

# Localizer Performance With Vertical Guidance LPV

Presented to: Northwest Mountain Airports Conference

By: Jason Pitts, Manager, Western FPO

Date: April 17, 2007



Federal Aviation  
Administration



# LPV

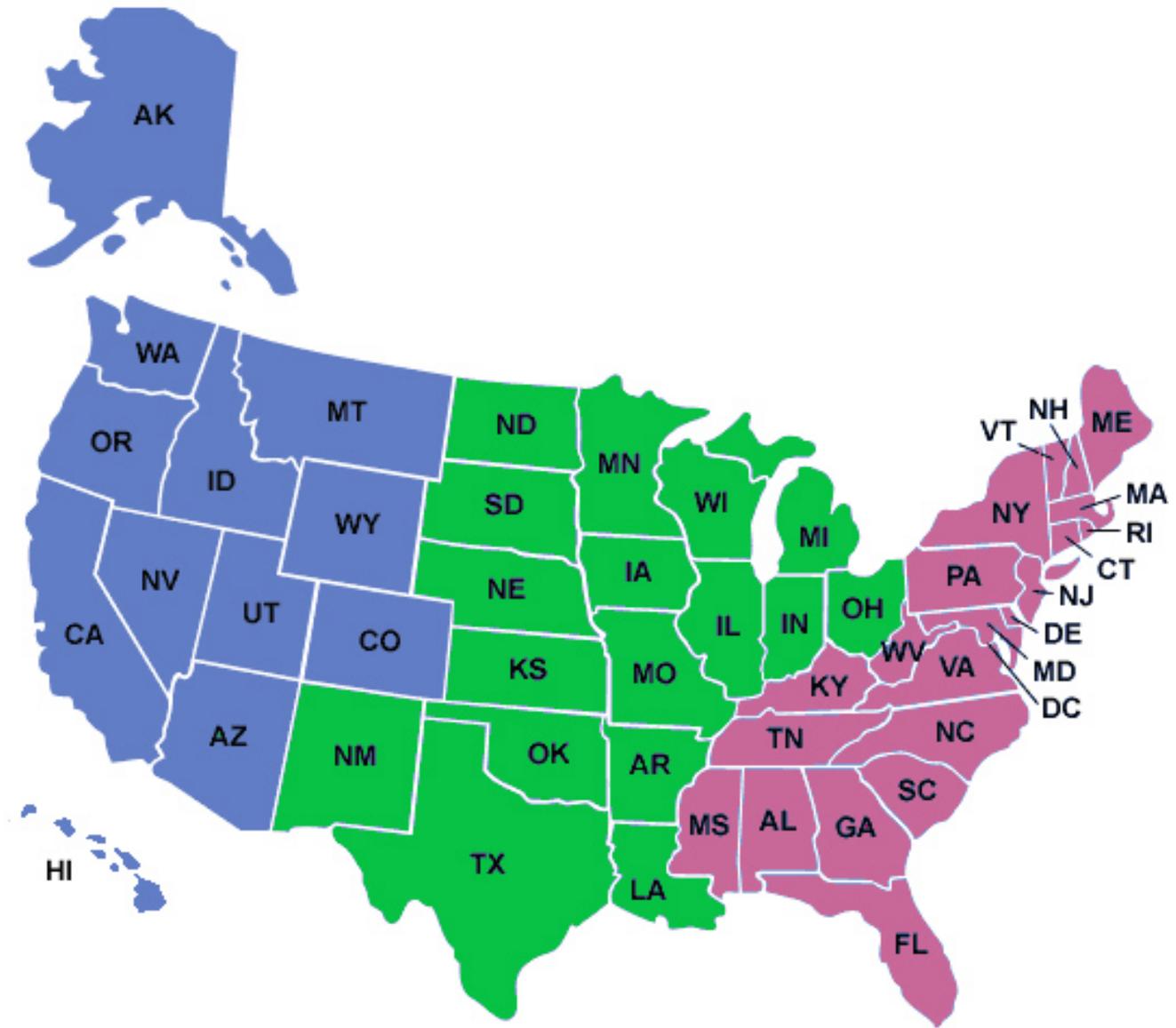
- **FPO States**
- **Northwest Mountain (ANM) Projects**
  - Past
  - Current
  - Future
- **LPV**
- **Survey Requirements**
  - AC 150/5300-13, Appendix 16
  - Application
- **Next**
  - RNP



# Western Flight Procedures Office (FPO)

12 States Plus All of Pacific





# ANM – Projects

- **12/22/05 through 12/21/06**
  - 317 projects with 45 LPVs
- **1/18/07 through 12/20/07**
  - 366 projects with 48 LPVs
- **Remaining**
  - 1000 (+ / -) with 133 LPVs
- **Perspective**
  - WFPO *versus* ANM
    - 1750~ with 222 LPVs



# LPV

- **Localizer Performance with Vertical Guidance (LPV)**



# LPV – Why GPS?

- 1. Strengthen and maintain our national security.**
- 2. Encourage acceptance and integration of GPS into peaceful civil, commercial and scientific applications worldwide.**
- 3. Encourage private sector investment in and use of U.S. GPS technologies and services.**
- 4. Promote safety and efficiency in transportation and other fields.**
- 5. Promote international cooperation in using GPS for peaceful purposes.**
- 6. Advance U.S. scientific and technical capabilities.**



# LPV - From GPS to RNAV to LPV to ...

- **Mid to Late 1990's**
  - GPS (Global Positioning System)
    - GPS RWY 18
- **Late 1990's**
  - RNAV (Area Navigation)
    - RNAV (GPS) RWY 18
      - LNAV (Lateral Navigation) 1 line of minima
      - LNAV/VNAV (Vertical "Information") 2 lines of minima
- **Midnight, May 1, 2000**
  - Selective Availability (SA) Degradation Ends



# LPV - Why

- **NAS Modernization**
- **Efficiency**
  - Airspace is finite
- **Accuracy**
- **Safety**
- **Reliability**
- **Cost**
  - 1 Receiver *versus* Multiple
  - Maintenance of the NAS



# NAS Maintenance

<b>RNAV (LNAV)</b>	<b>3,109</b>
<b>RNAV (VNAV)</b>	<b>1,072</b>
<b>RNAV (LPV)</b>	<b>707</b>
<b>TOTAL RNAV</b>	<b>4,888</b>
<b>TOTAL IFP</b>	<b>16,557</b>

