# Area II, Task A - Aircraft Flight Instruments and Navigation Equipment

**Section 2: Navigation Equipment | CFI-Instrument Ground Lesson**

### PTS Reference

FAA-S-8081-9D, Area of Operation II, Task A (Navigation Equipment elements)

### Lesson Objective

By the end of this lesson, the CFI-I applicant will be able to **TEACH** a student pilot to identify, explain, and operate the full suite of aircraft navigation equipment - VOR, DME, ILS components, ADF/NDB, GPS with WAAS, and RNAV systems - including signal generation, service volumes, error sources, receiver checks, regulatory requirements, and integration into IFR procedures. Instructional knowledge must be deep enough to teach in any certificated instrument aircraft, regardless of whether navigation is presented on a CDI, HSI, MFD, or PFD. (Bloom's Analysis / Application level.)

### Estimated Ground Time

2.5 - 3.0 hours (Section 2 only; Section 1 covers traditional flight instruments)

### Required Materials

- IFH (FAA-H-8083-15B), Chapter 9 - Navigation Systems
- AIM Chapter 1, Sections 1-1-3 (VOR), 1-1-7 (DME), 1-1-8 (Service Volumes), 1-1-9 (ILS), 1-1-17 (GPS), 1-1-18 (WAAS)
- Current IFR-equipped aircraft POH/AFM and avionics supplements (GTN/GNS/G1000)
- Current FAA AFD/Chart Supplement and instrument approach plates for local airports
- 14 CFR 91.205, 91.171, AC 90-100A (RNAV), AC 90-105 (RNP)

### PTS Task A - Navigation Equipment Objective Elements (FAA-S-8081-9D)

| # | Objective Element (Instructional Knowledge of...) |
|---|---|
| 2a | VHF Omnidirectional Range (VOR) - principles, indications, errors |
| 2b | Distance Measuring Equipment (DME) - operation, slant range, errors |
| 2c | Instrument Landing System (ILS) - localizer, glideslope, marker beacons |
| 2d | Marker beacons / compass locators / LOC, LDA, SDF approaches |
| 2e | Automatic Direction Finder (ADF) and NDB navigation |
| 2f | Global Positioning System (GPS) - constellation, RAIM, LOI |
| 2g | Wide Area Augmentation System (WAAS) - SBAS, LPV/LNAV/VNAV |
| 2h | Area Navigation (RNAV) and Required Navigation Performance (RNP) |
| 2i | Receiver checks, currency requirements, and equipment suitability |

### Required References

- FAA-H-8083-15B (IFH) - Chapter 9 (primary source for figures)
- AIM Sections 1-1-3 through 1-1-18 (NAVAID descriptions and SSV diagrams)
- 14 CFR 91.171 - VOR receiver check requirements
- AC 90-100A - U.S. Terminal and En Route Area Navigation
- AC 20-138 - Airworthiness Approval of GNSS Equipment

**CRITICAL:** EVALUATOR EMPHASIS - The CFI-I applicant must teach **both** the underlying signal physics (why a VOR works, how WAAS corrects GPS) AND the cockpit application (CDI deflection, RAIM annunciation, LPV vs LNAV minimums). Memorized procedures without underlying understanding will fail this task. The evaluator routinely asks 'why' three times deep.

## SECTION 1 - MOTIVATION: WHY THIS LESSON MATTERS

On July 17, 1996, the navigational landscape of general aviation began a permanent shift. By 2025 the FAA had completed the bulk of its VOR Minimum Operational Network (VOR MON) decommissioning, removing roughly half of the legacy ground-based VORs in favor of a satellite-based national airspace system. The CFI-Instrument applicant teaching today inherits a hybrid environment: GPS-equipped aircraft flying RNAV approaches to airports without ground navaids, alongside aircraft still required to demonstrate ground-based navigation proficiency for the practical test. *(AIM 1-1-3.k - VOR MON; AC 90-100A)*

This shift makes the navigation portion of Task A more demanding, not less. A CFI-I who only teaches GPS direct-to navigation has not prepared a student to fly a partial-panel ILS when the GPS suffers an integrity failure. A CFI-I who teaches VOR navigation but cannot explain what RAIM is, how WAAS provides vertical guidance, or why an LPV approach minimum may be lower than the ILS at the same airport, has not prepared a student to operate competently in today's NAS. Both skill sets must be present, both must be teachable, and both must be demonstrably understood at the analysis level. *(AIM 1-1-17, 1-1-18; IFH Ch.9)*

Consider the November 2018 NTSB investigation into a Cirrus SR22 that descended below minimums on an LPV approach in marginal IMC. The pilot, transitioning from a steam-gauge Cessna, did not recognize that the WAAS LPV vertical guidance was disabled because the GPS had reverted to LNAV mode (no vertical guidance available). The CDI presentation appeared normal; the missing vertical bar was the only cue. The pilot continued the descent using VSI estimation to the LPV decision altitude, well below the LNAV MDA published for the same approach. CFIT followed. *(NTSB - representative WAAS mode-confusion accident pattern)*

> ***Instructor Note:*** *Open this lesson with the question: 'What is the difference between an LPV approach annunciated as LNAV/VNAV vs. one annunciated as LNAV-only on the same approach plate?' The applicant must answer: LPV requires WAAS, provides angular vertical guidance to a decision altitude with ILS-like minimums; LNAV is non-precision with an MDA, no vertical guidance. If the applicant cannot articulate this in 30 seconds, the lesson has identified its central gap. (AIM 1-1-18; AC 90-107)*

## SECTION 2 - KEY CONCEPTS

### 1. VHF Omnidirectional Range (VOR) (PTS Objective 2a)

#### A WHAT TO TEACH

The VOR transmits two 30 Hz signals from a ground station: a **reference signal** (constant phase, omnidirectional) and a **variable signal** (rotating directional pattern). The phase difference between these two signals at the aircraft's receiver equals the magnetic radial from the station to the aircraft. The system produces 360 discrete radials (one per degree) like spokes on a wheel. *(IFH Ch.9, p.9-7 to 9-13; AIM 1-1-3)*

**Frequency and Identification:**

- Frequency band: 108.0 - 117.95 MHz (VHF)
- Even-tenths in 108.x range reserved for ILS localizers - VORs use odd-tenths from 108.10 to 111.95, plus all of 112.00 - 117.95
- Identified by 3-letter Morse code; voice ID may also be present (TWEB or HIWAS)
- If Morse ID is absent, the station may be undergoing maintenance - **navigation unreliable**

**VOR Errors and Limitations:**

- Line-of-sight only - VHF will not bend around obstacles or curve with the earth
- Cone of confusion: directly over the station, signal is unreliable for 60-90 seconds
- Bearing accuracy: standard VOR is ±4 deg as installed; ±6 deg airborne tolerance per 91.171
- Course scalloping near terrain or buildings - reflections cause needle oscillation
- Site error: nearby structures or terrain create predictable but un-correctable bearing offsets

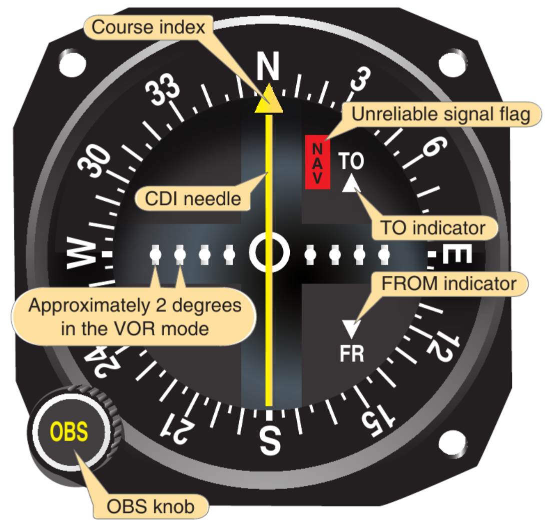


**Figure 9-12.** *The VOR indicator instrument.*

*Figure 1 - VOR receiver/CDI indicator. Components: course index, OBS knob, CDI needle, TO/FROM flag. Source: FAA-H-8083-15B, Chapter 9, Figure 9-12.*

**VOR Receiver Check (14 CFR 91.171):**

- IFR ops: check within preceding 30 days
- VOT: ±4 deg / Ground: ±4 deg / Airborne: ±6 deg / Dual: ±4 deg
- Logbook entry: date, place, error, signature

#### B VOR SERVICE VOLUMES - AIM REFERENCE

*FIG 1–1–1*
**Original Standard Service Volumes**

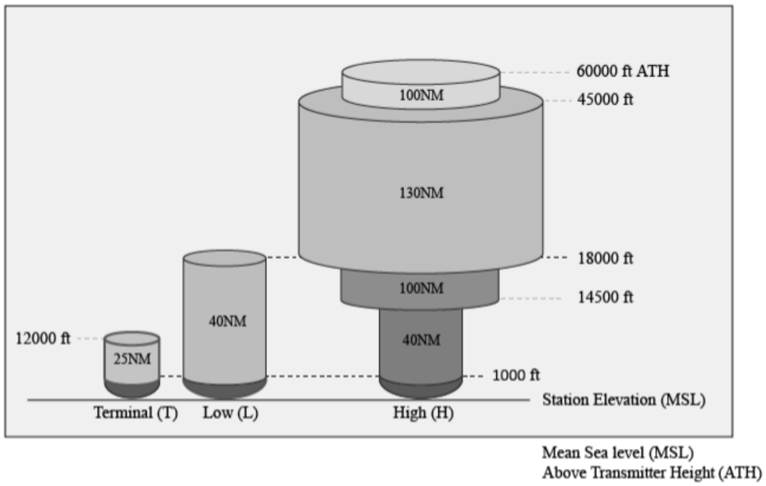


*Figure 2 - **Original Standard Service Volumes** (T, L, H classes). The classic stacked-cylinder representation: Terminal up to 12,000 ft / 25 NM; Low up to 18,000 ft / 40 NM; High up to 60,000 ft / 100-130 NM (varies by altitude). Source: AIM, Figure 1-1-1.*

