GPS for IFR Operations

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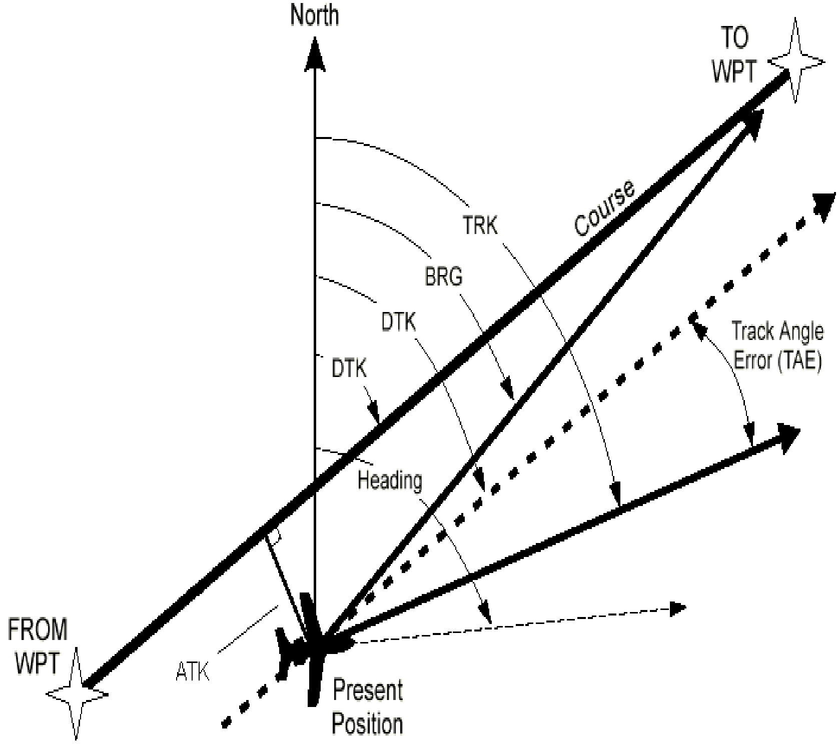
GPS for IFR Operations

- GPS Terminology
- GPS Navigation Terminology
- GPS Approaches
  - LNAV, LNAV/VNAV, LPV
- RAIM and WAAS
- Introducing the Avidyne IFD440 and Garmin 430W

GPS Terminology

- GPS – Global Positioning System
- RNAV – Area Navigation
  - A method of navigation that permits aircraft operation on any desired course within the coverage of station-referenced navigation signals or within the limits of a self contained system capability, or a combination of these.
  - Includes VOR/DME, TACAN/DME, LORAN C (phased out in February 2010), GPS, OMEGA (no longer in use) and self contained Inertial Navigation Systems (INS) or Inertial Reference Systems (IRS).
- WAYPOINT – A waypoint is a saved set of coordinates, LAT/LON
- GOTO or DIRECT– calculates the direction and distance from your actual location to the set of coordinates, represented by the indicated waypoint.
- BEARING – The GPS will continuously calculate which direction that waypoint is situated, seen from your actual position. The bearing will fluctuate all the time, if not traveling in a straight line.
- RAIM – Receiver autonomous integrity monitoring
- WAAS – Wide Area Augmentation System

GPS Navigation Terminology



Route Leg: Straight line between two waypoints, also know as course

ATK: Along Track Deviation

Distance of the aircraft from course

BRG: Bearing.

Direction to Waypoint

DTK: Desired Track.

Course Direction (between waypoints)

GS: Ground Speed

HDG: Heading.

