Runway End Siting Requirements

CEE 4674
Analysis of Air Transportation Systems

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Runway End Siting Requirements

- FAA AC 150/5300-13B Chapter 3 contains useful information about runway end siting requirements
- **Purpose:** Provides guidance on siting runway thresholds to meet **new* approach obstacle clearance requirements**
- **This analysis is independent** of FAR Part 77 requirements and, in general, dominates for sections adjacent to the runway threshold
- New runway siting requirements started in January 1, 2011 and apply today

Runway End Siting

- Sections 3.5 and 3.6 provide guidance on the preliminary design for the establishment of runway thresholds, approach, and departure runway ends
- "Displacement of the threshold may be required when an object obstructs the airspace required for landing and/or departing airplanes is beyond the airport owners' power to remove, relocate or lower the object" (FAA 2011)
- Detailed guidelines for acceptable Glide Path Angles (GPA) and Threshold Crossing Heights (TCH) are contained in FAA Order 8260.3B (TERPS Procedures Manual)

TERPS Manual

Very detailed guidelines for the design of approach procedures and terrain clearance issues as well as acceptable Glide Path Angles (GPA) and Threshold Crossing Heights (TCH) are contained in FAA Order 8260.3C (TERPS Procedures Manual)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

National Policy

ORDER 8260.3C

Effective Date: 03/14/2016

SUBJ: United States Standard for Terminal Instrument Procedures (TERPS)

This order prescribes standardized methods for designing and evaluating instrument flight procedures (IFPs) in the United States and its territories. It is to be used by all personnel responsible for the preparation, approval, and promulgation of IFPs. These criteria are predicated on normal aircraft operations and performance.

John S. Duncan
Director, Fight Standards Service

https://www.faa.gov/documentLibrary/media/Order/FAA_Order_8260.3C.pdf

Front Page of TERPS Procedures Manual

Chapter 1. Administrative

Section 1-1. Scope

1-1-1. Purpose of This Order. This order prescribes standardized methods for designing and evaluating instrument flight procedures (IFPs). It is to be used by all personnel responsible for the preparation, approval, and promulgation of IFPs. The criteria contained within this order are predicated on normal aircraft operations and performance.

1-1-2. Audience. All personnel who are responsible for IFP development and/or evaluation.

1-1-3. Where To Find This Order. You can find this order on the Federal Aviation Administration's (FAA) Web site.

1-1-4. What This Order Cancels.

a. Order 7130.3A, Holding Pattern Criteria, dated March 18, 1998.

b. Order 8260.3B, The United States Standard for Terminal Instrument Procedures (TERPS), dated July 7, 1976 and associated changes.

c. Order 8260.23, Calculation of Radio Altimeter Height, dated July 6, 1971.

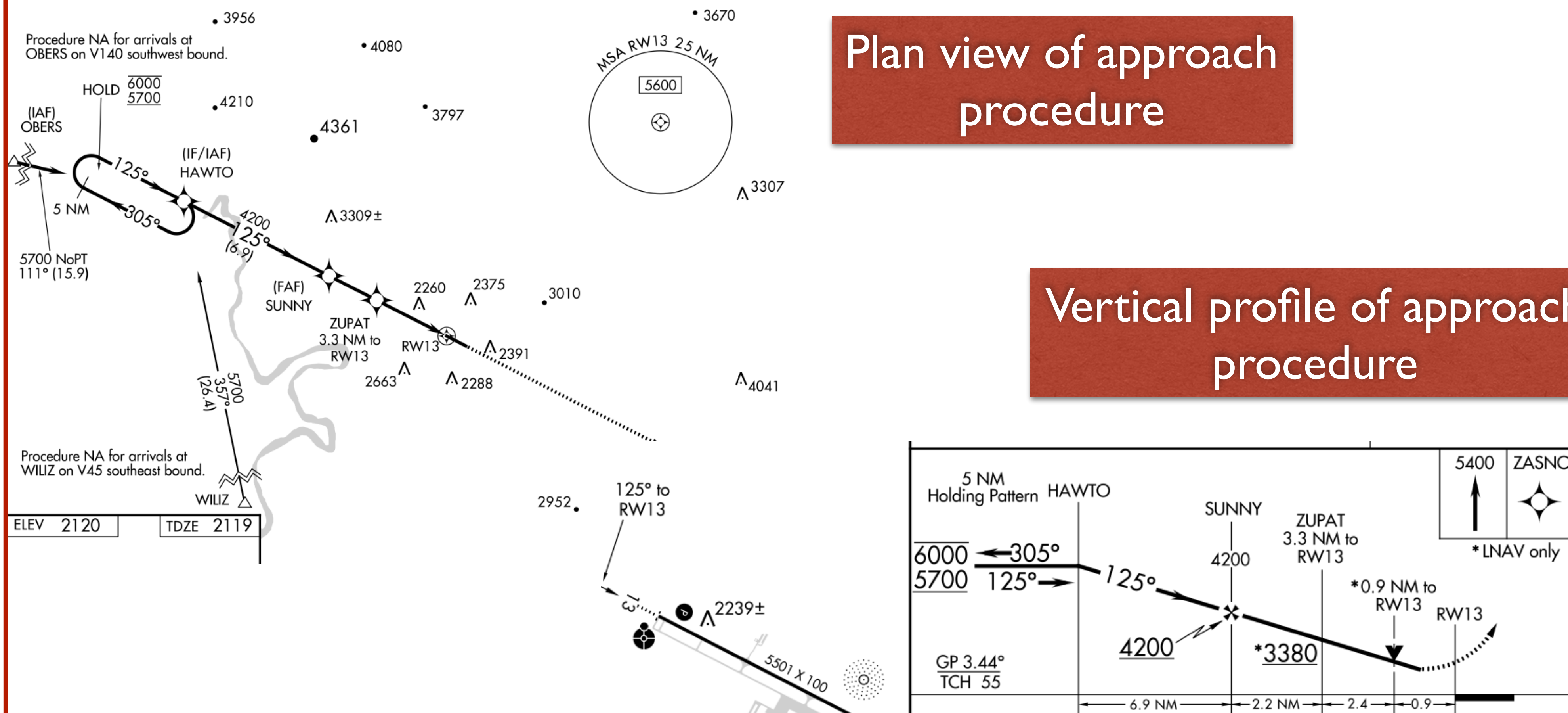
d. Order 8260.49, Simultaneous Offset Instrument Approach (SOIA), dated June 23, 2006 and associated changes.

