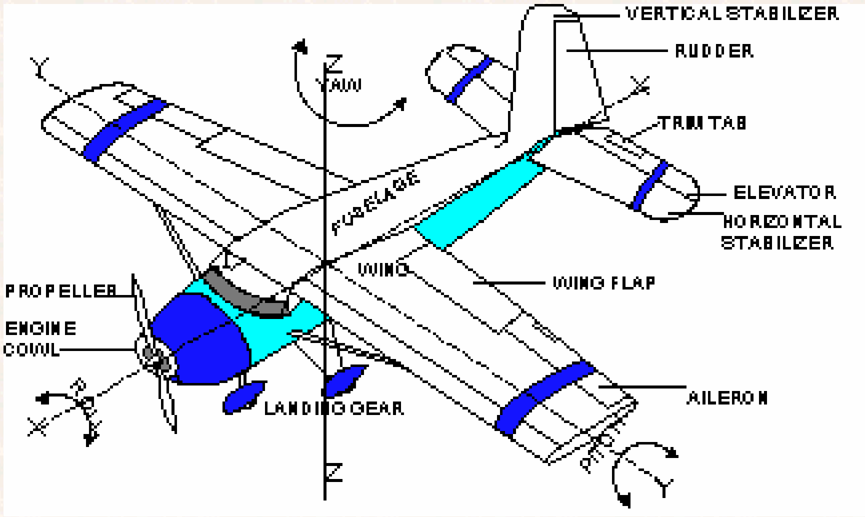
Home

Contents

OTHER AVIATION STUFF OF INTEREST

Major Airplane Components



A ***single engine*** airplane typically used by student pilots is shown above.

The ***fuselage*** is the structure which houses the Pilot and passengers, as well as the instrument panel and controls.

The ***Wings*** provide the major **LIFT** for the airplane.

Ailerons are located near the outer portion of the wing. The ailerons operate in opposition to each other; i.e. when the left aileron is up, the right aileron is down. This configuration causes the aircraft to "roll" to the left. Placing the ailerons in the opposite position causes a roll to the right.

Flaps are located on the inboard end of the wing, next to the fuselage. Flaps can be deployed during decent to landing to provide increased lift, and increased drag to slow the aircraft. Flaps permit a steeper decent without build-up of excessive speed.

The ***horizontal stabilizer and elevators*** are located on the tail of the fuselage. The horizontal stabilizers are fixed. The elevators are hinged at the aft end of the stabilizers. The Elevators control the pitch (nose-up or nose-down) state of the aircraft.

The ***vertical stabilizer*** is attached to the tail of the fuselage. The ***Rudder*** is hinged to the aft end of the vertical stabilizer. The Rudder permits the pilot to move the tail of the aircraft left or right by use of the rudder pedals in the cockpit..

The ***landing gear*** shown above is a "tricycle" type, which is comprised of the ***Main Gear*** and the ***Nose Wheel***. Some aircraft, however, have a tail wheel instead of the nose wheel. These aircraft are usually of earlier design, and are lovingly called "tail draggers" by many pilots. Most "training type" aircraft have "fixed" landing gear; i.e. the gear remains stationary in flight and cannot be "retracted". Higher performance aircraft usually are equipped with "retractable" landing gear to reduce aerodynamic drag during flight..

The ***engine and propeller*** provide the forward thrust necessary to attain sufficient speed to achieve flight. The engine is housed under the ***cowl***, at the nose of the aircraft.

Some aircraft have secondary control surfaces called ***Trim Tabs***. These tabs can be located on the elevators to aid in maintaining pitch of the aircraft. Other tabs can also be located on the ailerons and rudder to aid in stabilizing the roll and yaw characteristics as an assist in maintaining the flight configuration selected by the pilot.

Axes of Rotation
The aircraft is free to move around 3 different axes.

- The ***LONGITUDINAL AXIS*** is an imaginary line(line X - X) from nose to tail. Rotation around the LONGITUDINAL axis is called ***ROLL***. Roll is controlled by the ailerons. When the pilot turns the CONTROL WHEEL (or in some aircraft a control stick), to the RIGHT the right aileron deflects upward, while the left aileron deflects downward. This causes the right wing to produce less lift and the left wing to produce greater lift. This unequal lift causes the airplane to ROLL to the right as long as the ailerons remain in this condition. In order to stop the roll, it is necessary to neutralize the ailerons. The aircraft will remain in a "banked" condition until rolled back to level by application of opposite aileron action.

- The ***LATERAL AXIS*** is an imaginary line (line Y-Y) from wingtip to wingtip. Rotation around the LATERAL axis is called ***PITCH***. The "nose up" or "nose down" pitch of the aircraft is controlled by use of the elevator surfaces of the tail. When the pilot pulls the control wheel (or control stick) rearward, the elevators deflect upward, forcing the tail downward. This is referred to as a "nose up attitude". When the control wheel or stick is moved forward, the opposite reactions occur, causing a "nose down attitude".

- The ***VERTICAL AXIS*** is an imaginary vertical line (line Z_Z)running through the center of gravity of the aircraft. Rotation around the VERTICAL axis is called ***YAW***. Yaw is predominately controlled by use of the rudder. Left rudder pedal depression in the cockpit deflects the rudder surface to the left. This causes the tail of the aircraft to move to the right, creating a yaw to the left about the vertical axis. Application of right rudder similarly causes yaw to the right.

LIFT

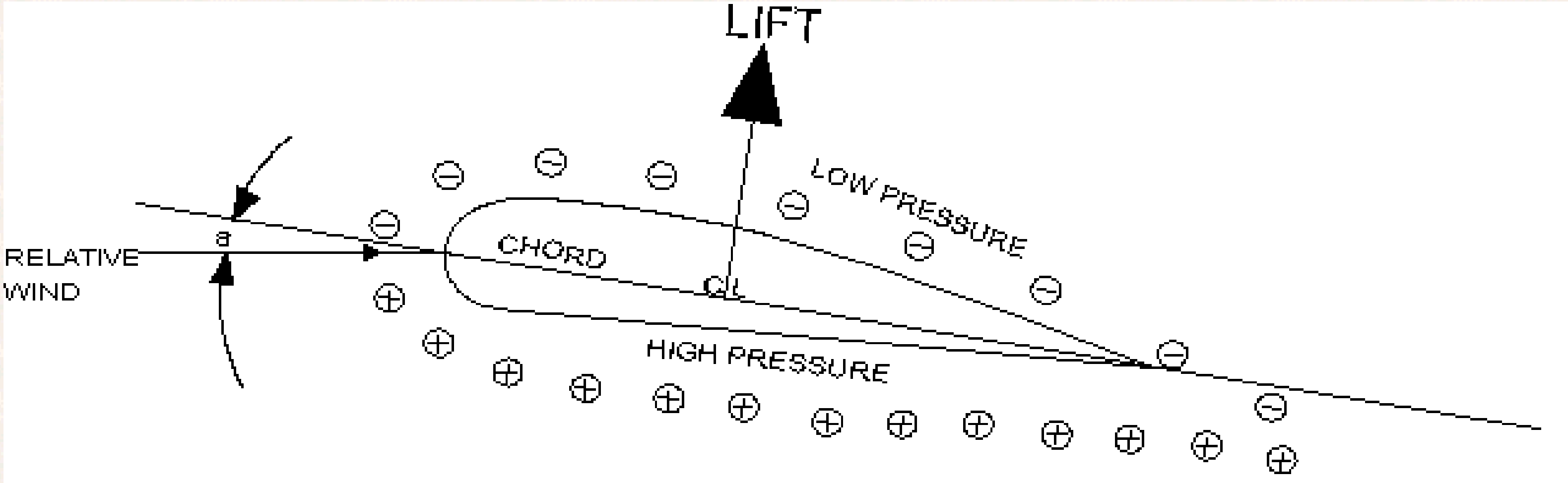
When Lift is mentioned, most people think primarily of the wings. However there are several other surfaces which generate lift, although not necessarily in an upward direction. These are the Propeller, Elevators, Rudder, Ailerons, and Flaps.

- Principles of Lift

The structure of the wing best demonstrates the principle of airfoil lift. In the 19th century a scientist named Bernoulli discovered that the intenal pressure of a fluid (liquid or gas) reduces the faster the fluid flows. If you take a tube, and make the tube smaller in diameter in the middle, this creates a "necked-down" section called a venturi. When air is forced through the pipe, as much air has to come out the exit as goes in the tube entrance. The air in the venturi section must travel faster to get through. Bernoulli found that the pressure at the venturi section was less than at the two ends of the pipe. This is because the speed of the air through the venturi section is traveling faster than at the ends of the tube.

- The Airfoil

The shape of a wing is called an ***AIRFOIL***. Usually the bottom of the wing is flat or nearly flat. The top of the wing is curved, with the wing being thicker at the front edge of the wing, and tapering to a thin surface at the trailing edge of the wing.



When a wing airfoil surface passes through the atmosphere, the atoms of the air on the top of the airfoil (shown as minus) must travel faster than their cousins (shown as plus) passing along the lower and flater surface. This occurs because the distance the air must pass over the curved top of the wing is longer than the distance along the lower surface. According to the Bernoulli Principle, the pressure above the wing is less than the pressure of air below it. Consequently, a pressure difference between the lower and upper surfaces exist. This results in LIFT being produced. The amount of lift depends on the airfoil design and the speed of the air over its surfaces.

- Camber

The curved surface of an airfoil is called Camber. It can be both Positive and Negative. The curved upper surface of a wing is called Positive Camber. If the lower surface of the airfoil is curved downward, this would constitute a negative camber.

- Chord

The chord of a wing is an imaginary line from the leading edge to the trailing edge of the wing. The term is used in the definition of "Angle of Incidence" and "Angle of Attack" (defined later).

- Angle Of Incidence

The angle which the chord of the wing makes with the longitudinal centerline of the aircraft is known as the Angle of Incidence. This angle in a given aircraft never changes. It is fixed by the construc tion of the aircraft.

- Angle Of Attack

As the aircraft passes through the air it traverses a particular line of flight. The air passing by the surfaces of the aircraft in the opposite direction of travel is called the ***Relative Wind***. The angle which the wing chord makes with this Relative Wind is called ***Angle of Attack***. An increase in angle of attack increases both lift and drag. If the angle becomes to great, it will pass the ***Critical Angle of Attack***. This is a point where the airflow over the wing becomes so disturbed that the wing ceases to produce lift. The wing then enters into a ***Stalled*** condition. Stalls will be described more fully later in this chapter.

- Center of Pressure

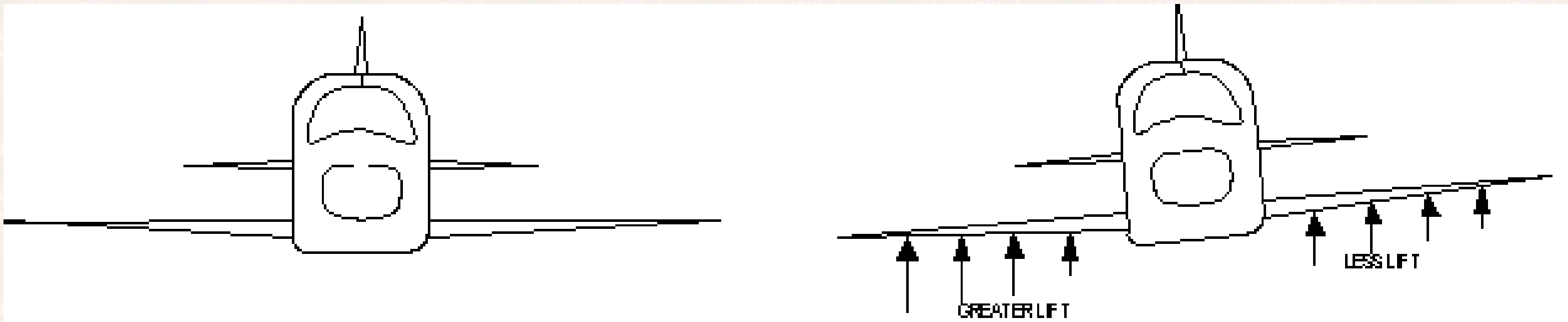
Even though the lift of an airfoil is distributed along its surface, the resultant force of all the lift forces can be considered to be at single point along the wing known as the ***Center of Pressure***.

- Center of Lift

The ***Center of Lift***(shown as CL in the diagram) is the same point as the Center of Pressure. You can think of all the lift of the wing as being a single force concentrated at this point on the wing.

- Dihedral

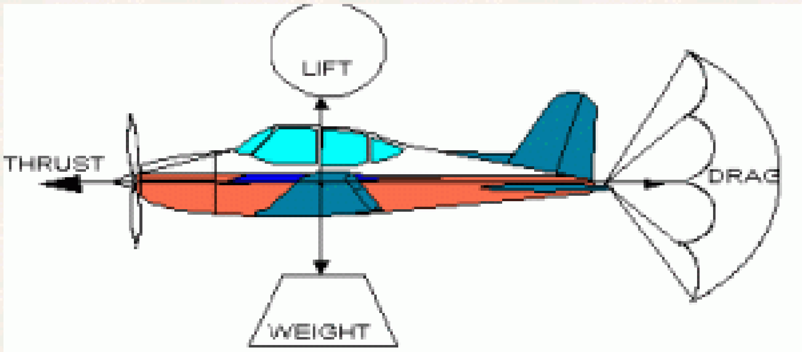
When you stand in front of an aircraft, looking toward the tail, the wings are usually higher at the wing tips than at the wing root (where the wing attaches to the fuselage). This upward angle from wing root to tip is called ***DIHEDRAL***.



On an aircraft with dihedral, when one wing drops, it will produce slightly greater lift than the other wing. The aircraft tends to return to a level status providing lateral stability to the aircraft.

Principles of Aerodynamics

Flight involves a balance of forces. These forces are THRUST, DRAG, LIFT and WEIGHT.



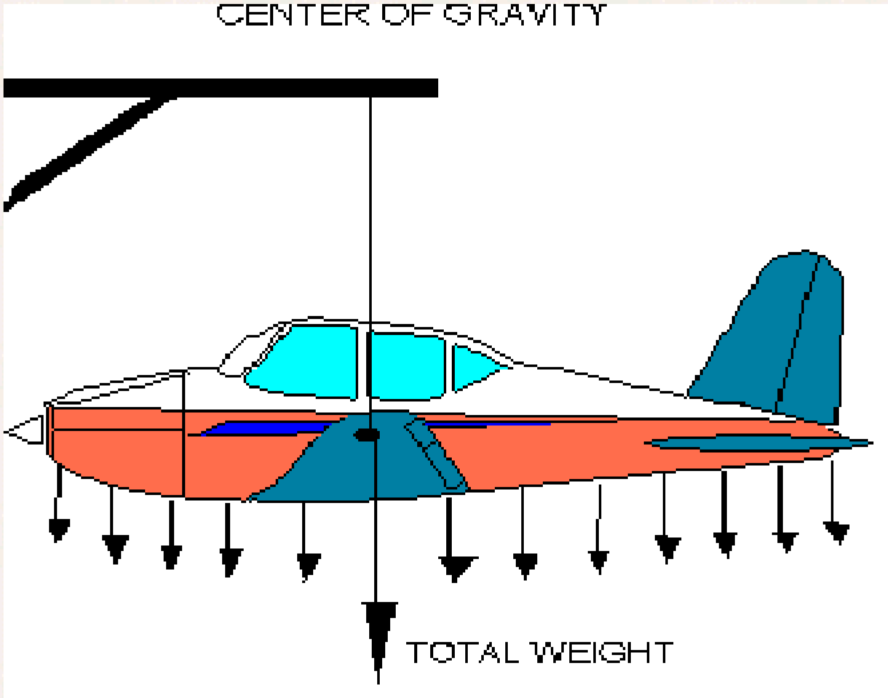
When ***Thrust*** and ***Drag*** are equal, the speed of the aircraft through the air (airspeed) will remain constant in smooth air. When ***Lift*** and ***Weight*** are equal, the aircraft will neither ascend or decend.

Attitude

The ***Attitude*** of an aircraft refers to it's relationship to the ground. When in a ***level attitude***, the longitudinal centerline of the aircraft is approximately paralell to the earth's surface. In this attitude, the horizon will appear to be just about on the nose of the aircraft(i.e. the top of the engine cowling is approximately aligned with the horizon).

When the nose of the aircraft is above the horizon, this is called a ***nose high attitude***. If the nose is below the horizon, the aircraft is in a ***nose low attitude***.

Center Of Gravity



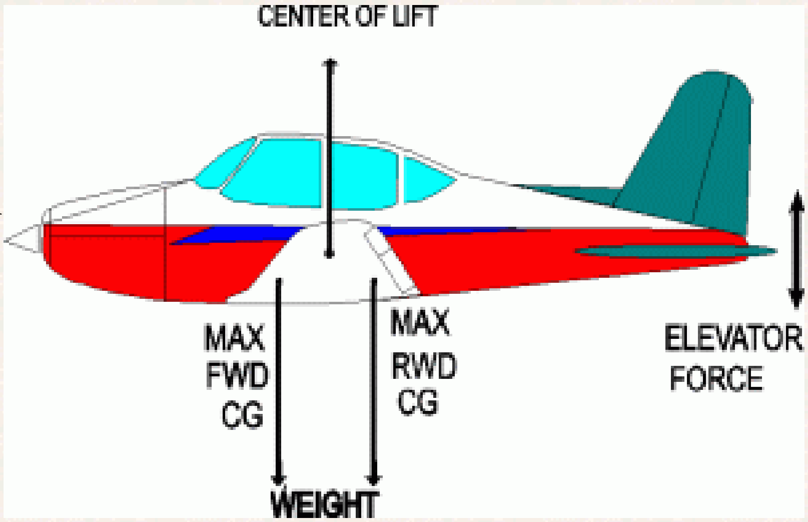
The weight of the airplane, pilot and passengers, fuel and baggage is distributed throughout the aircraft, as shown by the small downward arrows in the diagram. However, the total weight can be considered as being concentrated at one given point, shown by the larger downward arrow. This point is referred to as the ***Center of Gravity***. If the plane were suspended by a rope attached at the center of gravity (referred to as the CG) it would be in balance.

The Center of Gravity (CG) is affected by the way an aircraft is loaded. For example, if in a 4 place aircraft, there are 2 rather large individuals in the front seats, and no rear seat passengers or baggage, the CG will be somewhat toward the nose of the aircraft. If however, the 2 front seat passengers are smaller, with 2 large individuals in the rear seats, and a lot of baggage in the rear baggage compartment, the CG will be located more aft.

Every aircraft has a maximum forward and rearward CG position at which the aircraft is designed to operate. Operating an aircraft with the CG outside these limits affects the handling characteristics of the aircraft. Serious "out of CG" conditions can be dangerous.

Aircraft Balance

An aircraft in straight and level flight is similar to a childs "teeter-totter". There is a balance point in the middle (called a fulcrum), with weight on both sides of the fulcrum. For the "teeter-totter" to be in balance, the downward forces on both sides of the fulcrum must be equal.



In the diagram at right, the fulcrum of an aircraft in flight is the center of lift. Generally the CG is forward of the Center of Lift, causing the aircraft to naturally want to "nose down". The elevator located at the aft end of the aircraft provides the counter-balancing force to provide a level attitude in normal flight. Normally, the pilot will "trim" the elevators, by use of the trim tab control in the cockpit, to cause the elevators to provide the correct elevator balance force to relieve the pilot from constant elevator control.

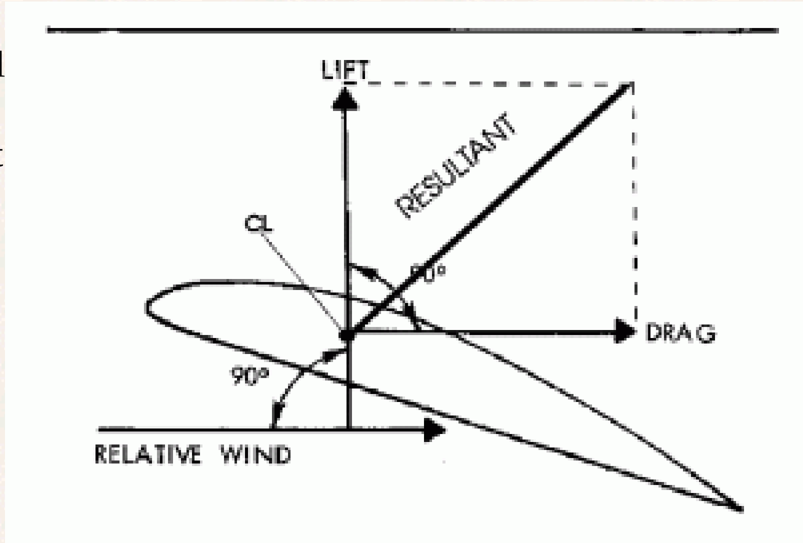
You can readily see that loading of the aircraft, which affects the CG, is a critical consideration in properly balancing the aircraft and it's controllability.

If the pilot pulls back on the control wheel, an "up-elevator" condition results. This forces the tail downward, causing the aircraft to assume a "nose up" attitude. Likewise, a forward movement of the control wheel by the pilot causes a "down elevator" state. This causes the tail to rise, forcing the aircraft into a "nose low" attitude. By use of the elevator trim control (a small wheel or crank in the cockpit), the pilot can cause the aircraft to remain in a nose-up, level, or nose down attitude.

As can be seen in the diagram above, when the CG is forward, a greater downward force is required by the elevators to produce a level attitude. Likewise, when the CG is aft, the elevators must produce less downward force to maintain level flight. NOTE: If the CG gets behind the Center of lift (the fulcrum) the aircraft becomes unstable because the CG is aft of the fulcrum. IT MAY BE POSSIBLE TO EXCEED THE TRIM CAPABILITY OF THE ELEVATORS SUCH THAT THE AIRCRAFT ALWAYS WANTS TO NOSE UP, AND BE UNSTABLE. Therefore the pilot must pay attention to proper loading of the aircraft. This will be discussed in greater detain under the subject of Weight and Balance.

Effects Of Attitude Change

When the wing is in a given attitude with respect to the ***Relative Wind (R W)*** as shown in the diagram below, the wing produces a ***Vertical Lift Force (LIFT)*** which is perpendicular to the Relative Wind..



There is also a DRAG component operating parallel to the Relative Wind in opposition to the forward motion of the wing. Drag is created as a natural part of producing lift. These two forces intersect at a point called the CL (center of lift}, or is also called the CP (center of pressure]. The LIFT and DRAG force vectors can be resolved into a single force vector called the RESULTANT force.

Envision if the ***Angle of Attack*** is increased. The Vertical Lift decreases in value, and the horizontal force of Drag increases. Therefore, when a pilot wants to slow the aircraft, the nose of the aircraft must be slowly raised into a greater "nose up" attitude, causing drag to increase, thus slowing the aircraft. This increase of angle of attack has limits, however. The wing design of most small aircraft, the wing has a ***"Critical Angle Of Attack"*** (somewhere around 18° to 20°) at which point the wing ceases to create sufficient lift to fly, and the wing ***STALLS***. The air flowing over the wing becomes so disturbed that adequate lift to sustain flight ceases, and the aircraft pitches "nose down". This is a **STALL**.

The primary way to recover from a stall is to push the nose further downward, thus decreasing the Angle Of Attack so that the wing flies again.

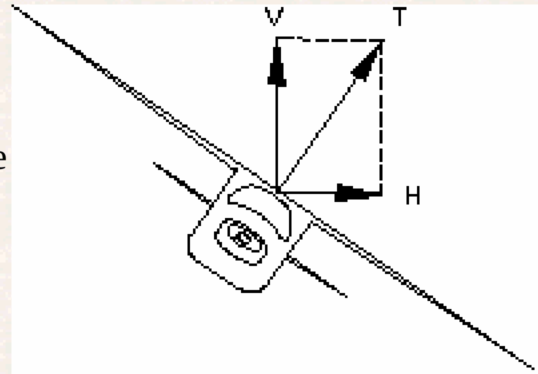
Also, envision in the diagram, when the pilot pushes the nose down by use of forward elevator, the Angle of Atack decreases, thus decreasing the drag. Therefore, when power is held constant, the angle of attack (nose high, level, or nose low) provides ***"Airspeed Control"***.

Assume for example, an aircraft has been cruising at 120 knots. When the aircraft enters the landing pattern of an airport, the pilot may want to reduce speed to 90 knots. The pilot must reduce power to prevent an altitude increase, and concurrently raise the nose of the aircraft so that the drag is increased sufficiently to slow the aircraft to 90. Later, when on the final approach for landing, the pilot may wish to slow even further, say to 70 knots. Power can be further reduced and the nose raised further, to again increase drag. In addition, the pilot may add 10,20 or 30 degrees of flaps to add an additional drag and lift.

The important point is that ATTITUDE is the primary control of airspeed; not THROTTLE! However, if level flight is to be maintained, appropriate changes in power must be made whenever the pitch attitude is made to prevent gaining or loosing altitude.

The Turn

In order to turn the aircraft, it must be placed into a ***BANKED*** state, where one wing is high, the other low. This state is pictured below.



In order to bank the aircraft, the pilot must turn the control wheel (or move the control stick) to the left. The ***Right Aileron*** lowers This increases the angle of attack of that part of the right wing, causing the right wing to rise. At the same time, the ***Left Aileron*** raises. The angle of attack of that part of the left wing decreases, causing the left wing to lower. This increased lift of the Right and decreased lift of the Left Wing causes the aircraft to roll to the Left.

NOTE: During the time the Right aileron is down, the right wing has ***MORE DRAG*** than does the left wing. The effects of this unequal drag is discussed later under ***Adverse Yaw.***

When the aircraft reaches the bank angle the pilot wishes, the ailerons must be neutralized. This causes equal lift by left and right wing, and the aircraft roll stops. Basically, the aircraft will remain in this banked attitude until the pilot rolls the aircraft back to level attitude by operating the control wheel (or stick) in the opposite direction.

Note in the diagram that some of the***Total Lift (force T)*** goes into a ***Horizontal Force (H)***. This is the force which pulls the aircraft in a circular motion (turn). Note also that the ***Vertical Lift (force V)*** becomes less. If the bank angle becomes large, say 45 degrees, the vertical lift is appreciably less. The pilot may have to hold some up elevator and/or add power to prevent loosing altitude.

Adverse Yaw

During the time that the ailerons are activated, an unwanted effect occurs. In the left turn shown above the pilot turns the control wheel to the left, raising the left aileron, and lowering the right aileron. The intent is to turn left.

Unfortunately while the ailerons are activated, the left wing has less drag; the right wing has more drag. This causes the airplane to want to turn to the ***Right***, and ***not to the left.*** This tendency to turn in a direction ***opposite*** to the intended turn direction is called ***ADVERSE YAW.*** So how does the pilot overcome this tendency to initially turn in the wrong direction? He uses the ***Rudder.*** By applying just the right amount of rudder in the direction of the turn, the pilot can offset the adverse yaw. When the pilot does this correctly, applying just the right amount of rudder, a ***Coordinated*** turn results. If the pilot applies too little or too much rudder, an***Un-Coordinated turn results.*** How the quality of the turn is measured will be covered in the Instruments section.

If the pilot uses too little rudder, the nose of the aircraft wants to stay yawed opposite the turn. The rest of the aircraft wants to "slip" toward the inside of the turn.

If the pilot applies too much rudder, the tail wants to remain outside the radius of the turn, and a "skid" results. Its similar to the rear end of an automobile wanting to skid outside the turning radius of a car.

Therefore, a principle use of the rudder is to control the adverse yaw while rolling into a bank.

Slips

A slip is created by applying rudder in the opposite direction to the turn. This is called ***Cross Controlling.*** There are 2 forms of the slip.

- Side Slip
- Forward Slip

Side Slip

This manuever is primarially used to compensate for a cross wind while landing. If the wind is from the right of the aircraft, the aircraft will drift to the left side of the runway unless some force is applied in the opposite direction keep the aircraft straight with and on the centerline of the runway. The pilot uses a ***Right Side Slip*** to compensate for the leftward drift caused by the wind. The pilot turns the control wheel to the right to initiate a right turn, but simultaneously applies opposite Left rudder just enough to keep the aircraft from turning. Thus the pilot induces just enough right side slip to offset the leftward wind drift. This way, the pilot can keep the aircraft both over the centerline of the runway, and aligned with the runway. This prevents a "side load" on the landing gear on touchdown.

Forward Slip

The forward slip is used primarially on aircraft with no flaps. This configuration is used to loose altitude quickly without increasing airspeed.

In this manuever, the pilot simultaneously turns the aircraft left or right, and applies a lot of opposite rudder so the side of the aircraft is presented to the relative wind. It is almost like slipping a sled down a hill somewhat sideways. The pilot maintains this configuration until the desired altitude is lost, whereupon he neutralizes controls to continue straight flight.

Since most modern aircraft have effective flaps to slow the aircraft on landing, and to allow a steeper decent, the forward slip in usually unnecessary. Some aircraft manufacturers state that forward slips should not be made with flaps deployed.

Stalls and Spins

The angle of attack which produces maximum lift is a function of the wing design, and is called the CRITICAL ANGLE OF ATTACK. A stall occurs when the Critical Angle of Attack is exceeded. Smooth air flow across the upper surface of the wing begins to separate and turbulence is created along the wing surface. Lift is lost and the wing quits “flying”. THE STALL IS A FUNCTION OF EXCEEDING THE CRITICAL ANGLE OF ATTACK, AND CAN OCCUR AT ANY AIRSPEED , ANY ATTITUDE, AND ANY POWER SETTING.

On most aircraft, the stall starts at the wing root, and progresses outward to the wing-tip. The wings are designed in this manner so that the ailerons are the last wing elements to loose lift. Flap and gear extension affect the stall characteristics. In general, flap extension creates more lift, thus lowering the airspeed at which the aircraft stalls.

Recovery from a stall requires that the angle of attack be DECREASED to again achieve adequate lift. This means that the back pressure on the elevators must be reduced. If one wing has stalled more than the other, the first priority is to recover from the stall, then correct any turning that may have developed.

A CG that is too far rearward can significantly affect the ease of stall recovery. The aft CG may inhibit the natural tendency of the nose to fall during the stall. It may be necessary to force a “nose down” attitude to recover.

Although weight does not have a direct bearing on the stall, an overloaded aircraft will have to be flown at an unusually higher angle of attack to generate sufficient lift for level flight. Therefore the closer proximity to the critical angle of attack can make an inadvertent stall due to pilot inattention more likely.

Snow, ice or frost on the wings can drastically affect lift of the wing. Even a small accumulation can significantly inhibit lift and increase drag. Due to the reduced lift, the aircraft can stall at a higher-than-normal airspeed. Takeoff with ice, snow or frost on the wings should never be attempted.

Stall recognition can come several ways. Modern aircraft are equipped with stall warning devices (usually an audible signal) to warn of proximity to the critical angle of attack. The aircraft may vibrate, control pressures are probably "mushy", the "seat of the pants" sensation that the aircraft is on the verge of loosing lift, and other sensations can tip off the pilot of an impending stall. Practice of slow flight and stalls at altitude is invaluable training in stall recognition.

A spin is a stall that has continued, with one wing more stalled than the other. The aircraft will begin rotation around the more stalled wing. The spin may become progressively faster and tighter until the stalled condition is "broken" (stopped).

Usually spin recovery procedures are covered in the Pilot Operating Handbook (POH) for the given type of aircraft. If one is not available, the following is the suggested spin recovery technique.

a. Close the throttle. Power usually aggravate the spin. b. Stop the rotation by applying opposite rudder. c. Break the stall with positive forward elevator pressure. d. Neutralize the rudder when rotation has stopped. e. Return to level flight.

Secondary Controls

Trim

There are some secondary "pilot-controlled" functions which can "trim" the elevators, rudder and ailerons for improved straight and level flight, thus freeing the pilot from constant attention and control of the major control surfaces. Most small aircraft have only Elevator Trim. As the sophistication of an aircraft design increases, Rudder Trim and Aileron Trim are added. In most cases, the elevator trim is an additional moveable surface on one of the elevator assemblies which causes a “nose up”, “level”, or “nose Down” trimmed attitude.

In some aircraft, rudder trim and aileron trim can also be accomplished by pilot from the cockpit.. The purpose of the trim action is to compensate for variations in aircraft loading or other minor factors which may tend to cause deviation from straight and level flight.

Flaps

Flaps are moveable surfaces on the trailing edge of the wing similar in shape to the ailerons. they are usually larger in surface area. They are located on inboard end if the wing next to the fuselage. Both sides are activated together so they do not produce a rolling action like the ailerons.

Flaps are usually deployed in "degree" increments. In small aircraft deployment is usually in 10 degree increments from zero degrees (non-deployed) to 40 degrees maximum. Larger or more sophisticated aircraft may have a different range of settings. Normally, the flaps operate electrically through a 4 or 5 position switch located on the instrument panel. In earlier aircraft the flaps were operated using a manual flap handle.

Deployment of flaps increases both the lift and drag of the wing. Flap activation increases the angle of attack across the wing / flap section. At 10 degrees, more lift than drag is produced. As the flap angle is increased more drag and less lift is produced for each increment of deployment.

The primary use of flaps is in landing. They permit a steeper decent without increase in airspeed. Flaps may be used in certain take-off situations(usually 10°) on short or soft fields.

Dynamics of Flight

Drag

Just as wind friction causes drag in an automobile, aerodynamic friction and displacement of air during flight creates aerodynamic DRAG. Drag occurs any time that air is displaced from its normal stable condition. Air has density and weight, and although compressible, it still requires energy to displace.

- INDUCED DRAG occurs as a by-product of lift.
- PARASITE DRAG results from friction with surfaces and appendages, and impact with structures

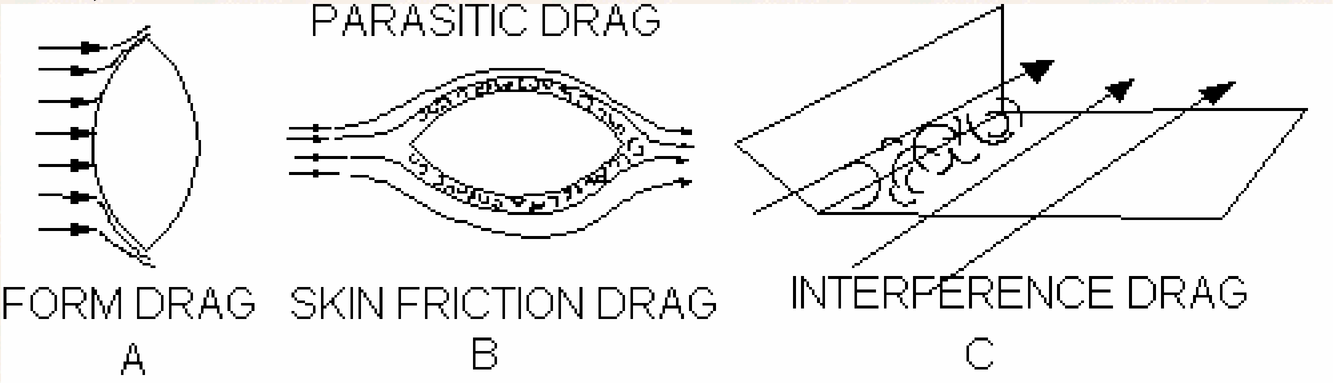
such as struts, landing gear, antennas, etc..

Induced Drag

Induced drag results from the creation of lift. The amount of drag depends on the airfoil design of the wing, its camber and angle of attack. Also due to the way the air flows across the wing during flight, vortices are generated at the wing tips which add to the induced drag component. .

Parasite Drag

Parasite drag is an unwanted resistance of the air to an object traveling through e air. The 3 types of parasite drag are Form, Skin and Interference as demonstrated below.



Form Drag

The form of the object and the effective frontal surface it presents to the air has a significant effect on the amount of drag generated. As shown in (A), a surface such as shown would present much more "frontal" drag than it would is it were rotated 90 degrees as in (B). Drag can be reduced in the aircraft design by streamlining objects such as wing struts to minimize the frontal appearance to the air flow.

Skin Friction

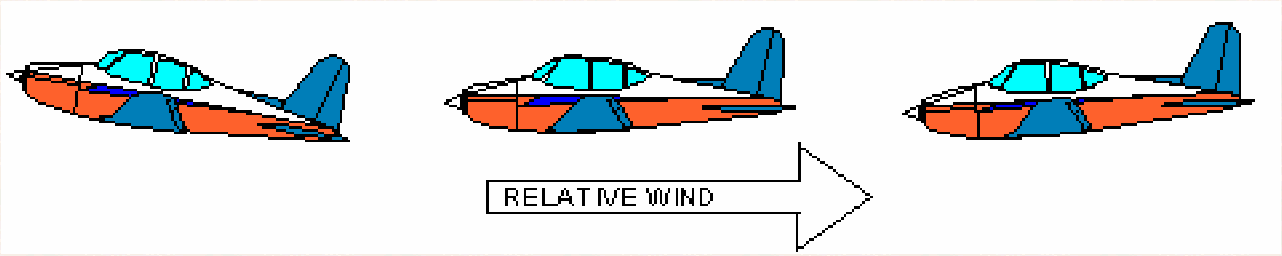
Even though the form in (A) above is re-oriented to shape (B), there is still some form drag. In addition, there is friction between the skin of the surface and the air flow. It is obvious that if the surface is dirty, has frost, ice or other obstructions, that drag will increase. Effects of skin drag can be reduced by smooth surfaces and flush riveting in the design, and by keeping the surface clean and waxed by the owner.

Interference Drag

Surfaces at angles to each other as in (C) create turbulence in the region of the joint. This occurs most frequently at the intersection of the fuselage and wing

Pitch, Power and Performance

The amount of lift that a wing generates is a function of it's design (camber, area, etc.), speed through the air, air density, and angle of attack. The effects of air density will be treated in more detail in a later chapter.



The three aircraft shown above can all be in ***constant altitude*** flight, but at ***different airspeeds***. Maintaining a fixed altitude at a given airspeed requires the pilot to control two factors; (1) ***Angle of Attack*** and (2) ***Power***. The angle of attack is controlled by the up, neutral, or downward trim position of the elevators. The power, is controlled by the "power setting" of the engine and propeller. For a "fixed pitch" propeller, this means adjusting the engine RPM. For a variable pitch propeller, this means adjusting both the throttle and the propeller pitch control.

The left aircraft could be at a 10 degree nose-up attitude with an indicated airspeed of say 70 nautical miles per hour (knots). The center aircraft could be at cruise with a 0 degree attitude and 110 knots. The right aircraft could be in a slightly high speed decent at minus 3 degrees of pitch and an indicated airspeed of 140 knots (abbreviated kts).

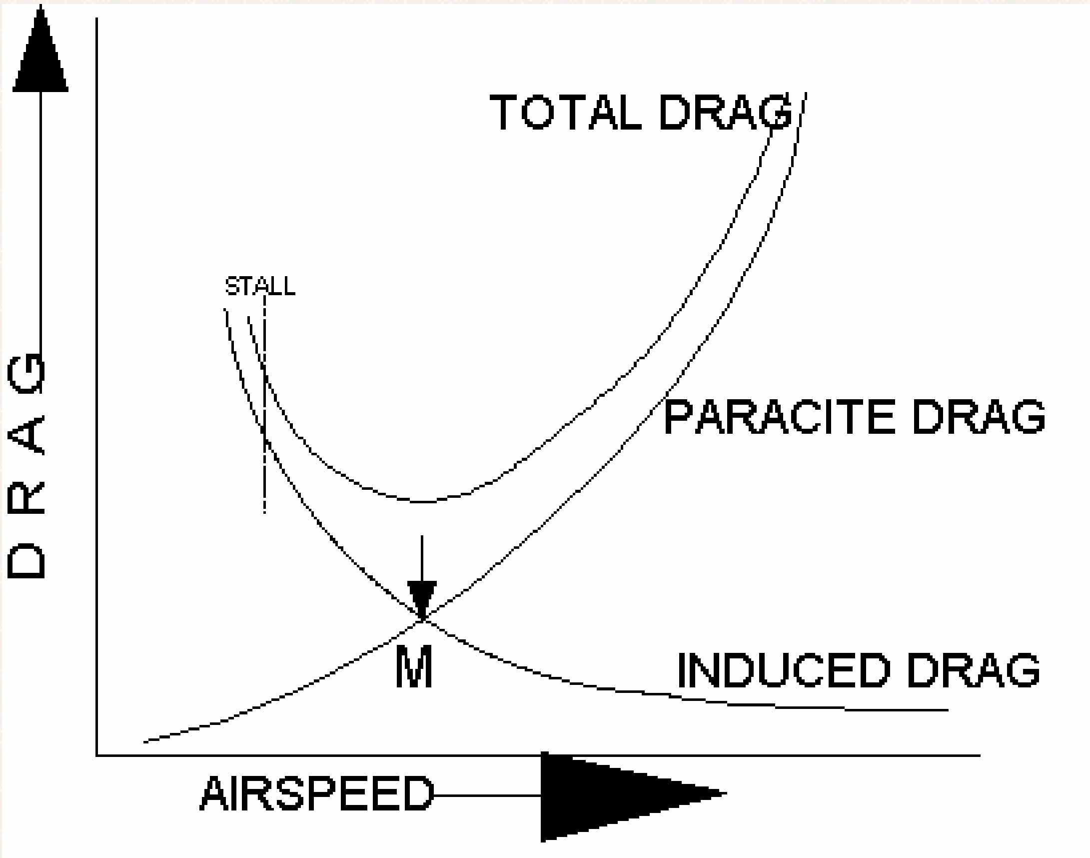
The pilot can control the Pitch, Power and Performance of the aircraft and can fly at a considerable range of attitudes, speeds and power settings.

