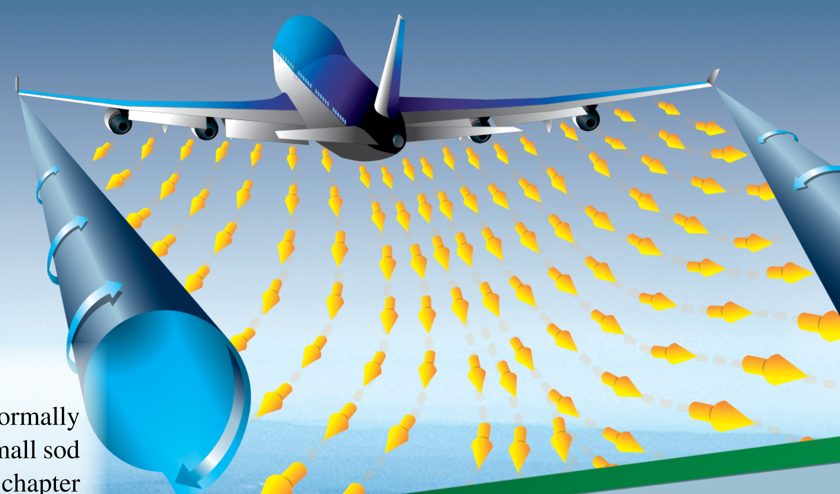
Chapter 14

Airport Operations

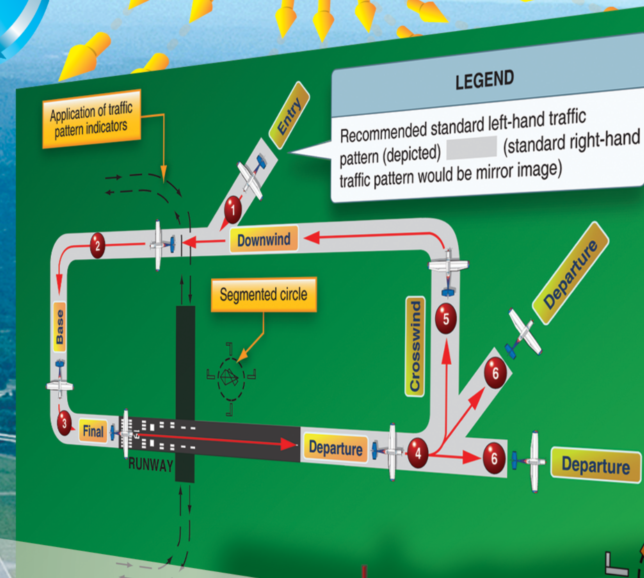


Introduction

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.

Airport Categories

The definition for airports refers to any area of land or water used or intended for landing or takeoff of aircraft. This includes, within the five categories of airports listed below, special types of facilities including seaplane bases, heliports, and facilities to accommodate tilt rotor aircraft. An airport includes an area used or intended for airport buildings, facilities, as well as rights of way together with the buildings and facilities.



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!!!!

The law defines airports by categories of airport activities, including commercial service, primary, cargo service, reliever, and general aviation airports, as shown below:

- Commercial Service Airports—publicly owned airports that have at least 2,500 passenger boardings each calendar year and receive scheduled passenger service. Passenger boardings refer to revenue passenger boardings on an aircraft in service in air commerce whether or not in scheduled service. The definition also includes passengers who continue on an aircraft in international flight that stops at an airport in any of the 50 States for a non-traffic purpose, such as refueling or aircraft maintenance rather than passenger activity. Passenger boardings at airports that receive scheduled passenger service are also referred to as Enplanements.
- Cargo Service Airports—airports that, in addition to any other air transportation services that may be available, are served by aircraft providing air transportation of only cargo with a total annual landed weight of more than 100 million pounds. "Landed weight" means the weight of aircraft transporting only cargo in intrastate, interstate, and foreign air transportation. An airport may be both a commercial service and a cargo service airport.
- Reliever Airports—airports designated by the FAA to relieve congestion at Commercial Service Airports and to provide improved general aviation access to the overall community. These may be publicly or privately-owned.
- General Aviation Airports — the remaining airports are commonly described as General Aviation Airports. This airport type is the largest single group of airports in the U.S. system. The category also includes privately owned, public use airports that enplane 2500 or more passengers annually and receive scheduled airline service.

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.

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 ATC 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

A 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 that 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 is identified in appropriate aeronautical publications. *Figure 14-1* lists recommended communication procedures. More information regarding radio communications is provided later in this chapter.

Nontowered airport traffic patterns are always entered at pattern altitude. How you enter the pattern depends upon the direction of arrival. The preferred method for entering from the downwind side of the pattern is to approach the pattern on a course 45 degrees to the downwind leg and join the pattern at midfield.

There are several ways to enter the pattern if you're coming from the upwind leg side of the airport. One method of entry from the opposite side of the pattern is to announce your intentions and cross over midfield at least 500 feet above

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 14-1. *Recommended communication procedures.*

pattern altitude (normally 1,500 feet AGL.) However, if large or turbine aircraft operate at your airport, it is best to remain 2,000 feet AGL so you are not in conflict with their traffic pattern. When well clear of the pattern—approximately 2 miles–scan carefully for traffic, descend to pattern altitude, then turn right to enter at 45° to the downwind leg at midfield. *[Figure 14-2]*

An alternate method is to enter on a midfield crosswind at pattern altitude, carefully scan for traffic, announce your intentions, and then turn downwind. *[Figure 14-3]* This technique should not be used if the pattern is busy. Always remember to give way to aircraft on the preferred 45° entry and to aircraft already established on downwind.

In either case, it is vital to announce your intentions, and remember to scan outside. Before joining the downwind leg, adjust your course or speed to blend into the traffic. Adjust power on the downwind leg, or sooner, to fit into the flow of traffic. Avoid flying too fast or too slow. Speeds recommended by the airplane manufacturer should be used. They will generally fall between 70 to 80 knots for fixed-gear singles and 80 to 90 knots for high-performance retractable.

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
- Chart Supplement U.S. (formerly Airport/Facility Directory)
- Notices to Airmen (NOTAMs)
- Automated Terminal Information Service (ATIS)

Aeronautical Charts

Aeronautical charts provide specific information on airports. Chapter 16, "Navigation," contains an excerpt from an aeronautical chart and an aeronautical chart legend, which provides guidance on interpreting the information on the chart.

Chart Supplement U.S. (formerly Airport/Facility Directory)

The Chart Supplement U.S. (formerly Airport/Facility Directory) 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 Chart Supplement U.S. is published in seven books, which are organized by regions and are revised every 56 days. The Chart Supplement U.S. is also available digitally at www.faa.

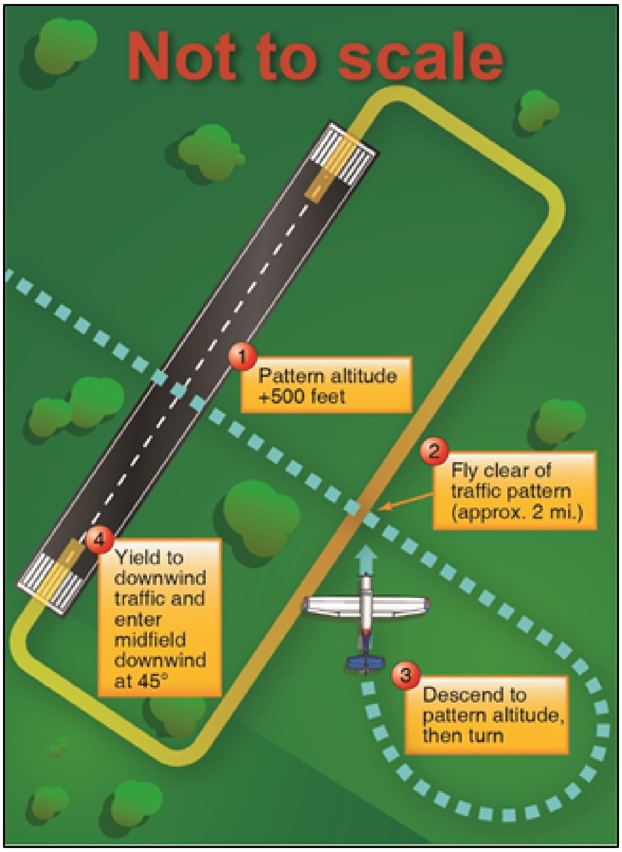


Figure 14-2. *Preferred Entry-Crossing Midfield.*

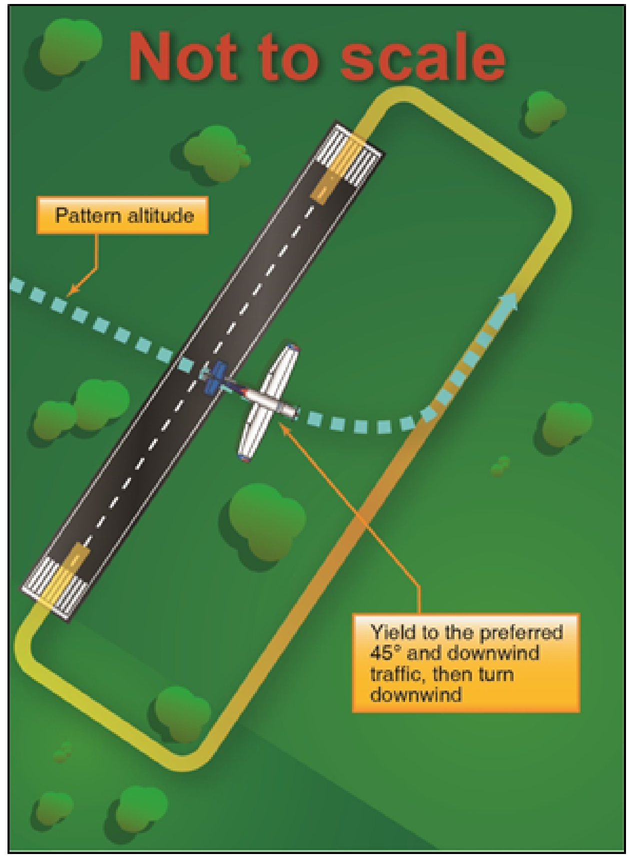


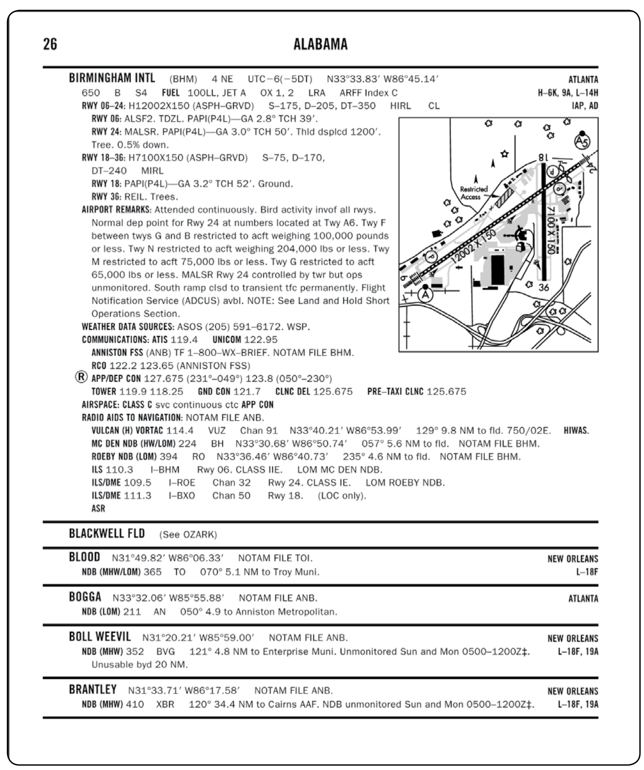
Figure 14-3. *Alternate Midfield Entry.*

gov/air_traffic/flight_info/aeronav. *Figure 14-4* contains an excerpt from a directory. For a complete listing of information provided in a Chart Supplement U.S. and how the information may be decoded, refer to the "Legend Sample" located in the front of each Chart Supplement U.S.

In addition to airport information, each Chart Supplement U.S. 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 is beneficial to review a Chart Supplement U.S. to become familiar with the information it contains.

Notices to Airmen (NOTAM)

Time-critical aeronautical information, which is of a temporary nature or not sufficiently known in advance to permit publication, on aeronautical charts or in other operational


26 ALABAMA

BIRMINGHAM INTL (BHM) 4 NE UTC–6(–5DT) N33°33.83′ W86°45.14′ — ATLANTA
650 B S4 **FUEL** 100LL, JET A OX 1, 2 LRA ARFF Index C — H–6K, 9A, L–14H
RWY 06–24: H12002X150 (ASPH–GRVD) S–175, D–205, DT–350 HIRL CL — IAP, AD
RWY 06: ALSF2. TDZL. PAPI(P4L)—GA 2.8° TCH 39′.
RWY 24: MALSR. PAPI(P4L)—GA 3.0° TCH 50′. Thld dsplcd 1200′. Tree. 0.5% down.
RWY 18–36: H7100X150 (ASPH–GRVD) S–75, D–170, DT–240 MIRL
RWY 18: PAPI(P4L)—GA 3.2° TCH 52′. Ground.
RWY 36: REIL. Trees.
AIRPORT REMARKS: Attended continuously. Bird activity invof all rwys. Normal dep point for Rwy 24 at numbers located at Twy A6. Twy F between twys G and B restricted to acft weighing 100,000 pounds or less. Twy N restricted to acft weighing 204,000 lbs or less. Twy M restricted to acft 75,000 lbs or less. Twy G restricted to acft 65,000 lbs or less. MALSR Rwy 24 controlled by twr but ops unmonitored. South ramp clsd to transient tfc permanently. Flight Notification Service (ADCUS) avbl. NOTE: See Land and Hold Short Operations Section.
WEATHER DATA SOURCES: ASOS (205) 591–6172. WSP.
COMMUNICATIONS: ATIS 119.4 **UNICOM** 122.95
ANNISTON FSS (ANB) TF 1–800–WX–BRIEF. NOTAM FILE BHM.
RCO 122.2 123.65 (ANNISTON FSS)
Ⓡ **APP/DEP CON** 127.675 (231°–049°) 123.8 (050°–230°)
TOWER 119.9 118.25 **GND CON** 121.7 **CLNC DEL** 125.675 **PRE–TAXI CLNC** 125.675
AIRSPACE: CLASS C svc continuous ctc **APP CON**
RADIO AIDS TO NAVIGATION: NOTAM FILE ANB.
VULCAN (H) VORTAC 114.4 VUZ Chan 91 N33°40.21′ W86°53.99′ 129° 9.8 NM to fld. 750/02E. **HIWAS.**
MC DEN NDB (HW/LOM) 224 BH N33°30.68′ W86°50.74′ 057° 5.6 NM to fld. NOTAM FILE BHM.
ROEBY NDB (LOM) 394 RO N33°36.46′ W86°40.73′ 235° 4.6 NM to fld. NOTAM FILE BHM.
ILS 110.3 I–BHM Rwy 06. CLASS IIE. LOM MC DEN NDB.
ILS/DME 109.5 I–ROE Chan 32 Rwy 24. CLASS IE. LOM ROEBY NDB.
ILS/DME 111.3 I–BXO Chan 50 Rwy 18. (LOC only).
ASR

BLACKWELL FLD (See OZARK)

BLOOD N31°49.82′ W86°06.33′ NOTAM FILE TOI. — NEW ORLEANS
NDB (MHW/LOM) 365 TO 070° 5.1 NM to Troy Muni. — L–18F

BOGGA N33°32.06′ W85°55.88′ NOTAM FILE ANB. — ATLANTA
NDB (LOM) 211 AN 050° 4.9 to Anniston Metropolitan.

BOLL WEEVIL N31°20.21′ W85°59.00′ NOTAM FILE ANB. — NEW ORLEANS
NDB (MHW) 352 BVG 121° 4.8 NM to Enterprise Muni. Unmonitored Sun and Mon 0500–1200Z‡. Unusable byd 20 NM. — L–18F, 19A

BRANTLEY N31°33.71′ W86°17.58′ NOTAM FILE ANB. — NEW ORLEANS
NDB (MHW) 410 XBR 120° 34.4 NM to Cairns AAF. NDB unmonitored Sun and Mon 0500–1200Z‡. — L–18F, 19A

Figure 14-4. *Chart Supplement U.S. (formerly Airport/Facility Directory excerpt.*

publications receives immediate dissemination by the NOTAM system. The NOTAM information could affect your decision to make the flight. It includes such information as taxiway and runway closures, construction, communications, changes in status of navigational aids, and other information essential to planned en route, terminal, or landing operations. Exercise good judgment and common sense by carefully regarding the information readily available in NOTAMs.

Prior to any flight, pilots should check for any NOTAMs that could affect their intended flight. For more information on NOTAMs, refer back to Chapter 1, "Pilot and Aeronautical Information" section.

Automated Terminal Information Service (ATIS)

The Automated Terminal Information Service (ATIS) is a recording of the local weather conditions and other pertinent non-control information broadcast on a local frequency in a looped format. It is normally updated once per hour but is updated more often when changing local conditions warrant. Important information is broadcast on ATIS including weather, runways in use, specific ATC procedures, and any airport construction activity that could affect taxi planning.

When the ATIS is recorded, it is given a code. This code is changed with every ATIS update. For example, ATIS Alpha is replaced by ATIS Bravo. The next hour, ATIS Charlie is recorded, followed by ATIS Delta and progresses down the alphabet.