The direction the aircraft is pointed

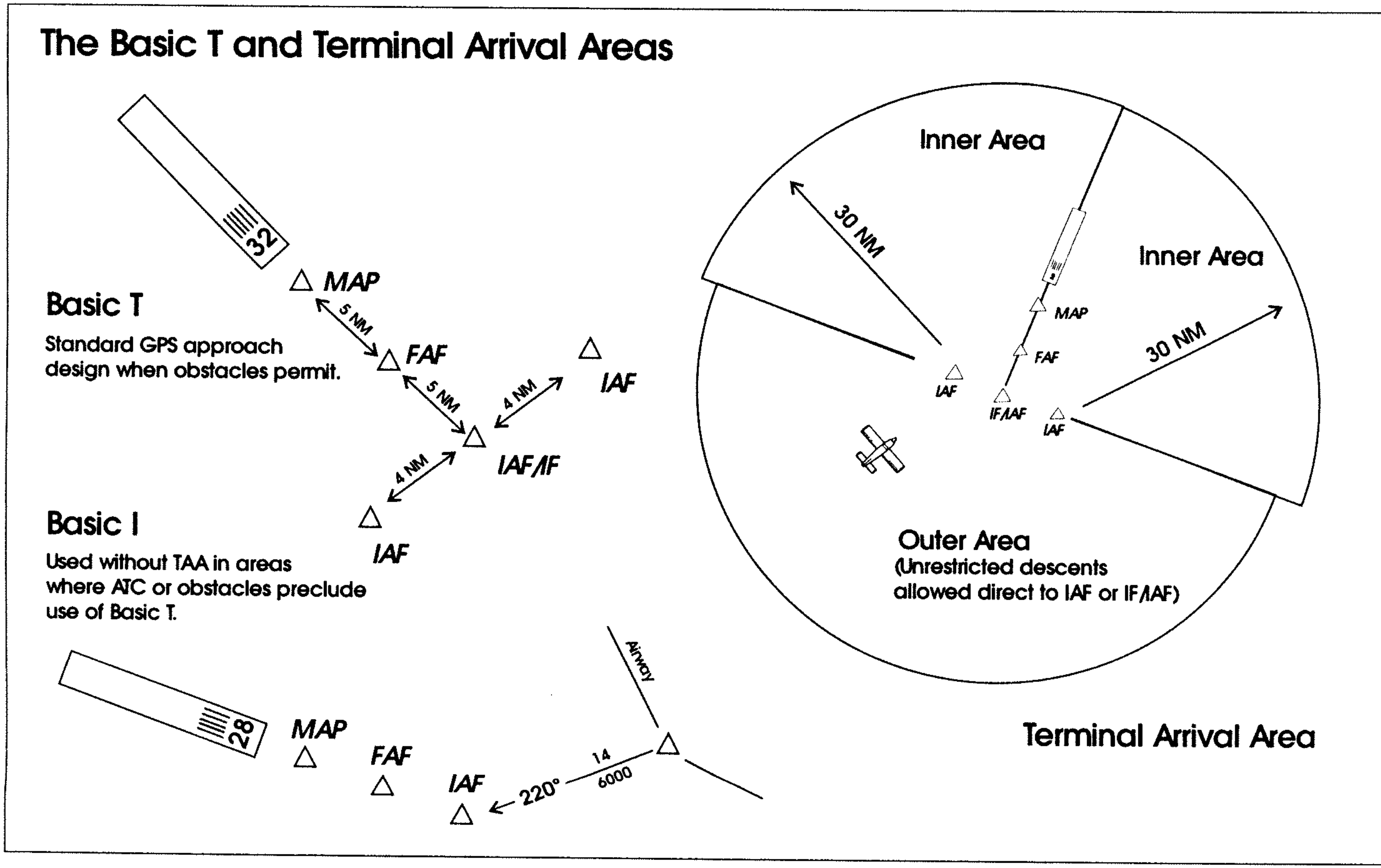
TAE: Track Angle Error

Difference between DTK and TRK

TRK:Track.

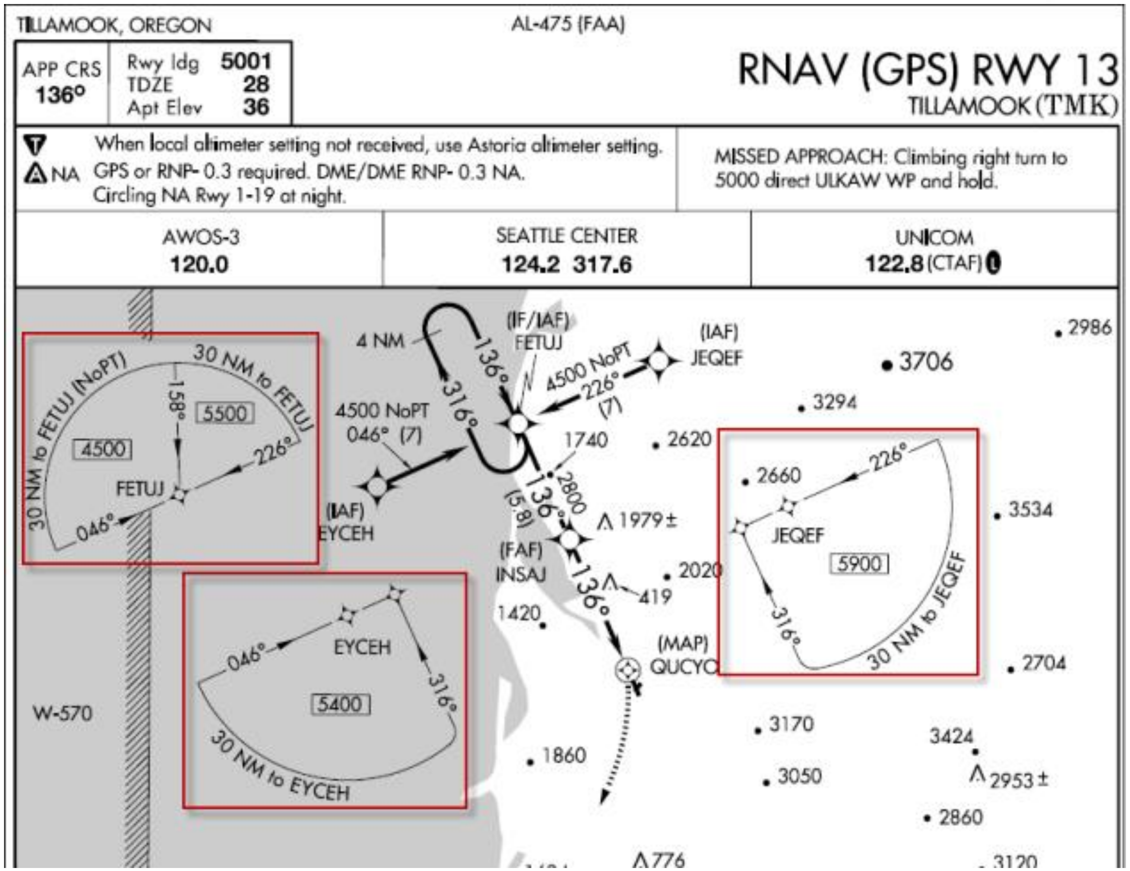
The direction the aircraft is actually going

