Part 2
Stabilized Instrument Approach & Landing

RNAV(GPS) Approaches

Presented to: National Capital Wing, Civil Air Patrol

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Purpose

- **After this presentation, you should understand:**
  - “Practice makes perfect”
  - GPS avionics and WAAS performance
  - Flight planning for RNAV(GPS) approaches
  - Flying RNAV(GPS) approaches and common errors
  - GPS and WAAS lines of minima

Practice makes perfect

- **“Stabilized” approach**
- **Achieved through currency**
  - Radio calls…know what you’re going to say
    - Check ATIS or ASOS/AWOS
    - Decide the number of approaches and sequence
    - Know how each approach will terminate
    - If VFR, clarify the request for “practice” instrument approaches
  - CFII or Safety pilot (§ 91.109)
- **Maintain situational awareness**
  - Tips offered in AC 61-134 “General Aviation Controlled Flight Into Terrain Awareness”

GPS Avionics Review

- **What's currently approved (AIM, TBL 1-1-6)**

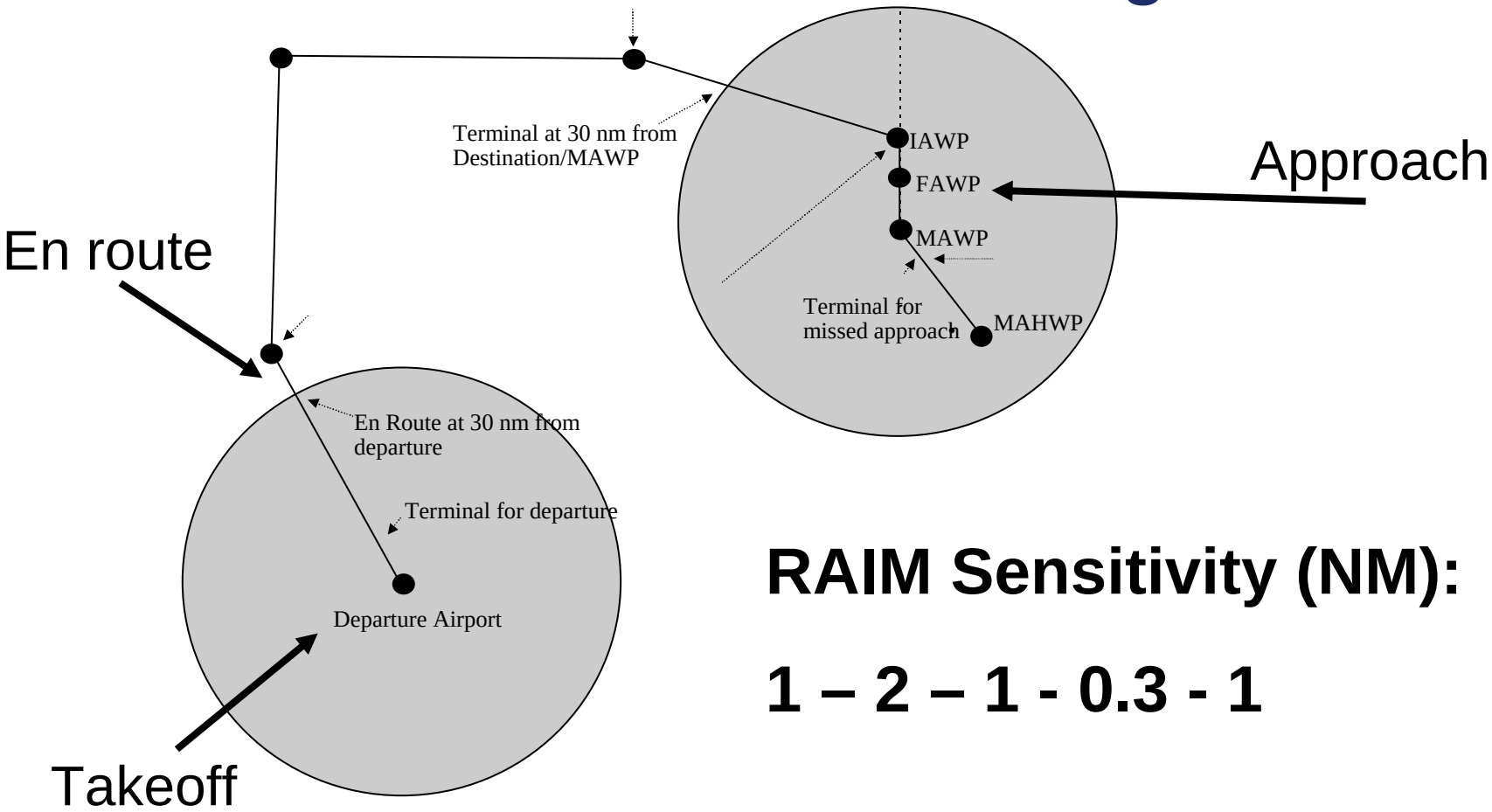
GPS Approval Required/Authorized Use

Equipment Type[1]	Installation Approval Required	Operational Approval Required	IFR En Route[2]	IFR Terminal[2]	IFR Approach[3]	Oceanic Remote	In Lieu of ADF and/or DME[3]
Hand held[4]	X[5]						
VFR Panel Mount[4]	X						
IFR En Route and Terminal	X	X	X	X			X
IFR Oceanic/ Remote	X	X	X	X		X	X
IFR En Route, Terminal, and Approach	X	X	X	X	X		X

What is covered under TSO-C129a?

- **IFR approach-certified TSO-C129a receiver always performing RAIM calculations**
- **Predictive NPA capability available ETA ± 15 minutes**
  - Requirement for predicting approach-RAIM is not new
  - RAIM not required for conventional operations using navaids
    - Aircraft “must have other approved navigation equipment installed and operating appropriate to the route of flight”
- **If primarily using GPS for new RNAV 1 & RNAV 2 procedures, must ensure RAIM availability**
- **Receiver en route/terminal predictive RAIM capability not required by TSO since original intent was supplemental navigation**

TSO-C129a GPS Mode Switching



RAIM Sensitivity (NM):

1 – 2 – 1 - 0.3 - 1

Avionics Review

17 JAN 2008 to 14 FEB 2008

RNAV minimums are dependent on navigation equipment capability, as stated in the applicable AFM, AFMS, or other FAA approved document, and as outlined below.

GLS (GLobal Navigation Satellite System (GNSS) Landing System)

The GLS (NA) minima line will be removed from existing RNAV (GPS) approach charts when LPV minima is published.

LPV (An Approach Procedure with Vertical Guidance (APV) based on WAAS lateral and vertical guidance)

Must have WAAS avionics approved for LPV approach.

LNAV/VNAV (Lateral navigation/Vertical navigation)

Must have either:

a.) WAAS avionics approved for LNAV/VNAV approach, or

b.) A certified Baro-VNAV system with an IFR approach approved GPS,or

c.) A certified Baro-VNAV system with an IFR approach approved WAAS, or

d.) An approach certified RNP-0.3 system with barometric vertical guidance (Baro-VNAV).

