3D GRAPHIC ACCELERATION

PRO PILOT '99™

THE COMPLETE FLIGHT SIMULATOR

FLIGHT COMPANION

Dynamix
A SIERRA COMPANY

PRO-PILOT '99™

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INTRODUCTION

Welcome to *Pro Pilot '99!*

The *Pro Pilot '99* Flight Companion is designed to inform you of the basic instruction required for flying in *Pro Pilot '99*. It is by no means an in-depth flight instruction manual, although we hope you find it comprehensive and informative. The intent is to give you enough of an understanding of flying to make *Pro Pilot '99* more enjoyable. After all, if you weren't familiar with the techniques required to keep a plane in the air, it wouldn't be much fun.

The *Pro Pilot '99* Flight Companion is written with all kinds of pilots in mind, from the first time, pre-solo student, to the licensed pilot desiring to brush up on certain areas, to the person who simply enjoys the flight simulation experience. Use the Flight Companion in conjunction with the library of flight instruction AVIs (movies) found inside *Pro Pilot '99*. These AVIs cover the flight maneuvers used in all aircraft such as power-on and power-off stalls, takeoffs, and landings. They are not designed to replace an actual flight instructor, but they will greatly enhance your understanding of the correct principles of flight. Application of proper flying skills and good judgment make the best pilots and *Pro Pilot '99* will hopefully help you in both areas.

There are hundreds of publications and Web sites on, and related to, flying. Those that were most useful in the development of this Flight Companion are listed in the bibliography. For a thorough explanation of any concept that may only be touched on here, consult any of these additional resources.

Overview

Chapter One: *Learning To Fly* covers the fundamentals of flying and the physics of flight. It covers the basic airplane controls, and flight maneuvers such as takeoffs and landings, stalls, climbs, glides, and turns.

Pro Pilot '99 allows you to fly six different aircraft, all with significantly different specifications. Chapter Two: *Aircraft and Systems* lists the flight specifications of the light, single-engine trainer, multi-engine and high performance aircraft, and jets, so you'll have some understanding of your airplane even before your first flight.

Chapter Three: *Airspace Classification and Radio Communication* defines the dimensions, operating requirements, and restrictions of each airspace classification. It also covers the proper radio communication techniques required in these airspaces.

Chapter Four: *Navigation* is a detailed explanation of radio communications venues, facilities, and agencies. Most of the navigation methods are covered, including NDB, VOR, DME, GPS, and good old-fashioned dead reckoning.

The challenge of learning to fly via instruments only is a rewarding experience and one that significantly broadens a pilot's skill level, as well as his opportunity to fly. Chapter Five: *Instrument Flying* is a comprehensive look at the basics of this advanced area of study and training.

Chapter Six: *Logging Your Hours* lists the FAA requirements for obtaining student, private, and commercial pilot certificates, as well as an instrument rating. The flight assignments given here will allow you to fly a variety of cross-country trips while testing your knowledge of everything else covered in the Flight Companion.

The acronyms and abbreviations used in flying are a language unto themselves. The *Acronyms and Abbreviations* section defines the common ones used throughout the Flight Companion, although there are many more that are not used here. *Appendix A* contains important tables and legends that are included in all Instrument Approach Procedure Chart books, but are reprinted here for your convenience. Finally, *Appendix B* contains some additional handy reference tables which you may want to consult from time to time.

It is always a unique and rewarding challenge to bring the flight experience to the desktop computer. We hope you enjoy flying *Pro Pilot '99* as much as we've enjoyed creating it.

— The *Pro Pilot '99* Development Team

Note: The navigational charts depicted in the Flight Companion are for illustration purposes only. They are not intended for use in actual flight. Navigational charts are continually updated with new, potentially critical information. Therefore, you should maintain your own library of the most recently published NOS or Jeppesen charts for your flight planning and navigation.

Chapter 1: Learning To Fly

The Four Forces

Four forces act on an airplane in flight: lift, weight, thrust, and drag.

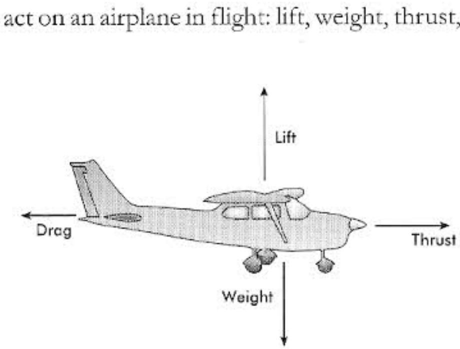


Figure 1.1 *The four forces that act on an airplane in flight.*

Lift

Lift is a force exerted by the wings which is created by the airfoil, the cross-sectional shape of the wing being moved through the air. The "relative wind" (the wind moving in relation to the wing and the airplane) is a big factor in producing lift.

Lift acts perpendicular to the wingspan. Therefore, as the wing moves through the air, lift is produced.

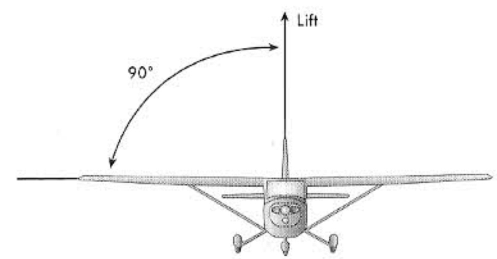


Figure 1.2 *Lift acts perpendicular to the wingspan.*

Lift works because the distance that air must travel over the top of the airfoil is greater than at the bottom. As the air moves over this greater distance it speeds up in an attempt to reestablish equilibrium at the trailing edge of the airfoil. The faster moving air exerts less pressure on the top of the airfoil than the slower moving air on the bottom. This causes a lifting effect across the wing that supports the weight of the aircraft in flight and overcomes the effect of gravity.

Angle of Attack

Angle of attack is the angle between the relative wind and the chord line of the airfoil. This is not to be confused with the angle of incidence, which is the *fixed* angle between the wing chord line and the reference line of the fuselage.

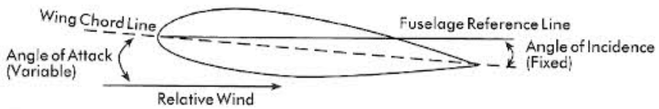


Figure 1.3 *The angle of attack, angle of incidence, chord line, and fuselage reference line.*

Angle of attack is controlled by the elevators. By easing back on the yoke, the elevators are raised. The force of the relative wind pushes the tail down (and the nose up), so the wings are rotated to a new angle of attack. At this new angle, the apparent curvature of the airfoil is greater, and for a short period, lift is increased. However, a higher angle of attack also produces greater drag (more on drag coming up), so the plane slows and equilibrium is once again attained (even though the plane could continue to climb).

The beginning pilot may believe that the reason an airplane climbs is because of an increased angle of attack. However, as angle of attack is increased, the plane slows because of increased drag at low airspeed and at a higher angle of attack. So the pilot continues to increase the angle of attack until it becomes so great that air can no longer pass smoothly over the airfoil. This results in a stall, which is the complete separation of air flow over the top of the wing, and all lift is lost.

In an airplane stall, the engine may be humming right along, but the lift has broken down so the wing is no longer doing its job of supporting the airplane. For the airplane to recover from the stall, the angle of attack must be decreased and the airflow reestablished to restore lift. For most light airplanes, the stalling angle of attack is 15°.

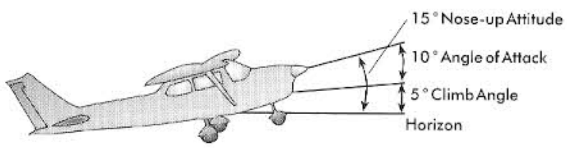


Figure 1.4 *The angle of attack, attitude, and climb angle.*

Air density also affects lift. This is discussed to some extent in the section on dead reckoning (see page 89). Air density decreases with increased altitude and/or temperature. Airplanes require more runway to take off on hot days or at airports of higher elevation because of decreased air density. Not only is the lift of the wing affected, but the less dense air results in less power being developed within the engine. Because the propeller is nothing more than a rotating airfoil, it also loses lift (or more properly, thrust). Lift remains at an almost constant value during climbs, glides, and straight and level flight at a given airspeed.

Thrust

Thrust is furnished by a propeller or jet. Newton's law states that "for every action, there is an equal and opposite reaction." The propeller or jet takes a large mass of air and accelerates it toward the rear of the plane. The equal and opposite reaction is the plane moving forward. There is also the theory that because a propeller is made of two airfoils, the plane is pulled by the low pressure of the prop, not by an opposing reaction, however, we'll leave that argument for another manual.

Horsepower Defined

Thrust is a force and is measured in terms of pounds, just like the other three forces (lift, weight, and drag). A force is defined as a tension, weight, or pressure. A force can be exerted on an object without the object moving. However, if it does move, then work has been created. Work, in engineering terms, is force times distance. If you lift your 20-pound computer ten feet off the floor, you've done 200 foot-pounds of work. If you lift a 200-pound computer one foot off the floor, you've done the same amount of work, whether you take all day or one second to do it. However, if you do take all day, you won't be generating as much power. The power used in lifting your 20-pound computer 10 feet in one second is expressed as:

Power = 200 foot-pounds per second

The most common measurement for power is horsepower. One horsepower is equal to 550 foot-pounds per second, or 33,000 foot-pounds per minute. This gives you a whole new appreciation of horses, doesn't it.

The airplane engine develops horsepower in its cylinders and, by rotating the propeller, exerts thrust. In straight and level flight, the thrust equals the drag of the airplane.

For light trainers with fixed-pitch propellers, the measure of power being used is indicated on the plane's tachometer in rpm's (revolutions per minute). The engine power is controlled by the throttle. For more power, the throttle is pushed forward or "opened"; for less power it is moved back or "closed." You'll use the throttle to establish certain rpm settings for cruise, climb, and other flight requirements.

Torque

Because the propeller is a rotating airfoil, certain side effects are encountered. One of these side effects is drag caused by the slipstream (see note below). Another less important contributor to the torque effect is the tendency of the airplane to rotate in a direction opposite that of the propeller. The plane's manufacturer may "wash in" the left wing so it has a greater angle of incidence than that of the right wing. This results in more lift and drag on the left side which may also cause a left-yawing effect.

Two additional factors that can contribute to the torque effect are gyroscopic precession and propeller disk asymmetric loading, or "P factor." Gyroscopic precession is created during attitude changes of the plane, such as moving the nose up or down or yawing it from side to side. Asymmetric loading is a condition usually encountered when the plane is flying at a constant, positive angle of attack, such as in a climb. The downward moving blade, which is on the right side of the propeller arc when viewed from the cockpit, has a higher angle of attack and higher thrust than the upward moving blade on the left. This results in a left-turning movement.

In summary, torque is a component of thrust, and usually includes the slipstream, gyro precession, asymmetric disk loading, and any other power-induced forces that tend to turn the plane left.

The Slipstream

The propeller rotates clockwise as seen from the cockpit of an airplane. This causes a rotating mass of air (slipstream) to be accelerated toward the rear of the plane. This air mass strikes the left side of the vertical stabilizer and rudder, which causes the plane to yaw left. Right rudder must be applied to hold the plane on a straight track. This reaction increases with power so it is most critical during the takeoff and climb portion of flight.

An offset vertical stabilizer may be applied to counteract this reaction. The vertical stabilizer is usually set for maximum effectiveness at the airplane's rated cruising speed, since the plane will be flying most of the time at this speed. The balance of forces results in no need for right rudder being held.

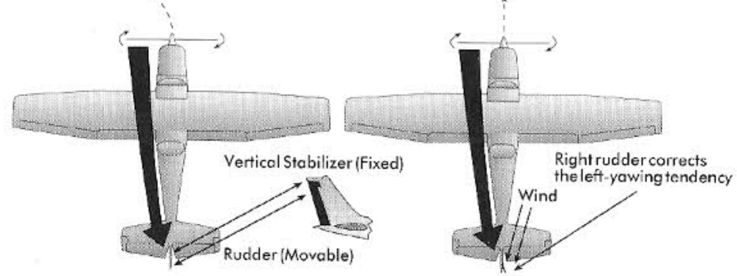


Figure 1.5 *An illustration of the propeller's slipstream.*

Drag

A plane moving through the air produces drag. Drag acts parallel to and in the same direction as the relative wind. Total drag is composed of parasite drag and induced drag.

Parasite Drag – the drag composed of the form drag (the landing gear, radio antennas, the wings, fuselage), skin friction, engine cooling air, and airflow interference between components, such as where the wings meet the fuselage. Parasite drag increases as the square of the airspeed increases. Double the airspeed and parasite drag increases four times. Triple it and parasite drag increases nine times.

Induced Drag – the drag that results from lift being produced. The relative wind is deflected downward by the wing, giving a rearward component to the lift vector. The air moves over each wing tip toward the low pressure on the top of the wings and vortices are formed that are proportional in strength to the amount of induced drag present. The strength of these vortices increases at higher angles of attack, so the slower the airplane flies, the greater the induced drag and vortices.

Weight

The fourth force acting on an airplane is weight. Gravity always acts in an earthward direction. Lift may not always be in equal opposition to the weight of the aircraft, therefore the plane will climb or descend.

Speed Definitions

There are several speed ranges that an airplane should be flown within depending on its aerodynamics, power capabilities, and structural capabilities. You will encounter the symbols for these limits frequently as you learn to fly. Those symbols are defined on the next page:

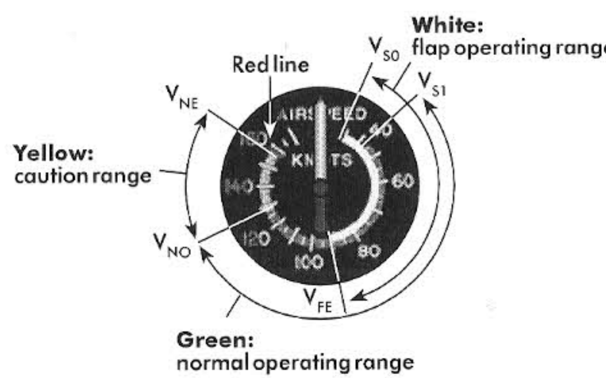


Figure 1.6 *The color coding on the airspeed indicator.*

Symbol	Definition	Airspeed Indicator Color Code
V_{SO}	The stall speed at the plane's maximum weight in a landing configuration (landing gear down, flaps down, power off).	Where white arc begins.
V_{S1}	The stall speed at the plane's maximum weight with landing gear up (if possible), flaps up, and power on.	Where green arc begins.
V_{FE}	Maximum speed with flaps extended.	Top of the white arc.
V_{NO}	The maximum structural cruising speed.	Where yellow arc begins.
V_{NE}	The never-exceed speed.	Where the highest red line is.
V_{LO}	The maximum speed while the landing gear is being extended or retracted.	Not indicated. Consult your airplane's Flight Manual.
V_{LE}	The maximum speed with the landing gear extended.	Not indicated. Consult your airplane's Flight Manual.
V_A or V_{MAN}	The maximum maneuvering speed.	Not indicated. Consult your airplane's Flight Manual.
V_B or V_{TURB}	The recommended target speeds for flying through turbulence.	Not indicated. Consult your airplane's Flight Manual.
V_X	Best angle-of-climb speed.	Not indicated. Consult your airplane's Flight Manual.
V_Y	Best rate-of-climb speed.	Not indicated. Consult your airplane's Flight Manual.

Flight Controls

Control	Affects:	Which is:	Controller
Elevators	Pitch	Rotation about the plane's lateral axis	In and out motion on yoke,wheel, or forward and back on the "stick"
Rudder	Yaw	Rotation about the plane's vertical axis	Foot pedals
Ailerons	Roll	Rotation about the plane's longitudinal axis	Left and right motion on yoke, wheel, or "stick"

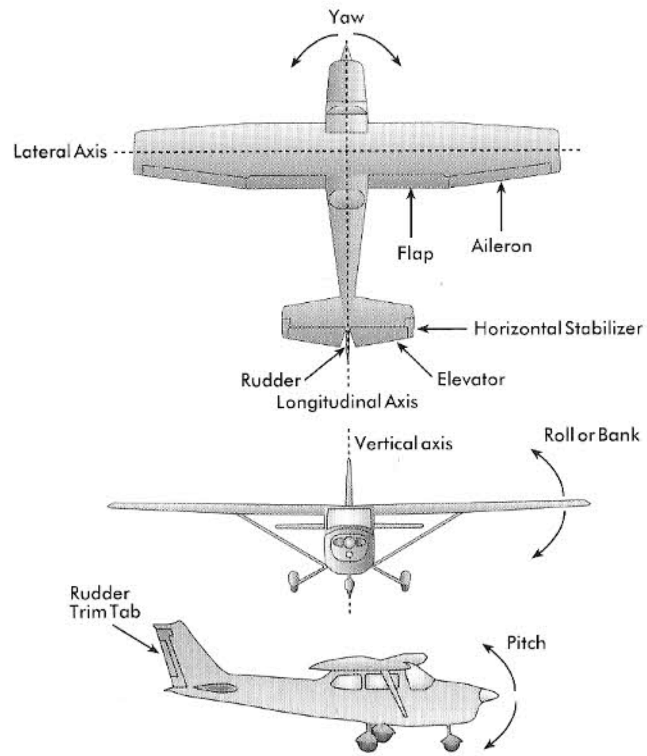


Figure 1.7 *The axes and controls of an airplane.*

Elevators

The elevators control the pitching motion of the airplane (horizontal axis), or angle of attack, and therefore act as the airspeed control for a given throttle setting. Under normal conditions, pulling back on the yoke moves the elevators up. The relative wind forces the tail downward, the nose moves up, and with sufficient power and airspeed, the plane climbs. Push the yoke forward and the tail rises, the nose dips, and the plane descends. Another way to put this into perspective during *all* plane attitudes, is to think yoke forward, nose forward; yoke toward you, nose toward you.

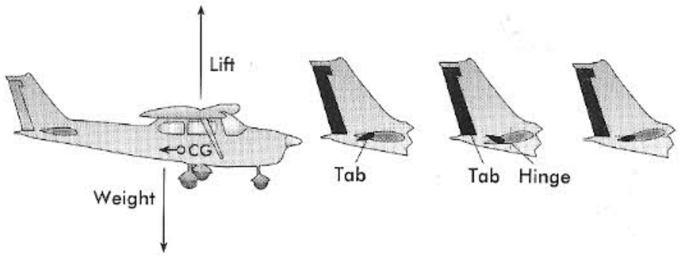


Figure 1.8 *The elevator, elevator trim tab, and stabilator.*

At lower airspeeds, an up elevator position, though intended to create a climb, may only cause the plane to decrease airspeed. The nose moves up, but the increased drag causes the plane to climb less or even sink. This is known as being on the back side of the power curve. Increased power combined with up elevator control makes the airplane climb.

Because most light planes don't have angle of attack indicators, you'll use the airspeed indicator to determine the plane's reactions to elevator control. This is why the elevators are considered to be the airspeed controller. The plane you're flying may be equipped with a stabilator. This is a stabilizer that pivots to act as the elevators. The principle of operation is the same, where the stabilator is an angle of attack and airspeed control and, like the elevator, has a trim tab to help correct for various airplane loadings and airspeeds.

Elevator trim tabs, as just mentioned, are used to reduce elevator or stabilator pressure for the pilot. For instance, if an unusually heavy load is placed in the rear baggage compartment, the tail would be heavy and the nose would rise. You would have to hold forward pressure to maintain level flight. The trim tab is controlled from the cockpit and can be set to hold the aircraft in a climb, glide, or straight and level flight with minimum control pressure.

Rudder

The rudder controls the yaw motion of the airplane (vertical axis). Push the left rudder pedal and the nose yaws to the left. Push the right rudder pedal and the nose yaws right. The primary purpose of the rudder is to overcome the adverse yaw of the aileron (more on this later) and to counteract the "p" factor of the propeller. Most of the time aileron and rudder are used together, however, in slip and crosswind landings, they are used in opposition to each other.

Unlike the rudder on a boat, the rudder on a plane is not the primary control for turning. It is auxiliary to the ailerons for that purpose. However, the plane will turn using rudder only, although in a process known as skidding, where one wing moves faster than the other. This creates added lift for that wing and causes the plane to bank.

A rudder trim tab is used to offset the left yawing effect of the slipstream and other torque effects (see page 12). This trim tab is sometimes controllable from the cockpit and can be adjusted as necessary for the desired reaction.

Ailerons

Ailerons control the roll of the airplane (longitudinal axis). As the yoke is turned to the left, the left aileron moves up and the right aileron moves down. The relative wind moving over the control surfaces causes the airplane to bank left. The plane will continue to roll as long as the ailerons are deflected.

Obtaining Flight Maneuver Proficiency: The Four Fundamentals

After familiarizing yourself with the controls, you may begin to work on the four fundamentals: the turn, the normal climb, the normal glide, and straight and level flight.

The Turn

It would be pretty easy if is all you had to do for a balanced turn was the same that you have to do in a car: turn the wheel. Although this will accomplish the turn in a plane, it is inefficient at best. With a turn of the yoke to the right, for instance, the right aileron moves up and the left aileron moves down. This creates more drag over the left wing because of the down aileron. The plane rolls to the right but the nose yaws left. This creates a slipping turn to the right although a balanced turn will eventually result. The left yaw tendency is called adverse aileron yaw. The rudder is used to correct for this.

Note: The rudder is used anytime the ailerons are used in a turn. To make a smooth turn to the left apply left rudder while turning the yoke to the left. As soon as the desired amount of bank is reached, neutralize the controls. This means smoothly returning the yoke to a neutral position and easing off on rudder pressure. The plane will remain in the turn even while the controls are neutralized. If you were to continue applying yoke and rudder pressure, the bank would become steeper and steeper, and eventually the airplane would perform a roll.

But, with the controls neutralized, a plane will not stay in a constant turn forever. For a simple explanation, suffice it to say that all of the lift is no longer vertical, or in balance with the weight of the plane. With this new imbalance, the plane loses altitude. To avoid losing altitude, the angle of attack must be increased. This is done by pulling back on the yoke to raise the elevators. So, the steps for a smooth bank are:

1. Apply left aileron and left rudder as needed to keep the ball centered.
2. As the bank increases, start applying back pressure on the yoke.
3. When the desired bank is reached, neutralize the rudder and ailerons while holding back pressure steady.

To roll out of the turn:

1. Apply right aileron and enough right rudder to keep the ball centered.
2. As the bank decreases, ease off the back pressure on the yoke.
3. When the plane is level neutralize the rudder, ailerons, and elevators.

If the rudder is used too little in a turn, slipping occurs. If it is used too much, skidding occurs. A slipping turn feels like you are sliding toward the inside of the turn. A skidding turn feels like a turn in a car, where you tend to slide to the outside of the turn.

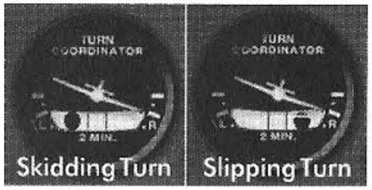


Figure 1.9 *How the turn coordinator appears in a skidding and a slipping turn.*

To improve your turning ability, think not in turns of control movement, but of control pressure. The smoother the pressure, the smoother the turn.

One other note about turns: in a side-by-side airplane you will be sitting to the left of the center of the fuselage. As you turn left, the nose will seem high and you'll have a tendency to correct for this, losing altitude in the process. The opposite holds true for a right turn, where you will have tendency to gain altitude. Experience will teach you to use a reference point on the cowling directly in front of you.

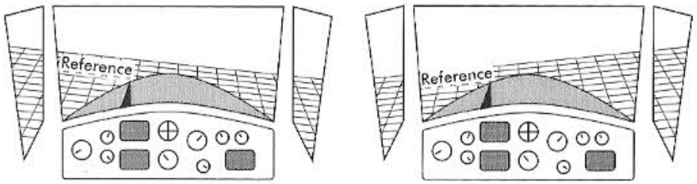


Figure 1.10 *Use a reference point on the cowling to avoid inadvertent altitude adjustments while turning.*

The Normal Climb

Proper climbs are made through a combination of elevator and rudder position, as well as power. The rudder is used to offset the effects of torque from the engine and slipstream and the engine is used to generate power (horsepower).

As a pilot, you will need to consider the recommended climb speed and power setting in order to attain a proper rate of climb (in feet per minute or fpm). The power setting is indicated by the tachometer (rpm). Rpm on a

fixed-pitch propeller plane is affected by the throttle position. The decreased airspeed in a climbing attitude will decrease the rpm below the cruising setting. Therefore, it is necessary to apply more throttle to attain climb power. Normal climb speed is about 1.4 to 1.5 times the stall speed and results in the best rate of climb.

Power Off **STALLING SPEEDS** MPH= Calibrated Air Speed

Gross Weight 2400 lbs.	ANGLE OF BANK			
CONDITION	0°	20°	40°	60°
Flaps UP	55	57	63	78
Flaps 20°	49	51	56	70
Flaps 40°	48	49	54	67

Figure 1.11 *Stall speeds under various conditions.*

To climb:

1. Ease the nose up to normal climb position and maintain back pressure to keep it there.
2. Increase power to the normal climb value.
3. As speed drops, apply right rudder to correct for torque.
4. Don't let the nose wander during the climb or the transition to the climb.

To level off from the climb:

1. Ease the nose down to level flight position.
2. As speed picks up, ease off on right rudder.
3. Throttle back to maintain cruise rpm.
4. Don't let the nose wander during transition.

The Climbing Turn

This is a combination of the two fundamentals described so far. To begin, make the turn out of an established straight climb. Make all climbing turns shallow, no more than 10°. Steeper turns during a climb result in a reduced rate of climb because more back pressure is required to keep the nose up (therefore, more drag is created).

The procedures for a climbing turn are:

1. Begin the straight climb.
   - Apply back pressure.
   - Apply right rudder to keep the ball centered.
2. Begin the climbing right turn.
   - Apply right aileron and more right rudder — keep the turn shallow.
   - Add back pressure.
   - Neutralize the ailerons and apply right rudder as needed to keep the ball centered.
3. Roll out to resume the straight climb.
   - Left aileron and very little left rudder.
   - As the wings become level, neutralize the ailerons and apply right rudder as needed to keep the ball centered.

The Normal Glide

In a normal glide, the throttle is pulled back to idle and the ailerons are set for straight flight. However, back pressure is maintained in order to avoid too steep a descent during the glide. With an engine in idle, the slipstream from the propeller becomes negligible. Airspeed decreases considerably because of this and because the drag becomes greater than the thrust. This means the relative wind speed also decreases. The plane noses down as a result. Normal glide attitude in most light planes is only slightly more nose-down than in straight and level flight.

Recommended normal glide speed is the one that produces the best glide ratio, that is number of feet forward versus feet in altitude lost. For a fixed gear trainer, this is 9:1. If the airspeed is too great, the 9:1 ratio drops to around 5:1. Watch the nose position and airspeed increase and feel for firm controls. These are all indicators of a glide that is too steep.

The symptoms of a glide with a nose-high attitude that is too steep are a high nose, a decrease in the wind noise, and elevator pressure that feels mushy. The angle of attack is so high that drag holds the plane back while gravity goes about its job of pulling the plane down with the same force as always. This results in a lower glide ratio.

To establish a glide from straight and level flight:

1. Pull the carburetor heat on (always recommended before closing the throttle in flight, unless the Pilot's Operating Manual indicates otherwise).

2. Close the throttle (to idle).
3. Hold the nose in level flight position.
4. As the airspeed drops to normal glide speed, ease the nose down slightly to the normal glide position. This position will vary by airplane.

You'll notice that quite a bit of back pressure is required to hold the nose up. You may use elevator trim to relieve this pressure. To return to straight and level flight:

1. Push in the carburetor heat and simultaneously increase power to cruise RPM. You will need to use a good amount of forward elevator to keep your pitch attitude the same.
2. Push carburetor heat off after cruising flight is established.
3. Re-trim the elevators for straight and level flight

When gliding to a specified altitude, begin leveling off about 50 feet before the desired altitude. The larger the plane and the faster the descent, the more margin you want to allow.

If back pressure is not eased off as soon as the throttle is opened, the nose will rise sharply in reaction to the newly created mass of air rushing over the elevators from the propeller.

Remember, the carburetor heat is the first thing on before the glide, and the last thing off after the glide.

The Gliding Turn

Again, this is a combination of two fundamental maneuvers, the glide and the turn. An extended steep, gliding turn is called a spiral. The biggest difference in the feel of the controls between a gliding turn and a climbing turn is that the rudder will seem to be ineffective. This is because of the lack of slipstream while the engine is at idle. Remember, anytime a turn is made, back pressure is required to maintain airspeed. More pressure is required in a gliding turn than in a straight glide. If insufficient back pressure is used:

1. In the climbing turn — no climb, only turn.
2. In the level turn — turn plus a shallow dive.
3. In the gliding turn — turn plus a steeper dive.

Straight and Level Flight

As easy as this sounds, even the experienced pilots have trouble with it. Viewing an airplane in straight and level flight is not the same as maintaining one in that position from inside the cockpit. The tendency for student pilots is to use the nose position to determine a straight direction, as well as longitudinal and lateral level flight, even though one wing may be low for a long time before the nose ever shows it.

A visual check for straight and level flying occurs at three points: the nose should be heading in the desired direction (no yaw); the nose should be at the proper position with respect to the horizon (longitudinally level); and the wings should be at the same distance above (for the high-wing craft) or below (for a low-wing craft) the horizon (laterally level).

The problem of unlevel flying occurs when you are unconsciously holding aileron one way or the other. This happens when you rest your arm on the stick or yoke which tends to pull the control left or right. Then, while the plane is in this slight bank and wants to turn, you hold opposite rudder to counter the nose yaw. Now you're in a slip and the plane gradually loses altitude. So you apply back pressure. Suddenly, you have three controls going on to maintain straight and level flight when you should be able to fly "hands free."

The proper procedure for attaining straight and level flight begins as soon as you reach the assigned practice altitude. Place the nose at the correct attitude, leave the climb power on until the expected cruise airspeed is reached, set up the cruise rpm, then trim until the wheel force against your hand is zero.

Larger planes are equipped with controllable tabs for the elevators, rudders, and ailerons which allow the pilot to trim the plane for attitude and speed desired. Smaller planes have bendable tabs which the pilot can adjust while on the ground.

Instrument Indications of the Four Fundamentals

During the practical flight test, the FAA requires that you demonstrate the ability to recover from an emergency situation such as accidentally flying into clouds or fog. This means that you must be able to recover from such a situation using flight instruments. Once you have attained visual proficiency in straight and level flight, glides, turns, and climbs, your instructor will direct your attention toward the instruments as you perform each one. Later, you will use a hood which will restrict your vision to the instrument panel. This will teach you to "see" what the plane is doing through the instruments.

Figures 1.12 through 1.17 illustrate the instrument indications of the four fundamentals, as well as climbing and descending turns.

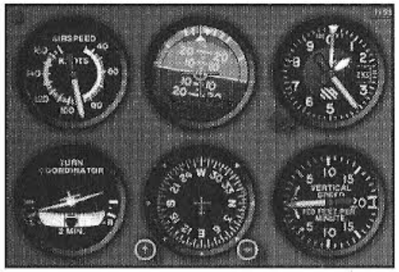


Figure 1.12 *The Turn: the airspeed is lower than normal cruise; the heading indicator shows a left turn, and the turn coordinator shows a balanced, standard-rate turn; altitude indicator is constant.*

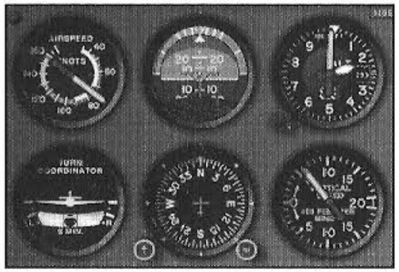


Figure 1.13 *The Normal Climb: the climb airspeed is steady; the attitude is nose up, wings level; the heading indicator shows a constant heading; the turn coordinator shows balanced, straight flight; and the altitude is increasing as shown by the altimeter and the vertical speed indicator.*

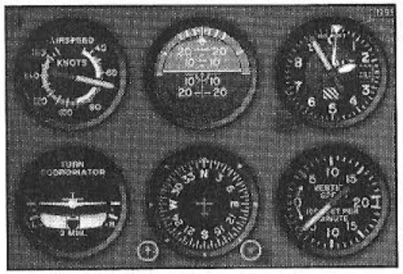


Figure 1.14 *The Normal Glide: the glide airspeed is steady; the attitude is nose low, wings level; the heading indicator shows a constant heading; the turn coordinator shows straight, balanced flight; and the altitude is decreasing as indicated by the altimeter and vertical speed indicator.*

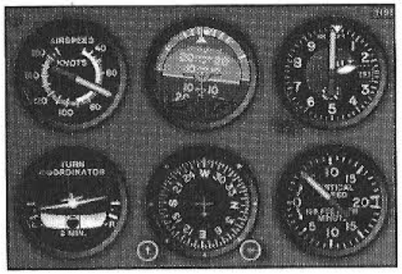


Figure 1.15 *The Climbing Turn: the climb airspeed is steady; the attitude indicator shows 8° of bank, climb attitude; the heading indicator shows a left turn; the turn coordinator shows a half standard-rate, balanced turn; altitude is increasing as shown by the altimeter and vertical speed indicator.*

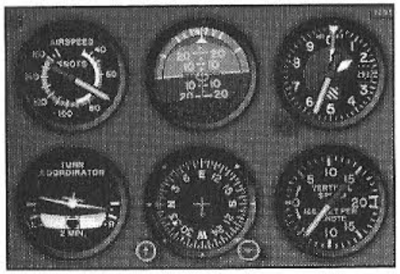


Figure 1.16 *The Gliding Turn: the glide airspeed is steady; the attitude indicator shows 5° of bank; the heading indicator shows a right turn; the altitude is decreasing as shown by the altimeter and the vertical speed indicator.*

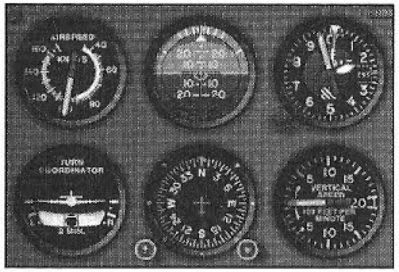


Figure 1.17 *Straight and Level Flight: the cruise airspeed is steady; the attitude indicator shows nose level, wings level flight; the heading indicator shows a constant heading; the turn coordinator shows straight and balanced flight; the altitude is constant as shown by the altimeter and the vertical speed indicator.*

Basic Precision Maneuvers

A Brief Note About Load Factors

Any force applied to an airplane to deflect its flight from a straight line produces a stress on its structure. The amount of this force is termed "load factor." A load factor is a ratio of the total airload acting on the airplane. For example, a load factor of 3 means that the total load on an airplane's structure is three times its gross weight. Load factors are usually expressed in terms of "G", that is, a load factor of 3 may be expressed as 3 G's.

This is defined here because load factor is important to pilots for two reasons:

1. the obviously dangerous overload that is possible for a pilot to impose on the aircraft structures; and
2. increased load factor increases stalling speed and makes stalls possible at seemingly safe flight speeds.

Note: A 60° bank turn produces a 2 G turn.

Steep Turns

A steep turn is one with a bank of 30° or more. The only difference between a steep turn and a normal turn, is the steepness of the bank. Recall that in order to create increased lift during a turn, it is necessary to apply increased back pressure. In a steep turn, the amount of back pressure required can become so great that the angle of attack becomes too steep and results in an accelerated stall.

In a steep turn, increased power may be necessary for two reasons: the additional back pressure means a greater angle of attack and greater induced drag; and the added load factor in the turn causes an increase in the stall speed (for more on stalls, see the Stalls section on page 32).

The 720° Power Turn

This maneuver is used to build confidence because it requires a coordination of bank angle and power adjustments. Locate a point on the horizon or a road below as a reference point for starting and ending the turn. The turn is done at an altitude of at least 1500 feet above ground level.

Look around for other traffic before starting the roll-in. As you begin the turn, open the throttle slowly to achieve a speed appropriate for climbing. This should be accomplished at the same time the desired bank angle is reached. Once the desired bank is reached, neutralize the ailerons and use rudder to correct for torque. Also use back pressure to maintain the nose position relative to the horizon.

Decrease the bank angle if you are losing altitude; increase the bank angle slightly if the plane is climbing. Check your wings, nose, and altitude as you turn, then watch for the reference point to indicate the completion of the first 360° turn. As you turn through the second 360° you will encounter your own wake turbulence. Make corrections as needed. You should begin your roll-out around 45° before returning to the reference point. Be sure to maintain a nose level attitude when rolling out of a steep turn.

Correcting For Wind Drift

A crosswind is one that is at an angle to the direction you are flying. A good course for practicing crosswind corrections is along a straight road with a wind crossing it diagonally. If you were to fly directly along the road, the wind would eventually blow you off track. If your destination is a point somewhere along the straight line of the road, you'd have a hard time reaching it by attempting to fly directly at it.

To correct for the wind, point the nose of the plane at an angle toward the wind. How much of an angle depends on the speed of the wind and your airspeed.

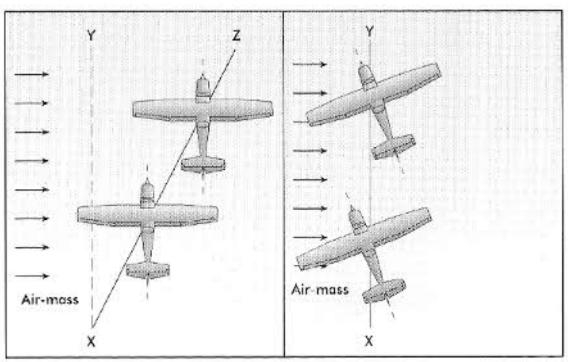


Figure 1.18 *A proper crosswind flying angle is shown at the right.*

Flying A Rectangular Course

This is where you'll learn to "steer" the plane on a track that your instructor designates. It is usually done around a rectangular field, at an altitude around 600 ft, and helps you coordinate your attention between the cockpit controls and outside references. It will also teach you crosswind flying and how to fly in a traffic pattern (see fig. 1.20).

For this example, we will assume that the wind is parallel to the two long legs of the course. This way, you will be correcting for wind drift on the crosswind legs of the pattern. The idea is to maintain a track that is about ¼-½ mile away, equidistant from and parallel to all four sides of the rectangle.

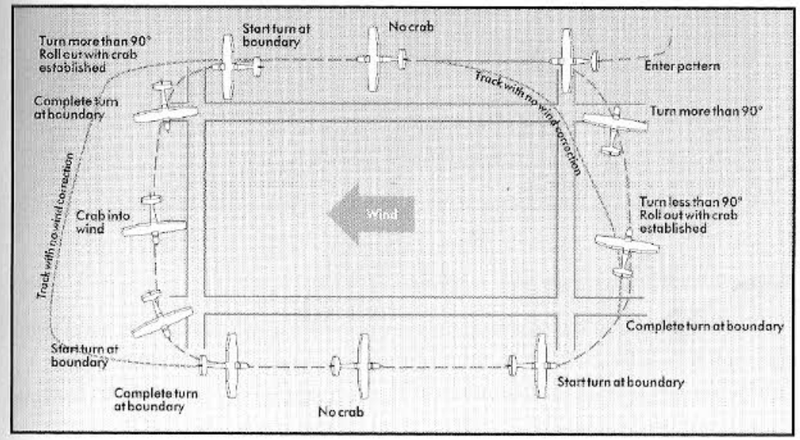


Figure 1.19 *The rectangular course.*

Enter the pattern from a 45° angle, flying downwind. The tailwind on this leg will result in increased ground speed. The first and all subsequent turns should begin when the plane is abeam the corners of the field boundaries. The bank should not exceed 45°. The first turn must be entered with a fairly fast rate of roll-in and relatively steep bank. As the turn progresses, gradually reduce the bank angle to compensate for the diminishing tailwind component and the decreasing ground speed.

The wind will tend to drift the plane off course on this leg, (the equivalent of the base leg in an airport traffic pattern) so a crab angle must be established into the wind. This means that the turn must be greater than 90° from the downwind leg to the base leg. As the wings become level, crab the airplane slightly toward the field and into the wind. Continue this track as you approach the upwind leg.

On all turns, you should always anticipate the drift and the turning radius prior to the turn. Since you are holding a crab angle on the base leg, you will need a turn of less than 90° into the upwind leg to align the plane parallel to the field boundary. This turn should be started with a medium bank angle with a gradual reduction to a shallow bank as the turn progresses. The rollout should be timed to assure a parallel track when the wings become level.

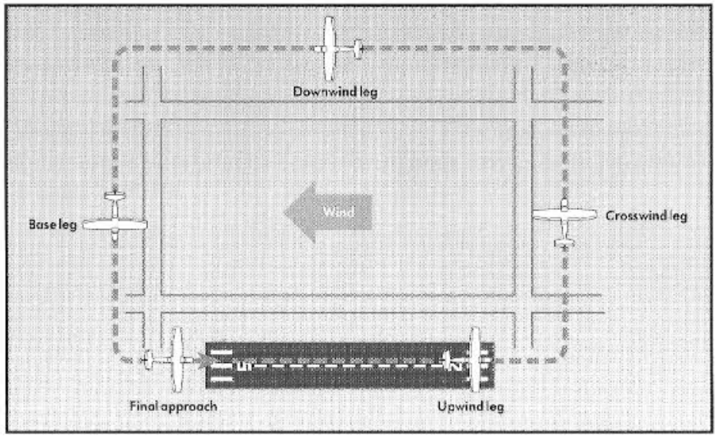


Figure 1.20 *The basic airport traffic pattern.*

Drift should not be encountered on either the upwind or downwind legs, although it may be difficult to find a situation where the wind is blowing exactly parallel to the field boundaries. This would make it necessary to crab the airplane on all four legs. It is important to anticipate the turns to correct for ground speed, drift, and turning radius. When the wind is behind the airplane, the turn must be faster and steeper. When the wind is ahead of the airplane, the turn must slower and shallower.

Flying S-Turns Across a Road

S-turns, like the rectangular course, are a good maneuver for dividing your attention between the airplane and the ground while compensating for drift during turns. S-turns consist of a series of semicircles of equal radii on each side of a selected road or other straight line on the ground. The straight line must lie perpendicular to the wind and should be of sufficient length to allow for a series of turns.

A constant altitude should maintained throughout the maneuver and should be low enough to easily recognize drift, but never lower than 500 feet above the highest obstruction. Cross the road at a 90° angle then immediately begin a series of 180° turns, of uniform radius in opposite directions, re-crossing the road at a 90° angle just as each 180° turn is complete.

To begin, enter the S-turns downwind. As soon as you cross the road, begin the first turn. This will be a steep turn to account for the wind "pushing" the plane away from the road. At about the midpoint of the semicircle,

the turn must be shallowed to account for heading into the wind. Otherwise the plane would continue at the same rate of turn, but as it begins to head into the wind, the ground speed drops. The plane would appear to pivot and would not follow the smooth curve of the semicircle.

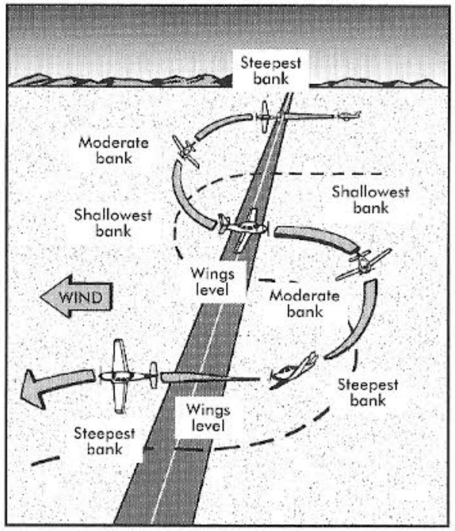


Figure 1.21 *S-Turns across a road.*

The shallowing of the first turn should be such that the wings are level as the plane crosses the road at the same altitude as the first crossing. After crossing the road, the bank should be a shallow one in the opposite direction. Remember, when the wind is ahead, turns should be shallower. If the turn is too steep, the curve of the semicircle becomes too sharp. The degree of bank should be that which is necessary to attain the proper crab so that the ground track describes an arc that is the same as the one established on the downwind side.

Halfway through the second turn, the wind from behind the airplane will require a steepening of the bank angle to get your wings level and perpendicular to the road just as you cross it a third time. The steeper bank is required because the tailwind increases your ground speed so the rate of closure with the road is faster. A constant altitude must be maintained throughout all turns.

With a strong wind, you may not have a shallow enough bank on the upwind side of the road, thus creating a flatter semicircle than on the downwind side. Another probable error is to begin the turn on the upwind side of the road with too much bank angle, thereby crossing the road again before the 180° turn is complete.

Other Proficiency Maneuvers

Several other maneuvers exist which help you develop the ability to subconsciously control the airplane while dividing attention between the flight path and ground references as you watch for other air traffic in the vicinity.

Turns Around a Point

In this training maneuver, the airplane is flown in two or more complete circles of uniform radii or distance from a prominent ground reference point using a maximum bank of approximately 45° while maintaining a constant altitude.

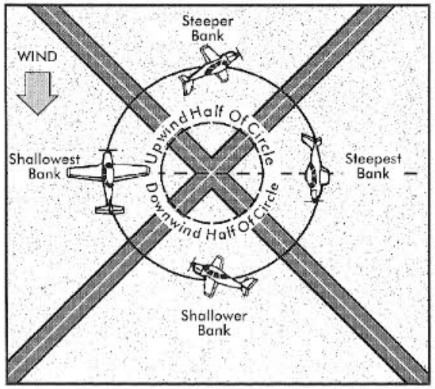


Figure 1.22 *Turns around a point.*

Eights Along a Road

Here, the ground track consists of two complete adjacent circles of equal radii on each side of a straight road or other reference line on the ground. The wind may be parallel to the road or directly across it.

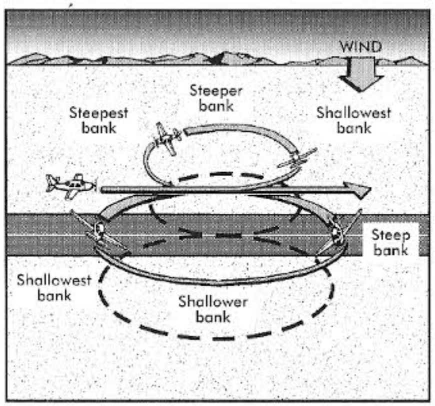


Figure 1.23 *Eights along a road.*

Eights Across a Road

This is a variation of eights along a road, except that at the completion of each loop of the figure eight, the airplane crosses an intersection of roads, or a specific point on a straight road. The loops are across the road and the wind is perpendicular to it.

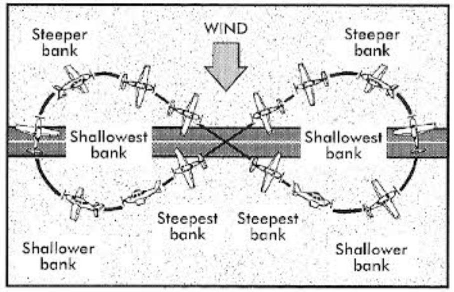


Figure 1.24 *Eights across a road.*

Eights Around Pylons

This maneuver applies the same principle as turns around a point, however, two ground points are used as references, and turns around each pylon are made in opposite directions to follow a ground track in the form of a figure eight.

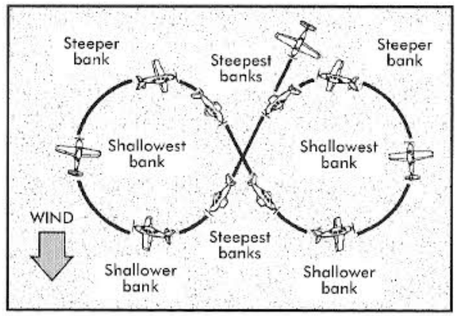


Figure 1.25 *Eights around pylons.*

Eights-On-Pylons

This maneuver varies from eights around pylons in that no attempt is made to maintain a uniform distance from the pylons. Instead, the airplane is flown at such an altitude and airspeed that a line parallel to the airplane's lateral axis, and extending from the pilot's eye appears to pivot on each of the pylons.

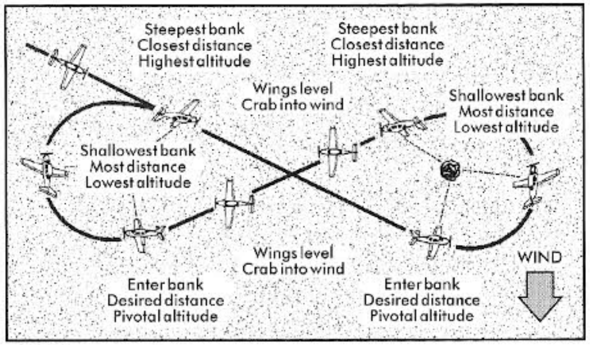


Figure 1.26 *Eights on pylons.*

Stalls

A stall is a condition in which the angle of attack becomes so great that the flow over the airfoil breaks down and the wing can no longer support the airplane. During the practice of intentional stalls, the objective is not to learn how to stall the airplane, but to recognize an incipient stall and take prompt corrective action. The proper recovery is always to decrease the angle of attack and get the air flowing smoothly again regardless of your airspeed.

A normal landing is nothing more than a stall. The average light plane landing begins at an altitude of 15 to 20 feet from a normal glide. From there, it becomes a matter of judgment to have the plane completely stalled (the wheel full back) just as it touches down.

Several practice maneuvers will help you recognize impending stalls in various situations and give you the ability to take appropriate corrective action.

Imminent Approach Stalls

1. Clear the area.
2. Turn carb heat on.
3. Throttle back to idle.
   Once the airspeed falls to within the white arc, full flapsshould be added.
4. Apply gentle back pressure to raise the nose to about the landing touch-down attitude.
5. Keep the nose directionally straight by referencing a point on the horizon. As the airplane is slowed by the elevators, the nose will tend to drop. This requires more back pressure to maintain the nose-up attitude, thus slowing the plane even more, which requires still more back pressure, and so on, until full back pressure is applied. The point where the wheel is full back and the nose drops is called the stall "break." An approach to stall does not complete this break. Instead, you should recognize the impending stall through sight (attitude and airspeed indicators); feel (ineffective and mushy controls, the plane shudders and vibrates); and sound (diminished wind and engine noise).

6. Lower the nose to level flight and throttle up to full power.
7. Turn the carb heat off.
8. Flaps should then be slowly retracted to 0°.

Note that power is not the key to recovering from a stall. With enough altitude, a recovery can be made by altering the plane's attitude.

Imminent Departure Stalls

The only variation to this maneuver from the power-off stall is that you'll have to maintain a higher nose-up attitude to compensate for the increased airspeed. Also, the increased airspeed creates more torque and gyroscopic effects, thus making it more difficult to keep the wings level.

1. Clear the area.
2. Slow the airplane to climb speed or slightly below by throttling back and maintaining a constant altitude. Then set the rpm to takeoff power.
3. Apply slightly more back pressure than in the power-off stall (about 5° higher nose attitude).
4. Align the nose with a reference point on the horizon.
5. Note the approaching stall through sight, sound, and feel. Apply full power and lower the nose simultaneously.

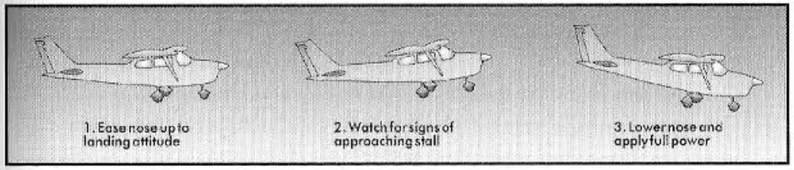


Figure 1.27 *An approach to a stall.*

Practice these maneuvers with as little altitude loss as possible. It is a good habit to form in case you find yourself low someday with little time to reason and recover.

Normal Stall — Power-Off

This is good for landing practice with altitude. Unlike the approach to stalls, the normal stall completes the break described earlier. It is easy for student pilots to create what's called a secondary stall. This occurs when the back pressure is released to recover from the stall, then, in an attempt to lose as little altitude as possible, the student re-applies back pressure too soon or too heavy-handed. The plane stalls again and the process repeats itself. Always recover firmly, but don't get rough with the airplane.

1. Clear the area.
2. Turn carb heat on.
3. Throttle down to idle.
4. Ease the nose up to a landing attitude.
   Once the airspeed falls to within the white arc, full flaps should be added.

5. Maintain the nose-up attitude with continued back pressure. If you are simulating a landing, check your view out the left window while keeping the wings level and the correct nose-up position.
6. When the stall breaks, apply full power and lower the nose while minimizing altitude loss.
7. Flaps up in increments, if used.
8. Turn carb heat off.
9. Level the wings with coordinated use of ailerons and rudder.

Normal Stall — Power-On

1. Clear the area.
2. Ease the nose up into a slightly higher nose-up attitude than in the power-off stall.
3. Keep the wings level.
4. When the stall break occurs, lower the nose and apply full power while keeping the wings level.

Stalls In Climbing Turns

This type of stall will give you practice in recovering from stalls encountered in a climbing turn during takeoff and departures. They are practiced in both straight flight and with moderate 20° banked turns. They are always practiced with lift-off speed and the angle of attack is slowly increased until the stall occurs.

1. Throttle back and slow the plane to a landing approach speed.
2. With the airspeed about 5-10 knots above the stall speed, open the throttle to the recommended takeoff power and begin a 20° bank climbing turn in either direction.
3. Continue to increase the angle of attack until the stall occurs.
4. When the break is definite, lower the nose and apply full power.
5. Level the wings with coordinated controls.

Stalls In Gliding Turns

This is similar to the climbing turn stall, although it emulates the landing approach stall. Because of the decreased airspeed, the rolling tendency is minimized, however the stall break will not be as pronounced. This may require a faster rate of back pressure. Heavier planes don't require much effort to stall and faster planes will stall with comparatively little warning.

1. Turn carb heat on.
2. Establish a normal gliding turn in either direction.
3. Add back pressure until the nose is at the landing attitude or slightly higher.

4. When the break occurs, stop any rotation, release back pressure, and apply full power.
5. Turn carb heat off.
6. Raise gear and flaps (if applicable) and climb to an altitude at least 300 feet above the recovery altitude.

Flying at Minimum Controllable Airspeed

This maneuver demonstrates the flight characteristics and degree of controllability of an airplane at its minimum flying speed. This is important in that pilots must avoid stalls in any airplane they may fly at lower airspeeds which are characteristic of takeoffs, climbs, and landing approaches.

By definition, *flight at minimum controllable airspeed* means a speed at which any further increase in the angle of attack or load factor, or reduction in power will cause an immediate stall. This critical airspeed depends on various circumstances like gross weight and CG (center of gravity) location of the airplane, maneuvering loads imposed by turns and pullups, and the existing density altitude.

1. Throttle back to a power setting much less than required to maintain level slow flight.
2. Maintain altitude as the plane slows by slowly raising the nose.
   Once the airspeed falls to within the white arc, full flaps should be added.
3. As the required speed is approached, add power to maintain a constant altitude.
4. Maintain a constant heading.
5. Maintain airspeed through a coordinated use of throttle and elevators.
6. Make a shallow turn in each direction while maintaining altitude.
7. Level the wings and gradually decrease power to idle.
8. Lower the nose to maintain a glide at the minimum controlled airspeed of 5-10 K above the stall speed. Make 20-30° banked turns in each direction.
9. Return to level, slow flight by applying power and easing the nose up. Maintain airspeed during this transition.
   Slowly retract the flaps to 0°.
10. Increase power and raise the nose to a climb at minimum speed. Make shallow turns in each direction.

This series of transitions from level flight to glide to climb without varying the airspeed with minimal variation in the airspeed will require heavy concentration, but will give you an excellent feel for the aircraft.

Takeoffs and Landings

Takeoffs and Departure Climbs

Although the takeoff and departure climb is one continuous maneuver, there are essentially three parts to it: the takeoff roll, the liftoff, and the initial climb. Before taxiing onto the runway, the pilot should ensure that the engine is operating properly and that all controls, including flaps and trim tabs, are set for takeoff.

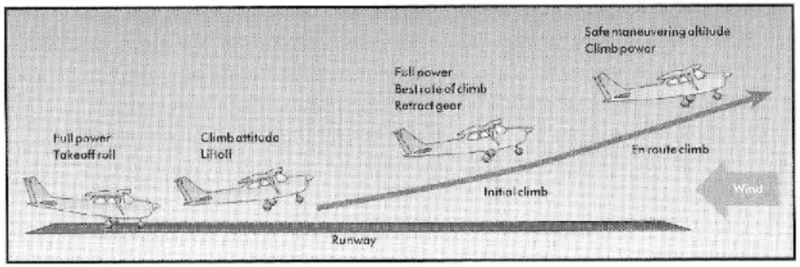


Figure 1.28 *The normal takeoff and climb.*

Takeoff Roll Procedure

1. The takeoff roll begins from a standstill at the center line of the runway. Line up with a reference point at the end of the runway and use it to maintain directional control during the takeoff.
2. Open the throttle slowly to get the plane rolling then smoothly apply full power. Keep your hand on the throttle and check your engine instruments.
3. As the airplane starts to roll forward, slide both feet down the rudder pedals so the balls of your feet are on the rudder portions, not the brake portions of the pedals.
4. Maintain directional control with smooth, prompt, positive rudder corrections.
5. As the speed increases, the pressure increases on the flight controls, especially the rudder and elevators.

Liftoff Procedure

The ideal takeoff attitude requires only minimum pitch adjustments after the airplane lifts off in order to attain the speed for the best rate of climb. Each type of airplane has its own best pitch attitudes for normal liftoff. Varying field and runway conditions may make a difference in the required takeoff technique.

1. Gradually apply back pressure to raise the nosewheel slightly off the runway, thus establishing the takeoff attitude. This procedure is often referred to as "rotating."

2. Not the position of the nose in relation to the horizon and apply elevator pressure as necessary to maintain this attitude.
3. Apply aileron pressure to keep the wings level.
4. Allow the plane to gain altitude without applying undue back pressure.
5. In strong, gusty wind conditions, allow the plane to attain a greater takeoff speed before it is allowed to leave the ground, because a takeoff at the normal speed may result in a lack of positive control, or a stall, if the airplane encounters a sudden lull in the wind.

Initial Climb Procedure

1. The plane should be at an attitude that will allow it to accelerate to its best rate-of-climb airspeed. This airspeed is the one at which the most altitude is gained in the shortest period of time. Apply back pressure to hold this attitude.
2. After it is certain that the airplane will remain airborne and a definite climb is established, retract flaps and landing gear (if the airplane is so equipped).
3. Maintain takeoff power until an altitude of at least 500 feet above the surrounding terrain or any obstacles is attained.
4. Control the airspeed by making slight pitch adjustments using the elevators. Watch the attitude of the airplane in relation to the horizon first, then glance at the airspeed indicator to check for corrections. The airplane will not accelerate or decelerate immediately upon pitch changes, so don't chase the needle on the airspeed indicator. Continue pitch adjustment until the desired climbing attitude is established.

Takeoffs for Airplanes with Tailwheels

Training will also occur in tailwheel type airplanes, and the takeoffs vary.

1. Align the tailwheel with the center of the runway before the takeoff roll. At low roll speeds, the rudder will have little or no effect, so you'll be steering via the tailwheel. As the speed picks up, the rudder becomes more effective.
2. Hold the elevators at neutral or slightly ahead of neutral. Don't force the tail up abruptly as doing so might cause loss of directional control. Without effective rudder, the plane may be turned to the left before it can be stopped with rudder. If the elevator trim tab was set at neutral during pre-takeoff, then the tail will come up by itself when the time is right.
3. While the plane is rolling out in three-point position, you have both tailwheel control and effective rudder control at higher speed. When the tail comes up, all control relies on the rudder, which will have to be adjusted for torque correction. This is the tricky part of the rollout for student pilots.
4. As the plane picks up speed, the controls become firmer and the plane assumes the attitude of a shallow climb. This makes it possible for the plane to liftoff itself as flying speed is reached.

5. If the plane begins to skip or bounce, apply back pressure to bring the plane off.
6. Follow steps 2-4 as outlined above.

As you progress, your instructor will teach you crosswind, short field, and soft field (grass, sand, mud, snow) takeoffs and climbs.

Approach to Landings and Landings

There are five phases involved in the last part of the approach and the actual landing:

1. the base leg.
2. the final approach.
3. the roundout.
4. the touchdown.
5. the after-landing roll.

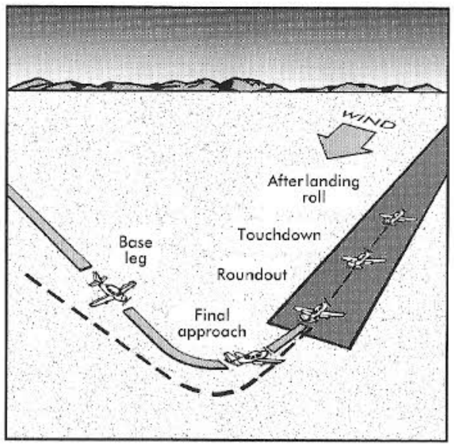


Figure 1.29 *Segments of the approach and landing.*

All of the phases will be discussed assuming normal approach and landing conditions: engine power is available, the wind is light or the final approach is made directly into the wind, the final approach path has no obstacles, and the landing surface is firm and of ample length to gradually bring the airplane to a stop.

The Base Leg

This is the portion of the traffic pattern along which the airplane proceeds from the downwind leg to the final approach. It is on this leg that the pilot judges the distance and altitude which the plane must descend to the desired landing point.

1. The landing gear should be lowered (if necessary) prior to reaching the base leg.
2. Start the descent at 1.4 times the stalling speed with power off, landing gear and flaps down (V_{so}).
3. Partially lower the landing flaps.
4. Establish drift correction to follow a ground track that is perpendicular to the extended centerline of the runway. Since the final approach is usually made directly into the wind, the base leg will have a crosswind that will require establishing a crab angle to maintain the proper ground track.
5. Continue the base leg to the point where a medium to shallow-banked turn will align the airplane's path directly with the centerline of the runway. This turn should be high enough above the runway elevation to permit a final approach long enough for the pilot to estimate the touchdown point while maintaining the proper approach airspeed.
6. If an extremely steep bank is required to prevent overshooting the final approach path, it is advisable to discontinue the approach, go around, and attempt a smoother landing.

The Final Approach

This is the last part of the traffic pattern during which the airplane is aligned with the landing runway, and a straight line descent is made to the point of touchdown.

1. Set the flaps and adjust the pitch attitude for the desired rate of descent. Adjust pitch attitude and power to maintain the desired approach airspeed, approximately 1.3 times the power off stalling speed (V_{so}).
2. With pitch attitude and airspeed stabilized, re-trim the airplane to relieve any control pressures.
3. Control the descent angle so the airplane will land in the center of the first third of the runway. Because all four forces affect the descent angle, you will need to adjust airspeed, attitude, power, and drag.
4. Descend at an angle that will permit the airplane to reach the desired touchdown point at an airspeed which will result in a minimum of floating just before touchdown.
5. If the approach is too high, lower the nose and reduce power. If the approach is too low, add power and raise the nose. If the approach is extremely high or low, reject the landing and go around for another try.
6. Flaps decrease airspeed (assuming no other adjustments are made). Use more flaps if it appears that the airplane will overshoot the desired touchdown point. However, never retract flaps to correct for undershooting as this will result in a sudden decrease in lift. Instead, increase pitch attitude and power to adjust the descent angle and airspeed.

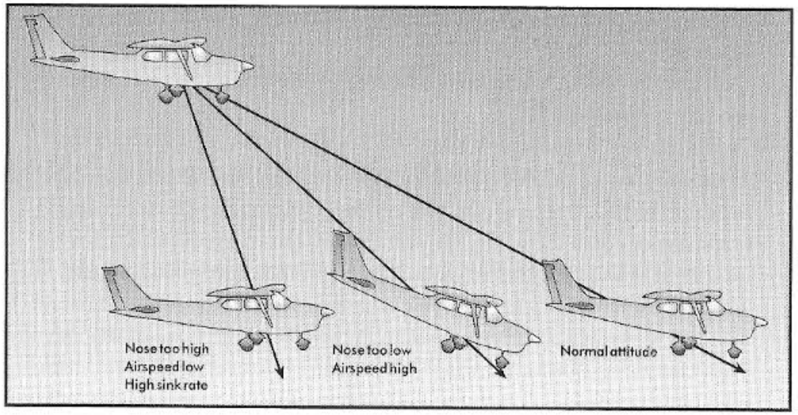


Figure 1.30 *The effect of pitch attitude on approach angle.*

The Roundout

This part of the final approach, also called the flare, is where the plane makes the transition from the approach attitude to the touchdown attitude. It begins when the plane is within 10 to 20 feet above the ground, by gradually applying back pressure to increase the angle of attack and pitch attitude. The angle of attack should be increased at a rate that will allow the airplane to continue settling slowly as forward speed decreases.

When the angle of attack increases, the lift is momentarily increased, thereby decreasing the rate of descent. Since power is normally reduced to idle during the roundout, the airspeed will also gradually decrease. As airspeed continues to decrease, lift will also decrease, so the nose must be held higher to maintain lift. The roundout should be executed so that the proper landing attitude and the proper touchdown airspeed are achieved just as the wheels contact the runway.

The rate of the roundout depends on the airplane's height above the ground, the rate of descent, and the pitch attitude. An airplane with full flaps has a considerably lower pitch attitude than in a no-flap approach. This means the nose must travel through a greater pitch change to attain the proper landing attitude before touchdown. Therefore, the rate of roundout is much faster in a full-flaps approach although the rate is still proportionate to the plane's downward motion.

Once the roundout is begun, elevator control should not be pushed forward. If too much back pressure has been exerted, then slightly relax or hold the pressure constant. It may be necessary to advance the throttle to prevent an excessive rate of sink. Therefore, it is recommended that you keep one hand on the throttle throughout the approach and landing.

Recheck that the landing gear is down and that the propeller control is in a high rpm position, if the plane is so equipped.

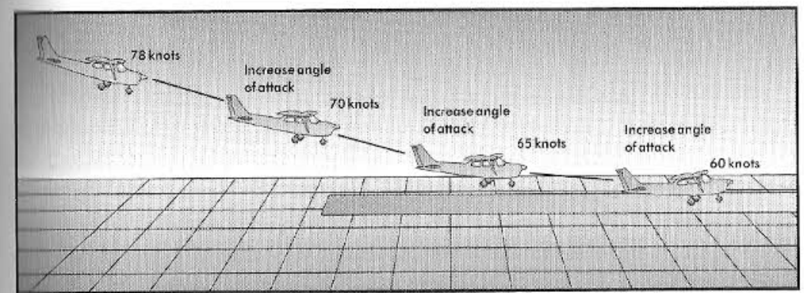


Figure 1.31 *Changing the angle of attack during roundout.*

The Touchdown

This is the actual point of the wheels making contact with the landing surface and where the full weight of the plane is being transferred from the wings to the wheels. It is done with the engine idling and the airplane traveling at approximate stalling speed. The way to make an ideal landing is to hold the plane's wheels a few inches above the ground as long as possible using elevators. Because the airplane is already close to stalling and is already settling, the additional back pressure will only slow the settling and result in a gentler landing.

Tricycle-gear type airplanes should touchdown in a tail-low attitude with the main wheels touching down first, so that little or no weight is on the nosewheel. The main gear and tailwheel in a tailwheel type airplane should touch down simultaneously, in a 3-point landing.

In tricycle-gear type airplanes hold back elevator pressure after touchdown to maintain a positive angle of attack for aerodynamic braking and to hold the nosewheel off the ground until the plane decelerates. Gradually decrease back pressure to allow the nosewheel to settle. In tailwheel type planes, also hold back pressure after touchdown to hold the tailwheel on the ground.