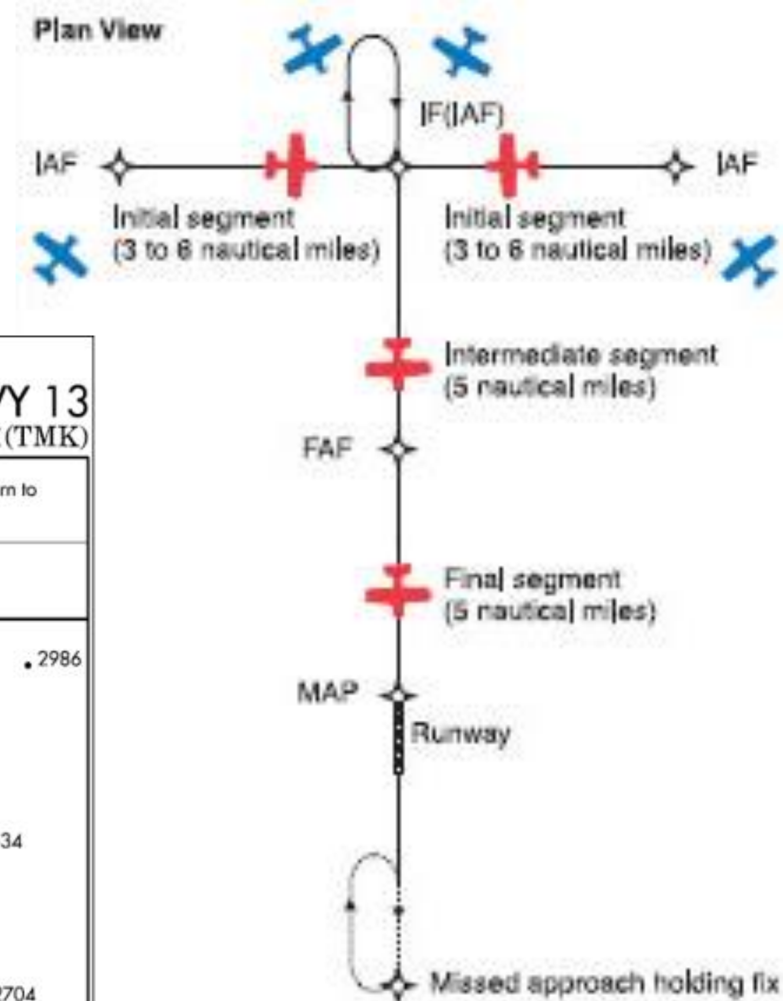
Basic T Approach Design



TERPS – FAA Terminal Instrument Procedures and Design

Basic T with TAA





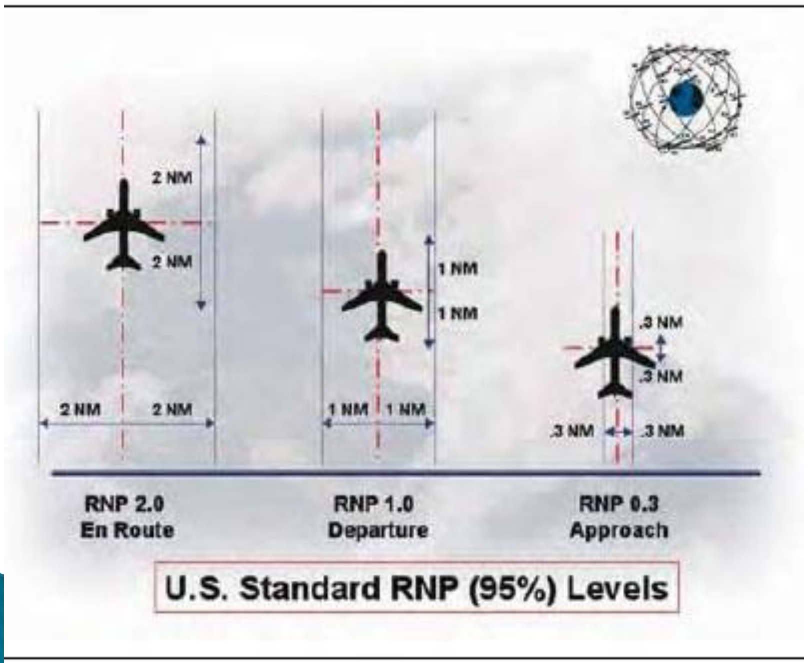
TAA- Terminal Arrival Area begins to replace MSA – Minimum Safe Altitude and has NoPT

