WAAS it all about?

New capabilities with your enhanced-accuracy GPS Navigator

Ed Williams

SMXGIG 2007

WAAS (Wide Area Augmentation Service):

- Augments GPS by providing better position accuracy with usable vertical guidance.
- Provides both differential corrections and integrity information.
- By providing greater accuracy, availability, continuity and integrity enables pilots to rely on GPS for all phases of flight.
- Has the potential to provide near-precision approach accuracy to almost all runways in the continental US (including Alaska). (The FAA goal is 8900 WAAS procedures. As of 3/15/2007 there are 707 LPV, 1072 LNAV/VNAV and 3109 LNAV procedures published.*)
- The current minimum DH is 200'AGL with ½ mile visibility required. Most approaches are 250' DH.
- To make use of these capabilities you need a properly-installed TSO C146a receiver. (The CNX80/GNS80 has been joined by the Garmin 430W/530W upgrades.

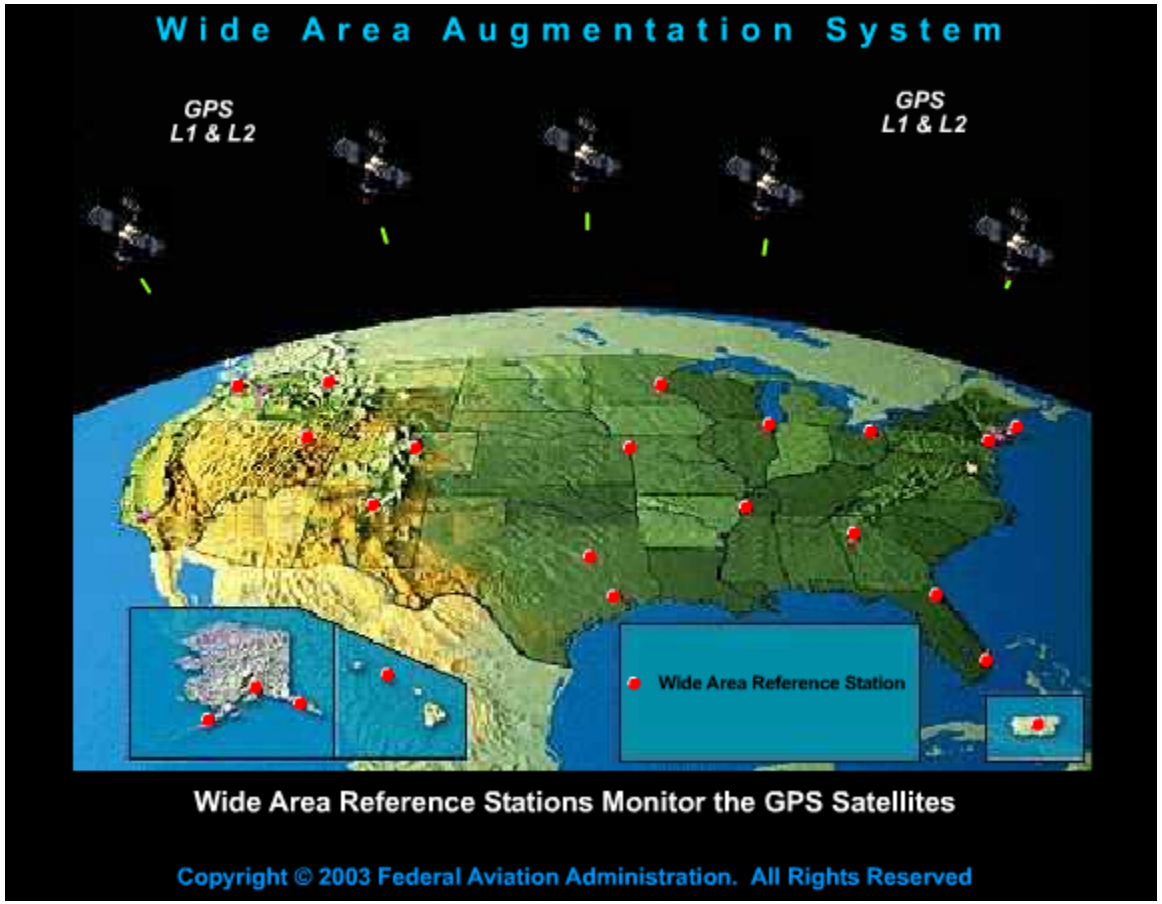
* See http://avnweb.jccbi.gov/schedule/production for the IAP production plan.

A GPS receiver finds position by determining its distance from a number of orbiting GPS satellites.

- The GPS signals are encoded with their transmission time. The time of flight multiplied by the speed of light (300m/μs) gives the distance.
- The GPS signals are also encoded with *ephemeris* information describing the satellite's precise orbit. The GPS receiver uses this to figure where the satellite was at the time of transmission.

