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

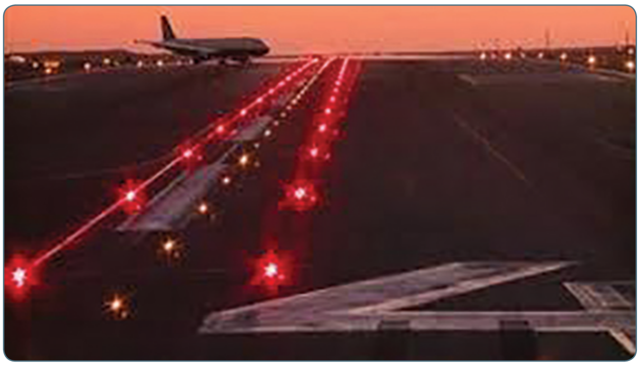


Figure 14-36. *Takeoff Hold Lights (THL).*

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

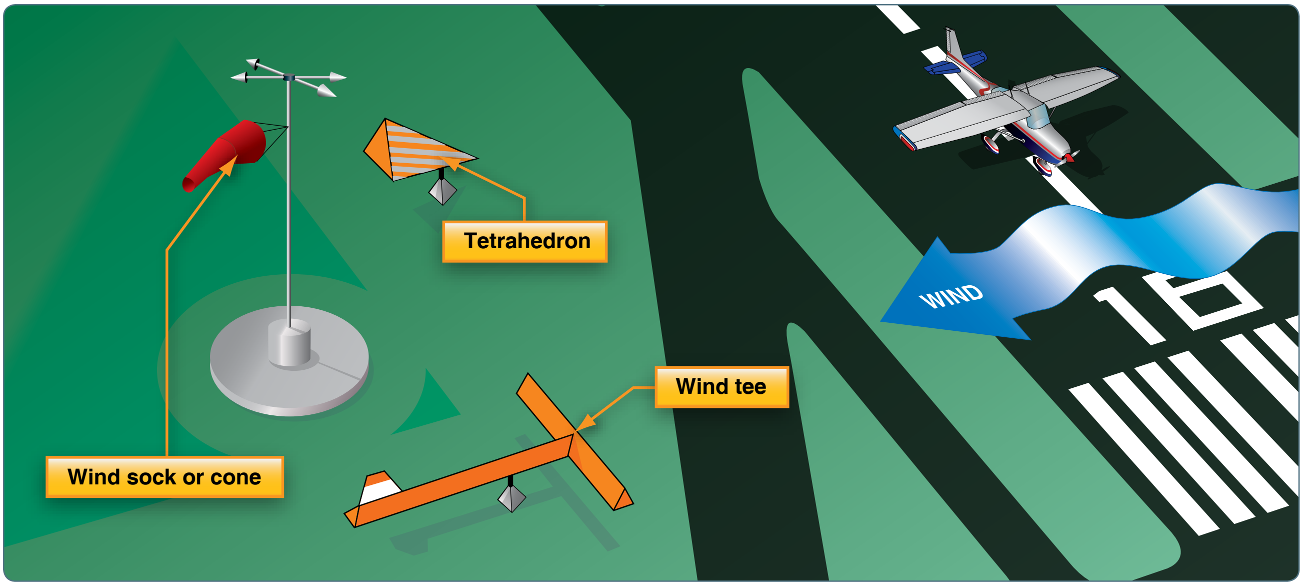


Figure 14-37. *Wind direction indicators.*

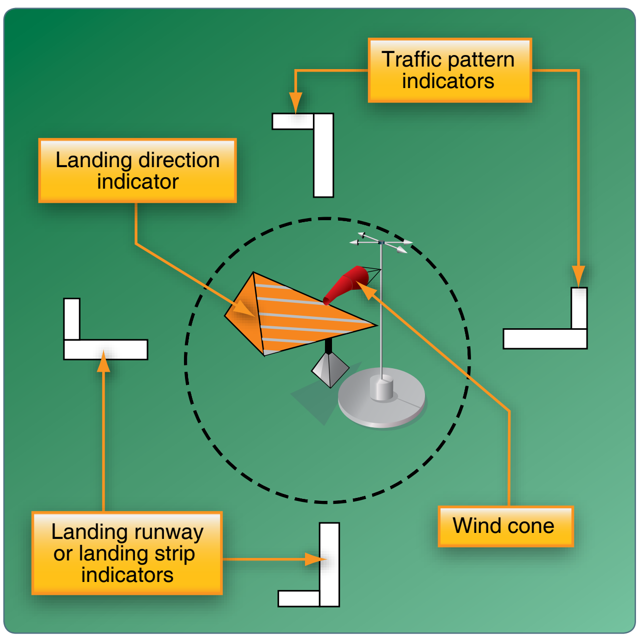


Figure 14-38. *Segmented circle.*