Lift versus Drag

An aircraft with a given total gross weight can be operated in level flight over a range of power settings and airspeeds. Since Lift and Weight must be equal in order to maintain level flight, it is obvious that there is a relationship between Lift (L), Airspeed (V), and Angle of Attack (AT). This relationship can be "generalized" with the following expression. (Note: the expression is not an exact equation).

Lift = Angle of Attack x Velocity

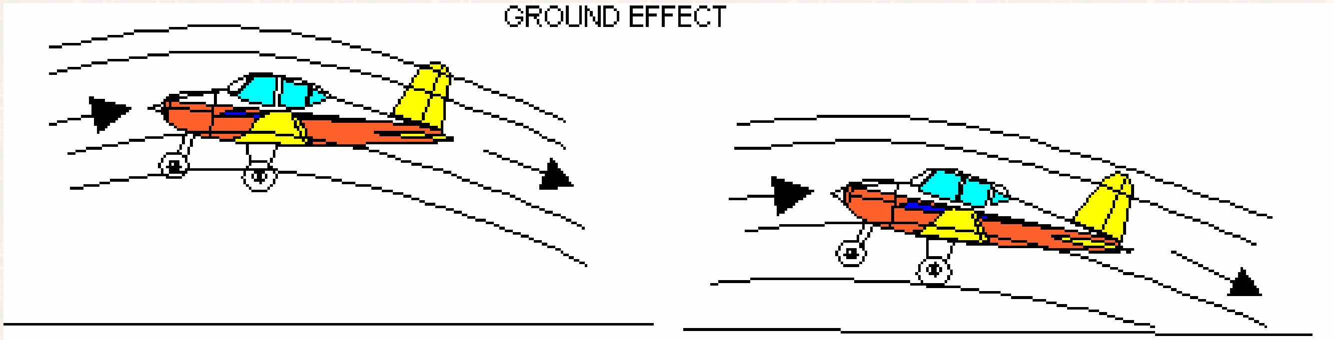
Since angle of attack and speed also have a relationship to Induced Drag and Parasite Drag, the relationship of Lift/Drag is shown by the graph below.



Parasite drag ***increases with speed***. ***Induced*** drag ***decreases with speed***. The SUM of the two drags (Total Drag curve) shows that there is only one airspeed for a given airplane and load that provides MINIMUM total drag. This is the point ***M*** which is the maximum lift over drag ratio (L/D). It is the airspeed at which the aircraft can glide the farthest without power (maximum glide range). This is the airspeed which should immediately be set up in the event of a power failure. This maximum glide airspeed is different for each aircraft design. The Pilot Operating Handbook should be consulted for this airspeed and the pilot should memorize it to eliminate need to search manuals during an emergency.

Ground Effect

An aircraft can be flown near the ground or water at a slightly slower airspeed than at altitude. This is known as Ground Effect.



The airflow around the left aircraft at altitude can flow around the surface of the aircraft in a normal manner. The airflow around thr right aircraft is disturbed by the proximity to the ground. The normal downwash of air produced by the wing and tail surfaces cannot occur, and the air becomes compressed under these surfaces. A "cushioning" effect occurs which allows the airplane to fly at slightly slower airspeed than at altitude.

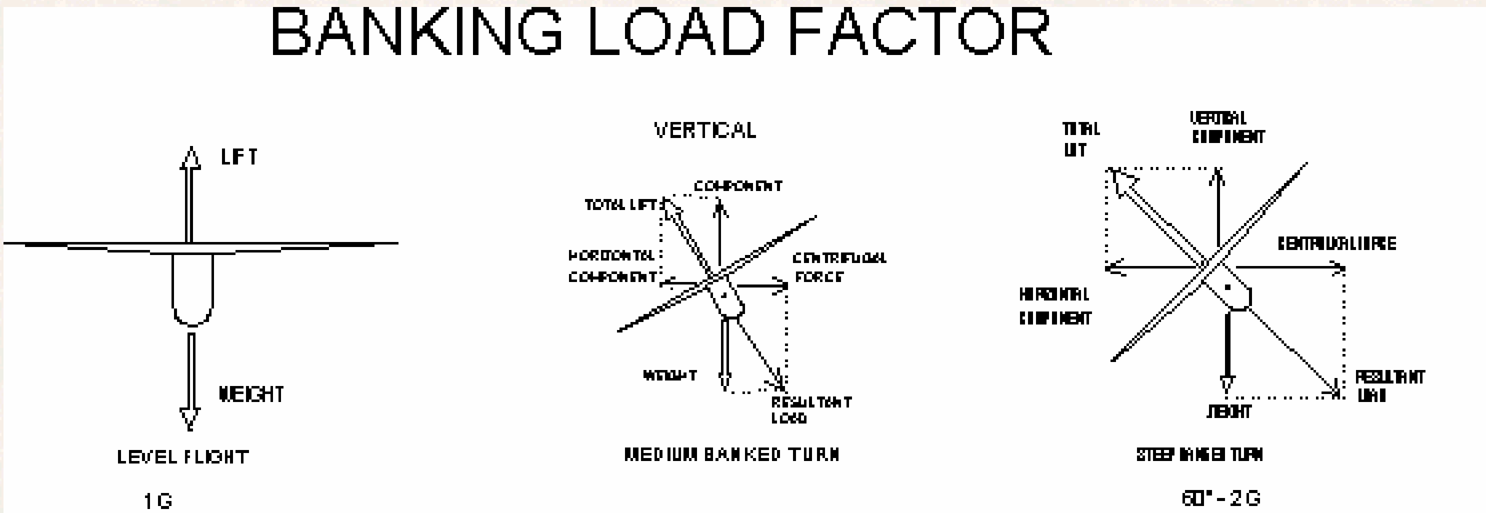
The maximum ground effect occurs at approximately 1/2 the wingspan above the ground. It is this effect which causes the plane to seem to float when near the ground on landing. It also allows the aircraft to be "pulled" off the ground before adequate climb speed is achieved.

Load Factor

The load factor is the total load supported by the wings divided by the total weight of the airplane. In straight and level flight, the load factor is 1; i.e. the weight supported by the wings is equal to the weight of the loaded aircraft. The load factor is described as 1G Force. With a load factor of 1, the G force is 1. In other terms, the load supported by the wings equals the total weight of the loaded aircraft.

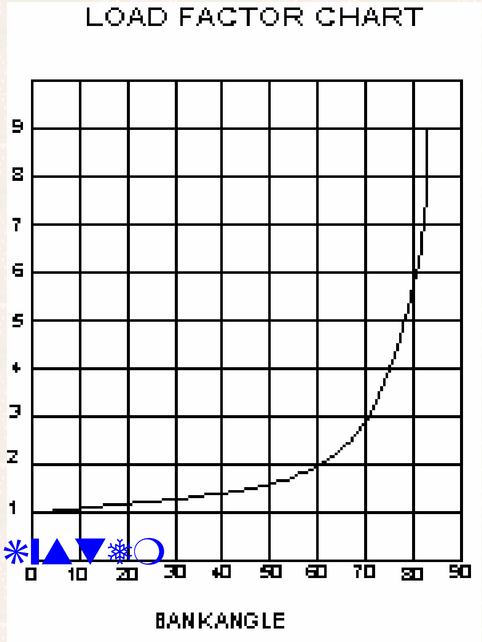
In a turn, the weight of the aircraft ***increases*** due to the addition of ***centrifugal force***. The rate of turn determines the total weight increase. A faster turn (steeper bank) generates ***greater*** centrifugal force. The centrifrugal force is straight out from the center of the turn. When the downward weight of the aircraft is mathematically resolved with the horizontal centrifrugal force, the load on the wings is the ***Resultant Load***.

In a 45



degree banked turn, the resultant load factor is approximately 1.4 G. In other words, the load on the wings is 1.4 times the loaded weight of the aircraft. In a 60 degree banked turn, the load factor is 2G. The load on the wings is ***TWICE*** the loaded weight of the aircraft. The G force is greater than 1 in a loop maneuver for the same reason; i.e. a centrifugal force adds to the airplane's weight. An abrupt change from level to nose down creates an upward centrifugal force, decreasing the G load to less than 1G.

The effects of the bank angle is shown in the graph on the right. The G Force is shown on the Left Side, and the Bank Angle is shown on the bottom of the graph.



The maneuver of most importance to the private pilot is the forces in a turn. The most critical time is in tu rns in the traffic patern, when airspeeds are low, and the attention to bank angle and airspeed may be distracted by other duties.

Pitot and Static System

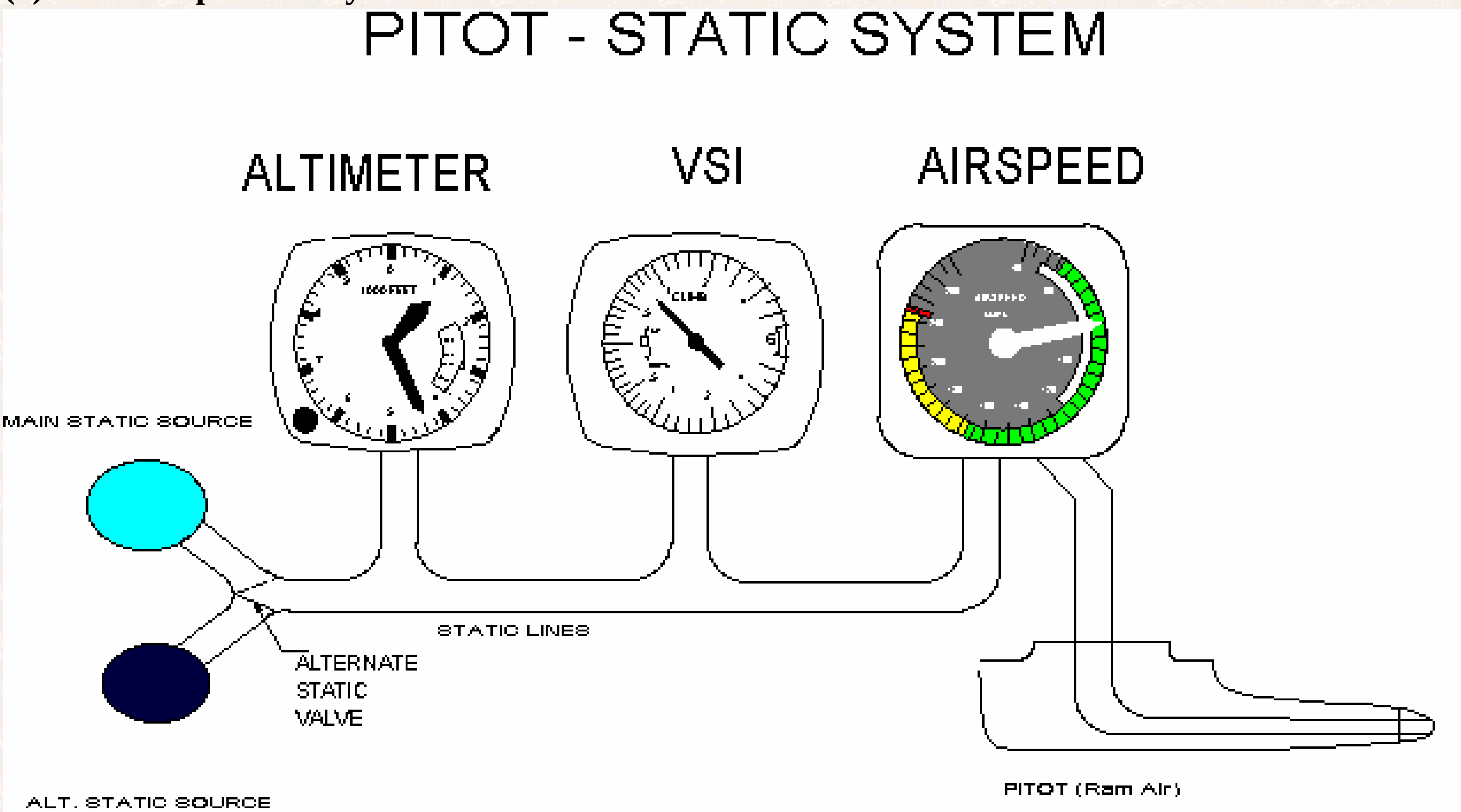
The Pressure System

The pitot-static pressure system provides the source of air pressure for the

- ***ALTIMETER (ALT)***
- ***VERTICAL SPEED INDICATOR (VSI)***
- ***AIRSPEED INDICATOR (ASI)***

>

The two parts of the system are
(1) the pitot tube and pressure line
(2) the static pressure system and lines.



The **pitot tube** is normally mounted on the leading edge of a wing. The pitot tube on an aircraft used only for flight under ***Visual Flight Rules (VFR)*** may not be heated to prevent icing. Aircraft to be used under ***Instrument Flight Rules (IFR)*** are heated electrically, to prevent icing when operating in visible moisture and cold temperatures. A switch in the cockpit controls Pitot heat.

The **static pressure port** is normally found on the side of the fuselage. On later model aircraft, an alternate static source is provided inside the cockpit. The pilot can select the internal static source if the outside source becomes clogged with ice.. When the pilot selects the alternative source, the instruments relying on the static pressure may operate slightly differently.

1. The altimeter (ALT) may indicate a higher-than-actual altitude.
2. The vertical speed indicator (VSI) will momentarily indicate a climb, then will settle back the initial indication.
3. The Airspeed Iindicator (ASI) will indicate greater-than-normal airspeed. Altimeter (ALT)

THE ALTIMETER

The **Altimeter** (ALT) allows the pilot to determine the height above Mean Sea Level (MSL). Correct altitude indication is very important for several reasons.

a) The pilot must be sure the aircraft is being flown high enough to clear terrain and other obstacles.

b) The pilot must maintain altitude according to certain air traffic rules and instructions to minimize the possibility of mid-air collision.

c) The pilot can often select more favorable winds at certain altitudes.

d) True Airspeed calculation requires that the altitude be known.

The Altimeter measures the pressure of the outside air. A small bellows inside the altimeter which contains a constant pressure inside expands when the aircraft climbs, and contracts when the aircraft decends. This bellows is connected to a gear arrangement which causes the hands to turn as the bellows expands or contracts. The altimeter is essentially a barometer which is measuring the outside air pressure, but the indications on the dial indicate hundreds and thousands of feet.

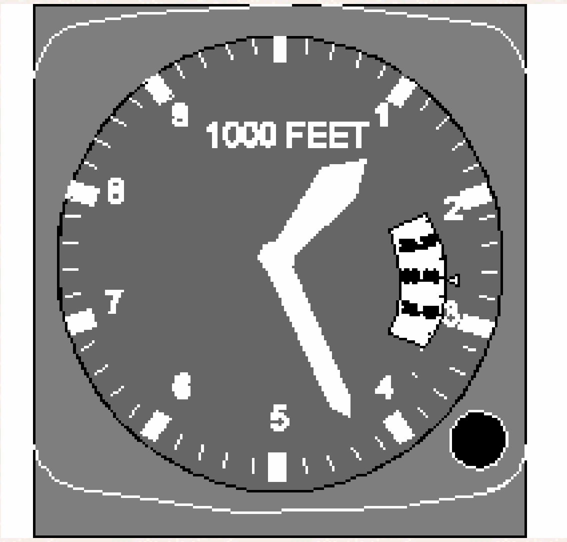
Most altimeters have either 2 or 3 pointers. If 2 pointers, the longer one indicates hundreds of feet, and the shorter pointer indicates thousands of feet. A third very short pointer which indicates ten's of thousands altitude exist on some altimeters. The indication in the diagram shown below is 1,430 feet.

Altimeter Setting.

The altimeter is an aneroid barometer. It is correct only when in a known atmosphere. An International Standard Atmosphere has been defined as a barometric Sea Level pressure of 29.92 inches of Mercury (Hg), and a temperature of 15 degrees Celsius.

Effects of Atmospheric Pressure Changes

Whenever the altimeter is in a non-standard temperature and pressure the altimeter reads incorrectly, and an adjustment means must be provided to compensate for the non-standard conditions. Atmospheric pressure change has the greatest effect on the instrument.



On modern altimeters, an adjusting knob and scale is provided to allow adjustment for non-standard pressure. In the diagram of the altimeter face above, a window on the right of the instrument shows a graduated barometric scale, called the altimeter setting. The pilot can adjust the altimeter setting with the knob on the lower left. The setting shown is 30.00.

If the altimeter is not periodically readjusted to the local barometric pressure, the plane will be too high if the local sea level pressure pressure is higher than 29.92 and will be too low if the local sea level pressure is less than 29.92 in. Hg.

As one flies cross country, the altimeter should be adjusted every 100 miles or so. If flying from a low to a higher pressure area, the aircraft will be higher than indicated if appropriate altimeter adjustment is not made periodically. For example, if the altimeter indicates 5000 feet, it will actually be ***above*** 5000 feet when in the higher pressure area.

Likewise, when flying from a high pressure area to a lower pressure area, the aircraft will be falsely low if no adjustment is made. If the altimeter is indicating 5000 feet, the aircraft will be ***below*** 5000 feet when in the lower pressure area..

The altimeter setting can be obtained in flight from any Air Traffic Control facility or from any FAA Flight Service Station. If taking off from an airport where no contact can be made with such a facility, set the altimeter to the altitude of the airport prior to takeoff.

When flying at or above 18,000 feet (Flight Level 180) the altimeter must be set to 29.92. These altitudes are primarially used by fast jet aircraft. Since there is no possibility of ground collision, all aircraft operate with the same altimeter setting.

Effects of Temperature

Temperature affects the indicated altitude. The effect is not as drastic as pressure changes. Altimeters in small aircraft have no simple means to compensate for non-standard temperature. The effect is similar to high and low pressure changes. When going from low temperature to higher temperature, the aircraft will be higher than the indicated altitude. When going from high temperature to low, the aircraft will be lower than indicated on the altimeter. The pilot should keep this in mind if terrain clearance is a factor in the flight.

MEMORY AID: From high to low (pressure or temperature) LOOK OUT BELOW.

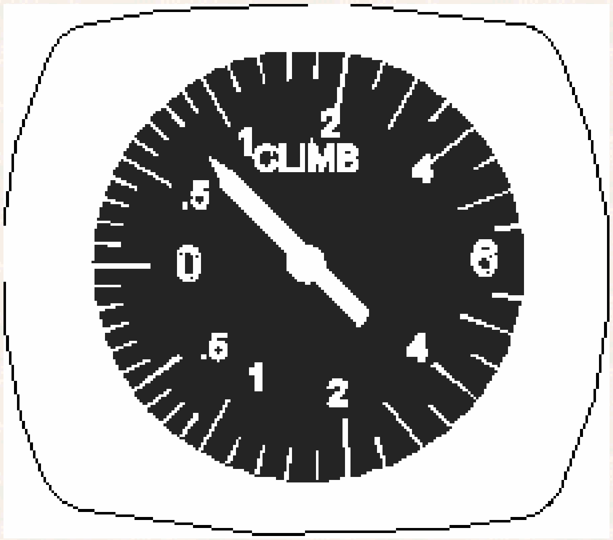
When flying over mountainous terrain, atmospheric conditions can cause the altimeter to indicate erroneous altitude by as much as 1,000 feet. Therefore, a generous margin of safety should be planned when flying over mountainous terrain..

Vertical Speed Indicator (VSI)

The mechanism of the VSI is similar to the altimeter except the bellows contains a small calibrated hole that allows the pressure inside the bellows to slowly adjust to the same pressure as in the case. Therefore the pressure inside the bellows is similar to what it was a few seconds ago.

If the change in pressure is slow, the up or down reading will be small. If the up or down altitude change is large over a short time, the rate of climb or decent will be large. If the pressure both inside and outside the bellows stays the same, the VSI will indicate zero.

The single pointer indicates level flight (indicating 0), climb in feet per minute (pointer deflected upward), and decent in feet per minute (pointer deflected downward).



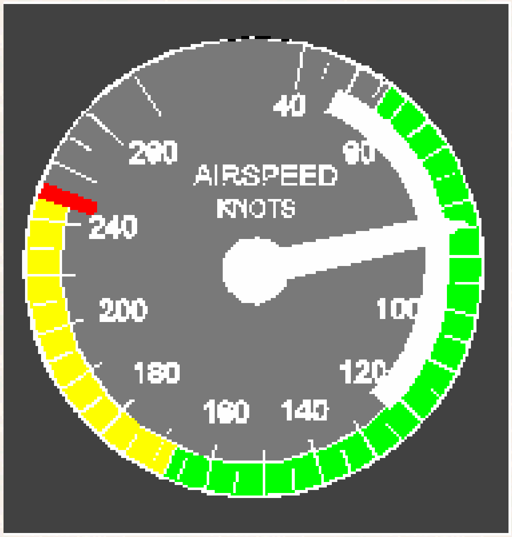
In small piston engine powered aircraft, the rate of climb will usually be less that 1000 feet per minute. Usual rate of decent enroute or approach to landing will be in the 500 feet per minute range. When flying straight and level, the instrument should indicate zero. Also when sitting stable on the ground the instrument should indicate zero. Most instruments are equipped with a small adjusting screw to calibrate the zero position when the aircraft is at rest on the ground.

Airspeed Indicator (ASI)

The Airspeed Indicator (ASI) measures the ***speed of the aircraft through the air***. This should not be confused with groundspeed. Winds can affect how fast the aircraft tracks over the ground. Groundspeed is seldom the same as airspeed.

Principle of Operation

"Impact" air hiting the opening of the pitot tube which is pointing in the direction of travel creates a pressure in the pitot tube line. This pressure is connected by a small tube to the inside of a bellows in the ASI instrument. The outside atmospheric static pressure enters the case from the static line. The mechanism inside the ASI therefore measures the difference between the pitot pressure and the static pressure. Since the impact pressure of the pitot tube is proportional to the speed through the air, the speed through the air is indicated by the instrument.



Indicated Airspeed (IAS)

The color coding of the airspeed indicator has meaning. The color arcs are as follows.

White Arc - Stall Speeds and Flap operating Range
----- -- Lower end of arc is the Power Off Stall speed with flaps and landing gear in the landing position.
----- -- Upper end of arc is the maximum flaps extend speed.
Green Arc - Normal operating airspeed range
------- Lower end of arc is the power off stall speed clean (flaps and gear up)
------- Upper end of arc is maximum structural cruise speed. (Max normal operating speed).
Yellow Arc - Caution range. Avoid this area unless in smooth air.
Red Line - Never exceed speed.
-------This is the maximum speed at which the aircraft can operate safely. ------- It should never be intentionally exceeded.

Calibrated Airspeed (CAS)

Although aircraft designers attempt to keep airspeed errors to a minimum, it is not possible to achieve complete accuracy throughout the complete range of the instrument. Two types of errors can be introduced.

a. Installation error caused by the static ports sensing erroneous pressure. This is due to the unpredictability of the effects of the slipstream around the aircraft at various speeds and attitudes.

b. The pitot tube does not always present the same frontal appearance to the atmosphere at varying attitudes.

The pilot should consult the Pilot Operating Handbook (POH) for the table applicable to the aircraft being flown.

True Airspeed (TAS)

As altitude increases , air density decreases. The impact pressure at the port of the pitot tube is less at higher altitudes. The airplane is actually traveling through the air faster than indicated on the ASI. Consequently as altitude increase, Indicated Airspeed decreases.

A mathematical correction factor must be applied to Indicated Airspeed (or Calibrated Airspeed) to arrive at a correct True Airspeed (TAS). This calculation can be made with he E6B Flight computer, or an approximate correction can be made by adding 2 percent per 1,000 feet of altitude to the IAS.

EXAMPLE: Given IAS is 140kt and ALT is 6,000 feet. Find TAS.

2% x 6 = 12% (.12)
140 x 0.12 = 16.8
140 + 16.8 = 156.8 kt. (TAS)

Some airspeed indicators have built-in adjustment scales that allows the pilot to adjust the instrument for temperature and pressure. Both the IAS and TAS can be read from such an airspeed indicator.

V Speeds

The Pilot Operating Handbook normally lists various airspeeds for differing situations and conditions. The definition of the usual V speeds is shown below. is an abbreviation for Velocity.

VA. ..... design maneuvering speed
VFE.... Maximum flap extend speed
VLE.... maximum landing gear extend speed

VLO....maximum landing gear operating speed
VNE....never exceed speed
VNO...maximum structural cruising speed
VR......rotation speed
VS0.... the power-off stalling speed or minimum flight speed in landing configuration
VS1.... the power-off stalling speed (clean) with flaps and landing gear retracted.
VX...... best angle of climb speed
VY......best rate of climb speed
Best Glide Speed

Gyroscopic Instruments

Gyroscopic instruments may be driven either electrically or by vacuum. In most light aircraft the Turn Coordinator (TC) is electrically driven. Usually the Heading Indicator (HI) and Attitude Indicator (AI) are vacuum driven.

Gyroscopic Principles

Any spinning object possesses gyroscopic characteristics. The central mechanism of the gyroscope is a wheel similar to a bycycle wheel. It's outer rim has a heavy mass. It rotates at high speed on very low friction bearings. When it is rotating normally, it resists changes in direction.

The gyroscope exhibits two predominant characteristics.

Rigity in Space
Precession

Rigidity in Space.

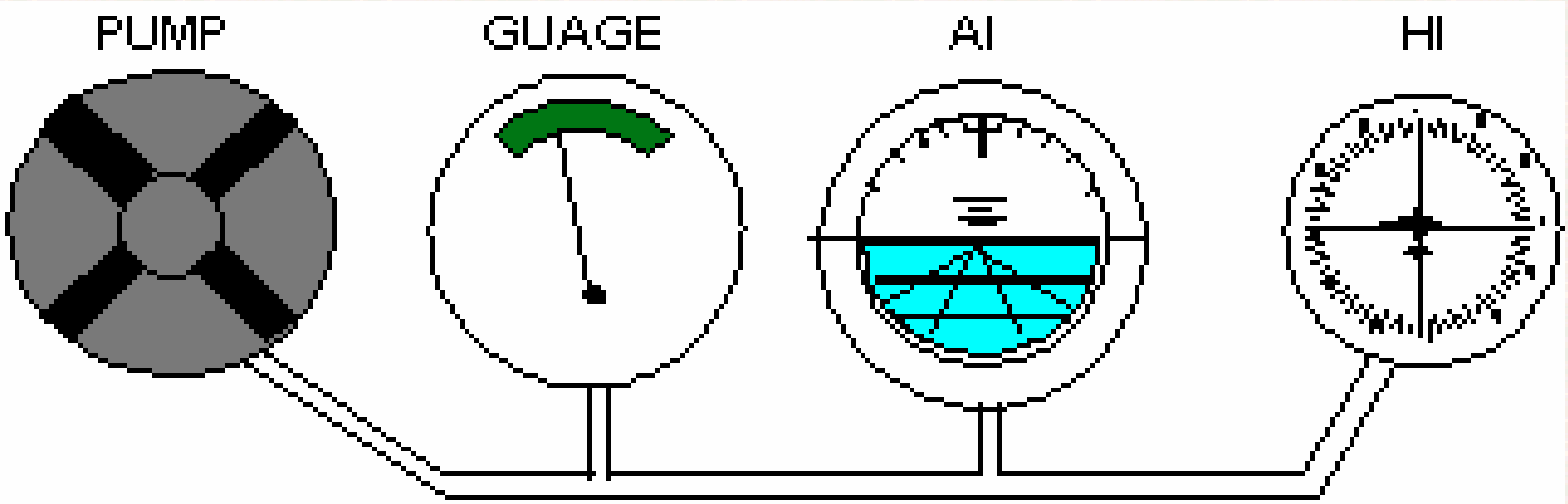
The gyroscope resists turning. When it is "gimbaled" (free to move in a given direction) such that it is free to move either in 1, 2 or 3 dimensions, any surface such as an instrument dial attached to the gyro assembly will remain ***rigid*** in space even though the ***case of the gyro turns***. The ***Attitude Indicator (AI)*** and the ***Heading Indicator (HI)*** use this property of ***rigidity in space*** for their operation. The ***HI*** responds only to ***change of heading***. The ***AI*** responds to both changes in ***Pitch and in Roll.***

Precession

Precession is the deflection of a spinning wheel 90 ° to the plane of rotation when a deflective force is applied at the rim. If a force is applied the top of the rim (the plane of rotation), the precession (turn) will be 90° in the horizontal plane to the left. The ***Turn Coordinator (TC)*** uses this precession property. For example, then taxiing on the ground, the Turn Coordinator will move, with the small airplane in the instrument showing a bank, even though the aircraft is level. The banking of the small aircraft presentation indicates only that the aircraft is turning.

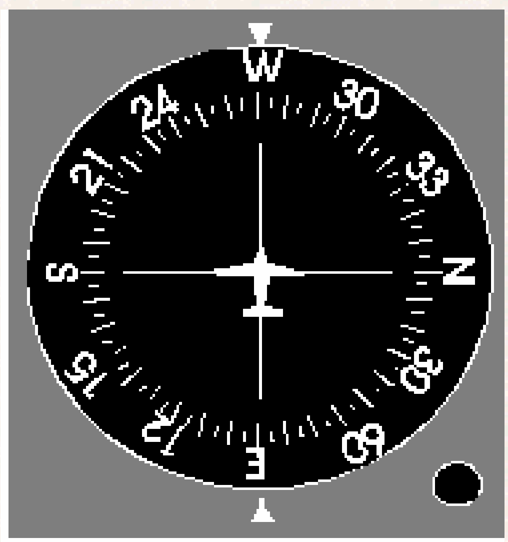
The Vacuum System

The ***Attitude Indicator (AI)*** and the ***Heading Indicator (HI)*** n light aircraft are usually driven by a vacuum system. The principal components are shown below. Not shown are auxillary devices such as valves, filters etc. A pump provides the vacuum to the AI and HI through a system of vacuum lines. A Vacuum Gauge is attached to the lines which gives the pilot an indication that adequate vacuum is being generated.



Heading Indicator (HI)

The Heading Indicator (HI) uses the principle of Rigidity In Space for it's operation. The Gyro is mounted such that it registers changes around the vertical axis only; i.e. direction changes. The compass card attached to the gyro appears to the pilot as though it is turning. In reality, it and the attached gyro are remaining rigid in space, while the aircraft and case turn about the gyro.



The HI is not automatically synchronized with the magnetic compass. It must be set to the compass heading while level on the airport surface prior to take-off.

The HI gyroscope may precess in small amounts over time. Therefore, the HI should be checked against the compass in 15 minute intervals. The check should be done only while flying in straight, level and un-accelerated flight. If adjustment is required, the heading can be reset using the adjustment knob shown.

The compass card has letters for the cardinal headings N, E, S, and W. Each numbered interval is every 30 degrees. The graduations are further divided by the longer marks every 10 degrees, and intervening short marks at the 5 degree points.

A significant advantage of the HI over the magnetic compass is its steadiness in turbulence and various aircraft movements. As will be discussed later in the section on the magnetic compass, the compass can have several errors introduced during turns, acceleration and deceleration. The HI is unaffected by these maneuvers and by turbulence, and is a reliable instrument as long as the precession re-adjustment in made in timely fashion.

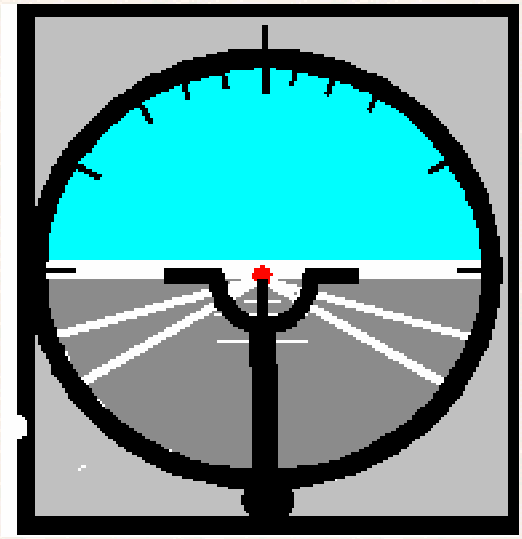
Some makes of HI’s may "tumble" , loosing their gyroscopic characteristics, if subjected to more than 55 degrees of pitch or bank. In this condition, the heading card spins rapidly, and cannot be used for navigation until reset by the adjustment knob.

Attitude Indicator (AI)

The Attitude Indicator shows rotation about both the longitudinal axis to indicate the degree of bank, and about the lateral axis to indicate pitch (nose up, level or nose down). It utilizes the rigidity characteristic of the gyro. It is gimbaled to permit rotation about the lateral axis indicating pitch attitude, and about the longitudinal axis to indicate roll attitude.

The principal parts of interest to the pilot are:

· The miniature wings attached to the case remain parallel to the wings of the aircraft.
· The horizon bar which separates the top (light) and bottom (dark) halves of the ball
· The degree marks on the upper periphery of the dial. The first 3 on both sides of center are 10 degrees apart, then 60 degree bank marks, and 90 degree bank arks. Fifteen degrees of bank is called a ***standard rate turn***.

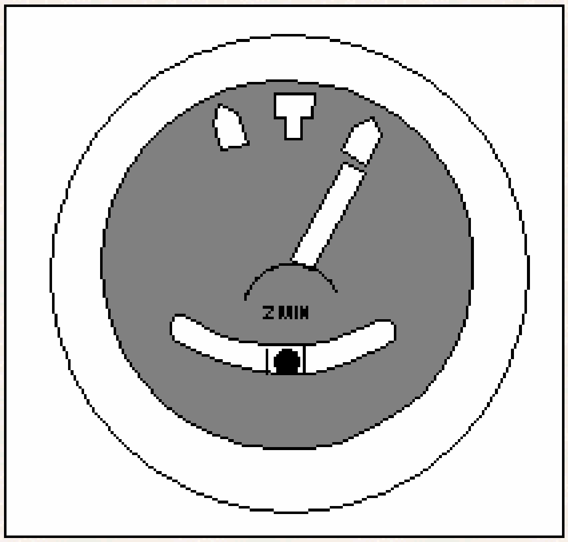


The adjustment knob is used to adjust the wings up or down to align with the horizon bar. This allows adjustment to the height of the pilot. Preferably, the adjustment should be made when level on the ground.

When the wings are aligned with the horizon bar, the aircraft is in level flight. If the wings are above the horizon bar, the aircraft is in a climb. Wings below the horizon bar indicates a decent. The upper blue part of the ball represents the sky. The miniture airplane wings (fixed to the case) represent the wings of the aircraft. In the past, the instrument has been refered to as "an artificial horizon". When in a left turn, the blue portion of the ball will have rolled to the right, as tho you were looking at the horizon over the nose of the aircraft. In a right turn, the blue portion will have rolled to the left.

Turn and Slip Indicator

The instrument is comprised of two components.



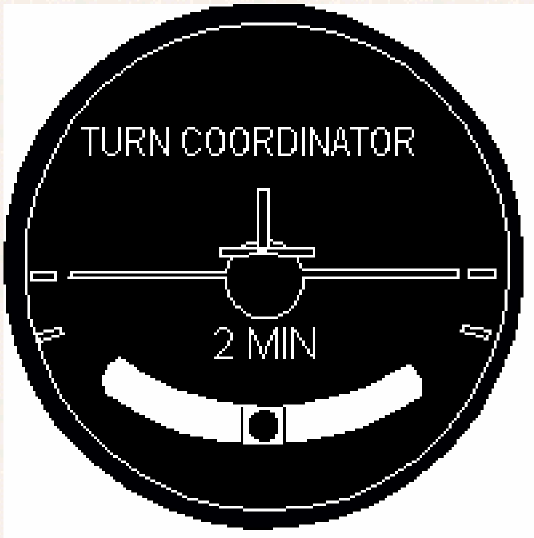
· The turn needle is an electrically driven gyroscope which indicates the rate of turn. The marks (often called the doghouse) on either side of center represents a bank angle of 15 degrees. This is termed a Standard Rate Turn. The rate of turn is 3 degrees per second. It takes 2 minutes to turn 360 degrees.

· The glass level containing the black ball is called the Inclinometer. It provides the pilot with a measure of the Turn Quality. During both straight and level flight and during turns the ball should stay centered.

The ***Turn and Slip Indicator*** acts as a partial backup to the Attitude Indicator in that it shows ***rate of turn***. This type of instrument is usually found in older aircraft.

Turn Coordinator

The Turn Coordinator is similar to the Turn and Slip indicator. It is found in more modern aircraft. The main difference is in the presentation of the turn. A miniature airplane is used to show the bank instead of a needle.



There are 2 marks on each side. The upper ones indicate level flight when the wing align with them. The lower marks indicates a bank angle of 15 degrees, which produces a standard rate turn. When the aircraft turns right, the minature aircraft in the instrument indicated a right bank. When turning left, it indicates a left bank.

Turn Quality

The inclinometer in both the Turn and Slip Indicator and the Turn Coordinator measures the turn quality. As mentioned previously, when in a turn, part of the lift of the wing goes into "turning" the aircraft. This is called the Horizontal Component of Lift (HCL). This HCL is directed toward the center of the turn. Also, a force directed outward and away from the center of the turn exists. This is called Centrifugal Force (CF). For the turn to be ***coordinated*** these two opposing forces must be equal. When they are equal, the ball in the inclinometer will remain in the middle.

When ***too much rudder*** is applied, a skid results. The Centrifrugal Force is bigger than the Horizontal Component of Lift (HCL). This makes the ball go toward the outside of the inclinomenter (i.e. the ball in NOT in the middle).

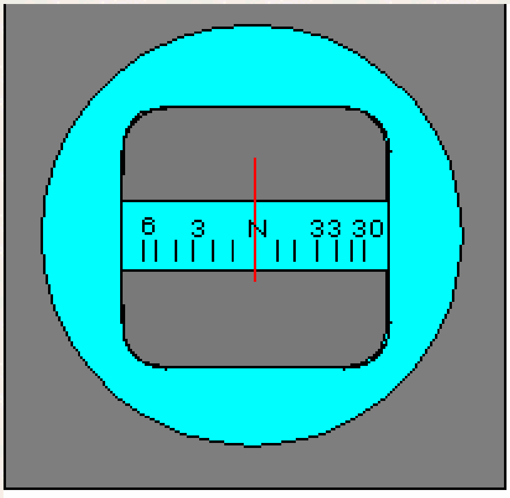
When ***insufficient rudder*** is applied, a slip results. The Horizontal Component of Lift (HCL) is larger than the Centrifrugal Force (CF). The ball rolls toward the lower side(or inside) on the inclinometer.

The term ***step on the ball*** is often used as a memory aid in overcoming a slip or skid. In actuality, more rudder pressure (or less bank) must be applied in a slip. Less rudder pressure (or more bank) must be applied in a skid. In both cases correction must be made so that HCL = CF to keep the ball centered.

Back to Home	Back to Table of Conents	To Magnetic Compass

Magnetic Compass

The magnetic compass is the only instrument in the aircraft by which the pilot determines the direction of flight. Magnets in the compass cause it to align with the Magnetic North Pole.



The compass card has the four cardinal headings shown as N, E, S, and W. Numbers appear every 30 degrees. Long vertical marks occur in 10 degree increments, with intervening short marks at 5 degree points.

The compass card containing the magnets are mounted on a small pivot point in the center of the card assembly. This allows the compass card to rotate and float freely. It is somewhat like suspending a paper cup, upside down, on a pencil point located at the center of the cup bottom. The enclosure is filled with white kerosene to provide a medium to dampen out some vibration and unwanted oscillations. A "lubber line" in etched on the glass face of the instrument to enable exact reading of the compass.

Magnets in the compass align themselves along a Magnetic North-South orientation. Whenever the aircraft is headed toward magnetic North, the compass will indicate N. If the aircraft turns from this direction, the ***magnets*** in the compass still align to this N-S direction. Similar to a gyro, the case of the compass and the lubber line is fixed to the aircraft. Thus when the airplane turns, the the case turns about the compass card. The lubber line will then show a reading other than North.

Compass Errors

Magnetic lines of force surround the Earth, flowing from the North to South Magnetic poles. The magnetic field strength is greatest near the magnetic poles and weakest at the Equator. Several compass errors can occur.

