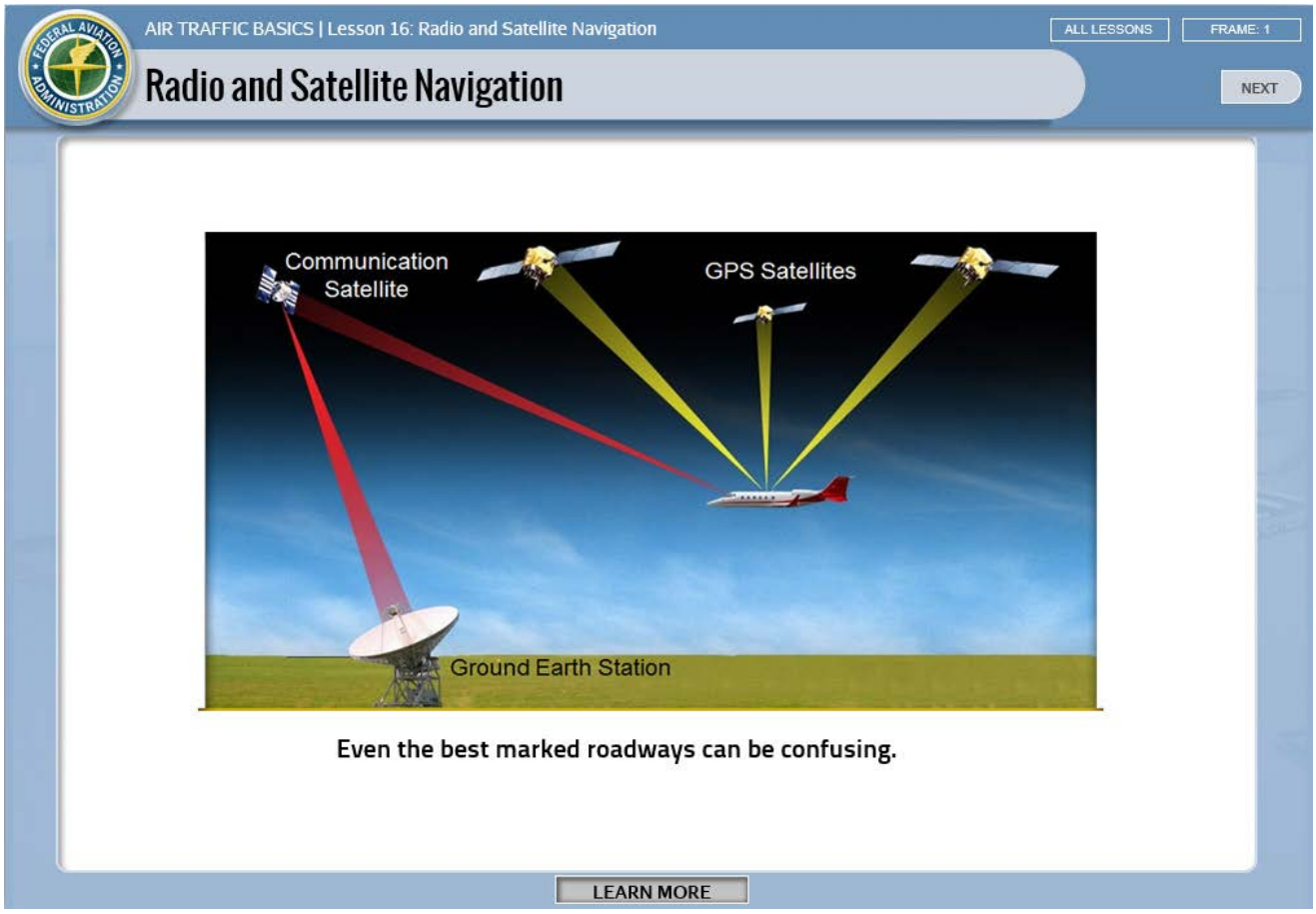
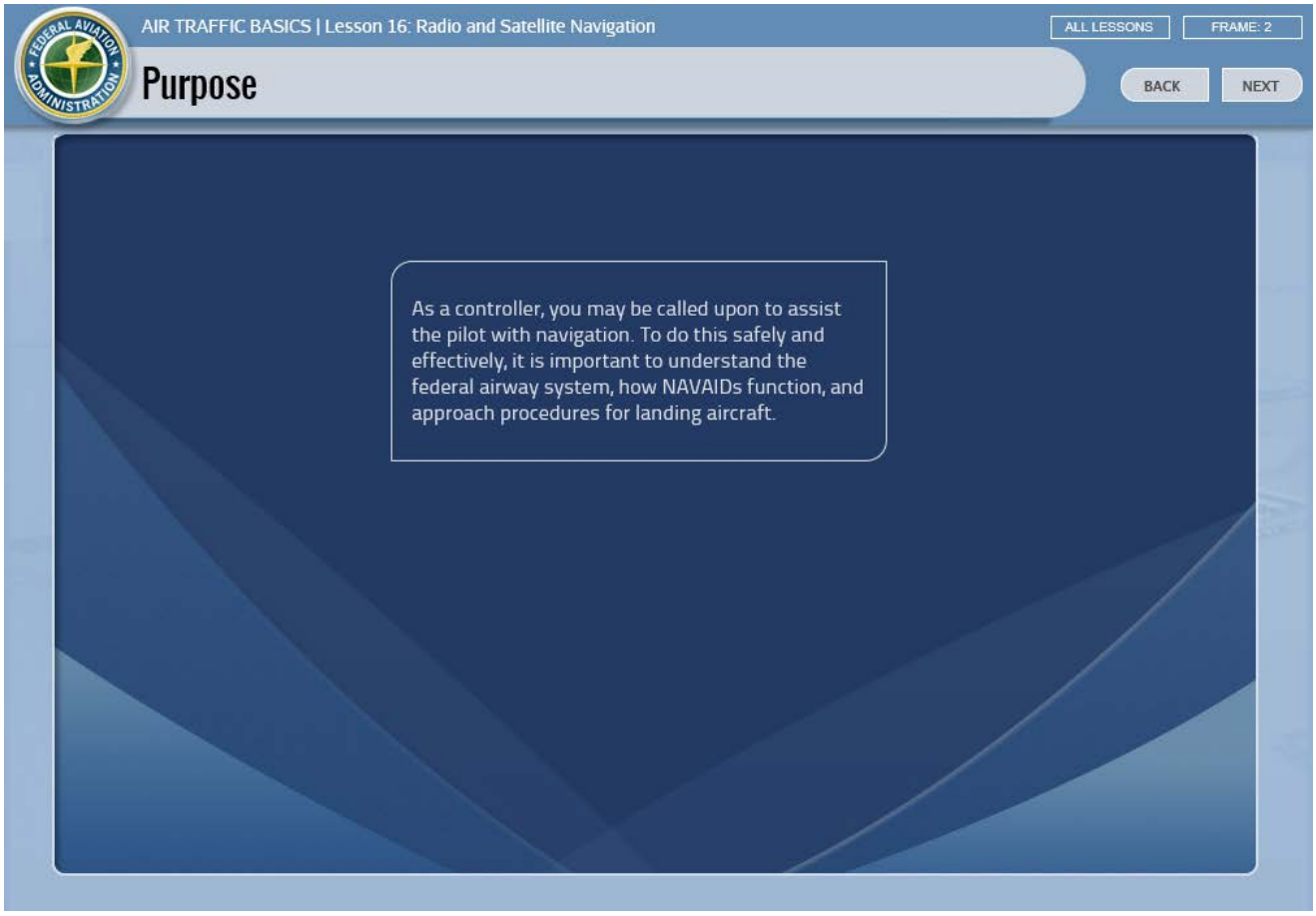
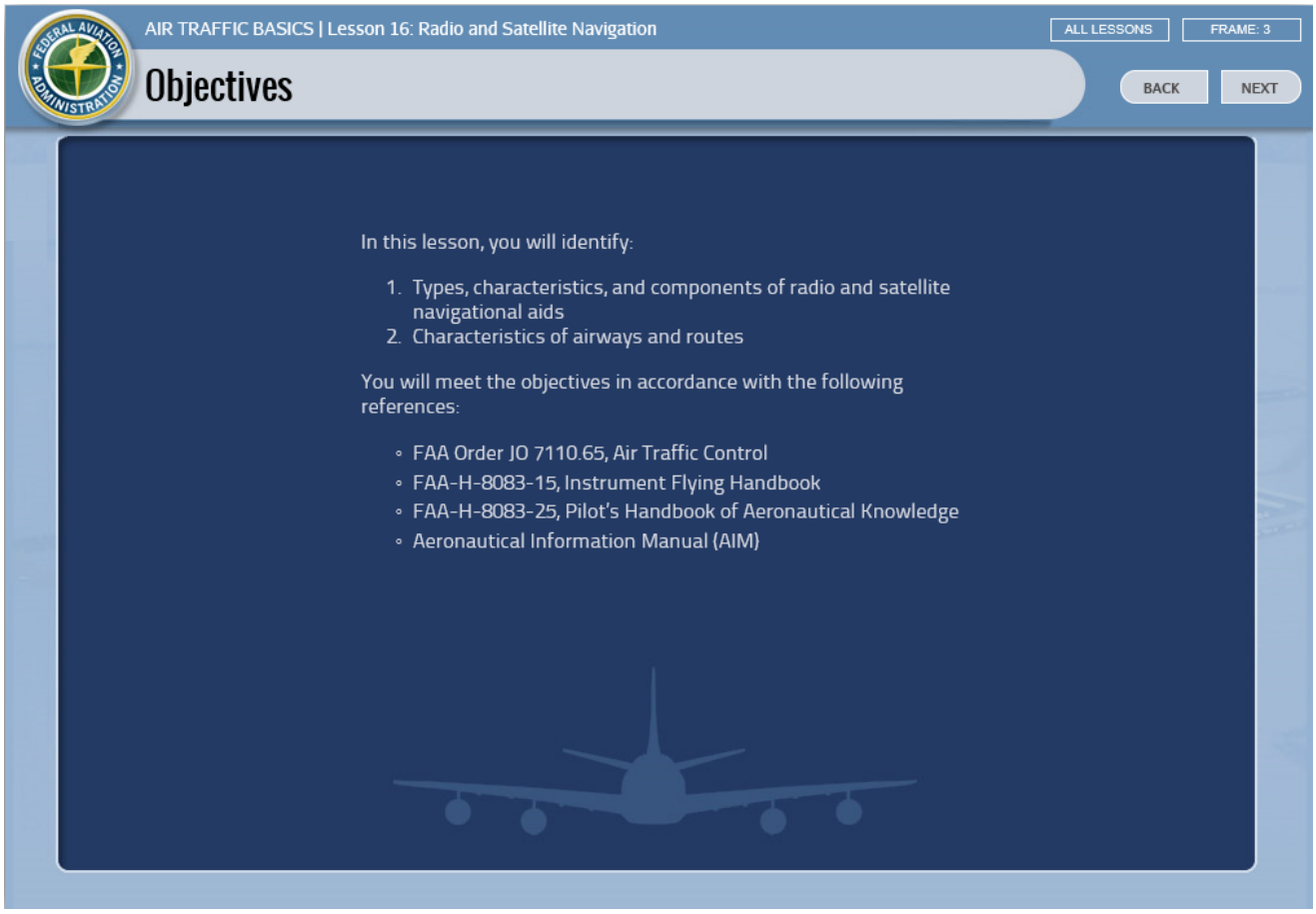


On the ground, at least a driver can stop and ask directions. Since pilots have no lines to follow or signs to read in the air, they must depend on other methods to help them reach their destination, such as ground-based, satellite-based, and approach navigational aids (NAVAIDs). Your understanding of the uses and functions of NAVAIDs will provide you with guidelines to issue realistic clearances.


AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation
ALL LESSONS
FRAME: 2
Purpose
BACK
NEXT
As a controller, you may be called upon to assist the pilot with navigation. To do this safely and effectively, it is important to understand the federal airway system, how NAVAIDs function, and approach procedures for landing aircraft.


AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation
ALL LESSONS
FRAME: 3
Objectives
BACK
NEXT
In this lesson, you will identify:
1. Types, characteristics, and components of radio and satellite navigational aids
2. Characteristics of airways and routes
You will meet the objectives in accordance with the following references:
FAA Order JO 7110.65, Air Traffic Control
FAA-H-8083-15, Instrument Flying Handbook
FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
Aeronautical Information Manual (AIM)

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 4

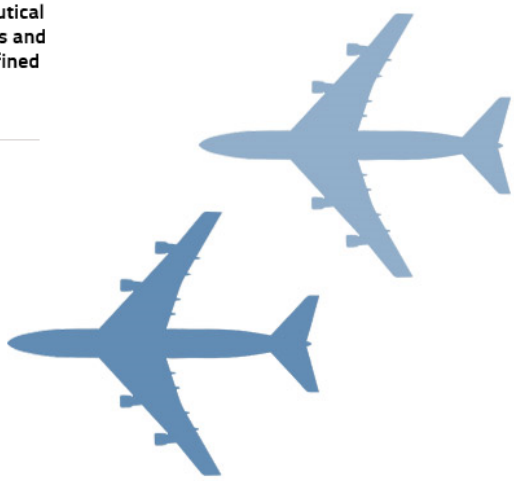
Radio - Based Navigation

BACK NEXT

Uses

- A radio navigational aid is any electronic device, airborne or on the surface, which provides point-to-point guidance information or position data to aircraft in flight.
- Aircraft are equipped with radios that provide a means of navigation and communication with ground stations.
- Advances in navigational radio receivers installed in aircraft, aeronautical charts which show the exact location of ground transmitting stations and their frequencies, global satellite positioning systems, along with refined cockpit instrumentation make it possible for pilots to navigate with precision to almost any point desired.

