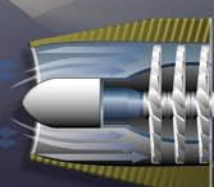
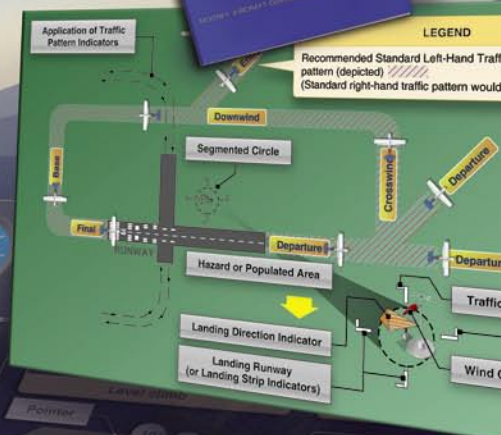
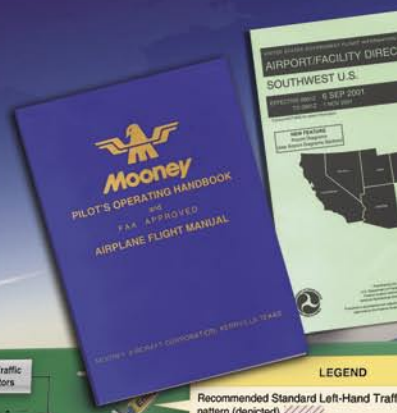
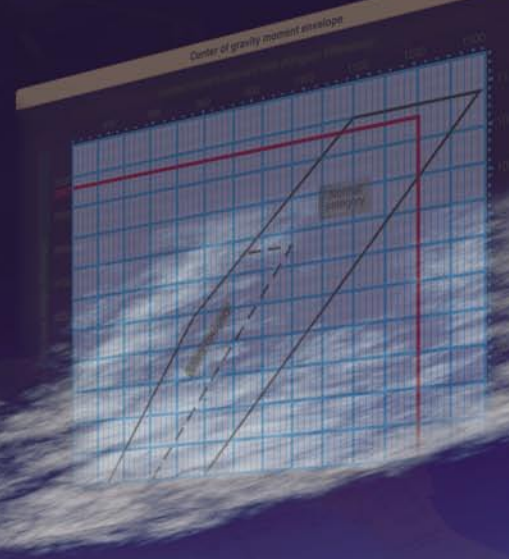


Pilot's Handbook of Aeronautical Knowledge



U.S. Department of Transportation
Federal Aviation Administration



Pilot's Handbook of Aeronautical Knowledge

2008

U.S. Department of Transportation
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service

Preface

The Pilot's Handbook of Aeronautical Knowledge provides basic knowledge that is essential for pilots. This handbook introduces pilots to the broad spectrum of knowledge that will be needed as they progress in their pilot training. Except for the Code of Federal Regulations pertinent to civil aviation, most of the knowledge areas applicable to pilot certification are presented. This handbook is useful to beginning pilots, as well as those pursuing more advanced pilot certificates.

Occasionally the word "must" or similar language is used where the desired action is deemed critical. The use of such language is not intended to add to, interpret, or relieve a duty imposed by Title 14 of the Code of Federal Regulations (14 CFR).

It is essential for persons using this handbook to become familiar with and apply the pertinent parts of 14 CFR and the Aeronautical Information Manual (AIM). The AIM is available online at www.faa.gov. The current Flight Standards Service airman training and testing material and learning statements for all airman certificates and ratings can be obtained from www.faa.gov.

This handbook supersedes FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge, dated 2003.

This handbook is available for download, in PDF format, from www.faa.gov.

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Airport Operations

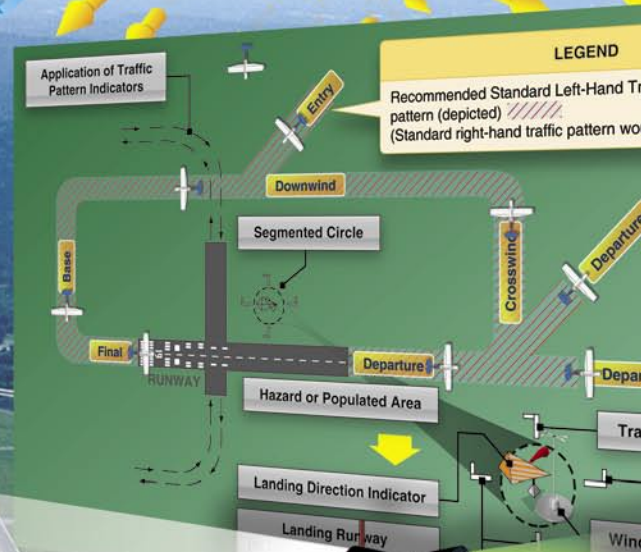
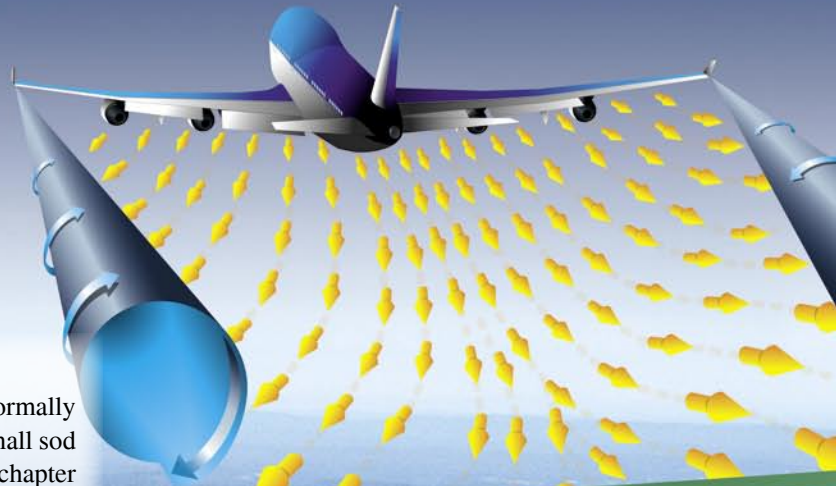
Introduction

Each time a pilot operates an aircraft, the flight normally begins and ends at an airport. An airport may be a small sod field or a large complex utilized by air carriers. This chapter examines airport operations, identifies features of an airport complex, and provides information on operating on or in the vicinity of an airport.

Types of Airports

There are two types of airports—towered and nontowered. These types can be further subdivided to:

- Civil Airports—airports that are open to the general public.
- Military/Federal Government airports—airports operated by the military, National Aeronautics and Space Administration (NASA), or other agencies of the Federal Government.
- Private airports—airports designated for private or restricted use only, not open to the general public.



Airport Sign Systems			
Type of Sign	Action or Purpose	Type of Sign	Action or Purpose
4-22	Taxiway/Runway Hold Position: Hold short of runway on taxiway		Runway Safety Area/Obstacle Free Zone Boundary: Exit boundary of runway protected areas
26-8	Runway/Runway Hold Position: Hold short of intersecting runway		ILS Critical Area Boundary: Exit boundary of ILS critical area
8-APCH	Runway Approach Hold Position: Hold short of airstair on approach		Taxiway Direction: Defines direction & designation of intersecting taxiway(s)
ILS	ILS Critical Area Hold Position: Hold short of ILS approach critical area		Runway Exit: Defines direction & designation of exit taxiway from runway
	No Entry: Identifies areas where aircraft entry is prohibited	22 ↑	Outbound Destination: Defines directions to taxiway airways
B	Taxiway Location: Identifies taxiway on which aircraft is located		Inbound Destination: Defines directions for arriving aircraft
22	Runway Location: Identifies runway on which aircraft is located		Taxiway Ending Marker: Indicates taxiway does not continue
4	Runway Distance Remaining: Provides remaining runway length in 1,000 foot increments		Direction Sign: Identifies location of multiple airways

Towered Airport

A towered airport has an operating control tower. Air traffic control (ATC) is responsible for providing the safe, orderly, and expeditious flow of air traffic at airports where the type of operations and/or volume of traffic requires such a service. Pilots operating from a towered airport are required to maintain two-way radio communication with air traffic controllers, and to acknowledge and comply with their instructions. Pilots must advise ATC if they cannot comply with the instructions issued and request amended instructions. A pilot may deviate from an air traffic instruction in an emergency, but must advise ATC of the deviation as soon as possible.

Nontowered Airport

An nontowered airport does not have an operating control tower. Two-way radio communications are not required, although it is a good operating practice for pilots to transmit their intentions on the specified frequency for the benefit of other traffic in the area. The key to communicating at an airport without an operating control tower is selection of the correct common frequency. The acronym CTAF, which stands for Common Traffic Advisory Frequency, is synonymous with this program. A CTAF is a frequency designated for the purpose of carrying out airport advisory practices while operating to or from an airport without an

operating control tower. The CTAF may be a Universal Integrated Community (UNICOM), MULTICOM, Flight Service Station (FSS), or tower frequency and is identified in appropriate aeronautical publications. UNICOM is a nongovernment air/ground radio communication station which may provide airport information at public use airports where there is no tower or FSS. On pilot request, UNICOM stations may provide pilots with weather information, wind direction, the recommended runway, or other necessary information. If the UNICOM frequency is designated as the CTAF, it will be identified in appropriate aeronautical publications. *Figure 13-1* lists recommended communication procedures. More information on radio communications is discussed later in this chapter.

Sources for Airport Data

When a pilot flies into a different airport, it is important to review the current data for that airport. This data provides the pilot with information, such as communication frequencies, services available, closed runways, or airport construction. Three common sources of information are:

- Aeronautical Charts
- Airport/Facility Directory (A/FD)
- Notices to Airmen (NOTAMs)

Facility at Airport	Frequency Use	Communication/Broadcast Procedures		
		Outbound	Inbound	Practice Instrument Approach
UNICOM (no tower or FSS)	Communicate with UNICOM station on published CTAF frequency (122.7, 122.8, 122.725, 122.975, or 123.0). If unable to contact UNICOM station, use self-announce procedures on CTAF.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	
No tower, FSS, or UNICOM	Self-announce on MULTICOM frequency 122.9.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	Departing final approach fix (name) or on final approach segment inbound.
No tower in operation, FSS open	Communicate with FSS on CTAF frequency.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	Approach completed/terminated.
FSS closed (no tower)	Self-announce on CTAF.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	
Tower or FSS not in operation	Self-announce on CTAF.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	

Figure 13-1. Recommended communication procedures.

