Cross Country Planning and Flying Guide

Planning the Flight:

- Methods of Navigation
- Optimum Cruise Altitude
- Weather Prediction
- Diverting to an Alternate

Radio Navigation:

- VOR Operations

Sparky Imeson

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By Sparky J. Imeson

Aurora Publications
SAN: 297-5262 ISBN: 1-880568

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The purpose of the information is to provide a format of a general guide for gound and flight operations. The information is not meant to replace a flight instructor.

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Flight Planning

Chapter One
PLANNING AND EXECUTING THE FLIGHT

Perhaps everyone has, at one time or another, experienced a learning situation (public school or flight school) where an instructor asks a question and the student draws a blank. We aren’t talking about the temporary situation where anxiety or pressure causes the student to “freeze up.” This is the circumstance where the student avows, with absolutely no recollection, that he has never before heard of the question. This can occur when the student is overloaded with information, determines some subjects as being important, and filters the rest out of their minds.

Instructors usually present to their student pilots all the information necessary to carry out cross-country flights; however, this information isn't always retained by the student. Or if it is, it is not organized in any particular manner. This leads the student to have feelings of doubt about going on solo cross country flights.

The following information will provide a chronological listing of the items to be considered on a cross country flight.

- METHODS OF NAVIGATION
- DOUBLE CROSS SYSTEM FOR NAVIGATION
- CRUISE ALTITUDE
- PREFLIGHT PREPARATION
- DIVERTING TO AN ALTERNATE AIRPORT
- LOST PROCEDURES

Methods of Navigation

There are several methods of navigating from one point to another. While you can use any one of them for a flight, it is best to use a combination of them. This redundancy will keep you from becoming temporarily misplaced (lost).

PILOTAGE

Flying cross country when using only a chart and flying from one visible landmark to another is known as pilotage. This method requires that the flight be conducted at comparatively low altitudes so the landmarks ahead may be easily seen and identified. Therefore, it cannot be used effectively in areas that lack prominent landmarks or under conditions of low visibility.

Advantages - It is comparatively easy to perform and it does not require special equipment.

Disadvantages - A direct course is usually impractical because it is often necessary to follow a zigzag route to prominent geographical landmarks. This often results in a longer flight.

DEAD RECKONING

Dead reckoning is the navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction and speed, ground speed and elapsed time. To oversimplify, it is a system of “determining where the airplane should be on the basis of where it has been.” In other words, it is literally deduced reckoning, which is where the term came from. That is, the abbreviation “deduced” or “ded” reckoning.

The most common form of VFR navigation is a combination of dead reckoning and pilotage, during which the course flown and the airplane's position are calculated by true dead reckoning and then constantly corrected for error and variables after visually checking nearby landmarks.

RADIO NAVIGATION

Radio navigation includes any method by which a pilot follows a predetermined flight path over the earth's surface by utilizing the properties of radio waves. The primary systems are VOR, ADF, GPS, and LORAN. Other aspects of flight preparation and procedures will be examined before discussing radio navigation.

DOUBLE-CROSS SYSTEM FOR NAVIGATION

Confusion often exists when dealing with the terms true, magnetic and compass courses and true, magnetic and compass headings. It seems the definitions seldom make sense and if they do, there are so many definitions you never have the capacity for remembering everything. The double cross system is designed to be easily remembered. From it, definitions can be derived to answer any practical written or oral test question, and you eliminate the possibility of making errors when dealing with courses and headings.

The Double Cross

The double cross should be committed to memory and used whenever a course or heading is mentioned or used during your flying career.

To make a double cross, draw a vertical line with two crossing lines:

Make the cross large enough to allow numerals to be written into their proper places.

Next, label each alternate space and line using the mnemonic aid, True Virgins Make Dull Company (or some similar memory aid such as "TV Makes Dumb Children"). The first space is a T, the line is V, the next space is M, the line is D and the last space is C.

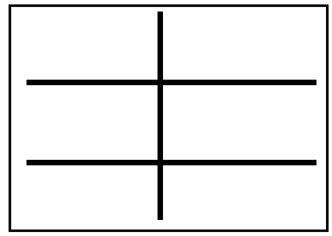


Figure 1.

The vertical line is labeled WCA, representing the wind correction angle. Whenever a course is corrected for the effect of the wind, a heading results. Courses are on the left side of the double cross. Headings are on the right side of the double cross.

The top left space will be used to log the true course. The horizontal line represents variation. The next space is magnetic course, the line is deviation and the last space is the compass course.

That is all the memorization required. Just be able to draw the double cross and label it using the memory aid. It will be of immense value to you throughout your flying career.

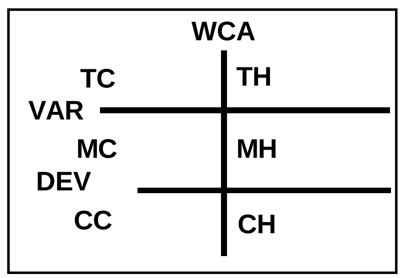


Figure 2. Double Cross

Double Cross Operation

How does the double cross work? In the upper left of the cross is the true course, represented by TC. This is the line drawn on the chart from the departure airport to the first checkpoint or between checkpoints. It is measured in relation to a meridian of longitude (the lines printed on the chart that connect the South Pole and the North Pole. The measurement is taken near the mid-point of the course line to average variation.

If you used the VOR compass azimuth to determine this course, it is a magnetic course and should be placed in the space labeled MC.

A new double cross must be drawn for each route segment.

True course is the intended track (path over the ground) measured clockwise from true north (meridian of longitude) on the aeronautical chart.

Beneath the true course is a line that separates true course from magnetic course. This is the ***variation line***. If you cross this line, going from true course to magnetic course, you must correct for variation. *Magnetic course is the true course corrected for variation.*

Variation

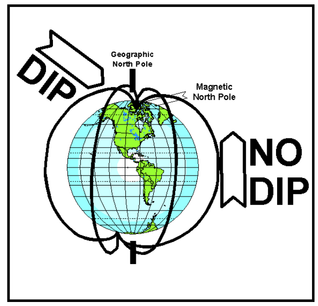


Figure 3. Magnetic Equator and Poles

Variation is the angular difference between the geographic North Pole (True North Pole) and the Magnetic North Pole. It results because the Magnetic North Pole is located some 800 miles south of the True North Pole near Ellef Ringnes Island in northern Canada at 70 degree north latitude and 100 degrees west longitude (in 1975). It drifts west about 0.2 degrees each year. An *agonic line* (zero variation) passes through the east central United States. To the east and west of the agonic line are isogonic lines (declination). These are represented by dashed lines on aeronautical charts and denote the number of degrees of east variation or west variation for any particular area.

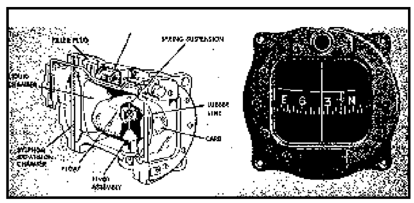


Figure 4. Magnetic compass

A compass in an airplane located west of the agonic line (western U.S.) points to the Magnetic North Pole. In doing so, it points east of the True North Pole. This is called east variation. If an airplane was pointed at Magnetic North and east variation was subtracted from the compass indicated direction, true north would be determined.

When moving from the magnetic course to the compass course, you have to cross the line labeled deviation. Apply the deviation from the compass correction card which is found in the airplane.

In a no-wind condition a flight from the departure airport using the compass course would end up over the first checkpoint after a certain amount of time. However, the wind is usually blowing. Therefore, when a course is corrected for wind (wind correction angle), a heading results. The right side of the double cross is labeled in the same manner as the left, but instead of “c” for “course,” use “h” for “heading.” The vertical line separating the courses and headings is called the WCA line (wind correction angle). This value is obtained from the wind side of the computer.

There are two simple rules to help you remember how to correct for variation and the wind correction angle.

VARIATION RULE

“East is least, west is best.” From the true course or true heading, subtract an east variation and add a west variation. This works only when moving vertically downward from either True Course to Magnetic Course or True Heading to Magnetic Heading.

WCA RULE

“Left is least.” The WCA rule doesn't really need to be memorized, since its use involves common sense. If you are flying in any one direction of the 360 degrees of a circle and turn to the left for the wind correction angle, it will result in a smaller heading. So “left is least” just reminds us to subtract a left WCA. This rule only works when moving horizontally in the double cross from left to right. That is, from any course (true, magnetic or compass) to any heading.

Whenever you do flight planning involving courses or headings, there is a chronological order in the use of the double cross, down and to the right. The variation rule and WCA rule is based on this premise. You always begin the double cross with the true course (measured from the chart at the mid-point in relation to the meridian of longitude) or the magnetic course (read from the chart using the VOR compass azimuth which is aligned with magnetic north).

During a written exam, you may be given a compass heading and be asked for the true course. This is “going against the grain.” This will require reversing the variation rule and WCA rule. Instead of subtracting east variation when moving in the double cross from magnetic heading to true heading or magnetic course to true course, it is necessary to add.

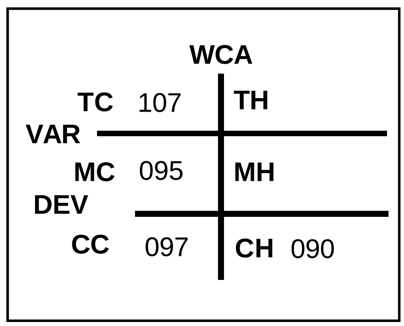


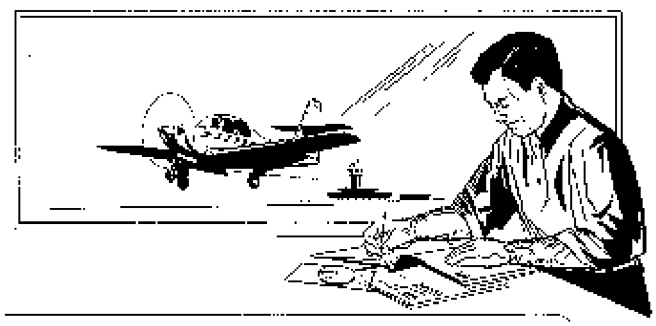
Figure 5. Sample of exam problem.

For example, you may be told the compass heading is 090 degrees, the WCA is 7 degrees left, the deviation is +2 degrees and the variation is 12 degrees east. In determining the true course, write 090 in the bottom right of the double cross. If you were moving from the CC to the CH, you would subtract the 7 degrees left WCA; but instead, you add it, arriving at a CC of 097 degrees. Moving up from CC to MC, the deviation is +2; but it is now subtracted, making the MC 095 degrees. Moving from the MC to the TC would involve adding the 12 degrees east variation (which is normally subtracted, east is least), the TC would be 107 degrees.

After working through a test problem in this manner, it is a good idea to go back through the double cross using the proper rules to check your math. Instead of moving down to the magnetic course and compass course and over to the compass heading, try moving to the true heading and then the magnetic heading and finally the compass heading. Apply variation and deviation in the proper manner. If you obtained the CH of 090 degrees, you worked the double cross correctly.