FAA-H-8083-25, Chap. 14



AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 5

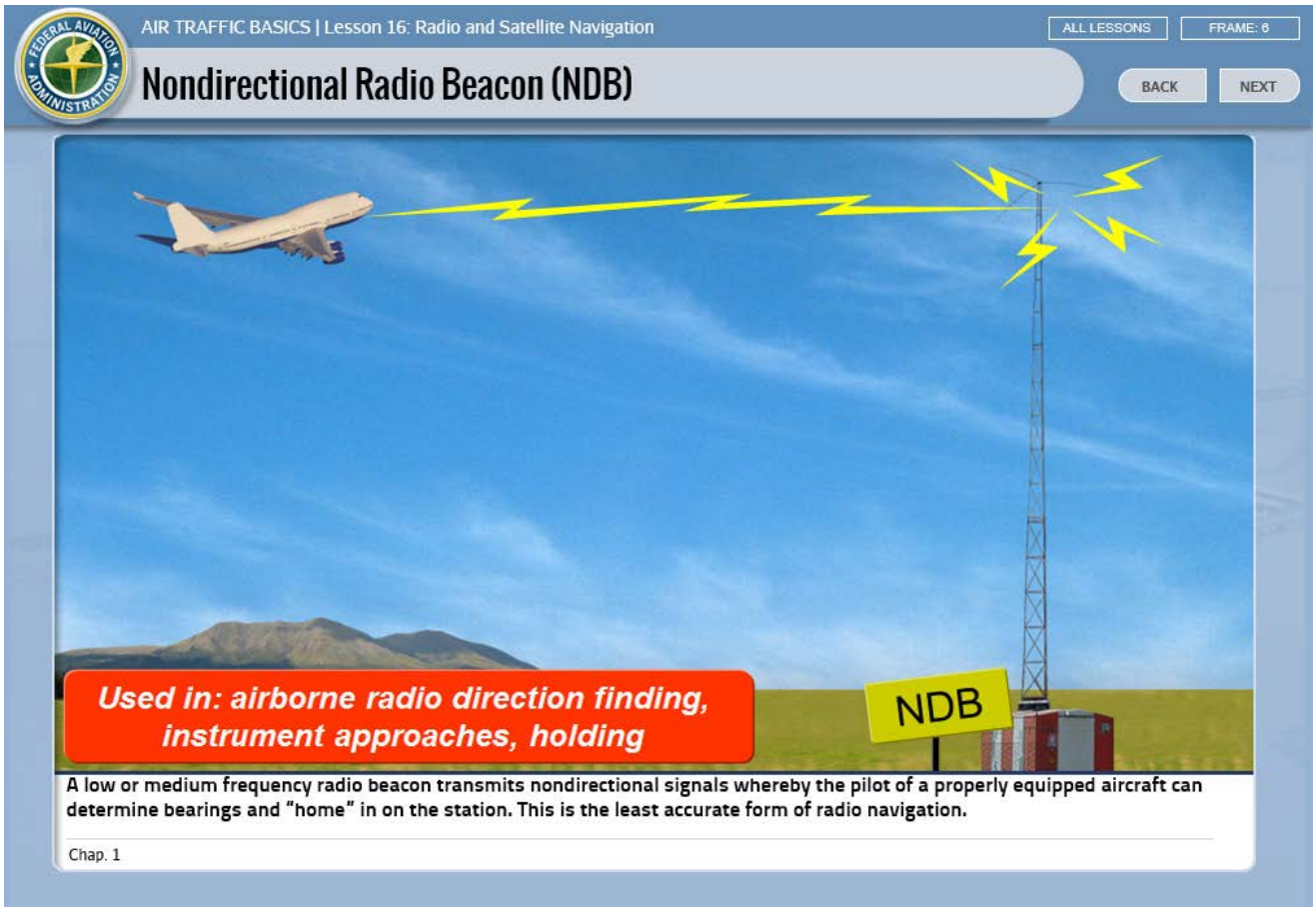
Radio and Satellite Based Navigation

BACK NEXT

Systems

There are eight radio, self contained, and satellite navigation systems available for use. They are:

- Nondirectional Radio Beacon (NDB)
- Very High Frequency (VHF) Omni-Directional Range (VOR)
- Tactical Air Navigation (TACAN)
- Distance Measuring Equipment (DME)
- VHF Omni-Directional Range/Tactical Air Navigation (VORTAC)
- Instrument Landing System (ILS)
- Inertial Navigation System (INS)
- Global Positioning System (GPS)


AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation
ALL LESSONS
FRAME: 6
Nondirectional Radio Beacon (NDB)
BACK
NEXT
Used in: airborne radio direction finding, instrument approaches, holding
NDB
A low or medium frequency radio beacon transmits nondirectional signals whereby the pilot of a properly equipped aircraft can determine bearings and "home" in on the station. This is the least accurate form of radio navigation.
Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 7

Nondirectional Radio Beacon (NDB)

BACK NEXT

Characteristics

These facilities normally operate in the low frequency (LF)/medium frequency (MF) band and transmit a continuous signal.

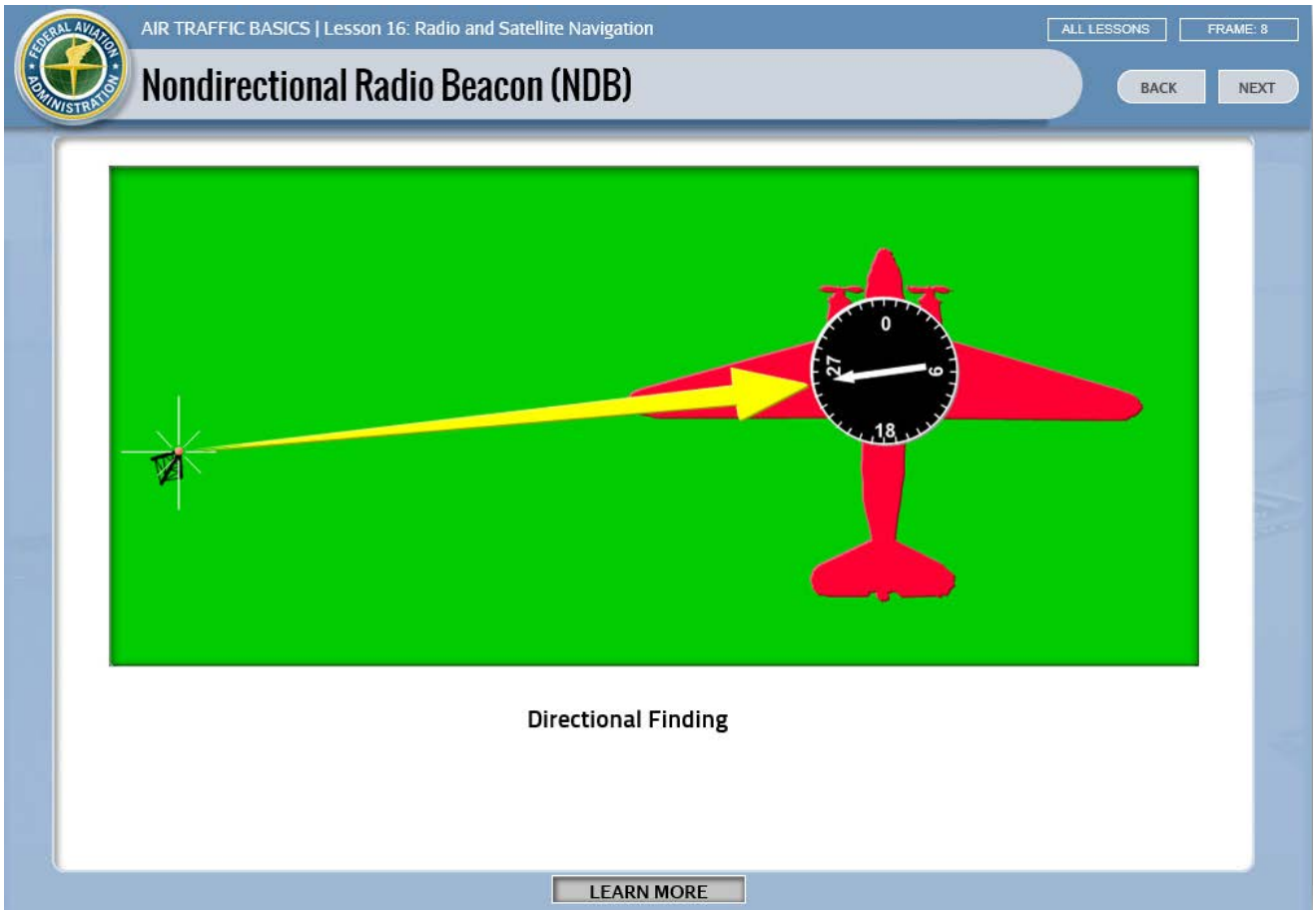
All radio beacons, except the compass locators, transmit continuous three-letter identification in Morse Code except during voice transmissions.

When a radio beacon is used in conjunction with the Instrument Landing System (ILS) markers, it is called a compass locator.

NOTE: ILS will be taught later in this lesson.

Voice transmissions can be made on radio beacons unless the letter "W" (without voice) is included in the class designator (HW).

AIM, Chap. 1; FAA-H-8083-15, Chap. 7



Radio beacons are subject to disturbances that may result in erroneous bearing information.

- Such disturbances result from factors such as lightning, precipitation, and static.
- At night, radio beacons are vulnerable to interference from distant stations.

The NDB receiver in the aircraft converts a nondirectional signal to directional information in relative bearing from the aircraft.

- Needle points to the station and is tuned on the aircraft receiver indicator.

References:

- AIM, Chap. 1
- FAA-H-8083-15, Chap.7

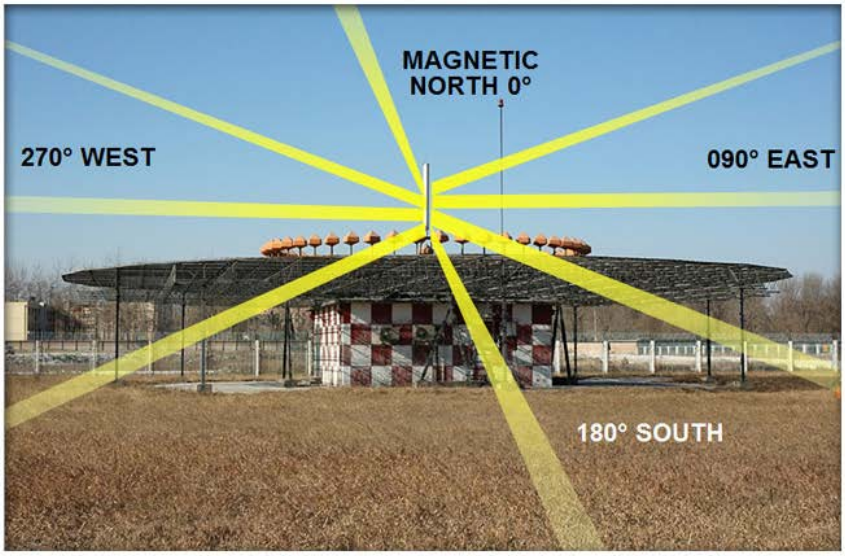
AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 9

VHF Omni-Directional Range (VOR)

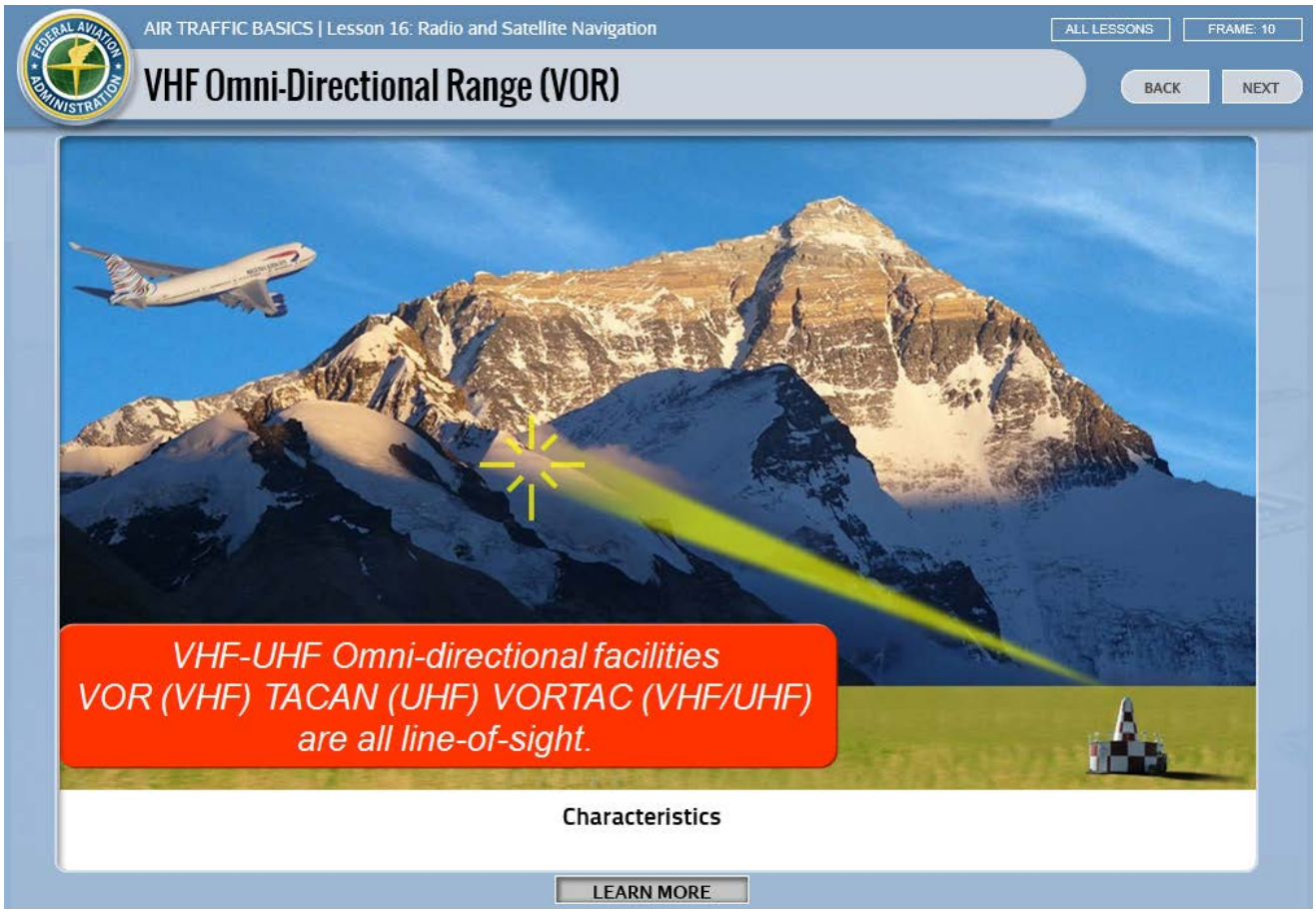
BACK NEXT

VOR Definition



Very High Frequency Omni-Directional Range (VOR) is a ground-based electronic navigational aid transmitting a very high frequency navigation signal, 360 radials, oriented to magnetic north.

JO 7110.65, Pilot/Controller Glossary



Characteristics

- The VOR is the primary navigation facility for civil aviation in the National Airspace System (NAS).
- As a VHF facility, it eliminates atmospheric static interference and other limitations associated with low-frequency facilities.
- The VOR ground station transmits azimuth information to the aircraft, providing 360 magnetic courses.
  - These courses are called radials and are oriented from the station.
  - Using the airborne VOR receiver, a pilot can select any of these 360 courses to navigate to or from the VOR station.
- VORs are subject to line-of-sight restrictions.
  - Signals do not penetrate mountains.

Note: TACANs and VORTACs will be covered later in this lesson.

References:

- FAA-H-8083-15, Chap. 7
- FAA-H-8083-25, Chap. 14

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 11

VHF Omni-Directional Range (VOR)

BACK NEXT

CLASS	DISTANCE AND ALTITUDES	(MILES)
T	12,000` and below	25
L	Below 18,000`	40
H	Below 14,500`	40
H	14,500` - 17,999`	100
H	18,000` - FL450	130
H	Above FL450	100

Range and Classification

VORs have a power output necessary to provide coverage within their assigned operational service volume and are classified according to operational use.

