacon receiver capable of receiving the IM and a CAT II approved autopilot. At the IM a white light on the aircraft's instrument panel flashes and high-frequency dots sound from the loudspeaker.

CAT II Approach Plates

Five features distinguish a CAT II approach plate from a standard (CAT I) ILS approach plate. See the illustration below, from the CAT II ILS Rwy 9 approach Plate for Stewart Int'l airport in Newburgh, New York.



Profile view, CAT II ILS Rwy 9 approach Plate, Stewart Int'l airport, Newburgh, New York.

- The approach plate is identified as CAT II adjacent to the Approach Title.
- The plate carries an aircrew and aircraft certification notice.
- Two "S-ILS 9" lines exist in the profile view, one for 150 DH, 1600 RVR, and the other for 100 DH, 1200 RVR.
 - For six months after the first issuance of a CAT II authorization, the pilot must adhere to the 150/16 limitation.
 - If the aircraft has no IM receiver (or it's inop), and the pilot relies on a barometric-pressure altimeter for DH, the pilot must adhere to the 150/16 limitation.
 - The 100/1200 CAT II approach is authorized when the pilot confirms completion of three CAT II ILS approaches to a landing under actual or simulated conditions with a 150-foot DH within six months of the date of original issuance (after the first six months).
- Radio (Radar) Altimeter readings are shown on the approach plate for the 150 and 100 ft. DH points.
- The TDZE, Touch-Down Zone Elevation appears on the profile view.

Radio (Radar) Altimeter



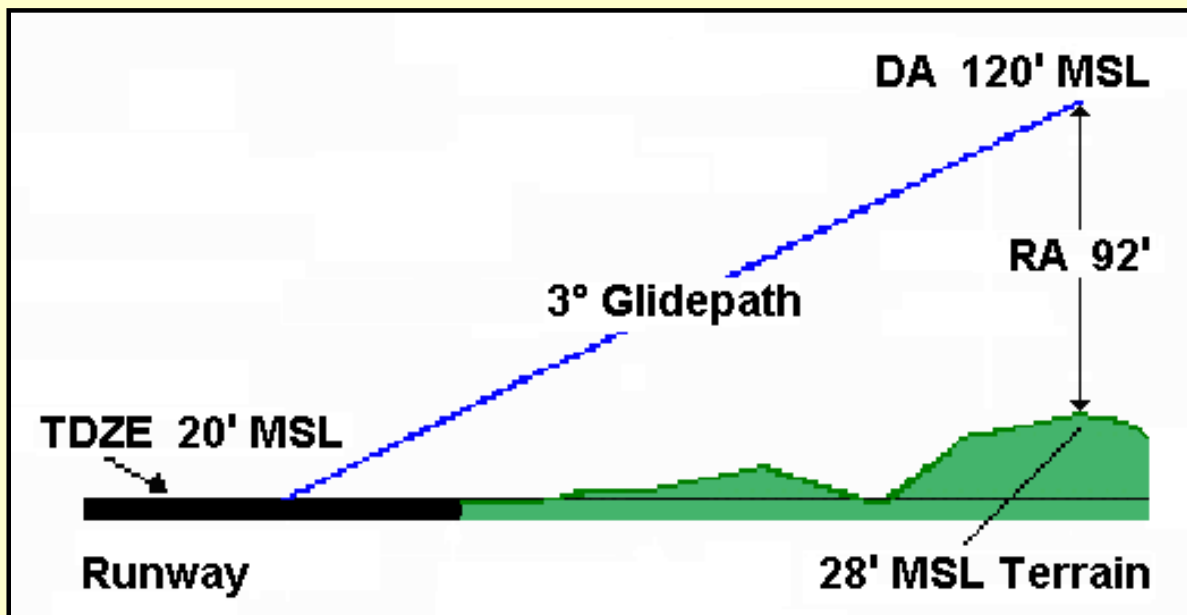
The radio altimeter, or terrain-clearance indicator, is an absolute altimeter; it indicates the actual altitude over terrain, however uneven. It operates by first sending a radio signal from the aircraft to the earth's surface. A receiver in the aircraft then picks up the reflection of the signal from the surface. The time it takes for the signal to travel to the earth and back is converted into absolute altitude which is displayed on a gauge.

