Navigation Systems

3.1 DISTANCE MEASURING EQUIPMENT (DME)

1. DME displays slant range distance in nautical miles.

2. Ignore slant range error if the airplane is 1 NM or more from the ground facility for each 1,000 ft. AGL.
   a. The greatest slant range error comes at high altitudes very close to the VORTAC.
   b. EXAMPLE: If you are 6,000 ft. AGL directly above a VORTAC, your DME will read 1.0 NM.

3.2 VOR RECEIVER CHECK

1. The Chart Supplement provides a listing of available VOR receiver ground checkpoints and VOTs (VOR receiver test facilities).

2. Over airborne checkpoints designated by the FAA, the maximum permissible bearing error for the VOR receiver is plus or minus 6° of the designated radial.

   a. An alternative to a certified airborne checkpoint is a prominent ground reference point that is more than 20 NM from a VOR station that is along an established VOR airway.

      1) Once over this point with the Col needle centered, the OBS should indicate plus or minus 6° of the published radial.

3. The maximum difference between two indicators of a dual VOR system is 4° between the two indicated bearings to the VOR.

   a. The Col needles should be centered and the indicated bearings checked rather than setting to identical radials and looking at the Col needles.

4. VOTs are available at a specified frequency at certain airports. The facility permits you to check the accuracy of your VOR receiver while you are on the ground.

   a. The VOT transmits only the 360° radial in all directions.

   b. Tune the VOR receiver to the specified frequency, and turn the OBS (omnibearing /selector) to select an omnibearing course of either 0° or 180°.

      1) The COI needle should be centered; if not, then center the needle.
      2) If 0°, the TO/FROM indicator should indicate FROM.
      3) If 180°, the TO/FROM indicator should indicate TO.
      4) The maximum error is plus or minus 4°.

5. When making a VOR receiver check with your airplane located on the designated ground checkpoint, the designated radial should be set on the OBS.

   a. The CDI must center within plus or minus 4° of that radial with a FROM indication.

3.3 VERY HIGH FREQUENCY OMNIDIRECTIONAL RANGE (VOR) STATION

1. When VORs are undergoing maintenance, the coded and/or voice identification is not broadcast from the VOR.

2. OMEITACAN coded identification is transmitted one time for each three or four times the VOR identification is transmitted.

    a. If the VOR is out of service, the OME identification will be transmitted about once every 30 seconds at 1350 Hz.

3. A full-scale (from the center position to either side of the dial) deflection of a VOR CDI indicates a 10° deviation from the course centerline.

    a. About 10° to 12° of change of the OBS setting should deflect the COI from the center to the last dot.

4. An (H) Class VORTAC facility has a range of 40 NM from 1,000 ft. AGL to 14,500 ft. AGL, and a range of 100 NM from 14,500 ft. AGL to 18,000 ft.

    a. To use (H) Class VORTAC facilities to define a direct route of flight at 17,000 ft. MSL, the facilities should be no farther apart than 200 NM.

    b. Generally, for IFR operation off of established airways below 18,000 ft., VOR navigational aids should be no more than 80 NM apart.

5. VOR station passage is indicated by a complete reversal of the TO/FROM indicator.

    a. If after station passage the CDI shows a 1/2-scale deflection and remains constant for a period of time, you are flying away from the selected radial.

6. Airplane displacement from a course is approximately 200 ft. per dot per NM on VORs.

    a. At 30 NM out, one dot is 1 NM displacement; two dots, 2 NM.
    b. At 60 NM out, one dot is 2 NM displacement; two dots, 4 NM.

7. Time/distance to station formula. When tracking inbound, make a 90° turn and measure time and degrees of bearing change.

