Federal Aviation Administration

Memorandum

Date: OCT 03 2011

To: Chas. Frederic Anderson, Acting Director, Aeronautical Products, AJV-3

From: Leslie H. Smith, Manager, Flight Technologies and Procedures Division, AFS-400

Subject: Revised Performance Based Navigation (PBN) Fly-By (FB) /Radius-to-Fix (RF) Turn Maximum Bank Angle Limits; Omni-Directional Tailwind Requirements; and Minimum Initial Departure Leg Segment Length Design Criteria

This memorandum provides guidance and supersedes all previous guidance on the maximum bank angle design limits for FB and RF turns, reiterates the harmonized method for determining omni-directional tailwinds (V_{KTW}) and establishes the minimum initial departure leg length design criteria. It is applicable to PBN instrument procedures: area navigation (RNAV), required navigation performance (RNP), and RNP with authorization required (RNP AR). The July 15, 2011 AFS-400 memorandum, subject "Performance Based Navigation (PBN) Fly-By (FB) /Radius-to-Fix (RF) Turn Maximum Bank Angle Limits", is canceled.

1. **Bank Angle**. For terminal and transitions from en route to terminal operations, the following two rules are added to design standards to determine the maximum bank angle limit for use in procedure design for FB and RF turns at and below 19,500 feet above mean sea level:

a. FB Rule: The maximum design bank angle is:

(1). For track change less than 50 degrees: one half the magnitude of track of change; e.g., a 44 degree turn maximum bank angle is 22 degrees $\left\{\frac{44}{2}=22\right\}$.

or

(2). For track changes equal to or greater than 50 degrees: 25 degrees (20 degrees for RNP/ATT less than 1.0).

***EXCEPTION**: Where minimum segment length is necessary and application of paragraph 1a is required but not operationally acceptable, it may be ignored if the succeeding segment is compliant with minimum segment length and bank angle rules.*

b. RF Rule: Calculated RF bank angle based on the design radius not to exceed 25 degrees* (20 degrees for RNP/ATT values less than 1.0). *Revised from July 15, 2011 AFS-400 memorandum.

c. Both FB and RF: The maximum bank angle below 500 feet above airport elevation is 3 degrees.

2. **Tailwind.** The method to determine the standard omni-directional tailwind values used for design parameters outlined in FAA Order 8260.52 and FAA Order 8260.54A has been harmonized. The V_{KTW} speed is added to true airspeed to determine ground speed values used in turn radius and bank angle calculations. FAA Order 8260.54A Formula 2-3b ($V_{KTW}=0.00198\times alt_{Turn}+47$) is the harmonized standard used to determine V_{KTW}.

Alternatively, if the formula 2-3b value is considered excessive at a specific location, the **99%tile** wind speed values determined from analysis of a five year locally measured database may be substituted. Use of a 5-year locally measured database is addressed in AFS-400 memorandum, October 2, 2009, "Minimum Segment Length" and is superseded by above.

3. **Minimum Initial Departure Leg Segment Length.** Attachment 1 defines the design criteria for a minimum initial departure leg length. The principle design is for FB turns, but an exception is included to allow for a shorter initial departure leg length if the inside of the turn is protected as a FB turn and the outside protected as a Fly-over turn. Refer to AFS-400 Memorandum, October 2, 2009, "Minimum Segment Length" for Along-Track Tolerance consideration for all other minimum segment length designs.

The memorandum will be incorporated into Order 8260.PBN. If you have any questions, please contact Mr. Rick Dunham, Manager, Flight Procedure Standards Branch, AFS-420, at (405) 954-4164.