Aeronautical Charts

Aeronautical charts provide specific information on airports. Chapter 15, Navigation, contains an excerpt from an aeronautical chart and an aeronautical chart legend, which provides guidance on interpreting the information on the chart.

Airport/Facility Directory (A/FD)

The A/FD provides the most comprehensive information on a given airport. It contains information on airports, heliports, and seaplane bases that are open to the public. The A/FD is published in seven books, which are organized by regions and are revised every 56 days. The A/FD is also available digitally at www.naco.faa.gov. Figure 13-2 contains an excerpt from a directory. For a complete listing of information provided in an A/FD and how the information may be decoded, refer to the “Directory Legend Sample” located in the front of each A/FD.

In addition to airport information, each A/FD contains information such as special notices, Federal Aviation Administration (FAA) and National Weather Service (NWS) telephone numbers, preferred instrument flight rules (IFR)

routing, visual flight rules (VFR) waypoints, a listing of very high frequency (VHF) omnidirectional range (VOR) receiver checkpoints, aeronautical chart bulletins, land and hold short operations (LAHSO) for selected airports, airport diagrams for selected towered airports, en route flight advisory service (EFAS) outlets, parachute jumping areas, and facility telephone numbers. It would be helpful to review an A/FD to become familiar with the information it contains.

Notices to Airmen (NOTAMs)

NOTAMs provide the most current information available. They provide time-critical information on airports and changes that affect the national airspace system (NAS) and are of concern to IFR operations. NOTAM information is classified into three categories. These are NOTAM-D or distant, NOTAM-L or local, and flight data center (FDC) NOTAMs. NOTAM-Ds are attached to hourly weather reports and are available at automated flight service stations (AFSS) or FSS.

FDC NOTAMs are issued by the National Flight Data Center and contain regulatory information, such as temporary flight restrictions or an amendment to instrument approach

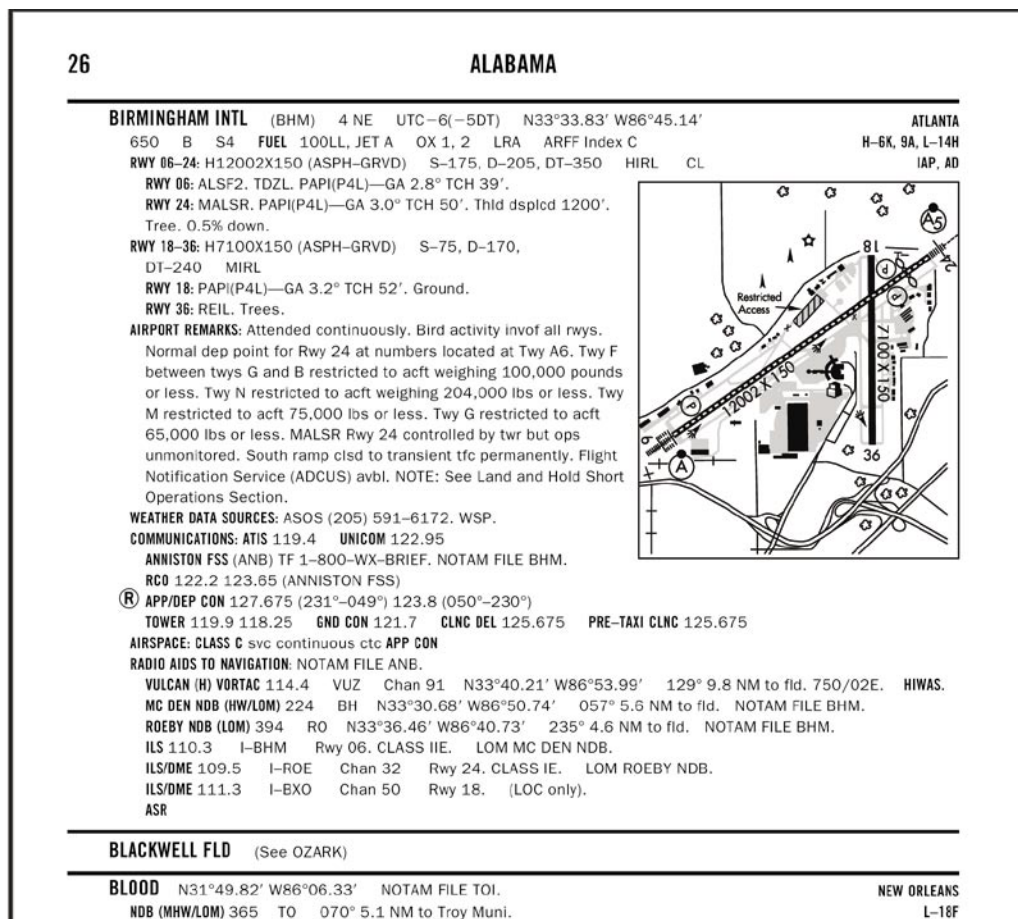


Figure 13-2. Airport/Facility Directory excerpt.

procedures. The NOTAM-Ds and FDC NOTAMs are contained in the NOTAM publication, which is issued every 28 days. Prior to any flight, pilots should check for any NOTAMs that could affect their intended flight.

NOTAM-D information includes such data as taxiway closures, personnel and equipment near or crossing runways, and airport lighting aids that do not affect instrument approach criteria, such as visual approach slope indicator (VASI). NOTAM-D information is distributed locally only and is not attached to the hourly weather reports. A separate file of local NOTAMs is maintained at each FSS for facilities in their area only. NOTAM-D information for other FSS areas must be specifically requested directly from the FSS that has responsibility for the airport concerned.

Airport Markings and Signs

There are markings and signs used at airports, which provide directions and assist pilots in airport operations. Some of the most common markings and signs are discussed. Additional information may be found in Chapter 2, Aeronautical Lighting and Other Airport Visual Aids, in the Aeronautical Information Manual (AIM).

Runway Markings

Runway markings vary depending on the type of operations conducted at the airport. *Figure 13-3* shows a runway that is approved as a precision instrument approach runway and some other common runway markings. A basic VFR runway may only have centerline markings and runway numbers.

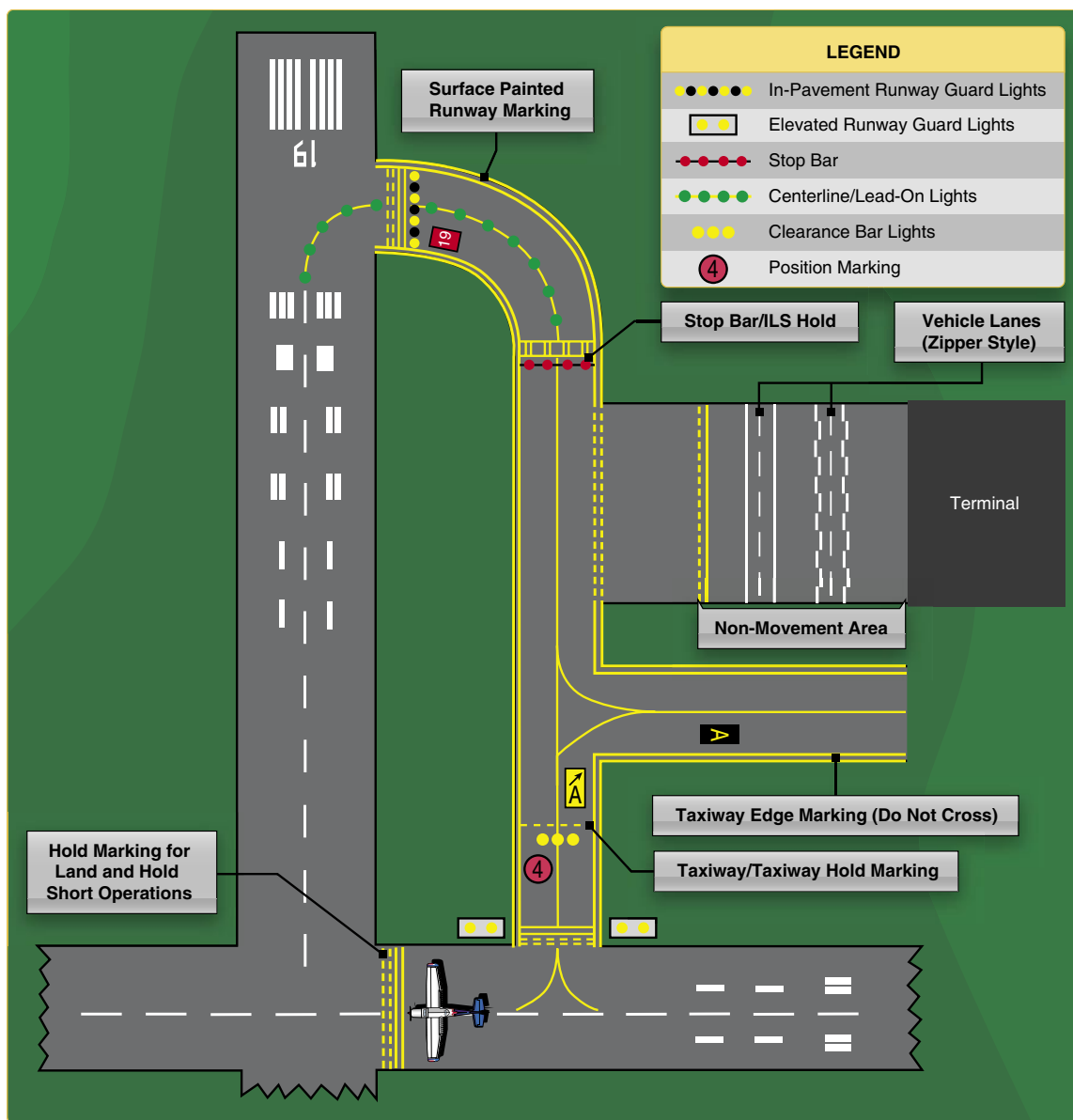


Figure 13-3. Selected airport markings and surface lighting.

Since aircraft are affected by the wind during takeoffs and landings, runways are laid out according to the local prevailing winds. Runway numbers are in reference to magnetic north. Certain airports have two or even three runways laid out in the same direction. These are referred to as parallel runways and are distinguished by a letter added to the runway number (e.g., runway 36L (left), 36C (center), and 36R (right)).