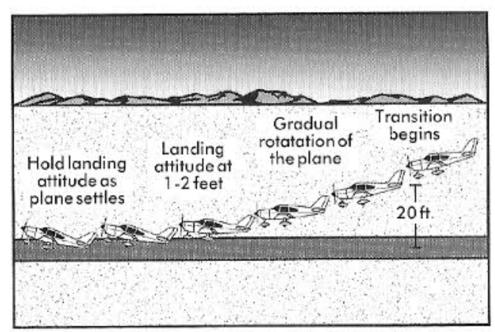


Figure 1.32 *The proper tricycle-gear landing.*

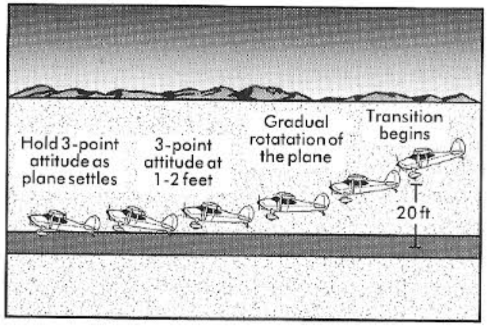


Figure 1.33 *The proper "tail-dragger" landing.*

After-Landing Roll

The landing isn't complete until the airplane decelerates to the normal taxi speed or has been brought to a complete stop clear of the landing area. Directional control must be maintained during the touchdown and after-landing roll. Loss of control may lead to an aggravated, tight turn on the ground, called a "ground loop." Tailwheel type airplanes are most susceptible to ground loops late in the after-landing roll because rudder effectiveness decreases as the airplane slows.

The brakes of an airplane can be used to reduce the speed on the ground and to maintain directional control when the rudder becomes ineffective. Slide your toes up the rudder pedals to use the brakes. If you are using rudder pressure at the time, do not release it or control may be lost before the brakes can be applied.

Aileron control can also be used on the ground in the event that one wing starts to rise. Like the rudder, aileron control becomes less effective as the speed of the airplane on the ground decreases.

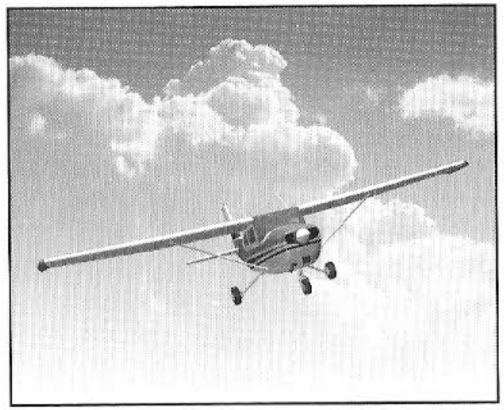
After the plane is clear of the landing area, the plane may be "cleaned up."

There are a wide variety of conditions that are present during approaches and landings which require you to take corrective action. These include slip and power-off approaches, go-arounds (rejected landings), as well as approaches and landings for crosswind, turbulent air, short and soft field, and emergency conditions. Your instructor will teach you the procedures required for all of these conditions.

Chapter 2: Aircraft and Systems

This chapter provides you with some of the more useful specifications and limitations of the six aircraft that are available to fly in *Pro Pilot '99*. All of the figures included here are excerpted from the specific Pilot Operating Handbook for each airplane. It is important to remember, however, that the numbers in a POH are arrived at under conditions which are almost impossible to replicate. The planes are flown by a certification test pilot sitting behind the yoke of a brand new airplane with optimum conditions all around. These numbers do provide a foundation for planning flight operations, but should be considered as guidelines only.

Trainer: Cessna Skyhawk 172P



Speed:

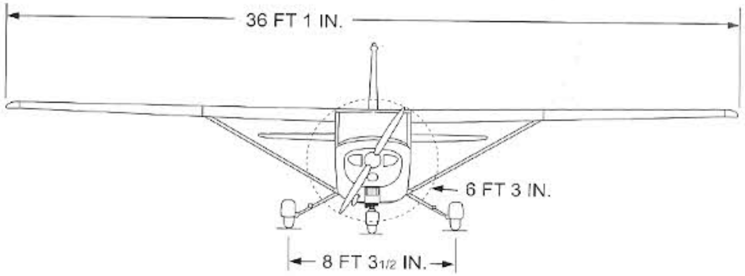
Max. @ Sea Level	123 Knots
Cruise, 75% power @ 8,000 ft	120 Knots

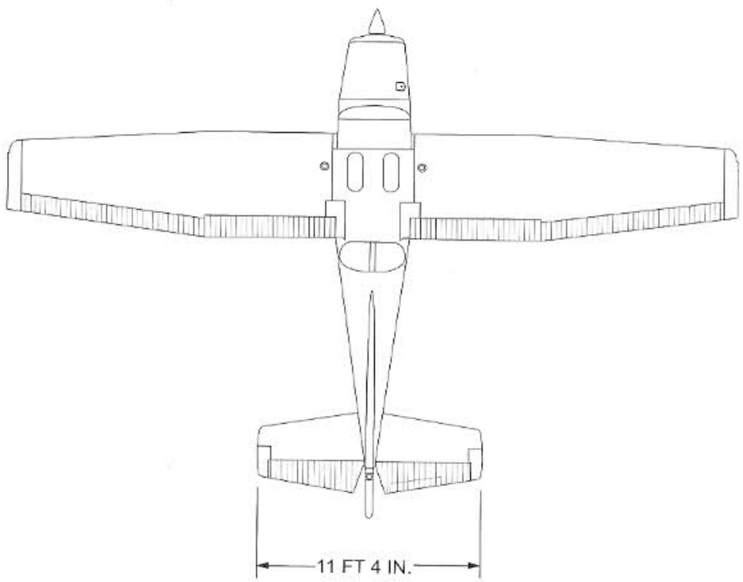
Cruise: Recommended lean mixture with fuel allowance for engine start, taxi, takeoff, climb, and 45 minutes reserve.

75% power at 8,000 ft	Range 440 NM
40 gallons usable fuel	Time 3.8 hours
Max. range at 10,000 ft	Range 520 NM
40 gallons usable fuel	Time 5.6 hours

Rate of climb at sea level	700 fpm
Service Ceiling	13,000 ft
Takeoff Performance	
Ground Roll	890 ft
Total distance over 50-ft obstacle	1,625 ft

172





Landing Performance	
Ground Roll	540 ft
Total distance over 50-ft obstacle	1,280 ft
Stall Speed (KCAS):	
Flaps up, power off	51 knots
Flaps down, power off	46 knots
Maximum Weight:	2407 pounds
Ramp Takeoff or Landing	2400 pounds
Standard Empty Weight	1414 pounds
Max. Useful Load	993 pounds
Baggage Allowance	120 pounds
Oil Capacity	8 quarts

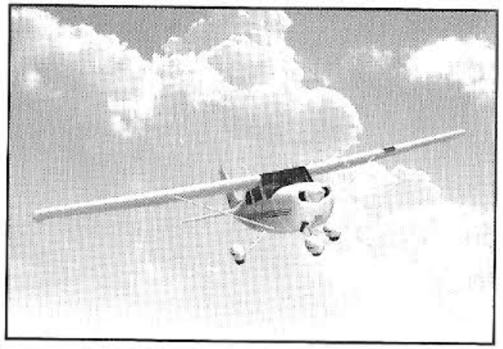
Airspeed Limitations	Speed	KCAS	KIAS
V_{NE}	Never Exceed Speed	152	158
V_{NO}	Maximum Structural Cruising Speed	123	127
V_A	Maneuvering Speed: 2400 pounds 2000 pounds 1600 pounds	 97 91 81	 99 92 82
V_{FE}	Max. Flap Extended Speed: 10° flaps 10°–30° flaps	 108 84	 110 85

Airspeed Indicator Markings	KIAS Value or Range	Remarks
White Arc	33–85	Full flap operating range. Lower limit: Max. weight V_{SO} in landing configuration. Upper limit: Max. speed with flaps extended.
Green Arc	44–127	Normal operating range. Lower limit: Max. weight V_S at most forward C.G. with flaps retracted. Upper limit: Max. structural cruising speed.
Yellow Arc	127–158	Conduct operations with caution and only in smooth air.
Red Line	158	Max. speed for all operations.

Instrument	Red Line Minimum Limit	Green Arc Normal Operating	Red Line Maximum Limit
Tachometer:			
Sea Level	—	2100 – 2450 rpm	—
5,000 ft.	—	2100 – 2575 rpm	2700 rpm
10,000 ft.	—	2100 – 2700 rpm	—
Oil Temperature	—	100° – 245° F	245° F
Oil Pressure	25 psi	60 – 90 psi	115 psi

Fuel, 2 standard tanks: 21.5 gallons each; 1.5 gallons unusable fuel each tank

Cessna Skyhawk 172R



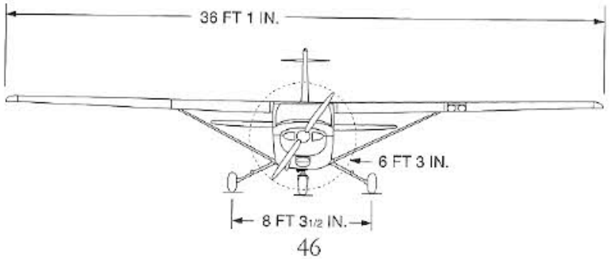
Speed:

Max. @ Sea Level	123 KTAS
Cruise, 75% power @ 8,000 ft	120 KTAS

Cruise: Recommended lean mixture with fuel allowances for engine start, taxi, takeoff, climb, and 45 minutes reserve.

80% power at 8,000 ft 53 gallons usable fuel	Range 580 NM Time 4.8 hours
Max. range at 10,000 ft 53 gallons usable fuel	Range 687 NM Time 6.6 hours

Rate of climb at sea level	720 fpm
Service Ceiling	13,500 ft
Takeoff Performance	
Ground Roll	945 ft
Total distance over 50-ft obstacle	1,685 ft
Landing Performance	
Ground Roll	550 ft
Total distance over 50-ft obstacle	1,295 ft
Stall Speed (KCAS):	
Flaps up, power off	51 knots
Flaps down, power off	47 knots
Maximum Weight:	2457 pounds
Ramp Weight	2457 pounds
Maximum Takeoff Weight	2450 pounds
Standard Empty Weight	1600 pounds
Max. Useful Load	857 pounds
Baggage Allowance	120 pounds
Oil Capacity	8 quarts

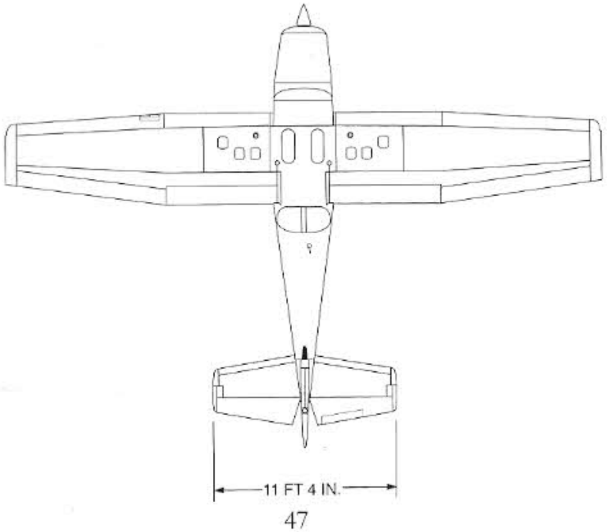


Airspeed Limitations	Speed	KCAS	KIAS
V_{NE}	Never Exceed Speed	152	158
V_{NO}	Maximum Structural Cruising Speed	123	127
V_A	Maneuvering Speed: 2400 pounds 2000 pounds 1600 pounds	 97 91 81	 99 92 82
V_{FE}	Max. Flap Extended Speed: 10° flaps 10°–30° flaps	 108 84	 110 85

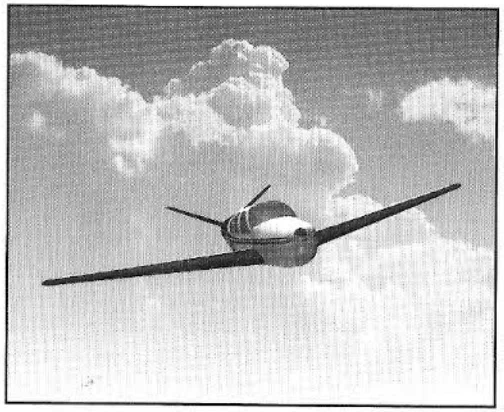
Airspeed Indicator Markings	KIAS Value or Range	Remarks
White Arc	33–85	Full flap operating range.
Green Arc	44–129	Normal operating range.
Yellow Arc	129–163	Opperations must be conducted with caution.
Red Line	163	Max. speed for all operations.

Instrument	Red Line Minimum Limit	Green Arc Normal Operating	Red Line Maximum Limit
Tachometer	—	1900 – 2400 rpm	2400 rpm
Oil Temperature	—	100° – 245° F	245° F (118° C)
Oil Pressure	20 psi	50 – 90 psi	115 psi

Fuel, 2 standard tanks: 28 gallons each; 1.5 gallons unusable fuel each tank



High Performance Aircraft: Beechcraft Bonanza V35



Capacities

Oil	12 quarts
Fuel	
Total Capacity	50 gallons
Total Usable	44 gallons

Weights

Maximum Ramp Weight	3,412 pounds
Maximum Takeoff Weight	3,400 pounds
Maximum Landing Weight	3,400 pounds
Maximum Weight in Baggage Compartment	270 pounds

Airspeed Limitations

Speed	KCAS	KIAS	Remarks
Never Exceed Speed (V_{NE})	195	196	Do not exceed this speed in any operation.
Maximum Structural Cruising (V_{NO} or V_C)	165	167	Do not exceed this speed except in smooth air and then only with caution.
Maneuvering (V_A)	132	134	Do not make full or abrupt control movements above this speed.
Maximum Flap Extension/ Extended (V_{FE})	122	123	Do not extend flaps or operate with flaps extended above this speed.
Maximum Landing Gear Operating/ Extended (V_{LO} or V_{LE})	152	154	Do not extend, retract, or operate with landing gear extended above this speed (except in emergency).

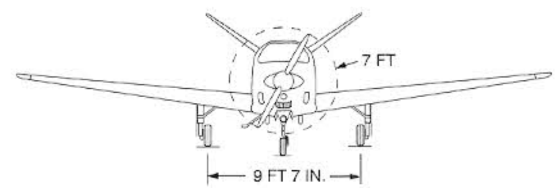
Airspeed For Safe Operation

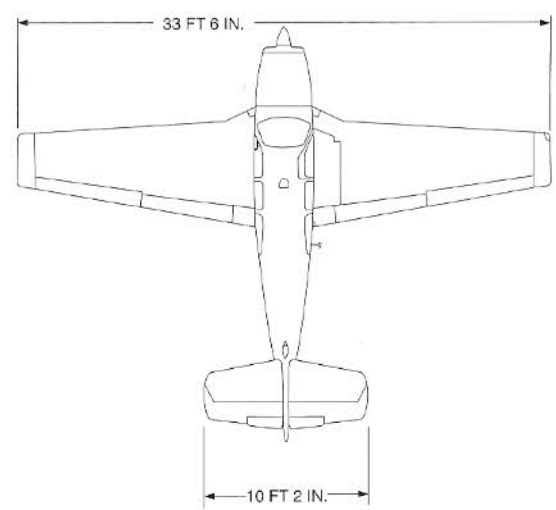
Takeoff	
Liftoff	71 KIAS
50 Ft.	77 KIAS
Maximum Climb	
Best Rate (V_Y)	96 KIAS
Best Angle (V_X)	77 KIAS
Cruise Climb	107 KIAS
Maximum Turbulent Air Penetration	134 KIAS
Balked Landing	70 KIAS
Landing Approach	70 KIAS
Maximum Demonstrated Crosswind	17 knots

Emergency Airspeeds

Emergency Descent	154 KIAS
Glide	105 KIAS
Emergency Landing Approach	83 KIAS

Bonanza





Airspeed Indicator Markings

Marking	KCAS	KIAS	Description
White Arc	53 – 122	52 – 123	Full Flap Operating Range
Green Arc	64 – 165	64 – 167	Normal Operating Range
Yellow Arc	165 – 195	167 – 196	Operate with caution only in smooth air
Red Line	195	196	Maximum speed for all operations

Power Plant Limitations

Engine Speed	2700 rpm
Cylinder Head Temperature	460° F / 238° C
Oil Temperature	240° F / 116° C
Oil Pressure	
Minimum	30 psi
Maximum	100 psi
Fuel Pressure	
Minimum	1.5 psi
Maximum	17.5 psi

Power Plant Instrument Markings

Oil Temperature	
Caution (Yellow Radial)	100° F / 38° C
Operating Range (Green Arc)	100° – 240° F / 38° – 116° C
Maximum (Red Radial)	240° F / 116° C
Oil Pressure	
Minimum Pressure (Red Radial)	30 psi
Operating Range (Green Arc)	30 – 60 psi
Maximum Pressure (Red Radial)	100 psi
Fuel Flow	
Minimum (Red Radial)	1.5 psi
Operating Range (Green Arc)	6.6 – 24.3 gph
Maximum (Red Radial)	17.5 psi
Tachometer	
Operating Range (Green Arc)	1800 – 2700 rpm
Maximum RPM (Red Radial)	2700 rpm
Cylinder Head Temperature	
Operating Range (Green Arc)	200° – 460° F / 93° – 238° C
Maximum Temperature (Red Radial)	460° F / 238° C
Manifold Pressure	
Operating Range (Green Arc)	15 – 29.6 in. Hg
Maximum (Red Radial)	29.6 in. Hg
Instrument Vacuum	
Minimum (Red Radial)	3.75 in. Hg
Operating Range (Green Arc)	3.75 – 5.25 in. Hg
Maximum (Red Radial)	5.25 in. Hg
Fuel Quantity	
Yellow Band	E to ½ full

Approved Maneuvers

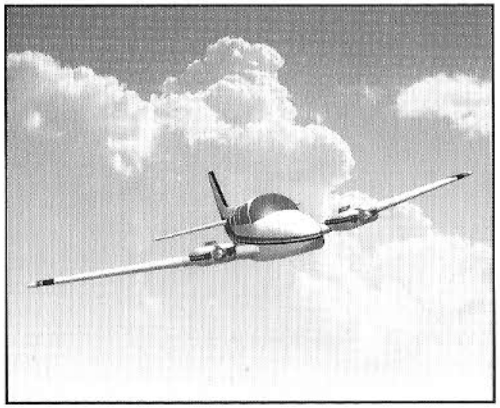
Maneuver	Entry Speed (CAS)
Chandelles	132 knots
Steep Turns	132 knots
Lazy Eight	132 knots

A Note On Flying Twin-Engine Planes

Light twin-engine aircraft (Baron and King Air) sound and look different than their single engine counterpart (Skyhawk and Bonanza), and, in general, they are faster. However, climb rates and overall takeoff performance are not greatly enhanced by the dual power plant configuration. Turbojets (CitationJet) on the other hand, do greatly enhance aircraft performance because of the extra power provided with relatively little increase in weight. Climb rates, cruise altitude, and airspeeds are all increased for jet-powered planes.

When one engine fails during flight on a twin-engine plane, the airplane will experience an immediate and significant yaw toward the dead engine side. If this happens, you must use a combination of aileron and rudder pressure to maintain a degree of straight flight. However, unless the minimum controllable speed (V_{MCA}) is maintained there won't be enough airflow over the rudder and aileron to offset the asymmetrical thrust of the remaining engine.

Multi-Engine Aircraft: Beechcraft Baron B58



Capacities

Oil	12 quarts
Fuel	
Total Capacity	142 gallons
Total Usable	136 gallons

Weights

Maximum Ramp Weight	5,524 pounds
Maximum Takeoff Weight	5,500 pounds
Maximum Landing Weight	5,400 pounds
Maximum Weight in Baggage Compartment	
Main Cabin Extended	400 pounds
Aft Compartment	120 pounds
Nose Compartment	300 pounds

Airspeed Limitations

Speed	KCAS	KIAS	Remarks
Never Exceed Speed (V_{NE})	223	223	Do not exceed this speed in any operation.
Maximum Structural Cruising (V_{NO} or V_C)	195	195	Do not exceed this speed except in smooth air and then only with caution.
Maneuvering (V_A)	156	156	Do not make full or abrupt control movements above this speed.
Maximum Flap Extension/ Extended (V_{FE}) Approach (15°) Full Down (30°)	 152 122	 152 122	Do not extend flaps or operate with flaps extended above this speed.
Maximum Landing Gear Operating/Extended (V_{LO} or V_{LE})	152	152	Do not extend, retract, or operate with landing gear extended above this speed (except in emergency).
Single Engine Minimum Control Speed (V_{MCA})	84	84	Minimum speed for directional controllability after sudden loss of engine.

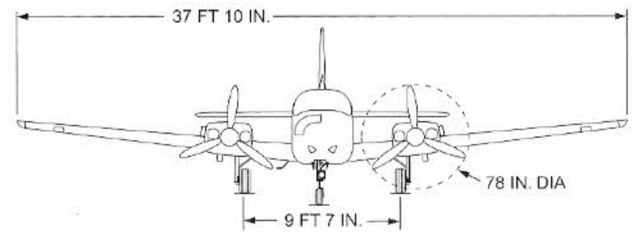
Airspeed For Safe Operation

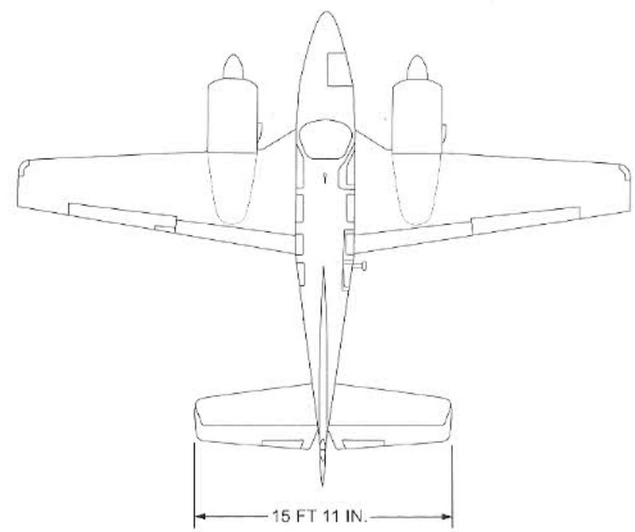
Takeoff	
Rotation	85 KIAS
50 Ft. Speed	100 KIAS
Maximum Climb	
Best Rate (V_Y)	105 KIAS
Best Angle (V_X)	92 KIAS
Cruise Climb	136 KIAS
Maximum Turbulent Air Penetration	156 KIAS
Balked Landing Climb	95 KIAS
Landing Approach (5,400 lbs., flaps down 30°)	95 KIAS
Minimum During Icing Conditions	130 KIAS
Maximum Demonstrated Crosswind	22 knots

Emergency Airspeeds (5,500 pounds)

One-Engine-Inoperative Best-Angle-of-Climb (V_{XSE})	100 KIAS
One-Engine-Inoperative Best-Rate-of-Climb (V_{YSE})	101 KIAS
Air Minimum Control Speed (V_{MCA})	84 KIAS
One-Engine-Inoperative En Route Climb	101 KIAS
Emergency Descent	152 KIAS
One-Engine-Inoperative Landing (5,400 lbs.)	
Maneuvering to Final Approach	107 KIAS
Final Approach (Flaps Down 30°)	95 KIAS
Intentional One-Engine-Inoperative Speed (V_{SSE})	88 KIAS
Maximum Glide Range	115 KIAS

Baron





Airspeed Indicator Markings

Marking	KCAS	KIAS	Description
White Arc	72 – 122	75 – 122	Full Flap Operating Range
White Triangle	152	152	Maximum Flap Approach Position 15°
Blue Radial	100	100	Single Engine Best Rate-of-Climb Speed
Red Radial	84	84	Minimum Single Engine Control
Green Arc	83 – 195	84 – 195	Normal Operating Range
Yellow Arc	195 – 223	195 – 223	Operate with caution only in smooth air
Red Radial	223	223	Maximum speed for all operations

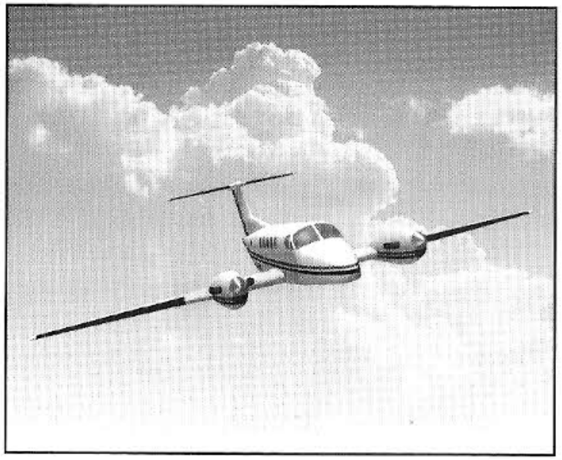
Power Plant Limitations

Takeoff and maximum continuous power	Full throttle and 2700 rpm
Cylinder Head Temperature	238°C
Oil Temperature	116°C
Minimum Takeoff Oil Pressure	24°C
Minimum Oil Pressure (Idle)	10 psi
Maximum Oil Pressure	100 psi

Power Plant Instrument Markings

Oil Temperature	
Caution (Yellow Radial)	24°C
Operating Range (Green Arc)	24° – 116°C
Maximum (Red Radial)	116°C
Oil Pressure	
Minimum Idle (Red Radial)	10 psi
Caution Range (Yellow Arc)	10 – 30 psi
Operating Range (Green Arc)	30 – 60 psi
Maximum Pressure (Red Radial)	100 psi
Fuel Flow	
Operating Range (Green Arc)	3.0 – 30.0 gph
Maximum (Red Radial)	30.0 gph
Tachometer	
Operating Range (Green Arc)	2000 – 2700 rpm
Maximum RPM (Red Radial)	2700 rpm
Cylinder Head Temperature	
Operating Range (Green Arc)	116° – 238°C
Maximum Temperature (Red Radial)	238°C
Manifold Pressure	
Operating Range (Green Arc)	15 – 29.6 in. Hg
Maximum (Red Radial)	29.6 in. Hg
Instrument Pressure	
Operating Range (Green Arc)	3.75 – 5.25 in. Hg
Deice Pressure Gauge	
Operating Range (Green Arc)	9 – 20 psi
Maximum Operating Pressure (Red Radial)	20 psi
Propeller Deice Ammeter	
Operating Range (Green Arc)	14 – 18 amps
Fuel Quantity	
Yellow Band	E to 1/8 full

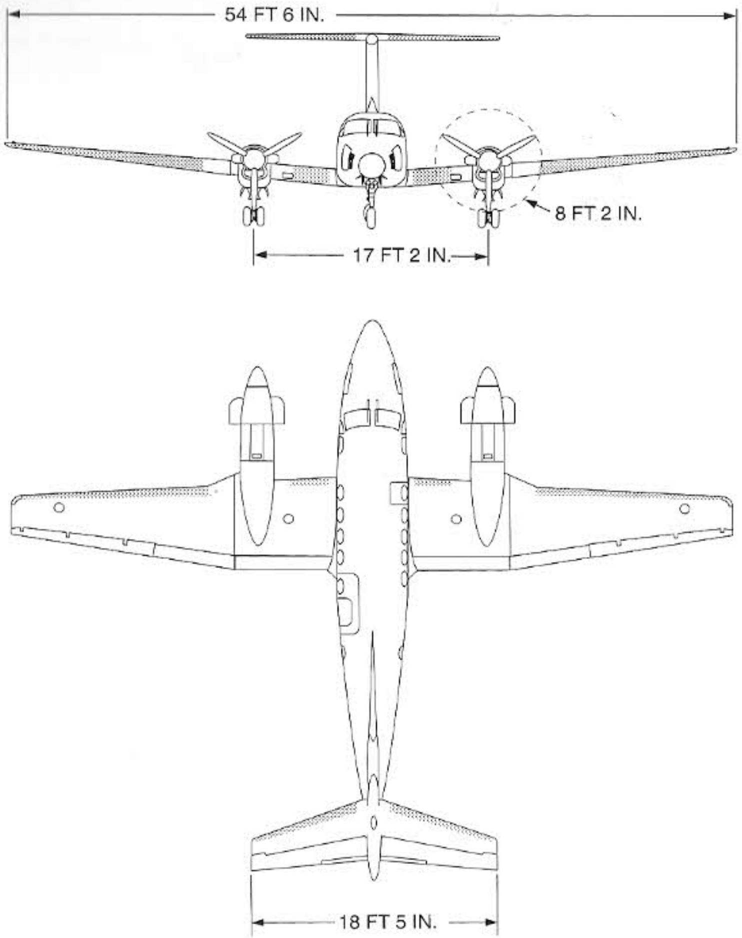
Multi-Engine Aircraft: Beechcraft Super King Air B200



Maximum Weight:	
Ramp	12,590 pounds
Takeoff or Landing	12,500 pounds
Baggage Allowance	510 pounds
with fold-up seats	550 pounds

Airspeed For Safe Operation

Takeoff (Flaps Up)	
Rotation	95 KIAS
50-ft Speed	121 KIAS
Takeoff (Flaps Approach)	
Rotation	94 KIAS
50-ft Speed	106 KIAS
Two-Engine Best Angle of Climb (V_X)	100 KIAS
Two-Engine Best Rate of Climb (V_Y)	125 KIAS
Cruise Climb:	
Sea Level – 10,000 ft	160 KIAS
10,000 – 20,000 ft	140 KIAS
20,000 – 25,000 ft	130 KIAS
25,000 – 35,000 ft	120 KIAS
Maximum Airspeed for Effective Windshield Anti-icing	226 KIAS
Maneuvering Speed (V_A)	181 KIAS
Turbulent Air Penetration	170 KIAS



Airspeed Limitations

	Speed	KCAS	KIAS	Remarks
V_A	Maneuvering Speed: 12,500 pounds	182	181	Do not make full or abrupt control movements above this speed.
V_{FE}	Max. Flap Extended Speed: Approach Position: 40% Full Down Position: 100%	200 155	200 157	Do not extend flaps or operate with flaps in prescribed position above these speeds.
V_{LO}	Extension Retraction	182 164	181 163	Do not extend or retract landing gear above these speeds.
V_{MCA}	Air Minimum Control Speed	91	86	Lowest airspeed at which the airplane is directionally control lable with one engine inoperable and the other at take-off power.
V_{MO} M_{MO}	Max. Operating Speed	260 .52 Mach	259 .52 Mach	Do not exceed this airspeed or Mach number in any operation.

Airspeed Limitations

Airspeed Indicator Markings	KCAS Value or Range	KIAS Value or Range	Remarks
Red Line	91	86	Air Minimum Control Speed (V_{MCA})
White Arc	80 – 155	75 – 157	Full-flap operating range
Wide White Arc max.	80 – 102	75 – 99	Lower limit = Stalling Speed at weight with full flaps and idle
power.Narrow White Arc102 – 1	5575 – 99		Lower Limit = Stalling Speed at max. weight with flaps up and idle power. Upper limit is max. speed permissible with flaps extended beyond 40%.
White Triangle	200	200	Max. Speed with Approach (40%) Flaps
Blue Line	122	121	One engine inoperative, best-rate-of-climb speed.
Red & White Hash-Marked Pointer	260*	.259*	Max. speed for all operations.

* (or value equal to .52 Mach, whichever is lower).

Fuel and Oil Capacity

Total Usable Fuel Quantity:	544 gallons
Each Main Fuel Tank System:	193 gallons
Each Auxiliary Fuel Tank:	79 gallons
Total Oil Capacity (Each Engine)	14.2 quarts

Power Plant Instrument Markings

Instrument	Red Line Minimum Limit	Green Arc Normal Operating	Red Line Maximum Limit
Propeller Tachometer	–	1600 – 2000 rpm	2000 rpm
Oil Temperature	–	10°–99°C	99°C
Oil Pressure*	–	100 – 135 psi	200 psi

* A dual-band yellow green arc extends from 85 to 100 psi indicating the extended range of normal oil pressures for operation at or above 21,000 feet.

Jets: Cessna CitationJet 525

Capacities

Oil (Usable Each Engine)	Approx. 2.5 quarts
Fuel (Maximum Usable)	Approx. 476 gallons (3220 pounds)

Weight Limitations

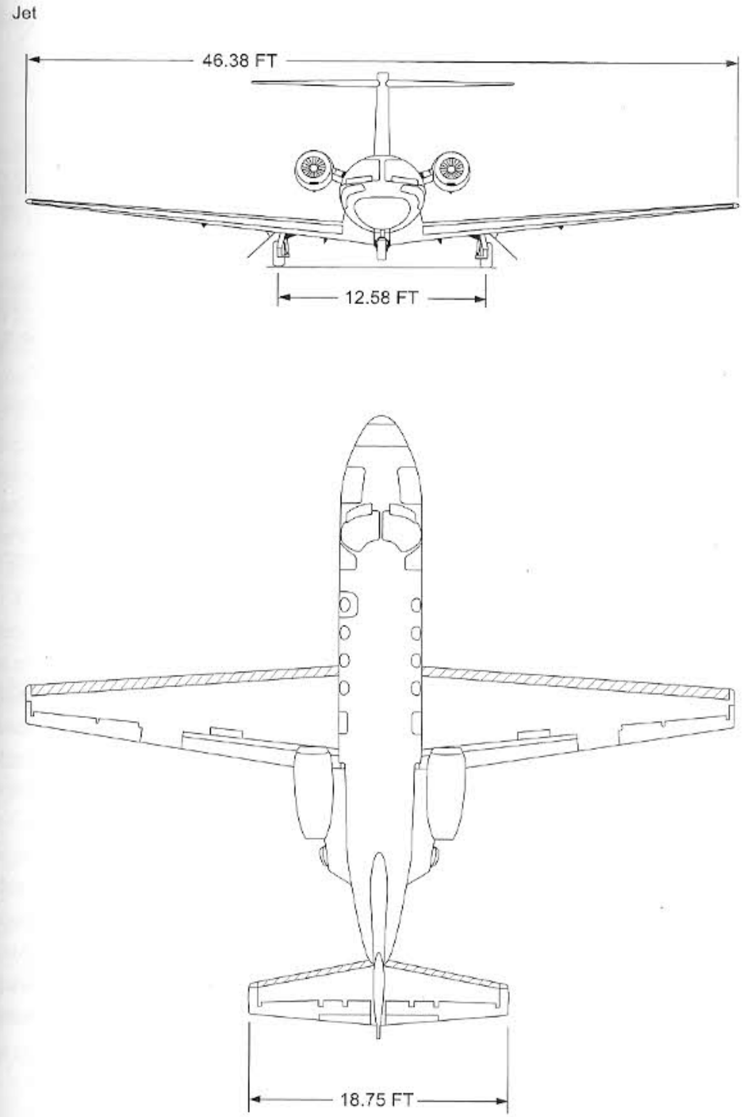
Maximum Design Ramp Weight	10,500 pounds
Maximum Design Takeoff Weight	10,400 pounds
Maximum Design Landing Weight	9,700 pounds
Maximum Design Zero Fuel Weight	8,100 pounds

Speed Limitations

Design Speed Envelope	
At a maximum design zero fuel weight of 7,900 pounds:	
Maximum operating MACH – M_{MO} (above 30,500 ft)	0.710 Mach (indicated)
Maximum Operating KNOT – V_{MO} (SL to 30,500)	263 KIAS
Maximum Flap Extended Speed – V_{FE}	
Full Flaps – Land Position (35°)	161 KIAS
Partial Flaps – Takeoff and Approach Position (15°)	200 KIAS
Maximum Landing Gear Operating/ Extended Speed – V_{LO}/V_{LE}	186 KIAS
Minimum Control Speed, Air – V_{MCA}	92 KIAS
Minimum Control Speed, Ground – V_{MCG}	95 KIAS
Maximum Autopilot Operation Speed	263 KIAS

Takeoff, Landing, and Operating Limitations

Maximum Takeoff or Landing Altitude	10,000 ft.
Maximum Calibrated Operating Altitude	41,000 ft.
Minimum Airspeed for sustained flight in icing conditions	160 KIAS



Performance

(all figures are under International Standard Atmosphere conditions and at a weight of 10,400 pounds, unless otherwise indicated)

Range (includes takeoff, climb, cruise at 41,000 ft, descent and 45-minute reserve)	1,485 NM with full fuel
Stall Speed (landing configuration)	85 KCAS
Single Engine Climb Rate (sea level)	868 fpm
Takeoff Runway Length (sea level)	3,080 ft
Landing Runway Length (sea level)	2,750 ft (at 9,700 lbs.)
Cruise Speed (max. cruise thrust at 35,000 ft)	380 knots (TAS at 8,800 lbs.)

Chapter 3: Airspace Classification and Radio Communication

This chapter discusses the airports within the various classes of airspace and the "rules of the road" that pertain to each. It begins with a discussion on the busiest controlled airports, Class B and Class C airports. Next, controlled airports with part-time Towers or Flight Service Stations on the property (Class D when the Tower is open; Class E when it's closed) are covered, followed by unicom-serviced airports (either Class G or Class E). This section concludes with a discussion on uncontrolled airports, where there is no air-to-ground radio communication. This sequence follows a pattern of airports with a decreasing volume of air traffic and, therefore, less complex communications requirements.

Controlled Airspace/Airports

This section covers classified airspace and airports (Classes A, B, C, D, and E) where air traffic is controlled for IFR (Instrument Flight Rules) and VFR (Visual Flight Rules) flights.

Class A Airspace

Only IFR traffic is permitted within Class A airspace. It begins at 18,000 ft MSL and extends to 60,000 ft MSL (FL600). It includes the airspace over ocean waters within 12 nautical miles of the coasts of the 48 contiguous states and Alaska, as well as designated airspace beyond the 12 mile limit within which domestic radio navigation signals or ATC radar coverage is possible and domestic procedures are applied.

Class B Airspace

Class B airspace is defined as the airspace surrounding the 34 busiest airports, based on passenger enplanements and IFR operations. Each Class B airspace is designed to meet the needs of the airport so the size and structure of the airspace varies. All however, are circular shaped and increase in radius as altitude increases. The core of the airspace, measured from the center of the airport, has a radius of five to 15 nautical miles, depending on the airport, while the highest layer may extend 20 to 30 nautical miles or more. The ceilings of Class B airspaces vary, but the most common is 8,000 ft MSL.

Class B airspace is designated on sectional charts by blue rings that radiate outward from primary airports, each ring representing a different altitude layer, and is boxed in by a thick blue line that represents the geography covered in the VFR Terminal Area Chart (TACs are explained on page 87). TACs should be consulted when flying in Class B airspace and pilots are always required to establish radio contact with Approach Control and have permission before entering Class B airspace.

Class B Airports

Traffic control is accomplished at Class B airports by Approach and Departure Control through the use of the Automatic Radar Tracking System.

The locations of the Class B airports are:

Andrews AFB	Kansas City	Phoenix
Atlanta	Las Vegas	Pittsburgh
Baltimore	Los Angeles	St. Louis
Boston	Memphis	Salt Lake City
Charlotte	Miami	San Diego
Chicago	Minneapolis	San Francisco
Cleveland	Newark	Seattle
Dallas/ Ft. Worth	New Orleans	Tampa
Denver	LaGuardia (New York)	Dulles (Washington, D.C.)
Detroit	John F. Kennedy	National (Washington, D.C.)
Honolulu	Orlando	
Houston	Philadelphia	

Departing a Class B Airport and Airspace

The VFR pilot, when so instructed by the Tower at a Class B airport, must change radio frequencies, contact Departure Control, and be subject to vectors and altitude assignments while in the limits of the airspace and until released by departure. At all times, the VFR pilot must remain VFR and clear of clouds, regardless of instructions, and must advise the controller if a given instruction, other than a non-VFR altitude assignment while in the airspace, would result in a VFR violation.

Clearance Delivery (CD), an agency at Class B airports, has its own assigned frequency to communicate clearances to departing VFR and IFR aircraft in order to reduce congestion at the Ground Control frequency. CDs and their frequencies are listed in the Airport/Facility Directory. CD clears the pilot for departure, establishes the initial post-takeoff heading and altitude, and gives the pilot the appropriate departure control frequency and the transponder squawk code.

Arrival at a Class B Airspace and Airport

As a VFR pilot, you must be cleared by Approach Control prior to entering any of the airspace of a Class B primary airport. Once cleared, Approach Control vectors and directs altitude changes to properly sequence your aircraft with others for landing. When you near the ATA (Airport Traffic Area), approach control then has you contact the Tower for landing instructions.

A VFR aircraft is only required to remain clear of clouds when flying in Class B airspace, instead of complying with the standard clearances of 500 ft below, 1,000 ft above, and 2,000 ft horizontal (see *VFR Visibility and Cloud Distances* on page 74). This is because the standard clearances could result in hazardous air traffic conditions for the high volume of IFR traffic, as VFR pilots climb, descend, or otherwise alter their routes to comply. The standard clearances still apply in all other controlled airspaces.

Approach Control has the option of denying any VFR aircraft access to the controlled airspace. This usually occurs because of a heavier-than-normal volume of IFR traffic, pilot incompetence, or lack of a Mode C transponder (more on transponders starting on page 137). The controller is also not obligated to explain the denial and no appeal of the denial is allowed. Most controllers, however, clear VFR pilots into the airspace as long their ability to handle the IFR traffic is not affected.

Finally, a transiting VFR pilot must also contact Approach Control to receive clearance into the airspace. Usually, the pilot is vectored through the airspace around any existing IFR traffic, even if this means an indirect route for the VFR aircraft.

Class C Airspace

This is the airspace associated with more than 130 airports that are just busy enough to warrant communication and radar control of all air traffic. Like Class B airspace, Class C airspace (formerly called an Airport Radar Service Area, ARSA) is circular and the radius from the center of the airport increases as altitude increases. This radius starts at five nautical miles at ground level and extends to 10 nautical miles starting at 1,200 ft AGL. Class C airspace has a ceiling of 4,000 ft AGL, but this varies from airport to airport. A third outer area that extends to a radius of 20 nautical miles is not shown on sectional charts and radio communication with Approach Control is optional.

Figure 3.1 ***The Albany Class C airport as shown on the New York sectional chart.***

Airspace Classification and Radio Communication

All of the regulations around Class B and D airspaces apply to Class C airspace with one important addition: Class C airspace is designated by magenta rings around it on sectional charts. Each ring represents a different altitude layer, as noted above. Two-way radio contact with Approach Control is required prior to entering the outer ring (at 10 nautical miles) of Class C airspace. This means a positive acknowledgment by the controller who must use your aircraft identification in the response to your initial contact. It is also illegal to enter the airspace when there is no response by Approach Control to your call.

Mode C transponders are required within Class C airspace from the surface to 10,000 ft MSL, as is the standard VFR cloud separation (see table on page 75).

Class D Airspace

This identifies all other airspace over tower-operated airports that are not large enough or busy enough to justify a Class C rating. Class D airspace is cylindrical in shape (with extensions for instrument approaches) within a five-nautical-mile radius from the center of the airport, and typically extends to 2,500 ft AGL. Sectional charts show Class D airspace by a blue dashed circle around the airport. The airport itself, like all tower-controlled airports, is shown in blue. The upper limit of the airspace is indicated, in hundreds of feet MSL, in a blue dashed square. Radio contact with the Tower before entering the airspace is mandatory and must be maintained while in it.

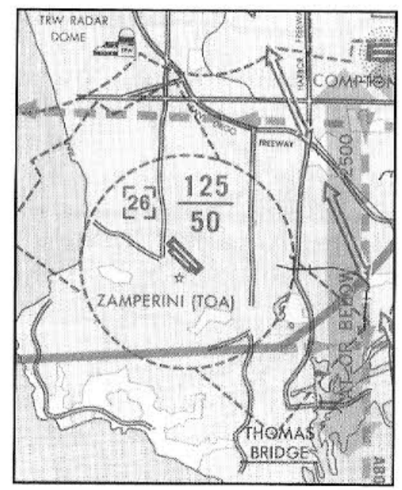


Figure 3.2 ***Only the dashed circle here indicates the Class D airspace around Zamperini.***

The area within the dashed blue circle surrounding Class D airports is known as the Airport Traffic Area, or ATA. It is the area where all traffic is controlled, two-way radio communication is required with the Tower, and clearance from the Tower is required for operation within the area. This same ATA exists at all Class B and C airports even though it is not depicted on sectionals. The reason for this is that Approach Control must separate and sequence all IFR and VFR aircraft within Class B or C airspace, an area that extends much further from the airports than the ATA itself.

Radar coverage at Class D airports is unlikely. Instead, if a Class B or C Approach Control facility is nearby, and the Class D airport is equipped with Bright Radar Tower Equipment (BRITE), then Approach Control receives the radar images and transmits them to the Class D Tower via a television microwave link. This allows the Class D controller to provide radar-determined advisories to all transponder-equipped aircraft operating within the five-mile Class D area.

Certain Class D airports may show an accompanying magenta shape near the dashed blue circle on the sectional chart. This area is established to protect and expedite arriving and departing IFR traffic in Instrument Meteorological Conditions (IMC). This airspace is Class E if it extends for more than two nautical miles from the ATA, with its ceiling extending only to the floor of Class E airspace, 700 or 1,200 ft AGL. If the extension is two nautical miles or less, it is included in the Class D ATA.

ATIS (Automatic Terminal Information Service)

Most Class D airports offer an airport weather and advisory service called ATIS (Automatic Terminal Information Service). ATIS is a continually-running recording that provides, in this sequence:

- Airport name.
- ATIS ID.
- Time in "Zulu".
- Winds.
- Visibility.
- Restricted visibility description.
- Sky Condition.
- Temperature in degrees Celcius.
- Dewpoint in degrees Celcius.
- Altimeter in inches if Mercury.
- Landing and Departing runways.
- Local NOTAMs.
- ATIS ID once again.

ATIS improves control effectiveness and reduces the amount of radio chatter, thus freeing the controllers (and the frequencies) for flight operation matters.

Here's an example of an ATIS broadcast:

"Los Angeles information Sierra. One eight five zero Zulu. One zero thousand scattered. Temperature five niner. Dewpoint five five. Winds calm. Altimeter two niner niner one. ILS two five left approach in use. Landing and departing runway two five left. Advise controller on initial contact. Information Sierra."

You should tune to the ATIS frequency (listed on sectional charts and in the Airport/Facility Directory) just prior to starting your engine on departure, or about 15-20 nautical miles out on arrival. Write down the information if necessary.

You should advise Ground Control, on departure, that you have listened to the ATIS broadcast when requesting taxi instructions. Likewise, you should advise the Tower of the same when requesting landing instructions. This is done by terminating your initial contact with the phrase "with Charlie," assuming Charlie is the current broadcast. For example: "Cheyenne Ground, Skyhawk 9572 at the terminal taxi for takeoff with Charlie." This indicates to Ground Control that you are ready to taxi out for takeoff with the ATIS information.

Ground Control

Ground Control is responsible for regulating all traffic (aircraft and ground vehicles) moving on the taxiways and on runways not currently in use. Active runways are the responsibility of the Tower which is on a different frequency. The Tower controller has jurisdiction over aircraft in the process of landing or taking off. Ground Control must clear any aircraft to touch a taxiway, or to cross an active runway. If a ground controller authorizes you to taxi to an assigned takeoff runway without any holding instructions, then this automatically authorizes you to cross any active runway except the assigned takeoff runway. Only if the controller issues a "Hold short..." instruction do you need to wait for clearance to cross that active runway.

Always acknowledge all runway crossings, hold short, and takeoff clearances. If you're not sure how to proceed, wait until you do. Don't hesitate to ask for help.

Ground Control frequencies range from 121.6 to 121.9 MHz (with a few exceptions) and are reserved for communications between Ground Control and aircraft on the ground. In addition to controlling ground movements, these frequencies are used to provide information such as where a given FBO (Fixed Base Operator) is located, or, if you're unfamiliar with the airport, how to taxi to a certain location.

After landing, wait until directed to do so by the Tower controller before switching to the Ground Control frequency.

Clearance Delivery (CD)

At smaller airports, there is usually only one Ground Control frequency. At the larger ones with heavy IFR traffic, however, a second frequency is provided for Clearance Delivery (CD). This is the agency that provides pre-taxi clearances for both VFR and IFR traffic. The frequency for CD is listed in the Airport/ Facility Directory along with the frequencies for Ground and Tower Control.

Note: Clearance Delivery has nothing to do with the direct control of air or ground traffic.

Taxiing

Here is a good summary of some taxiing requirements:

- Always obtain clearance from Ground Control before touching any taxiway or runway. This does not include ramps, parking areas, hangar spaces, fueling areas, and other terminal building facilities.
- Always state your position on the ground when contacting Ground Control for taxi clearance.
- Upon clearance by Ground Control to taxi to a particular runway, you are allowed to cross any intersecting runways, active or inactive, *as long as no "hold clear" or "hold short" instructions were issued along with the clearance.*
- Clearance to taxi *to* a particular runway does not constitute permission to taxi *on* that runway.
- Taxi clearances are based on known information by Ground Control. It still remains the responsibility of the pilot to avoid collisions with other aircraft or other obstructions.
- Don't hesitate to ask for clarification of any instructions, especially when it comes to crossing an active runway.

Class E Airspace

This ranges from a floor of 700 to 1,200 feet AGL, up to 18,000 ft MSL. Included in this airspace classification are non-towered airports, areas reserved for IFR aircraft making the transition from a terminal to an en route environment and vice versa, and the federal airways from 1,200 ft AGL to 18,000 ft MSL. Also included are Class D airports that have part-time control towers. When the tower is closed, the airport becomes Class E.

VFR Flight Within Class E Airspace

It's important to understand the operating freedoms and limits imposed on flying within Class E controlled airspace. VFR aircraft operating within this airspace could potentially fly coast to coast along VOR airways, receiving continuous traffic advisories from Centers, and land at non-towered, Class G airports, without once being controlled by a Center or other ATC agency. The only requirements are that you abide by all VFR regulations. If you have been receiving air traffic advisories, you are responsible for advising the controller of

route deviations or altitude changes, or if you intend to leave the controller's frequency for any reason. Most important, however, is that you remain VFR at all times and stay on the alert for other aircraft.

These freedoms end when landing or taking off from a Class B, C, or D controlled airport or when flying an IFR flight plan. On IFR, you are in a strictly controlled environment and subject to ATC clearances, instructions, and approvals. The advantage to IFR is added safety in VFR weather conditions and to be able to fly in bad weather conditions. IFR pilots are also in constant contact with ATC controllers who clear you to certain altitudes and headings, advise you of potential conflicting traffic, approve or deny route deviations, monitor your progress, transfer you between controllers as you move across country, coordinate your arrival with Approach Control as you near your destination, and generally watch over and assist you from flight departure to termination.

Uncontrolled Airspace/Airports

All airspace between the surface and up to 700 ft or 1,200 ft AGL that is not included in Class A, B, C, D, and E airspace, as well as airports without control towers, is uncontrolled. When the tower is closed at airports with part-time control towers, the airport is uncontrolled, but pilots are still subject to FAA visibility and cloud separation minimums, as well as certain radio communications responsibilities.

About 95 percent of the airports in the U.S. are uncontrolled. This means that they are open to the public for unrestricted use. These uncontrolled airports fall into one of two categories: unicom and multicom.

Unicom

Unicom airports are identified on sectional charts by their magenta coloring, the airport field elevation (MSL), the length of the *longest* runway (in hundreds of feet), an "L" if the runway is lighted, and the unicom's frequency (printed in italics). The unicom is a non-government radio facility that is usually manned by the local fixed-base operator (FBO). At unicom airports that have no Tower and no FSS, the unicom frequencies are almost universally 122.7, 122.8, or 123.0. However, you should consult the appropriate Airport/ Facility Directory for the frequency of each airport.

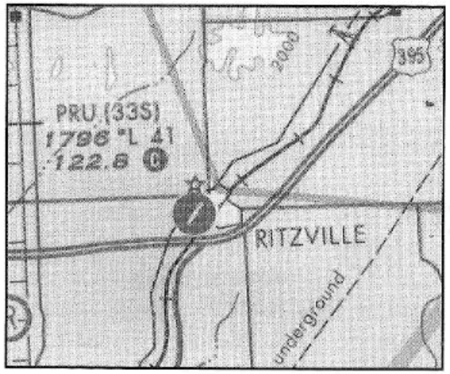


Figure 3.3 *A unicom airport from the Seattle sectional chart.*

Unicom operators provide information on wind direction and velocity, altimeter settings, runway in use, and reported traffic in the pattern. This is done so at the request of the pilot as a "field advisory." The unicom operator should not be considered a traffic controlling agency, but only as a source of basic airport information.

Unicom is also useful for requesting ground transportation (upon arrival) and phone calls, alerting the FBO to needed mechanical repairs, and so on. Calls like this should be delivered as: "(Airport name) unicom," followed by your request. For field advisories, the initial contact is made beginning with "(Airport name) unicom," followed by your aircraft type, call sign, position, altitude, intentions, and ending with, "Request field advisory." Subsequent position reports are similar to those at a multicom airport (see page70) except they are addressed to "(Airport name) *Traffic*," instead of "(Airport name) unicom."

Smaller airports with part-time Control Towers are considered uncontrolled when the Tower is closed. Field advisories are still available over the unicom frequency (if the FBO is open). Once the advisory has been received, all calls are then addressed to "(Airport name) *Traffic*" over the Tower frequency, not the unicom Common Traffic Advisory Frequency (CTAF). The structure of these calls are handled the same way as at any uncontrolled airport.

Airport Advisory Service (AAS)

In a situation where the airport has no tower, but where there is an FSS on the field, the FSS provides an Airport Advisory Service on the 123.6 frequency. Included in the advisory is wind direction and velocity, the designated runway, the current altimeter setting, known traffic (traffic that has elected to communicate with the FSS), NOTAMs, airport taxiways, airport traffic patterns, and instrument approach procedures.

The FSS is not a traffic controlling agency, nor does it perform the courtesy services of a unicom. You are not required to contact it to land or take off,

although it is strongly recommended. Calls to the FSS are addressed as "(airport name) Traffic." When opening, closing, or filing a flight plan, or when requesting an airport advisory, address calls to "(Airport name) Radio."

Because there are so many combinations of open and closed communications facilities, along with the existence of Remote Communication Outlets (RCOs), the table below should help you sort them out.

Tower Status	On-Site FSS Status	On-Site RCO	FBO Status	Field Advisories type/frequency	Frequency for position reports	ATC Radio frequency
Open						Tower
Closed	Open			AAS/Tower[5]	Tower	
Closed	Closed	RCO	Open	UFA/unicom[1]	Tower	
Closed	Closed	RCO	Closed	FFA/RCO	Tower	
Closed	Closed	RCO	No FBO	FFA/RCO	Tower	
Closed	Closed	No RCO	Open	UFA/unicom	Tower	
Closed	Closed	No RCO	No FBO	N/A	Tower	
Closed	No FSS	RCO	Open	UFA/unicom[1]	Tower	
Closed	No FSS	RCO	Closed	FFA/RCO	Tower	
Closed	No FSS	RCO	No FBO	FFA/RCO	Tower	
Closed	No FSS	No RCO	Open	UFA/unicom	Tower	
Closed	No FSS	No RCO	Closed	N/A	Tower	
Closed	No FSS	No RCO	No FBO	N/A	Tower	
None	FSS	Open		AAS/123.6[3]	123.6[2]	
None	Closed	RCO	Open	UFA/unicom[1]	123.6[2]	
None	Closed	RCO	Closed	FFA/RCO	123.6[2]	
None	Closed	RCO	None	FFA/RCO	123.6[2]	
None	Closed	No RCO	Open	UFA/unicom	123.6[2]	
None	Closed	No RCO	Closed	N/A	123.6[2]	
None	Closed	No RCO	No FBO	N/A	123.6[2]	
None	No FSS	RCO	Open	UFA/unicom	unicom	
None	No FSS	RCO	Closed	FFA/RCO	unicom	
None	No FSS	RCO	No FBO	FFA/RCO	122/9[4]	
None	No FSS	No RCO	Open	UFA/unicom	unicom	
None	No FSS	No RCO	Closed	N/A	unicom	
None	No FSS	No RCO	No FBO	N/A	122.9[4]	

[1] last hour's official weather observation from FSS over RCO, if weather observer on duty.
[2] Or as listed in A/FD.
[3] Where available. Some AFSSs may not offer this service.
[4] Multicom.
[5] FSS will reply on tower frequency.

AFSS: Automated Flight Service Station
ATC: Air Traffic Control
FBO: Fixed Base Operator with unicom
FSS: Flight Service Station
RCO: Remote Communications Outlet
ASS: FSS Airport Advisory Service (winds, weather, favored runway, altimeter setting, reported traffic within 10 miles of airport)
FFA: FSS Field Advisories (last hour's winds, weather, and altimeter setting, if observer is on duty at airport)
UFA: Unicom Field Advisories (winds, favored runway, known traffic, altimeter setting [at some locations])

Multicom

Multicom airports have no air-to-ground (and vice versa) communication. All communication is between aircraft only. All calls made around a multicom airport are made over the Common Traffic Advisory Frequency (CTAF), always 122.9, and are for the purpose of "self announcing." This announcement should include your aircraft type, call sign, present position and altitude, and your intentions (whether it's to land, practice touch-and-goes, etc.).

Approximately 10 to 15 miles out from the airport, tune in the frequency and listen for other aircraft in the pattern, if any, and what runway they are using. If you are doing touch-and-goes or landing, your self announce should be followed by reports on the downwind leg, base leg, final approach, and when clear of the runway. If you are transiting the area, below 3,000 ft AGL, announce your position once you're over the field and again when you're clear of the area.

Multicom airports are indicated on sectional charts in the same manner as unicom airports.

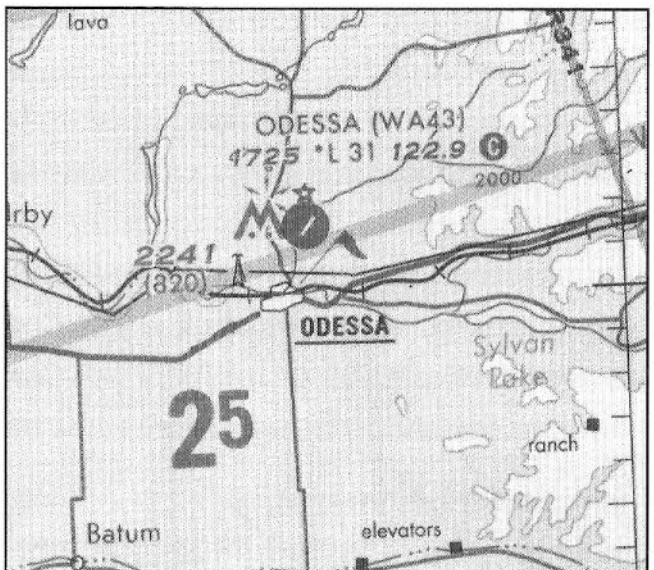


Figure 3.4 ***Odessa Municipal, a multicom airport on the Seattle sectional chart.***

Note: This chapter covers Class A, B, C, D and E airspace, and mentions Class G airports. Why no Class F airspace? In 1993, the U.S. adopted the International Civil Aviation Organization's (ICAO) system and reclassified its airspace to coincide with common nomenclature and structure. However, the U.S. has no airspace that is comparable to the Class F definition.

Identifying Airspace

After some practice, airspace can easily be identified when referring to sectional charts. The legend of a sectional chart is a useful reference for identifying the markings of airspace information and airport traffic. Refer to these legends for a detailed description (in color) of every symbol and all airspace.

Symbol	Description
Thick blue line	Class B Airspace
Thick magenta line	Class C Airspace
Dashed blue line	Class D Airspace
Dashed magenta line	Class E Airspace
Thick fading magenta line	Class E Airspace with 700 ft AGL floor
Thick fading blue line	Class E Airspace with 1200 ft AGL floor that abuts Class G Airspace

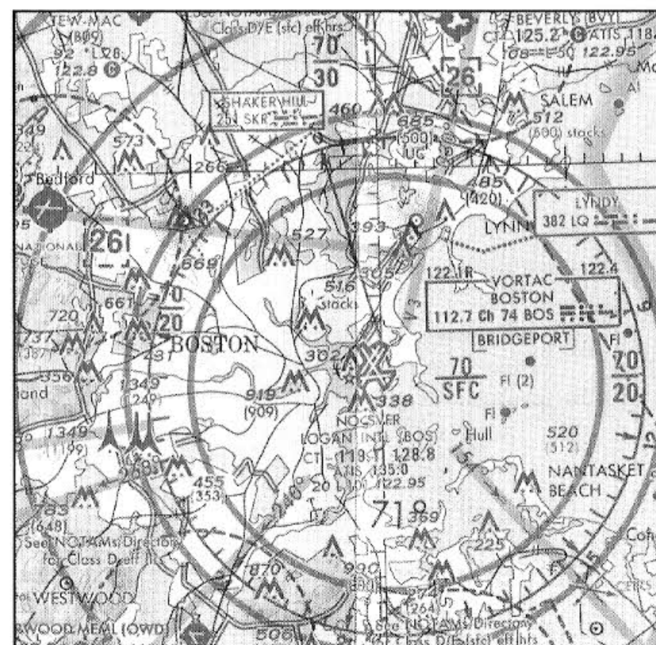


Figure 3.5 ***The Class B airspace around Logan International Airport in Boston, MA.***

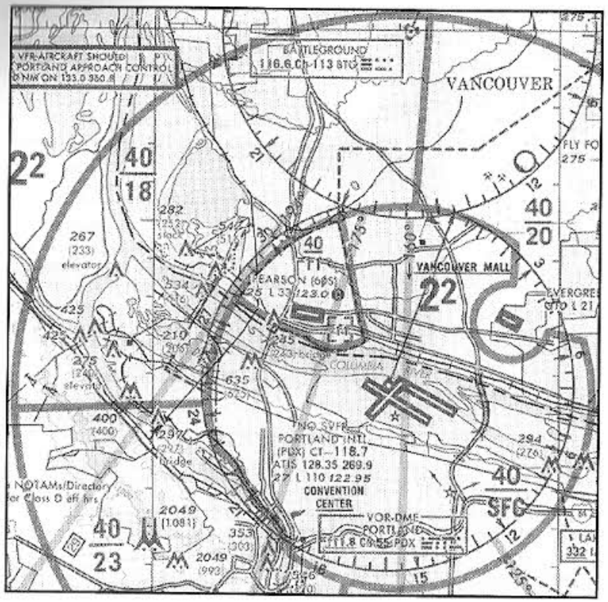


Figure 3.6 *The Class C Airspace around the Portland International Airport.*

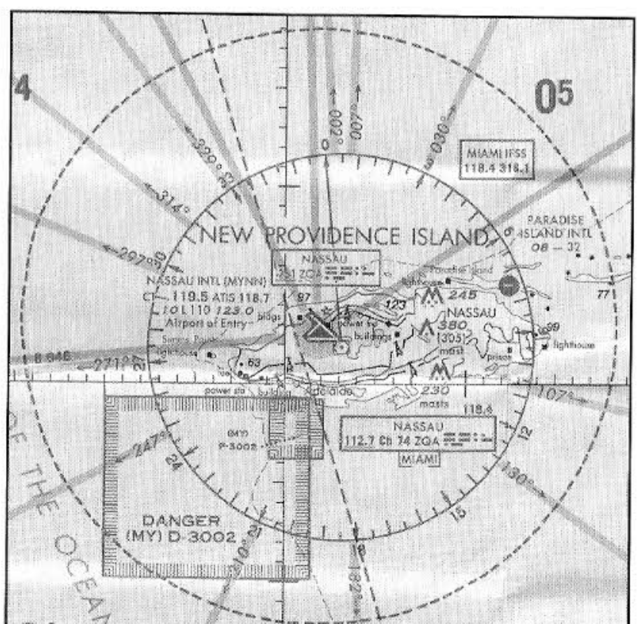


Figure 3.7 *The Class D Airspace around Nassau Island.*

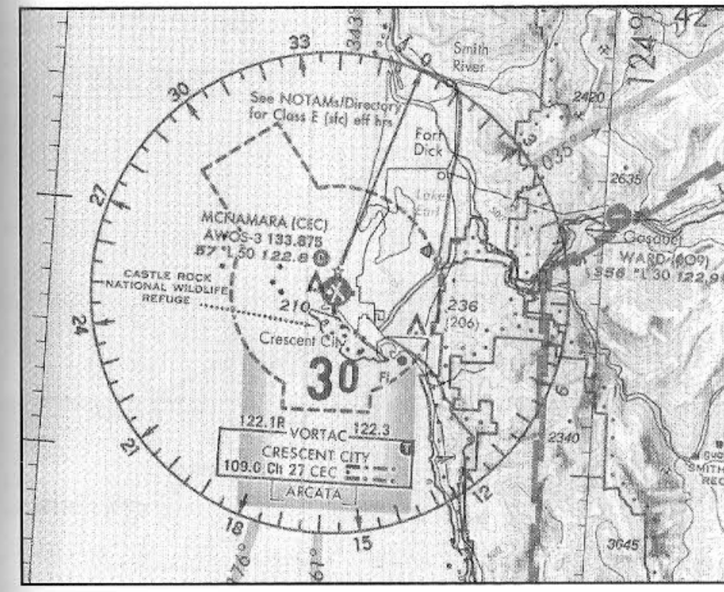


Figure 3.8 *The Class E Airspace around Jack McNamara Field near Crescent City, CA.*

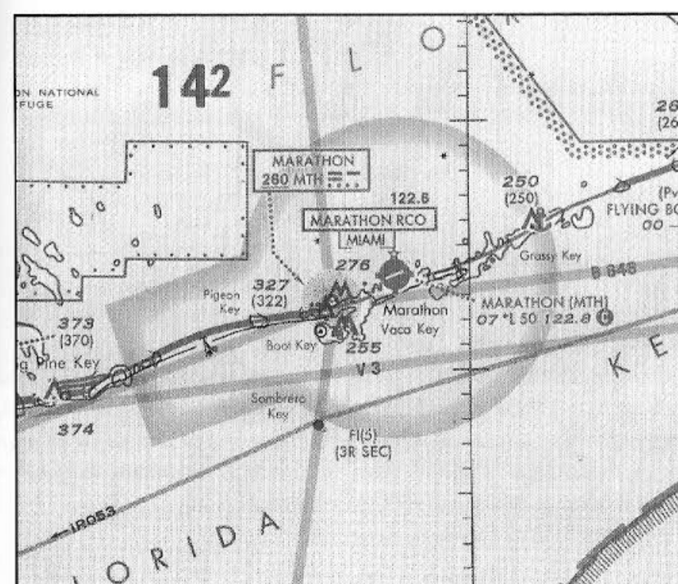


Figure 3.9 *The Class E Airspace (700 ft floor) aound Marathon in the Florida Keys.*

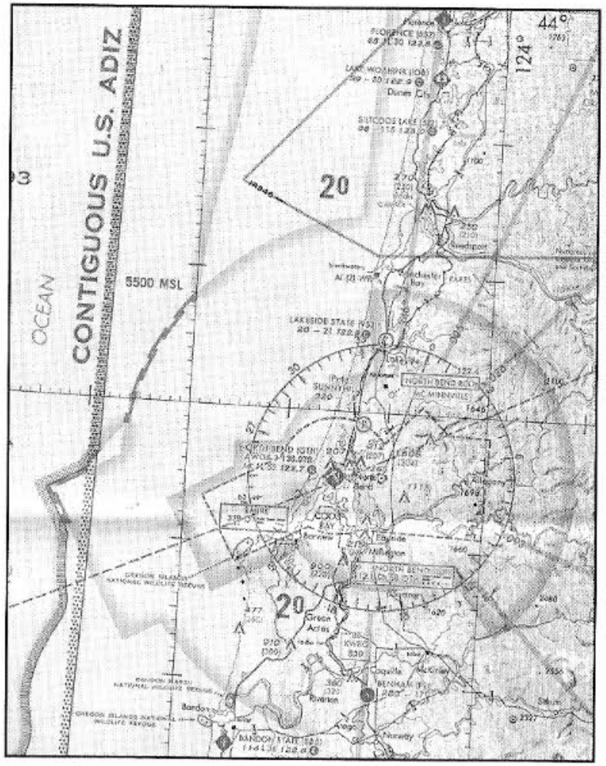


Figure 3.10 *The Class E Airspace (1200 ft floor) off the coast of Oregon.*

Airspace and VFR Requirements

The Federal Aviation Administration has established rules which govern VFR flight to assist pilots in seeing and avoiding other aircraft. The two basic requirements are those relating to flight visibility and distance from clouds; and those that designate VFR altitudes and flight levels.