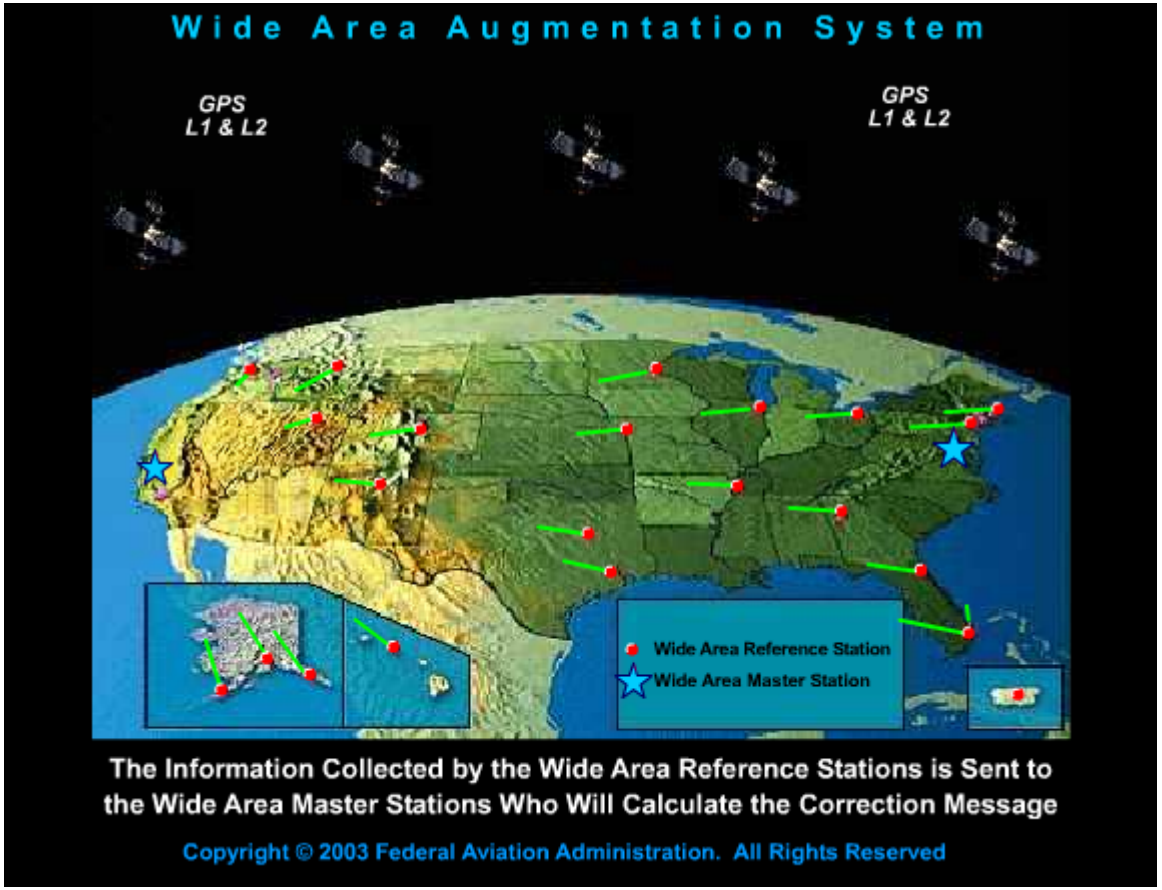
The largest contributor to the resulting position uncertainty (~10 meters) is the (unknown) delay of the GPS signal as it passes through the ionosphere enroute to the receiver. WAAS dramatically reduces this.

25 Wide Area Reference Stations monitor the GPS satellites



Comparing actual to computed range, ionospheric delay on the line of sight can be estimated.

The data is sent to two Wide Area Master stations which calculate the correction message.

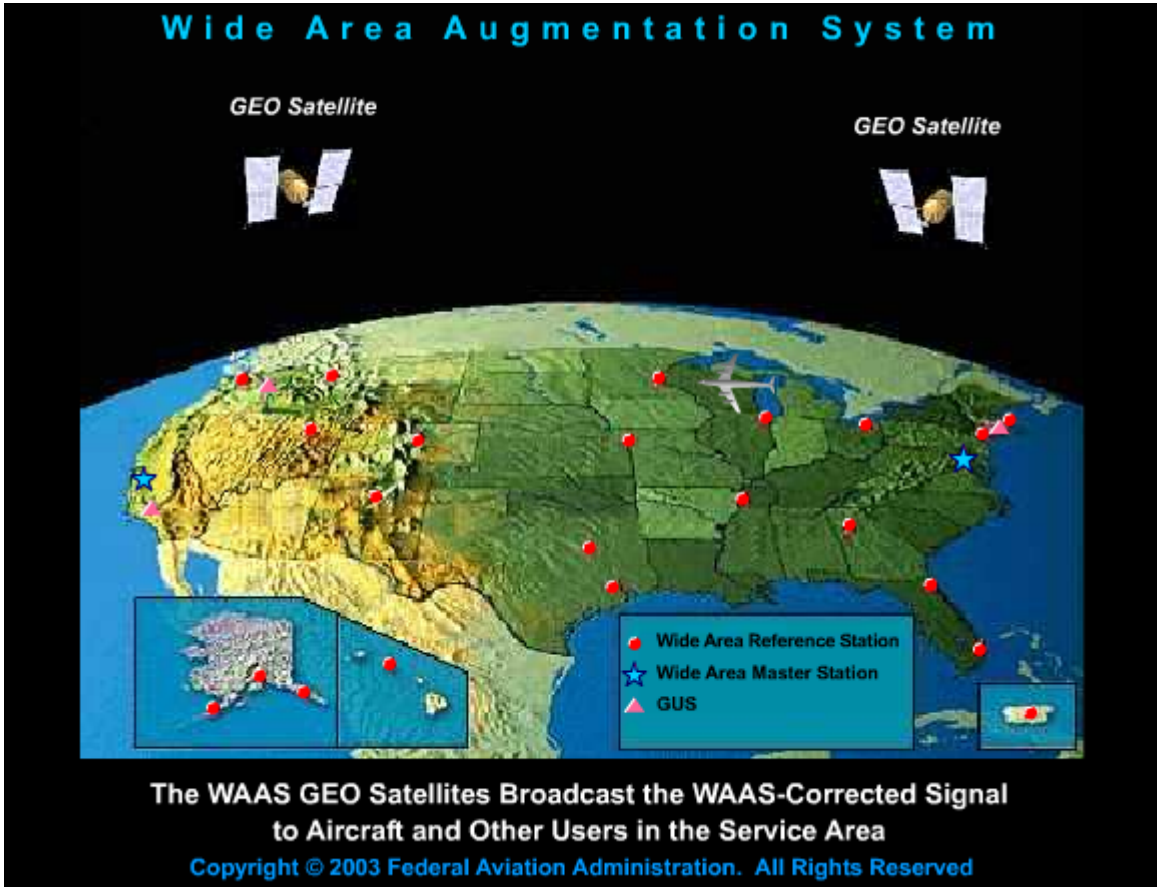


From the data a parametric fit to the ionospheric delay, together with its uncertainty, is created.

The correction message is up-linked to two geo-stationary WAAS satellites.

The GEO satellites also provide GPS signals – increasing the number visible in the sky.

The WAAS GEO satellites broadcast the correction signal to the users.



A WAAS-enabled GPS receiver is required.

Garmin 430W

Garmin 530W

Most modern handhelds have some WAAS capability – but don't monitor signal integrity. You can't use them for IFR.