Another feature of some runways is a displaced threshold. A threshold may be displaced because of an obstruction near the end of the runway. Although this portion of the runway is not to be used for landing, it may be available for taxiing, takeoff, or landing rollout. Some airports may have a blast pad/stopway area. The blast pad is an area where a propeller or jet blast can dissipate without creating a hazard. The stopway area is paved in order to provide space for an aircraft to decelerate and stop in the event of an aborted takeoff. These areas cannot be used for takeoff or landing.

Taxiway Markings

Aircraft use taxiways to transition from parking areas to the runway. Taxiways are identified by a continuous yellow centerline stripe and may include edge markings to define the edge of the taxiway. This is usually done when the taxiway edge does not correspond with the edge of the pavement. If an edge marking is a continuous line, the paved shoulder is not

intended to be used by an aircraft. If it is a dashed marking, an aircraft may use that portion of the pavement. Where a taxiway approaches a runway, there may be a holding position marker. These consist of four yellow lines (two solid and two dashed). The solid lines are where the aircraft is to hold. At some towered airports, holding position markings may be found on a runway. They are used when there are intersecting runways, and ATC issues instructions such as “cleared to land—hold short of runway 30.”

Other Markings

Some other markings found on the airport include vehicle roadway markings, VOR receiver checkpoint markings, and non-movement area boundary markings.

Vehicle roadway markings are used when necessary to define a pathway for vehicle crossing areas that are also intended for aircraft. These markings usually consist of a solid white line to delineate each edge of the roadway and a dashed line to separate lanes within the edges of the roadway. In lieu of the solid lines, zipper markings may be used to delineate the edges of the vehicle roadway. [Figure 13-4]

A VOR receiver checkpoint marking consists of a painted circle with an arrow in the middle. The arrow is aligned in the direction of the checkpoint azimuth. This allows pilots to check aircraft instruments with navigational aid signals.

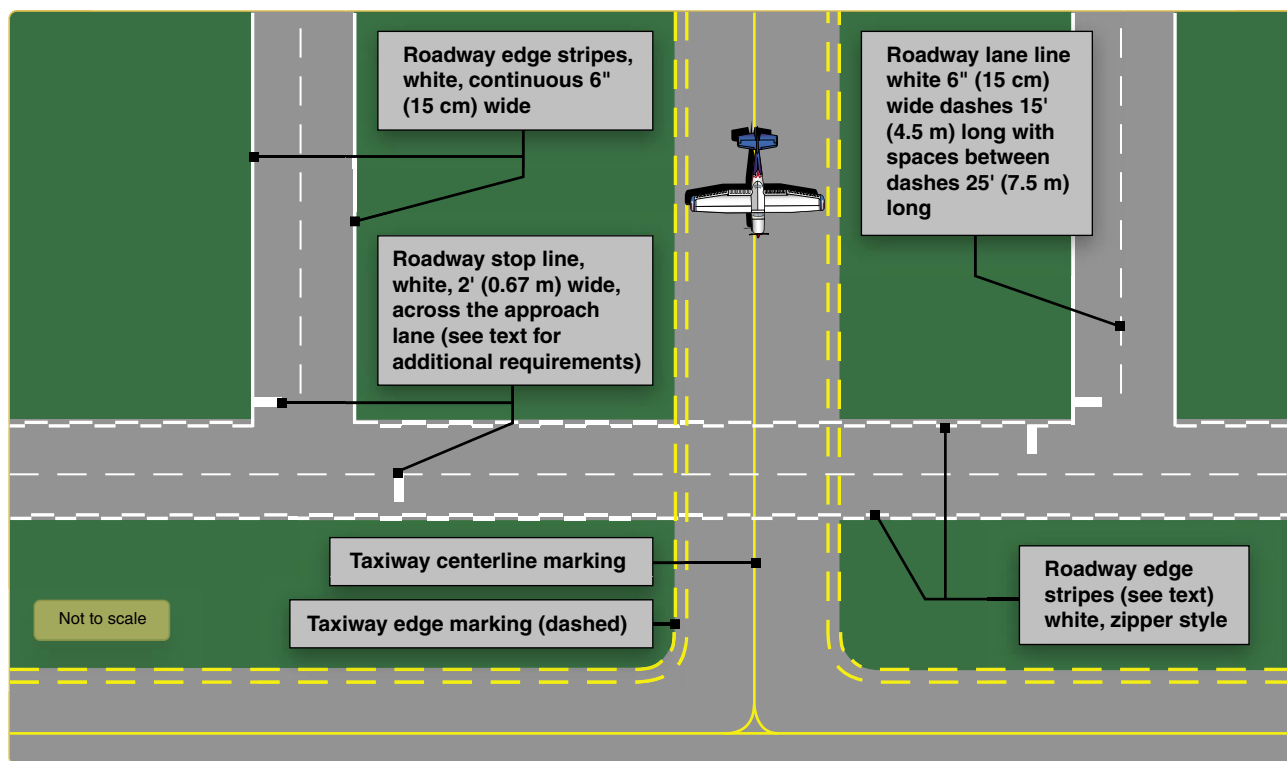


Figure 13-4. Vehicle roadway markings.

A non-movement area boundary marking delineates a movement area under ATC. These markings are yellow and located on the boundary between the movement and non-movement area. They normally consist of two yellow lines (one solid and one dashed).

Airport Signs

There are six types of signs that may be found at airports. The more complex the layout of an airport, the more important the signs become to pilots. *Figure 13-5* shows examples of signs, their purpose, and appropriate pilot action. The six types of signs are:

- Mandatory instruction signs—red background with white inscription. These signs denote an entrance to a runway, critical area, or prohibited area.
- Location signs—black with yellow inscription and a yellow border, no arrows. They are used to identify a taxiway or runway location, to identify the boundary of the runway, or identify an instrument landing system (ILS) critical area.
- Direction signs—yellow background with black inscription. The inscription identifies the designation of the intersecting taxiway(s) leading out of an intersection.
- Destination signs—yellow background with black inscription and also contain arrows. These signs provide information on locating things, such as

runways, terminals, cargo areas, and civil aviation areas.

- Information signs—yellow background with black inscription. These signs are used to provide the pilot with information on such things as areas that cannot be seen from the control tower, applicable radio frequencies, and noise abatement procedures. The airport operator determines the need, size, and location of these signs.
- Runway distance remaining signs—black background with white numbers. The numbers indicate the distance of the remaining runway in thousands of feet.

Airport Lighting

The majority of airports have some type of lighting for night operations. The variety and type of lighting systems depends on the volume and complexity of operations at a given airport. Airport lighting is standardized so that airports use the same light colors for runways and taxiways.

Airport Beacon

Airport beacons help a pilot identify an airport at night. The beacons are operated from dusk till dawn. Sometimes they are turned on if the ceiling is less than 1,000 feet and/or the ground visibility is less than 3 statute miles (VFR minimums). However, there is no requirement for this, so a pilot has the responsibility of determining if the weather meets VFR requirements. The beacon has a vertical light

















Type of Sign	Action or Purpose	Type of Sign	Action or Purpose
	Taxiway/Runway Hold Position: Hold short of runway on taxiway		Runway Safety Area/Obstacle Free Zone Boundary: Exit boundary of runway protected areas
	Runway/Runway Hold Position: Hold short of intersecting runway		ILS Critical Area Boundary: Exit boundary of ILS critical area
	Runway Approach Hold Position: Hold short of aircraft on approach		Taxiway Direction: Defines direction & designation of intersecting taxiway(s)
	ILS Critical Area Hold Position: Hold short of ILS approach critical area		Runway Exit: Defines direction & designation of exit taxiway from runway
	No Entry: Identifies paved areas where aircraft entry is prohibited		Outbound Destination: Defines directions to takeoff runways
	Taxiway Location: Identifies taxiway on which aircraft is located		Inbound Destination: Defines directions for arriving aircraft
	Runway Location: Identifies runway on which aircraft is located		Taxiway Ending Marker: Indicates taxiway does not continue
	Runway Distance Remaining: Provides remaining runway length in 1,000 feet increments		Direction Sign Array: Identifies location in conjunction with multiple intersecting taxiways

Figure 13-5. Airport signs.

distribution to make it most effective from 1–10° above the horizon, although it can be seen well above or below this spread. The beacon may be an omnidirectional capacitor-discharge device, or it may rotate at a constant speed, which produces the visual effect of flashes at regular intervals. The combination of light colors from an airport beacon indicates the type of airport. [Figure 13-6] Some of the most common beacons are:

- Flashing white and green for civilian land airports;
- Flashing white and yellow for a water airport;
- Flashing white, yellow, and green for a heliport; and
- Two quick white flashes alternating with a green flash identifying a military airport.

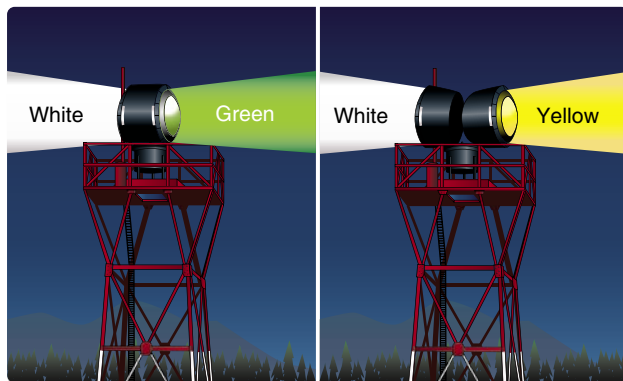


Figure 13-6. Airport rotating beacons.

Approach Light Systems

Approach light systems are primarily intended to provide a means to transition from instrument flight to visual flight for landing. The system configuration depends on whether the runway is a precision or nonprecision instrument runway. Some systems include sequenced flashing lights, which appear to the pilot as a ball of light traveling toward the runway at high speed. Approach lights can also aid pilots operating under VFR at night.

Visual Glideslope Indicators

Visual glideslope indicators provide the pilot with glidepath information that can be used for day or night approaches. By maintaining the proper glidepath as provided by the system, a pilot should have adequate obstacle clearance and should touch down within a specified portion of the runway.

Visual Approach Slope Indicator (VASI)

VASI installations are the most common visual glidepath systems in use. The VASI provides obstruction clearance within 10° of the runway extended runway centerline, and to four nautical miles (NM) from the runway threshold.

