

The ATPL Cheat Sheet

062 Radio Navigation

The facts that actually get tested, stripped to the bone: definitions, key numbers, formulas, mnemonics and the classic exam traps for each subject. Built for the night before, the commute, and the last scroll before you walk into the exam hall.

062 Radio Navigation

54 memory items

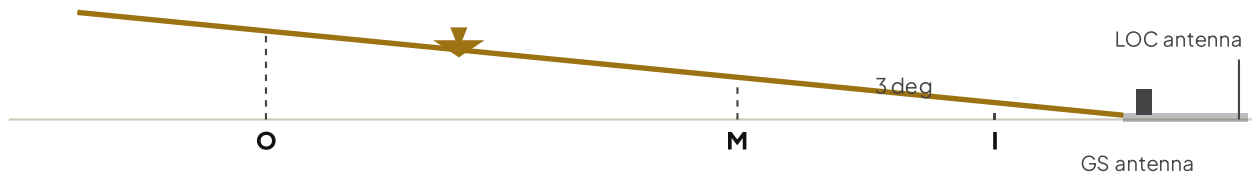
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Radio waves, NDB, VOR, DME, ILS, radar, SSR, GNSS.

◆ ILS: LOCALISER, GLIDE PATH AND MARKERS



Localiser 108.10 to 111.95 MHz (odd first decimals) gives the centreline; **glide path** 328.6 to 335.4 MHz UHF is auto-paired, nominal 3 degrees. **Markers** all on 75 MHz: **O**uter blue low tone, **M**iddle amber medium, **I**nnner white high. Localiser full-scale is about plus or minus 2.5 degrees.

◆ MUST-KNOW DEFINITIONS AND CONCEPTS

- **Ground (surface) wave** follows the Earth's curvature by diffraction (LF/MF), with greater range over sea than over land; it does not depend on the ionosphere.
- **Sky wave** is refracted back by the ionosphere (mainly HF); range varies with day/night, season and solar activity.
- **Space (direct) wave** is line-of-sight (VHF/UHF/SHF), limited by Earth curvature and height, not the ionosphere.
- **D layer** (daytime only) absorbs MF/HF; its disappearance at night lets sky waves travel much farther. **E and F layers** reflect HF sky waves; F splits into F1/F2 by day.
- **Skip distance** is the dead zone between the ground-wave limit and where the first sky wave returns.
- **ADF/NDB**: the needle shows Relative Bearing (RB) to the station, clockwise from the nose.
- **QDM** (magnetic bearing to the station) = RB + magnetic heading; **QDR** (bearing from the station) = QDM plus or minus 180.
- **VOR reference phase**: 30 Hz FM, omnidirectional, constant everywhere. **VOR variable phase**: 30 Hz AM, its phase changes with azimuth.
- A **VOR radial** is the phase difference, read as the magnetic bearing **from** the station. The **cone of confusion** is unreliable indications directly overhead.
- **DME** measures **slant range** (line of sight), largest error overhead and negligible far out.
- **ILS**: the localiser gives lateral guidance on the extended centreline, the glide path gives vertical guidance at nominally 3 degrees; **marker beacons** cross the approach at set points.
- **SSR Mode S** assigns a unique 24-bit address for selective interrogation and data link,

reducing garbling versus Mode A/C.

- **RNAV** allows any desired path within coverage; **RNP** adds onboard performance monitoring and alerting; **PBN** is the ICAO framework of numbered specifications.
- **WGS-84** is the geodetic datum in which GPS positions are expressed.