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]*

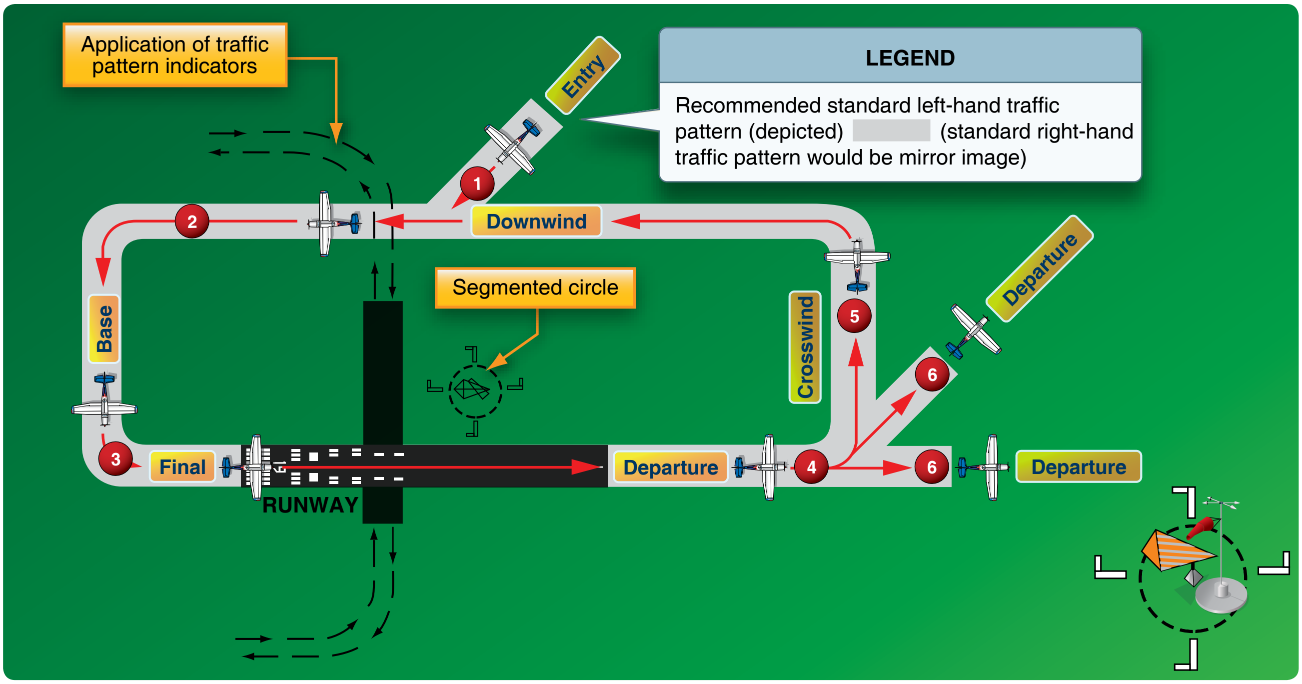


Figure 14-39. *Traffic pattern operations—single runway.*

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

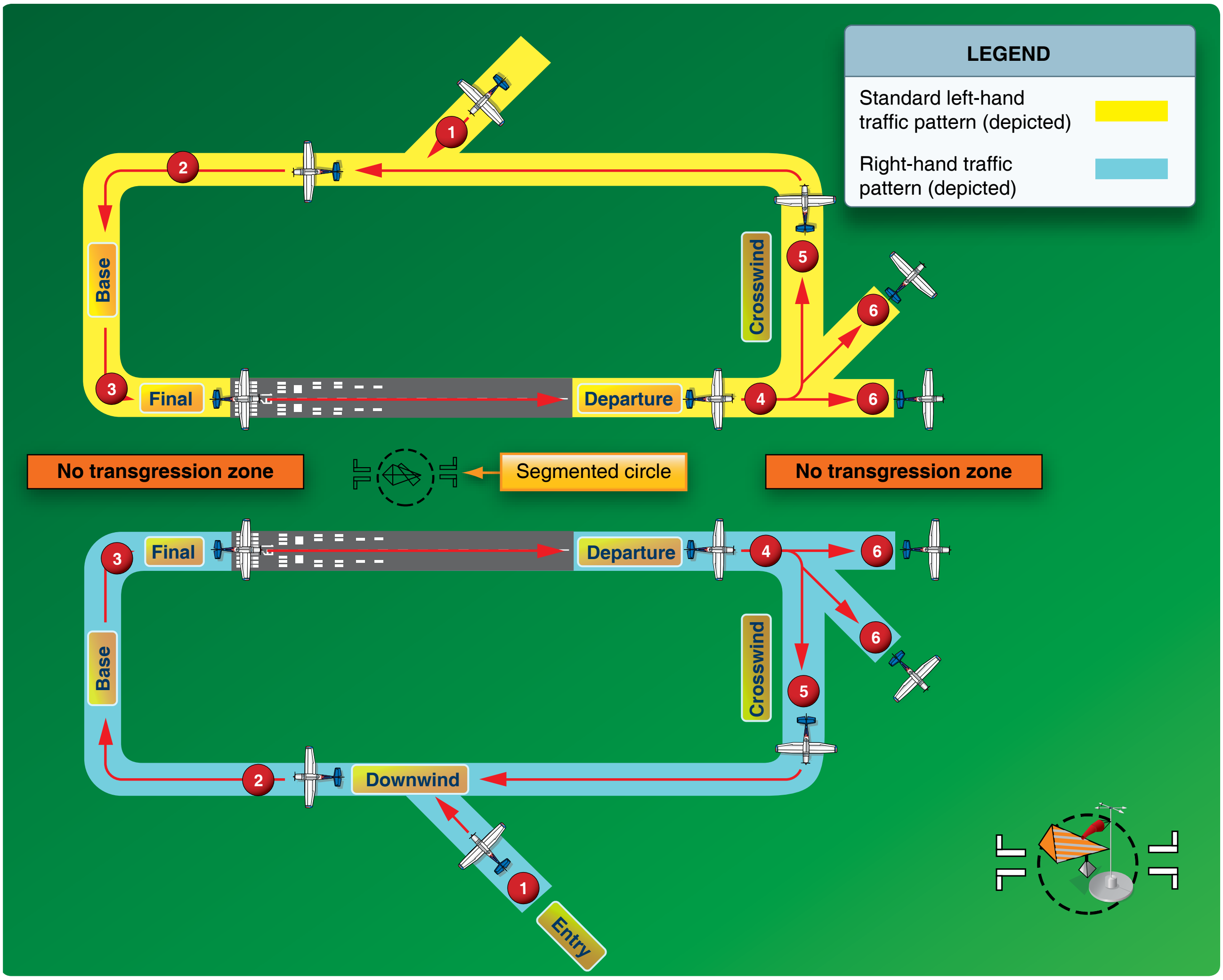


Figure 14-40. *Traffic pattern operation—parallel runways.*

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.

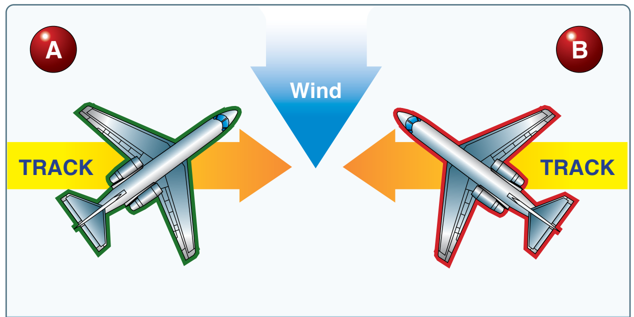
The ADS–B system is composed of aircraft avionics and a ground infrastructure. Onboard avionics determine the position of the aircraft by using the GPS and transmit its position, along with additional information about the aircraft, to ground stations for use by ATC and nearby ADS-B equipped aircraft.