Prior to calling ATC, tune to the ATIS frequency and listen to the recorded broadcast. The broadcast ends with a statement containing the ATIS code. For example, "Advise on initial contact, you have information Bravo." Upon contacting the tower controller, state information Bravo was received. This allows the tower controller to verify the pilot has the current local weather and airport information without having to state it all to each pilot who calls. This also clears the tower frequency from being overtaken by the constant relay of the same information, which would result without an ATIS broadcast. The use of ATIS broadcasts at departure and arrival airports is not only a sound practice but a wise decision.

Airport Markings and Signs

There are markings and signs used at airports that provide directions and assist pilots in airport operations. It is important for you to know the meanings of the signs, markings, and lights that are used on airports as surface navigational aids. All airport markings are painted on the surface, whereas some signs are vertical and some are painted on the surface. An overview of the most common signs and markings are described on the following pages. Additional information may be found in Chapter 2, "Aeronautical Lighting and Other Airport Visual Aids," of the Aeronautical Information Manual (AIM).

Runway Markings and Signs

Runway markings vary depending on the type of operations conducted at the airport. A basic VFR runway may only have centerline markings and runway numbers. Refer to Appendix C of this publication for an example of the most common runway markings that are found at airports.

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)).

Relocated Runway Threshold

It is sometimes necessary, due to construction or runway maintenance, to close only a portion of a runway. When a portion of a runway is closed, the runway threshold is relocated as necessary. It is referred to as a relocated threshold and methods for identifying the relocated threshold vary. A common way for the relocated threshold to be marked is a ten foot wide white bar across the width of the runway. *[Figure 14-5A* and *B]*

When the threshold is relocated, the closed portion of the runway is not available for use by aircraft for takeoff or landing, but it is available for taxi. When a threshold is relocated, it closes not only a set portion of the approach end of a runway, but also shortens the length of the opposite direction runway. Yellow arrow heads are placed across the width of the runway just prior to the threshold bar.

Displaced Threshold

A displaced threshold is a threshold located at a point on the runway other than the designated beginning of the runway. Displacement of a threshold reduces the length of runway available for landings. The portion of runway behind a displaced threshold is available for takeoffs in either direction, or landings from the opposite direction. A ten feet wide white threshold bar is located across the width of the runway at the displaced threshold, and white arrows are located along the centerline in the area between the beginning of the runway and displaced threshold. White arrow heads are located across the width of the runway just prior to the threshold bar. *[Figure 14-6A* and *B]*

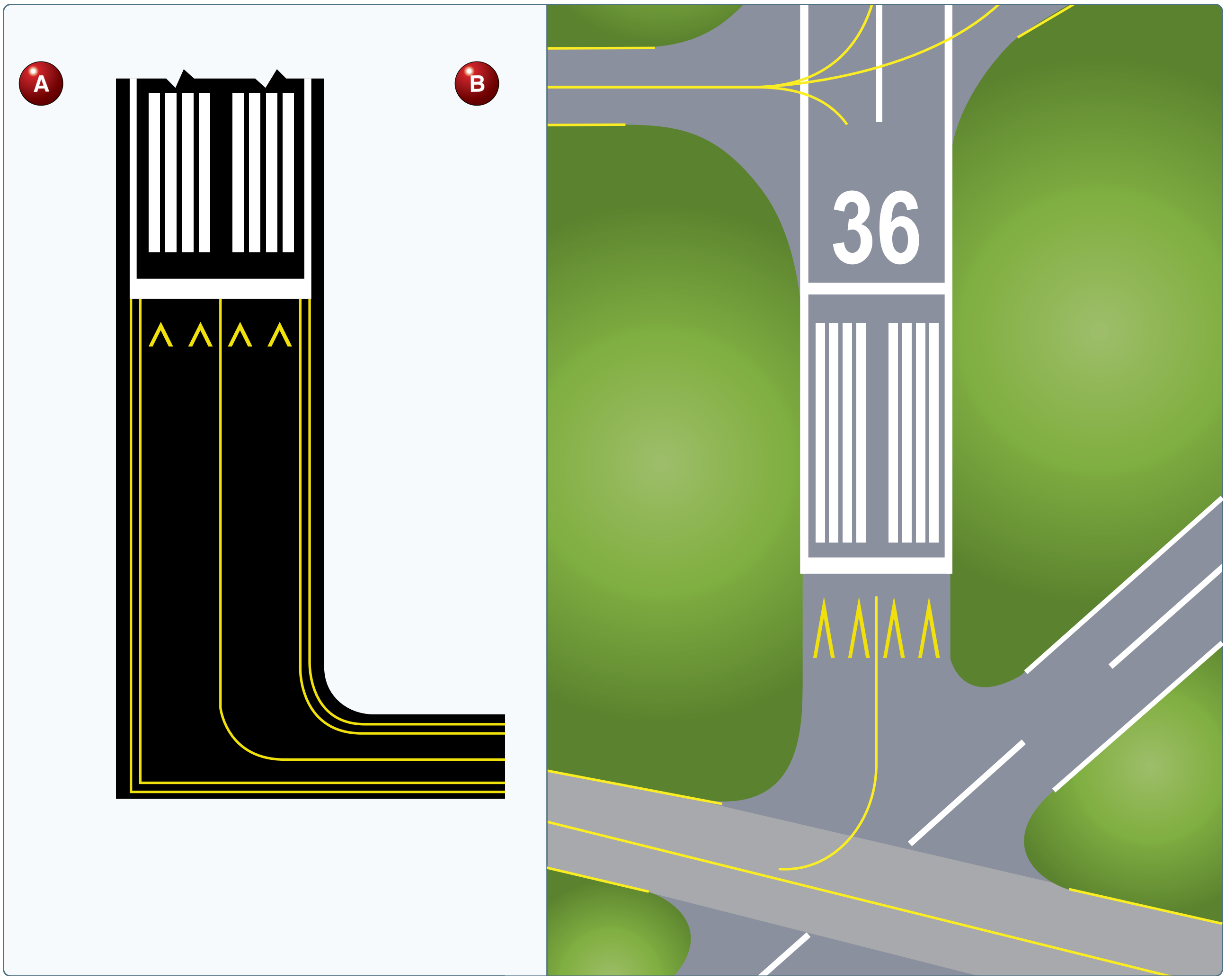


Figure 14-5. *(A) Relocated runway threshold drawing. (B) Relocated threshold for Runway 36 at Joplin Regional Airport (JLN).*

Runway Safety Area

The runway safety area (RSA) is a defined surface surrounding the runway prepared, or suitable, for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway. The dimensions of the RSA vary and can be determined by using the criteria contained within AC 150/5300-13, Airport Design, Chapter 3. Figure 3-1 in AC 150/5300-13 depicts the RSA. Additionally, it provides greater accessibility for firefighting and rescue equipment in emergency situations.

The RSA is typically graded and mowed. The lateral boundaries are usually identified by the presence of the runway holding position signs and markings on the adjoining taxiway stubs. Aircraft should not enter the RSA without making sure of adequate separation from other aircraft during operations at uncontrolled airports. *[Figure 14-7]*

Runway Safety Area Boundary Sign

Some taxiway stubs also have a runway safety area boundary sign that faces the runway and is visible to you only when exiting the runway. This sign has a yellow background with black markings and is typically used at towered airports where a controller commonly requests you to report clear of a runway. This sign is intended to provide you with another visual cue that is used as a guide to determine when you are clear of the runway safety boundary area. The sign shown in *Figure 14-8* is what you would see when exiting the runway at Taxiway Kilo. You are out of the runway safety area boundary when the entire aircraft passes the sign and the accompanying surface painted marking.

Runway Holding Position Sign

Noncompliance with a runway holding position sign may result in the FAA filing a Pilot Deviation against you. A

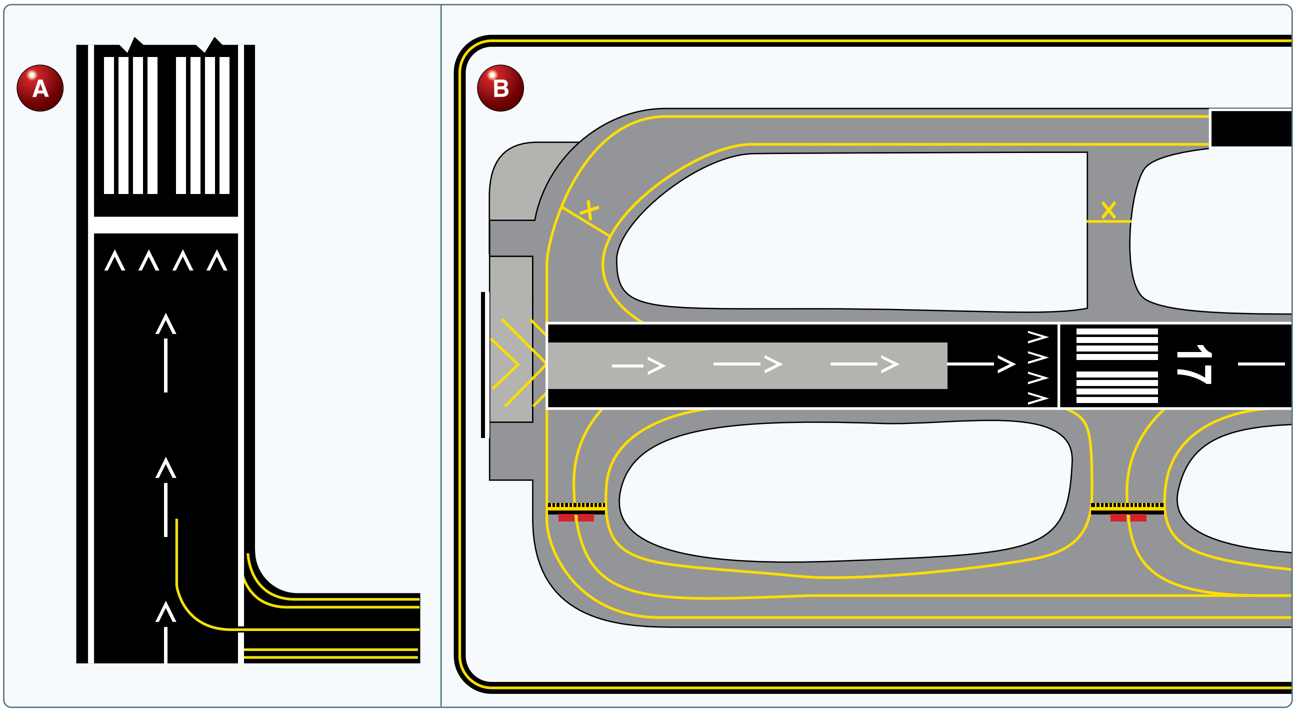


Figure 14-6. *(A) Displaced runway threshold drawing. (B) Displaced threshold for Runway 17 at Albuquerque International Airport (ABQ).*

runway holding position sign is an airport version of a stop sign. *[Figure 14-9]* It may be seen as a sign and/or its characters painted on the airport pavement. The sign has white characters outlined in black on a red background. It is always collocated with the surface painted holding position markings and is located where taxiways intersect runways. On taxiways that intersect the threshold of the takeoff runway, only the designation of the runway may appear on the sign.

If a taxiway intersects a runway somewhere other than at the threshold, the sign has the designation of the intersecting runway. The runway numbers on the sign are arranged to correspond to the relative location of the respective runway thresholds. *Figure 14-10* shows "18-36" to indicate the threshold for Runway 18 is to the left and the threshold for

Figure 14-8. *Runway safety area boundary sign and marking located on Taxiway Kilo.*

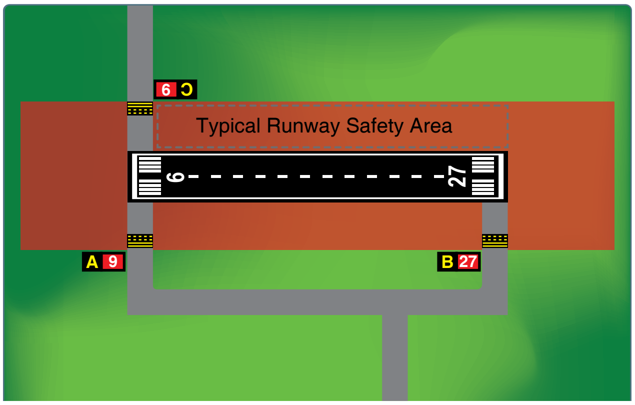


Figure 14-7. *Runway Safety Area.*

Figure 14-9. *Runway holding position sign at takeoff end of Runway 14 with collocated Taxiway Alpha location sign.*

Figure 14-10. *Runway holding position sign at a location other than the takeoff end of Runway 18-36 with collocated Taxiway Alpha location sign.*

Runway 36 is to the right. The sign also indicates that you are located on Taxiway Alpha.

If the runway holding position sign is located on a taxiway at the intersection of two runways, the designations for both runways are shown on the sign along with arrows showing the approximate alignment of each runway. *[Figure 14-11A* and *B]* In addition to showing the approximate runway alignment, the arrows indicate the direction(s) to the threshold of the runway whose designation is immediately next to each corresponding arrow.

This type of taxiway and runway/runway intersection geometry can be very confusing and create navigational challenges. Extreme caution must be exercised when taxiing onto or crossing this type of intersection. *Figure 14-11A* and *B* shows a depiction of a taxiway, runway/runway intersection and is also designated as a "**hot spot**" on the airport diagram. In the example, Taxiway Bravo intersects with two runways, 31-13 and 35-17, which cross each other.

Surface painted runway holding position signs may also be used to aid you in determining the holding position. These markings consist of white characters on a red background and are painted on the left side of the taxiway centerline. *Figure 14-12* shows a surface painted runway holding position sign that is the holding point for Runway 32R-14L.

You should never allow any part of your aircraft to cross the runway holding position sign (either a vertical or surface painted sign) without a clearance from ATC. Doing so poses a hazard to yourself and others.

When the tower is closed or you are operating at a nontowered airport, you may taxi past a runway holding position sign only when the runway is clear of aircraft, and there are no aircraft on final approach. You may then proceed with extreme caution.

Runway Holding Position Marking

Noncompliance with a runway holding position marking may result in the FAA filing a Pilot Deviation against you. Runway holding position markings consist of four yellow lines, two solid and two dashed, that are painted on the surface and extend across the width of the taxiway to indicate where the aircraft should stop when approaching a runway. These markings are painted across the entire taxiway pavement, are in alignment, and are collocated with the holding position sign as described above.

As you approach the runway, two solid yellow lines and two dashed lines will be visible. Prior to reaching the solid lines, it is imperative to stop and ensure that no portion of the aircraft intersects the first solid yellow line. Do not cross the double solid lines until a clearance from ATC has been received. *[Figure 14-13]* When the tower is closed or when operating at a nontowered airport, you may taxi onto or across the runway only when the runway is clear and there are no aircraft on final approach. You should use extreme caution when crossing or taxiing onto the runway and always look both ways.

When exiting the runway, the same markings will be seen except the aircraft will be approaching the double dashed lines. *[Figure 14-14]* In order to be clear of the runway, the entire aircraft must cross both the dashed and solid lines. An ATC clearance is not needed to cross this marking when exiting the runway.

Runway Distance Remaining Signs

Runway distance remaining signs have a black background with a white number and may be installed along one or both sides of the runway. *[Figure 14-15]* The number on the signs indicates the distance, in thousands of feet, of landing runway remaining. The last sign, which has the numeral "1," is located at least 950 feet from the runway end.

Runway Designation Marking

Runway numbers and letters are determined from the approach direction. The runway number is the whole number nearest one-tenth the magnetic azimuth of the centerline of the runway, measured clockwise from the magnetic north. In the case where there are parallel runways, the letters differentiate between left (L), right (R), or center (C). *[Figure 14-16]* For example, if there are two parallel runways, they would show the designation number and then either L or R beneath it. For three parallel runways, the designation number would be presented with L, C, or R beneath it.

