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FEDERAL AVIATION ADMINISTRATION

National Policy

ORDER

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Effective Date:
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SUBJ: The United States Standard for Area Navigation (RNAV)

The Global Positioning System (*GPS*) provides greater flexibility in the design of instrument approach procedures. FAA Order 8260.38, Civil Utilization of Global Positioning System (*GPS*), introduced *GPS* approach procedures into the National Airspace System (*NAS*) in 1993. Order 8260.48, Area Navigation (*RNAV*) Approach Construction Criteria (1999) and Order 8260.50, The United States Standard for *LPV* Approach Procedure Construction Criteria (2002), introduced Wide Area Augmentation System (*WAAS*) approach construction criteria. As the *NAS* evolves from one based on conventional navigation aids to an *RNAV* system, the capability of the *GPS* based systems is being more clearly quantified. This document consolidates and refines *RNAV* criteria, incorporating *GPS*, *WAAS*, and Local Area Augmentation System (*LAAS*) navigation systems.

Original Signed By
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Chapter 1. General

1.0 Purpose of This Order.

This order specifies criteria for obstacle clearance evaluation of area navigation (*RNAV*) approach procedures; e.g., Localizer Performance with Vertical Guidance (*LPV*), Lateral Navigation (*LNAV*), Lateral Navigation/Vertical Navigation (*LNAV/VNAV*), and Localizer Performance (*LP*). These criteria support adding an instrument landing system (*ILS*) line of minimums to an *RNAV* (*GPS*) approach procedure using *LPV* construction criteria at runways served by instrument landing system. Apply feeder segment criteria (*paragraph 2.7*) to satisfy *RNAV* Standard Terminal Arrival Route (*STAR*) and Tango (*T*) Air Traffic Service (*ATS*) route obstacle clearance requirements.

Note: These criteria do not support very high frequency (VHF) omni-directional range/distance measuring equipment (VOR/DME) RNAV, inertial navigation system (INS), or inertial reference unit (IRU) RNAV operations, or DME/DME RNAV final or missed approach operations.

1.1 Audience.

This order is distributed in Washington headquarters to the branch level in the Offices of Airport Safety and Standards and Communications, Navigation, and Surveillance Systems; Air Traffic Organization (Safety, En Route and Oceanic Services, Terminal Services, System Operations Services, and Technical Operations Services), and Flight Standards Services; to the National Flight Procedures Office and the Regulatory Standards Division at the Mike Monroney Aeronautical Center; to branch level in the regional Flight Standards and Airports Divisions; special mailing list ZVS-827, and to Special Military and Public Addressees.

1.2 Where Can I Find This Order? This information is also available on the FAA's Web site at <http://fsims.avr.faa.gov/fsims/fsims.nsf>.

1.3 Cancellation.

Order 8260.38A, *Civil Utilization of Global Positioning System (GPS)*, dated April 5, 1995; Order 8260.48, *Area Navigation (RNAV) Approach Construction Criteria*, dated April 8, 1999, and Order 8260.51, *United States Standard for Required Navigation Performance (RNP) Instrument Approach Procedure Construction*, dated December 30, 2002.

1.4 Explanation of Changes.

These criteria were written for automated implementation. Formulas are presented in Math notation and standard text to facilitate programming efforts.

Calculation examples were eliminated. Instead, an Adobe Acrobat version of the criteria document is available where each formula performs the calculation as an imbedded calculator.

- 1.4.1 Chapter 1.**
- 1.4.1 a. Paragraph 1.** Clarifies that these criteria support *RNAV STARS*, and *T-Routes*.
- 1.4.1 b. Paragraph 1.4.** Reflects addition of new criteria.
- 1.4.1 c. Paragraph 1.6.** Removes definition of nonprecision approach with vertical guidance (*APV*) and touchdown zone elevation (*TDZE*), replaces height above touchdown (*HAT*) definition with height above threshold (*HATh*), adds *LP* definition, and redefines Precise Final Approach Fix (*PFAF*).
- 1.4.2 Chapter 2.**
- 1.4.2 a. Paragraph 2.0.** Adds explanation of Math notation and support for *RNAV STARS* and *T-routes*.
- 1.4.2 b. Paragraph 2.1.2.** Updates to reflect formulas are written for “radian” calculation. Changes the calculation value of a nautical mile (*NM*) from 6076.11548 to 1852/0.3048. Adds conversions to and from degrees/radians, feet to meters, meters to *NM*, *NM* to feet, and temperature Celsius to Fahrenheit.
- 1.4.2 c. Paragraph 2.1.3.** Adds Geospatial standards.
- 1.4.2 d. Table 2-1.** Adds *LP*.
- 1.4.2 e. Paragraph 2.3.** Adds feeder segment.
- 1.4.2 f. Tables 2-2 and 2-3.** Adds feeder segment.
- 1.4.2 g. Paragraph 2.4.** Adds method for determining turn altitude.
- 1.4.2 h. Formula 2-1a.** Updates to harmonize with International Civil Aviation Organization (*ICAO*).
- 1.4.2 i. Table 2-3.** Adds feeder segment.
- 1.4.2 j. Formula 2-1b.** Updates to be consistent with *ICAO*.
- 1.4.2 k. Formula 2-1c.** Updates and renumbers radius formula for accuracy. Adds notes for bank limitations above FL 195.

- 1.4.2 **l. Formula 2-2.** Renumbers formula from 2-3 and provides clarification to more accurately represent 6 seconds using new definition of *NM*.
- 1.4.2 **m. Figures 2-4 and 2-5.** Updates figures for clarity.
- 1.4.2 **n. Formula 2-5.** Adds distance turn anticipation (*DTA*) computation.
- 1.4.2 **o. Formula 2-7.** Provides a formula to calculate minimum length of track to fix (*TF*) leg following a Fly-by turn.
- 1.4.2 **p. Paragraph 2.5.3.** Adds radius to fix (*RF*) turn criteria.
- 1.4.2 **q. Figure 2-7.** Renumbers figure to 2-8.
- 1.4.2 **r. Formula 2-5.** Updates and renumbers formula to 2-8.
- 1.4.2 **s. Paragraph 2.7.** Adds feeder segment.
- 1.4.2 **t. Section 2.** Renumbers paragraph starting with 2.8.
- 1.4.2 **u. Paragraph 2.8.1.** Adds course reversal.
- 1.4.2 **v. Formula 2-6.** Renumbers formula to 2-9.
- 1.4.2 **w. Paragraph 2.8.6.** Adds Holding Pattern Initial Segment.
- 1.4.2 **x. Paragraph 2.8.** Renumbers paragraph to 2.9. Adds standards for *LNAV/VNAV*, *LNAV*, and *LP*. Renumbers figures for intermediate segment. Adds additional figures supporting offset intermediate segment construction.
- 1.4.2 **y. Formula 2-7.** Renumbers formula to 2-10. Updates to be consistent with new definition of nautical mile.
- 1.4.2 **z. Table 2-4.** Adds *LPV* glidepath angle restrictions for *HATH* values < 250.
- 1.4.2 **aa. Table 2-5.** Deletes Standard *LPV* Landing Minimums. Adds reference to Order 8260.3B, United States Standard for Terminal Instrument Procedures (*TERPS*) chapter 3. Renumbers the remaining tables.
- 1.4.2 **bb. Paragraph 2.13.** Renumbers paragraph "Determining Precise Final Approach Fix/Final Approach Fix (*PFAF/FAF*) Coordinates." Revises to calculate *PFAF* based on Barometric vertical navigation (*Baro VNAV*) when publishing combined procedures (*LPV* with *LNAV/VNAV*). Adds associated formulas.
- 1.4.2 **cc. Section 4.** Adds "Missed Approach General Information."

1.4.3 Chapter 3.

Adds "Non vertically Guided Procedures" and *LP* and *LNAV* segment construction.

1.4.4 Chapter 4.

Adds "Lateral Navigation with Vertical Guidance (*LNAV/VNAV*)."

1.4.5 Chapter 5.

1.4.5 a. Paragraph 5.1.4. Removes paragraph and incorporates in paragraph 5.2.2, formula 5-5.

1.4.5 b. Paragraph 5.2. Changes how obstacle surfaces are applied. All final segment obstacle clearance surface (*OCS*) [W, X, and Y] obstacles are evaluated relative to the height of the **W** surface based on their along-track distance (*OBS_X*) from the landing threshold point (*LTP*), perpendicular distance (*OBS_Y*) from the course centerline, and mean sea level (*MSL*) elevation (*OBS_{MSL}*) adjusted for earth curvature and **X/Y** surface rise if appropriate. This changes the numbering of subsequent formulas.

1.4.5 c. Paragraph 5.8. Adds section 1 of the *LPV* missed approach segment.

1.4.6 Chapter 6.

Reorganizes chapter 6 for simplification. Renumbers paragraphs and formulas. Updates figures for clarity and some re-labeling. Most of the figures are full page illustrations; therefore, all figures are grouped at the end of the chapter.

1.4.7 Appendix 1.

This appendix provides a listing of formulas in text format.

1.4.8 Appendix 2.

This appendix provides the standard geodetic formulas for use in development of *TERPS* instrument procedures.

1.5 Background.

The National Airspace System (*NAS*) is evolving from a system of conventional ground based navigational aids [*VHF* omnidirectional radio range (*VOR*), nondirectional radio beacon (*NDB*), etc.] to a system based on *RNAV* [*GPS*, wide area augmentation system (*WAAS*), local area augmentation system (*LAAS*), etc.]

and **RNP**. This order provides criteria for the application of obstacle clearance standards to approaches based on **RNAV**.

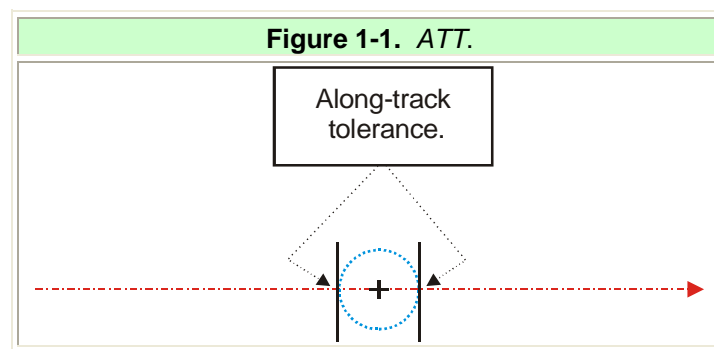
1.6 Effective Date. January 1, 2008

1.7 Definitions.

1.7.1 Along-Track Distance (ATD).

A distance specified in nautical miles (**NM**) along a defined track to an **RNAV** fix.

1.7.2 Along-Track (ATRK) Tolerance (ATT). The amount of possible longitudinal fix positioning error on a specified track expressed as a \pm value (*see figure 1-1*).



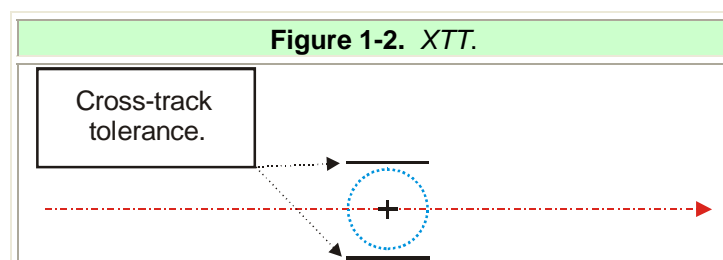
*Note: The acronym **ATRK FDT** (along-track fix displacement tolerance) has been used instead of **ATT** in the past. The change to **ATT** is a step toward harmonization of terms with **ICAO Pans-Ops**.*

1.7.3 Barometric Altitude.

A barometric altitude measured above mean sea level (**MSL**) based on atmospheric pressure measured by an aneroid barometer. This is the most common method of determining aircraft altitude.

1.7.4 Cross-Track (XTT) Tolerance.

The amount of possible lateral positioning error expressed as a \pm value (*see figure 1-2*).



*Note: The acronym **XTRK FDT** (cross-track fix displacement tolerance) has been used instead of **XTT** in the past. The change to **XTT** is a step toward harmonization of terms with ICAO Pans-Ops.*

1.7.5 Decision Altitude (DA).

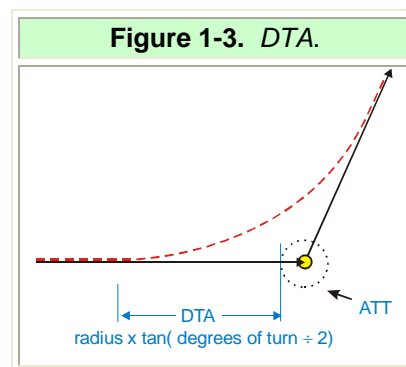
The **DA** is a specified barometric altitude at which a missed approach must be initiated if the required visual references to continue the approach have not been acquired. **DA** is referenced to **MSL**. It is applicable to vertically guided approach procedures.

1.7.6 Departure End of Runway (DER).

The **DER** is the end of the runway that is opposite the landing threshold. It is sometimes referred to as the stop end of runway.

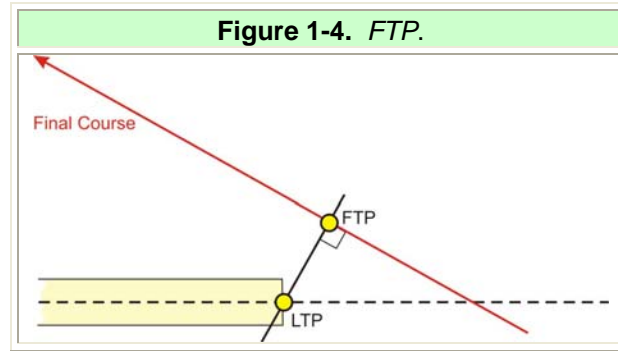
1.7.7 Distance of Turn Anticipation (DTA).

DTA represents the maximum distance from (prior to) a fly-by-fix that an aircraft is expected to start a turn to intercept the course of the next segment. The **ATT** value associated with a fix is added to the **DTA** value when **DTA** is applied (see figure 1-3).



1.7.8 Fictitious Threshold Point (FTP).

The **FTP** is the equivalent of the landing threshold point (**LTP**) when the final approach course is offset from the runway centerline and is not aligned through the **LTP**. It is the intersection of the final course and a line perpendicular to the final course that passes through the **LTP**. **FTP** elevation is the same as the **LTP** (see figure 1-4). For the purposes of this document, where **LTP** is used, **FTP** may apply as appropriate.



1.7.9 Fix Displacement Tolerance (*FDT*).

FDT is a legacy term providing 2-dimensional (*2D*) quantification of positioning error. It is now defined as a circular area with a radius of *ATT* centered on an *RNAV* fix (see figure 1-3). The acronym *ATT* is now used in lieu of *FDT*.

1.7.10 Flight Path Alignment Point (*FPAP*).

The *FPAP* is a 3-dimensional (*3D*) point defined by World Geodetic System of 1984/North American Datum of 1983 (*WGS-84/NAD-83*) latitude, longitude, *MSL* elevation, and *WGS-84* Geoid height. The *FPAP* is used in conjunction with the *LTP* and the geometric center of the *WGS-84* ellipsoid to define the final approach azimuth (*LPV* glidepath's vertical plane) associated with an *LP* or *LPV* final course.