*FIG 1–1–4*
**New VOR Service Volumes**

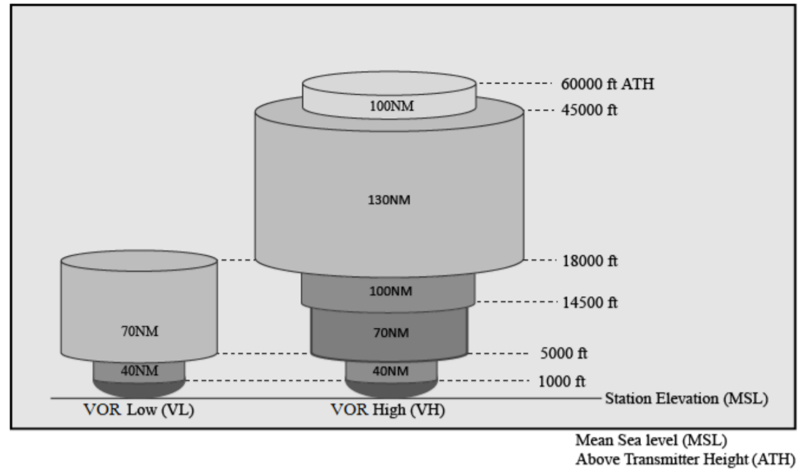


*Figure 3 - **NEW VOR Service Volumes** (VL and VH classes added 2020 to support VOR MON). VL extends to 70 NM at 5,000 ft; VH extends to 70 NM at 14,500 ft and 100 NM at 45,000 ft. Source: AIM, Figure 1-1-4.*

***Instructor Note: Service Volume - Teach the Distinction:** Original SSVs (T, L, H) were defined when the VOR network was dense; an aircraft below the High volume's lower edge could rely on a Low or Terminal VOR nearby. Post-MON decommissioning, that backup density does not exist - so the FAA added the VL (VOR Low) and VH (VOR High) classes with extended low-altitude reach (70 NM at 5,000 ft AGL) to provide continuous coverage of the MON network. The applicant must be able to look at a chart-published VOR class designation (e.g., 'VORTAC ABC (H)' vs. '(VH)') and explain the difference in usable range. (AIM 1-1-8; FAA Order 1100.161 - VOR MON Implementation)*

## VOR (continued) - CDI Interpretation and Teaching

## A CDI INTERPRETATION - THE CENTRAL TEACHING SKILL

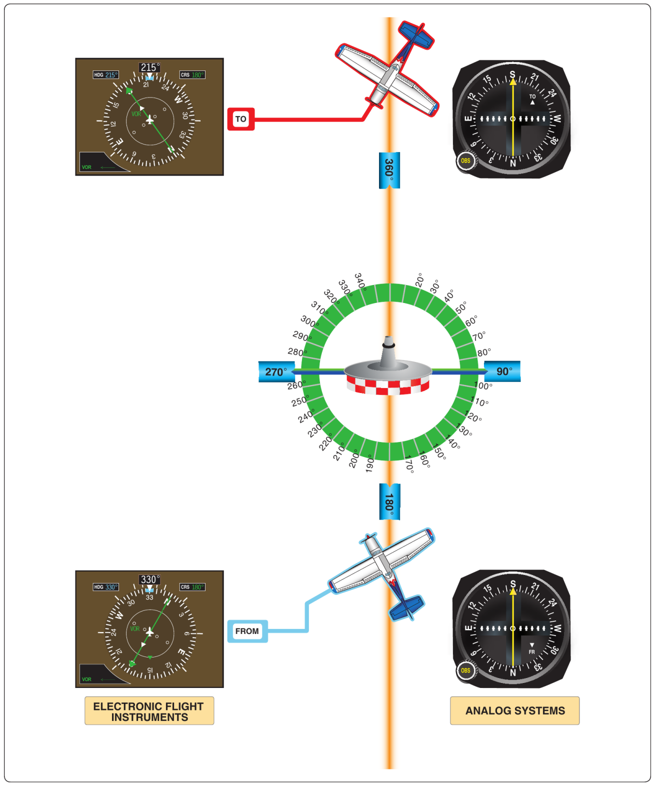


**Figure 9-15.** *CDI interpretation. The CDI as typically found on analog systems (right) and as found on electronic flight instruments (left).*

*Figure 4 - CDI interpretation: aircraft crossing a radial shows TO above the station, FROM below. Both analog (right) and electronic presentations (left) shown. Source: FAA-H-8083-15B, Chapter 9, Figure 9-15.*

The CDI shows three pieces of information simultaneously: **(1) the radial selected with the OBS**; **(2) the aircraft's lateral position relative to that radial** (full deflection = 10 deg in VOR mode, 2.5 deg in LOC mode); **(3) the direction to fly** (TO or FROM via the flag). *(IFH Ch.9, p.9-11)*

### Five-Step CDI Read - Drill Until Automatic:

- **Tune and identify** - frequency dialed, Morse matches chart
- **Set OBS** to desired course (radial inbound or outbound)
- **Read the flag** - TO or FROM (off-flag = unreliable)
- **Read the needle** - turn toward needle deflection
- **Cross-check heading** - heading that centers the needle

### Reverse Sensing:

When OBS is set to the OUTBOUND course but you fly inbound (or vice versa), the CDI displays reverse sensing - deflection opposite to needed correction. Impossible on HSI (auto-orients), standard on basic CDI. Cure: always set OBS to the course you intend to fly.

## B HOW TO TEACH IT

**Sequence:**

- Whiteboard: draw a VOR with 8 cardinal radials. Place a tiny aircraft on each. Have student state OBS setting and TO/FROM for each.
- Tabletop: use the actual aircraft GPS/CDI in BENCH or simulator mode. Force the student to verbalize each of the five CDI read steps.
- In flight: tune a known VOR. Have student call out OBS, TO/FROM, deflection, and heading correction every 30 seconds during cruise.
- Failure mode drill: announce 'OFF flag' and have student state actions: do not navigate by needle, cross-check with second source, suspect station maintenance.

**Common Misconceptions:**

- Students believe a centered needle means 'on the radial' regardless of OBS setting - it does not; OBS must equal the actual radial flown
- Students confuse TO/FROM with direction of flight - the flag describes the OBS-selected course, not the aircraft heading
- Students fail to identify the station - tune correct frequency but Morse ID never verified

***Instructor Note:*** *Reverse sensing is one of the highest-yield teaching opportunities in this entire task. Set up a scenario in flight: 'Track inbound to BHM on the 090 radial.' If the student sets OBS to 090 and tries to fly inbound, sensing is reversed. The classic trap. Most students discover it only after they have flown 10+ degrees off course. Catch it in the briefing. (IFH Ch.9, p.9-11)*

## D ANALOGY

*"Explaining VOR signal generation to a student: 'Imagine a lighthouse with two beams - one that always shines straight up like a flash every second, and one rotating beam that sweeps the horizon once per second. By measuring the time between the flash overhead and the moment the rotating beam hits you, you know exactly which radial of the lighthouse you are on. The VOR does this with phase difference between two 30 Hz radio signals instead of light, but the geometry is identical. Once you see the lighthouse picture, the CDI presentation makes sense for life.'"*

## 2. Distance Measuring Equipment (DME) (PTS Objective 2b)

### A WHAT TO TEACH

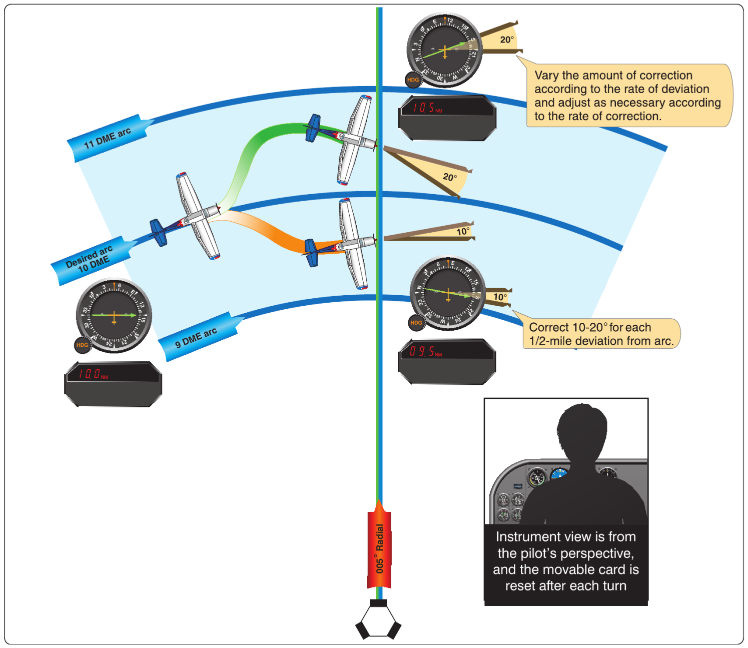


*Figure 5 - Using DME and RMI to fly a DME arc. Note the slant-range geometry annotated in the right callout: at 3,000 ft AGL and 0.5 NM ground distance, slant range reads 0.6 NM. Source: FAA-H-8083-15B, Chapter 9, Figure 9-18.*