The VASI consists of light units arranged in bars. There are 2-bar and 3-bar VASIs. The 2-bar VASI has near and far light bars and the 3-bar VASI has near, middle, and far light bars. Two-bar VASI installations provide one visual glidepath which is normally set at 3°. The 3-bar system provides two glidepaths, the lower glidepath normally set at 3° and the upper glidepath ¼ degree above the lower glidepath.

The basic principle of the VASI is that of color differentiation between red and white. Each light unit projects a beam of light, a white segment in the upper part of the beam and a red segment in the lower part of the beam. The lights are arranged so the pilot sees the combination of lights shown in Figure 13-7 to indicate below, on, or above the glidepath.

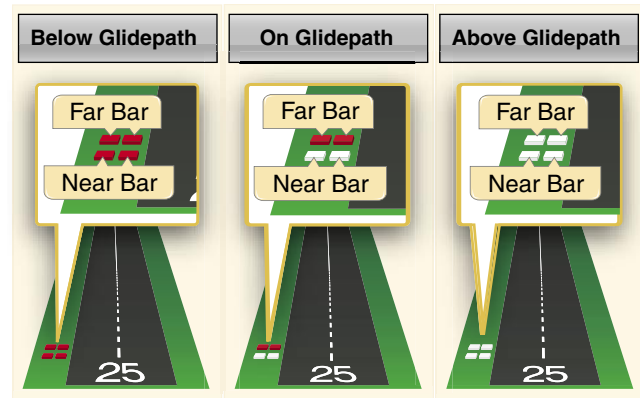


Figure 13-7. Two-bar VASI system.

Other Glidepath Systems

A precision approach path indicator (PAPI) uses lights similar to the VASI system except they are installed in a single row, normally on the left side of the runway. [Figure 13-8]

A tri-color system consists of a single light unit projecting a three-color visual approach path. Below the glidepath is indicated by red, on the glidepath is indicated by green, and above the glidepath is indicated by amber. When descending below the glidepath, there is a small area of dark amber. Pilots should not mistake this area for an “above the glidepath” indication. [Figure 13-9]

Pulsating visual approach slope indicators normally consist of a single light unit projecting a two-color visual approach path into the final approach area of the runway upon which the indicator is installed. The on glidepath indication is a steady white light. The slightly below glidepath indication is a steady red light. If the aircraft descends further below the glidepath, the red light starts to pulsate. The above glidepath indication is a pulsating white light. The pulsating rate increases as the aircraft gets further above or below the desired glideslope.

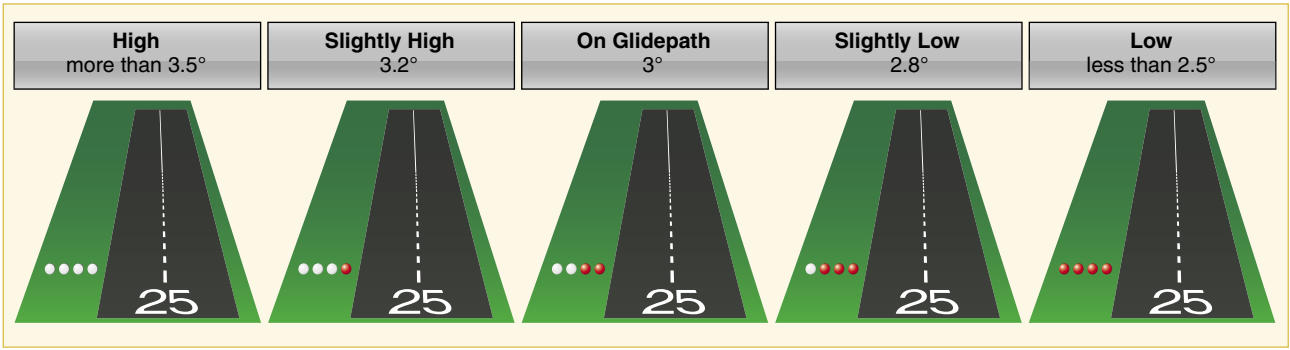


Figure 13-8. Precision approach path indicator.

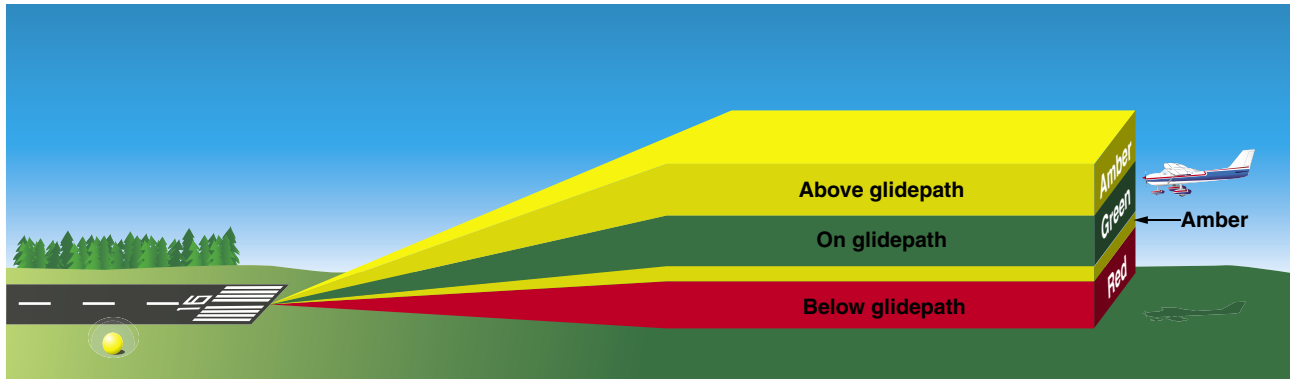


Figure 13-9. Tri-color visual approach slope indicator.

The useful range of the system is about four miles during the day and up to ten miles at night. [Figure 13-10]

Runway Lighting

There are various lights that identify parts of the runway complex. These assist a pilot in safely making a takeoff or landing during night operations.

Runway End Identifier Lights (REIL)

Runway end identifier lights (REIL) are installed at many airfields to provide rapid and positive identification of the approach end of a particular runway. The system consists

of a pair of synchronized flashing lights located laterally on each side of the runway threshold. REILs may be either omnidirectional or unidirectional facing the approach area.

Runway Edge Lights

Runway edge lights are used to outline the edges of runways at night or during low visibility conditions. These lights are classified according to the intensity they are capable of producing: high intensity runway lights (HIRL), medium intensity runway lights (MIRL), and low intensity runway lights (LIRL). The HIRL and MIRL have variable intensity settings. These lights are white, except on instrument runways

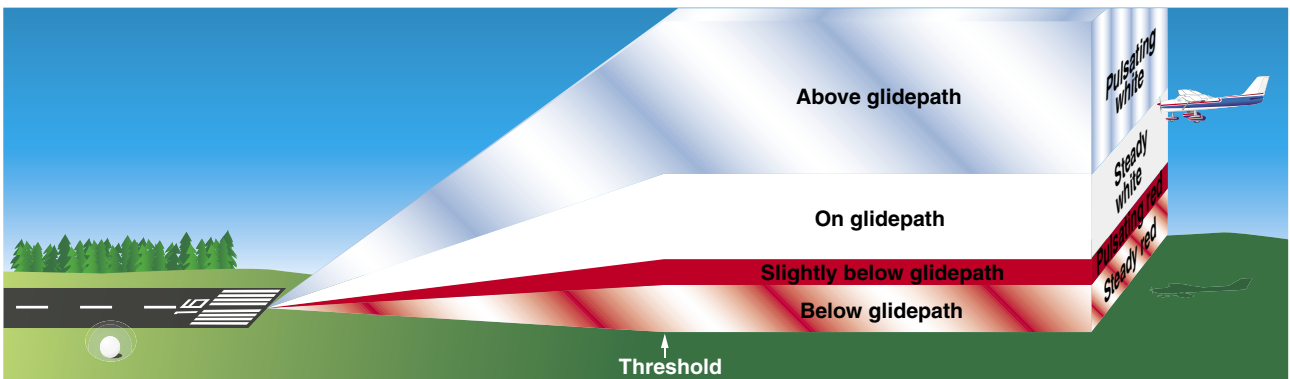


Figure 13-10. Pulsating visual approach slope indicator.

where amber lights are used on the last 2,000 feet or half the length of the runway, whichever is less. The lights marking the end of the runway are red.

In-Runway Lighting

Runway centerline lighting system (RCLS)—installed on some precision approach runways to facilitate landing under adverse visibility conditions. They are located along the runway centerline and are spaced at 50-foot intervals. When viewed from the landing threshold, the runway centerline lights are white until the last 3,000 feet of the runway. The white lights begin to alternate with red for the next 2,000 feet. For the remaining 1,000 feet of the runway, all centerline lights are red.

Touchdown zone lights (TDZL)—installed on some precision approach runways to indicate the touchdown zone when landing under adverse visibility conditions. They consist of two rows of transverse light bars disposed symmetrically about the runway centerline. The system consists of steady-burning white lights which start 100 feet beyond the landing threshold and extend to 3,000 feet beyond the landing threshold or to the midpoint of the runway, whichever is less.

Taxiway centerline lead-off lights—provide visual guidance to persons exiting the runway. They are color-coded to warn pilots and vehicle drivers that they are within the runway environment or ILS/MLS critical area, whichever is more restrictive. Alternate green and yellow lights are installed, beginning with green, from the runway centerline to one centerline light position beyond the runway holding position or ILS/MLS critical area holding position.

Taxiway centerline lead-on lights—provide visual guidance to persons entering the runway. These “lead-on” lights are also color-coded with the same color pattern as lead-off lights to warn pilots and vehicle drivers that they are within the runway environment or instrument landing system/microwave landing system (ILS/MLS) critical area, whichever is more conservative. The fixtures used for lead-on lights are bidirectional (i.e., one side emits light for the lead-on function while the other side emits light for the lead-off function). Any fixture that emits yellow light for the lead-off function also emits yellow light for the lead-on function.

Land and hold short lights—used to indicate the hold short point on certain runways which are approved for LAHSO. Land and hold short lights consist of a row of pulsing white lights installed across the runway at the hold short point. Where installed, the lights are on anytime LAHSO is in effect. These lights are off when LAHSO is not in effect.