The radio altimeter does not depend on barometric pressure settings. The Saab MFI-17 does not have a radio altimeter, but most FS heavy aircraft have one on their panel.

The radio altimeter has several unique

features:

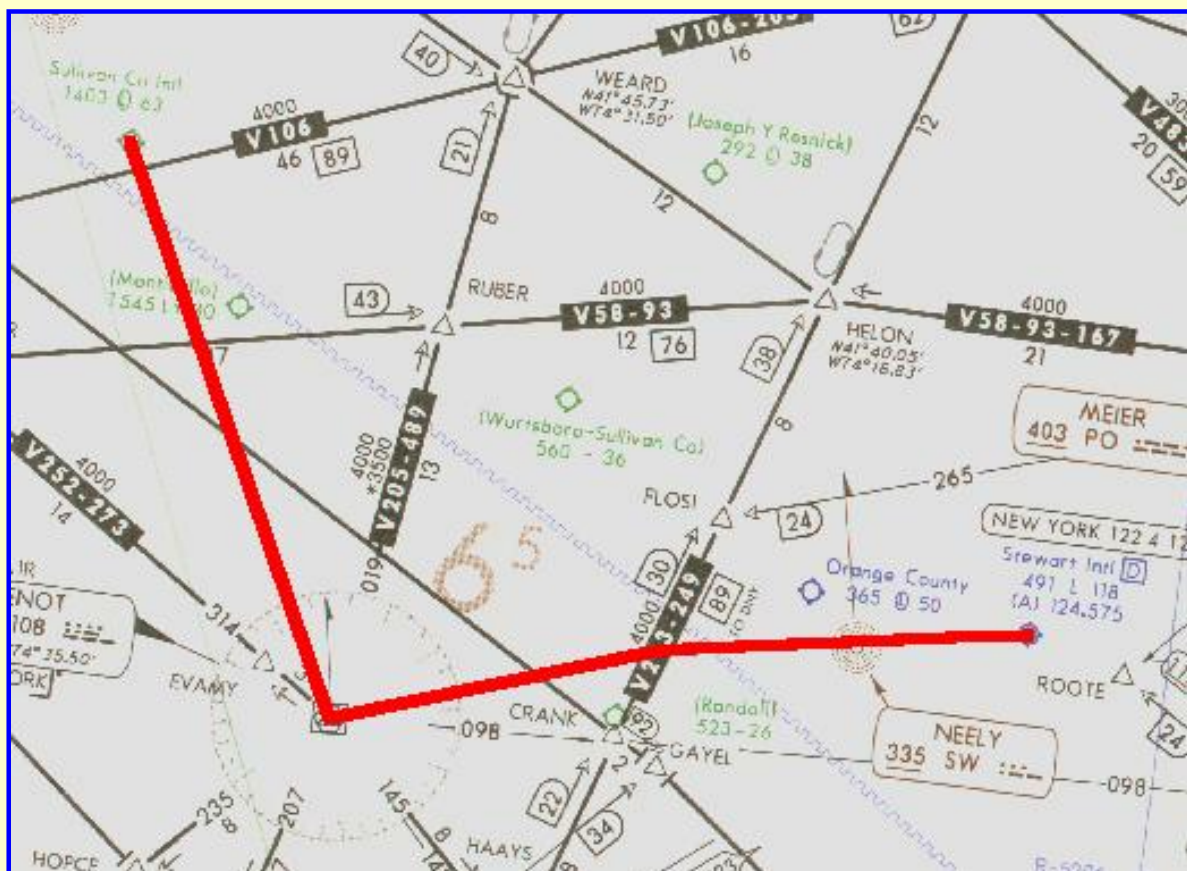
- The altitude scale is non-linear. Notice that as much space on the dial is devoted to 0–100 ft. as is used for 1000–2500 ft. The low end of the scale, when near the ground, is where the greatest resolution is needed.
- Here the altitude bug is set at 92 ft. This corresponds to the 100 ft. DH, 1200 ft RVR CAT II minimums at Stewart Int'l airport in Newburgh, N.Y.
- The radio altimeter can be coupled to the autopilot. When coupled, the green indicator shows on the dial. The radio altimeter only arms when the autopilot is coupled to the localizer of an ILS approach.
- The green indicator light switches to red when descending below the altitude set by the bug.
- In a CAT I or CAT II approach, the aircraft is manually flown on to the runway from the DH point. The autopilot must be switched off to allow manual flying. The radio altimeter automatically switches off the autopilot when the aircraft has descended to the altitude set by the bug.
- Modern radio altimeters are digital with an audio call-out at the bug setting in addition to the above features.