The definition of Visual Flight Rules is that you can maintain control of the aircraft via direct visual reference to the ground, ground obstacles, cloud formations, and other aircraft in the area of operation. VFR conditions require no ceiling or a ceiling that is greater than 3,000 ft AGL and the visibility is greater than five miles. Marginal VFR (MVFR) is a ceiling of 1,000 to 3,000 ft AGL and/or a visibility of three to five miles inclusive.

VFR Visibility and Cloud Distance

Federal Aviation Regulation (CFR) 91.155 states the minimum distances for cloud separation and visibility in both controlled and uncontrolled airspace. The chart below outlines these minimum distances. An easy way to remember cloud separation distances in the majority of VFR flying (in the

controlled airspace between 1,200 ft AGL and 10,000 ft MSL) is to start with 500 ft below (clouds), double it to 1,000 ft above, then double it again to 2,000 ft horizontally. In all cases, the visibility between 1,200 ft AGL and 10,000 ft MSL is three miles. Above 10,000 ft, it's 1,000 ft below, 1,000 ft above, and one mile horizontal, or "1-1-1."

Airspace	**Visibility**	**Distance from clouds**
Class A	Not Applicable	Not Applicable
Class B	3 statute miles	Clear of clouds
Class C	3 statute miles	500 ft below 1,000 ft above 2,000 ft horizontal
Class D	3 statute miles	500 ft below 1,000 ft above 2,000 ft horizontal
Class E:		
Less than 10,000 ft MSL	3 statute miles	500 ft below 1,000 ft above 2,000 ft horizontal
At or above 10,000 ft MSL	5 statute miles	1,000 ft below 1,000 ft above 1 statute mile horizontal
Class G:		
1,200 ft or less above the surface (regardless of MSL altitude)		
Day*	1 statute mile	Clear of clouds
Night*	3 statute miles	500 ft below 1,000 ft above 2,000 ft horizontal
More than 1,200 ft above the surface but less than 10,000 ft MSL		
Day	1 statute mile	500 ft below 1,000 ft above 2,000 ft horizontal
Night	3 statute miles	500 ft below 1,000 ft above 2,000 ft horizontal
More than 1,200 ft above the surface and at or above 10,000 ft MSL	5 statute miles	1,000 ft below 1,000 ft above 1 statute mile horizontal

* For airplanes, when the visibility is less than three statute miles, but not less than one statute mile during night hours, an airplane may be operated clear of clouds if operated in an airport traffic pattern within one-half mile of the runway.

VFR Altitudes

The regulations governing east and west flight altitudes for VFR flying between 3,000 ft AGL and 18,000 ft MSL are as follows:

Heading East – When flying a magnetic course of 0° to 179° inclusive, VFR altitudes are at *odd* thousands plus 500 ft. For example, 3,500 ft; 7,500 ft; etc.

Heading West – When flying a magnetic course of 180° to 359° inclusive, VFR altitudes are at *even* thousands plus 500 ft. For example, 4,500 ft; 8,500 ft; etc.

A good acronym for remembering this is WEEO (west even, east odd).

Note: Remember that flying over 18,000 ft MSL is reserved for IFR flight only.

Visual Flight Rules (Daytime)

Required instruments and equipment for daytime VFR flight:

1. Airspeed indicator.
2. Altimeter.
3. Magnetic direction indicator.
4. Tachometer for each engine.
5. Oil pressure gauge for each engine using pressure system.
6. Temperature gauge for each liquid-cooled engine.
7. Oil temperature gauge for each air-cooled engine.
8. Manifold pressure gauge for each altitude engine.
9. Fuel gauge for each tank.
10. Landing gear position indicator if aircraft has retractable landing gear.
11. Flotation device for each occupant and one pyrotechnic signaling device if aircraft is operated for hire over water and beyond power-off gliding distance from shore.
12. Approved safety belts for all occupants at least two years old.
13. An approved shoulder harness for each seat on planes manufactured after July 18, 1978.

Visual Flight Rules (Nighttime)

Required instruments and equipment for nighttime VFR flight:

1. All of the required daytime instruments and equipment.
2. Approved position lights.
3. An approved aviation red or white anti-collision light system on large aircraft, on small aircraft when required for an air worthiness certificate, and on all small aircraft manufactured after August 11, 1971.
4. One electric landing light if the aircraft is operated for hire.
5. An adequate source of electrical energy for all installed electrical and radio equipment.
6. One spare set of fuses or three spare fuses of each kind required.

Special Use Airspace

It is critical for the VFR pilot to understand the purpose of Special Use Airspace (SUA) and how to identify it on aeronautical charts. Most SUAs are restricted to military aircraft and are established for the purpose of national security, welfare, or environmental protection, as well as military training, research and development, testing, and evaluation. All of these areas, except for Controlled Firing Areas, are depicted on aeronautical charts.

Most of the airspaces reserved for security, welfare, and environmental reasons require flight detours or altitude changes which are small and infrequent enough to be relatively minor. Any areas restricted for military reasons, however, are usually geographically large, and involve training maneuvers, bombing runs, missile launches, aerial gunnery, and artillery practice which could be very hazardous to straying aircraft.

Prohibited Areas

All aircraft flight is prohibited in these areas which are defined by an area on the ground. These areas are established for security reasons or other reasons associated with the national welfare. Examples are the capitol in Washington, D.C., presidential homes or retreats, atomic or nuclear testing areas, and similar critical government or military facilities. The figure below shows a sectional chart with a prohibited area indicated by a blue hash-mark border.

Prohibited areas, as well as other special use airspace, are further defined in a table on the reverse side of the legend on all sectional charts. The table lists the airspace reference number, location, minimum flight altitude, times that flying is prohibited, and the controlling agency.

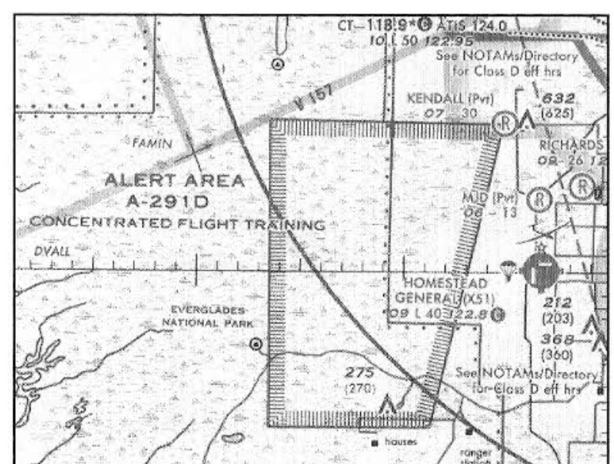


Figure 3.11 *Prohibited use airspace just west of Homestead, FL.*

SPECIAL USE AIRSPACE ON LOS ANGELES TERMINAL AREA CHART

Unless otherwise noted altitudes are MSL and in feet; time is local.
Contact nearest FSS for information.
†Other time by NOTAM contact FSS

The word "TO" on altitude means "To and including."
"MON-FRI" indicates "Monday thru Friday"
FL – Flight Level
NO A/G – No air to ground communications

U.S. P–PROHIBITED, R–RESTRICTED, A–ALERT, W–WARNING, MOA–MILITARY OPERATIONS AREA

NUMBER	LOCATION	ALTITUDE	TIME OF USE	CONTROLLING AGENCY**
R-2503 A	CAMP PENDLETON, CA	TO 2,000	0600-2400†	ZLA CNTR
R-2503 B	CAMP PENDLETON, CA	TO 15,000	0600-2400†	ZLA CNTR
R-2503 C	CAMP PENDLETON, CA	15,000 TO FL 270	INTERMITTENT BY NOTAM 24 HOURS IN ADVANCE	ZLA CNTR
R-2519	POINT MUGU, CA	UNLIMITED	CONTINUOUS	ZLA CNTR
W-289	POINT MUGU, CA	UNLIMITED	INTERMITTENT	ZLA CNTR
W-290	SAN DIEGO, CA	TO FL 600	INTERMITTENT	ZLA CNTR

**ZLA – Los Angeles

MOA NAME	ALTITUDE OF USE*	TIME OF USE†	CONTROLLING AGENCY
SAN ONOFRE HIGH	4,000 TO BUT NOT INCLUDING 8,000	INTERMITTENT BY NOTAM	SOCAL TRACON
SAN ONOFRE LOW	2,000 TO BUT NOT INCLUDING 4,000	INTERMITTENT BY NOTAM	SOCAL TRACON

*Altitudes indicate floor of MOA. All MOAs extend to but do not include FL 180 unless otherwise indicated in tabulation or on chart.
†Other time by NOTAM contact FSS

Figure 3.12 *Table of restricted/prohibited airspace locations.*

Restricted Areas

Restricted areas are similar to prohibited areas in that they contain hazards to non-participating aircraft, such as artillery firing, missile launches, and aerial gunnery. While prohibited areas are generally off limits continuously, restricted areas are only off limits during certain time periods. They are also designated by the same blue hash-mark borders as prohibited areas, and are listed in the same table on sectional charts.

Warning Areas

Warning areas also contain hazardous activity and are off limits to non-participating aircraft. There are two types of warning areas, both located in offshore airspace:

Non-regulatory Warning – Over international waters in international airspace beyond 12 nautical miles from the U.S. coastline, these areas are not regulated by the FAA.

Regulatory Warning – These areas extend from three to 12 nautical miles from the U.S. coastline in U.S. territorial waters and contain the same hazardous activities as non-regulatory waters. They are regulated by the FAA and the operating rules of CFR Part 91 apply.

Warning areas are designated by a blue hash-mark border. They are also listed in a table on the reverse side of the legend of all sectional charts.

Military Operations Area (MOA)

These are by far the largest special use areas and, as such, they represent the biggest obstacle to VFR flight. MOAs are airspaces of defined vertical and lateral limits established for the purpose of separating certain military flight training activities from non-military IFR traffic. Whenever an MOA is in use, non-participating IFR traffic can be cleared through the area as long as IFR

separation can be provided by Air Traffic Control. Otherwise, the non-participating IFR traffic is rerouted or restricted.

Unlike in restricted areas, VFR pilots are not prohibited from flying through MOAs at any time, but extreme caution should be used if doing so during any military activity. MOAs are designated on sectional charts by magenta hash-mark borders and also appear in a separate MOA table on the reverse side of the sectional chart's legend.

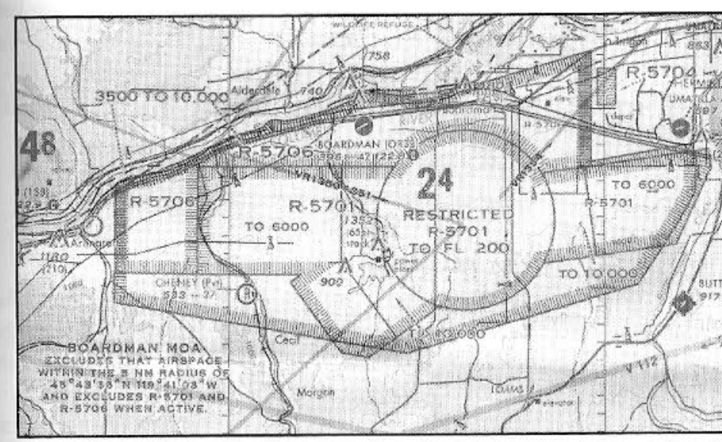


Figure 3.13 *The Boardman MOA near Pendleton, OR.*

MOA NAME	ALTITUDE OF USE*	TIME OF USE†	CONTROLLING AGENCY**
BOARDMAN	4000	0730-2359 MON-FRI †6 HRS IN ADVANCE	ZSE CNTR
CHINOOK A,B	300 TO 5000	CONTINUOUS DAYLIGHT	NAS WHIDBEY ISLAND APP CON
OKANOGAN A	9000	INTERMITTENT BY NOTAM	ZSE CNTR
OKANOGAN B,C	300 AGL TO BUT NOT INCLUDING 9000	INTERMITTENT BY NOTAM	ZSE CNTR
OLYMPIC A,B	6000	BY NOTAM	ZSE CNTR
RAINIER 1,2,3	2000 TO 9000	INTERMITTENT BY NOTAM	SEATTLE-TACOMA APP CON
ROOSEVELT A	9000	INTERMITTENT BY NOTAM	ZSE CNTR
ROOSEVELT B	300 AGL TO BUT NOT INCLUDING 9000	INTERMITTENT BY NOTAM	ZSE CNTR

*Altitudes indicate floor of MOA. All MOAs extend to but do not include FL 180 unless otherwise indicated in tabulation or on chart
†Other time by NOTAM contact FSS
**ZSE–Seattle

Figure 3.14 *Table of MOAs from the Seattle sectional chart.*

Note: The time of use in these MOA tables can be amended at any time as long as the using agency notifies the controlling ARTCC, which then coordinates the information with the appropriate FSS. It is your responsibility as a pilot to contact the FSS and confirm that any MOA through which you plan to fly is, in fact, inactive at the time you plan to enter it.

Also, a single altitude listed in the "Altitude of Use" column is the floor of the MOA. For instance, a listed altitude of 14,500 ft means that the MOA is from 14,500 to 18,000 ft (18,000 is the base of Class A airspace). If a range is listed, such as "100 AGL TO 6,500," then these are the floor and ceiling altitudes of the MOA.

Military Training Routes (MTRs)

MTRs are established by the FAA and the Department of Defense for the purpose of low-altitude, high-speed pilot training in the interest of national security. They are identified by thin gray lines on sectional charts, brown lines on en route low altitude charts, and pink on VFR wall planning charts. MTRs are subject to change every 56 days.

The type of route is identified by "IR" for IFR flights, and "VR" for VFR flights. All routes flown below 1,500 ft AGL are assigned a four-digit number (i.e., VR 1355). Routes with one or more segments over 1,500 ft AGL are assigned a three-digit number (i.e., IR 340).

The small arrow symbol next to the route number indicates the direction of flight within the route. Flight is always one way in an MTR. If there is traffic in the opposite direction along the same route line, then it is indicated by a different MTR number.

The standard MTR width is 5/5 (five miles from either side of the route center line), although it can vary from 7.5/7.5 to 10/10 to 16/25.

When planning a VFR cross-country flight, you should note where MTRs cross or parallel your flight path, then obtain information from the FSS on the military activity within those MTRs at the time you will be crossing or in them. Updated activity reports can be obtained en route from the nearest FSS or from the appropriate Air Route Traffic Control Center when within 100 miles of an MTR.

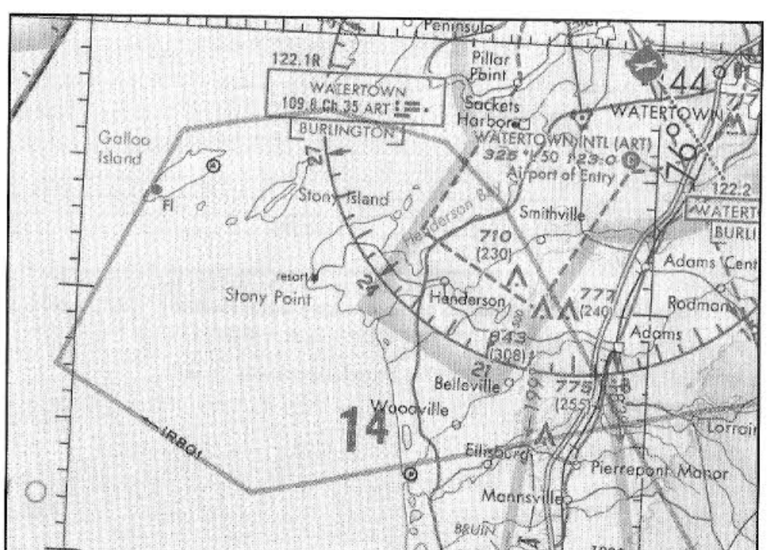


Figure 3.15 ***A military training route (IR 801) that extends over Lake Ontario.***

Airspace Classification and Radio Communication

Air Defense Identification Zones (ADIZ)

These zones are established in the interest of national security. An ADIZ is an area of airspace over land or water in which the ready identification, location, and control of civil aircraft is required in the interest of national security. CFR Part 99 lists the rules that pertain to operations within an ADIZ, including special security instructions; radio, flight plan, and transponder requirements; arrival or completion notices; position reports; radio failure; and other pilot regulations. ADI Zones are located along the Atlantic, Pacific, and Gulf coasts.

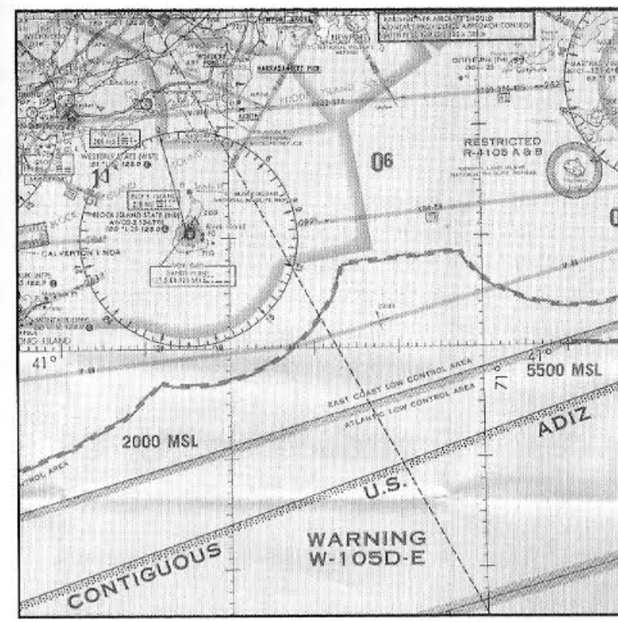


Figure 3.16 *The ADIZ markings along a section of the northeastern U.S. coastline.*

Alert Areas

Alert areas exist only to warn pilots of high levels of activity, such as pilot training, or of unusual types of aerial activity. Neither activity is hazardous to non-participating aircraft, however, they may be of such an intensity that all pilots should be particularly alert.

Alert areas are designated on sectional charts with the same markings as prohibited and restricted areas, and are also listed in the table on the reverse side of the chart's legend. In the "Controlling Agency" column of this table, all alert areas list "No A/G" which stands for "No air/ground communications." While radio communication may be taking place, it has nothing to do with the control of air traffic, radar control, or the issuance of traffic advisories in the area.

Temporary Flight Restrictions

These kinds of restrictions exist because of the possibility that some planned or unexpected event may cause hazardous traffic congestion aloft. Major catastrophes, big sporting events, or other events that attract large crowds, may also attract a large viewing audience from the air. Temporary flight restrictions in the vicinity of the event are designed to prevent hazardous situations, and are issued via NOTAMs. Such NOTAMs describe the area where the restrictions apply, normally the airspace within five miles of the event site and 2,000 ft AGL. Once the NOTAM is issued, aircraft is allowed to operate in the restricted area only under the following conditions:

1. The aircraft is participating in disaster relief activities and is to be directed by the agency responsible for disaster relief.
2. The aircraft is operating to or from an airport within the area and such operation will not hamper or endanger relief activities.
3. The operation is authorized under an IFR ATC clearance.
4. Flight around the area (to avoid it) is a) impractical because of weather or other considerations; b) advance notice is given to the air traffic facility specified in the NOTAM, and c) en route flight through the area will not hamper or endanger relief activities.
5. The pilot is carrying accredited new representatives or persons on official business concerning the incident, the flight is conducted in accordance with FAR 91, and a flight plan is filed with the air traffic facility stated in the NOTAM.

Operating In Controlled Airspace

With the exceptions of Class A, B, C, and D airspaces, and certain Special Use Airspaces, VFR pilots are relatively free of any ATC facility control as long as they adhere to the VFR visibility, cloud separation, and east-west altitude requirements.

This freedom also applies when flying VOR airways on a cross-country flights. In doing so, you can climb, descend, or deviate from the planned route as long as you comply with VFR requirements. You must also maintain appropriate radio communications at all times while in contact with a Center.

ARTCCs exist primarily to control IFR flight plan aircraft. This includes ensuring proper separation, issuing traffic advisories, warnings, or alerts, monitoring the IFR aircraft's fix-to-fix, point-to-point progress, and sequencing the aircraft both en route and into the terminal environment. Also, Centers will provide en route traffic advisories, workload permitting, such as alerting you to other traffic that could present a potential hazardous situation, guide you to the nearest airport in the event of an emergency, advise other ground agencies in the event of radio

failure, reorient you if you are lost, and alert you to MOAs. Centers will only provide this service under the following conditions:

1. You have established contact with a Center controller.
2. You have requested the service (referred to as "flight following" or "traffic advisories").
3. The controller has agreed to provide the service.
4. You remain in radio contact with the Center until the service is terminated.

ARTCC Locations

There are 24 Centers that cover the 48 contiguous states, plus Hawaii, Alaska, Guam, and San Juan. The map in figure 3.17 illustrates the area that each Center covers.

These 24 centers are located in:

Alaska	Honolulu	Minneapolis
Albuquerque	Houston	New York
Boston	Indianapolis	Oakland
Chicago	Jacksonville	Salt Lake City
Cleveland	Kansas City	San Juan
Denver	Los Angeles	Seattle
Fort Worth	Memphis	Washington, D.C.
Guam	Miami	

Each center has remote air-ground stations and remote radar antennas that are connected via a network of microwave links and land lines that allow for continuous coverage.

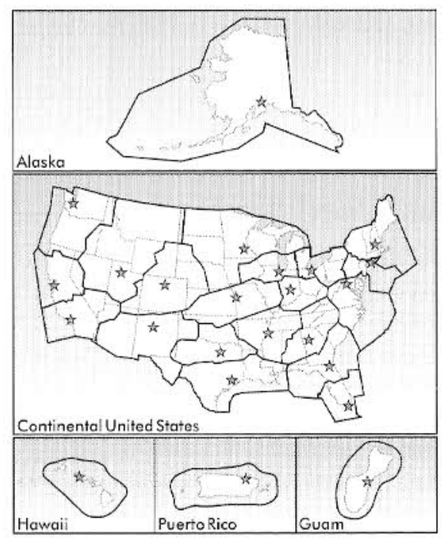


Figure 3.17 *ARTCC Locations.*

To establish radio contact with a Center, you need to know the frequency to use, given your location at the time of contact. The FSS is a good source while filing a flight plan or receiving a weather briefing. So is Ground Control, Clearance Delivery, the Tower at a controlled airport, or Departure Control at Class B or C airport. While in flight, call the nearest FSS for the frequency of the area where you are currently flying.

After contacting a Center, the controller tracks your progress on radar at your request and notifies you of when you are leaving that particular sector and what new frequency to tune in for the approaching sector. Usually, the controller also advises you of when you are approaching the boundary between Centers.

Contacting a Center: Pilot Responsibilities

- Be sure the controller responds to your initial call before you announce your position and request traffic advisories.
- After the controller acknowledges your call, state your present position, present or intended cruising altitude, the first point of landing, route of flight, then request en route advisories.
- Write down and repeat back the transponder code the controller gives you to avoid hesitation or confusion later.
- Listen carefully for calls addressed to your N-number, then respond promptly.
- Do not leave the controller's frequency without advance notice. Be sure to reestablish contact when you are back on the frequency.
- Do not change altitudes or deviate from the planned flight route without first informing the controller. Doing so can create a hazardous situation.
- Remain VFR at all times, regardless of altitude or flight route. If it is necessary to climb or descend to do so, advise the Center controller beforehand.

When being transferred from one controller to another, it's only necessary to give the receiving controller your N-number and the phrase "with you," followed by your present altitude.

Publications Used In Flying

This is a brief outline of the publications which are necessary to plan flights and communicate properly with the various air traffic facilities you will encounter over all phases of flight.

Aeronautical Information Manual (AIM) – Provides basic flight information and Air Traffic Control (ATC) procedures in U.S. national airspace. The AIM contains fundamentals required to fly in the U.S. and provides instructional and educational material, as well. It also contains a glossary of terms that are used in the ATC system, and other items concerning medical factors and flight safety. It is available by subscription and is issued every 112 days.

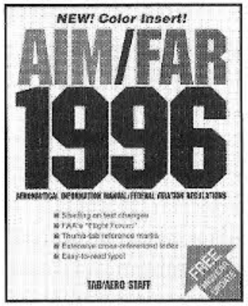


Figure 3.18 *The Aeronautical Information Manual.*

Airport/Facility Directory (A/FD) – Issued in seven volumes each covering a specific geographic area of the U.S. It is designed as a pilot's operational manual and contains all airports, seaplane bases, and heliports that are open to the public. It is indexed alphabetically by state and airport, and contains all relevant airport information, such as communications data, navigational facilities, and special notices and procedures. It is also subscription based and is issued every 56 days.

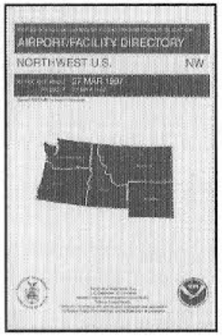


Figure 3.19 *The Northwest U.S. Airport/Facility Directory.*

Notice To Airmen (NOTAMS) – These are used in pre-flight planning and contain information not known sufficiently in advance to publish by other means. There are three types of NOTAMs:

- NOTAM D – Transmitted distantly. These contain time critical information which may affect safety, such as runway closures, or non-operating navaids.
- NOTAM L – Locally circulated by voice, phone or other means. These are used to satisfy local user requirements such as men or equipment crossing the runway, or a closed taxiway. NOTAM Ls are of a "nice-to-know" nature and are given by request upon departure, while en route, or just prior to landing.

– FDC NOTAMs – These are regulatory NOTAMs issued by the National Flight Data Center and are used to amend charts or establish restrictions to flight. They are given system-wide dissemination and contain information such as airports that are recently closed.

All NOTAMs are available from Flight Service Stations (FSS).

Sectional Charts – There are 37 sectional charts that cover the contiguous United States. Each one is named after the principal city that is located within the area it covers (i.e., Houston, Chicago, Klamath Falls). The scale is 1:500,000, or one inch equals 6.8 nautical miles. Sectional charts are issued every six months and their expiration dates are printed on the front panel of the chart. Also printed on the front panel is a color-coded elevation graph that indicates the highest elevation point on that particular chart.

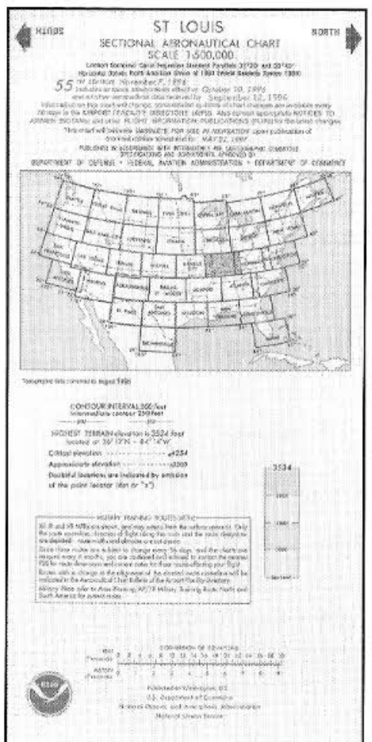


Figure 3.20 ***The front panel of the St. Louis sectional chart.***

Sectional charts are provided as a reference for navigation to medium and slow speed aircraft. They contain many of the topographic landmarks that a standard road map contains, like stadiums, railroads, outdoor theaters, and oil

wells. These are landmarks that can be easily identified from the air. The elevation (above sea level) of the top of obstructions is shown is blue numbers adjacent to the symbol for the obstruction. The elevation of the top of the obstruction above ground level is displayed just below the MSL figure in lighter blue numbers that are enclosed by parentheses.

To avoid going into too much detail here about all of the information that can be found on a sectional chart, you should refer directly to a sectional by starting with its legend. The legend explains everything printed on the chart. On the panel that is usually on the opposite side of the legend, you'll find a table that lists the frequencies of the various control towers within the chart. You'll also find the critical information for all of the Special Use Airspace contained in the chart, such as restricted areas and Military Operations Area (MOA).

Sectional charts also show isogonic lines (straight dashed magenta lines). These are the lines that connect points of constant variation between magnetic and true north.

Terminal Air Charts (TACs) – These are detailed charts of the 30-40 mile radius around Class B airspace which show landmarks, names, and symbols more legibly than a sectional chart. TACs are twice the scale of sectional charts, or 1:250,000 (one inch equals 3.43 nautical miles). TACs are reissued every six months.

VFR/IFR Planning Charts – These are also called wall charts because they measure 41" x 52" and are more suitable for mounting on a wall than for use inside a cockpit. For this reason they are used in planning cross-country flights. Planning charts are scaled at 1:2,333,232 (one inch equals 32 nautical miles) which means that two charts cover the entire United States, plus some. Planning charts display data for IFR planning on one side and data for VFR planning on the opposite side. However, the VFR data for the *western* half of the U.S. is on the opposite side of the IFR data for the *eastern* half of the U.S. This means that both charts are required to display the entire country for either IFR or VFR flight planning.

En Route Low Altitude Charts – These are used primarily for IFR flight below 18,000 feet. However, they are useful to the VFR pilot, when used in conjunction with sectional charts, who is skilled in dead reckoning and radio navigation (more on both of these topics in the chapter on Navigation beginning on page 88).

There are 28 en route charts that cover the 48 contiguous states, each labeled as "L-1," "L-2," and so on. Chart L-1 begins in the northwestern corner of the United States and, through a fairly meandering process, chart L-28 covers part of the northeastern seaboard.

The data found on en route charts covers limited airport information, radio aids to navigation data, FSS frequencies, VOR airways, Special Use Airspace, and essential data for IFR operations.

Chapter 4: Navigation

The pilot uses many forms of electronic navigational aids (navaids) to fly from point A to point B, whether it's between two airports within ten miles of each other or east-to-west coast. The navaids covered in this section include the Very high frequency Omni-Range/Distance Measuring Equipment (VOR/DME), the Non- Directional radio Beacon (NDB), and the Global Positioning System (GPS). This section also covers dead reckoning and instrument approaches.

The Compass Rose

Because all forms of navigation involve references to the directions on a compass, we will begin with a very brief discussion about the compass rose. There are eight cardinal directions on a compass rose: north, south, east, west, northeast, southeast, southwest, and northwest. North is at 360°, south is at 180°, northwest is at 315°, and so on. Pilots need to memorize the eight cardinal directions and their accompanying degree headings. Compass readings are based on magnetic information and do not align with true north as shown on a chart.

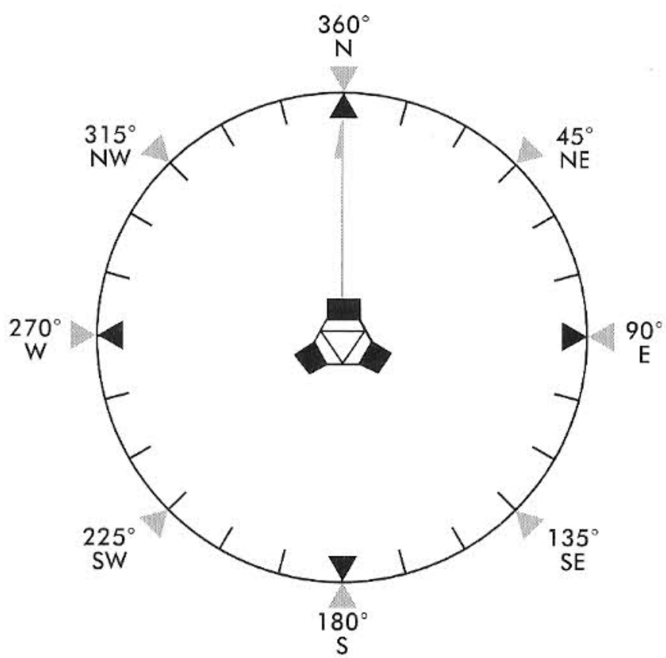


Figure 4.1 *The compass rose.*

Navigation By Dead Reckoning

All of the electrical navigation aids that every plane is equipped with, make the process of getting from point A to point B rather painless. As technologically advanced as they are, however, they would be useless in the event of an electrical malfunction. This is a primary reason for understanding one of the most fundamental forms of navigation: dead reckoning.

Dead reckoning is the determination of position by using distance traveled, direction traveled, and speed. In other words, it is a way of determining where you are by knowing where you've been. The name dead reckoning originates from "deduced reckoning" or "ded. reckoning."

Assuming no wind, it is fairly simple to predict the airplane's flight path. You know the en route time and you fly the proper direction for that amount of time.

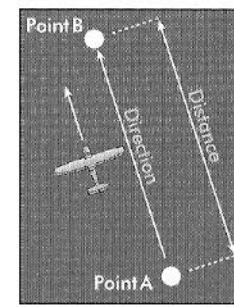


Figure 4.2 *Dead reckoning is the determination of position by using direction and distance traveled, as well as speed.*

Speed

Aircraft speed is measured in many ways. Assuming no wind, the airplane's ground speed (GS) equals its true airspeed (TAS). Because this is almost never the case, ground speed accounts for the speed of the wind. Therefore, an airplane traveling at a true airspeed of 250 knots *against* a 20 knot wind, has a ground speed of 230 knots. Likewise, if the same airplane is traveling *with* that same air mass, the ground speed is 270 knots.

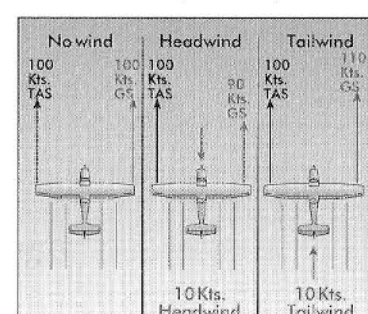


Figure 4.3 *Wind direction and wind speed affect ground speed.*

Unfortunately, an airplane's airspeed indicator rarely displays the airplane's true airspeed because of varying outside air densities. In order for a plane to fly, the wings of the plane must fly through enough air molecules to generate lift. Less dense air (such as at higher altitudes) means fewer air molecules. Therefore, the plane must travel faster to generate the same lift as at lower altitudes. The airspeed indicator is really an indicator of how many molecules are impacting the pitot tube, the measuring device for airspeed indication, which is displayed in knots (nautical miles per hour). The outside air density affects indicated airspeed (IAS).

Two planes traveling at identical indicated airspeeds (IAS) in air masses with two different densities, will have different true airspeeds (TAS). The airplane traveling through less dense air has a higher true airspeed than the airplane flying through more dense air.

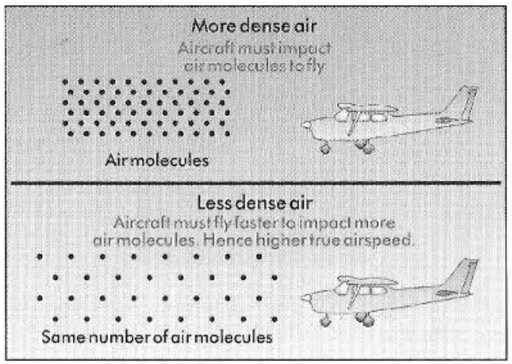


Figure 4.4 *Less dense air results in higher true airspeeds than more dense air.*

IAS is also affected by instrument errors. The hoses and tubing that lead to the indicator contain bends that create errors. This is compounded by errors inherent in the instrument itself. Aircraft manufacturers determine these errors and provide information for correcting them. Corrected indicated airspeed results in calibrated airspeed (CAS).

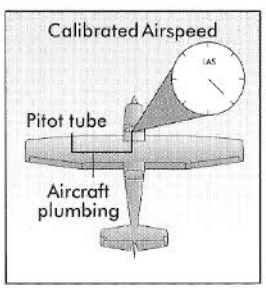


Figure 4.5 *The airplane's "plumbing" also affects indicated airspeed.*

One more definition: When flying near the speed of sound, air compresses ahead of the airplane. This compression affects the airspeed indicator and must be taken into account. Equivalent airspeed (EAS) is calibrated airspeed corrected for compressibility error.

Air density affects true airspeed. Air density, in turn, is affected by temperature and pressure. Generally, less dense air is associated with higher temperatures and lower pressure, and vice versa. Indicated air temperature (IAT) is read directly from the temperature gauge.

As temperature increases, air density decreases. Air density also decreases with altitude. The left diagram below shows how air density decreases with altitude on a standard day (standard temperature at sea level = 15° C). In the right diagram, the temperature at sea level is much higher. Therefore, air density is reduced.

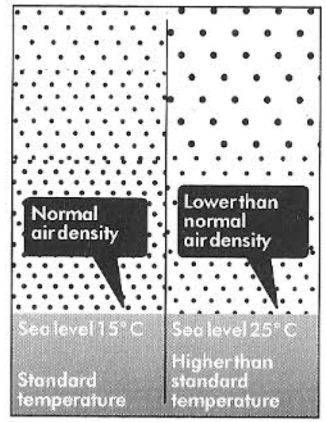


Figure 4.6 *Air density is lower at higher air temperatures.*

The air density of the warmer day can be described in terms of altitude. In this next diagram, the true altitude extends from 0 feet (sea level) up to 2000 feet. However, on a warmer day, the air density at sea level is the same as the air density at 2000 feet on the standard day. This is called density altitude. The warmer day can be said to have a density altitude of 2000 feet at sea level. Density altitude can be thought of as the standard altitude that the airplane "feels" it's flying through. It is calculated by correcting pressure altitude (the altitude read from an altimeter set to 29.92" mercury – more on pressure in the Instrument Flying chapter; see page 144) for non-standard temperature variations. An air data computer can sense air pressure, temperature and altitude, to compute density altitude. It can then determine true airspeed by correcting indicated airspeed for density altitude.

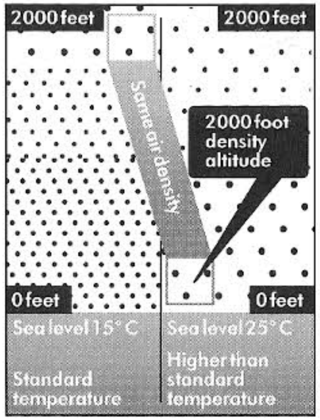


Figure 4.7 *An illustration of density altitude.*

Direction

Speed is one facet of dead reckoning. Direction is another. True north refers to the earth's geographic north pole. If you plot a course and measure it in relation to true north, you can determine your true course (TC). However, the issue of magnetic north must be addressed.

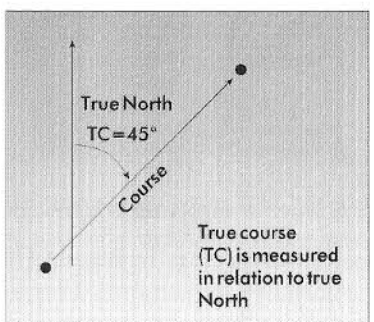


Figure 4.8 *True course is an angle measured from true north.*

All compasses point to magnetic north. The earth has a magnetic field that converges at magnetic north. Unfortunately, magnetic and true north are not located at the same points. Navigation charts are drawn according to true north yet the compass in an airplane points to magnetic north. You must account for this difference when plotting a course. This difference is called magnetic variation.

Magnetic variation is the angular difference, in degrees east or west, that magnetic north varies from true north at a given location.

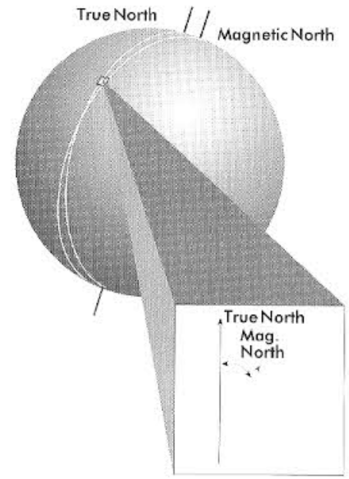


Figure 4.9 *Variation is the difference between true and magnetic north.*

On navigation charts, lines of constant variation are drawn and are called isogonic lines.

This diagram shows a course from airport A to airport B. The true course, as measured from the line of longitude, is 315°.

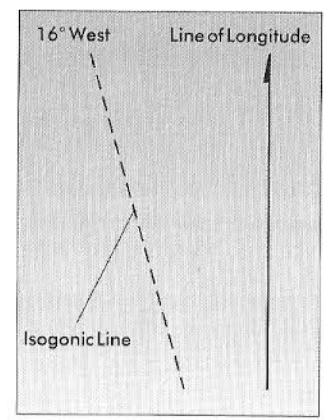


Figure 4.10 *Isogonic lines shown on charts indicate the magnetic variation in that area.*

The variation is shown by the dashed isogonic line. It indicates that the variation in this area is 16° west. If variation is easterly, *subtract* the variation from true course. If variation is westerly, *add* it to the true course. This provides your magnetic course. In this example, your magnetic course equals 315° + 16° = 331°.

Remember:
MC=TC + westerly variation
MC=TC – easterly variation
or "east is least, west is best."

Wind affects an airplane's path over the ground. This path, along with the ground speed, is determined by wind and heading (the direction the airplane is pointed in relation to magnetic north).

Wind will push the plane off the desired course. The result is a ground track that varies from the desired course. The difference between ground course and desired track is called drift angle.

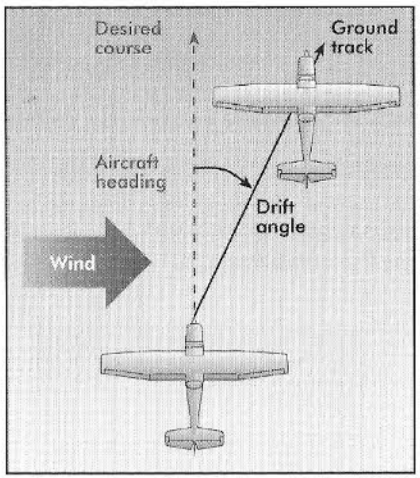


Figure 4.11 ***The wind, combined with the airplane's heading, determines the plane's track.***

If you fly slightly into the wind, you can maintain your desired course.

As shown in the diagram on the next page, you fly slightly left into the wind. This causes your ground track to be the same as your desired course. You are angled slightly left into the wind. This is called wind correction angle, and is the angle at which an aircraft must be headed into the wind in order to hold a desired ground track. It is the difference in degrees between that aircraft's true heading and true course.

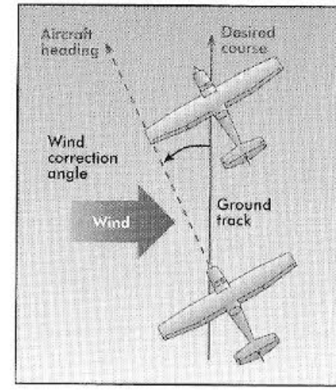


Figure 4.12 ***The difference, in degrees, between the airplane's true heading and true course equals the wind correction angle.***

In summary, these are the steps required to provide a dead reckoning course:

What To Do:	This Example:
1. Plot your desired course.	Airport A to Airport B. (see figure 4.12)
2. Use your performance charts to determine your true airspeed at the density altitude you'll be flying.	200 knots
3. Measure the distance.	45 NM
4. Determine your true course.	315°
5. Find your magnetic heading by taking true course and adding west variation or subtracting east variation.	315° + 16° = 331°
6. Adjust magnetic heading for compass errors, called deviation, to find compass heading.	331° + 2° = 333° (see figure 4.13)
7. Determine the wind direction and speed.	90°; 20 knots
8. Compute wind correction angle using a flight computer, and add or subtract it to find true heading.	5° 333° + 5° = 338° (see figure 4.14)
9. Compute your ground speed by adjusting your true airspeed for the wind component present.	
10. Determine estimated time en route (ETE = distance/GS).	
11. In this example, you'd fly a compass heading of 022 at true airspeed of 200 knots for 8 minutes, 30 seconds.	See figure 4.15.

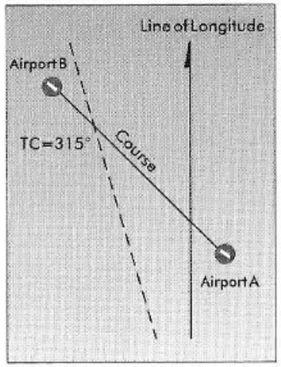


Figure 4.13 *The first step in dead reckoning navigation: plot a true course.*

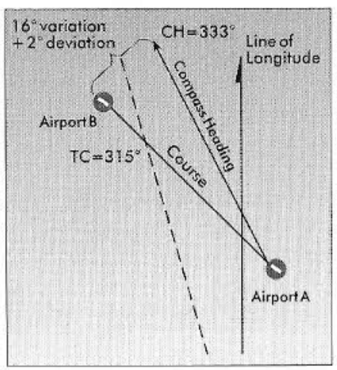


Figure 4.14 *Factor in the deviation and variation to determine the compass heading.*

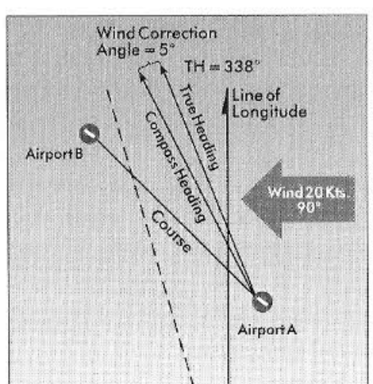


Figure 4.15 *Factor in the wind speed and wind direction to determine true heading.*

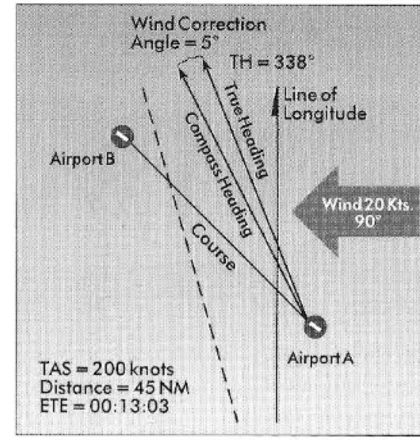


Figure 4.16 *Estimated time en route (ETE) = 13 minutes and three seconds.*

VOR/DME Navigation

There are four types of VOR (VHF Omnidirectional Range) radio aids:

1. VOR – the basic navigation facility, the VOR has only lateral sensing without the benefit of distance capability.

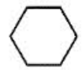


Figure 4.17 *The VOR chart symbol.*

2. VOR/DME – provides lateral VOR information plus distance (with Distance Measuring Equipment; see page 101) capability which indicates straight line distance from station.

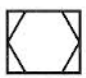


Figure 4.18 *The VOR/DME chart symbol.*

3. TACAN – Tactical Air Navigation, used only by the military. This requires special airborne TACAN receivers which are not generally found in civilian flying.

Figure 4.19 *The TACAN chart symbol.*

4. VORTAC – comprised of VOR, DME, and TACAN.

Figure 4.20 *The VORTAC chart symbol.*

For the purposes of our discussion, we will only refer to VOR and VOR/DME navaids.

There are two main components to the VOR/DME navigation system: the VOR stations (or transmitters) located on the ground, and the radio equipment installed in the aircraft. VORs are located all over the country and allow pilots to navigate from one point to another.

VOR's stations transmit radio signals which, when received by the nav radio, can help pilots calculate position. It is the pilot's responsibility to tune in the navigation radio (nav) equipment to use the VOR for navigation.

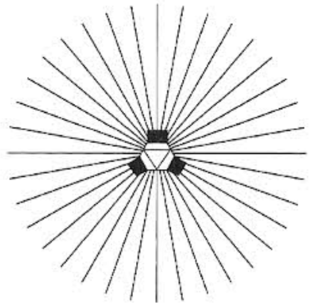


Figure 4.21 *A VOR has 360 radials that correspond to the 360 points of the compass.*

A VOR transmits its signal in a 360° circle, with the transmitter as the hub of the circle. Imagine a wheel with 360 spokes coming out from the hub. Each spoke is a radio signal, or a radial which aligns with the magnetic heading from the station. Radials are named for the degree heading they extend toward. The radial that extends from the VOR to the east is the 90 radial. The VOR that extends from the VOR to the southwest is the 225 radial. Remember, radials extend FROM a VOR, not TOWARD it (they only extend TOWARD a degree heading). A radial only has one name – the 360 radial is not also the 180 radial, it is only the 360 radial.

The VOR operates in the frequency range of 108.00-117.95 MHz and uses even tenths frequencies (108.2, 109.6, 110.8, etc…). VHF and UHF always use a decimal point. Frequencies are read by individual digits. For instance, 117.95 would read "one-one-seven-point-nine-five."

There are three VOR class (service volume) designations:

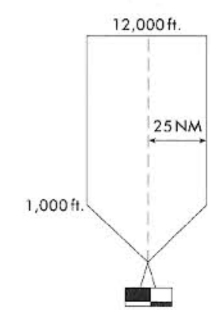


Figure 4.22 *The Terminal VOR.*

Terminal VOR – Up to and including 12,000 ft AGL at radial distances out to 25 NM.

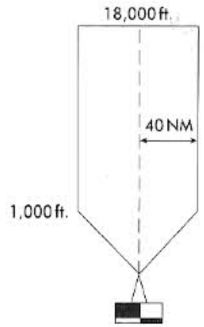


Figure 4.23 *The Low Altitude VOR.*

Low Altitude VOR – Up to and including 18,000 ft AGL at radial distances out to 40 NM.

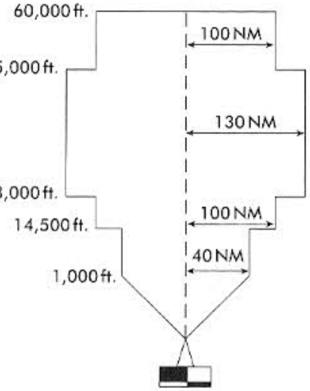


Figure 4.24 *The High Altitude VOR.*

High Altitude VOR – Up to and including 14,500 ft AGL at radial distances out to 40 NM; plus, from 14,500 ft AGL up to and including 60,000 ft AGL at radial distances out to 100 NM; plus, from 18,000 ft AGL up to and including 45,000 ft AGL at radial distances out to 130 NM.

A VOR's class is designated by its abbreviation in the Airport Facility Directory (A/FD), such as TVOR (terminal class VOR) or HVORTAC (high class VORTAC).

Service volumes are important for determining the distance from the VOR where you'll pick up or lose its signal. Also, if a VOR has a non-standard service volume, it will be classified as restricted in the A/FD, or it may be published in a Notice To Airmen (NOTAM).

Typical VOR receiving navigational equipment inside an airplane can consist of an audio panel, a NAV receiver, a DME (distance measuring

equipment) radio, and a NAV display. Each ground-based VOR has a three-letter identifier that is represented by Morse code that is transmitted continuously over that VOR's frequency. VOR Morse code identifiers are broadcast to indicate a reliable signal for navigation and are displayed on aeronautical charts as follows:

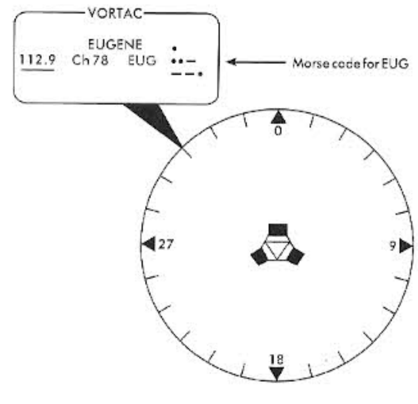


Figure 4.25 *The VORTAC at Mahlon Sweet Field, Eugene, Oregon.*

The NAV radio is first tuned to the correct frequency of the VOR. Then the audio panel is turned on to listen to the NAV radio and to ensure the VOR is operational. When the NAV radio is tuned to the correct frequency and the VOR is operational, you will hear the Morse code identifier of the VOR you are tracking.

Many VORs also have voice identification. In the example, above, the Morse code for the Eugene VOR would be accompanied by the words "Eugene VOR." If a VOR is inoperable or not trustworthy, the Morse code and voice will be removed, indicating an unreliable signal.

Figure 4.26 *The audio panel found on board* **Pro Pilot '99** *aircraft.*

The DME tells a pilot how far the airplane is from the VOR at line of sight. In other words, if you're flying at an altitude of 6,000 ft directly over the VOR, the distance indicator will never show less than one mile. The DME radio is tuned to the desired VOR in the same manner as the NAV radio. The DME radio then emits the Morse code for the tuned VOR. A panel shows the distance in nautical miles to the VOR. Depending on the equipment, it also shows the number of minutes to the station, and the ground speed of the airplane in knots. This is only true if you are flying directly to or from the station.

Figure 4.27 *The DME radio found on board* Pro Pilot '99 *aircraft.*

On certain DME radios, there are switches for three settings: the N1 setting shows that the DME is set to the NAV 1 radio; N2 is the NAV 2 radio; and Hold keeps the DME on the last selected frequency even if the NAV frequency selectors are subsequently changed.

The VOR instrument head, or indicating device (as opposed to the NAV radio) tells you where the airplane is in relation to the VOR selected. The Omni Bearing Selector (OBS) on the VOR is used to dial in the radial being referenced on the VOR. As the OBS is turned, the compass rose inside the VOR head rotates. The number at the top of the instrument shows the radial being referenced for navigation.

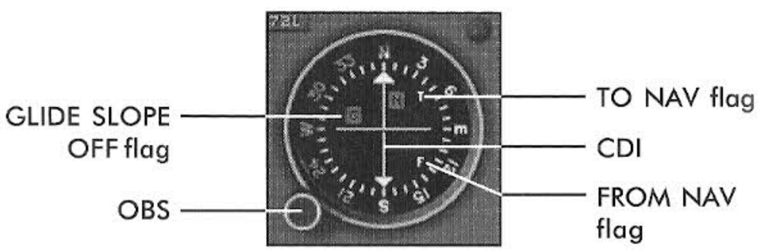


Figure 4.28 *The NAV display found on board* Pro Pilot '99 *aircraft.*

The NAV instrument displays "T" (or TO), "F" (or FROM), and "OFF" flags. These reference the position of the plane relative to the station and the assigned radial. OFF indicates a zone above the VOR where the signal becomes unreliable. The higher the altitude above the station, the larger the diameter of this zone. This is called the zone of ambiguity or the cone of confusion. The VOR will display the NAV flag while in this zone or when the plane is too far away from the station to reliably detect the signal.

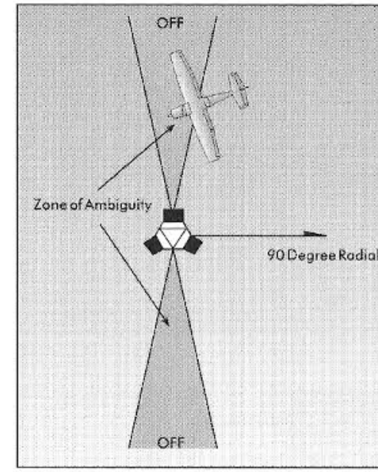


Figure 4.29 *Where the VOR signal becomes unreliable is called the zone of ambiguity.*

When the plane is in this zone, the OFF flag is displayed and the VOR cannot be used for navigation.

Suppose the 180 radial is dialed in. As the plane turns south and heads away from the VOR, the flags switches to the FROM flag, indicating that the plane is in the FROM sector of the VOR relative to the referenced radial. Note that heading doesn't affect the TO-FROM flags. If the plane is heading north, but is still located south of the VOR, it is still in the FROM sector because the 180 radial is dialed in.

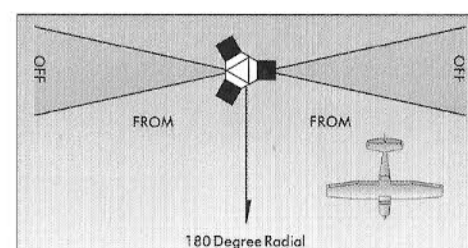


Figure 4.30 *The NAV displays a FROM flag when the plane is on the same side of the VOR as the dialed-in radial.*

On the other hand, if the 360 radial is dialed in, and the plane is south of the VOR, the plane would then be in the TO sector and the TO flag is displayed on the NAV. Again, in this example, the plane could be heading in any of 360 directions. But because the 360 radial is dialed in, the plane is in that radial's TO sector. The TO sector is always on the opposite side of the radial that is being referenced.

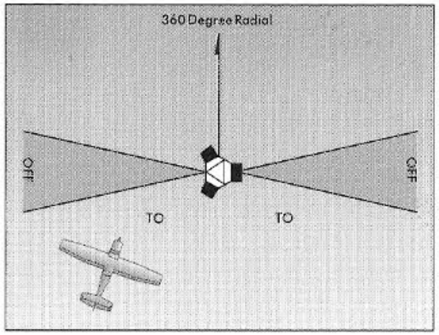


Figure 4.31 *The NAV displays a TO flag when the plane is on the opposite side of the VOR as the dialed-in radial.*

The vertical bar at the center of the compass rose is the Course Deviation Indicator (CDI), also known as the "needle." This shows where the airplane is in relation to the selected radial. The needle moves as the OBS is adjusted when near the designated radial. It also moves as the position of the plane shifts relative to the position of the radial. If the needle is centered, then the plane is on the referenced radial. However, the CDI will appear to the left or right of center if the plane is not on the referenced radial. If the plane's heading is toward the selected radial, then the CDI will shift in the direction of the radial.

For example, the 90 radial is selected and the plane is northeast of the VOR heading due east (so the FROM flag is displayed). This puts the plane north of the 90 radial and the VOR head would appear as shown. You must fly to the right to bring the plane in line with the radial. An intercept angle of five degrees toward the RADIAL will get you back on course. Further distances away may require an intercept angle of up to 45 degrees.

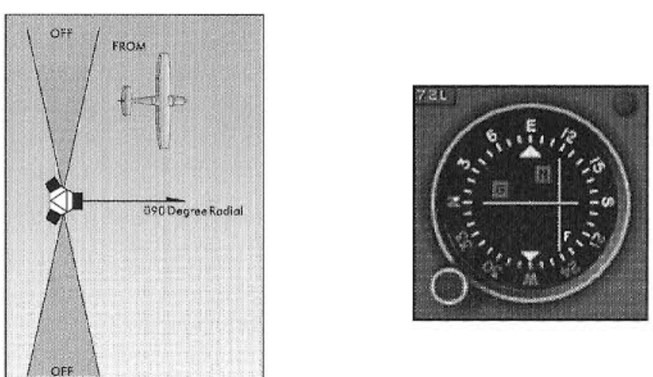


Figure 4.32 *The VOR head display as it appears when the plane is on the same side of the VOR and "to the left" of the referenced radial.*

If the plane is south of the radial, the CDI is to the left of center. If the plane is heading due east (figure 4.33), the pilot must fly to the left to bring the plane in line with the radial.

For quick reference of your location from a VOR, center the OBS with the FROM indication. Turn to that magnetic heading and you will be flying straight away from the VOR on that radial. Reverse the direction 180° and you will be flying directly to the station. To track in-bound, change the OBS 180° and track the opposite in-bound course to the station.

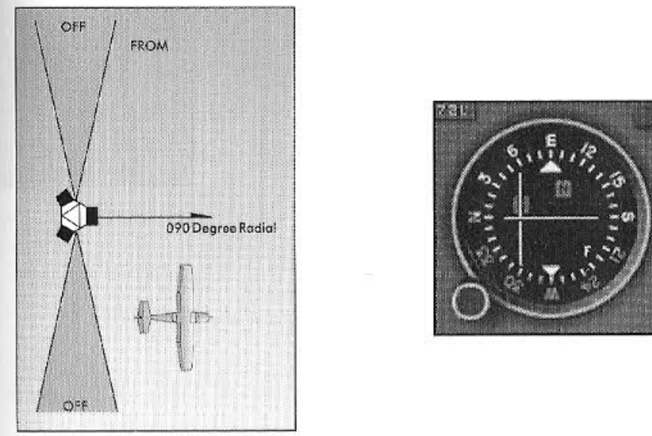


Figure 4.33 *The NAV display as it appears when the plane is on the same side of the VOR and "to the right" of the referenced radial.*

If the plane is heading due west (figure 4.34), the CDI doesn't change. The pilot, however, would have to steer right to align with the radial.

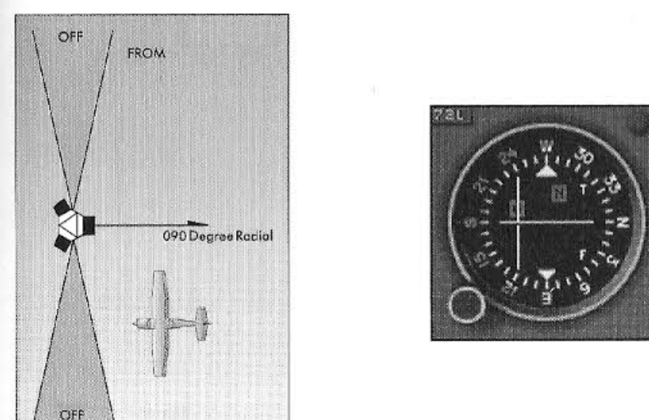


Figure 4.34 *Even though the plane is considered to be "to the left" of the radial, note how the CDI doesn't change.*

Just a few more examples for clarity. If the plane is on the opposite side of the VOR from the selected radial (in the TO sector), the flag will read TO. In figure 4.35, the plane is over the reciprocal of the selected radial, so the flag reads TO.

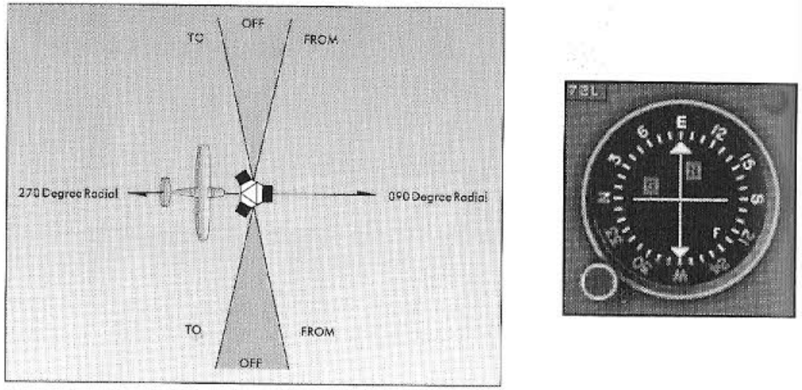


Figure 4.35 *The NAV display as it appears when the plane is on the reciprocal of the referenced radial.*

In figure 4.36, the plane is north of the reciprocal, so the CDI is to the right of center. The pilot must steer right to align with the radial.

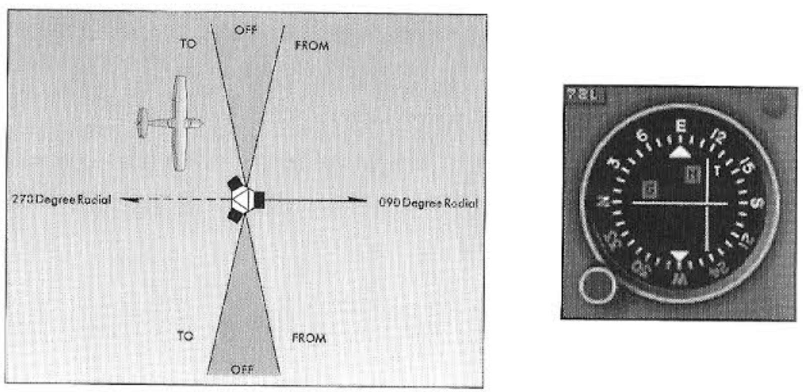


Figure 4.36 *The NAV display as it appears when the plane is north of (or "to the left of") the reciprocal radial.*

Finding Position

There are two methods used for finding position: one VOR and DME; and two VORs.

One VOR and DME

For this example we will use the Eugene VOR (EUG), 112.9, and we will assume we are on a course as shown in figure 4.38. First, the NAV radio is tuned to 112.9. The Morse code is identified to ensure the VOR is working properly.

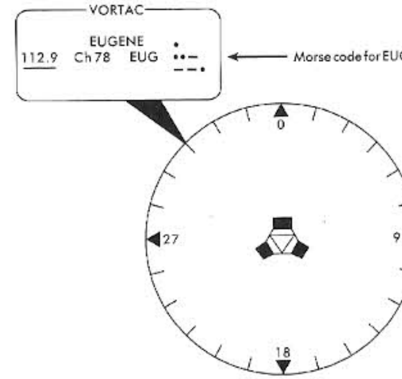


Figure 4.37 *The Eugene VOR.*

To determine where the plane currently is relative to the selected VOR, center the CDI using the OBS with a FROM indication. Then read the number at the top of the NAV.

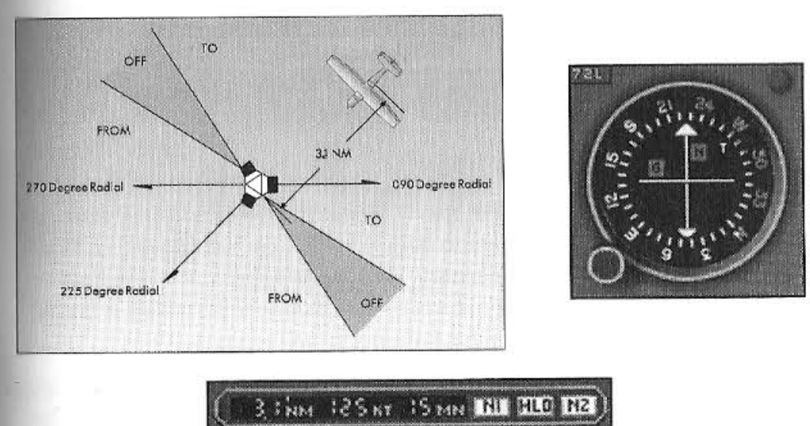


Figure 4.38 *Finding your way in the world.*

For this example, the plane is opposite the 225 radial. Note the TO flag which indicates that the plane is on the opposite side of the VOR as the referenced radial. The DME indicates a distance of 3.1 nautical miles, a ground speed of 125 knots, and a time of 15 minutes to reach the VOR station.

Two VORs

Navigation via two VORs requires two sets of NAV radios and instruments or switching one radio between two VOR radio frequencies. This method of finding position is also referred to as triangulation. It is useful when the DME is inoperative or unavailable. For this example, refer to the illustration below which shows the Eugene and Corvallis VORs and their corresponding frequencies.

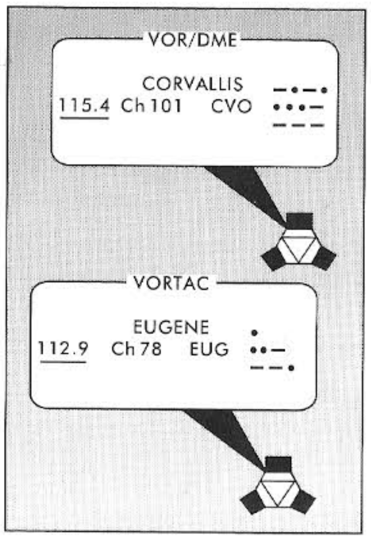


Figure 4.39 *The Eugene and Corvallis VORs.*

The NAV 1 radio is tuned to 112.9 (EUG) and the NAV 2 radio is tuned to 115.4 (CVO). The Morse codes on both radios are identified. At first, the NAV instruments show where the plane is relative to both VORs. But to make sense of it, the OBS is used to center the CDI on NAV 1 with a FROM flag. This gives an indication of which radial the plane is on from the Eugene VOR. In this example, the plane is somewhere along the 360 radial. A line is drawn on the chart to represent the 360 radial from the Eugene VOR.

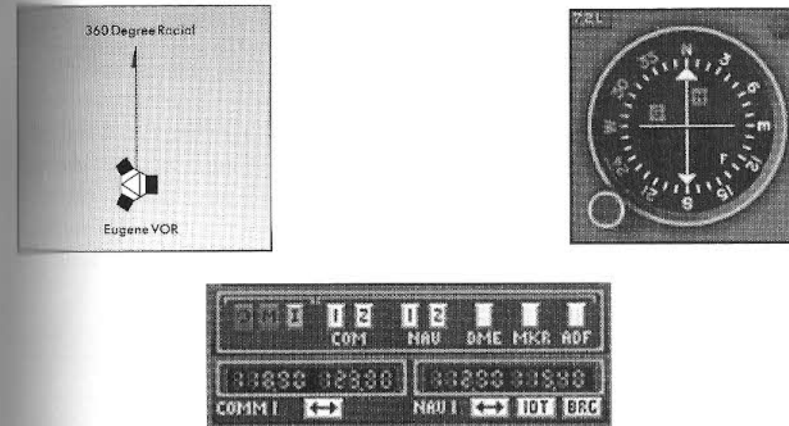


Figure 4.40 *Determining the Eugene radial.*

The next step is to determine at what point along that 360 radial the plane is located. Following the same procedure as with the NAV 1 instrument, the needle on the NAV 2 instrument is centered with a FROM flag. Doing so shows that the plane is on the 170 radial of the Corvallis VOR. Again, a line is drawn on the chart to represent the 170 radial from the Corvallis VOR.