A C146a WAAS-enabled IFR GPS gives access to vertically-guided “near-precision” approaches.

- LPV (Localizer performance with vertical guidance)
- LNAV/VNAV These approaches were original designed for FMS-equipped airplanes that used altimeter data to construct the glidepath (called baro-VNAV). These can be flown using a WAAS GPS.
- LNAV A classic non-precision GPS approach – only requires a C129a (non-WAAS) IFR GPS – but no glideslope.
- LNAV+V Flown to LNAV minimums but has an advisory WAAS glidepath allowing a “stabilized” (rather than “dive and drive”) approach path.

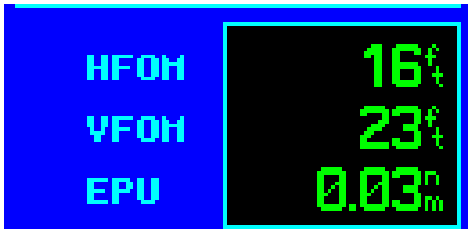
CATEGORY	A	B	C	D	E
LPV DA	2849/24 250 (300-½)				
LNAV/ VNAV DA	2956/40 357 (400-¾)				
LNAV MDA	3240/24 641 (600-½)		3240/60 641 (600-1¼)	3240-1½ 641 (600-1½)	3240-1¾ 641 (600-1¾)
CIRCLING	3240-1¼ 597 (600-1¼)		3240-1¾ 597 (600-1¾)	3240-2 597 (600-2)	3740-3 1097 (1100-3)

TUCSON INTL (TUS)

RNAV (GPS) Z RWY 11L

The WAAS receiver constantly monitors (and looks ahead at) the HPL and VPL

- H/VPL are the horizontal/vertical protection levels. Statistically, you only have 1 chance in 100,000,000 of the GPS being in error by more than the H/VPL.
- A 250’ DH LPV approach requires the VPL to be <=50 meters. (200’ <=35m)
- You will be locked out of the LPV approach if the required H/VPL is not met. Downgraded approaches (LNAV/VNAV, LNAV+V, LNAV) wil be offered if their H/VPL requirements are met.
- One of the specifications of the WAAS system is that the user should be warned within six seconds of any loss of signal integrity.
- Garmin reports H/VFOM are which are a fraction of the H/VPL numbers and represent the 95% (rather than 99.99999%) confidence in the horizontal and vertical accuracy.



On the satellite status page

The receiver annunciates the available approach mode on the intermediate leg, approaching the FAF.

(pre-WAAS the annunciations were OCN, ENR, TERM and APR)

LPV Follow lateral and vertical guidance to LPV minimums. A yellow background indicates the current VPL and/or HPL values are not adequate for the approach and is an early indication that downgrading will occur if conditions do not improve.

L/VNAV GPS approach identified in the database as LNAV/VNAV. Fly to LNAV/VNAV minimums.

LNAV+V Non-precision GPS approach with advanced vertical guidance. Note that some LNAV/VNAV approaches are not yet marked in the database as such and will show up as LNAV+V. If the chart shows the approach as LNAV/VNAV, it can be flown to LNAV/VNAV minimums.

LNAV Non-precision GPS approach or non-GPS approach, such as ILS or Localizer.

MAPR Missed Approach, indicates the system is providing missed approach integrity and CDI full-scale deflection ±0.3NM. This also shows that the pilot has initiated a Missed Approach by pressing the OBS key after crossing the MAP.

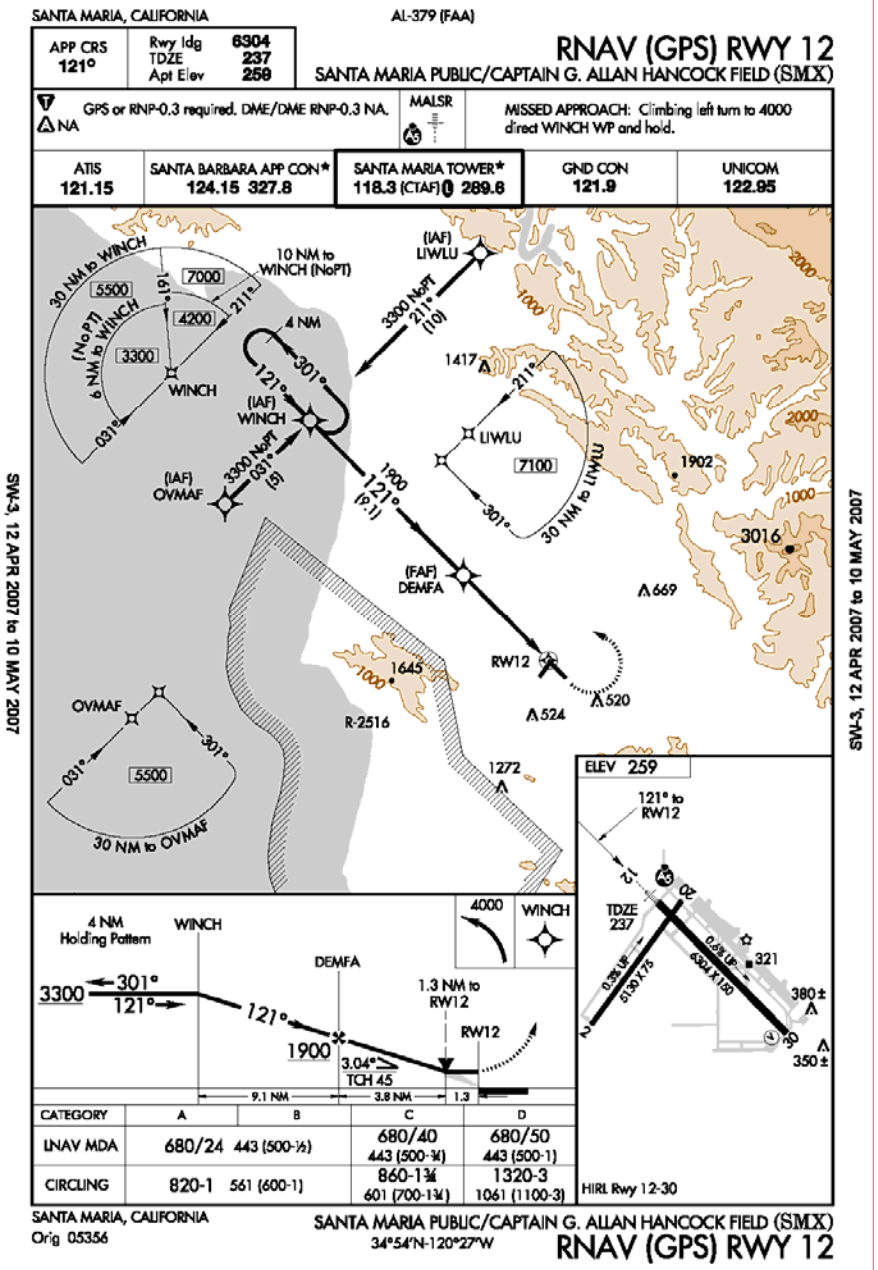
ENR En route, CDI full-scale deflection is 2.0 NM or current CDI scale selection, whichever is smaller.