## IFP Maintenance (Bi-Annual)

$11,669 \text{ (non-RNAV)} / 3 = 3890\sim \times \$15,000 = \$58\text{M}$

$4,888 \times \$0 = \$0$



# LPV - Why

## A Comparison of Lateral Obstacle Clearance Criteria (LNAV/VNAV vs. LPV)

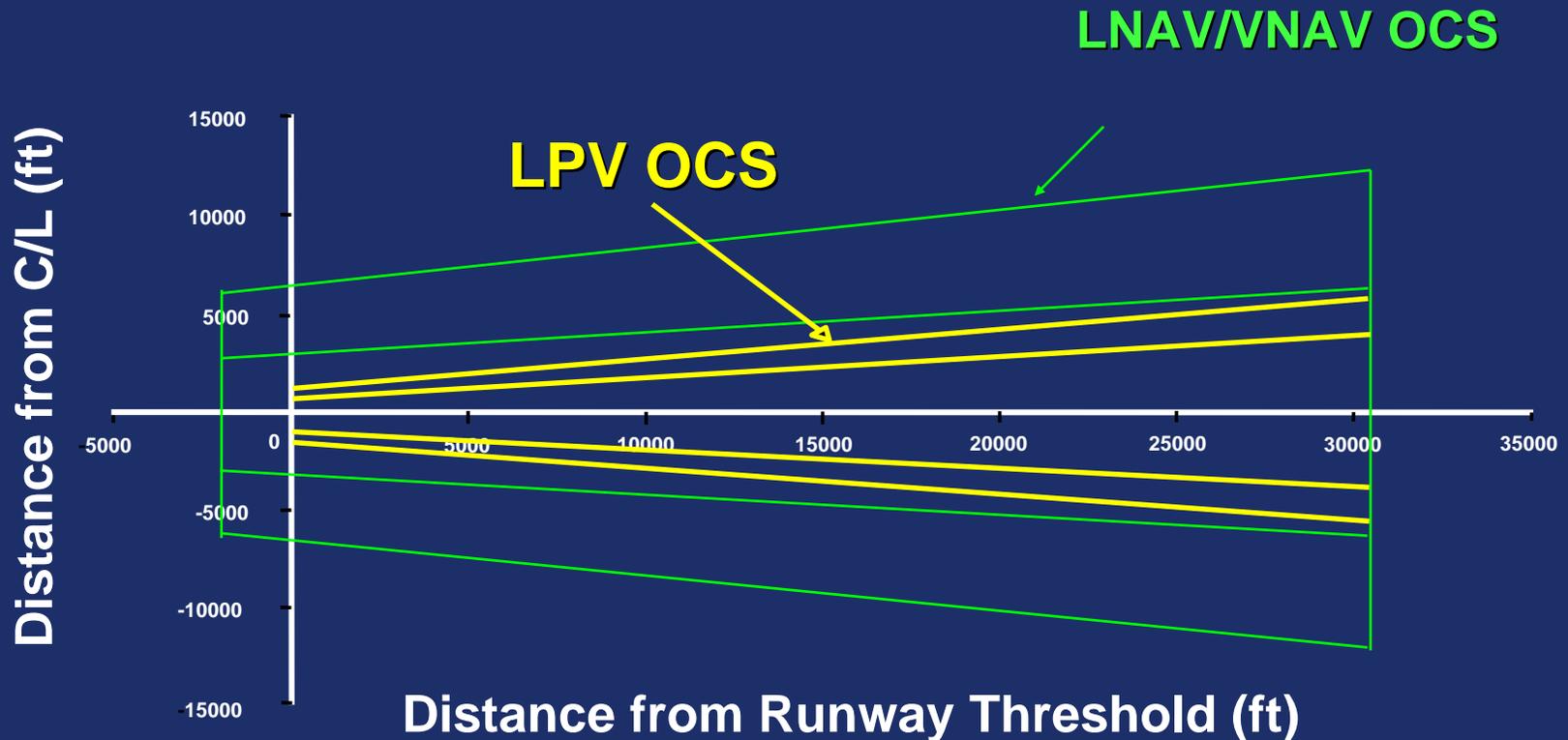
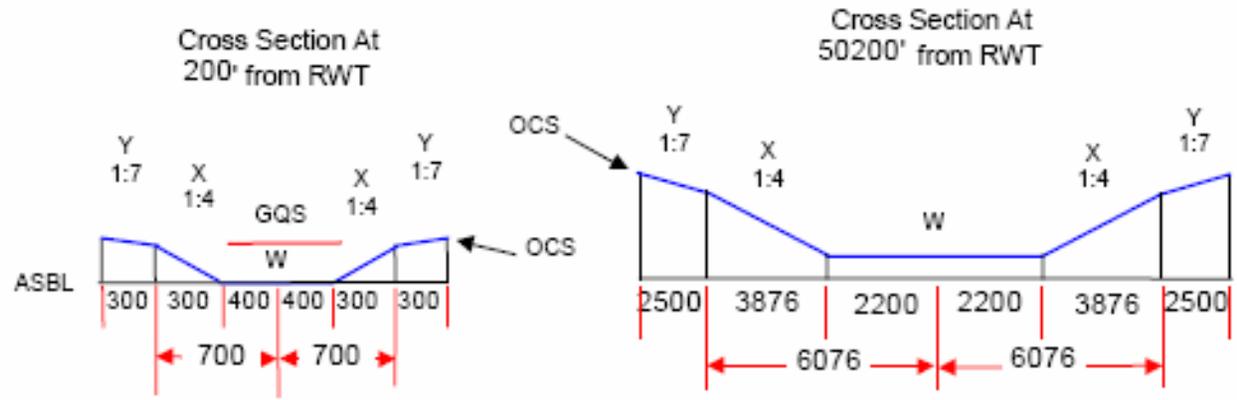
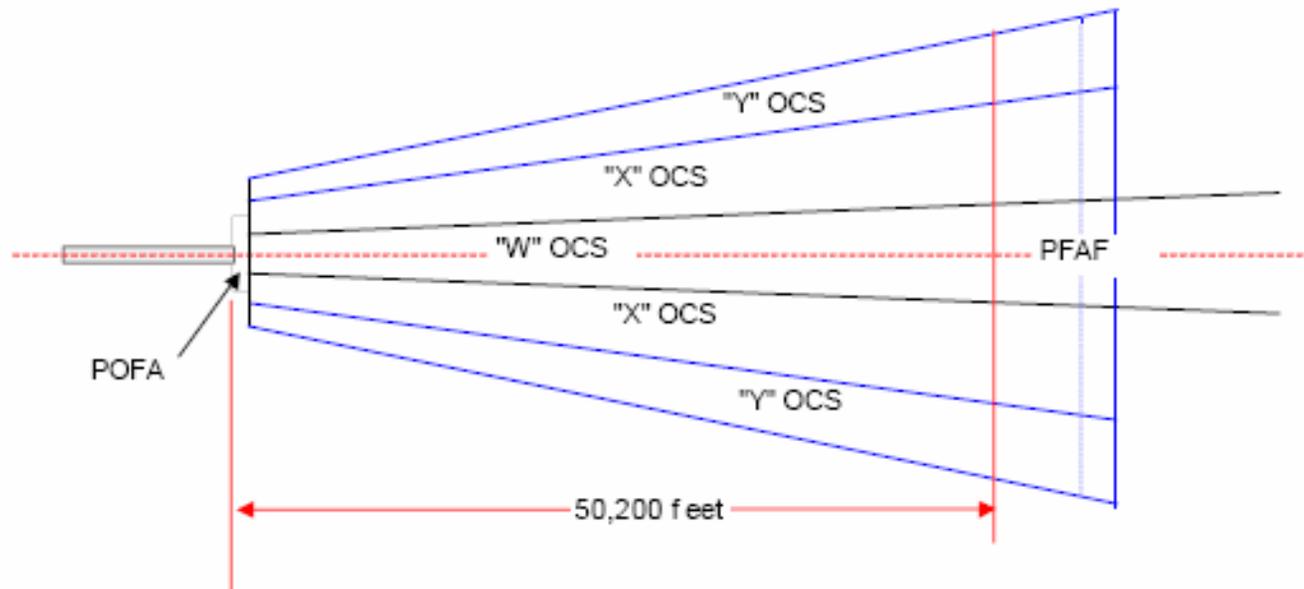


