Objectives	▪ The Student Will Understand The Elements Related to The Navigation Systems and Radar Services Provided By ATC.
Elements	▪ VOR / VORTAC ▪ Satellite Based Navigation ▪ Radar Services & Procedures
Schedule	▪ Review lesson objectives ▪ Review lesson material ▪ Conclusion & Review
Equipment	▪ White Board / Markers ▪ References
CFI Actions	▪ Present lesson ▪ Use teaching aids ▪ Ask/ answer questions
Student Actions	▪ Participate in discussion ▪ Take notes ▪ Ask / answer questions
Completion Standards	▪ The Student Will Understand the Operation of Different Navigation Systems as Well As Their Use in The Airplane.

Additional Notes: ____

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Introduction

Overview

Review objectives / Elements

What

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

Why

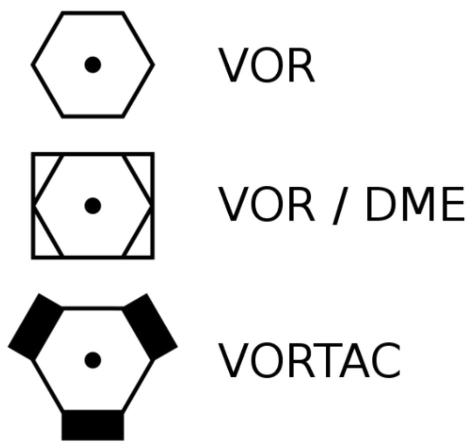
It is important to understand how the navigation systems function in order to properly use them.

How

VOR/VORTAC (Very High Frequency Omnidirectional Range)

Three types of VORS

- **VOR – The VOR by itself, provides magnetic bearing information to and from the station**
- **VOR / DME – When DME (Distance Measuring Equipment) is also installed with the VOR**
- **VORTAC – When military tactical air navigation (TACAN) equipment is installed with a VOR**
  - DME is always an integral part of a VORTAC