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 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).



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.*

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]*

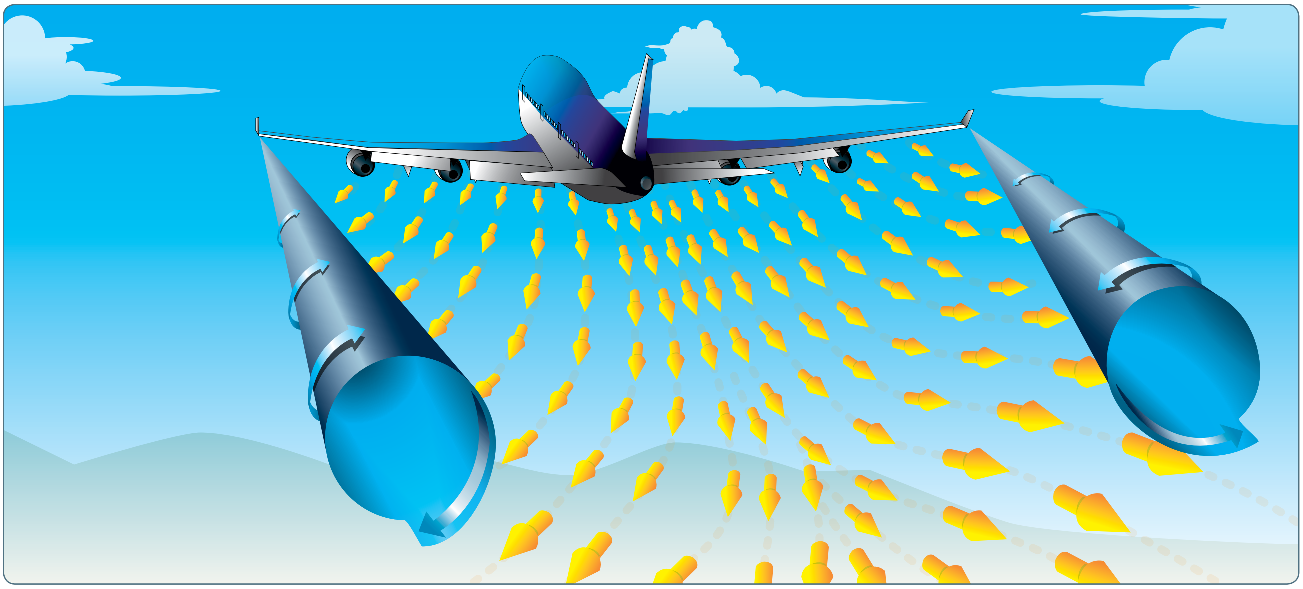


Figure 14-45. *Vortex generation.*

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