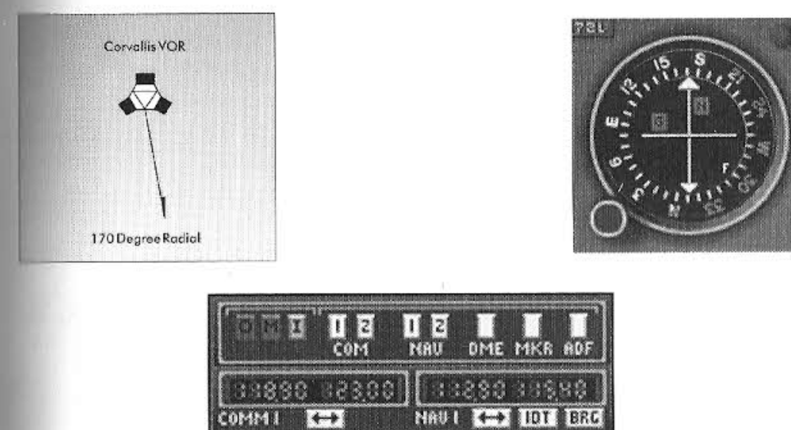


Figure 4.41 *Determining the Corvallis radial.*

Both lines are drawn long enough to intersect. The point of the intersection is the location of the plane. This is the triangulation method of determining position.

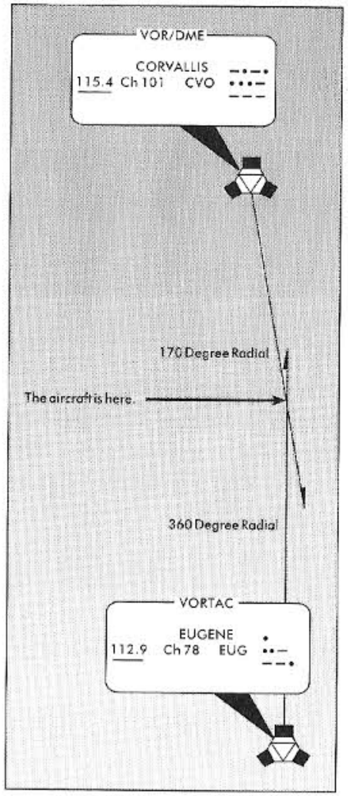


Figure 4.42 ***The Triangulation method.***

Note: Although we know the position of the airplane relative to the two VORs, the plane can be heading in any direction.

Navigation Via VORs

It's one thing to understand your position relative to a VOR at a single point in time, but it's a completely different ball game to understand your position over a period of time. Using VORs to move from point A to point B is where the navigation comes in. It's pretty simple: track inbound a particular radial as you head toward a VOR. When you reach the VOR, track another radial outbound. When in range of another VOR, track a radial inbound to it.

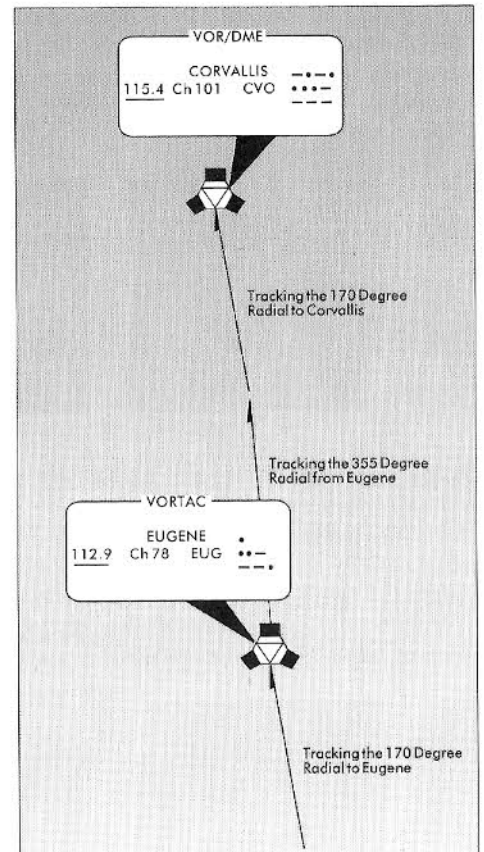


Figure 4.43 ***Tracking inbound and outbound radials between VORs.***

Heading also plays a role in VOR navigation. Heading is indicated by a Directional Gyro (DG), or Heading Indicator. Although the DG is not a compass, it still provides heading information. Set the heading on the Heading Indicator to match the heading of the compass prior to use. As the plane turns, the compass rose on the DG also turns to indicate the heading at the top.

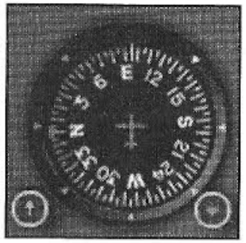


Figure 4.44 *The Directional Gyro found on board the aircraft in* Pro Pilot '99.

To determine the plane's location, first center the CDI on the NAV with the FROM flag showing. In the example below, the plane is on the 165 radial with a heading of 325. This puts the plane roughly south-southeast of the VOR.

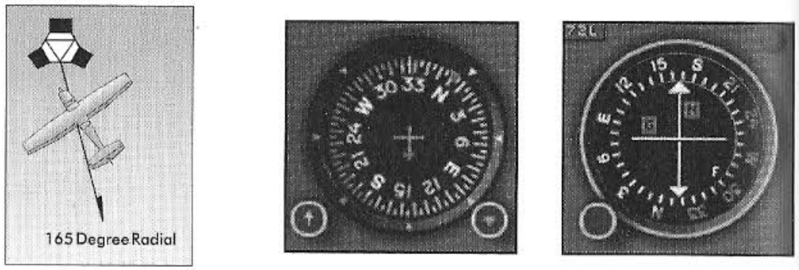


Figure 4.45 *The Directional Gyro and NAV 1 instrument.*

In the example below, the goal is to track the 180 radial to the VOR. To do this, you must first join the 180 radial, then turn north on a heading of 360. In order to use the NAV most effectively, the 360 radial is dialed in using the OBS so the NAV shows a TO flag, the sector the 180 radial is in. The CDI is positioned left of center (just as the 180 radial is positioned to the left of the airplane).

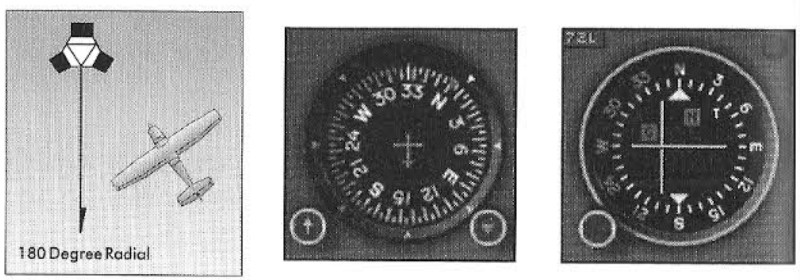


Figure 4.46 *Tracking the 180 degree radial.*

So why tune the 360 radial with a TO flag, instead of the 180 radial with a FROM flag? As the example shows, this allows for a direct interpretation of the CDI needle where the needle is positioned relative to the center of the NAV, in the same way the radial is positioned relative to the plane (imagining the plane as at the center of the NAV). As the plane moves closer to the 180 radial, the CDI moves closer to the center of the NAV.

With a heading of 325, the CDI is positioned to the left of center, just as the radial is positioned to the left of the airplane. Because the current heading is northwesterly, the plane will eventually join the radial. The general rule is to fly toward the needle to get on the selected radial. As this happens, the CDI will move toward the center of the NAV. Once centered, you must turn to a heading of 360 to track inbound to the VOR.

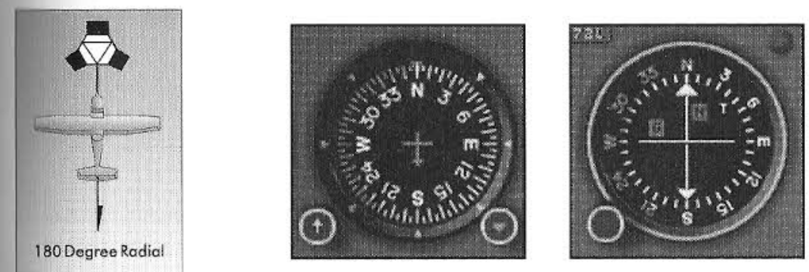


Figure 4.47 *Switching to a heading of 360.*

With the needle centered, the plane is on course, but will it stay this way? Most likely not, unless it was a perfect world and the wind was always at our tail. Since this is not always the case, the CDI will drift left or right over time given a constant heading. In this example, the wind is directly out of the east. Notice that the needle has drifted to the right (just as the radial has "moved" to the right of the plane).

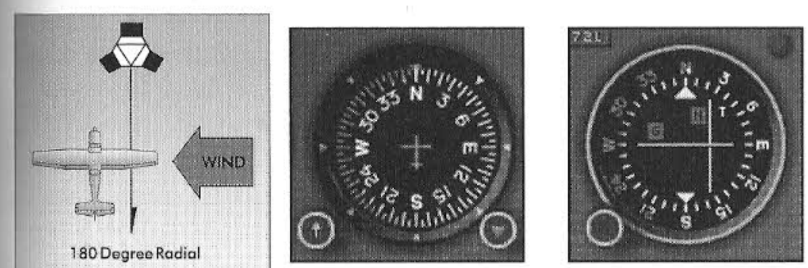


Figure 4.48 *Recognizing drift.*

This means that you must turn the plane to the right to get back on course. The amount of correction will depend on the wind speed and direction, as well as the plane's distance from the VOR. The closer the plane is to the VOR, the more sensitive the CDI becomes. This means that smaller corrections should be made as the plane nears the VOR. Larger intercept angles can be used at farther distances. The amount of correction will be more recognizable with more experience.

Once the plane is back on the desired course, you must make a constant heading adjustment in order to maintain the course while considering the wind factor. The appropriate adjustment should be roughly half the angle required to bring the plane back on course. In this example, if a heading correction of 20 degrees is required to re-intercept the radial, then a new heading of 10 on the DG should keep the plane on track.

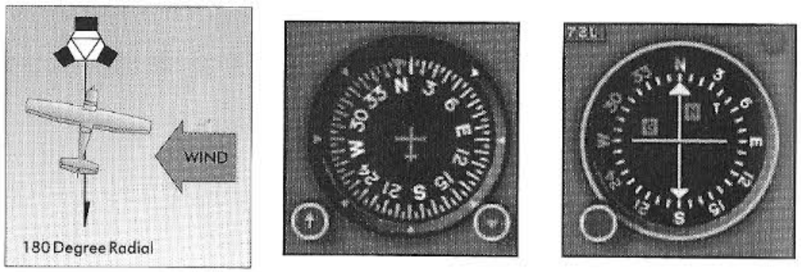


Figure 4.49 *Compensating for wind.*

In stronger winds, more of an angle into the wind is required to maintain course. Even so, you may find yourself off course, which requires turning to re-intercept it. This process is called "bracketing."

As mentioned earlier, the closer to the VOR, the more sensitive the CDI becomes. You can tell how close to the VOR the plane is when the needle begins to fluctuate radically or by reading the DME. As this happens, continue on the heading that maintained the course before. This holds true for when the OFF flag appears on the NAV indicating that the plane is in the zone of ambiguity.

Once the plane passes through the VOR, the flag will shift from OFF to FROM. The same needle fluctuation will occur until the plane is far enough away from the VOR on the other side. Once the CDI is stable, you will probably need to maintain the same heading that worked earlier in order to maintain course.

GPS Navigation

Understanding the Global Positioning System

As mentioned earlier, the Global Positioning System is basically a dead reckoning computer that uses satellites as its source of navigational information. The Navstar Global Positioning System is a satellite-based radio positioning system which allows for highly accurate positioning and guidance. Until recently, GPS was available only to the military which began its development in the mid 70's. GPS is currently under the control of the United States Air Force Space Command, Second Space Wing, Satellite Control Squadron at Falcon Air Force Base, Colorado.

Some of the advantages of GPS over other forms of navigation are its global coverage and that it is available 24 hours a day. It is also not limited by the number of people using the system simultaneously.

The GPS system consists of 24 satellites which orbit the earth on similar paths in six groups of four. The orbit altitude is 10,900 nautical miles and a single satellite completes its orbit twice every 24 hours.

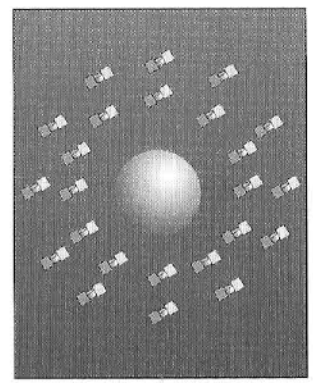


Figure 4.50 *The GPS satellite array.*

The satellite array makes up a constellation that is used much like celestial navigation uses the stars. The GPS receiver calculates its position based on a relative position from these satellites. The even spacing of all satellite groups ensures complete coverage worldwide at all times.

The GPS system comprises three segments:

1. Space – 24 satellites orbiting the earth
2. Control – the master control station at Falcon Air Force Base, Colorado and four monitoring stations located in Hawaii, Ascension Island, Kwajalein, and Diego Garcia
3. User – end users tapping into the system from all around the world.

The four monitor stations collect orbit and track data from all 24 satellites and send it directly to the master control station. At Falcon AFB, the performance, position, and timing of the entire satellite network is maintained and updated.

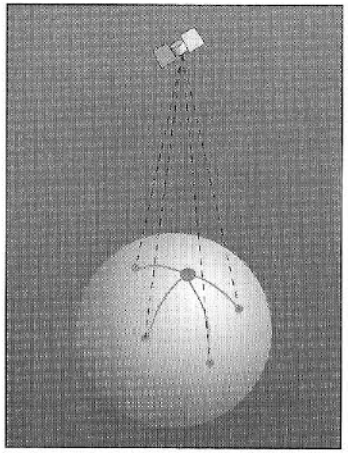


Figure 4.51 ***The four earthbound receiving stations collect satellite data and transmit it to the master control center.***

Four atomic clocks are contained inside each orbiting satellite. An atomic clock is a finely-tuned, precision timepiece without which the GPS system wouldn't work. The accuracy of every land-based GPS receiver's internal time is maintained by the satellite-based atomic clocks. This accuracy is important for two reasons:

- The satellites are moving at such a speed in space that their timing requires measurements in millionths of a second.
- Accurate positioning on the earth requires accurate distance measurement between the user and the satellite. This requires that the satellite's clock and the GPS receiver's clock be in exact synchronization.

The GPS system offers two standards of navigational accuracy:

1. Precise Positioning Service – this service allows accuracy to within 16 meters vertically and horizontally. It is used only by the military.
2. Standard Positioning Service – also called Coarse Acquisition Mode. This service is open to the general public during peacetime. It allows accuracy to within 100 meters horizontally, or 156 meters horizontally and vertically. This service can be biased or shut down by the military during war or conflict.

GPS is a passive service. This means that it works constantly and does not require a signal from the user. Each satellite transmits its own unique radio signal. All satellites transmit this signal at exactly the same time which is another reason for the onboard clocks.

The GPS receiver collects the radio signal from a nearby satellite, then identifies the satellite by matching its signal with a predetermined code. Included in the radio signal are the almanac (the satellite's constellation) and the ephemeris (the satellite's position data). This tells us exactly where the satellite is. Now, by multiplying the signal transmission time by the speed of light, it is easy to determine your distance from the satellite. Knowing the position and location of the satellite relative to the earth, you can get an idea of your location.

The satellite transmits an omnidirectional signal. When the signal reaches an airplane's receiver, a line of position (distance and position) is calculated. This indicates that the airplane is somewhere at the edge of the satellite's radio transmission sphere.

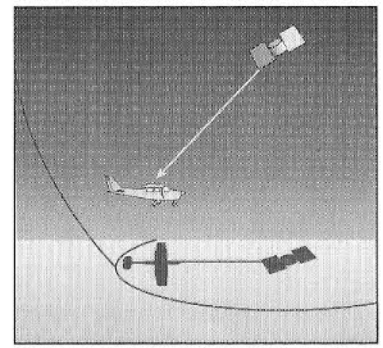


Figure 4.52 ***Each satellite transmits an omnidirectional signal.***

However, in order to calculate the plane's position, more information is required. A second satellite's signal is received and a second line of position is determined by the airplane's receiver. Now you know that the plane is somewhere near the intersection of the two lines of position.

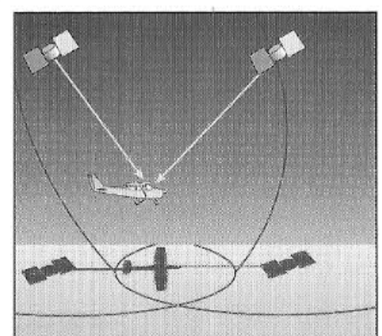


Figure 4.53 ***The signals from two satellites provide a more accurate position.***

The receiver now recognizes a third satellite, thus providing a third line of position. You now have a three-way intersection which allows the receiver to calculate the plane's position on earth. Since the intersecting signals are spherical, the point of intersection actually extends above the earth. This means that the receiver can also calculate the plane's altitude. However, because of civilian use of the Standard Positioning Service, altitude computations are not precise enough for aircraft altitude control.

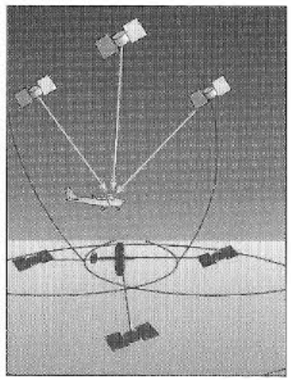


Figure 4.54 *The signals from three satellites provide even more accurate position information.*

Finally, a fourth satellite is recognized for time synchronization and altitude measurement although altitude measurements are still unusable. This four-satellite arrangement ensures that the receiver corrects for the proper time when making its calculations.

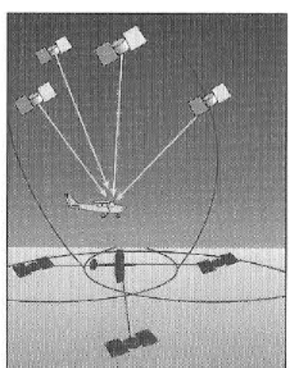


Figure 4.55 *Feedback from four satellites provides position and altitude information.*

Many GPS receivers are capable of tracking up to eight satellites at a time, which, in some cases, improves the receiver's accuracy.

NDB Navigation

Figure4.56 *The NDB symbol as shown on aeronautical charts.*

NDB Defined

NDB, or Non-Directional Beacon, is a form of navigation that allows you to fly between two locations using ground-based transmitters and aircraft receivers. Of all the navigational methods discussed in this manual, NDB navigation is the easiest to use.

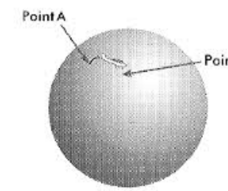


Figure 4.57 *NDB uses ground-based transmitters to guide you from point A to point B.*

The NDB itself is a ground-based radio transmitter which aircraft use as navaids, and which instrument-rated pilots use to locate airports during instrument approaches. Sometimes even AM radio stations are used as NDB transmitters.

An NDB emits a continuous radio signal which an airplane's ADF, Automatic Direction Finder, picks up, assuming it is within range of the signal. Like the VOR, every NDB, assuming it is in working order, is identified by an audible Morse code signal which is broadcast continuously over the NDB's frequency. NDB frequencies lie between 190 kHz and 535 kHz. The Morse code ID and the frequency of every NDB is displayed on aeronautical charts.

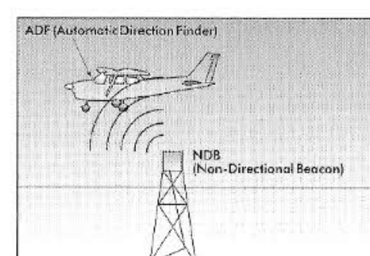


Figure 4.58 *The main components of NDB equipment.*

To understand NDB navigation better, you must memorize the cardinal directions on a compass rose.

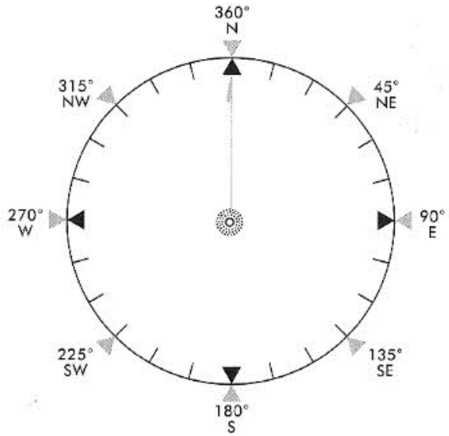


Figure 4.59 *The compass rose.*

Also, as explained in VOR navigation, envision a bicycle wheel with 360 spokes coming out from the hub of the wheel. Each spoke (bearing) is a path that can be taken to reach the hub (NDB).

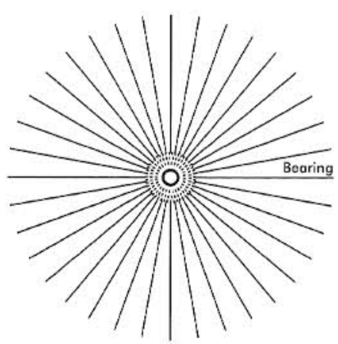


Figure 4.60 *Envision the NDB bearings as 360 spokes on a wheel.*

Each spoke of the wheel is represented in degrees, as in the 360 degrees of a compass, and is referred to as a bearing. But here's where the potential confusion comes in: an NDB bearing is the 180° opposite of a compass direction. For instance, a plane on a 180 bearing is actually due north of the NDB, as illustrated on the next page. Think of the bearing as the path the plane must take to reach the NDB. Therefore, a plane on the 180 bearing must travel a 180° course to reach the NDB. If it's tempting to think of this as a 360 bearing — think again!

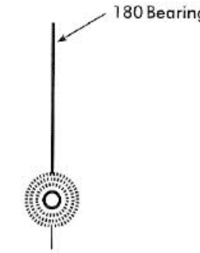


Figure 4.61 *Every NDB bearing is the 180°-degree opposite its accompanying compass point.*

Likewise, figure 7 shows the 315 bearing, not the 135. To further illustrate this concept, figure 8 shows a plane on the 360 bearing. It also happens to be on a 360° heading, so it is tracking the 360 bearing TO the NDB. However, the plane in figure 9, although on the same bearing, is traveling a 180° course. It is tracking the 360 bearing FROM the NDB.

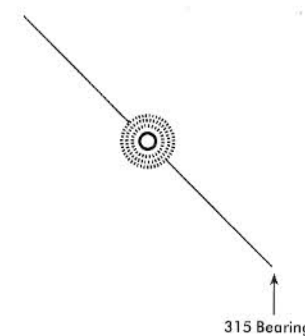


Figure 4.62 *This is the 315 NDB bearing, but the 135° point on the compass.*

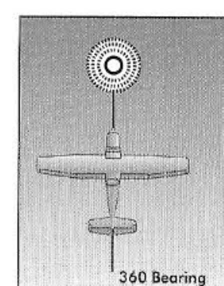


Figure 4.63 *The airplane is on the 360 bearing to the NDB.*

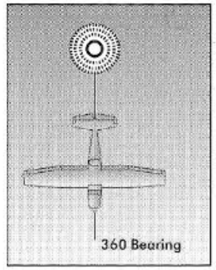


Figure 4.64 *Airplane is still on the 360 bearing to even though it is heading 180°.*

Let's apply these concepts to an actual situation. Roberts Field (Redmond, Oregon) along with the BODEY NDB is shown in the map below. You must fly from the NDB to the airport.

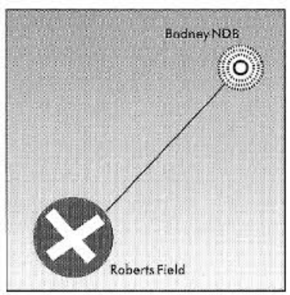


Figure 4.65 *Roberts Field near Redmond, Oregon and the BODEY NDB nearby (artist's concept).*

Drawing a straight line from the NDB to the airport shows that you must travel along the 223° bearing from the NDB to Roberts Field. This means traveling a course of 223°.

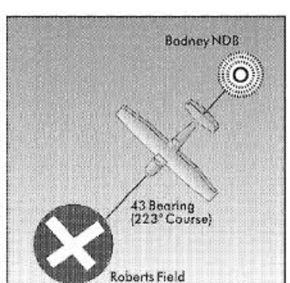


Figure 4.66 *On the 223° bearing from the NDB with a course of 223°.*

If you were to fly from the airport to the NDB, then the plane would be on a course of 43° *and* a bearing of 43.

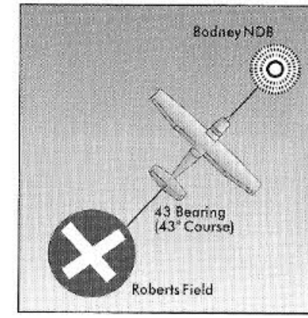


Figure 4.67 *On the 43° bearing to and 43° course.*

NDB Classes

NDB's are classified four ways depending on their range of use, or their service volumes.

Compass Locator Class — 15 nautical miles
MH Class — 25 nautical miles
H Class — 50 nautical miles
HH Class — 75 nautical miles

The service range of individual facilities may vary from what is listed here. Consult the latest Notice To Airmen (NOTAMs) and your Airport/Facility Directory (AF/D) for individual station specifications.

Instruments for Navigating With NDB

The on-board instruments for navigating via NDB include the Automatic Direction Finder (ADF) Receiver, the ADF Indicator, and the ADF switch on the audio panel. In the radio stacks found inside the cockpits of *Pro Pilot '99* aircraft, the audio panel allows you to select any of the NAV or COM radios for monitoring.

Figure 4.68 *The ADF receiver found on board the aircraft in* **Pro Pilot '99.**

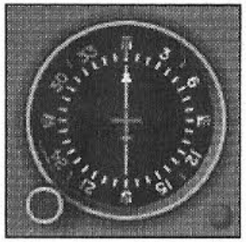


Figure 4.69 *The ADF Indicator found on board the aircraft in* Pro Pilot '99.

Figure 4.70 *The audio panel found in* Pro Pilot '99 *aircraft. This unit also contains marker beacon lights.*

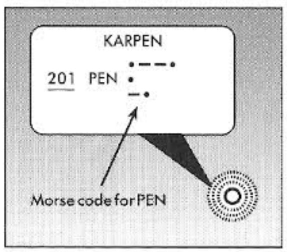


Figure 4.71 *This shows the KARPEN NDB near Astoria, Oregon. The name of the NDB is shown, along with its frequency (201), the alphabetic identifier (PEN), and the Morse code identifier.*

Click on the frequency digits on the ADF receiver in *Pro Pilot '99's* aircraft, to tune the ADF receiver to the desired frequency. The frequency displayed on the left is the current one. The frequency displayed on the right is the standby. Use the double-headed arrow button to toggle between the two frequencies. Then push the ADF button on the audio panel to hear the Morse code signal. If the plane is within range of the signal and the NDB is in working order, the appropriate Morse code tones will be audible. If you plan to navigate via NDB, you must continually identify the station by leaving the ADF button depressed. You have to rely on the audible Morse code signal to determine the integrity of the NDB.

Once the NDB has been identified using the receiver/audio panel combo, the needle on the ADF Indicator points in the direction of the NDB station. That's all there is to it.

The ADF Indicator on board *Pro Pilot '99* aircraft has an adjustable compass rose which can be rotated to align it with the magnetic compass.

In this example, the ADF receiver is tuned to the PRAHL NDB at a frequency of 366. Note that the indicator needle shows that the NDB station is located somewhere off the right wing of the airplane.

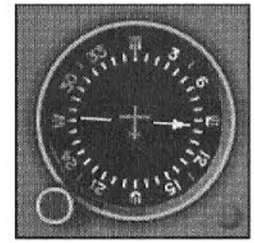
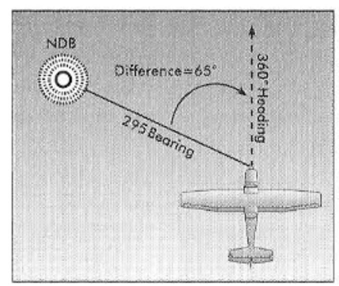


Figure 4.72 *With the PRAHL NDB frequency tuned in, the ADF needle points to the direction of the NDB station.*

You can orient the location of the airplane relative to the NDB station by using relative bearing. Relative bearing is simply the direction to the NDB, relative to the nose of the airplane. For instance, in the illustration below, the airplane is on a heading of 360° and the NDB station is off to the left. Given the airplane's current position, it is on the 295° bearing to the station. This means that measuring clockwise on the ADF Indicator's compass rose, the station is 295° relative to the plane's nose. Another way of looking at this is that the NDB is 65° to the left of nose.



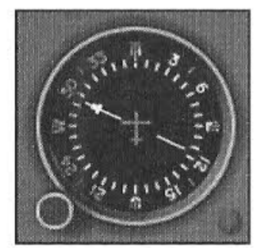


Figure 4.73 *The relative bearing of the NDB here is 65° to the left of the airplane's nose.*

In this next example, the plane is heading east-southeast and the NDB station is to the right of the plane. The ADF Indicator needle points to the station and shows a relative bearing of 65°. In other words, the station is 65° right of nose.

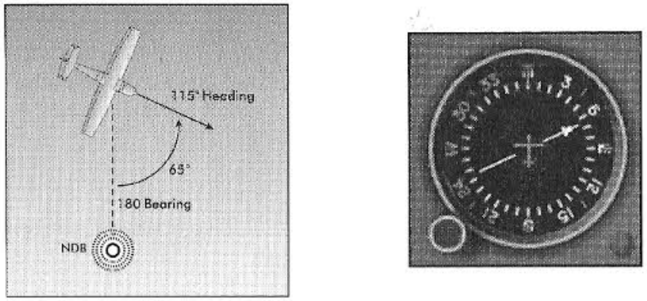


Figure 4.74 *The relative bearing of the NDB is 65° to the right of the airplane's nose.*

Determining Position With NDB

Position cannot be determined by relative bearing alone. Heading is another required ingredient. This is shown on the Directional Gyro, or Heading Indicator.

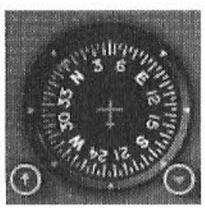


Figure 4.75 *The Directional Gyro.*

In the example below, the directional gyro shows a heading of 45° and the ADF needle is pointing to the NDB station with a relative bearing of 30°. This puts the station northeast of the plane as shown in the diagram. So by knowing the heading and the relative bearing, the position of the plane can be plotted.

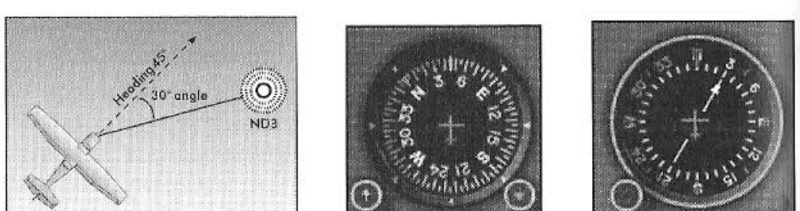


Figure 4.76 *Knowing the heading and relative bearing of the NDB allows you to plot the position of the airplane.*

In the previous example, you could determine that the plane was southwest of the NDB, but there is still a way to determine the exact NDB bearing the plane is on. In the example below, simply superimpose the ADF needle over the directional gyro face to determine the bearing you're on. Here, the gyro shows a heading of 270° and the superimposed ADF needle is pointing to 210°.

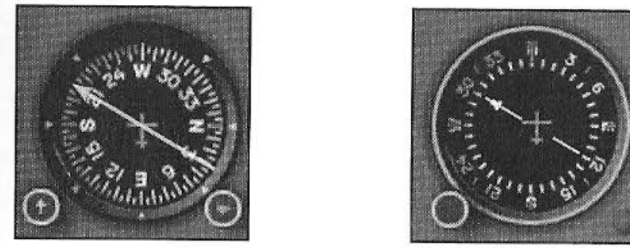


Figure 4.77 *Superimpose the ADF needle over the directional gyro face to determine the bearing you're on.*

This means that the plane is on the 210° bearing from the NDB station, on a heading of 270° as shown below.

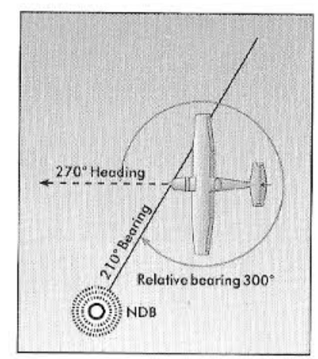


Figure 4.78 *The plane on a 270° heading and on the 210° bearing puts it northeast of the NDB.*

Another way of finding position for practical use is by this formula:

Magnetic Heading + Relative Bearing = Magnetic Bearing

Therefore, if your magnetic heading is 230 and your relative bearing is 070, then your magnetic bearing is 300. If the total is more than 360, then subtract 360 from the total for your magnetic bearing.

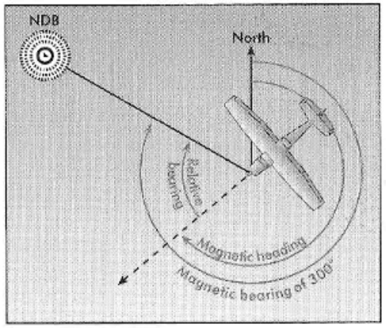


Figure 4.79 *Magnetic Heading + Relative Bearing = Magnetic Bearing.*

Flying NDB's

There are three ways to fly NDB's: Homing, Intercepting, and Tracking.

Homing

This is the easiest method of flying NDB's, although it is also the most inefficient because it does not take into account winds aloft. In the example below, the directional gyro shows a heading of 270° and the ADF shows that the NDB is straight ahead.

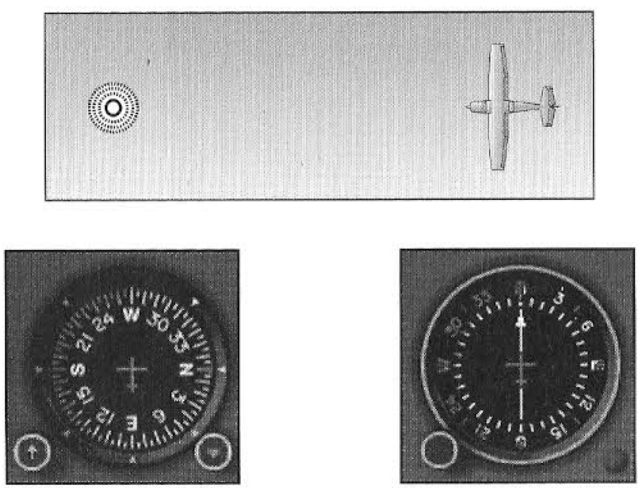


Figure 4.80 *Heading 270° with the NDB directly ahead.*

In a perfect world, you could fly directly to the NDB just like this. But wind is part of everyday flying, so before long the plane will be off track if it continues on the same heading.

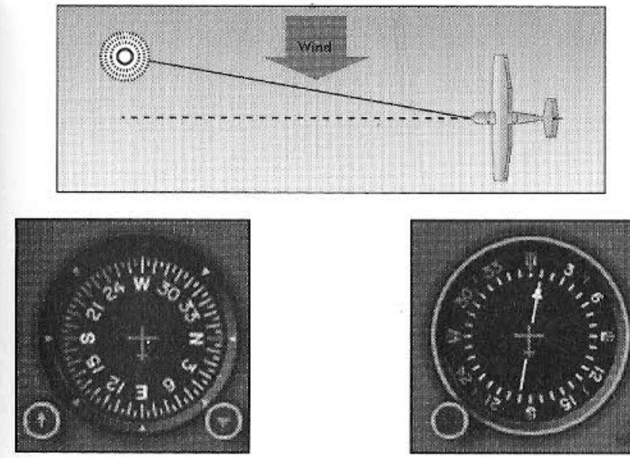


Figure 4.81 *Wind from north veers the plane south, but the gyro still shows 270.*

Note how the ADF now shows the station at 10 degrees right of nose with the same heading of 270°. To correct for this, the plane must be turned right 10° so the needle once again points straight ahead (360).

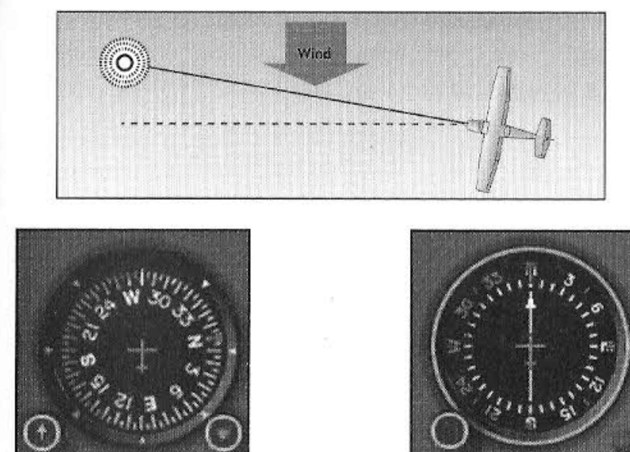


Figure 4.82 *A 10° correction puts the NDB straight ahead once again.*

Note the new heading of 280° to get the plane back on a course for the NDB. The wind will continue to veer the plane off course. As this happens, continue turning the plane so the ADF needle always points to 360 (straight ahead). After a while, the plane will cover a track as illustrated on the next page.

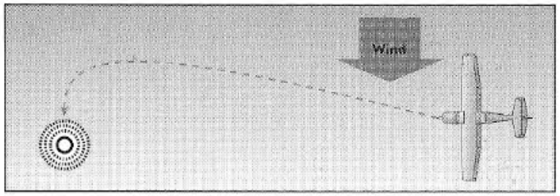


Figure 4.83 *Typical NDB homing track.*

Intercepting

Intercepting an NDB is required when your flight path does not allow for a direct route to the station. In this example, you'll need to intercept the NDB shortly after takeoff. However, a restricted Military Operations Area (MOA) requires that you fly around it.

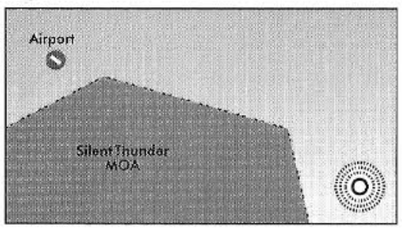


Figure 4.84 *A hypothetical MOA situation.*

To intercept the NDB course to the station, you need to first establish the intercept bearing. In this case, it is the 135 bearing that will allow you to safely track the NDB while avoiding the restricted airspace. To intercept that bearing, you will need to fly a heading of 090.

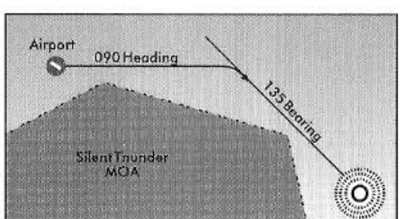


Figure 4.85 *Establish the intercept bearing that will allow you to navigate around the restricted area.*

Next, you need to determine an intercept angle. This is the angle between your heading and the bearing, in this case, 45°.

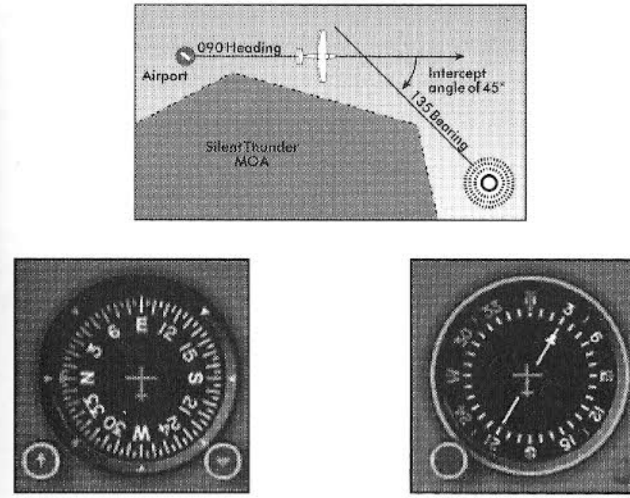


Figure 4.86 *Establish the intercept angle which will allow you to pick up the intercept bearing.*

As the plane approaches the 135 bearing, the needle of the ADF will start moving toward the back of the airplane. This is referred to as the needle "falling toward the tail." This means that the needle will also be creeping up on the 045 relative bearing. When the needle reaches the relative bearing that is equal to the intercept angle, then you have reached the intercept bearing.

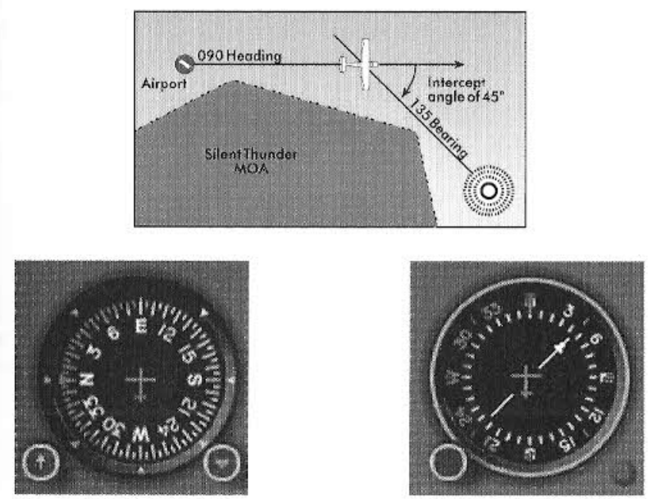


Figure 4.87 *When the needle reaches the relative bearing that is equal to the intercept angle, the plane has reached the intercept bearing.*

Another way of knowing when you have reached the intercept bearing is by superimposing the ADF needle over the face of the directional gyro. In this case, when it points to 135, then the plane is on the bearing.

Remember to turn on course (turn until the needle points to 360) once you have reached the intercept bearing or you'll fly right through it.

Tracking

To track a bearing requires more work, but it is also a more precise and more efficient method of navigation. In this example, you will track the 270 bearing to the station. Your heading is 270 and you are on the 270 bearing.

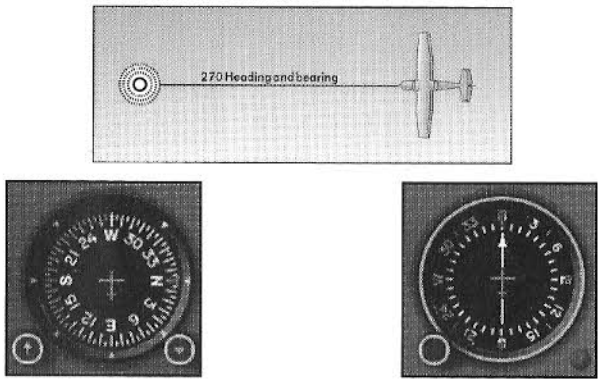


Figure 4.88 *On a heading of 270° with the NDB directly ahead.*

Eventually the wind will blow you off course so that you are south of the station even though your heading doesn't change. Now the needle points to the right because the station is to the right of nose. Note that if you are still flying the same heading as the course (in this case, the heading and the course are both still 270) then the needle will always point toward the course.

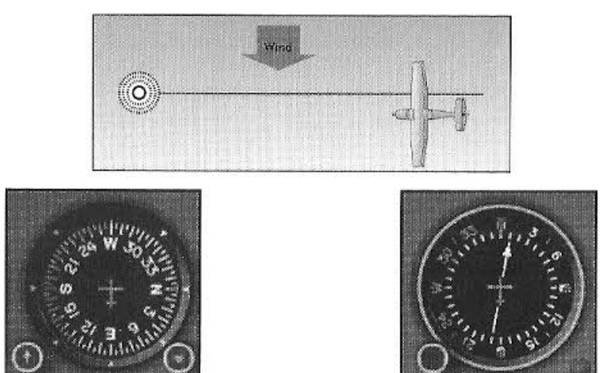


Figure 4.89 *The wind has blown the plane south of the NDB station.*

Now you must correct to get back on course. How much to correct depends on the wind speed and direction, the speed of the airplane, and the distance from the station. For this example, correct your heading by 30° to re-intercept the bearing.

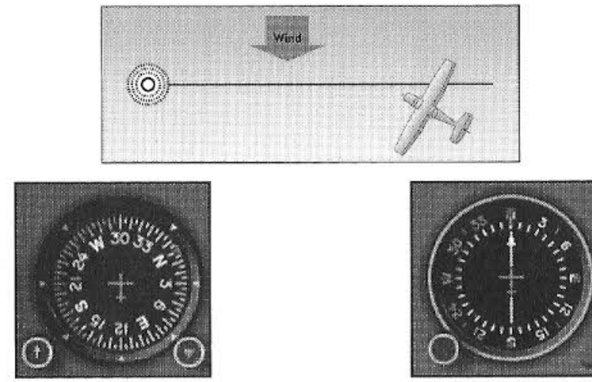


Figure 4.90 *Correct the plane's heading by 30° to re-intercept the bearing.*

This makes the new heading 300°. Now the ADF needle points 20° left of nose. Once the needle reaches the re-intercept mark of 330° (30° left of nose), then the plane will be back on course, as indicated below.

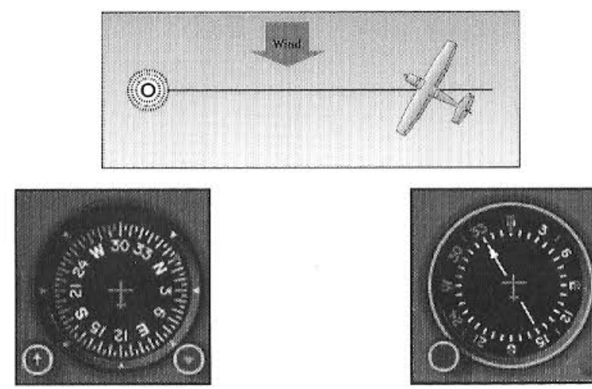


Figure 4.91 *With the new heading the plane eventually re-intercepts the original bearing.*

Now, to prevent the plane from being blown off course again, you'll want to fly a crab angle somewhere in between the re-intercept angle and the original course. If you make this new correction 20°, then your new heading should be 290° and the needle should point to 20° left of nose (or 340).

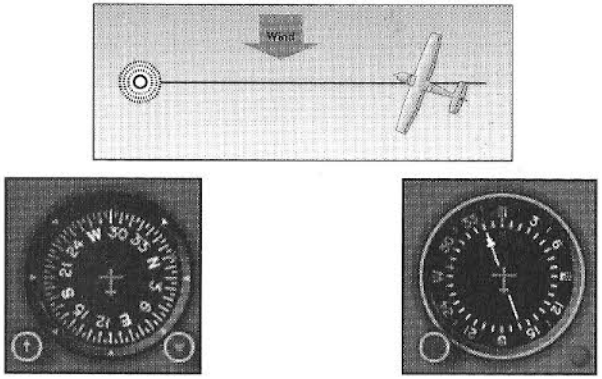


Figure 4.92 ***Fly a crab angle somewhere in between the re-intercept angle and the original course to stay on track.***

It's possible, however, that this new crab angle will cause you to fly right through the intended course. In this case, you would end up north of the 270 bearing as shown below.

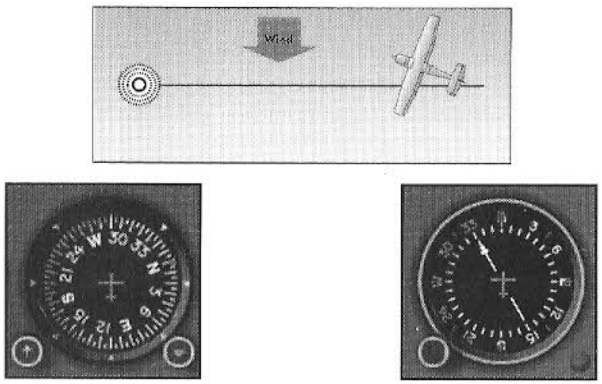


Figure 4.93 ***Too much correction for the wind can cause the plane to fly right through the course.***

You know you've flown through the course if the needle falls toward the tail beyond your intercept angle. To correct, fly the original 270° heading and allow the wind to blow the plane back on course.

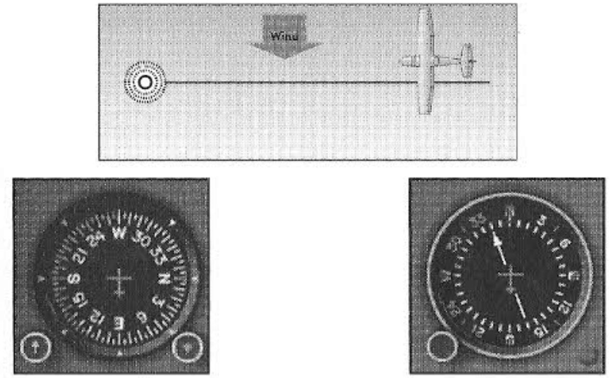


Figure 4.94 ***If you've flown through the course on the same side as the wind, let the wind blow you back on course.***

Now the plane is back on course, but with the wind, will soon be south of the course unless corrective action is taken. This time, however, you'll want to correct less than the 20° angle you flew before. Try a 10° correction this time, as shown.

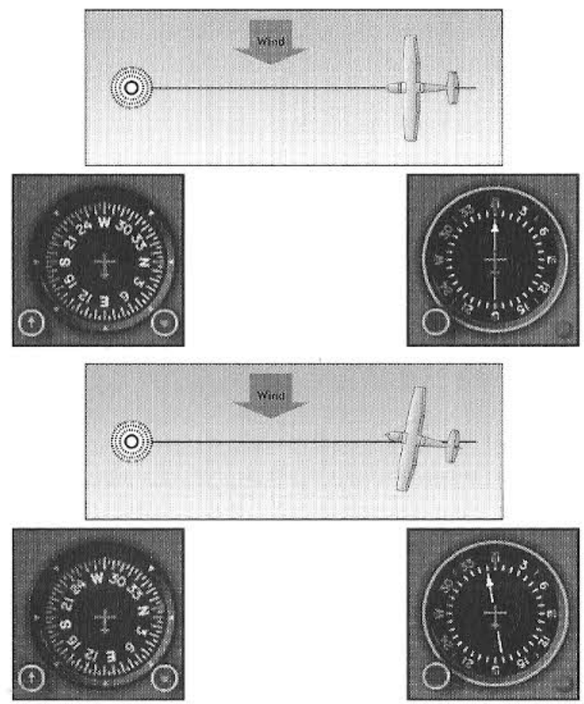


Figure 4.95 ***To avoid flying through the course again, crab at a lesser angle to the wind.***

The heading indicator now reads 280° and the needle points to 10° left of nose. At this heading into the wind, you should cross directly over the NDB station. As this happens, the needle will fall rapidly toward the tail. As the plane leaves the NDB behind, the needle should be 180° opposite where it was when the plane was heading toward the station.

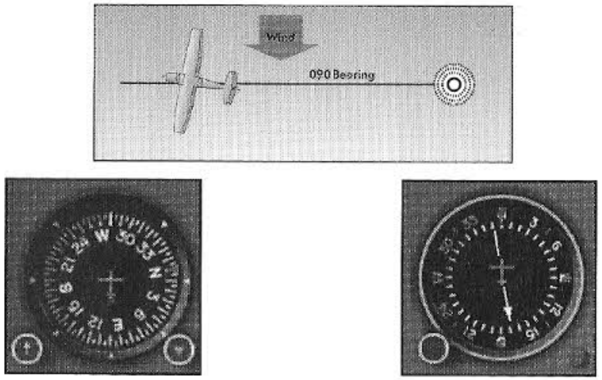


Figure 4.96 ***Leaving the NDB station behind, the heading indicator reads 280° and the needle points to 170°.***

Transponders

A transponder is a small, aircraft-based receiver/transmitter which assists pilots and controllers in radar navigation. The transponder is one component of the Air Traffic Control Radar Beacon System (ATCRBS). The other components are the interrogator and the decoder.

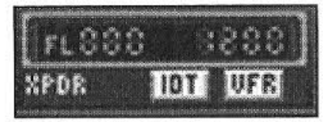


Figure 4.97 ***The transponder panel found on board all aircraft in Pro Pilot '99.***

The interrogator is part of the radar antenna that transmits a coded pulse sequence signal in a 360° arc over the 1030 MHz frequency. This signal "interrogates" all transponder-equipped aircraft and awaits a reply. Transponders reply over the 1090 MHz frequency which ultimately results in a distinct image on the controller's radarscope. This image indicates that the airplane is equipped with a transponder, that it is functioning, and is able to receive a discrete frequency assigned by air traffic control on the standard VFR transmission code of 1200. If the transponder is Mode C equipped, it also supplies altitude information to the controller when the transponder's function knob is turned to ALT (see below).

The transponder acts as the aircraft's identifier. In fact, it consists of an IDENT (identifier) button that, when depressed by request of the controller, transmits a signal to the interrogating antenna, and ultimately to the controller's radarscope, to specifically identify the aircraft. The IDENT button is never to be activated unless requested by an ATC controller.

A reply light flashes each time the transponder is interrogated. Interrogator sweeps are made every 10-15 seconds, however, if the light is flashing almost continuously, this means it is responding to multiple interrogators.

Transponders also have a mode selection knob with five positions: OFF, SBY (Standby), ON, ALT (Altitude), and TST (Test). Standby is used after engine start to allow the transponder to warm up. It must be turned to ON or ALT (if Mode C) *before* takeoff, unless otherwise instructed by ATC. Return this knob to SBY or OFF as soon after landing as possible.

Transponder Codes

On a typical transponder, there are four control knobs for entering a code assigned by the controller (or by the pilot in emergency situations). Each of these knobs can select a digit from 0 to 9. The common terminology for referring to transponder codes is "squawk." For instance, a controller may request you to "squawk VFR," which means your set should be dialed in to the standard VFR code of 1200. Codes are spoken as individual numerals (i.e., "Squawk Two Five Three Four").

Note: The transponder on board the aircraft in Pro Pilot '99 *is controlled via mouse input. Therefore, the control knobs described above are absent.*

Certain codes are restricted to military or emergency use, as indicated in the chart below.

Transponder Code	Type of Flight	When Used
0000*	Military	North American Air Defense
1200	VFR	Up to 18,000 feet otherwise by ATC
4000*	Military, VFR/IFR	In Warning and Restricted areas
7500	VFR/IFR	Hijacking
7700	VFR/IFR	Emergency – "Mayday"
7600	VFR/IFR	Loss of radio communications
7777*	Military	Intercept operations
Any Code	VFR/IFR	When using Center or Approach Control and ATC assigns a specific, or discreet, code

* For military operations only – never to be used by civilian pilots.

When making routine code changes on the transponder set, be careful not to inadvertently enter restricted codes. For example, on the way to dialing in 7200 from 2700, switch first to 2200, then to 7200, thereby avoiding 7700 and momentary false alarms.

Transponders are limited to line-of-sight use. Any obstructions between the aircraft set and the interrogating radar antenna will reduce the signal's range.

If Mode C equipped, you should report your exact altitude to the nearest 100-foot increment when establishing initial contact with an ATC facility. This confirms that the stated altitude matches that on the Mode-C readout. ATC requires this information before relying on Mode-C altitudes for separation of air traffic.

Transponder Modes

There are seven transponder modes that are currently available, however, only two are important to point out here:

1. Mode 3/A transponders are used by both military and civilian aircraft. Any aircraft equipped with this type of transponder is required to have it turned to the ON position.
2. Mode C is a 3/A transponder equipped with altitude reporting capability. Any aircraft equipped with this type of transponder is required to have it turned to the ALT position.

Mode C transponders are required in certain airspace areas:

- At or above 10,000 ft MSL over the contiguous 48 states or the District of Columbia, excluding the airspace below 2,500 ft AGL.
- Within 30 nautical miles of a Class B primary airport below 10,000 ft MSL, with certain exceptions for balloons, gliders, and aircraft not equipped with an engine-driven electrical system.
- Within and above Class C airspace, up to and including 10,000 ft MSL.
- Within 10 miles of certain designated airports, excluding the airspace that is both outside the Class D surface area and below 1,200 ft AGL. Balloons, gliders, and airplanes not equipped with an engine-driven electrical system are also excluded from this requirement (per AIM 4-19(3)).

Chapter 5: Instrument Flying

This section is divided into categories of instrument flight as it pertains to departures, en route flight, approaches, and arrivals. However, because a majority of instrument-related topics cover all instrument flight, we will begin with a general discussion.

Instrument Flight Rules

A ceiling of 500 ft to less than 1,000 ft AGL and/or visibility of one to less than three miles constitute IFR (Instrument Flight Rules) conditions. Marginal VFR (MVFR) is ceiling 1000' to 3000' and/or visibility between 3-5 miles. Mode C transponder required above 10,000'.

The required instruments and equipment for IFR flight are:

1. All of the required daytime and nighttime VFR instruments and equipment (see page 74).
2. Two-way communications equipment. NAV equipment appropriate to the ground facilities used.
3. Gyroscopic rate of turn indicator except on large airplanes with a third attitude instrument system usable through flight attitudes of 360°of pitch and roll and installed in accordance with FAR 121.
4. Slip-skid indicator.
5. Sensitive altimeter adjustable for barometric pressure.
6. A clock that displays hours, minutes, and seconds with a sweep-second pointer or digital presentation.
7. Generator or alternator of adequate capacity.
8. Gyroscopic pitch and bank indicator (attitude indicator).
9. Gyroscopic direction indicator (heading indicator or equivalent).
10. Distance Measuring Equipment (DME) if aircraft is operated above 24,000 ft MSL.

Instruments and Scanning Techniques

All of the aircraft in *Pro Pilot '99*, with a few exceptions, have the standard six-instrument configuration arranged in two rows of three each. These are divided into gyro instruments and pressure instruments.

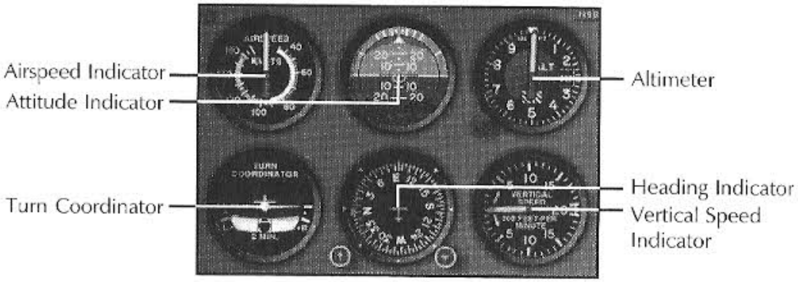


Figure 5.1 *The standard six-instrument configuration.*

Gyro Instruments

The gyro instruments are the attitude indicator, the heading indicator, and the turn coordinator. The middle instrument in the top row of the panel is the **attitude indicator**, or artificial horizon. This shows the relationship of the nose and wings to the horizontal plane. All movements of the flight controls, such as changing pitch or bank, are done by direct reference to this instrument.

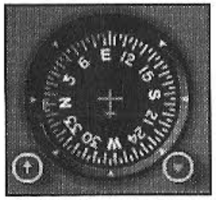
Figure 5.2 *The attitude indicator showing: A) Straight and level flight; B) 15 degrees of left bank, level pitch attitude; C) 18 degrees of right bank, two dots below the horizon.*

The first 30° of bank are shown on the bank index in 10° increments. Then there is a tick mark for 60° and 90° banks. Pitch attitude is named by reference to the center dot in the airplane symbol, as one dot above the horizon, two dots below the horizon, etc...

Note that a bank indicated on this instrument doesn't necessarily translate as a turn. A plane in a forward slip with one wing low, for instance, will appear as a bank on the attitude indicator event though it is not turning. Likewise, a plane in slow flight with a nose-up attitude will appear nose high on the indicator, although this does not translate to a climb. In fact, a plane in descent can appear nose-high on the attitude indicator, so be careful about how you interpret this instrument.

The **heading indicator**, or directional gyro appears just below the attitude indicator on the panel. It operates on an internal gyroscope that provides accurate heading information *once it is set to the correct heading using the magnetic compass.* This should be done by the pilot prior to taxiing. The airplane's heading then appears at the top of the instrument. Set yourheading indicator to your mag compass every 15 minutes due to precession error. The King Air and Citation Jet have "slaved" heading indicators that normally do not need resetting.

Figure 5.3
The heading indicator.



Consult the heading indicator as you approach a runway to confirm its heading. This is especially useful in circling approaches (more on this later in this section).

The heading bug (pointer) on the heading indicator is set to a desired heading for the autopilot to hold (if the airplane is so equipped). It can also be used as a reminder to stop turning when flying manually. When tracking a VOR or localizer, and the course is set on the OBS (Omni-Bearing Selector; see VOR/DME Navigation on page 100), the heading bug can be adjusted to reflect the wind correction required to stay on course.

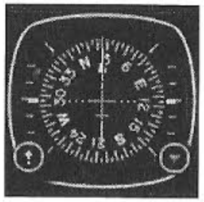


Figure 5.4 *The Horizontal Situation Indicator.*

The **Horizontal Situation Indicator** (HSI) is a combined heading indicator and VOR display. It also comprises a course selector, a heading bug, a CDI (Course Deviation Indicator), and TO-FROM flags.

Figure 5.5 *The Turn Coordinator.*

The **turn coordinator** is the lower left instrument on the panel. It consists of a rate of turn/ quality of turn indicator (the miniature airplane) and the slip-skid indicator (the floating ball). It shows two hash marks that indicate standard left and right turns. In instrument flight all turns are made at a rate of 3° per second. At this standard rate, a complete 360° turn is made in two minutes. Smaller turns (5-10° heading changes) require a less-than-standard rate turn.

In a coordinated turn, the airplane's weight (earthward force) and centrifugal force (the force exerted toward the outside of the turn) are balanced so that the resultant force is directed straight through the floor of the cockpit. A centered ball proves a coordinated turn. A ball on the inside of a turn (plane banked right, ball to the right of center) means the turn is slipping. This means the plane isn't turning fast enough for the degree of bank. Apply rudder pressure to increase the turn rate.

A ball on the outside of a turn (plane banked right, ball to the left of center) means the turn is skidding. This means the plane is turning too fast for the degree of bank. Relieve rudder pressure to decrease the turn rate.

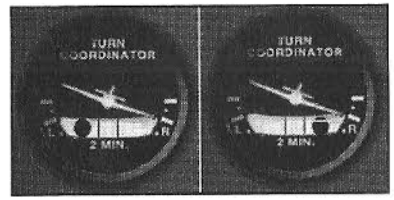


Figure 5.6 *Turn Coordinator showing a skidding and a slipping turn.*

The attitude indicator provides information about angle of bank. The turn coordinator provides rate-of-turn information.

Pitot-Static Instruments

The pressure instruments are the airspeed indicator, the altimeter, and the vertical speed indicator. They are driven by the pitot-static system which includes the pitot tube, static port(s), a plumbing system, and an alternate static source.

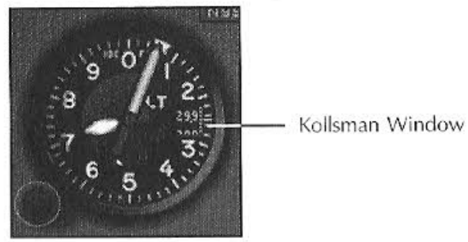


Figure 5.7 *The altimeter.*

The **altimeter** is located at the top right corner of the six-instrument panel. The Kollsman window within the instrument face shows the pressure plane setting which is adjusted with the knob at the lower left of the instrument. The altimeter setting at an airport is the local barometric pressure adjusted to sea level, not the actual atmospheric pressure at the station. Therefore, if the Kollsman setting is the current sea level pressure, then the altimeter reads your altitude above sea level.

Standard sea level pressure is 29.92 inches of mercury. At higher altitudes, there is less air above you, so the pressure is less. Atmospheric pressure decreases by one inch of mercury with every 1,000 feet of altitude. At Denver on a standard day, where the altitude is 5,000 feet, the barometer reads 24.92", or five inches below standard sea level pressure. Adjusted to the standard sea level pressure however, the correct altimeter (Kollsman) setting is 29.92, just as it is anywhere else.

Controllers are required to give the local altimeter setting at least once while you are in their sectors. Prior to IFR flight, however, it is important to input the correct altimeter setting and compare the altimeter reading to the local field elevation. The difference should be no more than 75 feet, although there are exceptions to this.

If pressure drops during flight, the altimeter will read higher without an appropriate adjustment to the altimeter setting. This means you would descend to maintain a certain indicated altitude. Pressure can change by several inches over a long flight, and without the appropriate adjustment to the altimeter setting, you could find yourself at a dangerously low altitude. There is a saying about pressure drops that goes: "From high to low, look out below."

Likewise, an increase in pressure will result in a lower indicated altitude and would cause you to climb to maintain an indicated altitude. *Enter the new altimeter setting each time a controller provides it.*

There are five definitions of altitude that pilots need to understand:

1. **Indicated Altitude** – the number read off of the altimeter. This should agree with true altitude if the altimeter setting is accurate and there is no instrument error.
2. **True Altitude** – actual height above mean sea level (MSL). This is used by all aircraft below 18,000 ft and is the basis for IFR separation.
3. **Absolute Altitude** – the height above the terrain. The aneroid altimeter cannot measure this. Only a radar altimeter can, as well as your own direct observation.
4. **Pressure Altitude** – the height above the pressure plane which is where the pressure is 29.92". The pressure plane is also called the standard datum plane and is equal to true altitude on a standard day. To determine the pressure altitude, enter 29.92 as the altimeter setting and read the indicated altitude.
5. **Density Altitude** – this is pressure altitude corrected for non-standard temperature. It is a computed value that accounts for temperature and pressure variations. At the 29.92" pressure plane, 15˚C is the standard temperature. On a standard day, this temperature decreases predictably with increases in altitude (it's usually colder in the mountains, right). When the temperature varies from this standard, aircraft performance is affected.

Higher temperatures and altitudes reduce air density and decrease aircraft performance. Lift decreases so airplanes need a longer takeoff roll, have a slower rate of climb, and have slower indicated airspeeds on hot days and at higher elevations.

Density altitude is found by using a computer or a density altitude chart as shown below. It is the basis for calculating true airspeed which you show on IFR flight plans.

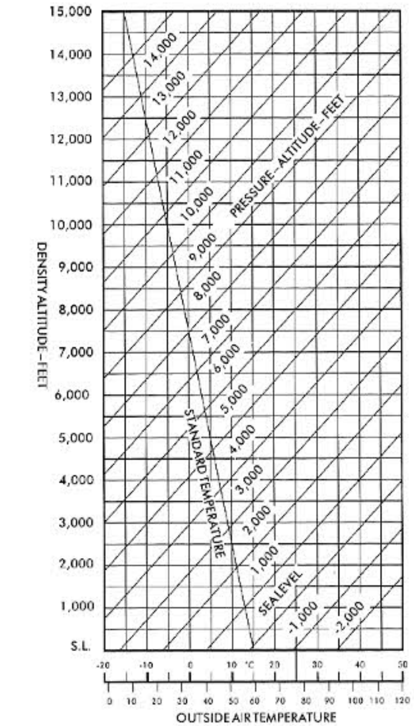


Figure 5.8 *A density altitude chart.*

The **Vertical Speed Indicator** (VSI) is another pressure instrument located at the bottom right of the six-instrument array.

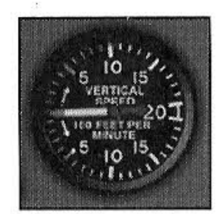


Figure 5.9 *The Vertical Speed Indicator.*

The VSI measures the rate of climb or descent via a combination of static and ambient pressure. In level flight, the instrument reads zero. The needle will indicate immediately any change in vertical speed (the trend), but the rate displayed tends to lag behind what is actually happening except in sustained climbs, descents, and level flight. Don't rely on the VSI for pitch information especially when the pitch is constantly changing, such as in turbulent weather.

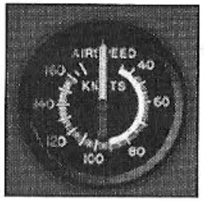


Figure 5.10 *The airspeed indicator.*

The **airspeed indicator** is in the upper left corner of the instrument panel. Modern airspeed indicators show knots on the outer scale and mph on the inner scale.