Control of Airport Lighting

Airport lighting is controlled by air traffic controllers at towered airports. At nontowered airports, the lights may be on a timer, or where an FSS is located at an airport, the FSS personnel may control the lighting. A pilot may request various light systems be turned on or off and also request a specified intensity, if available, from ATC or FSS personnel. At selected nontowered airports, the pilot may control the lighting by using the radio. This is done by selecting a specified frequency and clicking the radio microphone. For information on pilot controlled lighting at various airports, refer to the A/FD. [Figure 13-11]

Key Mike	Function
7 times within 5 seconds	Highest intensity available
5 times within 5 seconds	Medium or lower intensity (Lower REIL or REIL off)
3 times within 5 seconds	Lowest intensity available (Lower REIL or REIL off)

Figure 13-11. Radio controlled runway lighting.

Taxiway Lights

Omnidirectional taxiway lights outline the edges of the taxiway and are blue in color. At many airports, these edge lights may have variable intensity settings that may be adjusted by an air traffic controller when deemed necessary or when requested by the pilot. Some airports also have taxiway centerline lights that are green in color.

Obstruction Lights

Obstructions are marked or lighted to warn pilots of their presence during daytime and nighttime conditions. Obstruction lighting can be found both on and off an airport to identify obstructions. They may be marked or lighted in any of the following conditions.

- Red obstruction lights—flash or emit a steady red color during nighttime operations, and the obstructions are painted orange and white for daytime operations.
- High intensity white obstruction lights—flash high intensity white lights during the daytime with the intensity reduced for nighttime.
- Dual lighting—a combination of flashing red beacons and steady red lights for nighttime operation, and high intensity white lights for daytime operations.

Wind Direction Indicators

It is important for a pilot to know the direction of the wind. At facilities with an operating control tower, this information is provided by ATC. Information may also be provided by FSS personnel located at a particular airport or by requesting information on a CTAF at airports that have the capacity to receive and broadcast on this frequency.

When none of these services is available, it is possible to determine wind direction and runway in use by visual wind indicators. A pilot should check these wind indicators even when information is provided on the CTAF at a given airport because there is no assurance that the information provided is accurate.

The wind direction indicator can be a wind cone, wind sock, tetrahedron, or wind tee. These are usually located in a central location near the runway and may be placed in the center of a segmented circle, which identifies the traffic pattern direction, if it is other than the standard left-hand pattern. [Figures 13-12 and 13-13]

The wind sock is a good source of information since it not only indicates wind direction, but allows the pilot to estimate the wind velocity and gusts or factor. The wind sock extends out straighter in strong winds and tends to move back and forth when the wind is gusty. Wind tees and tetrahedrons can swing freely, and align themselves with the wind direction. The wind tee and tetrahedron can also be manually set to align with the runway in use; therefore, a pilot should also look at the wind sock, if available.

Traffic Patterns

At those airports without an operating control tower, a segmented circle visual indicator system [Figure 13-13], if installed, is designed to provide traffic pattern information. Usually located in a position affording maximum visibility to pilots in the air and on the ground and providing a centralized location for other elements of the system, the segmented circle consists of the following components: wind direction indicators, landing direction indicators, landing strip indicators, and traffic pattern indicators.

A tetrahedron is installed to indicate the direction of landings and takeoffs when conditions at the airport warrant its use. It may be located at the center of a segmented circle and may be lighted for night operations. The small end of the tetrahedron points in the direction of landing. Pilots are cautioned against using a tetrahedron for any purpose other than as an indicator of landing direction. At airports with control towers, the tetrahedron should only be referenced when the control tower is not in operation. Tower instructions supersede tetrahedron indications.

Landing strip indicators are installed in pairs as shown in Figure 13-13 and are used to show the alignment of landing strips. Traffic pattern indicators are arranged in pairs in conjunction with landing strip indicators and used to indicate the direction of turns when there is a variation from the normal left traffic pattern. (If there is no segmented circle installed at the airport, traffic pattern indicators may be installed on or near the end of the runway.)

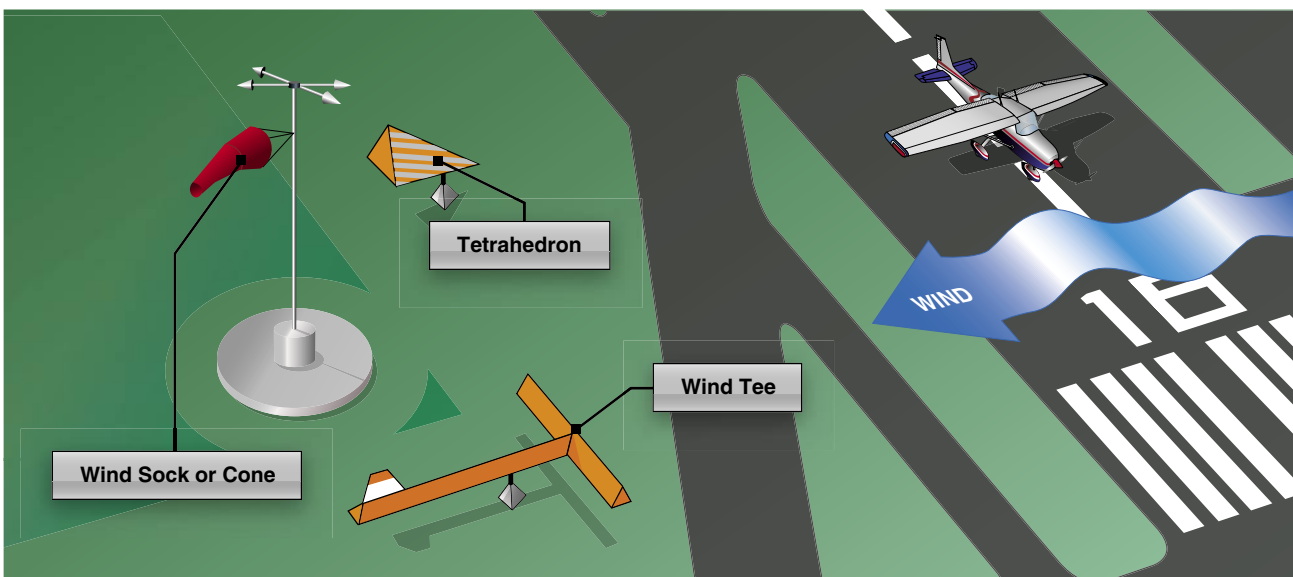


Figure 13-12. Wind direction indicators.

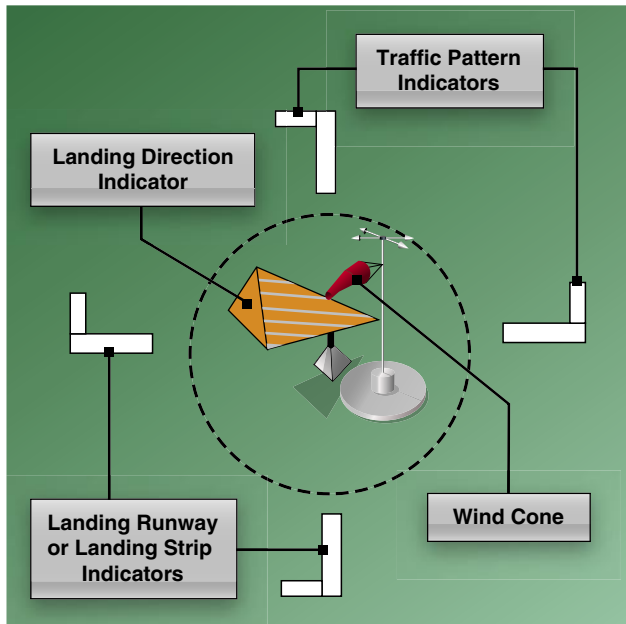


Figure 13-13. *Segmented circle.*

At most airports and military air bases, traffic pattern altitudes for propeller-driven aircraft generally extend from 600 feet to as high as 1,500 feet above ground level (AGL). Pilots can obtain the traffic pattern altitude for an airport from the A/FD. Also, traffic pattern altitudes for military turbojet aircraft sometimes extend up to 2,500 feet AGL. Therefore, pilots of en route aircraft should be constantly on the alert for other aircraft in traffic patterns and avoid these areas whenever possible. When operating at an airport, traffic pattern altitudes should be maintained unless otherwise required by the applicable distance from cloud criteria in Title 14 of the Code of Federal Regulations (14 CFR) section 91.155. Additional information on airport traffic pattern operations can be found in Chapter 4, Air Traffic Control, of the AIM. Pilots can find traffic pattern information and restrictions such as noise abatement in the A/FD.

Example: Key to Traffic Pattern Operations— Single Runway

1. Enter pattern in level flight, abeam the midpoint of the runway, at pattern altitude. (1,000' AGL is recommended pattern altitude unless established otherwise.)
2. Maintain pattern altitude until abeam approach end of the landing runway on downwind leg.
3. Complete turn to final at least ¼ mile from the runway.
4. Continue straight ahead until beyond departure end of runway.

5. If remaining in the traffic pattern, commence turn to crosswind leg beyond the departure end of the runway within 300 feet of pattern altitude.
6. If departing the traffic pattern, continue straight out, or exit with a 45° turn (to the left when in a left-hand traffic pattern; to the right when in a right-hand traffic pattern) beyond the departure end of the runway, after reaching pattern altitude. [Figure 13-14]

Example: Key to Traffic Pattern Operations— Parallel Runways

1. Enter pattern in level flight, abeam the midpoint of the runway, at pattern altitude. (1,000' AGL is recommended pattern altitude unless established otherwise.)
2. Maintain pattern altitude until abeam approach end of the landing runway on downwind leg.
3. Complete turn to final at least ¼ mile from the runway.
4. Continue straight ahead until beyond departure end of runway.
5. If remaining in the traffic pattern, commence turn to crosswind leg beyond the departure end of the runway within 300 feet of pattern altitude.
6. If departing the traffic pattern, continue straight out, or exit with a 45° turn (to the left when in a left-hand traffic pattern; to the right when in a right-hand traffic pattern) beyond the departure end of the runway, after reaching pattern altitude.
7. Do not overshoot final or continue on a track which penetrates the final approach of the parallel runway.
8. Do not continue on a track which penetrates the departure path of the parallel runway. [Figure 13-15]

Radio Communications

Operating in and out of a towered airport, as well as in a good portion of the airspace system, requires that an aircraft have two-way radio communication capability. For this reason, a pilot should be knowledgeable of radio station license requirements and radio communications equipment and procedures.