Figure 3-1. Obstacle Clearance Areas



# LPV

- **NW Mountain Region**
  - Between April 13, 2006 and December 31, 2020
    - 186 RNAV (GPS) with LPV Minima
    - CO 16, ID 28, MT 28, OR 28, UT 7, WA 58, WY 21
  - 23 Published prior to April 13, 2006
  - List growing
    - Input from
      - ADO
      - Individual Airport
      - Users
      - FAA Program Office



## From Slide 4

- **12/22/05 through 12/21/06**
  - 317 projects with 45 LPVs
- **1/18/07 through 12/20/07**
  - 366 projects with 48 LPVs
- **Remaining**
  - 1000 (+ / -) with 133 LPVs

## From Slide 11

- Between April 13, 2006 and December 31, 2020
  - 186 RNAV (GPS) with LPV Minima



# LPV - When

- **See**

- <http://avnweb.jccbi.gov/schedule/production>

- Can search by:

- Airport ID; Airport Name, State, Region, Pub Date, Type
  - May include historical data



# LPV - When

- **December 31, 2020**

## Placeholder Only



# LPV - Next

- **April 23, 2004 WAAS Benefits Register\***
  - “WAAS (LPV) will ultimately achieve the International Civil Aviation Organization’s approach standards for a Global Navigation Satellite System (GNSS) Landing System (GLS); equivalent to a Category I precision approach.”
    - Precision minimums are 200 HAT and ½ mile visibility
    - Currently, LPV limited to 250 HAT and ¾ mile visibility
      - GLS PA DA                      NA

\*Available: <http://gps.faa.gov> (Site Map, then WAAS Benefits)



CATEGORY	A	B	C	D
GLS PA DA	NA			
LNAV/ VNAV DA	4600-2¼ 751 (800-2¼)			
LNAV MDA	4740-¾ 891 (900-¾)		4740-2¼ 891 (900-2¼)	4740-2½ 891 (900-2½)
CIRCLING	4740-2¾ 866 (900-2¾)		4900-3 1026 (1100-3)	

△4174

REIL Rwy 9 **L**  
MIRL Rwys 5-23 and 16-34 **L**  
HIRL Rwy 9-27 **L**

HELENA, MONTANA  
Orig 05244

46° 36'N - 111° 59'W

HELENA REGIONAL (HLN)  
**RNAV (GPS) RWY 27**

CATEGORY	A	B	C	D
LPV DA	3950/40 366 (300-¾)			
LNAV/ VNAV DA	4200-2¼ 616 (600-2¼)			
LNAV MDA	4120/24 536 (500-½)		4120/50 536 (500-1)	4120/60 536 (500-1¼)
CIRCLING	4200-2¼ 548 (600-2¼)			4220-2¼ 568 (600-2¼)

Rwy 10R-28L  
3801 X 75

28R

REIL Rwys 25 and 28R  
HIRL Rwy 10L-28R  
MIRL Rwys 7-25 and 10R-28L

BILLINGS, MONTANA  
Amdt 1 06103

45° 48' N-108° 33' W

BILLINGS LOGAN INTL (BIL)  
**RNAV (GPS) RWY 10L**



# LPV - Next

- **Category I ILS limited to 200 HAT and ½ Mile Visibility (RVR)**
- **LPV Limited 250 HAT and ¾ Mile Visibility (RVR)**



# LPV - Next

- **If current ILS has 200 &  $\frac{1}{2}$  (or RVR Equivalent)**
- **And RNAV (GPS) has 250 &  $\frac{3}{4}$  (or RVR Equiv.)**
- **Then a candidate for LPV to 200 -  $\frac{1}{2}$** 
  - If no current RNAV (GPS) with LPV still could be a candidate



# ILS RWY 26R

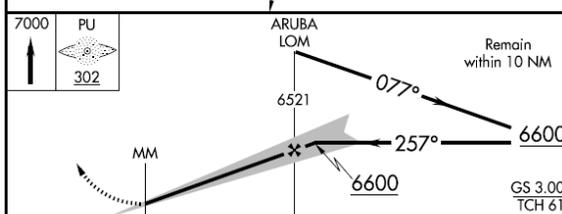
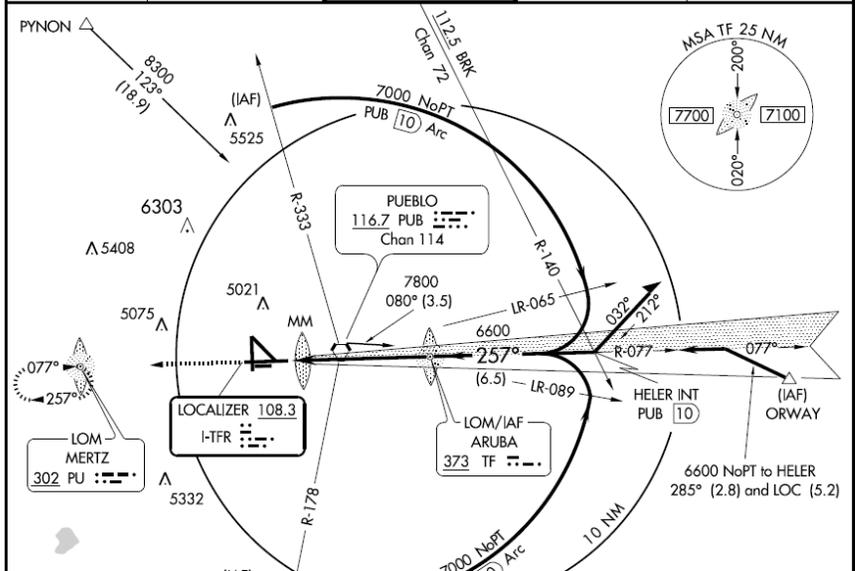
PUEBLO MEMORIAL (PUB)