https://www.faa.gov/documentLibrary/media/Order/FAA_Order_8260.3C.pdf

TERPS Manual Is Used by the FAA to Design Approach and Departure Procedures

Plan view of approach procedure

Vertical profile of approach procedure

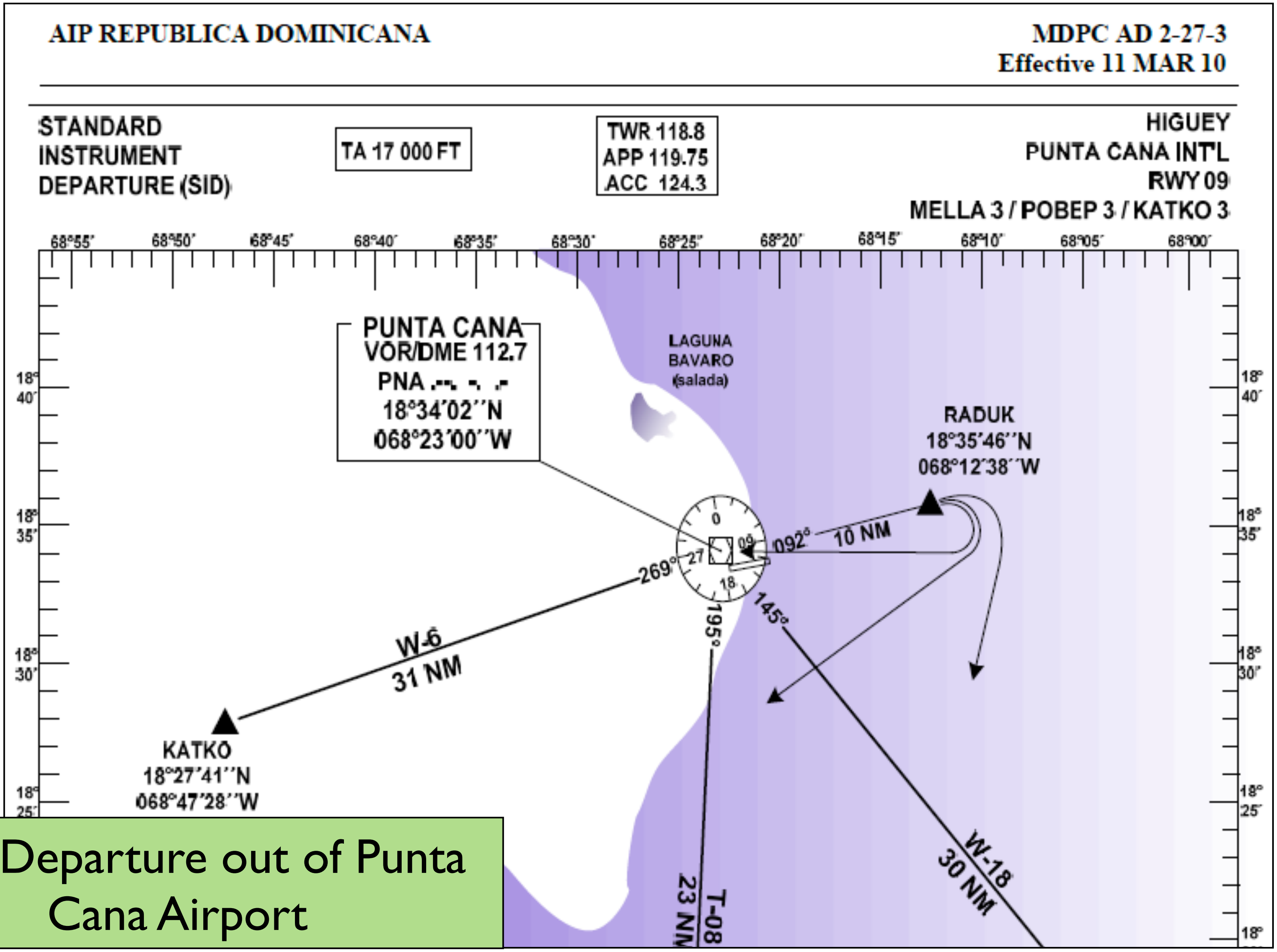


CATEGORY	A	B	C	D
LPV DA	2389-1 270 (300-1)			NA
LNAV/ VNAV DA	2419-1 300 (300-1)			NA
LNAV MDA	2520-1 401 (400-1)			NA
CIRCLING	2760-1 640 [illegible]0-1)	2820-1 700 (700-1)	2980-2½ 860 (900-2½)	NA

REIL Rwy 31
MIRL Rwy 13-31

GPS (RNAV) Approach to Runway 13 Blacksburg

ICAO Has Similar Manuals to Design Procedures outside the US



VOR Departure out of Punta Cana Airport

Relation with FAR 77 and FAA Runway Siting Rules in Chapter 3 of AC 150/5300-13B

- TERPS procedures are used to design approaches by FAA and ICAO specialists
- They are complementary to the criteria stated in FAR Part 77 (imaginary surfaces) and the FAA guidance on runway siting contained in Chapter 2
- **As an airport engineer you need to be aware of both procedures**
- Siting compliance using FAR Part 77 and FAA Chapter 3 150 5300-13B suffices for airport design work

Reasons for Displacing Runway Thresholds

1. When is not possible to remove (or relocate) an obstruction beyond the airport control

2. To obtain additional Runway Safety Area (RSA) prior to the threshold

3. To obtain or comply with Runway Object Free Area (ROFA) requirements prior to the threshold

4. To locate the Runway Protection Zone (RPZ) to mitigate unacceptable incompatible land

Example 1: Old Blacksburg Airport
To comply with RSA requirements prior to landing

Example 2: San Diego, California
To comply with Approach Surface Requirements

Types of Analyses and Outcomes (from TERPS Analyses)

- **Approach Surfaces**
  - Object is removed
  - Threshold is displaced
  - The Glide Path Angle (GPA) or Threshold Crossing Height (TCH) are modified
  - A combination of threshold change or GPA/TCH changes
  - Visibility minimums are raised
  - Night operations are prohibited

Types of Analyses and Outcomes

- **Departure Surfaces**
  - Object is removed, relocated or lowered to preclude penetration
  - Decrease Takeoff Distance Available (TODA)
  - Modify instrument departure procedures (this requires consultation with Flight Procedures Office at FAA for guidance)

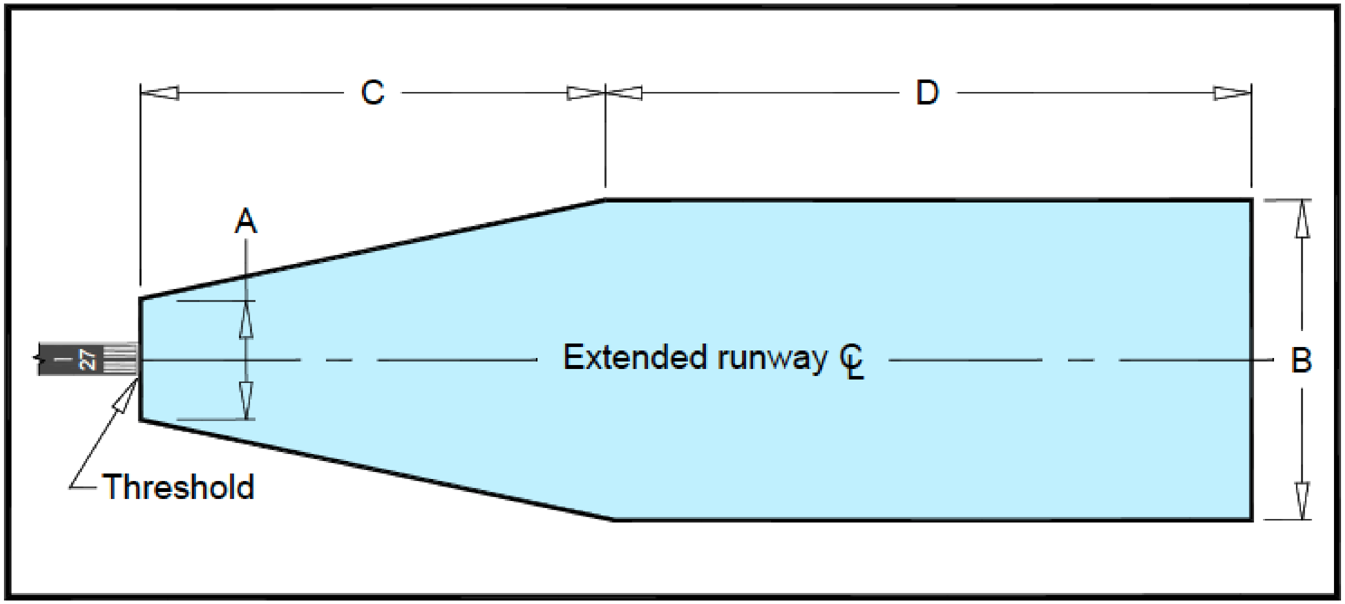
Factors Considered in Runway End Siting Analysis