1.7.11 Geoid Height (*GH*).

The *GH* is the height of the Geoid relative to the *WGS-84* ellipsoid. It is a positive value when the Geoid is above the *WGS-84* ellipsoid and negative when it is below. The value is used to convert an *MSL* elevation to an ellipsoidal or geodetic height - the height above ellipsoid (*HAE*).

Note: The Geoid is an imaginary surface within or around the earth that is everywhere normal to the direction of gravity and coincides with mean sea level (*MSL*) in the oceans. It is the reference surface for *MSL* heights.

1.7.12 Glidepath Angle (*GPA*).

The *GPA* is the angle of the specified final approach descent path relative to a horizontal line tangent to the surface of the earth at the runway threshold (see figure 1-5). In this order, the glidepath angle is represented in formulas and figures as the Greek symbol theta (θ).

1.7.13 Glidepath Qualification Surface (GQS).

The **GQS** is a narrow inclined plane centered on the runway centerline that limits the height of obstructions between the **DA** and **LTP**. A clear **GQS** is required for authorization of vertically-guided approach procedure development.

1.7.14 Height Above Ellipsoid (HAE).

The elevation of the glidepath origin (threshold crossing height [**TCH**] point) for an **LPV** approach procedure is referenced to the **LTP**. **RNAV** avionics calculate heights relative to the **WGS-84** ellipsoid. Therefore, it is important to specify the **HAE** value for the **LTP**. This value differs from a height expressed in feet above the geoid (essentially **MSL**) because the reference surfaces (**WGS-84** ellipsoid and the geoid) do not coincide. Ascertain the height of the orthometric geoid (**MSL** surface) relative to the **WGS-84** ellipsoid at the **LTP**. This value is considered the **GH**. For Westheimer Field, Oklahoma the **GH** is -87.29 ft. This means the geoid is 87.29 ft *below* the **WGS-84** ellipsoid at the latitude and longitude of the runway 35 threshold. To convert an **MSL** height to an **HAE** height, algebraically add the geoid height* value to the **MSL** value. **HAE** elevations are not used for instrument procedure construction, but are documented for inclusion in airborne receiver databases.

NOTE for users of the Aviation System Standards Information System (AVNIS) Database: The “Ellipsoid Elev” field value is the HAE for the runway threshold.

Formula 1-1. HAE Example.		
HAE = Z + GH		
Given Variables	Runway ID	ANYTOWN RWY 35
	Latitude	35° 14' 31.65" N
	Longitude	97° 28' 22.84" W
	MSL Elevation (Z)	1117.00
	Geoid Height* (GH)	-87.146 feet
Z+GH		
Calculator		
Calculation	Z =	
	GH =	
	HAE =	

* Calculate **GH** for CONUS using NGS **GEOID03** program, for Alaska, use **GEOID06**. See the NGS website - <http://www.ngs.noaa.gov/TOOLS/>.

1.7.15 Height Above Threshold (*HATh*).

The *HATh* is the height of the *DA* above *LTP* elevation; i.e.,

Formula 1-2. <i>HATh</i> Example.		
$HATh = DA - LTP_{elev}$		
DA-LTP _{elev}		
Calculator		
LTP _{elev}	<input type="text"/>	Click Here to Calculate
DA	<input type="text"/>	
HATh	<input type="text"/>	

1.7.16 Inner-Approach Obstacle Free Zone (*OFZ*).

The inner-approach *OFZ* is the airspace above a surface centered on the extended runway centerline. It applies to runways with an approach lighting system of any authorized type. (USAF NA)

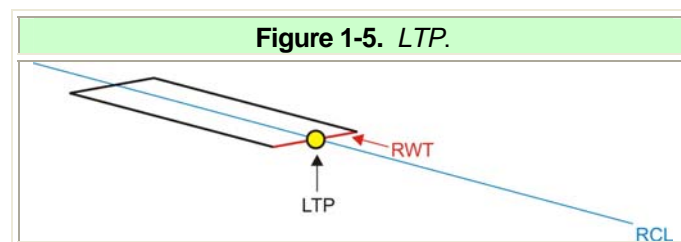
1.7.17 Inner-Transitional *OFZ*.

The inner-transitional *OFZ* is the airspace above the surfaces located on the outer edges of the runway *OFZ* and the inner-approach *OFZ*. It applies to runways with approach visibility minimums less than $\frac{3}{4}$ statute miles (*SM*). (USAF NA)

1.7.18 Landing Threshold Point (*LTP*).

The *LTP* is a *3D* point at the intersection of the runway centerline and the runway threshold (*RWT*). *WGS-84/NAD-83* latitude, longitude, *MSL* elevation, and geoid height define it. It is used in conjunction with the *FPAP* and the geometric center of the *WGS-84* ellipsoid to define the vertical plane of an *RNAV* final approach course (see figure 1-5). (USAF must use *WGS-84* latitude and longitude only.)

Note: Where an *FTP* is used, apply *LTP* elevation (*LTP_E*).



1.7.19 Lateral Navigation (LNAV).

LNAV is *RNAV* lateral navigation. This type of navigation is associated with nonprecision approach procedures (*NPA*) because vertical path deviation information is not provided. *LNAV* criteria are the basis of the *LNAV* minima line on *RNAV GPS* approach procedures.

1.7.20 Lateral Navigation/Vertical Navigation (LNAV/VNAV).

An approach with vertical guidance (*APV*) evaluated using the *Baro VNAV* obstacle clearance surfaces conforming to the lateral dimensions of the *LNAV* obstruction evaluation area (*OEA*). The final descent can be flown using *Baro VNAV*, or *LPV* vertical guidance in accordance with Advisory Circular (*AC*) 90-97, *Operational Approval of Barometric VNAV Instrument Approach Operations Using Decision Altitude*.

1.7.21 Localizer Performance (LP).

An *LP* approach is an *RNAV NPA* procedure evaluated using the lateral obstacle evaluation area dimensions of the precision localizer trapezoid, with adjustments specific to the *WAAS*. See chapter 3. These procedures are published on *RNAV GPS* approach charts as the *LP* minima line.

1.7.22 Localizer Performance with Vertical Guidance (LPV).

An approach with vertical guidance (*APV*) evaluated using the *OCS* dimensions (horizontal and vertical) of the precision approach trapezoid, with adjustments specific to the *WAAS*. See chapter 5. These procedures are published on *RNAV GPS* approach charts as the *LPV* minima line.

1.7.23 Obstacle Evaluation Area (OEA).

An area within defined limits that is subjected to obstacle evaluation through application of required obstacle clearance (*ROC*) or an obstacle clearance surface (*OCS*).

1.7.24 Obstacle Clearance Surface (OCS).

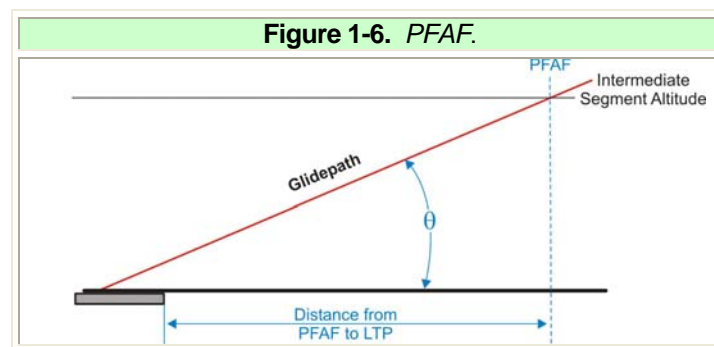
An *OCS* is an upward or downward sloping surface used for obstacle evaluation where the flight path is climbing or descending. The separation between this surface and the vertical path angle defines the **MINIMUM** required obstruction clearance at any given point.

1.7.25 Obstacle Positions ($OBS_{X,Y,Z}$).

$OBS_{X,Y\&Z}$ are the along track distance to an obstacle from the **LTP**, the perpendicular distance from the centerline extended, and the **MSL** elevation, respectively, of the obstacle clearance surfaces.

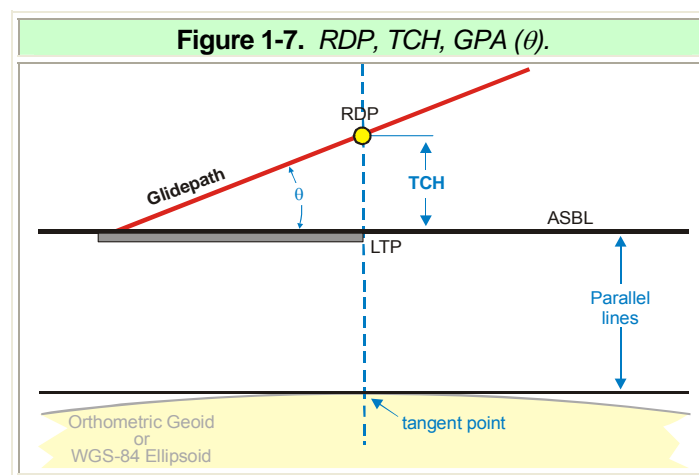
1.7.26 Precise Final Approach Fix (**PFAF**).

The **PFAF** is a calculated **WGS-84** geographic position located on the final approach course where the designed vertical path (**NPA** procedures) or glidepath (**APV** and **PA** procedures) intercepts the intermediate segment altitude (glidepath intercept altitude). The **PFAF** marks the beginning of the final approach segment (see figure 1-6). The calculation of the distance from **LTP** to **PFAF** includes the earth curvature.



1.7.27 Reference Datum Point (**RDP**).

The **RDP** is a **3D** point defined by the **LTP** or **FTP** latitude/longitude position, **MSL** elevation, and a threshold crossing height (**TCH**) value. The **RDP** is in the vertical plane associated with the final approach course and is used to relate the glidepath angle of the final approach track to the landing runway. It is also referred to as the **TCH** point or flight path control point (**FPCP**) (see figure 1-7).



1.7.28 Runway Threshold (RWT).

The **RWT** marks the beginning of the part of the runway that is usable for landing (*see figure 1-5*). It includes the entire width of the runway.

1.7.29 Start of Climb (SOC).

The **SOC** is the point located at a calculated along-track distance from the decision altitude/missed approach point (**DA/MAP**) where the 40:1 missed approach surface originates.

1.7.30 Threshold Crossing Height (TCH).

The height of the glidepath above the threshold of the runway measured in feet (*see figure 1-7*). The **LPV** glidepath originates at the **TCH** value above the **LTP**.

1.7.31 Visual Glide Slope Indicator (VGSI).

The **VGSI** is an airport lighting aid that provides the pilot a visual indication of the aircraft position relative to a specified glidepath to a touchdown point on the runway.

1.7.32 Wide Area Augmentation System (WAAS).

The **WAAS** is a navigation system based on the **GPS**. Ground correction stations transmit position corrections that enhance system accuracy and add satellite based **VNAV** features.

1.8 Information Update.

For your convenience, FAA Form 1320-19, *Directive Feedback Information*, is included at the end of this order to note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this order. When forwarding your comments to the originating office for consideration, please use the "Other Comments" block to provide a complete explanation of why the suggested change is necessary.

Chapter 2. General Criteria

Section 1. Basic Criteria Information

2.0 General.

The following FAA orders apply.

8260.3, *United States Standard for Terminal Instrument Procedures (TERPS)*.

8260.19, *Flight Procedures and Airspace*.

7130.3, *Holding Pattern Criteria*.

The feeder, initial, intermediate, final, and missed approach criteria described in this order supersede the other publications listed above. See *TERPS*, Volume 1, chapter 3 to determine visibility minima. The feeder criteria in *paragraph 2.7* may be used to support *RNAV* Standard Terminal Arrival Route (*STAR*) and Tango (*T*) Air Traffic Service (*ATS*) route construction.

Formulas are numbered by chapter and depicted in standard mathematical notation and in standard text to aid in computer programming. Each formula contains a java script functional calculator.

The diagram illustrates a formula calculator interface. At the top, a red header reads "Formula x-x. Formula Title." Below this, the formula $Y = \frac{X^2}{\tan\left(3 \cdot \frac{\pi}{180}\right)}$ is displayed in red. A callout points to this formula, stating "Formula in math notation". Below the formula, the text "where X = variable value" is shown. A yellow bar contains the formula in standard text notation: $x^2/\tan(3*\pi/180)$. A callout points to this bar, stating "Formula in standard text notation". Below the yellow bar is a grey bar labeled "Calculator". Underneath, there are two input fields: "X" and "Y". The "X" field is labeled "input value here" and is highlighted in green. A callout points to this field, stating "Enter variable values in the green areas". The "Y" field is labeled "Calculated Result" and is highlighted in yellow. A callout points to this field, stating "The calculated answer is printed after the grey button is clicked". To the right of the input fields is a grey button labeled "Click here to calculate". A callout points to this button, stating "Click here after entering input values to make the calculator function".

2.1 Data Resolution.

Perform calculations using an accuracy of at least 15 significant digits; i.e., floating point numbers must be stored using at least 64 bits. Do not round intermediate results. Round only the final result of calculations for documentation purposes. Required accuracy tolerance is 1 centimeter for distance and 0.002 arc-second for angles. The following list specifies the minimum accuracy standard for **documenting** data expressed numerically. This standard

applies to the documentation of final results only; e.g., a calculated adjusted glidepath angle of 3.04178 degrees is documented as 3.05 degrees. The standard does not apply to the use of variable values during calculation. Use the most accurate data available for variable values.

2.1.1 Documentation Accuracy:

- 2.1.1 a. **WGS-84 latitudes and longitudes** to the nearest one hundredth (0.01) arc second; [*nearest five ten thousandth (0.0005) arc second for Final Approach Segment (FAS) data block entries*].
- 2.1.1 b. **LTP mean sea level (MSL) elevation** to the nearest foot;
- 2.1.1 c. **LTP height above ellipsoid (HAE)** to the nearest tenth (0.1) meter;
- 2.1.1 d. **Glidepath angle** to the next higher one hundredth (0.01) degree;
- 2.1.1 e. **Courses** to the nearest one hundredth (0.01) degree; and
- 2.1.1 f. **Course width at threshold** to the nearest quarter (0.25) meter;
- 2.1.1 g. **Distances** to the nearest hundredth (0.01) unit [*except for "length of offset" entry in FAS data block which is to the nearest 8 meter value*].

2.1.2 Mathematics Convention.

Formulas in this document as depicted are written for *radian* calculation.