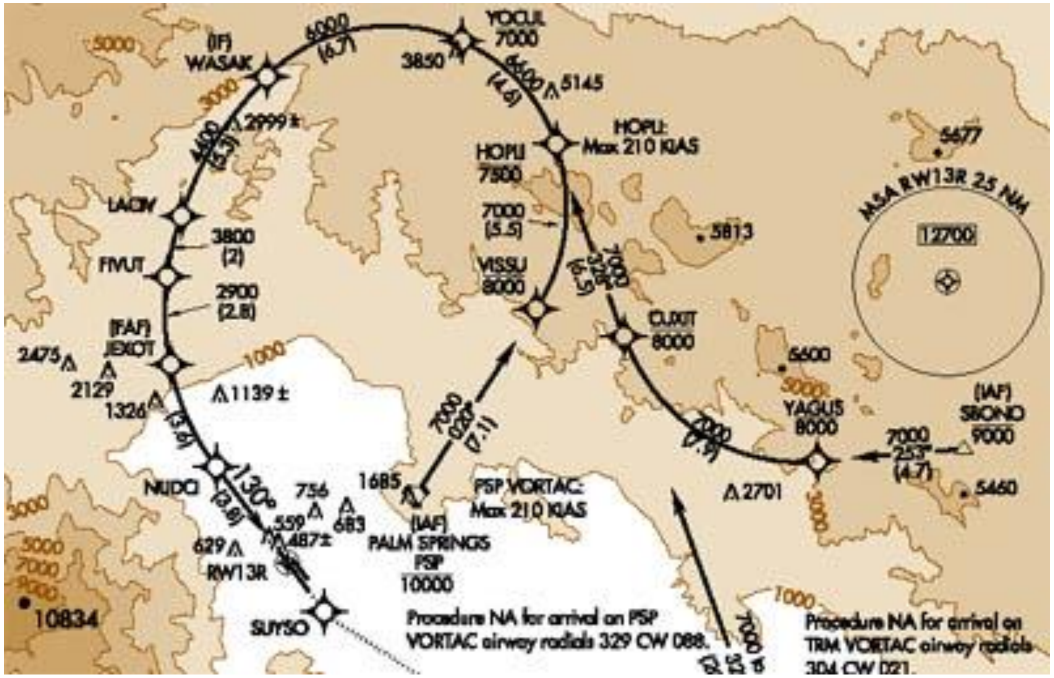
GPS Substitution for Navaids

- IFR GPS needs to be certified for En-route and Terminal Operations
- It can be used as a substitute for DME, ADF, VOR
  - In Lieu of DME: DME Fix, Arcs
  - In Lieu of ADF, VOR
  - Properly installed equipment, POH/AFM Supplement
  - The required integrity for these operations must be provided by at least en route RAIM, or equivalent.
  - Waypoints, fixes, intersections, and facility locations in GPS database
  - The database must be current.

GPS RNP

- RNP – Required Navigation Performance, each RNP standard applies to airspace, routes, and procedures
- RNP levels of 0.3, 1.0 and 2.0 are outlined in AIM.