- Aircraft using the runway and their climb/landing performance
- Operational impacts of accepting higher minimums
- Cost of removing, ,relocating and lowering objects
- Cost/penalties of reduced landing/takeoff distances when runway is wet or icy
- Cost of runway extension
- Noise and environmental costs

Visual Runway Approach Surfaces

Surface	Runway Type	A ft (m)	B ft (m)	C ft (m)	D ft (m)	Slope
Surface 1	Approach end of runways serving small airplanes with approach speeds less than 50 knots.	120 (37)	300 (91)	500 (152)	2,500 (762)	15:1
Surface 2	Approach end of runways serving small airplanes with approach speeds of 50 knots or more.	250 (76)	700 (213)	2,250 (686)	2,750 (838)	20:1
Surface 3	Approach end of runway serving large airplanes (>12,500 lbs (5,669 kg))	400 (122)	1,000 (305)	1,500 (457)	8,500 (2,591)	20:1

Note: Approach surface begins at the runway threshold.



Note 1: Refer to Table 3-2 for dimensional values.
Note 2: Surface slopes upward and away from starting point.

source: FAA AC 150/5300-13B (Figure 3-4)

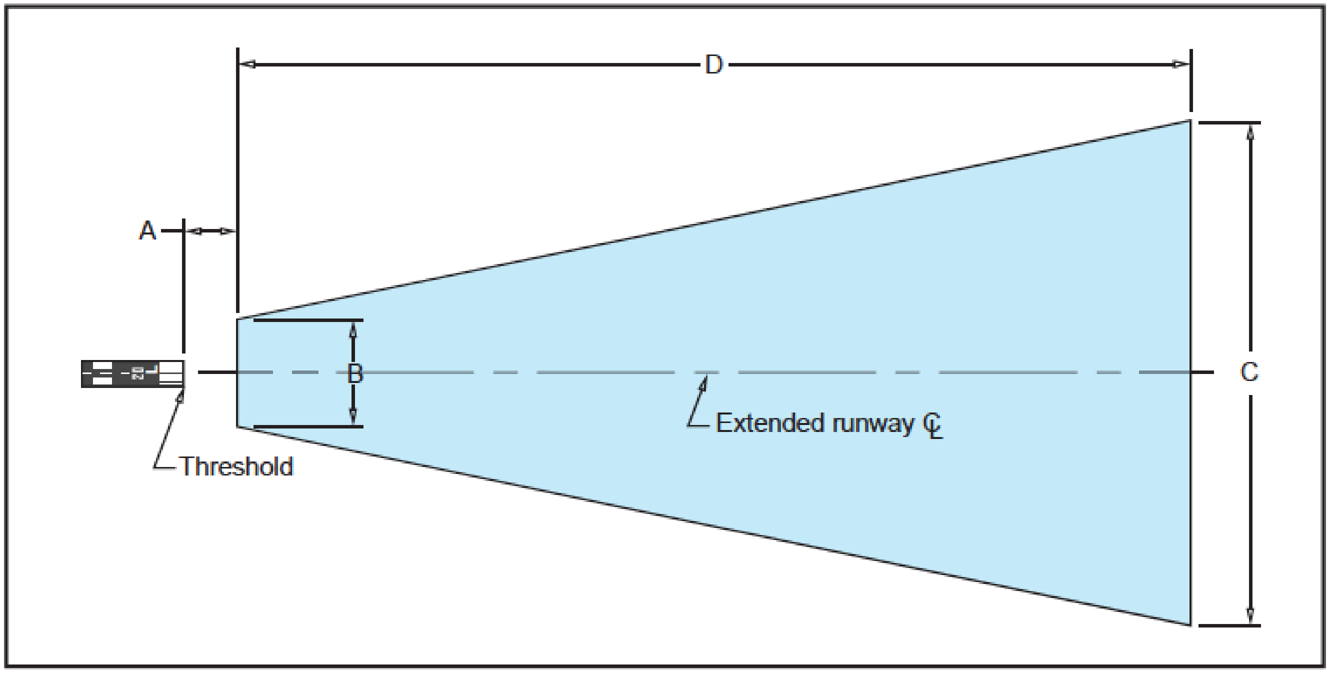
Non-Precision Runway Approach Surfaces

Surface	Runway Type	Visibility minimums	A ft (m)	B ft (m)	C ft (m)	D ft (m)	Slope
Surface 4	Approach end of runways that supports IFR circling procedures and procedures only providing lateral guidance (VOR, NDB, LNAV, LP, TACAN, VORTAC, ASR, and LOC).	≥ ¾ statute mile (1.2 km)	200 (61)	400 (122)	3,400 (1,036)	10,000 (3,048)	20:1
		< ¾ statute mile (1.2 km)	200 (61)	400 (122)	3,400 (1,036)	10,000 (3,048)	34:1

Note 1: Dimension A is relative to the runway threshold.
Note 2: Refer to the U.S Terminal Procedures Publication (TPP) to determine if circling minimums are available.
Note 3: Marking and lighting of obstacle penetrations to this surface or the use of a Visual Guidance Lighting System (VGLS) may mitigate displacement of the threshold. Contact the Flight Procedures Team if existing obstacles penetrate this surface.
Note 4: 10,000 feet (3,048 m) represents a nominal value for planning purposes. The length is dependent on the Visual Descent Point (VDP) location.

source: FAA AC 150/5300-1B (Table 3-3)

Includes IFR Circling Approaches



Note: Refer to Table 3-3 for dimensional values.

source: FAA AC 150/5300-13B (Figure 3-6)