Note: The value for 1 NM was previously defined as 6,076.11548 ft. For the purposes of RNAV criteria, 1 NM is defined as the result of the following calculation:

$$\frac{1852}{0.3048}$$

2.1.2 a. Conversions:

- Degree measure to radian measure:

$$\text{radians} = \text{degrees} \cdot \frac{\pi}{180}$$

- Radian measure to degree measure:

$$\text{degrees} = \text{radians} \cdot \frac{180}{\pi}$$

- Feet to meters:

$$\text{meters} = \text{feet} \cdot 0.3048$$

- Meters to feet

$$\text{feet} = \frac{\text{meters}}{0.3048}$$

- Feet to Nautical Miles (*NM*)

$$\text{NM} = \text{feet} \cdot \frac{0.3048}{1852}$$

- *NM* to feet:

$$\text{feet} = \text{NM} \cdot \frac{1852}{0.3048}$$

- *NM* to meters

$$\text{meters} = \text{NM} \cdot 1852$$

- Meters to *NM*

$$\text{NM} = \frac{\text{meters}}{1852}$$

- Temperature Celsius to Fahrenheit:

$$T_{\text{Fahrenheit}} = 1.8 \cdot T_{\text{Celsius}} + 32$$

- Temperature Fahrenheit to Celsius

$$T_{\text{Celsius}} = \frac{T_{\text{Fahrenheit}} - 32}{1.8}$$

2.1.2

b. Definition of Mathematical Functions and Constants.

$a + b$ indicates addition

$a - b$ indicates subtraction

$a \times b$ or ab or $a \cdot b$ or $a * b$ indicates multiplication

$\frac{a}{b}$ or a/b or $a \div b$ indicates division

$(a - b)$ indicates the result of the process within the parenthesis

$|a - b|$ indicates absolute value

\approx indicates approximate equality

\sqrt{a} or $a^{0.5}$ or $a^{\wedge}0.5$ indicates the square root of quantity "a"

a^2 or $a^{\wedge}2$ indicates $a \times a$

$\ln(a)$ or $\log(a)$ indicates the natural logarithm of "a"

$\tan(a)$ indicates the tangent of "a" degrees
 $\tan^{-1}(a)$ or $\text{atan}(a)$ indicates the arc tangent of "a"
 $\sin(a)$ indicates the sine of "a" degrees
 $\sin^{-1}(a)$ or $\text{asin}(a)$ indicates the arc sine of "a"
 $\cos(a)$ indicates the cosine of "a" degrees
 $\cos^{-1}(a)$ or $\text{acos}(a)$ indicates the arc cosine of "a"

e The constant **e** is the base of the natural logarithm and is sometimes known as Napier's constant, although its symbol (**e**) honors Euler. With the possible exception of π , **e** is the most important constant in mathematics since it appears in myriad mathematical contexts involving limits and derivatives. Its value is approximately 2.718281828459045235360287471352662497757...

r The **TERPS** constant for the mean radius of the earth for spherical calculations in feet. **r = 20890537**

2.1.2

c. Operation Precedence (Order of Operations).

First: Grouping Symbols: parentheses, brackets, braces, fraction bars, etc.
 Second: Functions: Tangent, sine, cosine, arcsine, and other defined functions
 Third: Exponentiations: Powers and roots
 Fourth: Multiplication and Division: Products and quotients
 Fifth: Addition and subtraction: Sums and differences

e.g.,

$5 - 3 \times 2 = -1$ because multiplication takes precedence over subtraction

$(5 - 3) \times 2 = 4$ because parentheses take precedence over multiplication

$\frac{6^2}{3} = 12$ because exponentiation takes precedence over division

$\sqrt{9 + 16} = 5$ because the square root sign is a grouping symbol

$\sqrt{9} + \sqrt{16} = 7$ because roots take precedence over addition

$\frac{\sin(30^\circ)}{0.5} = 1$ because functions take precedence over division

$\sin\left(\frac{30^\circ}{0.5}\right) = 0.8660254$ because parentheses take precedence over functions

Notes on calculator usage:

1. Most calculators are programmed with these rules of precedence.

2. When possible, let the calculator maintain all of the available digits of a number in memory rather than re-entering a rounded number. For highest accuracy from a calculator, any rounding that is necessary should be done at the latest opportunity.

2.1.3 Geospatial Standards.

The following standards apply to the evaluation of obstacle and terrain position and elevation data relative to **RNAV OEA**s and **OCS**s. Terrain and obstacle data are reported in **NAD-83** latitude, longitude, and elevation relative to **MSL** in National Geodetic Vertical Datum of 1929 (**NGVD-29**) or North American Vertical Datum of 1988 (**NAVD-88**) vertical datum. Evaluate obstacles using their **NAD-83** horizontal position and **NAVD-88** elevation value compared to the **WGS-84** referenced course centerline (along-track and cross-track), **OEA** boundaries, and **OCS** elevations as appropriate.

- 2.1.3 a. WGS-84[G873] for Position and Course Construction.** This reference frame is used by the FAA and the U.S. Department of Defense (**DoD**). It is defined by the National Geospatial-Intelligence Agency (**NGA**) (formerly the National Imagery and Mapping Agency, formerly the Defense Mapping Agency [**DMA**]). In 1986, the Office of National Geodetic Survey (**NGS**), redefined and readjusted the North American Datum of 1927 (**NAD-27**), creating the North American Datum of 1983 (**NAD-83**). The **WGS-84** was defined by the **DMA**. Both **NAD-83** and **WGS-84** were originally defined (in words) to be geocentric and oriented as the Bureau International d l'Heure (**BIH**) Terrestrial System. In principle, the three-dimensional (**3D**) coordinates of a single physical point should therefore be the same in both **NAD-83** and **WGS-84** Systems; in practice; however, small differences are sometimes found. The original intent was that both systems would use the Geodetic Reference System of 1980 (**GRS-80**) as a reference ellipsoid. As it happened, the **WGS-84** ellipsoid differs very slightly from **GRS-80**. The difference is 0.0001 meters in the semi-minor axis. In January 2, 1994, the **WGS-84** reference system was realigned to be compatible with the International Earth Rotation Service's Terrestrial Reference Frame of 1992 (**ITRF**) and renamed **WGS-84 (G730)**. The reference system underwent subsequent improvements in 1996, referenced as **WGS-84 (G873)** closely aligned with **ITRF-94**, to the current realization adopted by the **NGA** in 2001, referenced as **WGS-84 (G1150)** and considered equivalent systems to **ITRF 2000**.
- 2.1.3 b. NAVD-88 for elevation values.** **NAVD-88** is the vertical control datum established in 1991 by the minimum-constraint adjustment of the Canadian-Mexican-U.S. leveling observations. It held fixed the height of the primary tidal bench mark, referenced to the new International Great Lakes Datum of 1985 local **MSL** height value, at Father Point/Rimouski, Quebec, Canada. Additional tidal bench mark elevations were not used due to the demonstrated variations in sea surface topography, (i.e., the fact that **MSL** is not the same equipotential surface at all tidal bench marks).
- 2.1.3 c. OEA Construction and Obstacle Evaluation Methodology.**
- 2.1.3 c. (1) Courses, fixes, boundaries (lateral dimension).** Construct straight-line courses as a **WGS-84** ellipsoid geodesic path. If the course outbound from a fix differs from the course inbound to the fix (courses measured at the fix), then a turn is indicated. Construct parallel and trapezoidal boundary lines as a locus of points

measured perpendicular to the geodesic path. *(The resulting primary and/or secondary boundary lines do not display a “middle bulge” due to curvature of the ellipsoids surface since they are not geodesic paths.)* **NAD-83** latitude/longitude positions are acceptable for obstacle, terrain, and airport data evaluation. Determine obstacle lateral positions relative to course centerline/**OEA** boundaries using ellipsoidal calculations (see appendix 2).

- 2.1.3 c. (2) Elevations (vertical dimension).** Evaluate obstacles, terrain, and airport data using their elevation relative to their orthometric height above the geoid (for our purposes, **MSL**) referenced to the **NAVD-88** vertical datum. The elevations of **OCSs** are determined spherically relative to their origin **MSL** elevation (**NAVD-88**). Department of Defense (**DoD**) procedure developers may use EGM-96 vertical datum.

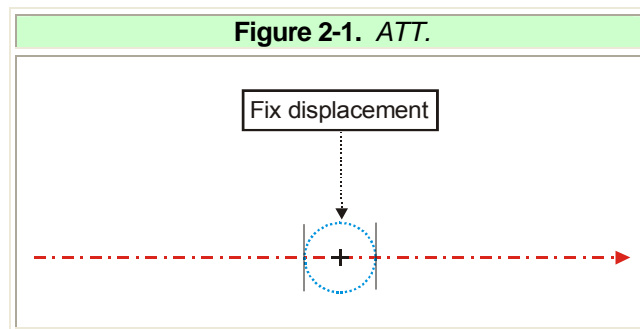
2.1.4 Evaluation of Actual and Assumed Obstacles (AAO).

Apply the vertical and horizontal accuracy standards in Order 8260.19, paragraphs 272, 273, 274, and appendix 3. (USAF, apply guidance per AFI 11-230)

Note: When applying an assumed canopy height consistent with local area vegetation, contact either the National Forestry Service or the FAA regional Flight Procedures Office (FPO) to verify the height value to use.

2.1.5 ATT Values.

ATT is the value used (for segment construction purposes) to quantify position uncertainty of an **RNAV** fix. The application of **ATT** can; therefore, be considered “circular;” i.e., the **ATT** value assigned describes a radius around the plotted position of the **RNAV** fix (see figure 2-1 and table 2-1).



Note: Cross-track tolerance (XTT) values were considered in determining minimum segment widths, and are not considered further in segment construction.

Table 2-1. ATT Values.		
GPS	En Route (STARs, SIDs, Feeder, Initial, Intermediate, Missed Approach > 30 NM)	2.0 NM
	Terminal (STARs, SIDs, Feeder, Initial, Intermediate, Missed Approach ≤ 30 NM)	1.0 NM
	Approach (final)	0.3 NM
WAAS* (LPV & LP)	Approach (final)	40 meters

**Applies to final segment only. Apply GPS values to all other segments of the approach procedure.*

2.2 Procedure Identification.

Title **RNAV** procedures based on **GPS** or **WAAS**: “**RNAV (GPS) RWY XX.**” Where more than one **RNAV** titled approach is developed to the same runway, identify each with an alphabetical suffix beginning at the end of the alphabet. Procedures with the lowest minimums should normally be titled with a “Z” suffix.

Examples

RNAV (GPS) Z RWY 13 (Lowest **HATh**: example 200 ft)
RNAV (RNP) Y RWY 13 (2nd lowest **HATh**: example 278 ft)
RNAV (GPS) X RWY 13 (3rd lowest **HATh**: example 360 ft)

Note: Operational requirements may occasionally require a different suffix grouping; e.g., “Z” suffix procedures are RNP SAAAR, “Y” suffix procedures contain LPV, etc.

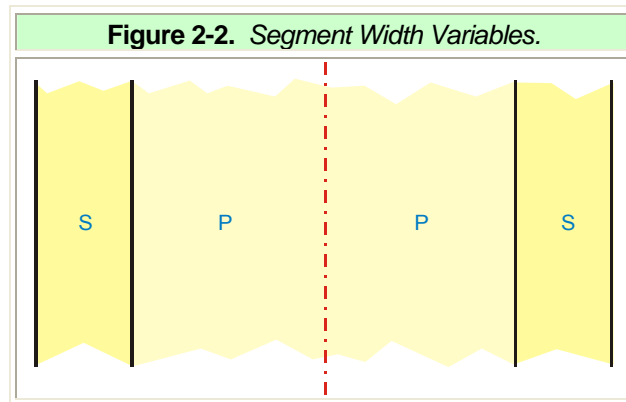
2.3 Segment Width (General).

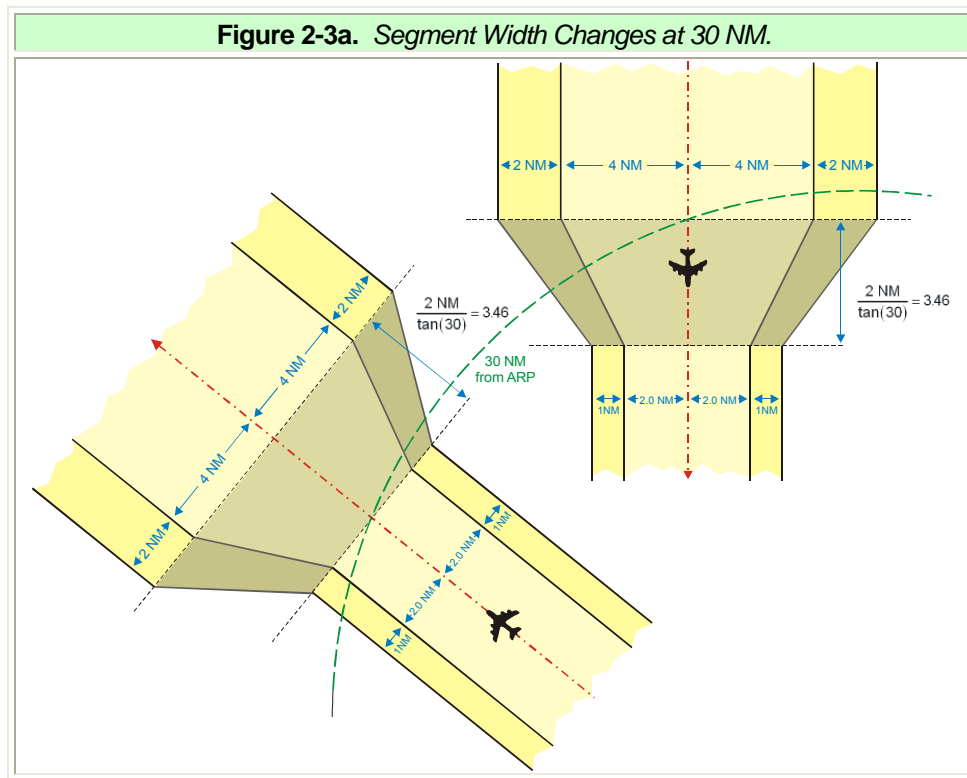
Table 2-2 lists primary and secondary width values for all segments of an **RNAV** approach procedure. Where segments cross* a point 30 **NM** from airport reference point (**ARP**), segment primary area width increases (expansion) or decreases (taper) at a rate of 30 degrees relative to course to the appropriate width (*see figure 2-3*). Secondary area expansion/taper is a straight-line connection from the point the primary area begins expansion/taper to the point the primary area expansion/taper ends (*see figure 2-2*). Reference to route width values is often specified as **NM** values measured from secondary area edge across the primary area to the secondary edge at the other side. For example, route width for segments more than 30 **NM** from **ARP** is “2-4-4-2.” For distances ≤ 30 **NM**, the width is “1-2-2-1.” *See table 2-2 and figures 2-2 and 2-3.*

**Note: STARs and Feeder segment width is 2-4-4-2 at all distances greater than 30 NM from ARP. A segment designed to cross within 30 NM of the ARP more than*

once does not taper in width until the 30 NM limit is crossed for approach and landing; i.e., crosses the limit for the last time before landing. A missed approach segment designed to cross a point 30 NM of the ARP more than once expands when it crosses the boundary the first time and remains expanded.

Table 2-2. RNAV Linear Segment Width (NM) Values.			
Segment		Primary Area Half-Width (p)	Secondary Area (s)
STARs, Feeder, Initial & Missed Approach	> 30 NM from ARP	± 4.00	2.00
		2-4-4-2	
STARs, Feeder, Initial, Missed Approach	≤ 30 NM from ARP	± 2.00	1.00
		1-2-2-1	
Intermediate		Continues initial segment width until 2 NM prior to PFAF. Then tapers uniformly to final segment width.	Continues initial segment width until 2 NM prior to PFAF. Then it tapers to final segment width.