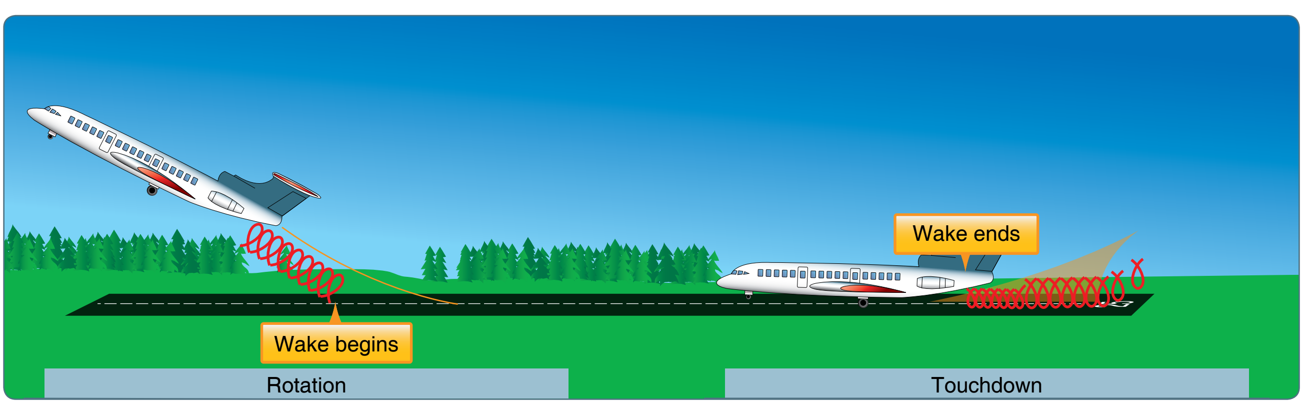


Figure 14-46. *Vortex behavior.*

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

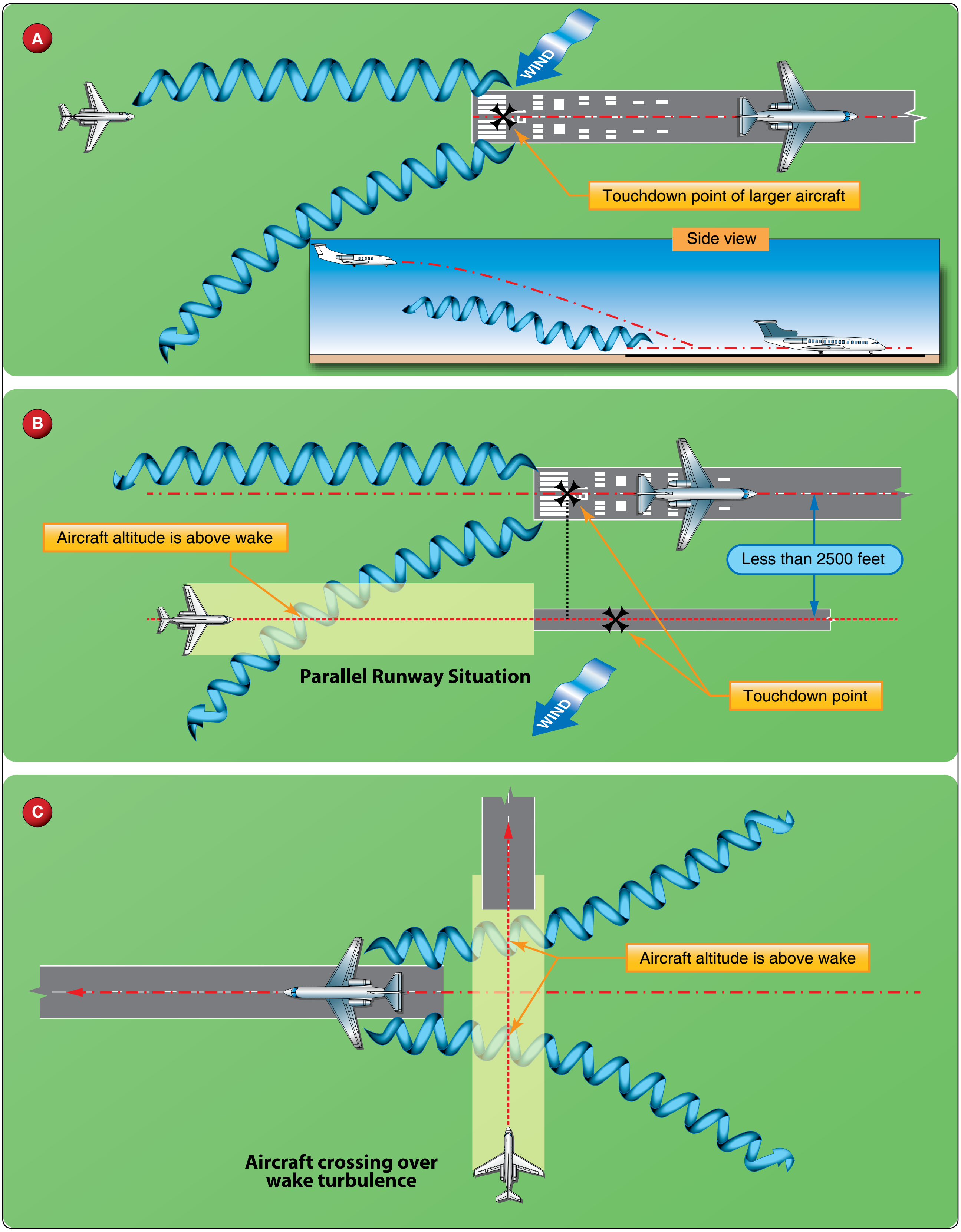


Figure 14-47. *Vortex avoidance procedures.*

maneuver. During instruction, the pilot should be asked to verbalize the clearing procedures (call out "clear left, right, above, and below").