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Attatchment 1. Minimum Initial Departure segment Leg Length

INITIAL DEPARTURE LEG *(FB turn evaluation only)*

1. The minimum length of the initial leg of a departure that will be designed to fly straight ahead to initiate a fly-by turn maneuver to enter a TF leg or a defined track (e.g. defined course to a fix) is:

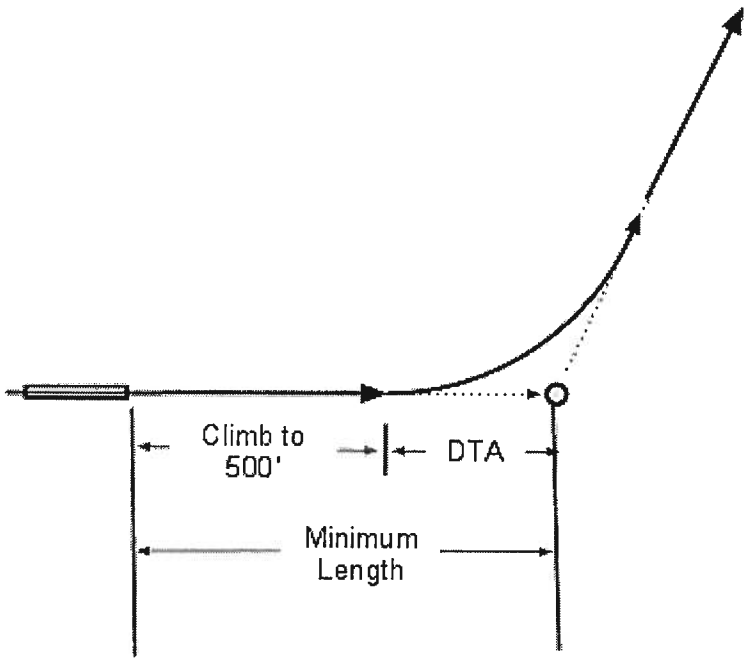
a. The distance required to climb to 500 feet above airport

plus

b. The distance of turn anticipation (DTA) value calculated for the turn.

Along-track tolerance (ATT) is not an additive for this initial departure leg minimum length calculation. The obstacle evaluation area (OEA) is constructed and evaluated as a FB turn executed at the turn waypoint or point of intersection of the initial departure track and the track intercepted.

Figure 1. Minimum Length



2. EXCEPTION. At locations where the initial departure leg must be shorter than the above minimum, the initial leg may be designed with a minimum length which is the greater of, The OEA for this exception is a hybrid; i.e., it **MUST** be evaluated as a FB turn on the turn side (inside) and a fly-over (FO) turn on the non-turning side (outside). The succeeding segment (leg entered at completion of turn) is considered to be at full width at a distance of DTA past the turn point.

a. One NM from DER

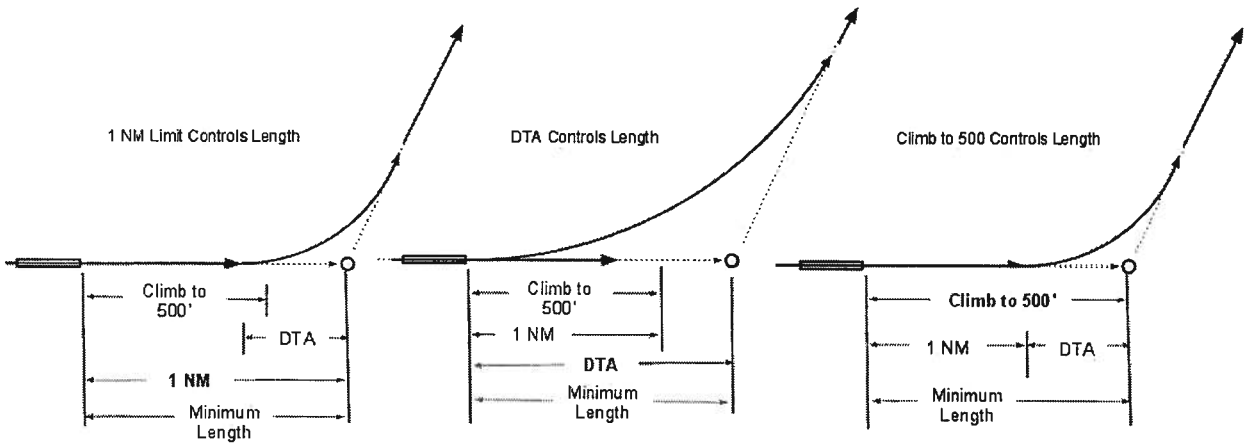
or

b. The distance required to climb to 500 feet above airport

or

c. The DTA value appropriate for the turn.