2.3.1 Width Changes at 30 NM from ARP (non-RF).

Receiver sensitivity changes at 30 NM from ARP. From the point the designed course crosses 30 NM from ARP, the primary OEA can taper inward at a rate of 30 degrees relative to course from ± 4 NM to ± 2 NM. The secondary area tapers from a 2 NM width when the 30 NM point is crossed to a 1 NM width abeam the point the primary area reaches the ± 2 NM width. The total along-track distance required to complete the taper is approximately 3.46 NM (21,048.28 ft). Segment width tapers regardless of fix location within the tapering section unless a turn is associated with the fix. Delay OEA taper until the turn is complete and normal OEA turn construction is possible. EXCEPTION: The taper may occur in an RF turn segment if the taper begins at least 3.46 NM (along-track distance) from the RF leg termination fix; i.e., if it is fully contained in the RF leg.

2.3.2 Width Changes at 30 NM from ARP (RF).

When the approach segment crosses the point 30 NM from airport reference point in an RF leg, construct the leg beginning at a width of 2-4-4-2 prior to the 30 NM point and taper to 1-2-2-1 width after the 30 NM point. Calculate the perpendicular distance (B_{primary} , $B_{\text{secondary}}$) from the RF segment track centerline to primary and secondary boundaries at any along-track distance (specified as degrees of RF arc " α ") from the point the track crosses the 30 NM point using formula 2-1 (see figure 2-3b).

Formula 2-1. RF Segment Taper Width.

$$D = \frac{4-2}{\tan\left(30 \cdot \frac{\pi}{180}\right)} \quad \alpha = \frac{180 \cdot D}{\pi \cdot R}$$

Calculates degrees of arc (α) to complete taper

$$B_{\text{primary}} = 4 - 2 \cdot \frac{\phi \cdot \pi \cdot R}{180 \cdot D}$$

$$B_{\text{secondary}} = 6 - 3 \cdot \frac{\phi \cdot \pi \cdot R}{180 \cdot D}$$

where R = RF leg radius
 ϕ = degrees of arc (RF track)
Note: "D" will be in the same units as "R"

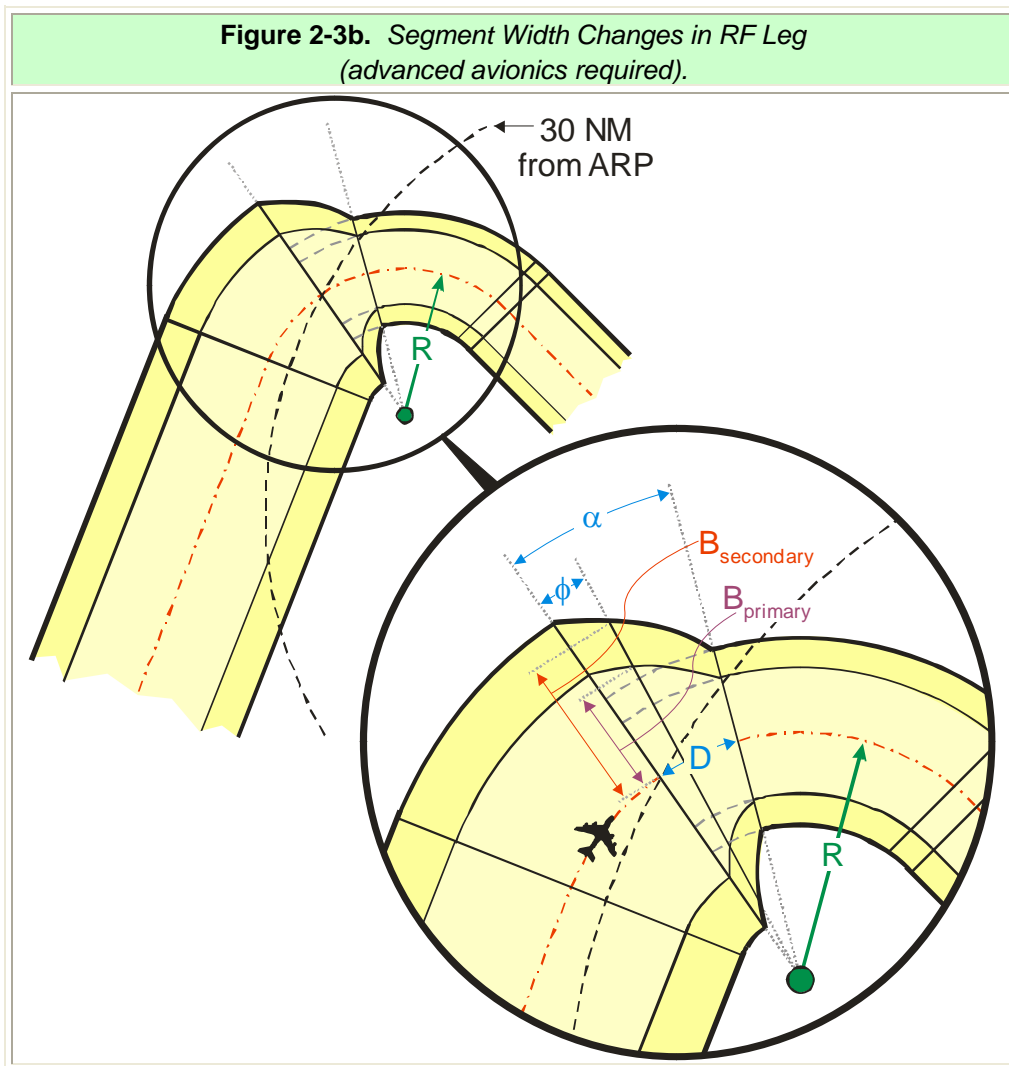
$$\alpha = (180 \cdot D) / (\pi \cdot R)$$

$$B_{\text{primary}} = 4 - 2 \cdot (\phi \cdot \pi \cdot R) / (180 \cdot D)$$

$$B_{\text{secondary}} = 6 - 3 \cdot (\phi \cdot \pi \cdot R) / (180 \cdot D)$$

Calculator	
R	
ϕ	
α	
D	
B_{primary}	
$B_{\text{secondary}}$	

Click Here to Calculate



2.4 Calculating the Turn Radius (R).

The design turn radius value is based on four variables: indicated airspeed, assumed tailwind, altitude, and bank angle. Apply the indicated airspeed from *table 2-3* for the highest speed aircraft category that will be published on the approach procedure. Apply the highest expected turn altitude value. The design bank angle is assumed to be 18 degrees.

Note: Determine the highest altitude within a turn by:

For approach – calculate the vertical path altitude (VP_{alt}) by projecting a 3-degree vertical path from the **PFAF** along the designed nominal flight track to the turn fix (see formula 2-2).

Formula 2-2. Vertical Path Altitude.		
$VP_{alt} = e^{\frac{D_z \cdot \tan\left(\frac{3 \cdot \pi}{180}\right)}{r}} \cdot (r + PFAF_{alt}) - r$		
where $PFAF_{alt}$ = Designed PFAF MSL altitude θ = glidepath angle D_z = distance (ft) from PFAF to fix		
<i>Note:</i> If D_z is a NM value, convert to feet by multiplying NM by 1852/0.3048		
$e^{((D_z \cdot \tan(3 \cdot \pi / 180)) / r) \cdot (r + PFAF_{alt}) - r}$		
Calculator		
PFAF _{alt}		Click Here to Calculate
θ		
D_z		
VP _{alt}		

For missed approach – project a vertical path along the nominal flight track from the SOC point and altitude to the turn fix, that rises at a rate of 250 ft/NM (Cat A/B), 500 ft/NM (Cat C/D) or a higher rate if a steeper climb gradient is specified. For turn at altitude construction, determine the altitude to calculate V_{KTAS} based on the climb-to altitude plus an additive based on a continuous climb of 250 (Cat A/B) or 500 (Cat C/D) ft per 12 degrees of turn [$\phi \cdot 250 / 12$ or $\phi \cdot 500 / 12$] (not to exceed the missed approach altitude). Cat D example: 1,125 ft would be added for a turn of 27 degrees, 958 ft would be added for 23 degrees, 417 ft for 10 degrees of turn.

Compare the vertical path altitude at the fix to minimum published fix altitude. The altitude to use is the higher of the two. For missed approach, the turn altitude must not be higher than the published missed approach altitude.

STEP 1: Determine the true airspeed (**KTAS**) for the turn using formula 2-3a. Locate and use the appropriate knots indicated airspeed (**KIAS**) from table 2-3. Use the highest altitude within the turn.

Formula 2-3a. True Airspeed.

$$V_{KTAS} = \frac{V_{KIAS} \cdot 171233 \cdot \sqrt{(288 + 15) - 0.00198 \cdot \text{alt}}}{(288 - 0.00198 \cdot \text{alt})^{2.628}}$$

where alt = aircraft MSL elevation
 V_{KIAS} = knots indicated airspeed

(V_{KIAS}*171233*((288+15)-0.00198*alt)^0.5)/(288-0.00198*alt)^2.628

Calculator

V _{KIAS}		Click Here to Calculate
alt		
V _{KTAS}		

Table 2-3. Indicated Airspeeds (Knots).

Segment		Indicated Airspeed by Aircraft Category (CAT)				
		CAT A	CAT B	CAT C	CAT D	CAT E
Feeder, Initial Intermediate, Missed Approach	Above 10,000	180	250	300	300	350
Feeder, Initial Intermediate	At/Below 10,000	150		250		
Final		90	120	140	165	165 or as Specified*
Missed Approach (MA)		110	150	240	265	265 or as Specified*

* Record Cat E final or **MA** indicated airspeed in procedure documentation if different than listed.

STEP 2: Calculate the appropriate tailwind component (V_{KTW}) using *formula 2-3b* for the highest altitude within the turn. **EXCEPTION:** If the **MSL** altitude is 2,000 ft or less above airport elevation, use 30 knots.

Formula 2-3b. Tailwind.		
$V_{KTW} = 0.00198 \cdot \text{alt} + 47$		
where alt = highest turn altitude		
<i>Note: If "alt" is 2000 or less above airport elevation, then $V_{KTW} = 30$</i>		
0.00198*alt+47		
Calculator		
alt		Click Here to Calculate
V_{KTW}		

**Greater tailwind component values may be used where data indicates higher wind conditions are likely to be encountered. Where a higher value is used, it must be recorded in the procedure documentation.*

STEP 3: Calculate **R** using formula 2-3c.

Formula 2-3c. Turn Radius.		
$R = \frac{(V_{KTAS} + V_{KTW})^2}{\tan\left(\text{bank}_{\text{angle}} \cdot \frac{\pi}{180}\right) \cdot 68625.4}$		
where $\text{bank}_{\text{angle}}$ = assumed bank angle (normally 14° for Cat A, 18° for Cats B-D)		
$(V_{KTAS} + V_{KTW})^2 / (\tan(\text{bank}_{\text{angle}} * \pi / 180) * 68625.4)$		
Calculator		
V_{KTAS}		Click Here to Calculate
V_{KTW}		
$\text{bank}_{\text{angle}}$		
R		

Note 1: (formula 2-3c) For fly-by turns where the highest altitude in the turn is between 10,000 ft and flight level 195, where the sum of " $V_{KTAS} + V_{KTW}$ " is greater than 500 knots, use 500 knots.

Note 2: (formula 2-3c) For fly-by turns, where the highest altitude in the turn is greater than flight level 195, use 750 knots as the value for " $V_{KTAS} + V_{KTW}$ " and 5 degrees of bank rather than 18 degrees. If the resulting DTA is greater than 20 NM,

then $R = \frac{20}{\tan\left(\frac{\phi}{2} \cdot \frac{\pi}{180}\right)}$ where ϕ is the amount of turn (heading change). Use formula

2-8 to verify the required bank angle does not exceed 18 degrees.

2.5 Turn Construction.

If the course outbound from a fix differs from the course inbound to the fix (courses measured at the fix), a turn is indicated.

2.5.1 Turns at Fly-Over Fixes (see figures 2-4 and 2-5).

2.5.1 a. Extension for Turn Delay.

Turn construction incorporates a delay in start of turn to account for pilot reaction time and roll-in time (rr). Calculate the extension distance in feet using formula 2-4.

Formula 2-4. Reaction & Roll Dist.		
$rr = 6 \cdot \frac{1852}{3600} \cdot 0.3048 \cdot V_{KTAS}$		
$6 \cdot 1852 / 0.3048 / 3600 \cdot V_{KTAS}$		
Calculator		
V_{KTAS}		Click Here to Calculate
rr		

STEP 1: Determine R . See formula 2-3c.

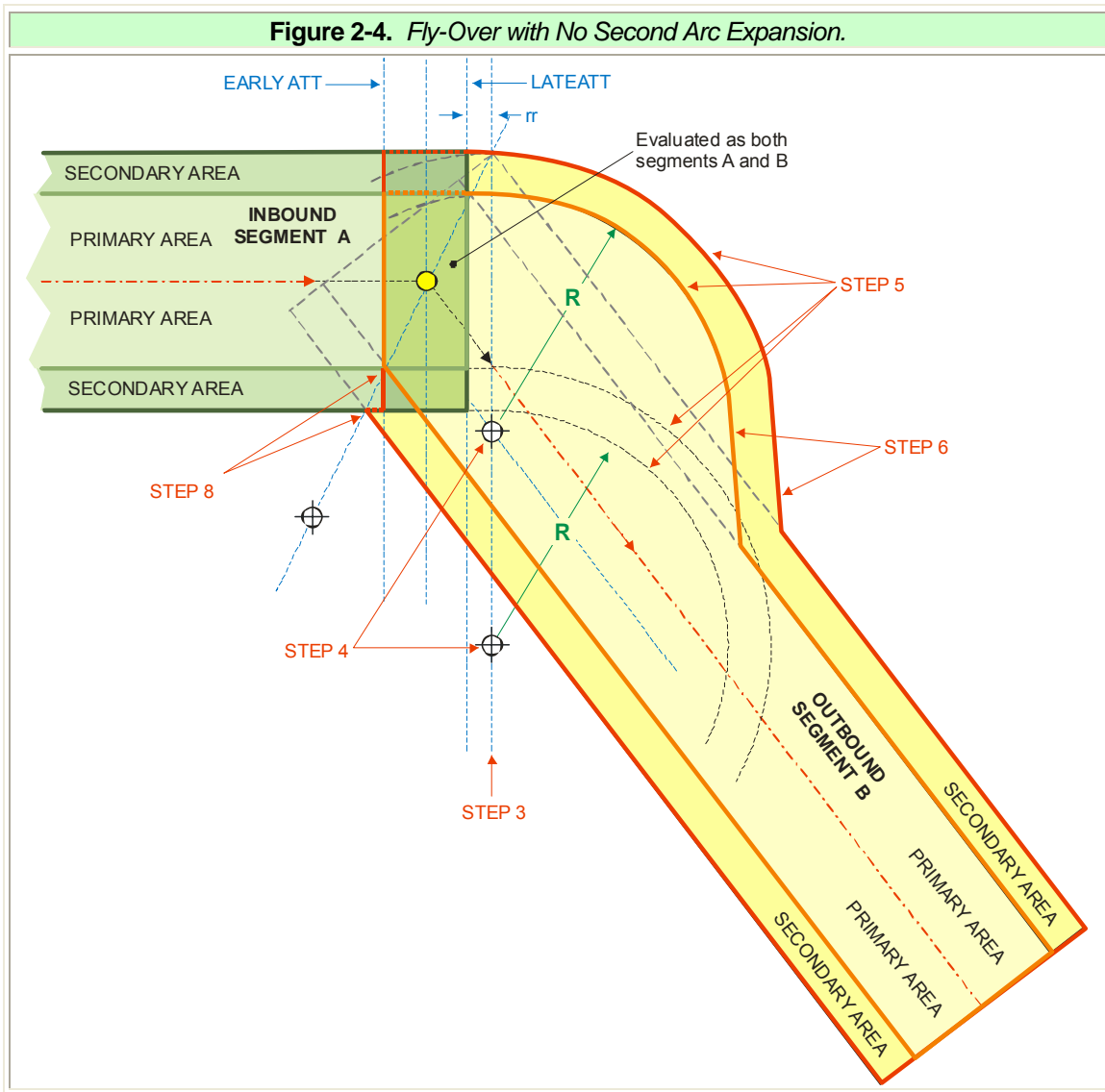
STEP 2: Determine rr . See formula 2-4.