There are three definitions of airspeed:

1. **Indicated Airspeed** – this is what the needle points to on the instrument and is the dynamic pressure sensed by the pitot/static system.
2. **Calibrated Airspeed** – the pitot tube may receive dynamic pressure differently at different angles of attack. Calibrated airspeed is indicated airspeed corrected for instrument error. A table in the airplane's operating manual shows the actual error at different airspeeds. Calibrated and indicated airspeeds can be used interchangeably for instrument flight.
3. **True Airspeed** – This is the calibrated Airspeed corrected for density altitude. Basically, as the air pressure decreases, TAS increases for a given CAS.

Generally, true airspeed is 2% higher than indicated for each 1,000 ft of altitude. True airspeed is entered on the flight plan and if it varies by more than 5% or 10 knots (whichever is greater), you have to report to ATC.

The Magnetic Compass

Figure 5.11 *The magnetic compass.*

The reading on the magnetic compass fluctuates during turns and speed changes because of "dip errors." The compass also bounces around in turbulence and pitch changes which makes it less reliable than the heading indicator. Set the heading indicator to the compass only during smooth, straight and level, cruising flight.

Dip errors are caused by the compass attempting to align itself with the magnetic lines of force. Briefly, as the plane turns to the north, the compass lags behind. As you turn to the south, the compass reading leaps ahead. The number of degrees of lag or lead will roughly equal your degrees in latitude. Also, as the plane accelerates the compass reading swings slightly to the north. As you decelerate, the reading swings slightly to the south. The speed dip errors are greatest on east-west headings and zero on north-south headings.

Engine Instruments

There are a few more instruments outside of the flight gauges that are important to the instrument pilot. The power instruments are used in controlling the airplane, and the ammeter, pressure gauges, and temperature gauges all indicate the health of the engine.

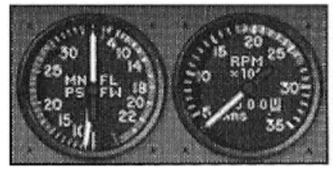


Figure 5.12 *The manifold pressure/fuel flow gauge and tachometer.*

The power instrument is the tachometer in a fixed-pitch propeller airplane and the manifold pressure/tachometer combination in a controllable prop airplane. The **tachometer** measures the speed of the propeller in revolutions per minute (rpm). The hours of operation are indicated on the number dial at the center of the tachometer. Tach time is measured by the number of engine revolutions, not by elapsed time, so an hour of engine time may not equal an hour of clock time. Only near the cruise setting will the two be equal. At slower speeds, the tach time is slower than the clock time, and vice versa.

The **manifold pressure gauge** measures the pressure inside the engine intake manifold. This gauge shows standard atmospheric pressure (about 30") with the engine off. At full throttle, the manifold pressure in the non-turbocharged engine will be slightly lower than the ambient pressure. At a constant throttle setting, the manifold pressure decreases approximately 1" per 1,000 feet of altitude.

Both the manifold pressure gauge and the tachometer are used to set engine power and should be consulted at each power adjustment.

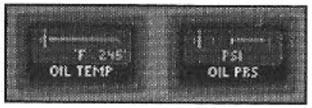


Figure 5.13 *The oil temperature and pressure gauges.*

The **oil pressure and temperature gauges** are usually the first instruments to give some warning of engine problems. Sudden changes or other unusual readings may be a good reason to terminate a flight. Low oil pressure could indicate a possible oil leak. Combine this symptom with high oil temperature and it becomes almost a certainty. High cylinder head temperature may indicate too much engine load or insufficient cooling airflow over the engine. Remedy this by opening cowl flaps, increasing airspeed, using a reduced power setting, or setting a richer mixture.

Figure 5.14 *The center zero type ammeter found on board* Pro Pilot '99 *aircraft.*

The **ammeter** measures electrical flow into and out of the electrical system via the alternator or generator. There are two types of ammeters in use: the center zero and the left zero type. A negative reading (center zero type) or a load drop (left zero type) could indicate complete or partial alternator failure. Electrical failure is always indicated by the ammeter, so it is a vital instrument in the scanning process, which is discussed in the next section.

Instrument Scanning

As important as it is to instrument flying, the discussion of instrument scanning could easily comprise an entire volume, which is not possible in this manual. In order to provide you with enough information within this limited space, certain key points are bulleted below, and others are condensed. Consult the bibliography on page 266 for references to excellent publications on instrument flying.

- Pitch can be said to control airspeed.
- Power changes at a constant angle of attack will not immediately affect airspeed.
- Power controls altitude, or rate of climb and descent.
- A combination of pitch and power controls airspeed and altitude.
- Use pitch to make altitude changes of 100 feet or less. Above 100 feet, also make a power change.
- In an ILS approach (discussed later), slight pitch changes are made with the elevators to maintain the glide slope.
- Within the speed range used in instrument flight, trim sets airspeed.

During flight in clouds or in total darkness, your instruments become your senses and provide you with critical information that your actual senses can only unreliably detect. Your sense of sight is still reliable, however, and is used to scan all of the instruments discussed in the prior section. To simply understand how valuable sight is in maintaining balance, stand on one foot and vigorously shake your head. It's not too difficult to remain balanced. Now try the same thing with your eyes closed. The average person stays upright for about two seconds.

Your sight is used to read the flight and engine gauges, as well as the navigation instruments, while covering the other details that claim a pilot's attention. The key to maintaining efficiency over all of these procedures is to develop a solid scanning technique. There are several techniques for varying situations, but the key factor is to avoid *fixating* on a single instrument, and to avoid *omitting* any of the instruments in the scan.

The instruments already discussed can be categorized by control and performance. The *control instruments* are those that show the attitude and the power settings directly. They are used in making control inputs. The attitude indicator is the only control instrument among the basic six, and the tachometer or manifold pressure gauge is the only engine control instrument. The other five basic instruments (altimeter, airspeed indicator, VSI, turn coordinator, and heading indicator) are performance instruments, which show indirect indications of the airplane's attitude. In other words, they show the results of control inputs.

The attitude indicator is the focal instrument in all scan patterns. It should be included as every second or third instrument scanned. However, because of this, fixating on it and omitting other instruments are also common problems.

The Six Scanning Configurations

With instrument flying, there are six flying attitudes for which it is important to know your airplane's performance settings: climb, cruise, cruise descent, (level) approach, approach descent, and non-precision descent. These performance settings are manifold pressure, rpm, pitch setting, airspeed, and VSI. Consistent pitch and power settings produce predictable performance. Knowing these settings for each flying attitude for your particular airplane will allow you to fly more efficiently.

Climbs

The scan for starting a climb is illustrated in figure 5.15.

1. Set the power using the tachometer.
2. Raise the nose using the attitude indicator.
3. Check for decreasing airspeed using the airspeed indicator.
4. Check for straight and coordinated flight using the turn coordinator.

5. Confirm a constant heading on the heading indicator.
6. Return to the power instrument to confirm the proper power setting (or with a fixed pitch propeller simply confirm full throttle).

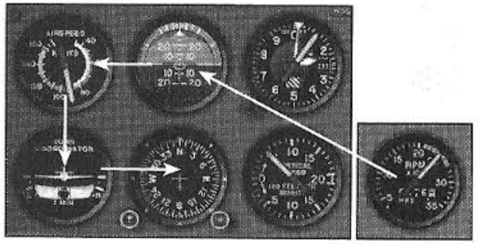


Figure 5.15 *The recommended scan for starting a climb.*

Transitioning To Level Flight

Subsequent scans depend on the instrument readings and individual preference.

1. To level off from a climb to cruising airspeed (figure 5.16), lower the nose on the attitude indicator.
2. Check for increasing airspeed.
3. Confirm a constant heading.
4. Monitor altitude, airspeed, and heading until the desired airspeed is reached.
5. Reduce power using the power instrument.

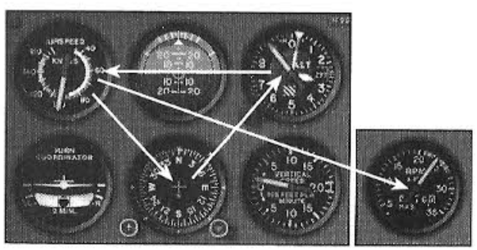


Figure 5.16 *The scan for leveling off from a climb at cruise airspeed.*

To level off at approach airspeed, as in proceeding to a holding fix after a missed approach, immediately lower the nose and reduce power. The scan is then altimeter, attitude indicator, power instrument.

Straight and Level

In straight and level flight, an unusually low airspeed indicates a nose-high attitude. Confirm this by looking for increasing altitude on the altimeter and a positive reading on the VSI. Use the attitude indicator to lower the nose.

The suggested scan for straight and level flight is shown in figure 5.17: attitude indicator, heading indicator, back to attitude indicator, VSI, altimeter. Add the airspeed indicator and the turn coordinator every few cycles for confirming information.

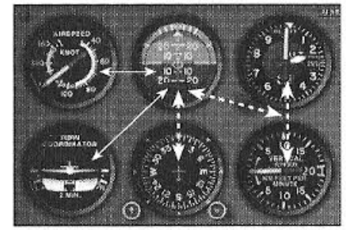


Figure 5.17 *The thicker, dashed arrows show the primary scan sequence for straight and level flight. The thinner arrows show secondary scans.*

Cruise Descents

A cruise descent is a descent to the last 1000 ft typically done at a rate of 500 feet per minute. To establish a cruise descent:

1. Reduce power (power instrument).
2. Lower the nose (attitude indicator).
3. Maintain a constant airspeed (airspeed indicator).
4. Check the attitude indicator again.
5. Maintain a constant heading (heading indicator).
6. Check the attitude indicator again.
7. Check for proper decreasing altitude and rate of altitude decrease (altimeter and VSI).
8. Check the attitude indicator.
9. Check the power instrument.
10. Check the attitude indicator one more time.

The scanning sequence is illustrated in figure 5.18: attitude indicator, airspeed indicator, attitude indicator, altimeter-VSI, attitude indicator, heading indicator.

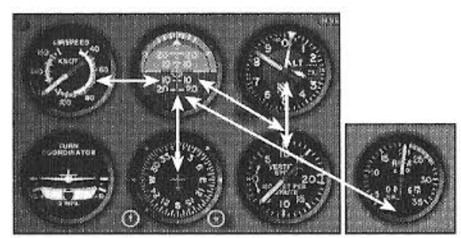


Figure 5.18 *The scan sequence for a cruise descent.*

To level off from a cruise descent, raise the nose and add power to the cruise level setting at 50 feet (10% of the descent rate) above the target altitude.

Approach Level

Approach level is the attitude used on approach. In most single-engine planes, the ideal approach speed is 90 to 100 knots. In light, twin-engine planes, it's 120 knots. To transition from cruise descent to approach level:

1. Set the power to the approach speed (power instrument).
2. Set the approach pitch attitude (attitude indicator).
3. Check the turn coordinator for any slipping or skidding.
4. Recheck to the attitude indicator.
5. Check the VSI/altimeter for any altitude changes.
6. Check the attitude indicator again.
7. Watch for declining airspeed (airspeed indicator).

After the approach attitude is reached, the instrument scan becomes the same as for a cruise descent (figure 5.18).

Approach Descent

To transition from approach level to approach descent:

1. Check that the power is at the approach speed setting (power instrument).
2. Check for proper approach pitch attitude (attitude indicator).
3. Check for constant airspeed.
4. Check back with the attitude indicator.
5. Check the heading.
6. Back to the attitude indicator.
7. Check the VSI and altimeter for the appropriate rate of descent (500 feet per minute for singles; 650 feet per minute for twins).
8. Attitude indicator, one more time.
9. Make any necessary power adjustments.

Perform your GUMPPS check before landing:

1. G — Gas on
2. U — Undercarriage down
3. M — Mixture rich
4. P — Propeller full forward
5. P — Fuel pump on
6. Safety — (seatbelts, doors, etc.)

Non-Precision Descent

On non-precision approaches, the idea is to be out of the clouds, at the minimum descent altitude, and in a good position for the final descent to landing well before the missed approach point. This means a normal approach airspeed at a higher descent rate (usually 1,000 feet per minute). It also means a lower power setting than for approach. The key is maintaining airspeed control.

Hold the nose at the desired pitch attitude by referencing the attitude indicator, and use the airspeed indicator to monitor the airspeed. In some airplanes, increasing the descent rate by decreasing power alone may overcool the engine. In this case, use partial flaps to slow the airplane.

Study and practice the procedures and instrument scan sequences required for normal and steep turns, climbing and descending turns, partial panel turns, rate climbs and descents, and unusual attitudes, including stalls. All of these should become part of the repertoire while training for your instrument rating.

Air Traffic Control Communications

Below is a checklist of the required Air Traffic Control communication procedures and dialog between two major terminals. These procedures will vary slightly when flying into or out of smaller airports.

1. Tune to ATIS and write down the recorded departure airport information.
2. Contact clearance delivery and copy the IFR clearance.
3. Contact ground control for permission to taxi to the active runway.
4. The tower gives permission to takeoff.
5. Departure control becomes your ATC contact while in the terminal area.
6. For IFR flights of less than two hours within approach control airspace, the tower can clear you for a tower-to-tower flight, called "tower en route control" (TEC). In this case, you will talk to several approach control sectors and no center. For longer flights, you are likely to talk to at least one center.
7. Tune to ATIS at the arrival airport and write down the recorded airport information.
8. Approach control provides approach clearance.
9. The tower clears you to land.
10. Ground control provides permission to taxi to the ramp.
11. Contact unicom for parking instructions and to request fuel.

DME/TACAN

Distance Measuring Equipment (DME) is first discussed in the chapter on navigation. For instrument flying, it pinpoints the airplane's position and time-to-station. It also helps identify intersections on en route charts when flying toward or away from a DME fix.

DME operates in conjunction with several navaids includin g VOR, TACAN, ILS or localizers and even NDBs. It provides useful time/distance to station information to the pilot.

The Five T's

A common method for remembering all of the tasks required during an instrument procedure is known as the "Five T's."

1. **Turn** – This is the initial action: as you cross a fix or begin a turn, first focus on completing the turn.
2. **Time** – Note the time or start the stopwatch to begin timing the leg.
3. **Twist** – Set the OBS to the desired course and change frequencies, if necessary.
4. **Throttle** – Set the power to approach speed, or to slow down and/or descend.
5. **Talk** – Make any required communication to ATC.

Figure 5.19 shows a good example of how the Five T's are applied.

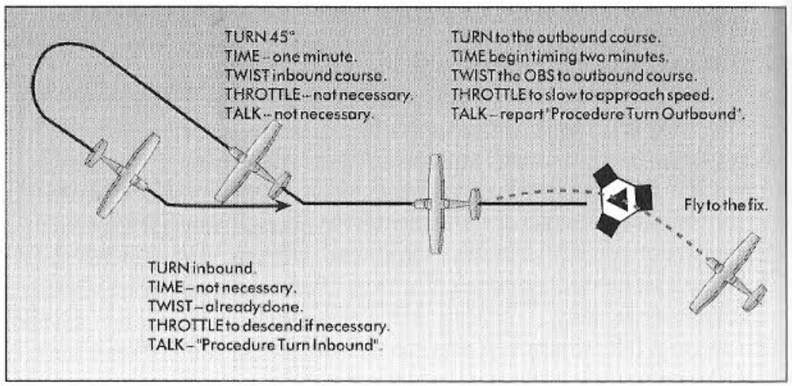


Figure 5.19 *Use the Five T's to create efficient instrument procedures.*

Get into the habit of saying the Five T's out loud as you cross fixes and make turns.

Determining An Alternate Airport

When filing an IFR flight plan, you are required to list an alternate airport in the event of radio failure and you are unable to land at your destination airport. An alternate is not required if the destination airport has an instrument approach and the weather forecast indicates a minimum 2,000 foot ceiling with three miles visibility for one hour before, until one hour after your ETA.

The forecast for the alternate airport must show the weather above alternate minimums at your ETA. Alternate minimums are listed in the front of NOS approach chart books or on the airport diagram of Jeppesen charts.

IFR Clearance

After you file a flight plan, it is transmitted by Flight Service to a computer at the Air Route Traffic Control Center (ARTCC). A flight strip is produced at the center and transmitted via teletype to the approach control facility, if one exists, at your departing airport. You are still required to copy the clearance from ATC prior to takeoff.

At a controlled airport, listen to the ATIS broadcast prior to calling for your clearance. Then contact the clearance delivery controller or the ground controller and advise them you have the current ATIS and request your IFR clearance. If the controller says, "clearance on request," it means he has requested your routing from the appropriate ARTCC facility and is waiting on a response from them.

At busier fields with a clearance delivery facility, tune to the frequency for the "clearance pre-taxi" instructions and copy the ATIS. Then call clearance delivery, copy the clearance, and call ground control for taxi information.

At uncontrolled airports, the clearance procedures vary according to local custom.

When receiving an IFR clearance:

1. Copy it down. It helps to develop your own form of shorthand to keep pace with the instructions as they are delivered, but if you don't catch it all, don't panic and don't interrupt the controller. Wait until he is finished to get clarification.
2. Read back the instructions you do have. Don't interpret them and don't try to remember anything you haven't written down. Just read what you have. If the instructions are incorrect or incomplete, the controller will let you know. Then repeat these first two steps until you have it all.
3. Compare the clearance to the one you filed in your flight plan. Trace the route from departure to destination on your charts and make sure it gets you where you want to go. Also, check the minimum en route altitudes along the way and that you and your airplane are comfortable with them.
4. Request any changes or clarification, such as a lower altitude, or a more direct route.
5. Set up your radios. Dial in the tower frequency in the first COM radio and your first departure control or center frequency in the second COM radio; set the first NAV radio to the first en route fix and dial the OBS to the course for this fix; set the second NAV radio to identify the first intersection and dial in the second OBS to the proper radial.
6. Set your transponder to the assigned squawk code after you have been cleared onto the assigned runway.

IFR clearance information contains the same seven items:

1. Your plane's full identification – make sure it's *your* ID.

2. Your clearance limit, which is your destination airport unless you've been cleared short for some reason.
3. Your route. Usually, this is "as filed."
4. If the controller issues a standard instrument departure (SID),they will tell you at this point. Should the controller leave out this information, an instrument departure is implied and you should refer to your IFR charts for the textual description of the departure.
5. Your altitude after takeoff and en route.
6. The frequency for departure control.
7. The transponder squawk setting.

Standard Instrument Departures (SIDs)

A Standard Instrument Departure (SID) is a coded, established departure route found at busier airports that simplifies clearance delivery procedures. SID charts are included along with an airport's approach charts in both NOS and Jeppesen books.

There are two kinds of SIDs:

1. **Pilot Navigation** – The pilot is primarily responsible for navigation along this kind of route. Terrain and safety-related factors usually call for pilot nav SIDs which may contain vector instructions that pilots are expected to comply with until instructions are given for resuming normal navigation on the filed route.
2. **Vector** – ATC provides radar navigational guidance to a filed route or to a fix depicted on vector SID charts.

Both types of SID charts are shown in figures 5.20 and 5.21.

Instrument Approaches

Reading Instrument Approach Procedure (IAP) Charts

There are literally thousands of instrument approach procedure charts for all of the runways around the United States, and to describe all of the symbols, abbreviations, and uses of a typical chart would require a separate manual thicker than this one. To read charts, take some time to review the legends of an approach chart publication, called U.S. Terminal Procedures. Some of the more useful legends are detailed in Appendix A (beginning on page 252).

The U.S. Terminal Procedures comprise 16 volumes that cover the various U.S. regions and are updated every 56 days.

Approach charts, or plates, are a detailed blueprint for an instrument approach with specific instructions for each part of the approach. NOS and Jeppesen charts show a top-to-bottom presentation of information about the procedure. The start of the approach is called the Initial Approach Segment and the necessary information is shown in the plan (bird's eye) view (see figure 5.22).

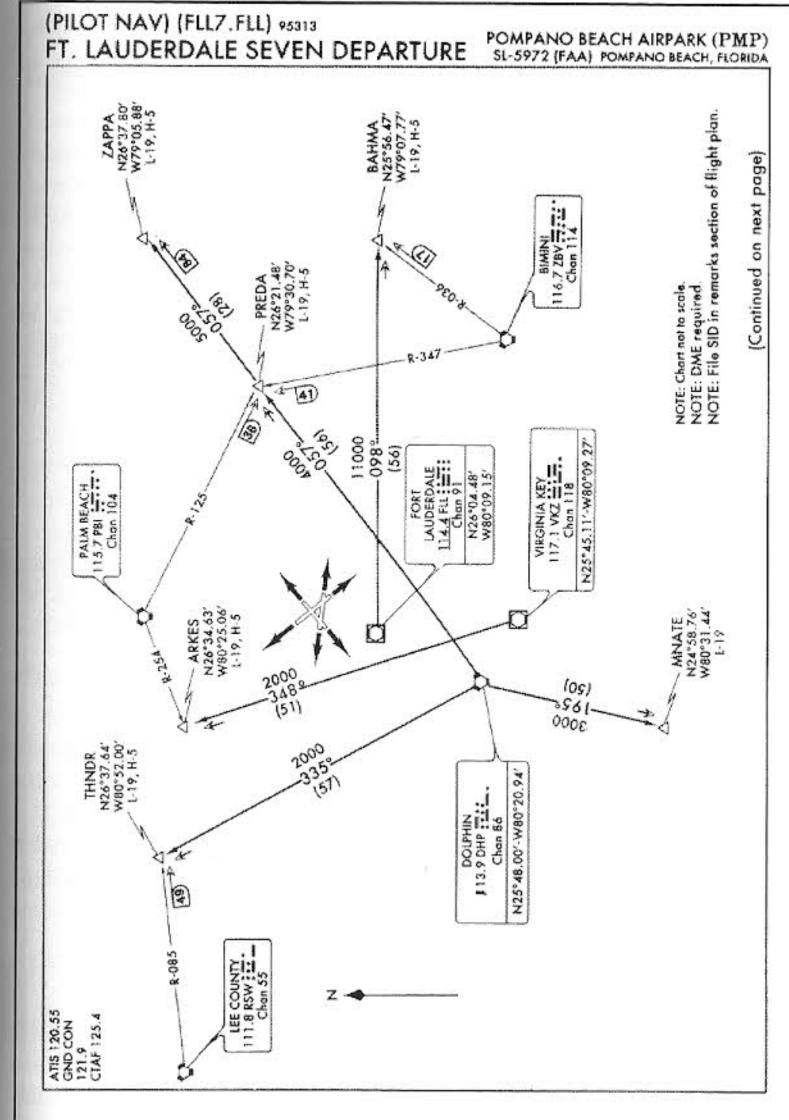


Figure 5.20 *The pilot navigation standard instrument departure for Pompano Beach Airpark, Florida.*

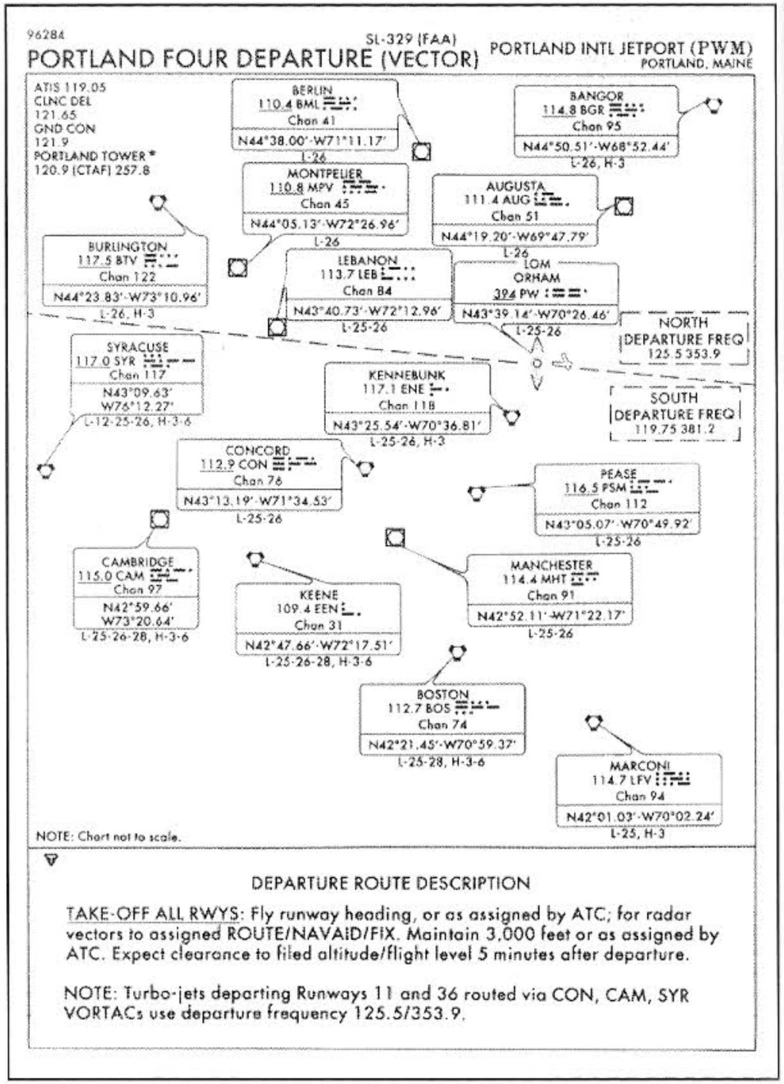


Figure 5.21 *The vector standard instrument departure for Portland International Jetport, Maine.*

The approach has already begun by the time the profile view comes into use, and the approach is almost finished when the minimum altitudes come into play. Remarks are listed below the minima and should be read first because they contain exceptions and qualifiers to the approach data.

There are two kinds of instrument approaches: precision and non-precision.

Non-Precision Approaches

Non-precision approaches provide lateral navigation assistance via an electronic avigation aid. A non-precision approach starts with a clearance to descend at a fix to an MSL altitude called a Minimum Descent Altitude (MDA). The plane is then flown in level flight at the MDA while the pilot attempts a visual identification of the airport. If the runway or airport is not visible by the time the plane reaches the Missed Approach Point (MAP), then the approach is aborted and another attempt is made from the beginning. The MAP is based on a specific position fix or timing from a specific position fix.

Approach Clearance

A clearance for approach means that you can fly the published instrument procedure and descend to the altitudes published on the approach plate. Upon clearance, you must remain on the published route whether it is an approach airway, transition, or segment. In an airway, you may descend to the minimum en route altitude (MEA) as long as you are within 22 NM of the VOR. You also cannot descend when flying direct to an approach fix unless you are on a published route.

Minimum Sector Altitudes (MSA)

MSAs are published at the top of NOS approach plates in a 25 nautical mile circle. The center point reference of the circle is the three-letter fix ID listed at the top of the circle. MSAs are for emergency purposes only.

On the plate for Laconia Muni (figure 5.23), the MSA center point is the Belknap (BLO) NDB. The MSA for the sector between the 135° and 225° bearings is 5500 ft. The MSA for the sector from the 225° to the 315° bearing is 4700 ft. And the MSA for the remaining sector is 4300 ft.

Approach Segments

There are several segments to an overall approach which, when individually defined, make the procedure much easier to understand. Each segment is clearly defined on approach plates, with a defined beginning and end, and each require specific tasks by the pilot. Not all of these segments are part of all instrument approaches. The NDB approach plate for runway 16 at Eugene Airport is shown in figure 5.24. A three-dimensional view of this approach is illustrated in figure 5.25 to help you visualize the segments.

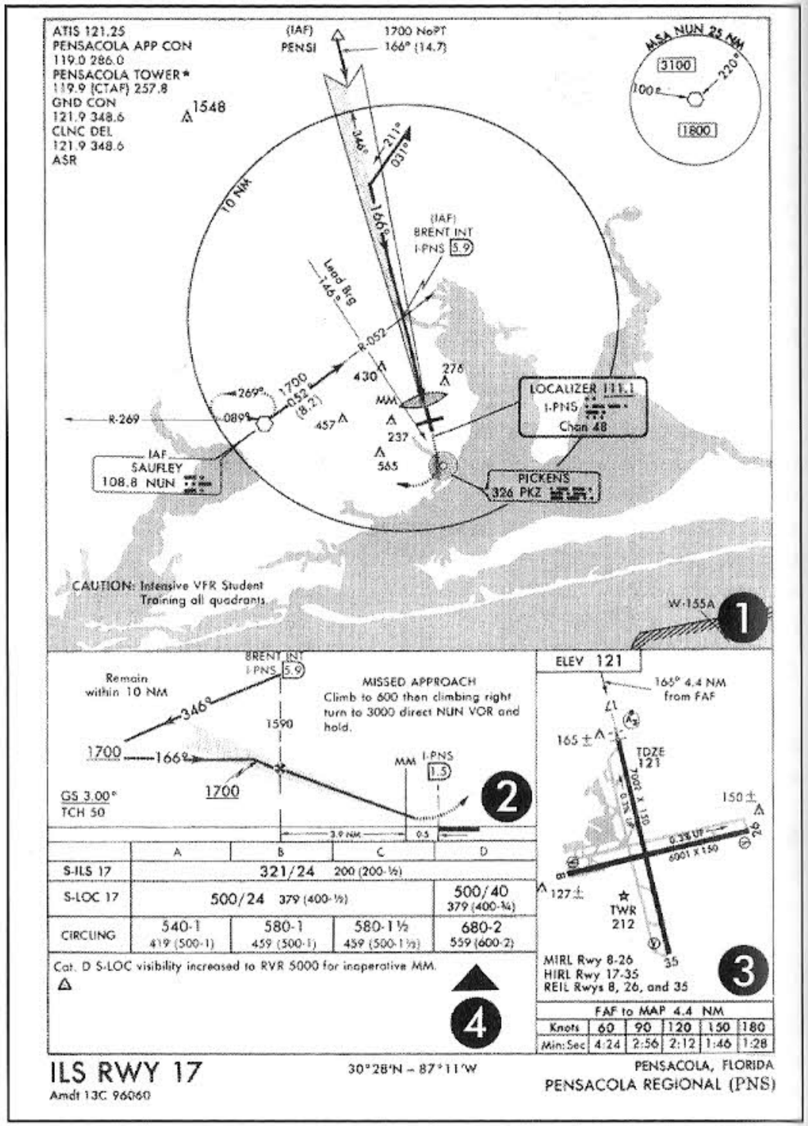


Figure 5.22 *ILS approach chart for the Pensacola Regional Airport Runway 17.* ❶ *Plan view;* ❷ *Profile view;* ❸ *Airport sketch;* ❹ *Minimums data.*

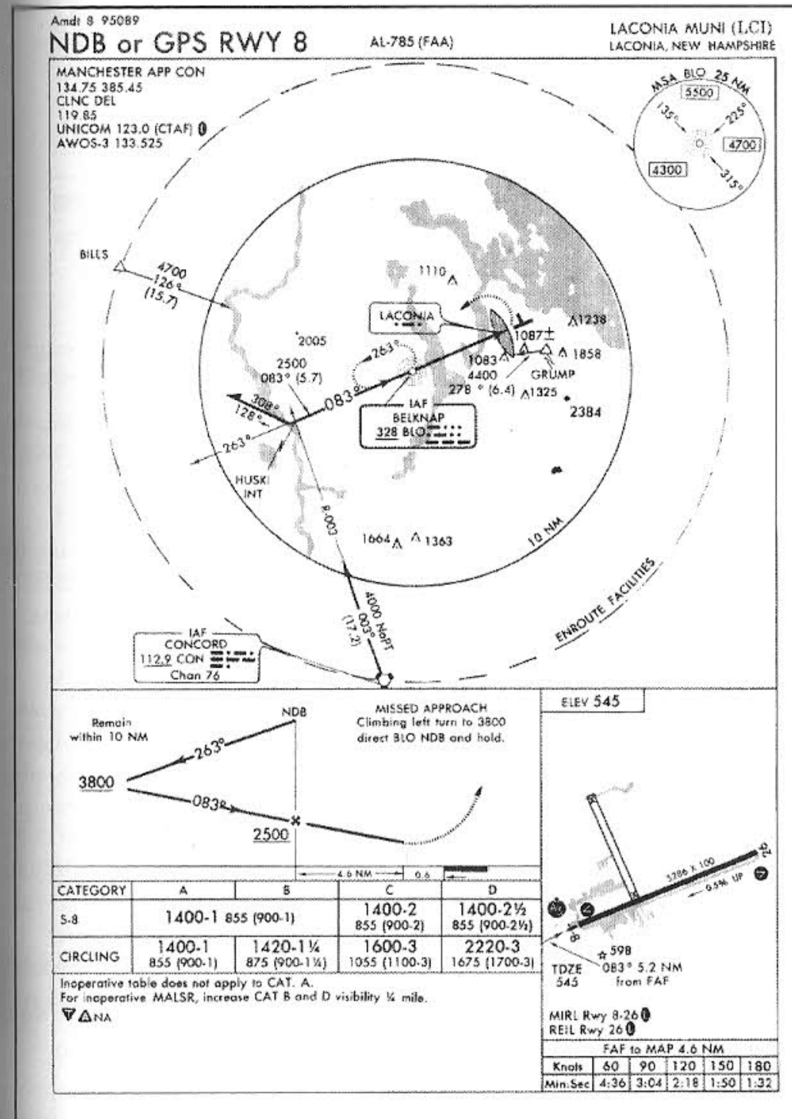


Figure 5.23 *MSAs are shown in a 25 NM circle at the top of approach plates.*

The **initial approach fix** (IAF), the Frakk LOM (locator outside marker), is where the approach begins. The LOM is collocated with an NDB. Upon reaching the fix, in this example, you turn to the 340° bearing (see profile view) outbound *from* the LOM to start the **initial segment**. The initial segment includes the entire procedure turn (more on this later), which begins with a 45-degree turn to a heading of 025°, followed by a 180-degree turn to a heading of 205°, and ending with another 45-degree turn back onto the 160° bearing *to* the LOM, all at an altitude of 2500 ft. The **intermediate**

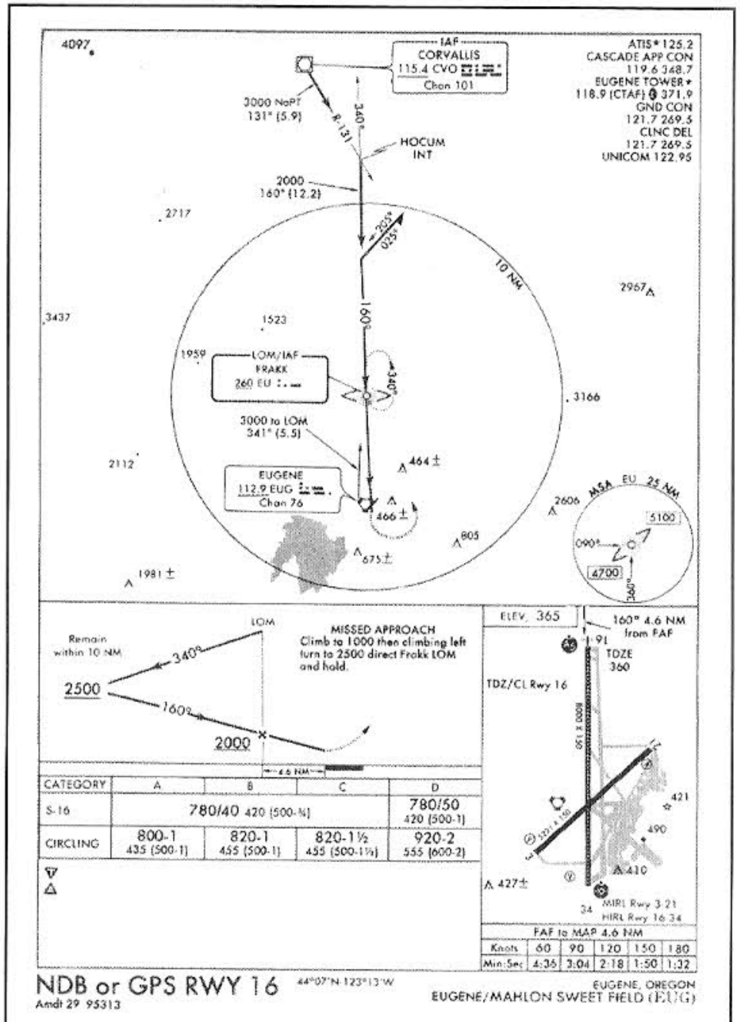


Figure 5.24 *The NDB approach for RWY 16 at Eugene Airport.*

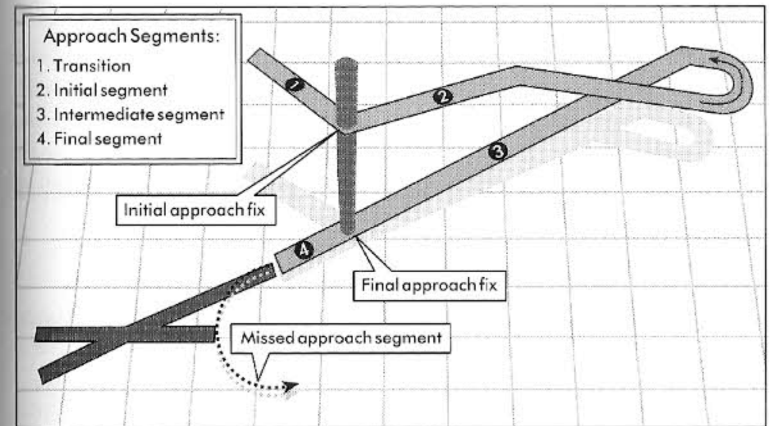


Figure 5.25 *A three-dimensional look at RWY 16 NDB approach into Eugene.*

segment begins at this point and continues until the final approach fix (FAF), which is also the Frakk LOM. This intermediate segment descends from 2500 ft at the end of the procedure turn, to 2000 ft at the FAF.

The **final segment** starts at the FAF and ends at the missed approach point (MAP). The final descent is made to the Minimum Descent Altitude (MDA) on this NDB approach, or 780 feet for a straight-in (with a runway visual range of 4000 ft), while still tracking the 160° bearing from the NDB. If you see the runway, you can land. If not, you must execute a missed approach.

The MAP in this approach is 4.6 NM from the FAF (see profile). You must time your segment from the FAF to the MAP to know when you've reached it. Consult the ground speed/time box in the lower right corner of the chart for assistance. The hashed curved line shows the path for a missed approach and the profile view gives a written description as follows: Climb to 1000 ft then make a climbing left turn to 2500 ft, proceed directly to the Frakk LOM, and enter the hold. Holding patterns are the "racetrack" symbol on approach charts.

More on holding, missed approaches, procedure turns, and other elements of the instrument approach appear later in this chapter.

Precision Approaches

Precision approaches provide *additional* vertical navigation assistance via an electronic glide slope. On precision approaches, the plane picks up the glide slope and descends to a level called the Decision Height (DH). If the runway is not in sight by the time the DH is reached, then a missed approach procedure is required.

The principle difference between precision and non-precision approaches is that the plane is in descending flight versus level flight at the minimum altitude.

A clearance for an instrument approach means you have permission to descend to the MDA or DH while following the procedure. To descend below the MDA or DH, you must have the runway, runway markings, or approach lights in sight and flight visibility cannot be less than specified on the approach chart. The airplane must be in a position from which a normal descent can be made to the runway. If these conditions do not exist, then you must perform a missed approach.

Instrument Landing System (ILS)

The goal of an Instrument Landing System (ILS), is to electronically guide the instrument pilot to where he or she can see the airport or runway at the correct time from the prescribed altitude. There are three areas of the Instrument Landing System: guidance, range, and visual information (see page 162).

Guidance consists of the localizer, which provides lateral guidance, and the glide slope, which provides vertical guidance.

Range is distance information, which is provided by the outer and middle markers. On some ILS approach charts, DME (distance measuring equipment) or other fixes may be shown as substitutes for the markers.

Approach lights, centerline lights, touchdown zone lights, and runway lights provide the visual information of an instrument landing system.

The Localizer

The localizer is an electronic extension of the centerline of the runway. The localizer transmitting antenna is located 1,000 feet beyond the rollout end of the runway. The transmitter operates on one of 40 ILS channels within the frequency range of 108.1 and 111.95 MHz. On approach charts, localizers are indicated by the letter "I" preceding the three-letter Morse code identifier. This avoids confusion with VOR fixes. Incidentally, the average localizer is four times more precise than a VOR.

Localizer signals are 700 feet wide at the approach threshold of the runway, or 350 feet to either side of the centerline of the runway.

The localizer has two close relatives. The Localizer Directional Aid (LDA) is a localizer with a signal that is more than 30° off the centerline of the runway, as demonstrated below. Some LDA approaches are created by using the localizer signal from one airport for an approach at a nearby airport. Others are created out of necessity for the surrounding terrain or neighboring prohibited airspace.

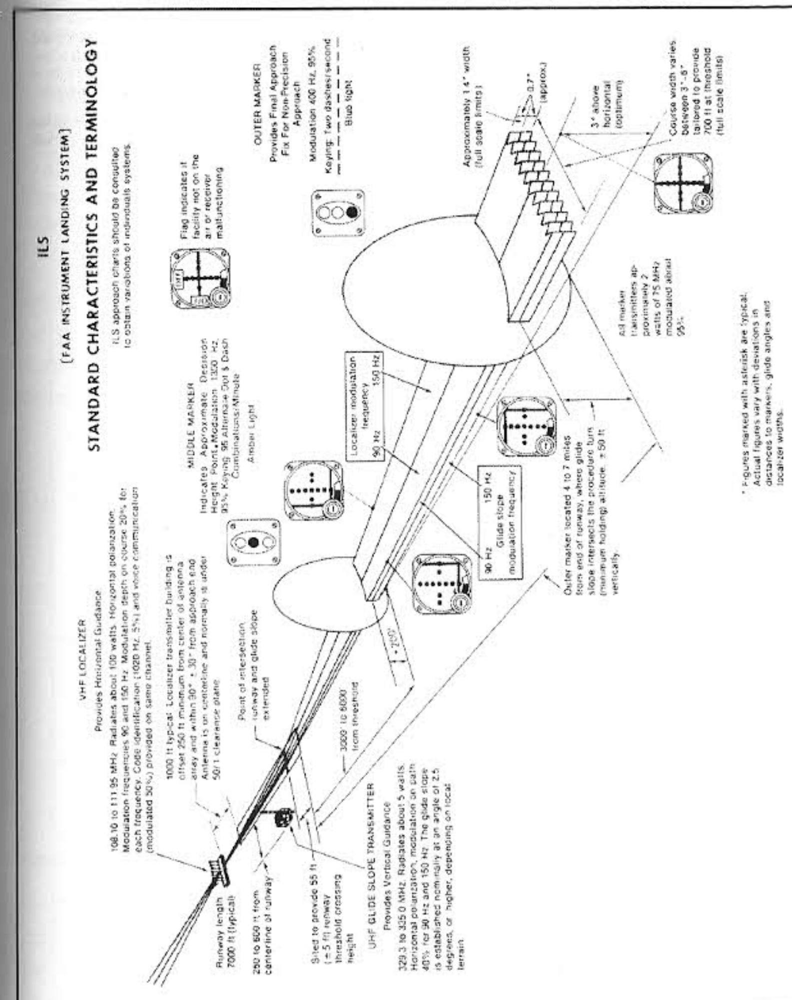


Figure 5.26 *The components of an ILS.*

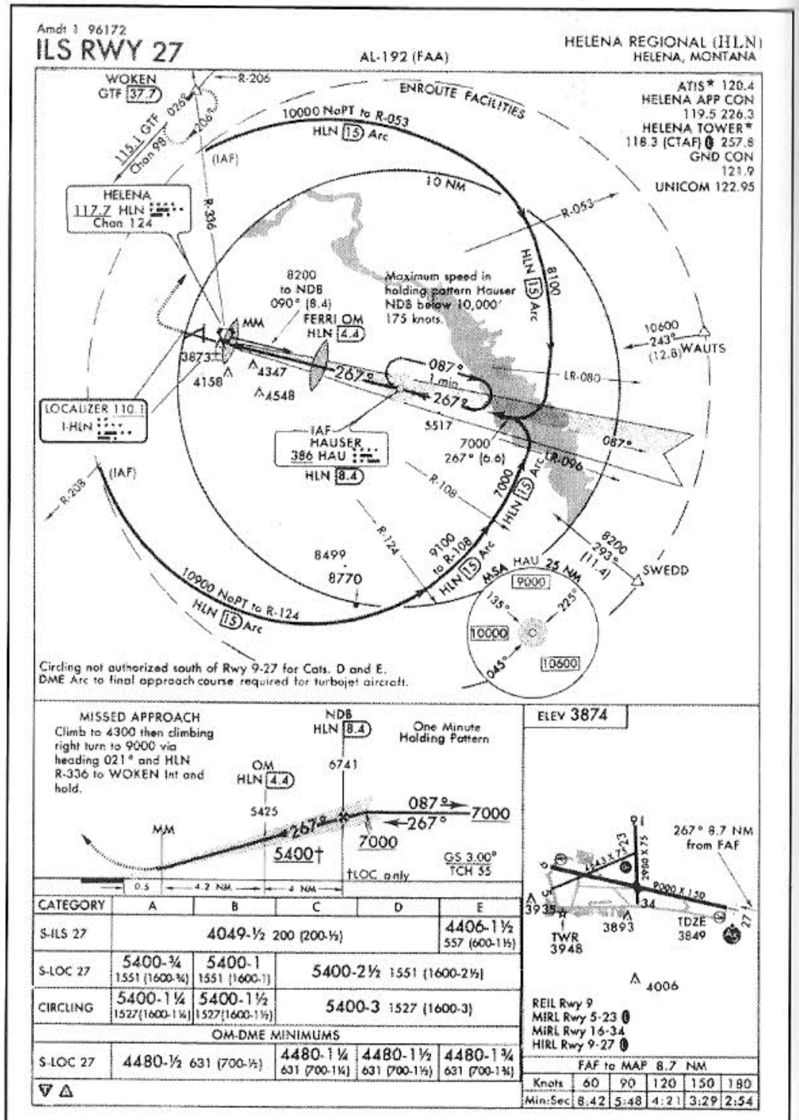


Figure 5.27 *The Runway 27 localizer at Helena Regional Airport in Montana.*

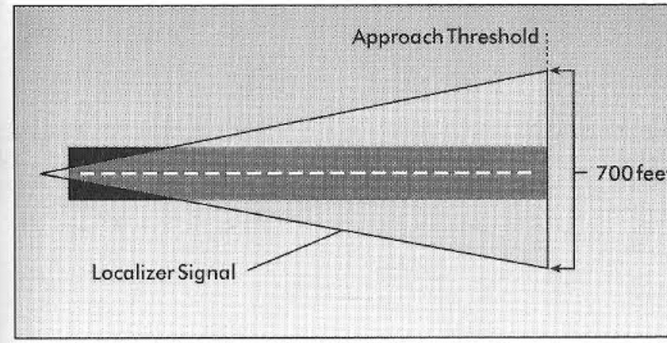


Figure 5.28 *All localizer signals cover a width of 350 feet to either side of the centerline at the approach threshold of a runway.*

Although rarely used, the Simplified Directional Facility (SDF) is a localizer without a glideslope, and with a signal that may or may not be aligned with the runway. All signals, however, are produced the same way, and all are considered localizers. SDF localizers do not have the letter "I" preceding the Morse code identifier on the approach chart.

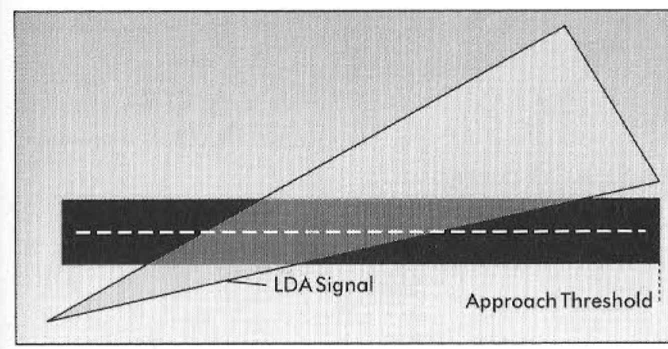


Figure 5.29 *The signal from a Localizer Directional Aid.*

The localizer signal is modulated at different frequencies on each side of the extended runway centerline, one side at 150 Hz, the other at 90 Hz. Where the two frequencies meet aligns with the center of the runway. Approach charts show one side of the localizer signal shaded. This is the 150 Hz side.

The CDI readings are as indicated in the above illustration when the airplane is positioned on course, and to the left and right of course. When the centerline of the runway is to the left of the plane, the needle is positioned left of center. When the centerline of the runway is to the right of the plane, the needle is positioned right of center. Imagine the needle as a symbol for the centerline of the runway. *Note: When flying a localizer, the CDI cannot be centered by using the OBS. This can only be done by positioning the airplane on the localizer centerline.*

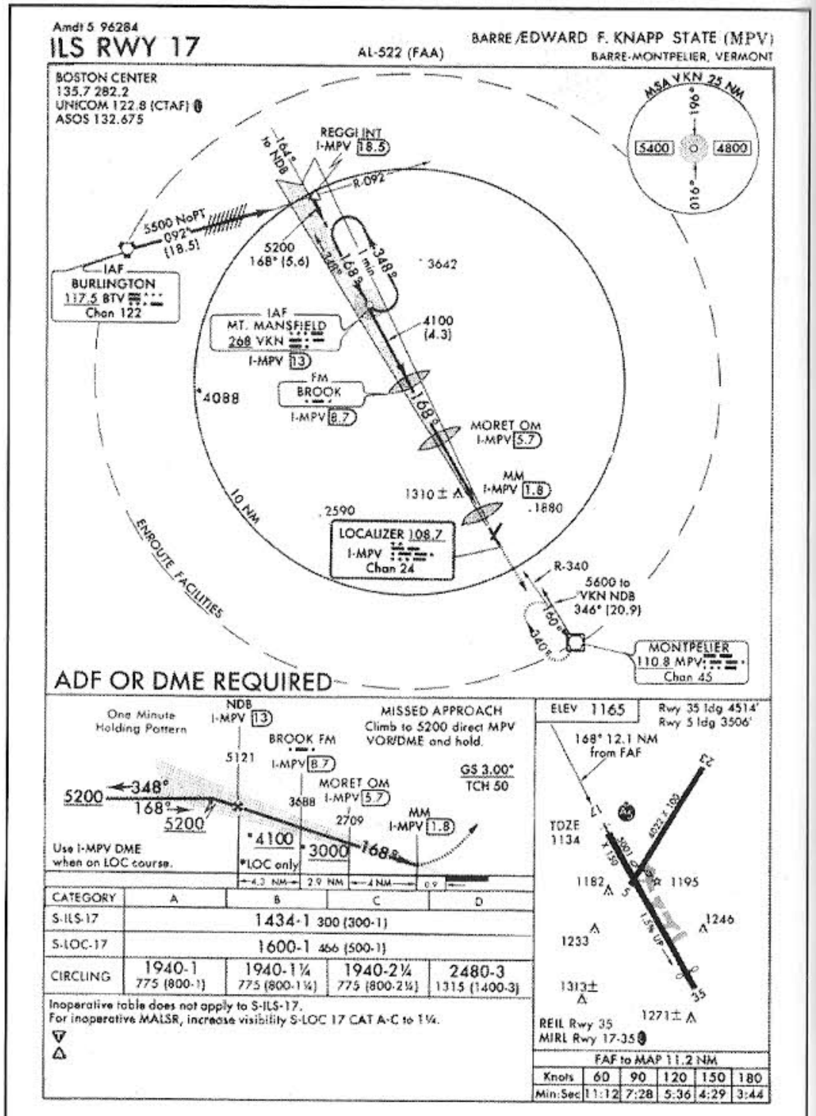


Figure 5.30 *An ILS approach chart for RWY 17 at Barre-Montpelier, Vermont.*

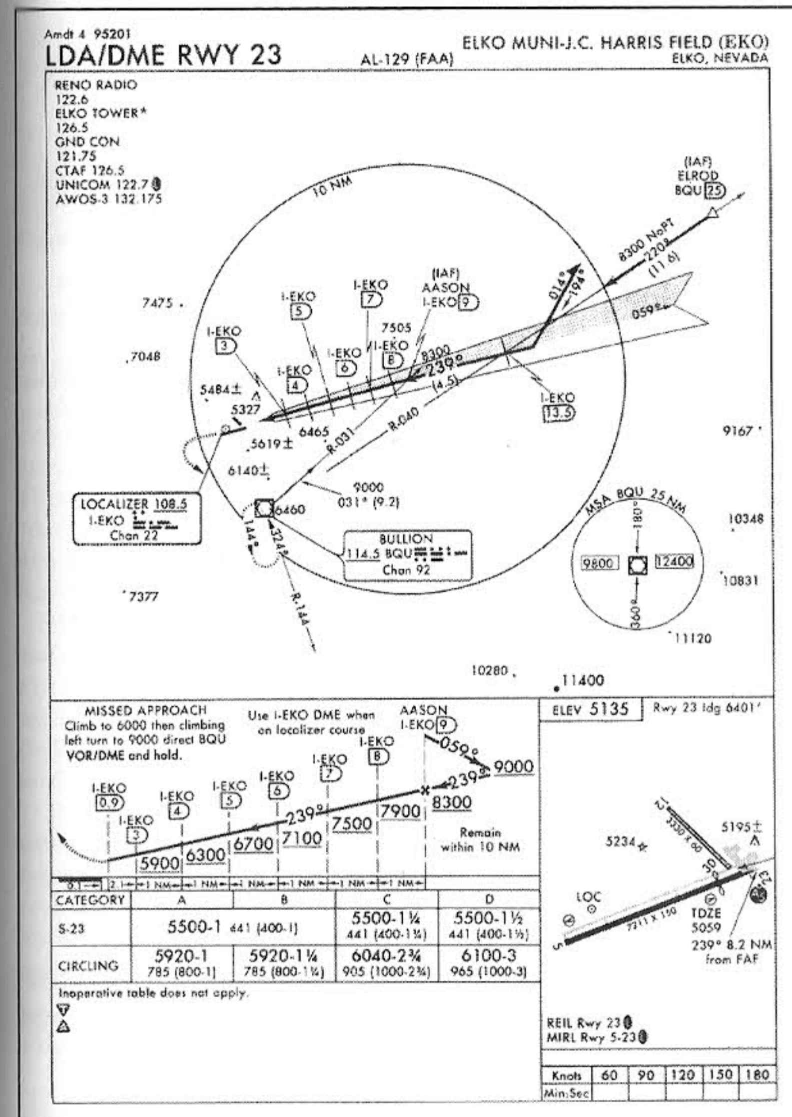


Figure 5.31 *An LDA approach chart for RWY 23 at Elko, Nevada.*

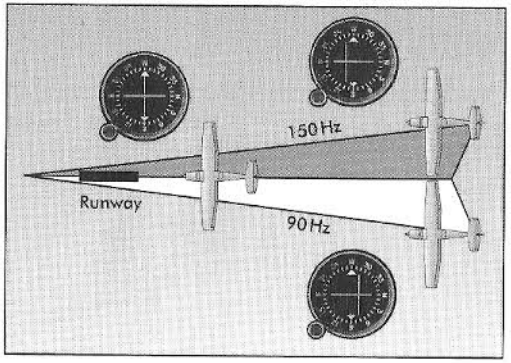


Figure 5.32 *The dual-modulation localizer signal.*

Localizer signals (including LDA's and SDF's) are transmitted on the front and back side of the localizer antenna. The two sides are called the front course and back course, respectively.

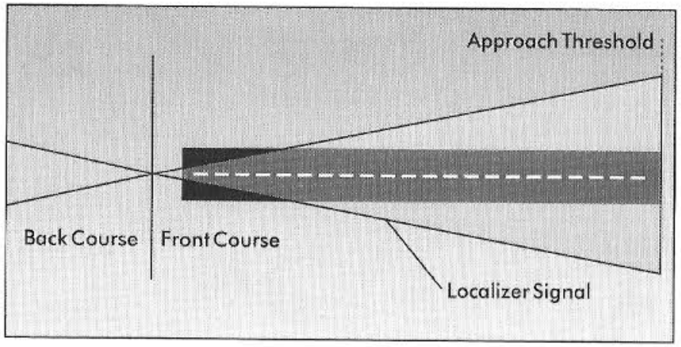


Figure 5.33 *The front and back course.*

The front and back course for a single localizer are displayed on two different approach charts. The back course chart is designated by a "BC" in the name of the chart. Note how the shaded side still appears on the same side of the runway for both the front and back course in the comparison of the two charts in figures 5.35 and 5.36.

Not all localizers have an approach for a back course. If this is the case, no chart exists for the back course.

When an approach is made using the back course, note, in the illustration below, how the CDI needle is positioned when the plane is on, left of, and right of the centerline. The left and right needle positions are the exact opposite of how they appear on a front course approach.

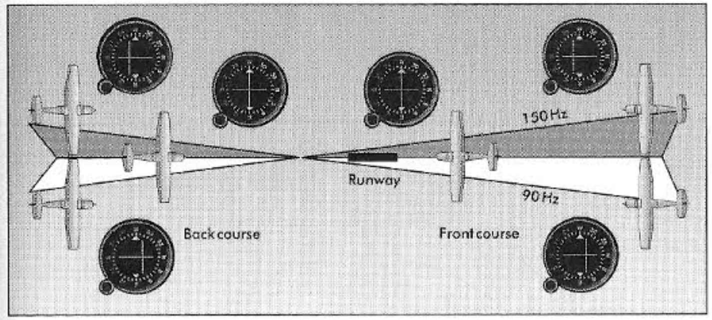


Figure 5.34 *CDI needle positions on a back course approach.*

This means that to correct toward the centerline while inbound on a back course approach, you would need to correct opposite the needle.

Flying the Localizer

As mentioned earlier, the localizer signal spans approximately 350 feet to either side of the centerline at the approach threshold of the runway. This means that on a 7,000 foot runway, the localizer signal is five degrees wide. Therefore, 6/10ths of a mile from the runway approach threshold, one "dot" on the face of the VOR represents approximately 100 feet of deviation. Five miles from the runway, one "dot" represents approximately 350 feet of deviation.

The tendency when flying the localizer, is to overcorrect for CDI readings that are off center. This results in flying S-turns across the extended centerline. The best practice is to limit heading changes to five degrees or less (unless the needle is fully deflected from center). As you can see from figure 5.34 above, the localizer signal becomes narrower as you get closer to the runway, so even smaller corrections are necessary.

Use the OBS to set the inbound heading – indicated on the chart – around four to seven miles out from the runway threshold. At this point, use two-degree heading changes to center the CDI. Be patient when correcting your heading – allow a little time for the CDI to reset. Also, you should only make these smaller heading changes with the rudder since there usually isn't enough time to do so by banking the airplane.

Marker Beacons

Marker beacons serve as the range components in the Instrument Landing System. Their signals are projected upward, from the ground, in an oval pattern (as indicated on approach charts) and provide distance information (see figure 5.39).

At 1,000 ft altitude above the marker beacon antenna, the dimensions of the marker beacon signal are 2,400 feet wide by 4,800 feet long. The airplane must be within the signal pattern to receive the signal.

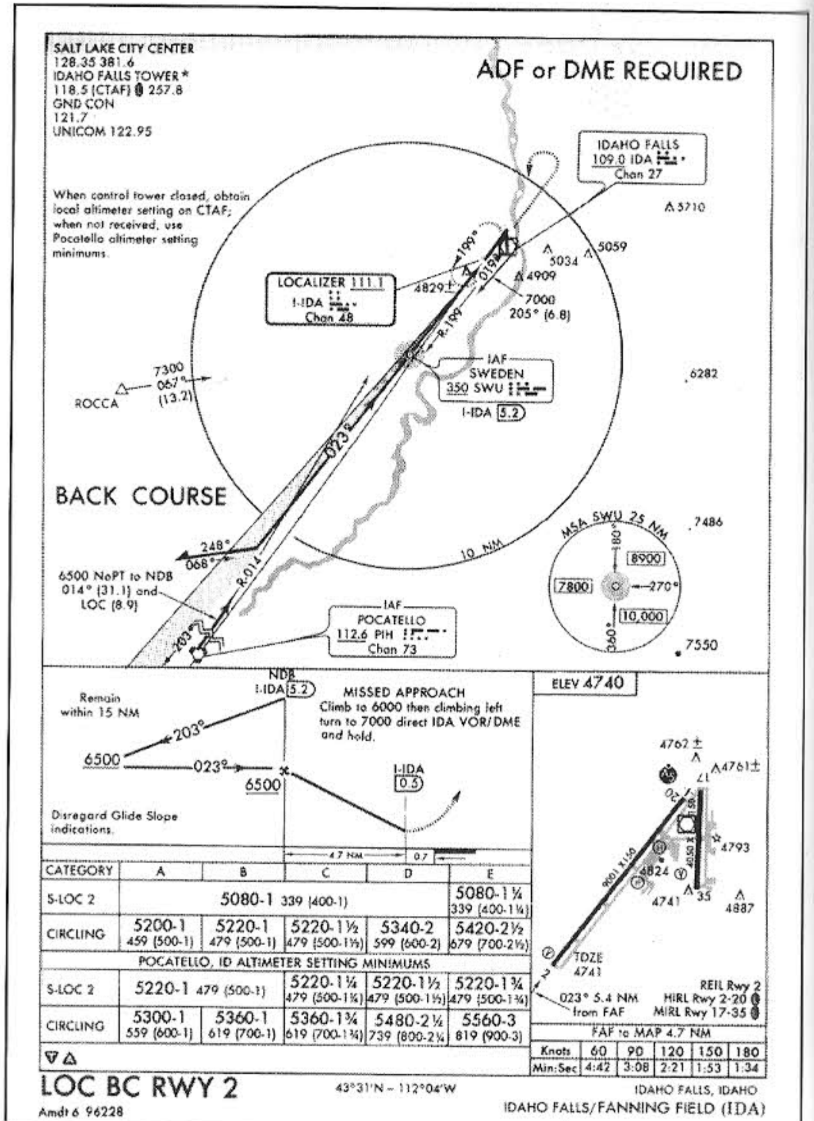


Figure 5.35 *This chart shows the localizer back course approach for RWY 2 in Idaho Falls.*

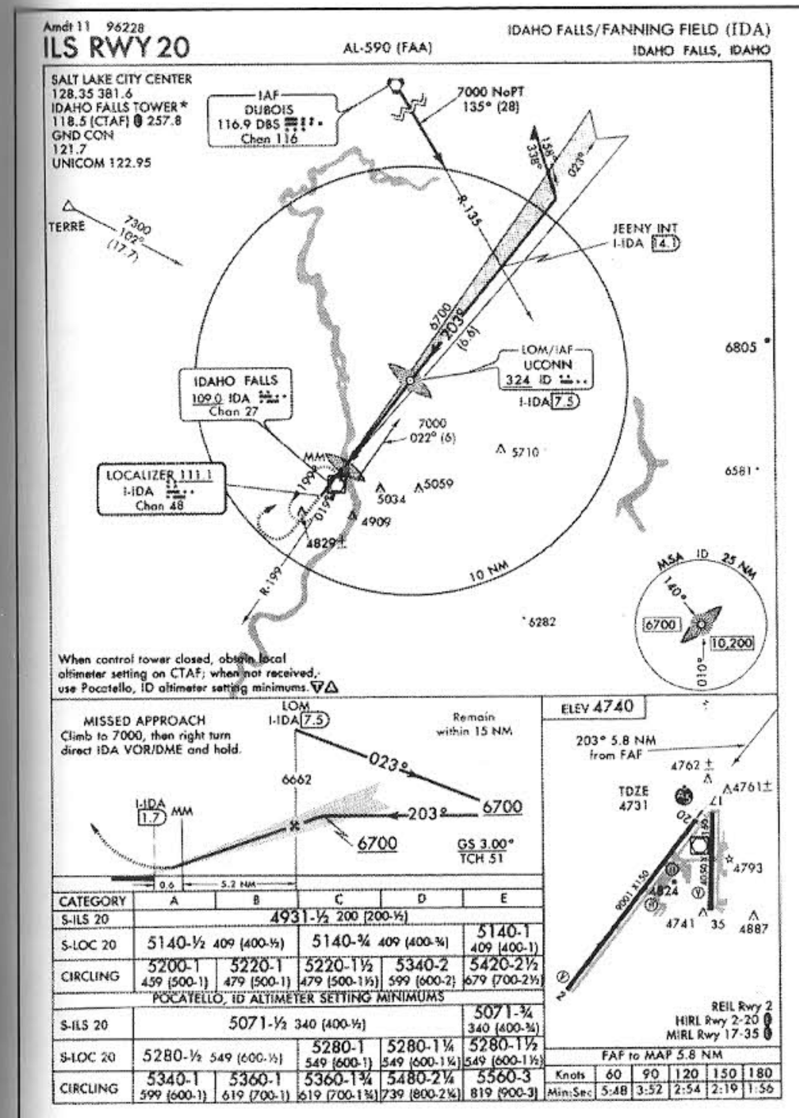


Figure 5.36 *The ILS "front course" approach for RWY 20 at Idaho Falls.*

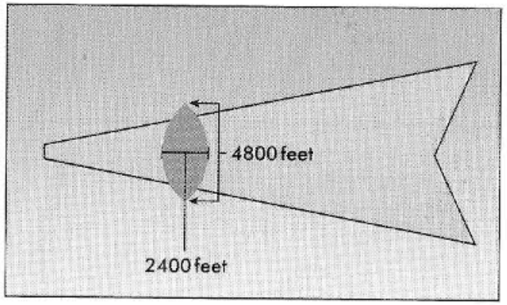


Figure 5.37 *The dimensions of a marker beacon signal.*

Outer markers are situated between four and seven miles from the approach threshold of the runway. You should intercept the glide slope just before the outer marker on the approach route. When the plane passes through the signal, the blue outer marker light (labeled "O") located on the audio panel flashes and you will hear a steady, low-tone series of beeps at the rate of two per second.

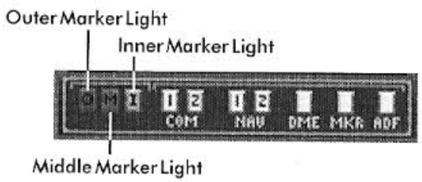


Figure 5.38 *The audio panel found on board* **Pro Pilot '99** *aircraft.*

Middle markers are situated about 3,500 feet from the approach end of the runway. At the middle marker, the glide slope centerline is about 200 feet above the runway touchdown zone. When the plane passes through the signal, the amber middle marker light (labeled "M") located on the audio panel flashes and you will hear an alternating long and short, high-pitch series of beeps at the rate of 95 pairs per minute.

The third light (white and labeled "I" on *Pro Pilot '99* audio panels), is reserved for inner, back course, and fan markers. Before discussing the inner marker, a little background on the categories of ILS approaches is required.

There are several categories of ILS approaches. Most fall into Category 1 ILS. The lowest possible DH in this category is 200 feet above the touchdown portion of the runway with a minimum visibility of ½ statute mile. The flight visibility may drop to 1,800 feet runway visual range (RVR) if the runway has touchdown zone and centerline lighting (more on lighting systems later in this section). RVR is a machine-measured horizontal visibility at the approach end of the runway.