Radio License

There is no license requirement for a pilot operating in the United States; however, a pilot who operates internationally is required to hold a restricted radiotelephone permit issued by the Federal Communications Commission (FCC). There

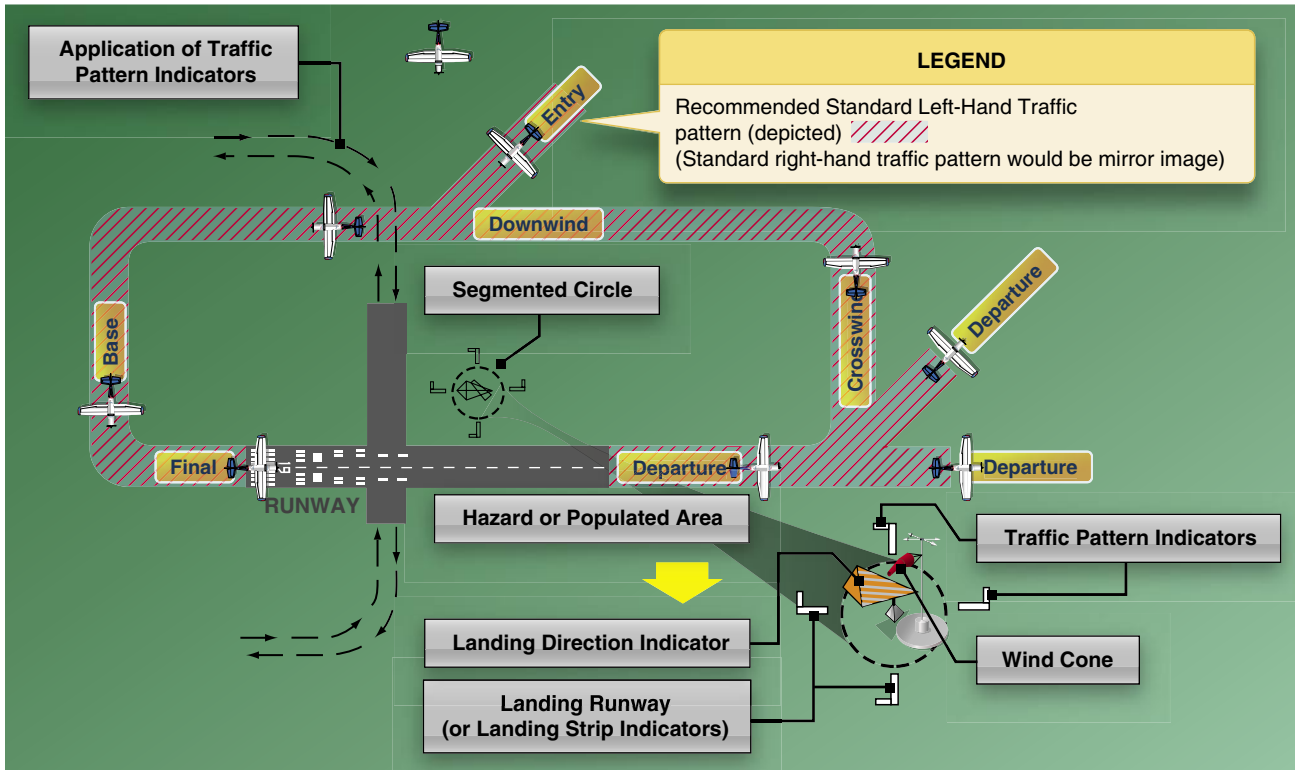


Figure 13-14. Traffic pattern operations—single runway.

is also no station license requirement for most general aviation aircraft operating in the United States. A station license is required however for an aircraft which is operating internationally, which uses other than a VHF radio, and which meets other criteria.

Radio Equipment

In general aviation, the most common types of radios are VHF. A VHF radio operates on frequencies between 118.0 and 136.975 and is classified as 720 or 760 depending on the number of channels it can accommodate. The 720 and 760 use .025 spacing (118.025, 118.050) with the 720 having a frequency range up to 135.975 and the 760 going up to 136.975. VHF radios are limited to line of sight transmissions; therefore, aircraft at higher altitudes are able to transmit and receive at greater distances.

In March of 1997, the International Civil Aviation Organization (ICAO) amended its International Standards and Recommended Practices to incorporate a channel plan specifying 8.33 kHz channel spacings in the Aeronautical Mobile Service. The 8.33 kHz channel plan was adopted to alleviate the shortage of VHF ATC channels experienced in western Europe and in the United Kingdom. Seven western European countries and the United Kingdom implemented the 8.33 kHz channel plan on January 1, 1999. Accordingly, aircraft operating in the airspace of these countries must have

the capability of transmitting and receiving on the 8.33 kHz spaced channels.

Using proper radio phraseology and procedures contribute to a pilot's ability to operate safely and efficiently in the airspace system. A review of the Pilot/Controller Glossary contained in the AIM assists a pilot in the use and understanding of standard terminology. The AIM also contains many examples of radio communications.

ICAO has adopted a phonetic alphabet, which should be used in radio communications. When communicating with ATC, pilots should use this alphabet to identify their aircraft. [Figure 13-16]

Lost Communication Procedures

It is possible that a pilot might experience a malfunction of the radio. This might cause the transmitter, receiver, or both to become inoperative. If a receiver becomes inoperative and a pilot needs to land at a towered airport, it is advisable to remain outside or above Class D airspace until the direction and flow of traffic is determined. A pilot should then advise the tower of the aircraft type, position, altitude, and intention to land. The pilot should continue, enter the pattern, report a position as appropriate, and watch for light signals from the tower. Light signal colors and their meanings are contained in Figure 13-17.

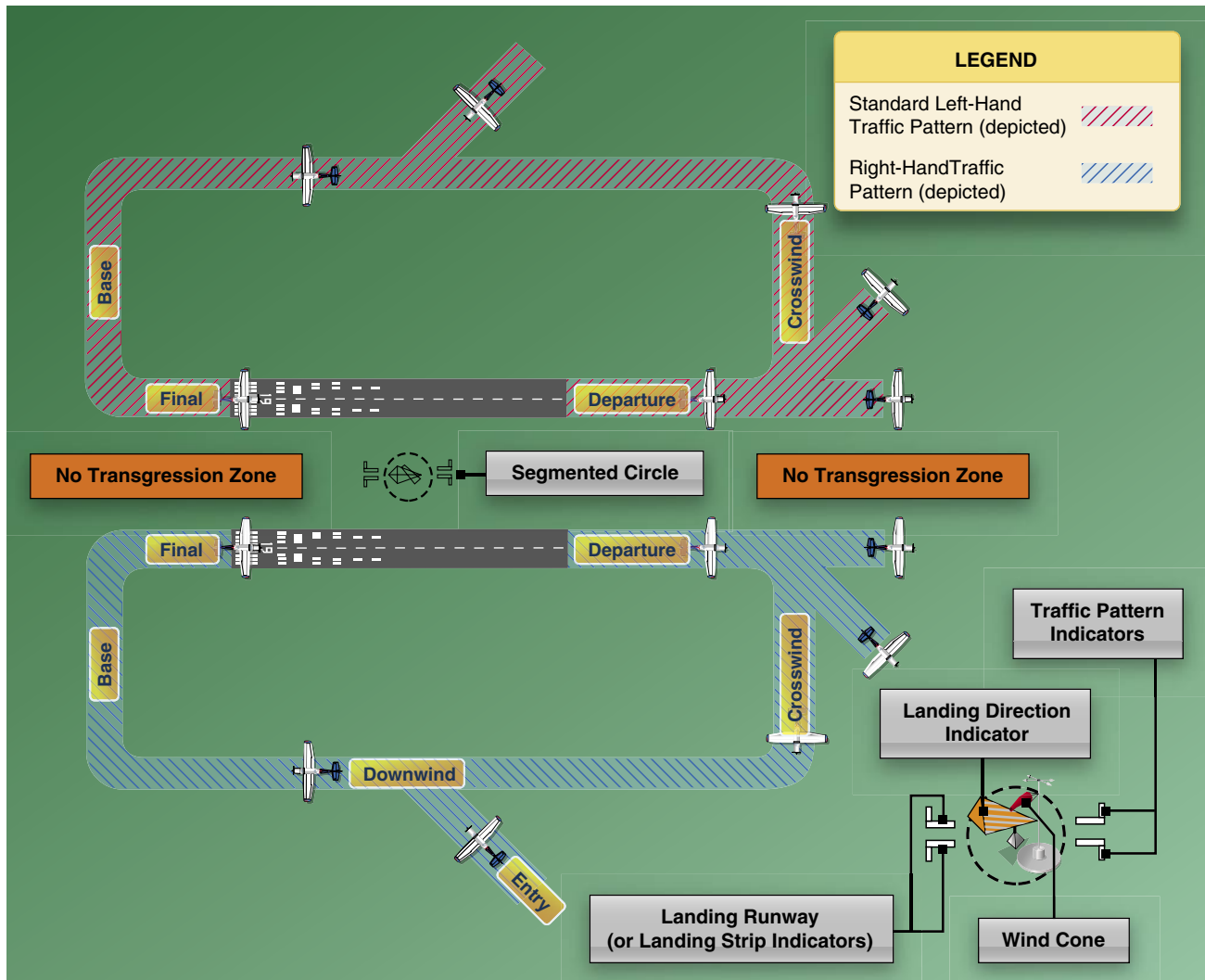


Figure 13-15. Traffic pattern operation—parallel runways.

If the transmitter becomes inoperative, a pilot should follow the previously stated procedures and also monitor the appropriate ATC frequency. During daylight hours ATC transmissions may be acknowledged by rocking the wings, and at night by blinking the landing light.

When both receiver and transmitter are inoperative, the pilot should remain outside of Class D airspace until the flow of traffic has been determined and then enter the pattern and watch for light signals.

If a radio malfunctions prior to departure, it is advisable to have it repaired, if possible. If this is not possible, a call should be made to ATC and the pilot should request authorization to depart without two-way radio communications. If authorization is given to depart, the pilot is advised to monitor the appropriate frequency and/or watch for light signals as appropriate.

