Ground Lesson: Radio Navigation

Objectives:

1. to understand basic navigational equipment and it's usage

Justification:

1. radio navigation is a primary means of cross country navigation
2. knowledge of, and proper execution of cross country flights is required for the private pilot checkride.

Schedule:

Activity	Est. Time
Ground	1.5
Total	1.5

Elements Ground:

- VOR Navigation
  - DME
- ADF Navigation
- Advanced Navigation
  - Loran-C
  - GPS

Completion Standards:

3. when the student is able to navigate using radio navigation and GPS

Presentation Ground:

VOR Navigation

1. Very High Frequency Omnidirectional Range (VOR) Navigation
   (1) ground equipment
      i. 360° radials emitting from station like the spokes on a wheel
         (i) accuracy is within ± 1°
         (ii)degrees are oriented with magnetic north
      ii. frequency range from 108.00 - 117.95 MHz
      iii. Each station has a three letter morse code identifier to:
         (i) identify correct frequency usage (may take up to 20 seconds to hear ident)
         (ii) check station online
         (iii) check to see if signal is reliable
      iv. restricted to line of sight
      v. Three types of VOR's with different ranges (optional)
         (i) Terminal VOR (TVOR) - within 25NM, below 12,000 AGL
         (ii) low altitude VOR (LVOR) - up to 40NM between 1,000 and 18,000 AGL
         (iii) high altitude VOR (HVOR) - up to 40NM up to 14,500, 100NM between 14,500 and 18,000, 130NM between 18,000 and FL450, 100NM between FL450 and FL600
   (2) aircraft equipment
      i. VOR receiver - where you tune in the frequency
      ii. VOR indicator - instrument which visually displays course information received from the receiver; main components are
         (i) to-from-off flags
         (ii) omnibearing selector (OBS)
         (iii) course deviation indicator (CDI)
      iii. VOR antenna
   (3) usage
      i. find radial **from** or course **to** VOR
         (i) tune in VOR and rotate OBS until CDI centers. from flag is radial, to flag is course
      ii. tracking to and from VOR
         (i) intercept radial using an appropriate intercept angle
         (ii) upon intercept, turn to correct heading and track CDI changes
         (iii) correct CDI deviations via WCA to correct for drift
      iii. cross checking position
         (i) using 2 VORs you can determine accurately your location
         (ii) using method (i), select radial **from** for 2 different VORs
         (iii) draw extensions of the 2 radials until intersection.
   (4) notes
      i. reverse sensing - situation in which the VOR indicator is set to the reciprocal of the desired course. In this case, the CDI deflections will be reversed.
      ii. off indication - can occur when the aircraft is directly over the station or when the VOR station signal is unreliable.
      iii. cone of confusion - area above the VOR station where you may see an off flag and erratic CDI indications. smaller as you get closer (vertically) to the station.

iv. VOR accuracy - via ground or air checkpoints, or by checking two VOR indicators against each other, you can determine the accuracy of the VOR instruments (±4° is acceptable)

2. Distance Measuring Equipment (DME)

(1) supplemental VOR navigational instrument that allows readings of distance from a VOR station

i. two types of stations allow DME - VORTAC and VOR-DME

ii. although it is usually paired to the VOR receiver, it is a separate piece of equipment with a separate antenna

iii. identify works in similar fashion as VOR except occurs every 30 seconds

(2) distance reading is slant range, thus at 6,000 ft, over the station, reading = 1NM

(3) allows position fix with only one VOR, using radial + distance to define fix

(4) some receivers have ETA information

ADF Navigation

3. Automatic Direction Finder (ADF) Navigation

(1) ground equipment

i. nondirectional radio beacons (NDB) transmit between 190 Khz and 535 Khz

ii. have three letter identifier for similar reasons to VOR

iii. *not* restricted to line of sight

iv. commercial broadcast stations (BS) can be used as well

(2) aircraft equipment

i. ADF antenna - directional antenna and sense antenna

ii. ADF receiver - where you can tune and identify NDBs

iii. ADF bearing indicator - provides visual representation of horizontal relative bearing to station (in relation to aircraft)

(i) MH + RB = MB to station

(3) usage

i. find radial off of NDB or BS

(i) tune in to NDB or BS and read the tail end of the ADF indicator once it stabilizes

ii. track to/from station

(i) tune in to NDB or BS and turn towards the station until head of indicator points at the 0 (or top) of the ADF indicator.

(ii) adjust as necessary for wind correction

a. heading *to* the station, indicator will show WCA, opposite direction of wind

b. heading *from* the station, indicator will show WCA, same direction of wind

(4) notes

i. limitations

(i) subject to many interferences including storms, mountains, ocean shoreline, atmosphere

(ii) no flag on ADF indicator, so no way to know of reliable signal except via ident

ii. HI accuracy when using NDB

(i) since the range of NDBs can be much higher than VOR, accurate HI settings are crucial. If not, a small deflection (when far away) may mean aircraft is far off course

iii. movable card indicator and RMI

(i) movable card indicator can rotate the indicator card to set heading to current heading

(ii) RMI is like a movable card, but indicator card rotates automatically

Advanced Navigation

1. Loran - Long Range Navigation

(1) navigation system based on ground stations which calculate differences in arrival times of pulses between “chains” of stations

(2) a chain consists of 1 master and at least 2 secondary stations (which is the minimum required for navigation)

(3) stations broadcast on low frequencies 90 - 110 Khz

(4) advantages:

i.highly accurate to with ¼ NM of actual position

ii.Loran receivers usually contain databases of most major waypoints (airports, intersections, etc), and also accommodate pilot waypoints (lat + long)

iii. a station single is usable for hundreds of miles

(5) disadvantages:

i. affected by weather, electrical disturbances, precipitation and even dust

(6) being phased out in favor of GPS

2. Global Positioning System (GPS)

(1) satellite based navigation system which uses multiple satellite information to determine position for the receiver

i. minimum of 4 satellites are required for 3D position (lat, long, alt)

ii. minimum of 3 satellites are required for 2D position (lat, long)

iii. some receivers can access up to 12 satellites at one time

(2) There are over 26 satellites in the GPS system

(3) advantages:

i. highly accurate to with hundreds of feet. With WAAS (Wide Area Augmentation System) accurate to within 6 ft; and with Differential GPS, to within 1 cm

(i) both WAAS and DGPS augment the satellites with ground based stations

ii. extensive databases with most major waypoints

iii. easy to use

iv. certain GPS receivers are approved as primary navigation for VFR and IFR

(4) disadvantages:

i. pilot may become dependent on GPS, neglecting alternative means of navigation, even for cross check purposes.