Figure 2. Minimum Length Determination



The OEA for this exception is a hybrid; i.e., it **MUST** be evaluated as a FB turn on the turn side (inside) and a fly-over (FO) turn on the non-turning side (outside). The succeeding segment (leg entered at completion of turn) is considered to be at full width at a distance of DTA past the turn point.

INSIDE EXPANSION.

For turns of 30 degrees or less, the initial climb area (ICA) splays at 15 degrees relative to the course/track following the turn and expands until reaching full (basic) segment width.
Secondary areas start at the point where the extended ICA crosses the basic width primary area boundary. See Figure 3.

For turns of more than 30 degrees, the inside boundary extends from the Departure Reference Point (DRP) to the succeeding segment basic width secondary boundary at a point perpendicular to the DTA roll-out point. From this point, the secondary area splays 30 degrees inward relative to the track following the turn. See Figures 4 thru 6.

OUTSIDE EXPANSION.

Order 8260.44A, paragraph 12.3 applies, with the following exceptions:

- The maximum allowable course change is 90 degrees.
- Use Order 8260.54A, Formula 2-3c to determine value R1.
- Value R2 is equal to value R1 + 1 NM. Paragraph 12.3.2: Use value R2 for the outer boundary radius, regardless of the distance from the DER to the first turn point.
- Establish the baseline for Points C, C', and B at a distance of 1 NM from the turn point away from the DER, perpendicular to the Runway Centerline (RCL).
- The secondary area starts at the point where the 30 degree splay crosses the basic width secondary boundary. See Figures 5 and 6.
- Where the outer boundary radius (R2) falls inside the basic width primary area, extend the ICA boundary to intersect the basic width secondary boundary (Point F'). The secondary area is truncated along the ICA boundary. See figure 3.
- Where the outer boundary radius (R2) falls inside the basic width secondary area, extend the ICA boundary to Point F'. The secondary area starts at Point F' and splays 30 degrees inward relative to the track following the turn. See Figure 4.

Figure 3.