STEP 3: Establish the baseline for construction of the turn expansion area as the line perpendicular to the inbound track at a distance past the turn fix equal to $(ATT+rr)$.

STEP 4: On the baseline, locate the center points for the primary and secondary turn boundaries. The first is located at a distance R from the non-turning side primary boundary. The second is located at a distance R from the turning side secondary boundary (see figures 2-4 and 2-5).

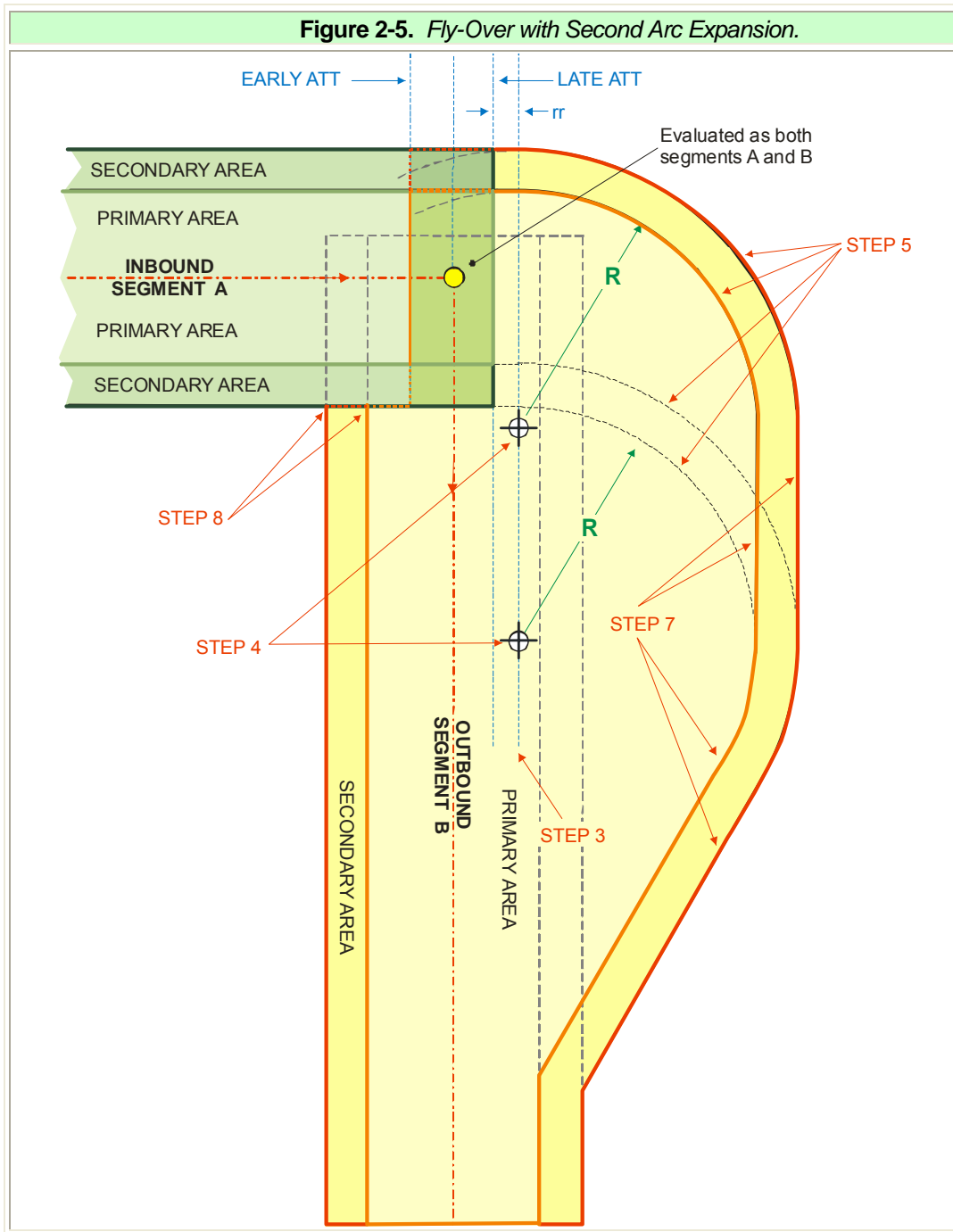
STEP 5: From these center points construct arcs for the primary boundary of radius R . Complete the secondary boundary by constructing additional arcs of radius $(R+W_S)$ from the same center points. (W_S =width of the secondary). This is shown in figures 2-4 and 2-5.

STEP 6: The arcs constructed in step 5 are tangent to the outer boundary lines of the inbound segment. Construct lines tangent to the arcs based on the first turn point tapering inward at an angle of 30 degrees relative to the outbound track that joins the arc primary and secondary boundaries with the outbound segment primary and secondary boundaries. If the arcs from the second turn point are inside the tapering lines as shown in *figure 2-4*, then they are disregarded and the expanded area construction is completed. If not, proceed to step 7.



STEP 7: If both the inner and outer arcs lie outside the tapering lines constructed in step 6, connect the respective inner and outer arcs with tangent lines and then construct the tapering lines from the arcs centered on the second center point as shown in *figure 2-5*.

STEP 8: The inside turn boundaries are the simple intersection of the preceding and succeeding segment primary and secondary boundaries.



The inbound *OEA* end (\pm *ATT*) is evaluated for both inbound and outbound segments.

2.5.1

b. Minimum length of *TF* leg following a fly-over turn. The leg length of a *TF* leg following a fly-over turn must be sufficient to allow the aircraft to return to course centerline. Determine the minimum leg length (*L*) using *formulas 2-5 and 2-6*.

Formula 2-5. Distance of Turn Anticipation.

$$DTA = R \cdot \tan\left(\frac{\phi \cdot \pi}{2 \cdot 180}\right)$$

where R = turn radius from formula 2-3c
 ϕ = degrees of heading change

$R \cdot \tan(\phi / 2 \cdot \pi / 180)$

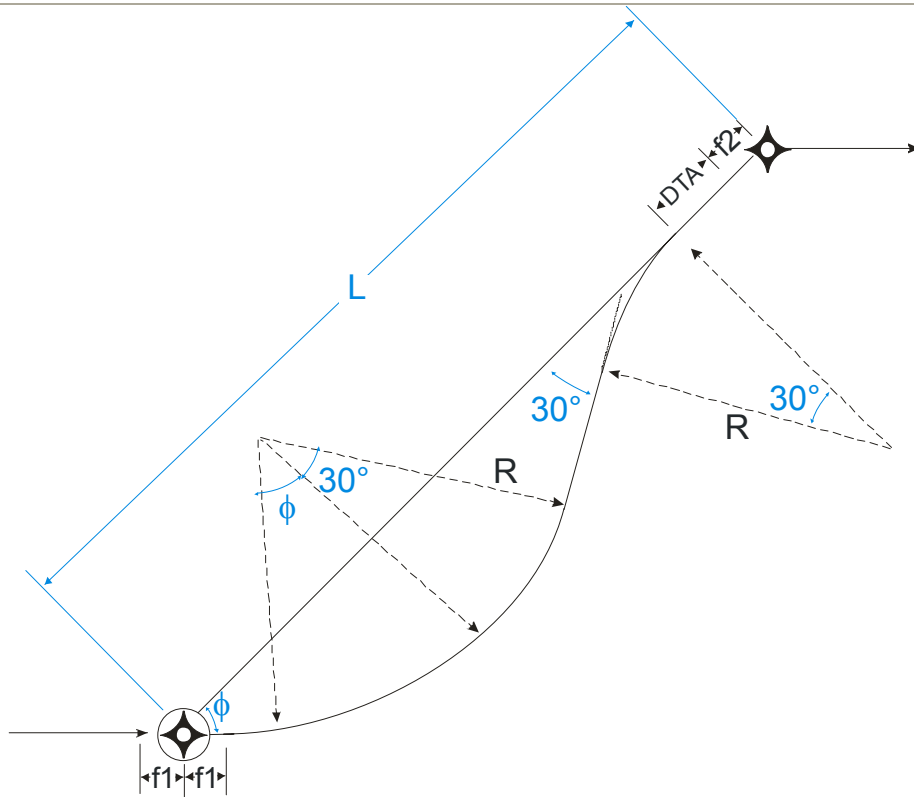
Calculator

R		Click Here to Calculate
ϕ		
DTA		

Formula 2-6. TF Leg Minimum Length Following Fly-Over Turn.

$$L = f1 \cdot \left(\cos\left(\phi \cdot \frac{\pi}{180}\right) + \sqrt{3} \cdot \sin\left(\phi \cdot \frac{\pi}{180}\right) \right) + R \cdot \left(\sin\left(\phi \cdot \frac{\pi}{180}\right) + 4 - \sqrt{3} - \sqrt{3} \cdot \cos\left(\phi \cdot \frac{\pi}{180}\right) \right) + DTA + f2$$

where R = turn radius (NM) from formula 2-3c
 ϕ = degrees of track change at fix
 f1 = ATT (NM) of fly-over fix (segment initial fix)
 f2 = ATT (NM) of segment termination fix
 DTA = value from formula 2-5 (applicable only if the fix is "fly-by")



$$f1 * (\cos(\phi * \pi / 180) + 3^{0.5} * \sin(\phi * \pi / 180)) + R * (\sin(\phi * \pi / 180) + 4 - 3^{0.5} - 3^{0.5} * \cos(\phi * \pi / 180)) + DTA + f2$$

Calculator

f1	<input type="text"/>	Click Here to Calculate
f2	<input type="text"/>	
ϕ	<input type="text"/>	
R	<input type="text"/>	
DTA	<input type="text"/>	
L	<input type="text"/>	

2.5.2 Fly-By Turn. See figure 2-6.

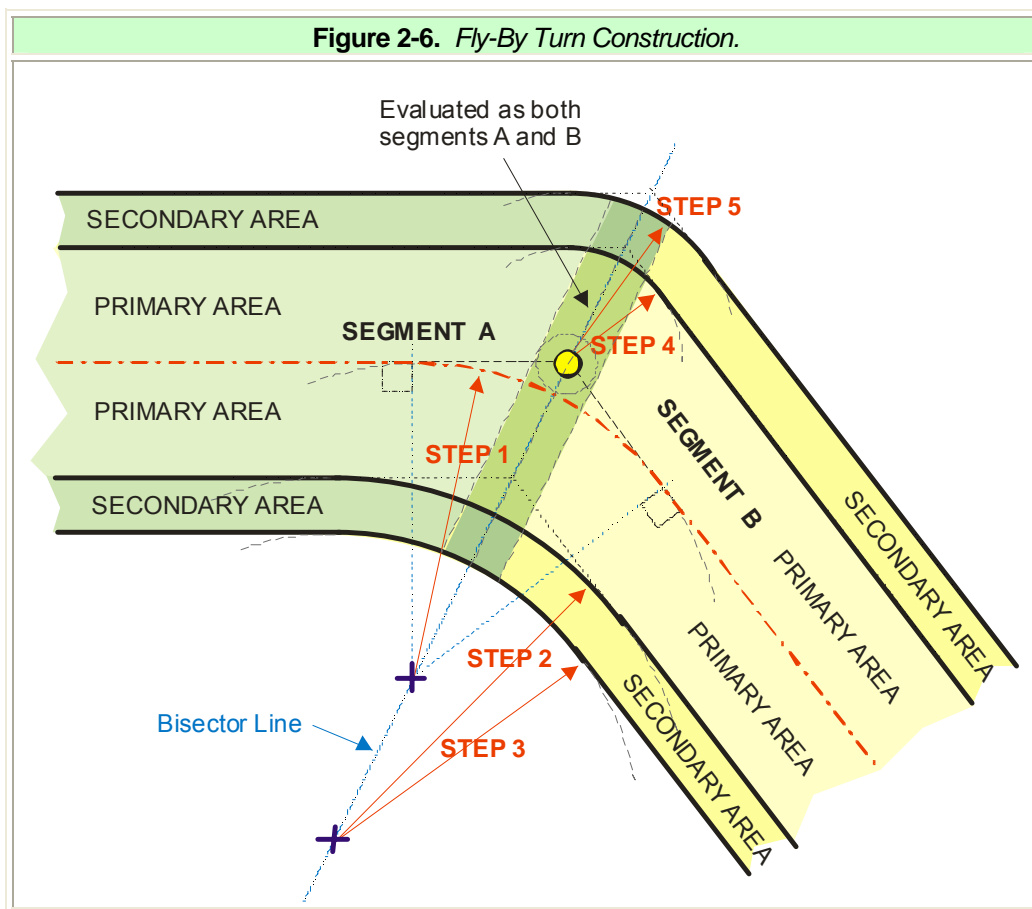
STEP 1: Establish a line through the turn fix that bisects the turn angle. Determine Turn Radius (R). See formula 2-3c. Scribe an arc (with origin on bisector line) of radius R tangent to inbound and outbound courses. This is the designed turning flight path.

STEP 2: Scribe an arc (with origin on bisector line) that is tangent to the inner primary boundaries of the two segment legs with a radius equal to $\frac{\text{Primary Area Half-width}}{2}$ (example: half width of 2 NM , the radius would be $R+1.0 NM$).

STEP 3: Scribe an arc that is tangent to the inner secondary boundaries of the two segment legs using the origin and radius from step 2 minus the secondary width.

STEP 4: Scribe the primary area outer turning boundary with an arc with a radius equal to the segment half width centered on the turn fix.

STEP 5: Scribe the secondary area outer turning boundary with the arc radius from step 4 plus the secondary area width centered on the turn fix.