LOC I-TRF <b>108.3</b>	APP CRS <b>257°</b>	Rwy ldg TDZE <b>10496</b> <b>4656</b> Apt Elev <b>4726</b>
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**Procedure not authorized when Pueblo altimeter setting not available.**

**MISSED APPROACH:** Climb to 7000 direct MERTZ LOM and hold. (TACAN aircraft climb to 5500 then climbing left turn to 8000 via PUB R-178 to HUNER 10 DME and hold south, right turns 358° inbound, 8 NM legs).

ATIS <b>125.25</b>	PUEBLO APP CON <b>120.1 290.5</b>	PUEBLO TOWER ★ <b>119.1 (CTAF) 0 257.8</b>	GND CON <b>121.9</b>	UNICOM <b>122.95</b>
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CATEGORY	A	B	C	D
S-ILS 26R	4856-3/4		200 (200-3/4)	
S-LOC 26R	5060-1	404 (400-1)	5060-1 1/4	404 (400-1 1/4)
CIRCLING	5340-1	614 (700-1)	5340-1 3/4	5360-2 614 (700-1 3/4)

# RNAV (GPS) RWY 26R

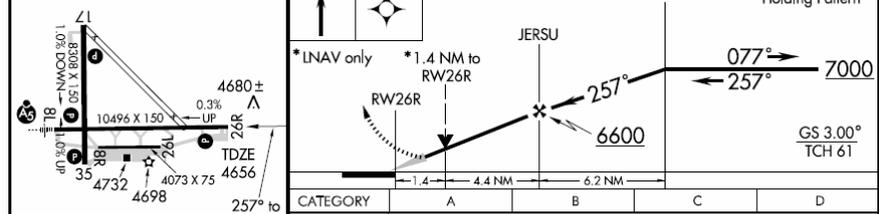
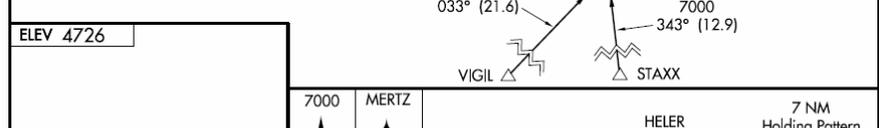
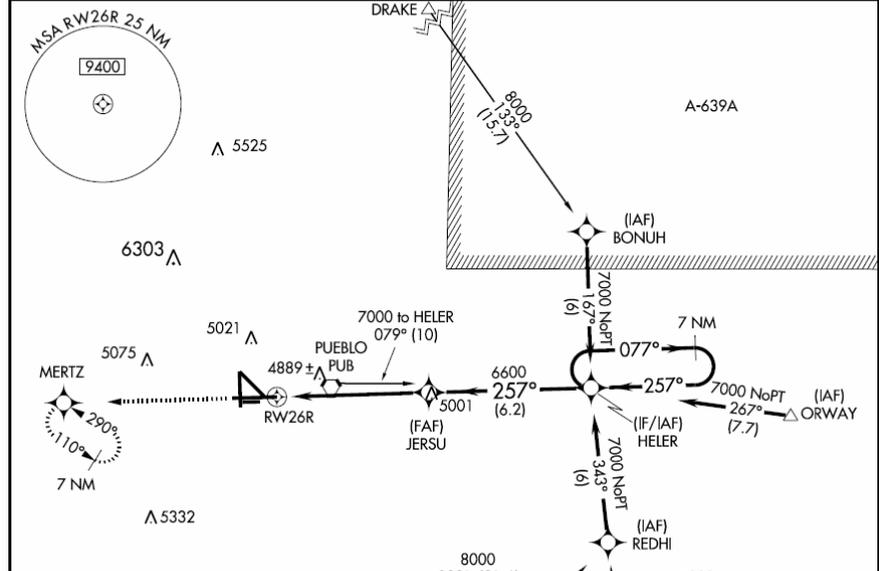
PUEBLO MEMORIAL (PUB)

WAAS CH <b>45702</b> <b>W26A</b>	APP CRS <b>257°</b>	Rwy ldg TDZE <b>10496</b> <b>4656</b> Apt Elev <b>4726</b>
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**DME/DME RNP-0.3 NA.**  
If local altimeter setting not received, use city of Colorado Springs Muni altimeter setting and increase all DAs 369 feet and MDAs 380 feet.

**MISSED APPROACH:** Climb to 7000 direct MERTZ and hold.

ATIS <b>125.25</b>	PUEBLO APP CON <b>120.1 290.5</b>	PUEBLO TOWER ★ <b>119.1 (CTAF) 0 257.8</b>	GND CON <b>121.9</b>	UNICOM <b>122.95</b>
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CATEGORY	A	B	C	D
LPV DA	4856-3/4 200 (200-3/4)			
RNAV/ VNAV DA	NA			
RNAV MDA	5140-1	484 (500-1)	5140-1 1/4 484 (500-1 1/4)	5140-1 1/2 484 (500-1 1/2)
CIRCLING	5340-1	614 (700-1)	5340-1 3/4 614 (700-1 3/4)	5380-2 654 (700-2)

# Survey Requirements

- **AC 150/5300-13, Appendix 16**
- **Application**



# AC 150/5300-13, Appendix 16

## 4. DEFINITIONS.

**a. Precision Approach.** An instrument approach procedure providing course and vertical path guidance conforming to ILS, or MLS, precision system performance standards contained in ICAO annex 10. Table A16-1A defines the requirements for ILS, LAAS, WAAS, MLS, and other precision systems.

# AC 150/5300-16, Appendix 16

## 4. DEFINITIONS.

**b. Approach Procedure with Vertical Guidance (APV).** An instrument approach procedure providing course and vertical path guidance that does not conform to ILS or MLS system performance standards contained in ICAO annex 10, or a precision approach system that does not meet TERPS alignment criteria. Table A16-1B defines the requirements for WAAS and authorized barometric VNAV.