This confirms that you performed the reversed rules properly while working your way backwards through the double cross.

Whenever working with the double cross your main objective is to determine the compass heading. The *Compass Heading* is the value that allows you to fly from point "a" to point "b," compensating for variation, deviation and wind drift. There is no need to determine the TH and MH if you originally moved vertically downward, then to the right; however, by determining them, it serves as a check of your mathematics.



CRUISE ALTITUDE

To fly cross country as quickly and efficiently as possible, much time and money can be saved by advanced planning. Maximum speed and maximum efficiency do not always go hand in hand. With a headwind, usually maximum cruising power yields the greatest efficiency. With a tailwind, the minimum cruising power will produce the greatest efficiency.

To obtain the best point-to-point speed requires consideration of the cruise altitude, wind, ground speed and cruise power.

Cruise Performance

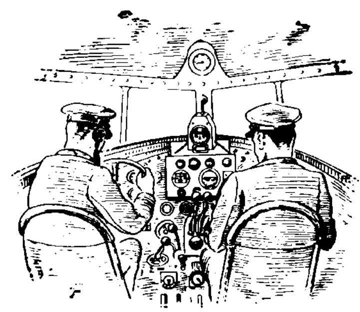
Cruise performance is defined as the ability of the airplane to present good speed and range characteristics while operating at the designed economical lift-drag ratio range. In other words, the best cruise performance will result in the fastest cruise speed and the greatest economy.

Thin Air

This air is the result of climbing. As altitude is gained, the density of the air decreases. From an aerodynamic standpoint, thinner air offers less resistance in the form of parasite drag, which makes it easier to propel the airplane. This allows the airplane to fly faster with any given power setting than it would at a lower altitude.

Since you never get something for nothing (except on the internet), this advantage is not without its disadvantage, from the standpoint of the engine. The *best power mixture* results when the fuel/air ratio is maintained at one pound of fuel for each 12½ pounds of air. As the airplane climbs above sea level, the volume of air entering the engine remains the same, but the weight of the air decreases as the air density decreases. The decrease in atmospheric pressure results in a loss of power since the ability of an engine to burn gasoline and develop power depends directly upon the quantity of air by weight that passes through it.

Optimum Cruise Altitude



The maximum obtainable cruise speed of an airplane in a no-wind condition and at a particular power setting, say 65 percent power, will be obtained at the highest altitude where the engine is able to develop 65-percent power at full throttle. The airplane is as high as possible to obtain maximum advantage from the thin air, yet not so high that the loss of air (by weight) causes cruise power to be reduced to less than that desired. This is called the optimum cruise altitude.

As the airplane climbs higher than this altitude, engine power will decrease from 65 percent due to a further loss of air by weight. This results in a greater decrease of airspeed than the gain realized from the decreasing resistance of drag on the airplane.

For any normally-aspirated (non-supercharged or non-turbocharged) engine, the optimum altitude for 75-percent power will usually be around 8,000 feet, depending on the temperature. If the temperature is colder than standard temperature, the optimum altitude will be higher, perhaps as high as 9,000 feet. If the temperature is hotter than standard, the optimum altitude will be lower, perhaps as low as 7,000 feet. The exact altitude should be obtained from the engine power setting chart (cruise performance chart).

The lower the desired power setting used, the higher will be the optimum altitude. The time and power it takes to climb to a favorable operating altitude must be considered when selecting your cruise altitude. Generally, the airplane with a normally-aspirated engine (non-supercharged, non-turbocharged) that has a cruise speed under 130 knots, should not be climbed to a cruise altitude above 9,000 or 10,000 feet above ground level unless the proposed flight is of two hours or greater duration or terrain features require greater altitude. It takes this long to amortize the additional time for the climb. However, the presence of a favorable tailwind could change this recommendation.

Depending upon the performance of your airplane, it is usually inefficient to climb more than 10 minutes per hour of estimated time enroute for the entire trip. If the rate of climb in your airplane is 500 feet per minute, you shouldn't climb more than 5,000 feet above ground level for each one hour of flight time.

EFFECT OF WIND

Occasionally the winds aloft are less at high altitudes than near the ground. For this reason it is wise to check the winds aloft at all altitudes where it is possible to fly. Although a headwind may be stronger at a higher altitude, its direction may be more favorable, allowing a greater ground speed. Additionally, the increase in true airspeed at higher altitudes may more than compensate for a stronger headwind as well as provide a smoother flight void of convection currents.

After takeoff, while climbing to the enroute cruising altitude, it is recommended that you climb at the best rate-of-climb airspeed whenever a no-wind condition or tailwind is present. A maximum rate schedule is used to conserve climb fuel for the more efficient operating environment at altitude, unless a lower pitch attitude is required for better forward visibility. When climbing into a headwind, use a faster cruise-climb airspeed to minimize the effect of a lower ground speed.

PREFLIGHT PREPARATION

Safety statistics show that many general aviation accidents could have been avoided with the proper flight planning. Air navigation begins and ends on the ground. Federal Aviation Regulations require that certain flight planning procedures be performed for a flight “not in the vicinity of an airport.” This has been interpreted to mean a flight of more than 25-nautical miles from the departure airport. It also requires weather and aircraft performance determinations. This includes obtaining pertinent weather information, plotting the course on an aeronautical chart, selecting checkpoints, measuring distances and computing flight time, headings, fuel requirements, weight and balance and takeoff and landing distances under the expected conditions of runway elevation and temperature (density altitude).

EQUIPMENT

Assemble all the materials needed for flight planning. In order to facilitate this, as well as to assist during enroute navigation, it is a good idea to keep all the equipment in one place. A flight bag is recommended for your charts, computer, plotter, lap board or knee board, Flight Guide or similar airport diagram book, notebook, pens and pencils, flashlight (with spare bulb and batteries), ear plugs, stop watch, screw driver and pliers, etc.

CHECKING WEATHER

Check the general weather trend to see if the proposed flight is feasible and which route would be the best. This is just a preliminary check to determine the weather is VFR and to obtain the winds aloft forecast to use in computing ground speeds and wind correction angles. A comprehensive check is made later and is called a *weather briefing*.

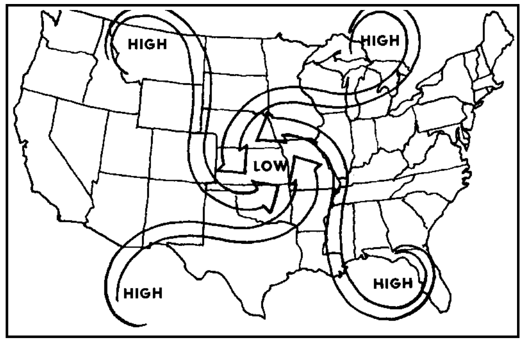


Figure 6. Surface wind flow and pressure areas.

Weather Prediction

Tom Herrod, Billings, Mont. taught many people to be good pilots. In addition to his demanding perfection, one reason for his success included the teaching of may "tricks-of-the-trade," which include: Buys Ballot's Law and Tom's Law.

Buys Ballot's Law

In aviation weather, if an observer in the Northern Hemisphere stands with his back to the wind, lower pressure will be on his left. This is known as *Buys Ballot's Law.*

Tom's Law

A modification to this law can be helpful in making *general* weather predictions when flying from an "outback" strip that does not have communications capability. The variation of the law is known as *Tom's Law.*

> **Tom's Law** – *Face the surface wind and extend your left arm 45º to the left; extend your right arm 135º to the right (a total of 180º). The left hand points to a high pressure area and good weather. The right hand points to a low pressure area and bad weather.*

Obviously you cannot tell how good or how bad the weather is going to be, but it is a starting point in developing a go/no-go decision when nothing else is available. It is also a method to check out the forecast weather with this rule.

Proving the Law

Having defined Tom's Law, let's examine why it is true. The atmosphere is in a constant state of change or motion. This motion is called circulation. Circulation is created primarily by the large difference between temperatures over the Tropics and over the Polar regions. This is further complicated by uneven heating of land and water surfaces.

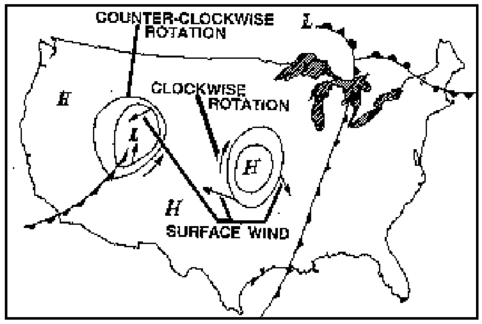


Figure 7. The surface wind blows 45-degrees inward on a low and 45-degree outward on a high. Above surface friction (2,000 ft) the wind blows parallel to the isobars.

A high pressure area is a center of high pressure that is surrounded on all sides by lower pressure. A low pressure area is a center of low pressure that is surrounded on all sides by higher pressure. The atmosphere is in a state of disarray. In trying to regain equilibrium, the high pressure areas subside and the low pressure areas fill in.

In the Northern Hemisphere, a low pressure area has counterclockwise winds associated with it. Above 2,000-feet AGL, the wind blows parallel to the isobars (lines of equal pressure). Below 2,000-feet AGL, because of *coriolis force* and surface friction, the ***wind blows 45º inward to the low,*** trying to fill the low pressure area. A ***high pressure*** area has clockwise circulation, with ***the surface winds blowing 45º outward.***

Look at a weather depiction chart and determine the wind direction from a station model, aviation sequence report (METAR), or by drawing a line, at any point along the isobar, 45º inward on a low. Remember the low has counterclockwise circulation, then make a pencil point at the desired location and draw the 45º angle line inward from the isobar. This represents the surface wind direction.

Facing the wind from this low pressure area results in the left hand pointing away from the low and toward a high pressure area; the right hand points directly toward the center of the low pressure area.

If looking at a hight pressure area on a chart, draw the line and the same rule applies. Remember clockwise circulation about a high, then draw the 45º angle line outward from the high. This represents the surface wind. Facing the wind from this high pressure area results in the left hand pointing toward the high and right hand pointing toward the low.

PLOTTING THE COURSE

Sectional aeronautical charts are the best for cross country flight planning because of their scale of 1:500,000 and the abundance of detail, as compared to the WAC Chart (World Aeronautical Chart) with a scale of 1:1,000,000.

Sectional Aeronautical Chart

Scale 1:500,000
8 statute miles per inch (6.95 nautical miles)

World Aeronautical Chart (WAC) and ONC Chart

Scale 1:1,000,000
16 statute miles per inch (13.9 nautical miles)

If your route of flight takes you near the border of the chart, be sure to have the charts of the area adjoining the flight route. In this way you are prepared if you need to circumnavigate weather or if you find you have become temporarily misplaced and need to locate your position.

1. DRAW A TRUE COURSE LINE.

Draw a line representing the course to be flown. Measure it in relation to the meridians of longitude. This is the true course. This course line should be drawn between the points of intended flight. It is not necessarily a direct line from the departure to the destination airport.