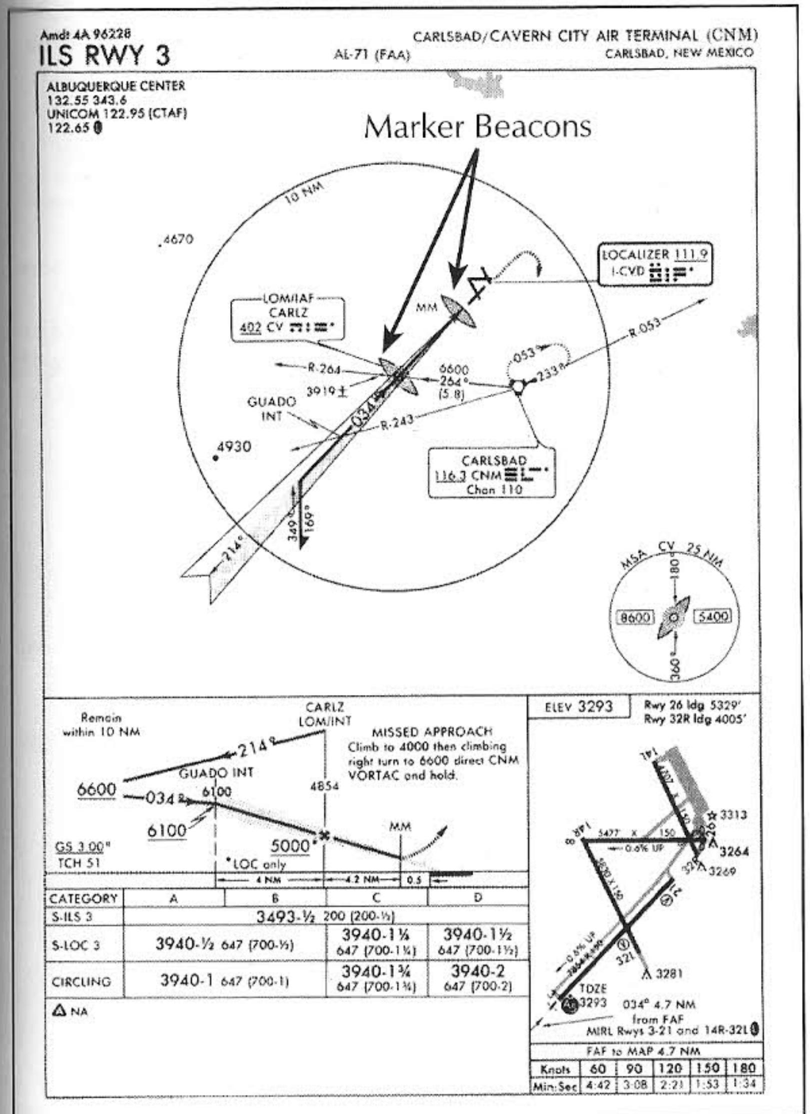


Figure 5.39 *Marker beacons are displayed on approach charts as shaded ovals along the approach route.*

At the other end of the spectrum is the Category 3c ILS which has a minimum DH of 0 feet and a minimum visibility of zero. This is a computer flown approach.

Category 2 and 3 ILS approaches use the inner marker which is located between the middle marker and the runway. Back course markers, though rare, are used as a final approach fix on a localizer back course approach. Inner and back course markers are identified by the flashing white light on the audio panel and a continuous high-pitched beep at the rate of six per second.

Fan markers, also rare, are used to establish a fix which is not part of an ILS or localizer approach.

The marker signal alone cannot be used to navigate to a marker beacon. Therefore, NDBs are situated at many marker sites and are referred to as compass locators. Compass locator signals can be received out to 15 miles and can be navigated to by using the ADF.

Outer compass locators (or locator outer markers, LOM) are identified by the first and second Morse code letters of the localizer identifier (see figure 41). Middle compass locators (or locator middle markers, LMM) are identified by the second and third Morse code letters of the localizer identifier. In the example in figure 5.42, the localizer for runway 22 at Albuquerque, New Mexico, is identified as AEG. The outer marker (LOM) is identified as AE. Similarly, in figure 5.43, the localizer for runway 16R into Reno, Nevada is identified as RNO. The middle marker (LMM) is identified as NO.

The Glide Slope

The glide slope provides vertical navigation for precision approaches. Glide slope signals are transmitted on ultrahigh frequencies. There are 40 localizer frequencies each paired with a glide slope frequency. On most receivers, the glide slope frequency is automatically tuned along with the localizer frequency.

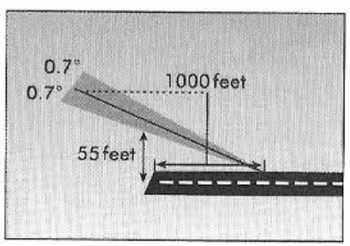


Figure 5.40 ***The glide slope signal height above the approach threshold of the runway is 55 feet.***

Think of a glide slope as a localizer turned on its side, only more accurate. The glide slope antenna is positioned on either side of the runway about 1,000 feet from the approach end so that the signal height above the approach threshold is 55 feet. The total depth of the signal is 1.4°, or 0.7° to either side of the glide slope centerline.

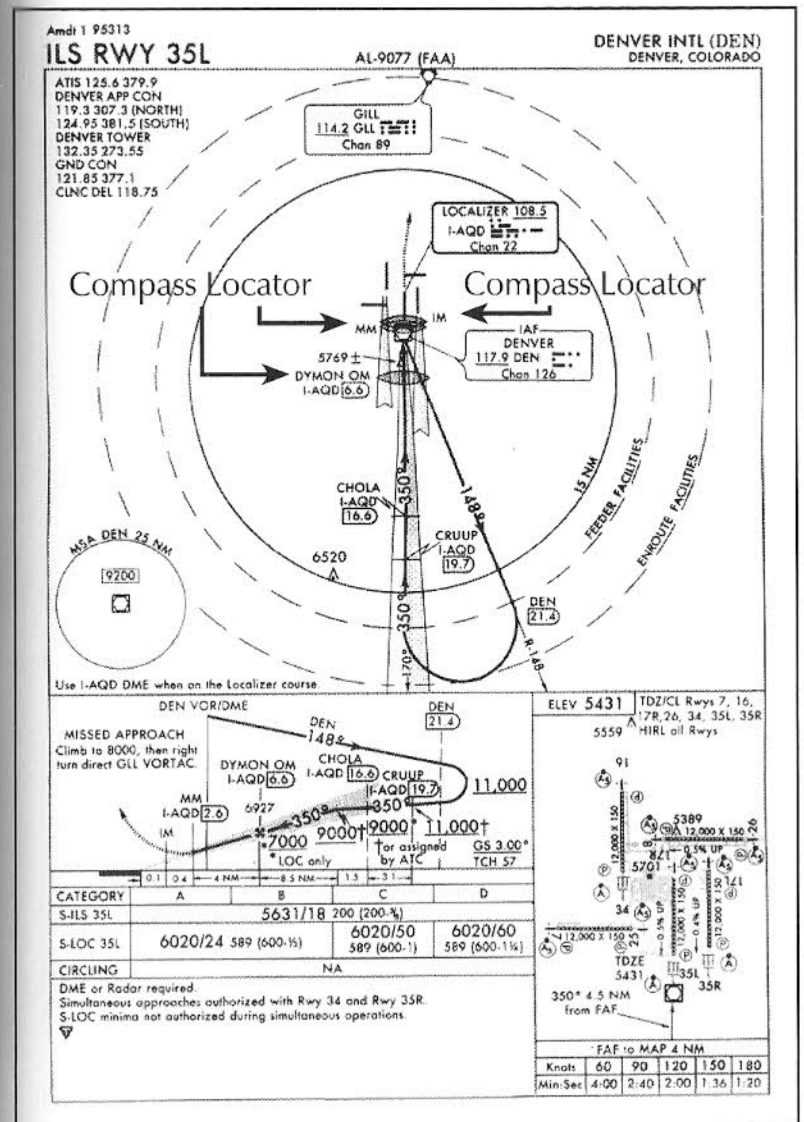


Figure 5.41 ***Compass locators are actually NDBs which are situated alongside a marker beacon.***

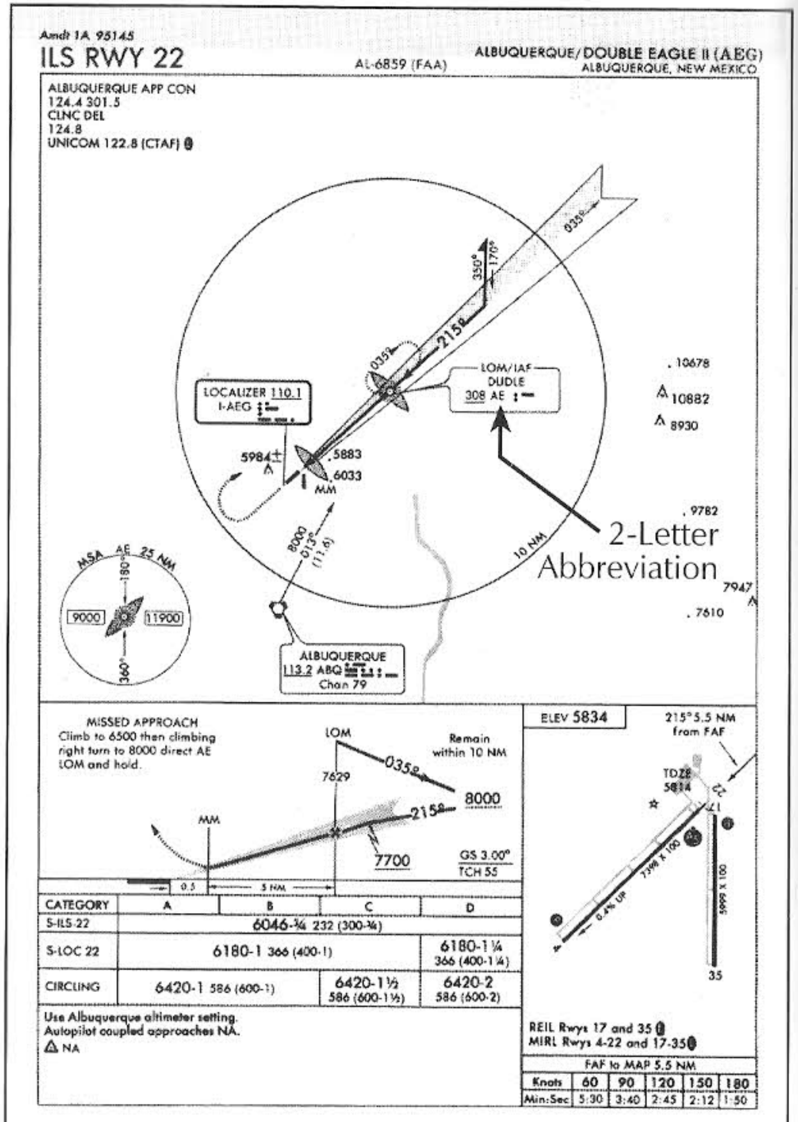


Figure 5.42 *The two-letter designation for the outer marker as depicted on NOS charts.*

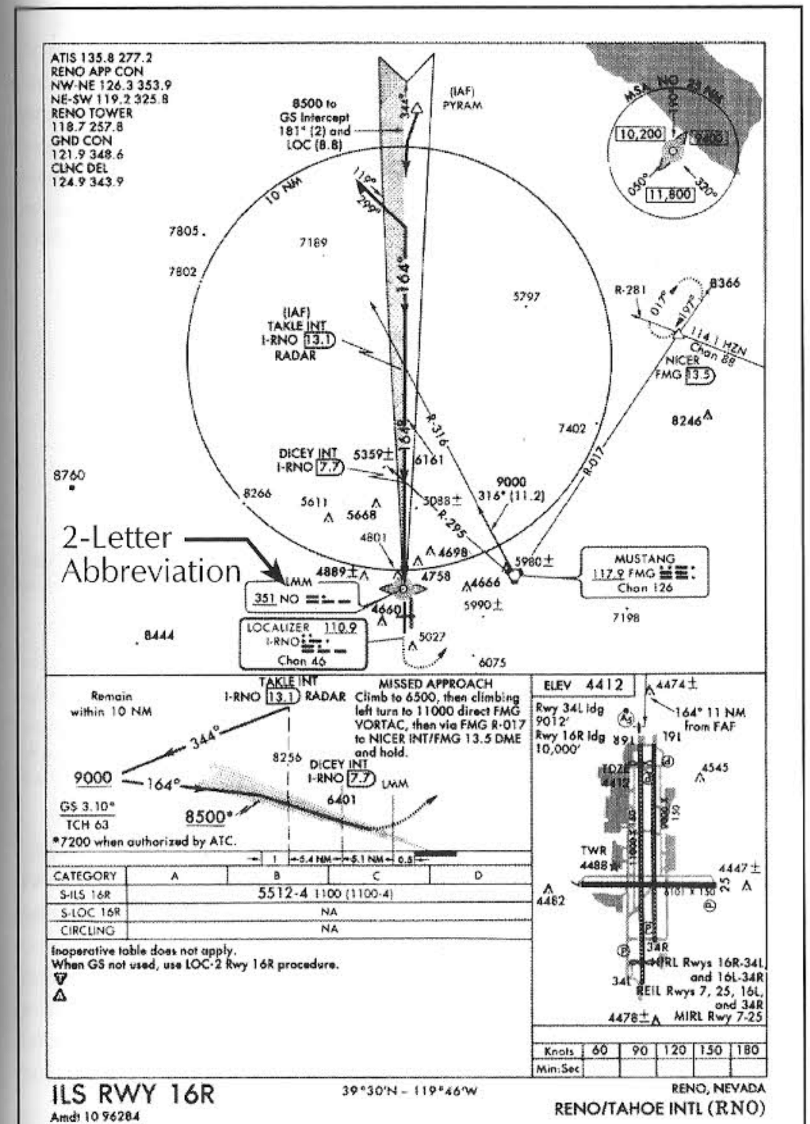


Figure 5.43 *The two-letter designation for the middle marker as depicted on NOS charts.*

The optimal angle for a glide slope is 3° above the horizon. Because glide slope signals are reflected signals, false glide slope signals may be picked up by the glide slope indicator. Approach procedures are designed to prevent intercepting a false signal. These false signals are always positioned above the real glide slope with the lowest one at 10° above horizontal. You will recognize a false glide slope by the high angle of descent (over 1,000 feet per minute) required to maintain it.

The glide slope indicator is the horizontal needle on the NAV instrument. When the needle is above center it means the plane is below the glide slope. When the needle is below center, the plane is above the glide slope. Glide slopes are only used when the approach chart specifies one.

The glide path is that portion of the glide slope that intersects the localizer signal. The dimensions of a typical glide path are shown below.

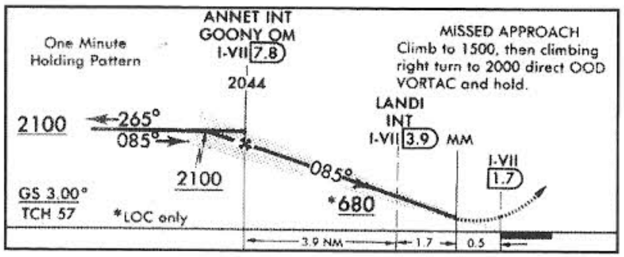


Figure 5.44 *A typical ILS glide path.*

The outer marker is 5.6 miles from the middle marker, which is 0.5 miles from the approach end of the runway. The outer marker glide path signal is about 2,000 feet above the runway elevation and the middle marker glide path signal is about 200 feet above the runway.

At the outer marker, the total depth of the glide slope signal is 400 feet above and below the centerline of the glide path. Therefore, a fully deflected needle on the glide slope indicator means the plane is 400 feet above or below the centerline of the glide path. Subsequently, a half-scale deflection represents about a 200-foot variation.

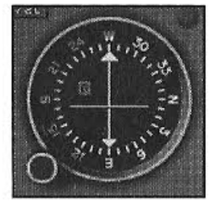
At the middle marker, the total depth of the glide slope signal is 50 feet above and below the centerline of the glide path. Therefore, a fully deflected needle on the glide slope indicator means the plane is 50 feet above or below the centerline of the glide path. Subsequently, a half-scale deflection represents about a 25-foot variation.

The rate of descent to stay on a 3° glide path is a function of the plane's groundspeed. The formula for determining this rate of descent is:

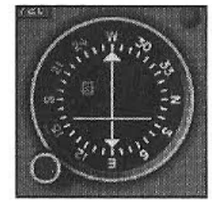
groundspeed/2 x 10

Therefore, a groundspeed of 60 knots requires a rate of descent of around 300 feet per minute (fpm) and a groundspeed of 180 knots requires a rate of descent around 900 fpm. Rate of descent tables can be found inside the NOS approach chart books.

Before you begin your approach, estimate your average groundspeed considering the wind speed at your altitude and the surface wind. As you intercept the glide path, reduce power to the setting that gives you the proper rate of descent. Any altitude deviations at less than half scale above or below the glide path should be corrected by pitch adjustments alone. Any deviations greater than half scale, or deviations that are happening quickly, should be corrected by a power adjustment.



Half scale or smaller deviation



Half scale or greater deviation

Figure 5.45 *Half scale or smaller deviations: correct with pitch changes; half-scale or greater deviations: correct with power change.*

Power adjustments should be kept small. If you are close to the proper power setting and the glide path deviation is small or happening quickly, an adjustment of 50 rpm for fixed pitch propellers, or a ½ inch in manifold pressure on constant speed propellers, is adequate.

Airport Lighting Systems

Approach lights, touchdown zone lights, centerline lights and runway lights provide the visual component of an ILS. The Approach Light System (ALS) assists IFR pilots in making the transition to visual flight for landing. It consists of a variety of configurations and sophistication depending on the complexity of a particular runway. For the most part, the ALS consists of flashing and steady lights that provide direction to the runway in use. For precision runways, the lights begin at the runway threshold and extend for 2,400-3,000 feet down the runway. For non-precision runways, the lights only extend 1,400-1,500 feet.

Runway lighting comes in many configurations. For a complete list, refer to Appendix A where you will find reproductions of the approach lighting systems legends found in all NOS charts. To see what the lighting system is for a particular runway, consult the airport diagram in the lower right corner of that runway's approach plate.

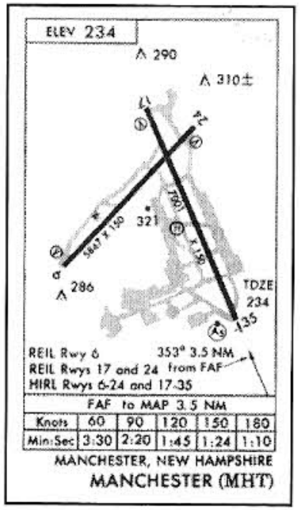


Figure 5.46 *The airport diagram on approach plates lists the runway lighting systems on each runway.*

VOR Approaches

Almost all en route navigation and many instrument approaches use VOR (VHF Omni-directional Range) signals. The IFR en route airspace structure consists of airways that are defined by VOR's. VOR was first discussed in the section on VOR navigation, so here we will simply summarize: Point the airplane toward (inbound) or away from (outbound) the VOR station on a specified radial while making a heading correction (if necessary) to account for any wind.

ADF Tracking and NDB Approaches

The Automatic Direction Finder (ADF) is covered in the section on NDB Navigation. Tracking NDB's on inbound and outbound radials using the ADF is a common method of instrument flying. In the United States, there are hundreds of airports served by NDB approaches that would otherwise be inaccessible for IFR conditions. ADF tracking is also a valuable option when other equipment fails.

DME Arcs

DME (distance measuring equipment) arcs are used as initial segments of some VOR-DME approaches (figure 5.44); as initial segments of some ILS and localizer approaches; and as intermediate, final, and missed approach fixes on some VOR approaches. In the latter case, radials from the VOR that intersect the arc are used as fixes.

Procedure Turns

Procedure turns were first mentioned in the discussion of approach segments. They are used to reverse direction on a specified course (i.e., from 180° to 360°). The procedure turn is part of the initial segment in an approach, which follows the initial approach fix (IAF). A procedure turn is essentially two 45° turns and one 180° turn. It is begun two minutes after crossing the IAF, on the outbound portion of the initial segment. Make a 45° turn to the specified side (the approach plate will show you whether a left or right turn is called for) and maintain that heading for one minute.

At this point, use the heading indicator to show the 45° heading change. Also, if you are tracking a VOR outbound, the CDI will move off center. Dial in the reciprocal of the outbound heading you were just on to set up for the inbound course. If you are tracking an NDB, the ADF should point to 45° off tail at the start of the turn.

The next step is to make a 180° turn to re-intercept the inbound course (the 180° reciprocal of the outbound course). At the end of this turn on a VOR fix, the CDI should be centered again and the heading indicator should have come a full 180°. On an NDB fix, the ADF needle should be 45° off the nose. Complete the 45° turn back to the inbound course to start the intermediate segment of the approach.

Procedure turns appear differently on Jeppesen and NOS charts. The only difference is that Jeppesen shows the entire turn, where NOS charts only show the initial 45° turn. The outbound and inbound 180°-turn headings are always displayed.

Holding

Holding is requested by ATC to delay your landing for any number of reasons, usually heavy traffic. You will also enter a hold after a missed approach or to allow minimum conditions to settle in should they not initially exist. Holding is a complex element of instrument approaches that requires a lot of study and practice. Only the rudimentary terms are covered here. Refer to any of the instrument publications in the bibliography for a thorough explanation on this topic.

The components of a standard holding pattern are:

Standard Hold – a hold where all turns are made to the right.

Non-Standard Hold – a hold where all turns are made to the left.

Holding Course – the course flown on the inbound leg *to* the holding fix.

Inbound Leg – the one-minute leg to the holding fix; this leg varies (1.5 minutes when flown above 14,000 ft MSL) if specified in a clearance.

Holding Fix – this can be a VOR, NDB, LOM, DME fix, or intersection.

Outbound Turn – a standard rate, 180°-turn, which is begun at the holding fix.

Abeam – the position opposite the holding fix where the outbound leg begins.

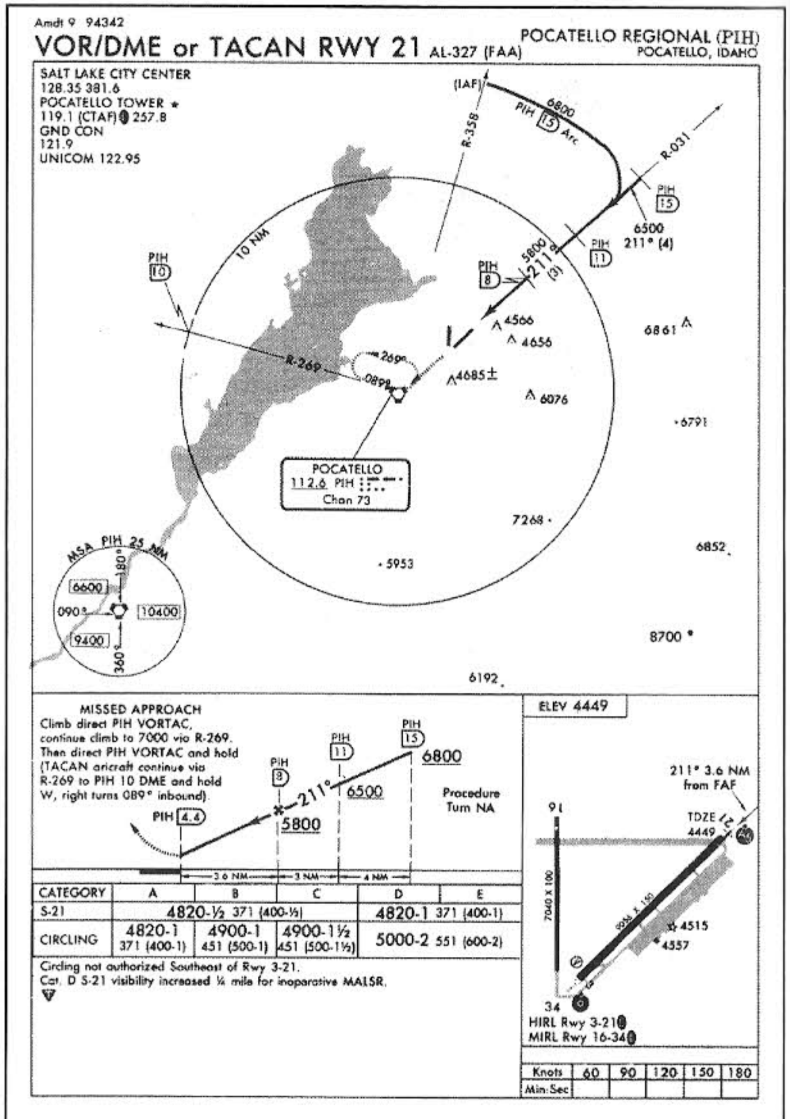


Figure 5.47 *A DME arc serves as the initial approach segment for the Pocatello VOR/DME approach to runway 21.*

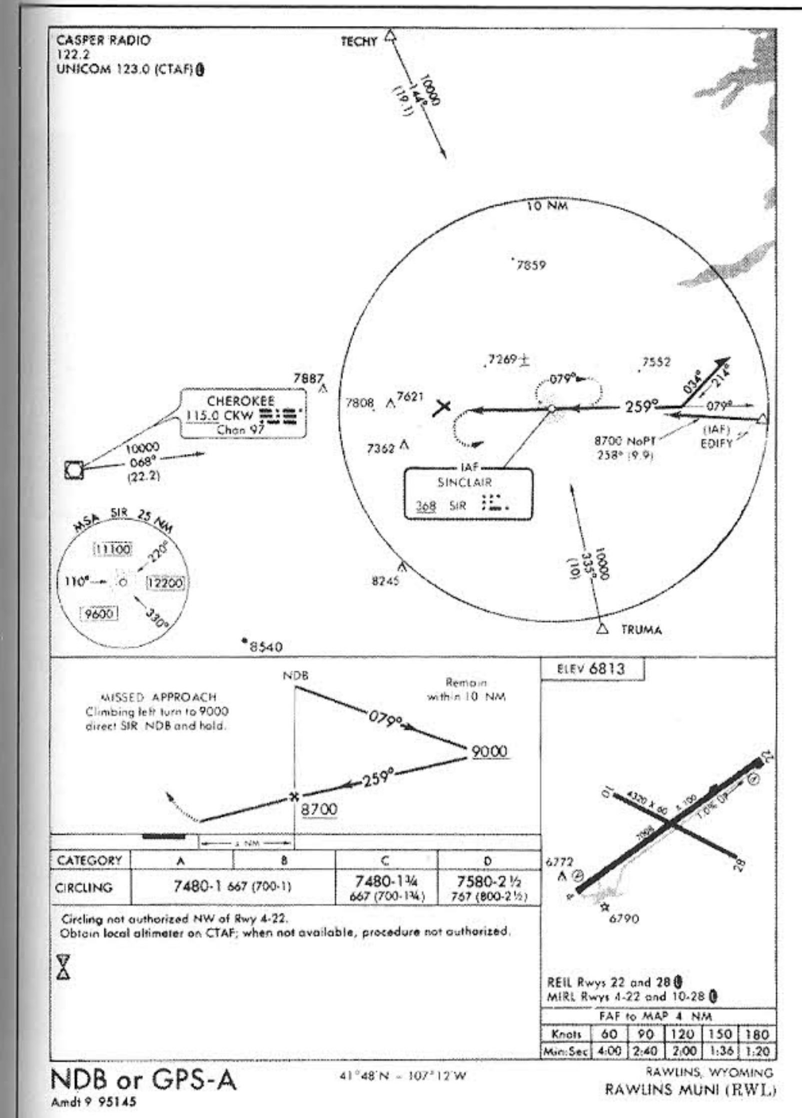


Figure 5.48 *The procedure turn for the NDB approach at Rawlins Muni, Wyoming. The outbound course from the IAF is 079°; the 45° turn is to the left on a heading of 034°; the 180° turn is made to a heading of 214°; and the second 45° turn is to the inbound course of 259°.*

Outbound Leg – this leg is defined by the inbound leg; adjust the outbound leg so the inbound leg is one minute and so the inbound turn (standard rate, 180°-turn) is completed just as the holding course is intercepted.

Holding Side – the side of the course where the hold is accomplished.

Non-Holding Side – the side of the course where you shouldn't be holding.

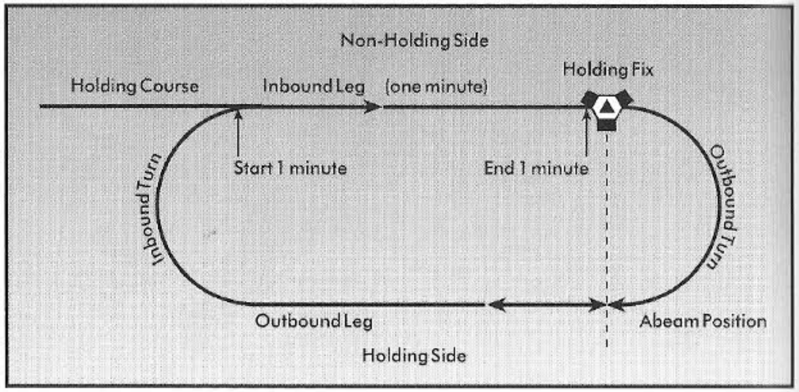


Figure 5.49 *The components of a standard holding pattern.*

The maximum legal holding speed is 175 knots for all propeller-driven aircraft.

There are three types of entries into a holding pattern depending on your initial orientation to the fix. The three possible entry regions are shown in figure 5.50. The respective entry procedures are displayed in figures 5.51, 5.52, and 5.53.

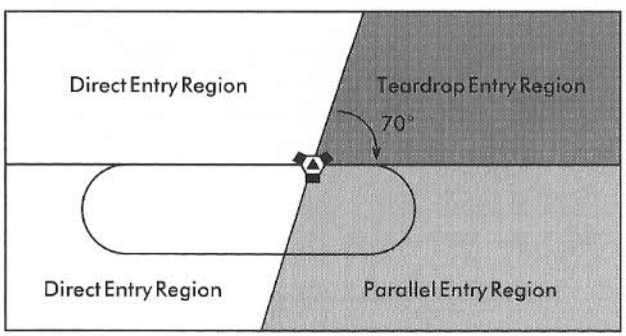


Figure 5.50 *The three possible entry regions to a holding fix are direct, teardrop, and parallel.*

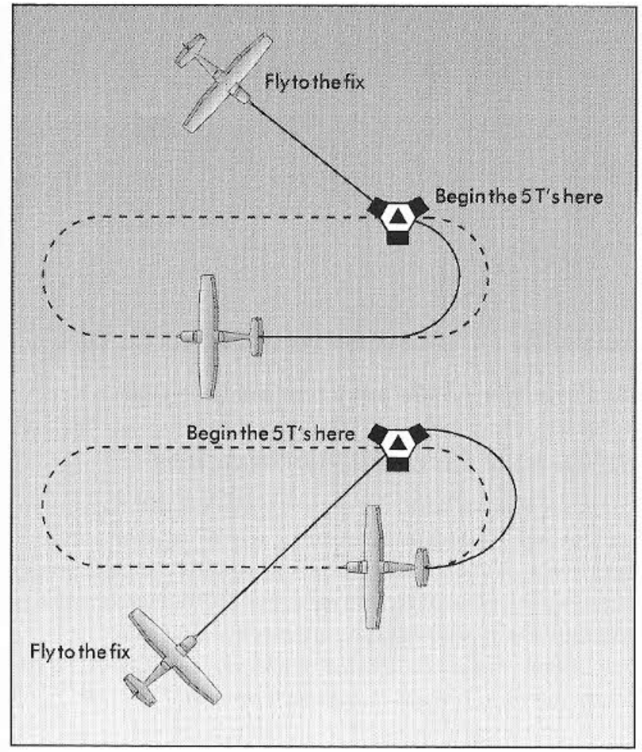


Figure 5.51 *The proper direct entry into a holding pattern.*

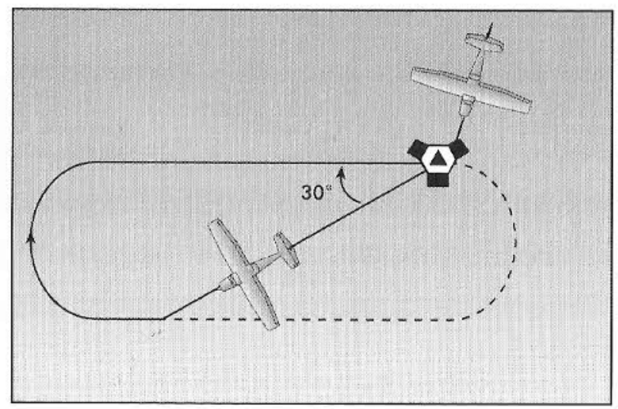


Figure 5.52 *The proper teardrop entry into a holding pattern.*

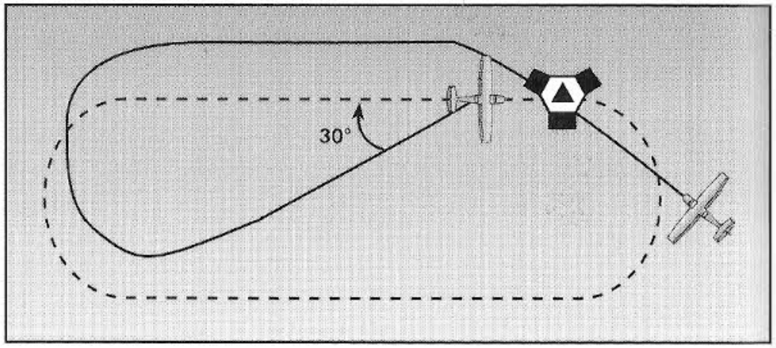


Figure 5.53 *The proper parallel entry into a holding pattern.*

Straight-In and Circling Approaches

Straight-in approaches are to the runway specified on the approach plate and require that the final approach course be at a 30° angle or less from the extended centerline of the runway. If the final approach angle is greater than 30°, or if the straight-in would require excessive descent upon making visual contact with the runway, then a circling approach is required.

Approach plates that are designated by a letter (i.e., VOR-A, NDB-B) in the title do not have any straight-in approach options.

One of the primary requirements of a circling approach is that you maintain visual contact at all times with the airport during the circling maneuver. A missed approach must be made if any part of the airport is not distinctly visible while circling at or above the MDA. A descent can only be made from the MDA or DH when the airplane is in a position where a normal rate of descent can be made using normal maneuvers.

The size of the circle flown is related to the speed of the aircraft as follows:

Approach Category	1.3 x V_{SO} speed* (knots)	Approach Area Radius(miles)
A	0-90	1.3
B	91-120	1.5
C	121-140	1.7
D	141-165	2.3
E	Above 165	4.5

* V_{SO} = the stall speed at the maximum weight in the landing configuration (power off, flaps down, gear down).

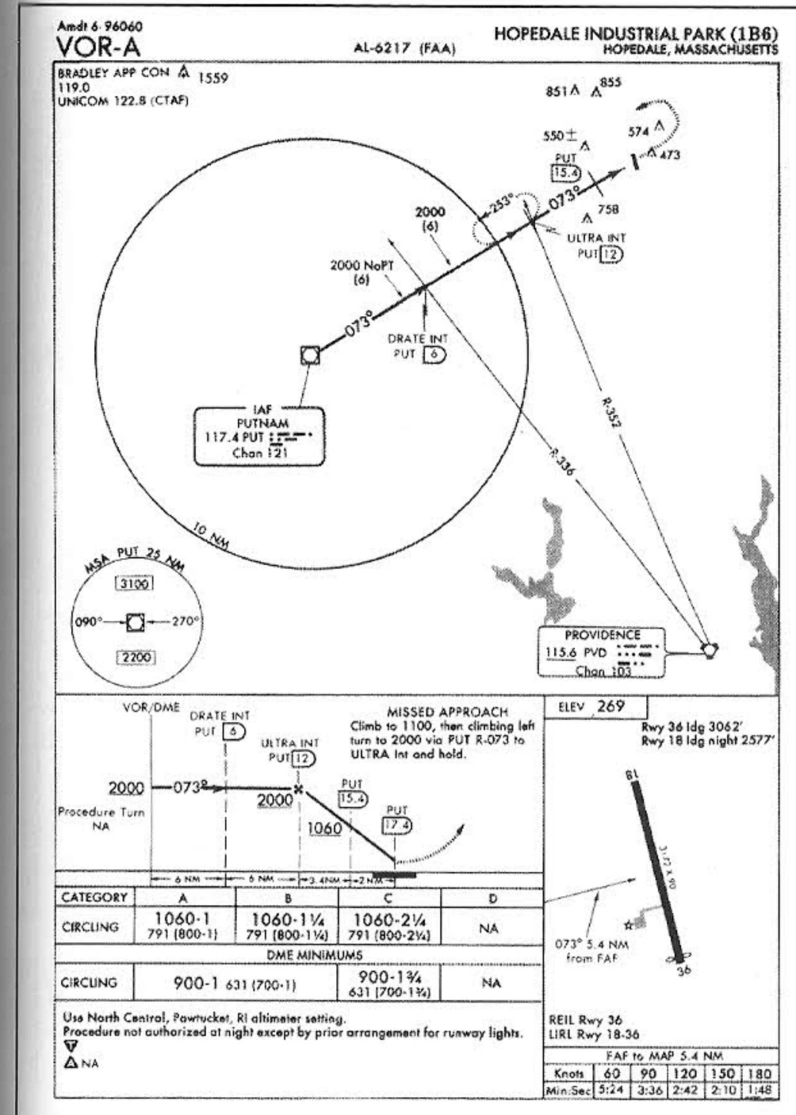


Figure 5.54 *The airport at Hopedale, Massachusetts has only one circling only approach.*

CATEGORY	A	B	C	D
CIRCLING	1060-1 791 (800-1)	1060-1¼ 791 (800-1¼)	1060-2¼ 791 (800-2¼)	NA
DME MINIMUMS				
CIRCLING	900-1 631 (700-1)		900-1¾ 631 (700-1¾)	NA

Figure 5.55 ***The minimums excerpt from the Hopedale approach plate.***

The minimums listed for the circling approach at Hopedale are translated as follows: for aircraft in category A on a non-precision approach, the MDA is 1,060 ft with a one mile runway visual range. At this altitude, the plane is 791 ft above the runway elevation. The numbers in parenthesis are for military use only.

Likewise, the MDA for aircraft in category B is 1,060 ft with an RVR of 1-1/4 mile. The altitude above the runway elevation is still 791 ft. Category C aircraft have an RVR of 2-1/4 miles.

The minimums for a precision approach, which involves a decision height instead of an MDA, are listed below the non-precision minimums.

On a circling approach, you should maneuver, by the shortest distance possible, to the base or downwind leg to set up for the landing.

Missed Approaches

All instrument approach procedures include a missed approach point (MAP). This is the point along the minimum descent altitude (MDA) or at the decision height (DH) where, if you do not have the runway in sight, you must execute a missed approach. Missed approach instructions vary, but usually require an immediate climb or a climbing turn, or both, followed by a route directly to a holding fix. Once in the hold, you must decide if the below-minimum ceiling was temporary or not. If so, you may try another approach if cleared. If not, and if you so request, you'll receive a clearance to fly to the alternate airport you listed on your flight plan.

Missed approach procedures are displayed in the profile view of all approach plates. The chart for the Centerville VOR runway 2 is shown in figure 5.56.

The procedure, printed next to the profile view, reads: "Climb to 2600 then right turn direct GHM VORTAC and hold." The GHM VORTAC in this case also happens to be the IAF, so upon a second clearance, you would begin the approach procedure from this fix to the procedure turn.

Standard Terminal Arrival Routes (STARS)

Standard Instrument Departures (SIDs) were mentioned earlier in this chapter. Think of STARS as their arrival counterparts. STARs are ATC coded IFR arrival routes established at busier airports to facilitate clearance delivery procedures.

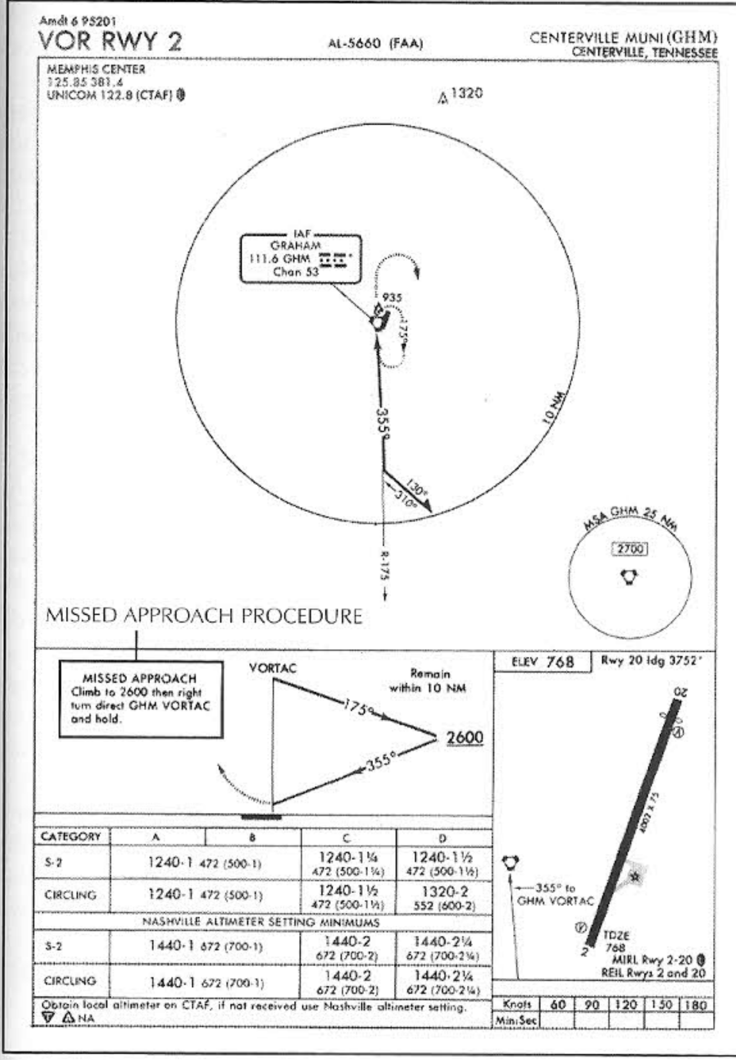
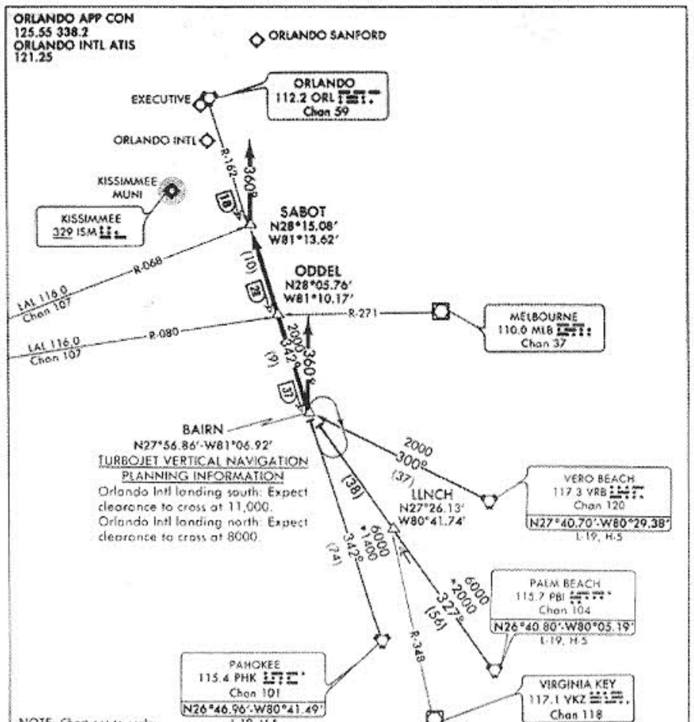


Figure 5.56 ***Example: Standard Terminal Arrival Route.***



PAHOKEE TRANSITION (PHK.GOOFY2): From over PHK VORTAC via PHK R-342 to BAIRN INT. Thence. . . .

PALM BEACH TRANSITION (PBI.GOOFY2): From over PBI VORTAC via PBI R-327 to BAIRN INT. Thence. . . .

VERO BEACH TRANSITION (VRB.GOOFY2): From over VRB VORTAC via VRB R-300 to BAIRN INT. Thence. . . .

ORLANDO INTL:

. . . . RWY 17/18: From over BAIRN INT via the ORL R-162 to SABOT INT. Depart SABOT INT heading 360° for vectors to final approach course.

. . . . RWY 35/36: Depart BAIRN INT heading 360° for vector to final approach course.

EXECUTIVE, KISSIMMEE, ORLANDO SANFORD:

. . . . From over BAIRN INT via ORL R-162 to SABOT INT. Expect radar vectors to the airport.

GOOFY TWO ARRIVAL (BAIRN.GOOFY2) ORLANDO, FLORIDA

96116

Chapter 6: Logging Your Hours

The FAA has established a specific course of study, testing and hours-to-log in order to earn your student, recreational, private, commercial and ATP (Airline Transport Pilot) certificates as well as all Flight Instructor and other aircraft ratings. The Code of Federal Regulations that cover these requirements are paraphrased in this chapter for your convenience.

ProPilot allows you to log simulated hours through the completion of the flight assignments that accompany this section. The logging of simulated hours within ProPilot, of course, cannot replace the hours logged in an actual airplane with the guidance of an authorized flight instructor, but they are helpful supplements to your real world flight training.

Because, at this stage, ProPilot features several fixed-wing land-based airplanes, the selected CFR references describe all of the requirements as they relate to airplanes only. Therefore, you may find references in other sections within the complete list of regulations that do not appear here. Please refer to the bibliography beginning on page 266 for sources of the complete listings of regulations.

Notes:

AC-61-126 Update

The FAA issued an Advisory Circular in June 1997 that allows the use of devices based on Personal Computers to be used in training for the instrument rating. The AOPA's Air Safety Foundation, AC-61-126, entitled "Qualifications and Approval of Personal Computer-based Aviation Training Devices," establishes personal computer-based training devices (PC-ATD) as a new category of training device, distinct from stand-alone flight simulators and dedicated desktop devices. The new AC allows a 10-hour flight time credit for training with an approved PC-ATD under the guidance of a flight instructor.

However, the FAA has not approved the devices for maintaining instrument currency of for any portion of the instrument rating practical test. The new AC also spells out approval requirements for PC-ATDs. In addition to response and display quality requirements, the FAA requires aircraft-like physical controls including a self-centering control yoke or stick, self-centering rudder pedals and a physical throttle lever.

Format Update

Due to the fact that the Federal Government publishes revisions to the CFRs every six calendar months, attempts to recreate the CFRs are for informational purposes only and reference to the current CFRs should be made for legal or instructional purposes. These paraphrases are based on the interpretation of the CFRs as of September 1st, 1998.

Reference 14 CFR 61

14 CFR 61.51- Pilot Logbooks

The aeronautical training and experience used to meet the requirements for a certificate or rating, or for the purposes of currency, must be shown by reliable record. Any other flight time is not required to be logged.

Logbook Entries:

All FAA approved logbooks contain the appropriate information required to log a flight "by reliable record." A sample logbook page is included on the *Pro Pilot '99* CD and can be printed to make your own logbook. (logbook path here) Below are descriptions of "flight time" as related in the CFRs.

- Solo flight – A pilot may log solo flight time only when he/she is the sole occupant of the aircraft.
- Pilot-In-Command flight time - Anytime an appropriate rated pilot is the sole manipulator of the controls of the aircraft (including solo time). Authorized flight instructors can log all instruction time as PIC.
- Second-In-Command – Only loggable when you are the second pilot of an airplane that requires more than one pilot. Logged when you are not the PIC or Flight Engineer.
- Instrument flight time – Logged when you operate the aircraft solely by reference to the instruments, whether in simulated or actual instrument conditions. If you fly "under the hood", you must be accompanied by either a flight instructor, or a private pilot or better that is rated in your airplane.
- Dual or instruction time – All time logged as dual must be certified by the instructor from which your instruction was received.

Presentation of logbooks

When asked by an FAA inspector or nearly any law-enforcement official, you must be able to produce your logbook.

Student Pilot logbook requirements

A student pilot must have their logbook on their person during all solo flights. Each student pilot must be appropriately endorsed by an authorized instructor for each solo flight.

14 CFR 61.56 Flight Review

The FAA requires each licensed pilot complete a flight review every two years. This Biennial Flight Review (BFR) must include at least one hour of ground instruction and one hour of flight instruction. It can be given by any appropriately rated flight instructor. The only exception is, if you earn a certificate or rating, you are good for another two-years from the date you completed the practical test for your new rating. Also, if you were to take a checkride with the military or the airlines within the preceding two years, you don't need a BFR.

14 CFR 61.57 Recent Flight Experience

In general terms, in order to be qualified to carry passengers you must have done three landings as the sole manipulator of the controls, in the preceding 90 days. These landings must be made in the category and class of aircraft you intend to act as PIC in.

To be night current, the same applies, 3 landings in 90 days (at night). If you are flying a conventional gear airplane (a taildragger) you must complete these items in a taildragger to remain tailwheel current. The difference here is, both night and tailwheel currency must be full-stop landings, touch and go's don't count.

And finally, in order to remain instrument current, you must complete the following within 6 calendar months:

- 6 instrument approaches in actual or simulated conditions
- 3 approaches must be in an airplane
- must complete holding procedures, intercepting and tracking of navigation courses or, an Instrument Proficiency Check

14 CFR 61.65 Instrument rating requirements

This section spells out the requirements for an instrument rating. Please refer to the current federal regulations and advisory circulars available at your local FBO for more information.

14 CFR 61.87 Student and Recreational Pilots

This explains what is required for a student pilot to be allowed to solo. Basically, you are required to have completed certain flight maneuvers and ground tests. Then, when your instructor deems you ready, he/she signs your logbook endorsement, your medical and wishes you a fond "Good Luck!" Solo endorsements are good for 90 days.

14 CFR 61.93 Cross-country flight requirements (for student and recreational pilots seeking private pilot certification.)

A student pilot must have completed and demonstrated competency in various flight maneuvers and cross-country planning. Each cross-country flight over 25nm must have a separate endorsement by the instructor. There are also endorsements for repeated flights within 25nm of the airport and flights into Class B airspace.

14 CFR 61.98 and 61.99 Recreational Pilots

Explains the knowledge required for the Recreational Pilots license. (refer to current Practical Test Standards for more information)

14 CFR 61.105, 61.107 and 61.109 Private Pilots

These sections spell out the requirements to earn a Private Pilots license. (refer to current Practical Test Standards for more information)

14 CFR 61.125, 61.127 and 61.129 Commercial Pilots

These sections spell out the requirements to earn a Commercial Pilots license. (refer to current Practical Test Standards for more information)

Flight Assignments

This section contains 20 flight assignments. The flight assignments help you log hours as you pursue your licenses and ratings. Each one covers a variety of distances, airspace classifications, and navigational aids. Most are VFR assignments, but a few are flown under IFR conditions.

VFR Flights

Departure / Destination	Sectionals Used	Page #
Bakersfield, CA to Modesto, CA	Los Angeles, San Francisco	198
Des Moines, IA to Grand Island, NE	Omaha	200
Duluth, MN to Grand Marais, MI	Green Bay	203
Eugene, OR to Palo Alto, CA	Klamath Falls, San Francisco	206
Eugene, OR to Paine Field, WA	Klamath Falls, Seattle	209
Fargo, ND to Sioux City, IA	Omaha, Twin Cities	211
Gary, IN to Oshkosh, WI	Chicago	213
Livermore, CA to Reno, NV	San Francisco	215
Morris, MN to Flying Cloud, MN	Twin Cities	217
Orange County, CA to Van Nuys, CA	Los Angeles	220
Portland, OR to Lewiston, ID	Seattle	221
Rochester, MN to Sparta/Fort McCoy, WI	Chicago	224
The Bay Cruise	San Francisco	226
Traverse City, MI to Mosinee, WI	Green Bay	228
Walla Walla, WA to Yakima, WA	Seattle	230

IFR Flights

Departure / Destination	Type of Approach	Page #
Albany, NY to Manchester, NH	LOC	233
Bangor, ME to Boston, MA	ILS	237
Medford, OR to Eugene, OR	SID, NDB	240
Pueblo, CO to Denver, CO	ILS	245
Salem, OR to Hillsboro, OR	Hold, VOR, DME	248

Bakersfield, CA to Modesto, CA

From the San Francisco and Los Angeles Sectionals

Flight Skills: Cross-Country Flight Using VOR-DME Navigational Aids

You will be departing Meadows Airport located at Bakersfield, California, which lies at the southern end of the San Joaquin Valley. This area of California is known for its dairies and crop lands.

Identifier	Checkpoint	Time Off					
		Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
BFL	Bakersfield-Meadows Airport	313	3.7	110	2500	3	12L/30R-10860
EHF	Shafter VOR						
		327	56.2	110	4500	32	
VIS	Visalia VOR						
		306	67.5	110	4500	37	
HYP	El Nido						
		298	35.9	110	1000	20	
MOD	Modesto Airport						10L/28R-5910
		Distance:	163.3		Time:	1:32	

You should first check ATIS on 118.6 for current airport conditions. Set your VOR radio for the Shafter VOR on 115.4 and set the OBS to 313°. The first leg to Shafter VOR is very short—only 3.7 miles.

When ready to depart, contact tower on 118.1 for a departure on Runway 30R. For this flight, you can cruise at 4,500 ft. After crossing Shafter, turn the OBS to 327° while turning the aircraft to the same heading for the next checkpoint, the Visalia VOR. It is 56.2 miles away. When you are approximately halfway, tune the VOR radio to Visalia on 109.4 and continue to track inbound with the OBS set to 327°.

After crossing the Visalia VOR, the heading will be 306° to the El Nido VOR, frequency 114.2. As you cross the El Nido VOR, you will turn to a heading of 298° to the Modesto Airport.

Modesto Airport has a VOR on the field on a frequency of 114.6. About 20 miles away from Modesto, listen to ATIS on 127.7 for airport landing information, then contact Modesto approach on 120.95 for landing sequencing instructions. Approach control will turn you over to Modesto Tower on 125.3 as you approach the airport. You will be landing on Runway 28R. Modesto's field elevation is 97 ft. The pattern altitude is 1,000 ft MSL.

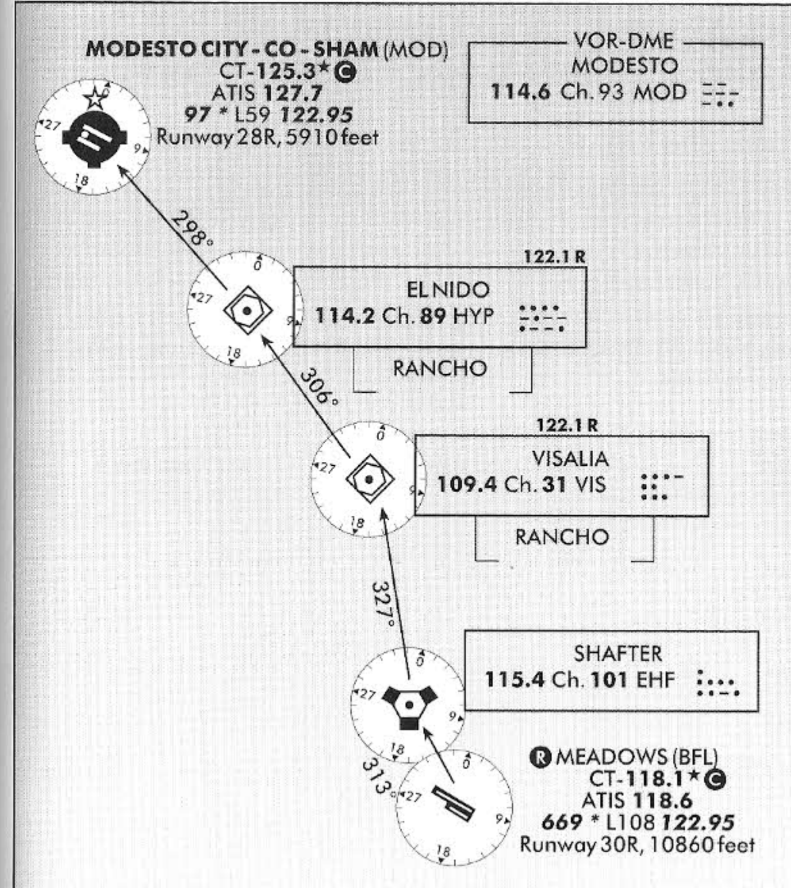


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Ident.	Location	VOR	ATIS	App./Dep.	Tower	Ground	Unicom
BFL	Meadows Apt.		118.6	118.8	118.1	121.7	122.95
EHF	Shafter VOR	115.4					
VIS	Visalia VOR	109.4					
HYP	El Nido	114.2					
MOD	Modesto Apt.	114.6	127.7	120.95	125.3	121.7	122.95

Des Moines, IA to Grand Island, NE (Central Nebraska Regional Airport)

From the Omaha Sectional

Flight Skills: VFR Cross-Country Using NDB Navigational Aids

This is a cross-country flight using NDB navigational aids from Des Moines, Iowa to Central Nebraska Regional Airport over some very flat farming land known for its great corn production. NDB navigation is not as accurate for cross-country flying, so make sure to keep track of your times. Also, watch out for landmarks along the way. These can be found on the sectional charts.

Identifier	Checkpoint	Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
		Time Off					
DSM	Des Moines Intl. Airport						
		247	37.4	110		24	5/23-6500
GFZ	Greenfield						
		212	24.3	110		13	
CRZ	Corning						
		269	22.5	110		12	
RDK	Red Oak						
		259	30.2	110		17	
PMV	Plattsmouth						
		259	54.5	110		30	
SWT	Seward						
		270	23.0	110		13	
JYR	York						
		263	17.2	110		10	
AUH	Aurora						
		282	14.8	110		11	
GRI	Central Nebraska Regional Airport						4/22-7190
		Distance:	223.9		Time:	2:10	

Listen to ATIS on 119.55 for current airport information at Des Moines. You will depart from Runway 23. When ready to depart, contact tower on 118.3 for a straight out departure.

Your first heading will be 247° and will require only a slight right turn after departure. Your first checkpoint is 37.4 miles to the Greenfield NDB at a frequency of 338. The needle should be pointing straight up. Continue to maintain your heading. As you pass Greenfield, you will notice that the needle swings to the tail of the airplane.

Next, dial in the Corning NDB on a frequency of 296. The new heading to Corning is 212°, a distance of 24.3 miles. Again, the needle should be toward the nose of the airplane on the ADF and should swing to the rear of the airplane as you pass Corning.

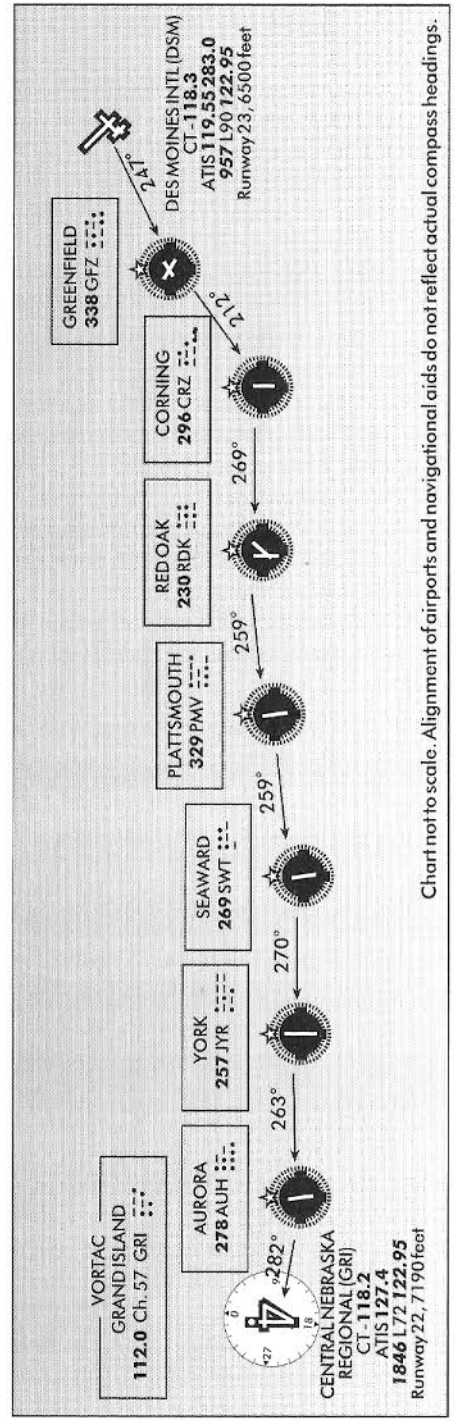


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Next, dial in Red Oak on a frequency of 230. Red Oak is on a heading of 269° at a distance of 22.5 miles from Corning. Follow the same procedure of watching the ADF for the needle swing indicating station passage.

Your next checkpoint is at Plattsmouth on a frequency of 329. The heading to Plattsmouth is 259° at a distance of 30.2 miles from Red Oak. Again, note the swing of the ADF needle indicating station passage as you head on to your next checkpoint, which is Seward. It is found on a frequency of 269, and the heading to Seward is 259°. The distance is 54.5 miles from Plattsmouth. Again, watch for the needle swing, which indicates passage of Seward.

Your next checkpoint is the York NDB, found on a frequency of 257. York is 23 miles away at a heading of 270°. Again, watch the needle for station passage. The next checkpoint is Aurora at a heading of 263° and a distance of 17.2 miles from York. Aurora's frequency is 278.

After leaving Aurora, turn to a heading of 282°. You should have already listened to ATIS on 119.55 and contacted approach control on 127.40. The field elevation at Central Nebraska Regional Airport is 1,846 ft, and its pattern altitude is 2,646 ft. Approach will turn you over to tower on 118.2 for clearance to land. You will land on Runway 22.

Often because of winds aloft, you will drift off course and start homing to the NDB. If you have trouble, consult the chapter on tracking inbound and outbound on NDB's.

Ident.	Location	NDB	Tower	Unicom	ATIS	App./Dep.	Ground
DSM	Des Moines Intl. Airport		118.3	122.95	119.55	123.90	121.9
GFZ	Greenfield	338					
CRZ	Corning	296					
RDK	Red Oak	230					
PMV	Plattsmouth	329					
SWT	Seward	269					
JYR	York	257					
AUH	Aurora	278					
GRI	Central Nebraska Regional Airport		118.2	122.95		127.40	121.9

Duluth, MI to Grand Marais, MI

From the Green Bay Sectional

Flight Skills: International flight using VOR and NDB navigational aids.

This flight departs Duluth International Airport and will take you along the western shore of Lake Michigan using NDB navigational aids. You will land at an uncontrolled airfield and will not have radio communications with a control tower for clearance to land. You will announce your position as you approach the field and also on final for other aircraft in the vicinity.

Identifier	Checkpoint	Time Off Mag. Hdg.	Dist.	Speed	Altitude	Time	Rwy-L
DLH	Duluth Apt.	46	22.2	110	Climb to 5500	15	9/27-10150
TWM	Two Harbors NDB	46	18.0	110	5500	10	
BFW	Silver Bay NDB	46	54.6	110	Patt. Alt. 1638	30	
CKC	Grand Marais Airport						14/32-2350
		Distance:	94.8		Time:	55	

Listen to Duluth ATIS on 124.1 for current airport conditions before departure. You will depart on Runway 9 from Duluth Airport for a straight out departure. You should have your VOR set to the Duluth VOR on 112.6 and your OBS set to 46°. Keep looking for a FROM flag in the TO-FROM window.

When cleared by the tower, takeoff and climb to 5500 ft. Since the VOR is south of the field, our route is slightly to the east. Fly the runway heading until the needle on the VOR comes off from full deflection. As it centers, turn to a heading of 46° on the Heading Indicator. Two Harbors NDB is your first checkpoint, so set the ADF to a frequency of 243 and watch for the needle swing as you pass the station. Note the time for a double check of your flight plan estimated time.

Continue on the heading of 046°. The VOR needle should be centered. Set the ADF for your next checkpoint of Silver Bay, and check for the ADF needle swing as you pass by again. Note the time. About halfway between the Silver Bay and Grand Marais NDBs, switch to the final navigational aid at Grand Marais.

Start your descent to a pattern altitude of 1638. The field is at 838 ft. Use the Unicom frequency on 122.8 to announce your arrival and land on Runway 32.

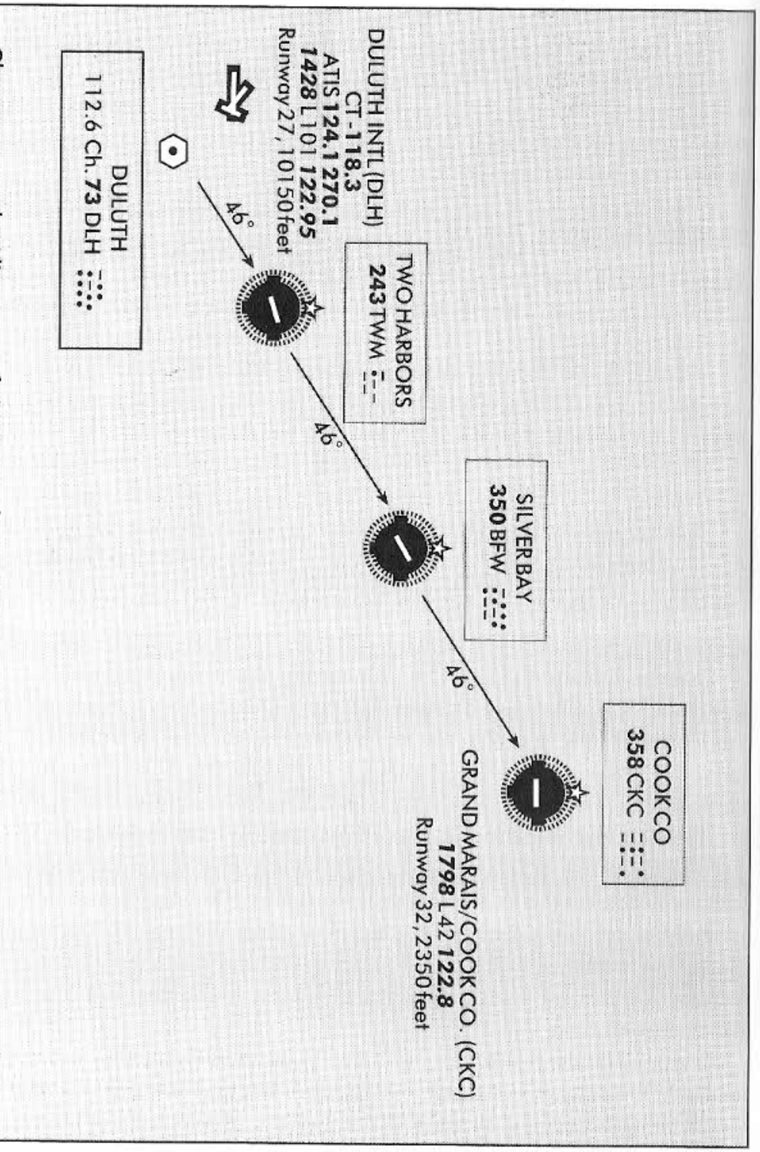


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Ident.	Location	VOR	NDB	ATIS	App./Dep.	Tower	Ground	Unicom
DLH	Duluth Intl. Apt.	112.6	379	124.1	125.45	118.3	121.9	122.95
TWM	Two Harbors		243					
BFW	Silver Bay		350					
CKC	Grand Marais Apt.		358					122.8

Eugene, OR to Palo Alto, CA

From the Klamath Falls and San Francisco Sectionals

Flight Skills: Long Cross-Country Using VOR Over Mountainous Terrain

Some people, because of weather concerns and a lack of alternatives, will usually avoid long cross-country flights over mountainous terrain because of potential problems that can develop with the airplane. This flight is conducted over the Siskiyou Mountain Range in Southern Oregon and Northern California. Good route planning can help provide a margin of safety over the mountains.

IFR usually stands for Instrument Flight Rules, but there is another acronym that you can use for flights over mountain passes and long cross-country trips over mountains. It is "I Follow Roads." This flight will follow the Interstate 5 freeway somewhat from Oregon to California.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
EUG	Eugene Apt.	167	57	110	5500	34	16/34-8000
RBG	Roseburg VOR	136	53	110	7500	29	
MFR	Rogue Valley VOR	122	15	110		9	
SØ3	Ashland Apt.	146	59	110		32	
1O6	Dunsmuir Airport	165	45	110		25	
RDD	Redding Apt.	161	72	110		39	
MXW	Maxwell VOR	159	44	110		24	
BESSA	Intersection	168	52	110		29	
OAK	Oakland	147	17	110		10	
PAO	Palo Alto Airport						12/30-2500
		Distance:	414		Time:	3:51	

You will be departing on Eugene's Runway 34, and will be requesting a downwind departure to a heading of 167°. Listen to the ATIS on 125.2 before departing. When ready to takeoff, contact the tower on 118.9 and request a right downwind departure. Tune and identify the Eugene VOR on 112.9 and set the OBS to 167°. Depart Eugene and climb to 5,500 ft.