DME measures **slant-range distance** from the aircraft to the ground station - not ground distance. The aircraft transmits an interrogation pulse on one frequency; the ground station replies on a paired frequency 63 MHz offset. The receiver measures the round-trip time, divides by two, multiplies by the speed of light, and displays the result in nautical miles. *(IFH Ch.9, p.9-15 to 9-19)*

#### Frequency Pairing:

- DME operates 962-1213 MHz (UHF) - 252 channels
- Each VOR/DME or VORTAC pairs DME with the VOR frequency automatically (channel pairing in IFR receivers)
- Pilot tunes the VOR frequency; receiver auto-tunes the paired DME
- ILS/DME and TACAN systems also use DME pairing

#### Slant Range Error - Critical Teaching Point:

- DME displays slant distance, NOT ground distance
- Error is greatest when aircraft is HIGH and CLOSE to station
- Rule of thumb: at 1 NM ground distance per 1,000 ft altitude, slant range error is negligible
- Directly over the station at FL350: DME reads ~5.8 NM (the altitude itself in NM)
- Ground speed shown on DME is also slant-range based - reads zero or near-zero passing overhead

**CRITICAL:** On a DME arc approach, slant range error matters. At 3,000 ft AGL flying a 7 NM arc, slant range reads about 7.04 NM (negligible). At 9,000 ft AGL on the same arc, slant range reads about 7.16 NM (still under 1% error). But within 5 NM of the station at high altitude, the error becomes operationally significant. Teach the student to think about it. *(IFH Ch.9, p.9-19)*

### E INSTRUCTOR NOTE

***Instructor Note:*** *Most modern GPS units display 'distance to waypoint' that looks identical to a DME readout but is GPS-derived ground distance, not slant range. A student who has only used GPS will be confused the first time DME slant range matters - typically during a training-only DME arc. Highlight: GPS gives you ground distance; DME gives you slant range. Same units, different geometry. (IFH Ch.9, p.9-15 to 9-19; AIM 1-1-7)*

## 3. Instrument Landing System (ILS) (PTS Objective 2c)

### A  WHAT TO TEACH - ILS COMPONENTS OVERVIEW

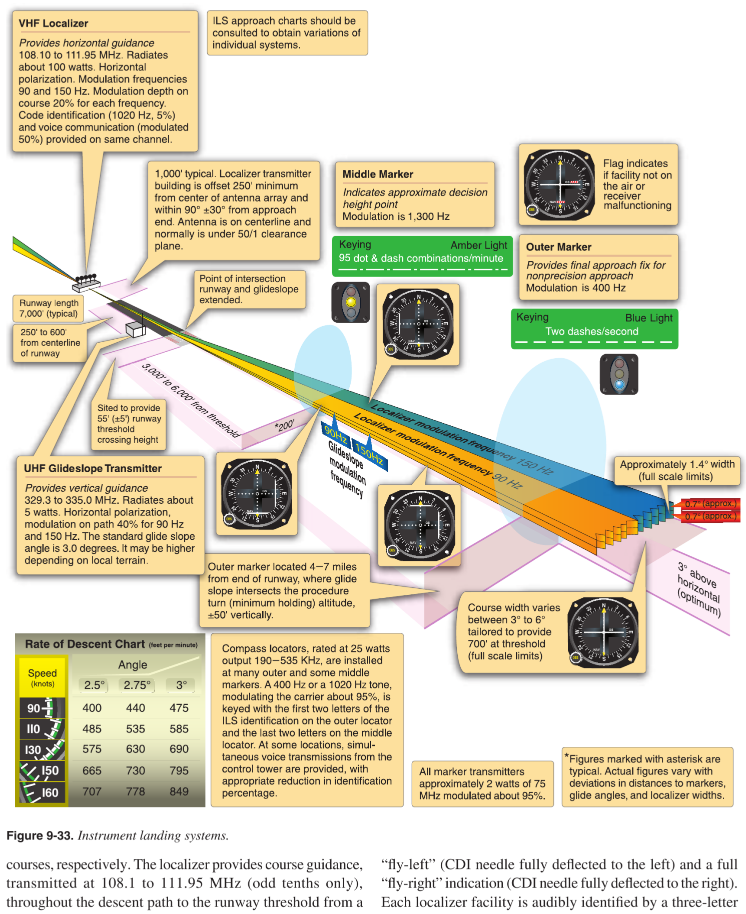


*Figure 6 - Instrument landing system: VHF localizer, UHF glideslope, and 75 MHz marker beacons (OM/MM/IM). Note the rate-of-descent chart for various glideslope angles and airspeeds at the bottom-left. Source: FAA-H-8083-15B, Chapter 9, Figure 9-33.*

An ILS is a precision approach aid combining three radio systems plus visual aids. All three radio components are **paired** - the pilot tunes only the localizer frequency; the glideslope and marker beacons are automatically associated. *(IFH Ch.9, p.9-36 to 9-42; AIM 1-1-9)*

#### The Three Radio Components:

- **Localizer (LOC)**: VHF, 108.10 - 111.95 MHz *(odd tenths only)* - provides lateral (horizontal) guidance
- **Glideslope (GS)**: UHF, 329.15 - 335.00 MHz - provides vertical guidance, paired with LOC
- **Marker beacons**: 75 MHz vertical cones - distance information (OM / MM / IM)

#### Identifier and Audio:

- Localizer ident: 3-letter Morse with leading 'I' (e.g., I-BHM)
- Voice ID/ATIS may be carried on the LOC frequency
- Always identify before commencing the approach - unreliable signal = no ID

#### ILS Categories - Minimums:

- CAT I: 200 ft DH, RVR 2400 (1800 with TDZ/CL lights)
- CAT II: 100 ft DH, RVR 1200 - special crew/aircraft auth
- CAT III a/b/c: below 100 ft DH; autoland-equipped only

## ILS (continued) - Localizer Coverage and Approach Lighting

## B LOCALIZER COVERAGE & APPROACH LIGHTING SYSTEMS

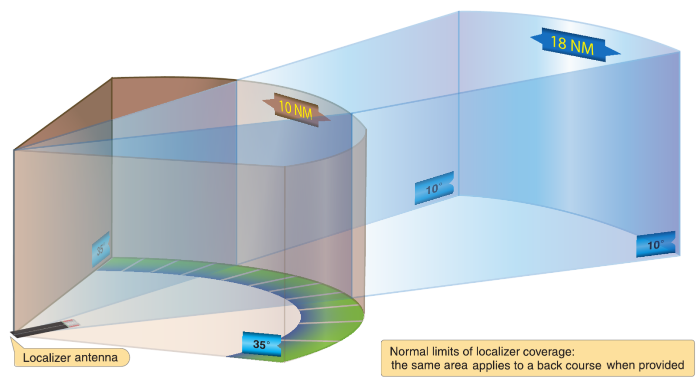


**Figure 9-34.** *Localizer coverage limits.*

*Figure 7 - Localizer coverage limits: 18 NM out at ±10 deg from course, 10 NM out at ±35 deg from course. Beyond these limits, the LOC signal is unreliable. The back-course coverage (when provided) mirrors the front-course volume. Source: FAA-H-8083-15B, Chapter 9, Figure 9-34.*

### Localizer Signal Characteristics:

- Course width: tailored to provide 700 ft total at threshold (3 to 6 deg total beam)
- 90 Hz modulation LEFT of centerline, 150 Hz RIGHT (looking inbound)
- Full CDI deflection = 2.5 deg (much more sensitive than VOR's 10 deg)
- **Back course**: rearward LOC lobe - reverse sensing on conventional CDI; correct on HSI
- Localizer-only approaches (LOC, LDA, SDF) use the LOC signal without GS - non-precision

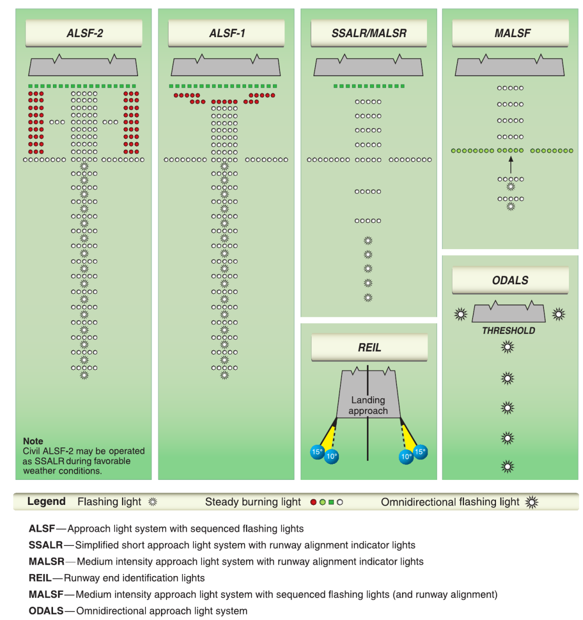


**Figure 9-36.** *Precision and nonprecision ALS configuration.*

*Figure 8 - Approach lighting system (ALS) configurations: ALSF-2, ALSF-1, SSALR/MALSR, MALSF, REIL, ODALS. The ALS visible to the pilot during a CAT I approach affects whether RVR minimums can be reduced (e.g., 2400 ft to 1800 ft with TDZ/CL lighting). Source: FAA-H-8083-15B, Chapter 9, Figure 9-36.*