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

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.

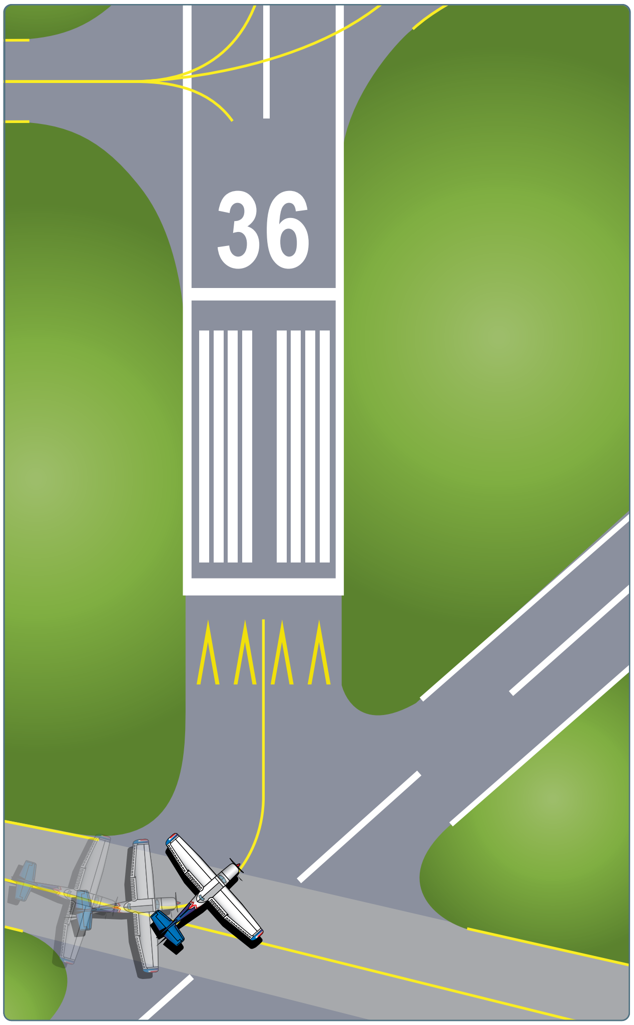


Figure 14-49. *Confusing runway/runway intersection.*

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.*

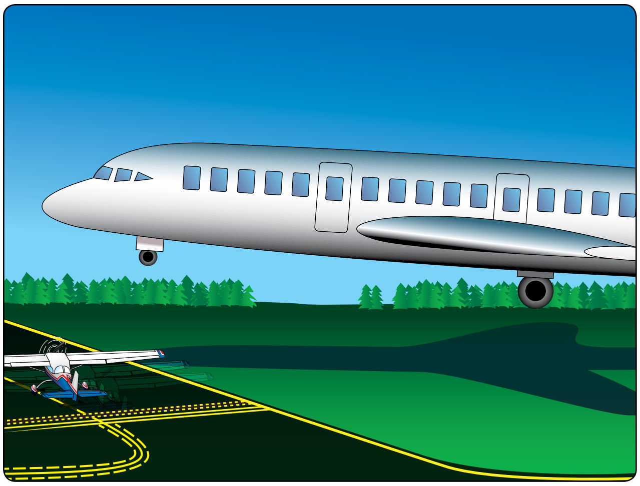


Figure 14-51. *Do NOT cross a runway holding position marking without ATC clearance. If the tower is closed or you are operating from a non-towered airport, check both directions for conflicting traffic before crossing the hold position marking.*

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

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 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.