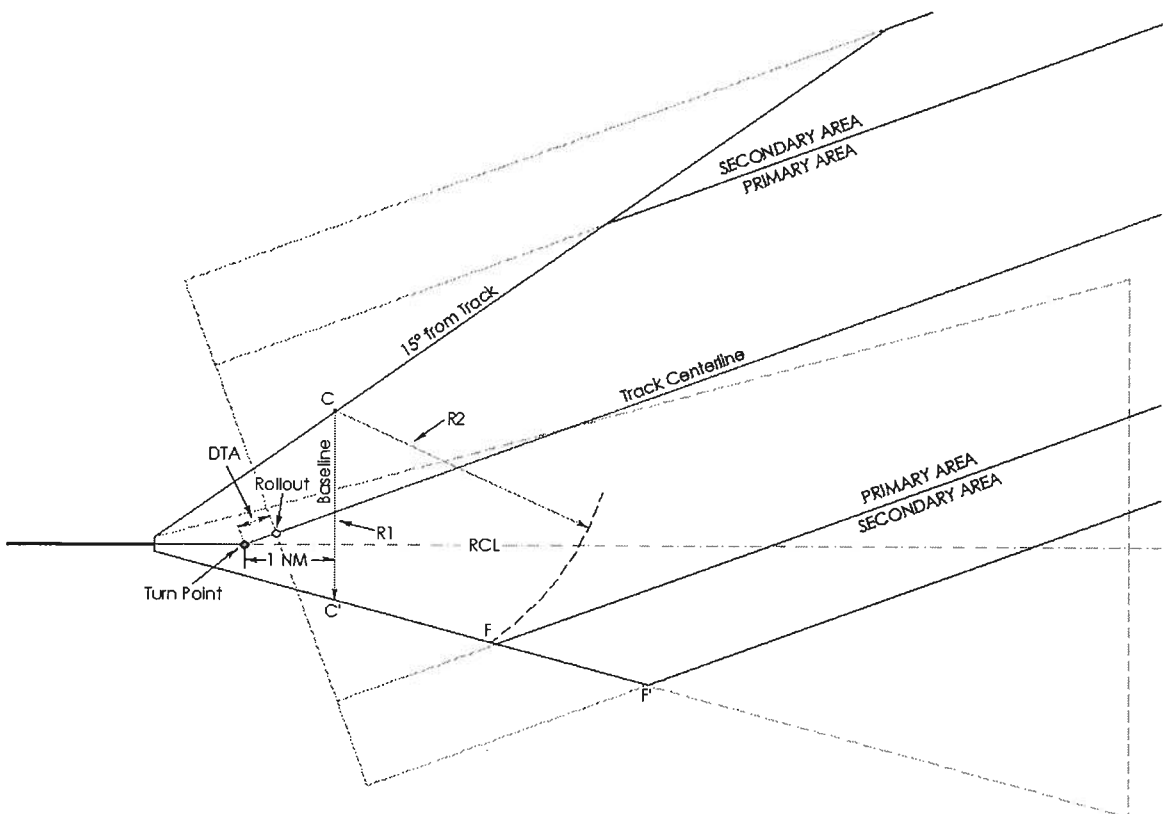


Figure 4.

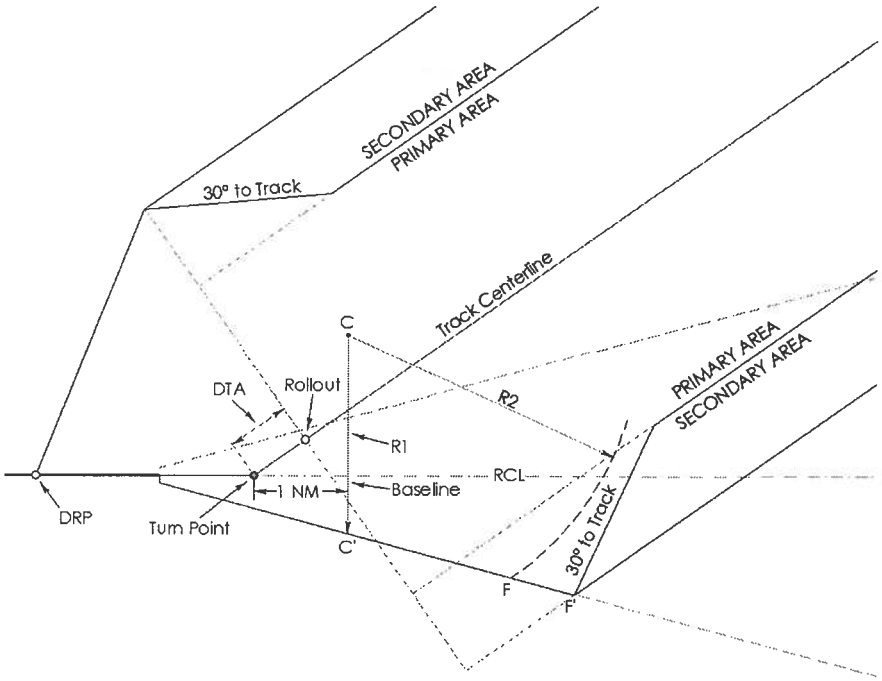


Figure 5.