TERM Terminal, CDI full-scale deflection is 1.0 NM or current CDI scale selection, whichever is smaller.

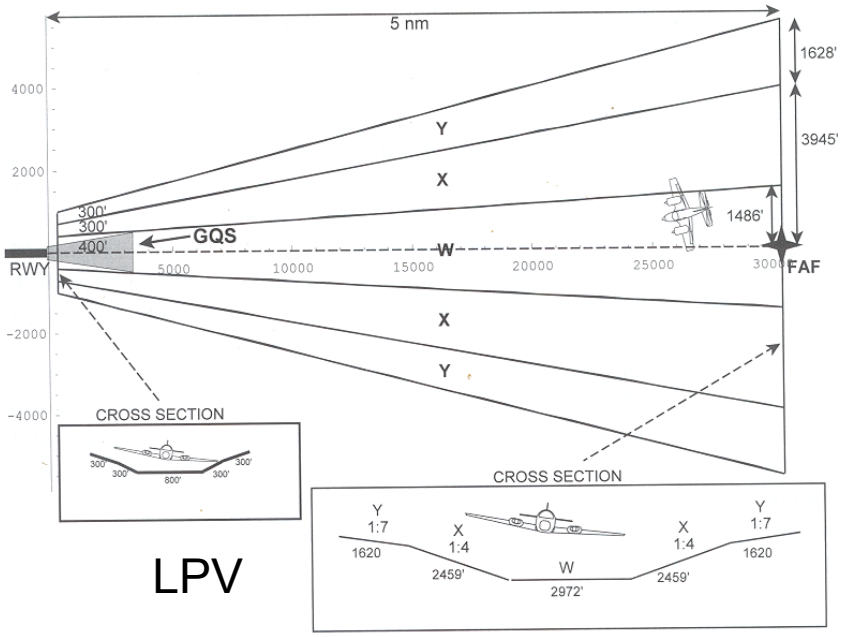
DPRT Departure, indicates the system is using non-precision approach integrity. HAL = 0.3 and CDI full-scale deflection is 0.3 NM.

OCN Oceanic, CDI full-scale deflection is 2.0 NM.

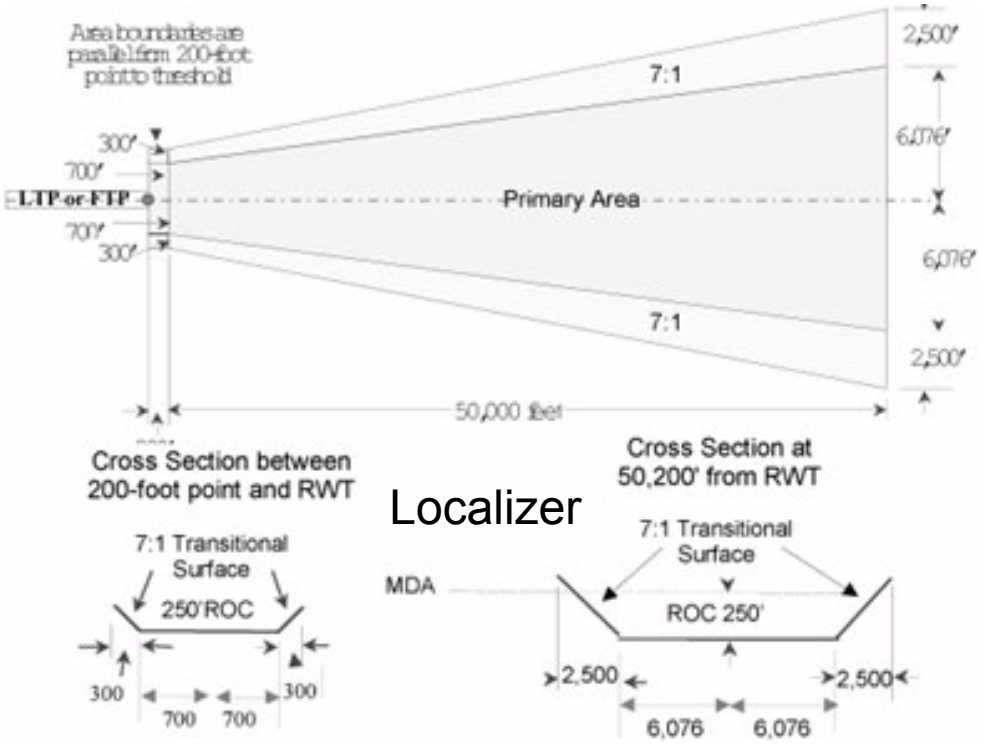
Flying the SMX GPS 12 approach with a Garmin 530W