> ***Instructor Note: Teach the ALS distinction*** *- Many CFI-I applicants miss this on the checkride: the type of approach lighting installed at the runway is what determines whether CAT I minimums can be reduced from RVR 2400 to RVR 1800. Specifically, RVR 1800 requires* ***TDZ/CL*** *(touchdown zone + centerline) lights AND the approach lighting system. Without TDZ/CL, RVR 2400 minimum applies regardless of ALS. (14 CFR 91.175; AIM 2-1-1)*

## ILS (continued) - Glideslope Signal and False GS Hazard

## C GLIDESLOPE SIGNAL VISUALIZATION + LOC/LDA/SDF/CL VARIANTS

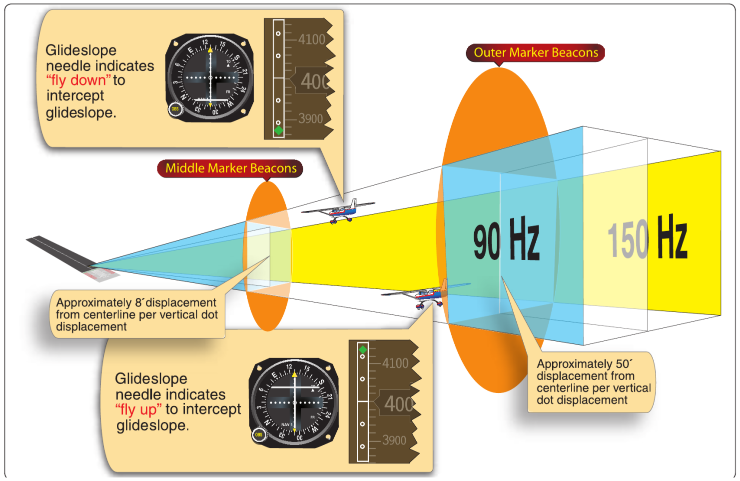


*Figure 9 - Glideslope receiver indication and displacement: 90 Hz upper lobe = 'fly down' to intercept; 150 Hz lower lobe = 'fly up' to intercept. Approximately 50 ft vertical displacement per CDI dot at the runway threshold. Marker beacons (OM/MM) and their vertical signal cones are shown on the right. Source: FAA-H-8083-15B, Chapter 9, Figure 9-39.*

### Approach Variants - LOC, LDA, SDF, Compass Locator:

- **LOC**: localizer only, no glideslope (non-precision MDA)
- **LDA** (Localizer-type Directional Aid): LOC-class signal not aligned with runway (>3 deg offset); may have GS
- **SDF** (Simplified Directional Facility): like LOC but wider beam (6 or 12 deg); may not align with runway
- **Compass Locator**: low-power NDB (under 25 W) co-located with OM or MM, used for IAF or missed approach hold

### Glideslope Operating Characteristics:

- Standard angle: 3.0 deg; some sites 2.5 to 4.0 deg for terrain
- Full CDI deflection: ±0.7 deg (±0.35 deg per dot)
- Coverage: 10 NM out, ±8 deg of localizer course
- Marker Beacons - Outer Marker (4-7 NM, BLUE), Middle Marker (~3,500 ft, AMBER), Inner Marker (CAT II DH, WHITE)

### False Glideslope - Always Teach This:

Because the GS antenna radiates standing-wave lobes, secondary lobes exist at approximately 6 deg, 9 deg, and 12 deg above horizontal. A pilot intercepting the glideslope from **above** may capture a false 6 deg lobe and follow it down at twice the normal descent rate. *(IFH Ch.9, p.9-42)*

### The Cure:

- Always intercept the glideslope from BELOW - cross FAF at published altitude
- Verify GS capture by cross-checking VSI (~500 fpm at 90 KIAS for 3 deg)
- If descent rate is double expected value, suspect false GS - go missed

**CRITICAL:** False glideslope intercept above the published GS angle is a recurring CFIT cause. Teach: 'If your descent feels too steep, you are on a false glideslope, period. Apply the missed approach.' *(IFH Ch.9, p.9-42; FAA InFO 16012)*

## 4. Global Positioning System (GPS) (PTS Objective 2f)

### A WHAT TO TEACH - GPS FUNDAMENTALS

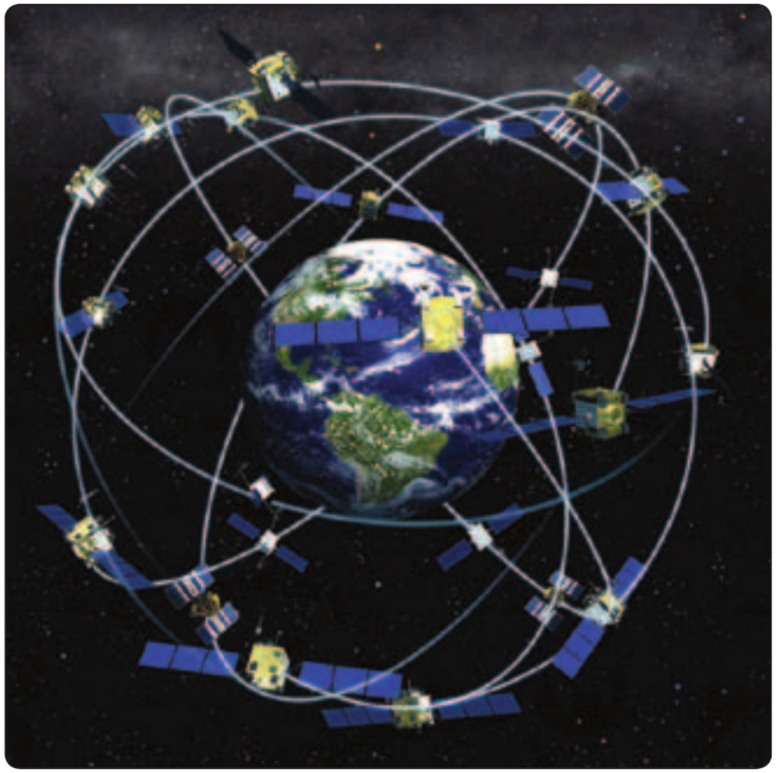

**Figure 9-27.** *Typical GPS satellite array.*

such as distance and bearing to a WP and groundspeed, are computed from the aircraft's current position (latitude and longitude) and the location of the next WP. Course guidance

*Figure 8 - GPS satellite constellation: 24+ NAVSTAR satellites in 6 orbital planes inclined 60 deg apart, ~11,000 NM altitude, ~12-hour orbital period. Source: FAA-H-8083-15B, Chapter 9, Figure 9-27.*

GPS consists of three segments: **Space** (24+ NAVSTAR satellites), **Control** (master station at Schriever AFB plus monitor stations), and **User** (aircraft receiver). Each satellite continuously broadcasts a pseudo-random code timing message and orbital ephemeris. The receiver computes its position by trilaterating from at least **four** satellites simultaneously - three for position (latitude, longitude, altitude) and one for time correction. *(IFH Ch.9, p.9-25 to 9-27)*

#### Why FOUR Satellites?

The receiver does not have an atomic clock; its onboard clock has microsecond-level drift. With three satellites you can solve for X, Y, Z in a perfect world - but a 1-microsecond clock error produces a 300-meter position error. Adding a fourth satellite lets the receiver solve simultaneously for X, Y, Z, AND clock error. More satellites = better geometry = better accuracy.

#### RAIM - Receiver Autonomous Integrity Monitoring:

- Requires AT LEAST 5 satellites in view (6 for fault exclusion / FDE)
- Compares each satellite's solution to all others; flags 'rogue' satellites
- RAIM availability is REQUIRED for IFR GPS approaches without WAAS
- Pilots must check RAIM availability before flight and at the FAF if non-WAAS
- Loss of Integrity (LOI) annunciation: GPS no longer reliable; revert to alternate nav

### B REGULATORY AND OPERATIONAL

### Equipment Categories (TSO):

- **TSO-C129/C129a**: legacy non-WAAS GPS - VFR or IFR with RAIM check required
- **TSO-C145/C146**: WAAS-capable - no separate RAIM check needed for ops within WAAS coverage
- **TSO-C196**: portable IFR GPS - now common in retrofit installations
- Approach approval: must be in approved flight manual supplement (AFMS) for the specific aircraft

### Database Currency:

- 28-day FAA NavData cycle - must be current before commencing IFR GPS operations
- Out-of-date database: GPS may be used for situational awareness only, not for primary nav
- CFI-I must teach the student how to verify cycle date and what to do when expired

### GPS Errors and Failure Modes:

- Multipath: signal reflection from terrain or aircraft structure - usually small
- Atmospheric: ionospheric and tropospheric delay - corrected by WAAS
- Ephemeris/clock errors: small, monitored by RAIM
- Selective availability: deactivated 2000; no longer a factor
- Spoofing/jamming: increasing concern; RAIM may not detect deliberate spoofing
- Total signal loss: indoor, in tunnels, behind terrain - rare but possible