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

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]*

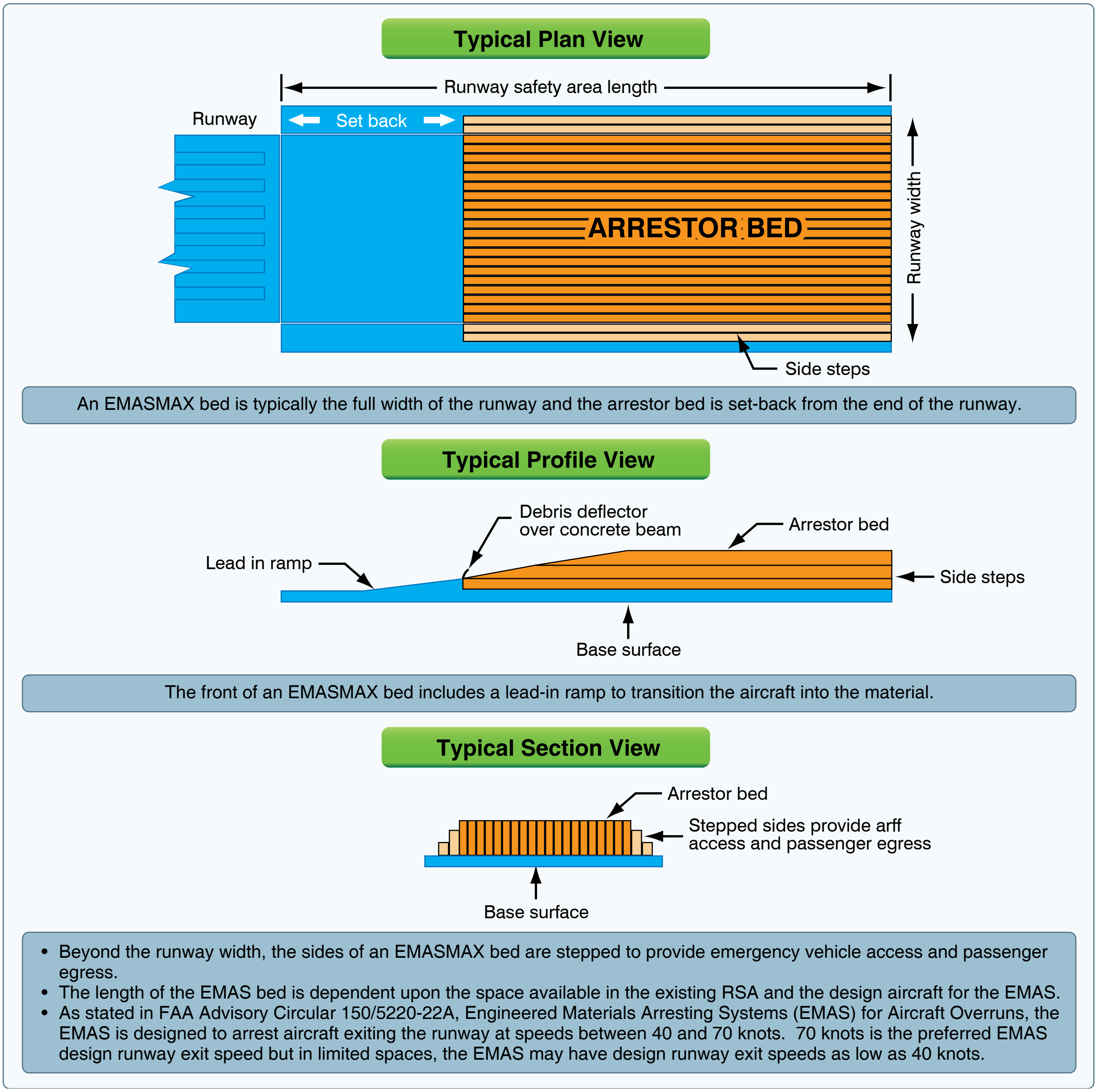


Figure 14-56. *Diagram of an EMASMAX system.*

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

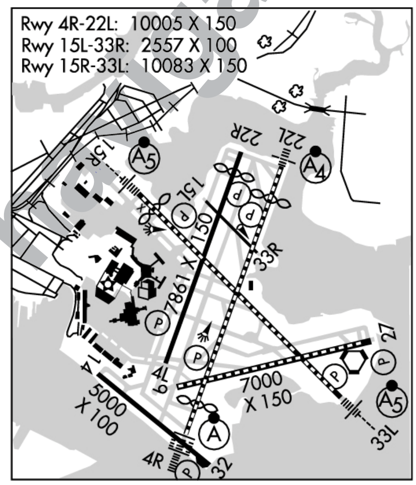
The chapter identifies best practices to help you avoid errors that may potentially lead to runway incursions. Although the chapter pertains mostly to surface movements for single-pilot operations, all of the information is relevant for flight crew operations as well.