Consider this CAT II approach. The DH is 100 ft., and with a TDZE of 20 ft., the DA (Decision Altitude) is 120 ft. If the terrain were absolutely flat, at the DA point, the Radio Altimeter would register 100 ft. above the ground. But at the DA here the terrain is 28 ft. MSL, 8 ft. above the TDZE, so the RA correctly shows that the aircraft is only 92 ft. above the terrain.

* * *

Monticello, New York to Newburgh, New York



Sullivan County airport, Monticello, New York to Stewart Int'l airport, Newburgh, New York with an ILS approach to Runway 9. Click the image to access the complete flight-information package.

The final flight in this section culminates in a CAT II ILS approach. This flight originates at Sullivan County airport, Monticello, New York with a destination of Stewart Int'l airport, Newburgh, New York. The CAT II ILS approach is to Runway 9. Click on the image above to download the flight-information package, msv-swf.zip. The zip-file includes the IFR chart, the CAT II approach plate for ILS Rwy 9 at Stewart, and this text description of the flight.

This CAT II flight will use the autopilot.

You may wonder why Stewart Int'l airport, not near a major city, has an 11,818 ft. runway. Those living in the region will remember it as Stewart Air Force Base, an installation closed down for budget reasons.

We proceed south-bound from Monticello to the Huguenot VOR and turn east to intercept the localizer to Stewart's Runway 9, followed by the CAT II approach.

As usual, do nothing until you have gone through the step-by-step details of the flight with this text and your charts.

- Set the flight simulator weather conditions to 630 ft overcast, cloud tops at 10,000 ft., and one-quarter mile visibility. The wind is calm.
- Move the aircraft to Sullivan County's Runway 15, airport MSV, and retract the flaps to 0°.
- Tune the Primary Nav. receiver to Stewart's Runway 9 Localizer, 110.1 MHz., ident I-SWF.
- Set the Primary VOR OBS to 092° as a reminder of the runway heading.
- Tune the Secondary Nav. receiver to the Huguenot VOR, 116.1 MHz., Ident HUO.
- Set the Secondary VOR OBS to 165°. Fly the first leg with Nav-2.
- Switch the DME to Nav-2.
- Fly Nav-2. Takeoff from Runway 15 with a right turn to 165° on climb-out.
- Pay close attention to VOR-2. The OFF flag will be showing because the aircraft is out of range of the HUO Omni until you gain sufficient altitude. Turn on and leave on the VOR-2 ident so that you will hear when this VOR becomes active. Check that the OFF flag is no longer visible before relying on this gauge.
- Intercept and track the 165° radial to Huguenot VOR.
- ATC has cleared you to 5000 ft. Climb at 90 kts., then cruise at 120 kts. after reaching your assigned altitude.
- At Huguenot VOR turn left to heading 080°.
- Change VOR-2 OBS to 080°.
- Begin descent to 2900 ft.
- Track HUO's 080° radial to the MANEE intersection, the intercept of Stewart's Runway 9 Localizer.
- Fly Nav-1. On localizer intercept, turn right to 092°.
- Turn On the autopilot and activate the Approach function—APR.
- Descend to 2400 ft.
- Monitor the flight instruments to be certain that the autopilot is accurately tracking the localizer.

- Drop one notch of flaps and slow to 80 kts.
- On glide slope intercept, reduce the RPMs to maintain 80 kts.
- Monitor Airspeed and all other flight gauges closely. Don't let anything wander.
- The DH is 582 ft., 100 ft. above the runway.
- Don't look away from the gauges until very shortly before reaching the DH, at the Inner Marker (series of high-speed dots from speaker.)
- At the DH, disconnect the autopilot (press "Z") and manually fly the aircraft to touchdown.
- Stewart's Runway 9 TDZE is 482 ft.
- Flight time: 26 minutes.

* * *

CONGRATULATIONS!

You've completed the Tutorial, and that deserves an award.



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