Air Traffic Control (ATC) Services

Besides the services provided by an FSS as discussed in Chapter 12, Aviation Weather Services, numerous other services are provided by ATC. In many instances a pilot is required to have contact with ATC, but even when not required, a pilot finds it helpful to request their services.

Primary Radar

Radar is a device which provides information on range, azimuth, and/or elevation of objects in the path of the transmitted pulses. It measures the time interval between transmission and reception of radio pulses and correlates the angular orientation of the radiated antenna beam or beams in azimuth and/or elevation. Range is determined by measuring the time it takes for the radio wave to go out to the object and then return to the receiving antenna. The direction of a detected object from a radar site is determined by the position

Character	Morse Code	Telephony	Phonic Pronunciation
A	• —	Alfa	(AL-FAH)
B	— •••	Bravo	(BRAH-VOH)
C	— • — •	Charlie	(CHAR-LEE) or (SHAR-LEE)
D	— ••	Delta	(DELL-TAH)
E	•	Echo	(ECK-OH)
F	•• — •	Foxtrot	(FOKS-TROT)
G	— — •	Golf	(GOLF)
H	••••	Hotel	(HOH-TEL)
I	••	India	(IN-DEE-AH)
J	• — — —	Juliett	(JEW-LEE-ETT)
K	— • —	Kilo	(KEY-LOH)
L	• — ••	Lima	(LEE-MAH)
M	— —	Mike	(MIKE)
N	— •	November	(NO-VEH-BER)
O	— — —	Oscar	(OSS-CAH)
P	• — — •	Papa	(PAH-PAH)
Q	— — • —	Quebec	(KEH-BECK)
R	• — •	Romeo	(ROW-ME-OH)
S	•••	Sierra	(SEE-AIR-RAH)
T	—	Tango	(TANG-GO)
U	•• —	Uniform	(YOU-NEE-FORM) or (OO-NEE-FORM)
V	••• —	Victor	(VIK-TAH)
W	• — —	Whiskey	(WISS-KEY)
X	— •• —	Xray	(ECKS-RAY)
Y	— • — —	Yankee	(YANG-KEY)
Z	— — ••	Zulu	(ZOO-LOO)
1	• — — — —	One	(WUN)
2	•• — — —	Two	(TOO)
3	••• — —	Three	(TREE)
4	•••• —	Four	(FOW-ER)
5	•••••	Five	(FIFE)
6	— ••••	Six	(SIX)
7	— — •••	Seven	(SEV-EN)
8	— — — ••	Eight	(AIT)
9	— — — — •	Nine	(NIN-ER)
0	— — — — —	Zero	(ZEE-RO)

Figure 13-16. *Phonetic alphabet.*

of the rotating antenna when the reflected portion of the radio wave is received.

Modern radar is very reliable and there are seldom outages. This is due to reliable maintenance and improved equipment. There are, however, some limitations which may affect ATC

services and prevent a controller from issuing advisories concerning aircraft which are not under his or her control and cannot be seen on radar.

The characteristics of radio waves are such that they normally travel in a continuous straight line unless they are “bent” by atmospheric phenomena such as temperature inversions, reflected or attenuated by dense objects such as heavy clouds and precipitation, or screened by high terrain features.

ATC Radar Beacon System (ATCRBS)

The ATC radar beacon system (ATCRBS) is often referred to as “secondary surveillance radar.” This system consists of three components and helps in alleviating some of the limitations associated with primary radar. The three components are an interrogator, transponder, and radarscope. The advantages of ATCRBS are the reinforcement of radar targets, rapid target identification, and a unique display of selected codes.

Transponder

The transponder is the airborne portion of the secondary surveillance radar system and a system with which a pilot should be familiar. The ATCRBS cannot display the secondary information unless an aircraft is equipped with a transponder. A transponder is also required to operate in certain controlled airspace as discussed in Chapter 14, Airspace.

A transponder code consists of four numbers from 0 to 7 (4,096 possible codes). There are some standard codes, or ATC may issue a four-digit code to an aircraft. When a controller requests a code or function on the transponder, the word “squawk” may be used. *Figure 13-18* lists some standard transponder phraseology. Additional information concerning transponder operation can be found in the AIM, chapter 4.

Radar Traffic Advisories

Radar equipped ATC facilities provide radar assistance to aircraft on instrument flight plans and VFR aircraft provided the aircraft can communicate with the facility and are within radar coverage. This basic service includes safety alerts, traffic advisories, limited vectoring when requested, and sequencing at locations where this procedure has been established. ATC issues traffic advisories based on observed radar targets. The traffic is referenced by azimuth from the aircraft in terms of the 12-hour clock. Also, distance in nautical miles, direction in which the target is moving, and type and altitude of the aircraft, if known, are given. An example would be: “Traffic 10 o’clock 5 miles east bound, Cessna 152, 3,000 feet.” The pilot should note that traffic position is based on the aircraft track, and that wind correction can affect the clock position


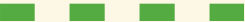

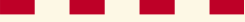
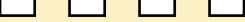
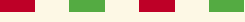
Color and Type of Signal	Movement of Vehicles, Equipment and Personnel	Aircraft on the Ground	Aircraft in Flight
Steady green 	Cleared to cross, proceed or go	Cleared for takeoff	Cleared to land
Flashing green 	Not applicable	Cleared for taxi	Return for landing (to be followed by steady green at the proper time)
Steady red 	Stop	Stop	Give way to other aircraft and continue circling
Flashing red 	Clear the taxiway/runway	Taxi clear of the runway in use	Airport unsafe, do not land
Flashing white 	Return to starting point on airport	Return to starting point on airport	Not applicable
Alternating red and green 	Exercise extreme caution!!!!	Exercise extreme caution!!!!	Exercise extreme caution!!!!

Figure 13-17. Light gun signals.

at which a pilot locates traffic. This service is not intended to relieve the pilot of the responsibility to see and avoid other aircraft. [Figure 13-19]

In addition to basic radar service, terminal radar service area (TRSA) has been implemented at certain terminal locations. TRSAs are depicted on sectional aeronautical charts and listed in the A/FD. The purpose of this service is to provide separation between all participating VFR aircraft and all IFR aircraft operating within the TRSA. Class C service provides approved separation between IFR and VFR aircraft, and

sequencing of VFR aircraft to the primary airport. Class B service provides approved separation of aircraft based on IFR, VFR, and/or weight, and sequencing of VFR arrivals to the primary airport(s).

Wake Turbulence

All aircraft generate wake turbulence while in flight. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips. The vortices from larger aircraft pose problems to encountering aircraft. The wake of these aircraft can impose rolling moments exceeding the roll-

Radar Beacon Phraseology	
SQUAWK (number)	Operate radar beacon transponder on designated code in MODE A/3.
IDENT	Engage the "IDENT" feature (military I/P) of the transponder.
SQUAWK (number) and IDENT	Operate transponder on specified code in MODE A/3 and engage the "IDENT" (military I/P) feature.
SQUAWK Standby	Switch transponder to standby position.
SQUAWK Low/Normal	Operate transponder on low or normal sensitivity as specified. Transponder is operated in "NORMAL" position unless ATC specifies "LOW" ("ON" is used instead of "NORMAL" as a master control label on some types of transponders).
SQUAWK Altitude	Activate MODE C with automatic altitude reporting.
STOP Altitude SQUAWK	Turn off altitude reporting switch and continue transmitting MODE C framing pulses. If your equipment does not have this capability, turn off MODE C.
STOP SQUAWK (mode in use)	Switch off specified mode. (Used for military aircraft when the controller is unaware of military service requirements for the aircraft to continue operation on another MODE.)
STOP SQUAWK	Switch off transponder.
SQUAWK Mayday	Operate transponder in the emergency position (MODE A Code 7700 for civil transponder, MODE 3 Code 7700 and emergency feature for military transponder).
SQUAWK VFR	Operate radar beacon transponder on Code 1200 in MODE A/3, or other appropriate VFR code.

Figure 13-18. Transponder phraseology.

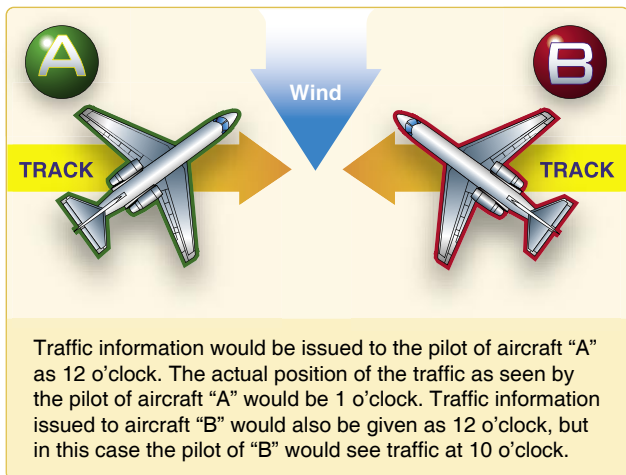


Figure 13-19. Traffic advisories.

control authority of the encountering aircraft. Also, the turbulence generated within the vortices can damage aircraft components and equipment if encountered at close range. For this reason, a pilot must envision the location of the vortex wake and adjust the flightpath accordingly.

During ground operations and during takeoff, jet engine blast (thrust stream turbulence) can cause damage and upset smaller aircraft at close range. For this reason, pilots of small aircraft should consider the effects of jet-engine blast and maintain adequate separation. Also, pilots of larger aircraft should consider the effects of their aircraft's jet-engine blast on other aircraft and equipment on the ground.

Vortex Generation

Lift is generated by the creation of a pressure differential over the wing surface. The lowest pressure occurs over the upper

wing surface, and the highest pressure under the wing. This pressure differential triggers the rollup of the airflow aft of the wing resulting in swirling air masses trailing downstream of the wingtips. After the rollup is completed, the wake consists of two counter rotating cylindrical vortices. Most of the energy is within a few feet of the center of each vortex, but pilots should avoid a region within about 100 feet of the vortex core. [Figure 13-20]

Vortex Strength

The strength of the vortex is governed by the weight, speed, and shape of the wing of the generating aircraft. The vortex characteristics of any given aircraft can also be changed by the extension of flaps or other wing configuration devices as well as by a change in speed. The greatest vortex strength occurs when the generating aircraft is heavy, clean, and slow.

Vortex Behavior

Trailing vortices have certain behavioral characteristics that can help a pilot visualize the wake location and take avoidance precautions.