These are:

1. Magnetic Variation
2. Compass Deviation
3. Magnetic dip
4. Compass Card oscillation

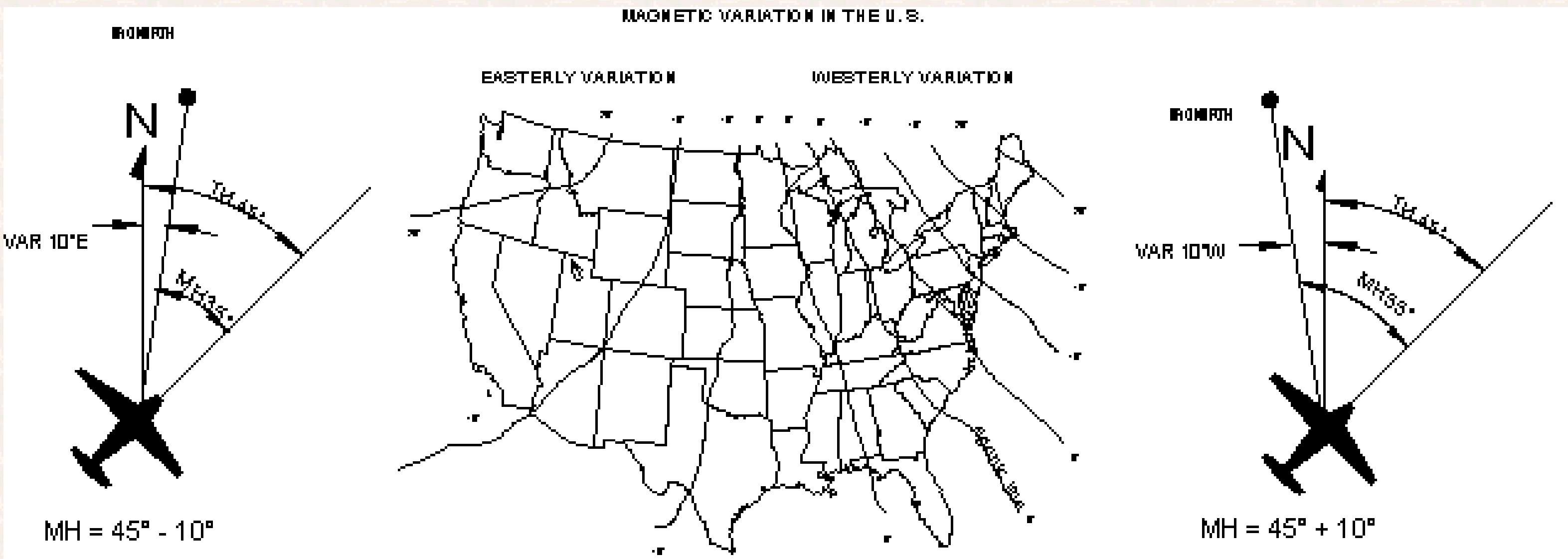
Magnetic Variation

The ***Magnetic North Pole*** and the ***True North Pole*** are not at the same location on the surface of the earth. ***Magnetic Variation*** at any given location on the earth's surface is the difference between the ***Compass North*** and ***True North***. The map below shows the magnetic variation at various locations in the US.

The ***Agonic Line*** is the line of zero degree variation. It proceeds from upper Michigan through central South Carolina. Variation values to the East of the agonic line are called ***Westerly Variation***; i.e. the magnetic north pole is ***West of True North***. Likewise, the variation values west of the agonic line are known as ***Easterly Variation***; i.e. the Magnetic North Pole is ***East of True North***.

Magnetic North changes in small amounts each year. Aeronautical charts are updated periodically to correct for this yearly change.

When plotting a course on an aeronautical chart, the degrees of heading are measured against latitude and longitude lines. This is called a ***True Course (TC)*** because it is being measured relative to the ***True North Pole***. Since the pilot relies on the magnetic compass for direction, the pilot will be steering the aircraft relative to the ***Magnetic North Pole***. Therefore, the pilot must convert the True Course (TC), as plotted on the navigation chart, to a Magnetic Course (MC) by which to steer using the compass. . To convert from TC to MC, Westerly Variations must be ***ADDED*** to TC to get MC (see right hand example below). MC = TC + VAR. (MC = 45° + 10° = 55°). In other words, the pilot must steer 55° magnetic to fly over a true course of 45°. Likewise, Easterly Variation must be SUBTRACTED from TC to get MC (see left hand example below).



Compass Deviation

Magnetic deviation is the difference between the compass indications when installed in the aircraft compared to the indications when the compass is outside the aircraft. The cause of this difference is that the compass magnets can be influenced by magnetic fields within the aircraft due to electronic equipment and other factors. These magnetic disturbances may cause the compass readings to be slightly in error. Such errors are called ***Compass Deviation.***. In other words, the compass reading when inside the aircraft "deviates" from a normal reading.

To determine compass deviation, the aircraft is parked on a compass rose painted on a level surface such as a ramp or taxiway. All of the electronic equipment is powered on as in normal operation. The nose of the aircraft is placed on the Magnetic North marking on the ground. Deviation in the compass reading (from North) is recorded. The aircraft is then rotated to 30 degrees to the right, and the deviation noted. The aircraft is turned in increments of thirty degrees through the 360 degrees, and deviation from the proper reading is noted. This procedure is called ***swinging the compass***. These errors are posted on a **Deviation Card** placed at the lower portion of the compass. For example, it may state for a course of 180, steer 178°.

Usually the errors are only a few degrees, but should be taken into consideration by the pilot then tracking a given magnetic course.

Compass Dip Errors

Any time the compass card is not perfectly level, the magnets **dip** downward toward the earth. The result is that the compass does not correctly align with Magnetic North the same as when the card is level. This results in erroneous indication while in the non-level state. ***Dip occurs under 2 conditions.***
1. During turns from the north and south. (i.e. Plane is in a bank.
2. During acceleration or deceleration while on an East or West heading.

Compass Turning Errors

When the aircraft initiates a right turn from the North, the dip of the compass causes the compass to initially indicate a turn ***IN THE OPPOSITE DIRECTION*** (i.e. the compass turns left). The amount of initial error is approximately equal to the Latitude position of the aircraft. If at a 30 degree latitude, and a right turn from North is initiated, **the compass card will initially turn LEFT to 330 degrees**. As the right turn to the EAST proceeds, the compass will start to ***catch up***, so that when EAST (090) degrees is reached the compass will indicate correctly, even though the aircraft is still banked.

If the turn is ***LEFT*** from NORTH, the compass will turn ***right to 030 degrees***, and will catch up by the time WEST (270) degrees is reached.

THEREFORE, WHEN TURNING FROM NORTH, THE COMPASS LAGS. If turning to the North, you will have to roll back to straight and level approximately 30 degrees prior to reaching North on the compass.

When turning from SOUTH, the opposite action occurs; the compass LEADS by the amount of the degrees Latitude. If at 30 degrees Latitude, the lead will be approximately 30 degrees. If you are turning to the South, you will have to roll back to straight and level approximately 30 degrees past South reading.

MEMORY AID: Turn to N, Under Shoot. Turn to South, Over Shoot.

Compass Acceleration Errors

When the aircraft is on an East or West heading, acceleration or deceleration of the aircraft causes the compass card to tilt forward or backward, respectively. This tilting causes the compass card magnets to swing downward toward the earth, which in turn causes the compass to rotate to an incorrect indication.

This error is maximum when on an East or West heading, and gradually diminishes to zero when a North or

South heading is reached. ***Acceleration*** of the aircraft causes the compass to erroneously swing to the ***North***. **Deceleration** causes erroneous rotation toward the ***South***

.

Again, the error is approximately equal to the Latitude degrees of the aircraft location. At 30 degrees Latitude, acceleration causes the swing to a northerly reading to be approximately 30 degrees. Once the acceleration ceases, and the aircraft assumes a constant forward velocity, the compass will return to it's original East or West reading.

In like manner, deceleration of he aircraft causes an erroneous swing to a southerly reading of approximately 30 degrees at the same Latitude.. ***MEMORY AID: A N D S - Accelerate North, Decelerate South***

Back to Home	Back to Table of Conents	To Engine Fundamentals

Engine

Most light aircraft use a conventional 4 stroke engine. It operates similarly to an automobile engine. There may be 4, 6, or 8 pistons in the engine. The four strokes are:

1. Intake
2. Compression
3. Power
4. Exhaust

· ***Intake Stroke*** - The piston goes downward during the intake stroke. A valve called the Intake Valve is open, such that an air/fuel mixture enters the cylinder through the carburetor. During this operation a second valve, the Exhaust Valve closed.

· ***Compression Stroke*** - During this stroke, the piston is forced upward by the crankshaft. Both the Intake and Exhaust valves are closed. Consequently the air/fuel mixture in the closed cylinder is compressed by the upward movementof the piston.

·

Power Stroke - As the piston nears the top of the cylinder, the spark plugs fire under control of the magnetos. There are 2 spark plugs in each cylinder, with a separate magneto supplying the electrical spark current to each plug. The spark ignites the fuel/air mixture, causing an explosion to occur in the cylinder. This forces the cylinder downward, and imparts power to the crankshaft. While one cylinder is performing the power stroke, other cylinders are in some phase of the other three strokes. Therefore the power stroke is the only one contributing to propulsion of the aircraft.

·

Exhaust Stroke - When the piston reaches the bottom of the power stroke, the Exhaust Valve opens. The piston is pushed upward by the crankshaft, causing the burned fuel / air mixture to be purged from the cylinder. The exhaust valve closes, and the piston is now in a position for another intake stroke.

The pistons connect to the crankshaft through connecting rods. They attach the piston, which has an up-down motion, to the crankshaft which turns in a rotary motion. The crankshaft is usually directly connected to the propeller. In some aircraft, a gear arrangement connects the propeller to the crankshaft. The crankshaft may also drive auxiliary devices such as the Magnetos, Vacuum Pumps, Alternator and other devices. The connection may be directly or through lleys, belts and gears.

The ignition system is comprised of the magnetos and spark plugs, and is independent of the electrical system. Even if the alternator and battery are inoperable, the ignition system continues to function. If there is insufficient battery power to crank the engine, the engine can be started on most small aircraft by “hand propping”. This is a procedure wherein the propeller is turned swiftly by hand to get the magneto system to fire, and start the engine. It is similar to pulling the starter cord on a lawn mower.

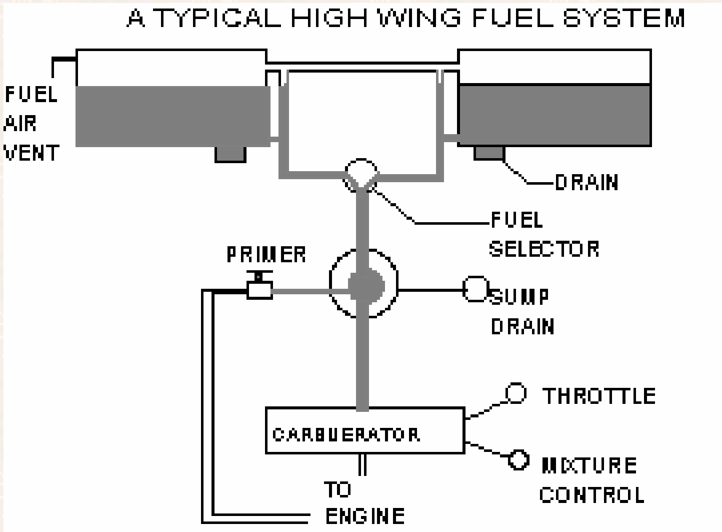
EXTREME CAUTION MUST BE EXERCISED WHEN HAND PROPPING AN ENGINE.

A meter within the cockpit called the ***Tachometer*** indicates the engine ***Revolutions per Minute (RPM)***. Monitoring devices such as the Oil Pressure and Oil Temperature gauge in the cockpit may be attached to the engine.

Back to Home	Back to Table of Conents	To Fuel System

Fuel System

Most modern aircraft are equipped with 2 or more fuel tanks (or cells). In high wing aircraft, the cells are housed in the wings. Since they are higher than the engine, the fuel flows down to the engine by the force of gravity. A typical high wing system is shown at right.



On low wing aircraft fuel pumps are required. To initially get fuel to the engine for starting, an electrical “boost pump” is turned on to pump fuel to the engine. After the engine is started, a mechanical fuel pump driven by the engine feeds fuel to the engine. The electric boost pump can now be turned off.

Each fuel tank is equipped with a drain valve located at the lowest point in the tank. This drain allows the pilot during preflight walk-around to check for and drain off any water which may have accumulated in the fuel tank. There is usually another drain located at the lowest part of the fuel piping system. This valve must also be drained during pre-flight to eliminate any water which may have accumulated in the fuel lines. Associated with this drain is a fuel strainer which filters out foreign matter which may be in the fuel system.

A vent line allows air to enter the tank as fuel is used. During hot weather, fuel may expand and overflow through the vent when tanks are full.

A fuel selector valve located inside the cockpit allows the pilot to select which tank(s) are to be in use during flight. Most small aircraft operate with the selector set on ***Both,*** such that both the left and right fuel tanks are simultaneous feeding fuel to the engine. The pilot may set the selector on ***Left or Right*** tank as a means of equalizing the loading of the aircraft. Usually, the selector should be set to ***both*** for take-off and landing. Pilots of low wing aircraft should exercise caution in their fuel management if tank selection is other than ***both***. Running a tank ***dry*** can cause the engine to quit and vapor lock to occur in the fuel lines. It may be impossible to restart the engine under these conditions.

There is a ***fuel gauge*** in the cockpit for ***each fuel tank***. The lower 1/4 of the fuel gauge indication is marked with a red line as a caution to the pilot of a low fuel condition. The pilot should never rely on the fuel gauge as the sole measure of fuel remaining. The gauges on aircraft are subject to a variety of indicator errors. The pilot should therefore double check the fuel remaining based on the power setting of the engine in flight and time in flight.

Inside the cockpit a fuel mixture control and a fuel primer pump are located on the instrument panel. The mixture control is used to adjust the air/fuel mixture for the altitude being flown. It allows the pilot to adjust the fuel/air ratio entering the engine. As altitude is gained, the intake air becomes less dense. Less fuel must be fed through the carburetor to permit the fuel/air mixture to remain correct proportion. If leaning is not accomplished by the pilot, a ***rich mixture*** (too much fuel) results. This is not only wasteful of fuel, but can result in ***fouled spark plugs*** due to carbon and soot buildup on the spark plugs. A rough running engine results. An additional gauge called an Exhaust Gas Temperature Gauge can be installed in the aircraft as an aid in achieving the proper “leaning” of the engine.

The ***fuel primer*** is a plunger that can be used in cold weather to inject fuel directly into the carburetor as an assist in starting the engine in cold conditions.

Three different grades of fuel are used in reciprocating engine aircraft. These grades are designated by octane rating and are color coded so the pilot can insure the proper grade of fuel is being pumped into the tanks.

These grades are:

OCTANE RATING..........FUEL COLOR

· ..... 80/87........ ....Red
· ....100LL (low lead). ....Blue
· ...... 100/130.... ....Green

When refueling, if the appropriate grade of fuel is not available, USE THE NEXT HIGHER GRADE. Using a lower grade can cause overheating and damage to the engine. Sparks during refueling can be an extreme fire hazard. The following precautions should be taken when refueling is in progress.

1. Attach a ground wire between the fuel pump or truck to a metal part of the aircraft. This will neutralize any static charge which may exist between the pump and the aircraft.

2. The fuel nozzle should be grounded to the side of the fuel filler hole during refueling.

3. The fuel truck should be grounded to both the aircraft and the ground.

Do not use automotive fuel unless the engine has been specially modified for automotive fuel use.

Back to Home	Back to Table of Conents	To Induction System

Induction System

The engine receives ram air through an intake in the lower front portion of the engine cowling. An air filter is placed at the intake end of the duct. This filter removes dirt, dust and foreign matter from entering the carburetor. The air passes through an airbox, then to the carburetor intake. In the event that the airflow to the carburetor becomes blocked by carburetor ice or intake ice, an alternate heated air source can be selected by the pilot by pulling out a carburetor heat control in the cockpit. Use of the heated air will result in approximately 75 to 100 RPM drop.

A throttle is located on the instrument panel in the cockpit. When the throttle is closed, it is pulled rearward toward the pilot until it is stopped by mechanical means. At this setting, the engine continues to run, but at "idle" speed (a few hundred RPM). As the throttle is moved forward, the throttle valve in the carburetor opens allowing more air into the carburetor, thus increasing the RPM. When the throttle is full forward maximum RPM results. The throttle can be locked into a set position with a friction lock so that in cruise flight the power setting will remain set. This relieves the pilot from constant attention to the throttle.

Carburetor

The carburetor provides 2 principal functions.

· It mixes the fuel with the air in the proper proportion
· It regulates the amount of air (and thus fuel) that enters the engine.

The the air is routed from the intake through ducts into the carburetor. The carburetor on most engines are of the ***updraft type***; i.e. the carburetor is mounted on the bottom of the engine, and the fuel/air mixture is sucked upwardto the engine.

When the carbuerator heat control in the cockpit is pulled on, heated air enters the carbuerator. The air source comes from inside the cowling, and passes through a "heat" box to warm the intake air. The heated air can be selected when atmospheric conditions are conducive to carburetor icing or the normal intake duct become blocked by ice at the induction port and air filter.

The carburetor is equipped with a small chamber containing fuel and a float valve. The valve maintains a constant amount of fuel in the chamber. This provides a constant and sufficient source of fuel to satisfy the fuel demands of the engine.

The main air duct of the carburetor is a tubular structure which decreases in diameter near the middle of the duct, then increases in diameter near the intake manifold end of the carburetor. This is called the "venturi". This decreased diameter creates a vacuum in accordance to the Bernoulli principle. The fuel intake port is located in this section. A metered amount of fuel is sucked into the carburetor. The fuel vaporizes into fine particles in the intake air flow. This atomized fuel and air mixture is of proper proportion to cause correct burning of the fuel/air mixture in the engine.

The fuel / air mixture is set by design to be correct for operation at sea level. As the engine is operated over a range of altitudes and air densities, the pilot can adjust the mixture via manual means in the cockpit. It is called the “mixture control”. The correct mixture adjustment procedure is covered in the Pilot Operating Handbook (POH) for the given aircraft. Some aircraft are equipped with an Exhaust Gas Temperature Gauge in the cockpit. A proper fuel/air mixture will produce a given exhaust gas temperature. The pilot can adjust the fuel / air mixture to a fairly accurate measurement by observing that the exhaust gas temperature is within the proper range.

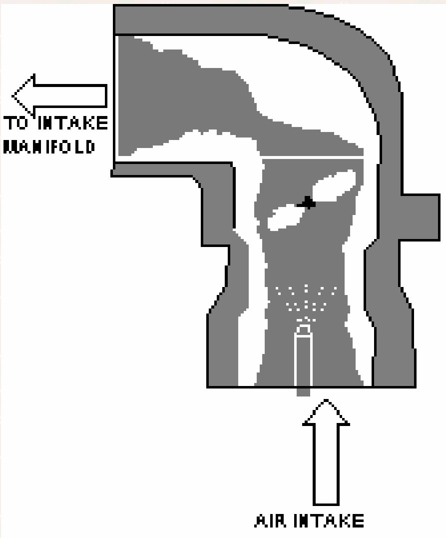
The throttle regulates the amount of fuel/air that enters the engine, thereby controlling the power that the engine develops. On aircraft with a “fixed pitch” propeller, the throttle directly controls the engine RPM. On aircraft with a variable pitch propeller, a Manifold Pressure Gauge directly measures the engine power being developed. A propeller pitch control controls the propeller blade angle. The power setting of the engine requires adjustment of both the throttle and propeller pitch control.

The carbuerator has an accelerator pump which will provide a “burst” of additional fuel for quick development of maximum horsepower, such as performing a **go around** from landing approach. An economizer valve allows the engine to idle when the throttle closed.

Icing

The predominate forms of icing affecting engine operation are carbuerator ice, throttle ice and induction ice.

Carbuerator Icing



Carburetor icing is a constant concern to the pilot when operating in high humidity and visible moisture conditions. Whenever the outside temperature is 20° to 70° F, ice creation in the throat of the carburetor is a possibility. Due to the Bernoulli effect and the vaporization of the fuel in the venturi, the temperature of the fuel / air mixture can be as much as 50 degrees lower than the outside air.

Induction Icing

The air induction port at the front of the cowling can become partially or totally clogged with ice when air temperatures are 32° F or below while flying in visible mousture. This is known as “impact” ice, and is most prevalent when the Outside Air Temperature (OAT) in around 25° F and super-cooled moisture exists.

Throttle Ice

Throttle ice in the carburetor occurs most often when the throttle is partially closed. This can occur at low cruise speeds or near idle situations such as approach to landing. Some manufacturers recommend that the alternate air source (carburetor heat on) be used anytime the power setting of the aircraft is below a certain point even though high atmospheric moisture content is not present. For fixed pitch propeller configurations, most aircraft should use carburetor heat below 2000 - 2100 RPM. The location of ice in the carbuerator is shown in the diagram at right.

The vaporization of the fuel in the venturi additionally cools the throttle area. Even a small amount of ice in the carburetor or the induction system will reduce power. Usually this condition is detected by a gradual drop in RPM (or Manifold Pressure). Application of carburetor heat will usually cause an additional temporary decrease in power, but as the ice melts, the power should be restored. If icing is persistent, it may be necessary to operate with some carburetor heat on continuously.

Fuel Injection

In these systems, the air intake system is similar to carbuerated systems. However, the fuel is not vaporized in a venturi, but rather is injected directly into the engine cylinder just prior to the spark plugs firing. A specific amount of fuel is injected and an appropriate amount of air is vented though the air induction system to provide for proper combustion.

There are several advantages to fuel injected systems.

· Less susceptibility to icing
· Fuel flow is better controlled
· Faster throttle response since the fuel is directly injected into the cylinder.
· Better distribution of fuel to each cylinder.
· Easier starting in cold weather.

Some disadvantages are:

· Starting a hot engine can sometimes be difficult.
· Vapor lock during ground operations on hot days.
· Difficult engine re-start if engine quit due to fuel starvation.

Back to Home	Back to Table of Conents	To Electrical System

Electrical System

Most small aircraft are equipped with a 28 volt direct current electrical system. The system is powered by an Alternator which drives the electrical devices and stores energy in the battery.

A simplified diagram is shown at below. Not shown are the starter, and starter switch, and various other electrical regulators and devices.

Electrical System

The Master Switch (labled MS) causes the electrical system to connect the electrical buses and devices to the battery. The battery provides the power to crank the starter. Once the engine is running, power is supplied by the alternator and the battery is recharged.

Numerous circuit breakers feed off the Primary Electrical Bus, and provide individual circuits to power the electrical devices. Although the arrangement will vary from one make and model aircraft to another, the basic principles are the same. By providing numerous circuit breakers and dividing the electrical load into several different circuits, a malfunction in one system can be turned off without adversely affecting the other circuits. The breakers will be labeled as to their general use, and the amperage will be marked on the face of the breaker push button. On older model aircraft, fuses are used instead of circuit breakers.

Usually an alternator light is located on the instrument panel to provide a means for the pilot to determine alternator is providing power to the system. In addition, an ammeter on the instrument panel can determine the general health of the electrical system. After the battery is used for starting, a considerable “charge” should be shown, indicating that the alternator is replenishing the power drained from the battery during engine cranking. If the indicator shows zero while electronic equipment is ON, failure of the alternator to charge the battery is indicated.

A second bus is provided to power the electronic and avionics equipment. This bus is connected to the Primary Bus via the Avionics Switch. This switch should not be turned on until the engine is started to prevent the possibility of high voltage transient currents resulting from engine starting from feeding into sensitive electronic equipment. The pilot should also turn this switch OFF prior to engine shut-down for the same reason.

Prior to start-up the pilot should check the status of all circuit breakers as a part of the pre-flight check. A “tripped” breaker will project out farther from the control panel than does a properly functioning breaker. Pushing the breaker in will reset it to it’s normal operating position. If it pops out again, there is a malfunction in the circuit which it feeds, and repair should be made prior to flight.

The pilot should turn on the master switch during the walk-around pre-flight inspection to insure that the rotating beacon and strobe lights (If present) are functioning. If all or part of the flight is to occur at night, the navigation lights, instrument panel lights, taxi and landing lights should also be checked for proper operation.

Back to Home	Back to Table of Conents	To Propulsion System

Propulsion System

The propeller is a rotating airfoil. It is subject to drag, stalls and other aerodynamic factors that apply to any airfoil. The propeller provides the thrust to pull the aircraft through the air. As seen at right, the cross section near the hub of the propeller is thick, and has a fairly large angle of attack. The angle of attack and the thickness decreases toward the tip of the blade. Since the linear speed at the tip is much faster than at the hub the change in angle of attack provides uniform thrust along the surface of the blade.

The propeller is normally connected directly to the engine crankshaft. Some aircraft , however, employ gear arrangements between the engine and the propeller.

Propellers fall into two main categories.

· Fixed Pitch
· Controllable pitch

Controllable pitch propellers allow the pilot to set the pitch of the blades, either directly or via a governor, to the best angle for the flight condition and performance desired. Usually for takeoff, a fairly “flat” angle of attack and high engine RPN is used to produce maximum horsepower and thrust. As altitude is gained the pilot can reduce RPM and increase pitch for a cruise climb condition. Once cruise altitude is reached the throttle, mixture and propeller pitch can be adjusted for the desired cruise performance.

The pilot has only one method of controlling thrust on fixed pitch propellers; that being adjusting engine RPM. With controllable pitch propellers, the pilot can adjust two controls; these being RPM (throttle) and Manifold Pressure (propeller pitch control). The Tachometer indicates RPM and the Manifold Pressure Gauge indicates the manifold pressure.

On constant speed propellers, a governor automatically adjusts the pitch of the propeller blade whenever the engine throttle setting is changed. Low RPM and High Manifold pressure should be avoided, as this places undue stress on engine components, and can lead to eventual engine failure.

For any given blade angle, the propeller has an ideal geometric pitch. It is designed to travel a certain distance in one revolution. However, due to slippage, the ideal geometric pitch is never attained. Therefore the effective pitch is always less than the geometric pitch. The propeller is never 100% efficient.

Back to Home	Back to Table of Conents	To Stall Warning System

Stall Warning System

Most aircraft are equipped with a Stall Warning system of some type. On some older aircraft, a small moveable flap located on the leading edge of the wing engages an electrical switch in the cabin, which activates a stall warning buzzer or horn. On some later aircraft, the system is pneumatic, with a small slot in the leading edge of the wing. Both types sense approach to stall, and sounds a device in the cabin, warning of impending stall.

Back to Home	Back to Table of Conents	To Weight and Balance

WEIGHT AND BALANCE

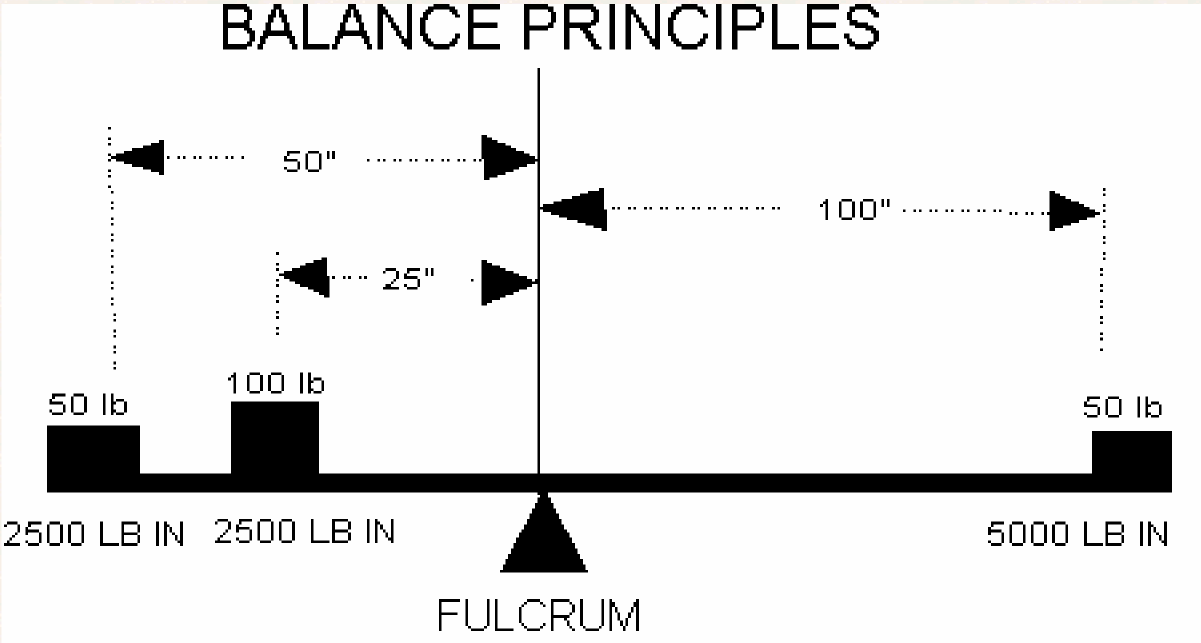
Overview

Weight affects the flight performance of an aircraft in many respects. An airplane which is overloaded will be deficient in performance because:

Higher takeoff speed is required.
Longer take-off run.
Reduced rate of climb performance
Shorter range of flight
Reduced cruise speed
Reduced maneuverability
Higher stall speed
Higher landing speed
Longer landing roll

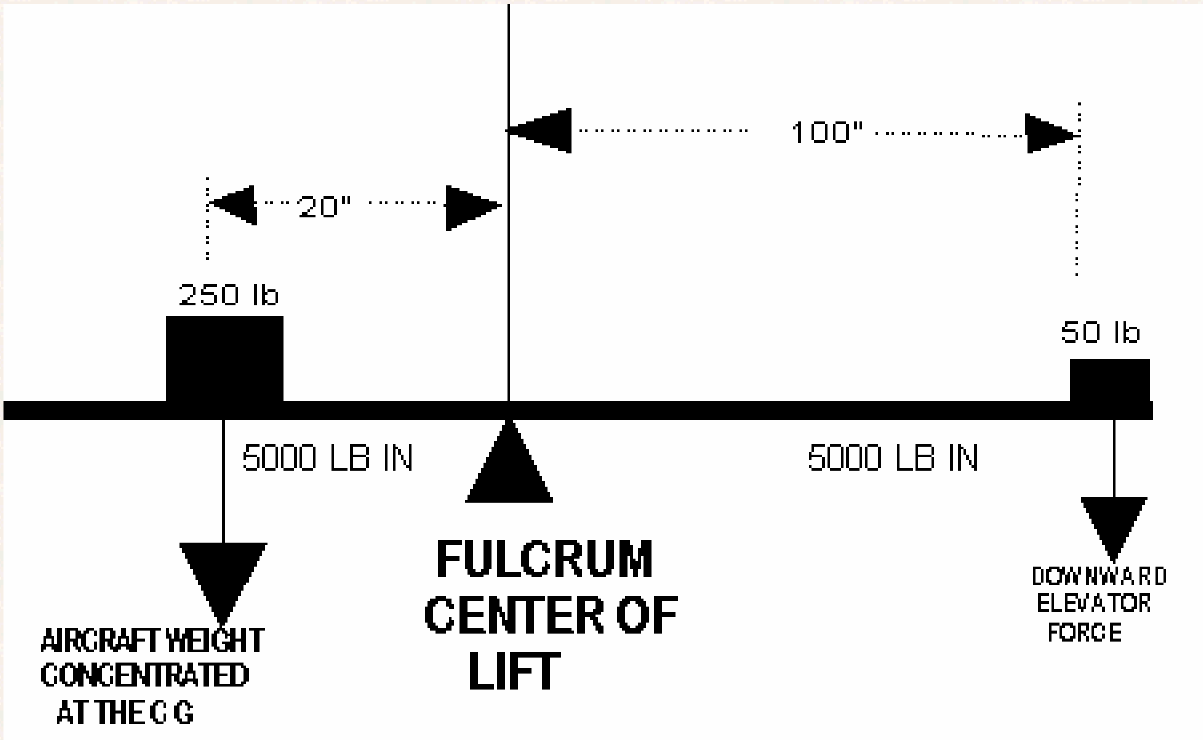
Balance Principles

As shown in the figure below, the aircraft is somewhat like a childs "teeter-totter" with respect to longitudinal balance. For the plank to be in balance, ***The sum of the moment s on each side of the pivot point (fulcrum) must be equal.*** A ***MOMENT*** is simply the weight multiplied by a moment arm (distance) from some reference point. In this example, the moments are measured from the center fulcrum point.



As seen, the plank is in balance because the sum of the moments on each side equals 5000 pound inches. If a weight on either side is moved, or a weight is changed, the plank will no longer be in balance.

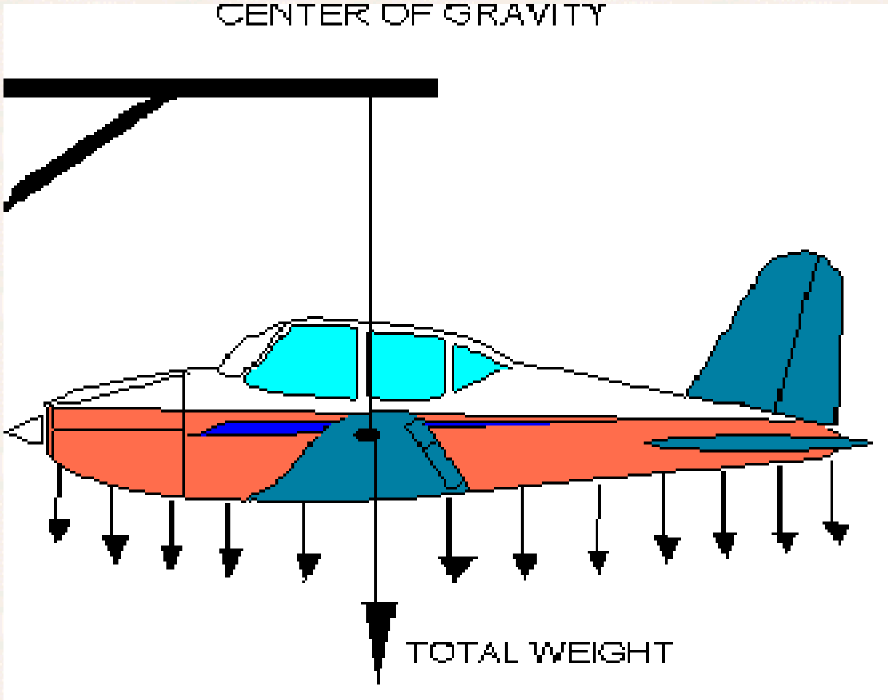
An aircraft in flight is very similar. The pivot point (fulcrum) is the located at the ***Center of Lift*** of the wing. The load on the left is the total weight of the aircraft located at the ***Center of Gravity (CG)*** with a counter-balancing force on the right provided by the elevators.



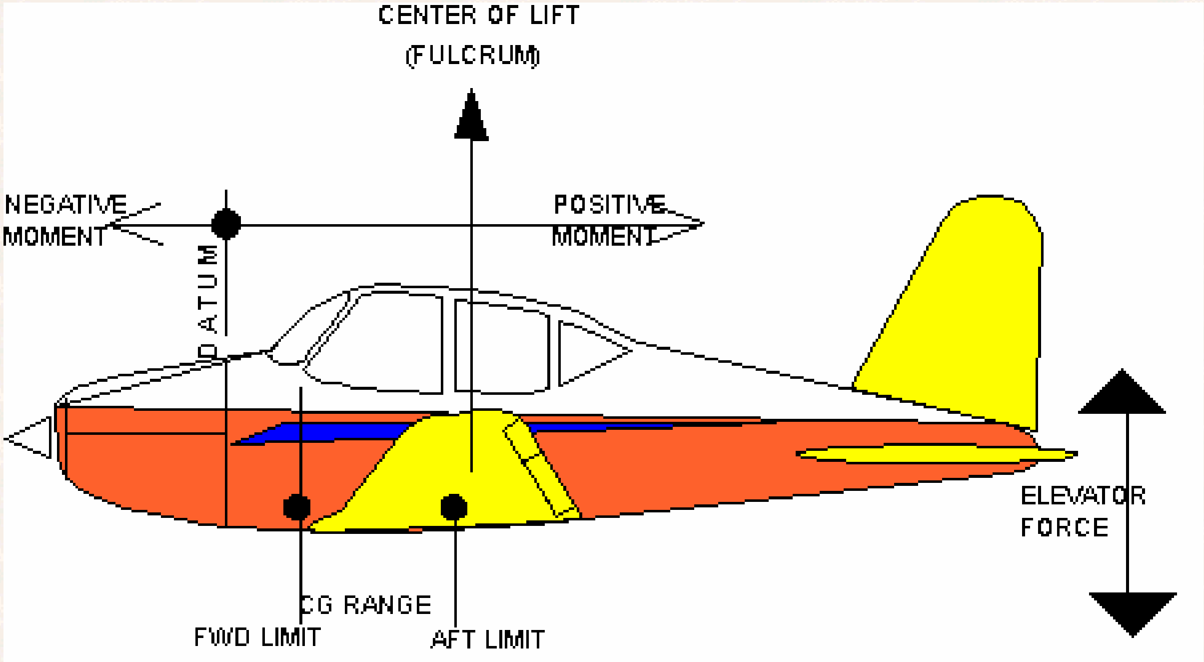
Note that if the location of the CG or the weight on the left changes, the elevator force must also change in order to maintain the balance. Also note, if the fulcrum (center of wing lift) changes, the elevator force must be changed to maintain a balanced condition. Such an event can occur when the angle of attack and/or engine thrust is changed.

The Center of Gravity

As previously stated, the weight of an aircraft and its load is distributed throughout the aircraft as shown below by the small downward arrows. All of the small individual weights can be resolved into one single weight acting at the ***Center of Gravity*** and shown as the large arrow..



From the analogy of the plank above, we can see that if we change either the weight of the aircraft, or the center of gravity, this in turn changes the force (either up or down) that the elevator must produce.



For each aircraft design, the manufacturer specifies a maximum weight for operation of the aircraft, and also a maximum forward and rearward location of the Center of Gravity (CG). This is called the ***CG RANGE***. For safe operation, the aircraft must be operated within these parameters.

In order to calculate where the center of gravity is located, the manufacturer specifies some point in the aircraft as a reference point ***(DATUM).*** In many Cessna 172 type aircraft, the datum is located at the lower firewall of the cabin, just ahead of the rudder pedals. You as a pilot do not need to know where this is located in order to calculate weight and balance, as the manufactirer provided moment arm and/or moment in the weight and balance tables for the aircraft. An aircraft mechanic must know where whis point is, however, if equipment change is made to the aircraft which changes either the aircraft CG or Empty Weight.

An airplane is designed and certified to withstand specified loading on it's structure. As long as the gross weight and load factor are within limits, the aircraft can be operated safely. Continued operaton of an aircraft in an overloaded condition can cause structural failures. Metal fatigue is hastened, and can lead to stress failures even in normal operating modes.

Effect on Wing Loading

The location of the CG affects the total load which the wings must sustain. If the CG is at or near the Center of Lift of the wing the elevators do not have to generate much (if any) downward force. If the CG is aft of the center of lift, the elevators must produce an upward force. If the aircraft is nose heavy (forward CG) the load on the wing and elevator surfaces will be greater.

An aft CG location causes the airplane to require more "nose down" elevator for stall recovery. A forward CG enhances stall recovery as the aircraft will naturally want to "nose down".

Definitions

MOMENT ARM -- a horizontal distance of an object measured from a defined "datum" point to the CG of the object, usually measured in inches. A (+) arm means the object is behind the datum. A (-) arm indicates the object is forward off the datum point.

MOMENT -- the product of a moment arm and the associated weight. (Weight x Arm)

EMPTY WEIGHT-- the combined weight of the aircraft, and permanently mounted equipment. It includes unusable fuel and hydraulic fluid. Most manufactures include the oil in the empty weight.

Center of Gravity -- the point at which the airplane will be in balance.

CG Limits -- the most forward and most rearward CG points specified by the manufacturer for safe control.

CG Range -- the distance from the most forward and rearward CG points as specified for the given aircraft.

DATUM -- a point in the aircraft from which all moment arms are measured.

FUEL LOAD -- the weight of the useable fuel. It does not include unusable fuel in the tanks and lines.

GROSS WEIGHT-- Total weight of aircraft, fuel, passengers and baggage.

MAX LANDING WEIGHT - Maximum gross weight allowed for landing.

MAX RAMP WEIGHT -- Maximum gross weight prior to taxi and take-off.

MAX TAKEOFF WEIGHT -- the maximum allowable weight at start of takeoff run

USEFUL LOAD -- Gross weight minus the empty aircraft weight.

STANDARD WEIGHTS -- Gasoline 6 lb. per gal; Oil 7.5 lb. per gal. (US Measure)

Methods of Determining Weight and Balance

The method of determining weight and balance may vary with aircraft manufacturer and type of aircraft. These methods are:

1. Center of Gravity Calculations
2. Center of Gravity Graphs
3. Center of Gravity Tables
4. Loading Schedules (Placards)

Center of Gravity Calculations

To determine the location CG, add up all the weights and all the moments. Divide the sum of the moments by the sum of the weights. This is illustrated in the diagram.