Next, you will dial in the Roseburg VOR on 108.2. Again, identify and track inbound on a heading of 167° to the station. At the Roseburg VOR, turn to a new heading of 136° and climb to 7,500 ft for a trip over the Siskiyous. The next checkpoint is the Rogue Valley VOR, which is 53 miles from Roseburg. Approximately halfway there, dial in the Rogue Valley VOR on 113.6. Maintain 7,500 ft.

After crossing the Medford VOR, turn to a new heading of 122°. By now you should have been tracking your speed and distance and calculating your time en route. Ashland Airport is 15 miles from the VOR. There are no navigational aids at Ashland. After identifying Ashland Airport, turn to a heading of 146° to the Dunsmir Airport, which will take you down through a pass overlooking Interstate 5. The distance is 59 miles.

Mt. Shasta is an identifying landmark for the route on this trip. After passing the Dunsmuir Airport, turn to a heading of 165° for the Redding Airport, which has a VOR on a frequency of 108.4. Dial 165° on the OBS, and track it for a distance of 45 miles from Dunsmuir. Note station passage by a swing of the needle on the VOR at Redding, then dial in the Maxwell VOR at 110.0. Maxwell is 72 miles from Redding.

Upon leaving Maxwell, turn to a heading of 159°. You will be turning at your next checkpoint, which is an intersection identified by BESSA. It is adjacent to Lake Berryessa, which will be on the right of the airplane. The intersection is also identified by the Williams VOR on 114.4, on a radial of 173°, and also by the Sacramento VOR on a radial of 270°. At BESSA, turn to a heading of 168° for the Oakland Airport, which is 52 miles away.

In route from the BESSA intersection, you will cross over the Carquinez Straits. You should contact Bay Approach on 127.0 for clearance into the San Francisco Bay Area. After crossing Oakland, turn to a new heading of 147°.

Reset the OBS and track outbound to the Palo Alto Airport. Monitor the Palo Alto ATIS on 120.6. Bay Approach will assign you a new frequency of 120.1 for the approach into Palo Alto. As you near the airport, Bay Approach will hand you off to the Palo Alto tower on 118.6 for clearance to land. You will be landing on Runway 12.

Ident.	Location	VOR	ATIS	App./Dep.	Tower	Ground
EUG	Eugene Apt.	112.9	125.2	119.6	118.9	121.7
RBG	Roseburg VOR	108.2				
MFR	Rogue Valley VOR	113.6				
S03	Ashland Apt.					
1O6	Dunsmuir Apt.					
RDD	Redding	108.4	124.1		119.8	
MXW	Maxwell VOR	110.0				
BESSA	Intersection					
OAK	Oakland	116.8	128.5	Bay App. 127.0	118.3	
PAO	Palo Alto		120.6	120.1	118.6	125.0

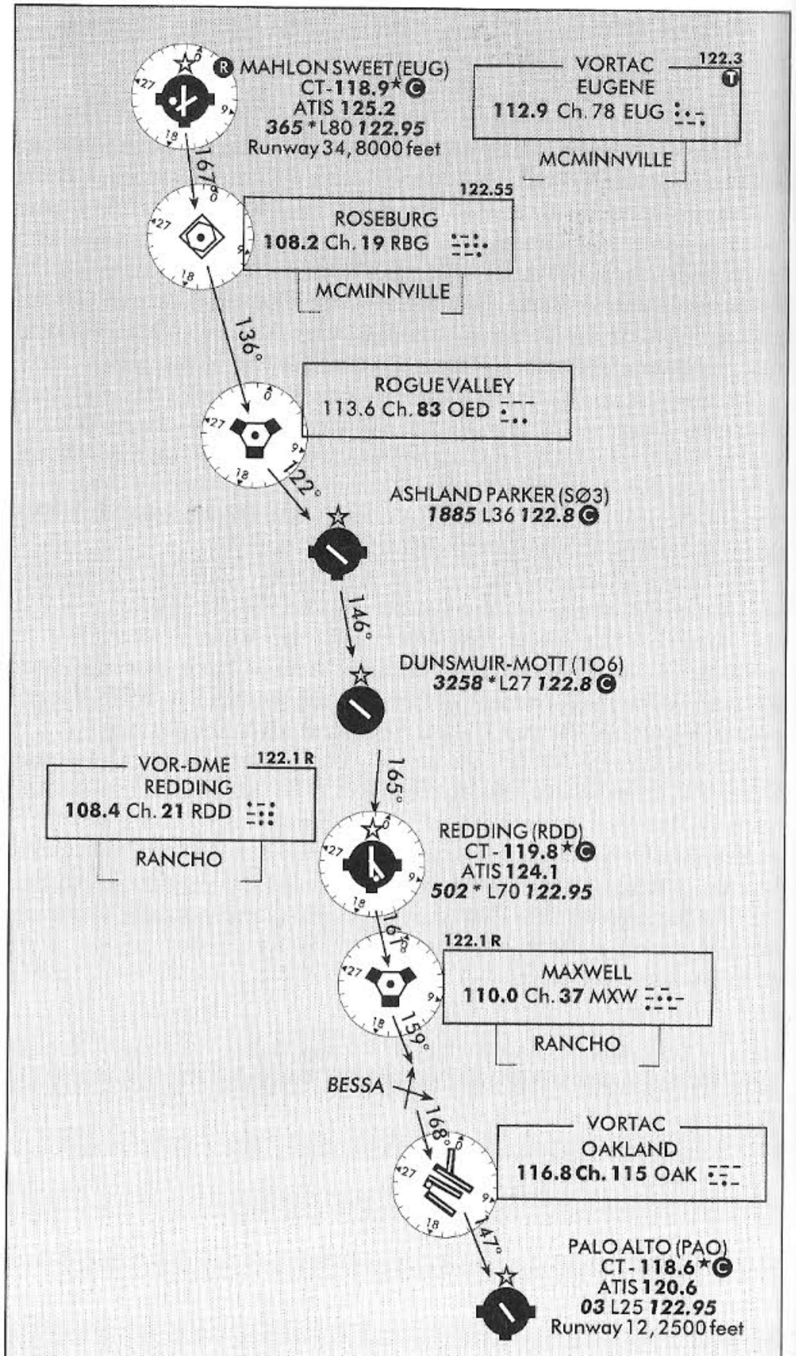


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Eugene, OR to Paine Field, WA

From the Klamath Falls and Seattle Sectionals

Flight Skills: VFR Cross-Country Using VOR/DME

Eugene is located in the southern end of the Willamette Valley. This flight will have us following the meandering Willamette River to Portland, Oregon on up to Paine Field up in the beautiful waterways of the Seattle area.

Identifier	Checkpoint	Time Off					
		Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
EUG	Eugene Apt.	334	22.7	110	Climb to 4500	12	16/34-8000
CVO	Corvallis VOR	357	52.9	110	4500	29	
UBG	Newberg VOR	016	28.7	110		16	
BTG	Battleground VOR	331	74.5	110		41	
OLM	Olympia VOR	351	53.5	110		29	
LOFAL	Intersection	056	16.3	110	Pattern Altitude	12	
PAE	Paine Field						11/29-4510
		Distance:	248.6		Time:	2:23	

You will be departing Eugene on Runway 34. Listen to the ATIS on 125.2 for current airport information. When you are ready to depart, contact the tower on 118.9 for a straight out departure.

Your first checkpoint is at a magnetic heading of 334° which is to the Corvallis VOR, a distance of 22.7 miles. The Corvallis VOR frequency is on 115.9. Make sure that you have the proper heading of 334° in the OBS. A switch of the TO-FROM flag will note station passage.

Turn to a new heading of 357° at an altitude of 4,500 ft to the next checkpoint, which is the Newberg VOR. Turn the OBS to the same setting and fly outbound on the radial. Halfway to the Newberg VOR, which is 52.9 miles away, switch frequencies to Newberg on 117.4. Always listen to the Morse code identification to confirm the proper station.

After passing the Newberg VOR, your next checkpoint is the Battleground VOR. It is 28.7 miles away from Newberg at a magnetic heading of 016°. Battleground's frequency is 116.6. Upon reaching Battleground, turn to the new heading of 331° and set the OBS for the checkpoint of Olympia VOR, which is 74.5 miles away. Track outbound for approximately 35 miles until you are able to receive the Olympia VOR on 113.4. Note station passage at Olympia.

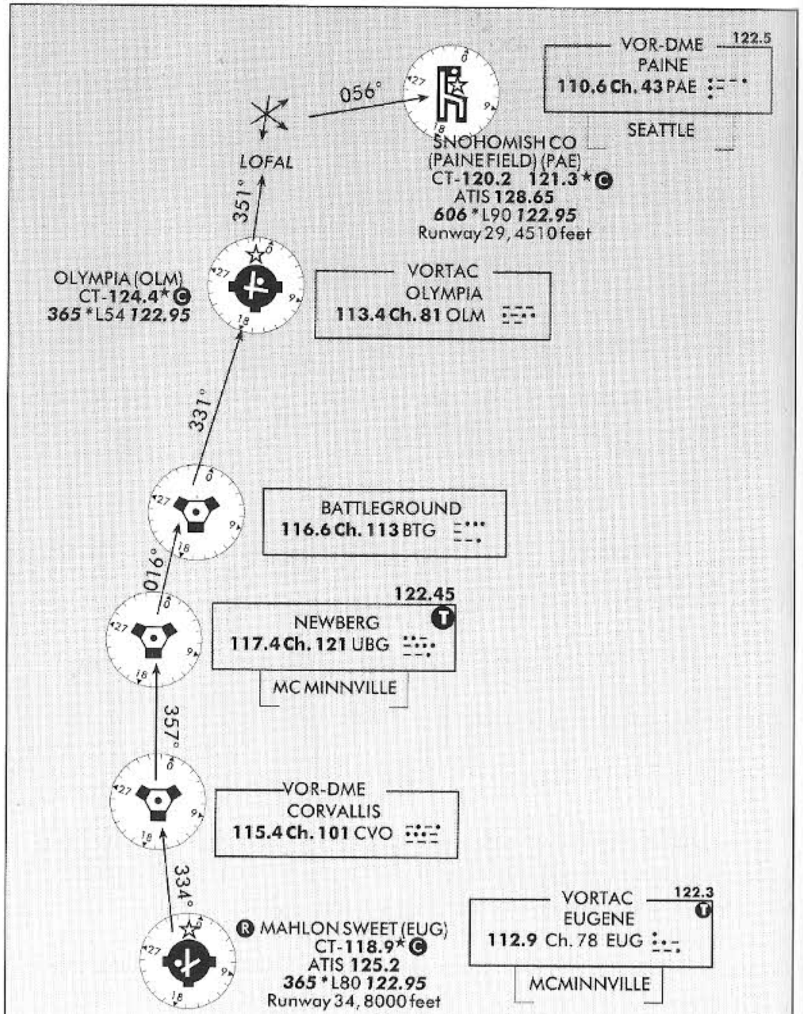


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

At an altitude of 4,500 ft, you will be below the Seattle Class B airspace. You will be flying on airway V-165-287 to the Intersection of LOFAL, which is defined by the 351° radial from Olympia and the 307° radial from the Seattle VOR on 116.8.

As the needle centers, turn right to a heading of 056° to Paine Field. It is a distance of 16.3 miles.

After listening to ATIS on 128.65, contact the tower on 121.3 for landing instructions. You will be landing on Runway 29. Paine Field's elevation is 606 ft, and its pattern altitude is 1,406 ft.

Ident.	Location	VOR	Tower	Unicom	ATIS	App./Dep.	Ground
EUG	Eugene Airport	112.9	118.9	122.95	125.2	119.6	121.7
CVO	Corvallis VOR	115.9					
UBG	Newberg VOR	117.4					
BTG	Battleground VOR	116.6					
OLM	Olympia VOR	113.4					
PAE	Paine Field Apt.	120.2	121.3	122.95	128.65		121.8

Fargo, ND to Sioux City, IA

From the Omaha and Twin Cities Sectional Flight

Skills: Long VFR Cross-Country Using VOR/DME Navigational Aids

This is a long, VFR cross-country flight using VOR/DME navigational aids. This is a relatively flat area of the United States, and the VOR's are a substantial distance apart. To increase your reception of the stations, you will climb to a higher altitude than normal for better radio reception.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
FAR	Hector Int. Apt.	183	10.1	110	Climb to 8500	9	17/35-9950
FAR	Fargo VOR	181	107	110	8500	59	
ATY	Watertown VOR	163	81.3	110	8500	44	
FSD	Sioux Falls VOR	163	50.1	110	8500	28	
ESTIS	Intersection	157	26.8	110	Pattern Alt. 2451	18	
SUX Airport	Sioux City						17/35-6600
		Distance:	275	Time:		2:38	

You will be departing on Runway 17. Tune into ATIS before departure on 124.50 for current airport information. Set your VOR to a frequency of 116.2 and the OBS to a magnetic heading or 183°. Contact the tower on 118.6 when you are ready to depart. After departure, climb up to 8,500 ft for this flight.

The Fargo VOR is 10.1 miles away. After this, turn to a heading of 181° while changing the OBS to the same setting. You will track this VOR outbound for approximately 50 miles until you are able to pick up the Watertown VOR on 116.6. The length of this leg is 107 miles.

Once you have reached the Watertown VOR, turn to the new heading of 163°. Be sure to turn the OBS to the same heading. Track outbound for

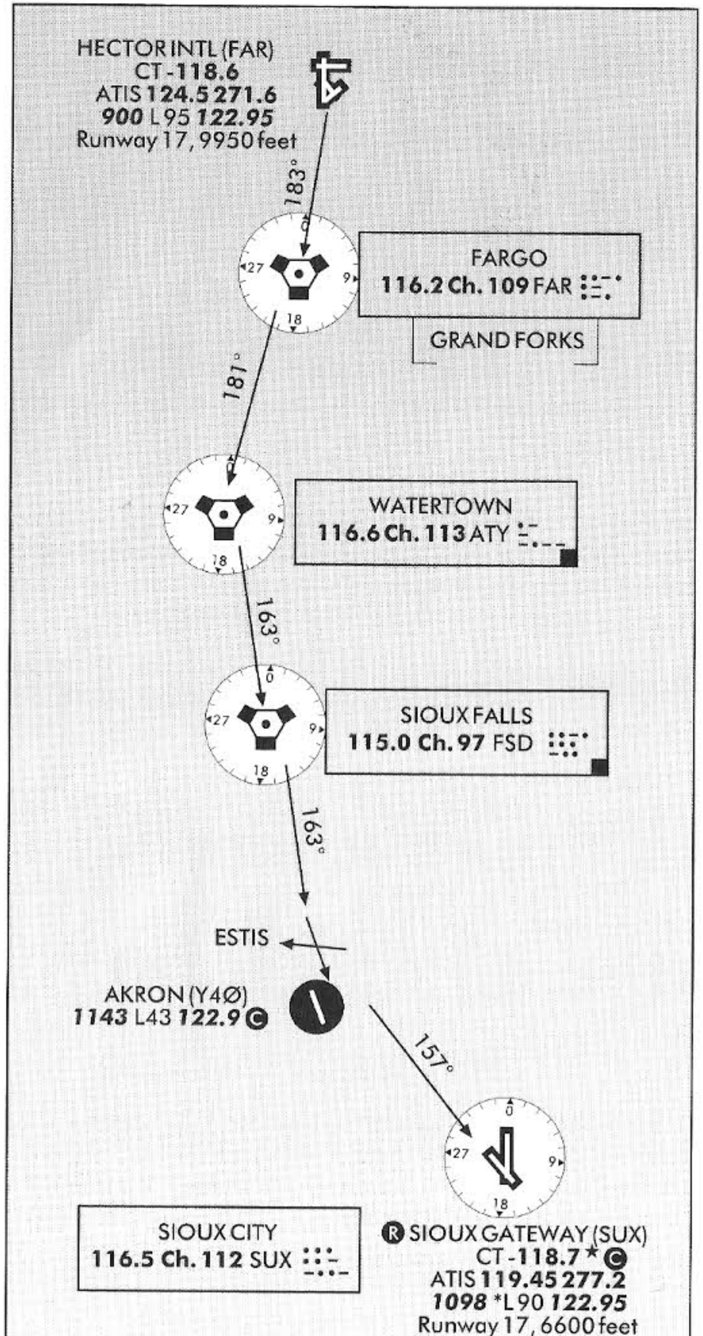


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

approximately 40 miles, then switch to the Sioux Falls frequency of 115.0 for tracking inbound on the same heading.

After you have crossed over Sioux Falls, the next checkpoint is the ESTIS intersection. It is on a heading of 163°, and is identified by VOR radials. You may also identify it by a distance of 50.1 miles from the Sioux Falls VOR. At ESTIS, turn to a new heading of 157°. Track inbound to the Sioux City Airport. It is 26.8 miles away. Sioux City Airport's field elevation is 1,651 ft, and its pattern altitude is 2,451 ft.

Within about 20 miles of the airport, listen to ATIS on 119.45 for current airport information. Contact Approach on 124.6 for landing sequencing. Approach will turn you over to the tower on 118.7 for clearance to land on Runway 17.

Ident.	Location	VOR	Tower	Unicom	ATIS	App./Dep.	Ground
FAR	Hector Int. Apt.	116.2	118.6	122.95	124.50	120.40	121.9
ATY	Watertown VOR	116.6					
FSD	Sioux Falls	115.0					
Y40	Akron			122.9			
SUX	Sioux City Apt.		118.7		119.45	124.6	121.9

Gary, IN to Oshkosh, WI

From the Chicago Sectional

Flight Skills: VFR Cross-Country in Heavy Traffic Class B Airspace and Busy Communication Areas Using VOR Navigational Aids.

Your flight from Gary, Indiana to Oshkosh, Wisconsin begins at the southern end of Lake Michigan. This flight will take you through some of the busiest airspace in the U.S.—Class B airspace for Chicago into Oshkosh, which, for a short period of time during the Experimental Aircraft Association Convention, is the busiest airport in the world.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
GYY	Gary Regional Airport						12/30-7000
		329	43.7	110		27	
OBK	Northbrook VOR	292	18.9	110		10	
FARMM	V228						
		321	65.3	110		36	
MSN	V9-341						
		036	60.8	110		36	
OSH	Oshkosh, Whitman						18/36-8000
		Distance:	118.7		Time:	1:49	

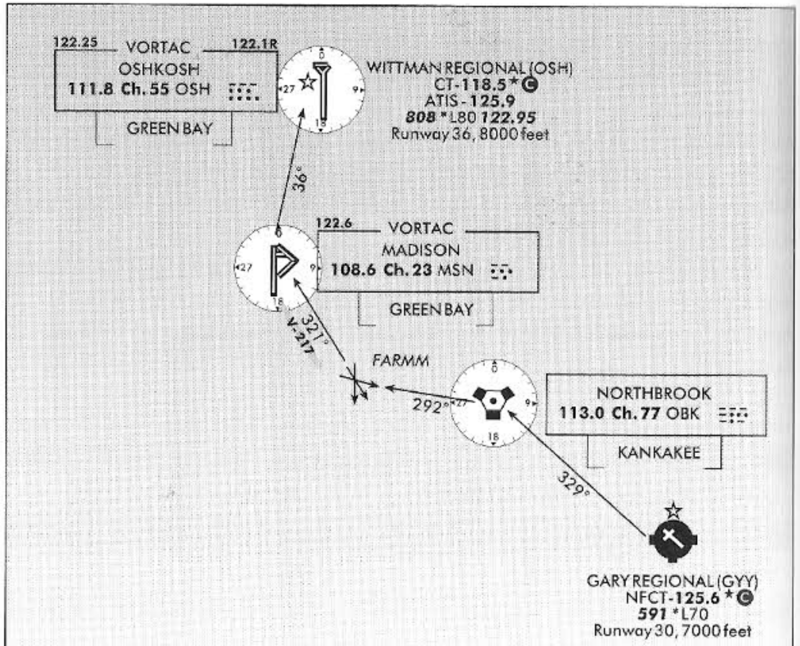


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

On departure at Gary, you will be entering Chicago's Class B airspace almost immediately. The tower frequency is 125.6. You will be departing on Runway 30. Make a slight right turn after departure to 329° to the Northbrook VOR on 113.0. Immediately after departure, contact Chicago Approach on 119.45 for clearance through this Class B traffic area. Climb to 3,000 ft.

At your first checkpoint of Northbrook VOR, you will pass well over old Meigs Field. Northbrook VOR is 43.7 nautical miles from Gary. As you pass the Northbrook VOR, turn to a magnetic heading of 292° and track outbound for 18.9 miles to the FARMM intersection which is defined by three radials: the Janesville VOR on 114.3, 109° radial; the Madison VOR on 108.6, 135° radial; and the Badger VOR on 116.4, 180° radial. Next, turn to the right following airway V-217 to the Madison VOR on the 321° radial—a distance of 65.3 miles.

Once at Madison, you will turn to the right and fly outbound on a heading of 36° on airway V-9-341 for a distance of 60.8 miles. You will be tracking inbound on the Oshkosh VOR on 111.8.

Listen to the ATIS on 125.9 as you approach and then contact the tower on 118.5 for landing instructions. You will be landing on Runway 36.

Ident.	Location	VOR	Tower	Unicom	ATIS	App./Dep.	Ground
GYY	Gary Regional Apt.		125.6			133.1	121.9
OBK	Northbrook VOR	113.0					
MSN	Madison VOR	108.6					
OSH	Oshkosh Airport	111.8	118.5	122.95	125.90		121.9

Livermore, CA to Reno, NV

From the San Francisco Sectional

Flight Skills: Cross-Country Using VOR Navigational Aids

Livermore, California is just east of the San Francisco Bay area and is protected from much of the bay fog by hills. It is open for VFR flight most of the time. Reno is the destination that will take you over the Sierra Mountains of California. The flight weather is forecast for clear and unlimited visibility which will give a great view of the Sierras and Lake Tahoe.

Identifier	Checkpoint	Time Off					
		Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
LVK	Livermore Airport	044	44.9	110	Climb to 5500	29	7L/25R-5260
LIN	Linden VOR	031	48.3	110	9500	29	
SPOOK	Intersection	013	50.0	110	11500	9	
FMG	Mustang VOR	344	8.0	110	Pattern Altitude 5212	5	
RNO	Reno Apt.						16L/34R-9000
		Distance:	151.2		Time:	1:12	

You will depart Livermore which is 397 ft MSL on Runway 7L. Listen to ATIS on 119.65 for current airport information. Set your navigational radio for the Linden VOR on 114.8 and set the OBS to 044°. When cleared by the tower, depart Runway 7L and then make a left turn to a heading of 044° on the heading indicator and climb up to 5,500 ft.

Check your progress on the DME and watch for station passage at Linden on the TO-FROM indicator. Begin your climb to 9,500 ft before your next checkpoint. Next, you will head to the SPOOK intersection on V-28-113 airway, which is on a heading of 031° from Linden and 48.3 miles DME. SPOOK is also identified by a FROM indication on the 120° radial from the Squaw Valley VOR on 113.2. Departing SPOOK, climb to 11,500 ft for terrain clearance for your inbound course to Reno.

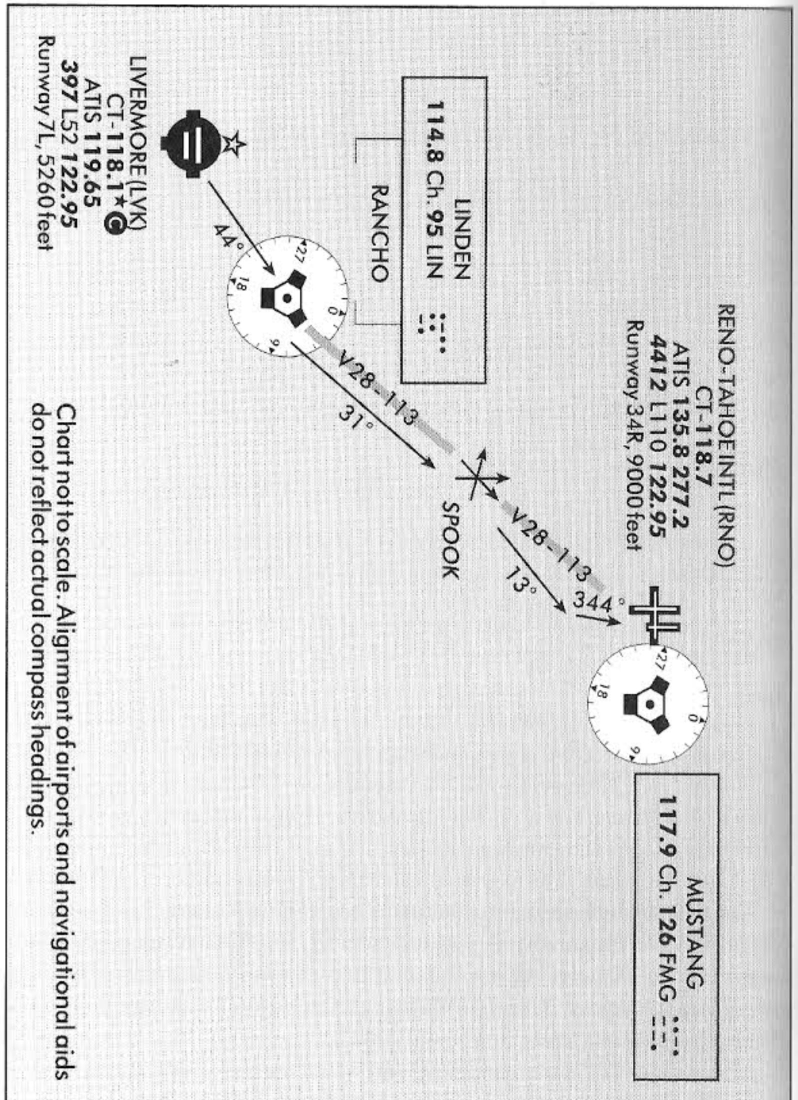


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

At SPOOK, turn to a heading of 013° to the Mustang VOR on 117.9 for 50 miles. Start your descent to land at 10 DME from the Mustang VOR and make your final heading of 334° into Reno Airport.

As you fly over Lake Tahoe, you should listen to Reno ATIS on 135.8 and contact Reno Approach on 119.2 for a sequence to land. Approach will hand you off to the tower on 118.7 for clearance to land on the 9,000-foot, Runway 34R. The pattern altitude is 5,212 ft and the field elevation is 4,412 ft.

Reno has a high elevation and is often hot during the summer, and the density altitude can be a real problem. Review the section on this topic (page 144) for its effects on aircraft performance.

Ident.	Location	VOR	ATIS	Dep.	Tower	Ground	App.
LVK	Livermore Apt.		119.65	135.4	118.1	121.6	123.85
LIN	Linden VOR	114.8					
FMG	Mustang VOR	117.9					
RNO	Reno Apt.		135.8	119.2	118.7	121.9	119.2

Morris, MN to Flying Cloud, MN

From the Twin Cities Sectional

Flight Skills: VFR Cross-Country Using VOR and NDB Navigational Aids

The middle of the U.S., around Minneapolis, Minnesota is a beautiful area to fly because of its many surrounding lakes. Navigation in the middle of the country is made up of VOR's and NDB's. This 120-nautical mile VFR trip will hop from VOR to NDB to VOR, etc. You will depart the uncontrolled airport at Morris, MN and arrive under the heavy traffic volume of the Class B airspace at Minneapolis–St. Paul. You will be landing at Flying Cloud, MN. The terrain is flat, but watch out for towers en route which are scattered throughout the Midwest.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
MOX	Morris Apt.	130	19.7	110	Climb to 3500	14	14/32-3400
BBB	Benson, MN	113	27.0	110	3500	15	
ILL	Willmar VOR	113	33.7	110	3500	19	
HCD	Hutchinson-Butler	088	39.3	110	3500	25	
FCM	Flying Cloud Airport, MN						9L/27R-3600
		Distance:	119.7		Time:	1:13	

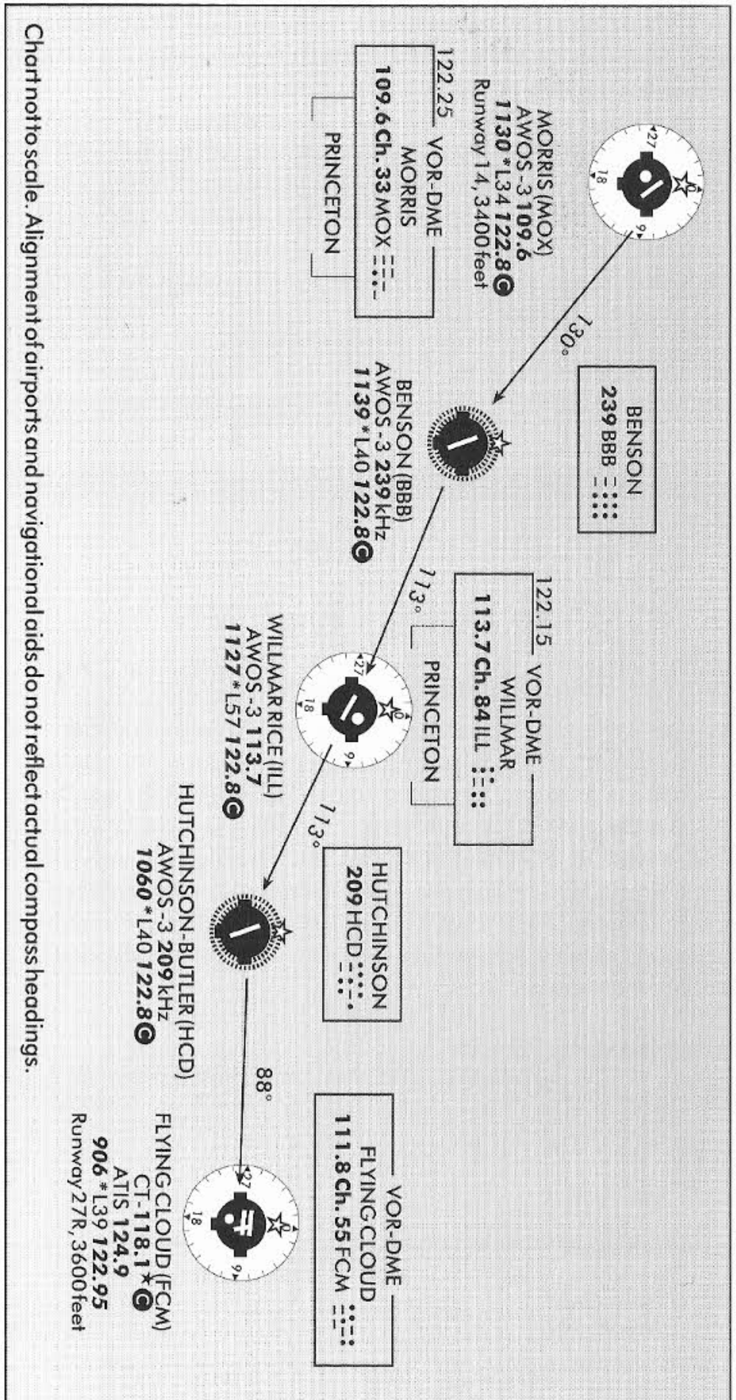


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

You will depart Morris Airport on Runway 14. After departure, climb to 5,500 ft, or any odd altitude plus 500 feet (because your headings will be between 0-179 degrees magnetic).

You will be intercepting the 130° radial flying outbound to the Benson NDB, which is 19.7 miles away. To do this, you will set the VOR radio to the Morris VOR on 109.6 and the OBS to 130°. On climb out, you will turn left 20° from the 140° heading of the runway to intercept the 130° radial. When the needle centers, turn to 130° magnetic.

Use Benson's NDB for your next navigational aid. You should have the ADF set to 239khz for navigation. The needle on the ADF should be pointed straight up. As you near the Benson NDB, switch the VOR radio to the Willmar VOR on 113.7 and set the OBS to 113° and look for the TO flag. Don't forget to check the Morse code identifier with the audio panel switch for the VOR and the ADF, to make sure the nav aids are working. As the ADF needle swings to the tail indicating the Benson station passage, turn to 113° magnetic heading for the Willmar VOR, 27 nautical miles away.

Hutchinson-Butler airport is your next checkpoint and is on the same heading of 113°. Station passage at Willmar VOR will be indicated by your VOR switching to the FROM flag. You will then be tracking outbound on the 113° radial. You also will track inbound on the Hutchinson NDB on 209kHz.

Along your route, you should continue to monitor weather. Through the audio panel on the VOR and ADF, make sure the volume is turned up. Hutchinson Station passage will again be indicated by a 180° needle swing on the ADF. The final leg is now on a heading of 088° to fly direct to the Flying Cloud Airport tracking the VOR on 111.8. (Set the OBS to 088°.)

As you approach Flying Cloud, you will enter the Class B airspace of Minneapolis-St. Paul and should contact them on 125.0 before you enter their airspace at 30 miles out from the center of Class B. Remember that you cannot enter unless they repeat your call sign and give you permission to enter. They will give you a discrete transponder code and advise you of traffic. The weather must be at least three miles visibility and clear of clouds. Your landing pattern altitude should be 1,900 ft MSL at Flying Cloud, so plan your descent accordingly. Center will hand you off to the Flying Cloud tower around 5 NM out and clear you for landing. Enter north of the airport in a right downwind traffic pattern for a landing on Runway 27R.

Ident.	Location	VOR	NDB	Tower	Unicom	AWOS	ATIS	App.
MOX	Morris Apt.	109.6			122.8	109.6		126.1
BBB	Benson		239		122.8	239		
ILL	Willmar	113.7			122.8	113.7		
HCD	Hutchinson		209		122.8	209		
FCM	Flying Cloud	111.8		118.1	122.95		124.9	125.0

Orange County, CA to Van Nuys, CA

From the Los Angeles Class B Airspace; Terminal Chart

Flight Skills: Heavy Traffic Area; VFR Flight.

John Wayne Airport-Orange County lies in one of the heaviest, small aircraft, VFR traffic areas in the nation. This flight will take you from John Wayne Airport to Van Nuys through a VFR corridor over the Los Angeles International Airport. After departure, you will align yourself with this corridor for a direct flight in to Van Nuys.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
SNA	John Wayne Airport-Orange Co.	274	20.3	110	4500	14	1L/19R-5700
WILMA	Intersection	323	28.7	110	Pattern Altitude 1600	16	
VNY	Van Nuys Airport						16R/34L-8000
		Distance:	49.0		Time:	:30	

Tune and listen to the ATIS frequency on 126.0 before departure. You will be departing on Runway 19R. When ready to takeoff, contact the tower on 119.9. After departure, you will turn to a magnetic heading of 274˚, which will take you over the Queen Mary Cruise Line ship and Dome visual reference point and align you with the VFR corridor, which is on the 140˚ radial from the Van Nuys VOR on 113.1.

Air traffic control will normally assign an altitude through this corridor. You will fly at 4,500 ft. Van Nuys is equipped with DME capability, and as you approach within 20 miles, you should contact Van Nuys Approach on 124.6 for arrival procedures. Their ATIS is on 118.45.

You will be landing on Runway 34L. Van Nuys Airport is 799 ft above sea level.

Ident.	Location	VOR	ATIS	App.	Dep.	Tower	Ground
SNA	John Wayne Airport – Orange Co.		126.0	121.3	128.1	119.9	120.8
VNY	Van Nuys Apt.	113.1	118.45	124.6	120.4	119.3	121.7

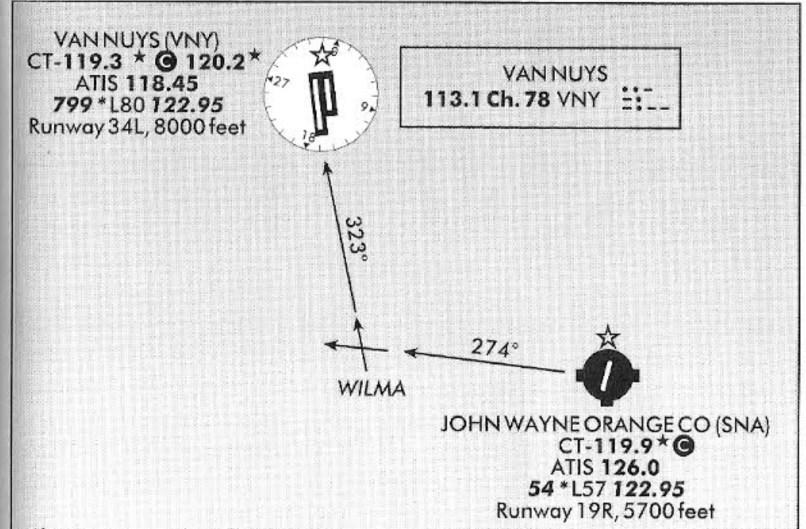


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Portland, OR to Lewiston, ID

From the Seattle Sectional

Flight Skills: VFR Cross-Country Flight Using VOR Navigational Aids

This flight begins in Portland, Oregon, adjacent to the Columbia River, which flows all the way down from Canada. Hydroelectric power drawn from the Columbia supplies electricity throughout the Northwest. These dams can be good checkpoints on VFR flights. The river also provides a pass for VFR aircraft when clouds obscure the Cascade Mountains.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
PDX	Portland Airport	064	63.2	110	Climb to 5500	38	10R/28L-11000
LTJ	Klickitat VOR	047	89.0	110	5500	49	
PSC	Pasco VOR	065	87	110	5500 to Pattern Altitude of 2500	48	8/26-6510
LWS	Lewiston Airport						
		Distance:	251.8		Time:	2:24	

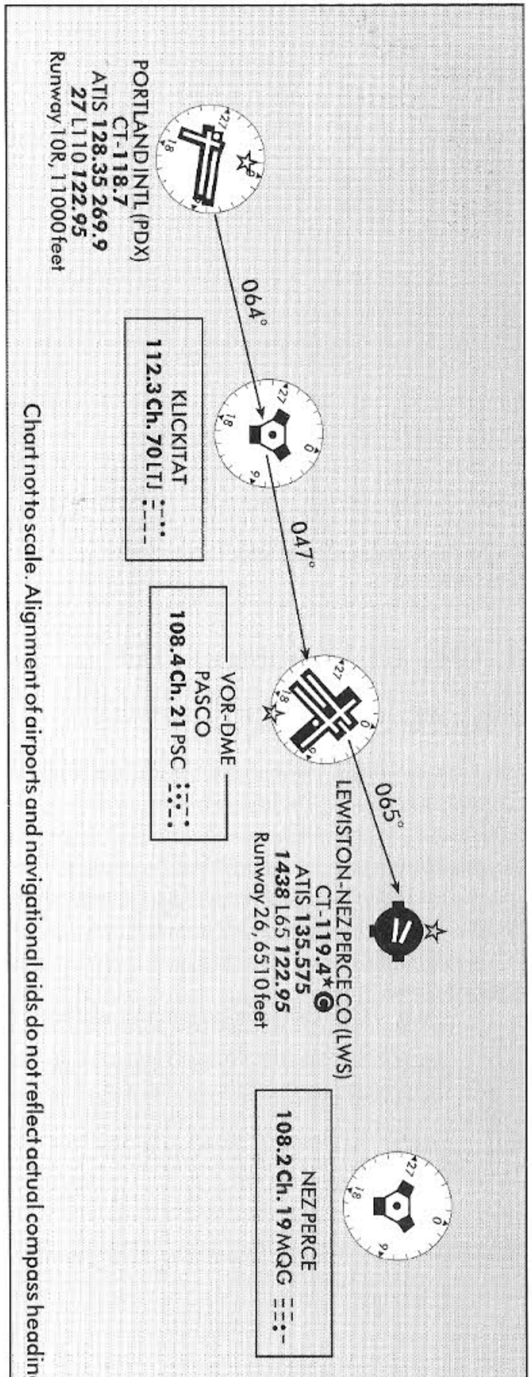


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

On this flight, you will be departing Portland International Airport on Runway 10R. Monitor the ATIS frequency on 128.35 for current airport information. When ready to depart the runway, contact Tower on 118.7. You will be making a straight out departure on Runway 10R.

After departure, turn left to a magnetic heading of 064°, and set the OBS to 064°. The first checkpoint is the Klickitat VOR found on frequency 112.3, 63.2 miles away from the Portland International Airport. Climb to 5,500 ft. Remember, when traveling between headings of 0° and 179°, always pick an odd altitude plus 500 feet for VFR flight.

After reaching the Klickitat VOR, the next checkpoint will be at the Pasco VOR, on a heading of 047°, with a frequency of 108.4. You will follow the airway V-520 with the OBS setting of 047° to Pasco. Upon reaching Pasco, turn to a heading of 065°, reset the OBS, and follow airway V-187 into the Lewiston Airport, which is 93.5 miles away. Halfway between the Pasco and Nez Perce VOR's, switch to the Nez Perce frequency on 108.2 for navigational information.

There is no approach control at Lewiston Airport. Therefore, contact the tower on 119.4 for landing instructions. Make sure to listen to the ATIS beforehand on 135.575. You will be landing on Runway 26. The pattern altitude is 2,500 ft.

Ident.	Location	VOR	Tower	Unicom	ATIS	App./Dep.	Ground
PDX	Portland Airport		118.7	122.95	128.35	118.1	121.9
LTJ	Klickitat VOR	112.3					
PSC	Pasco VOR	108.4					
MQG	Nez Perce VOR	108.2					
LWS	Lewiston Airport		119.4	122.95	122.95		121.9

Rochester, MN to Sparta/Fort McCoy, WI

From the Chicago Sectional

Flight Skills: Marginal VFR Cross-Country into IMC with Landing at Alternate Airport.

Part of the learning process in flying involves developing good judgment. This flight involves cross-country flight in marginal VFR conditions into instrument meteorological conditions (IMC) with a landing at an alternate airport.

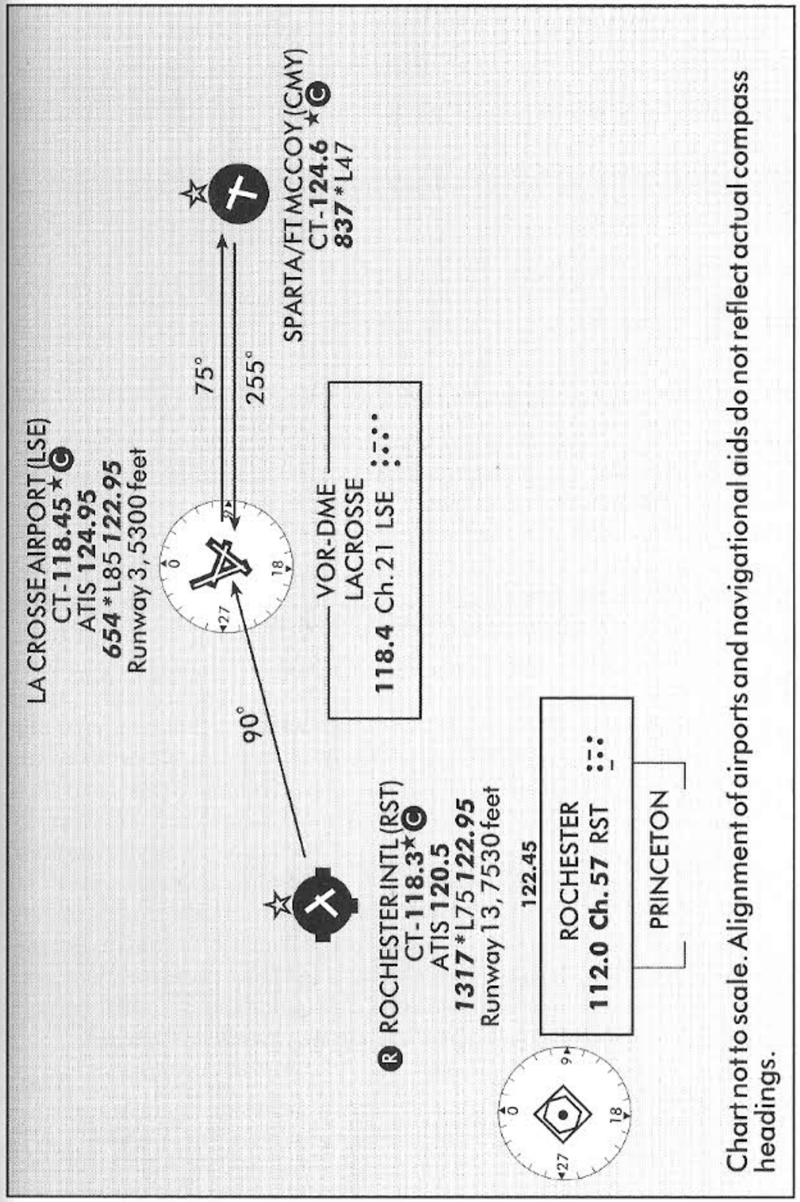
Identifier	Checkpoint	Time Off					
		Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
RST	Rochester Airport	090	53.7	110	Climb to 5500	32	13/31-7530
LSE	LaCrosse Airport	075	22.9	110	Pattern Altitude 1454	15	3/21-5300
CMY	Sparta Airport						11/29-4910 1/19-4300
		Distance:	76.6		Time:	:47	

You will be departing Rochester Airport. Monitor ATIS on 120.5 for current airport information. You will be using Runway 13. Contact the tower on 118.3 when you are ready to depart.

You will be making a left turn to a magnetic heading of 090˚. You will be using the LaCrosse VOR on 108.4 for navigation.

As you approach the Mississippi River, you will notice that the visibility is reducing and the ceiling is dropping. After you have crossed the LaCrosse VOR, indicated by a TO-FROM switch in the flag of your VOR, turn to a magnetic heading of 075˚ and reset your OBS to 075˚ for the Sparta Airport, 22.9 miles from the LaCrosse Airport.

Sometime during this leg, the visibility will decrease and eventually drop to zero, which indicates that you have entered IMC (Instrument Meteorological Conditions) and are unable to fly by visual reference. The proper procedure when this happens is to turn 180˚ using a standard rate turn on instruments only, and plan on a landing at LaCrosse Airport. The proper way to navigate back to LaCrosse is to turn the OBS on the VOR until the needle centers with a TO flag. This is your new magnetic heading back to the station. LaCrosse Airport is on the Mississippi River and is 9 miles east from the LaCrosse VOR station. In normal flight conditions, you would never allow yourself to proceed into these conditions unknowingly. LaCrosse's pattern altitude is 1,454 feet. You will be landing on Runway 3. Monitor ATIS as you approach the field, and then contact the tower on 118.45.



In an actual flight where you had filed a flight plan, you would contact the Flight Service Station to let them know of the deviation from your flight plan. You would then request that they close your flight plan by telling them that you have landed at LaCrosse Airport.

Ident.	Location	VOR	Tower	Unicom	ATIS	App./Dep.	Ground
RST	Rochester Airport	112.0	118.3	122.95	120.50	119.2	121.9
LSE	LaCrosse Airport	108.4	118.45		124.95		121.8
CMY	Sparta Airport		124.6				

The Bay Cruise (Concord, Sausalito, Oakland, San Jose, Concord)

From the San Francisco VFR Terminal Area Chart

Flight Skills: VFR Using Pilotage and Dead Reckoning

This flight will take you on a beautiful tour through the San Francisco Bay Area, a destination for many tourists. However, many busy airports serve this area, so you should be in contact with controllers throughout the entire flight.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
CCR	Buchanan	235 Airport	23.5	110	Climb	16 to 4500	1L/19R-5010
SAU	Sausalito VOR	103	16.3	110	3500	9	
OAK	Oakland VOR	132	24.9	110	3500	14	
SJC	San Jose VOR	337	37.3	110	Pattern Altitude 823	24	
CCR	Buchanan Field						14L/32R-4600
		Distance: 102			Time: 1:03		

You will be departing Buchanan Field, which is located in Concord, California. Listen to the ATIS frequency on 124.7 before departing on Runway 19R. When ready to depart, contact the tower on 119.7.

You will be making a right-hand turn after departure to a magnetic heading of 235°. Also, set the OBS to the same heading. Sausalito VOR ON 116.2 is your first checkpoint which is 23.5 miles away. Climb to an altitude of 4,500 ft. The next leg is from Sausalito to Oakland. You will be using the Oakland VOR as a navigational aid on 116.8. You should have a view on your right of the Golden Gate Bridge from the air after you have flown past

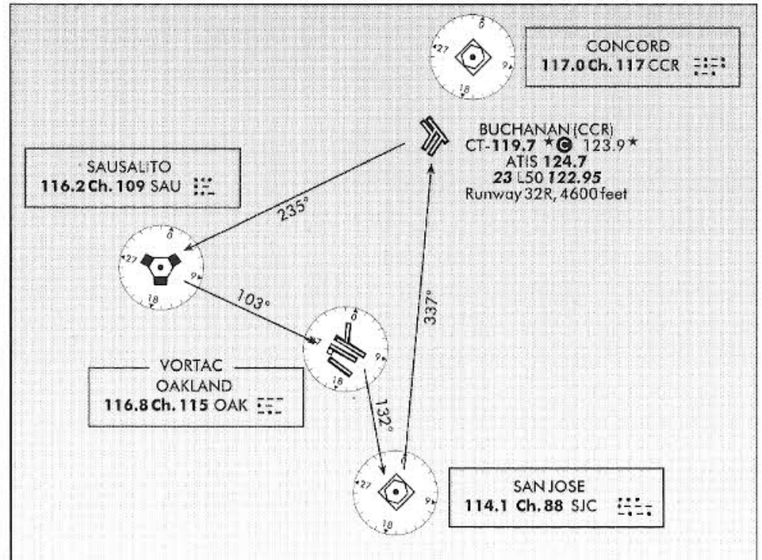


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Sausalito en route to Oakland, which is 16.3 miles away. Descend to 3,500 ft. Make sure the OBS is set to 103° for the Oakland VOR.

After you have passed the Oakland VOR, turn to the San Jose area on a heading of 132° and set the OBS accordingly. The trip to San Jose is 24.9 miles. After you have gone about halfway, dial in the San Jose VOR on 114.1 and track inbound. After arriving at the San Jose VOR, noted by a swing on the VOR needle, turn left to a new heading of 337° and climb back up to 4,500 ft as you fly back to Buchanan Field, which will take you over the hills on the east bay. Track outbound on the San Jose VOR. Turn the OBS to 337° as soon as you can.

Tune to the Concord VOR at 117.0 and track an inbound heading of 337°. As you approach Buchanan Field, listen to ATIS on 124.7 and contact Approach on 119.9 for landing sequencing. Approach control will turn you over to the tower on 119.7 for landing instructions. You will be landing on Runway 32R. Concord's altitude is 23 ft MSL, and its pattern altitude is 823 ft.

Ident.	Location	VOR	Tower	Unicom	ATIS	App./Dep.	Ground
CCR	Buchanan Airport		119.7	122.95	124.7	119.9	121.9
SAU	Sausalito VOR	116.2					
OAK	Oakland VOR	116.8					
SJC	San Jose VOR	114.1					
CCR	Buchanan Airport		119.7	122.95	124.7	119.9	121.9
CCR	Concord VOR	117.0					

Traverse City, MI (Cherry Capital Airport) to Mosinee, WI (Central Wisconsin Airport)

From the Green Bay Sectional

Flight Skills: VFR Cross-Country Using NDB Navigational Aids

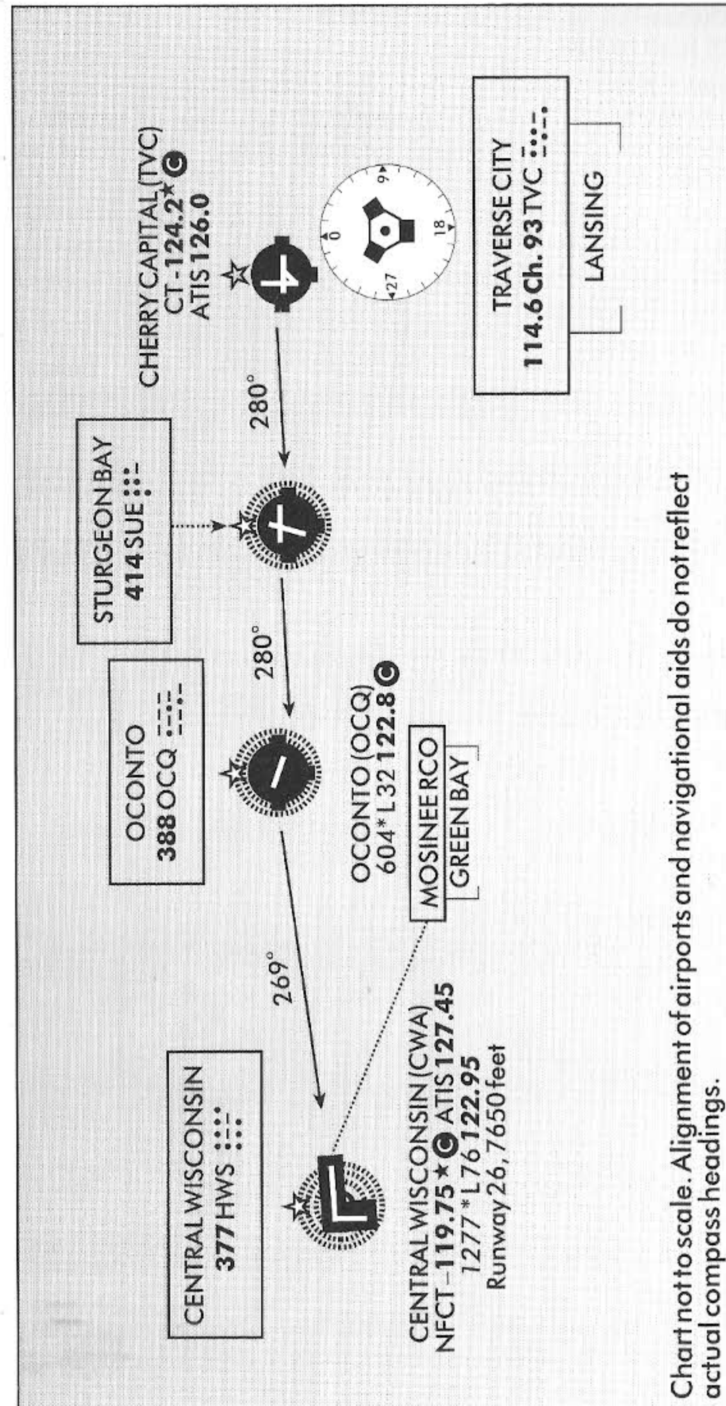
This flight is intended to build your cross-country skills using NDB navigational aids. NDBs are prevalent throughout the Midwest for navigation. They are Non-Directional Radio Beacons that do not have the advantages of the heading indications received from VOR's. However, they still can be used quite accurately. This flight will depart across Lake Michigan onto a landing in Mosinee, Wisconsin, which is the Central Wisconsin Airport.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
TVC	Cherry Capital Apt.	280	78.5	110	Climb to 4500	46	10/28-6500
SUE	Sturgeon Bay	280	20.9	110	4500	12	
OCQ	Oconto	269	74.9	110	Pattern Altitude 2077	44	
CWA	Central Wisconsin Airport						8/26-7650
		Distance:	174.3		Time:	1:42	

Listen to ATIS on 126.0 for current airport information before departing on Runway 28. When ready to depart, contact Tower on 124.2 for a straight out departure. Climb to 4,500 ft. Remember, on headings from 180° to 359°, fly at altitudes of even thousands plus 500 feet on VFR flights. As a cross-reference on your flight across Lake Michigan, you can always dial in the Traverse City VOR on 114.6 and use your DME to tell the distance across Lake Michigan.

Your first navigational aid is Sturgeon Bay, which is 78.5 miles from Cherry Capital Airport. The frequency on your ADF should be set to 414. The needle should center to the nose of the airplane on your VOR indicator. Track inbound on the 280° magnetic heading until you reach Sturgeon Bay. At Sturgeon Bay, you will notice that the needle on the ADF will swing to the tail of the airplane indicating station passage.

Your next checkpoint is Oconto, also at a magnetic heading of 280°. The frequency is 388, and the distance is 20.9 miles from Sturgeon Bay. Again, watch for station passage by a 180° needle swing on your ADF.



The next heading is 269° to the Central Wisconsin Airport. The frequency is 377. It is 74.9 miles away. The NDB is located on the field at Central Wisconsin Airport. Contact ATIS on 127.45 for current information, and then contact the tower on 119.75 for landing instructions. You will be landing on Runway 26. The field elevation in Central Wisconsin is 1,277 ft and the pattern altitude is 2,077 ft.

There is an excellent chapter on tracking inbound and outbound using NDB navigational aids beginning on page 117 in this manual. It is very helpful in refining your navigational skills and will eventually help you in the instrument landing approaches.

Ident.	Location	NDB	Tower	Unicom	ATIS	Ground
TVC	Cherry Capital Airport.		124.2	122.95	126.0	121.8
SUE	Sturgeon Bay	414				
OCQ	Oconto	388				
CWA	Central Wisconsin Airport.					
HWS	NDB	377	119.75	122.95	127.45	121.9

Walla Walla, WA to Yakima, WA

From the Seattle Sectional

Flight Skills: Cross-Country Using VOR Navigational Aids

This flight takes you over some very productive farmland in eastern Washington that is well known for its apple orchards.

Identifier	Checkpoint	Time Off					
		Mag. Hdg.	Distance	Speed	Altitude	Time	Rwy-L
ALW	Walla Walla Airport	269	35.8	110	Climb to 4500	23	2/20-7190
PSC	Pasco VOR						
		271	58.0	110	6500	33	
YKM	Yakima VOR						
		250	4.1	110	Pattern Altitude 1895	2	
YKM	Yakima Apt						9/27-7600
		Distance:	98.9		Time:	:58	

You will depart Walla Walla Airport on Runway 20 and request a straight out departure. You will be using the Walla Walla VOR on 116.4 as a navigational aid. There is no ATIS at Walla Walla. After completing the takeoff checklist, contact the tower on 118.5 for departure. Climb up to 4,500 ft. The OBS should be set for 269° and you should see a FROM flag in the window.

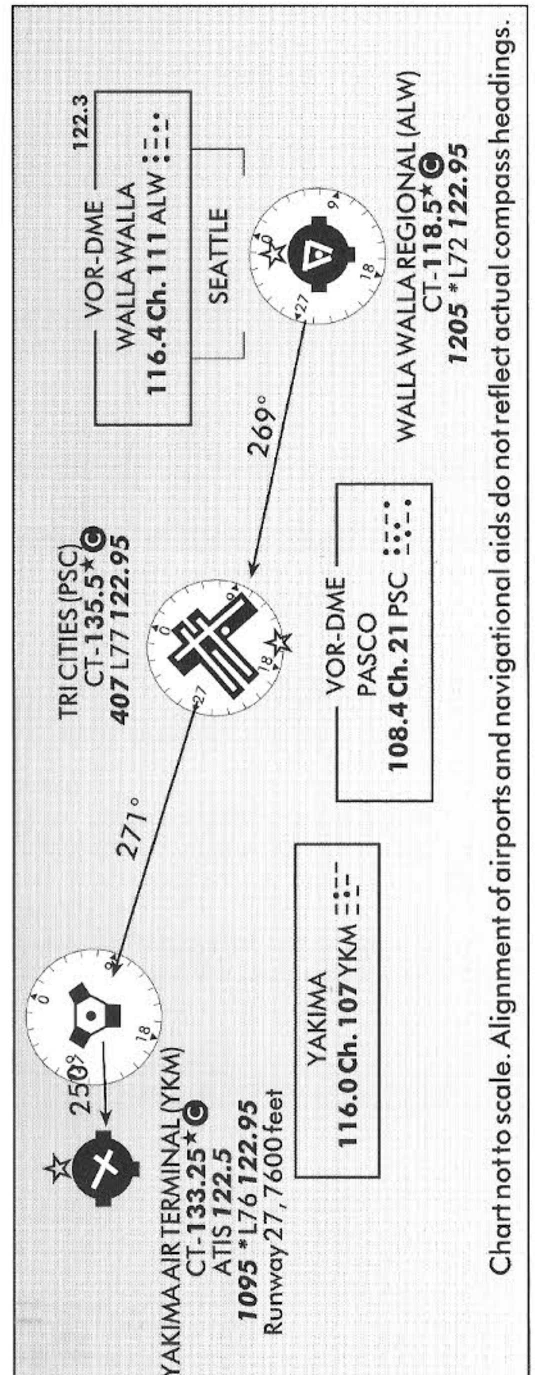


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

You will be flying on airway V-520 to Tri-Cities Airport where the Pasco VOR is located. After reaching 4,500 ft, tune in to the Pasco VOR on 108.4 with the OBS set on 269°. After passing Pasco VOR, you will turn to a new heading of 271° for the next leg of the flight. You should climb to 6,500 ft as you travel on airway V-204 to the Yakima VOR.

Twenty miles from the Yakima Airport, contact Yakima Approach on 123.8. You should have already monitored ATIS on 125.25. As you approach the Yakima VOR, start your descent for the approach into Yakima Airport. The airport is on a heading of 250° and is 4.1 miles from the VOR. You will be landing on Runway 27. Yakima's field elevation is 900 ft, and the pattern altitude should be 1,895 ft. Approach control will turn you over to Yakima Tower on 134.2 for clearance to land.

Ident.	Location	VOR	ATIS	Tower	Ground
ALW	Walla Walla Apt.	116.4		118.5	121.6
PSC	Pasco VOR	108.4	125.65	135.3	
YKM	Yakima Apt.	116.0	125.25	134.2	121.9

IFR Introduction

Preparing for an Instrument rating is considered the graduate school of flying. The diversity of information needed to fly by reference to instruments only, understanding weather patterns, aircraft systems, airway structure, ATC communications, and applicable Federal regulations, is truly a challenge worth achieving.

Pro Pilot '99 gives you an overview of instrument flying in its instructional chapters, and it gives you a chance to practice simulated IFR flights in these flight assignments. Each assignment has the information needed to complete the flight just as much as in the real world. This information has been taken from aviation charts that were current at the time of printing, but you should *never* rely on this information in an actual flight. Information can be changed or updated often by the FAA, so always make sure you have the most current information for an actual flight.

A clearance has been prepared for each flight as in an actual IFR flight. A copy of the clearance is printed in each assignment along with approach plates for landing, and an abbreviated en route chart.

You will receive air traffic control instructions throughout your flight as much as you would receive in an actual flight.

Albany, NY to Manchester, NH

Flight Skills: IFR flight, Landing with a Localizer Approach

Weather Forecast:
Albany, NY report: 500 scattered, 900 overcast, visibility 2 miles in haze. En route report: 1500 broken, 3 miles in haze. Pilot reports tops at 12,000. Manchester, NH: 900 overcast visibility 3 miles in haze. Freezing level for the flight is at 14,000 ft.
Clearance: Cessna 72 LIMA, cleared to Manchester Airport via the Cambridge VOR then as filed. Maintain 4000. Departure frequency will be on 118.05. Squawk 0523.

Identifier	Checkpoint	Time Off			
		Mag. Hdg.	Distance	Altitude	Rwy-L
ALB	Albany, NY	068	25.0	4000	1/19-7200
CAM	Cambridge VOR	108	56	6000	
V93 MHT	Manchester, NH	065	28	6000	
CON	Concord VOR	179	8.7	3000	
MHT	Manchester Airport				17/35-7000
		Distance:	117.7		

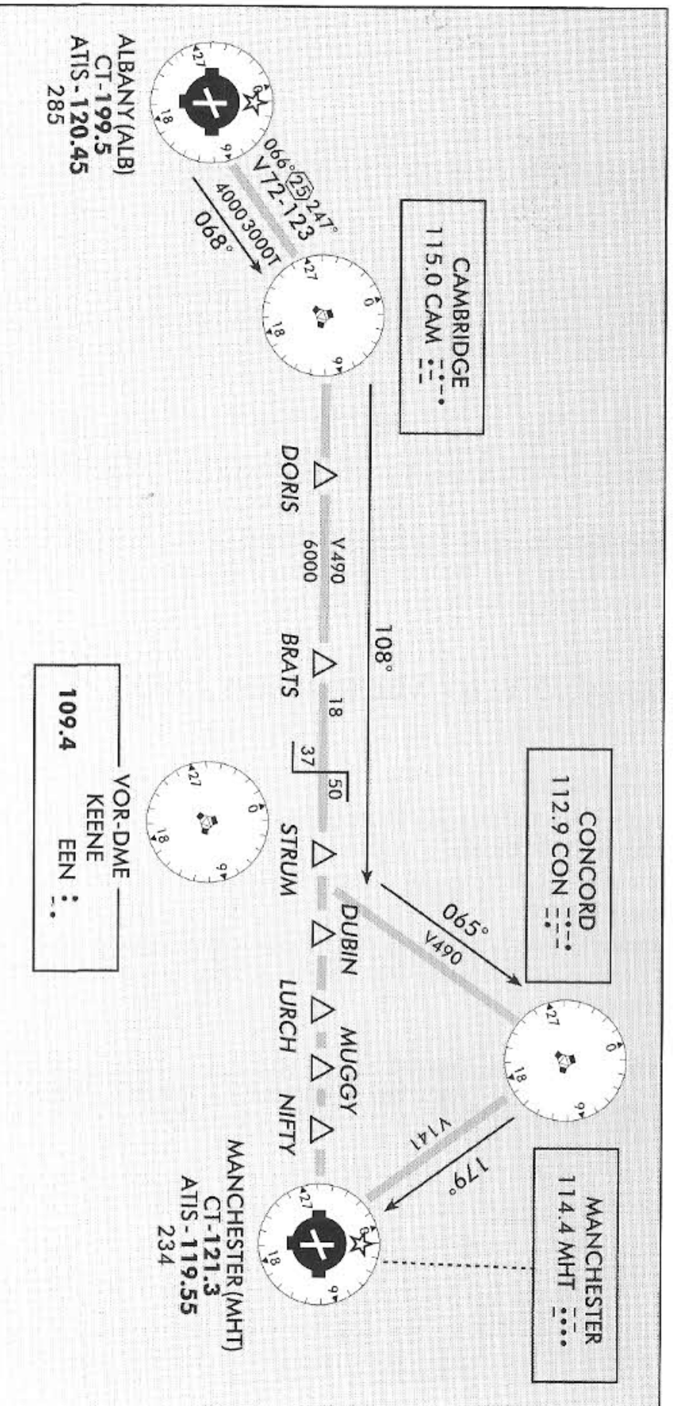
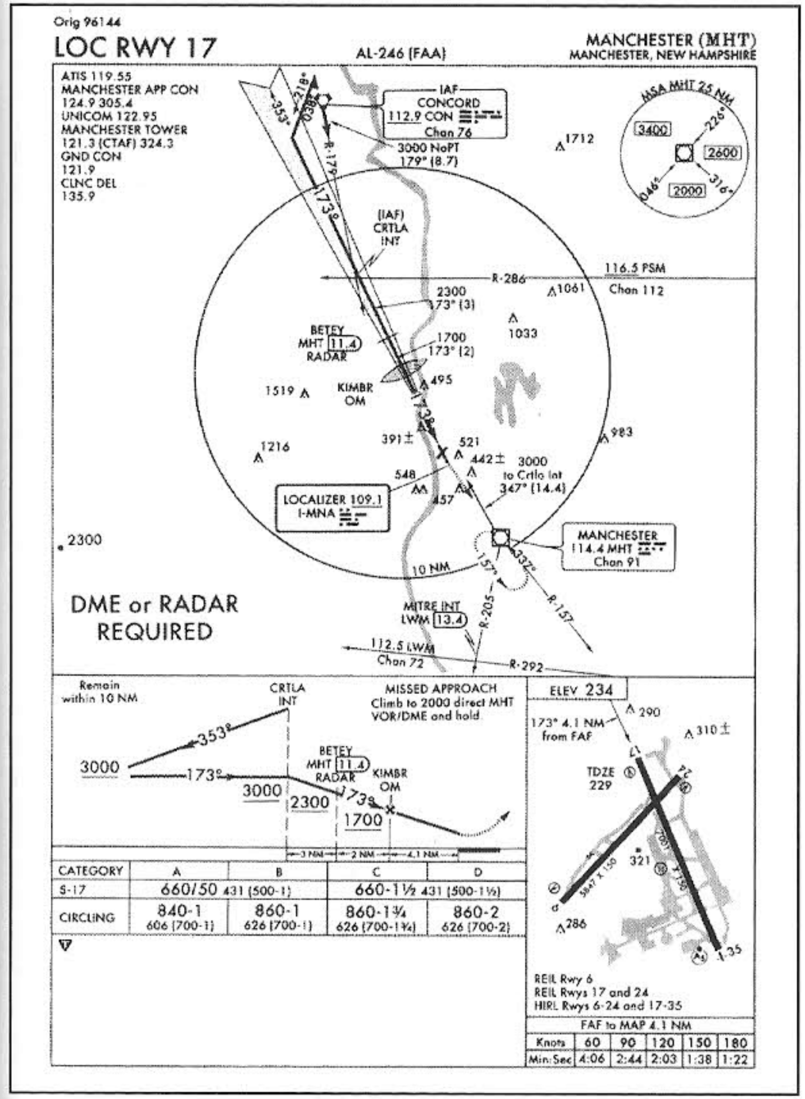


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

Logging Your Hours



CATEGORY	A	B	C	D
S-17	660/50 431 (500-1)		660-1½ 431 (500-1½)	
CIRCLING	840-1 606 (700-1)	860-1 626 (700-1)	860-1¾ 626 (700-1¾)	860-2 626 (700-2)

FAF to MAP 4.1 NM

Knots	60	90	120	150	180
Min:Sec	4:06	2:44	2:03	1:38	1:22

You have already received the weather brief and have filed a flight plan for your trip from Albany, NY to Manchester, NH. You will be flying direct to the Cambridge VOR on the V-72-123 airway and then on to Manchester on the V-490 airway. This flight will terminate using a localizer approach to Runway 17.