Other RNAV systems require special approval.

NOTES:

1. LNAV-VNAV minima not applicable for Baro-VNAV equipment if chart is annotated "Baro-VNAV NA" or when below the minimum published temperature, e.g., Baro-VNAV NA below -17° C(2° F).
2. DME/DME based RNP-0.3 systems may be used only when a chart note indicates DME/DME availability; e.g., "DME/DME RNP-0.3 Authorized." Specific DME facilities may be required; e.g., "DME/DME RNP-0.3 Authorized. ABC, XYZ required."

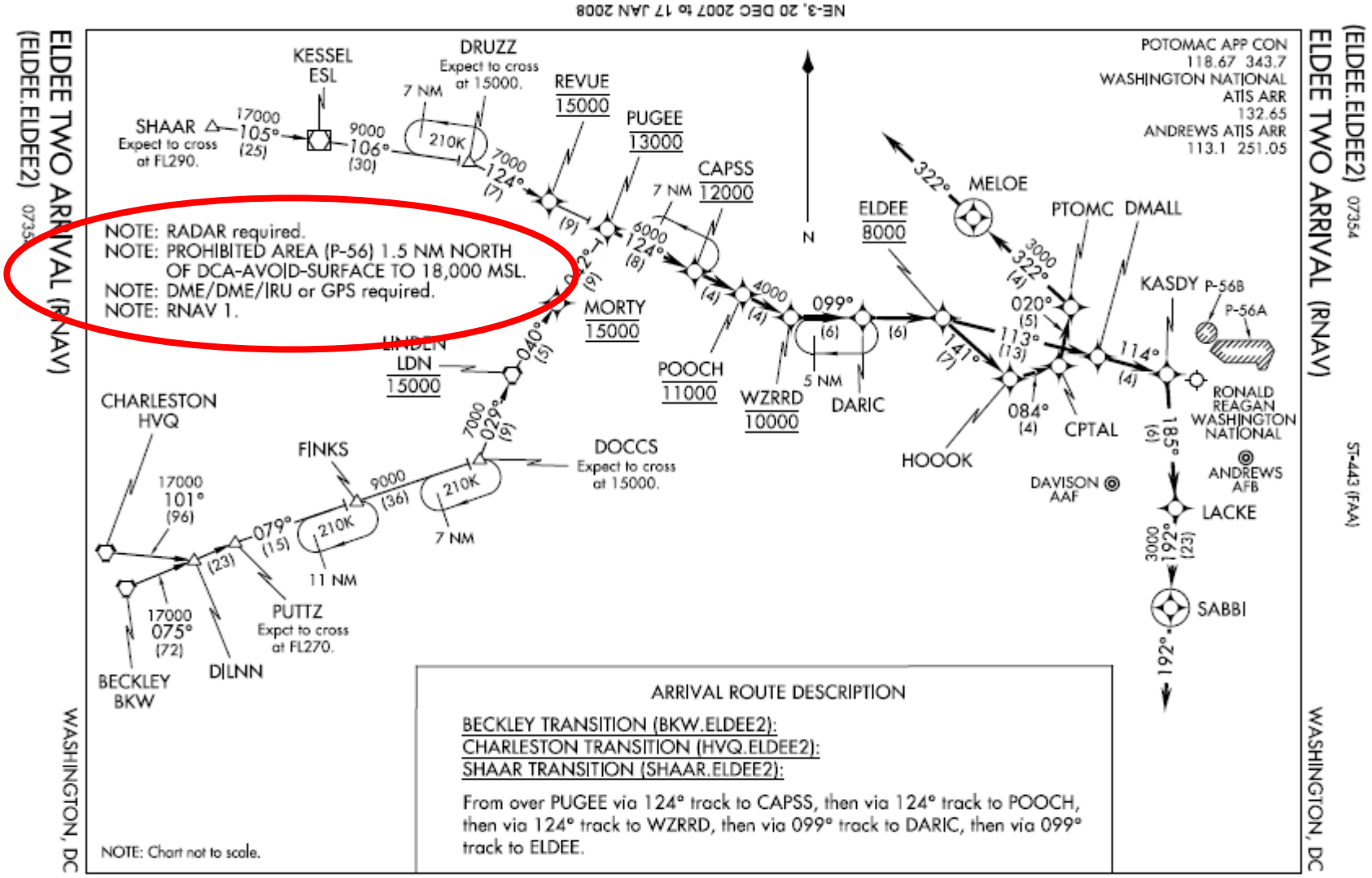
LNAV (Lateral navigation)

Must have IFR approach approved GPS, WAAS, or RNP-0.3 system.Other RNAV systems require special approval.

NOTE: DME/DME based RNP-0.3 systems may be used only when a chart note indicates DME/DME availability; e.g., "DME/DME RNP-0.3 Authorized." Specific DME facilities may be required; e.g., "DME/DME RNP-0.3 Authorized. ABC, XYZ required."

17 JAN 2008 to 14 FEB 2008

Why is it important to you as a pilot?



WAAS Overview

- **US version of the global Satellite Based Augmentation System (SBAS)**
- **WAAS augments the GPS signal in space to provide**
  - Integrity improvement - real time monitoring
  - Accuracy improvement - differential corrections
  - Availability improvement – additional ranging signals