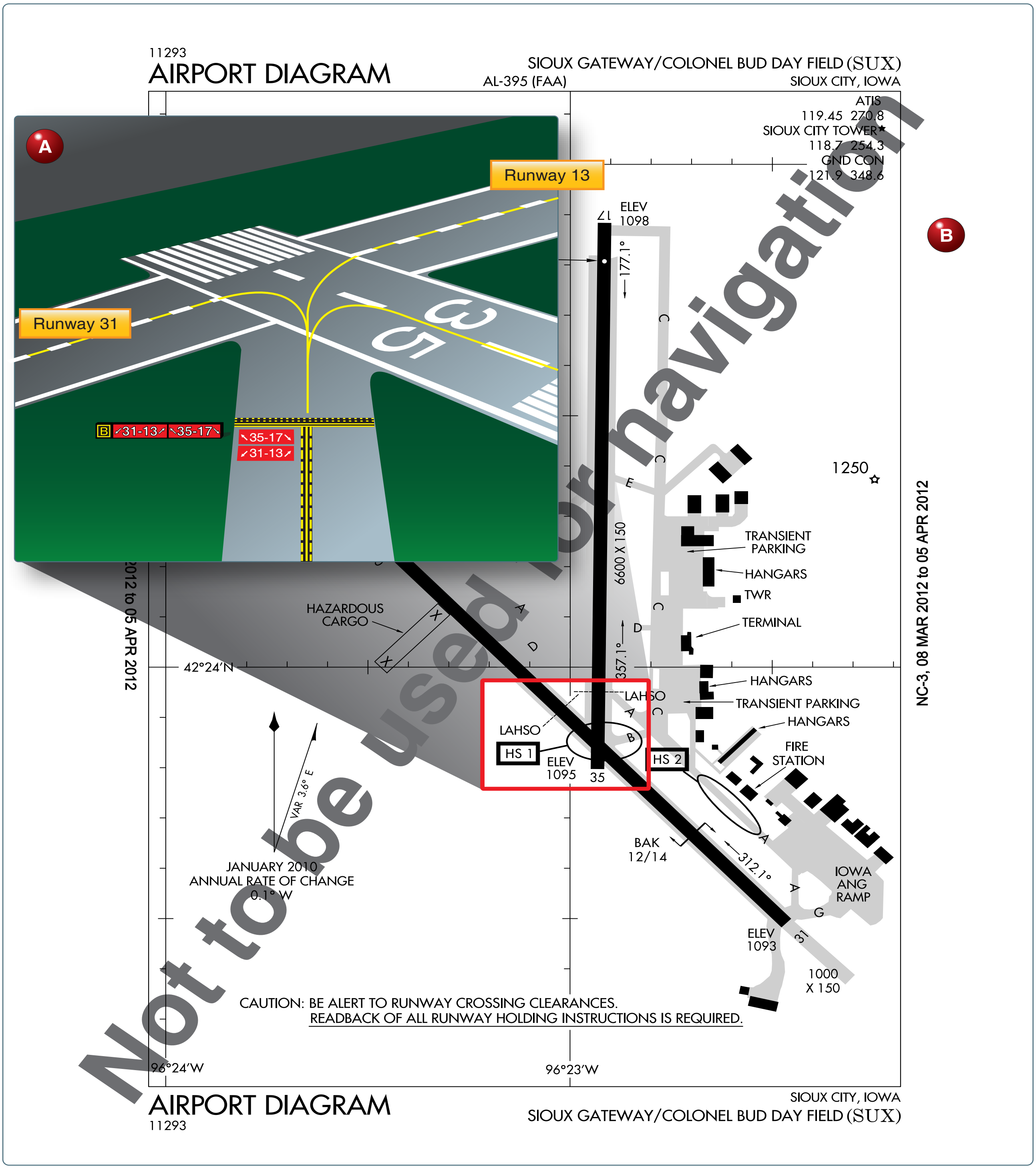


Figure 14-11. *(A) Taxiway Bravo location sign collocated with runway/runway intersection holding signs at Sioux Gateway Airport (SUX) (B) Airport diagram of Sioux Gateway Airport (SUX), Sioux City, Iowa. The area outlined in red is a designated "**hot spot**" (HS1).*

Figure 14-12. *Surface painted runway holding position signs for Runway 32R-14L along with the enhanced taxiway centerline marking.*

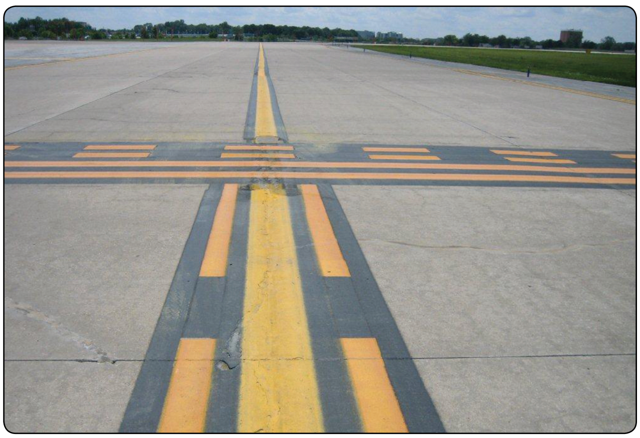


Figure 14-13. *Surface painted holding position marking along with enhanced taxiway centerline.*

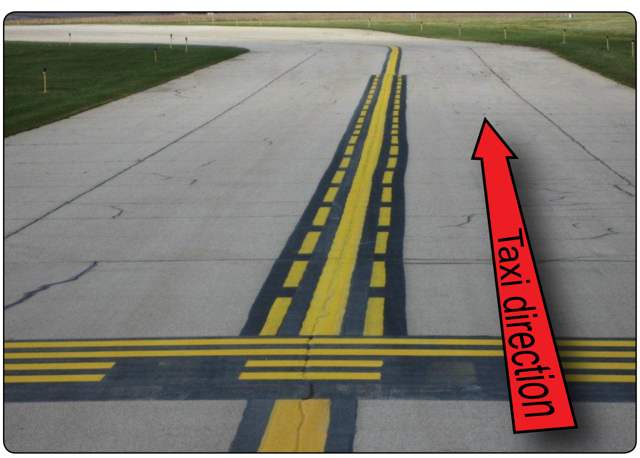


Figure 14-14. *Runway holding position markings as seen when exiting the runway. When exiting the runway, no ATC clearance is required to cross.*

Land and Hold Short Operations (LAHSO)

When simultaneous operations (takeoffs and landings) are being conducted on intersecting runways, Land and Hold Short Operations (LAHSO) may also be in effect. LAHSO is an ATC procedure that may require your participation and

Figure 14-15. *Runway distance remaining sign indicating that there is 2,000 feet of runway remaining.*

compliance. As pilot in command (PIC), you have the final authority to accept or decline any LAHSO clearance.

If issued a land and hold short clearance, you must be aware of the reduced runway distances and whether or not you can comply before accepting the clearance. You do not have to accept a LAHSO clearance. Pilots should only receive a LAHSO clearance when there is a minimum ceiling of 1,000 feet and 3 statute miles of visibility.

Runway holding position signs and markings are installed on those runways used for LAHSO. The signs and markings are placed at the LAHSO point to aid you in determining where to stop and hold the aircraft and are located prior to the runway/runway intersection. *[Figure 14-17]*

The holding position sign has a white inscription with black border around the numbers on a red background and is installed adjacent to the holding position markings. If you accept a land and hold short clearance, you must comply so that no portion of the aircraft extends beyond these hold markings.

If receiving "cleared to land" instructions from ATC, you are authorized to use the entire landing length of the runway and should disregard any LAHSO holding position markings located on the runway. If you receive and accept LAHSO instructions, you must stop short of the intersecting runway prior to the LAHSO signs and markings.

Below is a list of items which, if thoroughly understood and complied with, will ensure that LAHSO operations are conducted properly.

- Know landing distance available.
- Be advised by ATC as to why LAHSO are being conducted.

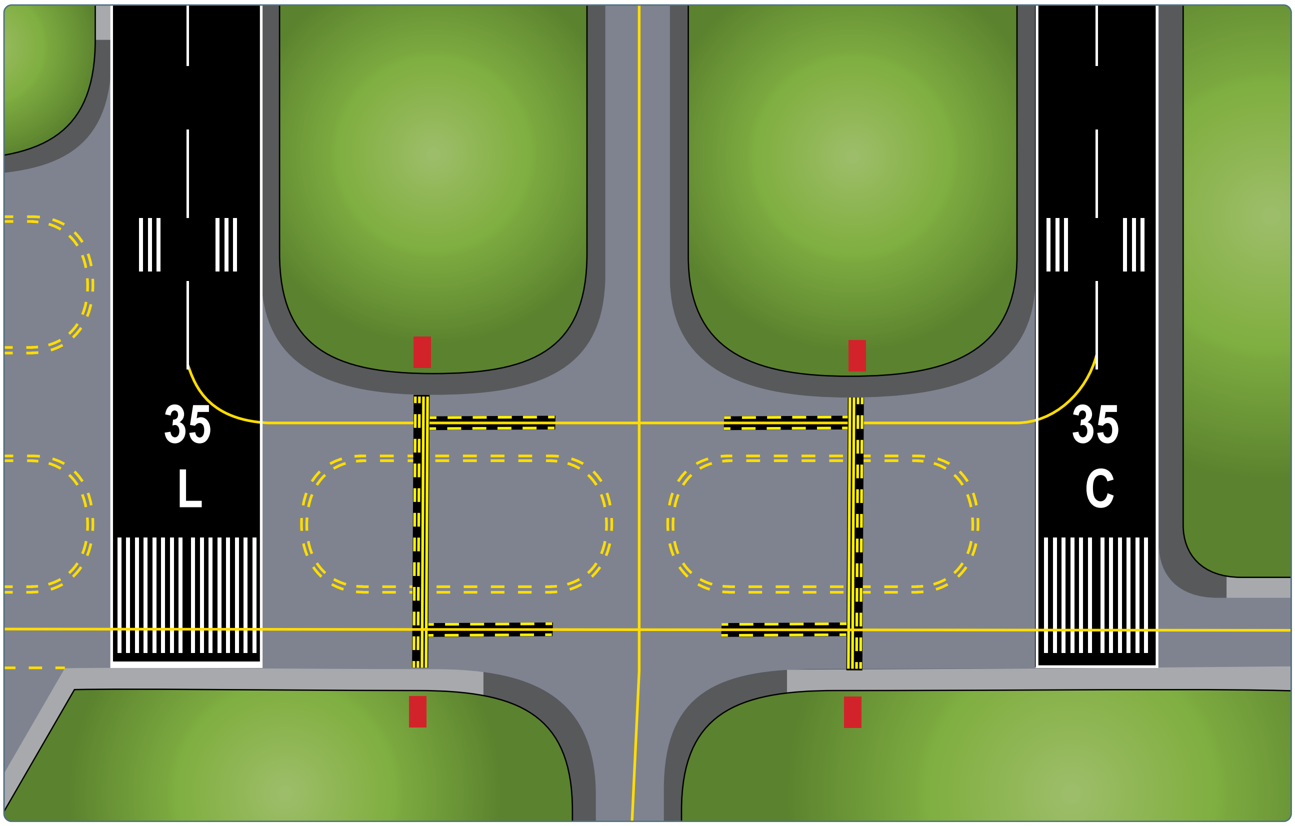


Figure 14-16. *Two of three parallel runways.*

- Advise ATC if you cannot comply with LAHSO.
- Know what signs and markings are at the LAHSO point.
- LAHSO are not authorized for student pilots who are performing a solo flight.
- At many airports air carrier aircraft are not authorized to participate in LAHSO if the other aircraft is a general aviation aircraft.
- Generally, LAHSO are not authorized at night.
- LAHSO are not authorized on wet runways.

Figure 14-17. *Runway holding position sign and marking for LAHSO.*

If you accept the following clearance from ATC: "Cleared to land Runway 36 hold short of Runway 23," you must either exit Runway 36 or stop at the holding position prior to Runway 23.

Taxiway Markings and Signs

Taxiway direction signs have a yellow background and black characters, which identifies the designation or intersecting taxiways. Arrows indicate the direction of turn that would place the aircraft on the designated taxiway. *[Figure 14-18]* Direction signs are normally located on the left side of the taxiway and prior to the intersection. These signs and markings (with a yellow background and black characters) indicate the direction toward a different taxiway, leading off a runway, or out of an intersection. *Figure 14-18* shows Taxiway Delta and how Taxiway Bravo intersects ahead at 90° both left and right.

Taxiway direction signs can also be displayed as surface painted markings. *Figure 14-19* shows Taxiway Bravo as proceeding straight ahead while Taxiway Alpha turns to the right at approximately 45°.

Figure 14-18. *Taxiway Bravo direction sign with a collocated Taxiway Delta location sign. When the arrow on the direction sign indicates a turn, the sign is located prior to the intersection.*

Figure 14-20A and *B* shows an example of a direction sign at a complex taxiway intersection. *Figure 14-20A* and *B* shows Taxiway Bravo intersects with Taxiway Sierra at 90°, but at 45° with Taxiway Foxtrot. This type of array can be displayed with or without the taxiway location sign, which in this case would be Taxiway Bravo.

Enhanced Taxiway Centerline Markings

At most towered airports, the enhanced taxiway centerline marking is used to warn you of an upcoming runway. It consists of yellow dashed lines on either side of the normal solid taxiway centerline and the dashes extend up to 150 feet prior to a runway holding position marking. *[Figure 14-21A* and *B]* They are used to aid you in maintaining awareness during surface movement to reduce runway incursions.

Destination Signs

Destination signs have black characters on a yellow background indicating a destination at the airport. These signs always have an arrow showing the direction of the taxi route to that destination. *[Figure 14-22]* When the arrow on the destination sign indicates a turn, the sign is located prior to the intersection. Destinations commonly shown on these types of signs include runways, aprons, terminals, military areas, civil aviation areas, cargo areas, international areas, and fixed-base operators. When the inscription for two or more destinations having a common taxi route are placed on a sign, the destinations are separated by a "dot" (•) and one arrow would be used as shown in *Figure 14-22.* When the inscription on a sign contains two or more destinations having different taxi routes, each destination is accompanied by an arrow and separated from the other destination(s) on the sign with a vertical black message divider as shown in *Figure 14-23.* The example shown in *Figure 14-23* shows two signs. The sign in the foreground explains that Runway 20 threshold is to the left, and Runways 32, 2, and 14 are to the right. The sign in the background indicates that you are located on Taxiway Bravo and Taxiway November will take you to those runways.

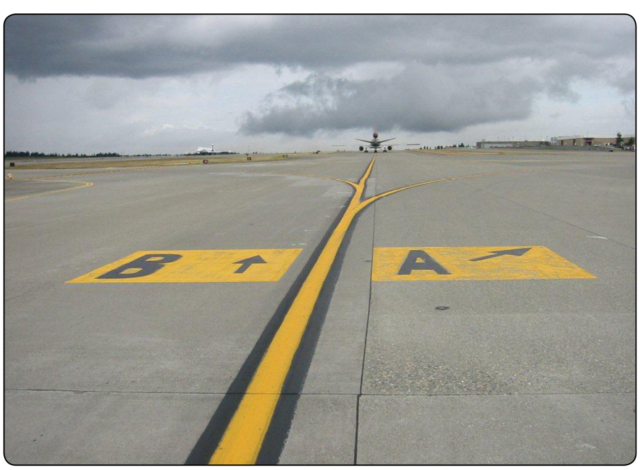


Figure 14-19. *Surface painted taxiway direction signs.*

Holding Position Signs and Markings for an Instrument Landing System (ILS) Critical Area

The instrument landing system (ILS) broadcasts signals to arriving instrument aircraft to guide them to the runway. Each of these ILSs have critical areas that must be kept clear of all obstacles in order to ensure quality of the broadcast signal. At many airports, taxiways extend into the ILS critical area. Most of the time, this is of no concern; however, during times of poor weather, an aircraft on approach may depend on a good signal quality. When necessary, ATC will protect the ILS critical area for arrival instrument traffic by instructing taxiing aircraft to "**hold short**" of Runway (XX) ILS critical area.

The ILS critical area hold sign has white characters, outlined in black, on a red background and is installed adjacent to the ILS holding position markings. *[Figure 14-24]* The holding position markings for the ILS critical area appear on the pavement as a horizontal yellow ladder extending across the width of the taxiway.

When instructed to "hold short of Runway (XX) ILS critical area," you must ensure no portion of the aircraft extends beyond these markings. *[Figure 14-25]* If ATC does not instruct you to hold at this point, then you may bypass the ILS critical area hold position markings and continue with your taxi. *Figure 14-24* shows that the ILS hold sign is located on Taxiway Golf and the ILS ladder hold position marking is adjacent to the hold sign.