All moments aft of the datum are positive numbers. All moments forward of the datum are negative. In the example, the oil is the only negative moment since it is forward of the DATUM.. Calculate the weight of oil at 7.5 pounds per gallon. Calculate fuel at 6 pounds (US) per gallon.

The procedure to calculate the CG is as follows:

1. Add up all weights, including empty aircraft
2. Multiply each weight by it's moment arm in inches to get the moment for that item.
3. Add up all the moments
4. Divide the sum of the moments by the total weight to get the CG

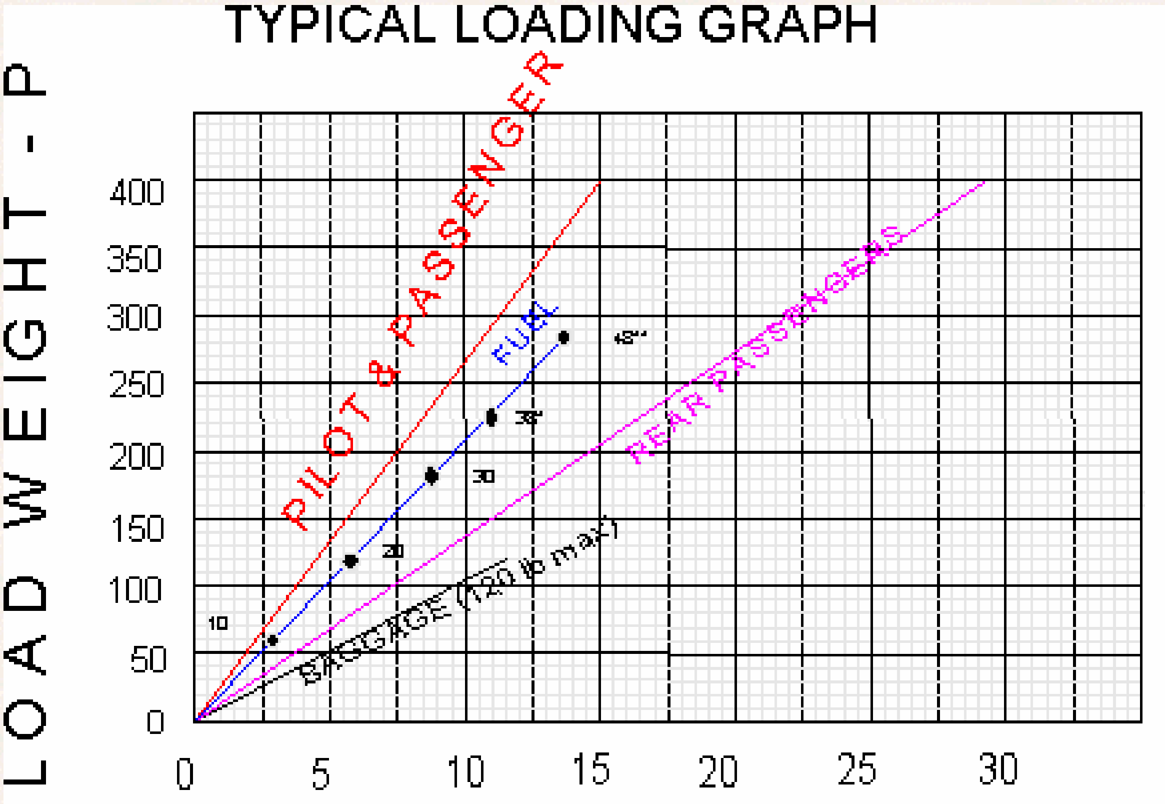
A TYPICAL W/B PROBLEM			
ITEM	WEIGHT lbs	MOMENT ARM in.	MOMENT LB IN

A = AIRCRAFT	1000	6	6000
P = PILOT	150	11	1650
B = BAGGAGE	40	32	1280
O = OIL	7.5	-4	-30
F = FUEL	120	16	1920
TOTAL	1317.5	CG?	10820

In the example, CG? = 10820/1317.5 = 8.21 in. aft of the datum.

Loading Graph

Frequently the manufacturer provides a graphical method for determining weight and balance.



Determine the load moment for each load item using the appropriate line in the graph. For example, for pilot and front seat passenger, total the combined load weight. Go up the Load Weight axis (Y axis) to the pilot & passenger weight. Then go horizontal to the pilot & passenger line (Red line). Then go down to the X axis to find the load moment/1000. Do the same for fuel (blue line), rear passengers (green Line) and baggage (black line). Total up the weight and the Load Moments.

EXAMPLE: Determine the Load and moment from the loading graph above for each of the following load items.

Weight and Balance Using Loading Graphs

	Weight	**Moment
Empty Weight	1,364	51.7
Front Seats	400	*15.0*
Baggage	120	*11.5*
Fuel (38 gal)	228	*11.0*
Oil (2 gal)	15	- 0.2
TOTAL	2,127	89.0

Derive the values as follows:

1. Empty Weight and moment are values provided by the manufacturer.

2. Pilot & Passenger - Add weight for Pilot and Passenger. In this example 400lb. Go up the left side (Y axis) of the graph to 400 lb. weight, then horizontal to the “Pilot & Passenger” line. Read vertically down from the intersection to the horizontal (X) axis, and read a Moment/1000 value of 15.0.

3. Baggage - The baggage weight is 120 lb. Go up left side of the upper graph to a load of 120 lb. Continue horizontally to intersect the “baggage” line. Go downward from this intersection and read a Moment/1000 value of 11.5.

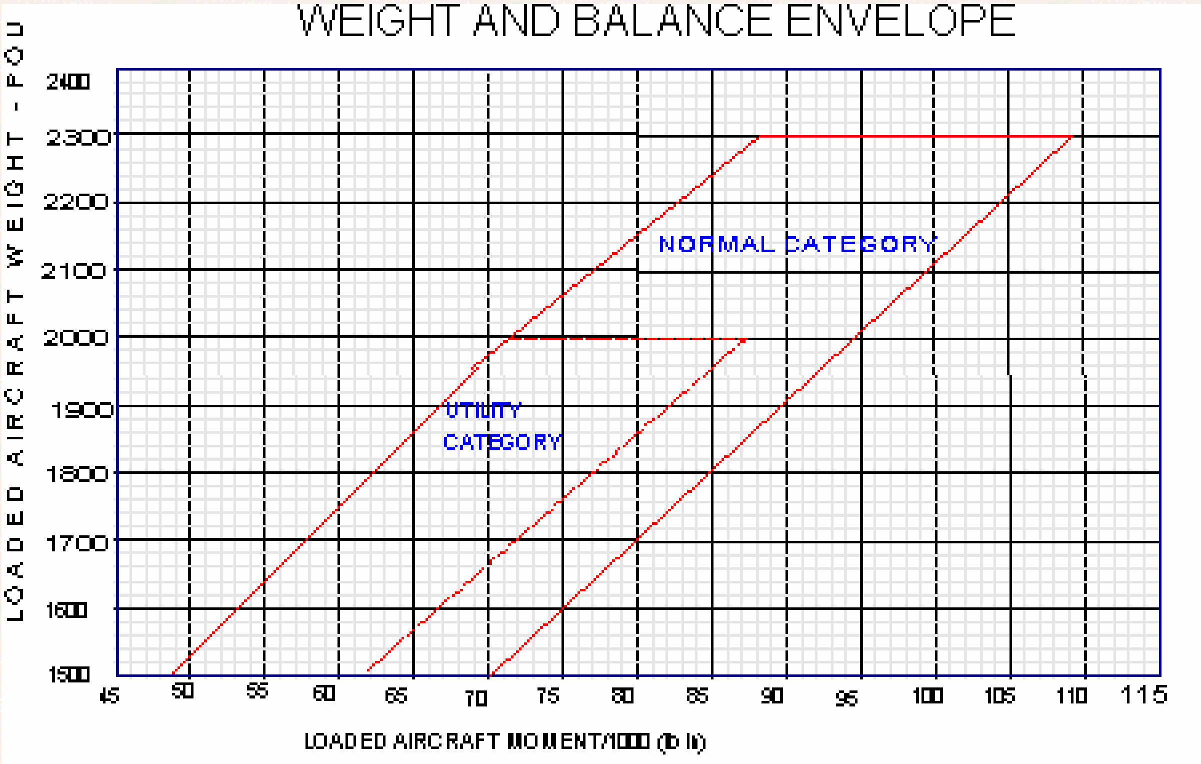
4. Fuel -- 38 gallons at 6 pounds per gallon is 228 pounds. Go up the left side of graph to a weight value of 228 lbs., then horizontally to intersect the“fuel line. Go downward to read a Moment/1000 value of 11.0.

5. Oil was not included in the empty weight of this aircraft, therefore it must be entered into the calculation. Two gallons of oil is 15 lb. The moment is -0.2 lb-in.

Loading Envelope

Once the total weight and the total moment/1000 is found, use the load and CG envelope to ascertain that the aircraft is properly loaded.

Go up the left side to a total load of 2127 lbs. Draw a horizontal line. Go along the bottom scale to find the loaded aircraft moment / 100 value of 89.0. Draw a vertical line. The aircraft is properly loaded if the intersection of the horizontal and vertical lines is within the envelope.



According to this envelope, if the weight is greater than 2300 pounds, the aircraft is overloaded. If the intersection is outside the envelope laterally, the loading is out of proper CG range.

Center of Gravity Tables

Some manufacturers provide tables instead of graphs or calculation. This method is fairly lengthy, and is used infrequently for small aircraft. Therefore this method will not be covered herein.

Weight Shift and Change

The approach to solving both Weight Change and Weight Shift is the same. The simplest method is to REMOVE a changed item, and to ADD the new or shifted item into the new location.

Weight Change

Example 1:
An airplane takes off with a Gross Weight of 6230 lb., and a CG of 79.0. The CG of the fuel is at 87.00 aft of datum. What is the ***New CG*** location after 50 gallons of fuel is burned?

Procedure:
Subtract the Weight and Moment of the burned fuel from the initial values to arrive at a new set of values. At 6 pounds per gallon, the burned fuel weight is 300 pounds.

WEIGHT CHANGE PROBLEM

	WEIGHT	CG	MOMENT
Initial Weight	6230	79.00	492,170
Burned Fuel	-300	87.00	-26,100
New Weight	5930	***New CG***	466,070

NEW CG (after Fuel Burned) = 466,070 / 5930 = 78.59

Weight Shift

Example 2:
The gross weight of the aircraft is 3,000 lbs. with a CG of 60 in. Since takeoff, 25 gallons of fuel has been used. The fuel cell CG is 65 in. aft of Datum (Station 65).

Also, a 200 pound passenger moves from Station 50 to Station 90. (Note: Some problems will state the CG location as "Station". The 50 and 90 are CG location in inches aft of datum respectively).

Find ***New CG***.

Procedure:
1. Subtract burned Fuel
2. Subtract Passenger who moves from the old location.
3. Add passenger who moves to the new location.

WEIGHT SHIFT PROBLEM

	Weight	CG Station	Moment
Initial Loading	3000	60.00	180,000
Fuel Burned	-150	65.00	9,750
Passenger Off	-200	50.00	-10,000
Passenger On	+200	90.00	+18,000
New Totals	2850	***New CG***	178,250

New Cg = 178,250 / 2850 = Station 62.54

Back to Home	Back to Table of Conents	To Aircraft Performance

Aircraft Performance

Factors Affecting Performance

Performance of the aircraft depends on the density of the air in which it flies.

Factors affecting air density are:
1. Barometric pressure
2. Altitude
3. Temperature
4. Humidity

Standard Atmosphere Definition

The International Standards Association (ISA) has defined a Standard Atmosphere as:
· Sea Level Barometric Pressure of 29.92 inches of Mercury (in. Hg)
· Sea Level Temperature of 15° Celsius (15° C or 59° F)
· Relative humidity of 0 %
· Standard temperature lapse rate of 2° C per 1000 feet altitude
· Standard pressure lapse rate of 1 in. Hg per 1000 feet altitude
· A standard decrease in density as altitude increases

The standard atmosphere definition provides a means for instrument and aircraft manufacturers to specify the performance of their products in a uniform way. This definition was arrived at by studying the average sea level pressure and temperature over a number of years, seasons, and locations around the world.

Seldom will an aircraft be in standard atmosphere conditions. In order to define peformance of an instrument or an aircraft in a non-standard atmosphere, conversions must be applied to adjust the readings or performance numbers to agree with the standard atmosphere. This adjustment is called Density Altitude, and will be more fully defined later in this chapter.

Effects of Non-standard Air Density

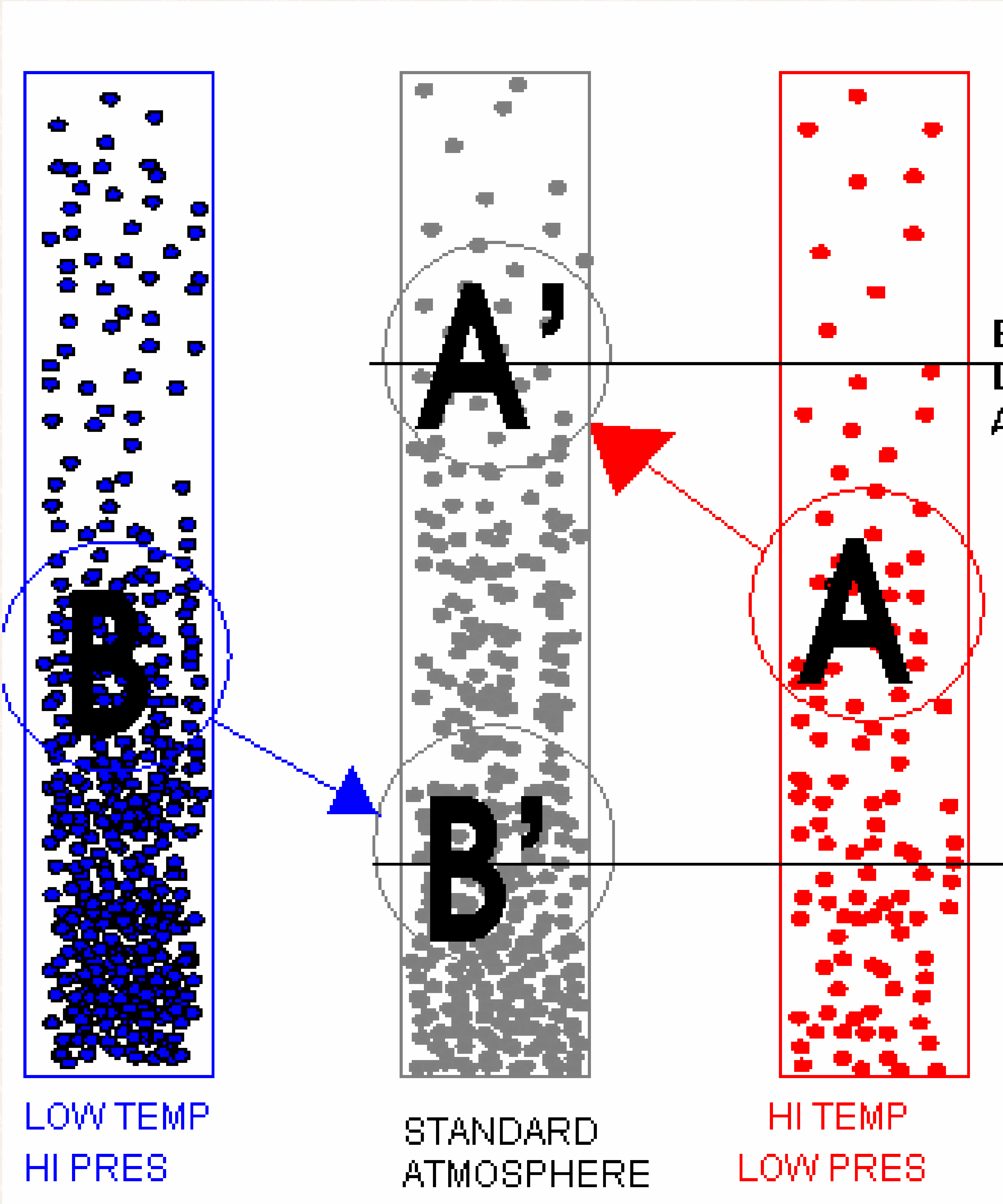
Air Density decreases:
· With Air Temperature Increase
· With Altitude Increase
· With Humidity Increase
· With Barometric Pressure Decrease

With lower air density:
· The engine develops less power.
· The propeller produces less thrust.
· The wings produce less lift.

This results in:
· Longer takeoff run
· Poorer climb performance
· Longer landing distance

Density Altitude

Density altitude is a way of relating the density of the air you are in compared to the standard atmosphere. Three atmospheres are illustrated. The Standard Atmosphere (29.92 in. Hg and 15 degrees Celsius) in middle shown in gray. A less dense atmosphere (A) (lower pressure and/or Higher Temperature) is shown on the right in red. A more dense atmosphere (B) (higher pressure and/or Colder Temperature) is illustrated on the left in blue.


A'
A
B
B'
LOW TEMP
HI PRES
STANDARD
ATMOSPHERE
HI TEMP
LOW PRES

If you are at an actual (true) altitude at location A in atmosphere (A) (the red atmosphere on the right), you will have to go to altitude (A') in the Standard Atmosphere to find the same air density. This altitude in the standard atmosphere at (A') is called the DENSITY ALTITUDE.

Similarly, if you are at atmosphere (B) (colder or high pressure shown as blue on the left) the air will be more dense than standard. Therefore you will have to go down to a lower actual altitude in the standard atmosphere at (B') to find the equivalent air density. This equivalent altitude in the Standard Atmosphere is the DENSITY ALTITUDE.

The reason that you need to convert your actual non-standard altitude (and thus your non-standard air density) to the standard density altitude is that all performance charts and data is based on a standard atmosphere. For example, if you are at a high altitude runway already, and the atmosphere pressure is low and temperature is high, it will require ***a significantly longer take off run*** than you may be accustomed to at your lower home base. If you are not aware of the effects of density altitude on your aircraft performance, it could lead to serious consequences.

Density Altitude Calculations

Density Altitude can be found in two ways

· Using conversion charts
· Using the E6B Flight Computer

Density Altitude calculation is a 2 step process.

Step 1. Find Pressure Altitude

Pressure Altitude adjusts for pressure difference between your air and standard atmosphere. The question is ***"What would your altimeter read if you were in a standard atmosphere at your current actual altitude?"*** This altitude is called PRESSURE ALTITUDE.

Pressure Altitude can be determined two ways.

· In the aircraft, adjust your altimeter setting to 29.92 in. Hg (standard pressure), and read the altitude value shown by the altimeter needles. Or...
· Apply a correction factor from a Pressure Altitude Correction Table as shown below.

PRESSURE ALTITUDE CONVERSION TABLE

In. Hg	Conv. Factor	In. Hg	Conf. Factor	In. Hg	Conv. Factor	In. Hg	Conv. Factor
28.0	1824	28.8	1053	29.6	298	30.3	-348
28.1	1727	28.9	975	29.7	205	30.4	-440

28.2	1630	29.0	863	29.8	112	30.5	-531
28.3	1533	29.1	768	29.9	20	30.6	-622
28.4	1336	29.2	673	29.92	0	30.7	-712
28.5	1340	29.3	579	30.0	-73	30.8	-803
28.6	1148	29.4	485	30.1	-175	30.9	-893
28.7	1148	29.5	392	30.2	-257	31.0	-983

EXAMPLE:
Airport Altitude = 2367 ft
Altimeter Setting = 30.40 In. Hg
Conversion Factor= -440 feet (from table)
Pressure Altitude = Airport Altitude + Conversion Factor =2367+(- 440) = 1927

NOTE: If your barometric pressure is *not shown* in the table (say a value such as 30.35) you will have to *interpolate* to get the correct pressure altitude adjustment.

Step 2. Find Density Altitude

Density Altitude uses Pressure Altitude as a basis, and adds in a correction factor for non-standard temperature.

Calculate Density Altitude using:
1. PRESSURE ALTITUDE and
2. Outside Air Temperature (OAT)

· Use E6B Flight Computer (see E6B instruction book)
· Use Density Altitude Chart like the one shown below.

Density Alt For Example: If you found the Pressure Altitude, doing either of the steps cited above, to be 4000 feet, and the outside Air Temperature (OAT) is 16° , do the following on the chart to find Density Altitude.

Locate 16° C on bottom scale. Go vertically up to intersect the 4000 foot Pressure Altitude slanted line (blue line). Go left horizontally (blue line) to read Density Altitude = 5000 feet from the left side scale. You have now adjusted for the difference from standard temperature by using the chart.

The red line on the chart is a Standard Atmosphere Temperature line.

Performance charts provided by the manufacturer are based on Standard Atmosphere. Therefore you must adjust your current situation (barometric pressure and temperature) to Standard Atmosphere. This is done by calculating your Density Altitude, then using this Density Altitude as the altitude in the manufacturers performance table when interpreting the performance table data.

Aircraft Performance Charts

Aircraft Performance Charts state performance figures in standard atmosphere conditions.

Takeoff Performance

You should consult the manufacturers Pilot Operating Handbook for the aircraft to be flown for take-off performance tables or graphs.

Takeoff performance is influenced by several factors.

· ***Adverse conditions***
1. High density altitude (high altitude runway, low pressure, high temperature)
2. Runway conditions - mud, soft field, slush, snow, tall grass, rough surface, uphill
3. Tailwind (downwind takeoff)
4. High gross weight or overload
5. High Humidity

· ***Favorable conditions***
6. Low density altitude (low altitude runway, low temperature, high pressure)
7. Downhill runway
8. Headwind
9. Low weight
10. Low Humidity

Takeoff performance data shown in the manufacturers' charts indicates the ***minimum runway requirements*** necessary for successful takeoff. Any factor that adversely affects the takeoff distance must be taken into account to insure safe operation. Consider that the listed minimum distance is for standard atmospheric conditions, ideal runway and wind conditions.

TAKEOFF PERFORMANCE

			0000' & 59 deg F		2500' & 50 deg F		5000' & 41 deg F		7500' & 32 deg F	
GROSS WT. POUNDS	IAS@50' MPH	HEAD WIND	GRND RUN	CLEAR 50' OBS	GRND RUN	CLEAR 50' OBS	GRND RUN	CLEAR 50' OBS	GRND RUN	CLEAR 50' OBS
2300	68	0	865	1525	1040	1910	1255	2480	1565	3855
2300	68	10	615	1170	750	1485	920	1955	1160	3110

2300	68	20	405	850	505	1100	630	1480	810	2425
2000	63	0	630	1095	735	1325	905	1625	1120	2155
2000	63	10	435	820	530	1005	645	1250	810	1685
2000	63	20	275	580	340	730	425	910	595	1255
1700	58	0	435	780	520	920	625	1095	765	1370
1700	58	10	290	570	355	680	430	820	535	1040
1700	58	20	175	385	215	470	270	575	345	745

Wind direction and velocity significantly affect takeoff distance. A direct headwind will greatest provide takeoff assist. A 90° crosswind will give no assistance in takeoff. A tailwind component significantly increases the takeoff roll.

Gross weight affects takeoff performance.

Increased gross weight:
· Requires a higher takeoff speed in order to achieve sufficient lift.
· Results in reduced acceleration due to greater inertia.
· Increases rolling friction , further reduceing acceleration.

Gusting or strong crosswinds require that the aircraft be held on the ground until definite liftoff can be achieved. Once liftoff has occured, sufficient speed is needed to prevent settling back onto the runway. If the landing gear contacts the runway when in a sideways drift, undue stress is placed on the landing gear.

Glide Performance

Glide performance is the distance that the aircraft will glide with an inoperative engine. The best distance is attained by gilding at an angle of attack that provides the maximum lift/drag ratio (L/Dmax).

In the event that the engine becomes inoperative, it is important to establish the maximum glide airspeed as quickly as possible. This will permit the maximum radius of emergency landing options. While gliding toward a suitable landing area, effort should be made to identify the cause of the failure. If time permits, an engine restart should be attempted as shown in the start-up check list.

Climb Performance

The Pilot Operating Handbook will contain a Climb Performance chart or Table similar to the one below for a given aircraft. Note that 4 different tables are provided. (Sea Level, 5000 ft, 10,000 ft and 15,000 ft). Note that these altitudes are PRESSURE ALTITUDES and the respective temperatures are Standard

Temperatures for those altitudes. In other words, the values are given for standard Density Altitudes.

MAXIMUM RATE OF CLIMB DATA												
	Sea Level & 59° F			5000' & 41° F			10,000' & 23°			15,000 & 5° F		
Gross Weight lbs.	Ind. Airspeed mph	Rate of climb ft/min	Fuel Used gal.	Ind. Airspeed mph	Rate of Climb ft/min	Fuel Used gal	Ind. Airspeed Ft/min	Rate of Climb ft/min	Fuel Used gal.	Ind. Airspeed mph	Rate of Climb ft/min	Fuel Used gal
2300	82	645	1.0	81	435	2.6	79	230	4.8	78	22	11.5
2000	79	840	1.0	79	610	2.2	76	380	3.6	75	155	6.3
1700	77	1085	1.0	76	825	1.9	73	570	2.9	72	315	4.4

NOTES:
1. Flaps up, full throttle, mixture leaned above 3000 feet for smooth operation.
2. Fuel Used includes, warm-up and take-off allowance.
3. For hot weather, decrease rate of climb 20 ft/min for each 10°F above standard day for the particular altitude.

Example:
Given: Gross weight 2000 lb: Pressure Alt. 5000 ft: Temperature 61° F.

SOLUTION:

The rate of climb is 610 at 5000 feet pressure altitude and standard temperature of 41° F. Since the temperature is 20° F higher that the standard 41°, subtract 40 feet per minute from the 610, to get a rate of climb = 610 - 40 = 570 ft/min.

Climb performance depends on the aircraft’s reserve power or thrust. Reserve power is the available power above that required to maintain level flight at a given airspeed. If an aircraft requires only 120 horsepower for a given cruise, and the engine is capable of delivering 180 hp., then the reserve horsepower available for climb is 60 hp.

Two airspeeds are important to the climb performance. These are:
Vx Best Angle of Climb
Vy Best Rate of Climb

These V-speeds are defined in the POH. The Best Angle of Climb produces the greatest altitude in a given distance. The principal use of Best Angle of Climb is for clearing obstacles on take-off. The Best Rate of Climb produces the greatest altitude over a given period of time. It is predominately used as climb to cruise altitude.

Many of the same factors that affect take-off and cruise performance also affect climb performance.

Adverse effects:
· Higher than Standard Temperature

· High Humidity
· Lower than Standard Pressure
· Heavy Weight

Heavy weight requires a higher angle of attack to develop adequate lift. The increased drag results in poorer climb performance. It takes longer to attain cruise altitude and requires the engine to develop full power for a longer period of time.

Consult the POH for Climb Performance data for the aircraft to be flown.

Cruise Performance

The cruise performance can be specified two ways.
· Maximum Range
· Maximum Endurance

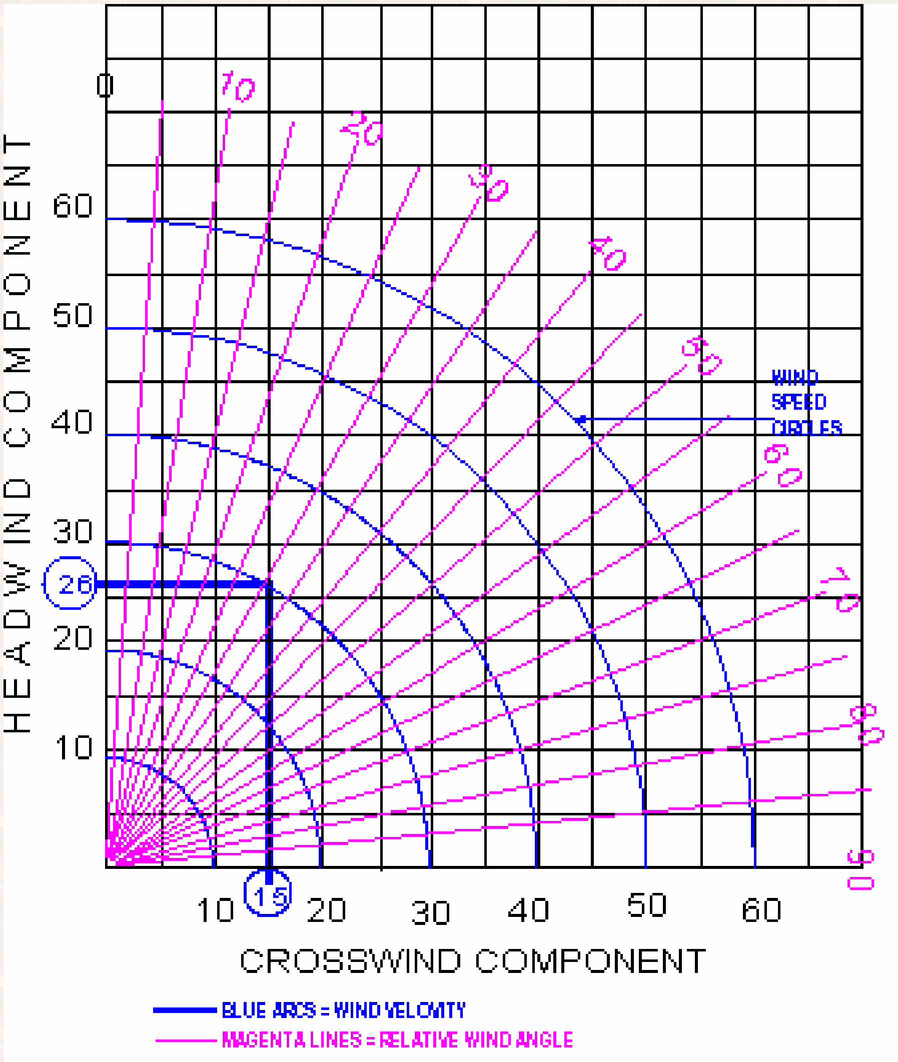
Maximum Range is the distance that an aircraft can fly at a given power setting. is requires maximum speed versus fuel flow. ***Maximum Duration*** is the maximum time the aircraft can fly. This requires that the flight condition must provide for a minimum of fuel flow.

CRUISE AND RANGE PERFORMANCE						
ALTITUDE	RPM	% PWR	TAS MPH	GAL/HR	END HRS	RANGE MI.
2500	2600	81	136	9.3	3.9	524
2500	2500	73	129	8.3	4.3	555
2500	2400	65	122	7.5	4.8	586
2500	2300	56	115	6.6	5.4	617
2500	2200	52	108	6.0	6.0	645
4500	2600	77	135	8.8	4.0	539
4500	2500	69	129	7.9	4.5	572
4500	2400	62	121	7.1	5.0	601
4500	2300	56	113	6.4	5.5	628
4500	2200	51	106	5.7	6.1	646
6500	2700	81	140	9.3	3.8	530
6500	2600	73	134	8.3	4.2	559
6500	2500	66	126	7.5	4.7	587
6500	2400	60	119	6.8	5.2	611
6500	2300	54	112	6.1	5.7	632

8500	2700	77	139	8.8	4.0	547
8500	2600	70	132	7.9	4.4	575
8500	2500	63	125	7.2	4.9	599
8500	2400	57	118	6.5	5.3	620
8500	2300	52	109	5.9	5.8	635
10500	2700	73	138	8.3	4.2	569
10500	2600	66	130	7.6	4.6	590
10500	2500	60	122	6.9	5.0	610
10500	2400	55	115	6.3	5.4	625
10500	2300	50	106	5.7	5.9	631

Crosswind Performance

Takeoffs and landings under significant cross wind conditions can be dangerous and should be avoided. Crosswinds can be so strong that the sideways drift cannot be sufficiently overcome by using a “side slip ” into the wind to compensate for the wind drift. Excessive side load on the landing gear can cause gear failure or an upset aircraft. The Maximum Crosswind Component for the aircraft will be listed in the



POH. The maximum crosswind is usually about 20% of the landing configuration stall speed. The diagram above can be used to calculate the headwind and crosswind components. For most light aircraft, the maximum tested crosswind component is in the 12 to 15 knot range. In the chart, the numbers around the periphery of the chart mark the degrees difference between the wind and the runway heading (magenta lines). The radial lines are are in 5° increments with numbers on each 10° line.

For example, with a wind of 150° at 30 kt and landing on runway 12 (120°), the degrees of crosswind will be 150° - 120° = 30°. Locate the 30° radial line out from the lower left of the graph. This is the differential between the wind direction and thr runway heading. Follow the 30° radial line (magenta) to the 30kt wind arc (blue). A vertical line (blue) from this intersection will be the cross-wind component of 15 kts. This is the same as if you had a wind of 15 kts directly from the side.

If you plot a horizontal (blue) line, you will see that your headwind component is 26 kts. This is the same effect as if you had a direct headwind of 26 kts.

Landing Performance

The minimum landing distance is attained by landing at the minimum safe speed which allows sufficient margin above the stall speed for satisfactory control and go-around capability. Gross weight and headwind are important considerations in determining minimum landing distance.

Excessive airspeed above that recommended in the POH will significantly increase landing distance. High density altitude increases landing distance. As a rule of thumb, the increase in landing distance is about 3.5% for each 1,000 feet in density altitude.

Braking

A number of factors affect braking. A wet, icy or snow covered runway will appreciably decrease braking ability. In crosswinds or gusty conditions, higher than normal approach speed will improve controllability, but will require longer rollout to stop. A down-sloping runway also increases stopping distance.

Braking immediately after touchdown is ineffective because the wings are still producing lift. The pilot should use the natural aerodynamic drag as much as possible to slow the aircraft. Maintain up-elevator to a high angle of attack as long as possible. The nose of the aircraft will settle naturally as airspeed is dissipated. Therefore it is not necessary (and is unwise) to force the nosewheel hard onto the runway.

After touchdown, hold up-elevators during braking to reduce the load on the nosewheel. Avoid severe braking to minimize stress on the nose gear and scrubbing of rubber from the main gear tires.

Gross weight affects stopping ability. Heavy loads and high touchdown speeds result in greater forward momentum, and require significantly more runway than normal. The most critical conditions for landing performance sult from some combination of high gross weight , high density altitude and unfavorable wind conditions. These conditions produce the greatest landing distance and require the greatest dissipation of energy by the brakes.

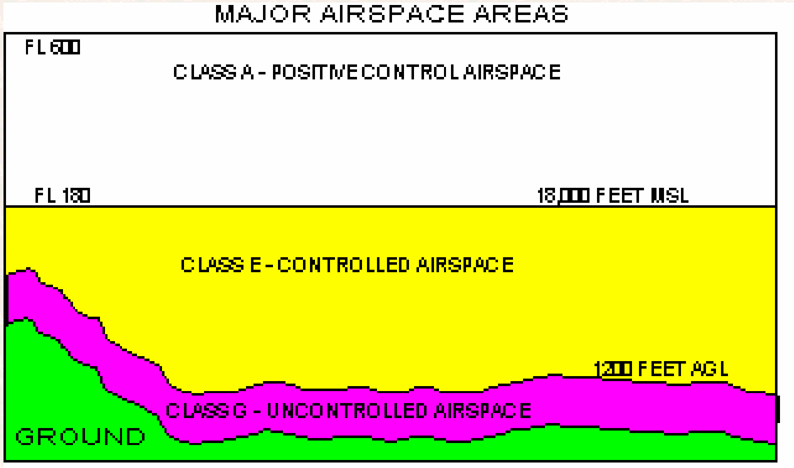
Back to Home	Back to Table of Conents	To Airspace Definition

AIRSPACE AND AIRPORT TYPES

In September 1993 the FAA adopted the International Civil Aviation Organization (ICAO) definition of airspace segments. The ICAO classifications of airspace are named A through G. The classification of "F" is not used in the USA.

NOTE: It will be helpful while studying this chapter to have a Sectional Aeronautical Chart available. Refer to the front panel of the chart as well as to content of the chart as you study this chapter.

The 3 predominant types of airspace are:
· Positive Control (Class A) - White
· Controlled (Class E - Yellow)
· Uncontrolled (class G) - Magenta



Class G Airspace

ATC exercises no jurisdiction over Class G airspace. It is the airspace shown in magenta at left, and generally extends from the ground up to 1200 feet above ground level (AGL). As such it is classified as ***Uncontrolled*** airspace.

ATC exercises some jurisdiction, at varying degrees to all other airspace. Thus all other airspace is classifies as ***Controlled*** airspace.

Class A -- Positive Control

ATC exercises complete control in the Positive Controlled airspace. Jet aircraft is the primary user of Class A airspace. It ranges from 18,000 feet (Flight Level 180) to 60,000 feet (FL600). Altitudes 18,000 feet and above are called Flight Levels.

Class A airspace is not specifically charted on aeronautical charts. Operation is in accordance to Instrument Flight Rules (IFR). The aircraft must be equipped with appropriate IFR instrumentation, including a Mode C altitude reporting Transponder. The Pilot must be Instrument rated. An IFR flight plan is required. ATC exercises full control of route, speed, and altitude. ATC is responsible for aircraft separation in Class A airspace.

See AIM Chapter 3 for further data on Class A Airspace

Class E -- Controlled

Class E airspace is from altitude 1200 feet Above Ground Level (AGL) up to 18,000 feet. All airspace from

14,500 feet (MSL) to 18,000 feet (MSL) is Class E. It contains the Low Altitude Victor airway system. These airways are designated on the aeronautical charts as blue lines about 1/16 inch wide, and have numbers like V12, V245, etc. written on them. They are ***roads in the sky***. All Victor airways are Class E extending 6 nautical miles each side of the airway centerline. In mountainous terrain, class G airspace may exist from the surface to 14,500 feet outside the boundaries of the airway. In non-mountainous terain (such as Eastern US) all the airspace above 1200 AGL is Class E unless specified otherwise.

ATC exercises no control over flights operating under Visual Flight Rules (VFR) in Class E airspace. Radio communication and Transponder are not required. Specific cloud clearance and visibility requirements apply to Class E airspace. These are listed in the chart at the end of this section. ATC does exercise control of aircraft operating under Instrument Flight Rules (IFR). IFR flights must maintain altitudes, routes and speeds a directed by ATC. IFR flights must be capable of communicating with ATC, and must be Mode C Transponder equipped (capable of reporting altitude to the radar scope).

There are no specific certification requirements, other than normal pilot certificates. Class E airspace may be designated from the surface upward as extension to class B, C, and D airspace (defined later) to accommodate IFR traffic requirements. Class E airspace will extend downward to 700 feet AGL around uncontrolled airports that have published instrument approach procedures.

These areas around uncontrolled airports where the Class E airspace goes down to 700 feet AGL instead of the standard 1200 feet AGL are depicted on Aeronautical Charts by a wide shaded magenta colored band around the airport. The reason the Class E airspace extends nearer to the ground is to provide a controlled airspace transition area for aircraft operating IFR and making an IFR approach.

See AIM Chapter 3 for further data on Class E Airspace

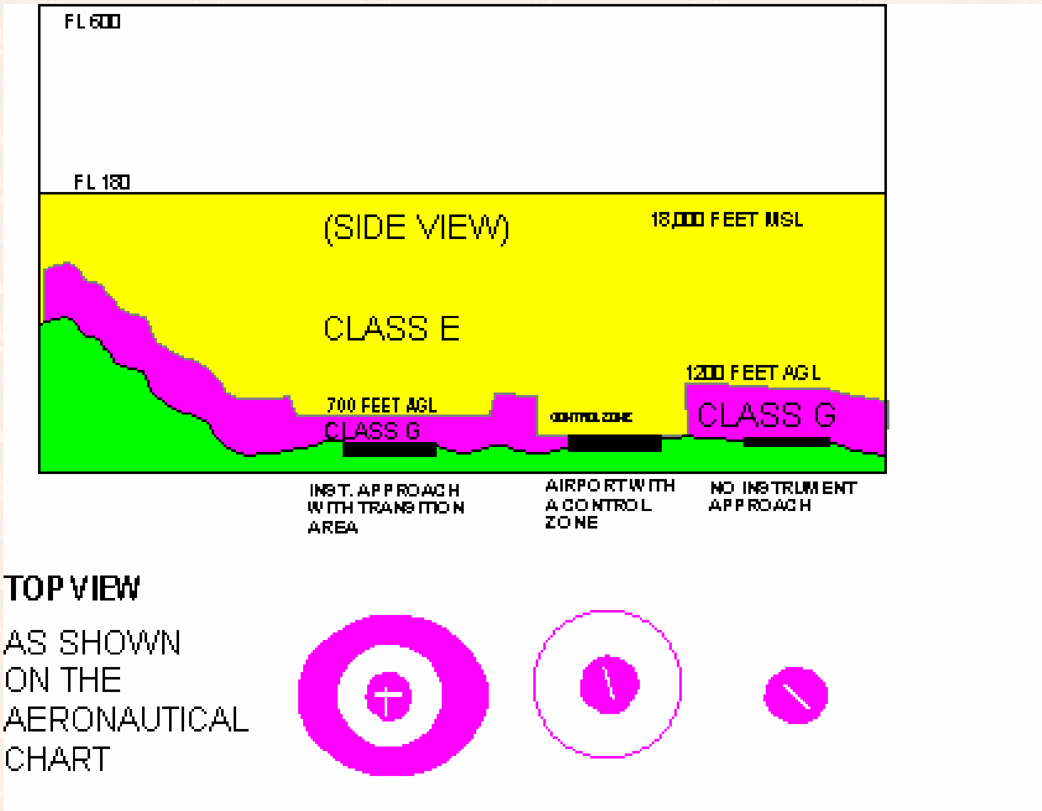
Class G -- Uncontrolled

Most Class G airspace is that space from the surface up to 1200 feet. However, there are areas in mountainous terrain where airspace outside the Victor Airways is Class G from the ground to 14,500 feet AGL. Class G space may underlie Classes B, C, and D, but has no specific symbol indicated on the chart. The presence of the airspace is implied. Less stringent minimum cloud clearance and visibility requirements apply to VFR flight in Class G space since ATC does not maintain jurisdiction over this airspace. See last page of this section.

