

Task II.L: Navigation Systems and Radar Services

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Lesson Overview

Objective

The student should develop knowledge of the elements related to the navigation systems and radar services provided by ATC as required in the necessary ACS.

Reference

FAA-H-8083-25B, Pilot’s Handbook of Aeronautical Knowledge (Chapter 16) FAA-H-8083-15, Instrument Flying Handbook (Chapter 9) AIM, Aeronautical Information Manual (Chapter 1)

Key Elements

- VOR
- GPS
- Radar services

Elements

- VOR/VORTAC
- Satellite based navigation
- Radar services and procedures

Equipment

- White board
- Markers
- References
- iPad

Schedule

1. Discuss objectives
2. Review material
3. Development
4. Conclusion

Instructor Actions

1. Discuss lesson objectives
2. Present lecture
3. Questions
4. Homework

Student Actions

- Participate in discussion Take notes

Completion Standards

The student understands the operation of different navigation systems, as well as their use in the airplane. The student also understands and uses the radar services provided by ATC

Instructor Notes

Attention

Understanding this will greatly decrease your chances of getting lost and provide more services for use.

Overview

Review Objectives and Elements/Key ideas

What

This lesson discusses the different navigation systems in use as well as radar services provided by ATC when in radar coverage and with established communication.

Why

It is important to understand how the navigation systems function in order to properly use them. It also is important to know the services provided by ATC to pilots.

Lesson Details

The general concepts of navigation were discussed in the Navigation and Flight Planning lesson plan. with radio navigation being one of the techniques included. This lesson goes into more detail about the available navigation systems and radar services. There are a small number of different navigation systems deployed in the United States. They include VOR/VORTAC, satellite based navigation (GPS), and radar services. Certain older systems have either been decommissioned, or are being reduced in their usage. The LORAN-C system was decommissioned in the US and Canada as of 2010. The system of Non-Directional Beacons (NDBs) is being slowly phased out, so they are no

longer considered a primary radio navigation system in the United States.

VOR

VORTAC — Very High Frequency Omnidirectional Range

VOR

The VOR by itself, providing magnetic bearing information to and from the station

VOR/DME

When Distance Measuring Equipment (DME) is also installed with the VOR.

VORTAC

When military tactical air navigation (TACAN) equipment is installed with the VOR. DME is always an integral part of a VORTAC.

Omnidirectional range—VHF-radio-transmitting ground station; projects straight line courses (radials) from the station in all directions. Radials projected with reference to the magnetic north. Radial—a line of magnetic bearing extending outward from the VOR station. Accuracy of course alignment with radials considered to be excellent (within $\pm 1^\circ$).

Projection distance depends on power output of the transmitter. VOR ground stations transmit within a VHF frequency band of 108.0-117.95 MHz. Signal transmitted is subject to line-of-sight restrictions. Range varies in direct proportion to altitude of receiving equipment.

VOR Classifications

Classified according to operational use—three classes with varying normal useful ranges.

- T — terminal
- L — low altitude
- H — high altitude

| Class | Altitudes | Radius (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' — FL 450 | 130 |
| H | FL 450 — 60,000' | 100 |

VOR checks

Periodic checks and calibrations—not required for VFR flight, but the best assurance of maintaining an accurate VOR receiver.

Verifies that the VOR radials the equipment receives are aligned with the radials the station transmits. Checkpoints are listed in the Chart Supplement.

- FAA VOR test facility (VOT)
- Certified airborne checkpoints
- Certified ground checkpoints located on airport surfaces
- Dual VOR check

IFR tolerances required are $\pm 4^\circ$ for ground checks and $\pm 6^\circ$ for airborne checks.

Using the VOR

The VOR is a radio receiver, and is tuned to the frequency of the VOR station to be used. The station can be identified by a Morse code identifier, or a voice telling the name of the station. If, however, the VOR is out of service the identifier is removed and the absence of an identifier means that the station should not be used for navigation. VOR receivers can also have an alarm flag to indicate when the signal strength is too weak (because the aircraft is too low, or too far away, or is out of the line-of-sight of the station) and should not be used for navigation. Finally, even if a Morse code is detected it should be confirmed that the VOR is not broadcasting the Morse for "test", as this is sometimes also done. If in testing a VOR should not, obviously, be used for navigation.

There are two components required for VOR radio navigation. These are the ground transmitter, and the airborne receiver. The ground station is at a specific known location on the surface, and it transmits on an assigned frequency. The receiver in the aircraft can tune that frequency and has a means to display information from that signal. This instrument is traditionally a "VOR head" (though these days electronic indicators are becoming more common) which has an omni bearing selector (OBS), referred to as a "course selector", a course deviation indicator (CDI) needle, and a To/From indicator. The source selector is an azimuth dial that is rotated to select a radial (and can be used to identify the magnetic course to/from the station if desired). When the OBS is rotated the CDI moves to show the position of the radial relative to the plane.

When the OBS is rotated such that the CDI is centered, this indicates the radial (magnetic course FROM the station) or its reciprocal (magnetic course TO the station). The CDI will also move right/left if the airplane is not on the selected radial

The To/From indicator indicates whether the selected radial denotes the course TO the station, or the bearing FROM the station. If To is shown and the indicated course is flown, the aircraft will travel to the station. If From is shown and the indicated course is flown, the aircraft will fly away from the station on that magnetic course.