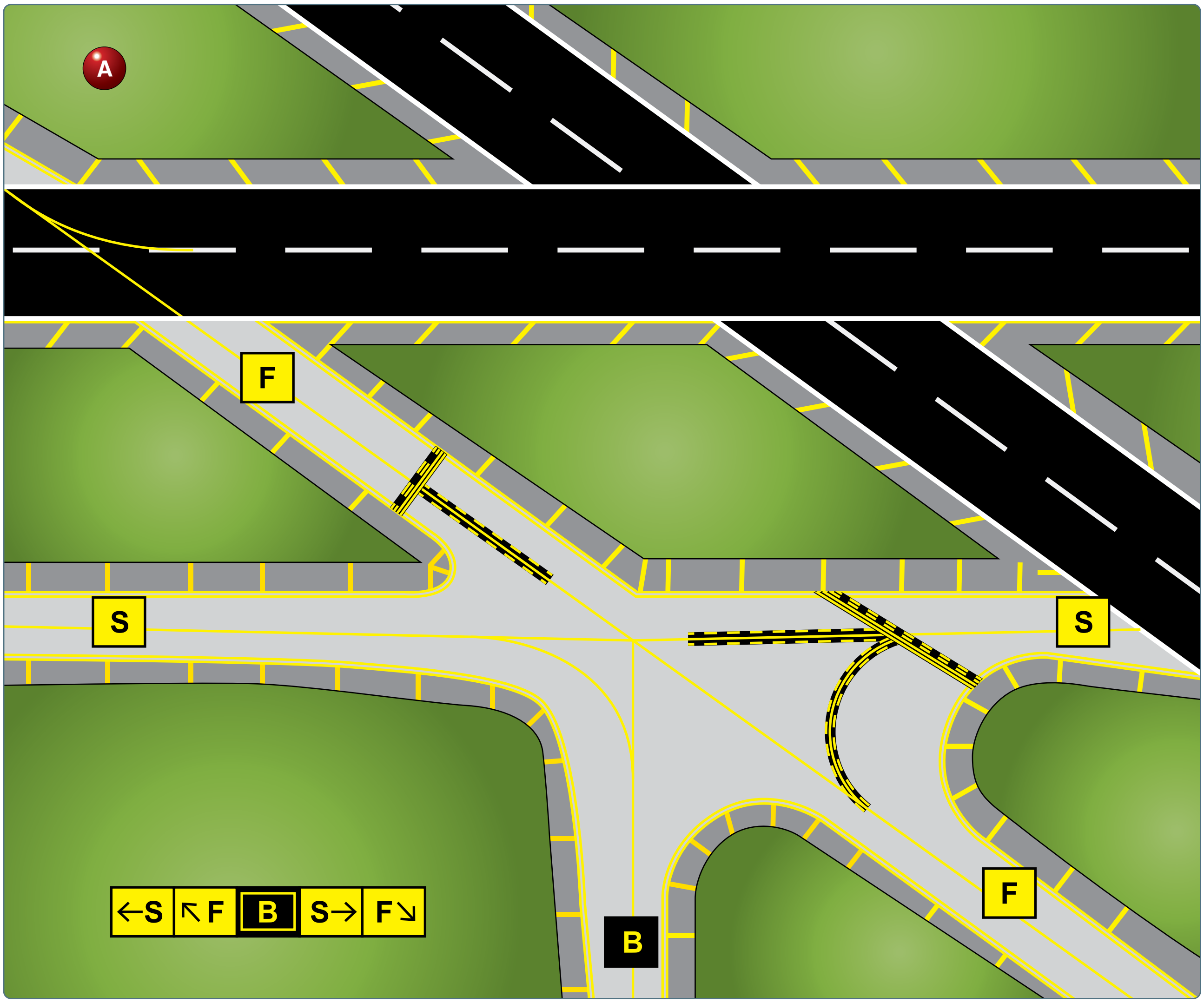


Figure 14-20. *Orientation of signs is from left to right in a clockwise manner. Left turn signs are on the left and right turn on the right. In this view, the pilot is on Taxiway Bravo.*

Figure 14-21. *(A) Enhanced taxiway centerline marking. (B) Enhanced taxiway centerline marking and runway holding position marking.*

Figure 14-22. *Destination sign to the fixed-base operator (FBO).*

Figure 14-23. *Runway destination sign with different taxi routes.*

Figure 14-24. *Instrument landing system (ILS) holding position sign and marking on Taxiway Golf.*

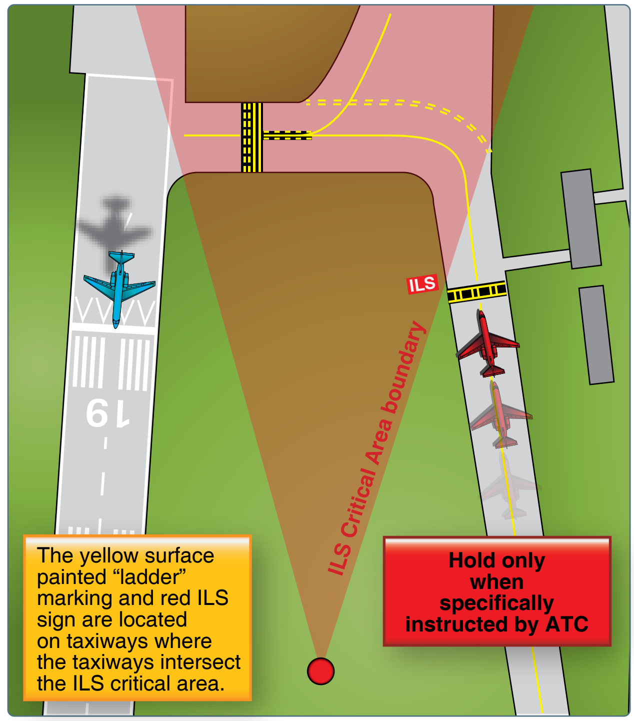


Figure 14-25. *Holding position sign and marking for instrument landing system (ILS) critical area boundary.*

Holding Position Markings for Taxiway/Taxiway Intersections

Holding position markings for taxiway/taxiway intersections consist of a single dashed yellow line extending across the width of the taxiway. *[Figure 14-26]* They are painted on taxiways where ATC normally holds aircraft short of a taxiway intersection. When instructed by ATC "hold short of Taxiway X," you should stop so that no part of your aircraft extends beyond the holding position marking. When the marking is not present, you should stop your aircraft at a point that provides adequate clearance from an aircraft on the intersecting taxiway.

Marking and Lighting of Permanently Closed Runways and Taxiways

For runways and taxiways that are permanently closed, the lighting circuits are disconnected. The runway threshold, runway designation, and touchdown markings are obliterated and yellow "Xs" are placed at each end of the runway and at 1,000-foot intervals.

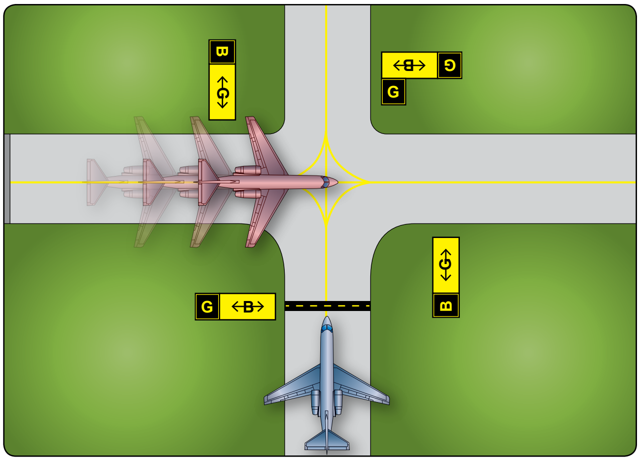


Figure 14-26. *Holding position marking on a taxiway.*

Temporarily Closed Runways and Taxiways

For temporarily closed runways and taxiways, a visual indication is often provided with yellow "Xs" or raised lighted yellow "Xs" placed at each end of the runway. Depending on the reason for the closure, duration of closure, airfield configuration, and the existence and the hours of operation of an ATC tower, a visual indication may not be present. As discussed previously in the chapter, you must always check NOTAMs and ATIS for runway and taxiway closure information.

Figure 14-27A shows an example of a yellow "X" laid flat with an adequate number of heavy sand bags to keep the wind from getting under and displacing the vinyl material.

A very effective and preferable visual aid to depict temporary closure is the lighted "X" placed on or near the runway designation numbers. *[Figure 14-27B* and *C]* This device is much more discernible to approaching aircraft than the other materials described above.

Other Markings

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

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. Appendix C of this publication shows examples of some signs that are found at most airports, 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.

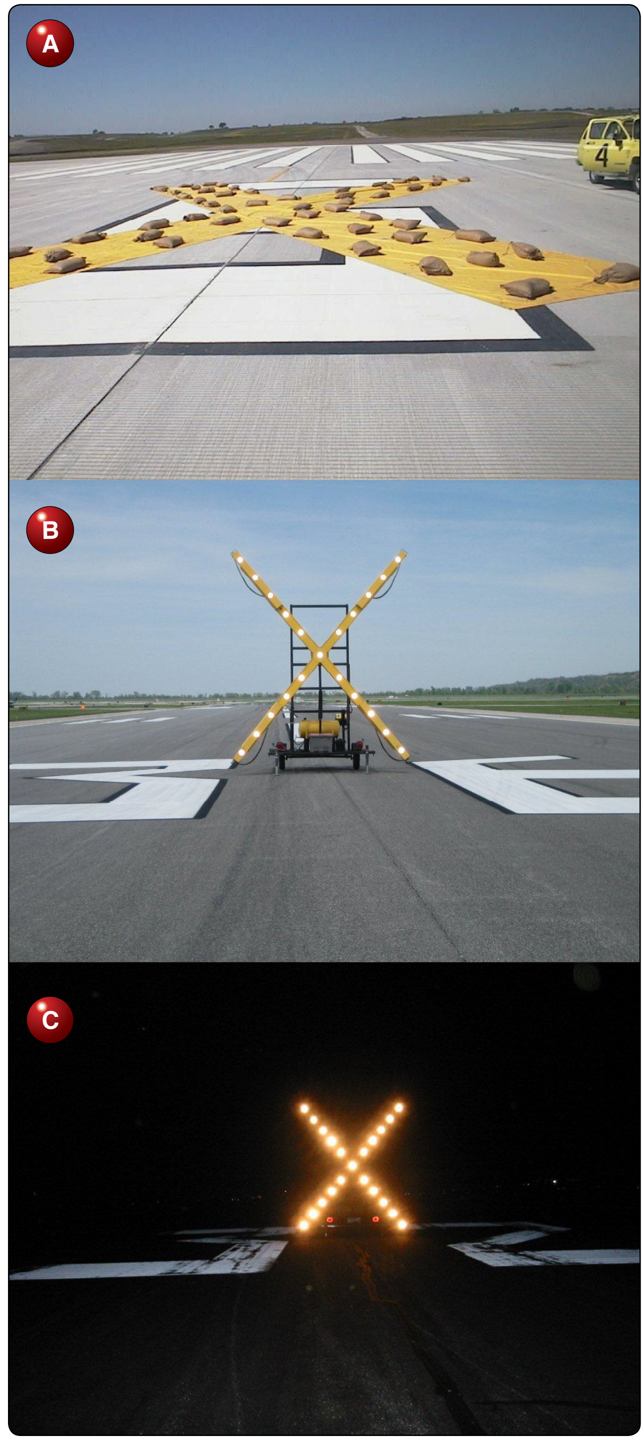


Figure 14-27. *(A) Yellow "X" placed on surface of temporarily closed runways. (B) Lighted "X" placed on temporarily closed runways. (C) Lighted "X" at night showing a temporarily closed runway.*

- 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 arrows. These signs provide information on locating areas, 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 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 normally operated from dusk until 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 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, that produces the visual effect of flashes at regular intervals. The combination of light colors from an airport beacon indicates the type of airport. *[Figure 14-28]* 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
- Two quick white flashes alternating with a green flash identifying a military airport

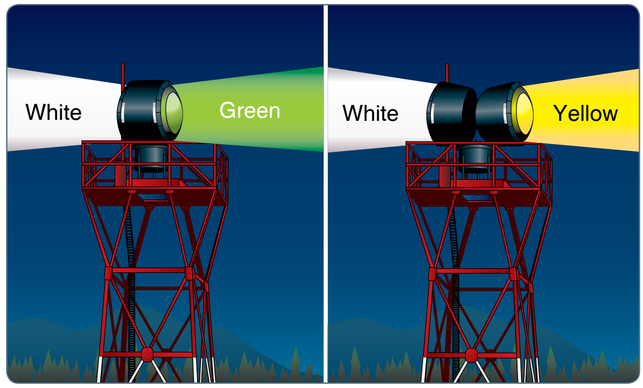


Figure 14-28. *Airport rotating beacons.*

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 that 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 extended runway centerline and up 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 that 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 14-29* to indicate below, on, or above the glidepath.

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 14-30]*

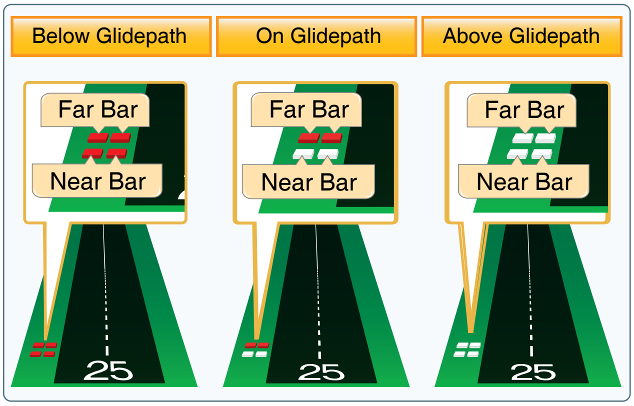


Figure 14-29. *Two-bar VASI system.*

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 14-31]*

Pulsating VASIs 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. The useful range of the system is about four miles during the day and up to ten miles at night. *[Figure 14-32]*

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. *[Figure 14-33]* These lights are classified according to the intensity they are capable of producing: high intensity runway lights (HIRL), medium intensity runway lights (MIRL), and

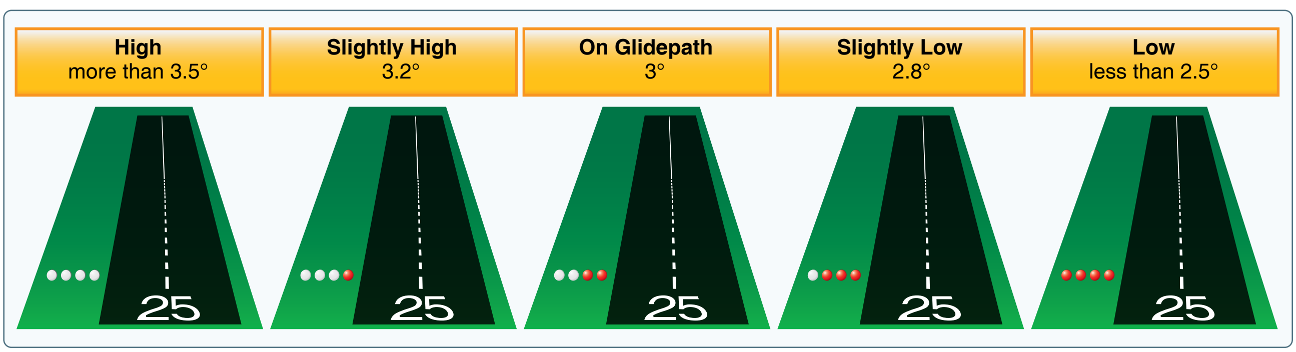


Figure 14-30. *Precision approach path indicator for a typical 3° glide slope.*

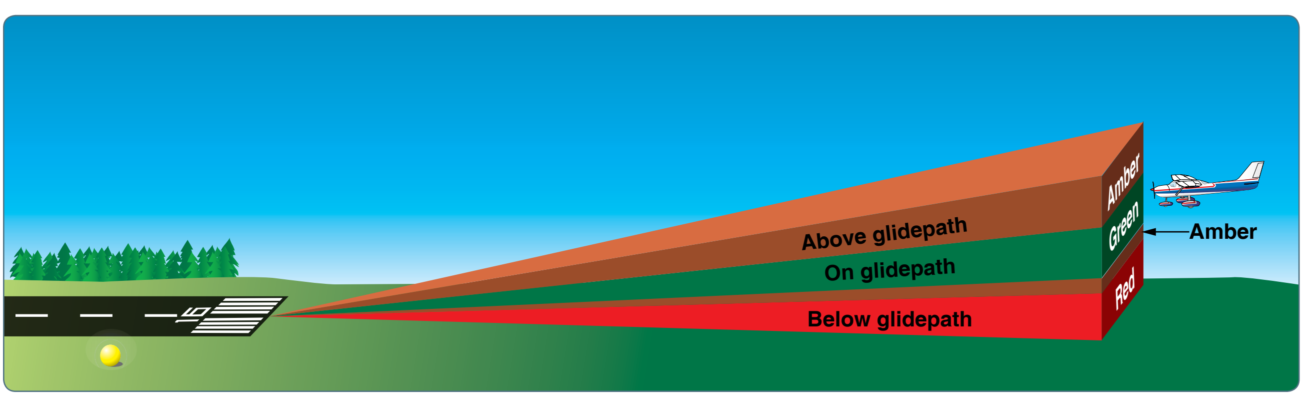


Figure 14-31. *Tri-color visual approach slope indicator.*

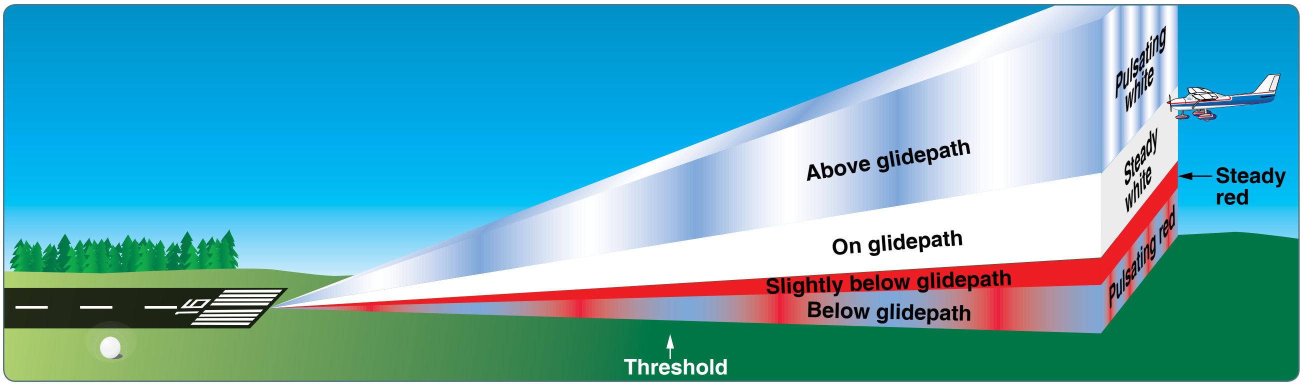


Figure 14-32. *Pulsating visual approach slope indicator.*

low intensity runway lights (LIRL). The HIRL and MIRL have variable intensity settings. These lights are white, except on instrument runways 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 that 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.