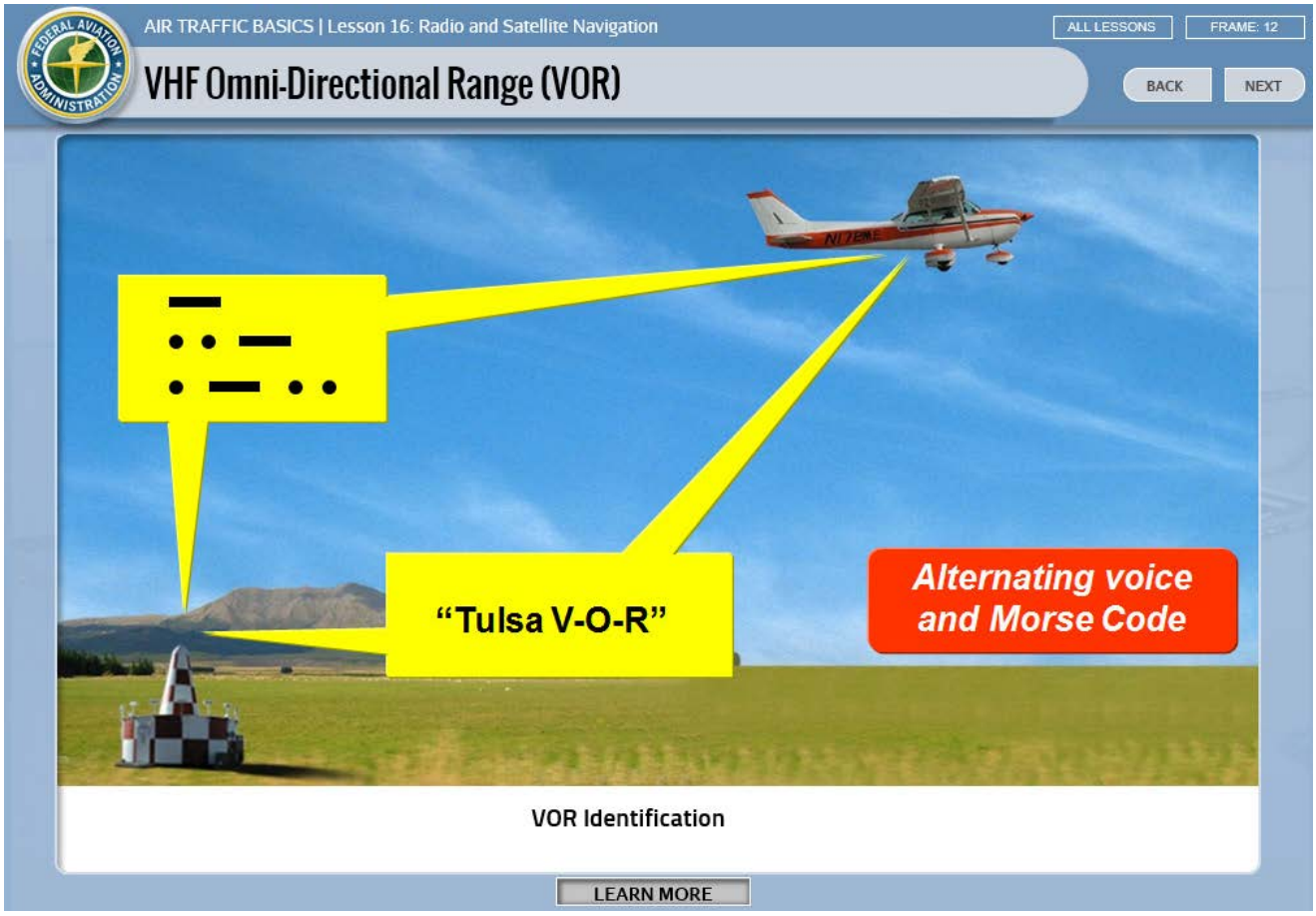
The three classes are:

- T (Terminal) - Used for navigation in a terminal area around an airport
- L (Low altitude) - Generally used to navigate on airways
- H (High altitude) - Used to navigate on all ATS routes

The standard service volume for the various classes are shown in the table above: Applies to VORs, TACANs, and VORTACs

NOTE: Some NAVAIDS may be flight checked for use at greater distances than shown.

JO 7110.65, Chap. 4; FAA-H-8083-25, Chap. 14



VORs may be equipped for voice transmission on the VOR frequency.

- VORs without voice capability are indicated by the letter "W" (without voice) in the Airport/Facility Directory (A/FD).
- VOR class is listed prior to the type NAVAID in the A/FD.

Example: Will Rogers VORTAC is listed as (H) VORTACW.

Class and voice capability are also annotated on the charts.

Reference: AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 13

VHF Omni-Directional Range (VOR)

BACK NEXT

VOR Identification

The only positive method of identifying a VOR is by its Morse Code identification or by the recorded automatic voice identification, which is always indicated by use of the word "VOR" following the name.

- The transmission consists of a voice announcement (e.g., "AIRVILLE VOR") alternating with the Morse Code identification.
  - Automated Flight Service Stations (AFSSs) are able to communicate through many VORs with different names. In most cases, none of the VORs have the name of the "parent" AFSS.
- During periods of maintenance, the facility may radiate a T-E-S-T code (-. ...-) or the code may be removed.

AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 14

VHF Omni-Directional Range (VOR)

BACK NEXT

VOR Effectiveness

The effectiveness of the VOR depends upon proper use and adjustment of both ground and airborne equipment.

- The accuracy of course alignment of the VOR is excellent, generally plus or minus 1 degree.
- On some VORs, an intermittent signal may be observed. (Some receivers are more susceptible to these irregularities than others.)
  - At a few stations, usually in mountainous terrain, the pilot may occasionally observe a brief course needle oscillation.

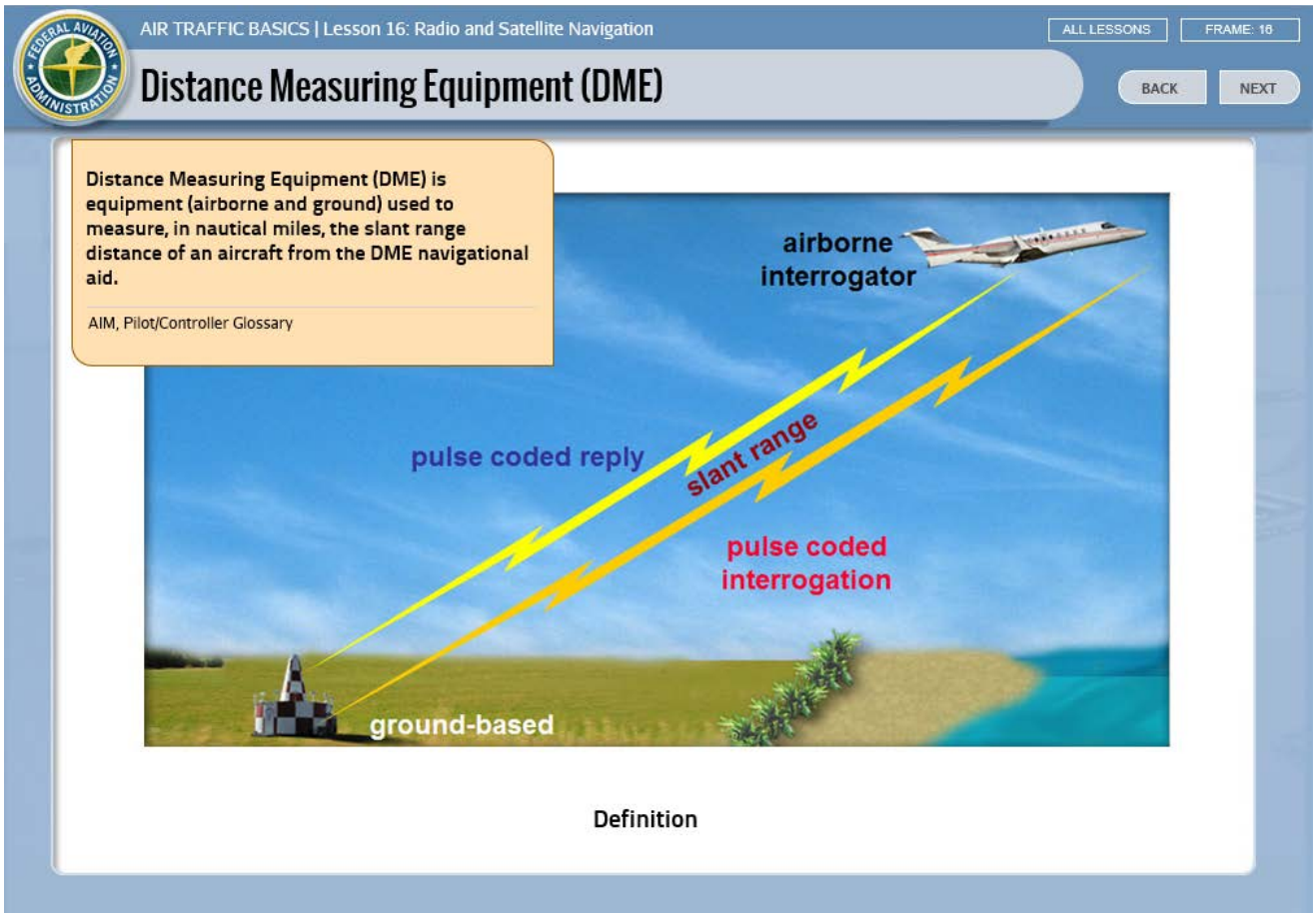
FAA-H-8083-25, Chap. 14

Tactical Air Navigation (TACAN) is a military navigational system, which provides suitably equipped aircraft continuous indications of bearing and distance to the TACAN station.

- Bearing and distance information is transmitted in the Ultra-High Frequency (UHF) band.
  - The bearing and distance frequencies are paired and assigned a channel number.
  - **Example:** Channel 101
- TACANs have the same classification and range as VORs.
- For reasons peculiar to military or naval operations (e.g., unusual site conditions, the pitching and rolling of a naval vessel, etc.) the civil VOR/DME system of air navigation is considered unsuitable for military or naval use.
  - The TACAN is more accurate than a VOR and is physically much smaller.
  - The TACAN is, therefore, used by the military forces.
- Like VORs, TACANs generate directional information and transmit it by ground equipment to the aircraft, providing 360 usable magnetic courses, called radials, measured outbound from the station.
- TACANs are subject to line-of-sight restrictions.
  - Signals do not penetrate solid objects.

References:

- JO 7110.65, Chap. 4, Pilot/Controller Glossary
- AIM, Chap. 1


AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation
ALL LESSONS
FRAME: 18
Distance Measuring Equipment (DME)
BACK
NEXT
Distance Measuring Equipment (DME) is equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid.
AIM, Pilot/Controller Glossary
airborne interrogator
pulse coded reply
slant range
pulse coded interrogation
ground-based
Definition

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 17

Distance Measuring Equipment (DME)

BACK NEXT

Characteristics

- **Distance information received from DME equipment is slant range distance and not actual horizontal distance.**
  NOTE: The difference between slant range and horizontal distance is greatest near the NAVAID, at high altitude.
- **In the operation of DME, paired pulses at a specific spacing are sent out from the aircraft (this is the interrogation) and are received at the ground station.**
- **The ground station (transponder) then transmits paired pulses back to the aircraft at the same pulse spacing, but on a different frequency.**
  NOTE: DME uses a transponder located on the ground, as opposed to radar which uses a transponder located in the aircraft.
- **The time required for the round trip of this signal exchange is measured in the airborne DME unit and is translated into distance (in nautical miles) from the aircraft to the ground station.**
- **Operating on the line-of-sight principle, DME furnishes distance information with a very high degree of accuracy.**
  - **Reliable signals may be received at distances up to 199NM at line-of-sight altitude with an accuracy of better than 1/2 mile or 3 percent of the distance, whichever is greater.**
- **DME operates on frequencies in the UHF spectrum.**
  - **Aircraft using TACAN equipment will receive distance information from a VORTAC automatically.**
    - **To receive DME, a VOR equipped aircraft must have a DME airborne unit.**

FAA-H-8083-15, Glossary; AIM, Chap.1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 18

VHF Omni-Directional Range/Tactical Air Navigation (VORTAC)

BACK NEXT

A VORTAC is a navigational facility consisting of two components:

- VOR
- TACAN

AIM, Chap. 1

VHF Omni-Directional Range/Tactical Air Navigation (VORTAC)

Characteristics

A VORTAC provides three individual services at one site:

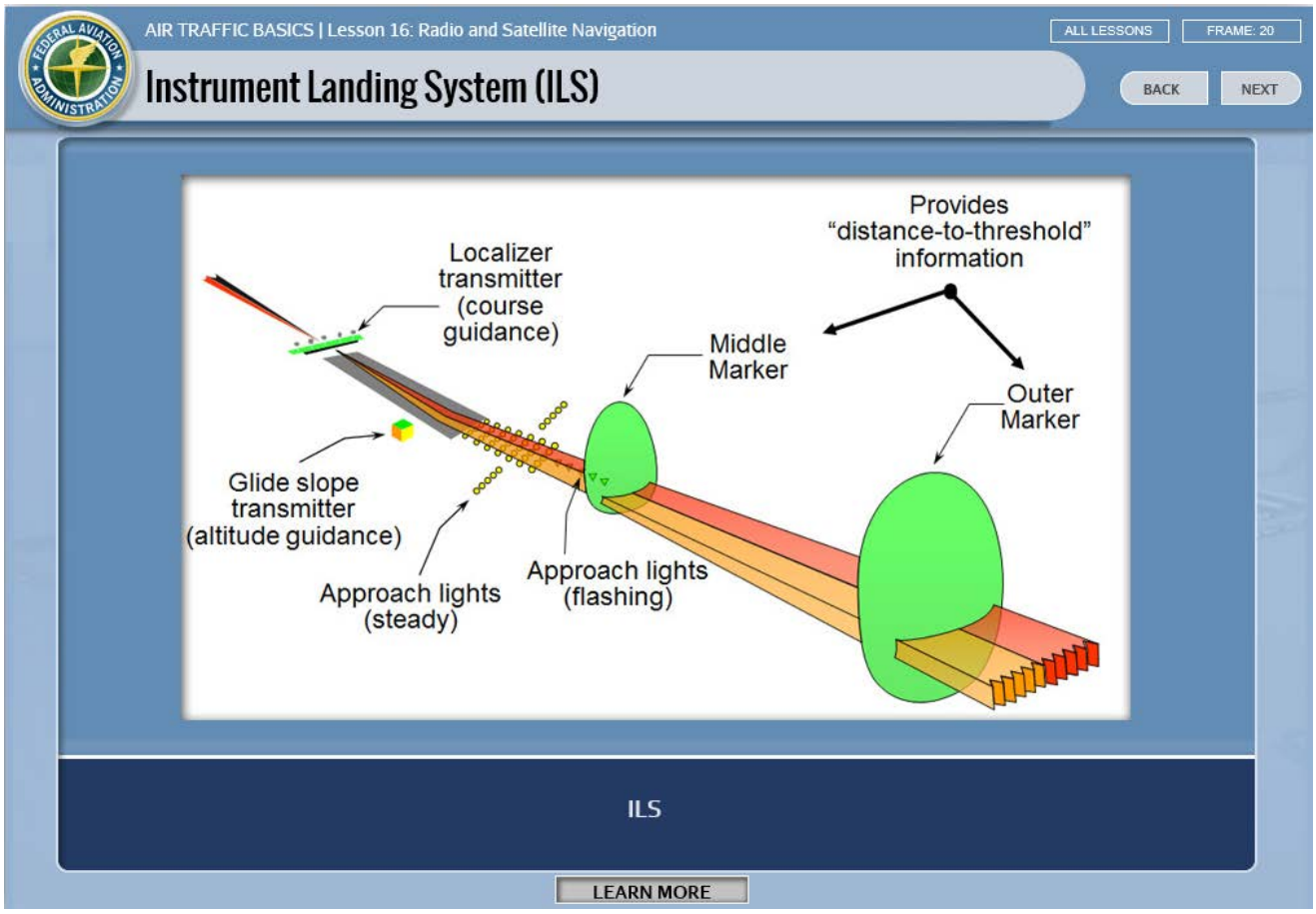
- VOR azimuth
- TACAN azimuth
- TACAN distance (DME)

A VORTAC is considered to be a unified navigational aid although it consists of more than one component, incorporates more than one operating frequency, and uses more than one antenna system.