As mentioned in the Class E section, airports with published instrument approached have class E airspace extending down to 700 feet AGL. Obviously, in these areas, Class G only extends from the surface to 700 feet AGL.

Uncontrolled Airports

Airports without a control tower are classifies as ***uncontrolled***. Three types of uncontrolled airports are shown below.



AIRPORTS WITHOUT CONTROL TOWER (UNCONTROLLED)

The airport on the right does not have an instrument approach or a control zone around the airport. The airspace overlying this type airport is Class G up to 1200 feet, then Class E above. It is depicted on the charts as a magenta circle (unpaved) or a solid circle with white runways (paved).

The airport in the middle has a Class E Control Zone around it, depicted by the dotted circle around it. If the line is magenta in color, it is a control zone at an airport where an FAA Flight Service Station (FSS) is on the field but no control tower. The FSS provides airport traffic advisory service. Class E airspace extends down to the surface. The zone is depicted on charts as a dashed MAGENTA circle around the airport. These airports usually have instrument approach procedures as well.

The airport at left has an instrument approach procedure for the airport. Such airports have a broad lightly shaded magenta band around them. Within the outer edge of the band, Class G airspace only extends up to 700 feet AGL. Class E extends down to 700 feet to provide a ***transition zone*** for aircraft making instrument approaches to the airport. The transition area is approximately 5 miles in radius.

Controlled Airports

These are airports that have sufficient air traffic to warrant a Control Tower, and in some cases Approach Control and Ground Control Radar. They are used by air carrier operations, and can have a mix of jet, high performance piston and turbine aircraft, as well as smaller single engine aircraft. The control tower is responsible for aircraft separation within its jurisdiction. Certain clearances must be obtained from ATC for operations on the airport surface, and within the controlled airspace around the airport.

There are 3 Classes of airspace around controlled airports. The type of airspace depends upon the traffic volume and types of flight. These Classes are B, C, and D airspace

Class D -- Airports with Control Tower

The lowest level of control is at airports with a low volume of traffic. It has a control tower and is depicted on the aeronautical charts as shown below.

Class D airports are depicted on aeronautical charts by a blue dashed circle around the airport symbol. Within the dashed circle is a number enclosed in a dashed square. This number indicates the top of the Class D airspace, expressed in hundreds of feet (MSL). In the diagram, the top is 4,600 feet MSL This airspace may have a Class E extension as shown in the diagram for an IFR approach transition area.

The control tower has jurisdiction within the Class D airspace which is 5 Statute Miles radius around the control tower. The top of the Class D airspace extends 2500 feet above the surface of the airport. Two way radio contact must be maintained with the Control Tower while in this airspace. The pilot should contact the control tower ***prior*** to entering the airspace.

See AIM Chapter 3 for further data on Class D Airspace

Terminal Radar Service Areas (TRSA)

Some Class D airports have a local radar service called a Terminal Radar Service Area.(TRSA). The service is available for conflict resolution and traffic sequencing to departing and arriving aircraft. However contact with the radar is not mandatory and the pilot may decline the service.

These airports are depicted on the aeronautical charts in the normal Class D manner, but have a dark gray circular line around the airport out at the boundary of the radar service range. Wilmington N.C. and Augusta Ga. are examples of airports with TRSA. There is no specified regulatory radius for the radar service.

See AIM Chapter 3 for further data on Terminal Radar Service Area

Class C Airspace (Mandatory Radar)

Class C airspace has two concentric tiers. The inner circle is 5 nautical mile core area extending to 4000 feet above the surface. It is similar in function to Class D airspace where the tower usually maintains jurisdiction.

A shelf area with an outer radius of 10 nautical miles surrounds the core area. It extends from 1200 feet AGL to 4000 feet AGL. The airspace is depicted on charts as 2 concentric magenta circles.

For example, an airport with a surface altitude of 500 feet MSL is depicted above. The left diagram is a side profile of the airspace. The right diagran shows how the airspace is depicted on the aeronautical chart.

The ceiling of the Class C airspace is 4,500 feet (MSL). This is calculated as runway altitude of 500 feet plus 4000 feet. The floor of the outer shelf is 1,700 feet MSL. (1200 + 500 feet). The space under the shelf is Class G. These altitudes are indicated by 45 over SFC for the core circle, and 45 over 17 on the outer shelf.

Contact with Approach and Departure Radar Control is ***mandatory*** within the core and shelf airspace. During takeoff and landing, the tower and radar controller coordinate their activity. You will be told by either controller when to switch frequency to the other controller. Aircraft must be capable of two-way communication with the radar facility and the tower. A 4096 Altitude Reporting (Mode C) Transponder is required when operating within, under or above Class C airspace.

Before entering Class C airspace, the pilot **MUST** establish communication with the radar service. Radio contact with radar and/or tower must be maintained when in this airspace.

You may request ***Flight Following Radar Service*** outside the 10 mile shelf. It may be granted on a ***workload permitting basis***. The service can usually be provided to about a 20 NM radius of the airport.

See AIM Chapter 3 for further data on Class C Airspace

Class B -- Large Terminal Airports

Large terminal areas such as the New York, Chicago, and Los Angeles areas have a high volume of air traffic. The airspace around these airports is under rigid control of ATC, and are called Class B airspace.

AIRCRAFT MUST HAVE ATC CLEARANCE PRIOR TO ENTRY INTO THIS AIRSPACE.

The airspace is composed generally of three concentric tiers. A core area around the airport is generally is surrounded by two additional shelf areas extending approximately 30 nautical mile radius from the primary airport.

The core area extends from the surface to 10,000 feet AGL. The second shelf has a wider radius and has both a floor and a ceiling. The ceiling is the same as the inner circle. The floor may vary at differing altitudes in various sections to accommodate smaller airports that underlie the middle tier of airspace.

The third shelf extends out approximately 30 Nm from the airport. It has the same ceiling as the other two tiers, but has a higher floor than the middle shelf. This floor may also be variable in altitude to accommodate airports lying beneath the Class B airspace.

The actual configuration of the airspace varies to accommodate local operational requirements. The purpose of the Class B structure is to allow large high performance jet traffic to transition down to landing at the airport under IFR procedures, and with positive control and traffic separation.

Class B operational rules require:
· Two way radio capable of communication with ATC.
· Private pilot (or special student certification). Several airports prohibit student operations entirely.
· Altitude reporting Transponder (Mode C).
·If operating IFR, an operable VOR or TACAN receiver.

NOTE: Student pilots must have had training in Class B operations and appropriate sign-off of a Certified Flight

Instructor.

A student may not operate from the following Class B airports.

Atlanta Hartsfield Airport, GA Newark Airport, NJ Boston Logan Airport, MA New York Kennedy, NY Chicago O'Hare Airport IL New York LaGuardia, NY Dallas/Ft.Worth Airport, TX San Francisco Airport, CA Loa Angeles Airport, CA Washington National Airport, DC Miami Airport, FL Andrews AFB, MD

See AIM Chapter 3 for further data on Class B Airspace

Mode C Veil

Around Class B airspace is an area called the ***Mode C Veil***. It is shown as a thin blue concentric line of 30 Nautical Mile radius around the Class B airport. An altitude reporting Transponder (Mode C) is required ***within this area*** and when operating under the floor or above the ceiling of the Class B airspace. Radio communication with ATC is not required as long as you stay outside the Class B airspace.

Special Use Airspace

A number of "special use" airspace areas exist for various usage. It means that certain activities have been confined to those areas of airspace. Limitations are placed on aircraft operations in these areas which are not a part of the activity. These are:

· Prohibited areas
· Restricted areas
· Warning Areas
· Military Operations Areas
· Alert Areas
· Controlled Firing Areas
· Military Training Routes
· Air Defense Identification Zone
· Temporary Restricted Areas

Prohibited and Restricted airspace are regulatory use airspace whose rules are defined by FAR Part 73. Warning areas, MOA's, Alert Areas, National Security Areas, and controlled firing areas are non-regulatory special use airspace.

Prohibited Areas

These are areas over which flight by civilian aircraft is prohibited by FAA Regulation. Operation within such an area can be justification for military interception or other action. The area around the White House in Washington D.C. is an example. The symbol is a blue feathered box shown at right with the words Prohibited in or near the box.

See Aeronautical Information Manual AIM 3-31 PROHIBITED AREAS .

Restricted Areas

These are designated areas in which flight, although not totally prohibited, are subject to certain restrictions. These areas denote the existence of unusual, often invisible, hazards to aircraft. Such activities may be artillery firing, aerial gunnery, or guided missiles. Penetration of these areas without authorization of the controlling agency may be extremely dangerous. They are marked on the charts by blue feathered boundaries.

An identifying number such as R-5306 will be listed near or within the area. A listing on the bottom of the aeronautical chart identifies the area by number, and indicates the location of the area, the altitude limits of the space, the time of use, and the name of the controlling agency. It is good practice to plan to avoid such areas. If penetration of such an area is planned, the controlling agency should be consulted as to the status of activity in the area prior to any penetration.

For more information, see AIM 3-32 RESTRICTED AREAS

Warning Areas

These are areas outside the 3 mile limit from shore in international airspace. They are similar to Restricted Areas. Activities which are unusual or may be dangerous to aircraft may be in progress. They cannot however be designated as Restricted Areas since they are over international waters

Warning areas are also identified by a blue feathered box with a number (such as W-74). Information concerning these areas is listed on the aeronautical charts in the same section as Restricted Areas. One should treat a Warning Area the same as a Restricted area, and follow the same procedures.

For more information, see AIM 3-33. WARNING AREA

Military Operation Areas (MOA)

MOAs consist of airspace of defined vertical and lateral limits for the purpose of separating certain military training activities and IFR traffic. They are depicted by magenta colored feathered areas similarly to Prohibited, Restricted and Warning areas. They are denoted by names such as Beaufort MOA within or near the MOA-defined area. ATC can grant clearance to IFR traffic through an MOA if adequate IFR separation can be assured. If not, ATC will restrict routing IFR traffic through the area.

Most military training activities necessitate acrobatic or abrupt maneuvers. Pilots operating under VFR should exercise extreme caution whole flying in an MOA when military activity is being conducted. Military pilots on officially designated operations are exempt from conducting aerobatic maneuvers on the regions of Victor Airways.

VFR pilots should maintain caution when flying through an MOA when it is active. Pilots should contact a Flight Service Station (FSS) within 100 miles of the MOA to obtain real-time report of activity within the MOA. Prior to entry, pilots should contact the controlling agency for traffic advisories. Information about MOAs is listed in the same location on the aeronautical chart as the Restricted and Warning area information. The data is printed in Magenta.

For mor information, see 3-34. MILITARY OPERATIONS AREAS (MOA)

Alert Areas

Alert areas are shown on charts to inform pilots of areas where intensive pilot training or other types of unusual aerial activity may take place. The area is depicted in a similar manner to the other special use areas, but indicated by a blue outline with the area crosshatched as shown.

For more information, see AIM 3-35. ALERT AREAS

Controlled Firing Areas

These areas contain operations such as artillery firing. They are not marked on charts, and pilots need not avoid. Spotter aircraft, radar or ground personnel monitor for aircraft in the area, and firing is suspended immediately upon the approach of aircraft.

See AIM 3-36. CONTROLLED FIRING AREAS

Military Training Routes

Military training routes are used by high speed military aircraft conducting low and medium level high speed training activity. The routes above 1500 feet AGL are designed to be flown mostly under IFR rules. They may occur in either IFR or VFR meteorological conditions. The routes at 1500 feet and below are generally developed to be flown under VFR rules. Flight visibility must be 5 miles or more, with ceilings 3000 feet or more.

MTR's with no segment above 1500 feet will be designated by a 4 digit number; i.e. IR 1206, VR 1207. Routes that include one or more segments above 1500 feet are designated by 3 digit numbers; i.e. IR206, VR207.

The routes are shown on aeronautical charts are gray in color, and will have numbers like IR718 or VR4003. Vigilance should be observed when operating near or crossing an MTR. Contact FSS within 100 miles to obtain current information on the activity along the MTRs. Give FSS your altitude and route of flight and destination when requesting MTR information.

For further information, see 3-41. MILITARY TRAINING ROUTES (MTR)

Temporary Restricted Areas

The FAA may publish temporary restricted areas that may be due natural disaster, or other events, in which unauthorized civilian flight is inadvisable or may interfere with rescue or relief efforts. These temporary restrictions are published through the system called “Notices To Airmen” (NOTAMS). They are disseminated through the FAA Flight Service Stations. Contact FSS prior to any flight which may be in the vicinity of such events as air crashes, earthquake damage, floods, etc.

Airspace Rules

The various types of airspace have rules concerning weather limitations and equipment requirements for operation in the given airspace. The listing below summarizes these requirements.

Standard VFR Cloud Clearance and Visibility

Hereinafter, reference will be made to standard VFR Rules for Cloud Clearance and Visibility. These are:

VFR Couud Clearance and Visibility Rules

	Visibility	Above Cloud	Below Cloud	Horizontal
Below 10,000 ft.	3	1000 ft	500 ft	2000 ft
Above 10,000 ft.	5	1000 ft.	1000 ft.	1 SM.

Class A Airspace Rules

- Operations - Instrument Flight Rules Only
- ATC Clearance Required - Yes
- Radio Contact Required - Yes
- Minimum Pilot Qualifications - Instrument Rating
- Mode C Altitude Encoding Transponder Required - Yes
- Cloud Clearance Requirements - None (IFR Rules apply)

Class B Airspace Rules

While in Class B airspace, the following rules apply.

- Operations Permitted - IFR and VFR
- ATC Clearance Required - Yes
- Radio Contact Required - Yes
- Minimum Pilot Qualifications - Private (Student if Signed-Off)
- Mode C Altitude Reporting Transponder required - Yes
- Cloud Clearance Requirements below 10,000 ft. - Clear of Clouds
- Cloud Clearance Requirements above 10,000 ft. - Standard VFR
- VFR Visibility Requirements below 10,000 ft. - Standard VFR
- VFR Visibility Requirements above 10,000 feet - Standard VFR

Class C Airspace Rules

While in Class C airspace, the following rules apply.

- Operations Permitted - IFR and VFR

- ATC Clearance Required - IFR - Yes : VFR - No
- Radio Contact Required - Yes
- Minimum Pilot Qualifications - Student
- Mode C Altitude Reporting Transponder required - Yes
- Cloud Clearance Requirements below 10,000 ft. - Standard VFR
- Cloud Clearance Requirements above 10,000 ft. - Standard VFR
- VFR Visibility Requirements below 10,000 ft. - Standard VFR
- VFR Visibility Requirements above 10,000 feet - Standard VFR

Airspace Class D Rules

While in Class D airspace, the following rules apply.

- Operations Permitted - IFR and VFR
- ATC Clearance Required - IFR -Yes: VFR - No
- Radio Contact Required - Yes
- Minimum Pilot Qualifications - Student
- Mode C Altitude Reporting Transponder required - No
- Cloud Clearance Requirements below 10,000 ft. - Standard VFR
- Cloud Clearance Requirements above 10,000 ft. - Standard VFR
- VFR Visibility Requirements below 10,000 ft. - Standard VFR
- VFR Visibility Requirements above 10,000 feet - Standard VFR

Airspace Class G Rules

While in Class G airspace, the following rules apply.

- Operations Permitted - VFR
- ATC Clearance Required - No
- Radio Contact Required - No
- Minimum Pilot Qualifications - Student
- Mode C Altitude Reporting Transponder required - No
- Cloud Clearance Requirements below 10,000 ft. - Clear of Clouds (Day) : Standard VFR (night)
- Cloud Clearance Requirements above 10,000 ft. - Standard VFR (day and Night
- VFR Visibility Requirements below 10,000 ft. - 1 SM (day): 3 SM (night)
- VFR Visibility Requirements above 10,000 feet - Standard VFR (day and night)

Back to Home	Back to Table of Conents	To Aeronautical Charts

Aeronautical Charts

Chart Types

Three types of charts are used for VFR flight. These are:
· Wide Area Charts(WAC) - Scale 1:1,000,000 (1 inch = 13.7 Nm)
· Sectional Chart.................- Scale 1:500,000 (1 inch = 6.86 Nm)
· VFR Terminal Charts........- Scale 1:250,000 (1 inch = 3.43 Nm)

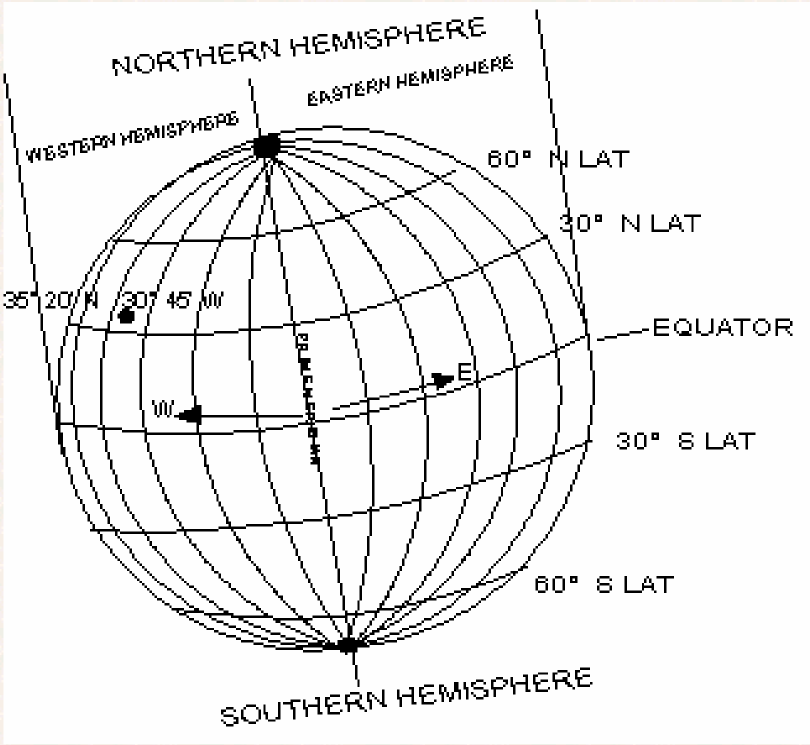
Most pilots use the Sectional chart. It provides good detail of topographical features, and is good for both the Student pilot as well as experienced pilot.

Since the WAC chart covers twice the area of the Sectional, pilots flying higher performance aircraft may prefer this chart. It shows less topographical features. It contains most of the electronic navigation features that are shown on the sectional charts. Both the WAC and Sectional charts show the Victor Airways.

VFR Terminal Charts are published for areas of concentrated air traffic, such as Charlotte, NYC, Los Angeles, etc. These charts show many more details. They contain landmarks often used by controllers not shown on the other chart types.

Charts show significant terrain and topographical detail, location of cities and towns, airports, navigational aids, prohibited, restricted and special use airspace, and many other symbols.

Longitude and Latitude



A system of X-Y coordinates is used to define a point on the earth's surface. These coordinates are called Meridians (longitude) and Parallels (latitude). Meridians span from the north pole to the south pole, and are measured in degrees from the PRIME MERIDIAN. It runs north and south through Greenwich, England. Measurement is either EAST or WEST from the Prime Meridian, and continues around the earth until they meet at meridian 180.The measurement, either East or West is measured in degrees, minutes and seconds. This measurement is called “Longitude”. The example dot on the diagram is at Longitude 30° 45’ W (30 degrees, 45 minutes West).

Meridians are not parallel. They converge at the poles, and have maximum distance between them at the equator. They represent the direction to True North. At the equator, one minute of arc longitude equals one nautical mile. The only place where 1° longitude = 1 Nm is on the equator. As one moves toward either pole, the lateral distance across one degree becomes less and less, and approaches zero at the pole. Since the earth makes one revolution of 360 degrees within 24 hours, it moves 15° in one hour.

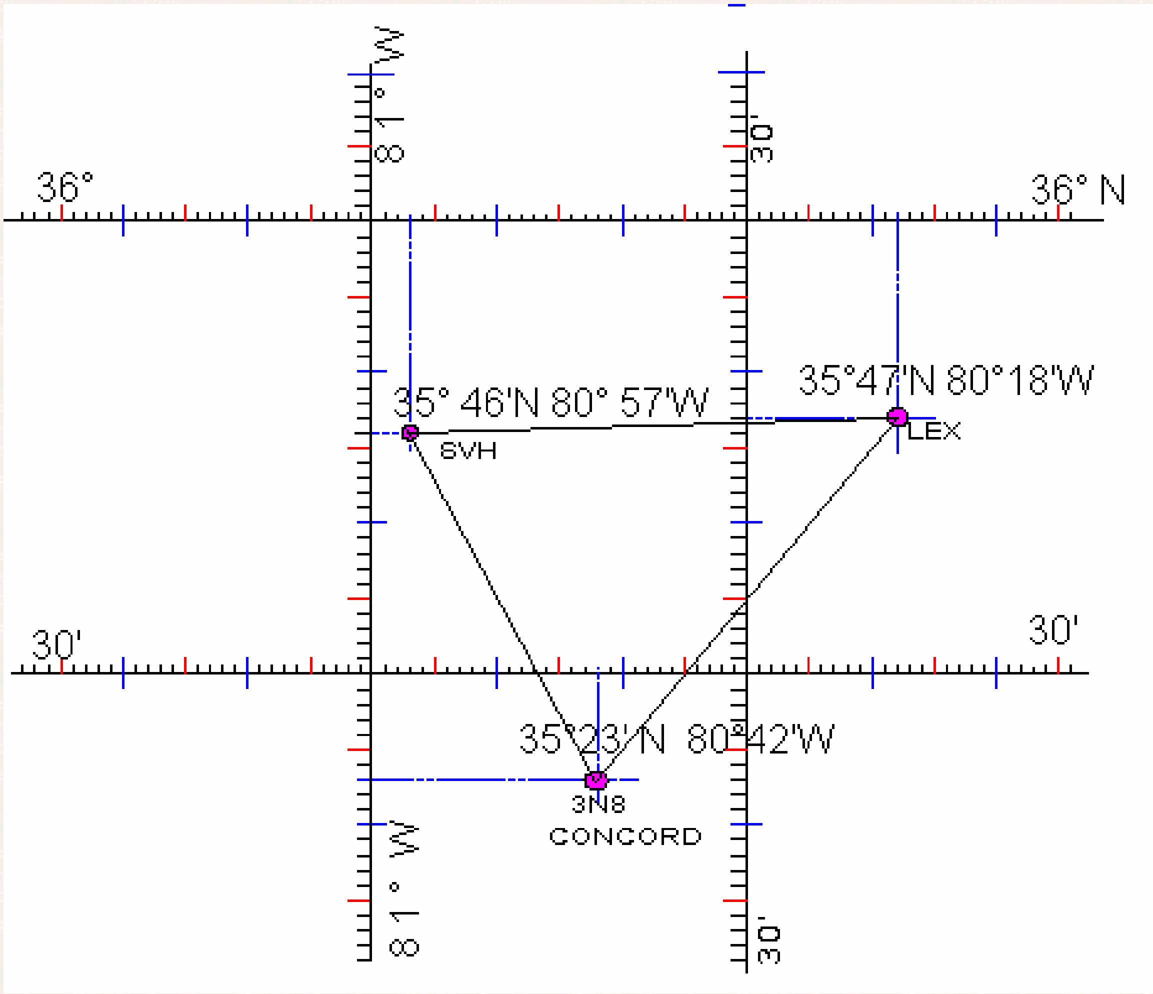
The lines running around the earth, parallel to the equator, are called lines of parallel (or parallels). They are measured from the equator to the poles in terms called degrees of latitude. They range from 0° latitude at the equator to 90° latitude at the poles. They are termed North latitude in the Northern Hemisphere, and South latitude in the Southern Hemisphere. Unlike Meridian Lines, lines of parallel are equidistant between them (since they are parallel and do not converge). ***One minute of latitude equals a nautical mile.***

The Latitude of the dot shown on the earth's surface in the diagram above is defined as 35° 20' N. Therefore, the location of the dot can be explicitly defined as ***35° 20'N - 30° 45' W.***

Aeronautical charts show horizontal latitude lines and vertical longitude lines at 30 minute intervals. They are labeled near the edges of the chart, and periodically along the line. There are 30 "tick" marks between each 30 minute line, each representing one minute. The 10 minute marks are long, and the 5 minute marks are intermediate in length. One can determine latitude by locating the line below the point in question, then count upward, adding the number of tick marks from the reference line. When parallel with the point, the latitude location has been reached. (NOTE: If the latitude line is above the point in question, count the tick marks downward. Subtract them from the latitude line value. When moving North, add degrees and minutes. When moving South, subtract degrees and minutes).

To find the longitude of a point is similar. Count the tick marks either East or West from the reference longitude line to the point in question. When going in a westerly direction, add degrees and minutes. Subtract degrees and minutes when going in an easterly direction. (Note: these rules apply only in the North and Western Hemisphere.)

Three airport locations are shown below. Listed below are their ID, Latitude and Longitude. The diagram shows how to find the location of each airport. (Note: These points are shown on the Charlotte Sectional Aeronautical Chart).



SVH 35° 46’ N 80° 57’ W
LEX 35° 47 N 80° 18’ W
3N8 35° 23’ N 80° 42’ W

Note: The 36 degree North Latitude line simply has the number 36° on it at the left end of the line.

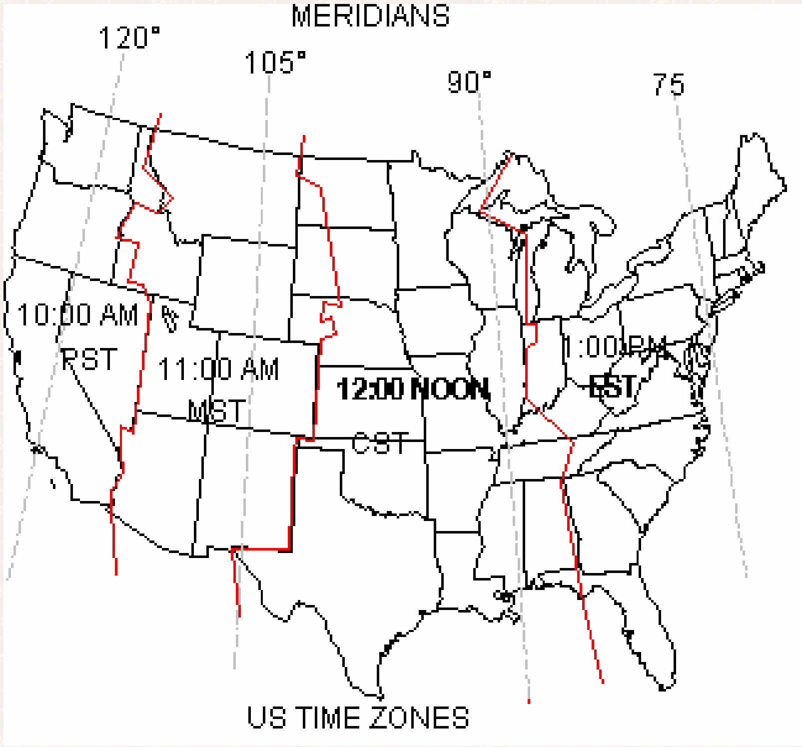
The line below it has 30’ on it. Although the number 35° does not occur on the chart, the line is 35° 30’ by inference. Charts such as this can occur on the Private Pilot Written Exam, so learn how to interpret the degree and minute legends on the charts.

To find the Lat/Lon of SVH, project a line both vertically and horizontally from the center of the airport (follow the blue dotted lines). Go to the 81° Longitude line, and count horizontally eastward by 3 minutes (3 tick marks east). When counting a number of tick marks toward the East, treat the count as a negative value. This yields a latitude = 81° 0’ - 0° 03’ = 80° 57’ W.

Likewise, go to the 35° 30’ Latitude line. Count upward 0° 16’ (16 tick marks). When counting northward, the count of the tick marks is positive) The Latitude of the airport is therefore 35° 30’ + 0°16 ‘ = 35° 46’ N. You could also have gone up to the 36° 00’ line and counted downward 14 minutes to also get a 46’ point north of Latitude 35°. In this case, you would have counted toward the South, so that the count of tick marks is negative.

In the US, when you encounter a line marked 30’ (30 minute), you must go to the next Lower Latitude Line to determine the degrees. Similarly, when a longitude line has only a 30’ (30 minute) label, you will have to go to the right (eastward) to the next line to determine the degree of Longitude.

Time Zones



The United States lies between 67°W and 125° W. This spans 4 time zones. Meridians are useful in determining time zones. When the sun is directly above a meridian, it is noon at that meridian. To the West of that meridian, it is forenoon; to the East, it is afternoon. Since it is impractical to define 360 noon's, the surface of the earth is divided into time zones, approximately 15° apart. However, as noted, due to local geographical and jurisdictional variations in the U. S., the actual time zone lines are irregular.

Since Greenwich, England is at the zero meridian, all time references used in flying is to the time at the zero meridian. This used to be Greenwich Mean Time. The terminology is now Coordinated Universal Time (abbreviated UTC). In aviation terminology, the word ***ZULU*** refers to UTC time, and is written with a Z suffix.

Examples: 1450Z, 0024Z, 0400Z, etc.

A conversion from local time in the US to UTC time is required for flight plans and communications with ATC. To convert local times to UTC, add the following values:

From EST to UTC add 5 hours.
From CST to UTC add 6 Hours.
From MST to UTC add 7 hours.
From PST to UTC add 8 hours.

NOTE: If the local time is Daylight Savings Time, reduce the added hours by 1 Hour (4, 5, 6, 7 respectively).

Controlled Airport Legend

CHARLOTTE
DOUGLAS INTERNATIONAL (CLT)
CT - 118.1 126.4
ATIS 121.15
749 L 100 122.95

Controlled airports with control towers (Class B, C, D) show information about the airport in ***BLUE*** lettering near the airport symbol, which is also blue. This type of data is typical of the airport information for Controlled airports with a control tower.

The data is interpreted as follows.

Airport Name: CHARLOTTE DOUGLAS INTERNATIONAL
USA Airport Identifier: CLT
Control Tower Frequency (CT) - 118.1 - 126.4
Automated Terminal Information Service (ATIS) 121.15
Airport Altitude - 749 feet MSL
L = Lighted
Longest Runway (100) = 10,000 feet
UNICOM frequency (for fuel, etc.) = 122.95

Non-Controlled Airport Legend

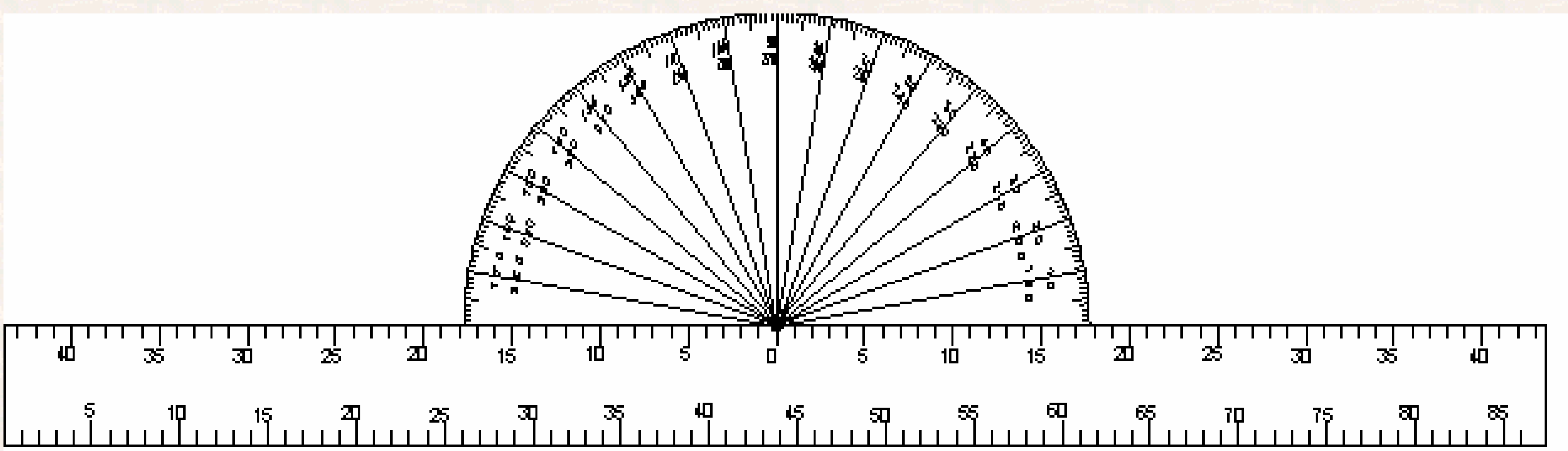
STATESVILE (SVH)
965 *L 50 123.05

Airports colored magenta on the charts have no control tower. The data associated with these airports is in magenta color also.

Airport Name: STATESVILLE
USA Identifier: SVH
Airport Altitude: 965 feet MSL
*L = Lighted part time (indicated by the *). Pilot controlled at other times.
Longest Runway (50) = 5,000 feet.
Common Traffic Advisory Frequency = 123.05

Plotting the Course

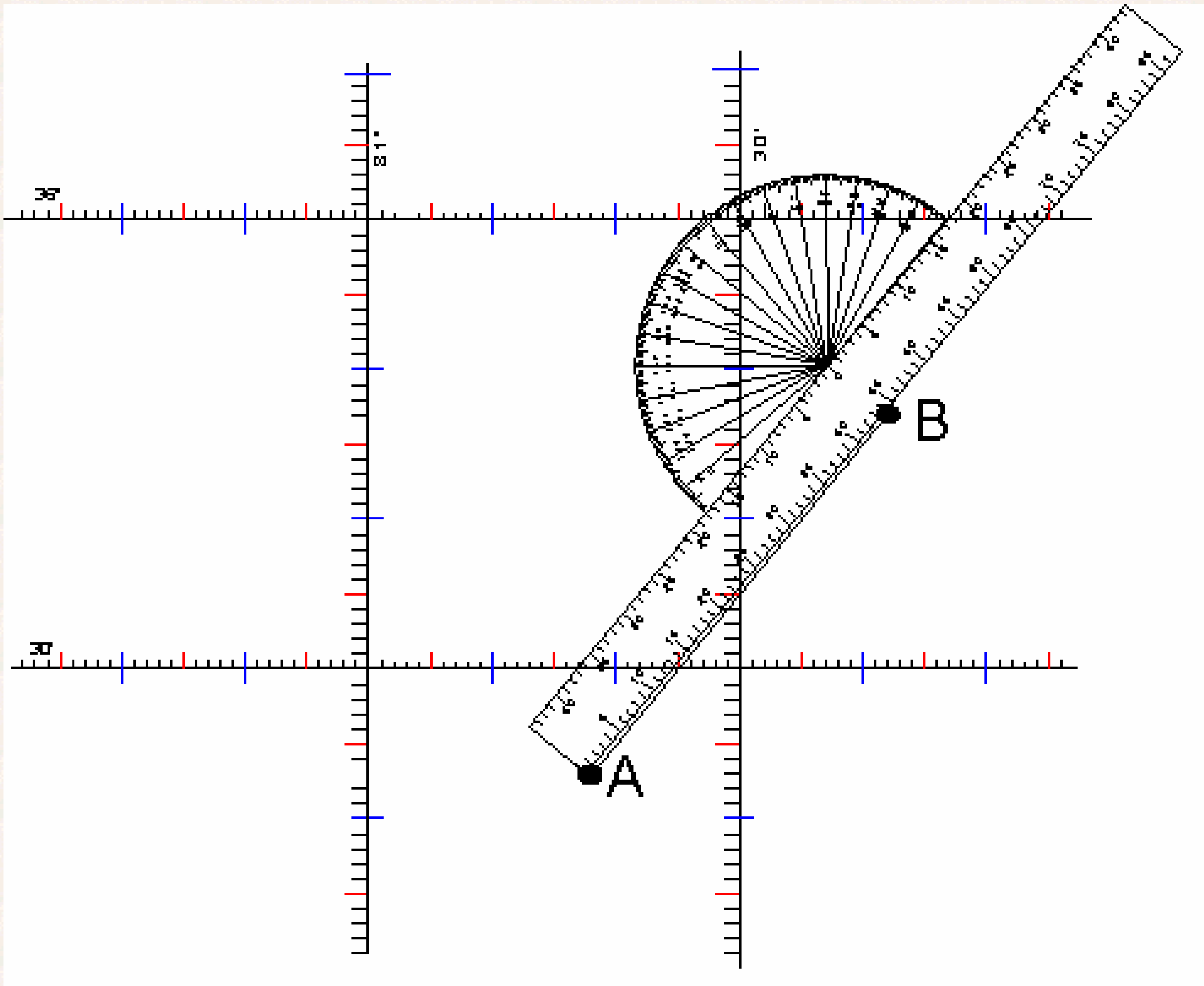
An instrument called a ***plotter*** is used to determine course distance and direction. It has a transparent scale and a protractor. It usually has both Sectional and WAC scales in both Nautical Mile and Statute Mile dimensions. When measuring distances from point to point, one must be careful to use the appropriate scale for the chart in use. Also, one must guard against mixing the use of the Nm and Sm scales. The scale shown on the diagram is in Nm for simplicity of the diagram.



The outer scale on the protractor is in degree divisions from 0° at the right to 180° at the left. The inner scale is from 180° at the right to 360° at the left side of the protractor.

Measuring Distance

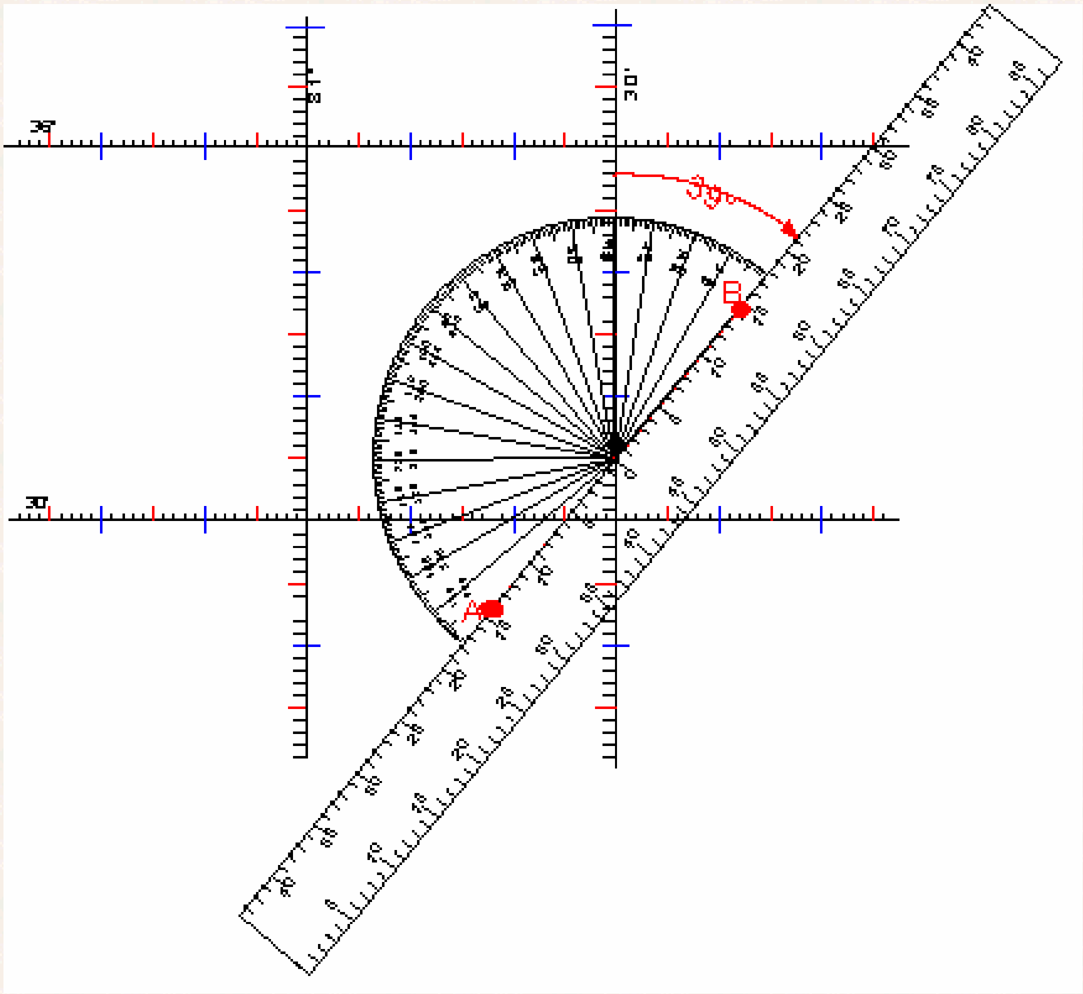
To find the distance between two points (A and B), draw a line between the two points and place the appropriate scale along the line. Read the distance from the scale. In the example, the Sectional Nautical scale is being used. The distance is 44 Nm.