2.5.2

a. **Minimum length of track-to-fix (TF) leg following a fly-by turn.** Calculate the minimum length for a TF leg following a fly-by turn using formula 2-7.

Formula 2-7. TF Leg Minimum Length Following Fly-by Turn.

$L = f1 + DTA1 + DTA2 + f2$

where f1 = ATT of initial fix
 f2 = ATT of termination fix
 R1 = turn radius for first fix from formula 2-3c
 R2 = turn radius for subsequent fix from formula 2-3c *Note: zero when ϕ_2 is fly-over*
 ϕ_1 = degrees of heading change at initial fix
 ϕ_2 = degrees of heading change at termination fix

DTA1 = $R1 \cdot \tan\left(\frac{\phi_1}{2} \cdot \frac{\pi}{180}\right)$
 DTA2 = $R2 \cdot \tan\left(\frac{\phi_2}{2} \cdot \frac{\pi}{180}\right)$ *Note: zero when ϕ_2 is fly-over*

$F1+DTA1+DTA2+F2$

Calculator

f1		Click Here to Calculate
f2		
R1		
R2		
ϕ_1		
ϕ_2		
DTA1		
DTA2		
L		

2.5.3 Radius-to-Fix (RF) Turn. *Incorporation of an RF segment may limit the number of aircraft served by the procedure.*

RF legs are used to control the ground track of a turn where obstructions prevent the design of a fly-by or fly-over turn, or to accommodate other operational requirements.* The curved leg begins tangent to the previous segment course at its terminating fix and ends tangent to the next segment course at its beginning fix (see figure 2-7). **OEA** construction limits turn radius to a minimum value equal-to or greater-than the **OEA** (primary and secondary) half-width. The **RF** segment **OEA** boundaries are parallel arcs.

**Note: RF legs segments are not applicable to the final segment or section 1 of the missed approach segment. RF legs in the intermediate segment must terminate at least 2 NM prior to the PFAF. Where RF legs are used, annotate the procedure (or segment as appropriate) “RF Required.” Use Order 8260.52, table 1-3 for V_{KTW} values for radius calculations for RF legs.*

STEP 1: Determine the segment turn radius (**R**) that is required to fit the geometry of the terrain/airspace. Enter the required radius value into formula 2-8 to verify the resultant bank angle is ≤ 20 degrees (maximum allowable bank angle). Where a bank angle other than 18 degrees is used, annotate the value in the remarks section of the FAA Form 8260-9 or appropriate military procedure documentation form.

Formula 2-8. RF Bank Angle.		
$\text{bank}_{\text{angle}} = \arctan \left(\frac{(V_{\text{KTAS}} + V_{\text{KTW}})^2}{R \cdot 68625.4} \right) \cdot \frac{180}{\pi}$		
where V _{KTAS} = value from formula 2-3a V _{KTW} = value from Order 8260.52, table 1-3 R = required radius		
$\text{atan}((V_{\text{KTAS}}+V_{\text{KTW}})^2/(R*68625.4))*180/\pi$		
Calculator		
V _{KTAS}		Click Here to Calculate
V _{KTW}		
R		
bank _{angle}		

Note: Where only categories A and B are published, verify the resultant bank angle is ≤ 15 degrees.

Segment length may be calculated using *formula 2-9*.

Formula 2-9. RF Segment Length.		
$\text{Segment}_{\text{length}} = \frac{\pi \cdot R \cdot \phi}{180}$		
where R = RF segment radius (answer will be in the units entered)		
ϕ = # of degrees of ARC (heading change)		
$\pi \cdot R \cdot \phi / 180$		
Calculator		
R		Click Here to Calculate
ϕ		
Segment _{length}		

STEP 2: Turn Center. Locate the turn center at a perpendicular distance **R** from the preceding and following segments.

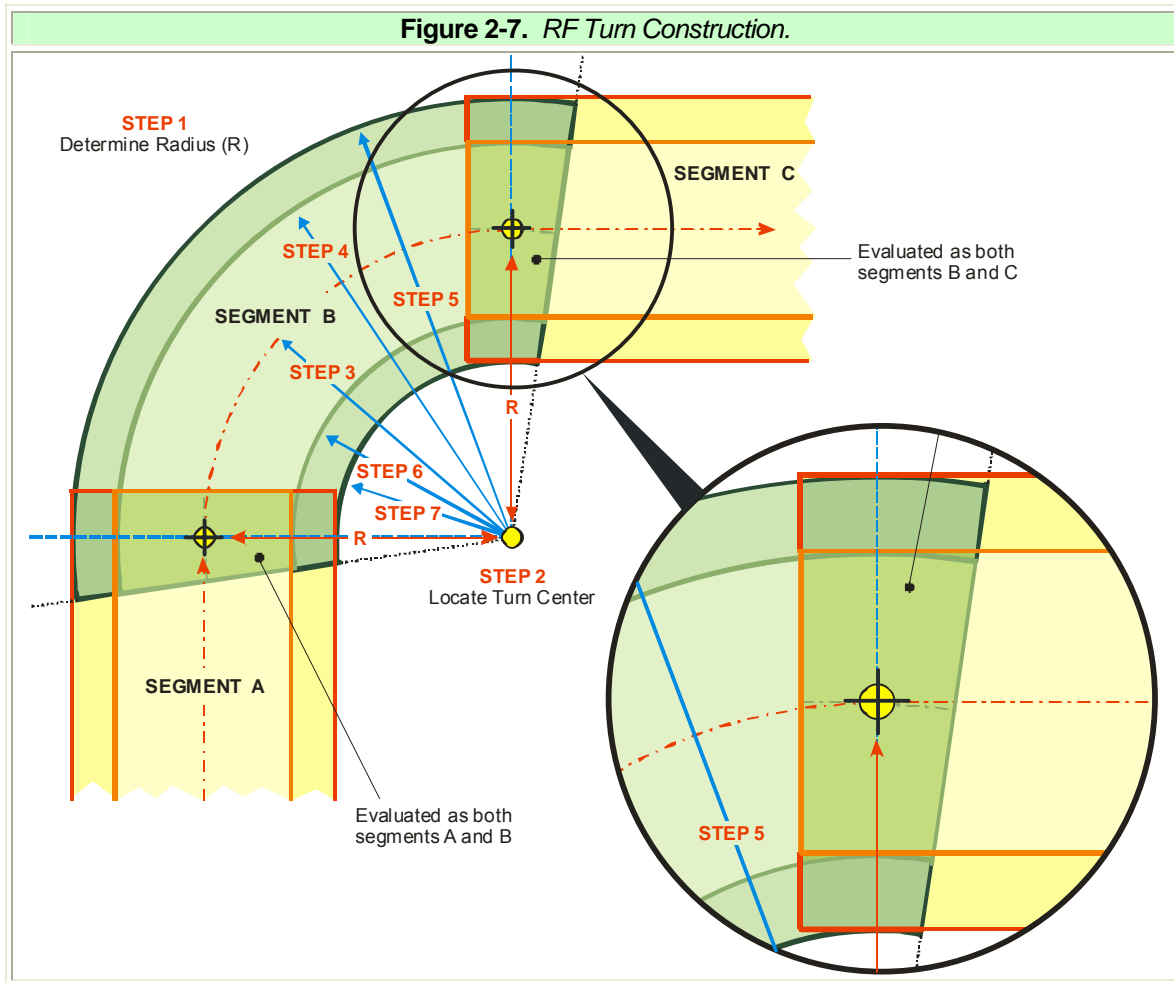
STEP 3: Flight path. Construct an arc of radius **R** from the tangent point on the preceding course to the tangent point on the following course.

STEP 4: Primary area outer boundary. Construct an arc of radius **R+Primary area half-width** from the tangent point on the preceding segment primary area outer boundary to the tangent point on the following course primary area outer boundary.

STEP 5: Secondary area outer boundary. Construct an arc of radius **R+Primary area half-width+secondary area width** from the tangent point on the preceding segment secondary area outer boundary to the tangent point on the following course secondary area outer boundary.

STEP 6: Primary area inner boundary. Construct an arc of radius **R-Primary area half-width** from the tangent point on the preceding segment inner primary area boundary to the tangent point on the following course inner primary area boundary.

STEP 7: Secondary area inner boundary. Construct an arc of radius **R-(Primary area half-width+secondary area width)** from the tangent point on the preceding segment inner secondary area boundary to the tangent point on the following course inner secondary area boundary.

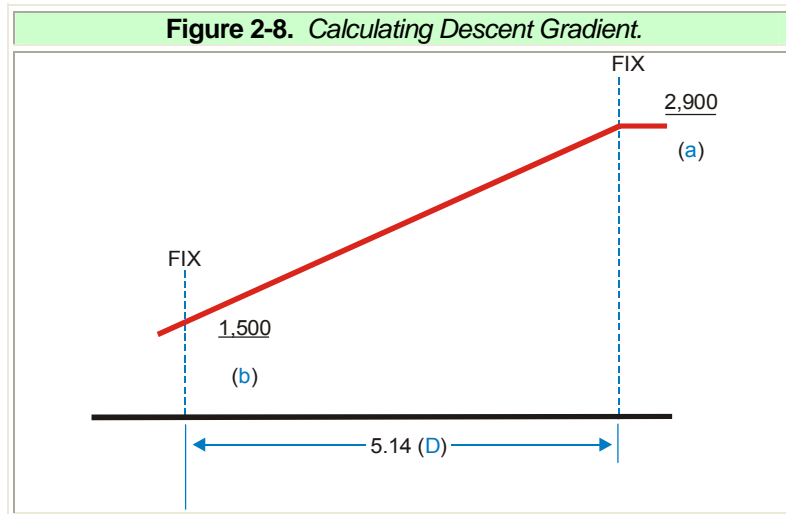


2.6 Descent Gradient.

The **optimum** descent gradient in the initial segment is 250 ft/NM (4.11%, 2.356°); **maximum** is 500 ft/NM (8.23%, 4.70°). For high altitude penetrations, the **optimum** is 800 ft/NM (13.17%, 7.5°); **maximum** is 1,000 ft/NM (16.46%, 9.35°). The **optimum** descent gradient in the intermediate segment is 150 ft/NM (2.47%, 1.41°); **maximum** is 318 ft/NM (5.23%, 3.0°).

2.6.1 Calculating Descent Gradient (DG).

Determine total altitude lost between the plotted positions of the fixes. Determine the distance (**D**) in *NM*. Divide the total altitude lost by **D** to determine the segment descent gradient (see figure 2-8 and formula 2-10).



Formula 2-10. Descent Gradient.

$$DG = \frac{r \cdot \ln\left(\frac{r+a}{r+b}\right)}{D}$$

where a = beginning altitude
 b = ending altitude
 D = distance (NM) between fixes
 r = 20890537

(r*ln((r+a)/(r+b)))/D

Calculator	
a	
b	
D	
DG	

Click Here to Calculate

2.7 Feeder Segment.

When the initial approach fix (**IAF**) is not part of the en route structure, it may be necessary to designate feeder routes from the en route structure to the **IAF**. The feeder segment may contain a sequence of **TF** segments (and/or **RF** segments). The maximum course change between **TF** segments is 70 degrees above FL190, and 90 degrees (70 degrees preferred) below FL190. *Formula 2-3c Notes 1 and 2 apply.* Paragraph 2.5 turn construction applies. The feeder segment terminates at the **IAF** (see figures 2-9a and 2-9b).

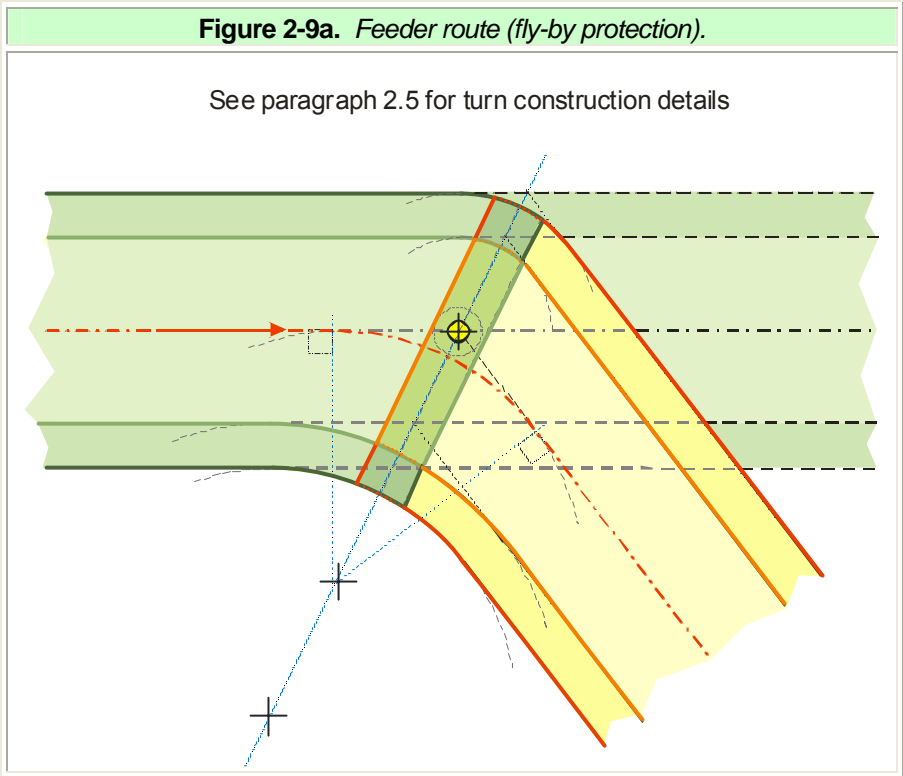
2.7.1 Length.