- Both components of a VORTAC are envisioned as operating simultaneously and providing the three services at all times.

Transmitted signals of VOR and TACAN are each identified by a three-letter Morse Code transmission and are interlocked so that pilots using VOR azimuth with TACAN distance can be assured that both signals being received are definitely from the same ground station.

- The frequency channels of the VOR and the TACAN at each VORTAC facility are paired to simplify airborne operation.



The ILS is designed to provide:

- An approach path with both course and altitude guidance.
- An exact alignment and descent of an aircraft on final approach to a specific runway.

The ground equipment consists of two highly directional transmitting systems and, along the approach, three (or fewer) marker beacons.

- The directional transmitters are known as the localizer and glide slope transmitters.

A more detailed diagram is provided in Appendix B.

References:

- FAA-H-8083-15, Chap. 7
- AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 21

Instrument Landing System (ILS)

BACK NEXT

Components

The ILS may be divided functionally into the following parts:

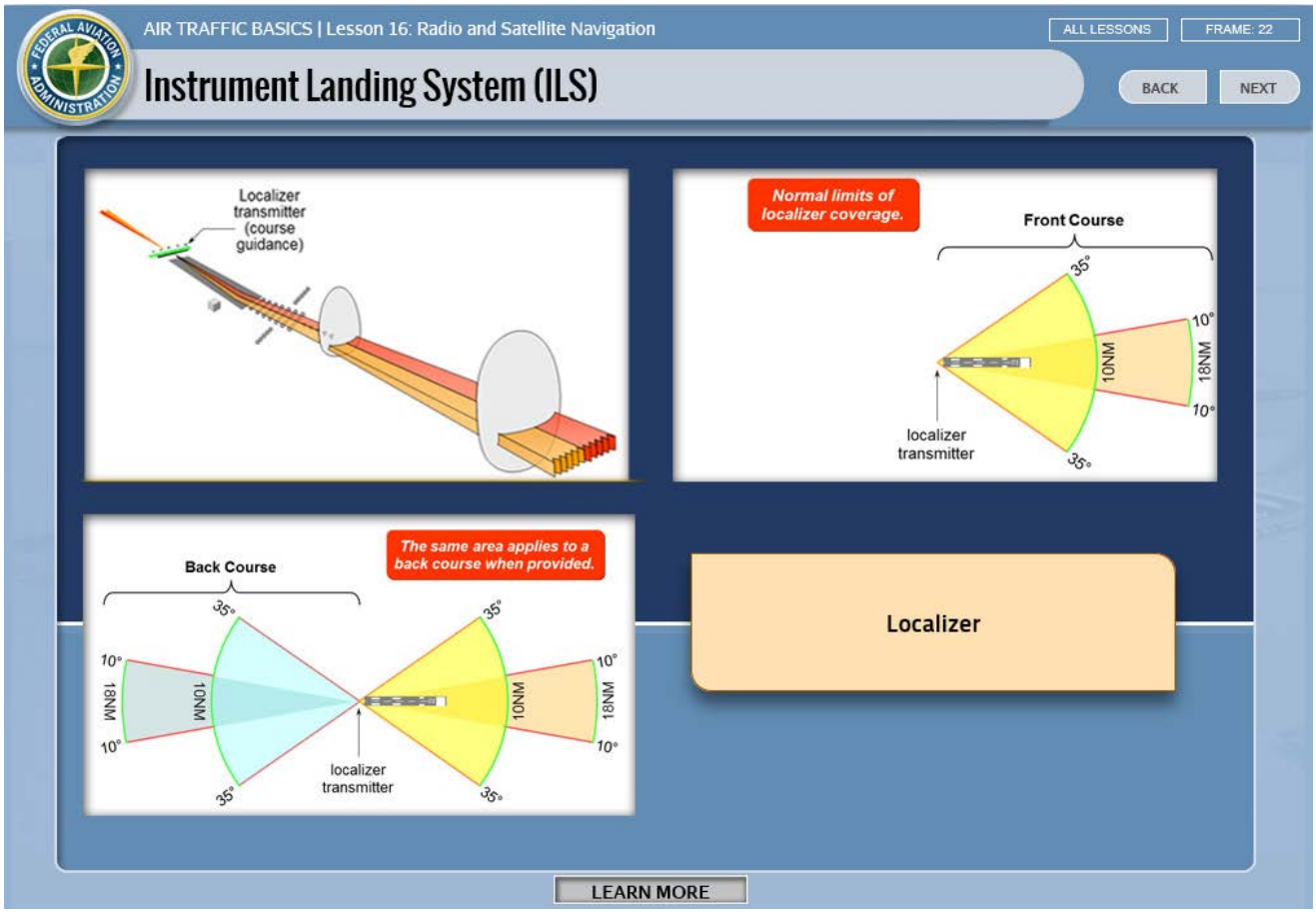
- The localizer provides horizontal (left/right) guidance along the extended centerline of the runway.
- The glide slope provides vertical (up/down) guidance along the descent path toward the runway touchdown point (usually at a 3° slope).
- Marker beacons give range information along the approach path.
  - DME may also be available to provide distance information.
- Visual information (includes approach, touchdown, centerline, and runway lights) provide transition from instrument to visual flight.

Precision radar, or compass locators located at the Outer Marker (OM) or Middle Marker (MM), may be substituted for marker beacons.

- DME, when specified in the procedure, may be substituted for the OM.

Where a complete ILS system is installed on each end of a runway (e.g., the approach end of Runway 4 and the approach end of Runway 22) the ILS systems are not in service simultaneously.

FAA-H-8083-15, Chap. 7



The localizer provides the pilot with course guidance to the runway centerline.

- The localizer transmitter operates in the VHF band.
- The approach course of the localizer is called the front course and is used with other functional parts (e.g., glide slope, marker beacons, etc.).
- The localizer signal is transmitted from the far end of the runway.
- The course line along the extended centerline of a runway, in the opposite direction to the front course, is called the Back Course (BC).
- Identification is in Morse Code and consists of a three-letter identifier preceded by the letter I (**..**) transmitted on the localizer frequency.

Example: I-DIA

Reference: AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 23

Instrument Landing System (ILS)

BACK NEXT

Localizer

The localizer signal is usable:

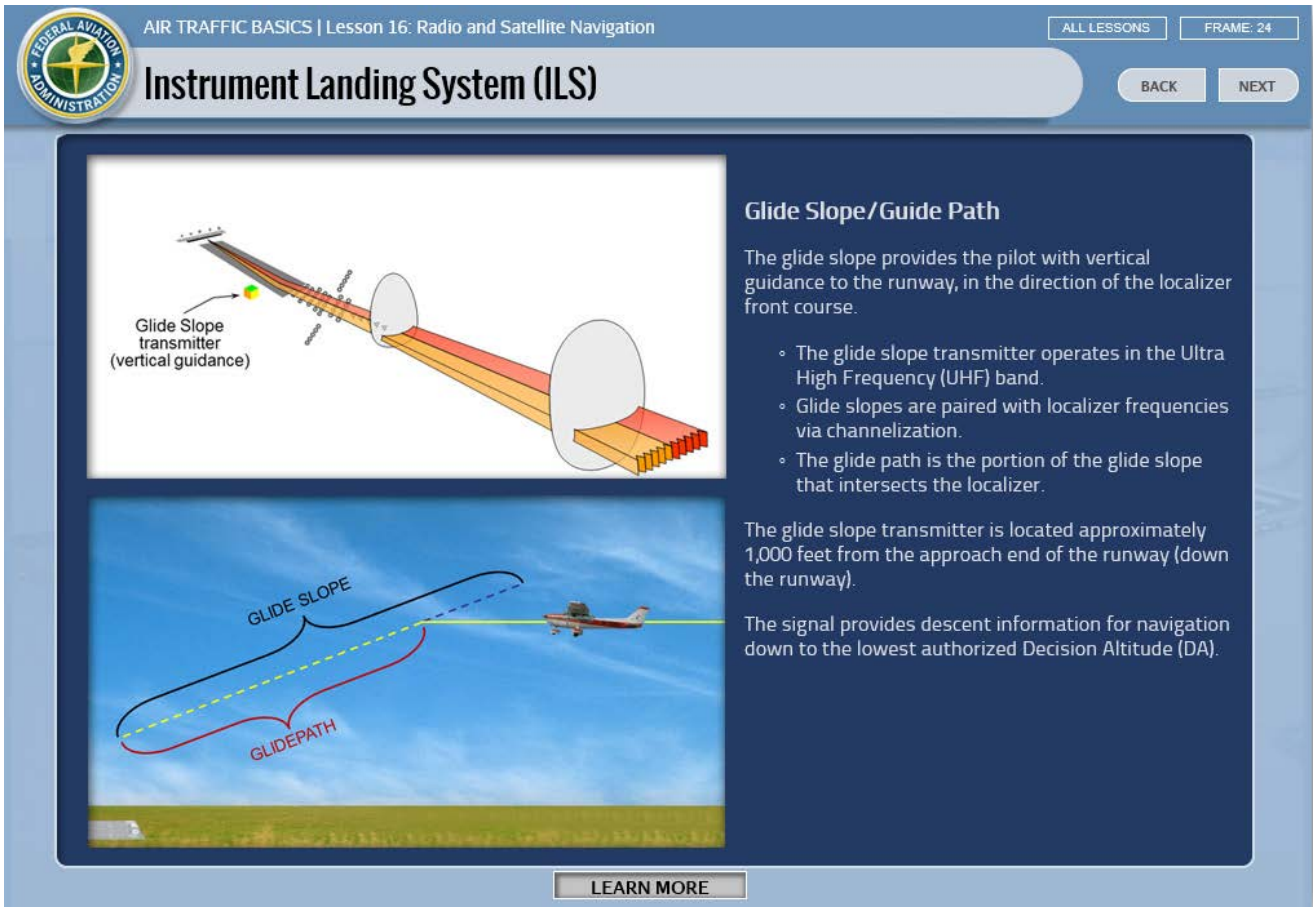
- Vertically
  - From a distance of 18NM from the antenna:
    - Between an altitude of 1,000 feet above the highest terrain along the course line

      and

    - 4,500 feet above the elevation of the antenna site
- Laterally
  - Proper off-course indications are provided throughout the following angular areas of the operational service volume:
    - To 10 degrees either side of the course along a radius of 18NM from the antenna
    - From 10 to 35 degrees either side of the course along a radius of 10NM
    - Unreliable signals may be received outside these areas. The pilot will receive an indication on their instruments if the signal is unreliable.

ILS approach is not usable if localizer is out of service.

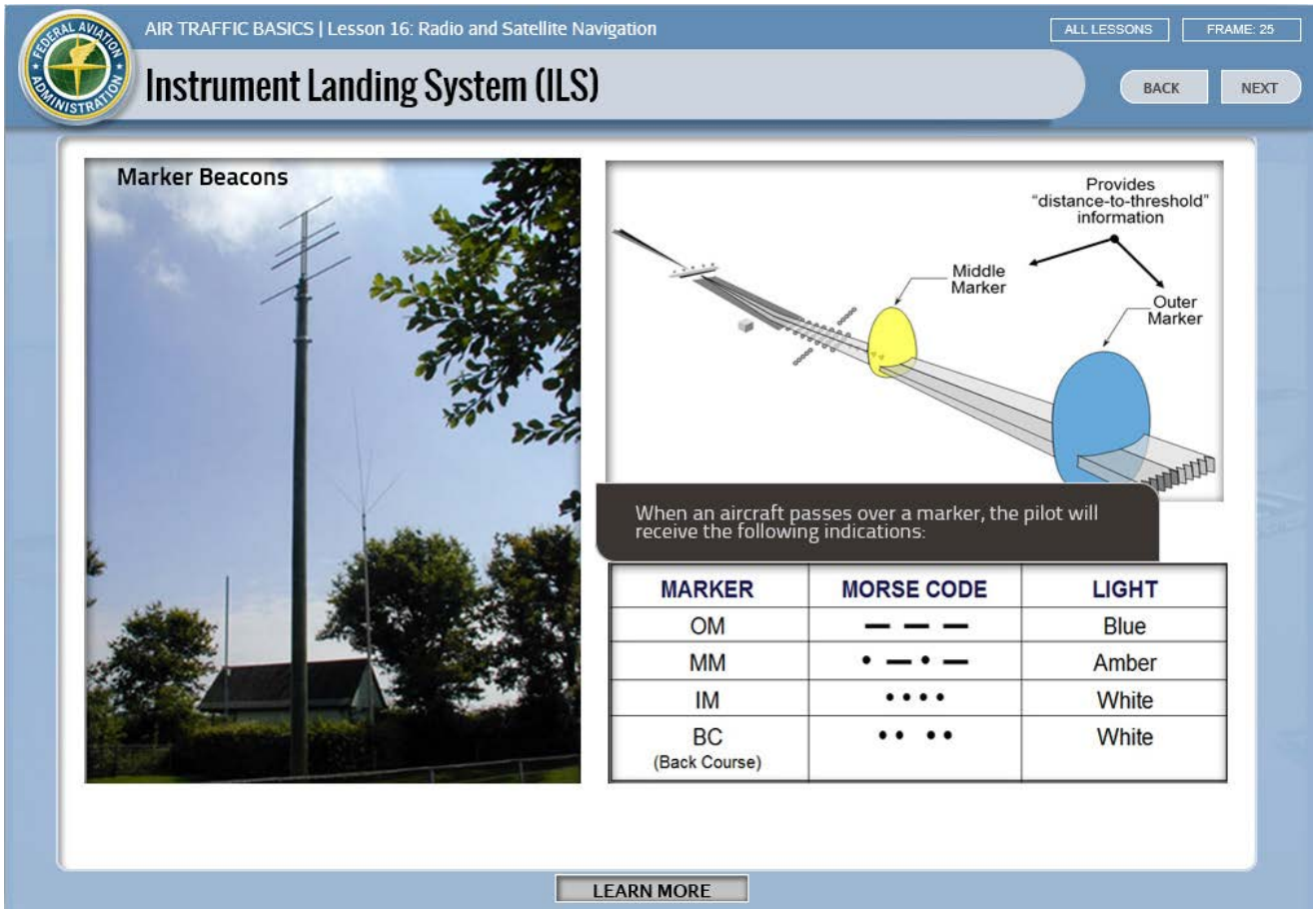
AIM, Chap. 1



The glide path descent angle is normally adjusted to 3 degrees above horizontal so that it intersects the Middle Marker (MM) at about 200 feet and the Outer Marker (OM) at about 1,400 feet above the runway elevation.