Increased availability of integrity

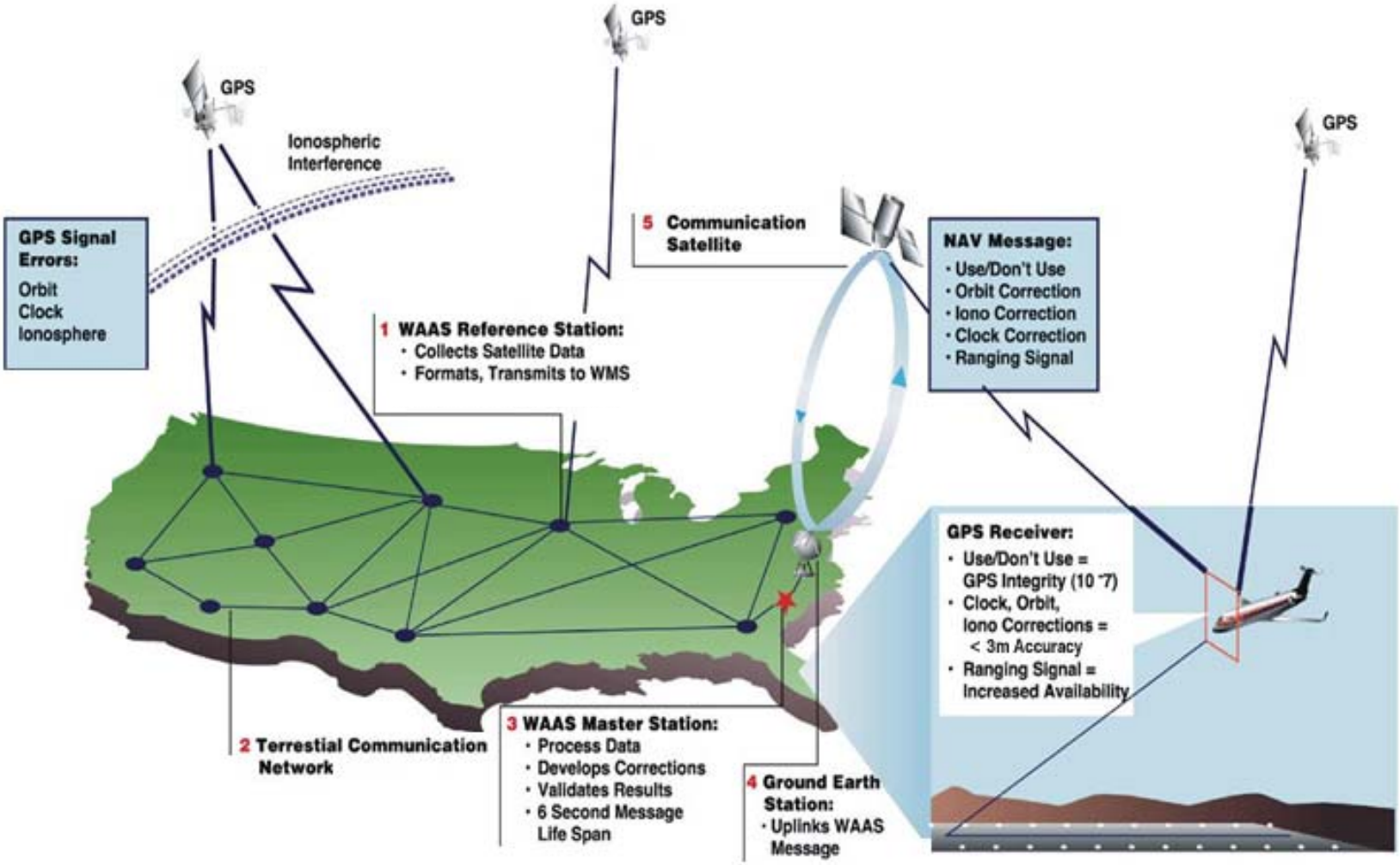
GPS Performance with WAAS

- **U.S. Federal Aviation Administration developed the Wide Area Augmentation System (WAAS) to provide necessary accuracy, integrity, and availability to support flight operations during all phases of flight**

	Performance Standard	Representative Performance
Best Site Accuracy Horizontal 95% Vertical 95%	 2.5 m 2.5 m	 .677 m .914 m
Worst Site Accuracy Horizontal 95% Vertical 95%	 2.5 m 2.5 m	 1.078 m 1.574 m

- ***Based on observations from January to March 2006. Results are valid when the Localizer Approach with Vertical Guidance (LPV) service is available. During this time frame, LPV was available 98% to 99% of the time.***

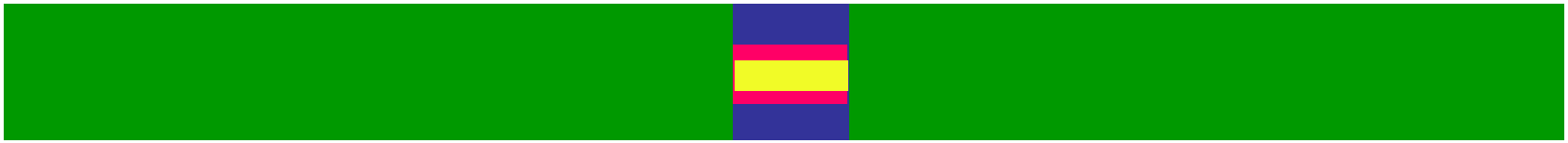
How WAAS Works



WAAS Class Gamma Receiver

- Stand-alone navigation function
  - Database, display outputs, pilot controls
- Operational class
  - Class I: Oceanic, domestic en route, terminal, approach (LNAV) and departure
  - Class II: Oceanic, domestic en route, terminal, approach (LNAV, LNAV/VNAV) and departure
  - Class III: Oceanic, domestic en route, terminal, approach (LNAV, LNAV/VNAV, LP, LPV) and departure
- Approved without requirement for other navigation equipment

Performance Comparison



LNAV (556 m horizontal alert limit)

LNAV/VNAV (556 m by 50 m)

LPV (40 m by 50 m)

Data base issue (by procedure). Can be as low as 35 meters.

APV II (40 m by 20 m)

Cat I Precision Approach (40 m by 15-10 m)

Flight Planning (1)

- **NOTAMS**
  - WAAS
    - Area wide WAAS UNAVAILABLE indicate loss or malfunction of WAAS
    - Site-specific WAAS UNRELIABLE indicate an expected level of service may not be available
    - The W symbol means site-specific WAAS UNRELIABLE NOTAMs or Air Traffic advisories are not provided for outages in WAAS LNAV/VNAV and LPV vertical service.
  - GPS
    - “KGPS” or “KNMH”
    - The term UNRELIABLE is used in conjunction with GPS NOTAMs.
      - UNRELIABLE means an advisory to pilots indicating the expected level of service may not be available.
      - GPS operation may be NOTAMed UNRELIABLE due to testing or anomalies.
      - Air Traffic Control will advise pilots requesting a GPS or RNAV (GPS) approach of GPS UNRELIABLE for:

Flight Planning (2)

- **IFR certified GPS can be used in lieu of NDB, DME, <u>and VOR</u> (AIM, 1-2-3.c.) – with caveats**
- **Confirm waypoints and names coincide with procedure chart and are in logical location**
- **GPS rcvr: GPS approach at destination (non-GPS approach at alternate)**
- **WAAS rcvr: GPS approach at destination (GPS approach at alternate okay, but <u>plan</u> LNAV minima)**
- **When using WAAS at an alternate airport, flight planning must be based on LNAV minima line**
  - Some airports will still list ⚠ **NA** for other reasons (no wx reporting)
  - LNAV was chosen assuming if vertical guidance was not available at destination, it would not be available at alternate

Flying a GPS approach

- **Two basic modes: Leg (Normal) and OBS**
- ***Resolverless* CDI relationship to course regardless of OBS setting (what's in your airplane?)**
  - Make sure your CDI source is GPS (and not VLOC or VAPP)
- **Procedure:**
  - Straight-in GPS approaches are max 15° off centerline
  - CDI sensitivity is linear, not angular (e.g., LNAV)
  - No timing, GPS distances are TO next waypoint
  - Ensure appropriate RAIM displayed before crossing FAF
    - 2 NM prior, but don't descend until crossing FAF!
  - Difference between fly-by and fly-over waypoints
    - Turn anticipation distance based on course change and ground speed

Flying a GPS approach (2)