More about LPV approaches…



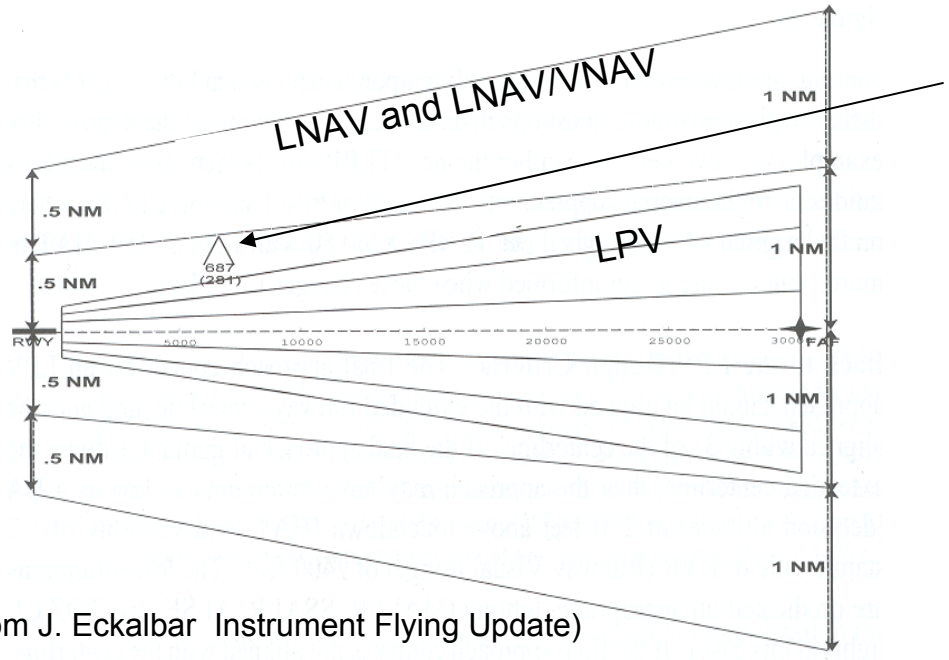
LPV



Localizer

- As with a localizer the obstacle-protected area narrows as you approach the threshold from the FAF. The CDI transitions to an angular scaling in 2 nm prior to the FAF.
- Lowest DAs are now 200' (with 35m VPL) e.g. PUB RNAV(GPS) 26R
- LPV approaches must be aligned within 2° of the runway centerline.
- If VPL is inadequate the Garmin units indicate "Approach downgraded - Use LNAV minima" or "Abort Approach - Loss of Navigation".

LNAV/VNAV approaches have a wider obstacle clearance surface and correspondingly higher minimums.



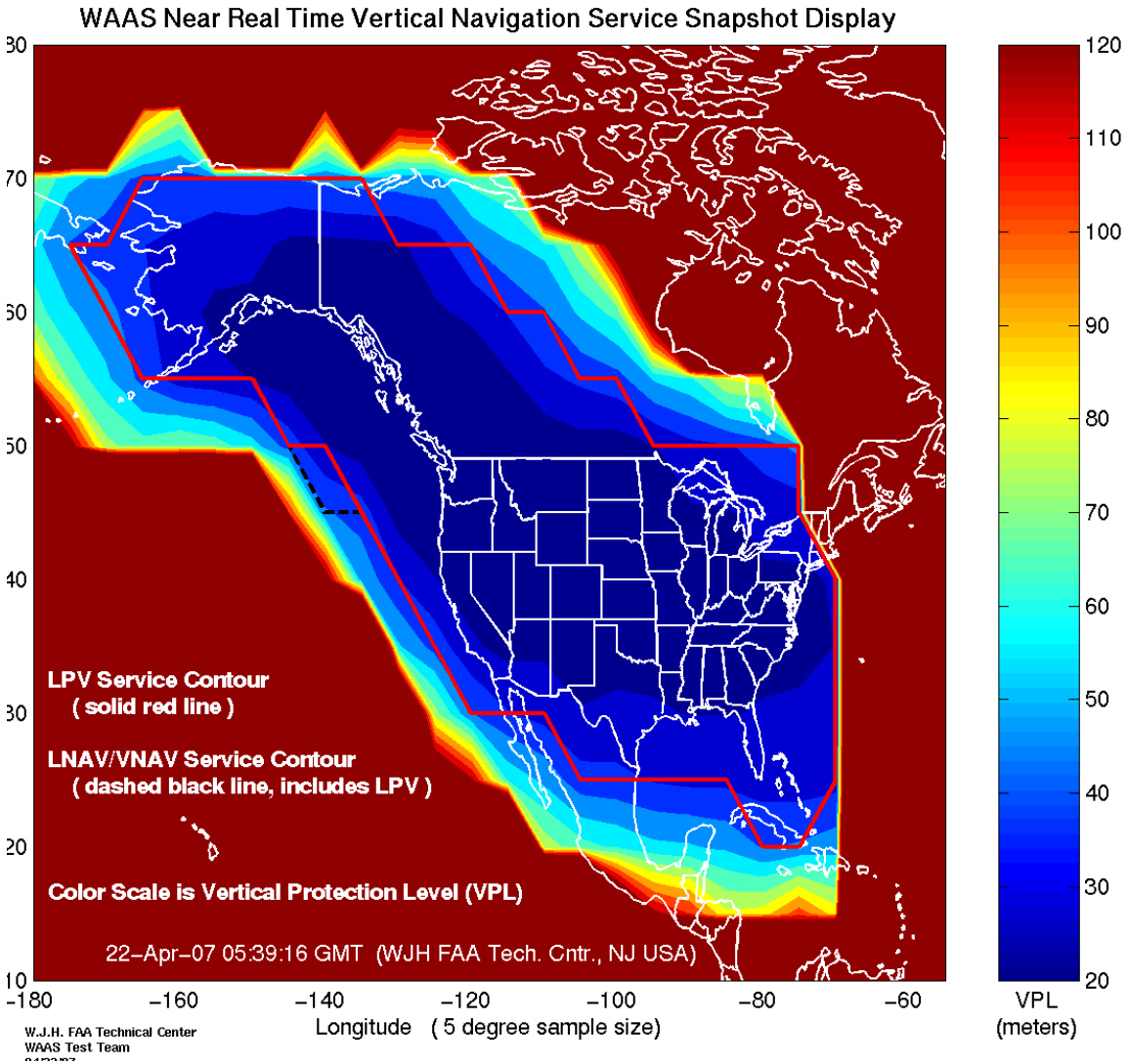
(from J. Eckalbar Instrument Flying Update)

Figure 16

This obstacle is inside the LNAV primary area but outside the LPV OCS.

LNAV and LNAV/VNAV have the same lateral OCS.