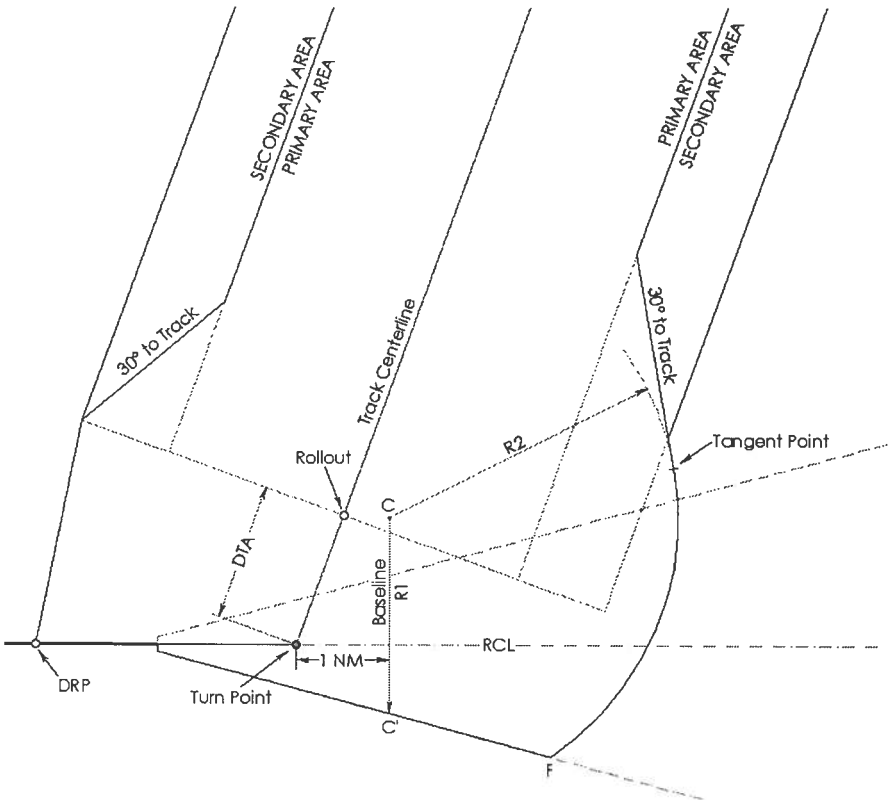