***Instructor Note:*** *Ask the applicant: 'Your GPS shows RAIM PREDICTED OUT in the cockpit before commencing an LNAV approach. Are you legal to fly the approach?' (Answer: depends. With WAAS, no RAIM check needed - LPV/LNAV+V/LNAV are ALL still legal. Without WAAS, RAIM is required by 14 CFR 91.205 GPS rules and the approach is NOT legal. Many applicants answer this wrong.) (AIM 1-1-17, 1-1-18; AC 90-100A)*

## 5. Wide Area Augmentation System (WAAS) (PTS Objective 2g)

### A WHAT TO TEACH - WAAS ARCHITECTURE

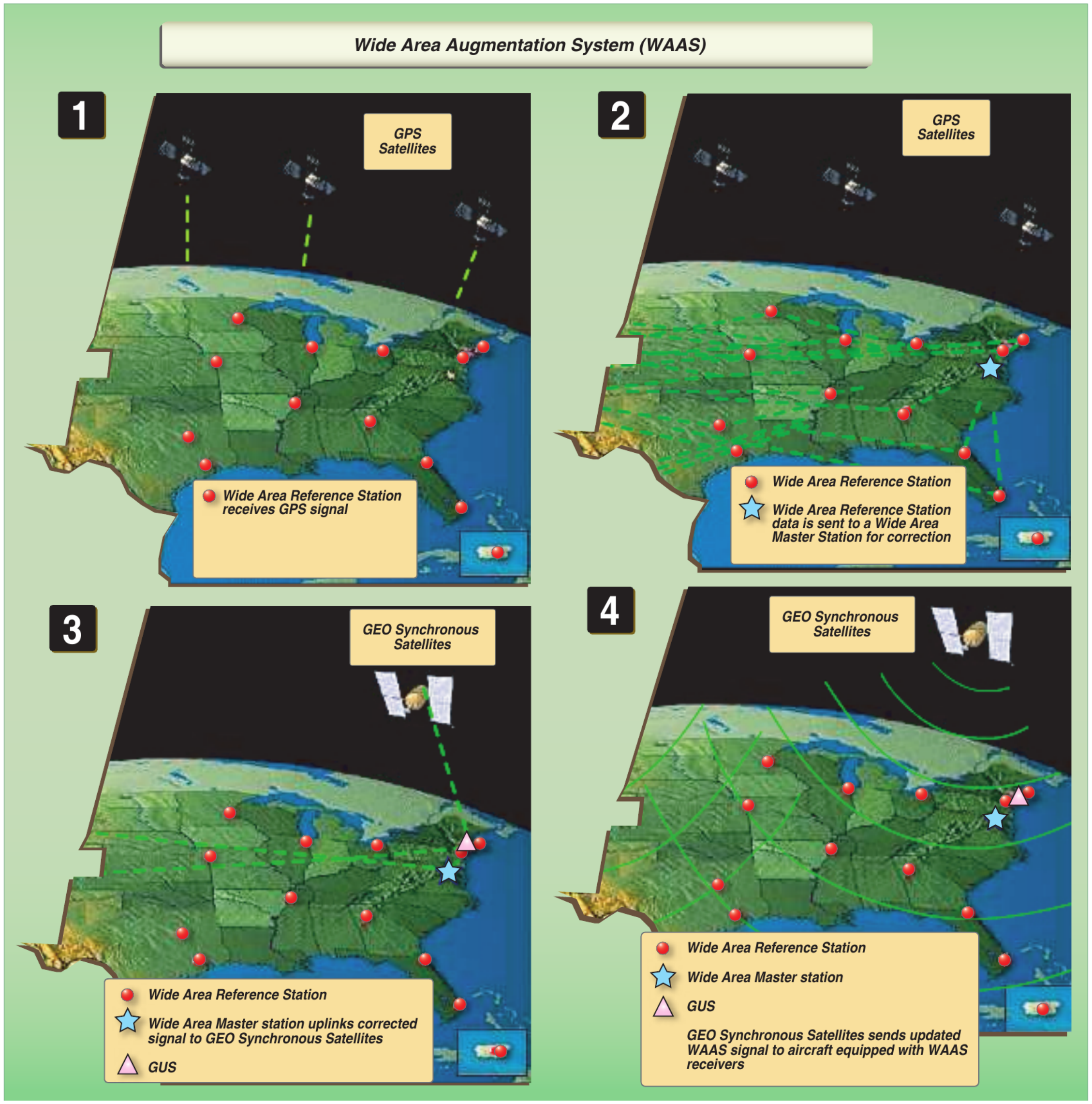


*Figure 9 - WAAS satellite-based augmentation system. Sequence: (1) Wide Area Reference Stations (WRS, ~38 sites) receive GPS signals; (2) data is forwarded to Wide Area Master Stations (WMS) for correction processing; (3) corrections are uplinked via Ground Uplink Stations (GUS) to geostationary (GEO) satellites; (4) GEO satellites broadcast corrected data to WAAS-capable aircraft receivers. Source:*

*FAA-H-8083-15B, Chapter 9, Figure 9-29.*

WAAS is a **Satellite-Based Augmentation System (SBAS)** that provides real-time ionospheric and ephemeris corrections to GPS, plus an integrity message that REPLACES the RAIM function for WAAS-capable receivers. WAAS reduces typical GPS position error from ~3 meters to under 1 meter horizontal and ~1.5 meters vertical, providing the integrity guarantee required for vertically guided approaches. *(IFH Ch.9, p.9-30 to 9-33; AIM 1-1-18)*

### What WAAS Enables - Approach Service Levels:

- **LPV** (Localizer Performance with Vertical guidance): angular vertical guidance to a Decision Altitude, often 200 ft AGL - *ILS-equivalent minimums without an ILS*
- **LNAV/VNAV**: linear vertical guidance from baro-VNAV or WAAS - DA typically 350-500 ft AGL
- **LNAV+V**: lateral guidance plus advisory glidepath (NOT regulatory; LNAV MDA still applies)
- **LP** (Localizer Performance): angular lateral, no vertical - non-precision MDA
- **LNAV**: basic lateral nav - non-precision MDA, available without WAAS

### WAAS Coverage:

- CONUS, Alaska, Hawaii, parts of Canada/Mexico
- Two GEO satellites visible from most CONUS - redundancy
- Gaps at high latitudes / Pacific - revert to non-WAAS GPS

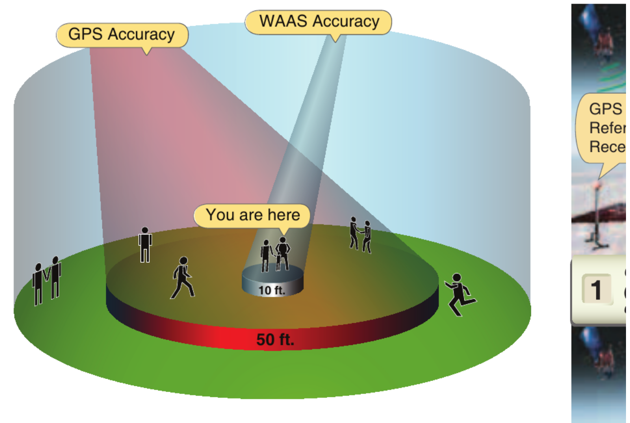


**Figure 9-30.** *WAAS provides performance enhancement for GPS approach procedures through real-time monitoring.*

**Inertial Navigation System (INS)**

Inertial Navigation System (INS) is a system that navigates precisely without any input from outside of the aircraft. It is fully self-contained. The INS is initialized by the pilot, who

*Figure 10 - WAAS vertical accuracy enhancement vs. unaugmented GPS. Source: FAA-H-8083-15B, Chapter 9, Figure 9-30.*

### WAAS Approach Mode Sequence:

- On RNAV(GPS) approach load: receiver picks highest available service level
- Annunciator: LPV / L/VNAV / LNAV+V / LP / LNAV - **check before FAF**
- If WAAS lost mid-approach: auto-downgrade (e.g., LPV→LNAV); new minimum applies
- Pilot applies minimums for ANNUNCIATED level, not briefed level

> ***Instructor Note: The most-tested WAAS question:*** *'You were cleared LPV (250 ft DA). After GS intercept the annunciator switches LPV→LNAV. What now?' (Revert to the LNAV MDA on the same plate - typically 500-700 ft AGL. Continue if you can level off; otherwise miss.) (AIM 1-1-18)*

## WAAS / GPS - Teaching Approach and Common Errors

### B HOW TO TEACH IT

**Sequence:**

- Begin with GPS fundamentals (4 satellites, trilateration) - whiteboard the geometry
- Introduce errors: clock, ephemeris, ionosphere - explain why corrections are needed
- Walk through the WAAS 4-panel sequence (Figure 9 in this lesson plan): GPS reaches WRS - WMS computes - GUS uplinks - GEO broadcasts to aircraft
- In the cockpit: have the student locate the WAAS annunciator and demonstrate mode display: LPV / L/VNAV / LNAV+V / LP / LNAV
- On a chart: show an RNAV(GPS) approach plate with multiple minima rows. Have the student state which row applies for each annunciated mode

**Common Misconceptions:**

- Students think 'WAAS' means 'GPS' - they are different systems; WAAS augments GPS
- Students believe LPV is a precision approach - it is technically classified as APV (approach with vertical), not precision in the regulatory sense, but it provides ILS-like minimums
- Students confuse LNAV+V (advisory) with LNAV/VNAV (authorized vertical guidance) - the '+V' has different regulatory status than '/VNAV'
- Students assume WAAS coverage is universal - high latitude and oceanic areas may have gaps