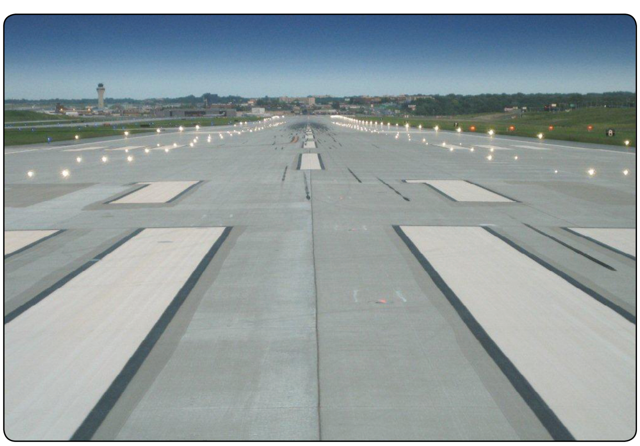


Figure 14-33. *Runway lights.*

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 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 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 ILS 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 ATC 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. *[Figure 14-34]* For information on pilot controlled lighting at various airports, refer to the Chart Supplement U.S. (formerly Airport/Facility Directory).

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 14-34. *Radio controlled runway lighting.*

Taxiway Lights

Similar to runway lighting, taxiways also have various lights which help pilots identify areas of the taxiway and any surrounding runways.

Omnidirectional

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 ATC when deemed necessary or when requested by the pilot. Some airports also have taxiway centerline lights that are green in color.

Clearance Bar Lights

Clearance bar lights are installed at holding positions on taxiways in order to increase the conspicuity of the holding position in low visibility conditions. They may also be installed to indicate the location of an intersecting taxiway during periods of darkness. Clearance bars consist of three in-pavement steady-burning yellow lights.

Runway Guard Lights

Runway guard lights are installed at taxiway/runway intersections. They are primarily used to enhance the conspicuity of taxiway/runway intersections during low visibility conditions, but may be used in all weather conditions. Runway guard lights consist of either a pair of elevated flashing yellow lights installed on either side of the taxiway, or a row of in-pavement yellow lights installed across the entire taxiway, at the runway holding position marking.

Note: Some airports may have a row of three or five in-pavement yellow lights installed at taxiway/runway intersections. They should not be confused with clearance bar lights described previously in this section.

Stop Bar Lights

Stop bar lights, when installed, are used to confirm the ATC clearance to enter or cross the active runway in low visibility conditions (below 1,200 ft Runway Visual Range (RVR)). A stop bar consists of a row of red, unidirectional, steady-burning in-pavement lights installed across the entire taxiway at the runway holding position, and elevated steady-burning red lights on each side. A controlled stop bar is operated in conjunction with the taxiway centerline lead-on lights which extend from the stop bar toward the runway. Following the ATC clearance to proceed, the stop bar is turned off and the lead-on lights are turned on. The stop bar and lead-on lights are automatically reset by a sensor or backup timer.

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.

New Lighting Technologies

A top priority of the FAA is to continue to enhance airport safety while maintaining airport capacity. Reducing runway incursions is a major component of this effort. Runway incursions develop quickly and without warning during routine traffic situations on the airport surface, leaving little time for corrective action. The Runway Status Lights (RWSL) System is designed to provide a direct indication to you that it is unsafe to enter a runway, cross a runway, or takeoff from or land on a runway when the system is activated.

Runway status lights are red in color and indicate runway status only; they do not indicate clearance to enter a runway or clearance to takeoff. The RWSL system provides warning lights on runways and taxiways, illuminating when it is unsafe to enter, cross, or begin takeoff on a runway. Currently, there are two types: Runway Entrance Lights (REL) and Takeoff Hold Lights (THL). *[Figures 14-35* and *14-36]*

REL provide a warning to aircraft crossing or entering a runway from intersecting taxiways that there is conflicting traffic on the runway. THL provide a warning signal to aircraft in position for takeoff that the runway is occupied and it is unsafe to take off. As of 2016, the RWSL system is operational at 14 of the nation's busiest airports with 3 more airports scheduled to receive the system by 2017.

Figure 14-35. *Runway Entrance Lights (REL).*

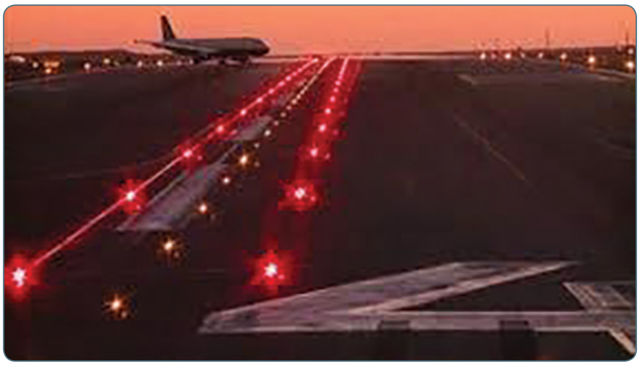


Figure 14-36. *Takeoff Hold Lights (THL).*

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 either located at a particular airport or remotely available through a remote communication outlet (RCO), 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 14-37* and *14-38]*

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/or gust factor. The wind sock extends out straighter in strong winds and tends to move back and forth when the wind is gusting. Wind tees and tetrahedrons can swing freely and align themselves with the wind direction. Since a wind tee or tetrahedron can also be manually set to align with the runway in use, a pilot should also look at the wind sock for wind information, if one is available.

Traffic Patterns

At airports without an operating control tower, a segmented circle visual indicator system, if installed, is designed to provide traffic pattern information. *[Figure 14-38]* 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 and are used to show the alignment of landing strips. *[Figure 14-38]* 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.)

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 Chart Supplement U.S. (formerly Airport/Facility Directory). 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 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 according to Title 14 of the Code of Federal Regulations (14 CFR) part 91, section 91.155. Additional information on airport traffic pattern operations

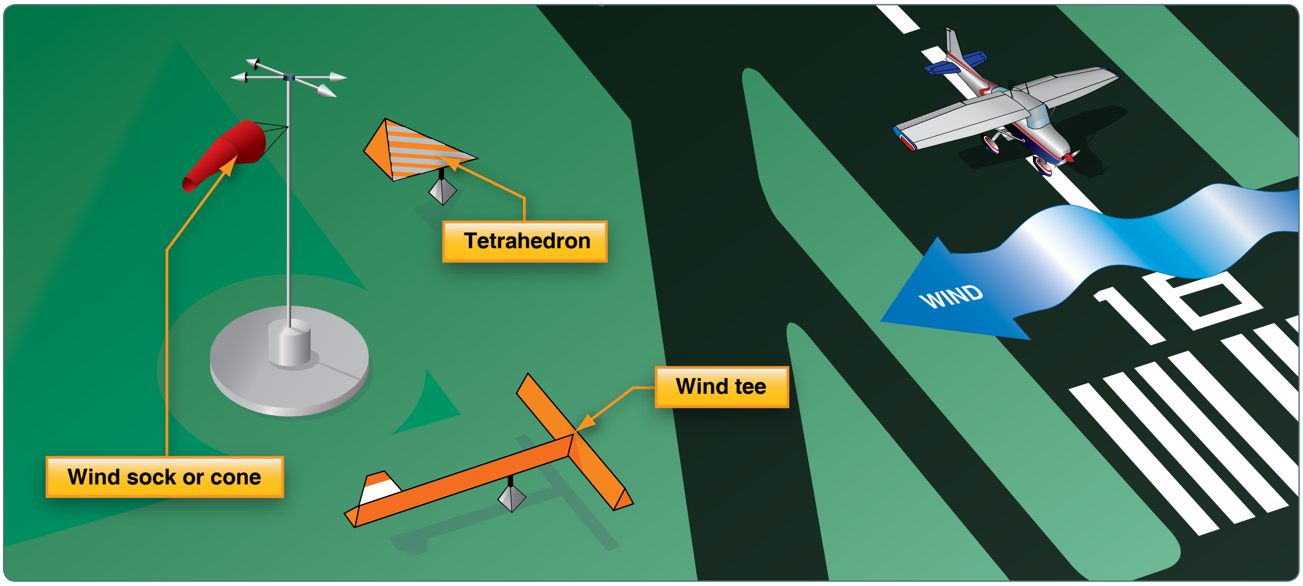


Figure 14-37. *Wind direction indicators.*

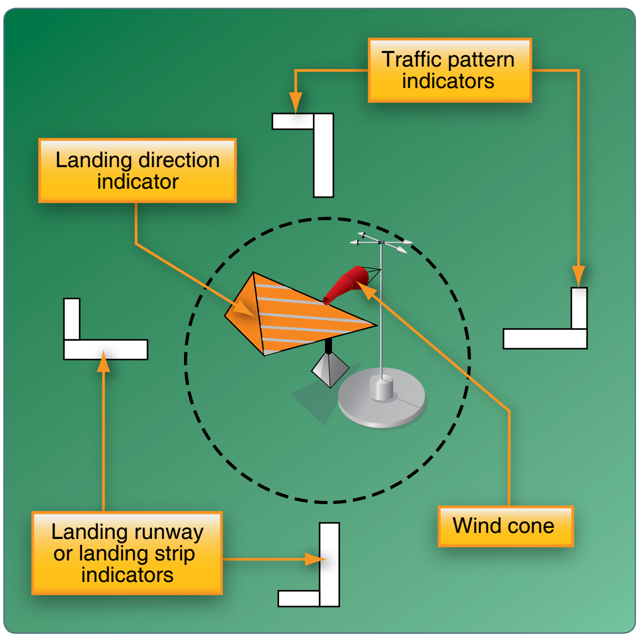


Figure 14-38. *Segmented circle.*

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 Chart Supplement U.S. (formerly Airport/Facility Directory).

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 otherwise established.) *[Figure 14-39]*
2. Maintain pattern altitude until abeam approach end of the landing runway on downwind leg. *[Figure 14-39]*
3. Complete turn to final at least ¼ mile from the runway. *[Figure 14-39]*
4. After takeoff or go-around, continue straight ahead until beyond departure end of runway. *[Figure 14-39]*
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. *[Figure 14-39]*
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 14-39]*

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 otherwise established.) *[Figure 14-40]*
2. Maintain pattern altitude until abeam approach end of the landing runway on downwind leg. *[Figure 14-40]*
3. Complete turn to final at least ¼ mile from the runway. *[Figure 14-40]*
4. Do not overshoot final or continue on a track that penetrates the final approach of the parallel runway
5. After takeoff or go-around, continue straight ahead until beyond departure end of runway. *[Figure 14-40]*

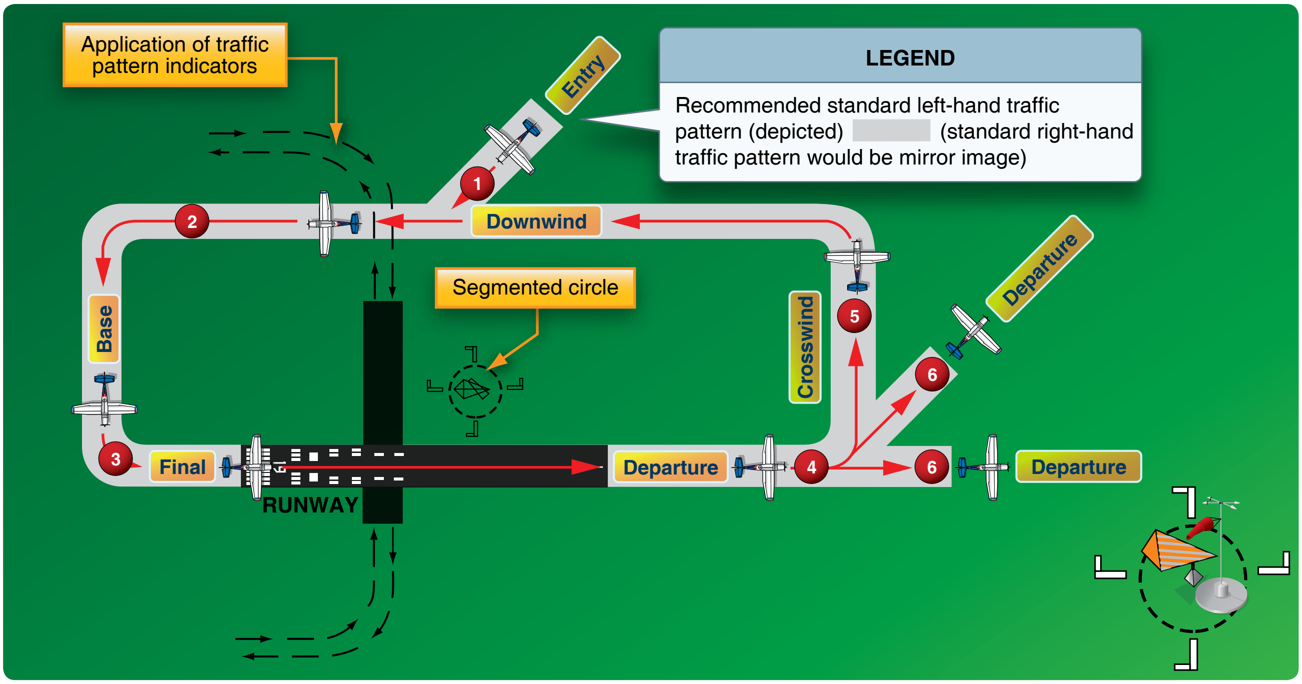


Figure 14-39. *Traffic pattern operations—single runway.*

6. If remaining in the traffic pattern, commence turn to crosswind leg beyond the departure end of the runway within 300 feet of pattern altitude. *[Figure 14-40]*
7. 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 14-40]*
8. Do not continue on a track that penetrates the departure path of the parallel runway. *[Figure 14-40]*

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 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 that is operating internationally, that uses other than a VHF radio, and that 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 megahertz (MHz) and 136.975 MHz and is classified as 720 or 760 depending on the number of channels it can accommodate. The 720 and 760 use .025 MHz (25 kilohertz (KHz) spacing (118.025, 118.050) with the 720 having a frequency range up to 135.975 MHz and the 760 reaching up to 136.975 MHz. 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 Procedures

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

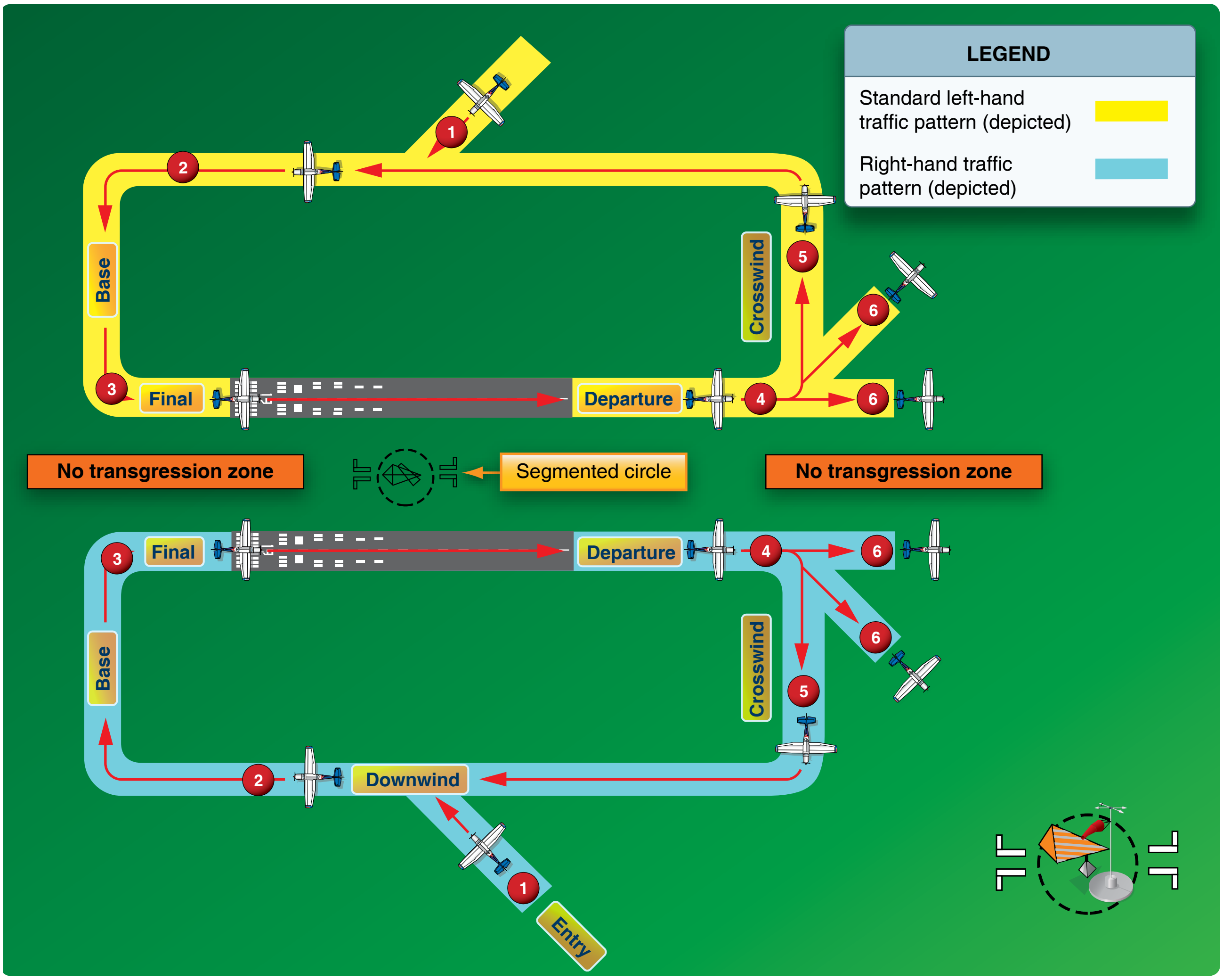


Figure 14-40. *Traffic pattern operation—parallel runways.*

standard terminology. The AIM also contains many examples of radio communications.