LPV minimums are available 98%+ of the time in most of the continental US



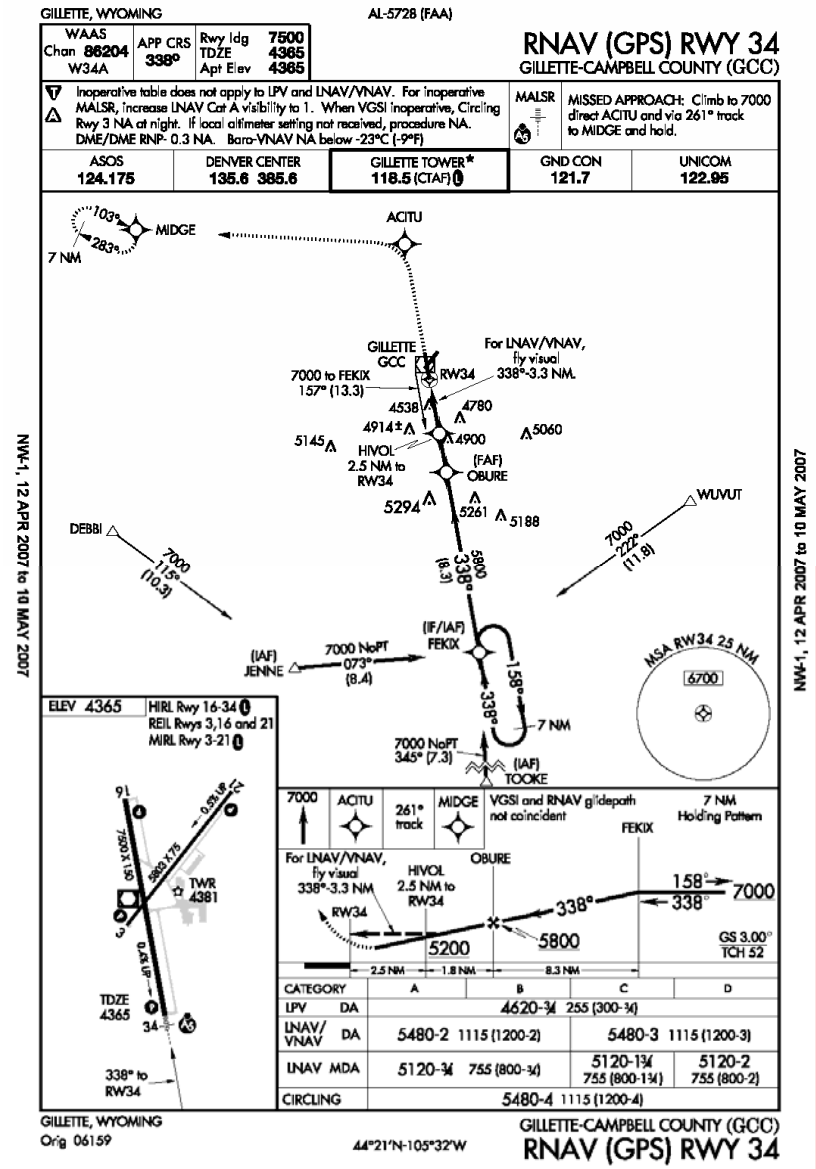
"WAAS UNAVAILABLE" NOTAMS describe area-wide outages. ATC/ATIS will provide them to pilots.

"WAAS UNRELIABLE" NOTAMS describe predicted site-specific loss of WAAS capability. "W" (NACO) or a note (Jepp) indication airports where no NOTAMS are provided because they have less than 98% coverage.

!LBB LBB WAAS LNAV/VNAV and LPV MNM UNREL WEF 0603281613-0603281628

http://www.nstb.tc.faa.gov/vpl.html

Sometimes LNAV minima are lower than LNAV/VNAV!



This a quirk of the TERPs rules that apply to approaches with glideslopes.

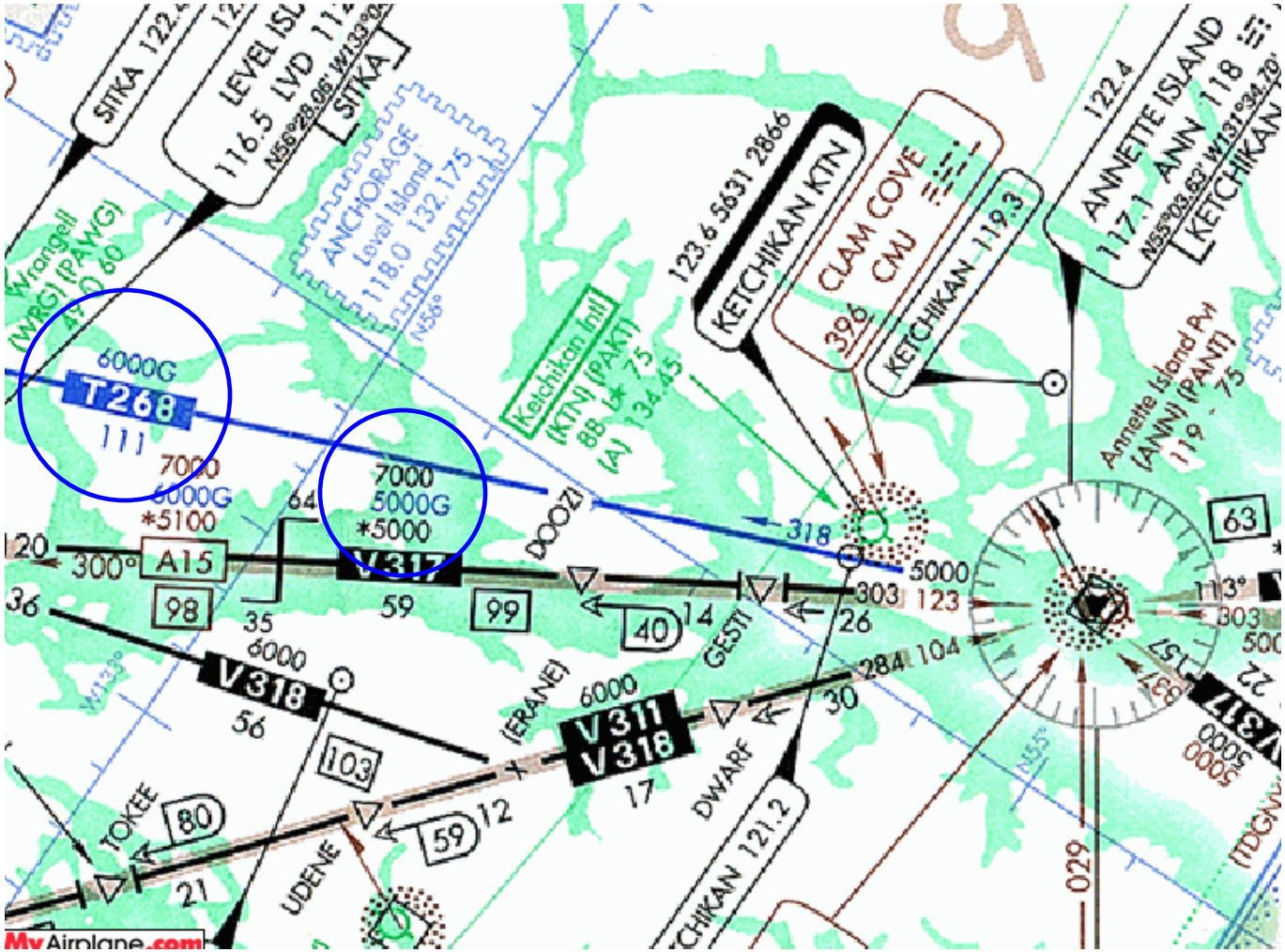
What to do if you need the LNAV minimum?