When measuring from an airport as one of the points, place the index end (zero end) at the CENTER of the airport symbol. If measuring along a Victor Airway, measure from the center dot of the VOR. Sometimes, the center of the VOR is on an airport surface. To place a VOR symbol over the airport symbol would be confusing. Therefore, the center of the VOR is represented by small white dot on the airport symbol. Measure from the white dot.

Measuring the Course

The True Course is the degrees between the direction of flight and True North measured clockwise from a Longitude Line. Shown is a course from point A to point B. The course line, A and B are shown in red. For the most accurate measurement, ***measure where the course line crosses a longitude line.*** If such an intersection does not exist between A and B, extend the course line until it does cross a longitude line.



The protractor has a small hole at the center. Place the hole over the intersection of the course line and the longitude line. The edge of the plotter on the protractor side must be along the course line. Read the true course degrees at the top of the protractor at the longitude line.

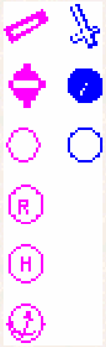
If the direction of flight is from point A to point B, read the ***True Course*** in degrees on the outer protractor scale (39° shown in red). If the direction of flight is from B to A, read the ***True Course*** in degrees on the inner protractor scale (219). NOTE: When the True Course (TC) is toward the East, use the outer scale. If the TC is toward the west, use the inner scale.

Aeronautical Chart Symbols

The following are some of the other symbols also shown on the aeronautical charts.

Airport Synbols

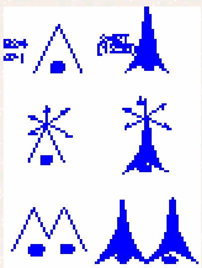
The symbols in Magenta are airports without a control tower. Symbols in Blue have a Control Tower.



Paved airport with a runway longer than 8096 feet
Paved airport with longest runway less than 8096 feet.
Un-paved airport
Private airport
Heliport
Sea Plane Base

Obstruction Symbols

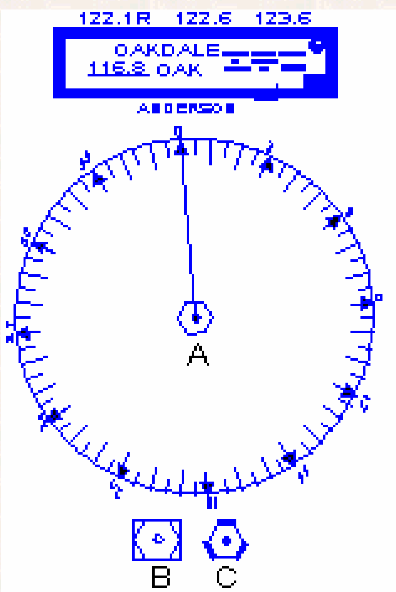
Obstruction symbols have two elevations shown near them. The one in **BOLD** letters (top number) is the elevation above mean sea level (MSL). The smaller numbers enclosed in parenthesis (bottom number) indicate the height above ground level (AGL). The symbols in the left hand column are less that 1000 feet AGL. The ones on the right are above 1000 feet AGL.



Single Un-lighted Obstruction
Lighted Obstruction
Group of Obstructions

Radio Navigation Beacons

VHF OmniRange Beacon (VOR)



A VOR is indicated on the chart as a compass rose. It is oriented toward Magnetic North, as indicated by the long arrow extending from the center to the zero degree mark. An information box near the VOR Compass Rose provides information such as the radio frequency, 3 letter Identification Code, and the morse code of the identifier. There is other miscellaneous data that may be contained in the box.

There are 3 types of VOR Ranges. They are indicated at the center of the rose.
Symbol A. VOR with no distance measuring capability.
Symbol B. VOR-DME: A VOR with distance measuring capability.

Symbol C. VORTAC: A VOR which has DME and military VORTAC capability.

For more detailed information on the VOR, see Aeronautical Information Manual:
Chapter 1-3 VOR
Chapter 1-4 VOR Receiver Check
Chapter 1-5 Military TACAN
Chapter 1-6 VORTAC
Chapter 1-7 Distance Measuring Equipment

Non-Directional Beacon (NDB)

A Non-directional Beacon is shown on the chart as a concentric series of Magenta colored dots, with the center of the circle being the location of the radio station. A magenta colored box near the circle shown the station name, the 2 or 3 letter station ID, and the morse code of the ID. This beacon is used by a navigation instrument in the aircraft called an "Automatic Direction Finder" (ADF).

For detailed information, see Aeronautical Information Manual Ch. 1-2 NDB

Back to Home	Back to Table of Conents	To Airport Information

Airport Information

Runways

There are a variety of runway types and markings. They range from sophisticated Instrument Landing System runways to small grass strips. The FAA has established a standard set of markings identifying the characteristics of the runway. Markings for runways are white. Markings on taxiways, closed or hazardous areas, and holding positions are Yellow.

Runway Markings

A number of standardized markings exist on the surfaces of paved runways. The runway markings identify whether the runway is equipped for Precision or Non-precision Instrument Approaches (IFR), or whether only Visual approaches are allowed (VFR). A combination of the following marking elements are used.

· Runway Number Designation
· Centerline Marking
· Threshold marking
· Aiming Point
· Touchdown Zone
· Side Stripes

Runway Numbering

Runway numbers and letters are determined based on the approach direction to the runway. The number is the whole number nearest one-tenth the magnetic azimuth of the runway centerline. For example, a runway with a magnetic heading from 035° through 044° is numbered 04. The third digit of the magnetic heading is dropped. The range of numbers is from runway 01 through 36.

The letters “L”, “C”, or ”R” is added to the number to identify the runway as being the left, center or right runway respectively. At some very large airports, there may be one set of parallel runways on one side of the airport (say 27L and 27R). On the other side of the airport another set of runways may exist with just one number difference (28L and 28R).

See AIM 2-31. AIRPORT MARKING AIDS for further information on airport markings from the Aeronautical Information Manual.

Centerline Marking

The runway centerline identifies the center of the runway. It is comprised of evenly spaced white line stripe and unpainted gaps.The centerline provides visual alignment during takeoff and landing.

Runway Aiming Point Marker

These markings are white rectangular line segments located on each side of the centerline, located approximately 1000 feet down the runway from the threshold. They serve as a visual aiming point for landing aircraft.

Touchdown Zone Markers

These markers are white stripes identifying the touchdown area of the runway. They are coded in groups of one, two and three rectangular bars, spaced 500 feet apart down the runway. The grouped bars are symmetrically placed on each side of the runway centerline.

Threshold Markings

They are longitudinal stripes located at the threshold end of the runway. There are usually eight bars, but wide runways may have a different configuration. They identify the beginning of the runway surface suitable for landing.

Side Stripes

These are continuous white lines along the edge of the runway to delineate the edge of the runway from surrounding terrain or other surfaces.

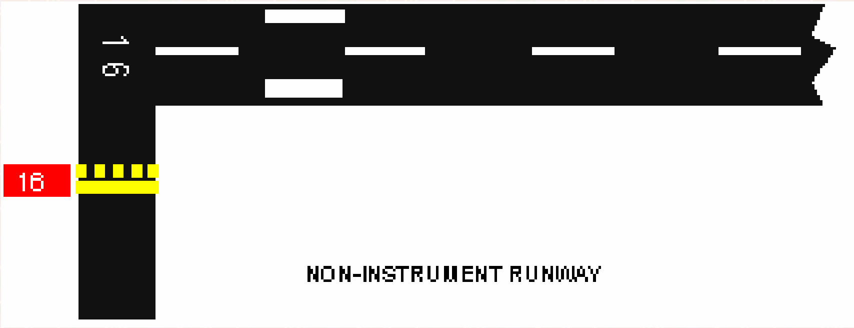
Runway Types

There are three types of paved runways. Each has a different set of markings. They are:

· VFR Runways
· Non-precision Instrument Approach Runways
· Precision Instrument Approach Runways

VFR Runways.

The runway depicted is a "VFR" runway only; i.e. it has no Instrument Approach Procedure.



The runway threshold shown identifies a VFR only runway. It contains a runway number and an aiming point marker on each side.

It may also contain threshold markings, fixed distance markers down runways long enough for jet aircraft (4000 feet and greater).. Yellow holding position lines occur on taxiways approaching the runway. Double solid yellow lines are on the “holding” side, and double yellow dashed lines on the runway side. There may also be a red holding sign with white runway numbers located at the hold line.

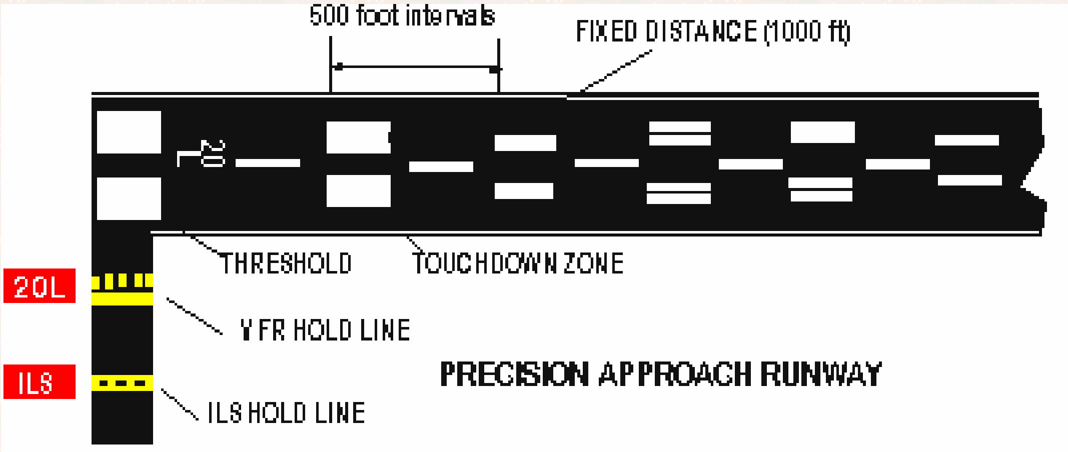
Non-Precision Instrument Approach Runways

A non-precision Instrument Approach runway, is one for which VOR or ADF instrument approach procedures are published and approved by the FAA. They do not have full Instrument Landing System (ILS) facilities.

Runways with non-precision instrument approaches are similar to the VFR runway with the addition of threshold markings.

Precision Approach Runway

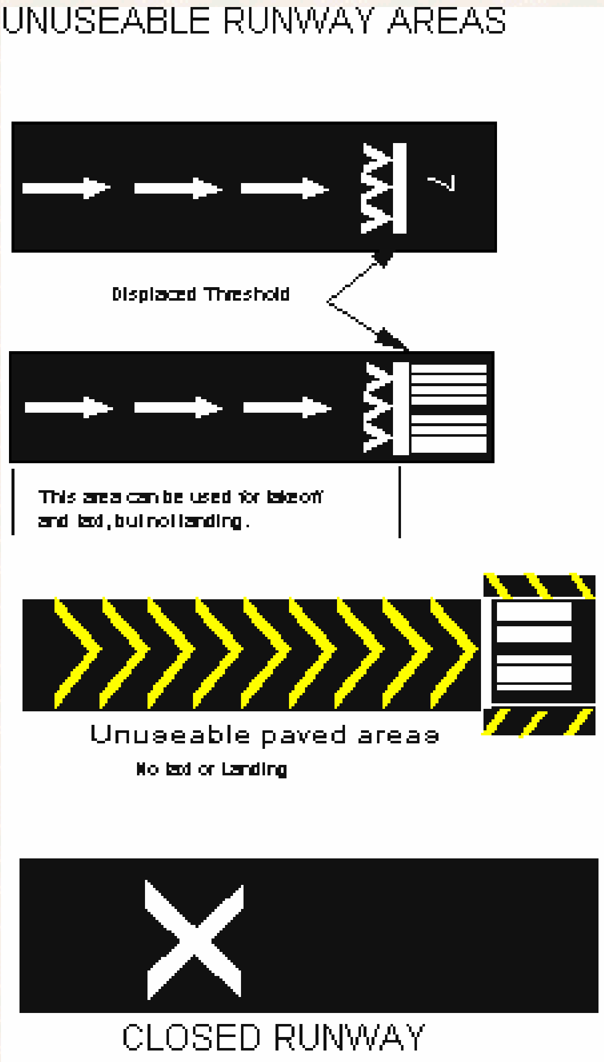
A precision Approach Runway is one equipprd with a full ILS capability.



The precision approach runway markings exist on runways equipped with ILS approach or other precision approach methods. Besides the non-precision markings, additional markings exist.

· Touchdown zone marking
· Line (ILS Hold Yellow lines)
· ILS Hold Sign (white ILS on red background)

Other Runway Markings



A Number of markings are used to indicate unuseable runway and airport areas. These are:

- Displaced Threshold
- Unuseable Surface
- Closed Runway

Displaced Thresholds

Some runways have displaced thresholds marked with white arrows leading to the threshold line. The area with the arrows maybe used for taxi and takeoff, but ***not for landing***. On landing, the wheels of the aircraft should not touch the runway before crossing the lateral threshold line.

There can be a number of reasons for the threshold displacement. The end of the runway may be too close to a road or other obstructions or hazards. The displaced area may not have sufficient runway strength to sustain the impact of landing aircraft.

Unusable Areas

An area containing yellow chevrons depict areas that cannot be used either for taxi, takeoff or landing. Often they are older or inadequate runway sections or used as an over-run area. They may be at either the approach or over-run end of the runway.

Closed Runway

An X on a runway indicates the runway is closed. It has become dangerous due to structural or other reasons. Use may be hazardous.

Taxiways

Taxiways provide paved surfaces connecting the parking ramps to the runways. Their centerlines are marked with a continuous yellow line. If the edge of the taxiway is marked, two yellow lines 6 inches apart are used.

See AIM 2-9. TAXIWAY LIGHTS for more information on taxiway lighting.

VFR Holding Line

Holding positions where aircraft must hold before crossing or entering the runway are marked by two dashed yellow lines nearest the runway, and two solid yellow lines are furthest from the runway. There may also be a white runway number on a red painted square located in front of the double solid lines.

Do not cross until clearance is given by the tower at a controlled airport. At an un-controlled airport, do not cross the solid lines until all aircraft are clear of the runway, no aircraft is on final approach. When taxiing to a runway, do not cross the solid lines untilon final approach, and it is determined that takeoff can be performed safely.

ILS Critical Holding Area

At larger airports where ILS instrument approaches are being made, taxiing aircraft should hold at the ILS Holding position line. The lines are yellow in color. A red ILS Holding sign will be along side the taxiway at this point. If the tower has instructed you to hold at the ILS Holding Line you should not taxi beyond this point until cleared by the tower.

Airport Signs

See AIM 2-32. AIRPORT SIGNS for additional information on Airport Signs from the Aeronautical Information Manual.

There are 5 types of signs used on airports. They are:
· Mandatory Instruction Signs

· Location Signs
· Direction Signs
· Destination Sign
· Runway Distance Remaining Signs

Mandatory Instruction Signs

These signs are White lettering on a Red background.

Holding position signs are used on taxiways that intersect runways at a point other than at the runway end. Holding position signs are also located at the yellow hold line on the taxiway at the end of the respective runway. it may be necessary to hold aircraft at a position on the taxiway other than at the runway end. These holding points prevent interference with landing or departing aircraft.

An ***ILS Critical Holding Area*** sign is used on taxiways serving a Precision Instrument Approach runway. It is used to hold departing aircraft farther from the ILS runway when instrument landings are in progress. It will be co-located with the ILS critical area taxiway marking.

A ***No Entry*** sign is used on taxiways with "one-way" traffic only, or at intersection with roadways that could be confused for a taxiway.

For further information on Mandatory signs, see AIM 2-33. MANDATORY INSTRUCTION SIGNS from the Aeronautical Information Manual.

Location Signs

Location signs are advisory in nature. They are yellow characters on a black background. They provide visual assistance to pilots in determining location on the runway or taxiway, and helps them determine when they have exited an area.

· ***Taxiway Location Signs.*** **<**BR> Alphabetic letters identifying taxiways.

· ***Runway Identification Signs***.
This runway identification sign indicates the runway number on which
the aircraft is located..

See AIM 2-34. LOCATION SIGNS from the Aeronautical Information Manual for further data.

Direction Signs

These are signs of a general informative nature. They show exits to runways, directions to parking ramps, etc. They are black letters or markings on a yellow background.

Taxi Boundary Sign

This is a runway boundary sign, as seen by the pilot exiting a runway onto the taxiway. The aircraft is “clear” of the runway after it has taxied beyond this sign.

ILS Critical Area Boundary Sign

This is an ILS Area Boundary sign. When the aircraft is exiting the runway, it is “clear” of the ILS Critical Area when past this sign. The sign is co-located with the ILS Critical marking on the taxiway.

Exit Signs

Direction signs show how to exit from an intersection. When used on a runway to indicate an exit, the sign is on the same side as the exit. They are black letters on a yellow background.

See AIM 2-35. DIRECTION SIGNS from the Aeronautical Information Manual for further information.

Destination Signs

These signs are black letters on a yellow background. They usually contain an arrow pointing to the destination, sych as General Aviation Ramp, Terminal, Parking Area, etc.

See AIM 2-36. DESTINATION SIGNS for additional information on these signs.

Information Signs

General information signs have black characters on a yellow background.

They provide the pilot of about such things as areas hidden from the control tower view, applicable radio frequencies, and noise abatement procedures. The airport operator determines the need, size and location for these signs.

See AIM 2-37. INFORMATION SIGNS for further information.

Runway Distance Remaining Signs

Runway distance remaining signs have white numbers on a black background. They are placed along side some runways to indicate remaining runway in thousands of feet.

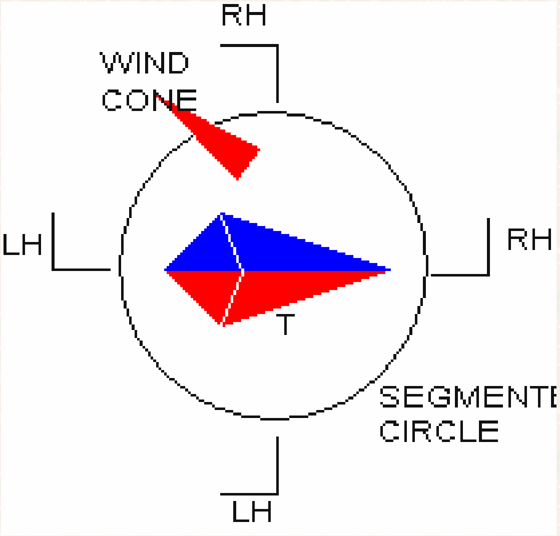
See AIM 2-38. RUNWAY DISTANCE REMAINING SIGNS for additional information.

Other Sign and Lighting Information

See Airport Markings Markings for runways and Taxiways.
for additional FAA information about airport signs, markings and aids.

Landing Indicators

A number of different wind and landing indicators are in use at airports. Virtually all airports have one or more of these indicators.



A segmented circle will be located near the center of the airport. The "L" shaped ears indicate landing pattern direction. The red cone is called a wind sock and indicates wind direction. The Tetrahedron (T) indicates the runway in use. It is usually manually set.

Wind Indicators

· Wind Sock - This is a cone shaped fabric indicator showing the wind direction. It also provides some measure of the wind velocity. The large open end of the cone faces the wind. Wind entering the open end fills the cone with air and it becomes more erect. The direction of the wind is from the large toward the small end of the cone. If the wind is calm, the cone will be limp. As wind velocity increases, the cone becomes more erect (in a horizontal direction).

· Wind Tee - (not shown) This looks like a small airplane with a body, vertical tail fin, and a wing. It orients with the wind with the wing on the upwind side and the tail downwind. The direction of the wind tee suggests the landing direction.

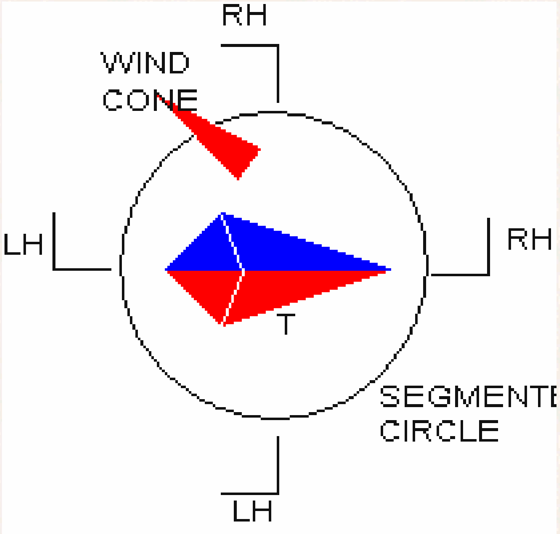
· If there is no wind indicator, observe smoke from factories, ground fires, etc. These will indicate wind direction. Also, the lee side of a lake (upwind direction) tends to be smooth.

Landing Indicators

A device called a Tetrahedron at some airports indicates the active runway. It is a pointed triangular shaped object shown in the diagram above as (T). One end configured in a long point (the front end). The rear end has a short, blunt triangular shape. Most are lighted to be visible at night. It is usually set into a fixed position by the airport personnel to indicate landing direction. It does not necessarily indicate true wind direction. The pilot should not rely on a tetrahedron as a wind indicator. Some are fixed and are not free to swing with the wind.

Segmented Circle

A dashed circle known as that Segmented Circle (shown below) is located in a position near the center of the airport. A wind cone, a tetrahedron or wind tee will be contained inside the circle. Outside the circle are landing traffic pattern indicators (the “L” shaped objects).

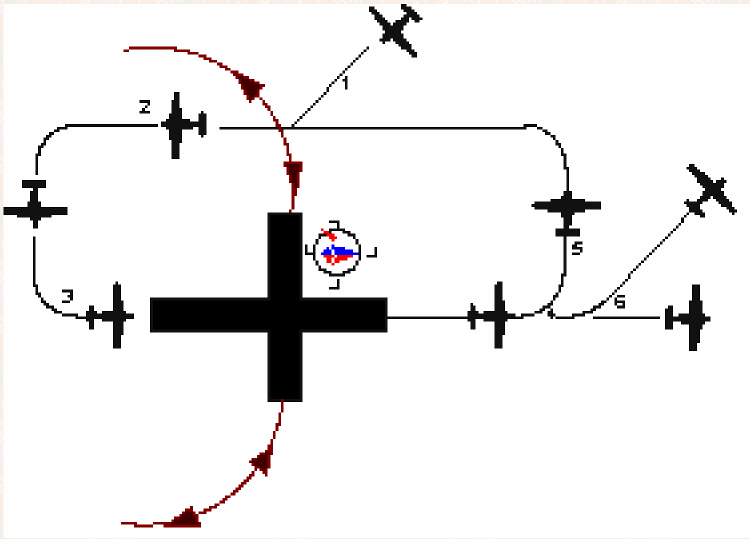


Assume that there are 2 runways at this airport; one 9 - 27 (East/West) and the other 18 - 36 (South/North) The tetrahedron is set to indicate landing on runway 9 to the East. The wind cone indicates the wind from the Southeast. The pattern indicators show the required direction of flight on the Base and Final legs of the approach to the runway. Departure flight pattern is defined by the pattern indicator for the departure end of the runway.

The traffic pattern indicators specify a left hand pattern for runways 9 (landing east shown by the indicator at the left) and 36 (landing north shown by the indicator at the bottom). The other indicators specify a right hand pattern for runways 27 (landing west as shown by the indicator on the right) and 18 (landing south as shown by the indicator on the top)

Traffic Pattern

The pattern of traffic around a non-controlled airport is as shown below.



An aircraft taking off eastward on runway 9 and staying in the traffic pattern will turn Crosswind (position 5) at approximately 400 feet above the runway, then Downwind to fly parallel the runway as shown at number 2 at an altitude approximately 800 feet above the runway. (Note: Some airports designate the pattern altitude to be 1000 feet.). Then when past the end of the runway will turn to Base between positions 2 and 3, while descending. The aircraft will the turn to Final at position 3. This is known as a ***Standard Left Hand Pattern.*** Also, according to the pattern indicators, a pattern for runway 36 is left hand. The downwind leg is on the west side of the airport, with all turns to the left.

The pattern indicators indicate landings on **Runways 27 and 18 are right hand patterns**. The downwind leg for runway 27 is north of the airport, with all turns to the right. Landing on 18, the downwind leg will be west of the airport, with all turns to the right.

Aircraft outside the pattern should enter the pattern approximately at mid point of the airport at a 45° angle to downwind (position 1). Aircraft leaving the traffic pattern should depart anywhere from “straight out" (position 6) to “crosswind” (position 5. A right turn departure from a left hand pattern is prohibited.

At airports with parallel runways, left hand pattern is used on the left runway; a right hand pattern is used on the right runway.

Traffic patterns at ***controlled airports with an operating control tower*** follow generally the same procedures. However, since the tower controller is responsible for traffic separation within the tower jurisdiction, the controller may grant or require other procedures. ***In all cases, except emergency, obey the controllers' instructions***. The traffic pattern at tower-controlled airports is usually 1000 feet Above Ground Level (AGL).

Airport Lighting

Runway Lighting

A lighted airport has runway lights situated on both sides of the runway. Some systems are able to operate at High (HIRL) Medium (MIRL) and Low (LIRL) intensity. Many airports have the lighting off during certain night hours, and the pilot must make active by clicks of the microphone. The intensity of HIRL and MIRL runway lights can be controlled by personnel on the ground. The pilot can control the intensity by clicking the microphone on the published Common Traffic Advisory Frequency (CTAF) for the airport. It takes 7 clicks to turn lights to high, 5 to medium, and 3 for low. Some airports may only provide medium and/or low brightness.

At large airports, there may also be high intensity centerline lighting. Some precision instrument runways have edge touchdown zone lights for the first 3000 feet of runway. These are transverse light bars on each side of the runway. These runways also have yellow end zone lights for the last 2000 feet. The end zone lights are yellow only to the pilot from the landing direction. They appear white from the opposite direction.

For further information on runway lighting, see
AIM 2-4. RUNWAY EDGE LIGHT SYSTEMS
AIM 2-5. IN-RUNWAY LIGHTING
AIM 2-6. CONTROL OF LIGHTING SYSTEMS
AIM 2-7. PILOT CONTROL OF AIRPORT LIGHTING

Taxiway Lighting

Taxiways edge lights are blue, and are on at night and during the day at times of reduced visibility. At larger airports, the tower personnel can control the intensity of the lights. Also, some taxiways may have imbedded green lights along the centerline of the taxiway. They are on during times of reduced visibility to mark the way between the runways and ramp areas.

Approach Lighting

There are numerous approach light systems at large airports with Instrument Landing Systems. These are beyond the scope of the beginning private pilot, and will not be addressed in detail in this material. For information on these systems, see AIM 2-1. APPROACH LIGHT SYSTEMS (ALS)

Several approach light systems are of interest to the VFR pilot. These are:

· Runway End Identifier Lights (REIL)

· Visual Approach Slope Indicators (VASI)

· Precision Approach Slope Indicators (PAPI)

Runway End Identifier Lights (REIL)

REIL's at many airports provide rapid and positive identification of the approach end of a runway. The system consists of a pair of synchronized high intensity flashing lights located on either side of the runway. They are particularly useful when the runway is surrounded with many other lights, in poor visibility conditions, and when the runway lacks contrast with the surrounding terrain. They may be omnidirectional, or may be focused toward the final approach path from the end of the runway.

See AIM 2-3. RUNWAY END IDENTIFIER LIGHTS (REIL) for more information.

Visual Approach Slope Indicators (VASI, PAPI)

There are several forms of VASI's. All employ lights that indicate a correct slope(s) for approach to landing. They may be used both for day and night operation. They provide an "on slope" glideslope angle of approximately 3°. The 2 bar VASI has 2 ranks of lights. Each rank may consist of one light or two lights side by side. You are "on glide slope" as shown in the center diagram (red over white). You are too high if both ranks are white, as on right. You are too low then both ranks are red as shown on left.

The 3 bar VASI has 3 ranks of lights, The two center show "on glide path" indications. The leftmost is a low path, and the rightmost is a high path. The all red is too low. The all white indication is too high.

Another approach slope indicator is the Precision Approach Path Indicator (PAPI). The system provides a more precise glideslope indication than does VASI. When all 4 lights are white, you are too high. When all are red, you are too low. When 2 are red and 2 are white you are on a 3° path. Three white on the left indicate a path of 3.2°. Three red on right indicate a 2.8° path. The open clear circles indicate white. The darkened circles indicate red.

The Tri-Color system is a single light that projects 3 colors. The ***above glide path*** indication is amber. ***On glide slope*** is Green. **Below glide slope** is red. When the aircraft descends from green to red, the pilot may see amber during the transition.

There is a similar system called the Pulsating Visual Approach Slope Indicator.(Not shown). It is somewhat similar to the Tri-color except a solid white indicates on glide path; steady red on a slightly low path. Pulsating white indicates too high. Pulsating red means too low.

See AIM 2-2. VISUAL GLIDESLOPE INDICATORS for additional information from the Aeronautical Information Manual.

Airport Beacons

Rotating beacons which operate at night and during times of poor weather assist the pilot to locate the airport from the air.

See AIM 2-8. AIRPORT (ROTATING) BEACONS for information on rotating beacon operation.

Wake Turbulence

All aircraft generate some turbulence, called Wake Turbulence. The turbulence from small aircraft is of little consequence. When the size and weight of the aircraft are great, the turbulence can be severe to other aircraft.

Cause

A number of factors contribute to wake turbulence. These are slipstream turbulence, jet blast, propeller wash, and wingtip vortices. The most severe of these disturbances is Wingtip Vortices. To over simplify, they are small tight horizontal tornadoes of air leaving the wing tips. The turbulence is a byproduct of the wing creating lift.

A pressure differential is created between the upper and lower surface of the wing. The low pressure is on the upper surface. This pressure differential creates a rolling airflow at the wing tip inward toward the fuselage. The ritating air mass trailis rearward. he right vortex rolls counterclockwise; the left vortex is clockwise.

Vortex Avoidance

Wingtip vortices have certain predictable characteristics. A large aircraft generates vortices from the moment of takeoff rotation. Takeoff rotation causes significant vortex.

In flight, the sink rate of the vortices is 400 to 500 feet per minute, and levels out 900 to 1000 feet below the aircraft. Near the runway surface, a tailwind can cause the vortex to persist near the ground for several minutes if the wind is light.

Large heavy aircraft generates significant vortex on landing. It has a high angle of attack of attack, and is slow and heavy. The point of greatest wing loading and vortex is the flare to touchdown. This is due to additional wing load caused by centrifugal force generated in the flare.

When operating on and near large airports with large aircraft operations, caution concerning wake turbulence must be observed. The strength of the wingtip vortices is greatest then the aircraft is HEAVY, CLEAN and SLOW. The greatest hazard to small aircraft is coming across a vortex while operating near the ground.

Each vortex is about 2 wingspans in width and one wingspan in depth. They remain spaced about one wingspan apart, drifting with the wind. In a no-wind situation, the vortices will persist on the runway. They move laterally outward about 2 to 3 knots on each side when striking the ground.

A cross wind will add or subtract from the natural 2 - 3 knot lateral movement of each vortex. With a light crosswind component of about 3 knots, the upwind vortex can persist for a considerable time. The vortex movement and the opposing crosswind oduce a stationary vortex.

STAY ABOVE AND UPWIND FROM THE VORTEX.
. Plan your strategy accordingly.
1. When landing on the same runway behind a large aircraft, stay at or above the larger aircraft's approach path. Note the touchdown point, and plan to land beyond that point. 2. If landing on a runway parallel to and within 2500 feet of one being used by a large aircraft, use the same procedure as in 1 above. 3. If landing on a runway crossing the larger aircraft's runway, cross the other runway above the large aircraft's flight path.
4. Land well short of a large departing aircraft's rotation point.
5. If a large aircraft is departing a crossing runway, note the rotation point of the large craft.
· If rotation is past the intersection, continue to land as you would normally.
· If it rotates before the intersection, avoid flight below the aircraft's flight path. Execute a missed approach unless you are sure you can stop well before the intersection.
6. If departing behind a departing large aircraft, note the rotation point of the departing aircraft. Become airborne before the rotation point, and stay higher and upwind of the larger aircraft's flight path. If unable, request the control tower for a change in flight direction away from the path of the larger aircraft.
7. If you takeoff at an intersection, be cautious that your departure path will not cross under the path of a larger aircraft.
8. You should ensure an interval of at least 2 minutes before takeoff or landing across or behind the path of a large aircraft that has executed a low pass, touch-and-go, or a missed approach.
9. Avoid flight below the path of a larger aircraft when enroute at altitude. Try to stay above or upwind of larger aircraft near your altitude.

See the Aeronautical Information Manual Wake Turbulence for further information.

Other Airport Operations Data

AIM Chapters Aeronautical Information Manual by Chapter.

Back to Home	Back to Table of Conents	Methods of Navigation

Navigation

Navigation is the procedure by which the pilot flies from one point to another. A single method of navigation is rarely used by the pilot operating under Visual Flight Rules (VFR). There are several methods of navigation in use today by the VFR pilot.

Methods of Navigation

The principal methods of navigation used today by light aircraft are:

- Dead Reckoning
- Pilotage
- VOR
- ADF
- LORAN
- GPS

Dead Reckoning

This is the primary navigational method used in the early days of flying before adequate aeronautical charts and electronic navigation were available. It is the method on which Lindberg relied during his first trans-Atlantic flight. It is based on Time, Distance, and Direction only. The pilot must know the distance from one point to the next, the magnetic heading to be flown, and have some idea of the effects of the winds expected to be encountered during the flight. It is the most fundamental aspect of VFR flight.

Even in todays environment, the pilot should prepare a basic planning log of check points along the route of flight. This planning log should include such data as True Course (TC), Distance, anticipated wind drift (or wind correction angle), estimated ground speed and magnetic heading by which to steer. This data should be measured, or in some cases estimated, for each leg of the flight. The purpose for this log is to allow the pilot to estimate the time and heading for each leg, and to make minor corrections to the plan for the next leg based on the experience of the previous leg.

A sample flight planning log will be demonstrated later in this section.

Pilotage

Pilotage is the art of following an aeronautical chart to fly from one point to another. True pilotage may not always follow straight lines for long distances, but rather may follow terrain features such as rivers, coastlines, mountain ridges, roads, railroads, etc. The pilot is relying on the recognition of major features shown on the chart, and correlating them to what is seen below..

The pilot may keep a primitave log of checkpoints, or may even write the time directly on the chart as prominant features are passed over.

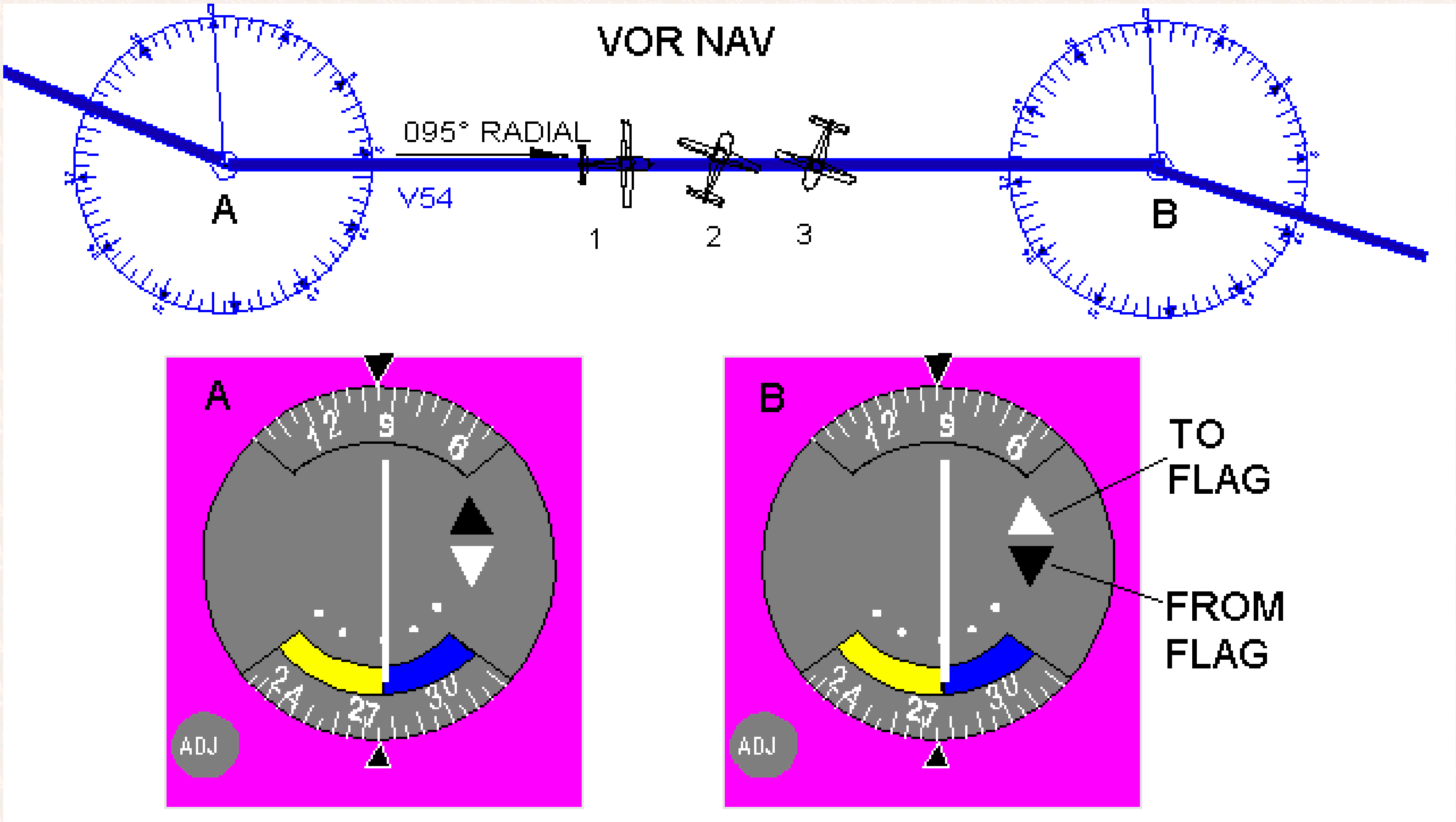
During training, instructors will usually train student pilots to navigate over a course of 50 to 100 miles, using a combination of dead reckoning and pilotage. This type training is important for later use, since electrical and electronic navigation equipment may occasionally malfunction. The experienced pilot should be able to fly relatively long distances using a combination of these two basic methods.

Even when using electronic means of navigation, it is a good procedure to also utilize dead reckoning and pilotage procedures in addition to the electronic instruments.

VOR Navigation

The principal electronic navigational system in use today is the VHF Omni-Range (VOR). This navigational method relies on a system of ground-based transmitters which emit signals that a VOR receiver can interpret. The VOR receiver can use the signal emitted by a selected ground station to arrive at an azimuth reading from the station. This azimuth FROM the station is called a ***RADIAL*** of the VOR. Another way to envision the VOR radial is to think of a wagon wheel with 360 spokes. One is called 360 (representing Magnetic North). The others are numbered 1 through 359. If a fly lands on spoke 37, the fly is on the 037° RADIAL of the wheel. It makes no difference which way the fly is headed. He can turn adound in a complete circle; but as long as he stays on the same spoke, he is on the 037° radial.

The diagram below demonstrates an aircraft (#1) flying on a Victor Airway (V54) whose outbound radial from VOR (A) is 095°. The VOR instrument shown on the bottom of the diagram is called a ***Omni Bearing Selector (OBS)*** (the ADJ knob and numbers on top and bottom) and then ***Omni Bearing Indicator (OBI)*** comprised of the needle, white dots and Yellow/Blue arcs and the TO/FROM flags.. When the ***needle*** of the instrument is centered, and the ***FROM FLAG*** is showing (is WHITE), the **radial** is indicated by the marks and numbers at the ***top of the instrument***



To fly an outbound radial of 095°, rotate the selector knob labled ADJ until the needle centers and the FROM (white) flag is showing. When this is achieved, you are on the 095° radial of VOR (A). **Note that the heading of the aircraft has no effect on the presentation of the instrument, or the radial you are on.**. The radial and the instrument presentation of aircraft #2 and #3 are the same as aircraft #1.