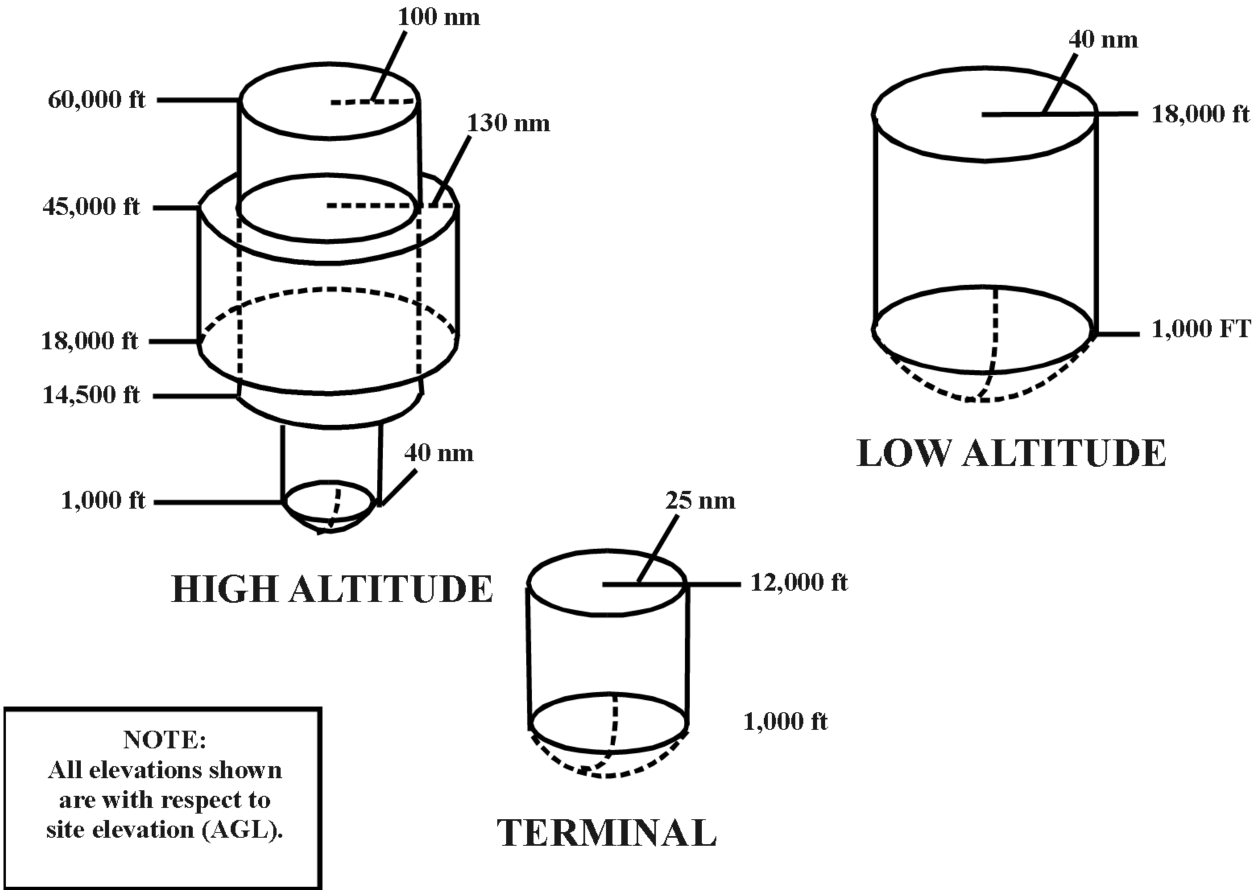


How it works

- **Omni means all**
  - An ***omni*directional range** is a VHF radio transmitting ground station that projects straight line courses (or radials) from the station in *all* directions
    - Think of it as being similar to the spokes from the hub of a wheel
- **The distance the radials are projected depends on the power output of the transmitter**
- **The radials projected are referenced to magnetic north**
  - A radial is defined as a line of magnetic bearing extending outward from the VOR station
  - The accuracy of course alignment with radials is considered to be excellent (within ± 1°)
- **VOR ground stations transmit within a VHF frequency band of 108.0 – 117.95 MHz**
  - Because the equipment is VHF, the signals transmitted are **subject to line-of-sight restrictions**
    - Range varies in direct proportion to the altitude of the receiving equipment

VOR classes

- **Classed according to operational use and are based on useful ranges:**
  - **T** (Terminal); **L** (Low Altitude); **H** (High Altitude)