To begin this flight, you first listen to ATIS on 120.45. Before you are ready to taxi, contact clearance delivery for your IFR clearance. Copy it down, and then read it back to the controller for accuracy. You will depart on Runway 1. Contact the tower on 119.5 for takeoff clearance.

After takeoff, the tower will transfer you to Albany Departure on 118.05. As you climb out, they will instruct you to turn to a heading of 068° to the Cambridge VOR. You should have already set the VOR radio to 115.3 and the OBS to 068° before departure. As you climb out, intercept the course and climb to 4,000 ft. This first leg is 25 miles.

After crossing the VOR, turn outbound to a heading of 108° and climb to 6,000 ft. When you are 37 miles from Cambridge, you will be at the crossover point for radio navigation, and you should switch to the Manchester VOR on 114.4. Since our initial approach fix is the Concord VOR, you will follow the V-490 airway on the 246° radial up to Concord using a heading of 065° from the Keene VOR on 109.4. Perform the 5 T's for the approach. You are also cleared to descend to 5,000 ft. Before reaching the Concord VOR, Manchester Approach, on 124.9, gives you the clearance to the Localizer 17 approach. Turn right to a heading of 173°. Maintain 3,000 ft until you pass CRTLA on the Localizer 17 approach. CRTLA is identified on the approach plate by two radials: PSM VOR, a 286° radial on 116.5, and Concord VOR, a 179° radial on 112.9. Switch to the localizer frequency on 109.1. Passing CRTLA, you are cleared to 2,300 ft until 11.4 miles DME at BETEY. Your heading should be 173°. Fly to center the needle.

When you reach the final approach fix at the KIMBR outer marker, it is identified on the marker beacon radio with a tone and light. Start your times after checking your groundspeed to calculate the missed approach point. You are cleared down to 660 ft. You should break out of the clouds at 850 ft for a straight in landing on Runway 17. Approach transfers you to Tower and you can report inbound and receive your clearance to land on Runway 17.

Ident.	Location	VOR	LOC	ATIS	Clnc. Del.	Approach	Tower	Ground	Dep.
ALB	Albany, NY	115.3		120.45	127.5	125.0	119.5	121.71	118.05
CAM	Cambridge, NY	115.0							
CON	Concord, NH	112.9							
MHT	Manchester, NH	114.4	109.1	119.55	135.9	124.9	121.3	121.9	124.9

Bangor, ME to Boston, MA (Logan Int'l. Airport)

Flight Skills: IFR flight, Landing with an ILS Approach

Weather Forecast:
Bangor weather is 1500 overcast and 3 miles visibility. En route forecast is 1000 overcast and 3 miles visibility. Boston forecast is 800 overcast and 3 miles visibility. Freezing level for the flight is 10,000 feet.
Clearance: Cessna 72 LIMA, cleared to Logan Field via the Manchester VOR as filed. Maintain 3000. Departure frequency will be on 124.9. Squawk 0476.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Altitude	Rwy-L
BGR	Bangor, Maine	239	72.4	3000	15/33-11440
BRNNS	Intersection				
		242	41	3000	
ENE	Kennebunk VOR				
		241	47.0	6000	
MHT	Manchester VOR				
		180	34.2	4000	
BOS	Boston Logan Airport				15R/33L-10000 4R/22L-10000
		Distance:	194.6		

You begin this flight by listening to and copying ATIS on 127.75 and then dialing in clearance delivery on 135.9. Request your clearance from Bangor to Boston. This clearance is based on information received in the weather brief and on filing a flight plan with a briefer. There are always possible changes from the flight plan you gave the briefer and what may appear on your clearance. You should always read back the clearance to confirm you have it correct.

Contact Tower when ready to depart on Runway 33. You should have your VOR radio set and identified to Bangor VOR on 114.8, and your OBS set to 239°.

After departure, turn left to a heading of 239° and fly to center the needle. Climb up to 3,000 ft, which is the assigned altitude for the first segment of this flight. You are to maintain the assigned altitude by plus or minus 100 ft. Tower will turn you over to Bangor Departure on 124.9 for radar vectors and traffic separation. After reaching about 1,500 ft AGL, you will enter the overcast, which was reported at Bangor, and fly by reference to instruments only. Remember to keep your instrument scan going and don't fixate.

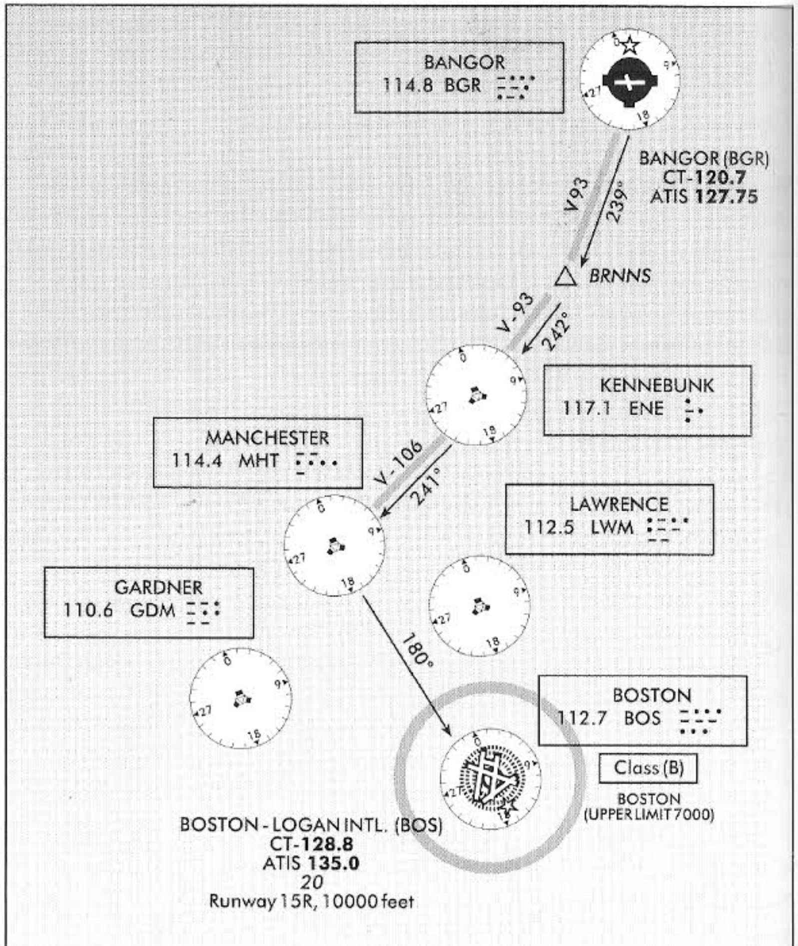
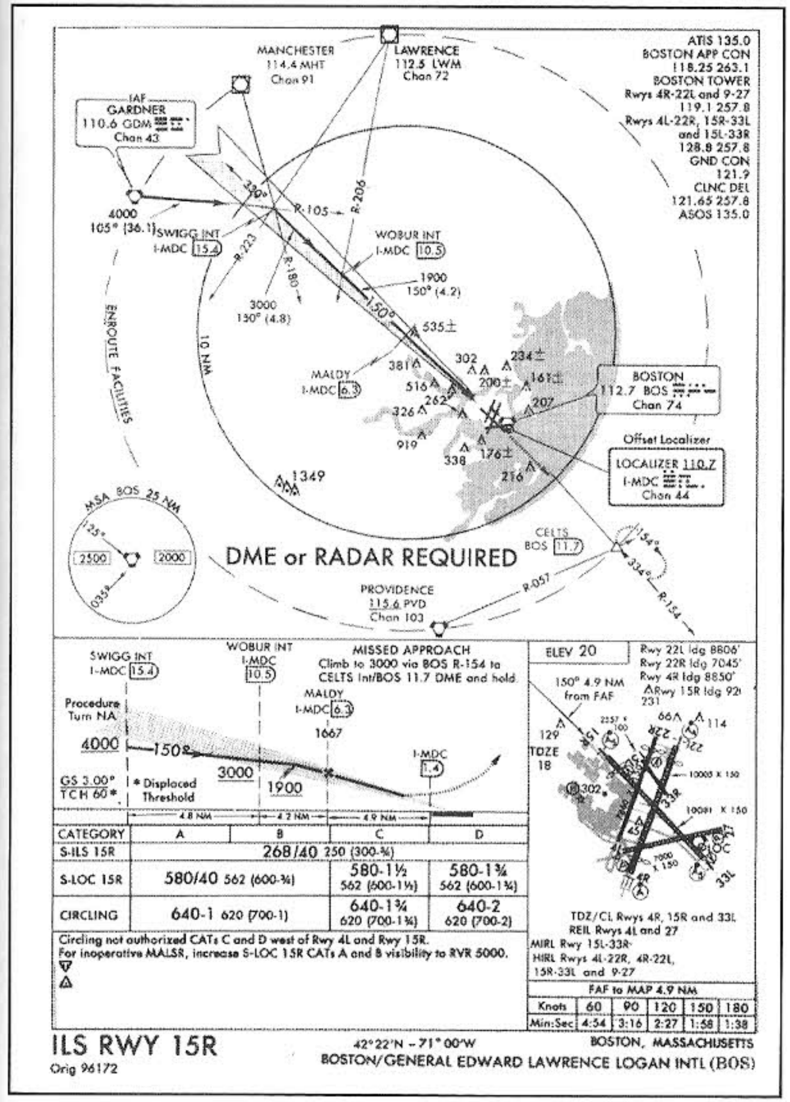


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

The first checkpoint is the BRNNS intersection on the V-93 airway, 73 DME from Bangor. You will then turn to a new heading of 242° and tune and identify the Kennebunk VOR on 117.1, which is 41 DME away. As you pass outbound from Kennebunk, the controller clears you to 5,000 ft to the Manchester VOR on 114.4 and a new heading of 241° flying the V-106 airway.

As you pass the Manchester VOR, you are cleared to 4,000 ft and a new heading of 180° for an approach to Boston. As you approach Boston Class B airspace, controllers will turn you over to the Boston approach course for the runway. "Cessna 72 LIMA, you are cleared ILS Runway 15 Right approach. Maintain 4000 until SWIGG." After this, you will read back clearance.



SWIGG is identified by multiple radials, which are as follows: the one that you are on, Manchester to 180°; the Gardner VOR 105° radial on 110.6; and the Lawrence 223° radial on 112.5.

Once you are at SWIGG, you are on the approach for Runway 15R, and you follow the published procedures as found on the approach plate. First, you turn to 150°. Tune in to the localizer frequency of 110.7 and listen for the Morse identification. You should be at 15.4 DME at SWIGG. You are now cleared down to 3,000 ft until WOBUR at 10.5 DME. Keep the localizer needle centered as you fly straight for the runway. Passing WOBER, you will intercept the glide slope, the second component of the ILS.

Check your list as you approach the final approach fix at MAIDY, 6.3 DME. Approach will now turn you over to Boston Tower on 128.8 and you report inbound. They will clear you to land on Runway 15R. At 800 ft, you break out of the clouds and you should have the runway in front of you if the needles are centered. From here on in, you fly a normal visual approach and land on 15R.

Ident.	Location	NDB	VOR	LOC	ATIS	Clnc. Del.	App./Dep.	Tower	Ground
BGR	Bangor Apt.	227	114.8	110.3	127.75	135.9	124.9	120.7	121.9
ENE	Kennebunk VOR		117.1						
MHT	Manchester VOR		114.4						
BOS	Boston (Logan)	375	112.7	110.7	135.0	121.65	118.25	128.8	121.9

Medford, OR to Eugene, OR

Flight Skills: IFR Flight with SID Departure and Landing and an NDB Approach

Weather Forecast:

Report for Medford: 1000 overcast, 10 mile visibility; En route Report: 1000 scattered, 3000 overcast, 10 mile visibility; Report for Eugene: 1000 overcast, 10 mile visibility; Freezing level is at 13,000 ft.

Clearance:

Cessna 72 LIMA, cleared to the Eugene Airport via the GNATS Two Departure MOURN transition as filed. Maintain 8000. Contact Cascade Departure on 124.3. Squawk 4602.

Identifier	Checkpoint	Time Off / Mag. Hdg.	Distance	Altitude	Rwy-L
MFR	Medford	(SID) GNATS	2	Departure	14/32-6700 9/27-3150
MFR	Medford				
EUG	Eugene	333	99	8000	16/34-8000 3/21-5200

Ident.	Location	NDB	VOR	LOC	ATIS	Approach	Tower	Ground
MFR	Medford	356	113.6	110.3	127.65	124.3	119.4	121.8
EUG	Eugene	260	112.9	109.5	125.2	119.6	118.9	121.7

Your planned flight from Medford to Eugene, Oregon is a direct flight and begins with a Standard Instrument Departure (SID), which provides a textual description and plan view of the possible departure options from Medford. This SID uses a 15-mile DME Arc to clear the airport and gain enough altitude to your en route segment with sufficient terrain clearance.

Note that a minimum climb rate of 400 ft per nautical mile is required for this departure. You will be departing on Runway 32, so note the instructions on the approach plate for *Take-off all other runways*, which says, "Climb direct to VIOLE SMM, then climb on the 270° bearing from the LMM to GNATS INT."

There are two reporting points that you will need to prepare for after departure. The first is GNATS, which is defined by a 216° radial from Rogue Valley on 113.6 and 6 DME from the station. The second is MERLI, and is 15 DME from Rogue Valley on the 251° radial. It is cross-checked by the Roseburg 154° radial.

In instrument flying, you must stay ahead of the decision process by setting up radios and other equipment as soon as possible to avoid a lot of tasks at any one time. If you find a lull, ask yourself what is next and whether you can set up for it now.

Medford does not have a clearance delivery frequency, so contact ground on 121.8 for your IFR clearance and read back. Listen to ATIS on 127.65 for current airport information prior to departure on Runway 32, a 6,700-foot long runway.

Contact tower on 119.4 for a clearance to takeoff. Immediately after departure, fly direct to the middle marker called VIOLE on a frequency of 356. Upon crossing VIOLE, turn to a heading of 270° and fly outbound on the 270° radial for a distance of 15 miles, which will place you at MERLI. Next, turn right to 324° to establish and maintain a 15-mile DME arc from Rogue Valley.

The route to Eugene follows the V-23 airway with an en route altitude of 8,000 ft. As you proceed around the arc, you will turn left to fly outbound on the 333° radial direct to Eugene. The Medford area is controlled by Cascade departure on 124.3. Cascade also provides approach control on 119.6 into Eugene.

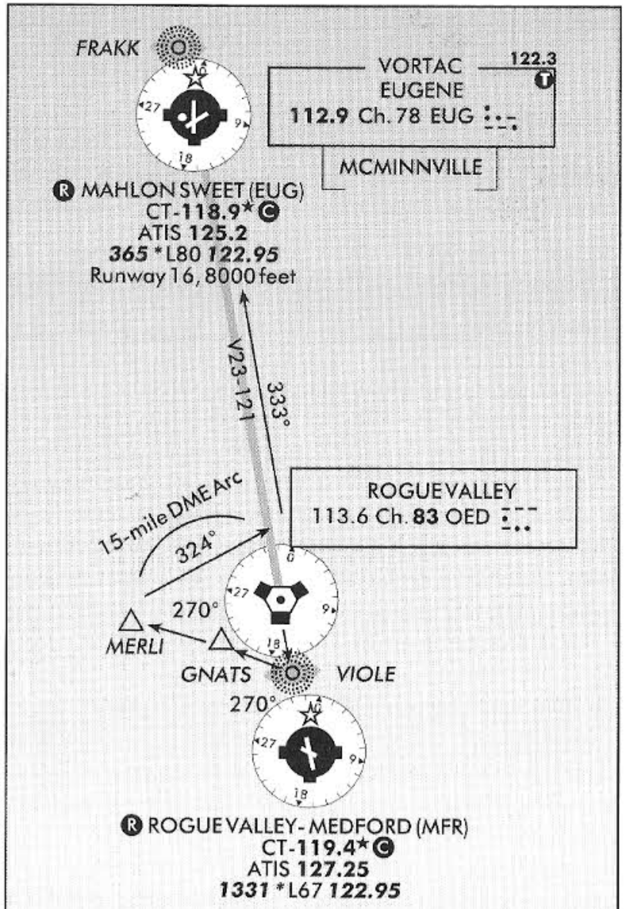
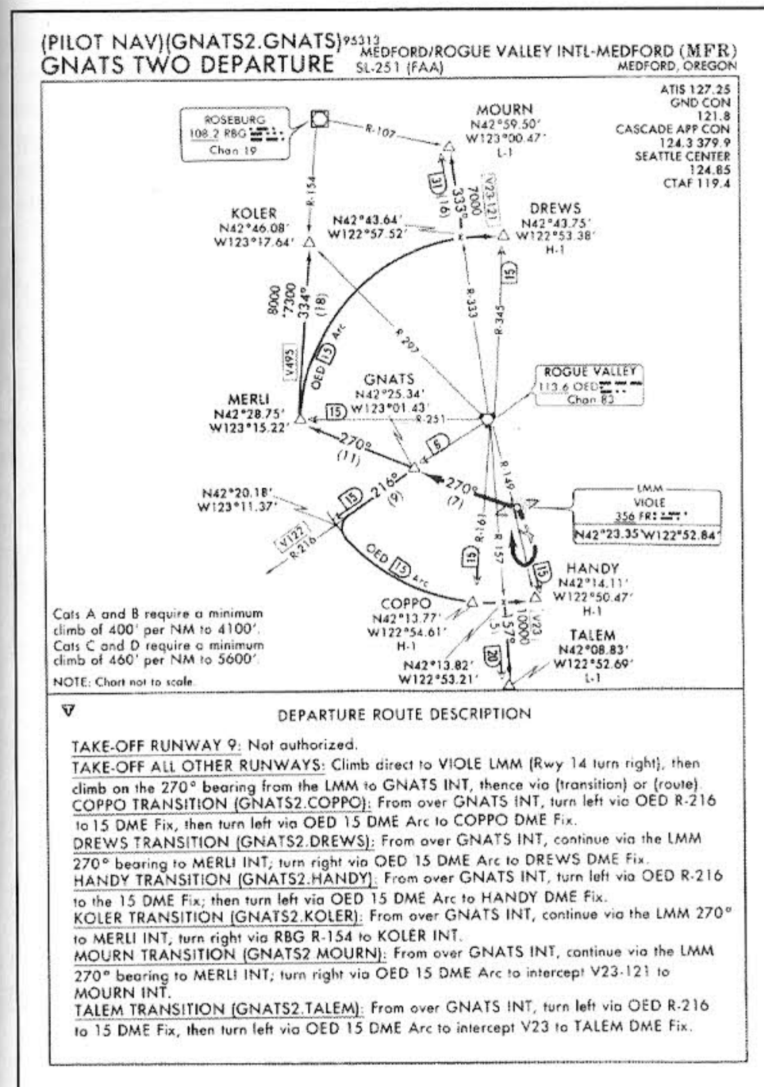


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.

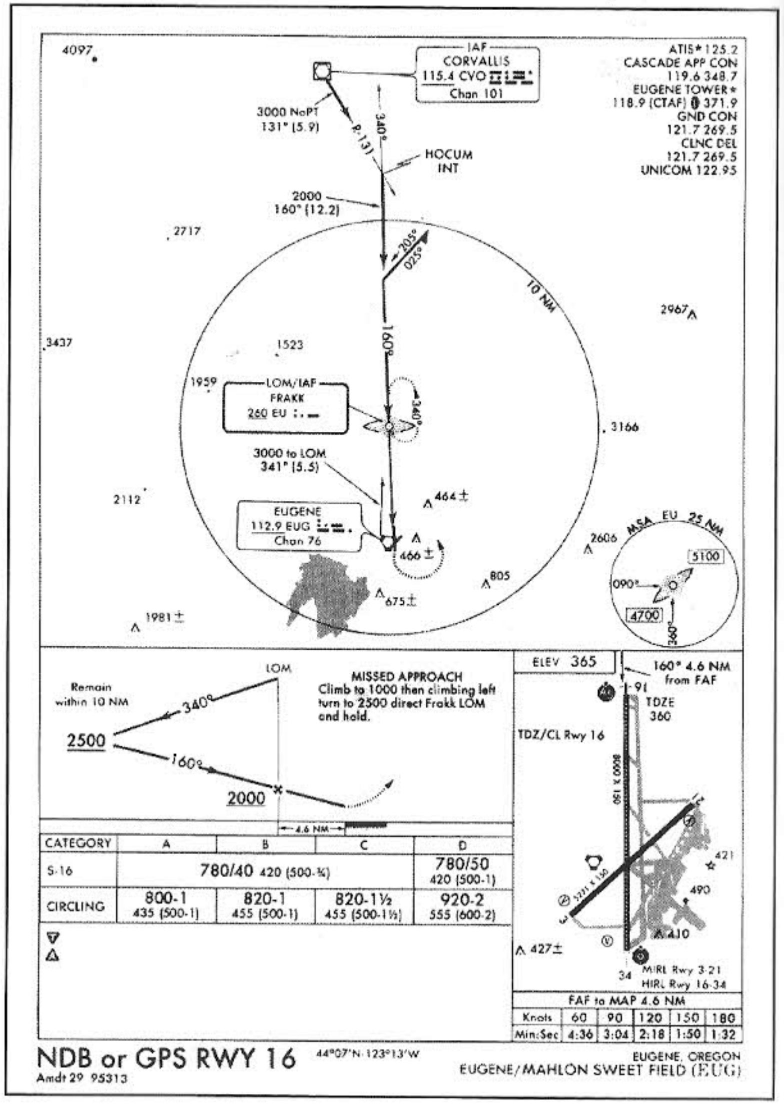
As you approach Eugene, listen to ATIS on 125.2 and contact Cascade for your NDB approach to Runway 16 at Eugene. Cascade clears you to descend to 4,000 ft 30 NM out. "Cessna 72 LIMA, you are clear the Eugene NDB 16 approach. Maintain 4000 till FRAKK." You read back approach instructions and continue direct to the Eugene VOR.

Crossing the VOR, turn outbound to a heading of 340°. Your ADF should be set to a frequency of 260. Passing over FRAKK, the ADF needle will sway to the tail. Start the timer and perform the five T's at the Initial Approach Fix. You will fly two minutes outbound from FRAKK, then start your procedure turn to the right on a heading of 025° for one minute. This is followed by a 180° turn back to 205° to intercept the final approach course of 160°. As you approach the 160° course, the ADF needle will point to 45° left of the nose.


(PILOT NAV)(GNATS2.GNATS)95313
GNATS TWO DEPARTURE SL-251 (FAA)
MEDFORD/ROGUE VALLEY INTL-MEDFORD (MFR)
MEDFORD, OREGON

DEPARTURE ROUTE DESCRIPTION

TAKE-OFF RUNWAY 9: Not authorized.
TAKE-OFF ALL OTHER RUNWAYS: Climb direct to VIOLE LMM (Rwy 14 turn right), then climb on the 270° bearing from the LMM to GNATS INT, thence via (transition) or (route).
COPPO TRANSITION (GNATS2.COPPO): From over GNATS INT, turn left via OED R-216 to 15 DME Fix, then turn left via OED 15 DME Arc to COPPO DME Fix.
DREWS TRANSITION (GNATS2.DREWS): From over GNATS INT, continue via the LMM 270° bearing to MERLI INT; turn right via OED 15 DME Arc to DREWS DME Fix.
HANDY TRANSITION (GNATS2.HANDY): From over GNATS INT, turn left via OED R-216 to the 15 DME Fix; then turn left via OED 15 DME Arc to HANDY DME Fix.
KOLER TRANSITION (GNATS2.KOLER): From over GNATS INT, continue via the LMM 270° to MERLI INT; turn right via RBG R-154 to KOLER INT.
MOURN TRANSITION (GNATS2 MOURN): From over GNATS INT, continue via the LMM 270° bearing to MERLI INT; turn right via OED 15 DME Arc to intercept V23-121 to MOURN INT.
TALEM TRANSITION (GNATS2.TALEM): From over GNATS INT, turn left via OED R-216 to 15 DME Fix, then turn left via OED 15 DME Arc to intercept V23 to TALEM DME Fix.



Now turn to a heading of 160°. You are clear to descend to 2,000 ft. The ADF needle should now be straight up. Adjust heading as needed and fly direct to FRAKK, which is the Final Approach Fix (FAF). Go through the four T's and start the clock so you can determine the missed approach point.

Passing FRAKK, you can descend to 780 ft MSL. Based on the forecast, you should break out of the clouds at 1,000 ft MSL for a straight in to Runway 16. Approach will have you contact Eugene Tower on 118.9 for a clearance to land. If you do not have the runway in sight by the missed approach point, you must execute a missed approach as published on the plate. Contact the tower to declare a missed approach and they will have you contact Cascade for further instructions.

Pueblo, CO to Denver, CO (Centennial Airport)

Flight Skills: IFR Flight, Landing with an ILS Approach

Weather Forecast:
Report for Pueblo: 1000 overcast; unrestricted visibility; Report for Denver: 600 overcast; 10 mile visibility; freezing level is 18,000 feet
Clearance: Cessna 72 LIMA, cleared to the Denver Centennial Airport via Victor 389, Falcon, direct. Maintain 9000. Departure frequency will be on 120.1. Squawk 1942.

Identifier	Checkpoint	Time Off				
		Mag. Hdg.	Distance	Speed	Altitude	Rwy-L
PUB	Pueblo, CO	349	55.9	110	9000	8L/26R-10500
LUFSE	Intersection					
		328	30.6	110	9000	
FQF	Falcon VOR					
		224	12.8	110	8700	
APA	Centennial Airport					17L/35R-10000
		Distance:	99.3			

Ident.	Location	NDB	VOR	LOC	ATIS	App./Dep.	Tower	Ground
PUB	Pueblo, CO		116.7	109.5	125.25	120.1	119.1	121.9
FQF	Falcon VOR		116.3					
APA	Centennial Airport	260		111.3		Denver 132.75	118.9	121.8

This IFR flight takes place on the east side of the Rocky Mountains. You will be landing using an ILS approach into Centennial Airport, which lies within Denver's Class B airspace.

You already have a weather briefing and have filed a flight plan. First listen to ATIS on 125.25, then contact ground control on 121.9 for your clearance to Denver. You will be departing on Runway 8L. Contact the control tower on 119.1 for a clearance to depart. You will be switching to Pueblo Departure on 120.1 as you fly outbound from the airport. Climb up to 9,000 ft as you track outbound on the Pueblo VOR on 116.7 using the 349° radial to the LUFSE intersection.

LUFSE is defined by the 148° radial from Falcon on 116.3, 31 DME, and the 23° radial from Colorado Springs on 112.5, 20 DME. At LUFSE, turn inbound to a heading 328° to the Falcon VOR. You will be in contact with Denver approach on 132.75 for your ILS approach into Centennial. The controller will call and say, "Cessna 72 LIMA, you are cleared the ILS Runway 35 Right approach. Maintain 9000 till CASSE."

Crossing Falcon, turn outbound on the 205 radial toward the Initial Approach Fix (IAF), which is CASSE, 17.7 DME, the outer marker. Upon reading CASSE, turn outbound to a heading of 167° toward the procedure turn. Start the five T's at the IAF, and watch for two minutes from the IAF prior to beginning the procedure. Turn to a heading of 122° for one minute, then start a right standard rate turn back to 302° to intercept the final approach course of 347°. You are cleared to descend to 8,000 ft MSL and intercept the glide slope at CASSE, the FAF. Perform the four T's, and before landing, check your list.

Follow the glide slope on down to the decision height of 6,083 ft MSL. You should break out of the clouds around 6,500 feet. Approach will have you contact the tower on 118.9 for clearance to land on Runway 35R.

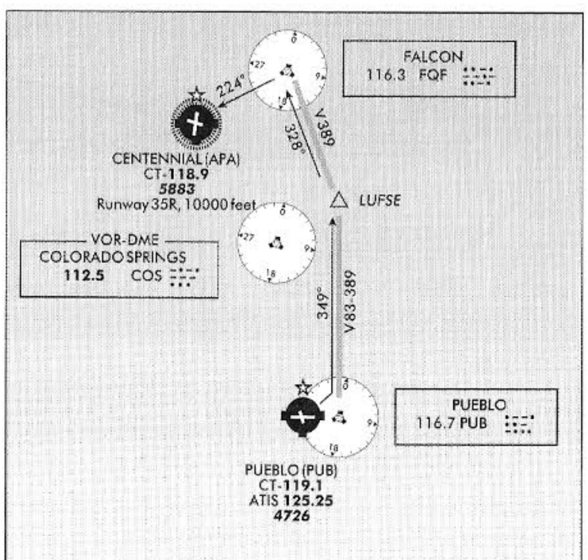
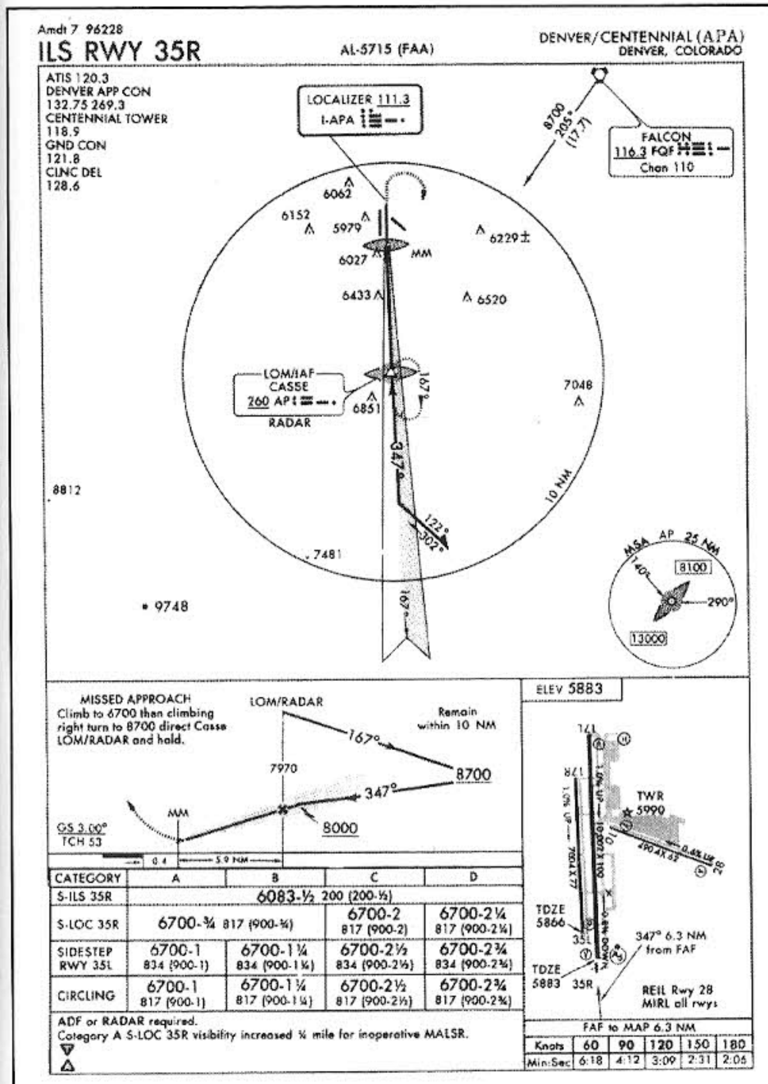


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.



Instrument Flight Assignment

Salem, OR to Hillsboro, OR

Flight Skills: IFR Flight, with a VOR Hold and VOR DME Approach.

Weather Forecast:
Report for Salem: 1900 overcast, 10 mile visibility; Report for Hillsboro: 1200 overcast, 10 mile visibility; freezing level at 8000
Clearance: Cessna 72 LIMA, you are cleared to the Hillsboro Airport. Maintain 3000. Contact Departure on 125.8. Squawk 0353.

Identifier	Checkpoint	Time Off Mag. Hdg.	Distance	Altitude	Rwy-L
SLE	Salem Airport	345	26	4000	13/31-5800
UBG	Newberg VOR				
		346	10.9	4000	
HIO	Hillsboro Airport				12/30-6600
		Distance:	36.9		

Ident.	Location	NDB	VOR	LOC	ATIS	App./Dep.	Tower	Ground
SLE	Salem Apt.	266		110.3	124.55	125.8 Seattle	119.1	121.9
UBG	Newberg VOR		117.4					
HIO	Hillsboro Apt.	356		110.7	127.65	126.0 Portland	119.3	121.7

This IFR flight is a short 36.9 miles, and will terminate in a VOR/DME approach into Hillsboro Runway 30. Controllers sometimes have to assign a holding pattern to increase separation between multiple aircraft en route to land. This flight will contain a hold as published on the Hillsboro VOR/DME or GPS A approach. This hold uses the Newberg VOR as the holding fix on the 183° radial. This is a non-standard hold in that the turns are made to the left. Because of the direction of your flight, you will have a direct entry into the hold. Review holding procedures in this manual for proper techniques. You will make three trips around the hold and then will be cleared into the VOR/DME approach.

Listen to ATIS on 124.55 at Salem for current airport information. You will be departing on Runway 31. You would have already contacted a briefer for weather information and filed a flight plan to Hillsboro. Salem's ground control is on 121.9 and will read you your clearance. Read back the clearance to ground control for accuracy.

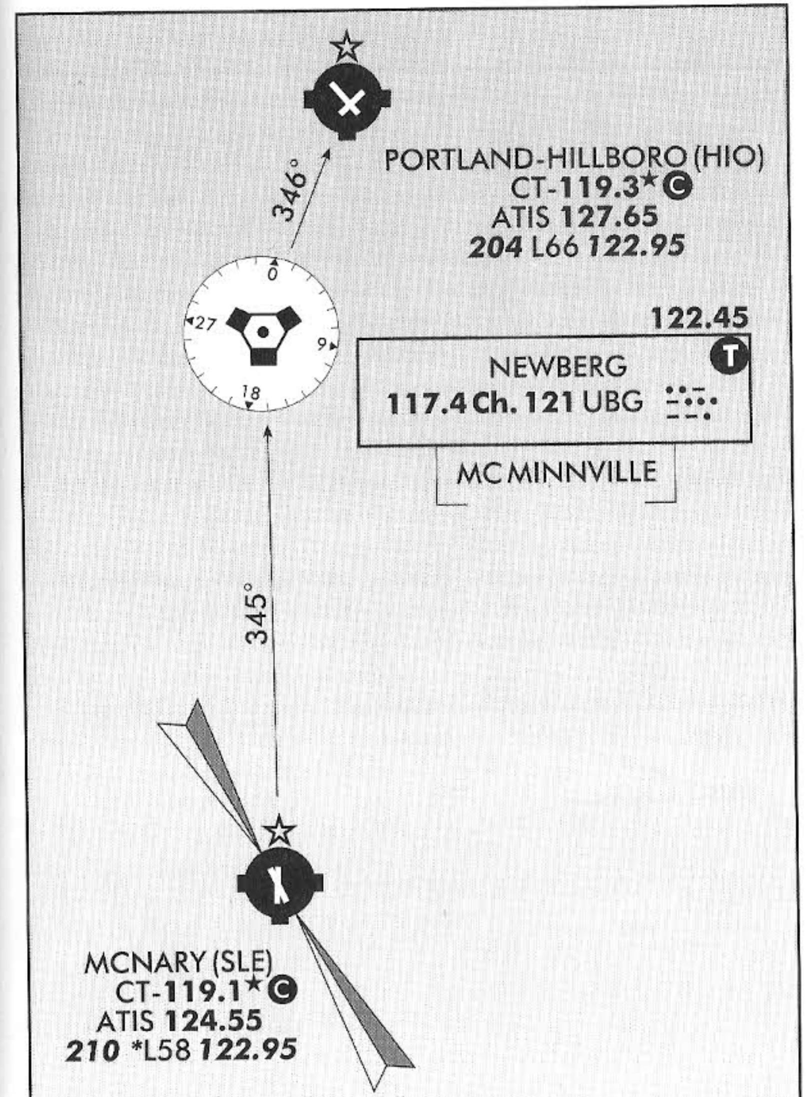
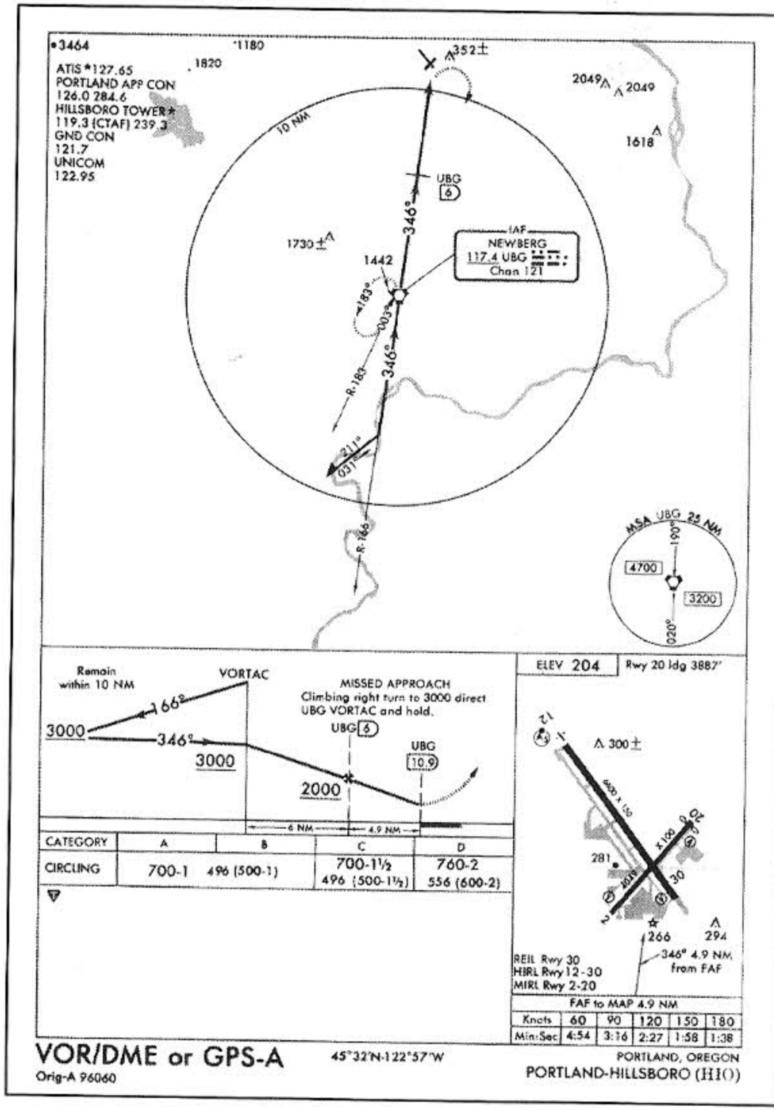


Chart not to scale. Alignment of airports and navigational aids do not reflect actual compass headings.



Contact Salem Tower on 119.1 for clearance to takeoff. Salem Tower will transfer you over to Seattle Center on 125.8 for an en route segment. Next, you will go to Portland Approach on 126.0. You will climb to 4,000 ft. Ten miles from the Newberg VOR, Portland Approach calls and says, "Cleared to Newberg VOR. Hold Southwest on the 183 degree radial; left turns; maintain 4000; expect further clearance at 12:25."

Slow down to 90 knots as you approach the VOR. As you cross the VOR noted by a TO-FROM change on the VOR, do the five T's and start a standard rate turn to the left to a heading of 183°. Contact Seattle Center to let them know you have entered the hold. When you roll out to level, start the timer for one minute. At one minute outbound, start another left-hand standard rate turn to a heading of 003°. The OBS should be set to 003° already. As you roll the wings level on the inbound, start the timer. Ideally, your inbound course should take one minute to reach the VOR. Repeat the process two more times and adjust the outbound time to give you a one minute inbound. If there is wind, correction also needs to be made in order to be centered on the 183° radial inbound.

As you approach the VOR, Seattle Center clears you for the approach by saying, "Cessna 72 LIMA, you are cleared the VOR/DME Alpha approach. Maintain 3000 till Newberg." Immediately following, you can descend to 3,000 ft until you cross the VOR. Your inbound course is 346°, which should be set in the OBS now. You are now cleared to descend to 2,000 ft until 6 DME from Newberg. At 6 DME, you are free to descend to 700 ft until 10.9 DME, which is the missed approach point.

If the forecast was correct, you should have broken out at about 1,200 ft MSL. Portland Approach will have turned you over to Hillsboro Tower on 119.3 for a clearance to land on Runway 30.

Appendix A

Required Climb Rate (ft. per NM)	Ground Speed (Knots) 30	60	80	90	100	120	140
200	100	200	267	300	333	400	467
250	125	250	333	375	417	500	583
300	150	300	400	450	500	600	700
350	175	350	467	525	583	700	816
400	200	400	533	600	667	800	933
450	225	450	600	675	750	900	1050
500	250	500	667	750	833	1000	1167
550	275	550	733	825	917	1100	1283
600	300	600	800	900	1000	1200	1400
650	325	650	867	975	1083	1300	1516
700	350	700	933	1050	1167	1400	1633

Required Climb Rate (ft. per NM)	Ground Speed (Knots) 150	180	210	240	270	300
200	500	600	700	800	900	1000
250	625	750	875	1000	1125	1250
300	750	900	1050	1200	1350	1500
350	875	1050	1225	1400	1575	1750
400	1000	1200	1400	1600	1700	2000
450	1125	1350	1575	1800	2025	2250
500	1250	1500	1750	2000	2250	2500
550	1375	1650	1925	2200	2475	2750
600	1500	1800	2100	2400	2700	3000
650	1625	1950	2275	2600	2925	3250
700	1750	2100	2450	2800	3150	3500

Table 1 *A rate of climb table is used in planning and executing takeoff procedures under known or approximate ground speed conditions.*

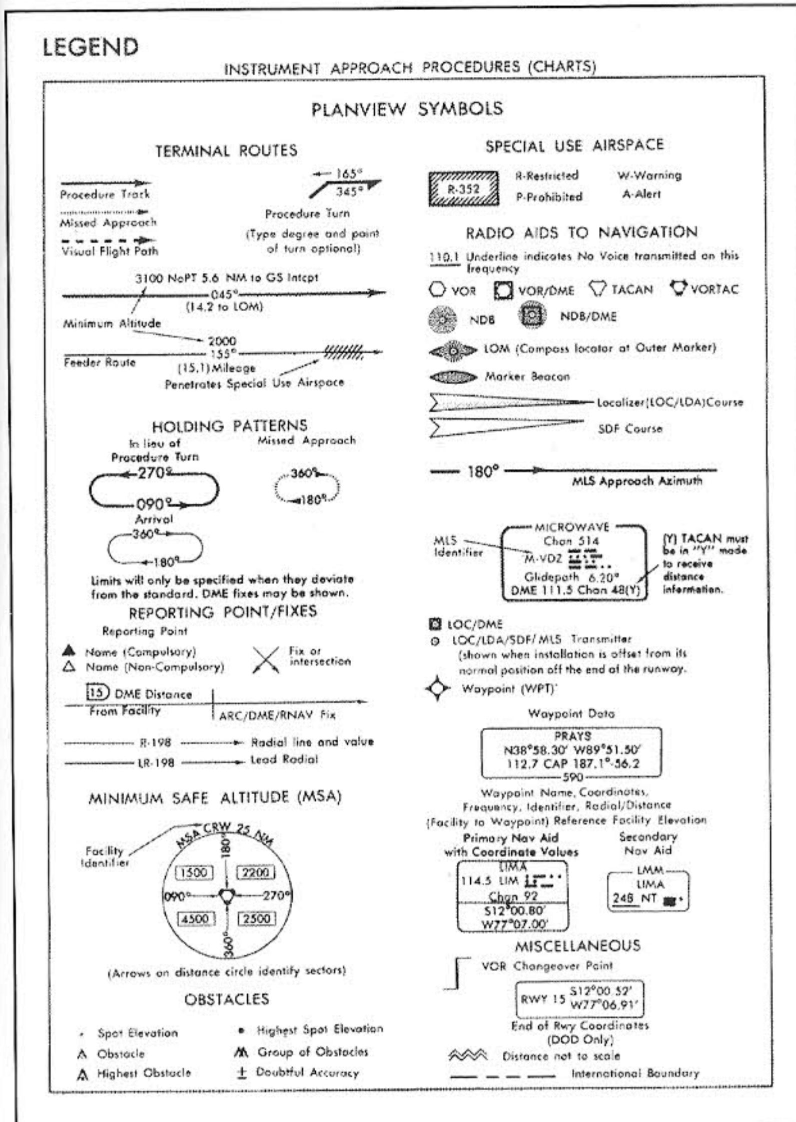


Figure A.1 *The plan view symbols legend found in all approach chart books.*

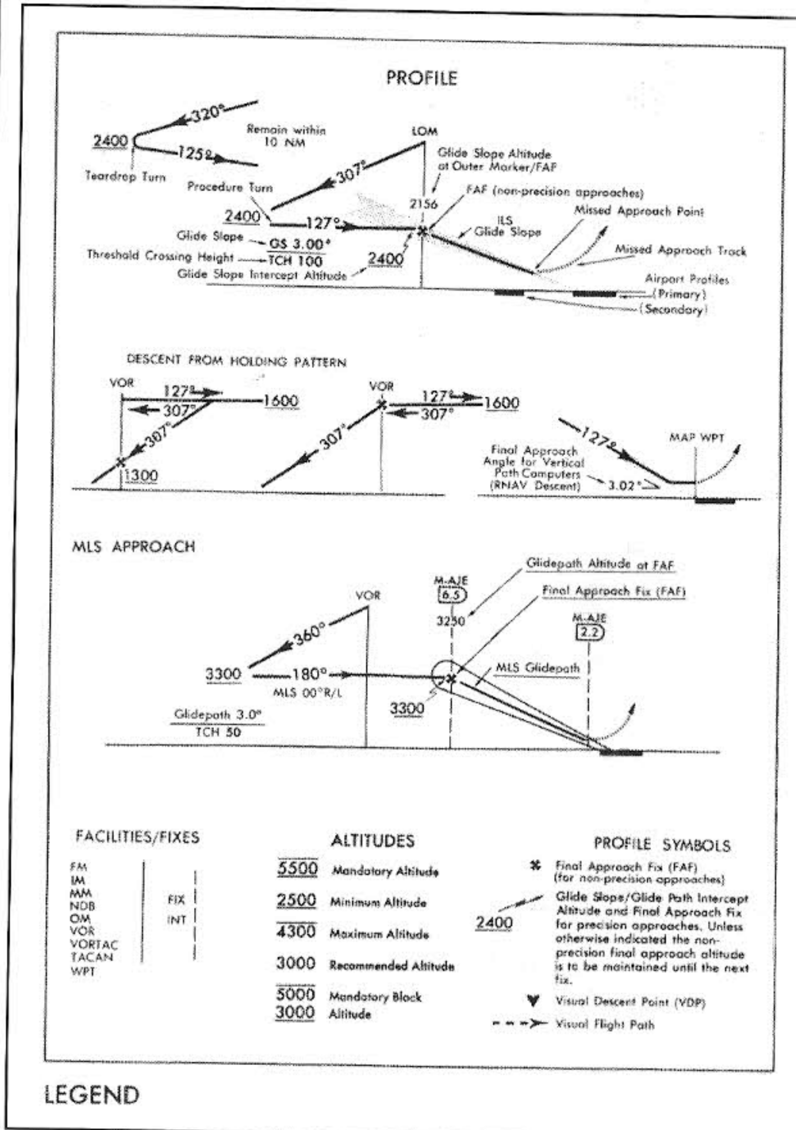


Figure A.2 *All instrument approach charts contain profile views. A legend in the approach chart book explains the data found in each one.*

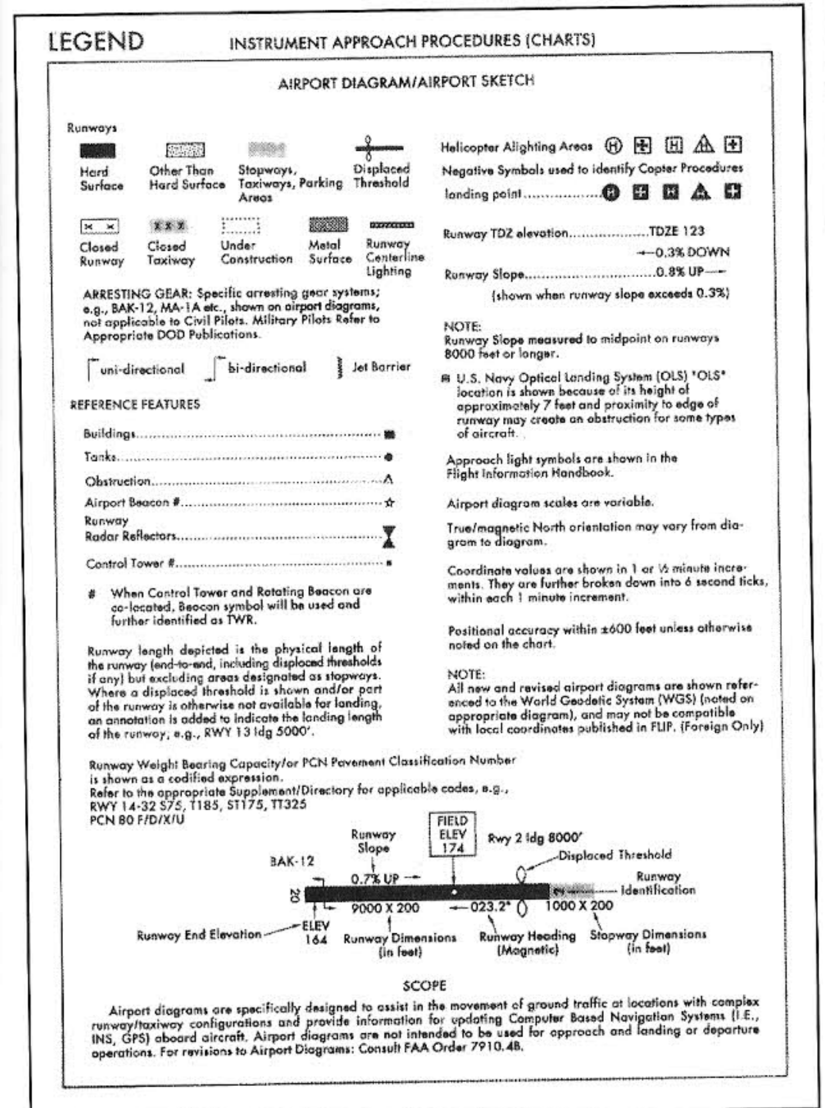


Figure A.3 *All instrument approach charts contain airport sketches. A legend in the approach chart book explains the data found in each one.*

IFR LANDING MINIMA

Landing minima are established for six aircraft approach categories (ABCDE and COPTER). In the absence of COPTER MINIMA, helicopters may use the CAT A minimums of other procedures. The standard format for portrayal of landing minima is as follows:

AIRCRAFT APPROACH CATEGORIES

Speeds are based on 1.3 times the stall speed in the landing configuration of maximum gross landing weight. An aircraft shall fit in only one category. If it is necessary to maneuver at speeds in excess of the upper limit of a speed range for a category, the minimums for the next higher category should be used. For example, an aircraft which falls in Category A, but is circling to land at a speed in excess of 91 knots, should use the approach Category B minimums when circling to land. See following category limits:

MANEUVERING TABLE

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

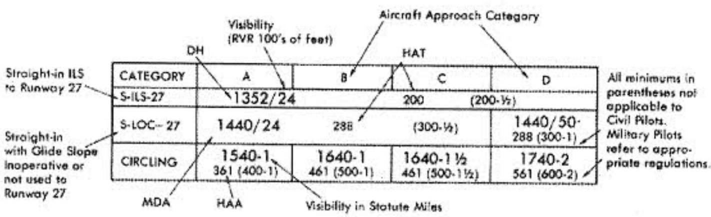
RVR/Meteorological Visibility Comparable Values

The following table shall be used for converting RVR to meteorological visibility when RVR is not reported for the runway of intended operation. Adjustment of landing minima may be required – see Inoperative Components Table.

RVR (feet)	Visibility (statute miles)	RVR (feet)	Visibility (statute miles)
1600	¼	4000	¾
2000	⅜	4500	⅞
2400	½	5000	1
3200	⅝	6000	1¼

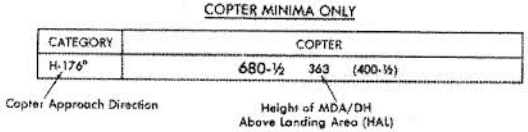
LANDING MINIMA FORMAT

In this example airport elevation is 1179, and runway touchdown zone elevation is 1152.



CATEGORY	A	B	C	D
S-ILS-27	1352/24		200	(200-½)
S-LOC-27	1440/24	288	(300-½)	1440/50- 288 (300-1)
CIRCLING	1540-1 361 (400-1)	1640-1 461 (500-1)	1640-1½ 461 (500-1½)	1740-2 561 (600-2)

COPTER MINIMA ONLY



CATEGORY	COPTER
H-176°	680-½ 363 (400-½)

No circling minimums are provided

TERMS/LANDING MINIMA DATA

Figure A.4 *An explanation of the landing minima terms and data used in approach charts.*

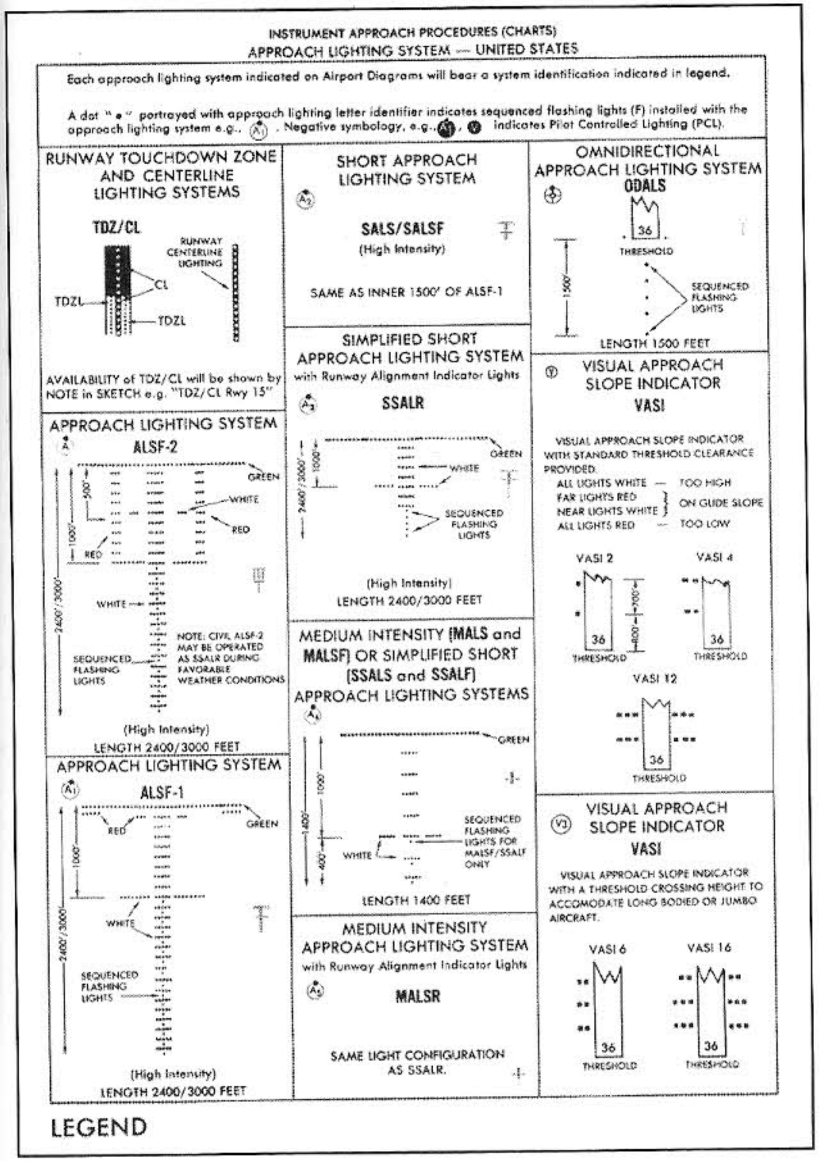
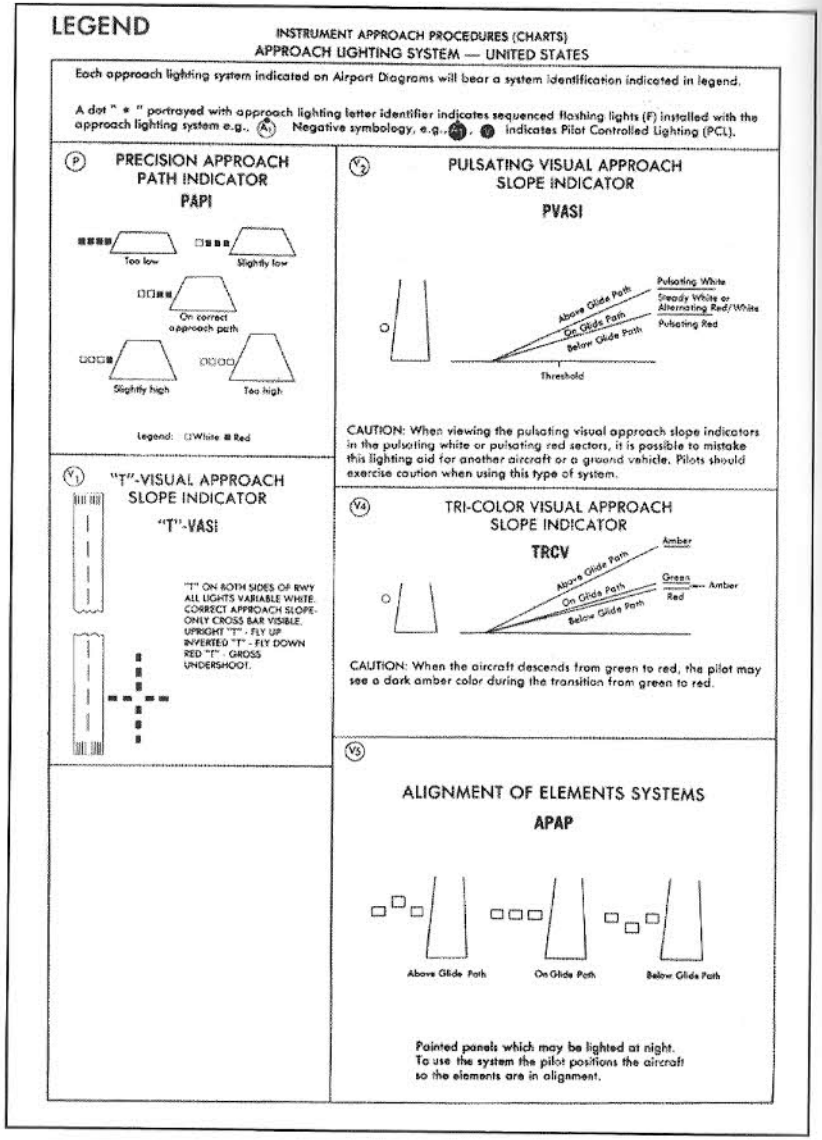


Figure A.5 *There is a variety of approach lighting systems, but they are explained in detail in the front of all approach chart books.*



Appendix B

Phonetic Alphabet

Alpha	Golf	Mike	Sierra	Yankee
Bravo	Hotel	November	Tango	Zulu
Charlie	India	Oscar	Uniform	
Delta	Juliett	Papa	Victor	
Echo	Kilo	Quebec	Whiskey	
Foxtrot	Lima	Romeo	X-ray	

Morse Code Symbols

A .–	K –.–	U ..–	5 .....
B –...	L .–..	V ...–	6 –....
C –.–.	M ––	W .––	7 ––...
D –..	N –.	X –..–	8 –––..
E .	O –––	Y –.––	9 ––––.
F ..–.	P .––.	Z ––..	0 –––––
G ––.	Q ––.–	1 .––––	. (period) .–.–.–
H	R .–.	2 ..–––	, (comma) ––..––
I ..	S ...	3 ...––	/ –..–.
J .–––	T –	4 ....–	? ..––..

The Four W's of Radio Communication

When contacting the tower or ground control it is important to always provide these four essential bits of information:

Who you are calling – either ground control or the tower.

Who you are – your aircraft make and callsign (minus the first letter).

Where you are – for takeoff, let them know where you are on the ground; for landings let them know how far away you are and in what direction you are heading.

What you want – directions for taxiing, takeoff, or landing.

Radio Frequency Bands

Very low frequency (VLF)	10-30 kilohertz
Low frequency (LF)	30-300 kilohertz
Medium frequency (MF)	300-3000 kilohertz
High frequency (HF)	3-30 megahertz
Very high frequency (VHF)	30-300 megahertz
Ultra high frequency (UHF)	300-3000 megahertz

Acronyms and Abbreviations

A

AD—Airworthiness Directive
ADF—Automatic Direction Finder
ADIZ—Air Defense Identification Zone
A/FD—Airport/Facility Directory
AFSS—Automated Flight Service Station
AGL—Above Ground Level
AI—Attitude Indicator
AIM—Aeronautical Information Manual
AIRMET—Airman's Meteorological Information
ALS—Approach Light System
ALT— Altitude; Altimeter
ARTCC—Air Route Traffic Control Center
ARTS—Automated Radar Terminal System
ASI—Airspeed Indicator
ASOS—Automated Surface Observing System
ATA—Airport Traffic Area
ATC—Air Traffic Control
ATCRBS—Air Traffic Control Radar Beacon System
ATCT—Air Traffic Control Tower
ATD—Actual Time of Departure
ATIS—Automatic Terminal Information Service
ATP—Airline Transport Pilot
AWOS—Automated Weather Observing System

B

BKN—Broken
BRITE—Bright Radar Indicator Tower Equipment

C

C—Centigrade (degrees)
CAS—Calibrated Airspeed
CAT—Clear Air Turbulence
CD—Clearance Delivery
CDI—Course Deviation Indicator
CFI—Certified Flight Instructor
CG—Center of Gravity
CH—Compass Heading
CRS—Course
CT—Control Tower
CTAF—Common Traffic Advisory Frequency

D

DA—Density Altitude
DF—Direction Finder
DG—Directional Gyro
DH—Decision Height
DME—Distance Measuring Equipment
DR—Dead Reckoning
DUAT—Direct User Access terminal

E

EFAS—En Route Flight Advisory Service
EGT—Exhaust Gas Temperature
ELT—Emergency Locator Transmitter

ETA—Estimated Time of Arrival
ETD—Estimated Time of Departure
ETE—Estimated Time En Route

F

F—Fahrenheit (degrees)
FAA—Federal Aviation Administration
FAR—Federal Aviation Regulation
FBO—Fixed Base Operator
FL—Flight Level
FPM—Feet Per Minute
FSS—Flight Service Station
ft—Feet

G

GC—Ground Control
GOES—Geostationary Operational Environmental Satellite
GPS—Global Positioning System
GS—Groundspeed; Glide Slope

H

HAA—Height Above Airport
HDG—Heading
HF—High Frequency
Hg—Mercury (barometric measure)
HI—Heading Indicator
HIRL—High Intensity Runway Lights
HSI—Horizontal Situation Indicator
Hz—Hertz (cycles per second)

I

IAF—Initial Approach Fix
IAS—Indicated Airspeed
ICAO—International Civil Aviation Organization
IFR—Instrument Flight Rules
ILS—Instrument Landing System
IMC—Instrument Meteorological Conditions

K

KCAS—Knots Calibrated Airspeed
kHz—Kilohertz
km—Kilometer
kt—Knots
KTAS—Knots True Airspeed

L

LDA—Localizer Directional Aid
LIFR—Low Instrument Flight Rules
LIRL—Low Intensity Runway Lights
LORAN—Long Range Navigation
LW—Landing Weight

M

MALSR—Medium Intensity Approach Light System with Runway Alignment
MAYDAY—International Distress Radio Signal
MC—Magnetic Compass; Magnetic Course
MDA—Minimum Descent Altitude
MEF—Maximum Elevation Figures
METAR—Meteorological Reports–Aviation Routine
MH—Magnetic Heading
MHz—Megahertz
MIRL—Medium Intensity Runway Lights
MLS—Microwave Landing System
MOA—Military Operations Area
MSA—Minimum Sector Altitude

MSL—Mean Sea Level

MTR—Military Training Route

Multicom—self-announcing radio frequency

MVFR—Marginal Visual Flight Rules

N

Navaid—Navigational Aid

NDB—Non-Directional Beacon

NM—Nautical Miles

NOS—National Ocean Service

NOTAM—Notice To Airmen

NTSB—National Transportation Safety Board

NWS—National Weather Service

O

OAT—Outside Air Temperature

OBS—Omni Bearing Selector

OVC—Overcast

P

PA—Pressure Altitude

PAPI—Precision Approach Path Indicator

PIREP—PIlot REPort

PVASI—Pulsating Visual Approach Slope Indicator

R

RAIL—Runway Alignment Indicator Lights

RBI—Relative Bearing Selector

RCLS—Runway Centerline Lighting System

RCO—Remote Communications Outlet

REIL—Runway End Identifier Lights

RNAV—Area Navigation

RPM—Revolutions Per Minute

RVR—Runway Visual Range

RWY—Runway

S

SCT—Scattered

SDF—Simplified Directional Facility

SIGMET—Significant Meteorological Advisory Alert

SM—Statute Mile

SPECI—Special Surface Observation

Squawk—Activate transponder code

SUA—Special Use Airspace

SVFR—Special Visual Flight Rules

T

TAC—Terminal Area Chart

TACAN—Tactical Air Navigation

TAF—Terminal Area Forecast

TAS—True Airspeed

TC—True Course

TCA—Terminal Control Area

TDZL—Touchdown Zone Lights

TH—True Heading

TRACON—Terminal Radar Approach Control

TRSA—Terminal Radar Service Area

T-VASI—T-form Visual Approach Slope Indicator

TWEB—Transcribed Weather Broadcast

U

UHF—Ultra High Frequency

Unicom—A non-governmental comunications facility

UTC—Universal Coordinated Time or Greenwich Mean Time

V

VAR—Variation

VASI—Visual Approach Slope Indicator

VFR—Visual Flight Rules

VHF—Very High Frequency

VOR—VHF Omnidirectional Range

VOR/DME—VOR with Distance Measuring Equipment

VORTAC—VOR with TACAN

VSI—Vertical Speed Indicator

W

WAC—World Aeronautical Charts

WCA—Wind Correction Angle

WSFO—Weather Service Forecast Office

WSO—Weather Service Office

Z

Zulu—Greenwich Mean Time or Coordinated Universal Time (UTC)

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AVweb, The Internet's Aviation Magazine – www.avweb.com

Experimental Aircraft Association (EAA) – www.eaa.org

Federal Aviation Administration (FAA) – www.faa.gov

FAA Regulations, Table of Contents – www3.landings.com/cgi-bin/get_file?pass=12345&fars.html

METAR/TAF Information Page – www.nws.noaa.gov/oso/oso1/oso12/metar.html

National Weather Service – www.nws.noaa.gov

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