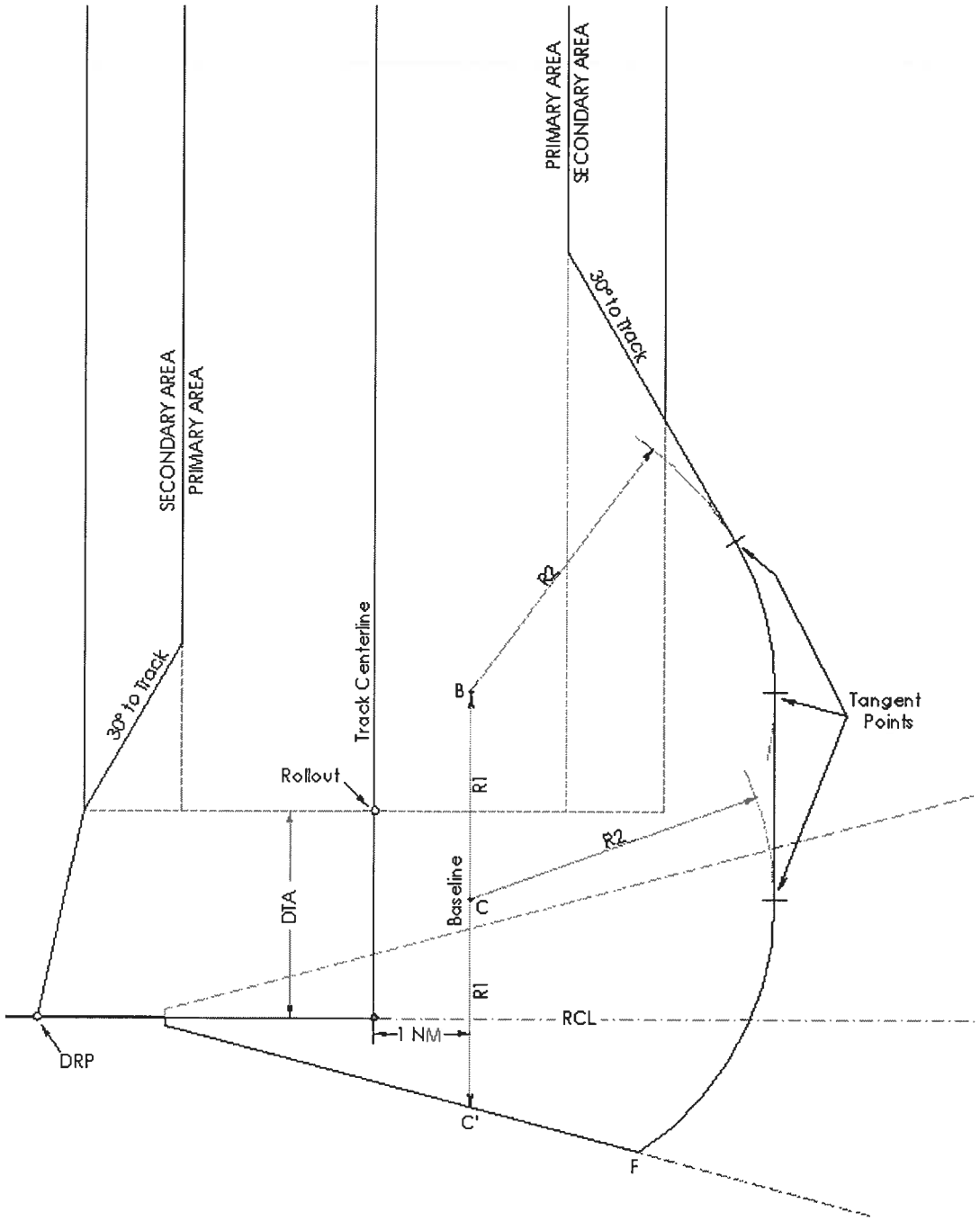