ICAO has adopted a phonetic alphabet that should be used in radio communications. When communicating with ATC, pilots should use this alphabet to identify their aircraft. *[Figure 14-41]*

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 14-42*.

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.

Radio malfunctions should be repaired before further flight. If this is not possible, ATC may be contacted by telephone requesting a VFR departure without two-way radio communications. No radio (NORDO) procedure arrivals are not accepted at busy airports. If authorization is given to depart, the pilot is advised to monitor the appropriate frequency and/or watch for light signals as appropriate.

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-VEM-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 14-41. *Phonetic alphabet.*

If radio communication is lost, it may be a prudent decision to land at a non-towered airport with lower traffic volume, if practical. When operating at a non-towered airport, no radio communication is necessary. However, pilots should be extra vigilant when not using the radio. Other traffic may not as easily be aware of your presence when they are expecting the standard radio calls.

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 may find their services helpful.

Primary Radar

Radar is a device that 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 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 that may affect ATC services and prevent a controller from issuing advisories concerning aircraft that 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. Radar signals degrade over distance, cannot penetrate through solid objects such as mountains, and the fastest radar updates every 4.7 seconds. By contrast, the satellite signals used with Automatic Dependent Surveillance–Broadcast (ADS–B) do not degrade over distance, provide better visibility around mountainous terrain and allows equipped aircraft to update their own position once a second with better accuracy.

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.

Growing air traffic in the National Airspace System (NAS) will be addressed through the use of ADS-B, which not only

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 14-42. *Light gun signals.*

provides all the same information the ATCRBS, but will do so more rapidly and with significantly more accuracy. By broadcasting aircraft position information to a ground station, ADS–B can also provide coverage in areas that do not have radar coverage. In addition, ADS–B provides trajectory information that includes speed and direction of motion.

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 15, "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 14-43* lists some standard transponder phraseology. Additional information concerning transponder operation can be found in the AIM, Chapter 4.

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 14-43. *Transponder phraseology.*

Automatic Dependent Surveillance–Broadcast (ADS-B)

Automatic Dependent Surveillance–Broadcast (ADS–B) is a surveillance technology being deployed throughout the NAS to facilitate improvements needed to increase the capacity and efficiency of the NAS, while maintaining safety. ADS-B supports these improvements by providing a higher update rate and enhanced accuracy of surveillance information over the current radar-based surveillance system. In addition, ADS-B enables the expansion of air traffic control (ATC) surveillance services into areas where none existed previously. The ADS-B ground system also provides Traffic Information Services-Broadcast (TIS-B) and Flight Information Services-Broadcast (FIS-B) for use on appropriately equipped aircraft, enhancing the user's situational awareness (SA) and improving the overall safety of the NAS.

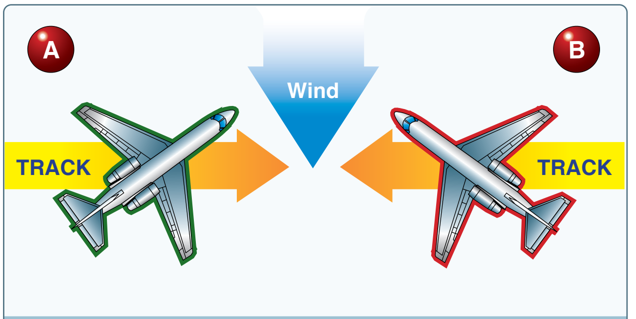
The ADS–B system is composed of aircraft avionics and a ground infrastructure. Onboard avionics determine the position of the aircraft by using the GPS and transmit its position, along with additional information about the aircraft, to ground stations for use by ATC and nearby ADS-B equipped aircraft.

In the United States, ADS–B equipped aircraft exchange information on one of two frequencies: 978 or 1090 MHz. The 1090 MHz frequency is associated with Mode A, C, and S transponder operations. 1090 MHz transponders with integrated ADS–B functionality extend the transponder message sets with additional ADS–B information. This additional information is known as an "extended squitter" message and referred to as 1090ES. ADS–B equipment operating on 978 MHz is known as the Universal Access Transceiver (UAT).

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 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 14-44]* In addition to basic radar service, terminal radar service



Traffic information would be issued to the pilot of aircraft "A" as 12 o'clock. The actual position of the traffic as seen by the pilot of aircraft "A" would be 1 o'clock. Traffic information issued to aircraft "B" would also be given as 12 o'clock, but in this case, the pilot of "B" would see traffic at 10 o'clock.

Figure 14-44. *Traffic advisories.*

area (TRSA) has been implemented at certain terminal locations. TRSAs are depicted on sectional aeronautical charts and listed in the Chart Supplement U.S. (formerly Airport/Facility Directory). 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 during 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-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 flight path accordingly.

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 lies within a few feet of the center of each vortex. *[Figure 14-45]*

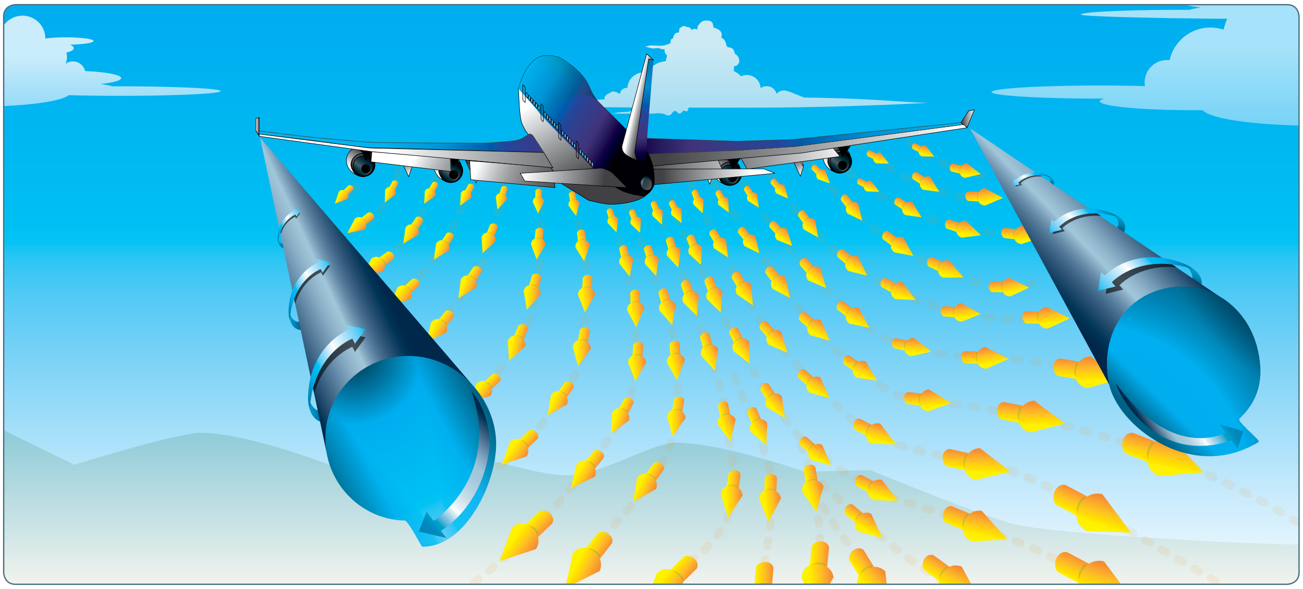


Figure 14-45. *Vortex generation.*

Vortex Strength

Terminal Area

Wake turbulence has historically been thought of as only a function of aircraft weight, but recent research considers additional parameters, such as speed, aspects of the wing, wake decay rates, and aircraft resistance to wake, just to name a few. The vortex characteristics of any aircraft will be changed with the extension of flaps or other wing configuration devices, as well as changing speed. However, as the basic factors are weight and speed, the vortex strength increases proportionately with an increase in aircraft operating weight or decrease in aircraft speed. The greatest vortex strength occurs when the generating aircraft is heavy, slow, and clean, since the turbulence from a "dirty" aircraft configuration hastens wake decay.

En Route

En route wake turbulence events have been influenced by changes to the aircraft fleet mix that have more "Super" (A380) and "Heavy" (B-747, B-777, A340, etc.) aircraft operating in the NAS. There have been wake turbulence events in excess of 30NM and 2000 feet lower than the wake generating aircraft. Air density is also a factor in wake strength. Even though the speeds are higher in cruise at high altitude, the reduced air density may result in wake strength comparable to that in the terminal area. In addition, for a given separation distance, the higher speeds in cruise result in less time for the wake to decay before being encountered by a trailing aircraft.

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 14-46]* The vortex circulation is outward, upward, and around the wingtips when viewed from either ahead or behind the aircraft. Tests with large

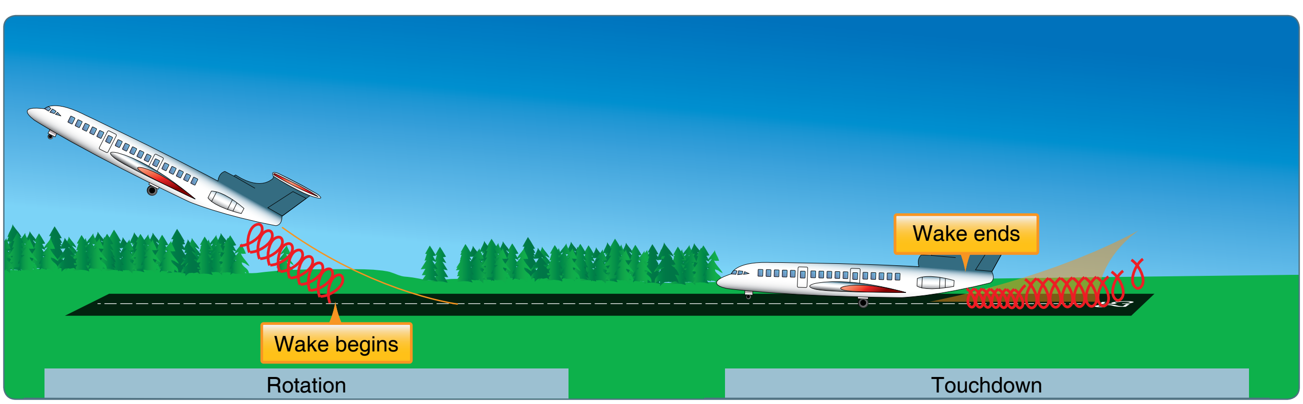


Figure 14-46. *Vortex behavior.*

aircraft 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.

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 light quartering tailwind presents the worst case scenario as the wake vortices could be all present along a significant portion of the final approach and extended centerline and not just in the touchdown zone as typically expected.

Vortex Avoidance Procedures

The following procedures are in place to assist pilots in vortex avoidance in the given scenario.

- Landing behind a larger aircraft on the same runway—stay at or above the larger aircraft's approach flight path and land beyond its touchdown point. *[Figure 14-47A]*
- 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 flight path and note its touchdown point. *[Figure 14-47B]*
- Landing behind a larger aircraft on crossing runway—cross above the larger aircraft's flight path.
- 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 flight path. Abandon the approach unless a landing is ensured well before reaching the intersection. *[Figure 14-47C]*
- 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 flight path, 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

Title 14 of the 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 are in place to assist pilots 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 that permit visual detection of other traffic, pilots should execute gentle banks left and right at a frequency that 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").

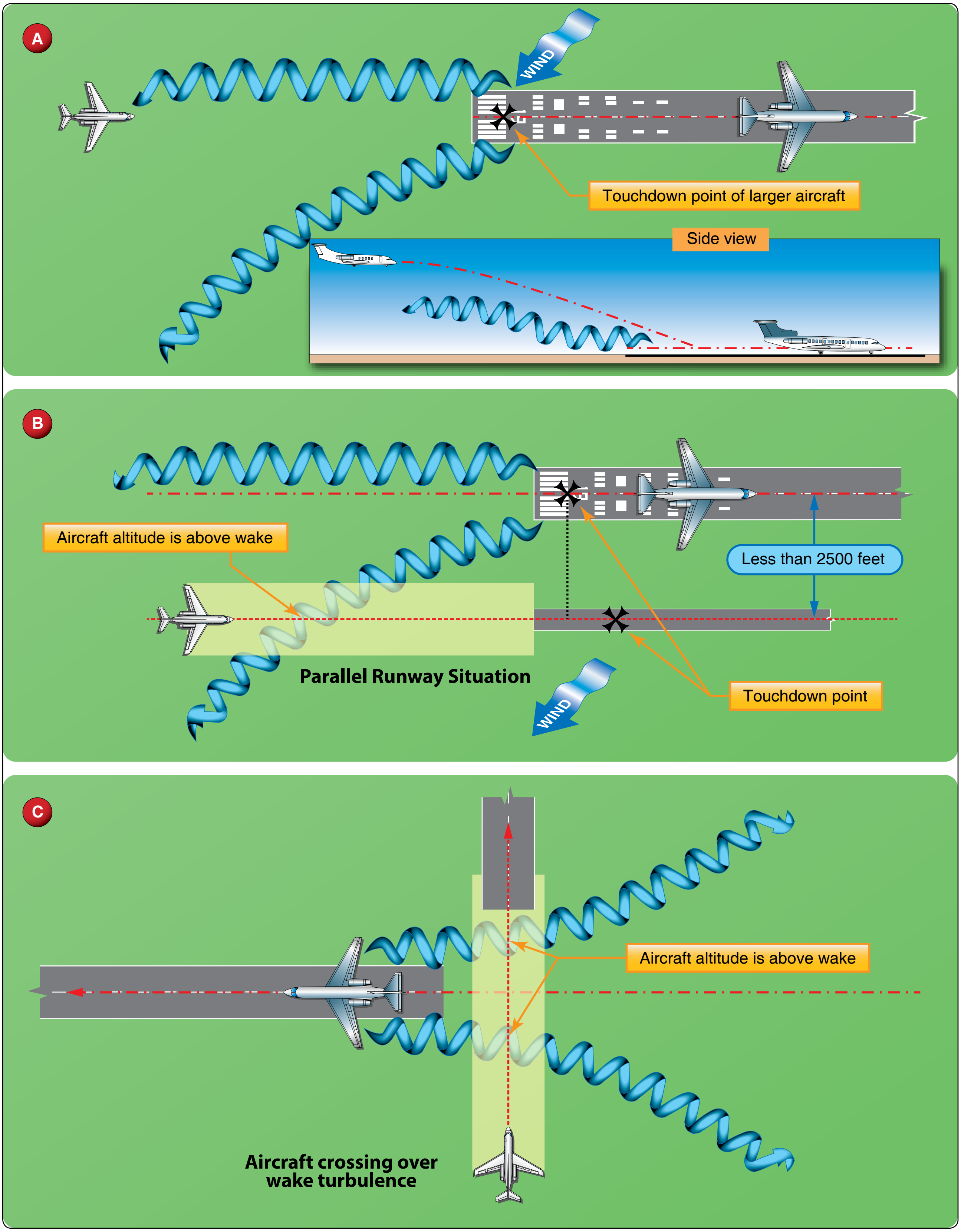


Figure 14-47. *Vortex avoidance procedures.*

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.

Training Operations

Operators of pilot training programs are urged to adopt the following practices:

- Pilots undergoing flight instruction at all levels should be requested to verbalize clearing procedures (call out "clear" left, right, above, or below) to instill and sustain the habit of vigilance during maneuvering.
- High-wing airplane. Momentarily raise the wing in the direction of the intended turn and look.
- Low-wing airplane. Momentarily lower the wing in the direction of the intended turn and look.
- Appropriate clearing procedures should precede the execution of all turns including chandelles, lazy eights, stalls, slow flight, climbs, straight and level, spins, and other combination maneuvers.

Scanning Techniques for Traffic Avoidance

- Pilots must be aware of the limitations inherent in the visual scanning process. These limitations may include:
- Reduced scan frequency due to concentration on flight instruments or tablets and distraction with passengers.
- Blind spots related to high-wing and low-wing aircraft in addition to windshield posts and sun visors.
- Prevailing weather conditions including reduced visibility and the position of the sun.
- The attitude of the aircraft will create additional blind spots.
- The physical limitations of the human eye, including the time required to (re)focus on near and far objects, from the instruments to the horizon for example; empty field myopia, narrow field of vision and atmospheric lighting all affect our ability to detect another aircraft.

Best practices to see and avoid:

- ADS-B In is an effective system to help pilots see and avoid other aircraft. If your aircraft is equipped with ADS-B In, it is important to understand its features and how to use it properly. Many units provide visual and/or audio alerts to supplement the system's traffic display. Pilots should incorporate the traffic display in their normal traffic scan to provide awareness of nearby aircraft. Prior to taxiing onto an airport movement area, ADS-B In can provide advance indication of arriving aircraft and aircraft in the traffic pattern. Systems that incorporate a traffic-alerting feature can help minimize the pilot's inclination to fixate on the display. Refer to 4-5-7e, ADS-B Limitations.
- Understand the limitations of ADS-B In. In certain airspace, not all aircraft will be equipped with ADS-B Out or transponders and will not be visible on your ADS-B In display.
- Limit the amount of time that you focus on flight instruments or tablets.
- Develop a strategic approach to scanning for traffic. Scan the entire sky and try not to focus straight ahead.

Pilot Deviations (PDs)

A pilot deviation (PD) is an action of a pilot that violates any Federal Aviation Regulation. While PDs should be avoided, the regulations do authorize deviations from a clearance in response to a traffic alert and collision avoidance system resolution advisory. You must notify ATC as soon as possible following a deviation.