GPS Scaling Sensitivity

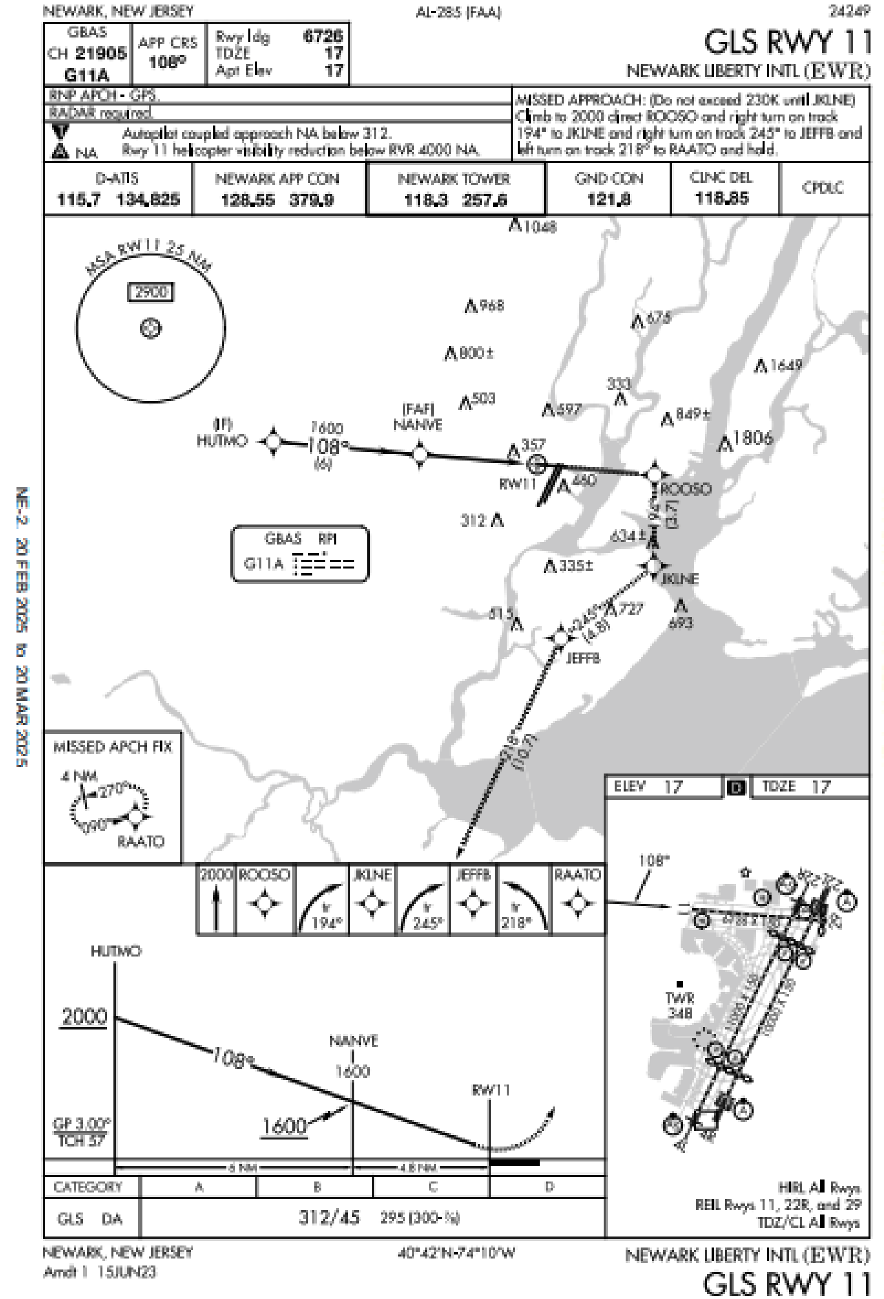
- **En-route Mode**
  - More than 30 NM from Airport
  - ± 5 NM CDI Scale Sensitivity
- **Terminal Mode**
  - Less than 30 NM from Airport
  - ± 1 NM CDI Scale Sensitivity
- **Approach Mode**
  - Less than 2 NM from Final Approach Fix
  - Established on course
  - Adequate RAIM
  - ± 0.30 NM CDI Scale Sensitivity

Types of RNAV GPS Approaches

- NPA – Non-precision approaches
  - LNAV with MDA
  - GPS Overlay approaches
  - GPS Standalone approaches RNAV (GPS) Rwy 23
- APV – Approach with Vertical Guidance
  - LNAV/VNAV
  - LPV
- PA – Precision approaches
  - Use of WAAS
  - LAAS (Local Area Augmentation System)
  - Ground-based Augmentation Systems (GBAS)
  - GLS (GBAS Landing System)