**Table A16-1B. Approach Procedure With Vertical Guidance (APV-RNP)**

**Approach Requirements**

Visibility Minimums <sup>1</sup>	< 3/4-statute mile	< 1-statute mile	1-statute mile	>1-statute mile <sup>14</sup>
Height Above Touchdown (HAT) <sup>2</sup>	250	300	350	400
TERPS Glidepath Qualification Surface (GQS) <sup>3</sup>	Table A2-1, Row 7, Criteria, and Appendix 2, par. 5a Clear			
TERPS Paragraph 251	34:1 clear	20:1 clear	20:1 clear, or penetrations lighted for night minimums (See AC 70/7460-1)	
Precision Obstacle Free Zone (POFZ) 200 x 800 <sup>4</sup>	Required	Recommended		
Airport Layout Plan <sup>5</sup>	Required			
Minimum Runway Length	4,200 ft (1,280 m) (Paved)	3,200 ft (975 m) <sup>6</sup> (Paved)	3,200 ft (975 m) <sup>6,7</sup>	
Runway Markings (See AC 150/5340-1)	Nonprecision (Precision Recommended)		Nonprecision <sup>7</sup>	
Holding Position Signs & Markings (See AC 150/5340-1 and AC 150/5340-18)	Nonprecision (Precision Recommended)		Nonprecision <sup>7</sup>	
Runway Edge Lights <sup>8</sup>	HIRL / MIRL		MIRL/LIRL	
Parallel Taxiway <sup>9</sup>	Required		Recommended	
Approach Lights <sup>10</sup>	Required <sup>11</sup>		Recommended	
Runway Design Standards; e.g., Obstacle Free Zone (OFZ) <sup>12</sup>	APV OFZ Required			
Threshold Siting Criteria To Be Met <sup>13</sup>	Table A2-1, Row 4 and 9, Criteria		Appendix 2, Table A2-1, Lines 4 and 8, Criteria	
Survey Required for Lowest Minima	Table A16-2, Row 6, Criteria			



# AC 150/5300-16, Appendix 16

## Approach Requirements

<b>Visibility Minimums<sup>1</sup></b>	< 3/4-statute mile	< 1-statute mile	1-statute mile	>1-statute mile <sup>14</sup>
<b>Height Above Touchdown (HAT)<sup>2</sup></b>	250	300	350	400

<b>Precision Obstacle Free Zone (POFZ) 200 x 800<sup>4</sup></b>	Required	Recommended		
<b>Airport Layout Plan<sup>5</sup></b>	Required			
<b>Minimum Runway Length</b>	4,200 ft (1,280 m) (Paved)	3,200 ft (975 m) <sup>6</sup> (Paved)	3,200 ft (975 m) <sup>6,7</sup>	
<b>Runway Markings (See AC 150/5340-1)</b>	Nonprecision (Precision Recommended)		Nonprecision <sup>7</sup>	

4. This is a new airport surface (see paragraph 306)
5. An ALP is only required for obligated airports in the NPIAS; it is recommended for all others.
6. Runways less than 3,200 feet are protected by 14 CFR Part 77 to a lesser extent (77.23(a)(2) is not applicable for runways less than 3,200 feet). However runways as short as 2400 feet could support an instrument approach provided the lowest HAT is based on clearing any 200-foot obstacle within the final approach segment.



**Table A16-2. Survey Requirements for Instrument Approach Procedures**

The table indicates the acceptable runway obstruction survey needed to support an instrument approach procedure. For a complete description of the survey types and associated requirements, refer to AC 150/5300-18.

	Approach	Runway Survey Type								
		None	AV	BV	ANP	C	SUPLC	D	ANAPC	PIR
1	Night Circling			X	X	X	X	X	X	X
2	Non-Precision Approach $\geq$ 1SM, Day Only	X	X	X	X	X	X	X	X	X
3	Non-Precision Approach $\geq$ 1SM				X	X	X	X	X	X
4	Non-Precision Approach $<$ 1SM					X	X	X	X	X
5	Non-Precision Approach $<$ $\frac{3}{4}$ SM								X	X
6	NPV Approach $\geq$ $\frac{3}{4}$ SM							X	X	X
7	NPV Approach $<$ $\frac{3}{4}$ SM								X	X
8	Precision CAT I Approach $<$ 1SM							X	X	X
9	Precision CAT I Approach $<$ $\frac{3}{4}$ SM								X	X
10	Precision CAT II Approach									X
11	Precision CAT III Approach									X

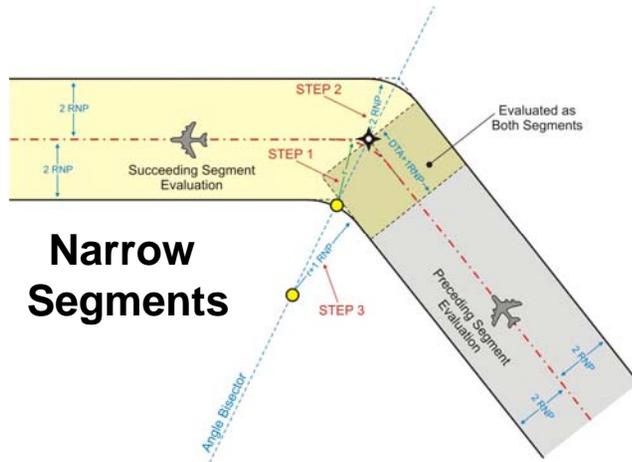
Note:

An “X” in each column for a given Approach (1 through 11) denotes a survey that is acceptable to support that approach. As shown, multiple surveys may support the approach, however the “X” farthest to the left indicates the minimum survey needed.

# RNP



# RNP SAAAR Procedure Design Features per Order 8260.52

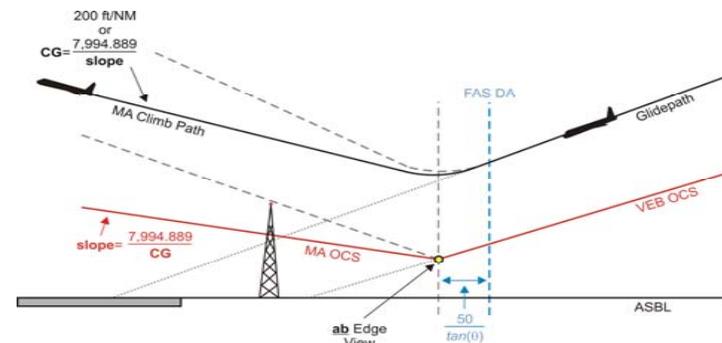
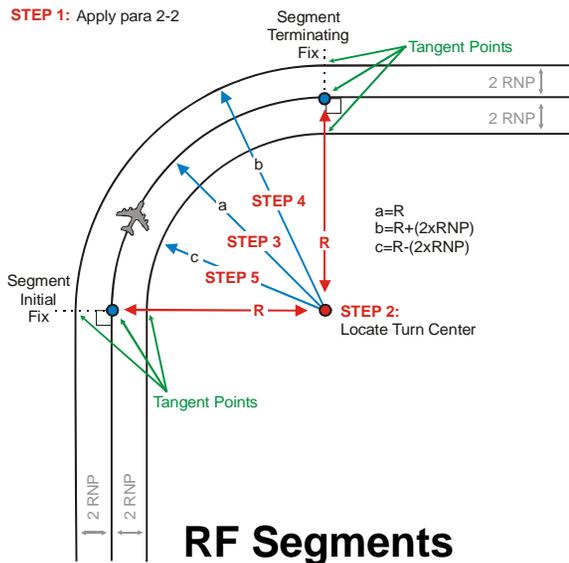