Pilot deviations can occur in several different ways. Airborne deviations result when a pilot strays from an assigned heading or altitude or from an instrument procedure, or if the pilot penetrates controlled or restricted airspace without ATC clearance.

To prevent airborne deviations, follow these steps:

- Plan each flight—you may have flown the flight many times before but conditions and situations can change rapidly, such as in the case of a pop-up temporary flight restriction (TFR). Take a few minutes prior to each flight to plan accordingly.
- Talk and squawk—Proper communication with ATC has its benefits. Flight following often makes the controller's job easier because they can better integrate VFR and IFR traffic.
- Give yourself some room—GPS is usually more precise than ATC radar. Using your GPS to fly up to and along the line of the airspace you are trying to avoid could result in a pilot deviation because ATC radar may show you within the restricted airspace.

Ground deviations (also called surface deviations) include taxiing, taking off, or landing without clearance, deviating from an assigned taxi route, or failing to hold short of an assigned clearance limit. To prevent ground deviations, stay alert during ground operations. Pilot deviations can and frequently do occur on the ground. Many strategies and tactics pilots use to avoid airborne deviations also work on the ground.

Pilots should also remain vigilant about vehicle/pedestrian deviations (V/PDs). A vehicle or pedestrian deviation includes pedestrians, vehicles or other objects interfering with aircraft operations by entering or moving on the runway movement area without authorization from air traffic control. In serious instances, any ground deviation (PD or VPD) can result in a runway incursion. Best practices in preventing ground deviations can be found in the following section under runway incursion avoidance.

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 always 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 taxing.
- 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.

Approximately three runway incursions occur each day at towered airports within the United States. The potential that these numbers present for a catastrophic accident is unacceptable. The following are examples of pilot deviations, operational incidents (OI), and vehicle (driver) deviations that may lead to runway incursions.

Pilot Deviations:

- Crossing a runway hold marking without clearance from ATC
- Taking off without clearance
- Landing without clearance

Operational Incidents (OI):

- Clearing an aircraft onto a runway while another aircraft is landing on the same runway
- Issuing a takeoff clearance while the runway is occupied by another aircraft or vehicle

Vehicle (Driver) Deviations:

- Crossing a runway hold marking without ATC clearance

According to FAA data, approximately 65 percent of all runway incursions are caused by pilots. Of the pilot runway incursions, FAA data shows almost half of those incursions are caused by GA pilots.

Causal Factors of Runway Incursions

Detailed investigations of runway incursions over the past 10 years have identified three major areas contributing to these events:

- Failure to comply with ATC instructions
- Lack of airport familiarity
- Nonconformance with standard operating procedures

Clear, concise, and effective pilot/controller communication is paramount to safe airport surface operations. You must fully understand and comply with all ATC instructions. It is mandatory to read back all runway "**hold short**" instructions verbatim.

Taxiing on an unfamiliar airport can be very challenging, especially during hours of darkness or low visibility. A request may be made for progressive taxi instructions which include step by step taxi routing instructions. Ensure you have a current airport diagram, remain "heads-up" with eyes outside, and devote your entire attention to surface navigation per ATC clearance. All checklists should be completed while the aircraft is stopped. There is no place for non-essential chatter or other activities while maintaining vigilance during taxi. *[Figure 14-48]*

Runway Confusion

Runway confusion is a subset of runway incursions and often results in you unintentionally taking off or landing on a taxiway or wrong runway. Generally, you are unaware of the mistake until after it has occurred.

Figure 14-48. *Heads-up, eyes outside.*

In August 2006, the flight crew of a commercial regional jet was cleared for takeoff on Runway 22 but mistakenly lined up and departed on Runway 26, a much shorter runway. As a result, the aircraft crashed off the end of the runway.

Causal Factors of Runway Confusion

There are three major factors that increase the risk of runway confusion and can lead to a wrong runway departure:

- Airport complexity
- Close proximity of runway thresholds
- Joint use of a runway as a taxiway

Not only can airport complexity contribute to a runway incursion; it can also play a significant role in runway confusion. If you are operating at an unfamiliar airport and need assistance in executing the taxi clearance, do not hesitate to ask ATC for help. Always carry a current airport diagram and trace or highlight your taxi route to the departure runway prior to leaving the ramp.

If you are operating from an airport with runway thresholds in close proximity to one another, exercise extreme caution when taxiing onto the runway. *Figure 14-49* shows a perfect example of a taxiway leading to multiple runways that may cause confusion. If departing on Runway 36, ensure that you set your aircraft heading "bug" to 360°, and align your aircraft to the runway heading to avoid departing from the wrong runway. Before adding power, make one last instrument scan to ensure the aircraft heading and runway heading are aligned. Under certain circumstances, it may be necessary to use a runway as a taxiway. For example, during airport construction some taxiways may be closed requiring re-routing of traffic onto runways. In other cases, departing traffic may be required to back taxi on the runway in order to utilize the full runway length.

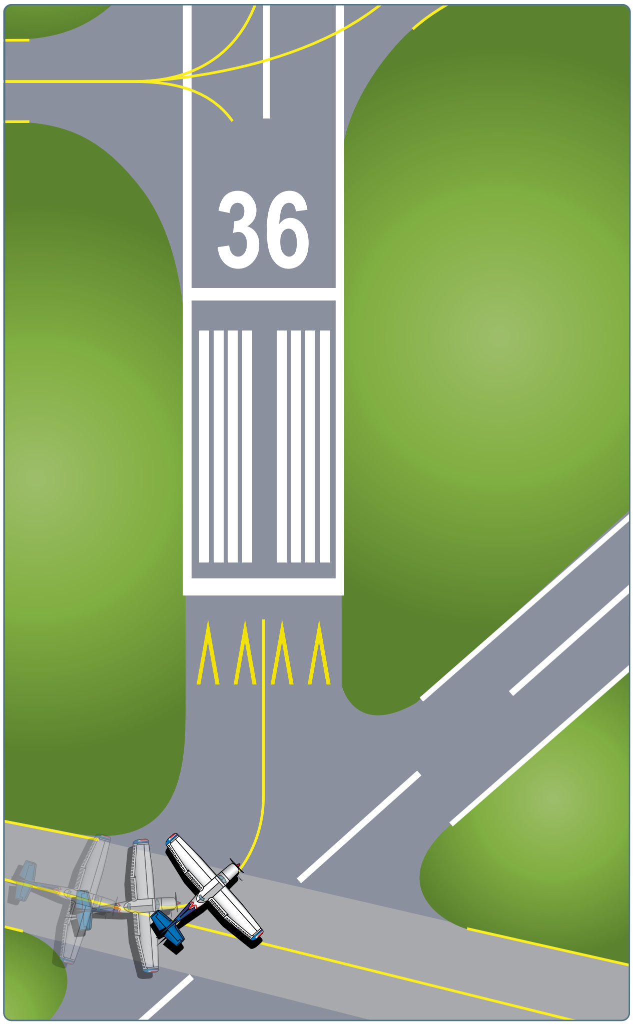


Figure 14-49. *Confusing runway/runway intersection.*

Since inattention and confusion often are factors contributing to runway incursion, it is important to remain extremely cautious and maintain situational awareness (SA). When instructed to use a runway as a taxiway, do not become confused and take off on the runway you are using as a taxiway.

ATC Instructions

Title 14 of the Code of Federal Regulations (14 CFR) part 91, section 91.123 requires you to follow all ATC clearances and instructions. Request clarification if you are unsure of the clearance or instruction to be followed. If you are unfamiliar with the airport or unsure of a taxi route, ask ATC for a "progressive taxi." Progressive taxi requires the controller to provide step-by-step taxi instructions.

The final decision to act on ATC's instruction rests with you. If you cannot safely comply with any of ATC's instructions, inform them immediately by using the word "UNABLE." There is nothing wrong with telling a controller that you are unable to safely comply with the clearance.

Another way to mitigate the risk of runway incursions is to write down all taxi instructions as soon as they are received from ATC. *[Figure 14-50]* It is also helpful to monitor ATC clearances and instructions that are issued to other aircraft. You should be especially vigilant if another aircraft has a similar sounding call sign so there is no mistake about who ATC is contacting or to whom they are giving instructions and clearances.

Read back your complete ATC clearance with your aircraft call sign. This gives ATC the opportunity to clarify any misunderstandings and ensure that instructions were given to the correct aircraft. If, at any time, there is uncertainty about any ATC instructions or clearances, ask ATC to "say again" or ask for progressive taxi instructions.

ATC Instructions—"Hold Short"

The most important sign and marking on the airport is the hold sign and hold marking. These are located on a stub taxiway leading directly to a runway. They depict the holding position or the location where the aircraft is to stop so as not to enter the runway environment. *[Figure 14-51]* For example, *Figure 14-52* shows the holding position sign and marking for Runway 13 and Runway 31.

When ATC issues a "**hold short**" clearance, you are expected to taxi up to, but not cross any part of the runway holding marking. At a towered airport, runway hold markings should never be crossed without explicit ATC instructions. Do not enter a runway at a towered airport unless instructions are given from ATC to cross, takeoff from, or "line up and wait" on that specific runway.

ATC is required to obtain a read-back from the pilot of all runway "**hold short**" instructions. Therefore, you must read back the entire clearance and "**hold short**" instruction, to include runway identifier and your call sign.

Figure 14-50. *A sound practice is to write down taxi instructions from ATC.*

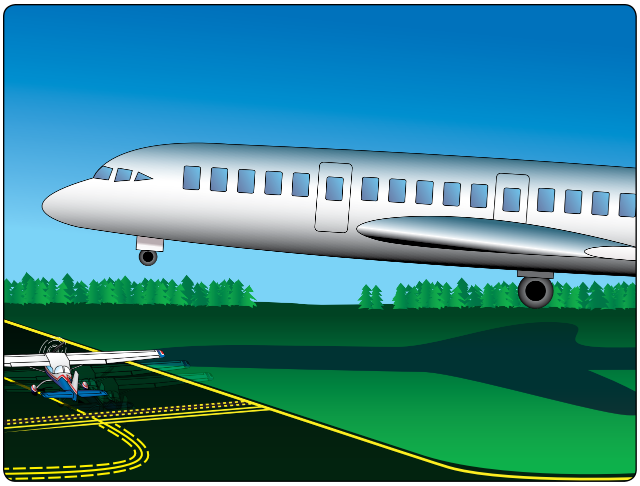


Figure 14-51. *Do NOT cross a runway holding position marking without ATC clearance. If the tower is closed or you are operating from a non-towered airport, check both directions for conflicting traffic before crossing the hold position marking.*

Figure 14-53 shows an example of a controller's taxi and "**hold short**" instructions and the reply from the pilot.

ATC Instructions—Explicit Runway Crossing

As of June 30, 2010, ATC is required to issue explicit instructions to "**cross**" or "**hold short**" of each runway. Instructions to "**cross**" a runway are normally issued one at a time, and an aircraft must have crossed the previous runway before another runway crossing is issued. Exceptions may apply for closely spaced runways that have less than 1,000 feet between centerlines. This applies to all runways to include active, inactive, or closed. *Figure 14-54* shows communication between ATC and a pilot who is requesting a taxi clearance. Extra caution should be used when directed by ATC to taxi onto or across a runway, especially at night and during reduced visibility conditions. Always comply with "**hold**

Figure 14-52. *Runway 13-31 holding position sign and marking located on Taxiway Charlie.*

Figure 14-53. *Example of taxi and "**hold short**" instructions from ATC to a pilot.*

short" or crossing instructions when approaching an entrance to a runway. Scan the full length of the runway and the final approaches before entering or crossing any runway, even if ATC has issued a clearance.

ATC Instructions—"Line Up and Wait" (LUAW)

ATC now uses the "line up and wait" (LUAW) instruction when a takeoff clearance cannot be issued immediately due to traffic or other reasons. The words "line up and wait" have replaced "position and hold" in directing you to taxi onto a runway and await takeoff clearance.

An ATC instruction to "line up and wait" is not a clearance for takeoff. It is only a clearance to enter the runway and hold in position for takeoff. Under LUAW phraseology, the controller states the aircraft call sign, departure runway, and "line up and wait." Be aware that "traffic holding in position" will continue to be used to advise other aircraft that traffic has been authorized to line up and wait on an active runway. Pay close attention when instructed to "line up and wait," especially at night or during periods of low visibility. Before

Figure 14-54. *Communication between ATC and a pilot who is requesting taxi procedures.*

entering the runway, remember to scan the full length of the runway and its approach end for other aircraft.

There have been collisions and incidents involving aircraft instructed to "line up and wait" while ATC waits for the necessary conditions to issue a takeoff clearance. An OI caused a 737 to land on a runway occupied by a twin-engine turboprop. The turboprop was holding in position awaiting takeoff clearance. Upon landing, the 737 collided with the twin-engine turboprop.

When ATC instructs you to "line up and wait," they should advise you of any anticipated delay in receiving your takeoff clearance. Possible reasons for ATC takeoff clearance delays may include other aircraft landing and/or departing, wake turbulence, or traffic crossing an intersecting runway.

- If advised of a reason for the delay, or the reason is clearly visible, expect an imminent takeoff clearance once the reason is no longer an issue.
- If a takeoff clearance is not received within 90 seconds after receiving the "line up and wait" instruction, contact ATC immediately.
- When ATC issues "line up and wait" instructions and takeoff clearances from taxiway intersection, the taxiway designator is included.

  Example – "N123AG Runway One-Eight, at Charlie Three, line up and wait."

  Example – "N123AG Runway One-Eight, at Charlie Three, cleared for takeoff."

If LUAW procedures are being used and landing traffic is a factor, ATC is required to:

- Inform the aircraft in the LUAW position of the closest aircraft that is requesting a full-stop, touch-and-go, stop-and-go, option, or unrestricted low approach.

  Example – "N123AG, Runway One-Eight, line up and wait, traffic a Cessna 210 on a six-mile final."
- In some cases, where safety logic is being used, ATC is permitted to issue landing clearances with traffic in the LUAW position. Traffic information is issued to the landing traffic.

  Example – "N456HK, Runway One-Eight, cleared to land, traffic a DeHavilland Otter holding in position."

  NOTE: ATC will/must issue a takeoff clearance to the traffic holding in position in sufficient time to ensure no conflict exists with landing aircraft. Prescribed runway separation must exist no later than when the landing aircraft crosses the threshold.
- In cases where ATC is not permitted to issue landing clearances with traffic in the LUAW position, traffic information is issued to the closest aircraft that is requesting a full-stop, touch-and-go, stop-and-go, option, or unrestricted low approach.

  Example – "N456HK, Runway One-Eight, continue, traffic holding in position."

ATC Instructions—"Runway Shortened"

You should review NOTAMs in your preflight planning to determine any airport changes that will affect your departure or arrival. When the available runway length has been temporarily or permanently shortened due to construction, the ATIS includes the words "warning" and "shortened" in the text of the message. For the duration of the construction when the runway is temporarily shortened, ATC will include the word "shortened" in their clearance instructions. Furthermore, the use of the term "full length" will not be used by ATC during this period of the construction.

Some examples of ATC instructions are:

- "Runway three six shortened, line up and wait."
- "Runway three six shortened, cleared for takeoff."
- "Runway three six shortened, cleared to land."

When an intersection departure is requested on a temporarily or permanently shortened runway during the construction, the remaining length of runway is included in the clearance. For example, "Runway three six at Echo, intersection departure, 5,600 feet available." If following the construction, the runway is permanently shortened, ATC will include the word "shortened" until the Chart Supplement U.S. (formerly Airport/Facility Directory) is updated to include the permanent changes to the runway length.

Pre-Landing, Landing, and After-Landing

While en route and after receiving the destination airport ATIS/landing information, review the airport diagram and brief yourself as to your exit taxiway. Determine the following:

- Are there any runway hold markings in close proximity to the exit taxiway?
- **Do not cross any hold markings or exit onto any runways without ATC clearance.**

After landing, use the utmost caution where the exit taxiways intersect another runway, and do not exit onto another runway without ATC authorization. Do not accept last minute turnoff instructions from the control tower unless you clearly understand the instructions and are at a speed that ensures you can safely comply. Finally, after landing and upon exiting the runway, ensure your aircraft has completely crossed over the runway hold markings. Once all parts of the aircraft have crossed the runway holding position markings, you must hold unless further instructions have been issued by ATC. Do not initiate non-essential communications or actions until the aircraft has stopped and the brakes set.

Engineered Materials Arresting Systems (EMAS)

Aircraft can and do overrun the ends of runways and sometimes with devastating results. An overrun occurs when an aircraft passes beyond the end of a runway during an aborted takeoff or on landing rollout. To minimize the hazards of overruns, the FAA incorporated the concept of a runway safety area (RSA) beyond the runway end into airport design standards. At most commercial airports, the RSA is 500 feet wide and extends 1,000 feet beyond each end of the runway. The FAA implemented this requirement in the event that an aircraft overruns, undershoots, or veers off the side of the runway.