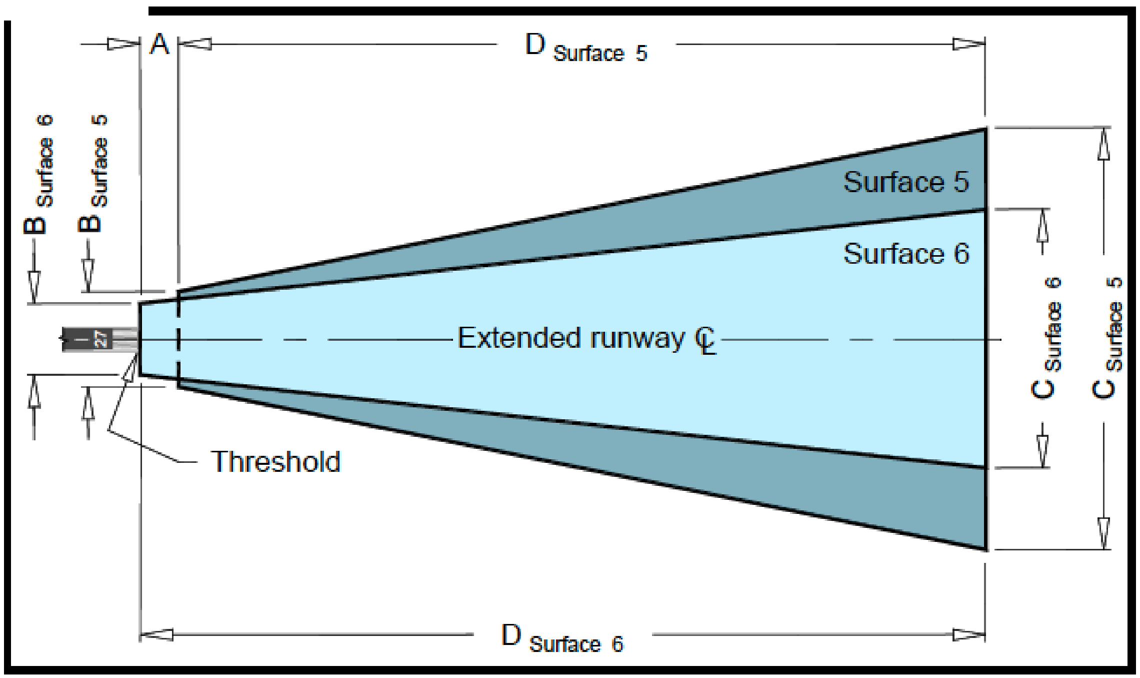
Precision Runway Approach Surfaces

Surface	Runway Type	Visibility minimums	A ft (m)	B ft (m)	C ft (m)	D [4] ft (m)	Slope
Surface 5	Approach end of runways providing ILS, MMLS, PAR, and localizer type directional aid with glidepath, LPV, LNAV/VNAV, RNP, or GLS.	≥ ¾ statute mile (1.2 km)	200 (61)	400 (122)	3,400 (1,036)	10,000 (3,048)	20:1
		< ¾ statute mile (1.2 km)	200 (61)	400 (122)	3,400 (1,036)	10,000 (3,048)	34:1
Surface 6	Approach end of runways providing ILS, MMLS, PAR, and localizer type directional aid with glidepath, LPV, LNAV/VNAV, RNP, or GLS.	All	0	Runway Width + 200 (61)	1,520 (463)	10,200 (3,109)	30:1

Note 1: Dimension A is relative to the runway threshold.
Note 2: Surface 5 represents the TERPS visual portion of the final approach segment. Surface 6 represents the TERPS Vertical Guidance Surface (VGS). Both surfaces apply for APV and PA procedures. Contact the Flight Procedures Team if existing obstacles penetrate this surface.
Note 3: The FAA assesses TERPS final approach segment criteria (e.g., W, X, Y surfaces) for all runway ends authorized for ILS, mobile microwave landing system (MMLS), precision approach radar (PAR), and localizer type directional aid with glide slope, LPV, and GLS procedures. Refer to FAA Order 8260.3 for additional information on TERPS surfaces.
Note 4: Represents a nominal value for planning purposes. The actual length depends on the precision final approach fix.

source: FAA AC 150/5300-1B (Table 3-4)

Includes APV approaches
APV = Approach Procedure with Vertical Guidance

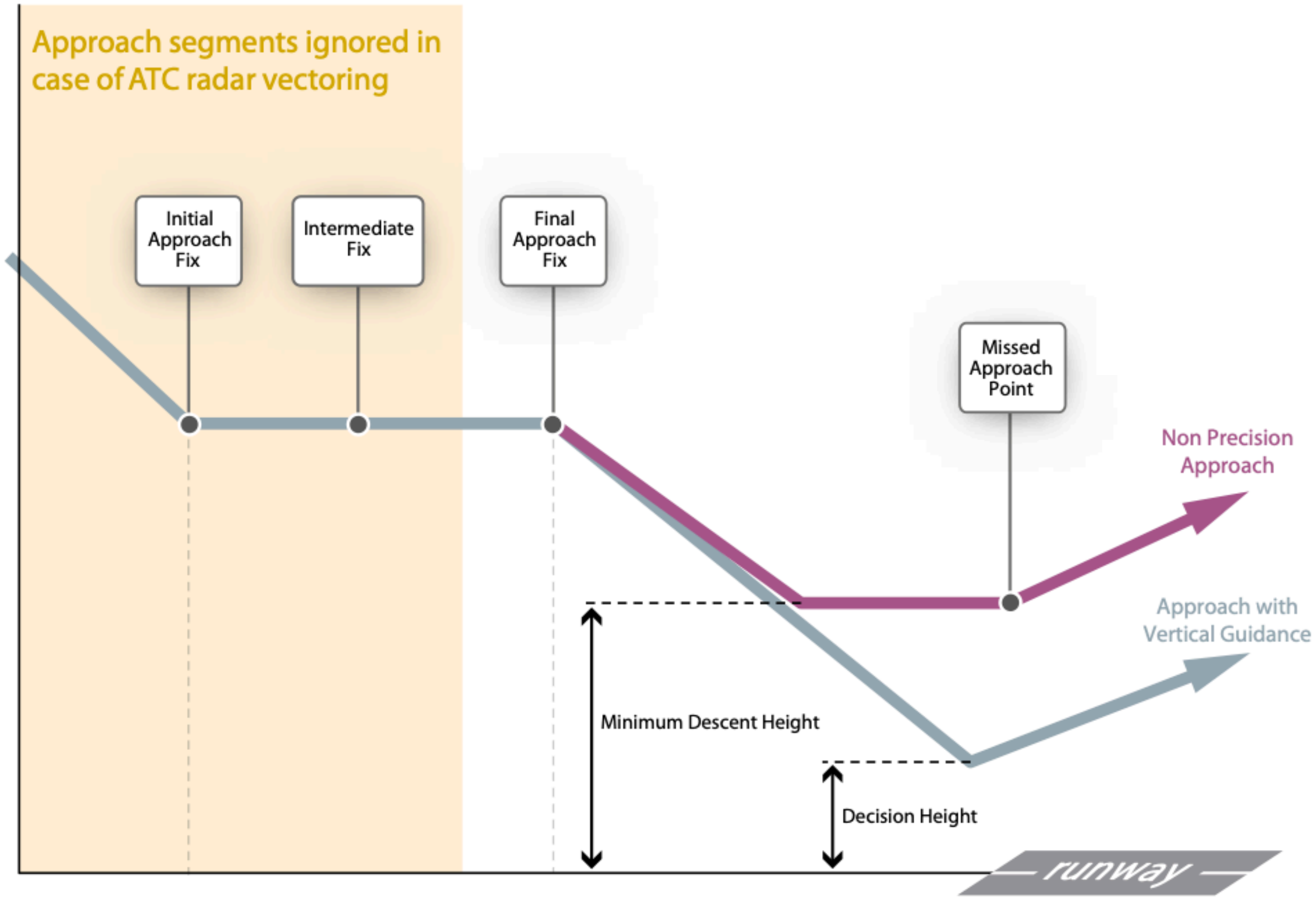


Note: Refer to Table 3-4 for dimensional values.

source: FAA AC 150/5300-13B (Figure 3-7)

Approaches with Vertical Guidance

APV Approaches = RNAV approaches with vertical guidance



Source: Eurocontrol (https://www.icao.int/EURNAT/Other%20Meetings%20Seminars%20and%20Workshops/PBN%20TF/PBN%20TF8/PBNTF8%20IP08_RNAV%20approaches.pdf)

Terminology:

RNAV: aRea NAVigation
APV: Approach with Vertical Guidance

LNAV: Lateral Navigation
VNAV: Vertical Navigation

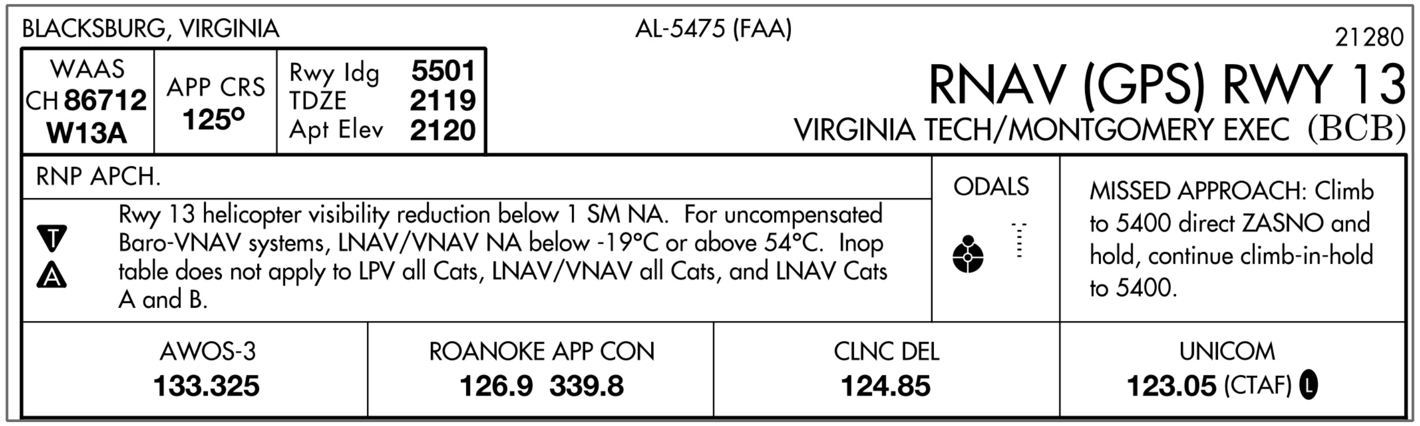
Guidance
MDA/H: Minimum Descent Altitude/Height

DA/H: Decision Altitude/Height

APV Baro - uses aircraft barometric sensors to guide the aircraft vertically to the runway

APV SBAS - uses Satellite Based Augmentation Systems (WAAS - Wide Area Augmentation System) in the United States