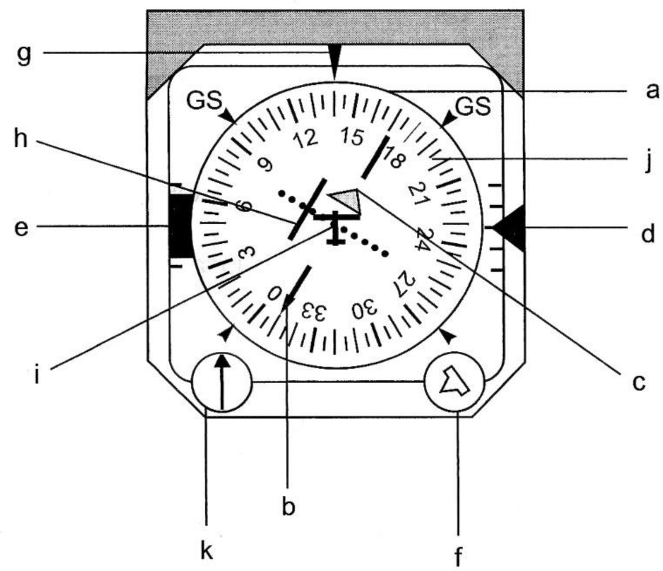
. . 60 x *Min. between bearings*
    a. *Min.* to *station = Degrees of bearing change*

. . TAS x *Min. between bearings*
    b. *Distance* to *station = Degrees of bearing change*

        1) You may also use your flight computer to calculate the distance.

3.4 HORIZONTAL SITUATION INDICATOR (HSI)

1. The horizontal situation indicator (HSI) is a combination of the heading indicator and the VOR/ILS indicator, as illustrated and explained below.



a. The azimuth card -- rotates so that the heading is shown under the index at the top of the instrument

1) The azimuth card may be part of a remote indicating compass (RIC), or

2) The azimuth card must be checked against the magnetic compass and reset with a heading set knob.

b. The course indicating arrow -- the VOR (OBS) indicator

c. The TO/FROM indicator for the VOR

d. Glide slope deviation pointer -- indicates above or below the glide slope, which is the longer center line

e. Glide slope warning flag -- comes out when reliable signals are not received by the glide slope receiver

f. Heading set knob -- used to coordinate the heading indicator (directional gyro, etc.) with the actual compass

1) If the azimuth card is part of an RIC, this knob is normally a heading bug (pointer) set knob that moves a bug around the periphery of the azimuth card.

g. Lubber line -- shows the current heading

h. Course deviation bar -- indicates the direction you would have to turn to intercept the desired radial if you were on the approximate heading of the OBS selection

i The airplane symbol -- a fixed symbol that shows the airplane relative to the selected course as though you were above the airplane looking down

j. The tail of the course indicating arrow -- shows the reciprocal of the OBS heading

k. The course setting knob -- used to adjust the OBS

2. Airplane displacement from a course is approximately 200 ft. per dot per NM on VORs.

    a. At 30 NM out, one dot is 1 NM displacement; two dots, 2 NM.

    b. At 60 NM out, one dot is 2 NM displacement; two dots, 4 NM.

3. A full-scale deflection of a VOR COI indicates a 10° deviation from the course centerline.

    a. About 10° to 12° of change of the OBS setting should defied the CDI from the center to the last dot.

    b. With the COI centered, rotate the OBS 180° to change the ambiguity (TO/FROM) indication.

4. Solve all VOR problems by imagining yourself in an airplane heading in the general direction of the omnibearing setting.

    a. If you are heading opposite your omnibearing course, the COI needle will point away from the imaginary course line through the VOR determined by your omnibearing selector.

    b. Remember that the VOR shows only your location (not your heading) with respect to the VOR.

5. A few of the questions on the FAA instrument rating knowledge test require you to identify the position of your airplane relative to a VOR given an HSI presentation.

    a. First, remember that the COI needle does not point to the VOR. It indicates the position of the airplane relative to VOR radials.