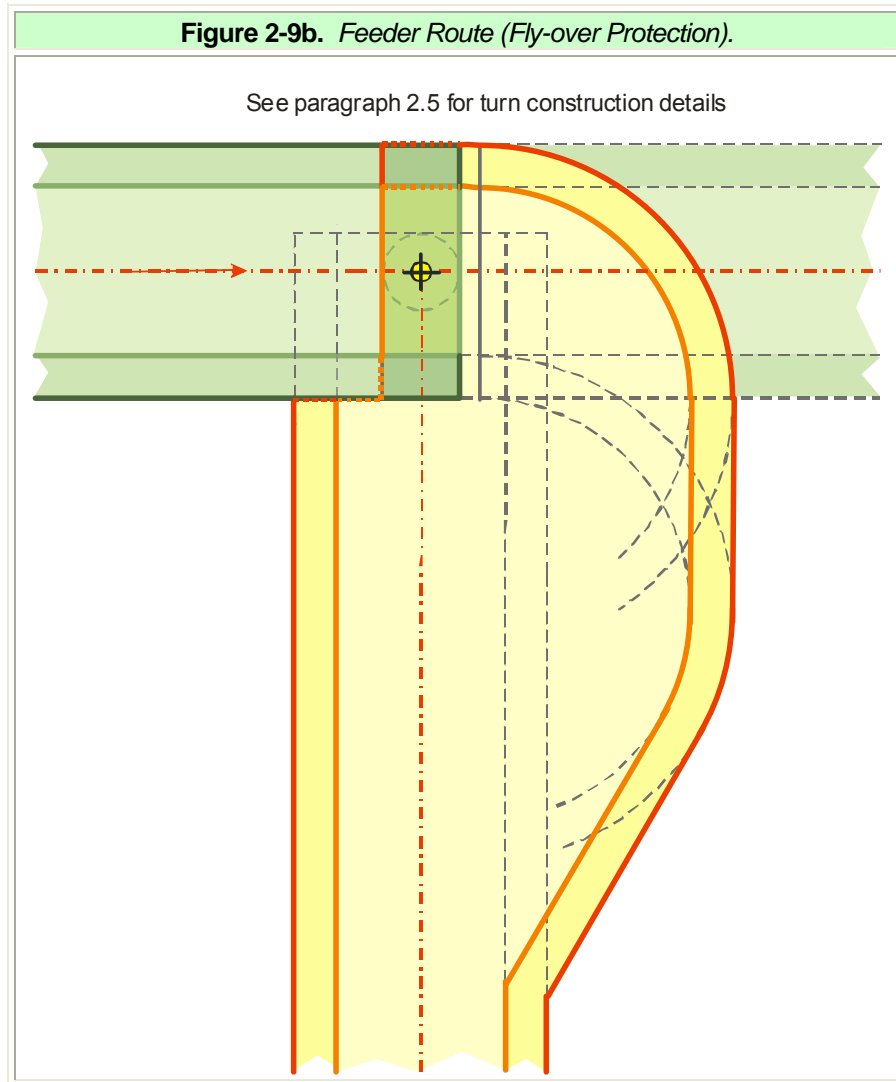
The **minimum** length of a sub-segment is determined under *paragraph 2.5.1b or 2.5.2a* as appropriate. The **maximum** length of a sub-segment is 500 miles. The total length of the feeder segment should be as short as operationally possible.

2.7.2 Width.

Primary area width is ± 4.0 **NM** from course centerline; secondary area width is 2.0 **NM** (2-4-4-2). These widths apply from the feeder segment initial fix to the approach **IAF**/termination fix. Where the initial fix is on an airway, *chapter 2* construction applies.

Note: These criteria also support STARS. STARS beginning ≤ 30 NM from ARP width is ± 2.0 NM from course centerline; secondary area width is 1.0 NM (1-2-2-1).





2.7.3 Obstacle Clearance.

The **minimum ROC** over areas *not* designated as mountainous under Federal Aviation Regulation (*FAR*) 95 is 1,000 ft. The **minimum ROC** within areas designated in *FAR* 95 as “mountainous” is 2,000 ft. *TERPS* paragraphs 1720 b(1), b(2) and 1721 apply. The published minimum feeder route altitude must provide at least the **minimum ROC** value and must not be less than the altitude established at the *IAF*.

2.7.4 Descent Gradient. *(feeder, initial, intermediate segments)*

The **optimum** descent gradient in the feeder and initial segments is 250 ft/**NM** (4.11%, 2.356°); **maximum** is 500 ft/**NM** (8.23%, 4.70°). *For high altitude penetrations, the optimum is 800 ft/**NM** (13.17%, 7.5°); maximum is 1,000 ft/**NM** (16.46%, 9.35°).* The **optimum** descent gradient in the intermediate segment is 150 ft/**NM** (2.47%, 1.41°); **maximum** is 318 ft/**NM** (5.23%, 3.0°).

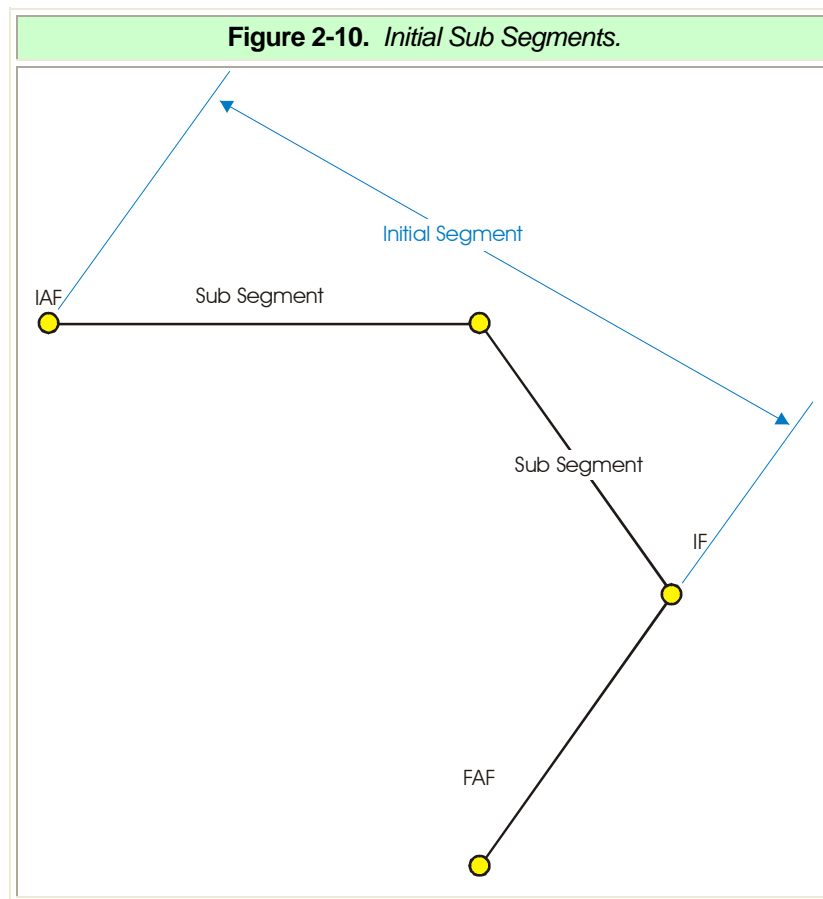
Chapter 2. General Criteria

Section 2. Terminal Segments

2.8 Initial Segment.

The initial segment begins at the **IAF** and ends at the intermediate fix (**IF**). The initial segment may contain sequences of straight sub segments (*see figure 2-10*).

Paragraphs 2.8.2, 2.8.3, 2.8.4, and 2.8.5 apply to all sub segments individually. The total length of all sub segments must not exceed 50 NM. For descent gradient limits, see paragraph 2.7.4.



2.8.1 Course Reversal.

The **optimum** design incorporates the basic **Y** or **T** configuration. This design eliminates the need for a specific course reversal pattern. Where the **optimum** design cannot be used and a course reversal is required, establish a holding pattern at the initial or intermediate approach fix. *See paragraph 2.8.6b.* The **maximum** course change at the fix (**IAF/IF**) is to 90 degrees (70 degrees above FL 190).

2.8.2 Alignment.

Design initial/initial and initial/intermediate **TF** segment intersections with the smallest amount of course change that is necessary for the procedure. No course change is **optimum**. Where a course change is necessary, it should normally be limited to 70 degrees or less; 30 degrees or less is preferred. The **maximum** allowable course change between **TF** segments is 90 degrees.

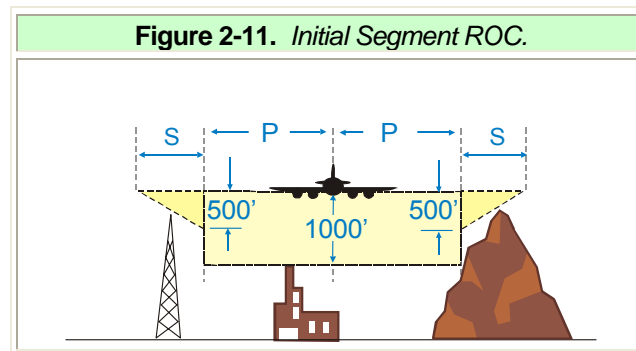
2.8.3 Area – Length.

The **maximum** segment length (total of sub segments) is 50 **NM**. Minimum length of sub segments is determined as described in *paragraphs 2.5.1b* and *2.5.2a*.

2.8.4 Area – Width (*see table 2-2*).

2.8.5 Obstacle Clearance.

Apply 1,000 ft of **ROC** over the highest obstacle in the primary **OEA**. The **ROC** in the secondary area is 500 ft at the primary boundary tapering uniformly to zero at the outer edge (*see figure 2-11*).



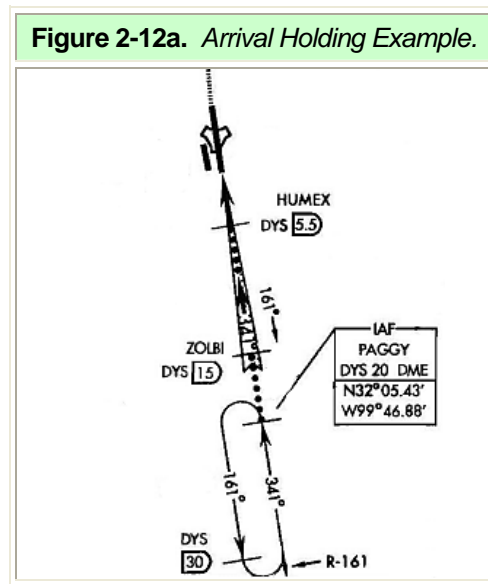
Calculate the secondary **ROC** values using *formula 2-11a*.

Formula 2-11a. Secondary ROC.		
$ROC_{\text{secondary}} = 500 \cdot \left(1 - \frac{d}{D}\right)$		
where D = width (ft) of secondary d = distance (ft) from edge of primary area measured perpendicular to boundary		
500*(1-d/D)		
Calculator		
d		Click Here to Calculate
D		
ROC _{secondary}		

2.8.6 Holding Pattern Initial Segment.

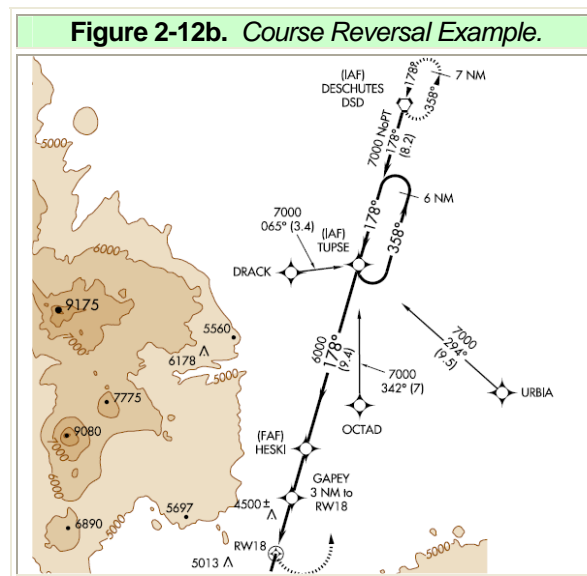
A holding pattern may be incorporated into the initial segment procedure design where an operational benefit can be derived; e.g., arrival holding at an **IAF**, course reversal pattern at the **IF**, etc. See FAA Order 7130.3, *Holding Pattern Criteria*, for **RNAV** holding pattern construction guidance.

- 2.8.6 a. Arrival Holding.** Ideally, the holding pattern inbound course should be aligned with the subsequent **TF** leg segment (tangent to course at the initial fix of the subsequent **RF** segment). See *figure 2-12a*. If the pattern is offset from the subsequent **TF** segment course, the subsequent segment length must accommodate the resulting **DTA** requirement. Maximum offset is 90 degrees (70 degrees above FL190). Establish the minimum holding altitude at or above the **IAF/IF** (as appropriate) minimum altitude. MEA minimum altitude may be lower than the minimum holding altitude.



2.8.6

b. Course Reversal. Ideally, establish the minimum holding altitude as the minimum *IF* fix altitude (see figure 2-12b). In any case, the published holding altitude must result in a suitable descent gradient in the intermediate segment: optimum is 150 ft/NM (2.47%, 1.41°); **maximum** is 318 ft/NM (5.23%, 3.0°). If the pattern is offset from the subsequent *TF* segment course, the subsequent segment length must accommodate the resulting *DTA* requirement. **Maximum** offset is 90 degrees.



2.9 Intermediate Segment.

The intermediate segment primary and secondary boundary lines connect abeam the plotted position of the **PFAF** at the appropriate primary and secondary final segment beginning widths.

2.9.1 Alignment (Maximum Course Change at the **PFAF**).

- **LPV & LNAV/VNAV.** Align the intermediate course within 15 degrees of the final approach course (15 degrees maximum course change).
- **LNAV & LP.** Align the intermediate course within 30 degrees of the final approach course (30 degrees maximum course change).

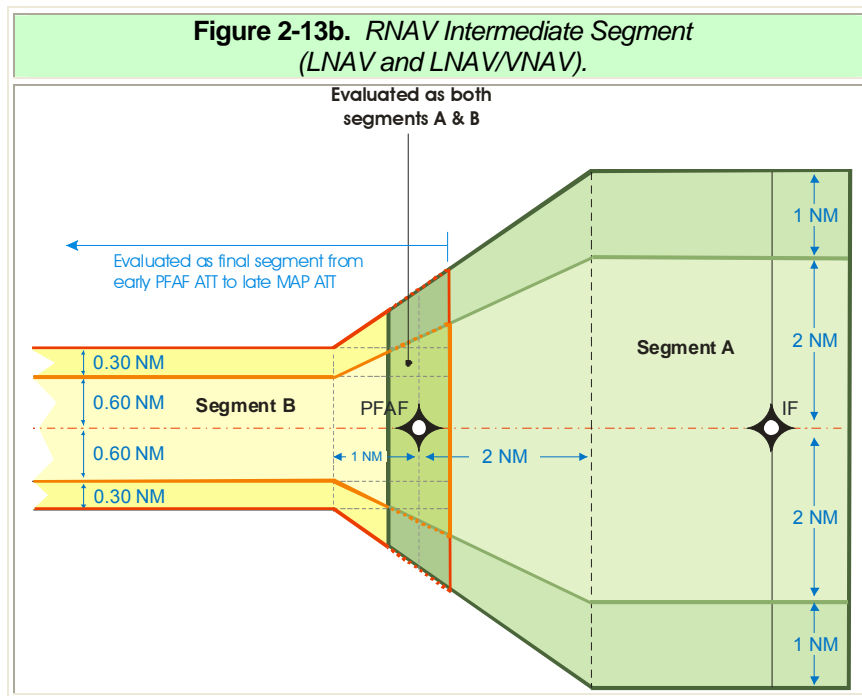
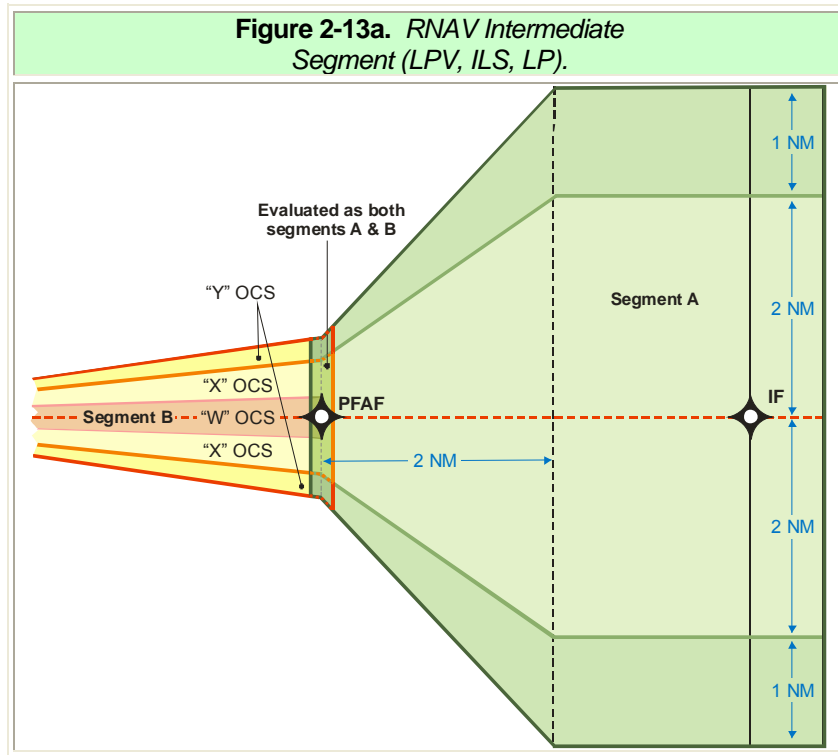
*Note: For RNAV transition to ILS final, no course change is allowed at the **PFAF**.*

2.9.2 Length (Fix to Fix).

The **minimum** category (**CAT**) A/B segment length is 3 **NM**; the **optimum** is 3 **NM**. The **minimum** **CAT** C/D segment length is 4 **NM**; the optimum is 5 **NM**, where turns over 45 degrees are required, the minimum is 6 **NM**. The **minimum** **CAT** E segment length is 6 **NM**. Where turns to and from the intermediate segment are necessary, determine minimum segment length using *formula 2-6 or 2-7* as appropriate.