The course line originates at the center of the departure airport and ends at the center of the destination airport. If a VOR is located near the departure airport or along the route of flight, it is recommended the flight go from the departure airport to the VOR and then on to the next checkpoint. Many pilots plan and fly their entire route from one VOR to another rather than making direct flights, since this makes VOR navigation easier.

The course line is drawn between the points (check points) of the intended flight. This line should be dark enough to be seen, but not so heavy as to obscure the symbols on the chart. A pencil is better than a felt tip marker. Do not get into the habit of using a red pen or pencil for drawing the true course line since at night the red lights used in many airplanes for cockpit lighting may make the line disappear, or so it will seem.

Select appropriate check points along the route and note them on the chart in some way. They should be easily recognizable.

Check along and to either side of your route for alert areas, warning areas, restricted areas, prohibited areas, intensive student jet training areas, Class B airspace (TCA), Class C airspace (ARSA) and Class D airspace (airport traffic area and control zone). Also, at this time, check for towers and other man-made obstructions.

Study the terrain along your route for the highest and lowest elevations. The highest elevation is needed to determine adequate terrain clearance. The lowest elevation is needed to conform with the VFR cruising altitude requirement, which states that when flying 3,000 feet or more above ground level (AGL) on a *magnetic course* of 0 degrees through 179 degrees, fly any odd-thousand-foot altitude plus 500 feet. On a magnetic course of 180 degrees through 359 degrees, fly any even-thousand-foot altitude plus 500 feet.

2. MEASURE THE TRUE COURSE.

Measure the course of each route segment. You want to ultimately end up with the compass heading to fly from point “a” to point “b.” This compensates for variation, deviation and the wind.

Measure the true course of each route segment. This is the angle between the course line and the meridian of longitude midway between the straight-line segments of the route. Because the earth is round, the meridians taper in toward the Poles. It is important to make the measurement of the true course on a meridian that is approximately half-way between checkpoints. This provides an accurate reading, averaging the error caused by the tapering meridians. Meridians are the vertical lines printed on the chart that converge at the North Pole and South Pole.

Determine the variation from the mid-isogonic line. Apply it using the rule, “east is least, west is best,” to the measured true course to obtain the magnetic course.

If there is a VOR station located on the airport, the magnetic course can be determined by reading it where the course line intersects the compass rose (azimuth) that surrounds the VOR station on the chart. This eliminates the need to measure the true course. Remember though, if your flight is “TO” the VOR, the course determined by reading the VOR compass azimuth is “FROM” the station. You must determine the reciprocal when flying “TO” the station.

3. MEASURE THE COURSE DISTANCES.

Measure the course distance between each checkpoint and note this on the flight log. Check the scale on the plotter against the distance scale on the bottom of the chart. If there is any discrepancy, use the distance scale on the chart. Sometimes the paper is stretched during printing or folding and it will have quite an error when compared with the plotter; however, since the paper is stretched, its scale is also stretched, making it the most accurate.

Mileage Conversions

1 nautical mile (6,076.115 feet) = 1.150779 statute miles

1 statute mile (5,280 feet) = 0.868976 nautical mile

1 kilometer (3,280.333 feet) = 0.621369 statute mile

1 kilometer (3,280.333 feet) = 0.539955 nautical mile

Based upon this information, the following mileage conversions can be made on the flight calculator:

Statute miles = 1.15 x nautical miles

Nautical miles = .87 x statute miles

Statute miles = .62 x kilometers

Nautical miles = .54 x kilometers

Kilometers = 1.61 x statute miles

Kilometers = 1.85 x nautical miles

4. DETERMINE THE GROUND SPEED.

Use the winds aloft forecast and the estimated true airspeed (TAS) with your computer to determine the ground speed for each route segment (between checkpoints). Since most pilots fly from VOR to VOR or use a flight log incorporating magnetic courses, it is recommended the wind, which is always given in true north and in knots in the air, be converted to magnetic. This usually results in only one conversion, rather than changing each magnetic course to the true course for each leg of the flight. This simplifies flight planning and will speed it up.

5. COMPUTE THE TIME AND FUEL REQUIRED.

From the computed ground speed and measured distance, use the flight computer and compute the time and fuel required for the flight. In preflight planning, accurate estimates of the estimated time enroute (ETE) must be made to establish the fuel requirements for the flight. The amount of fuel required and any necessary fueling stops enroute can be determined by computing the enroute time versus the rate of fuel consumption. The fuel capacity and rate of fuel consumption can be found in the Airplane Flight Manual, Pilot's Operating Handbook (POH), or Owner's Manual.

DIVERTING TO AN ALTERNATE AIRPORT

During an emergency that may be caused by mechanical malfunction, adverse weather or a medical emergency, there may not be time to dig out your plotter and computer to measure a new course. Yet it is essential to become established on the new course in the least amount of time.

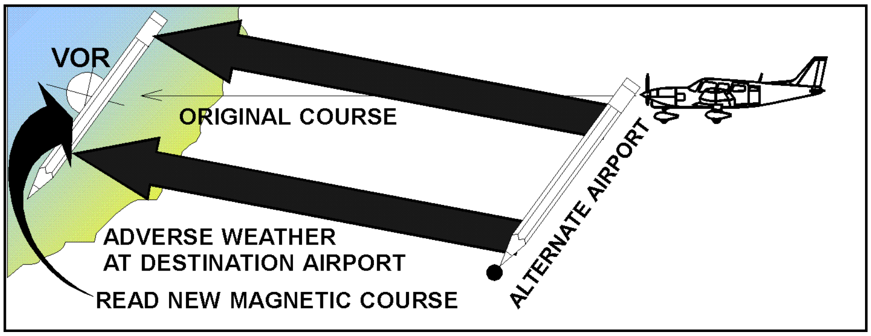


Figure 8. Emergency course measurement - align a pencil along the desired new course. Move the pencil parallel to the course to a VOR compass azimuth to read the new course

Among the aeronautical skills all pilots must have is the ability to plot courses in flight to alternate destinations when flight to the original destination becomes impractical. This may be accomplished by means of pilotage, dead reckoning or radio navigation. Advantage must be taken of all possible shortcuts and rule-of-thumb computations.

It is rarely practical while in flight to actually plot a course line on the chart and then mark checkpoints and distances as is usually done during preflight planning. Because the alternate airport selected in an emergency is usually not very far from the original course and known position, such actual plotting is seldom necessary.

COURSE MEASUREMENT

Assume radio navigation is not practical or possible and pilotage is impractical. That leaves us with dead reckoning. Courses to alternates can be measured accurately with a protractor or plotter. But they can also be measured with reasonable accuracy using a straight edge and the compass rose shown at VOR stations on the chart. VOR radials, the compass azimuth and airway courses are already oriented to magnetic north.

By knowing your approximate position on the chart, align a pencil from your position to the alternate airport. Next move the pencil to any VOR compass rose, carefully paralleling the desired course. Read the magnetic course from the azimuth scale of the VOR compass rose.

To complete all plotting, measuring and computations involved BEFORE diverting toward the alternate airport may only aggravate an actual emergency.

Use rule of thumb computations. If the airplane flies 120 knots per hour, the speed is two miles per minute. If 20 miles away from the alternate, it will take about 10 minutes.

DISTANCE MEASUREMENT

When a plotter is not handy and it is inconvenient to try to fold the aeronautical chart so the mileage scale along the bottom can be used, distances can be very accurately measured by using a straight edge such as a pencil or piece of paper in conjunction with the minute scale along any meridian of longitude (vertical true north line).

Another method is to hold the chart on your lap. Pick it up on each side so the top and bottom edges fold down. Pinch your known position with one hand and the new destination with the other, pull the chart taut and crease it between the known position and destination. Turn the chart on your lap so the crease is horizontal. Locate a VOR compass azimuth on either side of the crease. Roll the edge containing the VOR and move it to the crease. Another crease can be made through the center of the VOR. This will provide the magnetic direction to the destination. This is quite accurate since rolling the chart keeps the VOR parallel to the creased course.

The meridians of longitude which run vertically from the Poles through the equator are divided into degrees. The equator is the starting point or zero degrees. From the equator to either Pole is a quarter of a circle or 90 degrees. The Pole itself represents the 90 degree position. Each degree is divided into 60 minutes and is marked with a ticked line on the aeronautical chart. One minute of longitude is 6,076.115 feet (1,852 meters), which is the definition of a nautical mile.

By placing the point of a pencil (any straight edge) at one end of the course for which distance is to be measured, you can pinch the pencil along its length at the other end of the course to be measured. Then, move the pencil to a vertical position. The pinched part is held on any parallel of latitude (parallels of latitude run horizontally across the chart) with the pencil point up or down. Count the ticks vertically up or down (the minutes of longitude) to the point of the pencil. This will be the number of nautical miles of the route segment.

CAUTION: Do not measure distance horizontally along the parallels of latitude, only vertically along the meridians of longitude.

ESTIMATING TIME

To find out how many minutes are required to fly to the alternate airport, at various groundspeeds, use the following estimates:

80 knots groundspeed, multiply the distance by 0.75 to get minutes.

100 knots groundspeed, multiply the distance by 0.6 to get minutes.

120 knots groundspeed, divide distance by 2 to get minutes.

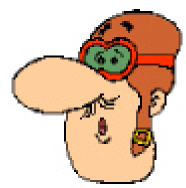
150 knots groundspeed, multiply the distance by 0.4 to get minutes.

180 knots groundspeed, divide distance by 3 to get minutes.

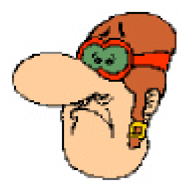
Drop the last digit of the airspeed (groundspeed if known); you will fly that many miles in six minutes.

LOST PROCEDURES

Plan your flight and fly your plan. Whether a pilot becomes lost, temporarily misplaced or his airplane becomes lost, doesn't really matter. Knowing where you are or being able to determine where you are, that's what is important.



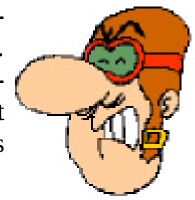
Whether a pilot becomes confused depends on whether or not a definite plan is followed. The greatest hazard to a pilot failing to arrive at a given checkpoint at a particular time, is panic. The natural reaction is to fly to where it is assumed the checkpoint is located. On arriving at that point and not finding the checkpoint, a second position is usually assumed and the panicked pilot will then fly in another direction for some time. As a result of several of these wanderings the pilot may have no idea where the airplane is located. Generally, if planning was correct and the pilot used basic dead reckoning until the estimated time of arrival (ETA) runs out, the airplane is going to be within a reasonable distance of the planned checkpoint.



At some time or another, though, all pilots become temporarily misplaced. Therefore, it is important to give some forethought to the procedures and practices that may be used when you become misplaced.

What should you do if you find yourself in this situation? First, don't fight the problem or push the panic button. Solve the problem. Solving the problem begins with a calm analysis and evaluation of your situation. What is your fuel supply? How does the weather affect your problem? What kind of equipment are you flying? Are you and the airplane qualified for IFR flight, if necessary? What is the terrain like? How much daylight remains?