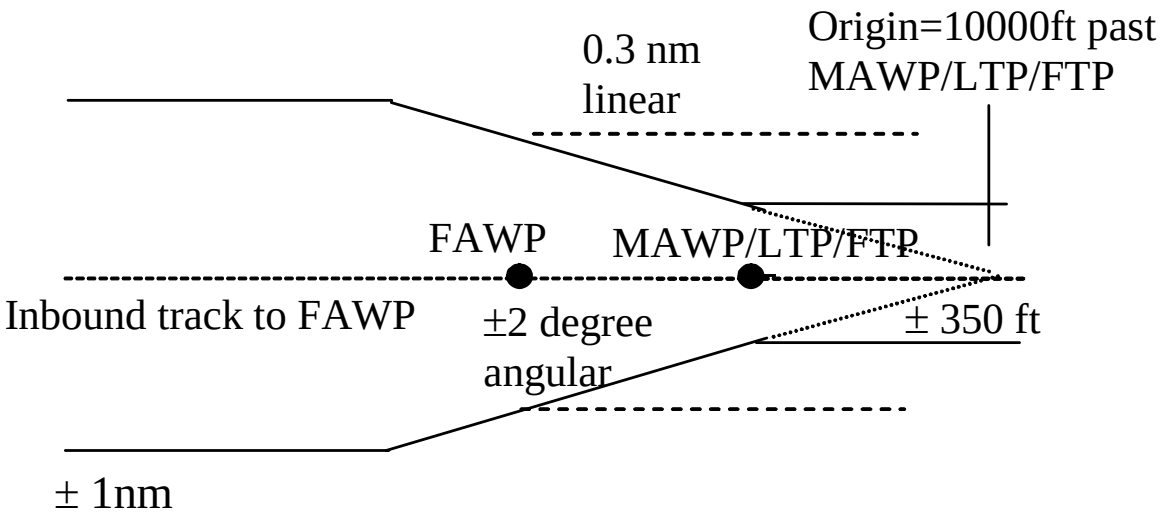
- **Small differences between charted and displayed course may exist (3º)**
- **Integrity annunciations:**
  - If RAIM failure occurs prior to final approach waypoint (FAWP), don't complete approach
  - If RAIM failure (msg) occurs after FAWP, execute missed approach
  - Manually setting CDI sensitivity does not automatically change the RAIM sensitivity on some receivers
- **Flying point to point does not assure compliance with published approach procedure**
  - Could "remove" approach sequencing performance
  - Need to follow (published) missed approach guidance
  - Must ensure approach is "activated"
- **VDP's not included in sequence of waypoints**
  - Unnamed step-down fixes will not be coded in waypoint sequence

G-1000 LPV approach selection

- **Database should contain procedures aircraft can legally fly**
- **Be familiar**
  - FAA expects to have more LPV approaches (995 now) than ILS approaches (1225 now) by June 2008

Flying a WAAS approach

- **If integrity alert inside FAF, equipment has reversionary mode to LNAV**



Common Errors

- **Unfamiliarity with equipment**
  - Fixation; belief avionics will compensate
- **Coupling to autopilot and not monitoring progress**
- **Not bringing Nav source annunciation into instrument scan**
- **Not understanding meaning of RAIM integrity annunciations (showing APR RAIM 2 NM from FAF)**
- **Making large course corrections just outside FAF**
  - LNAV: CDI scaling changes from 1 NM to 0.3 NM 2 NM from FAWP
- **Pushing direct-to key during approach, causing receiver to indicate direct course to MAWP and automatically centering CDI needle**
  - Perhaps going outside of protected airspace