- Deselect LNAV/VNAV in favor if LNAV if the unit will let you?

- Fly it as an LNAV (laterally identical), even use the glideslope as advisory – remembering you must treat the MDA as a hard floor not a DA?

CATEGORY	A	B	C	D
LPV DA	4620-¾ 255 (300-¾)			
LNAV/VNAV DA	5480-2 1115 (1200-2)		5480-3 1115 (1200-3)	
LNAV MDA	5120-¾ 755 (800-¾)		5120-1¾ 755 (800-1¾)	5120-2 755 (800-2)
CIRCLING	5480-4 1115 (1200-4)			

Your TSO C146a IFR WAAS GPS give you admission to Alaska T-routes.



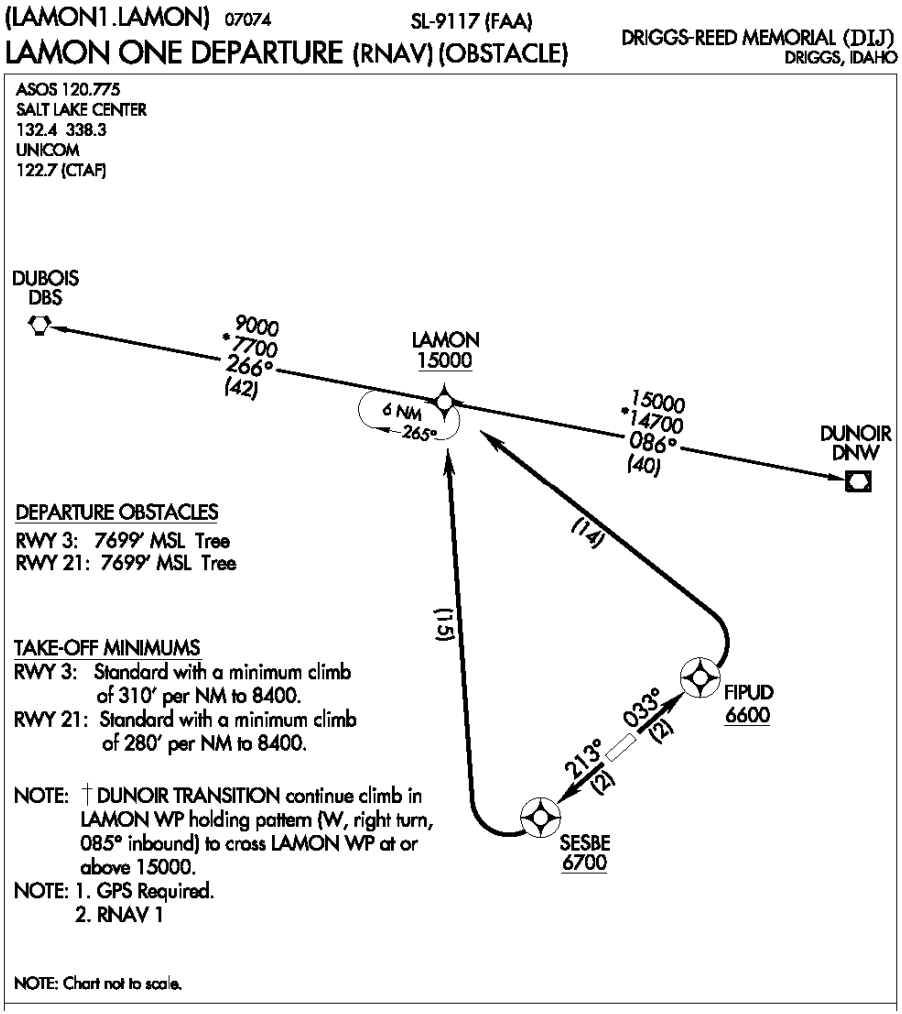
The lower G MEAs may allow icing avoidance. Need WAAS because no radar.

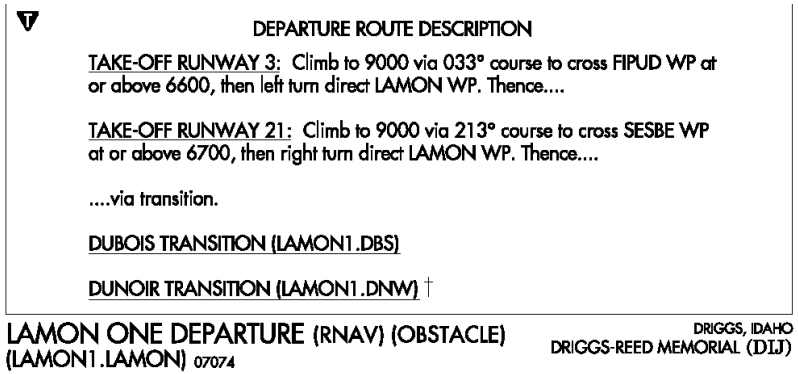
RITTRs : RNAV Terminal Transition Routes.