Accidents generally do not occur because of one mistake, but rather because the pilot lets his mistakes multiply over a period of time. Getting lost is no exception. Don't push your luck. If terrain or other conditions such as bad weather make it impossible to continue the flight, get the airplane on the



ground. Don't waste time searching for a perfect field, as anything usable will do in an emergency. Remember the nevers. Never fly until the fuel runs out. Never fly until the sun slowly sinks behind the horizon if you are not proficient at night flight. Never fly until the weather deteriorates to hazardous conditions.

There are several different actions to be followed when the pilot is unsure of the airplane's position while using pilotage and/or dead reckoning. The best choice depends upon the circumstances, but usually they should be applied in the following sequence.

CIRCLE OF ERROR

When unsure of your position, continue to fly the original computed heading toward the next checkpoint and watch for recognizable landmarks while rechecking the calculated position. By plotting the estimated distance and compass direction flown from the last noted checkpoint as though there were no wind, the point so determined will be the center of a circle within which the airplane's position may be located. This is often called a circle of error. The circle comes from the wind. For example, if the wind is 20 knots and you have been flying for one-half hour the maximum drift would be 10 nautical miles. Make a circle around the point with a 10 nautical mile radius. If the wind is 30 knots, make the circle with a 15 nautical mile radius around the point established from the no wind airplane position.

As an example, if the airplane has flown 36 minutes since the last known checkpoint and it has a true airspeed of 124 knots, it is traveling approximately two nautical miles per minute. Multiply the two times 36 and obtain 72 miles in a no wind condition. If you use a computer this works out to 74.4 miles. This distance would be plotted on the chart as the center of the circle of error. The velocity of the winds aloft forecast is then divided in half and this distance plotted to the north, south, east and west of the point. A circle is then drawn, connecting these points. It is then a matter of continuing straight along your computed course and checking the landmarks within this circle. The most likely position will be downwind from the desired course or point.

If this procedure fails to identify the position, the pilot should change course toward the nearest concentration of prominent landmarks shown on the chart. If some town or developed area is sighted, the pilot can circle low to observe identifiable features or markings, but be sure to comply with the minimum safe altitudes prescribed by FAR 91.79.

In the event these methods are ineffective in locating position or when fuel exhaustion or darkness is imminent, with no other alternative available such as radio navigation, a DF steer or radar vectors, it is recommended the pilot make a precautionary landing while adequate fuel and daylight are still available. It is desirable, or course, to land at an airport, but if one cannot be found a suitable field may be used.

When a landmark is finally recognized or a probable fix obtained, the pilot should at first use the information both cautiously and profitably. If there is a pronounced discrepancy, such as the location of a town on the chart without a railroad track or the location of a town along the ground with a railroad track, it is well to be dubious of the new fix until it can be positively identified. No abrupt change in course should be made until a second or third landmark is found to corroborate the first.

It is well to determine the probable cause of getting off the course originally so the error will not be repeated. Miscalculations in determining the ground track may arise from miscalculating the wind drift, applying the wind forecast at a level at which drift is opposite to that at cruising altitude, applying magnetic variation to the compass incorrectly, or simply from misreading the compass or failing to reset the heading indicator.

When the airplane seems to have made an abnormally high or low groundspeed, the error may be caused by using the wrong mileage scale (nautical versus statute, sectional versus WAC), misreading the clock, skipping mileage marks when scaling the course line on the chart, using improper airspeed indications (knots versus MPH) or from other causes. Whatever the error, once determined it should be borne in mind to avoid repetition on the remainder of the flight. In some cases it may be necessary to re-estimate the fuel hours remaining and to change the destination accordingly.

DF STEER

DF (VHF/UHF Direction Finder) equipment is of particular value in locating lost aircraft and in giving guidance to the pilot. The pilot needs only two-way VHF radio communications capability to make use of this service.

DF stations provide headings and bearings for aircraft on the primary or secondary frequencies of Flight Service Stations (FSS), some control towers, and some approach control or radar units.

All that is necessary is for the pilot to call a FSS or other facility and request a DF steer to a known position. The DF operator takes a bearing and directs the pilot to the airport.

DF equipment has long been used to locate lost aircraft and to guide aircraft to areas of good weather or to airports. DF instrument approaches are available for emergency use in IMC (instrument meteorological conditions) when the pilot has declared a distress or urgency condition. DF approach procedures provide maximum flight stability in the approach by using small turns and wings-level descents. The DF specialist will give the pilot headings to fly and tell him when to begin descent.

RADAR ASSISTANCE

Radar equipped FAA air traffic control (ATC) facilities will provide radar assistance (vectors to an airport) to VFR pilots requesting assistance providing you call the facility, are within radar coverage and can be radar identified. Factors such as limitations of the radar (not enough altitude in mountainous terrain), volume of traffic, communications frequency congestion and controller workload could prevent the controller from providing vectors unless the pilot is having an emergency.

An emergency can be either a distress or an urgency condition. Pilots don't seem to hesitate to declare an emergency when they experience a distress situation such as fire, mechanical failure or structural damage. However, too many pilots are reluctant to report an urgency condition. An urgency condition exists when the pilot is doubtful about his position, fuel endurance, weather or any other condition that could adversely affect flight safety. When this occurs, ask for help before the situation develops into a distress condition.

Most of the time the controller providing vectors will be unable to determine if he is vectoring you into instrument conditions. You should keep the controller advised of the weather conditions in which you are operating and along the course ahead.

THE FIVE Cs

When a pilot is in doubt about the airplane's position or feels apprehensive for the safety of the flight, there should be no hesitation to request assistance from the nearest FSS or other facility. These facilities, including radar, radio and DF stations are ready and willing to help. Delay in asking for help has often caused accidents.

The five Cs procedure should be strictly adhered to when lost and in trouble.

1. **CONFESS** - Admit to yourself that you have some type of problem whether it is running low on fuel, temporarily misplaced or whatever.

2. **CLIMB** - Altitude improves VHF reception capability.

3. **COMMUNICATE** - Tell someone what your predicament is.

Don't wait too long. Some pilots have waited until they have 10 minutes of fuel remaining and then expect the FSS to get them safely to an airport. FSS personnel are trained to help, if you let them.

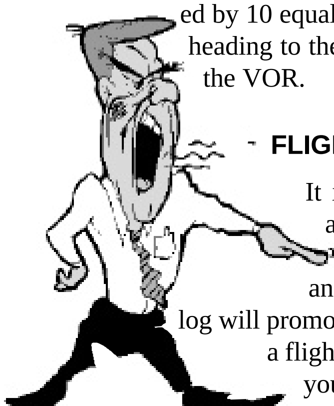
4. **CONSERVE** - Reduce power for slow flight to conserve fuel.

5. **COMPLY** - Comply with instructions from your ground contact.

RADIO AIDS

VOR or ADF can be used very effectively for orientation, if lost. Assuming an ADF station can be tuned and identified, the pilot can then home to the transmitting tower of the radio station and go on from there. If one VOR can be received, center the left/right needle with a from indication. This will give you a line of position on which the airplane is located. It doesn't tell you how far away you are without DME or another VOR cross-check, but if you're really lost you can center the needle with a "TO" indication and track to the station.

If you want to take the time to determine how far you are from a VOR, center the left-right needle with a "TO" indication. Next, turn the airplane until the heading is the same as the OBS setting. Now turn 90 degrees to the left or right. Re-center the left-right needle with the "TO" indication. Begin timing with a stop watch. Either add or subtract 10 degrees from the OBS setting depending upon which way you turned the 90 degrees to the left or to the right. If you turned left, add 10 degrees; if you turned right, subtract 10 degrees for the new OBS setting. Hold that heading you determined after turning 90 degrees and measure the time until the left-right needle centers again. The number of seconds you time for the needle to re-center divided by 10 is the number of minutes to the VOR. For example, if you timed two minutes, that's 120 seconds. 120 divided by 10 equals 12 minutes to the VOR. Now match the aircraft heading to the OBS setting (with a "TO" indication) and fly to the VOR.



FLIGHT LOG

It is necessary and important to have a systematic approach to flight planning. Using a "flight log" will give you the "need to know" information and eliminate the unnecessary information. A flight log will promote accurate and complete preflight planning. With a flight log, all the information for the actual flight is "in your lap," not scattered around the cockpit or stored in a flight bag.

The flight log will eliminate confusion, prevent the omission of important information and make valid use of the time you spend planning the flight. The item that allows this is the flight log.

Another advantage of a flight log is that it becomes an accurate and permanent record of the flight, allowing you to review the aircraft performance, pilot techniques and flight parameters after-the-fact, in the leisure of your home.

Any flight log that you decide to use should be satisfactory, whether it is purchased from a pilot supply store or picked up free from the Flight Service Station (if they are still available).

Regardless of the type flight log used, it should provide columns for at least the following:

Complete the following prior to the flight:

1. Navigational aid identification and frequency (if any).

2. Route (Victor airway or direct).

3. Course "TO" and "FROM."

4. Leg mileage.

5. Mileage remaining determined after the total mileage has been computed).

6. Point to point time (based on the ground speed and distance).

7. Cumulative time.

8. Ground speed.

9. Fuel required.

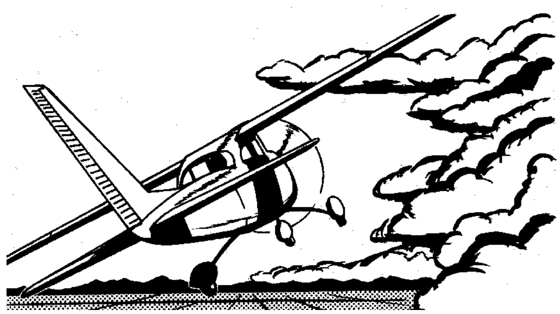
FIXES - or checkpoints. Starting with the point of departure, list all other check points in chronological order.

FREQUENCY COLUMN - The frequency of a radio navigation aid at the fix, if any.

MAGNETIC COURSE - List the magnetic course TO and FROM the check point on the same line. (The departure airport will only have a FROM listing and the destination airport will only have a TO listing).

DISTANCE - The miles between fixes are logged here. The total distance is logged either at the bottom of the form or at the top if there is a provision for determining the miles remaining. Try to get into the habit of using nautical miles. There is an advantage here because winds aloft are in knots and any reports to air traffic control should be in knots.

TIME - This column or combination of columns should provide an area where the ground speed can be divided into the distance to obtain a time for each leg of the flight or point-to-point time. There should be a column to allow you to add up all the point-to-point times for a cumulative time. Another column should provide a space to record the takeoff time. To this time is added the first point to point time to obtain an ETA for that fix. While the times are computed and written on the flight log prior to flight using the winds aloft forecast, the takeoff time and ETA is not completed until after takeoff. After arrival at the checkpoint the ATA (actual time of arrival) is written down and the next point-to-point time is added to this to derive an ETA (estimated time of arrival) for the next checkpoint.