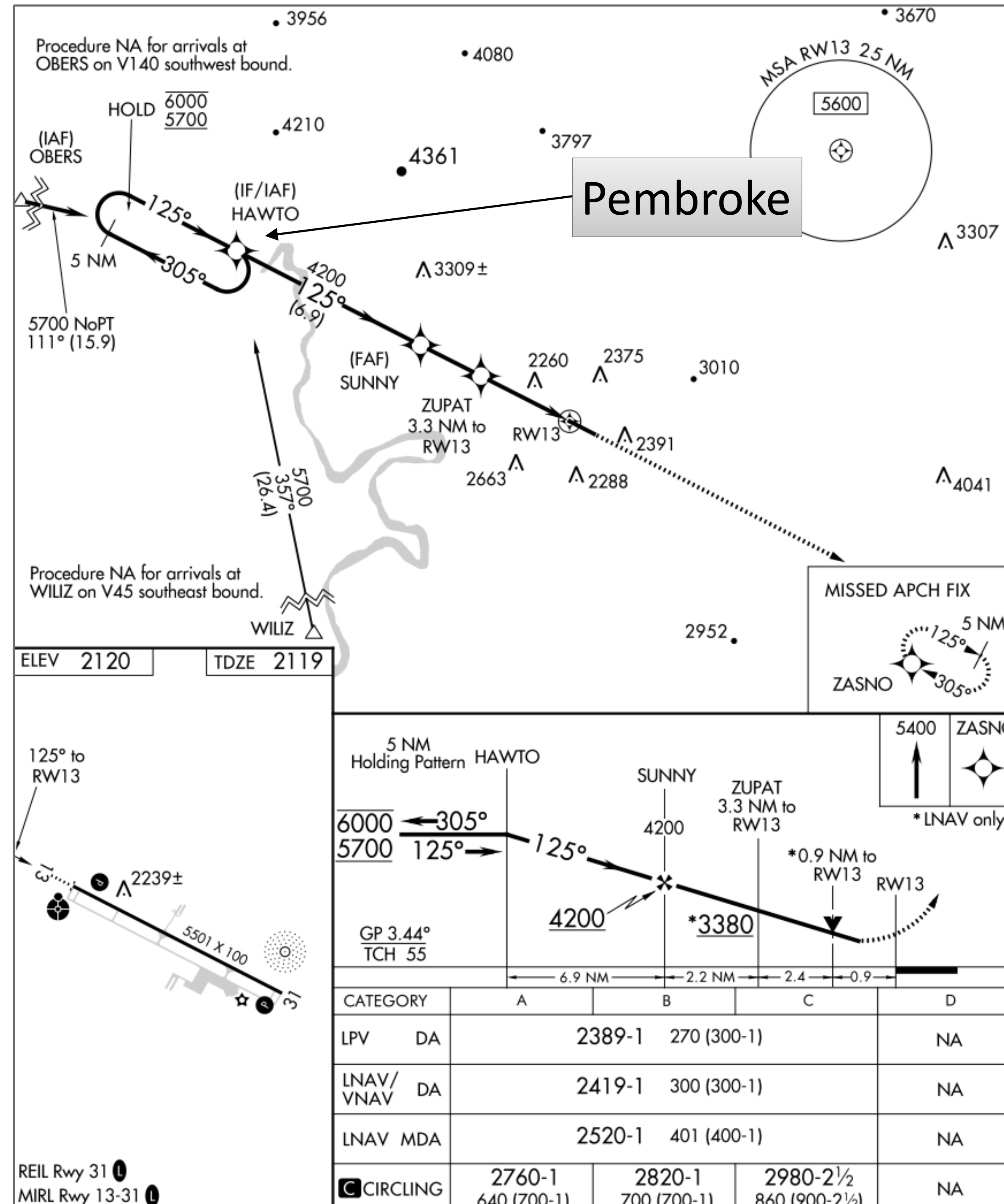
Approaches with Vertical Guidance



IFR Approach Header

Plan View of Approach

Side View of Approach
Note vertical guidance from HAWTO

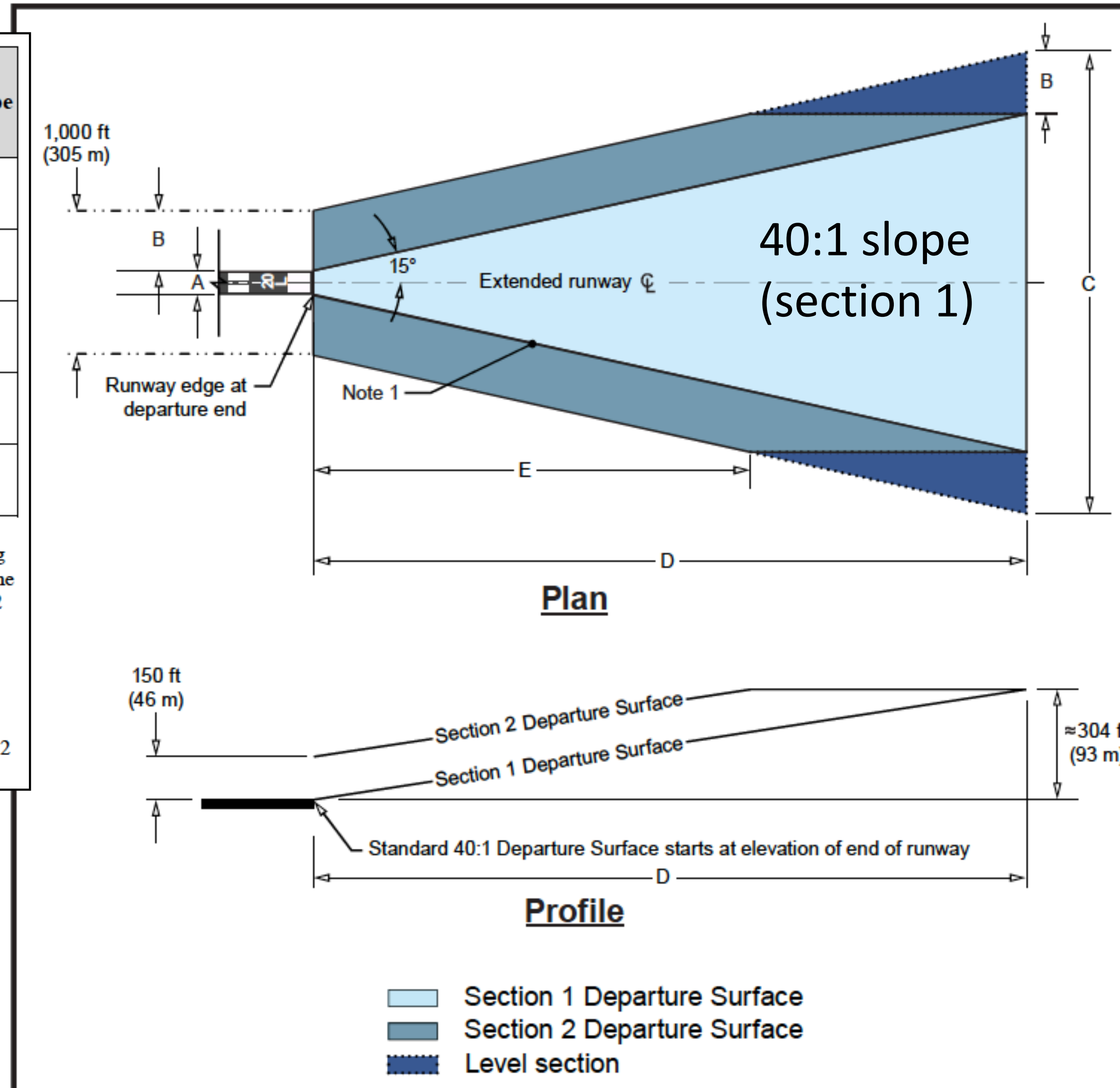


Instrument Runway Departure Surfaces

Surface	Runway Type	A ft (m)	B ft (m)	C ft (m)	D [4] ft (m)	E ft (m)	Section 2 Angle θ [2]	Section 2 Transverse Slope m^2
Surface 7	Runways providing instrument departure operations	60 (18.3)	470 (143)	7,512 (2,290)	12,152 (3,704)	6,152 (1,875)	17:7	3.13:1
		75 (22.9)	462.5 (141)				18.0	3.08:1
		100 (30.5)	450 (137)				18.4	3.00:1
		150 (46)	425 (130)				19.4	2.83:1
		200 (61)	400 (122)				20.6	2.67:1

Note 1: Section 1 of the departure surface starts at the DER elevation for the width of the runway and rises along the extended runway centerline at 40:1. Section 2 starts at an equal elevation to the adjoining Section 1. Section 2 continues until reaching 304 ft (93 m) and then levels off until reaching the line where Section 1 and Section 2 reach 304 ft (93 m) above DER elevation, then that part of Section 2 that leveled off continues at a 40:1 slope.
Note 2: See Figure 3-11 for a graphical depiction of these values.
Note 3: The start of the surface is relative to the departure end of the runway. For runways with published declared distances, the TODA indicates the beginning of the departure surface. See Figure 3-10.
Note 4: 12,152 feet (3,704 m) represents a 2 nm nominal value for planning purposes.
Note 5: For other runway width values, interpolation is required to determine the value of "B", the Section 2 angle, and the Section transverse slope.

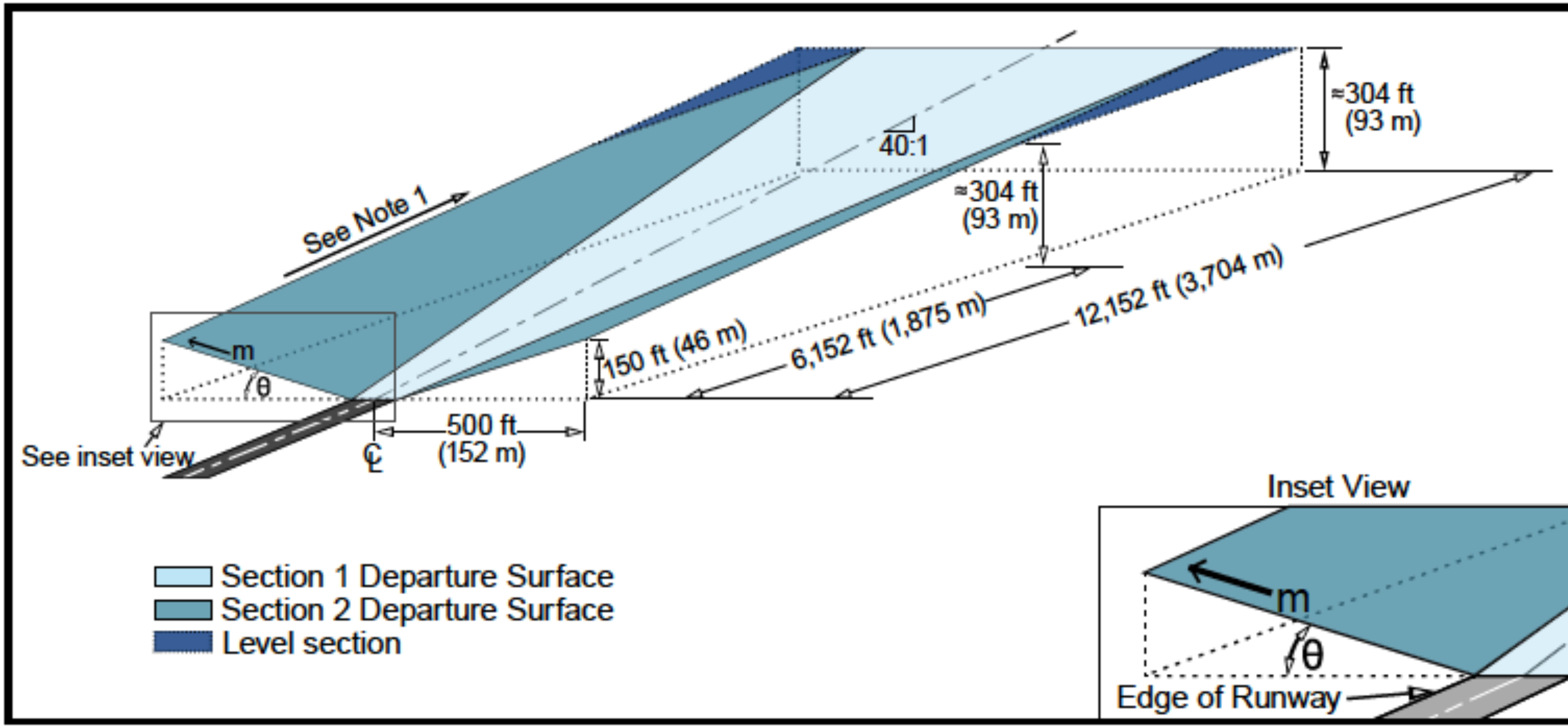
Source: Table 3-5 of FAA AC 150/5300-13B



Note 1: The half-width of Section 1 is calculated by the formula:
Section $1_{Half\ Width}$ = (1/2 RWY Width) + (Tan 15° × X), where X = distance from the departure end of the runway.
Note 2: See Table 3-5 for dimensional values.