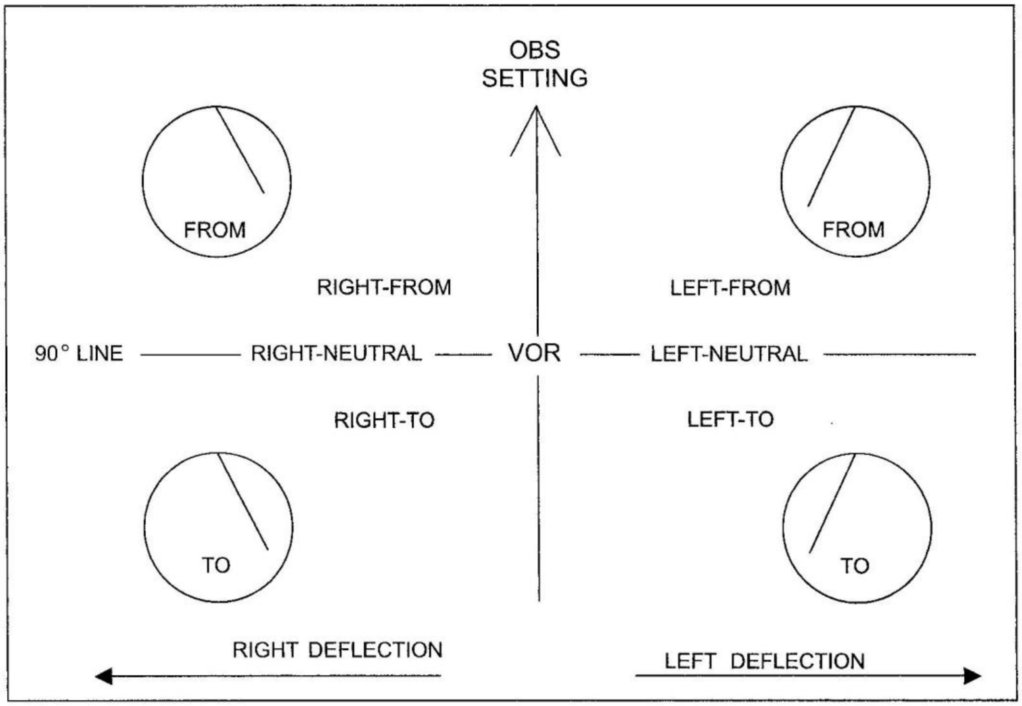
        1) Irrespective of your direction of flight, the COI needle always points toward the imaginary course line through the VOR determined by your omnibearing selector.

    b. The TO/FROM indicator operates independently of the direction (heading) of your airplane. It indicates which side of the VOR your airplane is on, based on the radial set on your omnibearing selector.

        1) Irrespective of your direction of flight, the TO/FROM indicator shows you whether you are before, on, or past a line 90° (perpendicular) to the course line determined by your omnibearing setting.

6. The following diagram explains the TO/FROM indicator and the COI needle.

    a. Remember that you must rotate the diagram so the omnibearing direction is pointed in the general direction in which your omnibearing selector is set.



3.5 HSI/LOCALIZER

1. When a VOR is tuned to a localizer frequency (108.10 to 111.95), the OBS (course selection) setting has no impact on the indications of the VOR.

2. When an HSI is tuned to a localizer frequency (108.10 to 111.95), the setting of the front course heading with the head of the needle will eliminate reverse sensing on back courses.

    a. Inbound on a back course, the tail of the needle will be at the top of the instrument, and you will have positive sensing.

    b. If the HSI needle is set to the front course heading, you will have normal sensing on the HSI whether you are flying a front course or a back course approach.

    c. If the HSI needle is set to the back course heading, you will have reverse sensing on the HSI whether you are flying a front course or a back course approach.

3. The localizer information is reported on the face of the HSI instrument just as VOR signals are.

    a. That is, it is based upon position rather than heading.

4. Similar to VORs, if you are going in the direction specified for an approach to a runway, a left deflection means you are to the right of course if you are facing in the approximate direction of the localizer.

NOTE: Be aware that presentations B, C, D, E, and I have backcourse settings of 90°, which means there is reverse sensing irrespective of the airplane's heading.