Figure 6.

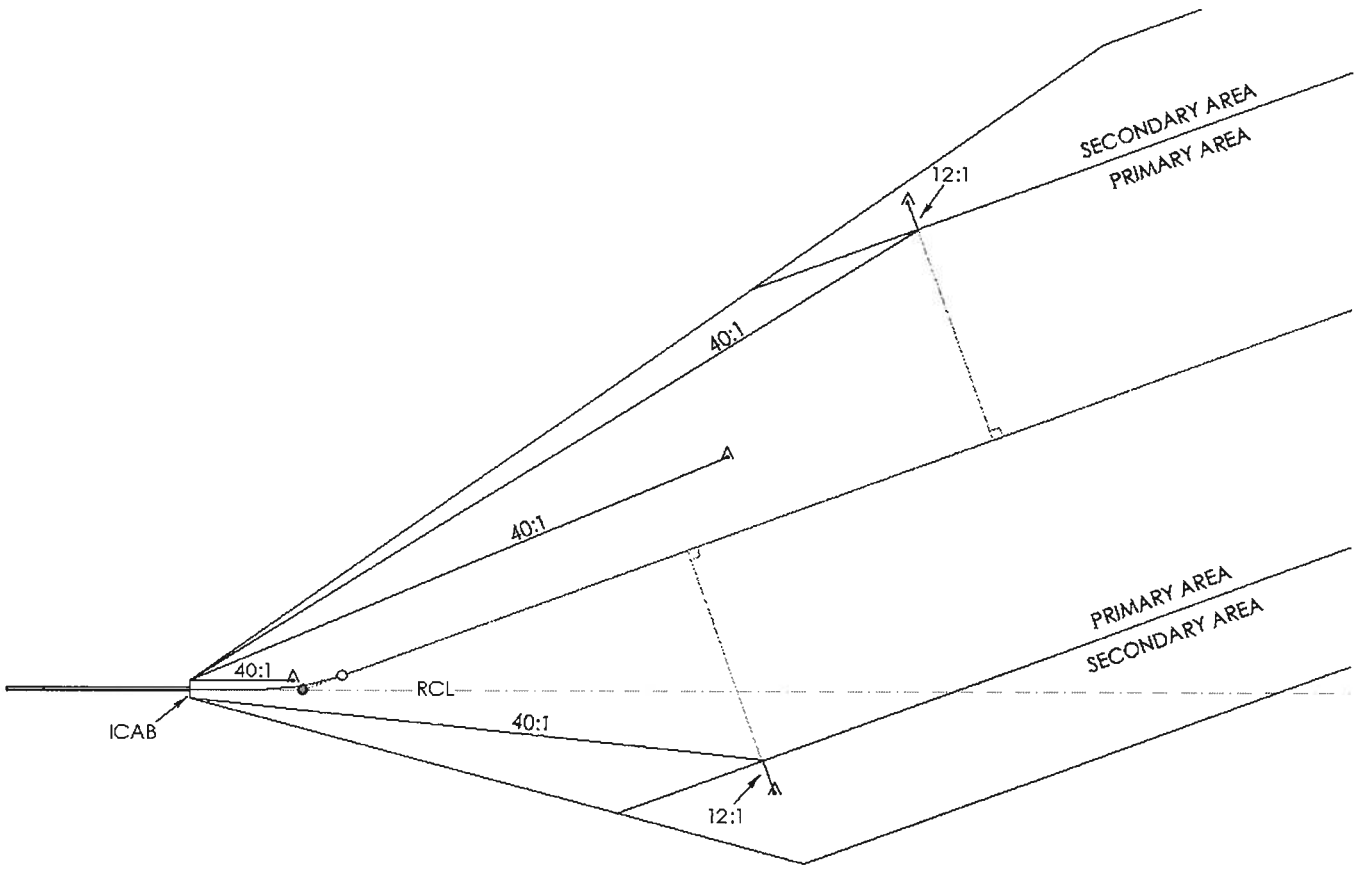

PRIMARY AREA
SECONDARY AREA
30° to Track
SECONDARY AREA
PRIMARY AREA
30° to Track
Track Centerline
R2
B
Tangent
Points
Rollout
R1
R2
DTA
Baseline
C
R1
RCL
1 NM
DRP
C
F

OBSTACLE EVALUATION.

The starting height for all 40:1 evaluations is DER elevation.

For turns of 30 degrees or less, measure the 40:1 surface rise along the shortest distance from the ICA beginning (ICAB) line to an obstacle located within the primary area. For an obstacle located in the secondary area, measure the 12:1 OCS distance perpendicular to the track centerline from the obstacle to the edge of the primary area. Determine the height of the 40:1 OCS by measuring the shortest distance from the ICAB line to the point on the primary area boundary abeam the obstacle. See Figure 7.

Figure 7.



Turns more than 30 degrees (See Figure 8).

Turn side of RCL. Measure the 40:1 surface rise from the DER or RCL, whichever is the shortest distance to an obstacle located within the primary area. For an obstacle located in the secondary area, measure the 12:1 OCS distance perpendicular to the track centerline from the obstacle to the edge of the primary area. Determine the height of the 40:1 OCS by measuring the distance from the DER or RCL, whichever is the shortest distance to the point on the primary area boundary abeam the obstacle.

Non-turn side of RCL. Measure the 40:1 surface rise along the shortest distance from the ICAB line to an obstacle located within the primary area. For an obstacle located in the secondary area (as applicable), measure the 12:1 OCS distance perpendicular to the track centerline from the obstacle to the edge of the primary area. Determine the height of the 40:1 OCS by measuring the shortest distance from the ICAB line to the point on the primary area boundary abeam the obstacle.

Figure 8.