◆ KEY NUMBERS, LIMITS AND VALUES

- Speed of radio waves **$c = 300,000,000 \text{ m/s}$** (3×10^8).
- Bands: VLF 3 to 30 kHz, LF 30 to 300 kHz, MF 300 to 3000 kHz, HF 3 to 30 MHz, VHF 30 to 300 MHz, UHF 300 to 3000 MHz, SHF 3 to 30 GHz.
- NDB operates in LF/MF, roughly 190 to 1750 kHz **VERIFY**.
- VOR band **108.00 to 117.95 MHz**, 50 kHz spacing; 108.00 to 111.95 shared with the ILS localiser.
- ILS localiser **108.10 to 111.95 MHz** on **odd** first-decimal channels; glide slope **UHF 328.6 to 335.4 MHz**, auto-paired to the localiser.
- DME **UHF 962 to 1213 MHz**, auto-paired to the VOR/ILS.
- Marker beacons all on **75 MHz**: Outer blue low tone, Middle amber medium tone, Inner white high tone.
- SSR: interrogation **1030 MHz**, reply **1090 MHz**. Radio altimeter **4200 to 4400 MHz** (SHF, frequency modulated continuous wave).
- Nominal ILS glide path **3 degrees** (about 2.5 to 3.5 depending on airfield).
- CDI full-scale: **VOR plus or minus 10 degrees** (each dot about 2), **ILS localiser plus or minus 2.5 degrees**.
- VOR aggregate accuracy about plus or minus 5 degrees; DME accuracy about the better of 0.5 nm or 3% of range **VERIFY**.
- Transponder codes: 7700 emergency, 7600 comms failure, 7500 hijack, 7000 VFR conspicuity (Europe), 2000 entering radar with no assigned code.
- ILS minima by category: **CAT I** DH 200 ft or above, RVR 550 m or above; **CAT II** DH 100 to 200 ft, RVR 300 m or above; **CAT IIIA** DH under 100 ft, RVR 200 m or above; **CAT IIIB** DH under 50 ft, RVR down to about 50 to 75 m **VERIFY**.

- GPS: nominally **24 satellites**, 6 planes, about 20,200 km, period about 12 hours **VERIFY**. A 3D fix needs **4 satellites** (3 gives 2D if altitude is known).
- RAIM: **5 satellites to detect** a fault, **6 to exclude** it.

◆ FORMULAS AND RELATIONSHIPS

- Wavelength (m) = c / f ; shortcut wavelength (m) is about $300 / f(\text{MHz})$.
- QDM (to the station) = Relative Bearing + Magnetic Heading (plus or minus 360 as needed).
- QDR (from the station) = QDM plus or minus 180.
- Radar range $R = (c \times t) / 2$, t = total there-and-back time.
- Ground range = $\sqrt{\text{slant range}^2 - \text{height}^2}$, same units.
- VHF/UHF line-of-sight horizon (nm) is about $1.23 \times \sqrt{\text{height in ft}}$; add both stations' terms for two heights **VERIFY**.

◆ MNEMONICS AND MEMORY ITEMS

- **RB + MH = MB**: Relative Bearing plus Magnetic Heading gives the bearing to the station (watch the 360 wrap).
- **A radial is always FROM** the station, never to it.
- VOR: **Reference is Fixed (FM), Variable is AM**.
- Localiser channels have an **odd first decimal** (108.10, 108.30); even tenths are VOR.
- Marker colour and tone step up toward the runway: **blue-low, amber-medium, white-high**.
- GPS segments: **Space, Control, User** (who transmits, who manages, who uses). RAIM: **5 to detect, 6 to correct**.

◆ COMMON EXAM TRAPS

- **Lower** frequency gives longer ground-wave range, and it is greater over sea than land.
- **Night effect** on the NDB is worst around dawn and dusk, when sky and ground waves interfere.
- **Coastal refraction** is zero when the path crosses the coast at 90 degrees and grows at oblique angles.
- **Quadrantal error** is maximum on the 045/135/225/315 relative bearings, zero on the cardinals.
- The **cone of confusion** (overhead geometry) is not the same as the VOR aggregate accuracy figure.
- **DME slant range** error is largest close in/overhead and negligible when range is much greater than height.
- The DME channel is **auto-paired** with the VOR/ILS, not tuned separately.
- **Mode C** reports pressure altitude on 1013.25, not QNH; ATC applies the correction.
- A GPS **3D** fix needs 4 satellites; 3 gives only a 2D fix if altitude is known.
- RAIM depends on satellite **geometry** as well as count.
- The 3 degree glide path is nominal, not universal.
- Do not mix up marker beacon colour/tone/pattern between Outer, Middle and Inner.
- Treat the CAT I/II/III minima as reference points; exact operational minima vary by aircraft, runway and approval.