> ***Instructor Note:*** *When teaching the LPV/LNAV downgrade scenario, use the actual aircraft's avionics. For a Garmin GTN 750: pull up an LPV approach in PROC menu, force-disable WAAS via the system menu (in simulator mode only), and demonstrate the LPV annunciator drop. The visual transition cements the concept far better than any whiteboard explanation. (AIM 1-1-18)*

### D ANALOGY

*"Explaining WAAS to a student: 'Think of GPS like getting your weight from a bathroom scale you trust to about 1 pound. WAAS is like having a calibration certificate from the National Bureau of Standards that says: at this minute, this scale is reading 0.3 pounds high - subtract that and you have your true weight, accurate to 1/10 of a pound. The bathroom scale is GPS. The certificate is the WAAS correction message coming from a geostationary satellite. With the certificate, you know your weight precisely enough to fly an approach to 200 feet above the runway. Without it, you might be 30 feet off in altitude - acceptable for cruise, unacceptable for an instrument approach.'"*

### E INSTRUCTOR NOTE

***Instructor Note:*** *Many CFI-I applicants have flown LPV approaches dozens of times but cannot articulate what the 'V' stands for or why an LPV minima is lower than the LNAV/VNAV minima on the same plate. The answer: LPV uses **angular** vertical guidance (like an ILS glide slope - smaller error as you approach the runway), while LNAV/VNAV uses **linear** guidance (constant width). Angular sensitivity allows lower minima because positional accuracy improves on short final. This is not a trick question - it is the heart of why WAAS exists. The applicant who cannot explain it in 60 seconds has not yet earned the CFI-I privilege. (AIM 1-1-18; AC 90-107; IFH Ch.9, p.9-30 to 9-33)*

## 6. ADF / NDB Navigation (PTS Objective 2e)

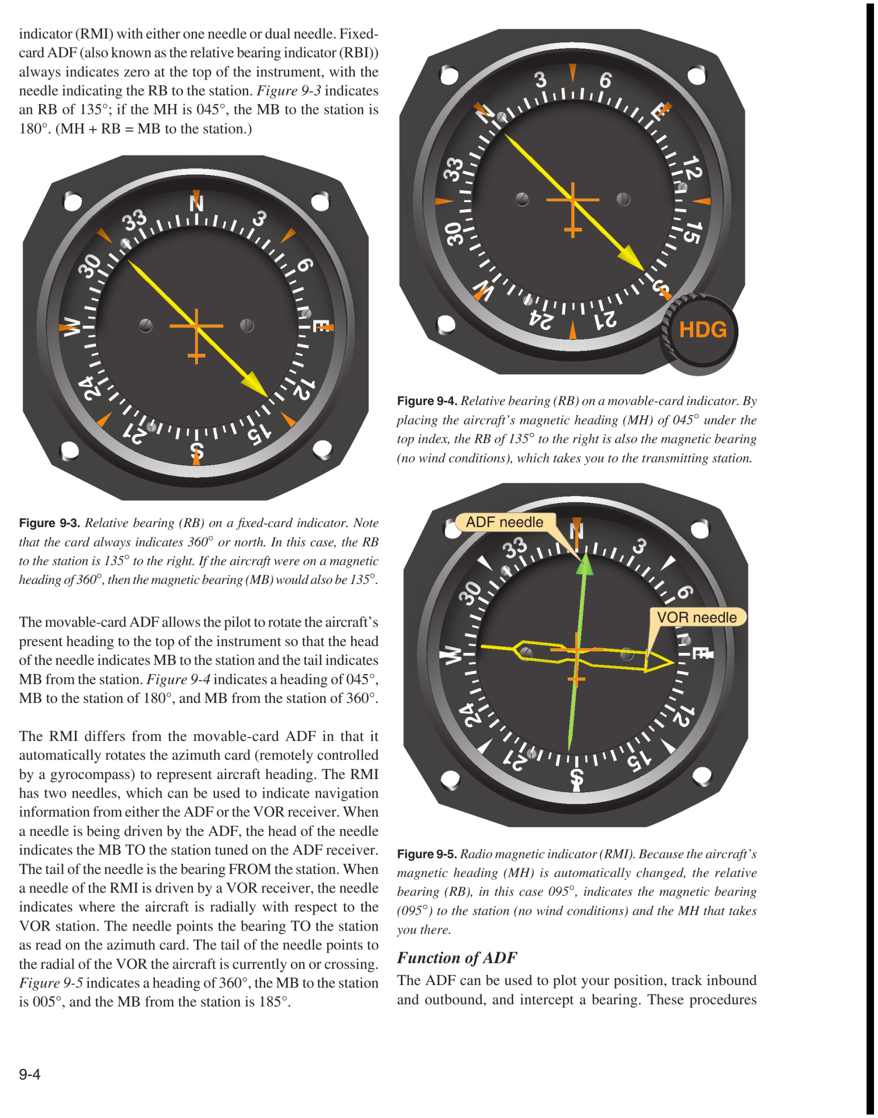
indicator (RMI) with either one needle or dual needle. Fixed-card ADF (also known as the relative bearing indicator (RBI)) always indicates zero at the top of the instrument, with the needle indicating the RB to the station. *Figure 9-3* indicates an RB of 135°; if the MH is 045°, the MB to the station is 180°. (MH + RB = MB to the station.)

**Figure 9-3.** *Relative bearing (RB) on a fixed-card indicator. Note that the card always indicates 360° or north. In this case, the RB to the station is 135° to the right. If the aircraft were on a magnetic heading of 360°, then the magnetic bearing (MB) would also be 135°.*

The movable-card ADF allows the pilot to rotate the aircraft's present heading to the top of the instrument so that the head of the needle indicates MB to the station and the tail indicates MB from the station. *Figure 9-4* indicates a heading of 045°, MB to the station of 180°, and MB from the station of 360°.

The RMI differs from the movable-card ADF in that it automatically rotates the azimuth card (remotely controlled by a gyrocompass) to represent aircraft heading. The RMI has two needles, which can be used to indicate navigation information from either the ADF or the VOR receiver. When a needle is being driven by the ADF, the head of the needle indicates the MB TO the station tuned on the ADF receiver. The tail of the needle is the bearing FROM the station. When a needle of the RMI is driven by a VOR receiver, the needle indicates where the aircraft is radially with respect to the VOR station. The needle points the bearing TO the station as read on the azimuth card. The tail of the needle points to the radial of the VOR the aircraft is currently on or crossing. *Figure 9-5* indicates a heading of 360°, the MB to the station is 005°, and the MB from the station is 185°.



**Figure 9-4.** *Relative bearing (RB) on a movable-card indicator. By placing the aircraft's magnetic heading (MH) of 045° under the top index, the RB of 135° to the right is also the magnetic bearing (no wind conditions), which takes you to the transmitting station.*

**Figure 9-5.** *Radio magnetic indicator (RMI). Because the aircraft's magnetic heading (MH) is automatically changed, the relative bearing (RB), in this case 095°, indicates the magnetic bearing (095°) to the station (no wind conditions) and the MH that takes you there.*

***Function of ADF***

The ADF can be used to plot your position, track inbound and outbound, and intercept a bearing. These procedures

9-4

*Figure 11 - ADF presentations: fixed-card (top left), movable-card (top right), and Radio Magnetic Indicator/RMI (bottom). Note bearing pointer always points TO the station. Source: FAA-H-8083-15B, Chapter 9, Figures 9-3, 9-4, 9-5.*

ADF/NDB navigation is largely deprecated in U.S. airspace - most NDBs have been decommissioned - but the principle remains testable on the CFI-I checkride and is still encountered internationally. The CFI-I applicant must understand the bearing indicator presentations and the basic homing/tracking technique. *(IFH Ch.9, p.9-3 to 9-7; AIM 1-1-2)*

### NDB Operating Frequencies:

- LF/MF band: 190 to 535 kHz (well below the AM broadcast band)
- Identification: 1- or 2-letter Morse code (low-power) or 3-letter (compass locator)
- Subject to thunderstorm, terrain, and shoreline-effect errors not seen in VHF systems

### Bearing Indicator Math:

- **Relative Bearing (RB)**: angle from aircraft nose to station, clockwise
- **Magnetic Heading (MH)**: aircraft heading from compass/HI
- **Magnetic Bearing TO (MB)** = MH + RB (subtract 360 if > 360)
- On RMI: arrow points TO the station; tail indicates FROM
- Compass locator (LOM/LMM): low-power NDB used as IAF or holding fix on ILS