RULE OF THUMB: Compute the altitude difference between the departure elevation and the cruise altitude. Use the computed ground speed for time and distance calculations along the entire distance. Add one minute per 1,000 feet of climb to the enroute time for the first leg to compensate for the reduced true airspeed during the climb. If your airplane has greater performance than most trainers you may find one minute too much. If so, try adding 30 seconds for each 1,000 feet of climb. If this doesn't work out, modify it to suit your airplane.

VFR FLIGHT PLAN

A flight plan is not required for VFR flight unless you fly into Canada, Mexico or penetrate a Coastal or Domestic ADIZ or DEWIZ. It is strongly recommended that you get into the habit of filing VFR flight plans for all your flights to ensure Search and Rescue protection. It's one of the cheapest insurance policies you will ever be exposed to.

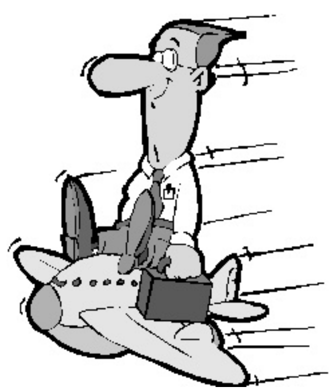
It is best to file a flight plan in person or by telephone rather than by radio, to reduce frequency congestion.

When a VFR flight plan has been filed, it will be held by the FSS until one hour after the proposed departure time and then cancelled unless:

1. The actual departure time is received; or
2. A revised ETD (estimated time of departure) is received; or
3. At the time of filing, the FSS is informed the proposed ETD will be met, but the actual time off cannot be given because of inadequate radio communications.

Once a departure report is received, the flight plan is activated. An aircraft is considered overdue when communications cannot be established with it and it fails to arrive 30 minutes after its ETA. This triggers the following actions:

1. The destination FSS attempts to locate the aircraft if it does not arrive within 30 minutes of its ETA.
2. If not located by the communications search, the departure station is notified and conducts a local check.
3. If the aircraft is not located within one hour after the ETA, an INREQ (information request) is sent to FSSs, towers, ARTCCs (air route traffic control centers) and RCC (rescue coordination center).
4. If the INREQ is negative or two hours after the ETA, the airplane is not found, an ALNOT (alert notice) is sent out. This expands the search area.
5. If one hour has elapsed since the ALNOT, the RCC then conducts an actual air and surface search.



When on a VFR flight plan and a 30-minute change in the ETA occurs, the pilot should contact any FSS and ask them to extend his time enroute.

You should make routine VFR position reports enroute. If something were to happen to you, at the end of the four hours when the air search begins, they will know where to begin the search. For example, if you made a position report half way along your route, the search will be conducted from that point to the destination rather than from the departure point to the destination.

> HINT: If you have trouble remembering to close your VFR flight plan, take along a clothespin and place in on the front of your shirt like a necktie bar. It reminds you to "clothes" your flight plan.

TAKEOFF

1. Just before you start your takeoff roll, write down the actual time on your flight log.
2. After clearing the traffic pattern you will have a chance to call the FSS and open your flight plan.
3. An estimate is made for the first checkpoint by adding the time enroute to the "takeoff" time. Note the arrival time at this checkpoint and enter it in the column labelled ATA (actual time of arrival). Add the point to point time to the ATA and write down the ETA (estimated time of arrival) for the next checkpoint.

ENROUTE

Note the time of arrival over each checkpoint on the flight log. Enter it in the column labelled ATA. Add the ETE for the next leg and obtain the ETA for the next checkpoint.

If you find the time significantly different on several legs, it is a simple matter to re-compute the ground speed and make new estimates for the remaining legs. This will also alert you to a pending fuel problem.

Note: Until you have become established in cruise flight (altitude and airspeed), the computed ground speed will not be completely accurate. Usually it is the third leg which provides you with a known distance and constant true airspeed.

By working with one leg of the flight at a time, if it turns out the winds aloft forecast was totally invalid (or sometimes the wrong scale on the plotter is used), the ground speed may be determined and new estimated point-to-point times written down. If the ETA for each leg was computed in advance, additional work would be involved.

DESCENT

This information may be of assistance in determining the descent to the destination airport. Without prior planning you may find yourself over the destination airport at cruise altitude.

Pilots work out their own system to determine when to begin a descent to the traffic pattern. Usually the descent rate and airspeed is used to calculate when to start down from enroute altitude to pattern altitude.

As an example of how this works, assume you are flying at 11,500 feet and are landing at an airport with an elevation of 5,500 feet. This means you have 6,000 feet to descend. If your descent rate is 500 fpm, it will take 12 minutes to descend (6000/500=12). Assume the ground speed is 120 knots in the descent. This means, at two miles per minute ground speed, that you should begin your descent 24 miles out.

Another method exists which involves simple mental computations rather than computer operations. This method compensates for changes of ground speed during the descent.

To use the descent rule, two definitions are required. First, altitude refers to the altitude in thousands of feet (or think of it as the altitude divided by 1,000). Second, rate of descent is equal to the ground speed divided by two and multiplied by 10. This might sound more complicated than it is as you can see from the following examples.

DESCENT RULE

Suppose we are flying an airplane with a groundspeed of 120 knots at 12,500 feet and are landing at an airport with an elevation of 6,400 feet. The pattern altitude is 7,200 feet. How far out should you begin the descent? The cruise altitude less the pattern altitude is the total number of feet to descend (12.5 - 7.2 = 5.3). This is 5,300 feet. Round it off to 5,000 feet. Remember we refer to altitude in thousands of feet, so 5,000 becomes 5. The distance out to begin the descent is 3 X 5 = 15 miles.

ALTITUDE X 3 = DESCENT POINT

GROUNDSPEED/2 = RATE OF DESCENT

What is the required rate of descent? The groundspeed divided by 2 and multiplied by 10 = the rate of descent. 120/2 = 60 X 10 = 600 fpm descent.

This descent rule will result in a 3-degree glide path for the descent. The nice thing about this rule is that it works for jet, turbo prop, reciprocating, pressurized and non-pressurized aircraft.

The rate of descent does not become excessive for non-pressurized aircraft since their ground speed does not lend itself to this. A ground speed of 150 knots results in a 750 fpm rate of descent.

The ground speed changes during the descent. This may be due to airplane performance (going down hill) or wind direction and velocity changes. Fluctuations in ground speed are adjusted by adjusting the rate of descent (divide the ground speed in half and multiply by 10).

CHECKING YOUR ALTITUDE

It is possible to check the progress of the descent by multiplying the distance from the airport by three. This gives the altitude (in hundreds of feet) above the pattern altitude which you should be at.

DISTANCE X 3 = ALTITUDE ABOVE PATTERN

For example, when you are 10 miles from the destination, 10 X 3 = 30 (in hundreds of feet, so multiply by 100). 30 X 100 = 3,000. You should be 3,000 feet above the pattern altitude. If not, you can adjust the rate of descent accordingly.

This descent rule is useful for crossing restrictions assigned by ATC (Air Traffic Control). For example, suppose ATC direct you to cross Podunk intersection at 7,000 feet while you are cruising at 15,000 feet. 15 - 7 = 8 thousand feet to descend. 8 X 3 = 24 miles out to begin the descent; however, the last 1,000 feet of descent should be at 500 feet per minute. Depending on ground speed, you can add an additional 5 miles or so to compensate for this without becoming involved with mathematical computations.

CROSS COUNTRY CHECKLIST

The following cross country checklist is comprised of a weather brief checklist, preflight planning checklist, flight log checklist and destination airport information checklist.

WEATHER BRIEF CHECKLIST

When telephoning for information, use the following procedure:

1. Identify yourself as a pilot;
2. State the intended route, destination, proposed departure time and estimated time enroute;
3. Advise if intending to fly only VFR; and

4. State the airplane type and identification.

Recommended Phraseology to incorporate all the above items: "This is John Doe, pilot of a Cessna 182, N7039W, planning a VFR flight from Jackson to Salt Lake City, leaving in an hour. I'll be one plus 30 enroute and would like a weather briefing."

WEATHER BRIEFING

The briefing should consist of the following items of weather for departure, enroute, destination and alternate:

1. Synopsis;
2. Current weather (hourly sequence reports) including ceiling and visibility;
3. Enroute forecast, including ceiling and visibility;
4. Destination forecast, including ceiling and visibility;
5. Winds/temperatures (aloft and on the ground);
6. Adverse conditions;
7. NOTAMS;
8. PIREPs;
9. Cloud tops, icing, turbulence, alternates, inversions, lapse rate, etc.

PREFLIGHT PLANNING (WET ROPE)

W - weight and balance computations complete.

E - elevation (for density altitude computations)

T - temperature (for density altitude computations)

R - Runway length for takeoff/rate of climb.

O - Obstructions near the airport (night flights)

P - Papers and inspections

E - Equipment (charts, computer, plotter, lap board, pencil, flashlight, etc.).

FLIGHT LOG

1. Plot course.
2. Select checkpoints; study terrain.

3. Measure courses; measure distance; use the double cross to obtain the COMPASS HEADING for each leg.
4. Compute groundspeed; compute time enroute.
5. Determine fuel required.
6. File a flight plan.

DESTINATION AIRPORT INFORMATION (WEAR RAGS)

W - Wind direction and velocity

E - Elevation of airport

A - Altitude of traffic pattern

R - Radio frequencies (ATIS, approach, tower, ground, unicom)

R - Runway in use, length, pattern (left or right)

A - Altimeter setting

G - “Gab,” call approach, tower, unicom

S - Skip not the landing checklist

Have fun with your flight planning!

Radio Navigation

Chapter Two
RADIO NAVIGATION

Radio Navigation

The primary navigation aid in the U.S. today which utilizes VHF is the VOR. The name very high frequency omnidirectional radio range makes the VOR sound very prohibitive, although it is fundamentally quite simple to use. The acronym, VOR, means Very high frequency Omnidirectional Radio range. It is normally called either a VOR or OMNI station. When two VORs are connected for navigation purposes the resulting airway for use below 18,000 feet MSL is called a Victor Airway. For use above 18,000 feet MSL an airway is called a Jet Route.

This system consists of several hundred ground stations placed strategically throughout the U.S. by the FAA and some state agencies. These VOR stations are ground radio facilities that transmit accurate navigational signals which are received by the aircraft receiver and converted into navigational information.

VOR Principle

Each VOR station transmits an infinite amount of VHF signals which radiate outward from the station in all directions (omnidirectional - all directional). The VOR broadcasts two signals, one by a fixed antenna and the other by a rotating antenna, which are in phase at the position of magnetic north. Thus, magnetic north is the base reference for all other directions used relative to the VOR station.

As the rotating antenna signal makes its 360-degree sweep, this signal is out of phase with the signal from the fixed antenna by a different amount for each degree of travel. The signals are 90 degrees out of phase at a point 90 degrees from magnetic north, 180 degrees out of phase at a point 180 degrees from magnetic north, and so on. The receiver in the airplane is able to detect out-of-phase relationships as a different degree of direction measured from the reference of magnetic north.