C129a /G sufficient for these. Radar monitored.

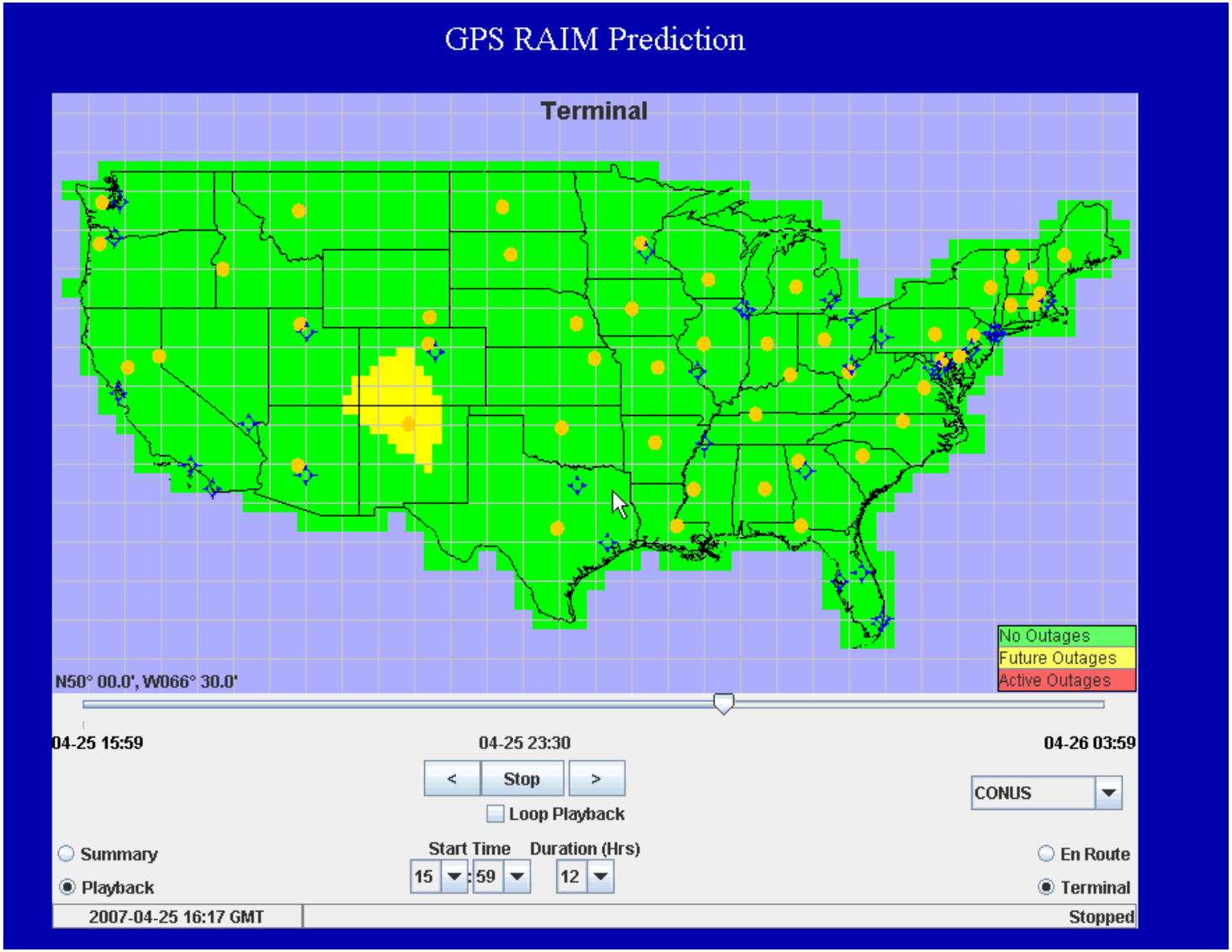
RNAV obstacle departures are flown like SIDs

AC 90-100A approval required - Not all IFR GPS's! RAIM check required for C129a in case of NOTAMed satellite outages. (FSS, PC or internal software.)
CDI/moving map, autopilot and/or FD required for RNAV 1.



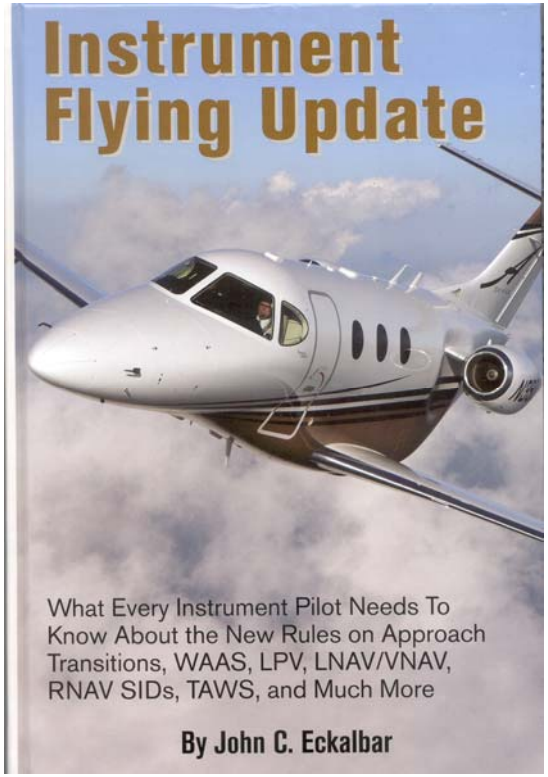


One convenient way to check RAIM is www.raimprediction.net



WAAS is providing a lot of new IFR capability

Resources:



AIM 1-1-19/20
AC 90-100A

http://www.aopa.org/whatsnew/newsitems/2005/050901rnav.html

http://www.nstb.tc.faa.gov/vpl.html

http://gps.faa.gov/

http://gps.faa.gov/FAQ/index.htm