**Lateral Width of 2 X RNP with no secondary buffers at RNP 0.3 nm or less**

**Curved Segments (optional)  
(Radius-to-fix legs)**

**Performance-Based Vertical Criteria  
(Vertical Error Budget)**

**Guided Missed Approaches (optional)  
(RNP 1.0 or less)**



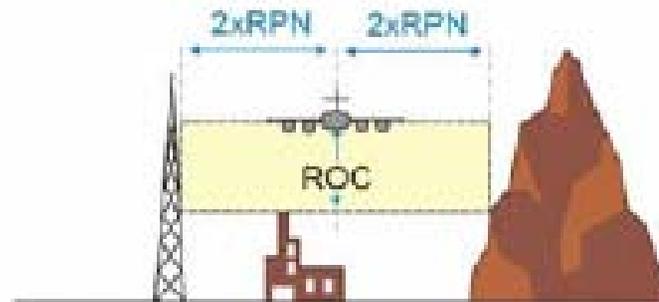
**VEB & Missed Approach**

**Figure 2-2. RNP Segment Width**

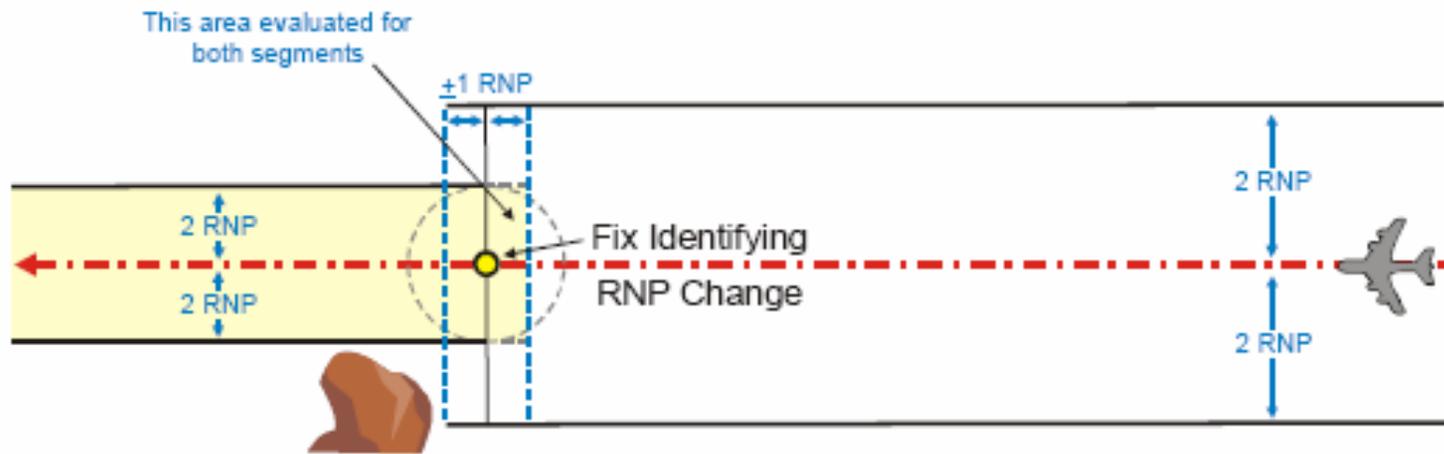
PLAN VIEW



PROFILE VIEW



**Figure 2-8A. RNP Reduction (Straight and Turning Segment)**



**Figure 2-8B. RNP Increase (Straight and Turning Segments)**

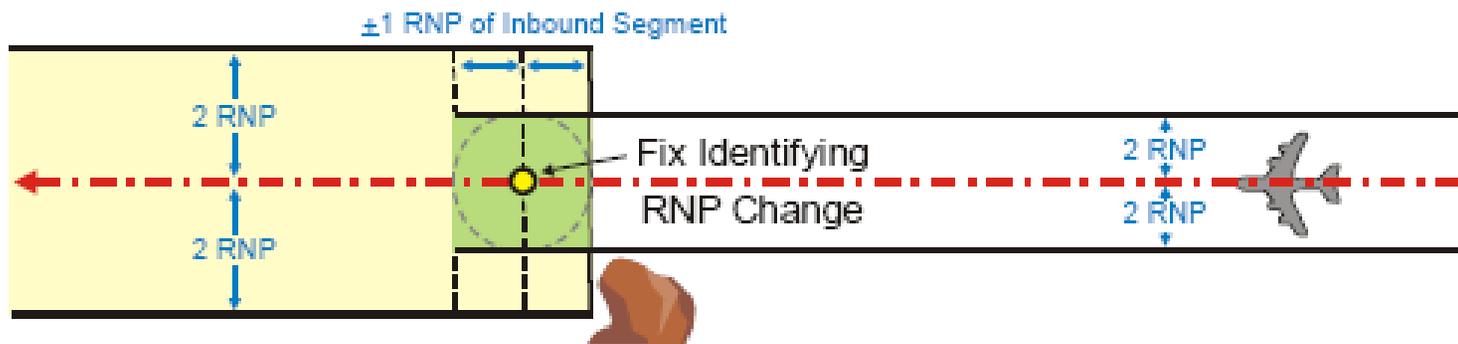