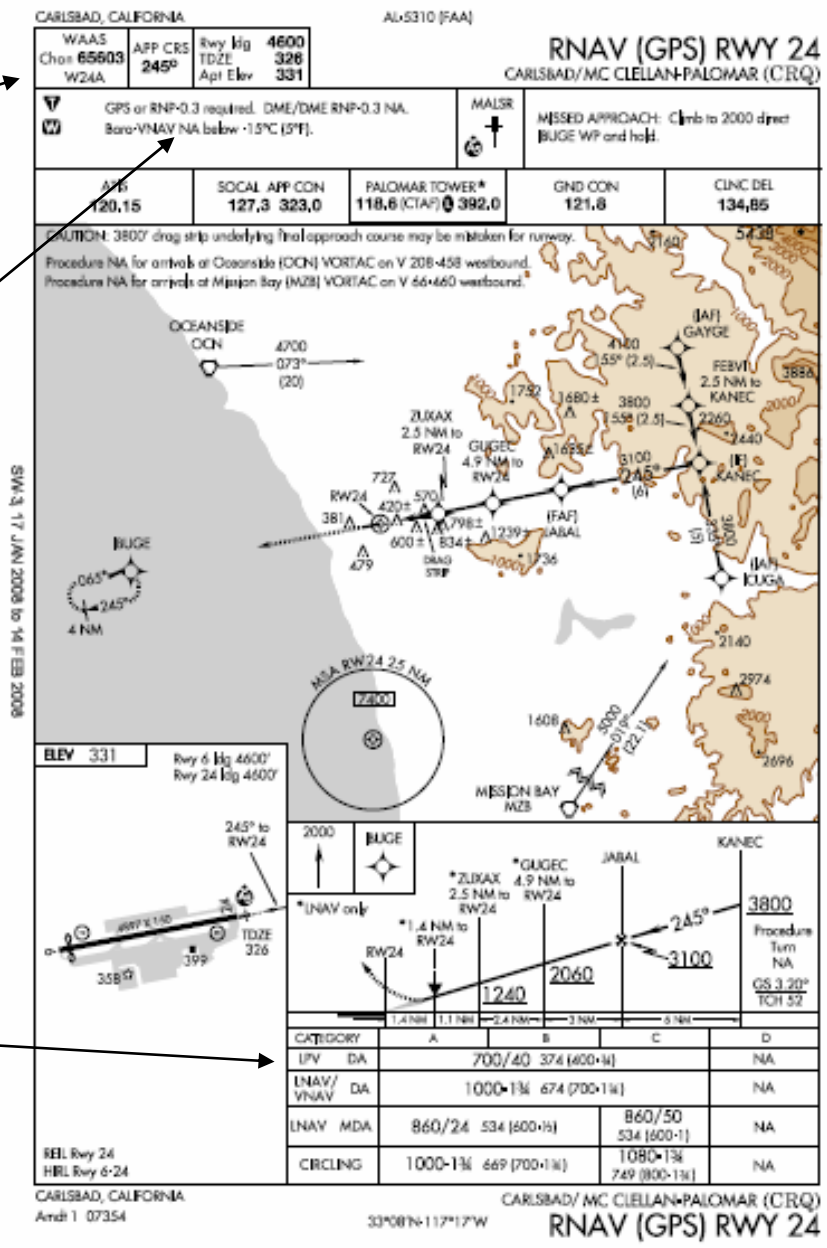
Charting with LPV Minimum Line

WAAS Channel Number

WAAS Approach ID: W24A
W: WAAS
24: Runway 24
A: 1st WAAS Approach
To Rwy 24

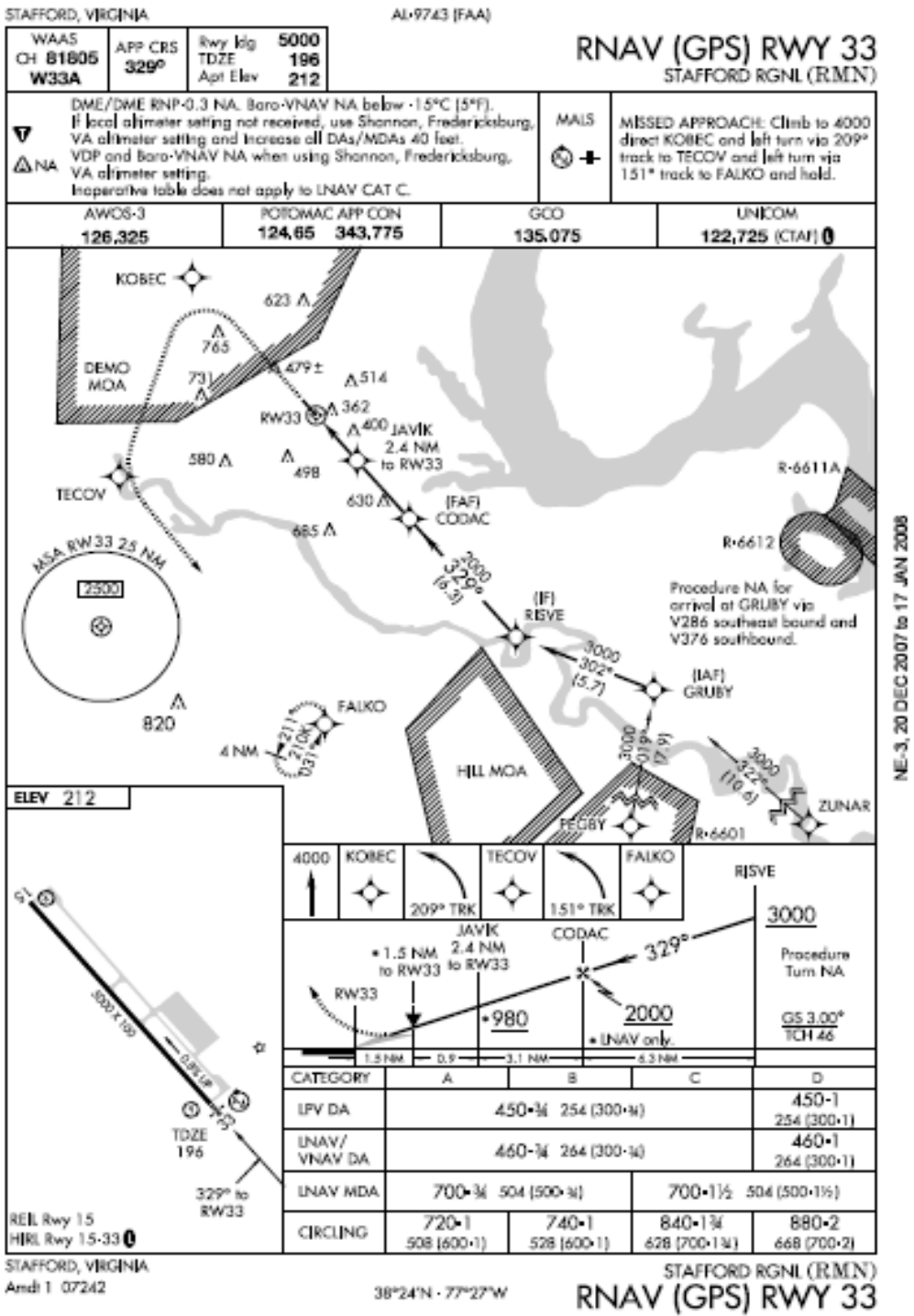
Temperature Restriction Does Not Apply to WAAS Equipment

LPV Minimum Line

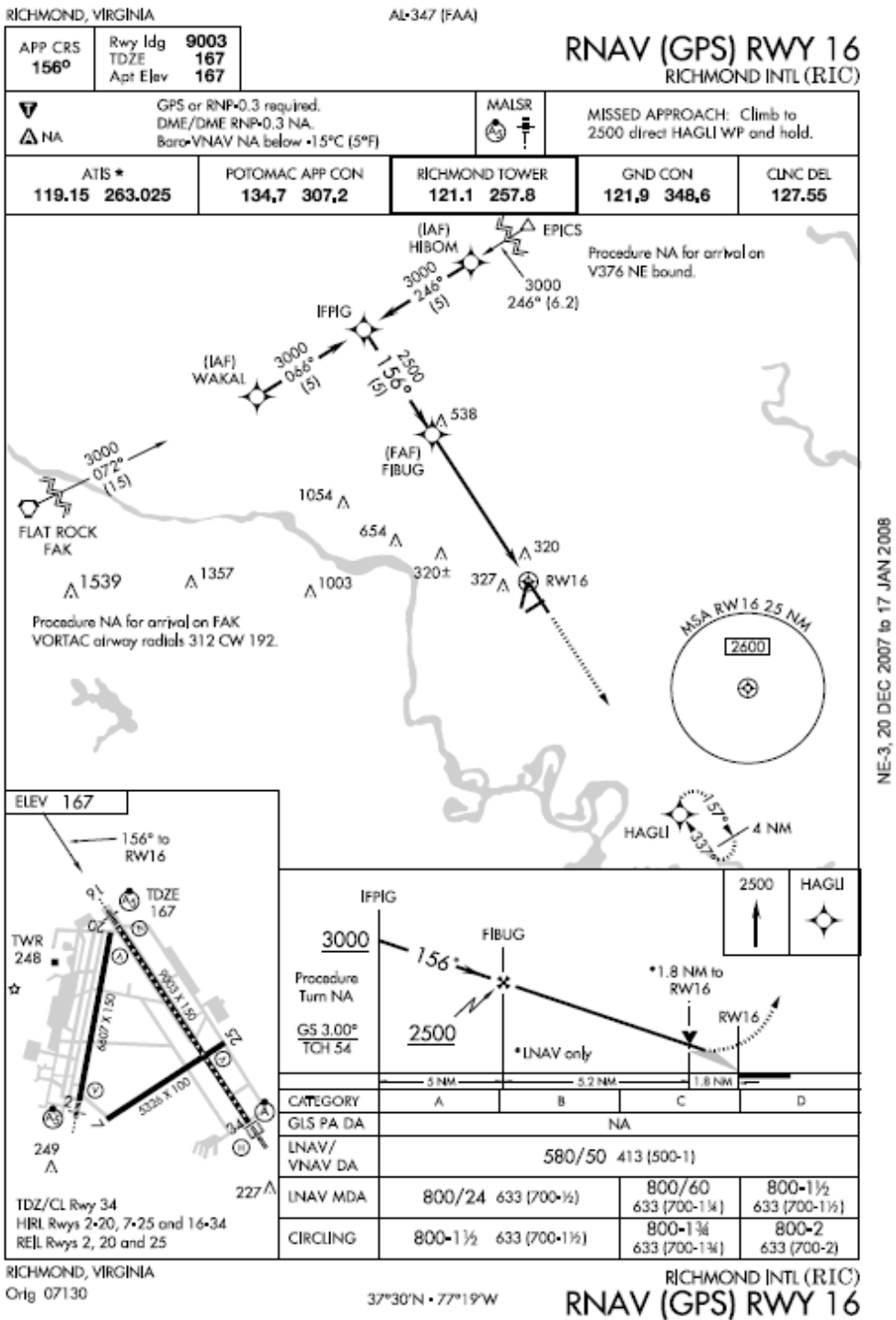


Sample Approaches

- Could you fly to the LPV minima line today (3/4 mile vis), with IFR-approved/ installed, TSO-C146a/b, Gamma class 3 receiver?
- If using KRMN as an IFR alternate and ILS not available, what is the required ceiling and vis for flight planning purposes (same eqpt)?