Although technically the VOR station broadcasts an infinite number of radials, the airplane's receiver generally detects only one full degree of difference. The VOR is accurate to a tolerance of one full degree; therefore, we assume 360 radials

Radials are like spokes of a wheel and are considered to point in a direction FROM the station.

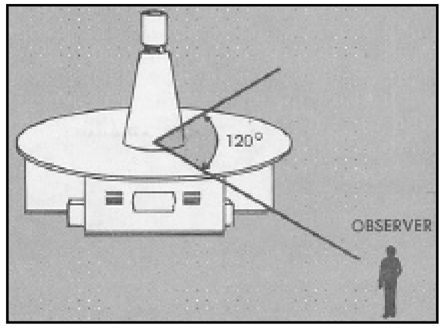


Figure 9. The VORTAC station has the 'chimney,' whereas the VOR has a small rounded dome.

Most VOR/VORTACs are painted white, but some are painted to match the aesthetic values of the surrounding terrain.

To simplify the use of the VOR station in conjunction with the aircraft compass, the radials are measured from magnetic north. The 0-degree radial points directly toward the magnetic north pole. The 090-degree radial is 90 degrees clockwise around the compass rose from magnetic north and points to a direction of magnetic east. Each radial can thus be considered to be a MAGNETIC direction radiating FROM the VOR station.

An advantage of the VOR is that since the VOR indicator shows the pilot his line of position along a radial it is possible to navigate by making wind corrections by keeping the needle centered without making any wind drift computations.

To facilitate the measurement of radials and inbound courses, a compass rose or compass azimuth is printed around the site of each civil VOR on aeronautical charts (unless chart clutter prohibits it).

The name of each Federal Airway and its magnetic direction from the VOR station is printed on aeronautical charts.

The VOR frequency is underlined if voice communications are not transmitted on the VOR frequency. The numbers above the VOR frequency box represent the communications frequencies available for air to ground communications with Flight Service Stations.

VORs can be used for many purposes other than for flights along Victor Airways. The pilot can fly to or from a VOR station. Position may be determined by using two or more VORs by determining the direction in which the airplane is located or one VOR and DME (distance measuring equipment). Many instrument approaches are done with precise VOR navigation techniques such as descending toward an airport while flying along a charted radial at charted altitudes.

In addition to navigation signals, most VORs also are used to transmit voice communications and scheduled weather broadcasts by the FSS.

1. VOR LINE OF SIGHT TRANSMISSION

VOR signals, like any other VHF signals, have the advantage of being comparatively free of atmospheric disturbances and static. However they are restricted to line of sight transmissions ONLY. These signals will not penetrate or follow terrain or obstructions. Any obstacles, including the curvature of the earth, mountains, buildings or terrain features block VOR signals and restrict the distance the signals can be received at certain altitudes.

2. VOR USABLE RANGE

The useable range of VOR signals for navigation depend on the altitude of the airplane above ground level. The curvature of the earth affects the line of sight characteristics of VOR, therefore the higher the altitude, the greater the distance that reliable navigation signals may be used.

VHF TRANSMISSION RANGE
(over flat terrain)

AIRCRAFT ALTITUDE AGL	RANGE NAUTICAL MILES
500	28
1,000	39
1,500	47
2,000	55
2,500	61
3,000	67
5,000	87
10,000	122
15,000	150
20,000	173
30,000	212
40,000	245

3. FREQUENCY RANGE OF VOR

The FCC has allotted the frequency range of 108.0 to 117.9 MHz for VHF navigation. Within this frequency range is a division of VHF navigational types. The odd-tenths decimals from 108.1 to 111.9 MHz have been allotted to the ILS (instrument landing system). The remaining frequencies from 108.0 to 112.0 on even-tenths have been reserved for L and T VORs. All the even and odd-tenths frequencies from 112.0 to 117.9 MHz are allotted for VOR.

4. CLASSIFICATION

Because of increased reception distance possible at high altitudes, an aircraft may receive erroneous indications due to interference between two different stations on the same frequency. Stations on the same frequency are spaced as far apart as possible. Nevertheless, there are more VORs than the 160 frequencies available (using 50 kHz spacing), so there would be some overlapping and interference. The solution has been to classify VORs according to usable cylindrical service volume.

The lowest classification of the VOR is the TVOR or terminal VOR. It is guaranteed to be accurate for distances up to 25 nautical miles. Terminal VORs are used primarily as airport navigational aids for VOR instrument approaches and for the transition to the enroute navigational structure.

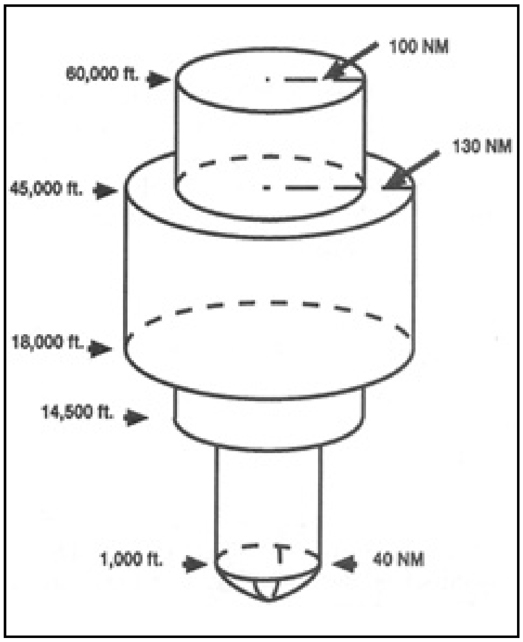


Figure 10. Service Volume - The service area for the low-altitude VORTAC is a cylinder 80 nm in diameter from ground level to 18,000 feet. The service area for the high-altitude facility is composed of four layers, all centered on the VORTAC site.

The next classification is the LVOR or low altitude VOR which may be used below 18,000 feet for distances of 40 nautical miles.

The highest classification is the HVOR or high altitude VOR. From 18,000 to 45,000 feet it has a frequency protection range of 130 nautical miles.

This frequency protection plan should not be confused with the transmitting power of the VORs which is normally about 200 watts for the L and H classifications.

5. STATION IDENTIFICATION

The only positive method of identifying a VOR is by its Morse code identification or by the recorded automatic voice identification which is always indicated by use of the word VOR following the range's name. Many FSS remotely operate several VORs and use the particular name of whichever facility they have been contacted on. The transmission may be broadcast over several VORs at the same time; therefore, reliance should not be placed on voice transmissions. For example, the Idaho Falls Flight Service Station may be talking to a pilot in Salmon, Idaho. He would say, "This is Salmon Radio." Another pilot may hear this on the Idaho Falls or Jackson VOR and assume they were tuned to the wrong VOR.

Audio signals from VOR stations are used for station identification and communications. Visual indications are used for navigation. A pilot who depends on the VOR should be aware that ground equipment may be taken out of service for maintenance or may become unusable or unreliable. The pilot will know if a VOR signal is unusable if the Morse code identification signal is not broadcast.

During periods of routine or emergency maintenance, the coded identification is removed to indicate to the pilot the signal, although it may be received, is unusable (not reliable). Another indication of unusable signals is the fluctuation of the VOR needle or appearance of an OFF warning flag on the aircraft VOR indicator.

The VORTAC Station

Military pilots use a navigational system called TACAN which is similar to VOR except that it utilizes signals in the UHF band. TACAN indicates to a military pilot, not only his direction from the station, but also his distance. Whenever a TACAN facility is collocated at a VOR site, this dual purpose unit is called a VORTAC. In fact, most VORs have now been converted to VORTACs. When the term VOR is used, it can be understood to be interchangeable with the VORTAC when transmitting positions to the FSS.

The advantage of colocating TACAN and VOR stations is that civilian pilots can use the DME (distance measuring equipment) feature of the TACAN with the direction indications of a VOR if DME equipment is installed in the airplane.

Airborne VOR Equipment

Although there are many types of VOR equipment in use in general aviation, they all have certain features in common. The VOR equipment includes the radio receiver and antenna, frequency selector and the VOR indicator.

For practical purposes we will consider the VOR to be comprised of (1) a radio used to tune and identify VOR stations, and (2) A remote indicator mounted on the panel which is used for navigation.

The VOR indicator includes the OBS (omnibearing selector) also known as the CS (course selector), the CDI (course deviation indicator) or left-right needle and the TO-FROM indicator or ambiguity indicator.

In addition to the normal VOR indications, some units are equipped to provide ILS (instrument landing system) localizer and glide slope indications.

TUNING AND IDENTIFYING THE VOR STATION

The frequencies used for navigational purposes are depicted in the frequency box associated with the VOR station on aeronautical charts. To tune and identify a VOR station:

1. Turn the set on.
2. Determine the station frequency and select it.
3. Adjust the navigation volume control to receive the Morse code and/or voice identification.
4. If the Morse code and/or voice identification match that of the frequency box on the chart, the station's signals are valid and may be used for navigation.

OMNIBEARING SELECTOR (OBS)

The omnibearing selector (OBS) or course selector (CS) knob is used to select the desired course. This selected course is displayed on the VOR indicator. Depending on the make and model, it is normally presented as a dial or card showing 360 degrees in five degree increments. The desired course is displayed at either the top or bottom of the instrument. Usually the selected course is marked with a small triangle called the "bearing selector pointer." The opposite side is marked with an index. It is called the "reciprocal marker."

Figure 11. COURSE DEVIATION INDICATOR - CDI

COURSE DEVIATION INDICATOR

The CDI or left/right needle is essentially represented by a vertical needle which is centered on the instrument dial when the airplane's position coincides with the course selected by the pilot with the OBS.

The airplane is assumed (use your imagination) to be in the center of the VOR indicator dial. The CDI, during proper sensing, tells the pilot if he is on his selected course (needle centered) or if the course is to the right (right needle) or left (left needle) of the airplane.

When the CDI is fully deflected to one side of the VOR indicator, the aircraft is 10 degrees or more away from the selected course. Needle displacement between the center and either side denotes proportionate displacement of the airplane from the desired course from 0 to 10 degrees. Full scale deflection from one side to the other represents 20 degrees of course. When tuned to an ILS, full scale deflection represents five degrees (two and one-half to either side of center).

When the airplane is approximately 60 (57.298688 actually) nautical miles away from the station, each degree off course is equal to one nautical mile. The ratio of this relationship is direct. For example, if the airplane is one degree off course and 30 miles away from the station, it is one half mile off course. Or, if the airplane is 120 miles from the VOR station and it shows one degree off course, it is two miles off course.

TO-FROM INDICATOR

The TO-FROM indicator is shown clearly in the window of the VOR indicator. If the station is too far away or the aircraft is too low for accurate course indications, the red OFF flag comes into view. When the selected radial is to the station, TO will appear in this window; when the selected radial will take you from the station, FROM appears in the window.

When tuned to an ILS, a “TO” indication is received regardless of whether flying inbound or outbound on the front course or back course.

Understanding the VOR

The VOR is basically very easy to use, once it is understood. And, for flying IFR, it must be totally understood. It is also a good idea for student pilots to be proficient in VOR orientation prior to beginning their cross country flight training. Total orientation must be accurate and immediate. Determining position as far as where the airplane is located is not difficult, but confusion sometimes exists in where the airplane should be going. The following should be helpful in developing this awareness.

