PRIVATE PILOT

VII. AREA OF OPERATION: NAVIGATION

B. TASK: NAVIGATION SYSTEMS AND RADAR SERVICES

OBJECTIVE

To determine that the applicant:

1. Exhibits knowledge of the elements related to navigation systems and radar services.
2. Demonstrates the ability to use an airborne electronic navigation system.
3. Locates the airplane's position using the navigation system.
4. Intercepts and tracks a given course, radial or bearing, as appropriate.
5. Recognizes and describes the indication of station passage, if appropriate.
6. Recognizes signal loss and takes appropriate action.
7. Uses proper communication procedures when utilizing radar services.
8. Maintains the appropriate altitude, +/-200 feet (60 meters), and headings, +/-15°.

ELEMENTS

1. Advances in radio navigation allow pilots to determine their exact position and to navigate almost anywhere with precision.
2. Beginning pilots should use this equipment to supplement navigation by visual reference to the ground – the use of pilotage will safeguard against disorientation in the event of a navigation radio malfunction.
3. There are four radio navigation systems available for VFR navigation:
    a. VHF Omnidirectional Range (VOR).
    b. Nondirectional Radiobeacon (NDB).
    c. Long Range Navigation (LORAN-C).
    d. Global Positioning System (GPS).
4. Very High Frequency (VHF) Omnidirectional Range (VOR) Station and VOR Receiver:
    a. Three types:
        i. VOR.
        ii. VOR/DME (VOR with distance measuring equipment, or DME)
        iii. VORTAC (VOR with military tactical air navigation, or TACAN).
    b. Provides magnetic bearing (in degrees) to and from the VOR station.
    c. VOR/DME and VORTAC stations provide distance from the station.
    d. Line courses based on magnetic north, or radials, are projected from the station.
    e. A compass rose is superimposed on aeronautical charts at the station location.
    f. VOR stations use the very high frequency (VHF) band of 108.0 - 117.95 MHz.
    g. Reception of signal is subject to line-of-sight restrictions.
    h. Three classes based on power: T (terminal), L (low altitude), and H (high altitude).
    i. Normal usable altitudes and radius distances:
        i. T: (12,000' and below) 25 nm.
        ii. L: (below 18,000') 40 nm
        iii. H: (below 14,500') 40nm, (14,500–17,999) 100nm, (18,000-FL450) 130, (FL450-FL600) 100.
    j. The accuracy is generally +/- 1°.
    k. The station is identified via transmitted Morse code or recorded voice identification.
    l. If the station is out of service for maintenance, the coded identifier is removed.
    m. The VOR receiver includes an alarm flag to indicate weak or no signal reception.
    n. The VOR receiver also includes:
        i. A rotating omnibearing selector (OBS) knob.
        ii. A course deviation indicator (CDI) needle (left-right needle).
        iii. TO - FROM indicator flags.
    o. The OBS is rotated to select a radial ("FROM" the station) or course ("TO" the station).
    p. Moving the OBS rotates the face of the instrument and moves the CDI needle to indicate the position of the course or radial relative to the airplane.
    q. If centered, the CDI will move off-center if the airplane drifts off the course or radial.
    r. If flying to the station with a "TO" indication or from the station with a "FROM" indication, a corrective turn toward the CDI will get back on the course or radial.

s. Station passage is indicated by the "TO" flag changing to a "FROM" flag.
t. If flying to the station with a "FROM" indication or from the station with a "TO" indication, the instrument will exhibit reverse-sensing:
    i. Flying away from the deflected needle will turn toward the course or radial.
    ii. Flying toward the deflected needle will turn away from the course or radial.
    iii. To remedy reverse-sensing, turn the OBS 180°.
u. Distance measuring equipment (DME) uses the ultra high frequency (UHF) band.
v. DME measures the nautical mile slant range distance from the station to the airplane.
w. The DME signal is also identified via transmitted Morse code identification.
x. Most DME receivers also provide groundspeed and time-to-station features.

5. Nondirectional Radiobeacon (NDB) Station and Automatic Direction Finder (ADF) Receiver:
    a. The pilot can tune an ADF receiver to an NDB frequency.
    b. An NDB marker is superimposed on aeronautical charts at the station location.
    c. NDB stations use the low to medium frequency band of 200 - 415 kHz.
    d. The lower frequency band is not limited by line-of-sight - signals follow the curvature of the Earth, but are susceptible to atmospheric disturbances. Reception distances:
        i. "Compass Locator" NDB's (under 25 watts) reception is about 15nm.
        ii. "MH" NDB's (under 50 watts) reception is about 25 nm.
        iii. "H" NDB's (50-1999 watts) reception is about 50 nm.
        iv. "HH" NDB's (2000 watts or more) reception is about 50 nm.
    e. The NDB station is identified via transmitted Morse code identification.
    f. Standard broadcast AM radio stations (KOMO, KVI, etc.) can also be received.
    g. Relative bearing (RB) to the station = value indicated by the needle (relative to airplane).
    h. Magnetic bearing (MB) to the station = magnetic heading (MH) + relative bearing (RB).
    i. Magnetic bearing (MB) from the station = magnetic bearing (MB) to the station +/- 180°.
6. Long Range Navigation (LORAN-C):
    a. LORAN-C operates from chains of LF transmitters maintained by the U.S. Coast Guard.
    b. Aeronautical charts do not show the location of LORAN stations.
    c. LORAN transmitters are scheduled to be decommissioned.
7. Global Position System (GPS):
    a. GPS is a satellite-based radio navigation system with global coverage.
    b. Composed of three major elements:
        i. Space segment: 26 satellites orbiting 10,900 nm above the Earth.
            1. Each GPS constellation satellite orbits once every 12 hours.
            2. Satellites contain highly stable atomic clocks.
            3. Each satellite transmits a unique code and navigation message.
            4. To be usable for navigation, satellites must be above the horizon.
        ii. Control segment: Master control station at Falcon AFB, Colorado.
            1. Augmented with five monitor stations and three ground antennas distributed around the Earth.
            2. Updates and corrections are uplinked to satellites via ground stations.
        iii. User segment: The GPS receiver
            1. Can be panel-mounted or hand-held.
            2. Receiver matches the satellite signal by shifting its own identical signal in a matching process, precisely measuring the time and thus distance.
    c. Receivers use at least four of the best-positioned satellites to yield a 3-dimensional fix.
    d. After selecting a destination, a GPS unit can provide a direct route and track progress.
    e. Not all GPS receivers are suitable for use in aviation.

REFERENCES

1. AC 61-23 / FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge, Chapter 14.
2. Navigation Equipment Operations Manuals.
3. AIM, Aeronautical Information Manual.