Figure 2-8C. RNP Change Involving RF Legs

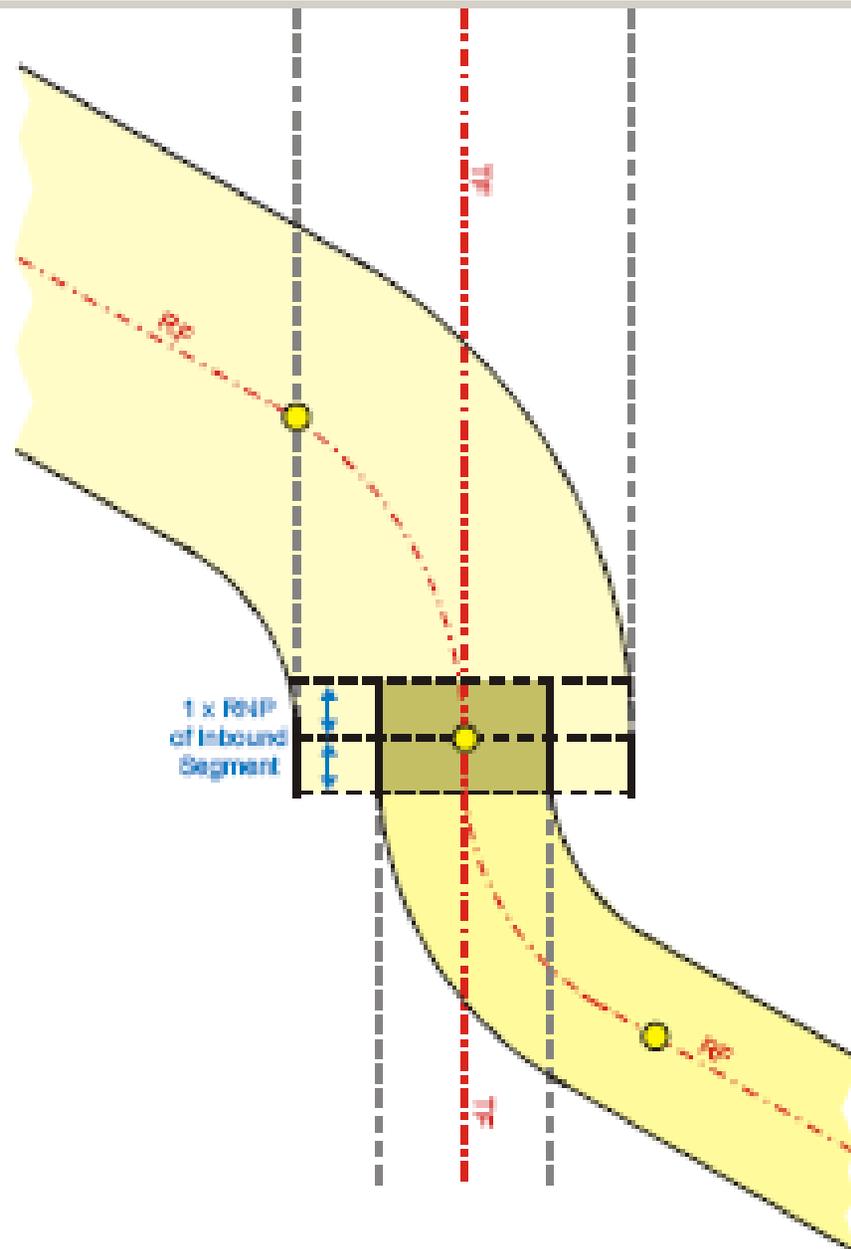
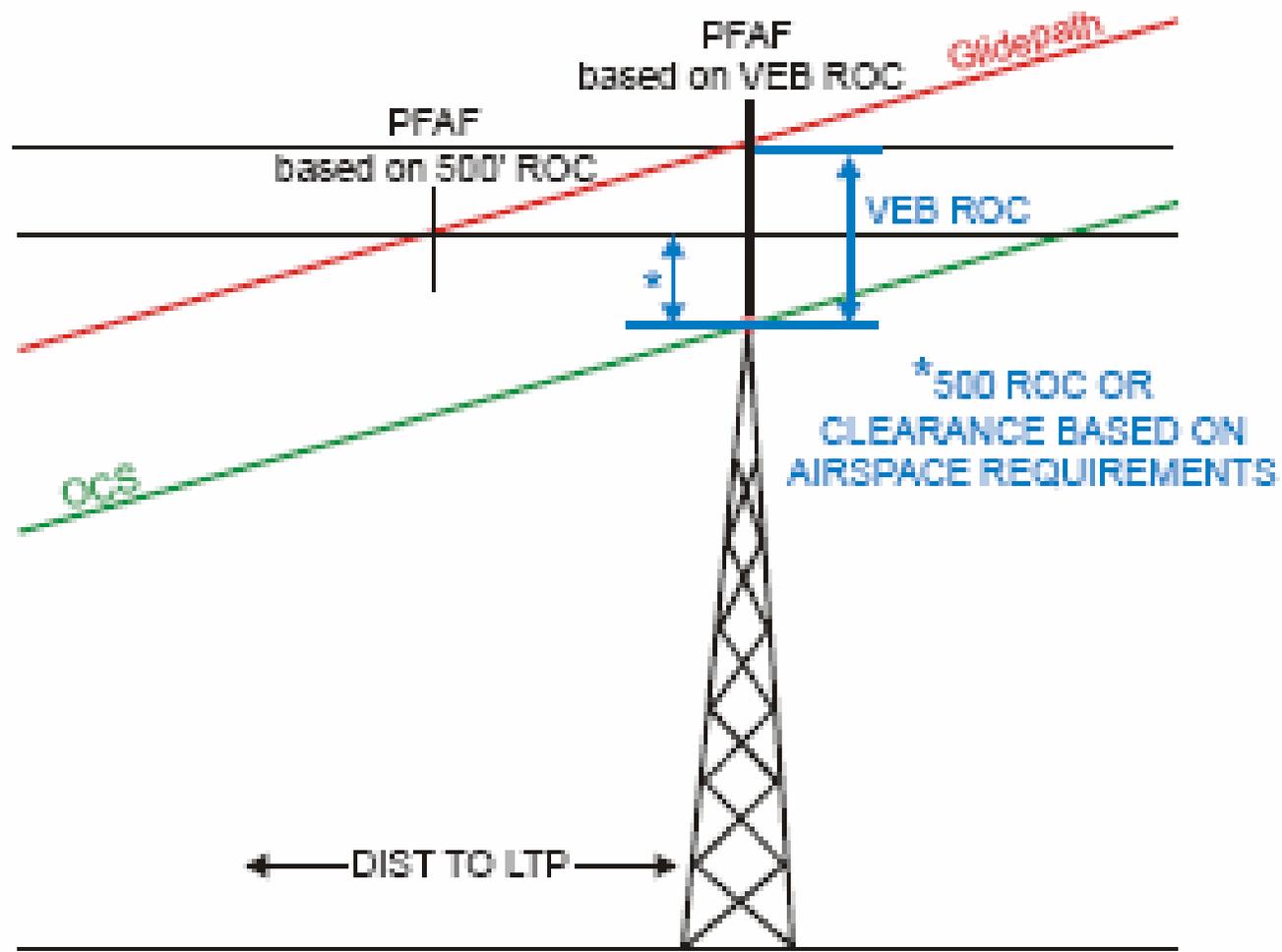


Figure 2-9. Application of VEB in Lieu of ROC in Intermediate Segment



# Vertical Error Budget (VEB) Formula

$$\sqrt{((6078.115)(1.225)RNP \cdot \tan \theta)^2 + (60 \tan \theta)^2 + 75^2 + ((-8.8 \cdot 10^{-8})(h + \Delta h))^2 + (6.5 \cdot 10^{-3})(h + \Delta h) + 50)^2}$$

where  $\theta$  is the vertical navigation (VNAV) path angle,  $h$  is the height of the local altimetry reporting station and  $\Delta h$  is the height of the aircraft above the reporting station.