VOR: the CDI shows POSITION vs the selected course

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1 Position, not heading

The CDI deflection and the TO/FROM flag depend only on where the aircraft is relative to the selected course. Turning the aircraft does not move the needle.

2 2 degrees per dot

Full-scale deflection is 10 degrees off the selected course, so each dot is 2 degrees: the bar 2 dots left here means the aircraft is about 4 degrees right of the 045 course.

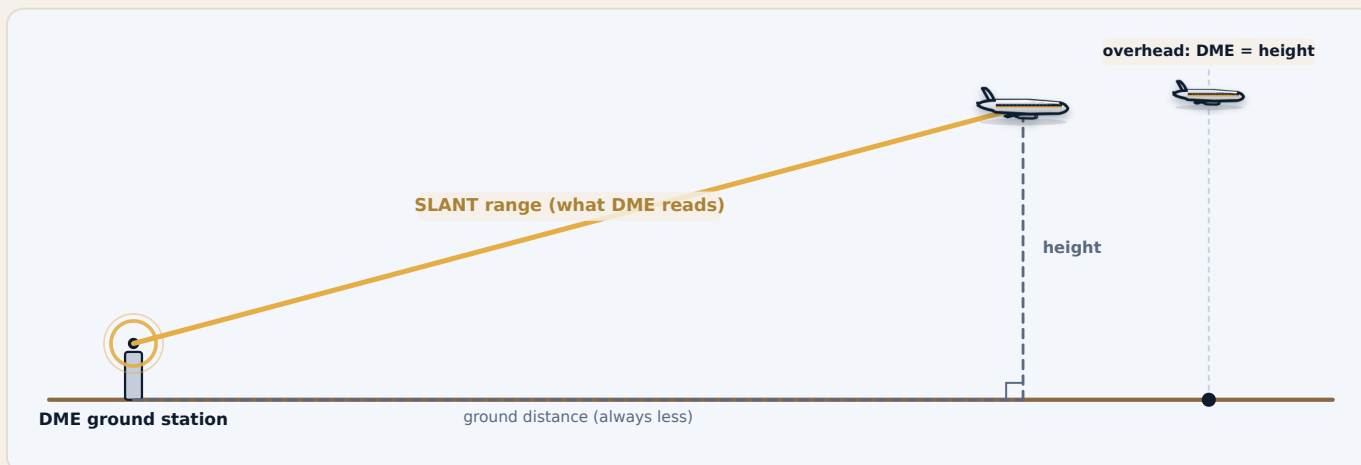
3 TO / FROM by the abeam line

The flag shows FROM when the station is behind the abeam line for the set course and TO when it is ahead. It is not a command to fly toward or away from the station.

4 OBS selects the course

The Omni Bearing Selector sets the reference course. Fly toward the bar to regain it: the needle is on the side the wanted course lies. An unrelated OBS gives a fixed off-centre bar.

A VOR CDI shows the aircraft's position relative to the OBS-selected course, 2 degrees per dot to 10 degrees full scale, and never responds to heading. Drawn in code.

**1 Slant range, not ground range**

DME times a pulse pair to the station and back, so it reads the straight-line SLANT distance. That is always a little more than the distance measured across the ground.

2 Overhead reads your height

Directly over the station the slant range equals the aircraft height, so a DME overhead shows your height in nautical miles, never zero. The error is largest high and close in.

3 Ground-speed read-out error

DME-derived ground speed is the rate of change of slant range, so it reads low near the station and zero overhead, even though the true ground speed is unchanged.

4 Paired and busy

DME is paired with a VOR or ILS frequency and auto-tunes with it. A beacon answers interrogations from many aircraft, so it serves about 100 at once before saturating.

DME reads slant range from a timed pulse pair, so overhead it shows the aircraft height and its ground-speed read-out falls to zero: slant range is never the ground distance. Drawn in code.

Two of the 369 code-drawn study figures inside the SkyStudy question bank. Try them with the free demo at skystudyatpl.com/demo.

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