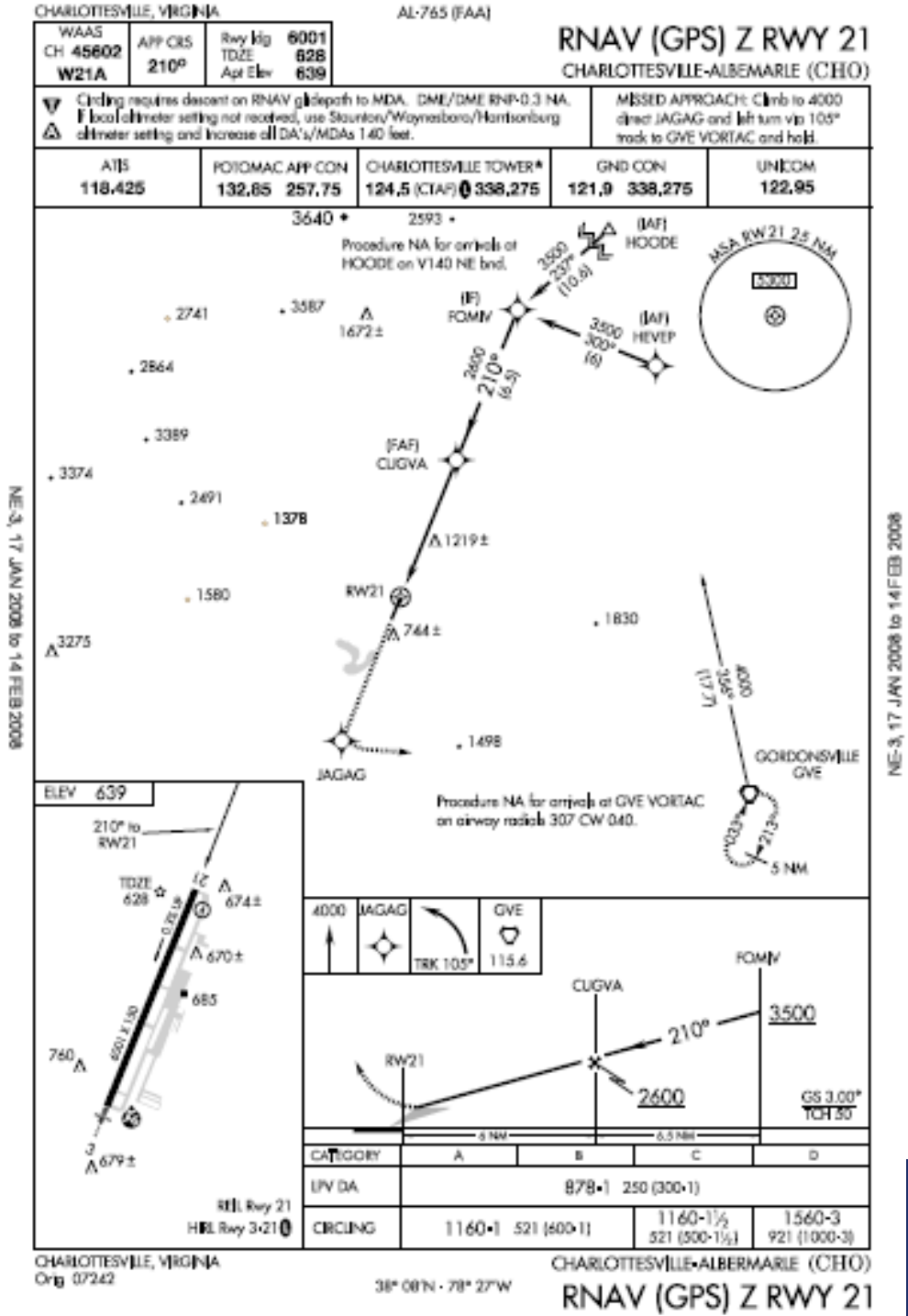


Advantages - Sample Approaches



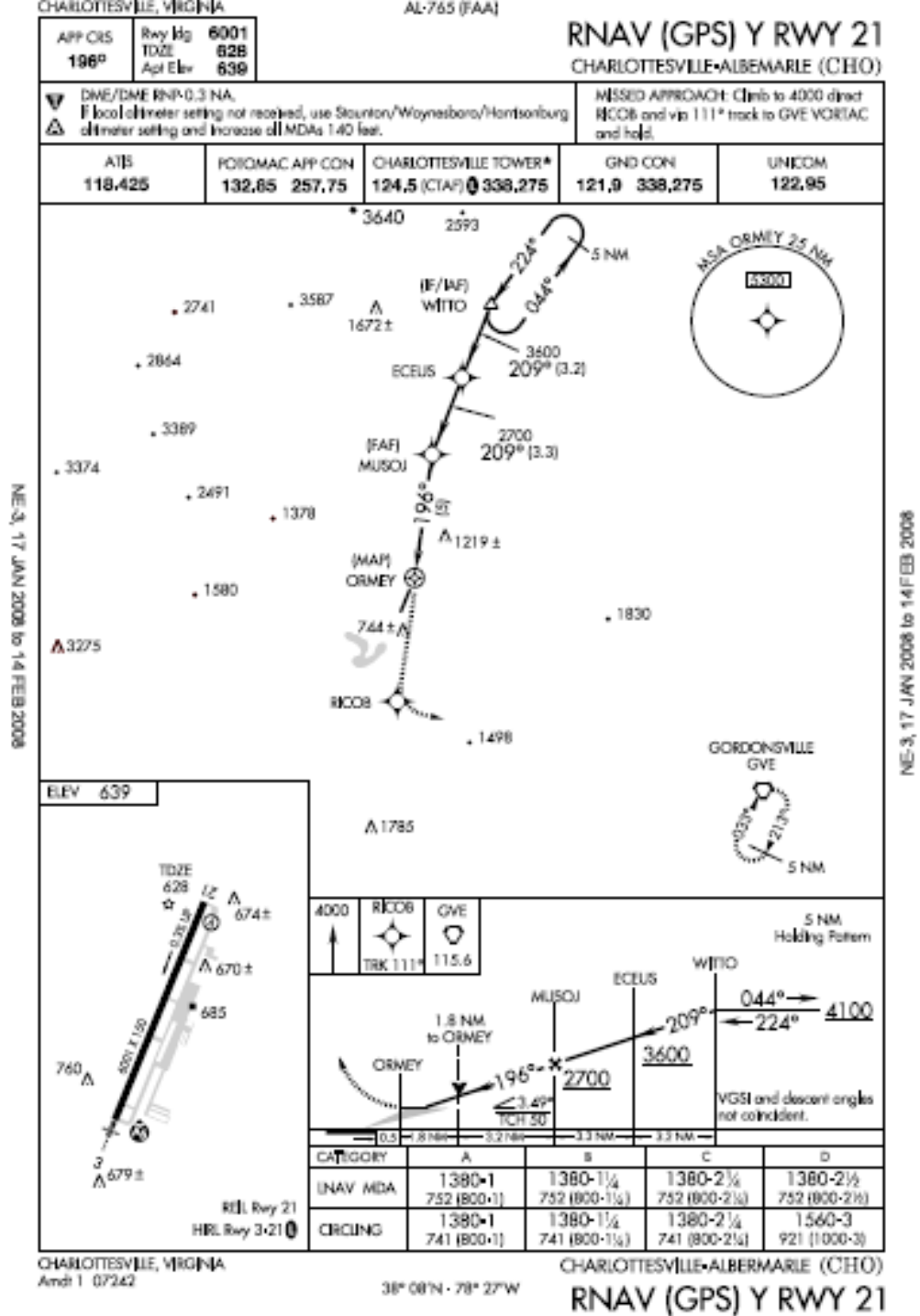
- Excepting any NOTAMS, could you fly to the LNAV/VNAV minima line with an IFR-approved and installed, TSO-C146a/b, Gamma class 3 receiver?