Vortices are generated from the moment an aircraft leaves the ground (until it touches down), since trailing vortices are the byproduct of wing lift. [Figure 13-21] The vortex circulation is outward, upward, and around the wingtips when viewed from either ahead or behind the aircraft. Tests have shown that vortices remain spaced a bit less than a wingspan apart, drifting with the wind, at altitudes greater than a wingspan from the ground. Tests have also shown that the vortices sink at a rate of several hundred feet per minute, slowing their descent and diminishing in strength with time and distance behind the generating aircraft.

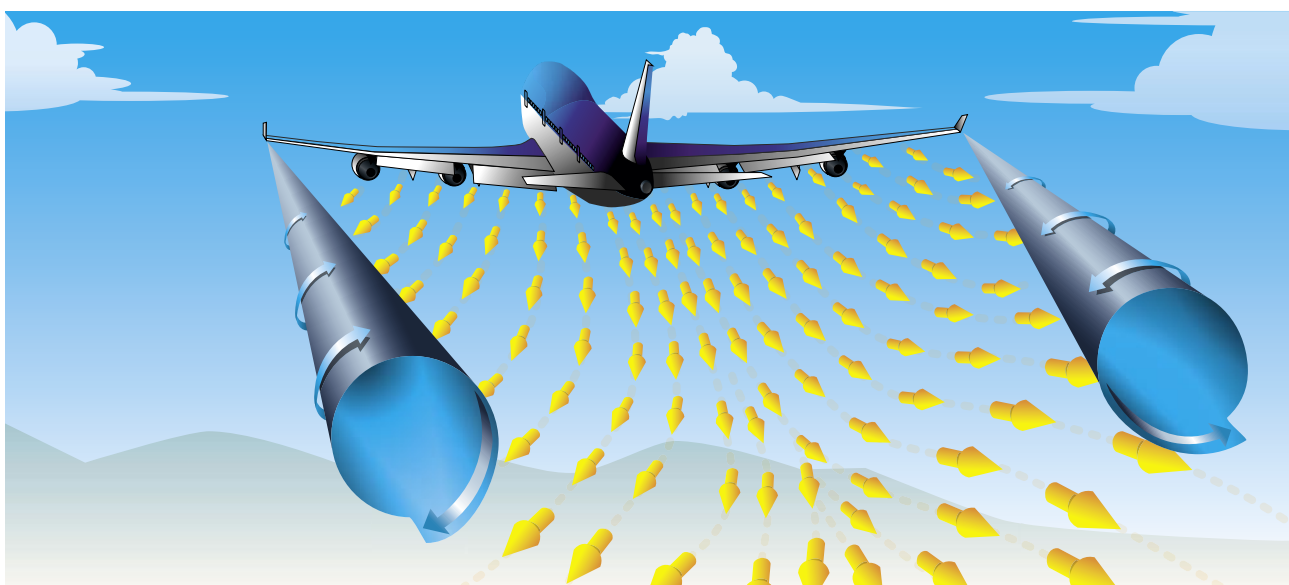


Figure 13-20. Vortex generation.

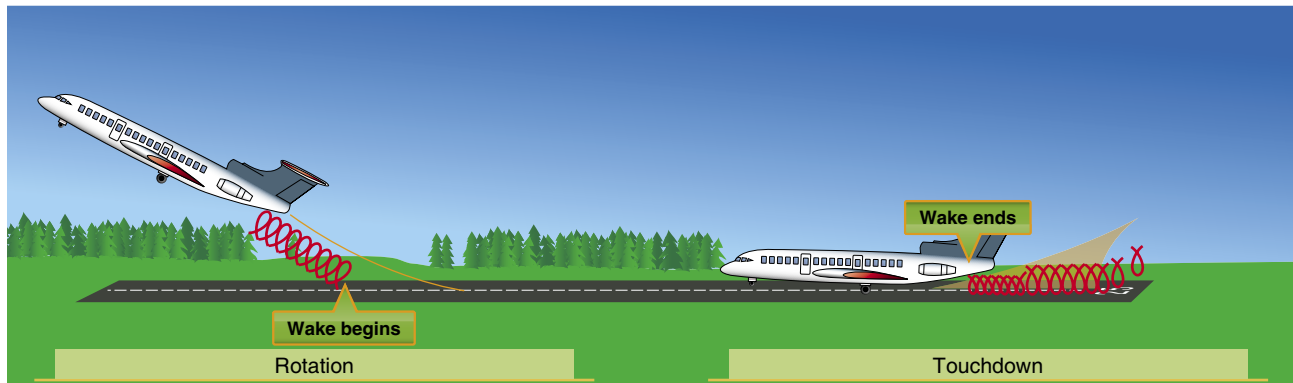


Figure 13-21. *Vortex behavior.*

When the vortices of larger aircraft sink close to the ground (within 100 to 200 feet), they tend to move laterally over the ground at a speed of 2–3 knots. A crosswind decreases the lateral movement of the upwind vortex and increases the movement of the downwind vortex. A tailwind condition can move the vortices of the preceding aircraft forward into the touchdown zone.

Vortex Avoidance Procedures

- Landing behind a larger aircraft on the same runway—stay at or above the larger aircraft’s approach flightpath and land beyond its touchdown point.
- Landing behind a larger aircraft on a parallel runway closer than 2,500 feet—consider the possibility of drift and stay at or above the larger aircraft’s final approach flightpath and note its touch down point.
- Landing behind a larger aircraft on crossing runway—cross above the larger aircraft’s flightpath.
- Landing behind a departing aircraft on the same runway—land prior to the departing aircraft’s rotating point.
- Landing behind a larger aircraft on a crossing runway—note the aircraft’s rotation point and, if that point is past the intersection, continue and land prior to the intersection. If the larger aircraft rotates prior to the intersection, avoid flight below its flightpath. Abandon the approach unless a landing is ensured well before reaching the intersection.
- Departing behind a large aircraft—rotate prior to the large aircraft’s rotation point and climb above its climb path until turning clear of the wake.
- For intersection takeoffs on the same runway—be alert to adjacent larger aircraft operations, particularly upwind of the runway of intended use. If an intersection takeoff clearance is received, avoid headings that cross below the larger aircraft’s path.

- If departing or landing after a large aircraft executing a low approach, missed approach, or touch and go landing (since vortices settle and move laterally near the ground, the vortex hazard may exist along the runway and in the flightpath, particularly in a quartering tailwind), it is prudent to wait at least 2 minutes prior to a takeoff or landing.
- En route it is advisable to avoid a path below and behind a large aircraft, and if a large aircraft is observed above on the same track, change the aircraft position laterally and preferably upwind.

Collision Avoidance

14 CFR part 91 has established right-of-way rules, minimum safe altitudes, and VFR cruising altitudes to enhance flight safety. The pilot can contribute to collision avoidance by being alert and scanning for other aircraft. This is particularly important in the vicinity of an airport.

Effective scanning is accomplished with a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field. Each movement should not exceed 10°, and each should be observed for at least 1 second to enable detection. Although back and forth eye movements seem preferred by most pilots, each pilot should develop a scanning pattern that is most comfortable and then adhere to it to assure optimum scanning. Even if entitled to the right-of-way, a pilot should yield if another aircraft seems too close.

Clearing Procedures

The following procedures and considerations should assist a pilot in collision avoidance under various situations.

- Before takeoff—prior to taxiing onto a runway or landing area in preparation for takeoff, pilots should scan the approach area for possible landing traffic, executing appropriate maneuvers to provide a clear view of the approach areas.
- Climbs and descents—during climbs and descents in flight conditions which permit visual detection of other traffic, pilots should execute gentle banks left and right at a frequency which permits continuous visual scanning of the airspace.
- Straight and level—during sustained periods of straight-and-level flight, a pilot should execute appropriate clearing procedures at periodic intervals.
- Traffic patterns—entries into traffic patterns while descending should be avoided.
- Traffic at VOR sites—due to converging traffic, sustained vigilance should be maintained in the vicinity of VORs and intersections.
- Training operations—vigilance should be maintained and clearing turns should be made prior to a practice maneuver. During instruction, the pilot should be asked to verbalize the clearing procedures (call out “clear left, right, above, and below”).

High-wing and low-wing aircraft have their respective blind spots. The pilot of a high-wing aircraft should momentarily raise the wing in the direction of the intended turn and look for traffic prior to commencing the turn. The pilot of a low-wing aircraft should momentarily lower the wing and look for traffic prior to commencing the turn.

Runway Incursion Avoidance

A runway incursion is “any occurrence in the airport runway environment involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land.” It is important to give the same attention to operating on the surface as in other phases of flights. Proper planning can prevent runway incursions and the possibility of a ground collision. A pilot should be aware of the aircraft’s position on the surface at all times and be aware of other aircraft and vehicle operations on the airport. At times towered airports can be busy and taxi instructions complex. In this situation it may be advisable

to write down taxi instructions. The following are some practices to help prevent a runway incursion:

- Read back all runway crossing and/or hold instructions.
- Review airport layouts as part of preflight planning, before descending to land and while taxiing, as needed.
- Know airport signage.
- Review NOTAM for information on runway/taxiway closures and construction areas.
- Request progressive taxi instructions from ATC when unsure of the taxi route.
- Check for traffic before crossing any runway hold line and before entering a taxiway.
- Turn on aircraft lights and the rotating beacon or strobe lights while taxiing.
- When landing, clear the active runway as soon as possible, then wait for taxi instructions before further movement.
- Study and use proper phraseology in order to understand and respond to ground control instructions.
- Write down complex taxi instructions at unfamiliar airports.

For more detailed information, contact the FAA’s Office of Runway Safety and Operational Services web site at <http://www.faa.gov/runwaysafety/> or visit http://www.aopa.org/asf/accident_data/incursions.html to access a learning tool developed by the FAA and the Aircraft Owners and Pilots Association (AOPA) to help pilots and maintenance technicians avoid runway incursions involving taxiing aircraft. Additional information can also be found in Advisory Circular (AC) 91-73, Part 91, Pilot and Flightcrew Procedures During Taxi Operations, and Part 135, Single-Pilot Procedures During Taxi Operations.

Chapter Summary

This chapter focused on airport operations both in the air and on the surface. For specific information about an unfamiliar airport, consult the A/FD and NOTAMS before flying. For further information regarding procedures discussed in this chapter, refer to 14 CFR part 91 and the AIM. By adhering to established procedures, both airport operations and safety are enhanced.