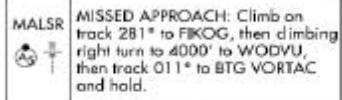
# RNAV (RNP) Z RWY 28R

ANYTOWN (ANY)

APP CRS	Rwy ldg	8000
281°	TDZE	26
	Apr Elev	30

For uncompensated Baro-VNAV systems, Procedure NA below  
 -5°C (23°F) or above 40°C (104°F). RF required. GPS required.  
 MALS R MISSED APPROACH: Climb on track 281° to FIKOG, then dimbing right turn to 4000' to WODVU, then track 011° to BTG VORTAC and hold.

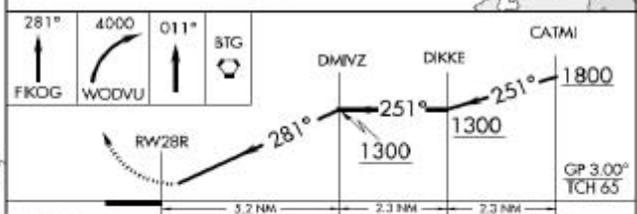
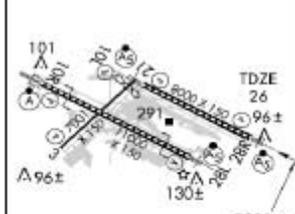
- Requires Missed Approach Climb Gradient of 380 ft/NM to 4000'.
- Requires Missed Approach Climb Gradient of 425 ft/NM to 4000'.
- Requires Missed Approach Climb Gradient of 360 ft/NM to 4000'.



ATIS	ANYTOWN APP CON	ANYTOWN TOWER	GND CON	CLNC DEL
ARR 128.35 269.9 DEP 120.625 239.25	124.35 299.2	Rwy 10L-28R 118.7 257.8 Rwys 3-21, 10R-28L 123.775 251.125	121.9 348.6	120.125 318.1



ELEV 30	Rwy 3 ldg 6321'
	Rwy 21 ldg 6321'



CATEGORY	A	B	C	D
• RNP 0.15		276/40	250 (300-4)	
•• RNP 0.3		346-1	320 (400-1)	
••• RNP 0.15		426-1	400 (500-1)	
RNP 0.3		486-1	460 (500-1)	

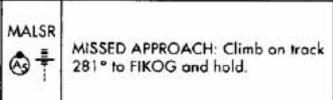
### SPECIAL AIRCRAFT & AIRCREW AUTHORIZATION REQUIRED

# RNAV (RNP) Y RWY 28R

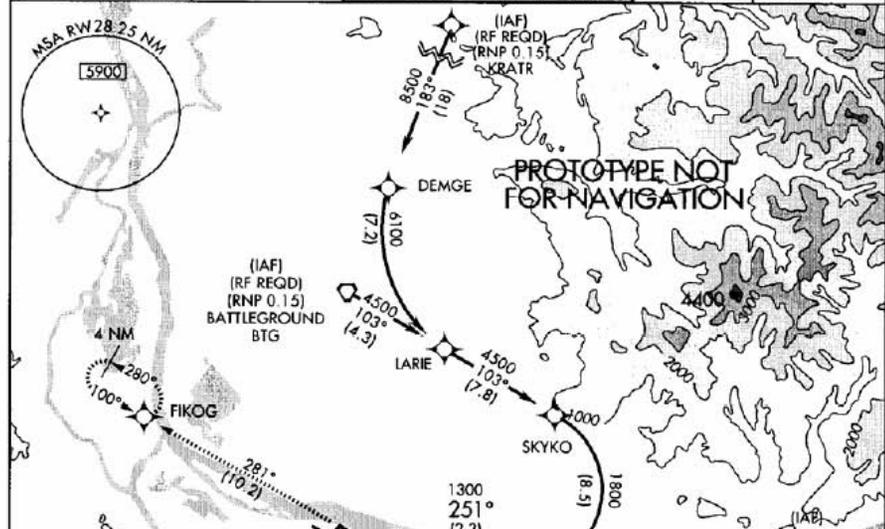
ANYTOWN (ANY)

APP CRS	Rwy ldg	8000
281°	TDZE	26
	Apr Elev	30

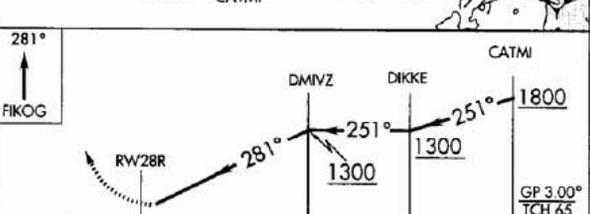
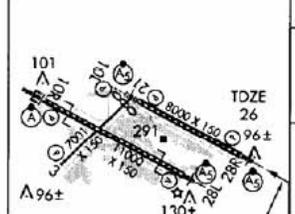
Procedure NA for aircraft with wingspan greater than 136 feet.  
 For uncompensated Baro-VNAV systems, Procedure NA below  
 -5°C (23°F) or above 40°C (104°F).  
 GPS required.



ATIS	ANYTOWN APP CON	ANYTOWN TOWER	GND CON	CLNC DEL
ARR 128.35 269.9 DEP 120.625 239.25	124.35 299.2	Rwy 10L-28R 118.7 257.8 Rwys 3-21, 10R-28L 123.775 251.125	121.9 348.6	120.125 318.1



ELEV 30	Rwy 3 ldg 6321'
	Rwy 21 ldg 6321'



CATEGORY	A	B	C	D
• RNP 0.15		276/40	250 (300-4)	
•• RNP 0.3		346-1	320 (400-1)	

### SPECIAL AIRCRAFT & AIRCREW AUTHORIZATION REQUIRED

# Questions