The most dangerous of these incidents are overruns, but since many airports were built before the 1,000-foot RSA length was adopted some 20 years ago, the area beyond the end of the runway is where many airports cannot achieve the full standard RSA. This is due to obstacles, such as bodies of water, highways, railroads, populated areas, or severe drop-off of terrain. Under these specific circumstances, the installation of an Engineered Materials Arresting System (EMAS) is an acceptable alternative to a RSA beyond the runway end. It provides a level of safety that is generally equivalent to a full RSA. *[Figure 14-55]*

Figure 14-55. *Engineered material arresting system (EMAS) located at Yeager Airport, Charleston, West Virginia.*

An EMAS uses materials of closely controlled strength and density placed at the end of a runway to stop or greatly slow an aircraft that overruns the runway. The best material found to date is a lightweight, crushable concrete. When an aircraft rolls into an EMAS arrestor bed, the tires of the aircraft sink into the lightweight concrete and the aircraft is decelerated by having to roll through the material. *[Figure 14-56]*

Incidents

To date, there have been several incidents listed below where the EMAS technology has worked successfully to arrest aircraft that overrun the runway. All cases have resulted in minimal to do damage to the aircraft. The only known injury was an ankle injury to a passenger during egress following the arrestment. *[Figure 14-57]*

- May 1999—A Saab 340 commuter aircraft overran the runway at John F. Kennedy International Airport (JFK).
- May 2003—A Cargo McDonnell Douglas (MD)-11 overran the runway at JFK.
- January 2005—A Boeing 747 overran the runway at JFK.
- July 2006—A Mystere Falcon 900 overran the runway at Greenville Downtown Airport (KGMU) in Greenville, South Carolina.
- July 2008—An Airbus A320 overran the runway at O'Hare International Airport (ORD).
- January 2010—A Bombardier CRJ-200 regional jet overran the runway at Yeager Airport (KCRW) in Charleston, West Virginia (WV). *[Figure 14-58]*
- October 2010—A G-4 Gulfstream overran the runway at Teterboro Airport (KTEB) in Teterboro, New Jersey (NJ).
- November 2011—A Cessna Citation 550 overran the runway at Key West International Airport (KEYW) in Key West, Florida.

EMAS Installations and Information

Currently, EMAS is installed at 63 runway ends at 42 airports in the United States with plans to install more throughout the next few years.

EMAS information is available in the Chart Supplement U.S. (formerly Airport/Facility Directory) under the specific airport information. *Figure 14-59* shows airport information for Boston Logan International Airport. At the bottom of the page, it shows which runways are equipped with arresting systems and the type that they have. It is important for pilots to study airport information, become familiar with the details and limitations of the arresting system, and the runways that are equipped with them. *[Figure 14-60]*

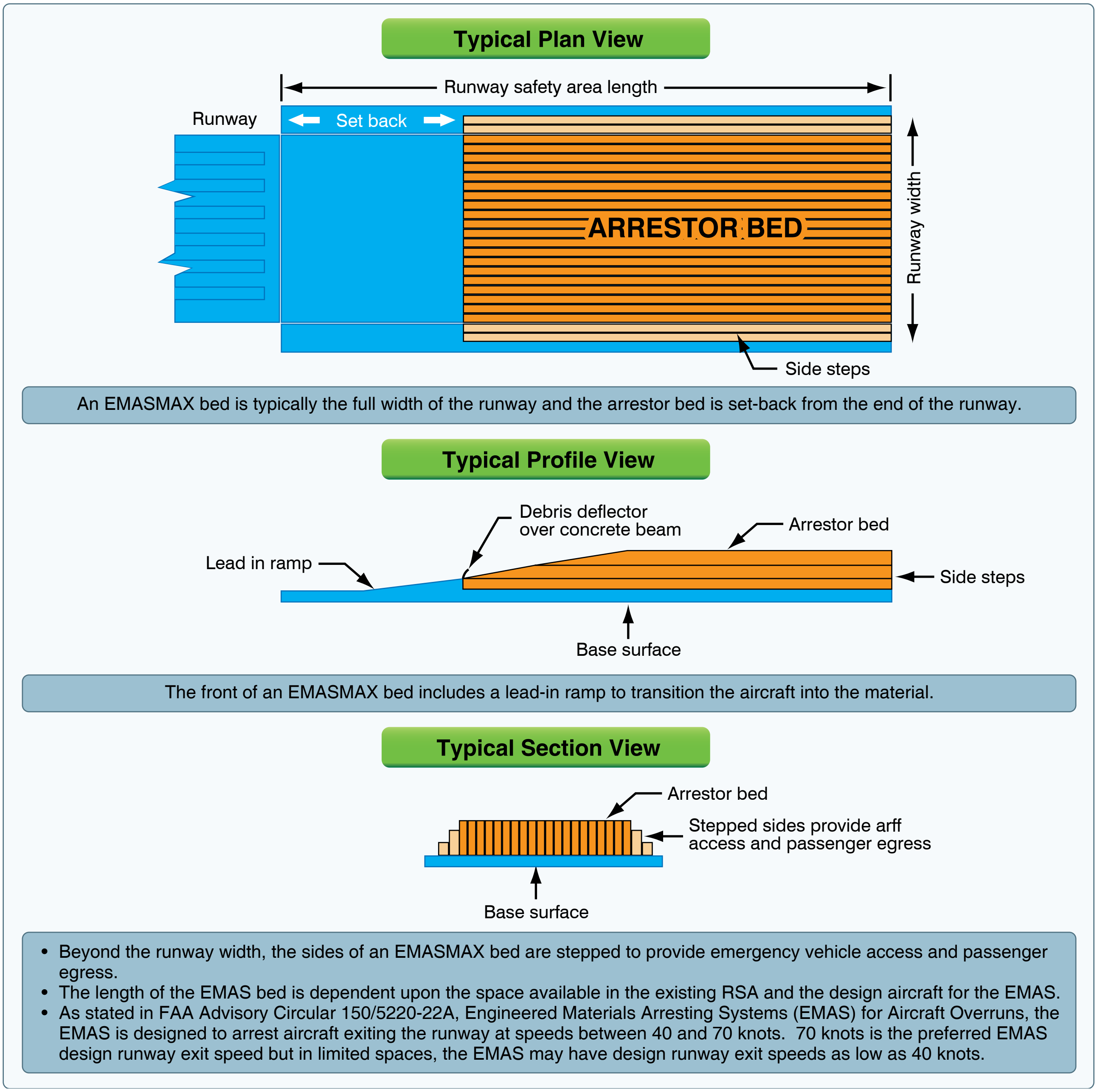


Figure 14-56. *Diagram of an EMASMAX system.*

Pilot Considerations

Although engaging an EMAS should not be a desired outcome for the end of a flight, pilots need to know what EMAS is, how to identify it on the airfield diagram and on the airfield, as well as knowing what to do should they find themselves approaching an installation in an overrun situation. *[Figure 14-59* and *Figure 14-60]* Pilots also need to know that an EMAS may not stop lightweight general aviation aircraft that are not heavy enough to sink into the crushable concrete. The time to discuss whether or not a runway has an EMAS at the end is during the pre-departure briefing prior to takeoff or during the approach briefing prior to commencing the approach. Following the guidance below ensures that the aircraft engages the EMAS according to the design entry parameters.

During the takeoff or landing phase, if a pilot determines that the aircraft will exit the runway end and enter the EMAS, the following guidance should be adhered to:

1. Continue deceleration - Regardless of aircraft speed upon exiting the runway, continue to follow Rejected/ Aborted Takeoff procedures, or if landing, Maximum Braking procedures outlined in the Flight Manual.

Figure 14-57. *There have been several incidents where the EMAS has successfully arrested the aircraft.*

Figure 14-58. *A Bombardier CRJ-200 regional jet overran the runway at Yeager Airport (KCRW) in Charleston, West Virginia.*

2. Maintain runway centerline - Not veering left or right of the bed and continuing straight ahead will maximize stopping capability of the EMAS bed. The quality of deceleration will be best within the confines of the bed.
3. Maintain deceleration efforts - The arrestor bed is a passive system, so this is the only action required by the pilot.
4. Once stopped, do not attempt to taxi or otherwise move the aircraft.

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 Chart Supplement U.S. (formerly Airport/Facility Directory) 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.

This chapter is also designed to help you attain an understanding of the risks associated with surface navigation and is intended to provide you with basic information regarding the safe operation of aircraft at towered and nontowered airports. This chapter focuses on the following major areas:

- Runway incursion overview
- Taxi route planning
- Taxi procedures
- Communications
- Airport signs, markings and lighting

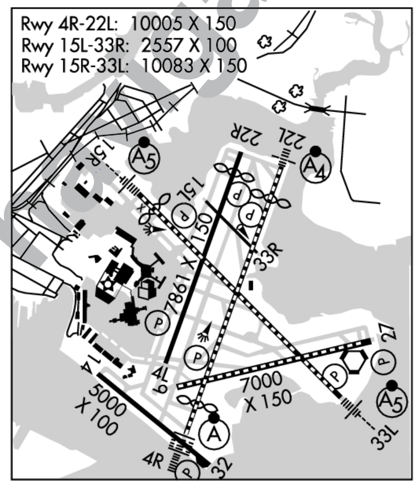
The chapter identifies best practices to help you avoid errors that may potentially lead to runway incursions. Although the chapter pertains mostly to surface movements for single-pilot operations, all of the information is relevant for flight crew operations as well.

Additional information about surface operations is available through the following sources:

- Federal Aviation Administration (FAA) Runway Safety website—www.faa.gov/go/runwaysafety
- FAA National Aeronautical Navigation Services (AeroNav), formerly known as the National Aeronautical Charting Office (NACO)—www.faa.gov/air_traffic/flight_info/aeronav
- Chart Supplement U.S. (formerly Airport/Facility Directory)—www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/search/
- Automatic Terminal Information Service (ATIS)
- Notice to Airmen (NOTAMs)—http://www.faa.gov/pilots/flt_plan/notams
- Advisory Circular (AC) 91-73, part 91 and part 135, Single-Pilot and Flight School Procedures During Taxi Operations
- Aeronautical Information Manual (AIM)—www.faa.gov/air_traffic/publications/atpubs/aim/
- AC 120-74, parts 91, 121, 125, and 135, Flight Crew Procedures During Taxi Operations

BOSTON

GENERAL EDWARD LAWRENCE LOGAN INTL (BOS) 1 E UTC–5(–4DT) **NEW YORK**
N42°21.78′ W71°00.39′ **COPTER**
20 B S4 **FUEL** 100LL, JET A OX 1, 2, 3, 4 LRA Class I, ARFF Index E **H–10J, 11D, 12K, L–33D, 34J**
NOTAM FILE BOS **IAP, AD**



RWY 15R–33L: H10083X150 (ASPH–GRVD) S–200, D–200, 2S–175, 2D–400, 2D/2D2–800 HIRL CL
RWY 15R: MALSR. TDZL. PAPI(P4L)—GA 3.0° TCH 60′. Thld dsplcd 880′. Trees.
RWY 33L: MALSR. TDZL. PAPI(P4R)—GA 3.0° TCH 57′. Boat.
RWY 04R–22L: H10005X150 (ASPH–GRVD) S–200, D–200, 2S–175, 2D–400, 2D/2D2–800 HIRL CL
RWY 04R: ALSF2. TDZL. PAPI(P4L)—GA 3.0° TCH 67′.Thld dsplcd 1154′. Boat.
RWY 22L: MALSF. PAPI(P4R)—GA 3.0° TCH 55′. Thld dsplcd 1199′. Boat.
RWY 04L–22R: H7861X150 (ASPH–GRVD) S–200, D–200, 2S–175, 2D–400, 2D/2D2–800 HIRL
RWY 04L: REIL. PAPI(P4L)—GA 3.0°TCH 50′. Boat.
RWY 22R: PAPI(P4L)—GA 3.0° TCH 50′. Thld dsplcd 815′. Boat.
RWY 09–27: H7000X150 (ASPH–GRVD) S–200, D–200, 2S–175, 2D–400, 2D/2D2–800 HIRL CL
RWY 09: Boat.
RWY 27: REIL. PAPI(P4L)—GA 3.0° TCH 71′. Boat.
RWY 14–32: H5000X100 (ASPH–GRVD) S–75, D–200, 2S–175, 2D–400, 2D/2D2–875 HIRL
RWY 14: Bldg. **RWY 32:** REIL. PAPI (P4L)—GA 3.0° TCH 45′.
RWY 15L–33R: H2557X100 (ASPH) S–200, D–200, 2S–175, 2D–400, 2D/2D2–800 MIRL

LAND AND HOLD SHORT OPERATIONS

LANDING	HOLD SHORT POINT	DIST AVBL
RWY 04L	15L–33R	5250
RWY 15R	09–27	6800
RWY 22L	09–27	6400
RWY 27	04R–22L	5650

RUNWAY DECLARED DISTANCE INFORMATION

RWY 04L:	TORA–7861	TODA–7861	ASDA–7861	LDA–7861
RWY 04R:	TORA–10005	TODA–10005	ASDA–10005	LDA–8851
RWY 09:	TORA–7000	TODA–7000	ASDA–7000	LDA–7000
RWY 14:	TORA–5000	TODA–5000	ASDA–5000	LDA–5000
RWY 15L:	TORA–2557	TODA–2557	ASDA–2557	LDA–2557
RWY 15R:	TORA–10083	TODA–10083	ASDA–10083	LDA–9203
RWY 22L:	TORA–10005	TODA–10005	ASDA–10005	LDA–8806
RWY 22R:	TORA–7861	TODA–7861	ASDA–7861	LDA–7046
RWY 27:	TORA–7000	TODA–7000	ASDA–7000	LDA–7000
RWY 32:	TORA–5000	TODA–5000	ASDA–5000	LDA–5000
RWY 33L:	TORA–10083	TODA–10083	ASDA–10083	LDA–10083
RWY 33R:	TORA–2557	TODA–2557	ASDA–2557	LDA–2557

ARRESTING GEAR/SYSTEM
RWY 04L: EMAS
RWY 15R: EMAS

Figure 14-59. *EMAS information for Boston Logan International Airport located in the Chart Supplement U.S. (formerly Airport/Facility Directory).*

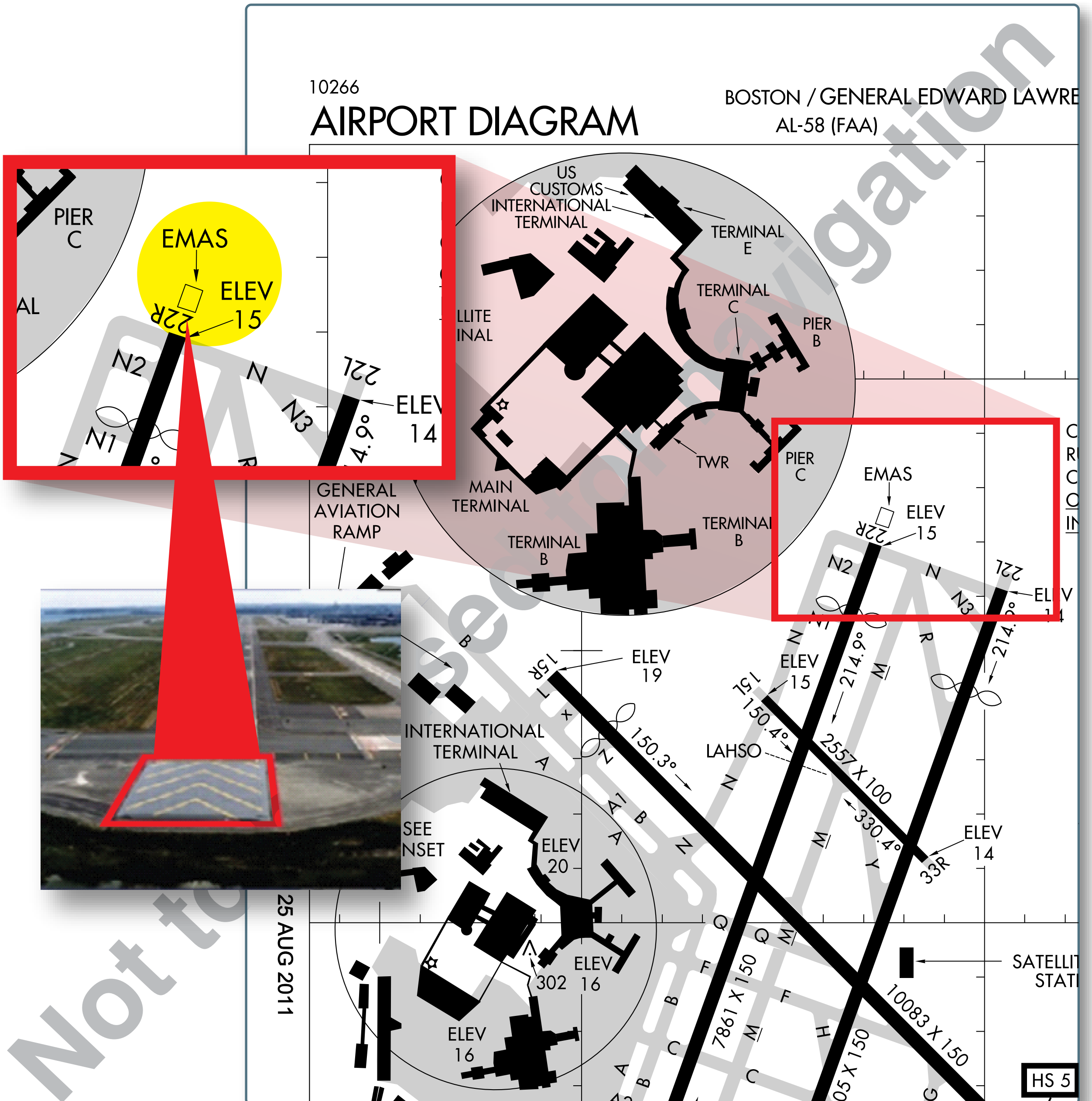


Figure 14-60. *An airport diagram with EMAS information.*