## 7. Area Navigation (RNAV) and Required Navigation Performance (RNP) (PTS Objective 2h)

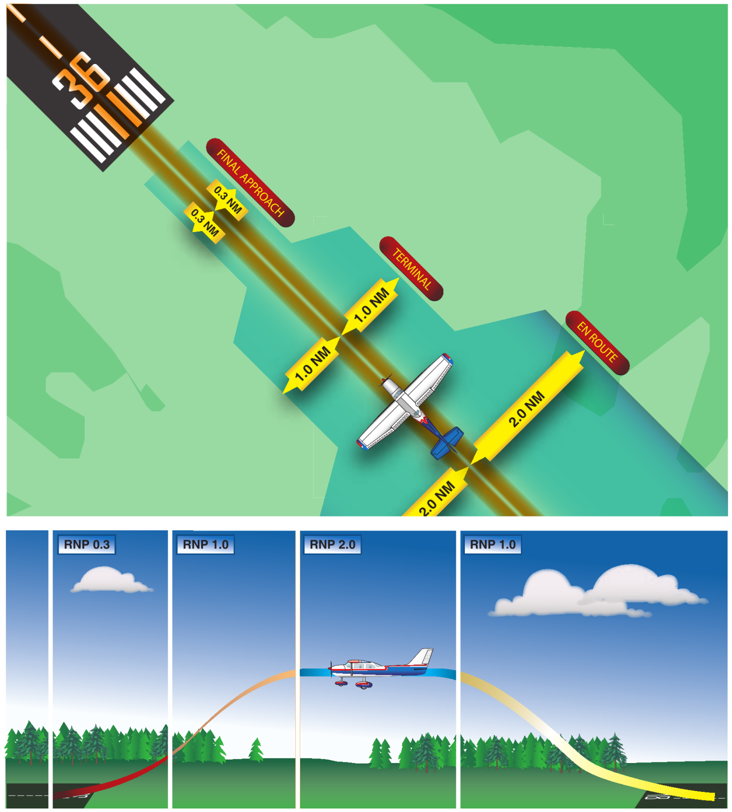


*Figure 12 - Required Navigation Performance corridors: Departure 1.0 NM / En Route 2.0 NM / Terminal 1.0 NM / Approach 0.3 NM. RNP value is the lateral containment the aircraft must achieve 95% of the time. Source: FAA-H-8083-15B, Chapter 9, Figure 9-41.*

**RNAV** is the broader category - any system that allows on-board computation of any flight path within sensor coverage. **RNP** is RNAV with on-board performance monitoring and alerting (PMA) - the aircraft tells the pilot when navigation accuracy is degraded below the required containment. *(IFH Ch.9, p.9-43; AC 90-100A; AC 90-105)*

### Performance-Based Navigation (PBN) Specifications:

- **RNAV 2**: ±2 NM (Q-routes, T-routes; en route)
- **RNAV 1**: ±1 NM (terminal, departure, arrival)
- **RNP 0.3**: ±0.3 NM lateral, applies to approach segment
- **RNP AR** (Authorization Required): below 0.3 down to 0.1 - special crew/equipment authorization

### RNAV(GPS) Approach Categories:

- RNAV(GPS) RWY 18 - the master plate; LPV/LNAV+V/LNAV/LP minima rows
- RNAV(RNP) RWY 18 - typically AR; tighter containment, special pilot training
- RNAV(VOR) - hybrid using GPS and VOR sensors - largely retired

> ***Instructor Note:*** *Most pilots refer to GPS approaches as 'GPS approaches' - the FAA terminology is RNAV(GPS) or RNAV(RNP). On the CFI-I checkride, use the FAA's terminology: 'RNAV (GPS) approach to runway 18 LPV minimums.' Precision in language signals precision in understanding. (AIM 5-4-5)*

## SECTION 3 - COMMON ERRORS: STUDENT AND CFI-I TEACHING ERRORS

| Common Error | How to Recognize It | How to Correct It |
|---|---|---|
| CFI-I confuses 'LPV' with 'precision approach' on chart briefing | Applicant briefs LPV as a 'precision approach' to evaluator; evaluator probes - applicant cannot explain APV vs precision distinction | Use FAA terminology: LPV is an APV (approach with vertical guidance) providing ILS-equivalent minimums but technically not classified as 'precision' under U.S. regulations. Drill with the applicant: 'LPV gives you 200 ft DA without an ILS. It is an APV. Say it three times.' Reference AIM 5-4-5 and AC 90-107. |
| Student fails to identify VOR by Morse code before navigating | Student tunes correct frequency, flag indicates TO, needle centers - student begins navigating without ID. Station is actually in maintenance with carrier on but no ID - bearings unreliable. | Mandate the call: 'Tuned, identified, monitored.' Every VOR navigation event begins with verifying the Morse code matches the chart. If Morse is absent or audio is dashes only, station is OFF the air for navigation - regardless of the flag. |
| Student does not check WAAS annunciator before FAF | On RNAV approach, student sees CDI active, follows it inbound. WAAS has dropped to LNAV mode. Student descends to LPV DA but the LNAV MDA is 300 ft higher. CFIT risk. | Drill the FAF check: 'Approach annunciator confirmed [LPV/LNAV/etc.], minimums [X], decision point [DA/MDA at Y].' This is a verbal callout, not a glance. Tie minimums to annunciation explicitly. AIM 1-1-18 and AC 90-107. |
| CFI-I cannot explain WAAS architecture without referring to the figure | Evaluator asks: 'Walk me through how a WAAS correction reaches the aircraft.' Applicant gives a vague answer about 'satellites talking to ground stations.' | Memorize the four-step sequence: WRS receives raw GPS - WMS computes corrections - GUS uplinks to GEO - GEO broadcasts to aircraft. Be able to draw this from memory. Reference IFH Fig. 9-29. The ability to teach the architecture is the test. |
| Student treats DME readout as ground distance (slant range error) | On a high-altitude DME arc, student's groundspeed reading drops to nearly zero passing nearest the station; student suspects equipment failure | Teach: DME measures slant range, NOT ground range. At 1 NM ground / 1,000 ft AGL the difference is negligible; high and close, error is significant. Also teach that DME-derived groundspeed reads zero passing overhead - it is geometric, not malfunction. IFH Ch.9, p.9-19. |
| CFI-I omits VOR receiver check log requirement (91.171) | Applicant teaches VOR navigation; evaluator asks 'When was the last VOR check on this aircraft and what's the tolerance?' Applicant unsure - cannot find the logbook entry. | Teach the 30-day check requirement, the four valid check types (VOT/ground/airborne/dual), and the tolerances (4/4/6/4 deg). Have the student physically locate the log entry on a real aircraft as part of the lesson. 91.171 is a regular checkride question. |
| Student intercepts glideslope from above and follows a false GS | On vectors-to-final, student is high. CDI captures GS at high intercept. Descent rate is 1,000+ fpm. Student follows it down. False GS at 6 deg. | Teach: ALWAYS intercept the GS from below at the published FAF altitude. If descent rate exceeds 700 fpm at approach speed, suspect false GS - go missed. Drill in the simulator with intentional high intercepts and false GS demonstrations. IFH Ch.9, p.9-42. |
| CFI-I does not understand the difference between LNAV+V and LNAV/VNAV minimums | On a chart with both rows, applicant briefs LNAV+V as the active minimum. Evaluator probes: 'Is the +V regulatory minimum?' Applicant answers incorrectly. | Teach: LNAV+V provides advisory vertical guidance with the LNAV MDA still applying as the regulatory minimum. LNAV/VNAV is a separate authorized vertical guidance minimum (DA). Different rows on the chart, different regulatory status. AIM 1-1-18; AC 90-107. |
| Student confuses VOR Original SSV with New SSV class designations | Chart shows '(VL)' next to a VORTAC. Student reads this as 'Low' (the original L class) and believes range is 40 NM at 18,000 ft - actually VL extends 70 NM at 5,000 ft. | Teach the new designations explicitly: T/L/H are the original SSVs; VL/VH are the new classes added 2020 to support VOR MON. The '(V)' prefix matters. Show the AIM Fig. 1-1-1 alongside Fig. 1-1-4 side by side. AIM 1-1-8. |

## SECTION 4 - COMPLETION STANDARDS (FAA-S-8081-9D, AREA II, TASK A)

The CFI-I applicant **EXHIBITS INSTRUCTIONAL KNOWLEDGE** of the following navigation equipment elements by explaining and demonstrating each to the evaluator as a teaching presentation.

### Completion Standard

| PTS Ref. | Standard |
|---|---|
| PTS Obj. 2a | Explains VOR signal generation (30 Hz reference vs. 30 Hz variable phase comparison), CDI interpretation including TO/FROM and reverse sensing, and the regulatory tolerances of the 91.171 receiver check (VOT/ground/airborne/dual ±4/4/6/4 deg). |
| PTS Obj. 2a | Distinguishes between Original (T/L/H) and New (VL/VH) Standard Service Volumes; correctly identifies usable range and altitude for each class given a charted VOR. Cites AIM 1-1-8. |
| PTS Obj. 2b | Describes DME operation including frequency pairing with VOR/ILS, slant range geometry, and the cases where slant range error is operationally significant. Explains why DME groundspeed reads zero passing overhead. |
| PTS Obj. 2c | Identifies all components of a complete ILS (LOC, GS, OM, MM, IM/Compass Locator), states their frequencies and modulation, and explains the false glideslope hazard with mitigation procedure. |
| PTS Obj. 2d | Distinguishes among ILS, LOC, LDA, and SDF approaches by signal characteristics and minima. Identifies a Compass Locator's role and frequency band. |
| PTS Obj. 2e | Explains ADF/NDB principles, Relative Bearing computation (MH + RB = MB to station), and presents on a fixed-card vs. movable-card vs. RMI indicator. Cites AIM 1-1-2. |