When you are about half way to VOR B, you can tune the same (or a second) VOR receiver to the frequency of VOR B. Again, you will rotate the ADJ knob (if necessary) in order to center the needle: ***but this time you want the TO FLAG to be showing (WHITE)*** since you are flying ***TO station B.***

As you pass over station B, you will encounter a ***zone of indecision***. The needle may swing wildly from one side to the other, and both the TO and FROM flag will be off (dark). Note in the diagram above, you will want to start tracking the 110° outbound from station B. When the FROM flag shows white, turn the aircraft to the new heading of 110° and rotate the ADJ knob until the 110° mark is under the selector arrow. You may need to turn a few degrees more until the needle centers, then track the 110° outbound radial.

The VOR station makes a good checkpoint. Not only do you get the "station passage" indication on the OBI, but you can visually see the VOR ground station in good visibility conditions. It is a low building with a truncated cone on the top, which houses the antenna. The truncated cone is fiberglass and white in color.

Whenever you tune the VOR receiver to a new station frequency, you should always turn the VOR receiver volume up to hear the 3 letter morse code identifier. The dots and dashes are shown in the VOR identification box near the VOR compass rose. Some stations may have voice identification in lieu of the Morse code. In this case, the full name of the VOR is spoken. See the VOR OmniRange description in the previous section titled Chart Symbols to review the how the station frequency, name, ID and morse code is indicated on the charts.

For additional information on VOR operation, see the Aeronautical Information Manual chapters for further information on VOR, TACAN and VORTAC stations.

AIM 1-3. VHF OMNI-DIRECTIONAL RANGE (VOR)
AIM 1-5. TACTICAL AIR NAVIGATION (TACAN)
AIM 1-6. VHF OMNI-DIRECTIONAL RANGE/TACTICAL AIR NAVIGATION (VORTAC)

Correcting for Wind Drift

Seldom when flying a course will the pilot encounter a "no wind" condition. Wind will always add or subtract from Indicated Airspeed to create a different speed across the ground called Ground Speed (GS). Wind will also drift you off course.

The OBS Selector (your radial) indicates the Magnetic Course (say 095°) that you want to fly over the ground. Seldom will the wind allow you to track your radial without making some correction to the left or right. The wind, will ***drift you off course***, either to the left or right of your radial. The OBI needle will start drifting to the left or right rather than staying centered.

If you are flying the 095° radial from VOR A for example, and the needle drifts right, it means the wind is blowing from your right (South), thus drifting you off course to the left. The needle always points in the direction toward which you need to make correction in order to get back on the selected radial. Take the 095° radial for example. After flying for a while holding a steady 095° heading on the compass (Magnetic Heading

MH) you see the needle has drifted to first dot on the right. This first dot represents a 5° deviation from the radial. What do you do to correct for the wind drift, and get back on course? If you said, change the OBS to 100°, **WRONG!. Do not change the OBS, because that is the Magnetic Course (MC) of 095° is what you want to track over the ground.**

Rather , change your magnetic heading to the right, say 10°, to a MH of 105°. Hold that for a while. If the needle drift ceases (it steadies), you are now flying parallel to your course, but to the left of course. You now need to ***get back on course***, so take another 10° correction to the right (now a 20° total correction) to a MH of 115°. When the needle comes back to center, you are back on the desired radial. Now remove that last 10° correction (i.e. come back to a Magnetic Heading (MH) of 105°). That should now hold you approximately on the 095° radial by holding a 10° right Wind Correction Angle (WCA) (i.e. holding a 105° MH on the compass).

However, if the initial 10° R WCA fails to stop the needle from drifting right, increase the WCA to 20° R (MH=115°). If the needle steadies, increase the MH to 120-130° to **get back on course**, then hold a 20° WCA (MH=115°). Maintain this for a while to see if that holds the needle centered.

Continue to make this type of correction, left or right until you have the correct WCA pinned down to hold you "on course" with needle remaining centered. Usually when flying cross country, you do not make large radial changes; so the WCA you held on the last leg should be close to appropriate for the next leg. After some practice, you will be able to estimate the WCA fairly quickly by watching how fast the needle drifts from center.

Testing the VOR Indicator for Accuracy

Generally, the accuracy of the VOR is within one degree. However, due to age or other factors, the error may increase. The accuracy of a VOR receiver can be checked several ways.

· FAA VOR Test Facilities (VOT)
· Airborne Check Points
· Ground Check Points

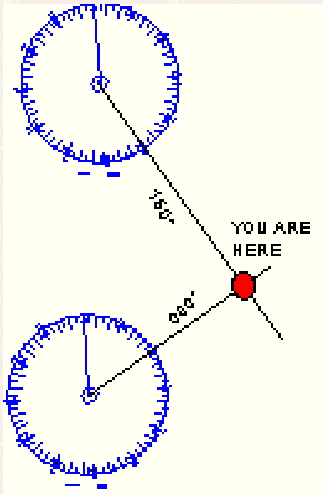
The Airport/Facility Directory is a document describing all public airports and navigational facilities. It can be purchased at most airports and pilot supply stores for a nominal fee. This document lists certified checkpoints that may be used to check VOR Receiver accuracy. These are selected ground or in-flight checkpoints which have a known radial bearing from the specified VOR.

The FAA VOR Test facility is called a VOT. These facilities are usually found at larger airports. It is a special test facility which can be tuned while on the ground at the airport. When you tune the VOT frequency, you will hear a series of dots, or a steady tone as the VOT identifier. Turn the OBS until the CDI centers. The course indicator should read either 0° or 180°. If 180°, the flag should be TO. If the OBS reads 0°, the flag should be FROM.

The OBS reading must be accurate to +/- 4 degrees for ground based checkpoints and +/- 6° for airborne checkpoints..

For mor information on VOR testing procedures, consult AIM 1-4. VOR RECEIVER CHECK

Using VOR Intersections



In the example, you read a radial of 150° from the top VOR, and 060° from the lower VOR. By drawing lines on the chart representing these radials, you are at the intersection of the lines. Often, where Victor Airways cross, the intersection will be indicated on the chart by crossed arrows and an intersection name.

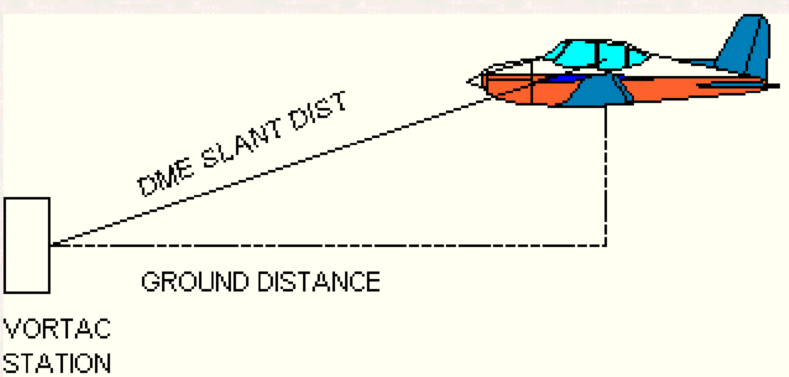
Distance Measuring Equipment (DME)

VOR/DME and VORTAC stations provide distance information for aircraft equipped with Distance Measuring Equipment (DME). DME operates in the UHF radio band on frequencies from 962 MHz to 1213 MHz. Whenever you tune the VOR station frequency, the DME receiver automatically selects the correct UHF frequency. This is called “paired frequency selection”. The pilot need not be concerned with the UHF frequency.

Some DME systems can also be “slaved” from a normal VOR receiver, so that the DME automatically operates on the VOR station selected by the VOR receiver. Tuning a DME receiver is similar to tuning the VOR receiver; i.e. the frequency of the VOR is selected on the DME tuner dials.

The DME unit uses a “shark fin” appearing antenna, normally mounted underneath the aircraft. The aircraft DME unit sends an interrogation signal to the VOR/DME or VORTAC station. The ground station then transmits a responding signal. The DME unit measures the time elapsed between sending the interrogating signal and receipt of the response signal. From this information, the DME unit calculates the distance to the station.

Some units also calculate groundspeed and “time to the station”. However, GS and time to the station are only valid if you are flying directly to or from the station. If you are flying in any other direction, these values will be incorrect. However, the distance to the station will be correct.



For example, if you are flying at 6000 feet, the DME will register 1 NM to the station when you are directly over the station. See the Aeronautical Information Manual AIM 1-7. DISTANCE MEASURING EQUIPMENT (DME) for further information.

Automatic Direction Finder (ADF)

Some aircraft are equipped with an ADF receiver. See the Aeronautical Information Manual AIM 1-2. NONDIRECTIONAL RADIO BEACON (NDB) for more information. They receive radio signals in the medium frequency band of 190 Khz to 1750 Khz. The ADF receiver can “Home” on both AM radio stations and Non-Directional Beacons. Commercial AM radio stations broadcast on 540 to 1620 Khz. Non-Directional Beacons (NDBs) operate in the frequency band of 190 to 535 Khz.

The aircraft equipment consists of two antennas, the ADF Receiver, and the ADF Instrument. The two antennas are called the (1) LOOP antenna and the (2) SENSE antenna.

The loop antenna can sense the direction of the signal from the station, but cannot discriminate whether the station is in front or behind the aircraft. The sense antenna can discriminate direction, and solves the ambiguity of the loop antenna.

The receiver unit has tuning dials to select the station frequency A volume control allows the audible volume to be controlled for identifying the station. The volume can be reduced to prevent interference with other communications. You should, however, continuously monitor the identifier while using the NDB for navigation.

There are 2 types of compass rose dials that can exist in the navigational unit. One is a fixed compass rose, called a “Fixed Card” ADF. Zero degrees is always shown on top of the card. The “Rotateable Card” ADF allows the compass rose card to be rotated. Interpretation of these displays will be more fully described in later paragraphs.

Non-Directional Beacon (NDB)

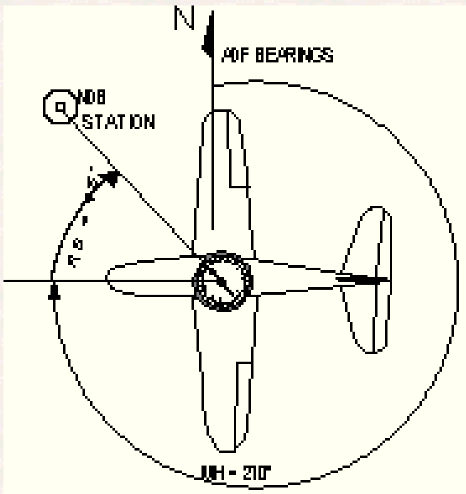
NDBs may be located on the surface of airports, or may be within a few miles from an airport. Sometimes they are co-located with the Outer Marker in ILS approaches. The NDB provides two principal functions; (1) homing for VFR operations, and (2) ADF instrument approach capability for IFR operations.

Because the frequency is below and within the commercial AM band, reception is subject to the same atmospheric disturbances as AM radio, in particular, noise generated by lightening.

ADF Orientation

The pointer end of the ADF navigation unit ALWAYS POINTS TO THE STATION. The degree reading on the display is dependent on the aircraft heading. In the diagram if the heading of the aircraft changes, the arrow will always point to the station and the degree reading on the instrument which the pointer indicates also changes..

Fixed Card ADF



✶❈❉ ❒❉●❆▼❇❏■▲❈❇❒ ❏❉ ▼❈❉ ❆❇❒❀❒❆❉▼ ▼❏ ▼❈❉ ▲▼❆▼❇❏■
❉●❉❍❉■▼▲ ▼❏ ❉❉▼❉❒❍❇■❇■❊ ✩✣✎ ✩■❉ ❇▲ ▼❈❉ ✡❉●❆▼❇❖
✩❆❊■❉▼❇❆ ★❉❆❉❇■❊ ✍✩★✉ ❏❉ ▼❈❉ ❆❇❒❀❒❆❉▼✎ ✶❈❇▲ ❒❉●

✩✣ ✍▼❏ ▼❈❉ ▲▼❆▼❇❏■✉ ✝✡✣ ☞ ✩★

In the example, the MH of the aircraft is 270° as read on the compass. The RB read from the ADF dial is 45° . Therefore the MB to the station = 270° + 45° = 315°. This equation applies to any problem on the FAA Written Exam relating to the Fixed Card ADF. If any two values are known, the third can be computed.

Moveable Card ADF

Some aircraft are equipped with an ADF instrument in which the dial face of the instrument can be rotated by a knob. This is called a Moveable Card ADF. By rotating the card such that the Magnetic Heading (MH) of the aircraft is adjusted to be under the pointer at the top of the card, the Bearing to the Station (MB) can be read directly from the compass card. More sophisticated instruments of later design automatically rotate the compass card of the instrument to agree with the magnetic heading of the aircraft. Thus MB to the station can be read at any time without manually rotating the compass card on the ADF face.

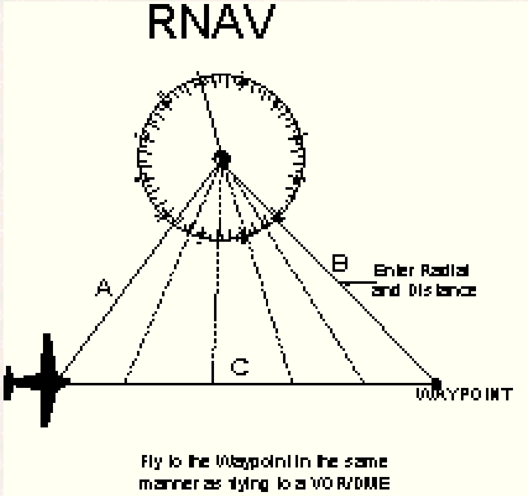
Area Navigation

Three types of navigation receivers can be called Area Navigation. They are:

· RNAV
· LORAN
· GPS

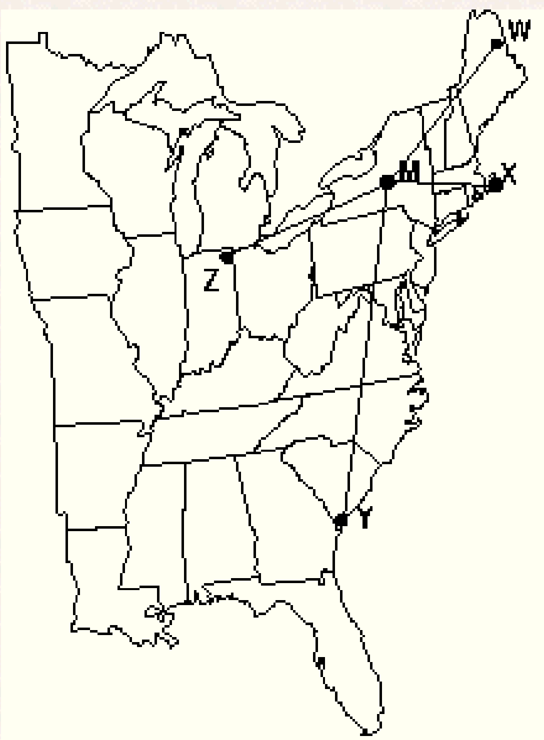
RNAV

This type of navigation allows a pilot to fly a selected course to a predetermined point without the need to overfly ground-based navigation stations. Flight can be from waypoint to waypoint. A waypoint is a position determined either by Latitude/Longitude or Radial and distance from a VORTAC or VOR/DME station.



Through triangulation, the navigation unit measures the radial and distance of leg A. By knowing the entered data for leg B, the azimuth and distance to the waypoint along path C is repeatedly calculated calculated. It is as though the VOR were located at the waypoint position.

Long Range Navigation (LORAN)



The LORAN unit can indicate:
· Present Position - in Latitude/Longitude and/or relative to a destination, waypoint or checkpoint.
· Bearing and distance to your destination.
· Groundspeed and estimated time enroute.
· Course Deviation Indicator.

· Storage in memory of all US airports, pilot selected fixes, minimum enroute and obstruction clearance altitudes, and Class B and C airspace warnings.
· Continuous computation of bearings and distances to the nearest airports. Computation of wind direction and velocity.
· Add ons, such as fuel flow analyzers to estimate fuel needed to reach destination and alternates; ELT's to transmit exact location of ELT.
· Add-on programmable and updatable databases.

Since LORAN operates on a low-frequency signal, it is subject to the same disturbances that AM radio sustains. It is possible to loose signal when operating near thunderstorm and in heavy rain areas.

The LORAN receivers know the frequency of the Master and secondary stations; no tuning by the pilot is necessary.

For more technical data about LORAN see, Loran C General LORAN Information. Also see Aeronautical Information Manual AIM 1-17. LORAN

Global Positioning System (GPS)

The GPS system is the latest in technology that can be used by aircraft. It has many of the attributes of LORAN. The complete system will contain up to 21 satellites in earth orbit. The "clocks" and "positional data" is updated periodically to insure accuracy of the data from the satellites. It sense 4 or more satellites in orbit. The system is maintained by the US Department of Defense. See an GPS Overview Pictoral for a general concept of the GPS system. See GPS Constellation to see the satellite orbits.

Like LORAN, it operates on a time-based methodology. Each satellite transmits coded pulses indicating it's position, and the precise time the pulses are sent. The GPS unit listens to the satellite's signal, and measures the time between the satellites transmission and receipt of the signal. By the process of triangulation among the several satellites being received, the unit computes the location of the GPS receiver. Not only can Latitude and Longitude be calculated, but altitude as well. See Geodetic Coordinate System for a pictoral showing how the GPS system can indicate these 3 parameters of LAT, LON, and HEIGHT.

Like LORAN, the GPS unit contains data about all the commercial airports in the US, including runway lengths, directions, and location. There are numerous forms of display among the various manufacturer. The units can range from “hand held” to “panel mount” with altitude information input from an encoding altimeter. They can warn of Class B, C, and Prohibited and Restricted airspace. They can calculate direction and time to nearest suitable alternate airports in event of emergency.

The database in most units can be updated via a connection to a Personal Computer. The maximum error is within 100 meters (0.05 Nm). Work is in progress to give the GPS system adequate precision for instrument approaches.

No frequency tuning is required, as the frequency of the satellite transmissions are already known by the receiver.

Work is currently underway to provide sufficient accuracy for use of GPS for instrument approaches.

For more technical data on GPS, see:

[AIM 1-23. GLOBAL POSITIONING SYSTEM (GPS)](#)

[GPS](#)

Flight Planning

When planning a cross country flight of any distance, the pilot is required by Federal Aviation Regulations to have knowledge of the destination airport, fuel requirements, estimated time enroute, weather expected along the route and destination, and any other information which may affect the safety of the flight. The pilot should get a thorough weather briefing from a Flight Service Station (FSS), and the filing of a flight plan for VFR flight is strongly recommended.

This section will cover the time, distance, groundspeed, heading, and fuel required aspects of the flight planning proccess.

Basic Parameters

The planning log must address several factors:

- Selection of Ckeckpoints
- Distances
- True Course
- Magnetic Variation
- Magnetic Course
- True Heading
- Magnetic Heading
- Wind Correction
- Ground Speed
- Time Enroute
- Fuel On-Board
- Fuel Duration
- Fuel Consumption

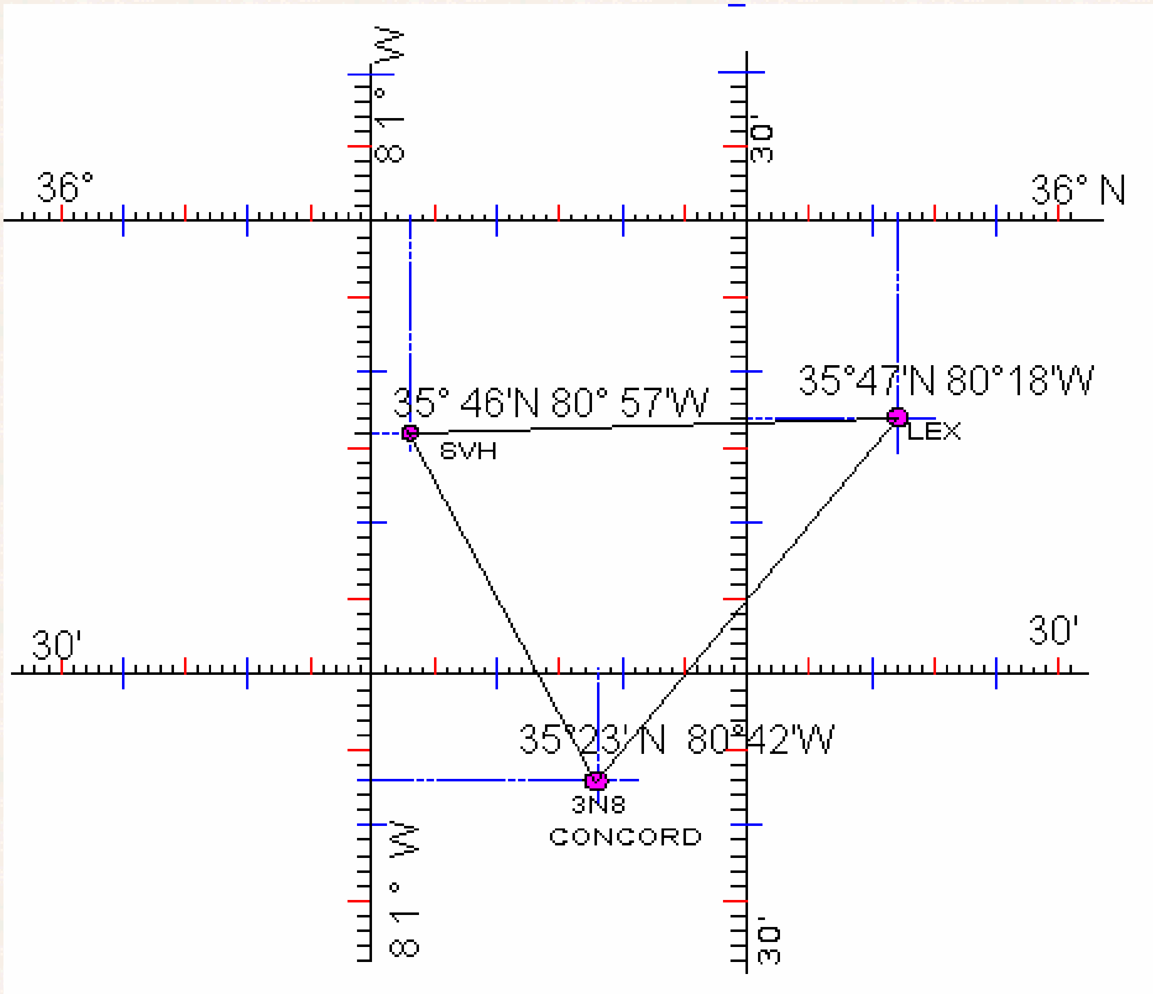
Definitions

Checkpoints

The pilot should determine the type of navigation to be used; Pilotage, VOR and/or Victor Airways, LORAN, GPS, etc. From that information, the pilot should establish checkpoints over which the flight is to pass. They may be prominent landmarks, VOR's, RNAV, LORAN or GPS waypoints. It is suggested for small slow speed aircraft that these checkpoints be within reasonable distances, say 50 Nm or so. Distances shorter than this requires a lot of record keeping for long flights. Distances much longer than this does not allow the pilot to verify actual performance versus the plan sufficiently often enough. Generally a checkpoint every 30-40 minutes is a suitable procedure for the experienced pilot.

The pilot should plot the Course of flight by drawing lines on the chart from checkpoint to checkpoint. It's like drawing your roadway in the sky which you plan to follow. These checkpoints should be written on the flight planning log in the Check Point column of your planning log.

An example flight is illustrated below. The flight is a simple one which a beginning student may be asked to fly. It is a triangular course, from SVH, LEX, 3N8, and back to SVH. You will note later that the wind will have a different effect on ground speed and headings for each leg. ***Note: This flight will be used as the basis for planning a simple flight and the associated flight planning log.***



A simple example log is shown below to demonstrate the basic values to be determined. This is a sample log designed by the author for teaching purposes only. There are numerous commercially prepared log forms on the market. You can purchase them at most airports and pilot supply shops.

FLIGHT LOG

AIRCRAFT #__________ DATE:________ FUEL USE________gph

FUEL ON BOARD:________

WINDS ALOFT ______________ TAS________ ATD:____________ FUEL DURATION ____ hrs ____ min

CHK PT	DIST	TC°	WCA°	TH°	VAR°	MH°	LEG			ETA	CUMULATIVE	
Statesville SVH							TIME	GS	FUEL	ATA	TIME	FUEL
							E / A	E / A	E / A			
Lexington LEX												
Concord 3N8												
Statesville SVH												
TOTALS												

You will note that there are a number of items of information whick the pilot must consider:

- Basic Information
  - Date
  - Winds Aloft - Get from Winds Aloft Forecast
  - True Airspeed (TAS) - Get from Pilot Operating Handbook
    See -- Cruise Performance for an example table.
  - Fuel Use (gph) - Get from Pilot Operating Handbook

    See -- Cruise Performance for an example table.
  - Fuel on Board - Based on refueling records
- Course Data
  - Leg Distances - From the chart
    - See -- Measuring the distance
  - True Course (TC) - From the chart
    -- See - Measuring the course ***Note: COURSE always refers to the "track over the ground".***
  - Wind Correction Angle (WCA) - Calculated
  - True Heading (TH) - Calculated
    Note: HEADING always refers to the "direction in which the nose of the aircraft is pointed".
  - Magnetic Variation (VAR) - From the chart
    See -- Magnetic Variation
  - Magnetic Heading (MH) - Calculated
- Time, Distance, Ground Speed, Fuel Computation
  - Calculate Ground Speed (GS) using E6B Computer (Wind triangle)
  - Use GS and Distance to calculate leg Time
  - Use Leg Time and Fuel Flow to calculate Fuel Used
  - Calculate Estimated Time of Arrival (ETA) to next check point.
  - Calculate Cumulative Time Enroute and Fuel Used.

Filling out the Planning Log

Heading Information

- Obtain Winds aloft data from pre-flight briefing by a Flight Service Station for the expected flight time.
- Consult the Pilot Operating Handbook for estimated Fuel consumption and TAS figures.
- If you know fuel amount on board, calculate flight duration from the POH.

Winds Aloft

Winds aloft are forecast by the Weather Bureau for numerous regions in the U.S. At the levels at which small aircraft fly, the forecasts will give wind direction and velocity in Kts. for 3, 9, and 12 thousand feet. You use the wind forecast nearest the altitude which you plan to fly to calculate whe wind drift you expect to encounter. This calculation also derives an estimated Ground Speed which you will use in further calculations. The ***Wind Correction Calculations*** are covered later.

True Airspeed and Fuel Consumption

Consult the Pilot Operating Handbook for the aircraft to be flown to determine the power setting you plan to use at the planned flight altitude. See -- Cruise Performance for an example table. From the cruise performance table for the aircraft you should be able to derive estimated TAS and Fuel Consumption in gph. You will later use this TAS to calculate both the estimated WCA and Ground Speed. You will use the fuel consumption figure (gph) to calculate the estimated fuel consumption for each leg.

Course Planning Information

Identify each checkpoint on the chart in some way. It may be a number, an airport name, a VOR name, or city, etc. Write the identification of the each checkpoint in the CHK PT column of the log. Note that the checkpoint lines are not aligned with the other lines in the blank log form shown above.

In our example, our checkpoints are:

CHECK POINTS
CHK PT
SVH
LEX
3N8
SVH

Distance

Measure the distance as shown in Measuring the distance . Enter the distance in Nautical Miles (preferred) in the DIST column for each leg.

DIST
32
31
26

True Course

Using the plotter, measure the TC for each leg, using the example in - Measuring the course example. True Course is always measured in relation to a Longitude Line on the chart (i.e. relative to True North). Enter the TC for each leg in the TC Column.

Compentating for Wind

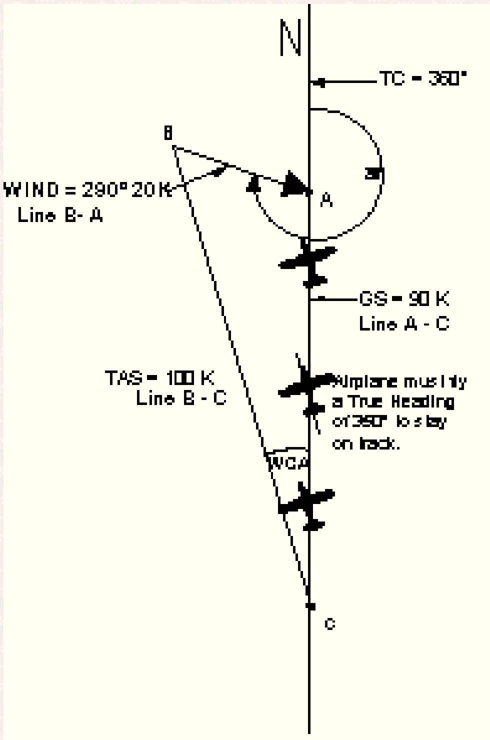
In order to keep being blown "off course" by the wind, you probably will have to maintain a heading to either left or right of course to stay on track(TC). This requires that you calculate a Wind Correction Angle (WCA) in order to stay on track.

You can use a manual or electronic E6B Flight computer to compute the WCA. Obviously, when you are riding in a moving air mass, the wind will tend to drift you "Off Course" from your intended ground track.

A Graphical Illustration of WCA

Shown below is a graphical illustration of calculating WCA.

You want to fly a True Course (TC) of 360°. The wind is from 290° at 20 Kts. Obviously the aircraft will drift right and off course unless a correction is made. The problem can be solved graphically. On paper, draw a TC line at 360°. Draw a wind vector to some scale (line B-A) at 290° and 20kts



according to your scale. Draw a TAS line to the same scale from point B to intersect the TC line at point C. In this example TAS = 100 kts. You have now constructed a ***Wind Triangle.*** The Wind Correction Angle (WCA) is the angle between line B-C and A-C. In this example it is 10° L. The Ground Speed is line A-C, which measures 90 Kts.

It is obvious from this triangle, you have a 10 knot headwind, and must steer a heading 10° to the Left. Therefore to convert your True Course (TC) over the ground to a True Heading (TH) to which to steer, you:

TH = TC + WCA	TH = 360° + (- 10°) = 350°
Treat R WCA as plus	Treat L WCA as minus

Normally the pilot will use eithae a manual or electronic E6B Flight Computer to solve WCA problems. Consult your E6B computer manual for problem solution methods.

WCA for the Example Flight

The example flight from SVH, LEX, 3N8, SVH is shown below. The wind aloft for this problem is 270 degrees true at 35 knots.On your planning chart, add and subtract the WCA's to the TC's to fill out the TH column.

True Course, Wind Correction, True Headings (degrees)		
TC	WCA	TH
088	01 L	087
220	15 R	235
332	17 L	315

Correcting for Magnetic Variation

As a refresher on Magnetic variation, see Magnetic Variation . True North and Magnetic North are not at the same location on the earth. In the eastern US, the Magnetic North Pole is west (left facing north) of the True North pole. The AGONIC LINE (where true and magnetic north are the same) runs from uper eastern Wisconsin, diagonally Southeastward through the central South Carolina coast. The difference between the True and Magnetic Norths is called Magnetic Variation (VAR). It is called Westerly Variation east of the agonic line; i.e. Magnetic north is west of True North. It is called Easterly Variation west of the agonic line.

To convert from TH to Magnetic Heading (MH), ***Add Westerly VAR, Subtract Easterly VAR.*** The variation is shown on the Aeronautical Charts as dashed magenta lines, running from the top to the bottom of the chart. They will be labled 6°W, 10°E, etc.

In your planning log, write the magnetic variation down in the VAR column (denoted by the *). Add or Subtract the VAR (W = +, E = -) to the TH to get the Magnetic Heading (MH) values. This portion of the example SVH, LEX, 3N8, SVH flight is shown below. The flight is totally within a region where the Magnetic Variation is 6 degrees WEST.

Course, Headings, Wind Correction, Magnetic Variation (degrees)

TC	WCA	TH	VAR (*)	MH
088	01 L	087	06 W	093
220	15 R	235	06 W	241
332	17 L	315	06 W	321

This completes the Course and Heading definition of the log.

Distance and Time

As a by-proudct of the wind triangle calculations to arrive at a Magnetic Heading for each leg, you also found the Ground Speed for each leg. Using this GS, and the DIST (distance) for each leg (or segment) of the flight, the time and estimated fuel usage can be calculated.

Time, Distance, Groundspeed, Fuel Used per Leg

DIST	GS	TIME	FUEL RATE	FUEL USE
32	139	:14	8.9 gph	2.0
31	78	:24	8.9 gph	3.5
26	83	:19	8.9 gph	2.8

Back to Home	Back to Table of Conents	To Communication

Radio Communication

Flying is greatly facilitated by the ability of the pilot to communicate with ground facilities and other aircraft. In the Navigation chapter, the term “NAV/COM” was used. This chapter will deal with the “COM” part of the radio.

Communication with the following facilities enhances safety, and in many cases is required; These are:

- 1. ATC
  - - Ground Control for taxi instructions
  - - Tower for takeoff and landing instructions
  - - Approach and Departure Radar
  - - ATC enroute Centers for clearances, radar surveillance, and traffic separation
- 2. FSS - Contact with Flight Service Stations for weather information and Flight Plans .
- 3. FBO - Contact Fixed Based Operators for fuel, airport advisories and service.
- 4. AIRCRAFT- Aircraft to aircraft communications. Announce takeoff and landing intentions.

Frequencies

The communication band for civilian aircraft operate in the range of 118.00 MHz to 135.975mhz.

Many transceivers can be tuned to only 360 frequencies(called 360 channels). The frequencies that can be selected are 118.00 to 135.95. Channels exist every 0.05 MHz. Later models are capable of 720 channel operation. They allow a 0 or 5 to be selected for the 6th digit by use of a toggle switch. In one position the 6th digit is zero; in the other position, it is 5. However, to date, virtually all FAA frequencies operate on the 360 channel frequencies.

Phraseology

Good phraseology and standard communication techniques enhance pilot-controller understanding. Jargon, “CB” slang, and vulgarities have no place in aviation communication. When initially identifying your aircraft “N” number, you should use the Phonetic Alphabet. Examples: 7434 X-Ray (7434X), 738 Alpha Lima (738AL), etc. Thereafter, following the initial call-up, controller and pilot will use only the last 3 numbers/letters. Example, 34 X-Ray, or 8 Alpha Lima.

The phonetic alphabet can also be used to spell out words or phrases when communication is difficult to understand. As shown in the table below, a Morse code is also associated with each letter and number. These codes will be heard over NDB and VOR stations as station identifiers.

☆❃❑■❄▼❇❁ ✡●❐❃❁✶❄▼ ❁■❄ ✭❑❐▲❄ ⌘❑❄❄▲

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		

Pronunciation of Figures

Figures indicating hundreds and thousands are pronounced as follows:
· 500 is FIVE HUNDRED
· 5,000 is FIVE THOUSAND
· 4,500 is FOUR THOUSAND FIVE HUNDRED
· 10,000 is ONE ZERO THOUSAND
· 12,600 is ONE TWO THOUSAND SIX HUNDRED

Victor airway numbers such as V12 are pronounced as “VICTOR TWELVE”.

When reciting other number combinations pronounce each digit. For 10, say “ONE ZERO”.

Altitudes are pronounced as ONE ZERO THOUSAND FIVE HUNDRED. Altitudes at and above 18,000 feet are called FLIGHT LEVELS, such as FL180, (Flight level One Eight Zero), FL230 (Flight Level

Two Three Zero), FL 390, etc.

Magnetic Headings are pronounced as:
- Magnetic Course 005° pronounced as “Zero Zero Five”
-True Course 050° as “Zero Five Zero True”
- Magnetic Bearing 256° as “Two Five Six”
- Magnetic Heading 125° as “One Two Five”
- Wind Direction and Velocity 220° at 35kt as “Two Two Zero at Three Five”
Note: Wind direction is given by ATC (Towers etc.) in Magnetic Direction.
Wind given in Weather reports, forecasts, etc. is True Direction

Speeds such as 125 kts. are pronounced as One Two Five Knots”. In communications where speed is implicit, such as a controller instruction to increase speed to 150 kts., the controller may omit the word “Knots”; i.e. may use the term “increase speed to 150”.

Coordinated Universal Time (UTC)

In aviation terminology, time is related to the time at the Zero Meridian, which runs North/South through Greenwich, England. It was formerly called Greenwich Mean Time (GMT). The current terminology is Coordinated Universal Time (abbreviated UTC). When speaking time, pilots and FAA personnel refer to UTC time as ZULU time. The time 1345Z would be pronounces as “One Three Four Five Zulu”.

To convert US time zones to UTC time, add the following hour values.

✮❏❃❁● ▼❏ ❂✶⌘ ✶❇❍❈ ⌘❏■❖❈❐▲❇❏■							
✮❏❃❁● ❋▼❁■❇❁❐❈ ✶❇❍❈ ❁❈❈				✮❏❃❁● ⌘❁❙●❇❁❁▼ ✶❇❍❈ ❁❈❈			
✥❋✶	⌘❋✶	✮❋✶	✩❋✶	✥⌘✶	⌘⌘✶	✮⌘✶	✩❋✶
☞ ✕ ❁❐	☞ ✖ ❁❐	☞ ✗ ❁❐	☞ ✘ ❁❐	☞ ✔ ❁❐	☞ ✕ ❁❐	☞ ✖ ❁❐	☞ ✗ ❁❐

To convert from ZULU time back to US time zones, subtract the number of hours shown.

In addition, time is expressed in Military Time (24 hour time).

Examples:

0000 is pronounced Zero Zero Zero Zero (midnight)
0925 is pronounced Zero Niner Two Five (9:25 a.m.)
1830 is pronounced One Eight Three Zero (6:30 p.m.)

Initial Call-Up Terminology

At your initial call-up, you generally use the following format:

· Who you are calling
· Who are you
· Where are you
· What you want to do or are doing.

Examples :
1. New York Approach, Bonanza Two Three Six Seven Yankee , Over

When calling Approach Control, or other ATC facilities, monitor how busy the controller is. If calling at an active time, simply state the ATC name, your identification, ending with the word OVER. This term means you are requesting the called party to respond.If the controller does not appear busy, and your message is short, you can state the entire message on initial call-up You could have also given your position and altitude. This shortens the total conversation time by initially providing the comtroller more information. Judgement is required here. If the controller cannot respond to your call immediately, their response will be “aircraft calling New York, stand by” or with “Bonanza Three Six Seven Yankee, stand by”.

Note that the controller does NOT say OVER, as no communication by the pilot is required until requested by the controller. The controller has recognized you and will come back as soon as possible.

2. Statesville Unicom, Beech Two Three Alpha Bravo TEN EAST, Airport Advisory, Over

End with the term OVER, since you are requesting a response.

3. Zahns Traffic, Bonanza Seven Four Three Four X-Ray turning base runway Two Zero.

You are announcing to other aircraft in the area where you are, and what you are doing. You do NOT end with the term OVER, as you are not requesting a response.

4. Gainsville Departure, Four Five Foxtrot, Out.

You use the term OUT to indicate the communication is ended, and no further response is expected.

Uncontrolled Airports

At airports without a control tower, it is very important to be alert for other aircraft which may be operating in close proximity to the airport. Other aircraft close to you may not have radio equipment. All radio equipped aircraft operating around an uncontrolled airport should communicate on a Common Frequency.

Common Traffic Advisory Freqiency (CTAF)

Most uncontrolled airports are equipped with a ground station for communication with ground personnel and air to air communication between aircraft operating in the vicinity. This frequency is published within the airport information block on the aeronautical chart. It is called the Common Traffic Advisory Frequency (CTAF) and is denoted by the letter C within either a Magenta or Blue filled circle following the frequency number.

The frequencies will normally be in the range of 122.7 to 122.95. Occasionally, due to a high volume of communication traffic within a geographical area, frequencies above 123.0 MHz may be used. When approaching such airports, call about ten miles out, requesting airport advisory. Normally ground personnel will respond with information about traffic, active runway and wind. It is important to note that such information is advisory in nature. The pilot is the final authority for operation of the aircraft.

You should announce your position and/or intentions for the following situations.

INBOUND
· Entry into downwind Leg
· Turn to Base Leg
· Turn to Final Leg
· Clear of the active runway

OUTBOUND · On the ramp, ready to taxi to departure runway
· Ready for departure, runway to be used , and direction of departure

Ground based stations at uncontrolled airports.

· LLA - Local Airport Advisory - used at airports where a FSS is located. Call the FSS on 123.6 and request airport advisory. Example: “Hickory Radio, Skyhawk 53417 is 10 miles East, at Three Thousand five hundred, landing Hickory. Request airport advisory”. The FSS will respond with Wind direction and Velocity, Altimeter setting, active runway, and any known traffic.