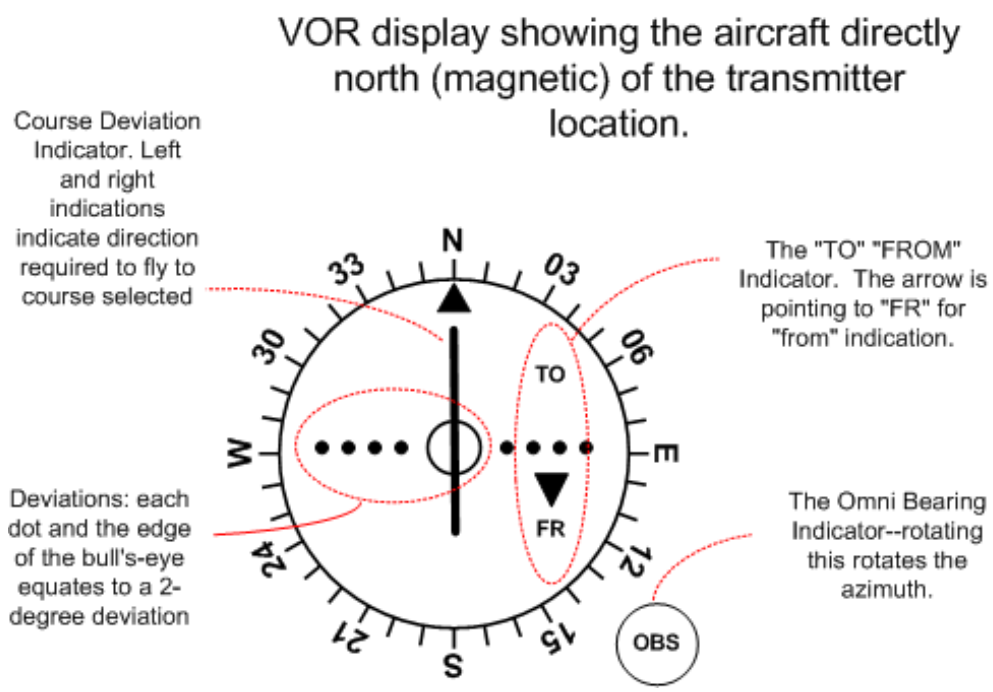
VOR Checks

- **The best assurance of maintaining an accurate VOR receiver is periodic checks and calibrations**
  - Not a regulation for VFR flight
- **Checks** (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**
- **Verifies the VOR radials the equipment receives are aligned with the radials the station transmits**
  - **IFR tolerances** required are **± 4° for ground checks** and **± 6° for airborne checks**

Using the VOR

- **Identifying It**
  - Station can be identified by its Morse code identification or a voice stating the name and VOR
  - If the VOR is out of service, the coded identification is removed and not transmitted
    - It should not be used for navigation

- VOR receivers have an alarm flag to indicate when signal strength is inadequate
  - The plane is either too far or too low and is out of the line-of-sight of the transmitting signal
- **There are 2 required components for VOR radio navigation**
  - **The ground transmitter and the receiver**
    - The ground transmitter is at a specific position on the ground and transmits on an assigned frequency
    - The airplane equipment includes the receiver with a tuning device and a VOR instrument
      - The navigation instrument consists of:
        - An **OBS** (Omni bearing Selector), referred to as the course selector
        - A **CDI** (Course Deviation Indicator) Needle
        - A **To/From Indicator**



  - The course selector is an azimuth dial that is rotated to select a radial
    - In addition, the magnetic course TO or FROM the station can be determined
  - When the OBS is rotated, the CDI moves to show the position of the radial relative to the plane
  - If OBS is rotated to center the CDI, the radial (magnetic course FROM the station) or its reciprocal (magnetic course TO the station) can be found
  - The CDI will also move to the right or left if the airplane is not on the selected radial

TO & FROM Indications

- **By centering the needle, either the course "FROM" or "TO" the station will be indicated**
  - If the flag displays "TO," and the course is flown, the airplane will fly **to** the station
    - The "TO" flag will be displayed ± 90° of the radial you are currently on
      - Examples: If you are on the 090° radial, the 360°-180° radials will indicate a TO flag, the other half of the circle will indicate From
  - If "FROM" is displayed and the course shown followed, the plane flies **away** from the station

Tracking with VOR

- **Tune the VOR frequency and check the identifiers (Morse Code) to verify the desired VOR is being received**
- **Rotate the OBS to center the CDI with a "TO" indication**
- **If centered with a "FROM" indication, rotate 180°**
  - From indicates the radial you are on, TO indicates to the station
- **Turn to the heading indicated on the VOR azimuth dial or course selector**
  - This will track directly to the station in a no wind situation
- **If there is a crosswind, and heading is maintained, you will drift off course**
  - If the crosswind is from the right, the airplane will drift to the left of course
    - The CDI will gradually move right
  - To return to the desired radial, the heading must be altered to the right
    - As the plane returns, the needle will move back to the center
  - When centered, the airplane is on the selected course, now it must be crabbed into the wind (right of course)
    - This will establish wind correction (the amount necessary will depend on the wind strength)
      - Trial and error will establish the necessary heading to maintain the desired track
      - If you have a GPS, use the aircraft track to determine when the aircraft is tracking the desired course (this eliminates the trial and error)
- **Upon arriving, and passing the VOR station, the "TO" indication will change to a "FROM" indication**
  - Generally, the same procedures apply for tracking outbound as inbound
    - If the intent is to continue on the same heading the course selector shouldn't be changed
    - If tracking outbound on a different course, the new course must be set into the selector
      - Turn to intercept this course and track the same as previously discussed