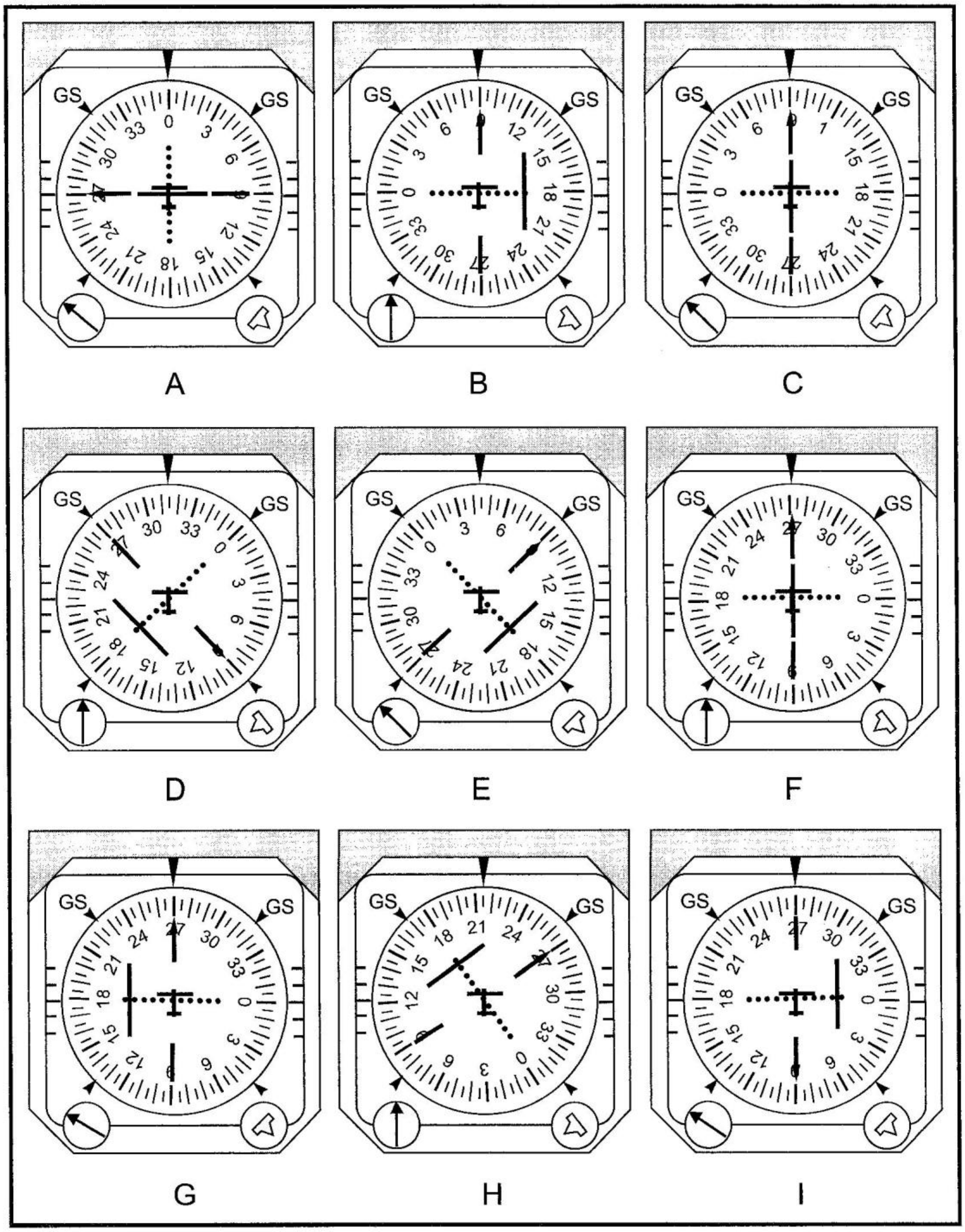


Figure 97. – HSI Presentation.

3.6 GLOBAL POSITIONING SYSTEM (GPS)

1. You should refer to the flight manual supplement to determine if an installed GPS is Technical Standard Order (TSO) TSO-C129 or TSO-C196 approved for IFR en route and IFR approaches.

    a. Handheld GPS systems and GPS systems certified for VFR operation may be used during IFR operations only as an aid to situational awareness.

    b. VFR waypoints are not recognized by the IFR systems and will be rejected for IFR routing.

2. During IFR en route and terminal operations using an approved TSO-C129 or TSO-C196 GPS system for navigation, the aircraft must be equipped with an approved and operational alternate navigation system that is appropriate to the route.

    a. Any ground-based navigational facilities required for use with the alternate navigation system (e.g., VORs, etc.) must be available and operational along the entire route of flight.

    b. It is not necessary to actively monitor an alternate means of navigation unless the GPS is not equipped with Receiver Autonomous Integrity Monitoring (RAIM), or RAIM becomes unavailable or predicts an outage.

3. To effectively navigate by means of GPS, pilots should

    a. Determine the GPS unit is approved for their planned flight

    b. Determine the status of the databases

        1) The current status of navigational databases, weather databases, NOTAMs, and signal availability should be ensured prior to takeoff.

        2) When in flight, compare the GPS database to the En Route Low Altitude chart. If they are the same, the GPS database is current. Comparing the two can verify the current status of the GPS database.

    c. Understand how to make and cancel all appropriate entries

        1) Stressful situations, heavy workloads, and turbulence make data entry errors real problems, and pilots should know how to recover basic aircraft controls quickly.

    d. Program and review the planned route

        1) Because each GPS layout can vary widely in type and function (knobs, switches, etc.), programming the units should be verified for accuracy.