- The glide slope is normally usable to the distance of 10NM. However, at some locations, the glide slope has been certified for an extended service volume, which exceeds 10NM.

Reference: AIM, Chap. 1



The purpose of marker beacons is to identify particular locations on the approach to an instrument runway.

- Marker beacons have a rated power output of 3 watts or less and an antenna array designed to produce an elliptical pattern with dimensions:
  - At 1,000 feet above the antenna
  - Approximately 2,400 feet in width and 4,200 feet in length
- Ordinarily, there are two marker beacons associated with an ILS, the Outer Marker (OM) and Middle Marker (MM).

NOTE: *In some locations, DME will be used in lieu of Marker Beacons. DME is transmitted from the localizer antenna.*

Reference: AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 26

Instrument Landing System (ILS)

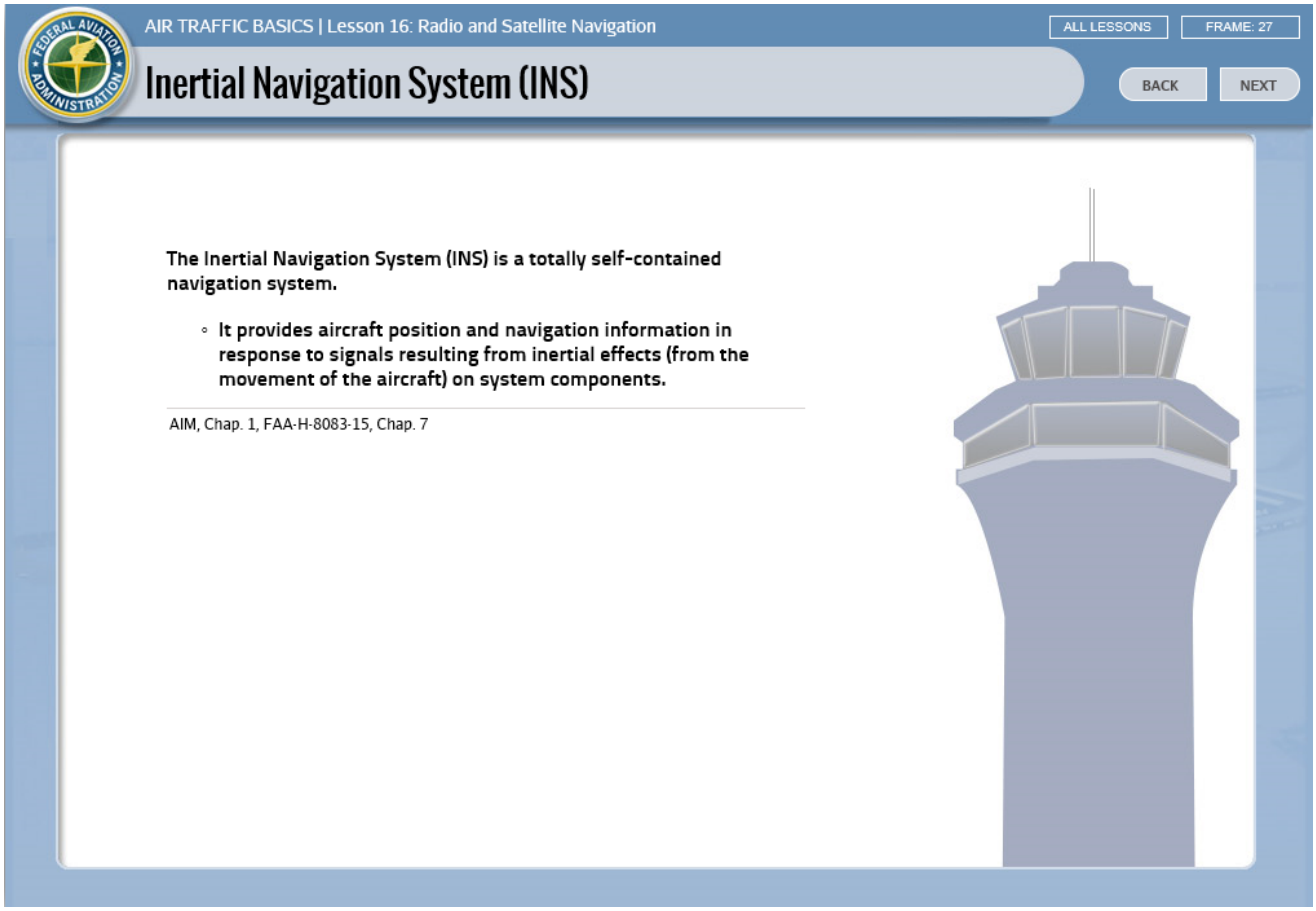
BACK NEXT

Approach Lights

Approach lights provide the basic means to transition from instrument flight to visual flight for landing.

- They are a configuration of signal lights starting at the runway threshold and extending into the approach area.
  - The configuration depends on the operational requirements of the runway.
- Some systems include sequenced flashing lights which appear to the pilot as a ball of light traveling towards the runway at high speed.

AIM, Chap. 2


AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation
ALL LESSONS
FRAME: 27
Inertial Navigation System (INS)
BACK
NEXT
The Inertial Navigation System (INS) is a totally self-contained navigation system.
It provides aircraft position and navigation information in response to signals resulting from inertial effects (from the movement of the aircraft) on system components.
AIM, Chap. 1, FAA-H-8083-15, Chap. 7

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 28

Inertial Navigation System (INS)

BACK NEXT

Characteristics

The INS is comprised of gyros, accelerometers, and a navigation computer.

- It does not require information from external references.

INS is aligned with accurate position information prior to departure and, thereafter, calculates its position as it progresses to the destination.

By programming a series of waypoints, the system navigates along a predetermined track.

- New waypoints can be inserted at any time if a revised routing is desired.

INS accuracy is very high following initial alignment and decreases with time at the rate of about 1-2 nautical miles per hour.

- Position update alignment can be accomplished in-flight using ground-based references.
  - Many INS systems now have sophisticated automatic updates using dual DME and/or VOR inputs.

INS may be approved as the sole means of navigation or may be used in combination with other systems.