Reverse Sensing

- **If flying toward a VOR with a FROM indication, the CDI will indicate opposite the direction it should** (this does not apply to an HSI, it will not reverse sense)
  - If the plane drifts to the right of course, the needle will move right, or point away from the radial

Tips for using a VOR

- **Positively identify the station by its Morse Code or Voice ID**
- **Remember that VOR signals are line-of-sight**
- **When navigating TO, determine the inbound course and use it**
- **When flying TO a station always fly the selected course with a TO indication**
- **When flying FROM a station always fly the selected course with a FROM indication**

Satellite Based Navigation

- **Satellite based navigation systems include**
    - **GPS** (Global Positioning System), **WAAS** (Wide Area Augmentation System), **LASS** (Local Area Augmentation System aka. GBAS(ground based augmentation system)

GPS

- **The GPS system is composed of 3 major elements**

Space Segment

- **Composed of a constellation of 31 satellites** approximately 11,000 NM above the earth
    - The US is committed to maintain 24 operational satellites 95% of the time
    - **Arranged so at any time, 5 are in view to any receiver** (4 are necessary for operation)
        - Each satellite orbits the Earth in approximately 12 hrs.
- Equipped with highly stable atomic clocks and transmit a unique code/nav message
    - The satellites broadcast in the UHF range (they are basically unaffected by weather)
    - Subject to line-of-sight reference
        - Must be above the horizon (in view of the antenna) to be usable for navigation

Control Segment

- Consists of a **master control station**, **5 monitoring stations**, and **3 ground antennas**
    - The monitoring stations and ground antennas are distributed around the earth to allow continual monitoring and communications with satellites
        - Updates/corrections to the nav message broadcast are uplinked as the satellites pass over the ground antennas

User Segment

- Consists of all components associated with the **GPS receiver**
  - Range from portable, hand-held receivers to those permanently installed in the plane
  - The receiver utilizes the signals from the satellites to provide:
    - Positioning, velocity, and precise timing to the user

- Solving for Location
  - The receiver utilizes the signals of at least 4 of the best positioned satellites to yield a 3D fix
    - 3D - Latitude, longitude, and altitude
    - Using calculated distance/position info from the satellite, the receiver calculates its location

Navigating

- **VFR navigation with GPS can be as simple as selecting a destination and tracking the course**
- **GPS Tracking**
  - Course deviation is linear - there is no increase in sensitivity when approaching a waypoint
    - Although tempting, never rely only on one means of navigation!

WAAS

- **Satellite based augmentation system that improves GPS signals for use in precision approaches**
  - Augments the basic GPS satellite constellation with additional ground stations/enhanced info transmitted from geostationary satellites
- **Worst case, WAAS accuracy is approximately 25 feet - 95% of the time**
- **Like GPS, WAAS includes the Space, Control, and User Segments**

LAAS

- **Satellite based augmentation system that improves GPS signals for use in precision approaches**
  - Functions similar to WAAS but **relies more on ground stations for signal correction / improvement**
- **Considered to be less cost effective than WAAS**
- **Considered to be capable of handling Category III instrument approaches**

Radar Services & Procedures

- **ATC facilities provide a variety of services to participating VFR aircraft on a workload permitting basis**
  - You must be able to communicate with ATC, be within radar coverage and be radar identified

Services provided

- **VFR radar traffic advisory service** (Flight Following) **and safety alerts**
- **Vectoring** (when requested)
- **Terminal Radar Programs (TRSA) – To separate all participating VFR aircraft and IFR traffic**
- **Radar assistance to lost aircraft**
- **Class C services include separation between IFR/VFR and sequencing of VFR traffic to the airport**
- **Class B services include separation based on IFR, VFR and/or weight and sequencing VFR arrivals**

Conclusion & Review

Review the Main Lesson Points

When navigating by VOR and you wish to head toward the station, ensure the flag indicates "TO" and follow the indicated heading. When tracking 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 is used for navigation. WAAS and LAAS are also satellite based navigation systems but they augment the GPS system with ground-based stations. Radar services provided by ATC are very useful and can be very helpful on any flight.

review

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