Source: Figure 3-8 of FAA AC 150/5300-13B

Instrument Runway Departure Surfaces



Note 1: The outer edge of the Section 2 Departure Surface has a slope of 40:1.
Note 2: The 304-foot (93 m) value represents the height above the DER.
Note 3: Refer to paragraph 3.6.2.1 for additional information.

Source: Figure 3-9 of FAA AC 150/5300-13B

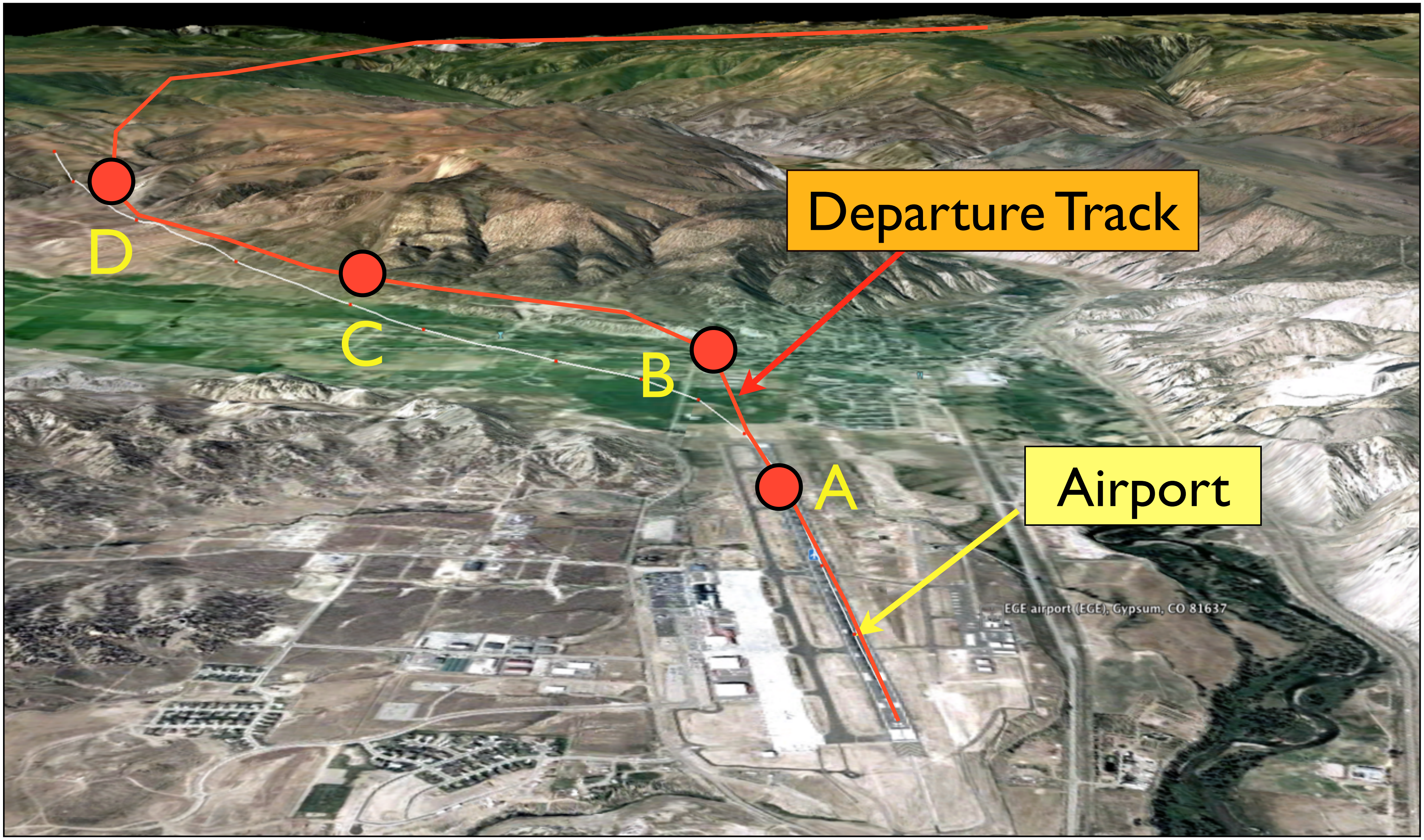
Observations

- The higher the precision of the runway, the stricter the Obstacle Clearance Surfaces (OCS)
- For runways supporting air carrier operations , the OCS standard is established at a slope of 40 : 1
- For runways supporting air carrier operations, the Obstacle Identification Surface (OIS) could be more strict than the 50 : 1 standard for precision runways required in FAR part 77 (see Figure A2-4)

Use of Airport Approach and Departure Aeronautical Charts

- To illustrate some challenging airport operational procedures related to runway end siting and aircraft climb performance we use some approach and departure aeronautical charts
- These charts are used by pilots and ATC to plan and fly arrival and departure procedures (flight tracks) to the airport. These are called Standard Terminal Arrival Routes (STAR), Standard Instrument Departures (SID), and Instrument Approach Procedures (IAP)
- You can obtain airport STAR, SID and IAP charts at: http://flightaware.com/
- More information on how to read these charts can be found:
  - http://www.naco.faa.gov/index.asp?xml=naco/online/aero_guide
  - http://sunairexpress.com/images/How_to_Read_Approach_Plates.pdf

Sample Departure Procedure (EGE Airport)



source: Google Earth (2009)