### Completion Standard (continued)

| PTS Ref. | Standard |
|---|---|
| PTS Obj. 2f | Describes GPS architecture (Space/Control/User segments), the necessity of 4 satellites for solution + clock correction, the role of RAIM in non-WAAS GPS operation, and the requirement for a current 28-day NavData cycle. |
| PTS Obj. 2g | Diagrams the WAAS architecture sequence (WRS → WMS → GUS → GEO → aircraft), explains how WAAS provides integrity (replacing RAIM for WAAS-capable receivers), and articulates the difference between LPV, LNAV/VNAV, LNAV+V, LP, and LNAV minima. |
| PTS Obj. 2g | Demonstrates correct response to WAAS approach mode downgrade (e.g., LPV→LNAV) during an active approach: revert to the annunciated minimum or execute missed approach. Cites AIM 1-1-18 and AC 90-107. |
| PTS Obj. 2h | Explains RNAV vs. RNP distinction (PMA capability) and identifies the four standard RNP corridors (Departure 1.0 / En Route 2.0 / Terminal 1.0 / Approach 0.3 NM). Cites AC 90-100A. |
| PTS Obj. 2i | Identifies the equipment installed in the checkride aircraft - sensor types, TSO certification, AFMS approach approval, database currency. Performs a real receiver check or RAIM check and logs it correctly per 91.171. |

***Instructor Note:*** *An applicant who can recite all eleven standards above but cannot articulate the analog-electronic signal architecture of WAAS or the geometric reasoning behind slant range error has not met the instructional knowledge standard. The evaluator will not accept memorized answers - calibrate teaching to the Analysis level (Bloom's). (AIH Ch.4 - Assessment; AIH Ch.2 - Levels of Learning)*

## SECTION 5 - REVIEW QUESTIONS & ANSWERS

| | |
|---|---|
| **Q1. How does a VOR generate radial information? Walk me through the signal physics.** | A: The VOR transmits two 30 Hz signals from the same antenna. The first is a REFERENCE signal with constant phase, broadcast omnidirectionally and frequency-modulated on a 9,960 Hz subcarrier. The second is a VARIABLE signal whose phase rotates around the station 30 times per second, amplitude-modulated. At magnetic North from the station, the two signals are in phase. As you move clockwise around the station, the variable signal's phase lags the reference proportionally to your radial. The receiver compares the two phases and displays the radial. 360 unique radials result, one per degree. *(IFH Ch.9, p.9-7)* |
| **Q2. A student is on an RNAV(GPS) approach with WAAS. After the FAF the annunciator changes from LPV to LNAV. The student is at the LPV decision altitude. What do you teach them to do?** | A: Immediately apply the LNAV minimums (MDA) on the same chart - this is typically 200-300 ft above the LPV DA. If the aircraft can level off at the LNAV MDA in time and continue the approach as a non-precision (no vertical guidance), do so - using altimeter and DME or distance-to-WP for step-down monitoring. If level-off is not possible (already below LNAV MDA), execute the missed approach immediately. The teaching point: WAAS minimums are tied to the ANNUNCIATION, not the briefing. A change in annunciation during the approach changes your applicable minimum. *(AIM 1-1-18; AC 90-107)* |
| **Q3. Explain the four major errors that affect VOR accuracy and the regulatory tolerances for the 91.171 receiver check.** | A: Errors: (1) Site error - structures or terrain near the transmitter - small, predictable. (2) Course scalloping - reflections from terrain cause needle oscillation, mostly mountains. (3) Cone of confusion - signal unreliable directly overhead, ~60-90 sec at typical speeds. (4) Bearing error from the receiver itself - small but accumulating. Regulatory tolerances from 91.171: VOT signal ±4 deg; published ground checkpoint ±4 deg; published airborne checkpoint ±6 deg; dual VOR cross-check ±4 deg between receivers. Check required within preceding 30 days for IFR ops; logbook entry required - date, place, error, signature. *(IFH Ch.9, p.9-13; 14 CFR 91.171)* |
| **Q4. What is the difference between an LPV approach and an LNAV/VNAV approach? Why does LPV typically have lower minimums?** | A: Both are vertically-guided RNAV approaches requiring WAAS (LNAV/VNAV can also use baro-VNAV). The key difference is in vertical guidance geometry: LPV provides ANGULAR vertical guidance - the deviation needle is sensitive to fractions of a degree from the published glidepath, like an ILS. LNAV/VNAV provides LINEAR vertical guidance - constant width regardless of distance. Angular sensitivity tightens as you near the runway, so the receiver knows your altitude with high precision near the DA. This is why LPV minimums can go as low as 200 ft AGL (ILS-equivalent), while LNAV/VNAV minimums are typically 350-500 ft AGL. *(AIM 1-1-18; AC 90-107)* |

| | |
|---|---|
| **Q5. Walk me through how a WAAS correction message is generated and reaches the aircraft.** | A: Four steps. (1) Wide Area Reference Stations (WRS) - approximately 38 sites across CONUS, Alaska, Hawaii, Canada, Mexico - continuously receive raw GPS signals. (2) The data is forwarded to one of two Wide Area Master Stations (WMS) which compute ionospheric, ephemeris, and clock corrections plus integrity bounds for each satellite. (3) Corrections are uplinked from Ground Uplink Stations (GUS) to geostationary (GEO) satellites. (4) GEO satellites broadcast the WAAS message on the same L1 frequency that GPS uses, where any WAAS-capable receiver applies the corrections to its position solution. End-to-end latency is approximately 6 seconds. Result: typical horizontal accuracy under 1 meter, vertical under 1.5 meters, with cryptographic integrity assurance suitable for vertical guidance operations. *(IFH Ch.9, p.9-30 to 9-33; AIM 1-1-18)* |
| **Q6. The DME readout passing directly over the station shows 5.8 NM. The aircraft altitude is 35,000 ft. Is the DME malfunctioning?** | A: No - this is normal. DME measures slant range distance, not ground distance. Directly above the station, slant range equals altitude in nautical miles. 35,000 ft = 5.76 NM. The DME is reading correctly. Additionally, the DME-derived groundspeed will read near zero or fluctuate wildly passing overhead because the rate of change of slant range distance is essentially zero at the closest point of approach. This is geometric reality, not equipment failure. Teach the student to expect this and not to chase the readings overhead. *(IFH Ch.9, p.9-19)* |
| **Q7. What is RAIM, when is it required, and what is RAIM availability prediction?** | A: RAIM = Receiver Autonomous Integrity Monitoring. It is the GPS receiver's ability to cross-check satellites against each other to detect a 'rogue' satellite providing erroneous data. RAIM requires at least 5 satellites in view with adequate geometry; 6 satellites enable Fault Detection and Exclusion (FDE). For non-WAAS IFR GPS operations, RAIM availability must be CONFIRMED before flight via online tools (FAA's NOTAM/RAIM prediction) and re-checked before the FAF. For WAAS-capable receivers operating within WAAS coverage, RAIM is replaced by the WAAS integrity message - no separate RAIM check is required. RAIM hole = predicted unavailability due to satellite geometry; pilots may need to delay approach or use an alternate procedure. *(AIM 1-1-17, 1-1-18; AC 90-100A)* |
| **Q8. What is the false glideslope, why does it occur, and how do you teach a student to avoid it?** | A: The glideslope antenna radiates a primary 3 deg lobe plus secondary lobes at approximately 6 deg, 9 deg, and 12 deg. A pilot intercepting the GS from ABOVE the published FAF altitude can capture a false 6 deg lobe. The CDI shows centered glideslope, but descent rate is roughly twice normal (~1,000 fpm at approach speed instead of ~500). By the time the deception is recognized, the aircraft can be substantially below the safe approach profile - a classic CFIT cause. Teaching: ALWAYS intercept the glideslope from BELOW at the published FAF altitude, never from above. Verify intercept by cross-checking VSI against expected descent rate (~5x airspeed in tens for a 3 deg glide path: 90 KIAS = 450 fpm). If descent rate exceeds 700 fpm at approach speed, suspect false GS - apply missed approach. *(IFH Ch.9, p.9-42; FAA InFO 16012)* |

| | |
|---|---|
| **Q9. Compare the original VOR Service Volumes (T, L, H) with the new (VL, VH) classes. When did the new classes come into use, and why?** | A: Original SSVs (Terminal, Low, High) were defined when the U.S. VOR network had ~1,000+ ground stations - sufficient density that an aircraft below the High volume's lower edge could rely on a nearby Low or Terminal station. T = 25 NM up to 12,000 ft; L = 40 NM up to 18,000 ft; H = 100-130 NM extending to 60,000 ft. The FAA began VOR MON (Minimum Operational Network) decommissioning around 2016, retiring approximately half of the legacy VORs as GPS became primary. The new VL and VH classes were added in 2020 to provide extended low-altitude reach: VL = 70 NM at 5,000 ft AGL; VH = 70 NM at 14,500 ft AGL extending to 100 NM at 45,000 ft. These are the backbone of the 2025+ MON network. On charts, look for the '(V)' prefix to distinguish. *(AIM 1-1-8; FAA Order 1100.161)* |

## SECTION 6 - LESSON SIGN-OFF

I certify that the above-named CFI-I applicant has received ground instruction in Area of Operation II, Task A - Aircraft Flight Instruments and Navigation Equipment (Section 2: Navigation Equipment) in accordance with FAA-S-8081-9D and has demonstrated instructional knowledge sufficient to teach instrument students on all navigation equipment objective elements listed.

| Instructor Signature / Certificate Number | Date | Applicant Signature | Date |
|---|---|---|---|

*EGH Aviation - CFI-Instrument Binder | Area II Task A (Section 2) | FAA-S-8081-9D | References: FAA-H-8083-15B Chapter 9; AIM Sections 1-1-3 through 1-1-18 | This lesson plan is for instructional use only and does not supersede current FAA publications.*