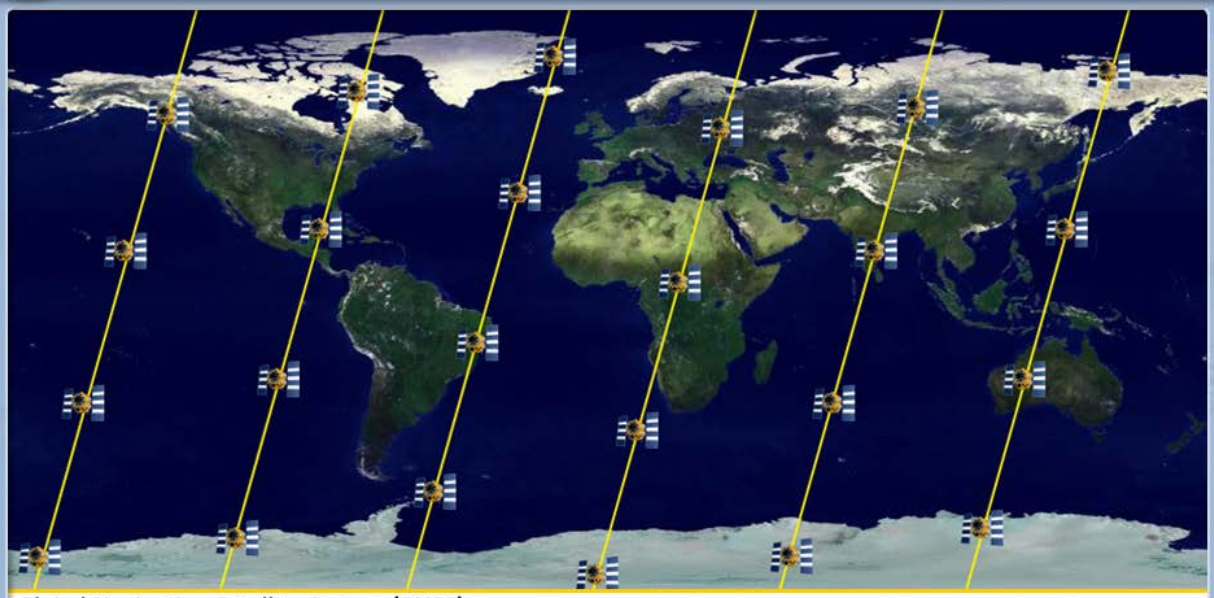
AIM, Chap. 1, FAA-H-8083-15, Chap. 7

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 29

Satellite-Based Navigation

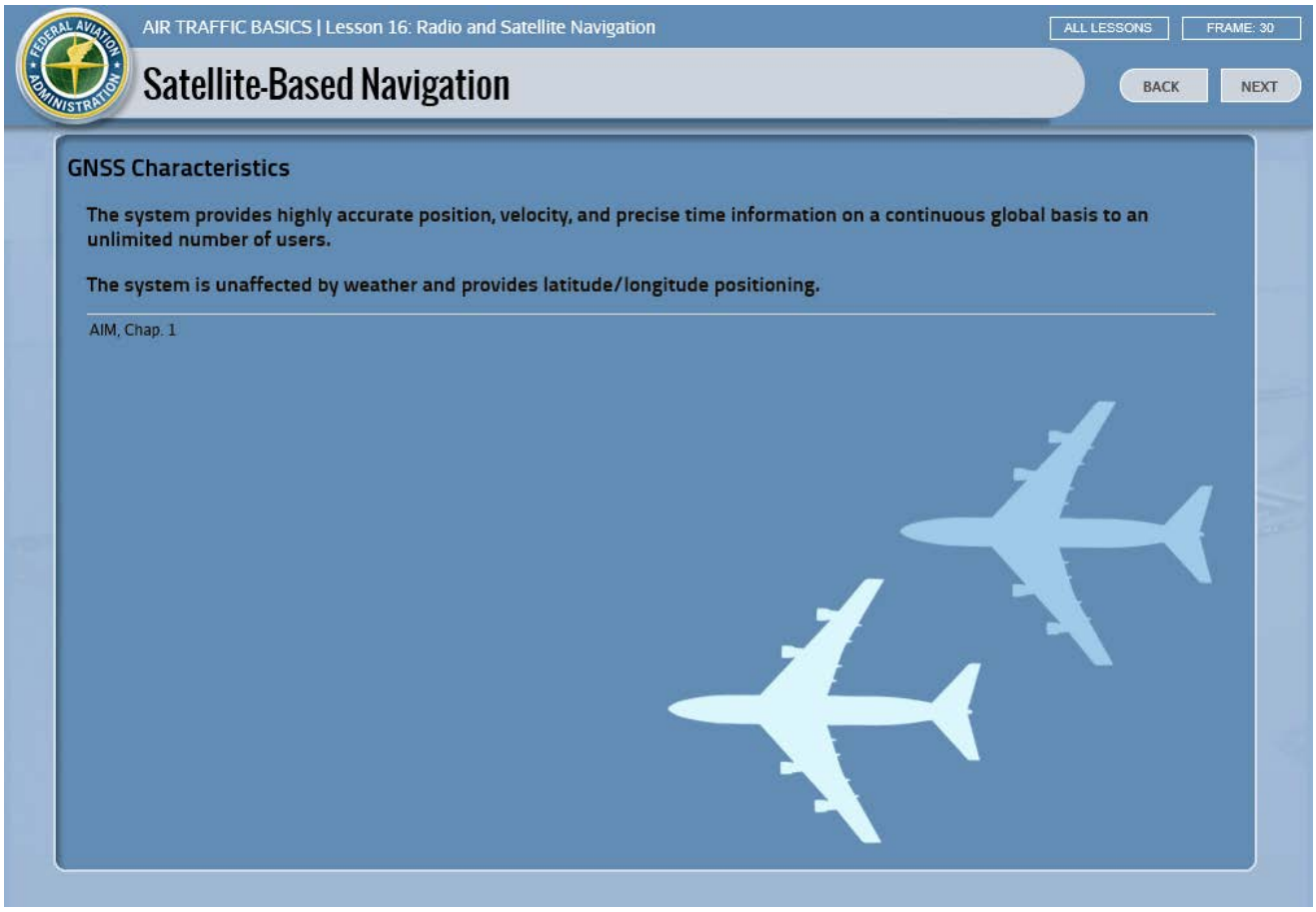
BACK NEXT

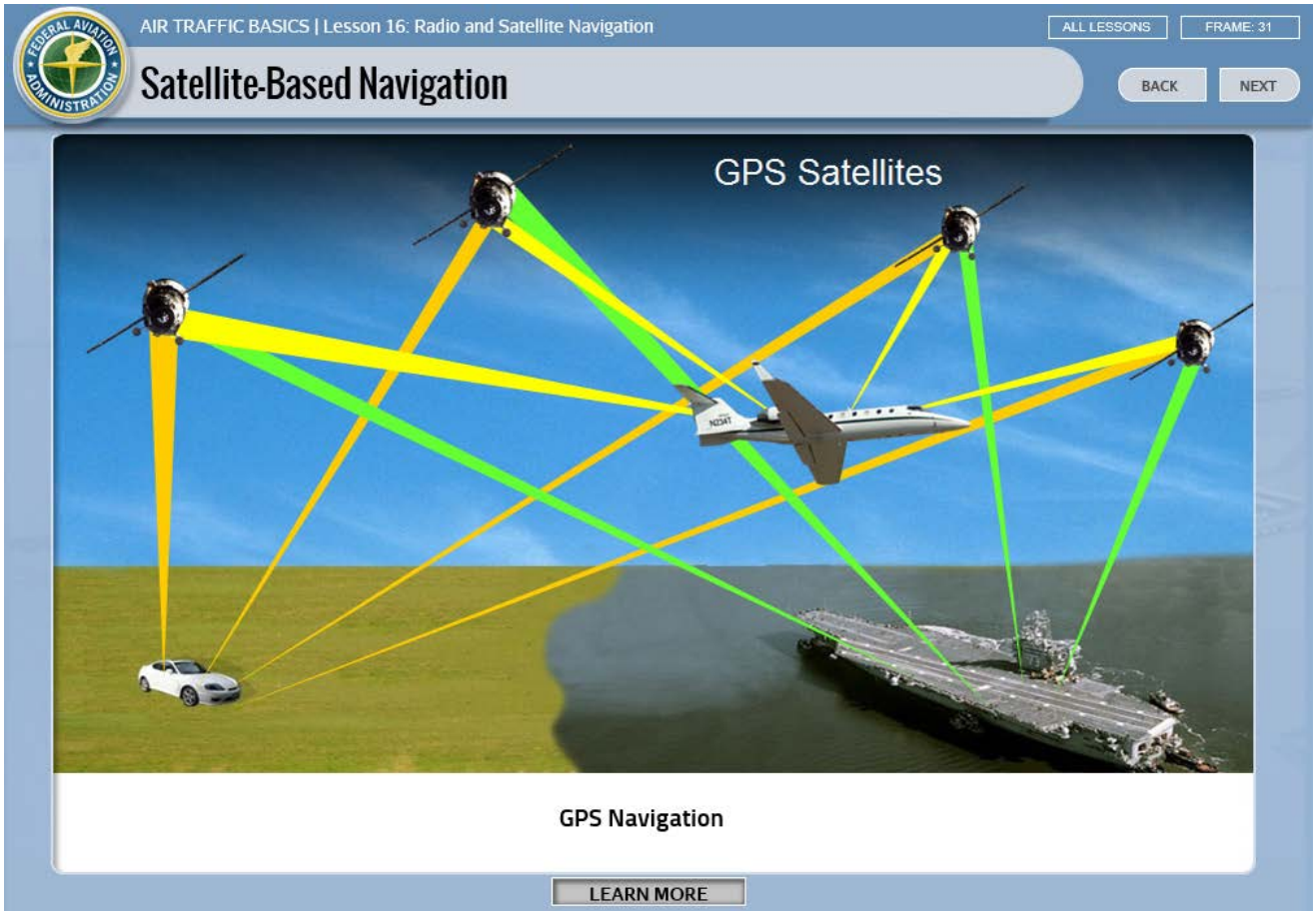


Global Navigation Satellite System (GNSS)

The Global Navigation Satellite System (GNSS) is the standard generic term for satellite navigation systems, which includes Global Positioning System (GPS), and is supplemented by the Receiver Autonomous Integrity Monitoring (RAIM), Wide Area Augmentation System (WAAS), or Local Area Augmentation System (LAAS).

JO 7110.65 Pilot/Controller Glossary


AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation
ALL LESSONS
FRAME: 30
Satellite-Based Navigation
BACK
NEXT
GNSS Characteristics
The system provides highly accurate position, velocity, and precise time information on a continuous global basis to an unlimited number of users.
The system is unaffected by weather and provides latitude/longitude positioning.
AIM, Chap. 1



GPS is a United States satellite-based radio navigational, positioning, and time transfer system operated by the Department of Defense (DoD).

GPS has a constellation of satellites that are designed so that a minimum of five are always observable by a user anywhere on Earth.

- Each GPS satellite transmits a position and time signal.
- The user's receiver measures the time delay for the signal to reach the receiver, which is the direct measure of the apparent range to the satellite.
- Measurements collected simultaneously from the satellites are processed to determine the three dimensions of position (latitude, longitude, altitude), velocity, and time.
  - Three satellites are required for two-dimensional accuracy.
  - Four satellites will add altitude information.

Reference: AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 32

Satellite-Based Navigation

BACK NEXT

GPS Characteristics

GPS provides two levels of service: Standard Positioning Service (SPS) and Precise Positioning Service (PPS).

- SPS provides, to all users, horizontal positioning accuracy of 100 meters, or less, with a probability of 95 percent, and 300 meters with a probability of 99.99 percent.
- PPS is more accurate than SPS; however, this is limited to authorized U.S. and allied military, federal government, and civil users who can satisfy specific U.S. requirements.

AIM, Chap. 1

AIR TRAFFIC BASICS | Lesson 16: Radio and Satellite Navigation

ALL LESSONS FRAME: 33

Satellite-Based Navigation

BACK NEXT

GPS Augmentation Systems

There are three systems used in aviation to confirm and improve GPS accuracy:

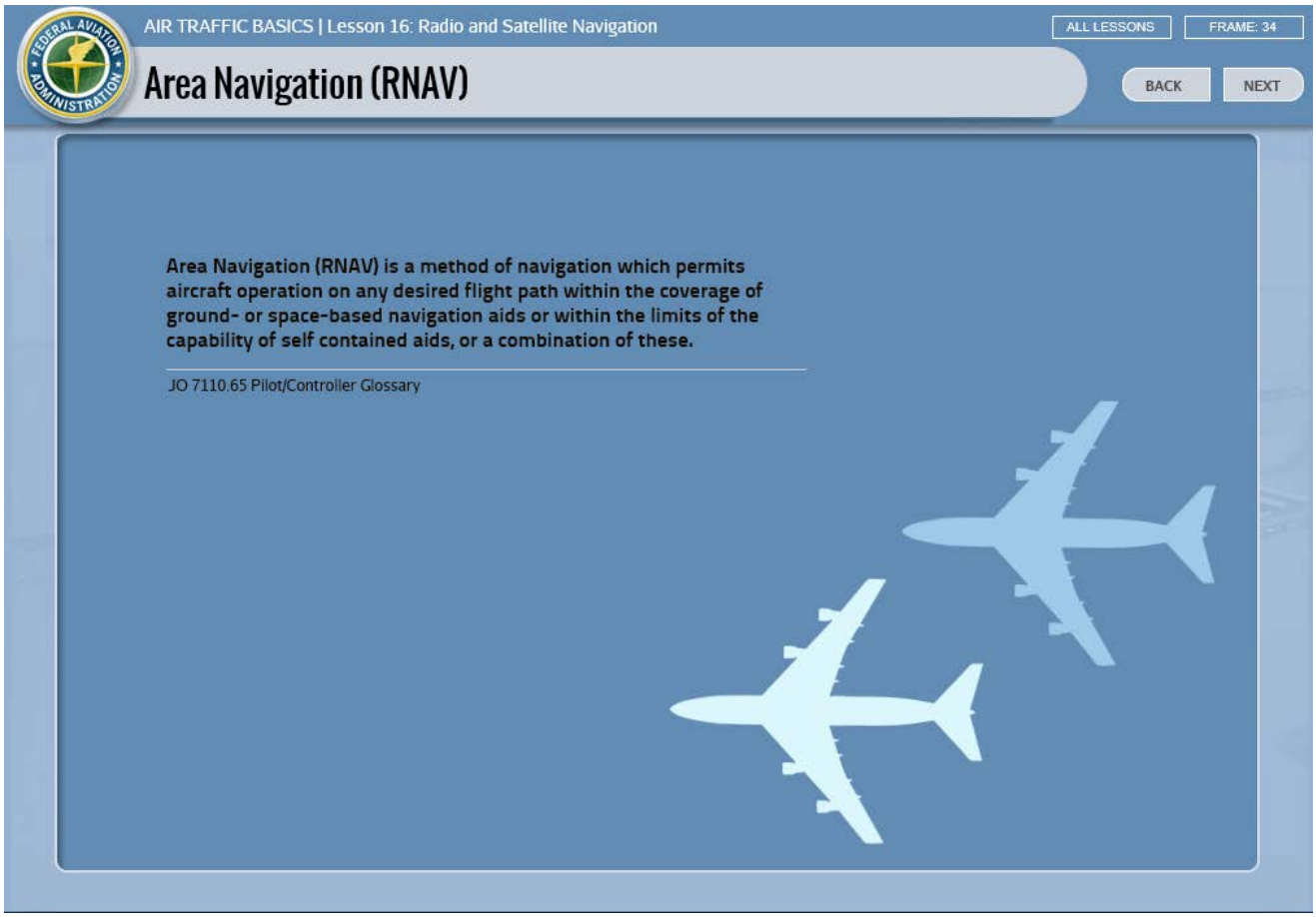
- **RAIM is an aircraft based, self-contained fault detection program, which can alert a user when questionable data is being received from a GPS satellite.**
- **WAAS is an FAA-developed, ground-based system to improve the accuracy, integrity, and availability of GPS signals.**
  - **It allows GPS to be used as an aviation navigation system from takeoff through landing.**

NOTE: The performance improvement is sufficient to enable GPS/WAAS approach procedures to provide vertical guidance, similar to a glide path.

- **LAAS is an FAA-developed satellite and ground-based system using GPS to develop an extremely accurate navigation signal.**
  - **Focused on the airport area (approximately a 20-30 mile radius) - it is not used in the En Route environment.**

NOTE: The performance improvement of LAAS is greater than for WAAS, enabling a more precise approach.

AIM, Chap. 1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Area Navigation (RNAV)
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Area Navigation (RNAV) is a method of navigation which permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self contained aids, or a combination of these.
JO 7110.65 Pilot/Controller Glossary

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Area Navigation (RNAV)

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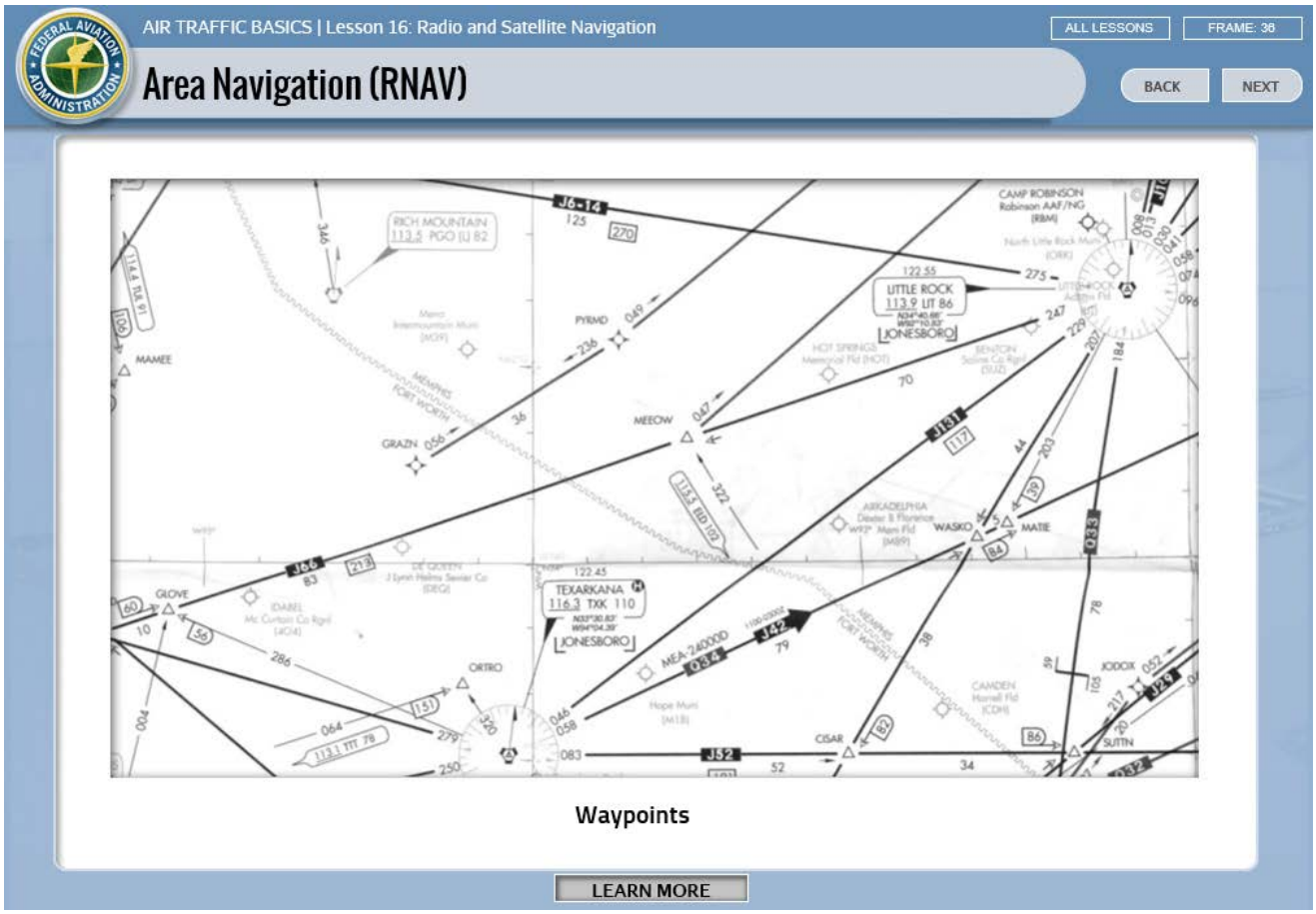
Characteristics

RNAV systems include VOR, DME, INS, GPS, WAAS.

- **Most RNAV systems include a Flight Management System (FMS) computer.**
- **The FMS uses a large database to allow routes to be pre-programmed and fed into the system by means of a data loader.**
- **The system is constantly updated by reference to navigation systems on the aircraft.**

JO 7110.65, Pilot/Controller Glossary



A **waypoint** is a predetermined geographical position used for route/instrument approach definition, progress reports, published VFR routes, or visual reporting points that are defined relative to a VORTAC station or in terms of latitude/longitude coordinates.

A series of waypoints make up an RNAV route.