Tracking

1. Tune the VOR frequency and check the identifiers to verify you are receiving the desired VOR.
2. Rotate OBS to center CDI to a "TO" indication. If centered with a "FROM" indication, rotate another 180° .
3. Turn to the heading indicated on the VOR azimuth dial or course selector, to track directly to the station in a no wind situation.

4. If there is a crosswind, and the heading is maintained, the aircraft will drift off course. Alter the heading to return to the desired radial, and once the CDI is centered and the aircraft is back on the radial, crab into the wind to establish wind correction. Trial and error will establish the necessary heading to maintain the desired track.
5. Upon arriving and passing the VOR station, the “TO” indication will change to a “FROM” indication.

Reverse sensing

If flying toward a VOR with a “FROM” indication, the CDI will indicate opposite the direction it should. If the plane drifts right of course, the needle will move right. The same applies when flying from a station with a “TO” indication.

VOR Tips

There are a number of things to remember, or actions to take, when navigating via VOR. One is to always positively identify the station by its code or voice ID. When tracking to a station determine the inbound course and use it. Don't succumb to the temptation to just twist the OBS to re-center the VOR. If done too much the aircraft will describe a spiral path to the station until the winds are directly in line with the course being flown, which is very sloppy flying. When flying TO a station always use a TO indication, and the reverse when flying away, thus avoiding the possible confusion of reverse sensing.

Satellite-based navigation

Satellite-based navigation systems include:

- GPS — global positioning system
- WAAS — wide area augmentation system
- LAAS — local area augmentation system

Global positioning system (GPS)

Over the last few decades GPS technology has started to pervade our lives, including our flying. Satellite based navigation have a number of components which include the GPS satellite system itself, the Wide Area Augmentation System (WAAS), and the Local Area Augmentation System (LAAS).

The broader GPS system is composed of three major elements. The Space Segment, the Control Segment, and the User Segment.

Space Segment

This segment is currently composed of 31 satellites each approximately 11,000 nm above the earth. The US is committed to maintain 24 operational satellites 95% of the time arranged so that at any time 5 are in view to any receiver (with 4 being the minimum necessary for operation). Each satellite orbits the earth in approximately 12 hours and are equipped with extremely stable atomic clocks each transmitting a unique code/nav message. These satellites broadcast in the

UHF frequency range which reduces the impact of weather on the signals. These signals are line-of-sight, so a satellite must be above the horizon to be "visible" to the GPS receiver.

Control Segment

This segment consists of a master control station, five monitoring stations, and three ground antennas. The monitoring stations and ground antennas are distributed around the globe to allow continual monitoring and communications with the satellites. Updates and corrections to the nav message broadcast are uplinked as the satellites pass over the ground antennas.

User Segment

This consists of all components associated with the GPS receiver. These can range from simple portable hand-held receivers to those permanently mounted in the aircraft. The receiver uses the signals from the satellites to calculate position, velocity, and precise timing to the user.

To solve for a location the GPS receiver uses the calculated distance and position information from the satellite from at least four satellites to yield a 3-D fix. This fix includes latitude, longitude, and altitude. VFR navigation with GPS can be as simple as selecting a destination and tracking the course (i.e. the Magenta Line). With GPS the course deviation is linear so that there is no increase in sensitivity when approaching a waypoint. It can be extremely tempting to rely exclusively on GPS, but never rely on one means of navigation.

WAAS

The Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) were deployed to achieve a higher degree of position precision for the GPS system. This improves the position calculation enough such that the GPS can be used for precision approaches. In the worst case WAAS precision is accurate to 25 feet 95% of the time. Like GPS the WAAS includes Space, Control, and User segments.

The LAAS is very similar to WAAS, but relies more on ground stations for signal correction and improvement. However, it is considered to be less cost effective than WAAS, but is also considered to be capable of handling Category III approaches.

□□ | WAAS accuracy is at a minimum of approximately 25 ft 95% of the time.

LAAS

Functions similarly to WAAS, but relies more on ground stations for signal correction/improvement. Less cost effective than WAAS; capable of handling Cat III instrument approaches.

Radar services and procedures

Finally, it is possible for ATC facilities to provide a variety of navigation services to participating VFR aircraft on a workload permitting basis. To use these facilities you must be able to establish two-way communications with ATC, be within radar coverage of the facility, and be radar identified. Services that can be provided include :

1. VFR radar traffic advisory service (flight following) and safety alerts
2. Vectoring (when requested)
3. Terminal radar programs (TRSA) to separate all participating VFR aircraft and IFR traffic
4. Radar assistance to lost aircraft
5. Class C services include separation between IFR/VFR traffic, and sequencing of VFR traffic to the airport.
6. Class B services include separation based on IFR/VFR and/or weight, and sequencing of VFR arrivals.

Conclusion

When navigating with a VOR and you wish to head toward the station ensure the flag indicates “TO” and follow the indicated heading. When it is necessary to track away from the station, ensure the flag indicates “FROM” and follow the heading indicated. Failing to do this could result in reverse sensing (not applicable to an HSI). GPS is a satellite based system that used for navigation. WAAS and LAAS are also satellite based navigation systems but they augment the GPS system with ground based stations allowing for more precise location information as well as vertical guidance. The radar services provided by ATC can be very helpful in almost any flight.

ACS Requirements

To determine that the applicant exhibits instructional knowledge of the elements related to navigation systems and radar service by describing:

1. One ground-based navigational aid (VOR/VORTAC, NDB, and DME).
2. Satellite-based navigation aids.
3. Radar service and procedures.
4. Global positioning system (GPS).