Sample Approaches



- Could you fly to the LPV minima line with a TSO-C129a receiver if you selected the RNAV RWY21 approach?
- What would you do if the LPV annunciator disappeared past the FAWP?

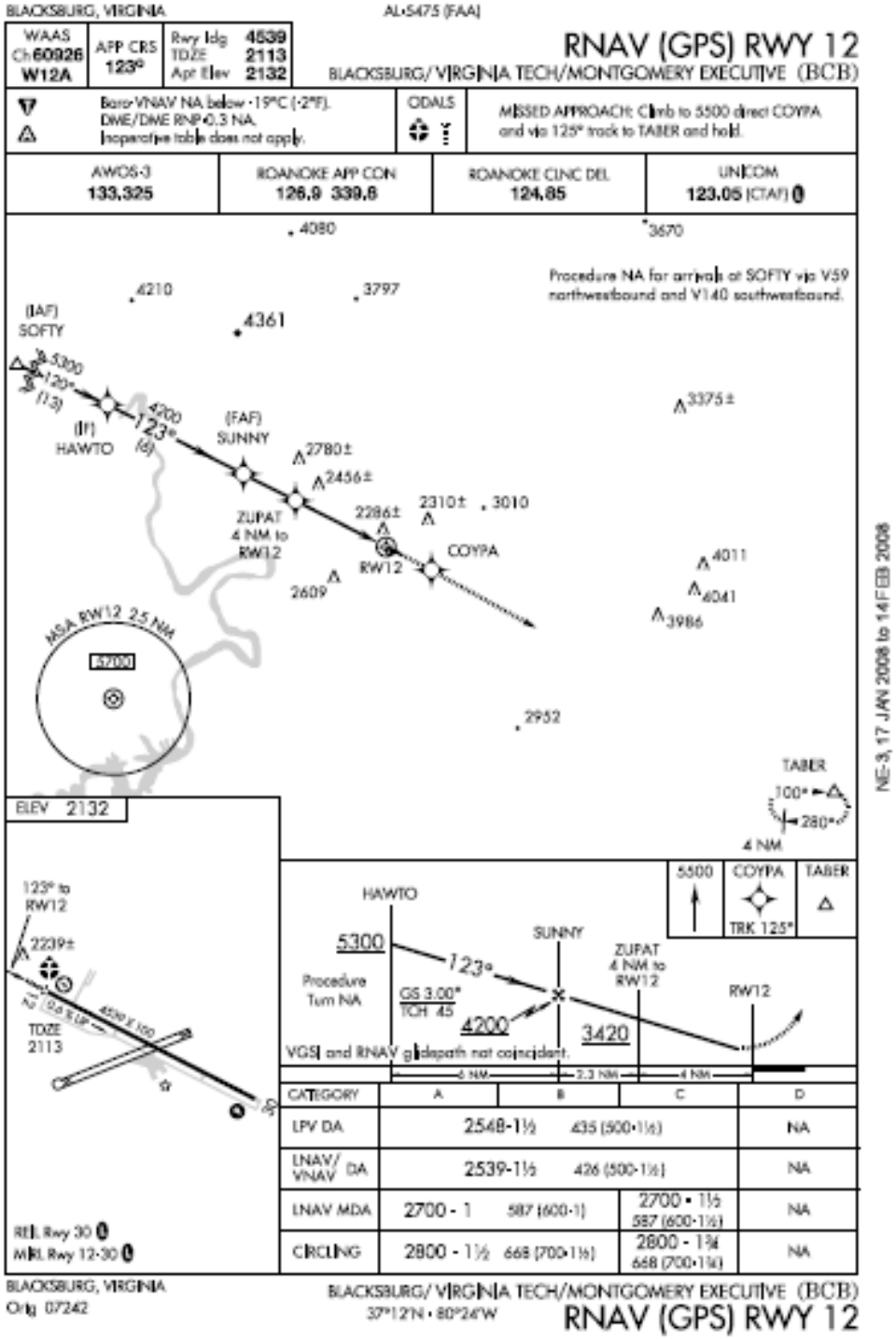
Sample Approaches



- Could you fly to the LNAV minima line with a TSO-C129a receiver if the approach was selected in your database?