        2) Name changes or spelling mistakes contribute to errors in flying appropriate routes.

    e. Ensure the track flown is approved by ATC

    f. Overriding an automatically selected sensitivity during an approach will cancel the approach mode annunciation.

4. One of the primary benefits of satellite-based area navigation (e.g., GPS or RNAV) is that it permits aircraft to fly optimum routes and altitudes.

5. Due to the use of, and reliance on, GPS systems for navigation, it is easy for pilots to lose proficiency in performing manual calculations on courses, times, distances, headings, etc. a. Emergency situations (i.e., electrical failures) make it important to maintain proficiency in these calculations.

6. Bear in mind that although handheld GPS units are an excellent aid to situational awareness, they are not an approved navigation source for any IFR operation, regardless of whether you are in visual or instrument meteorological conditions.

7. VFR waypoints have been created for VFR traffic only. These waypoints, identified with five letters and beginning with "VP," are for VFR pilots only. While VFR waypoints are specific to GPS users, they cannot be used in IFR flight plans.
    a. VFR waypoints are not recognized by the IFR systems and will be rejected for IFR routing.

8. There are limitations on and benefits to the operation of GPS units. These must be considered prior to flight.

    a. Aircraft using GPS TSO-C129 or TSO-C196 navigation equipment under IFR must be equipped with an approved and operational alternate means of navigation appropriate to the flight.

    b. GPS is not authorized as a substitute means of navigation guidance when conducting a conventional approach at an alternate airport.
        1) If the approach procedure requires distance measuring equipment (DME), the aircraft must be equipped with the appropriate DME avionics in order to use the approach as an alternate.

    c. GPS database updates are done on a 28-day cycle, which is the same schedule for updating the En Route Low Altitude charts. Compare the two to verify currency.

    d. WAAS improves the accuracy of GPS. If WAAS becomes unavailable, you can safely follow the lateral and vertical (LNAVNNAV) guidance information displayed on your GPS unit to fly to the LNAV MDA.

    e. Baro-VNAV is an RNAV system function that uses barometric altitude information from the aircraft's altimeter to compute and present a vertical guidance path to the pilot.

3.7 AUTOPILOTS

1. Autopilot systems are automatic flight control systems that keep an aircraft on a set course or in level flight during the en route or approach phase of flight.

    a. Autopilots contain servos, electromechanical devices that translate electrical commands into motion, moving the control surfaces.

2. Autopilot systems can be engaged so that an aircraft will fly a given

    a. Heading (set by turning the heading selection knob, tracking a VOR radial, or following the GPS track),

    b. Altitude (using the altitude hold function),

    c. Climb or descent (at a vertical speed chosen by the pilot), or

    d. Approach.

1) The approach mode can be used to execute both precision or nonprecision approaches that rely on ground-based navigation facilities or GPS steering.

3. Benefits of using an autopilot system in flight include

    a. A reduction of the physical and mental demands of the pilot

        1) EXAMPLE: During stressful situations, such as flying in a busy terminal area or executing a missed approach in adverse weather conditions, the autopilot puts the pilot in a managerial role of monitoring an aircraft, thus reducing workload.

    b. Improved situational awareness

        1) After engaging the autopilot, it is important to verify that the aircraft is tracking the intended flight profile.

4. Because most autopilots are not capable of changing power settings, pilots must manage the throttle to control all airspeed when the autopilot is engaged.

    a. Care should be taken so aircraft speed limitations are not exceeded in a descent.

    b. Pitch attitude and throttle settings should be monitored in climbs so that the aircraft does not enter a stall.

5. Disadvantages of using an autopilot include

    a. Forgetting to maintain manual flying skills. Because all equipment will fail at some time, a pilot needs to remain proficient in the skills required for manual flying.

    b. Turbulence. Some autopilot systems will disengage or default to certain settings during moderate or severe turbulence.

    c. Malfunction. A pilot should immediately disengage an autopilot system if an unexpected or uncommanded behavior presents itself.

6. A good practice to clarify whether the autopilot is controlling the aircraft is to audibly announce that the autopilot is engaged, similar to the positive exchange of flight controls when flying with two pilots.