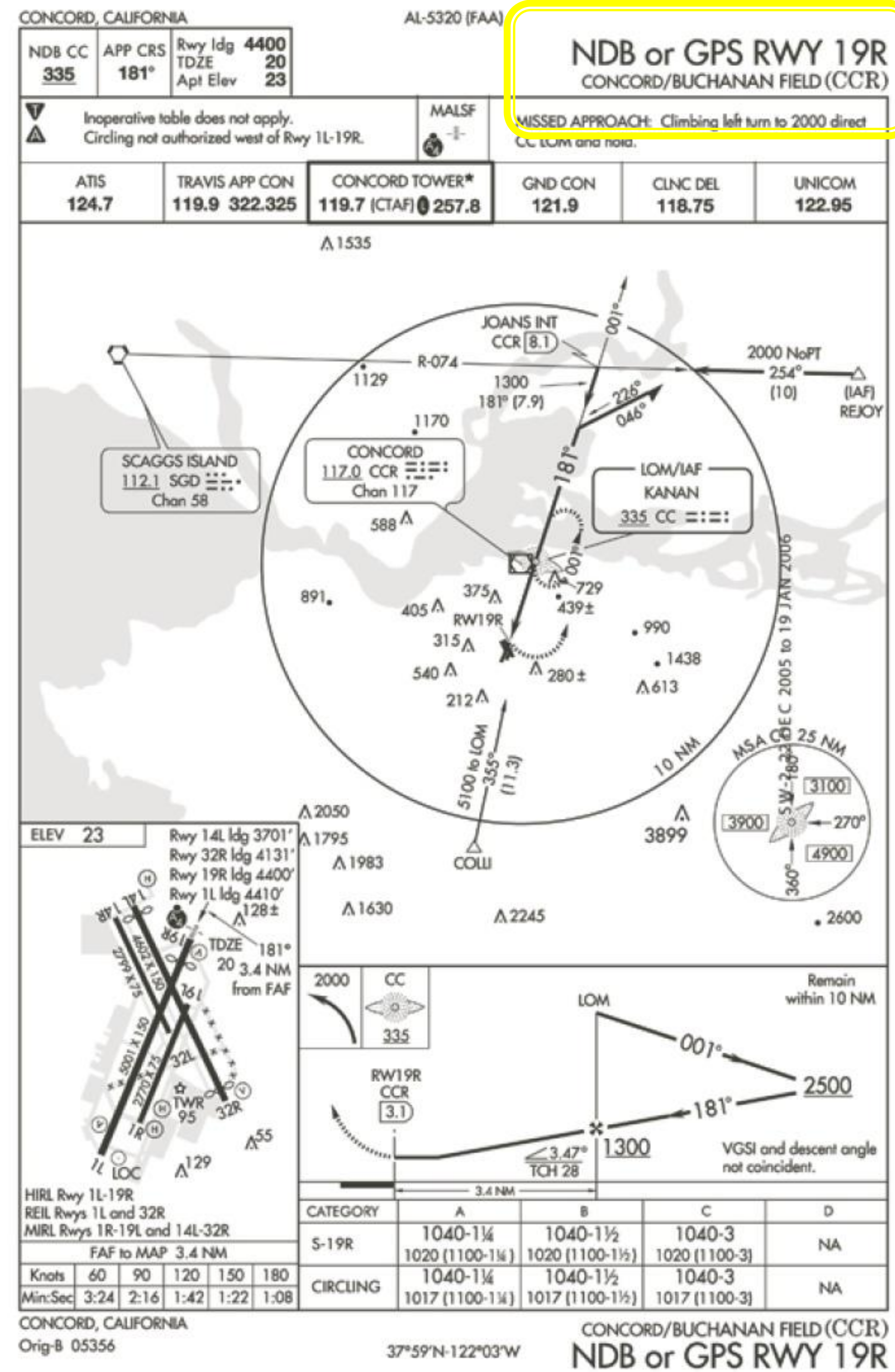
GLS Approach

- A GLS or GBAS Landing System is a Global Navigation Satellite System-dependent alternative to Instrument Landing System (ILS) which uses a single GBAS airport ground station to transmit corrected GNSS data to suitably-equipped aircraft to enable them to fly a precision approach with much greater flexibility.



GPS Overlay Approach

- GPS overlay program authorize pilots to fly non-precision approaches based on conventional nav aids such as LOC, LDA, SDF, NDB
  - The words "GPS" are found in title
  - *Note: When using GPS for navigation and approaches, any required alternate airport must have an approved operational approach procedure other than GPS.*



Three types of GPS Approaches

LNAV: Lateral Navigation

- The typical non-precision GPS approach minimums without WAAS capability
- Most restrictive minimums

LNAV/VNAV: Lateral Navigation + Vertical Navigation

- Non precision GPS approach minimums
- No WAAS capability needed. On board (FMS) equipment that satisfies TSO C129a
- Less restrictive than LNAV minimums

LPV: Localizer Precision with Vertical guidance

- Lateral Performance with Vertical Guidance
- GPS based precision approach that uses WAAS capability
- Minimums comparable to Cat I ILS

GPS Equipment Required

- RAIM – Receiver autonomous integrity monitoring (RAIM) is a technology developed to assess the integrity of global positioning system (GPS) signals in a GPS receiver system
- External Annunciators and CDI
- Navigational Database
  - Must be a current IFR nav database