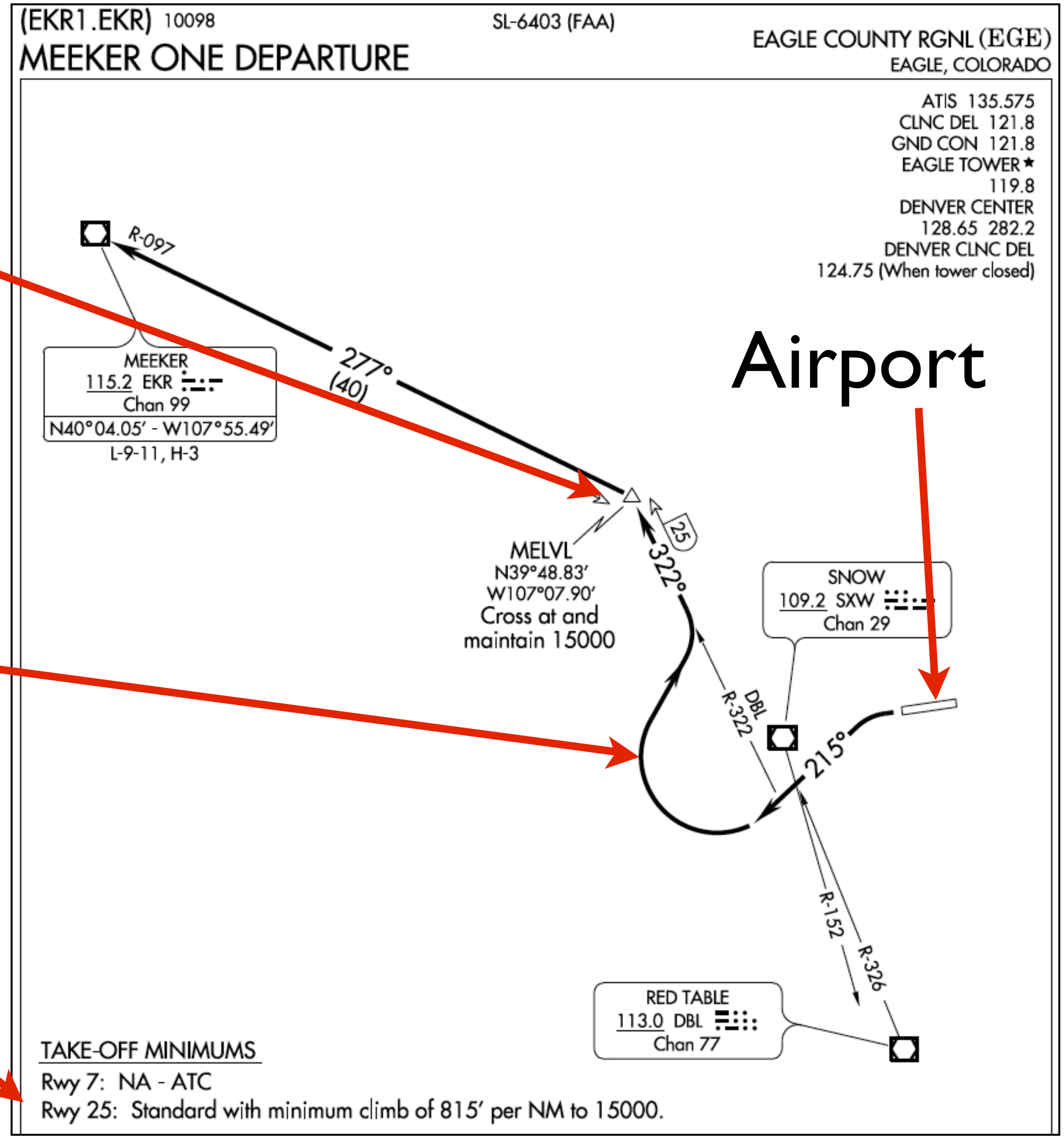
Departure Procedure from EGE (Runway 25)

Note crossing altitude restriction at MELVL

Climbing left turn heading 215 degrees to avoid natural terrain to the West of the airport

Requires 815 feet/nm of climb performance

Airport



source: FAA

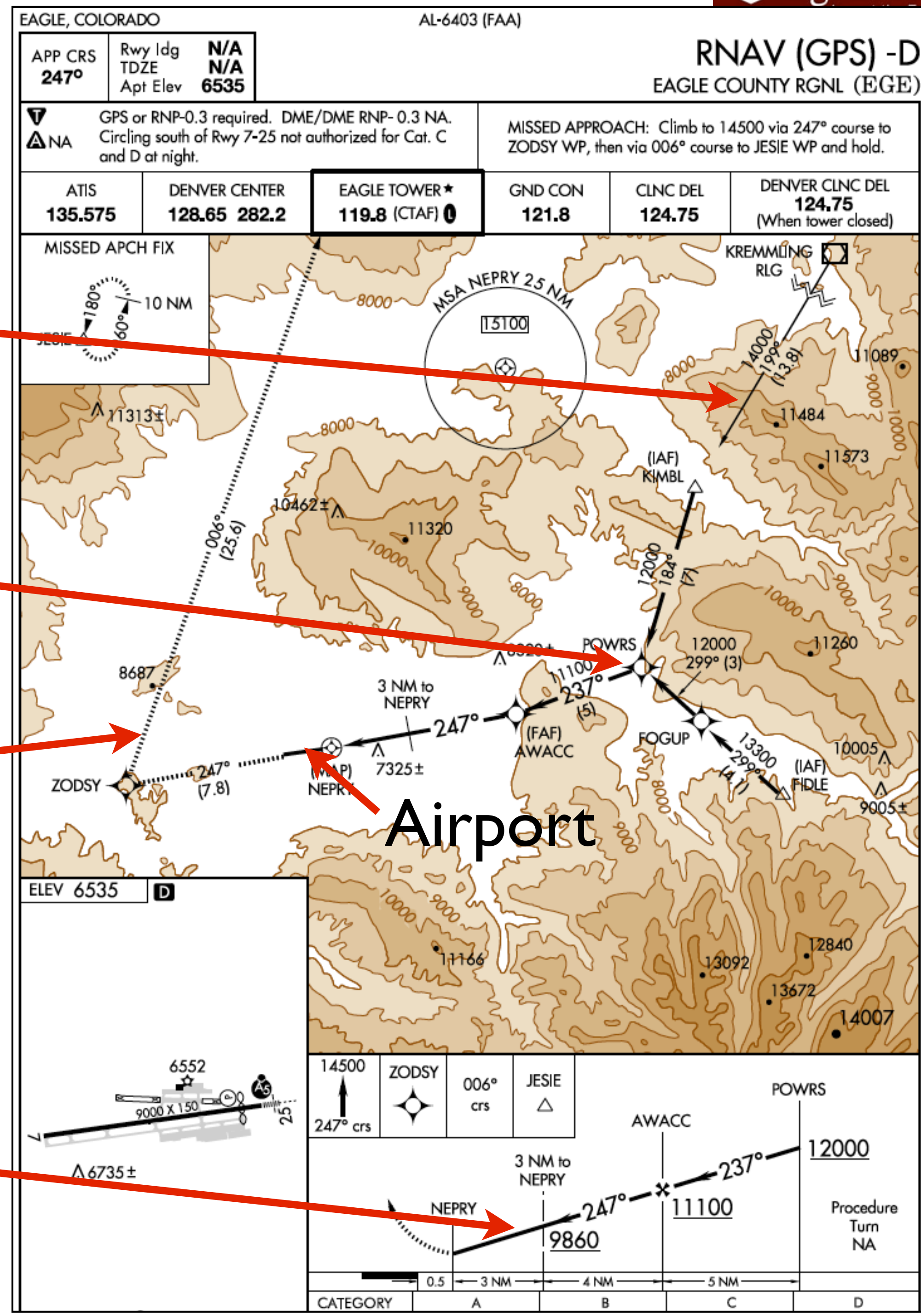
RNAV Approach Procedure to EGE (Runway 25)

Descent to the airport from NE avoids the highest terrain

RNAV waypoints provide a complex track

Missed approach track is a escape route through lower terrain

Vertical profile of approach track



source: FAA

Conclusions

- New criteria contained in Appendix A2 of the FAA AC 150/5300-13 could be a dominant effect in establishing the runway end siting requirements in the future
- TERP procedures have been published since 1979
- New GPS procedures with lateral and vertical guidance have required revisions to the TERP procedures
- The FAA has designed thousand of GPS and WAAS aided procedures to runways in the U.S.
- Some of these procedures offer lower landing minima comparable to ILS approaches (200 feet DH and 1/2 mile visibility)