When first beginning to study the VOR it can be quite perplexing, especially when asked on a written test to determine if an airplane's VOR indication will have a “LEFT” or “RIGHT” needle and a “TO” or “FROM” indication. In order to eliminate this confusion, the following system has been devised.

The VOR ground transmitting station has an area surrounding it in which its signals are reliably interpreted by the aircraft's VOR receiver. Although the receiver interprets accurately, the pilot might not. The pilot might be flying “to” or “from” the VOR, but the “little black box” doesn't know this. The radio must be properly “programmed” by the pilot.

For interpretation of the VOR indications the aircraft's heading must be ignored. For VOR orientation the heading must be considered.

VOR interpretation and orientation problems involve solving your position in relation to a VOR ground station. To solve any problem, use a two-step approach. (1) Determine the LEFT-RIGHT needle indication position (it may be called the CDI-course deviation indicator). (2) Determine the TO-FROM indication position.

1. LEFT-RIGHT NEEDLE INDICATION THE COURSE ARROW

Every VOR or VORTAC station has an area surrounding it in which its signals are reliably interpreted by a VOR receiver. Every time a course is selected with the OBS, this area is divided into two halves. It is useful to think of the dividing line between the two halves, or hemispheres, as a COURSE ARROW. The course arrow runs through the station and points in the direction of the selected course.

The course arrow divides the whole radio reception area into two hemispheres. If you will mentally orientate the airplane's nose in a direction the same as the course arrow, the hemisphere to the right side will be the LEFT HEMISPHERE. That is, an airplane located to the right of the course arrow will display a left needle indication meaning that the airplane would have to turn to the left to get back on course. If the airplane is pointed in a direction opposite of the course arrow it is said to have *“reverse sensing.”* If that airplane turned left it would place it further off course. Again, with the nose of the airplane aligned with the course arrow, the hemisphere to the left is known as the RIGHT HEMISPHERE. Any airplane located in the right hemisphere will display a right needle indication.

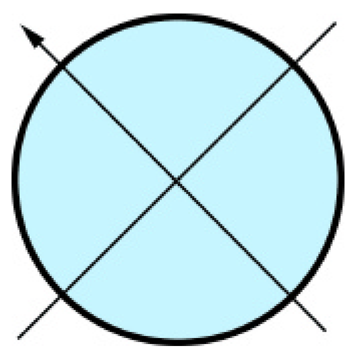


Figure 12. Draw a course arrow with the arrowhead pointing the same as the OBS setting.

CARDINAL RULE: *For doing test problems*, always point the airplane in the same direction as that indicated on the OBS before you make any interpretations of the instrument indications.

Draw (or visualize after you practice this until it becomes easy) a COURSE ARROW through the VOR ground station with the arrowhead of the course arrow pointing in the direction of the selected course.

Orientate yourself with the arrowhead of the course arrow, then label the “RIGHT” HEMISPHERE and the “LEFT” HEMISPHERE. Remember the RIGHT HEMISPHERE will be on the left side of the arrowhead of the course arrow and the LEFT HEMISPHERE will be on the right side of the arrowhead of the course arrow.

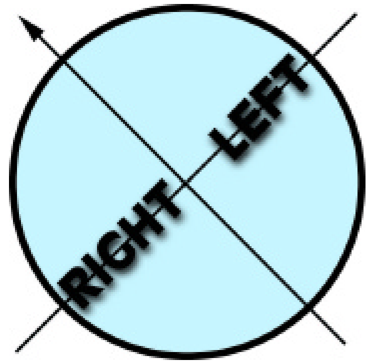


Figure 13. LEFT/RIGHT HEMISPHERE.

For example, if 090 degrees is selected with the OBS, we will either physically or mentally compose a circle representing the VOR compass azimuth. To begin with it is a good idea to physically draw the circle. This azimuth is divided into two quadrants. A line from 270 degrees to 090 degrees is the dividing line between the RIGHT HEMISPHERE (on the left side) and the LEFT HEMISPHERE (on the right side).

- **Any time an airplane is physically located in the RIGHT HEMISPHERE it will have a right needle indication regardless of the aircraft's heading.**
- **Any time an airplane is physically located in the LEFT HEMISPHERE it will have a left needle indication regardless of the aircraft's heading.**
- **If the airplane is physically located along the course pointer, the needle is centered.**

These statements are true *regardless of the aircraft's heading!* Selecting a course with the OBS results in an electronic division of the VOR signals parallel to the course chosen. Ignore the aircraft heading during VOR interpretation (you consider the heading during orientation). The heading of the aircraft has absolutely no effect on the indication of the VOR receiver. The left/right needle is based on the aircraft's position, not heading, with respect to the selected course on the OBS (omnibearing selector).

Sometimes confusion crops up when working with an OBS setting that does not easily afford orientation facing along the course pointer. In these cases it is necessary to rotate the paper with the compass azimuth so you face along the course arrow toward the arrowhead.

KEEP IN MIND THE VOR RECEIVER ELECTRONICALLY DIVIDES THE COMPASS AZIMUTH INTO HALVES PARALLEL TO THE OBS SETTING AND CAUSES A LEFT-RIGHT NEEDLE INDICATION BASED ON THE AIRPLANE'S PHYSICAL POSITION TO THE RIGHT FOR A LEFT NEEDLE OR LEFT FOR A RIGHT NEEDLE. THE DIRECTION THE NOSE OF THE AIRPLANE IS POINTING (AIRCRAFT HEADING) HAS NOTHING TO DO WITH THIS ELECTRONIC INTERPRETATION BY THE "LITTLE BLACK BOX."

Once a course is selected, the CDI shows the pilot in which of these hemispheres he is located. As long as the airplane stays in one of the hemispheres, the CDI will point to the same side of the receiver head.

Remember, the CDI needle indicates the airplane's position with respect to the selected course (course arrow). The position to the LEFT of the course arrow is called the RIGHT HEMISPHERE meaning any airplane, regardless of heading, will have a right CDI. The position to the RIGHT of the course arrow is called the LEFT HEMISPHERE meaning any airplane located in this area will have a left CDI indication regardless of its heading. You must remember the VOR is an electronic instrument that interprets electronic signals and this is the way it works. It is up to the pilot to have proper orientation.

2. TO-FROM INDICATION

Selecting a course also establishes the position of an imaginary line called a "CROSS-BAR," positioned across the course arrow horizontally at the center of the compass azimuth. It is always perpendicular to the course arrow.

The cross-bar divides the VOR reception area into two hemispheres. The component of the VOR indicator that shows in which of these two sectors the aircraft is located is the TO-FROM indicator. Once a course is selected by the OBS, the

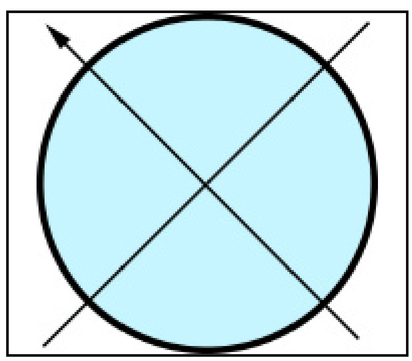


Figure 14. Draw a cross-bar with "TO" hemisphere and "FROM" hemisphere.

airplane has to be in one sector, on the dividing line between them or in the other sector. The TO-FROM indicator shows which hemisphere. All aircraft positions on the same side of the cross-bar as the arrowhead of the course arrow will display a FROM indication on the VOR indicator. This area is called the *"FROM" HEMISPHERE*. In this sector, the course arrow is pointing away FROM the station. The other sector is the *"TO" HEMISPHERE*.

Figure 15. FROM/TO hemispheres.

If an aircraft were to move along the course arrow in the direction of the selected course, the TO-FROM window would indicate whether the aircraft were starting in the TO hemisphere or the FROM hemisphere. If the aircraft began in the FROM hemisphere, it would fly away from the station and never see a change in the TO-FROM indicator as long as the aircraft were able to receive reliable signals from that station.

If the aircraft started in the TO hemisphere and flew along the course arrow in the direction of the selected course, the TO-FROM indicator would display a TO indication only as long as the aircraft were in the TO hemisphere. When the aircraft transitions from the TO hemisphere to the FROM hemisphere, the TO-FROM indicator would change from a TO indication to OFF to a FROM indication. The change from the TO hemisphere to the FROM hemisphere occurs directly over the VOR station or anywhere along the bisector line which is perpendicular to the COURSE ARROW. The time of passage over the station in this way is noted by watching the time of change from the TO to FROM.

The TO-FROM indicator on the VOR indicator is constructed so that when a transition from a TO to FROM indication is made between the two indications an OFF indication will be noted. If the aircraft is flying along the course arrow, the TO-FROM change occurs very rapidly when the station is passed. The cross-bar dividing the TO and FROM sectors however, is not a sharp line like the course arrow. There is an *AREA OF AMBIGUITY* along the cross-bar. A movement across the transition area is indicated by an ambiguous fluctuating TO-FROM signal. In this area the result of the opposing reference and variable signals that actuate the TO-FROM indicator is insufficient to produce a positive TO or FROM indication.

The area of ambiguity widens out with increasing distance from the station. The greater the distance from the station, the longer the receiver will say OFF as the aircraft transitions between the TO and FROM sectors.

The hemisphere containing the arrowhead of the course arrow is the “FROM” HEMISPHERE. The opposite side is the “TO” HEMISPHERE.

- Any time an airplane is located in the “FROM” HEMISPHERE it will have a FROM indication. This is true whether the airplane is flying to or from the station.
- Any time an airplane is located in the “TO” HEMISPHERE it will have a TO indication. This is true whether or the airplane is flying to or from the station.

Figure 16. Memorize the course arrow, cross bar and hemispheres!

These statements are true regardless of the aircraft's heading! Selecting a course with the OBS not only results in dividing the compass azimuth parallel to the course pointer, but also results in the establishment of an electronic bisector which is perpendicular to the course arrow and directly over the VOR ground station.

When an airplane is located on the half of the bisector containing the arrowhead of the course arrow, a FROM indication results. On the opposite half, the airplane would have a TO indication. Again this is an electronic interpretation and display that has nothing to do with whether or not the airplane is flying to or from the station.

The TO/FROM indication is based on the selected course on the OBS (omnibearing selector) and tells whether the course selected will take you to or from the station if the aircraft's heading is approximately the same as the OBS setting (approximate because of the wind correction angle).

SUMMARY

For VOR interpretation or orientation combine the course arrow, cross bar, left hemisphere, right hemisphere, “TO” hemisphere and “FROM” hemisphere into one drawing.

For example, if 360-degrees is selected with the OBS, we will either physically or mentally compose a circle representing the VOR compass azimuth. To begin with it is a good idea to physically draw the circle. This azimuth is divided into four quadrants. A vertical line from 0-degrees to 180-degrees is the dividing line between the RIGHT HEMISPHERE (on the left side) and the LEFT HEMISPHERE (on the right side). A horizontal line from 270-degrees to 090-

degrees is the dividing line between another two halves or hemispheres. The hemisphere containing the arrowhead of the course arrow is called the “FROM” HEMISPHERE. The hemisphere opposite the arrowhead of the course arrow is called the “TO” HEMISPHERE.