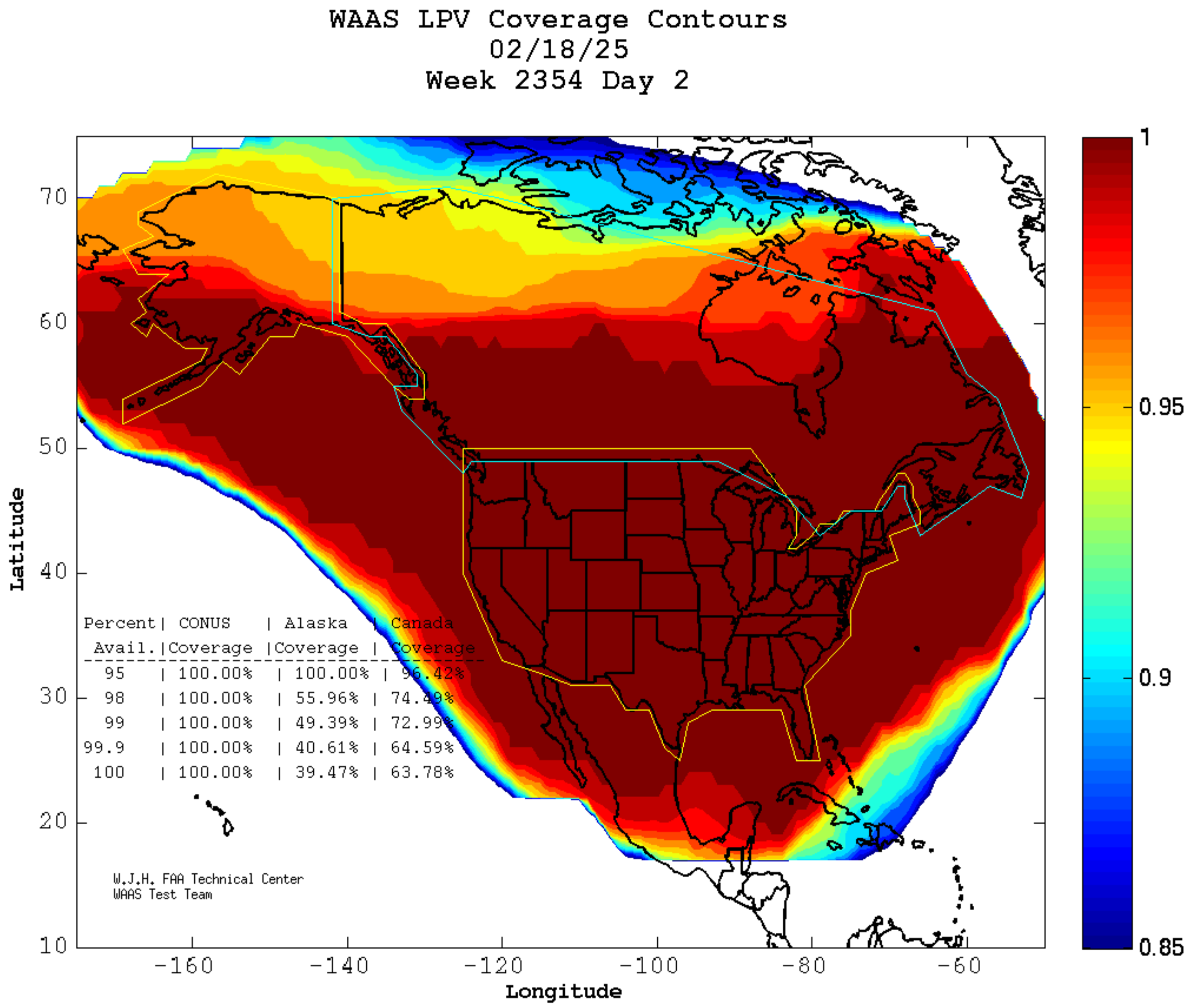
RAIM Explained

- The GPS receiver verifies the integrity (usability) of the signals received from the GPS constellation through Receiver Autonomous Integrity Monitoring (RAIM) to determine if a satellite is providing corrupted information.
  - A minimum of five satellites in view, or four satellites and a barometric altimeter baro-aiding to <u>detect an integrity anomaly</u>.
  - Six satellites in view (or five satellites with baro-aiding) to <u>isolate a corrupt satellite signal and remove it from the navigation solution</u>.
- Two types of RAIM messages
  - There are not enough satellites available to provide RAIM
  - RAIM has detected a potential error that exceeds the limit for the current phase of flight.
- Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position.

Wide Area Augmentation System (WAAS)

- Improves the accuracy (+/- 7 meters Horizontally & Vertically), integrity, and availability of GPS signals.
- Allows GPS to be used, as the aviation navigation system, from takeoff through Category I precision approaches with glide path guidance
- Covers more extensive service area than ground based aids
- Signals from the GPS satellites are monitored by these stations to determine satellite clock and ephemeris corrections. Each station in the network relays the data to a wide-area master station where the correction information is computed. A correction message is prepared and uplinked to a geostationary satellite (GEO) via a ground uplink and then broadcast on the same frequency as GPS to WAAS receivers within the broadcast coverage area.
- WAAS provides an additional measurement to the aircraft receiver; effectively an additional GPS satellite.
- FAA has completed installation of 25 wide area ground reference systems, two master stations, and four ground uplink stations