References:

- FAA-H-8083-15, Chap. 7
- JO 7110.65, Pilot/Controller Glossary

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Area Navigation (RNAV)

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Area Navigation (RNAV) Routes

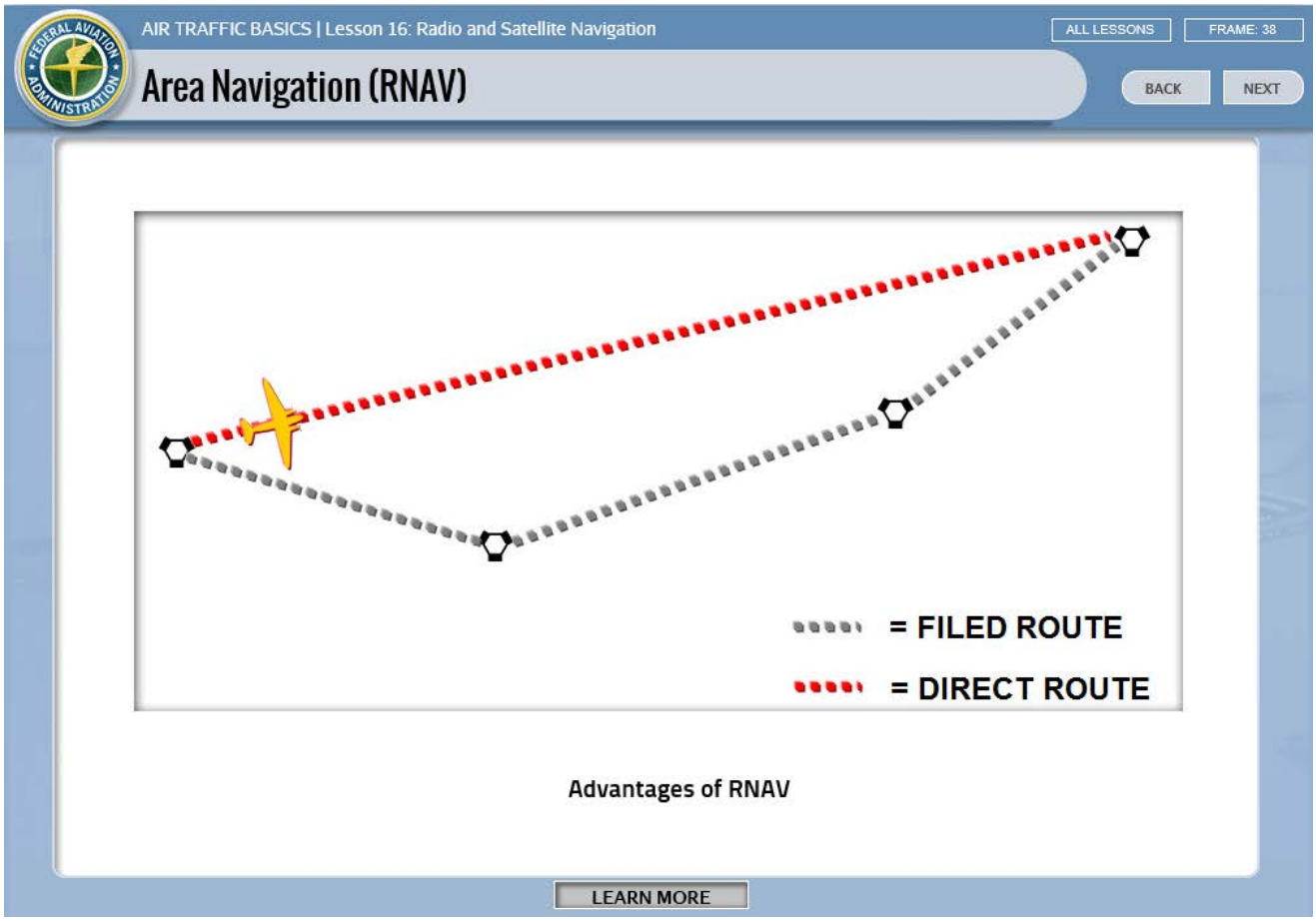
Published RNAV routes are permanent routes which can be flight planned for use by aircraft with RNAV capability.

Unpublished, or "random" RNAV routes are direct routes, based on RNAV capability, between waypoints defined in terms of any of the following:

- Published fixes
- Latitude/longitude coordinates
- Degree-distance fixes
- Offsets from established routes/airways at a specified distance and direction

Radar monitoring by ATC is required for all IFR aircraft on all random RNAV routes (except in Alaska).

AIM, Chap. 5 JO 7110.65, Chap. 4



The advantages of RNAV are:

- User-preferred routes
- Instrument Approach Procedures (IAP) where no ground-based navigational aids exist
- Accuracy
- Time and fuel savings
- Reduced dependence on radar vectoring, reducing required ATC radio transmissions
- More efficient use of airspace

Reference: FAA-H-8083-15, Chap. 7

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Airways and Routes

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Air Traffic Service (ATS) Routes

The term "ATS routes" is a generic term that includes VOR airways, colored federal airways, jet routes, RNAV routes, and other named routes.

- **The term "ATS routes" does not replace these more familiar names, but serves only as an overall title when listing the types of routes that comprise the United States route structure.**

JO 7110.65, Pilot/Controller Glossary

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Airways and Routes

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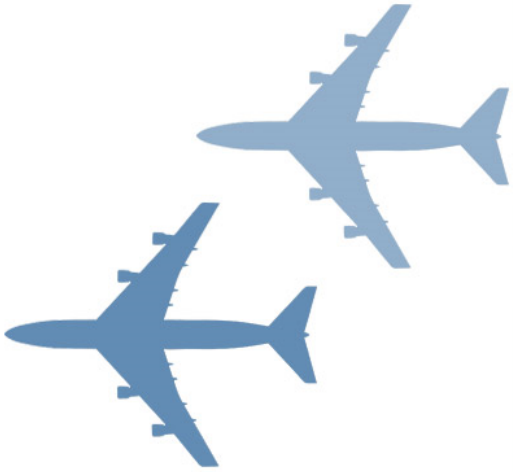
Three fixed route systems are established for air navigation purposes.

- **Airways (Class E airspace)**
- **Jet route system (Class A airspace)**
- **RNAV Routes (Class A and Class E airspace)**

AIM, Chap. 5



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Airways and Routes

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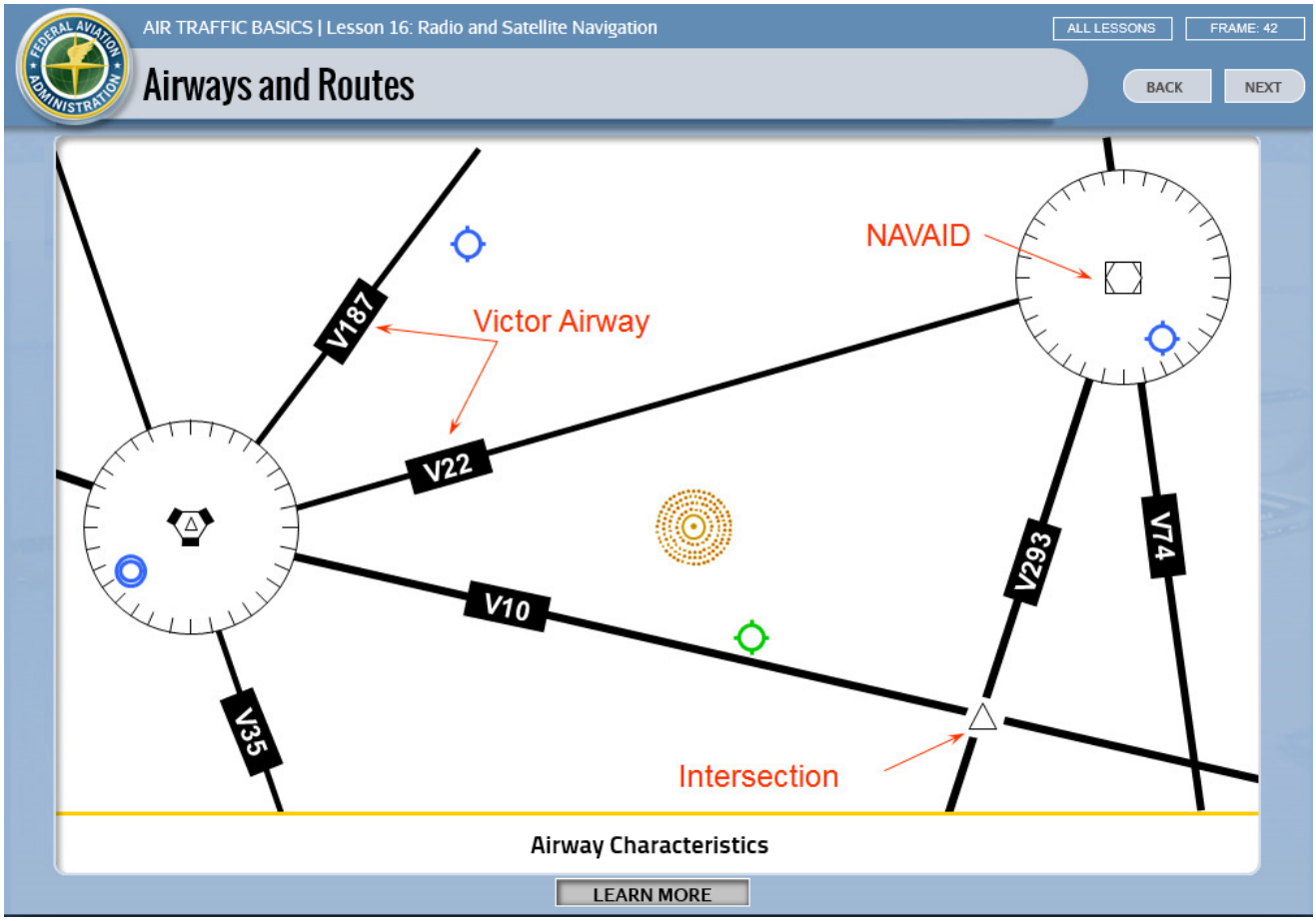
VOR to VOR Navigation

Many VORs are connected by specific radials forming routes called jet routes or victor airways.

- **Pilots navigate outbound from one VOR until reaching the changeover point, then navigate inbound to the second VOR.**
- **Unless otherwise charted, the changeover point is midway between NAVAIDS.**

AIM, Chap. 1



VOR airways are established in Class E airspace in the form of a corridor, the centerline of which is defined by radio navigational aids.

- VOR airways are defined by radials of VORs.

NOTE: *Navigational charts will be taught in a later lesson.*

The VOR airway system consists of airways designated generally from 1,200 feet AGL up to, but not including, 18,000 feet MSL.

- VOR airways and jet routes are generally aligned in an overlying manner to facilitate transition between Class A and Class E airspace.

VOR airways are identified on charts by the letter "V" followed by the route's identifying number.

- Odd-numbered airways are generally oriented north-south, while even-numbered airways are generally oriented east-west.
- The phraseology for VOR airways is to state the letter "V" phonetically (Victor) followed by the number in group form.

References:

- AIM, Chap. 5
- JO 7110.65, Chap. 6; Pilot/Controller Glossary

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Airways and Routes

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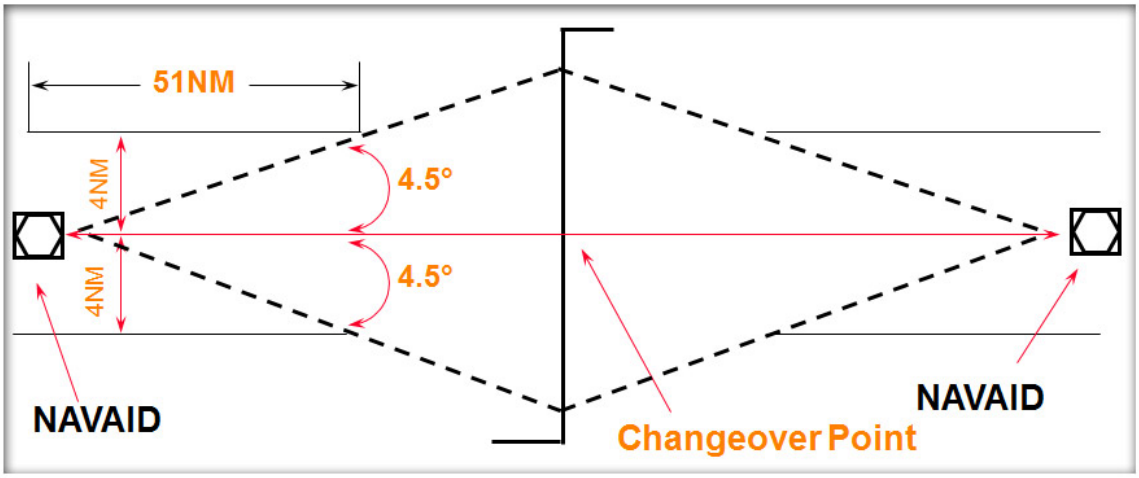
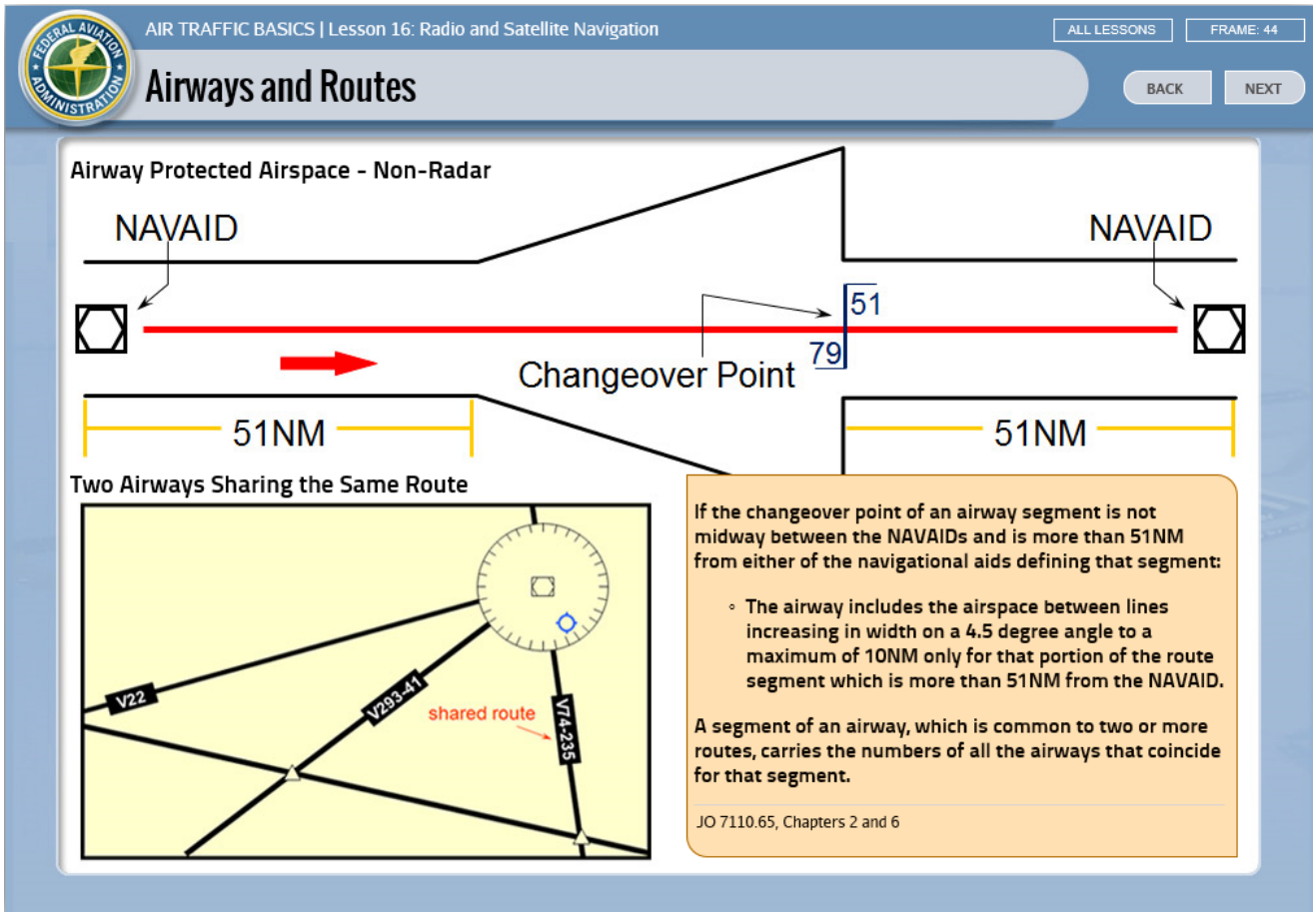
Protected Airspace - Non-Radar



The protected airspace for airways and jet routes extends 4NM either side of the centerline.