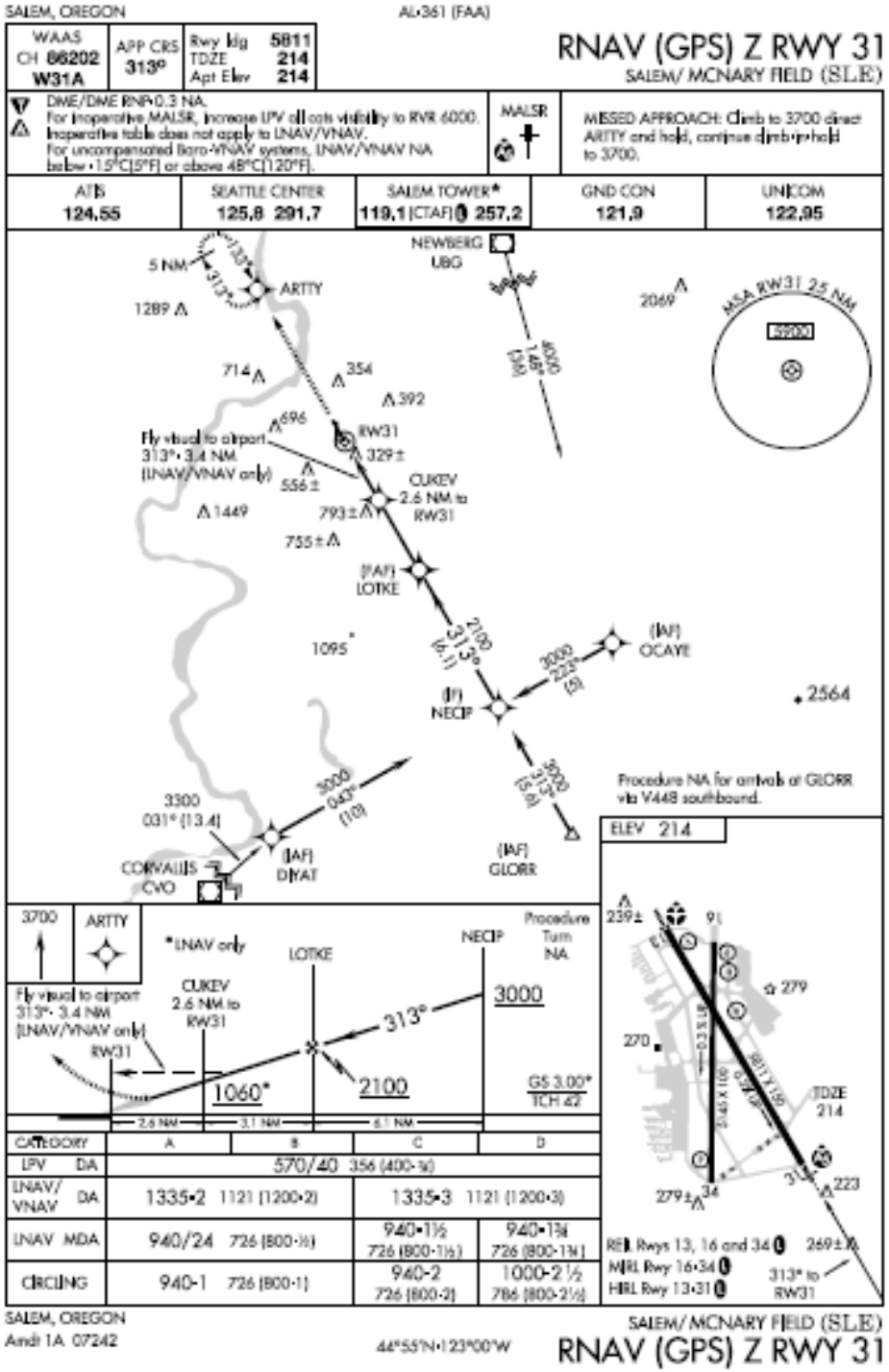
Sample approaches

- **LPV slightly higher than LNAV/VNAV**



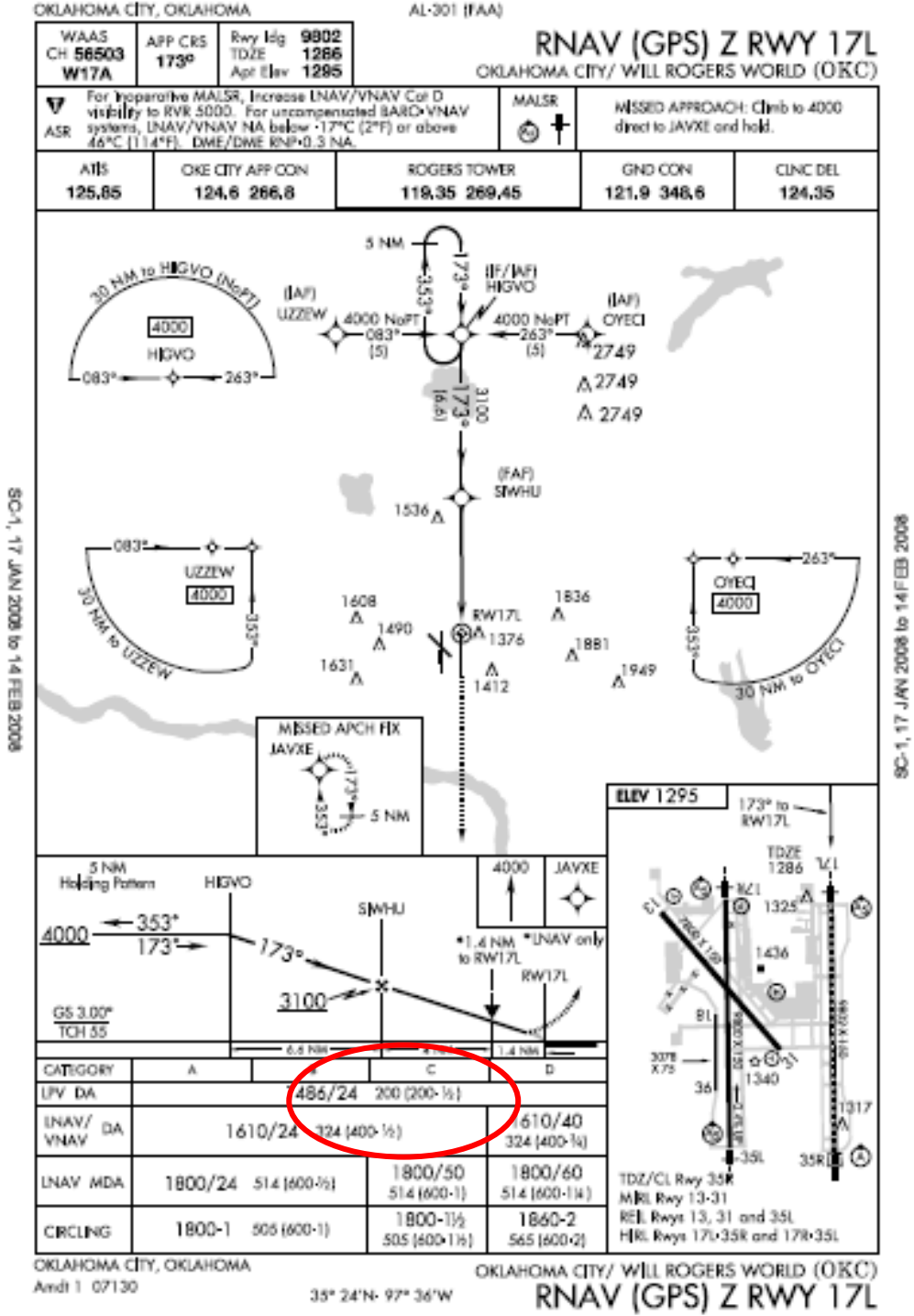
Sample approaches

- **LNAV/VNAV higher than LNAV**



Improved WAAS Minima

- **Changed vertical alert limit from 50 meters to 35 meters**
  - When permitted by terrain and airport infrastructure
- **Approach must be a standard 3.0º glidepath**
- **LP minima (coming in 2009)**



Summary

- Know what's allowed; know equipment limitations
- Gain experience in VMC before using in IMC
- Incorporate mode and source annunciation into instrument scan
- CAP G1000 training modules are available
- Simulator available for chair-flying
- AOPA/ASF offers online courses
- FLY SAFE!

Thank you for your attention!

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