The course arrow is vertical, pointing in the same direction as the selected course (360-degrees). Any aircraft located in the NW (northwest) or SW quadrants would be located to the left of the selected course. Therefore, any airplane to the left of the course would have a right CDI (left-right needle indication on the course deviation indicator) regardless of the heading of the aircraft.

The CDI will move to the center if the airplane is moved to any point along the course arrow. If the airplane moves to the right side of the selected course, the CDI will show a left needle indication.

If the OBS is changed, visualize the movement of the imaginary COURSE ARROW over the compass azimuth you composed.

THIS SYSTEM IS QUITE SIMPLE TO USE. IT INVOLVES THE FOLLOWING MEMORIZATION! DRAW A CIRCLE WITH THE CENTER REPRESENTING THE VOR STATION. DRAW A COURSE ARROW REPRESENTING THE OBS SETTING. ROTATE THE DRAWING UNTIL THE ARROWHEAD IS AT THE TOP. THE COURSE ARROW DIVIDES THE VOR AZIMUTH INTO THE RIGHT HEMISPHERE ON THE LEFT SIDE AND THE LEFT HEMISPHERE ON THE RIGHT SIDE. LABEL THESE AREAS. DRAW A CROSS BAR PERPENDICULAR TO THE COURSE ARROW AND POSITIONED OVER THE VOR STATION. THIS FORMS THE FROM HEMISPHERE ON THE SIDE WITH THE ARROWHEAD AND THE TO HEMISPHERE ON THE OTHER SIDE. LABEL THESE AREAS. THAT'S IT, ALL THERE IS FOR VOR INTERPRETATION!

Flying the VOR

VOR radials are always considered to be MAGNETIC direction FROM the station. When making a flight, the OBS is turned to the radial FROM the departure airport.

FLYING VICTOR AIRWAYS

For example, a flight along Victor airways from Jackson, Wyoming, to Pocatello, Idaho, would require 248 degrees be set into the OBS at the time of departure. Unless a change-over point is shown to indicate otherwise or reception becomes poor, the pilot should fly halfway on the first VORs signals and then switch to the next VOR.

At position “B” the VOR frequency is changed to the Idaho Falls VOR. The chart shows the 067 degree radial from Idaho Falls as forming the other portion of V-330. Remember that radials extend FROM the station and the airplane is flying "TO" the station. It is necessary to take the reciprocal of 067 degrees in order to fly "TO" the VOR (067 + 180 = 247). Note the reciprocal in this case is not the same value as the radial "FROM" Jackson. This may be caused by variation changes or local magnetic disturbances. Regardless of the cause, for precision navigation, the reciprocal should be used, rather than leaving the original OBS setting unadjusted.

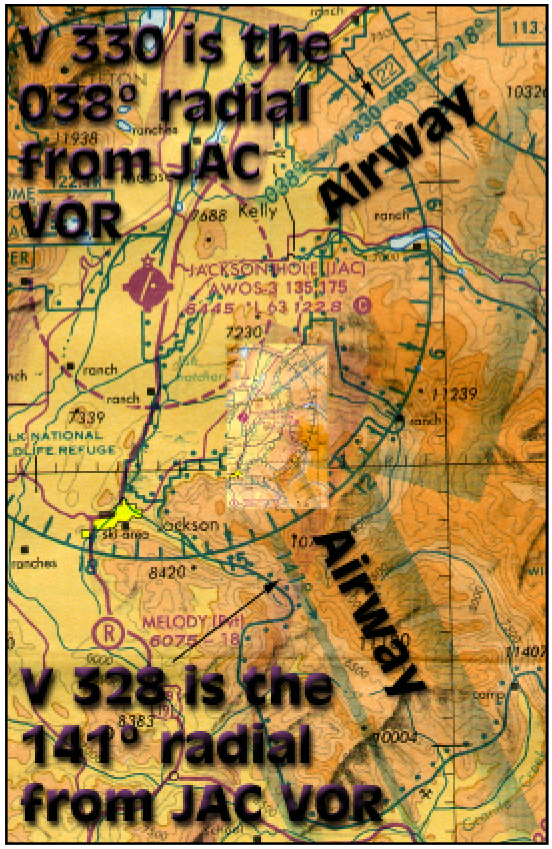


Figure 17. Airways.

Reciprocals

An easy way for figuring reciprocals is to take the first two digits of the "FROM" OBS setting and the last digit of the "TO" radial. For example, flying from Idaho Falls to Jackson on the reverse course, the OBS is set to 067 degrees upon departing. Take the first two digits "06" and the last digit of Jackson's "248" to form the reciprocal "068." Unless there is a visible dogleg in the course or the last digits involve the numerals "9" or "0" or "1," this will work. As an example of the last digits changing, look at V-328 southeast of Jackson to Big Piney, Wyoming. Using the rule of thumb, take the first two digits of Jackson "11" and the last of Big Piney "0." This forms 110 degrees which through common sense is approximately 10 degrees less than the original 119 degree course. In this case it would require making a logical change (by adding or subtracting ten degrees as the case requires) to come up with 120 degrees as the reciprocal.

Back to the flight. Suppose at position "B," air traffic control asked the pilot for his position. Although the heading of the airplane, in a no-wind condition, is 247 degrees and the OBS is set to 247 degrees, the position is reported as being on the 067 degree radial. This is orientation and must be learned. Position, like VOR radials, is in relation "FROM" the VOR station.

BRACKETING

In all the previous discussion a no-wind condition has been assumed. When the wind blows the aircraft drifts off course. Wind correction is accomplished in relation to HEADING CHANGES in a logical manner.

Too many pilots fly the left-right needle with no rhyme or reason. When they get a left needle, they turn left. If the needle doesn't move back toward being centered fast enough for them they turn left some more. When close to the station, the needle may move to the right side. This goes on with the path weaving back and forth across the sky in an erratic manner.

If the airplane is located some distance from the VOR, turning alone has no apparent effect on the left-right needle indication. For example, assume the airplane is 60 miles south of the VOR station. At this distance, one degree off course represents one nautical mile off course. Assume the VOR indicator shows the airplane has drifted five degrees to the right of the desired course. The left-right needle now shows a five degree left deflection. If the airplane is flown perpendicular to the desired course on a heading of 270 degrees, it must fly for one mile before the left-right needle indicates one degree of change. In this case, no amount of turning alone will re-center the left-right needle. The airplane must be flown for some distance before the left-right needle returns to the on course (centered) position.

When drifting is indicated (the needle isn't centered or doesn't remain centered) a course correction must be made in a direction toward the needle deflection. The amount of cut depends on the distance from the VOR and the wind velocity. Always make intentional predetermined heading changes with relation to the trend of left-right needle change, rather than instinctive changes. Analyze what the heading change has or has not accomplished with respect to left-right needle movement before making another heading change. When close to the VOR station, make a 20-degree heading change toward the needle. When farther away, make a 30-degree heading change toward the needle.

Suppose the pilot takes a 20-degree cut. He should do nothing further until the trend of the VOR needle is determined. If the needle moves farther away, the cut was insufficient. If the needle remains stationary, he has determined the approximate heading needed to keep the needle centered once the airplane is moved back on course. Take a further cut to center the needle, then fly the determined heading. If the needle begins moving back toward the centered position, this tells the pilot the heading necessary to keep the needle centered is somewhere between the original heading and the cut. Bracketing means that progressively smaller and smaller cuts are made in the “centering the needle” process until the magic heading that holds the needle centered is found.

TRACKING

Once the “magic” heading is determined by bracketing, it becomes easy to track the VOR to or from the station. If the left-right needle deflects, make small corrections to keep it centered.

REVERSE SENSING

Whenever the OBS setting and the aircraft heading are approximately the same (the wind correction angle may cause a difference), the VOR is said to display proper sensing, in which case corrections are made toward the needle. For example, a left needle indicates the desired course is to the left of the aircraft's position.

When the OBS setting and aircraft heading are approximately 180-degrees out of phase, reverse sensing results, and it becomes necessary to make course corrections in a direction opposite of the needle deflection. If this happens during a flight test for pilot certification, even though the pilot is aware of it and corrects properly for it, it is an automatic “bust.” The pilot should always fly using proper sensing. (Exception: When flying inbound on the back course or outbound on the front course of an ILS without an HSI, reverse sensing is unavoidable).

Taxi Controls

Chapter Three
CONTROL POSITIONING WHILE TAXIING

Introduction

Because of the importance of positioning the controls when taxiing in wind conditions, a short review is included.

Taxi Technique

Improper ground handling of the airplane under the influence of a surface wind can result in weather cocking, ground looping, nosing over or tipping over. When taxiing in a crosswind, the wind flows under the upwind wing and tries to flip the plane over. For this reason the ailerons should be positioned to increase the lift of the downwind wing when taxiing into a quartering headwind or to block the wind from flowing under the wing when taxiing with a quartering tail-wind. This is shown in figure 18.

Thumbs Up Method

Instead of trying to memorize this information or even reasoning it out while taxiing, it is sometimes easier and faster to use the thumbs up technique. Stick your thumb up vertically while holding the control wheel in the neutral position, then parallel the wind with your thumb.

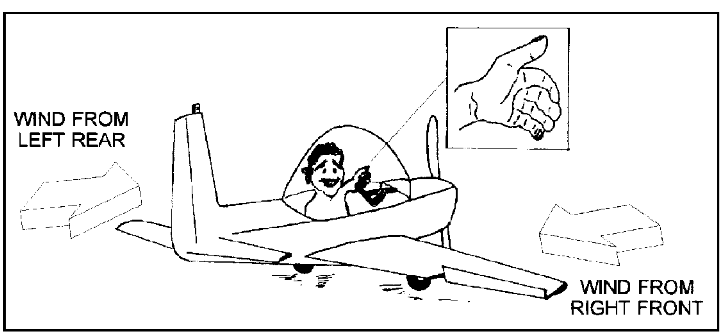


Figure 18. Parallel the wind with your thumb to properly position the ailerons during crosswind taxiing.

For example, with a left quartering tailwind or a right quartering headwind, paralleling the wind with the thumb results in the control wheel being turned to the right. This places the left aileron down (blocking the quartering tailwind or increasing lift to oppose a quartering headwind) and the right aileron up. Paralleling the wind with your thumb does all this thinking automatically. Similarly, paralleling the wind with the thumb in a left quartering headwind or a right quartering tailwind causes you to turn the control wheel left, automatically positioning the ailerons.

Down Wind Taxiing

Strong quartering tailwinds require extra caution. It is easy to acquire excess taxi speed which when making the turn to the runway can result in tipping over. Fuel in partially filled tanks will slosh to the outside of the turn to add to this tipping tendency. Eliminate the risk of tipping over by avoiding sudden bursts of the throttle, sharp braking and excess speed.