- At 51NM from the navigational aid, the protected airspace increases in width on a 4.5-degree angle to a maximum width of 10 miles either side of the airway centerline.

JO 7110.65, Chap. 4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Airways and Routes
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Airway Protected Airspace - Non-Radar
NAVAID
NAVAID
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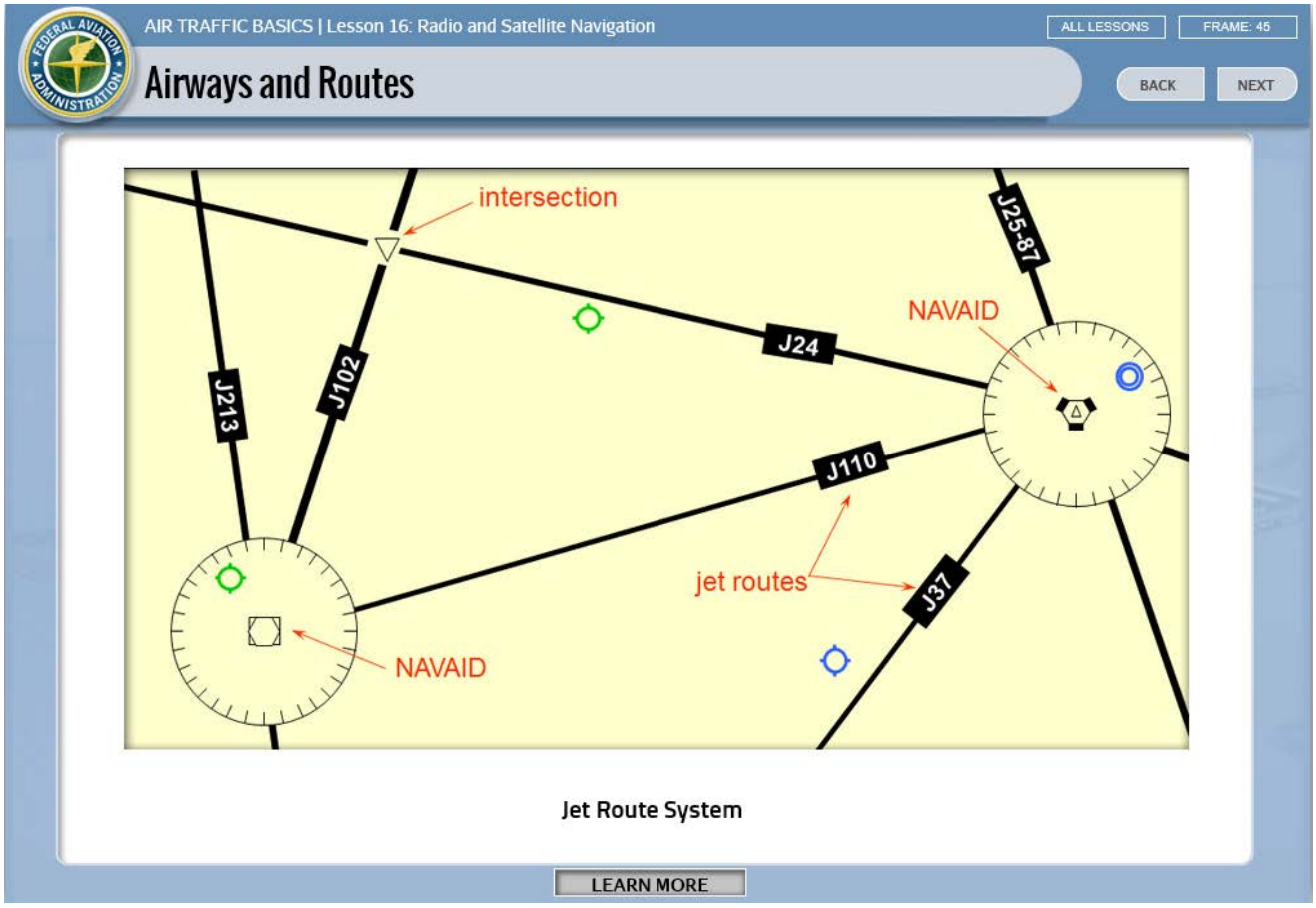
Changeover Point
51NM
51NM
Two Airways Sharing the Same Route
V22
V293-41
shared route
V74-235
If the changeover point of an airway segment is not midway between the NAVAIDs and is more than 51NM from either of the navigational aids defining that segment:
The airway includes the airspace between lines increasing in width on a 4.5 degree angle to a maximum of 10NM only for that portion of the route segment which is more than 51NM from the NAVAID.
A segment of an airway, which is common to two or more routes, carries the numbers of all the airways that coincide for that segment.
JO 7110.65, Chapters 2 and 6



The jet route system consists of routes established from 18,000 feet MSL to FL450, inclusive. These routes are depicted on En Route High Altitude Charts. In the conterminous United States, jet routes are defined in terms of radials of VORs.

Jet routes are identified on charts by the letter "J" followed by the route's identifying number.

- Odd-numbered routes generally go in a north-south direction, while even-numbered routes generally go east-west.
- The phraseology for jet routes is to state the letter "J" followed by the number in group form.

Example: J12 is spoken "J TWELVE."

Reference: JO 7110.65, Pilot/Controller Glossary

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Airways and Routes

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RNAV Route Characteristics

Published RNAV routes are routes which can be flight-planned for use by aircraft with area navigation capability.

There are two types of published RNAV routes:

- Q Routes
- T Routes

Q routes are for use by aircraft operating from 18,000 feet MSL up to and including FL450, and are depicted on En Route High Altitude Charts.

- The phraseology for Q routes is to state the letter "Q" followed by the number in group form.

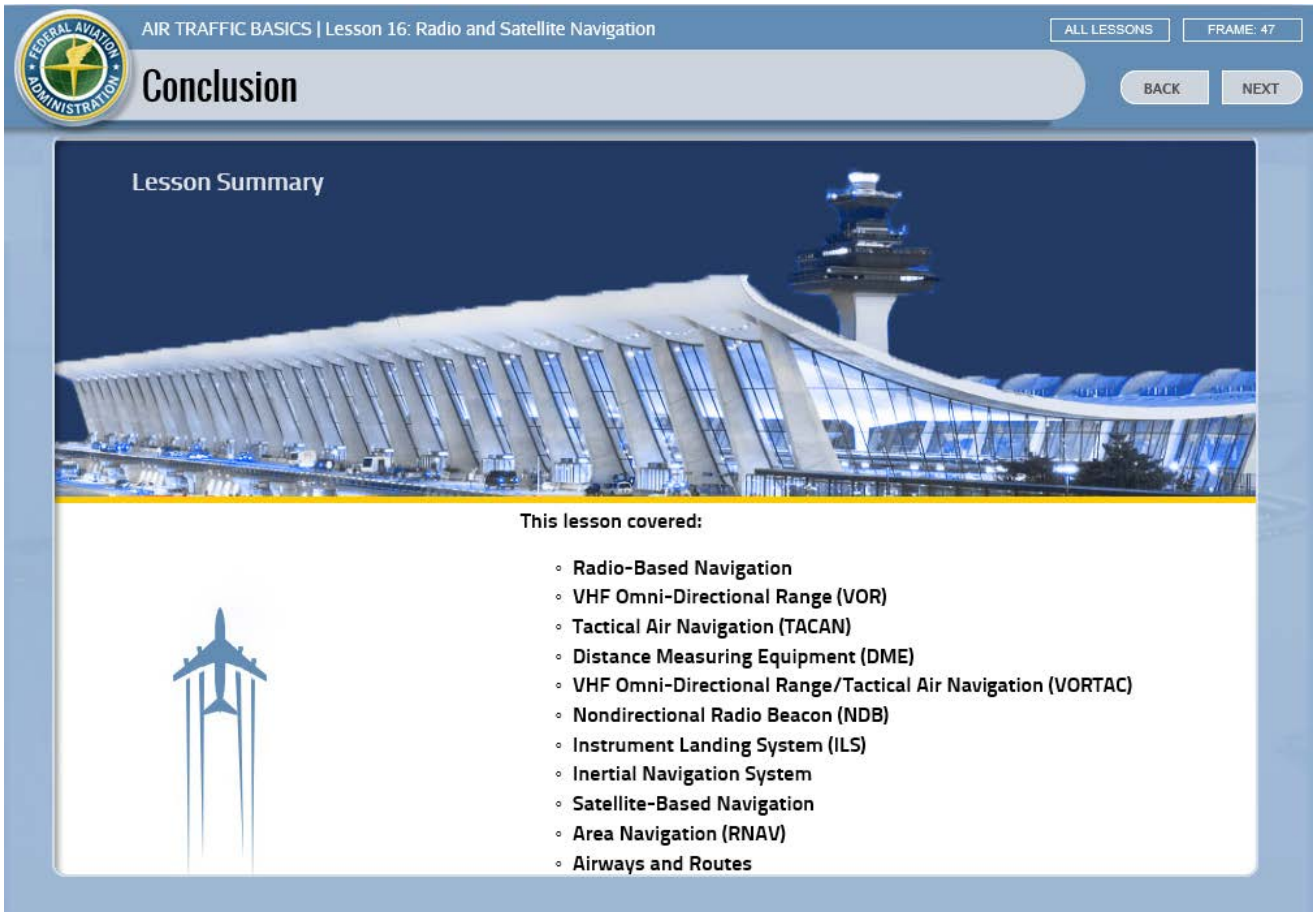
  Example: Q34 is spoken "Q THIRTY-FOUR."

T routes are for use by aircraft operating up to, but not including 18,000 feet MSL, and are depicted on En Route Low Altitude Charts.

- The phraseology for T routes is to state the letter "T" phonetically (Tango), followed by the number in group form.

  Example: T210 is spoken "TANGO TWO-TEN."

AIM, Chap. 5; JO 7110.65, Chap. 2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Lesson Summary
This lesson covered:
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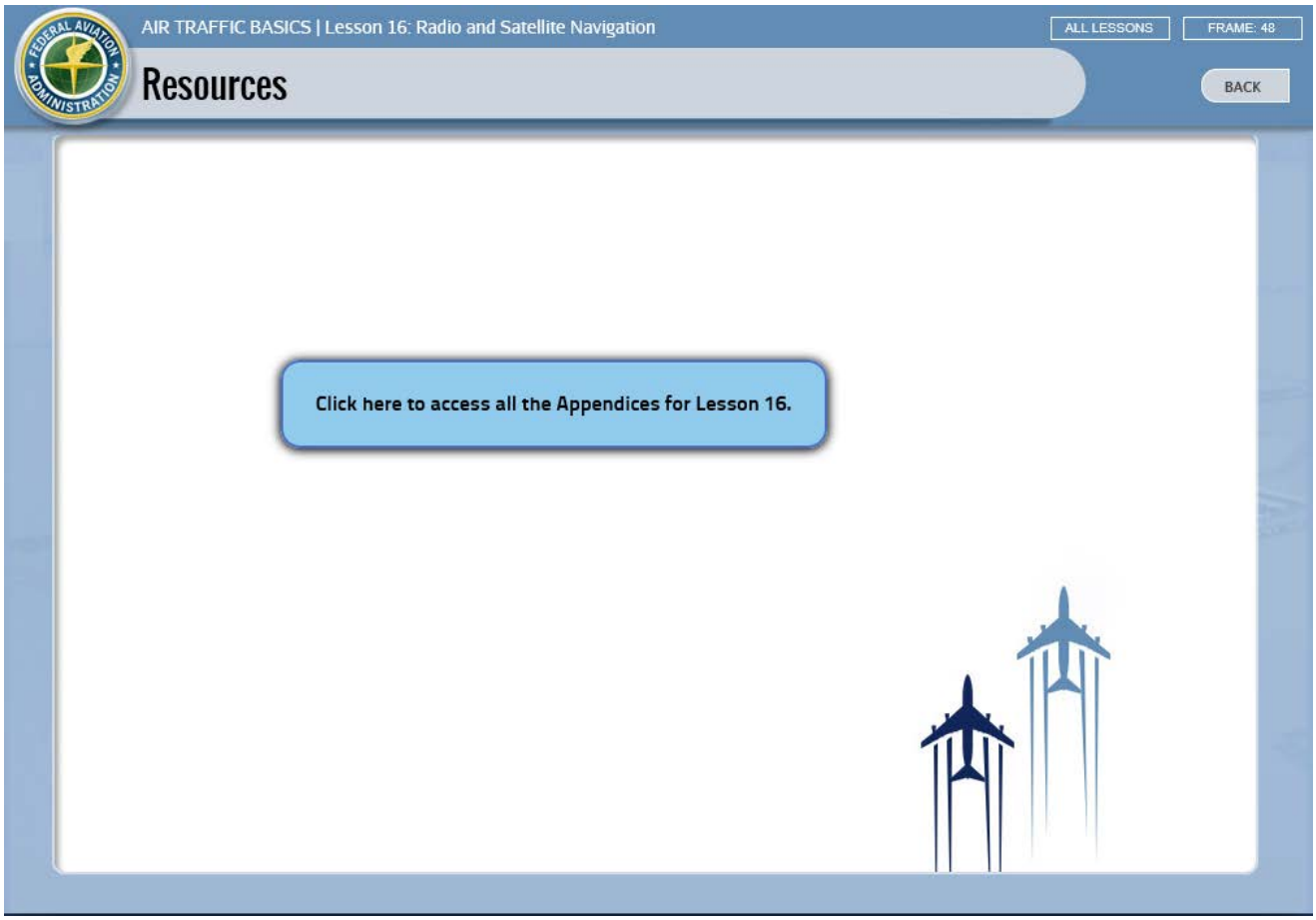
VHF Omni-Directional Range (VOR)
Tactical Air Navigation (TACAN)
Distance Measuring Equipment (DME)
VHF Omni-Directional Range/Tactical Air Navigation (VORTAC)
Nondirectional Radio Beacon (NDB)
Instrument Landing System (ILS)
Inertial Navigation System
Satellite-Based Navigation
Area Navigation (RNAV)
Airways and Routes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Click here to access all the Appendices for Lesson 16.