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

Not to be used for navigation

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

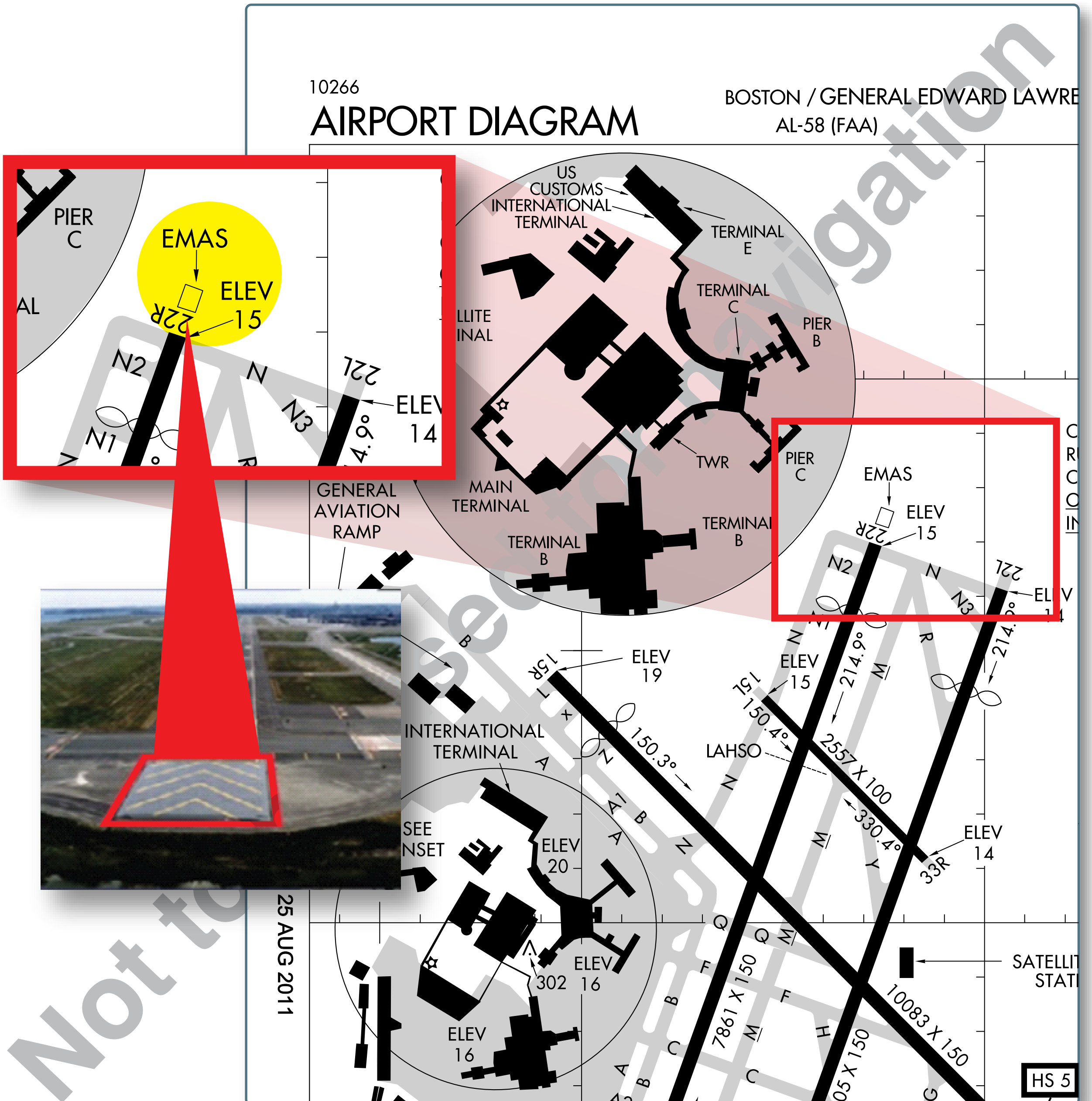


Figure 14-60. *An airport diagram with EMAS information.*