· UNICOM - these are non-government stations operated by the local operator or airport management, to advise about known traffic, which runway is being used, and may advise wind condition. They transmit on 122.7, 122.725, 1228, 122.975 and 123.0

· MULTICOM - frequency 122.9 MHz. Pilots should use this frequency at airports where there is no ground-based communication facility such as UNICOM or LAA. The pilot is to self-announce position and intentions the same as on UNICOM. This procedure allows other aircraft in the area to know where you are and your intentions. The MULTICOM frequency of 122.9 is shown on the charts the same as LAA and UNICOM, with the circled C indicator following the frequency.

Controlled Airports

Communication at control towered airports involve communication with at least 3 facilities.

· Automatic Terminal Information Service (ATIS) (Listen only)
· Ground Control
· Tower

Additionally, at larger airports, there will be:
· Clearance Delivery
· Approach Control
· Departure Control

ATIS

ATIS broadcasts a repetitive tape containing information such as runways in use, altimeter setting, weather conditions, wind direction and velocity, communication frequencies and other information pertinent to operating in the vicinity of or on the airport. Prior to departure, you should listen to ATIS before to calling Clearance Delivery or Ground Control. On arrival, listen to ATIS before callingApproach Control.

Whenever the weather or other conditions change during the day, the recording is updated. Each time a new recording is made, it is assigned an identifier name, starting with ALPHA. Subsequent updates are identified as BRAVO, CHARLIE, etc. When making initial contact with approach Control or Tower on arrival, and Clearance Delivery or Ground Control on departure you should state that you have the ATIS information. Use it’s identifier name; i.e. CHARLIE.

EXAMPLES:
· “Raleigh Clearance Delivery, Bonanza 345 Yankee Foxtrot, ready to depart VFR to the WEST, with information BRAVO. Request clearance.”
· “Greensboro Approach, Cherokee 8734 Juliet, Two Zero East, Three Thousand, inbound Greensboro, with information GOLF”.

Clearance Delivery

At larger airports which have a high volume of operations, Clearance Delivery provides initial departure information to the pilot. This frees Ground Control to concentrate directing traffic on the ramps and taxiways. Clearance Delivery coordinates information with Departure Control by assigning a transponder code prior to becoming airborne. This saves time both for the Ground Controller and the Departure Controller. It allows the pilot to set-up the transponder and departure frequencies prior to dparture, as well as giving the pilot advance information on departure procedures.

The Clearance Delivery Frequency is listed in the Airport/Facility Directory and is included in the ATIS information. In your call-up, state your aircraft type and identification, VFR or IFR, departure direction or destination, and planned altitude.

Clearance delivery will respond like this:

Seven Four Three Fouur X-Ray, you are cleared to depart runway 27 Right VFR westbound. Squawk One Three Five Two. Departure Control frequency is One Two Six Point Seven Five .Contact Ground Control on One Two One Point Niner prior to taxi.

Ground Control

Ground Control is responsible for the flow of aircraft taxiing on the ramps and taxiways. On your call up, identify your aircraft type and number, your location on the airport, with request to taxi. If no Clearance Delivery is at the airport, include the ATIS Identifier. Ground control frequencies can be found on the front panel of the Aeronautical Chart and the Airport/Facility Directory.

EXAMPLE: “Daytona Ground, Beech Six Three Five Four Two at Jet Service Ramp, request taxi, VFR southbound with information GOLF”.

The controller’s response will be similar to:

Beech Six Three Five Four Two taxi straight ahead to taxiway Alpha, turn left and taxi to One Eight Right. Contact tower on One Two Seven Point Five Five when ready.

You respond:

Roger, taxi to Alpha, then left to One Eight Right.
(Note: the term ROGER means that you understand the instruction, and know how to comply).

You should read back the controllers instructions, in particular any ***HOLD SHORT*** instructions. You are under the supervision of Ground Control during your taxi and run-up. When you are ready to depart, you then switch to the tower frequency. Ground and tower controllers are in the same room in the tower, and coordinate the hand-off of traffic to each other.

Tower Control

The tower controls operations on the runways and in the airspace around the airport. After you have completed all pre-flight actions, call the tower on their frequency with the following information.

· Address the Tower. “Memphis Tower
· Who you are . “Skyhawk Five Six Two Three ALFA “
· Your intention. “ ready for takeoff runway Five RIGHT”.

The tower may respond:
Roger, Two Three ALFA cleared to Five Right and Hold.

You acknowledge the instruction, and read back the holding instruction:
Roger Tower. Two Three Alpha, Holding Five Right.

The tower will subsequently clear you for takeoff.
1. It may be in the form :
TwoThree Alpha, taxi into position and hold.
You respond:
Roger, Position and Hold. You taxi onto the runway, but do not take off.

OR

2. It may be clearance for takeoff without holding:
Two Three Alpha, Cleared for Takeoff:

You may respond with “Roger”, or may simply depart. You should monitor the tower frequency until told by the tower to contact Departure Control or until tower ends the communication.

Tower will shortly hand you off to the Departure Control:

Two Three ALFA, contact Departure on One Three Two point Five Five.

You respond:
Departure, One Three Two point Five Five. Two Three ALFA out.

Departure Control

Departure Control is a Radar Service at Class B and C airports. To operate in this environment, you must be equipped with a Mode C (altitude reporting) transponder. The Departure Controller will assign altitudes and headings as required to provide traffic separation. If the controller’s instructions place you into a position to violate VFR rules (such as clearance from clouds) , you should inform the controller to get an amended clearance.

Your initial call to departure control will be something like this:
Memphis Departure, Shyhawk Five Six Two Three ALFA, climbing through One Thousand Niner Hundred, westbound.

Departure may respond:
Roger Two Three ALFA, Radar contact. Turn left to Two Three Zero and climb to two thousand five hundred.

After you are clear of the airport traffic area, the controller may terminate radar:
Two Three ALFA, radar service terminated. Resume your own navigation.

You respond:
Roger. Two Three ALFA Out.

The word "OUT" terminates the communication. However, often controllers and pilots will use "good day" as a more congenial ending.

Approach Control

Approach Control is a radar service similar to Departure Control. Contact with Approach Control is mandatory prior to entry into Class B and C airspace. On initial call-up, identify type and number of aircraft, position, altitude and destination. The controller will respond with a "SQUAWK" code for the transponder.

Example: The initial call-up can be:

Daytona Approach, Cherokee Six Five Two Three ROMEO, Saint Augustine VOR, Three Thousand Five Hundred, inbound Daytona.

Response:

Cherokee Six Five Two Three ROMEO, this is Daytona Approach. Squawk Two Three One Five and Ident.

You set the squawk code 2315 into the transponder, press the ident button, and respond:
Roger, Two Three One Five and ident.

After the controller identifies you on the radar screen, the controller will confirm:
Two Three ROMEO Radar Contact , Two miles south of Saint Augustine VOR. Descend to two thousand five hundred.

You respond:
Roger, Two Three ROMEO descending to two thousand five hundred.

You acknowledge the instruction. The radar controller will continue to track your "blip" on the radar screen, give traffic advisories as necessary, and may vector you into the downwind leg in the pattern. The controller will then hand you off to the tower controller for landing instructions.

If you are flying through Class C airspace without landing, tell the controller the planned route of flight and altitude you wish to maintain. Radar Flight Following will be granted outside the class B or C airspace on a "workload permitting" basis upon pilot request. The radar surveillance usually can be provided up to 20 or 30 miles from the radar site.

Transponder Operation

There have been a number of modes of transponder operation during it's history. The mode now required for operation in Class B and C airspace is Mode C. This mode couples an encoder in the altimeter which reports the altitude in hundreds of feet. The Transponder also has 4 digital dials, each with numbers 0 through 7. Therefore, number combinations from 0000 to 7777 can be dialed in. This is called the "SQUAWK code. The numbers 7500, 7600 , 7700 and 7777 are reserved for special use:

· 7700 - emergency
· 7600 - lost radio communications
· 7500 - code for hijacking
· 7777 - used by military

The transponder operates by receiving an interrogation signal from the radar station. It in turn returns certain coded information back to the radar when the transponder is set for normal operation. The SQUAWK code and the altitude in hundreds of feet are returned to the radar. The controllers radar scope shows a "blip" on the radar screen along with the SQUAWK code and altitude.

A Mode C altitude reporting transponder is required:
· When flying at or above 10,000 feet
· When flying within Class B Mode C veil (30 Nm around a Class B airport). (Note: there are exceptions for operations into smaller airports which lie within the 30 Nm veil).
· When flying in or above Class C airspace
· When crossing the U.S Air Defence Identification Zone (ADIZ).

The unit is equipped with a rotary switch with several positions.
· OFF - turns the transponder off
· STY - (Standby) - turns the transponder for warm-up. The transponder does NOT respond to the radar interrogation signals.
· ON - Turns the transponder on and allows it to respond in Mode A (No altitude reporting). This shown a blip on the radar screen but NO ALTITUDE DATA.
· ALT - Allows a reply in either Mode A (no altitude report) or Mode C (altitude report) as requested by the radar interrogating signal.

A button, called the IDENT BUTTON, when depressed sends a special identifying signal to the radar. The IDENT should only be sent when requested by the controller.

Controllers may use the following terminology when referring to transponder operation
· SQUAWK (number) - set the 4 digit code into the transponder. Example: Squawk 4316.
· IDENT - depress the IDENT Button
· Squawk (number) and IDENT - set code into the transponder dials, then IDENT.
· SQUAWK STANDBY - Switch function switch to STY
· SQUAWK ALTITUDE - Switch to ALT position
· STOP ALTITUDE SQUAWK - Switch from ALT to ON
· SQUAWK MAYDAY - select code 7700

· STOP SQUAWK - turn transponder off
· SQUAWK VFR - select code 1200 when operating without ATC contact. 1200 is known as the VFR squawk code.

Radar Assistance to Lost Aircraft

Never hesitate to contact radar services when in serious doubt of your location, are encountering poor weather, or are in need of other assistance. When flying cross untry, it is good practice to keep track of, or know where to find, the various approach control services available along your route. This should be a part of your flight planning. Even the Air Traffic Control Centers (ARTC) which normally handle enroute IFR flight will render assistance to lost aircraft.

If radar frequencies are not readily available, contact the nearest Tower or FSS, and provide then with the best location data you can. They will coordinate with, or refer you to the nearest radar facility. Usually an emergency situation can be avoided by requesting assistance as soon as you are not sure of your position.

ATC can give you radar vectors to your destination or suitable alternate airport.

Emergency Locator Transmitter (ELT)

Emergency locator Transmitters have been developed to transmit a locating signal in the event of significant impact. They are battery powered, and self contained. When activated by impact, they transmit a homing signal on 121.5 and 243.9 Mhz. This signal provides homing for search and rescue equipment.

The power source must be capable of sustaining the signal for 48 hours.

The ELT is equipped with a gravity activated switch, which automatically activated the ELT upon significant impact.

They generally have 3 switch positions:
· ON - causes a continuous broadcast of the signal on 121.5 and 243.0 MHz. This position is used for test purposes.
· OFF - no broadcast is possible
· ARMED - means the gravity switch can be activated in the event of sufficient impact.

DO NOT INADVERTENTLY ACTIVATE THE ELT WHILE ON THE GROUND. THIS COULD CAUSE AN UNNECESSARY EXPENSIVE SEARCH.

Aerobatics, or hard landing have been known to set off an ELT. A good check for a false ELT signal is to turn a radio receiver to 121.5 MHz prior to engine shut-down. If the ELT has been triggered, you will hear a steady signal on this frequency. Corrective action should be taken.

ELT's should be tested in accordance to manufacturers instructions. Testing should preferably be done in a shielded room. Tests should be conducted only during the first 5 minutes after the hour. If a test is to be made at any other time, it should be coordinated with the Control Tower or FSS.

ELT batteries must be replaced or recharged:

· If the battery has been used more than one hour cumulative.

· When 50% of the useful life of the battery has expired.

Principles of Weather

Weather for Pilots USA Today Pilots Information.
How The Weather Works Good classroom on weather.
Index of Weather Subjects USA Today General Weather Info.
Pressure Systems Explanation of Atmospheric Pressure.
The Atmosphere A guide to the atmosphere.
A Guide to Sattelite Images...Interpreting Sattelite Images

Back to Home	Back to Table of Conents	To Weather Reports

Weather Reports and Services

The U.S. Weather Service provides numerous weather forecasts, reports and warnings significant to aviation operations. These are generally of the following categories.

Aviation Forecasts and Reports	
Weather Pictorials	Sattelite and Radar Images
Forecasts	Area, Terminal (TAF) and Winds Aloft Forecasts
Current reports	Hourly Terminal Weather Reports (METAR)
Warnings	PIREPS, SIGMETS, AIRMETS

- Weather Pictorials include Radar Images and Sattelite Images. This allows the pilot to "get the big picture" of Highs, Lows and Fronts.
- Forecasts are of the type
  - Area Forecasts - this describes the weather patterns for a wide area, covering several states. They are designated by as an "FA" type designator. They are issued 3 times a day, It includes a ***12 hour forecast*** plus a ***6 hour outlook.***

    This link will connect you to the current National Weather Service Current Area Forecast page.
  - Terminal Forecasts (TAF) - these are forecasts made for large cities, and cover the general area around the designated city. See the METAR and TAF link below for a more detailed description. They are issued 3 times a day, and contain a ***12 hour forecast*** plus a ***6 hour outlook.***See the METAR/TAF conversion card definition for more information on TAF report format and interpretation.
  - Winds Aloft Forecasts (FD) - these are issued every 6 hours, and give the wind speed, direction and temperature at certain designated cities at graduated altitudes. These are 3000, 6000, 9000, 12,000, 18,000, 24,000, 30,000, 34,000 and 39,000 feet altitude. The forecast generally covers a fairly wide area around a central designated city. Click here for current Winds Aloft Forecasts. They are needed to calculate Wind Correction Angle and Estimated Groundspeed for your flight.
- Actual Weather Reports
  - METAR reports are the hourly terminal aviation reportsof the actual weather conditions at airports which have weather oberservation capability. The observation is usually made about 10 minutes before the hour, each hour. Therefore a report of actual weather conditions at the reported airports is available every hour. See the METAR/TAF conversion card definition for more information on METAR report format and interpretation. For actual current briefing information, view the National Weather Bureau's Standard Briefing Page. Caution: this is to be used for general information purposes only. You should get a **formal pre-flight**

briefing from the FFS station in your area prior to your flight.

- Warnings and In-flight Reports
  - PIREPS - Pilot Reports - These are in-flight reports made by pilots to ground stations whenever the pilot encounters conditions which are significant to other pilots operating in the area. They will usually report significant turbulence, change in weather conditions and cloud tops, etc. These are available only through the FSS station, and should be given to you, if applicable, during your Standard Weather Briefing.
  - SIGMETS- Significant Meterological Reports - are issued to advise pilots of nonconvective weather considered potetially hazardous to **ALL** aircraft. They include notification of Severe Icing, Severe or Extreme Turbulence, Duststorms, Volcanic Ash, or Sandstorms which lowers the in-flight or surface visibility below 3 Statute Miles. Volcanic eruption and tropical storms and hurricanes are also included. They are valid for 4 hours.
  - AIRMETS - These are reports of weather ***significant to light aircraft***. They are valid for 6 hours. They indicate moderate Icing, moderate Turbulence, sustained Surface Winds of 30kt or more, ceiling less than 1000 ft. or visibility less than 3 miles. Extensive Mountain Obscurement is also included,

---

This link is a source for many types of Aviation related Images, Forecasts and Reports. **See this link for current SIGMETS and AIRMETS.** This link will lead you to many National Weather Services. It should give you the latest up-to-date information on weather services.

Back to Home	Back to Table of Conents	To Other Publications

OTHER PUBLICATIONS

There are several additional publications of interest to the pilot. These are:

· Airport/Facility Directory (A/FD)
· Aeronautical Information Manual (AIM)
· Notices to Airmen (NOTAMs)

All three of these publications are very important to the general knowledge of the pilot and to safe flight operations. The AIM and A/FD should be a part of every pilot's library.

Airport/Facility Directory

The A/FD is published every eight weeks by the National Ocean Service (NOS), a division of NOAA. It is published for seven regions of the US.

1. Northwest
2. Southwest
3. North Central
4. South Central
5. East Central
6. Northeast
7. Southeast

The A/FD is a very important part of your flight planning.

Most airports which sell aeronautical charts and supplies will have the A/FD for their region. You may order any of the directories from National Chart Services (such as Jeppesen Sanderson, Inc.) or order directly from:

NOAA, N/CG33, Distribution Branch
Riverdale, MD 20737
Telephone (301) 436-6933

The directory covers the following information:

· Abbreviations used in the directory
· Legend for the A/FD information
· Airport and Facility Information (Airports, VOR's, NDB,s etc.)

· Heliports and Seaplane Bases
· Special Notices on airports, temporary restricted/special use airspace)
· FAA and Weather Service Telephone Numbers
· Air Traffic Control Center information
· Flight Service Station (FSS) communication frequencies.
· Flight Safety District Offices (FSDOs) Addresses and telephone numbers
· Preferred IFR routes
· VOR Receiver Checkpoints
· Parachute jumping areas
· Aeronautical Chart Bulletins (changes to charts since last publication)
· Enroute Flight Advisory Service (EFAS)
· Directory Legend

Aeronautical Information Manual

See the complete Aeronautical Information Manual

This publication contains extensive information for pilots. It is continually updated by the FAA and a complete re-write is published frequently. An individual update subscription service is available for those persons who need to be informed of the updates on a timely basis. The AIM covers the following subjects (Based on the 1996 edition).

Chapter 1 Navigation Aids

Aeronautical Information Manual Chapter 1
Section 1 Air Navigation Radio Aids
Section 2 Radar Services and Procedures

Chapter 2 Aeronautical Lighting and Other Airport Visual Aids

Aeronautical Information Manual Chapter 2
Section 1 Airport Lighting Aids
Section 2 Air Navigation and Obstruction Lighting
Section 3 Airport Marking Aids and Signs

Chapter 3 Airspace

Aeronautical Information Manual Chapter 3
Section 1 Airport Lighting Aids

Section 2 Controlled Airspace
Section 3 Class G Airspace
Section 4 Special Use Airspace

Chapter 4 Air Traffic Control

[Aeronautical Information Manual Chapter 4]

Section 1 Airport Lighting Aids
Section 1 Services Available to Pilots
Section 2 Radio Communication and Phraseology
Section 3 Airport Operations
Section 4 ATC Clearances and Separations

Chapter 5 Air Traffic Procedures

[Aeronautical Information Manual Chapter 5]

Section 1 Preflight
Section 2 Departure Procedures
Section 3 En Route Procedures
Section 4 Arrival Procedures
Section 5 Pilot/Controller Roles and Responsibilities
Section 6 National Security and Interception Procedures

Chapter 6 Emergency Procedures

[Aeronautical Information Manual Chapter 6]

Section 1 General
Section 2 Emergency Services Available to Pilots
Section 3 Distress and Urgency Procedures
Section 4 Two-Way Radio Communication Failure

Chapter 7 Safety of Flight

[Aeronautical Information Manual Chapter 7]

Section 1 Meteorology
Section 2 Altimeter Setting Procedures
Section 3 Wake Turbulence
Section 4 Bird Hazards and Flight Over National Refuges, Parks, Forests

Chapter 8 Medical Facts for Pilots

Aeronautical Information Manual Chapter 8
Section 1 Fitness for Flight

Chapter 9 Aeronautical Charts

Aeronautical Information Manual Chapter 9
Section 1 Types of Charts Available

Pilot/Controller Glossary

Airport Advisory Circulars

Non-regulatory information type documents are available to the aviation community called Advisory Circulars. A listing of these circulars may be obtained from:

U. S. Department of Transportation
General Services Section,
M-443.2
Washington, D. C. 20590

The circular numbers and ordering information is contained in a document called the “Advisory Circular Checklist AC.00-2

A major index of circular subjects is shown on the next page. The subjects are coded by General Subject Number and then by Specific Subject.

The General Subject Number of greatest interest to the Private Pilot are:

Notices to Airmen (NOTAM)

Notices to Airmen (NOTAMs) contain time-critical information that is either of a temporary nature, or has not yet been reflected on the latest charts and publications. They cover airport and runway closures, navigational facility outages or frequency changes, etc.

There are 3 typrs of NOTAMS of interest:
1. Locally Distributed NOTAMS(L)
2. NOTAMS Distributed to Distant Location - NOTAM(D)
3. Federal Distribution Center Notices (FDC NOTAMS)

A bi-weekly Notices to Airmen Publication called NTAP is published. Once the information has been published, it will not be provided in your pre-flight briefing by the FAA unless you request such information.

The publication contains two sections:

1. NOTAMs(D) that are expected to remain in effect for a long time and FDC NOTAMs which are expected to stay in effect for more than 7 days. Occasionally a NOTAM(L) will be included if it is deemed important to flight safety.
2. Special notices that are too long for normal publication or which cover large geographical areas.

These are NOTAMS that relate principally to facilities and airports within the jurisdiction of the issuing FSS station. It covers information handy to know, such as runway closings, construction areas at airports, and information that is not critical to safety or navigation.

It is distributed to Operators and Control Towers within the FSS jurisdiction. These NOTAMS are not routinely covered in pre-flight briefings unless requested by the pilot.

NOTAM (D)

These are notices about airports and facilities that are important to navigation and operational safety. They cover all navigational aids in the National Airspace System, and all airports listed in the A/FD. They are distributed broadly, and beyond the jurisdiction of the issuing FSS.

They are significant to your flight planning, and should be included in your pre-flight briefing. You should always insure that you have been briefed on the NOTAMS along you route of flight.

FDC NOTAMS

These are NOTAMs issued by the Federal Distribution Center and are regulatory in nature. They cover such things as changes to aeronautical charts, new hazards to flight, new restrictions to flight, changes in instrument approach facilities and procedures, etc.

Flight Service Stations are required to keep on file all FDC NOTAMS within 400 miles of their location.

Back to Home	Back to Table of Conents	To Federal Aviation Regulations

Overview of Federal Aviation Regulations

.
Federal Aviation Regulations

Back to Home	Back to Table of Conents	To Aeromedical Factors

AEROMEDICAL FACTORS

Medical Certification

All airplane pilots must be in possession of a valid Medical Certificate whenever exercising the responsibility of Pilot in Command, or when acting as a required crew member. A THIRD CLASS certificate is required for the Private Pilot not flying for hire.

The FAR's prohibit a pilot from performing crew member duties when you have a known medical condition which would normally disqualify you for the certificate. This includes a relapse of a former condition, of an aggravation of a medical condition which would not qualify for the certificate during such aggravation.

Personal Checklist

Pilot impairment is a greater contributor to accidents than is aircraft failure. Such accidents may be due to medical conditions, exceeding your personal experience level, flying into weather conditions for which you are unqualified to handle, alcohol or drug use, stress, or an "attitude of get there at all cost".

A good personal checklist is "IM SAFE".

I llness
M edication

S tress
A Alcohol
F atigue
E motion

Illness

Even minor illness can be a cause of concern. Fever, symptoms, and drugs can impair the ability to reason and calculate. Alertness and Memory may also be impaired. The best rule is "If not feeling well, don't fly".

Medication

Many medications such as antihistamines, blood pressure medication, tranquilizers, pain relievers, and cough suppressants may have narcotic effects affecting mental and physical faculties. The safest rule is not to fly while taking any medication. If in question about any medication, consult with an FAA

Designated Medical Examiner.

Stress

Stress, anger and worry can affect a persons rational thinking process. The stress and worries detract from the ability to remain mentally alert. Such mental interference can blur judgment, memory recall, and impede attention to the flight environment. It is best to wait until the stressful situation has passed, and to fly safely another day.

Alcohol

One ounce of liquor, a bottle of beer or four ounces of wine can significantly impair flying skills. Night flying and alcohol is a particularly deadly combination because if vision impairment.

The FAR's prohibit pilots from flying or acting as a crew member within 8 hours of consuming any alcohol. This is the MINIMUM. A much better rule is 24 hours from bottle to throttle. Alcohol can significantly contribute to altitude oxygen deficiency as alcohol inhibits adequate oxygen absorption by the brain.

Fatigue

Fatigue may not be apparent until you have made a serious mistake. It may be a short term condition such as too little sleep the night before. All you need to recover is a good nights rest. It may also be a long term condition to which you have become accustom, but which prevents you from your peak performance. Such a condition requires a prolonged period of rest.

Fatigue leads to lethargy in the cockpit, impaired reasoning and judgment. It can lead to "getting behind the situation" if sudden unexpected situations occur.

Emotion

Emotion applies to your state of mind. You may be angry, irritated, or just mildly "out of sorts". Obviously flying under these conditions is unwise. Emotion can also apply to your attitude about flying. Do you feel bold and invincible? Are you on the fence as whether the weather is go or no-go? Do you have a "must get there at all cost" mentality? Have you assessed your personal experience and capabilities for the given flight conditions? Have you set your "own go and no-go rules? Are you being bugged by a passenger "who has just got to get there NOW?

A good strategy is to evaluate your own experience, capability, and personal flight rules before you plan any flight. If the situation does not fit your pre-determined rules, THEN DON'T. When you feel uneasy about the flight conditions, the safest rule is wait for a better day or time. There is no cowardice in setting down and setting out the weather.

Scuba Diving

If you or a passenger have been scuba diving, you should allow sufficient time before flight to allow your body to rid itself of excess nitrogen in the blood. If this is not done, decompression sickness (the bends) can occur at altitude, creating a serious in-flight emergency.

For a dive which has not required controlled ascent, you should wait at least 12 hours before flying above 8,000 feet cabin altitude. For a dive that has required controlled ascent (decompression), the time allowed should be 24 hours for flight above 8,000 feet cabin altitude.

In-Flight Medical Conditions

The pilot should remain aware of several In-Flight conditions which can occur which will impair your ability to adequately function.

· Hypoxia
· Hyperventilation
· Carbon Monoxide
· Motion Sickness
· Sinus and Ear Block
· Spatial Disorientation
· Fear

Hypoxia

Hypoxia results from an oxygen deficiency. The lack of adequate oxygen affects the functioning of the brain and other organs. A sense of “well being”, belligerence, drowsiness, dizziness and headache can result. It has the same effect as early stages of inebriation.

Pilot performance can deteriorate significantly if operating at 15,000 feet for even a short time without supplemental oxygen. Visual acuity becomes impaired. Pheriperal vision turns gray, with only the central vision functioning (tunnel vision). Blue color (cyanosis) occurs at the extremities such as fingernails, and in the lip color.

At 15,000 feet you loose the ability to function correctly within 20 to 30 minutes. At 20,000 feet, these effects occur within 5 to 12 minutes.

Significant effects of hypoxia can occur at lower altitudes as a result of:

· Inhalation of carbon monoxide while smoking
· Small amounts of alcohol or certain drugs (antihistamines, tranquilizers, analgesics, sedatives).
· Extreme heat or cold

· Fever
· Anxiety or fear

Use of supplemental oxygen above 10,000 feet in day and 5,000 feet at night will inhibit the onset of hypoxia.

Hyperventilation

This is the abnormal increase in the volume of air breathed in and out. It can occur subconsciously when under stress or fear. The rapid breathing and excess oxygen flushes too much of the natural carbon dioxide from your system. The symptoms are dizziness, tingling of the extremities, hot and cold sensations, drowsiness, nausea and feelings of suffocation.

Recognition of these symptoms often lead to more apprehension and fear resulting in increased hyperventilation. Disorientation, muscle spasms, and unconsciousness if corrective action is not taken.

Corrective action can be breathing slowly into a paper bag held over your nose and mouth. Also, talking, singing, and counting out loud can assist in taking your mind off the apprehension causing the rapid breathing.

It should be noted that many of the symptoms are common to both hypoxia and hyperventilation. If you are using an oxygen system when symptoms occur, turn the oxygen regulator to 100%.

Carbon Monoxide

Carbon monoxide results from the incomplete burning of materials. It is usually found in engine exhaust and cigarette smoke. Carbon monoxide is tasteless, odorless, and invisible. It is however usually present in fumes which are detectable. In an aircraft, cabin air is heated by intake air flowing across the exhaust manifold. Lleakage of fumes from the exhaust system into the heated airflow can be dangerous. You should be particularly cautions when operating in cold weather.

Exposure of even a small amount of carbon monoxide over a long period of time can significantly impair pilot performance. Symptoms are feeling of sluggishness, headache, tightness across the forehead. These may be followed by increasing symptoms of throbbing in the temples, or ringing in the ears. Large accumulations can lead to vomiting, convulsions and death.

Motion Sickness

Motion sickness from the stimulation of the inner ear which controls your sense of balance. The symptoms are progressive. They are loss of desire for food, excessive saliva, perspiration, nausea, and tendency to vomit.

If you or a passenger are suffering from airsickness, you should:

· Open air vents
· Loosen clothing
· Use supplemental oxygen if available
· Keep eyes on a point outside the aircraft
· Avoid rapid or unnecessary head movements
· Land as soon as possible

Pilots susceptible to motion sickness should NOT take motion sickness drugs. Research has shown these drugs may cause temporary disorientation, loss of navigational skills, or other functions which demand keen judgment.

Sinus and Ear Block

During ascent and decent the pressure inside the sinuses normally adjust to the cabin pressure. Conditions such as colds and nasal infections can significantly close the passages which permit this pressure equalization. This causes sinus block. It can cause significant pain in the affected sinus region, tooth ache, and mucus discharge from the nasal passages.

During decent, the Eustachian tube of the middle ear opens to allow pressure relief into the nasal passages. During decent the pilot should periodically reopen the Eustachian tubes by swallowing, yawning, tensing muscles in the throat or chewing. If this fails, blowing with the nose with the mouth closed and the nose pinched off can usually equalize the pressure.

A cold or ear infection can produce enough mucus in the Eustation tube to prevent pressure equalization. This results in ear block.

If either sinus block or ear block persists for some period after landing , consult a physician. Rupture of the ear drum or infection in the ear can result from failure to relieve the condition after some period of time.

Spatial Disorientation

Spatial disorientation (formerly referred to as vertigo) results from loss of visual contact with terrain or other visual reference points. It is the result of confusing sensations sent to the brain by the muscles and inner ear when visual reference is lost. One cannot tell whether they are ascending, descending or turning.

It is a REAL threat to the VFR pilot who has had insufficient training in flying solely by reference to instruments. Much of the training of instrument pilots is devoted to the reliance and interpretation of the instruments instead of their sensations.

Situations which can quickly lead to spatial disorientation are:

· Flight into cloud
· Flight at night over unlighted terrain (loss of horizon reference)
· Facing the sun in haze condition
· Flying above a cloud layer with sloping top

If inadvertently caught in such condition, DON'T PANIC. If you have been trimmed out for straight and level, do not make any drastic or sudden moves in the attitude of the aircraft. LOOK AT YOUR COMPASS HEADING.

Get On The Gauges. Concentrate on flying by the instruments. Learn how to use them and to trust them. Keep a level attitude. Your worst enemy is getting into a steep bank. If need be, turn the aircraft with light rudder pressure only, with hands off the wheel or stick. Even though this is an un-coordinated turn, you will not get the aircraft into a dangerous unusual attitude. Try to get out of the condition by slowly doing a 180° turn, or a turn away from the conditions causing the disorientation. Keep your angle of bank 15° or less. A 15° bank will take you 1 minute to complete a 180° turn.

Fear

We all at times experience fear. The question is how do we respond to fearsome situations. Flying is not without it's anxious moments. It is easy to say "DON'T PANIC"; but that is exactly what is required of the pilot in command.

The best defense against fear is TRAINING. This is why your instructor will put you into situations which will test your perception and judgment skills. Even after you obtain your private license, continue to train and learn. Flying is a lifetime learning experience. After you have achieved some experience, consider obtaining an instrument rating. Weather situations will be the prime cause for anxious moments. The more confidence you can gain in handling instrument conditions, the safer you will be.

This does NOT mean pushing yourself beyond your training; rather it means getting the training and experience to handle whatever situation that may arise. There is a trite but true saying that "there are bold pilots, and there are old pilots; but there are no old bold pilots". There are however many old experienced pilots around who have flown thousands of hours safely and with confidence. Ability and confidence is the key to handling fear.

Vision

Good vision is important to safe flying. The eye contains two different light sensitive nerve endings called the RODS and the CONES. They are located in the back of the eye in the area called the retina.

The CONES are concentrated around the center of the retina, and decrease in number as the distance from the center of the retina increases. They are the nerves which predominately detect color, details and distant objects. They function in daylight and moonlight.

The RODS are concentrated around the area of the cones, and increase in number as the distance from the center of the retina increases. Their function is to detect objects in motion out of the corner of the eye (peripheral vision). They function in daylight, moonlight and darkness.

This is an important concept to understand with regard conflict avoidance with other aircraft. During the day, objects can best be seen by looking directly at them. Your scan for other aircraft and objects should be in deliberate scan increments of about 10 degrees. Look at this area for several seconds, then look at the next 10 degree increment in your scan. Pausing to concentrate on a given area of vision is important since the eye cannot detect distant objects when in a continuous scan movement.

At night, vision is more dependent on the RODS. “Off-center viewing” is best. The eye is more adept to seeing objects through the use of peripheral vision. With some practice, you can see objects better by using “off center” viewing rather than looking directly at them.

When entering darkness, the pupils of the eye enlarge to receive as much of the light as possible. It will take 5 to 10 minutes for the adjustment to increase your “dark” vision by a factor of 100. After 30 minutes, the rods will be fully adjusted, and the rod’s sensitivity to light will become approximately 100,000 times more sensitive to light than in bright light.

For night flight, you should allow your eyes to adapt to the darkness for some time to achieve best night vision acuity. Once your vision has adjusted, guard against exposing your eyes to bright light, as temporary blindness and illusion can result.

Night vision can be adversely by low oxygen levels at altitude. It is best to keep cabin altitude to 5,000 feet or less at night. In higher altitude is necessary, use of oxygen is advised. Smoking can reduce night vision by as much as 20%.

Personal Evaluation

Often pilots are tempted to demonstrate their skill to others, and to prove they are made of the right stuff. This leads many pilots into serious pitfalls. Every pilot should continuously and HONESTLY evaluate their medical fitness for flight, and their skills and competency.

Pitfalls

All experienced pilots have at one time or another had to face some dangerous attitude situations and pressures. Some of these are:

· **Peer Pressure -** This is based on an emotional response to equal or exceed the skills of your peers which push you beyond realistic evaluation of your situation

· **Mind Set -** may make you fail to realistically recognize and cope with the situation.

· **Get there at all Cost-** this can result in business schedules or friends who are relying on you "to get there". This is probably the greatest single cause of weather related accidents. It causes one to "press on" to the initial objective, rather than select safer alternative actions when things do not go as planned. There is no shame in "setting out the weather".

· **Duck Under -** the tendency for pilots to go below "minimums" on an instrument approach to "sneak a peek" hoping to avoid a "missed approach".

· **Scud Running -** is trying to fly below the scud (clouds) without hitting the ground. It's trying to make it there in poor MVFR (or less) conditions by dodging the clouds at low altitudes and visibility.

· **Continuing VFR into IFR conditions -** Continuing flight into weather conditions adverse to VFR flight.

· **Getting behind the aircraft** - this occurs when events are controlling you instead of you controlling the events.

· **Loss of positional awareness** - its the situation where your instructor says "Enough for today, take me back to the airport"; and you have no idea which way it is. You have been so occupied with other matters that you do not know where you are.

· Operating with inadequate Fuel Reserves - This occurs when the pilot fails to properly plan the trip, fails to observe flight progress, and becomes non-responsive to the VFR and IFR fuel reserve regulations. It also occurs to pilots who are lost, and delay getting help from ATC.

· **Inadequate Planning** - Failure to plan the course and alternative actions. Negligent pre-flight inspection. Failure to use check lists. Failure to maintain positional awareness in flight.

Hazardous Attitudes

· Authority (Don't tell me what to do)
· Impulsivity - (Do Something NOW!)
· Invulnerability - (It won't happen to me)
· Macho - (I can do anything)
· Resignation - (What's the use)

Back to Home	Back to Table of Conents

Preflight Services

All Air Traffic Control Specialists assigned to AFSS are certified by the National Weather Service as Pilot Weather Briefers. Pilot Weather Briefers are authorized to translate and interpret available NWS products describing the enroute and destination weather. The leading contributing factor to general aviation accidents is weather. Pilot Weather Briefers are trained to help you avoid dangerous situations.

PREFLIGHT BRIEFING

The Airman's Information Manual states that pilots-in-command, **BEFORE BEGINNING A FLIGHT**, shall familiarize themselves with all available information concerning that flight.

FSS's (Flight Servics Stations) are the primary source for obtaining preflight briefings and in-flight weather information. Pilots may walk into AFSS (Automated Flight Service Station) to review available aviation weather products and charts, or they may choose to use telephones or radio.

Three types of preflight briefings are available: the Standard Briefing, Abbreviated Briefing, and the Outlook Briefing. Make it clear to the briefer at the outset what type of briefing you require, and then provide background information about the proposed flight. Required background information includes:

- Type of Flight: VFR or IFR
- Aircraft Identification or Pilot's Name
- Aircraft Type
- Departure Point
- Estimated Time of Departure
- Altitude
- Route-of-Flight
- Destination
- Estimated Time Enroute

Background information is mandatory data for the weather briefer. If any of these nine items are missing, a briefer may be unable to properly tailor the briefing to the specific flight the pilot has planned.

STANDARD BRIEFING

A Standard Briefing includes complete weather and aeronautical information for flight planning. Request a Standard Briefing when the flight will occur within six hours of the briefing. A Standard Weather Briefing includes:

- *Adverse Conditions* - Current or forecast conditions which may adversely affect a planned flight, such as Convective SIGMETS, SIGMETS, AIRMETS, and Center Weather Advisories. Adverse conditions include (but are not limited to) icing, turbulence, thunderstorms, mountain obscuration, and instrument flight conditions.

- *VFR Flight Not Recommended (VNR)* - When VFR flight is proposed and the actual or forecast conditions, surface based or aloft, in the briefer's judgment, make visual flight doubtful. Remember, the final go/no-go decision always belongs to the pilot.
- *Synopsis* - A brief statement describing the type, location, and movement of weather systems affecting the flight.
- *Current Conditions* - A summary of the current weather along the proposed route. The current weather is omitted when the estimated time of departure is more than *two hours* from the time of the briefing, unless requested by the pilot.
- *Enroute Forecast* - Summarized from various sources, to provide forecast conditions along the proposed route of flight.
- *Destination Forecast* - A destination forecast including significant changes one hour before and after the estimated time of arrival.
- *Winds Aloft Forecast* - Available at 3,000; 6,000; 9,000; 12,000; 18,000; 24,000; 30,000; 34,000 and 39,000 feet.
- *Notices to Airmen* - NOTAM D, NOTAM L, and non-published FDC NOTAMS.
- *ATC Delays* - Information on known ATC delays (IFR only). Information on military training activity and published NOTAMS are provided upon request.

View the National Weather Bureau's Standard Briefing Page. Caution: this is to be used for general information purposes only. You should get a **formal pre-flight briefing from the FFS station** in your area prior to your flight.

ABBREVIATED BRIEFING

Request an Abbreviated Briefing to supplement or update previously received information. Here are three examples of situations where an Abbreviated Briefing will work to your advantage:

- You received a Standard Briefing earlier in the day. An Abbreviated Briefing could be requested for those items that have changed, such as current weather or updated forecasts. The briefer will need the background information and the time of the earlier briefing.
- When you want only one or two items, request an Abbreviated Briefing and state the specific aviation weather products you need. "This is N12345, I would like an Abbreviated Briefing, the current and forecast weather at Bakersfield." Remember to provide the briefer with enough information to complete your request. In this example, Estimated Time of Arrival at Bakersfield would be required.

The important point about an Abbreviated Briefing is what it does not do: it does not provide a complete weather picture of the route of flight. It should never be used as a shortcut for a standard briefing. An Abbreviated Briefing can save time if you have already received a Standard Briefing.

OUTLOOK BRIEFING

When the Estimated Time of Departure is more than six hours away, request an Outlook Briefing. After receiving the background information, the briefer will provide forecast data applicable to the proposed flight.

If any portion of a briefing is unclear to you, stop the briefer and get the point clarified. Save your general questions until the end of the briefing.

OTHER AVIATION LINKS

- Aviation Servers Harvard
- The NASA Homepage
- FAA Home Page
- FAA Technical Center
- Misc Aviation Misc Aviation Links

This page hosted by Get your own Free Home Page

Return to Index

OTHER WEATHER SOURCES

- Ohio State U. Atmospheric Science Program
- NCAR National Center for Atmospheric Research.
- Michigan State U. Actual Weather Images
- Indiana U. Actual Weather Images
- Weather Channel Actual Weather Images
- USA Today Weather Good Educational Stuff Also
- U. North Carolina Weather Page
- Intellicast Weather Search
- U. North Carolina at Charlotte East Coast Weather
- CNN WX Global Images
- How the weather works Good Educational Material.
- Weather Images.
- PurdueWeather Dept WX Images and Maps
- U. MichiganOver 300 Weather Locations