WAAS LPV Coverage



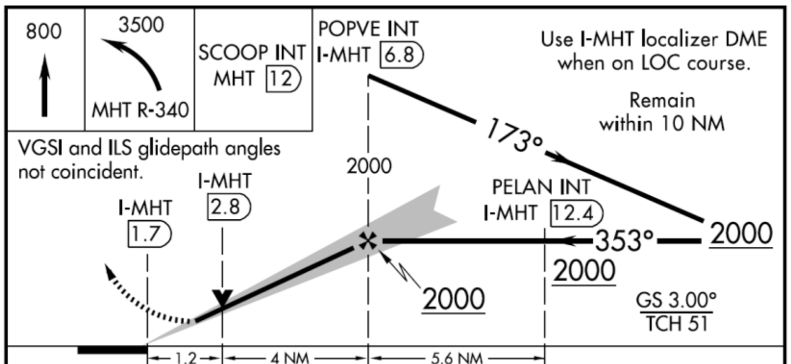
Approach Minimum Equipment

- How low can you go? Depends on your GPS equipment…

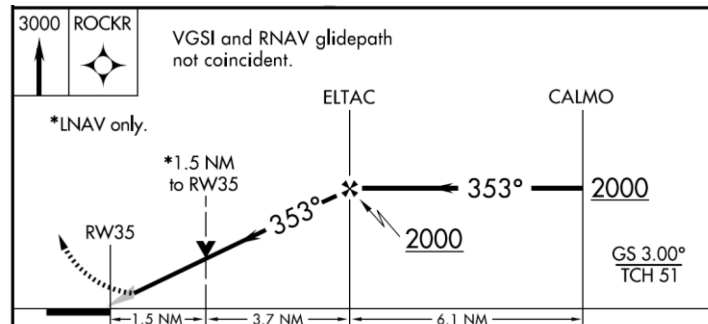
Types of GPS equipment req'd
WAAS
WAAS, Baro-GPS
WAAS or Baro-RNAV (GPS) or GPS
" " " "

CATEGORY	A	B	C	D	E
LPV DA	296/40 250 (300 - 3/4)				
LNAV/ VNAV DA	500/50 454 (500 - 1)				
LNAV MDA	640/40 594 (600 - 3/4)		640/50 594 (600 - 1)	640/60 594 (600 - 1 1/4)	640 - 1 1/2 594 (600 - 1 1/2)
CIRCLING	640-1 1/2 594 (600 - 1 1/2)			640-2 594 (600-2)	740/2 1/2 694 (700 - 2 1/2)

KMHT: ILS 35 and RNAV (GPS) 35



CATEGORY	A	B	C	D
S-ILS 35	465/18 200 (200-½)			
S-LOC 35	700/24 435 (500-½)		700/40 435 (500-¾)	700/50 435 (500-1)
CIRCLING	880-1 614 (700-1)		880-1¾ 614 (700-1¾)	880-2 614 (700-2)



CATEGORY	A	B	C	D
LPV DA	465/24 200 (200-1)			
LNAV/VNAV DA	739/60 474 (500-1¼)			
LNAV MDA	820/24 555 (600-½)		820/50 555 (600-1)	820/60 555 (600-1¼)
CIRCLING	880-1 614 (700-1)		880-1¾ 614 (700-1¾)	900-2 634 (700-2)

ILS 35

RNAV GPS 35

Handling Course Reversals

- LEG Mode:
  - GPS is sequencing from waypoint to waypoint
  - CDI Dial is “resolver less”. e.g. Localizer
- OBS Mode
  - GPS sequencing paused
  - CDI Dial is “resolver” CRS/OBS knob needs to be moved
- Manual Course Reversal
  - GPS Sequencing Stopped, course reversal completed, sequencing resumed
  - Example: KLN 89B systems
- Semi Automatic
  - GPS Prompts you whether a course reversal is required
  - Example: Garmin GNS 430, G1000 systems
- Automatic
  - GPS decides if course reversal is necessary depending on direction from Initial Approach Fix

Avidyne IFD440 Receiver

- IFD440 is a GPS/Nav/Comm solution with VOR/ILS and GPS Enroute and Approach Modes
- Touch Screen with Enhanced Situational Awareness

Garmin GNS430W Receiver

- GNS 430W is an all-in-one GPS/Nav/Comm solution with VOR/ILS and GPS Enroute and Approach Modes
- Enhance Situational Awareness and Autopilot Coupling

GPS Switchology for Dummies

- Outer Knob
  - Analogous to Space Bar or Tab Keys on qwerty keyboards
  - Changes MHz frequencies integers
- Inner Knob
  - Analogous to letter/number keys on the qwerty keyboards
  - Changes MHz frequencies decimals
  - Press to change between NAV and COM frequencies (Integrated GPS COM units e.g. GNS 430)
- Cursor Activation
  - GPS need to be told when we need to enter data
  - King: CRSR, Garmin: FMS Button, Press Inner Knob
- Clear Key
  - Analogous to Backspace/Delete keys on qwerty keyboards
  - Press & hold to go back to home screen on some units
- Range Key
  - Changes scaling of display

GPS Approach Tutorials

- **GPS WAAS**

  http://www.youtube.com/watch?v=kRQT9eybjao

  http://www.youtube.com/watch?v=MUcFDTs1dbw&feature=plcp

  http://www.youtube.com/watch?v=wDHNE_yBzuU&feature=plcp

  Flying LPV Approach with Garmin WAAS GPS 530W

  http://www.youtube.com/watch?v=KEHiXPaRH74&feature=related

  WAAS Approaches: Garmin G1000

  http://www.youtube.com/watch?v=uAu70e1BqV4&feature=relmfu

  Garmin 530 GPS Tutorial

  http://www.youtube.com/watch?v=rMGx_DFkWps&feature=related