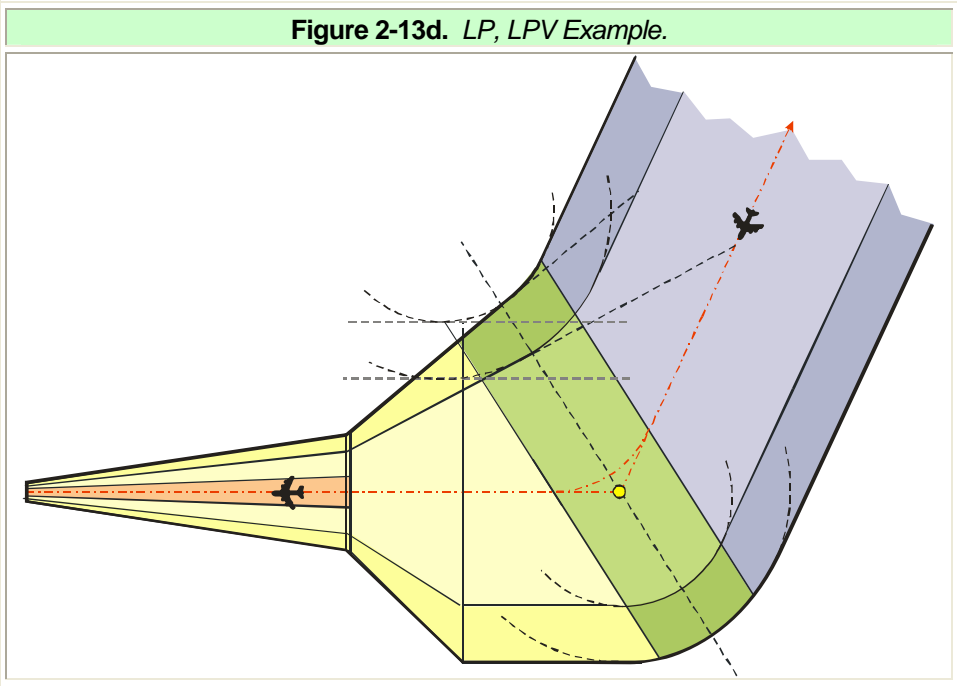
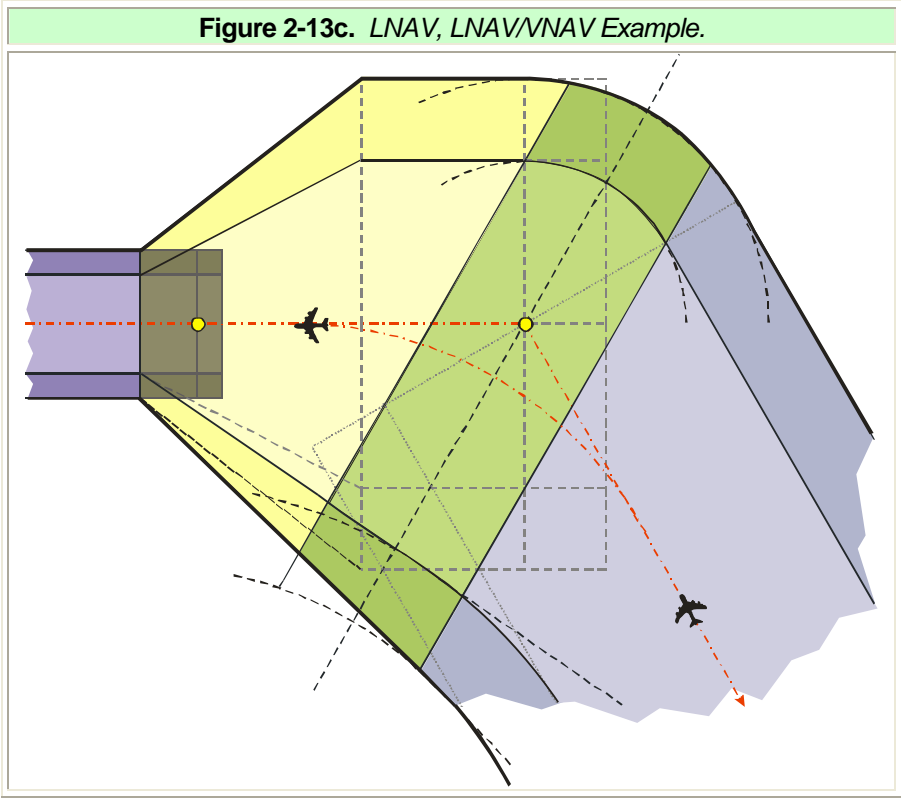
2.9.3 Width.

The intermediate segment primary area tapers uniformly from ± 2 **NM** at a point 2 **NM** prior to the **PFAF** to the outer boundary of the **X OCS** abeam the **PFAF** (1 **NM** past the **PFAF** for **LNAV** and **LNAV/VNAV**). The secondary boundary tapers uniformly from 1 **NM** at a point 2 **NM** prior to the **PFAF** to the outer boundary of the **Y OCS** abeam the **PFAF** (1 **NM** past the **PFAF** for **LNAV** and **LNAV/VNAV**). See *figures 2-13a and 2-13b*.



If a turn is designed at the *IF*, it is possible for the inside turn construction to generate boundaries outside the normal segment width at the taper beginning point 2 miles prior to the *PFAF*. Where these cases occur, the inside (turn side) boundaries are a simple straight line connection from the point 1 *NM* past the *PFAF* on the

final segment, to the tangent point on the turning boundary arc as illustrated in figures 2-13c and 2-13d.



2.9.3

a. LNAV/VNAV, LNAV Offset Construction. Where *LNAV* intermediate course is not an extension of the final course, use the following construction (*see figure 2-13e*).

STEP 1: Construct line **A** perpendicular to the intermediate course 2 *NM* prior the *PFAF*.

STEP 2: Construct line **B** perpendicular to the intermediate course extended 1 *NM* past the *PFAF*.

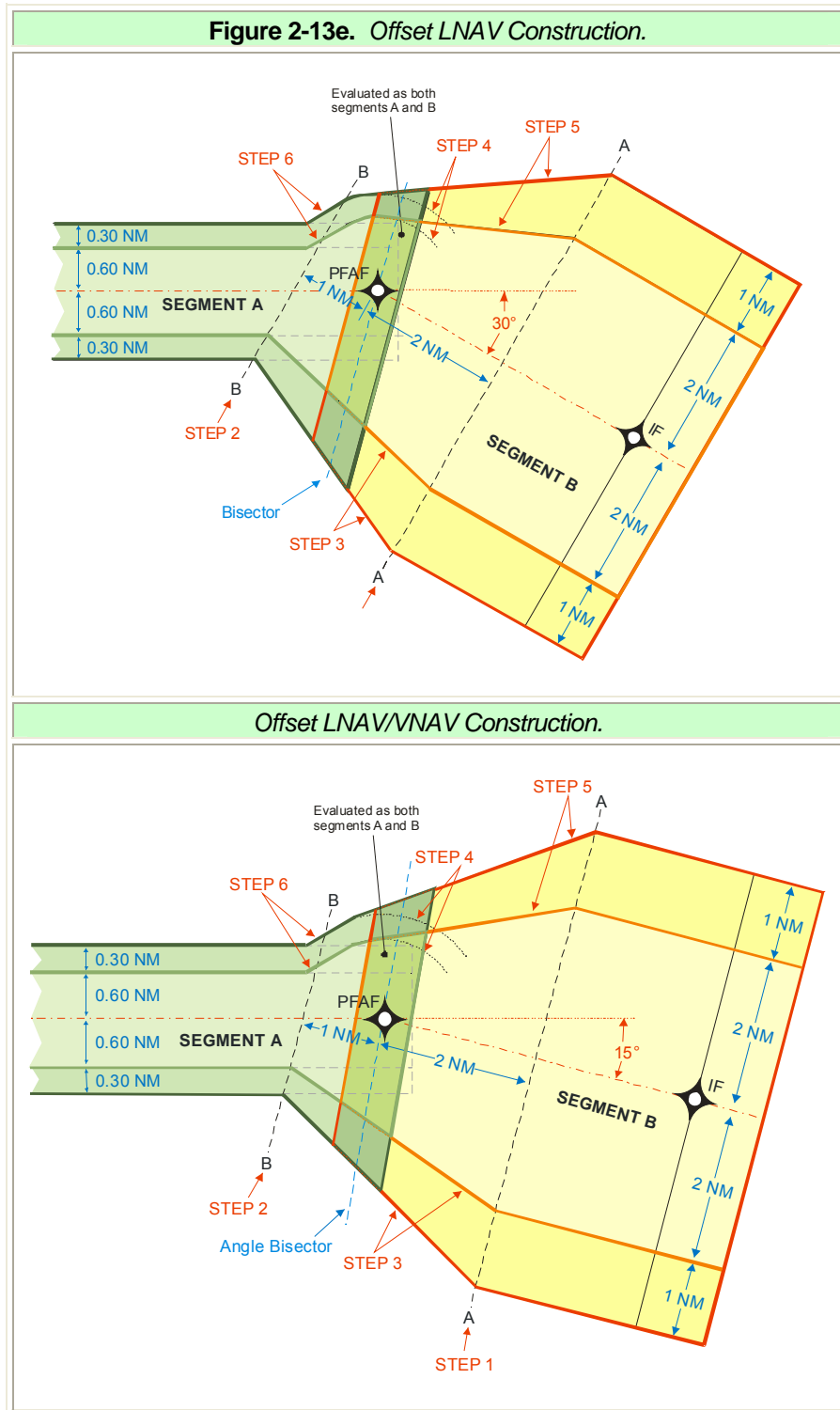
STEP 3: Construct the inside turn boundaries by connecting the points of intersection of line **A** with the turn side intermediate segment boundaries with the intersection of line **B** with the turn side final segment boundaries.

STEP 4: Construct arcs centered on the *PFAF* of 1 *NM* and 1.3 *NM* radius on the non-turn side of the fix.

STEP 5: Connect lines from the point of intersection of line **A** and the outside primary and secondary intermediate segment boundaries to tangent points on the arcs constructed in step 4.

STEP 6: Connect lines tangent to the arcs created in *step 4* that taper inward at 30 degrees relative to the *FAC* to intersect the primary and secondary final segment boundaries as appropriate.

The final segment evaluation extends to a point *ATT* prior to the angle bisector. The intermediate segment evaluation extends *ATT* past the angle bisector. Therefore, the area within *ATT* of the angle bisector is evaluated for both the final and intermediate segments.



2.9.3

b. *LPV, LP Offset Construction.* Where *LP* intermediate course is not an extension of the final course, use the following construction (*see figure 2-13f*).

STEP 1: Construct line **A** perpendicular to the intermediate course 2 *NM* prior the *PFAF*.

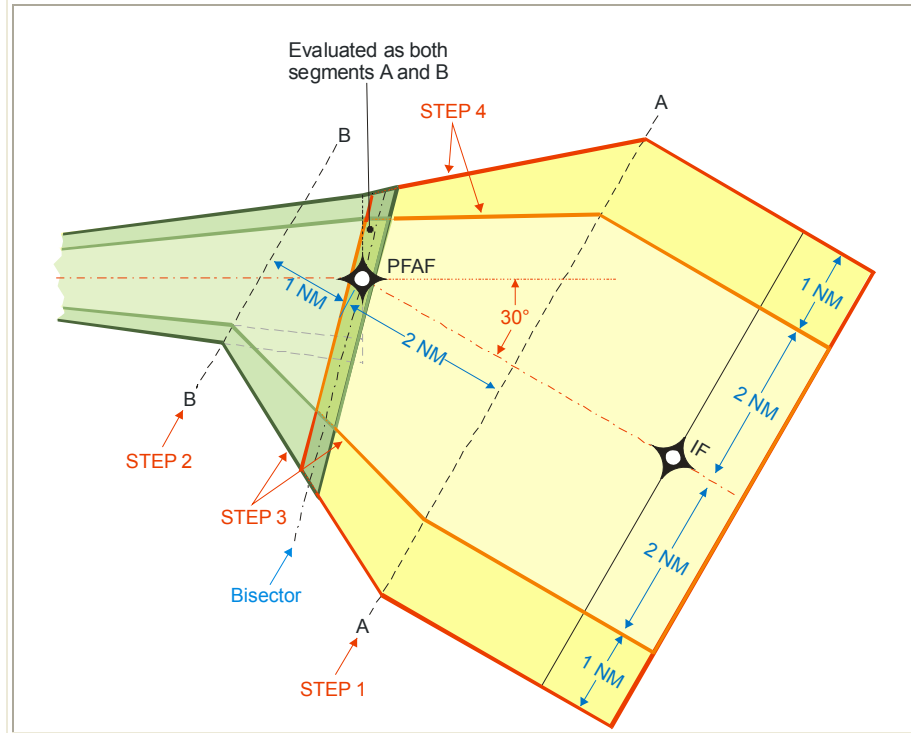
STEP 2: Construct line **B** perpendicular to the intermediate course extended 1 *NM* past the *PFAF*.

STEP 3: Construct the inside turn boundaries by connecting the points of intersection of line **A** with the turn side intermediate segment boundaries with the intersection of line **B** with the turn side final segment boundaries.

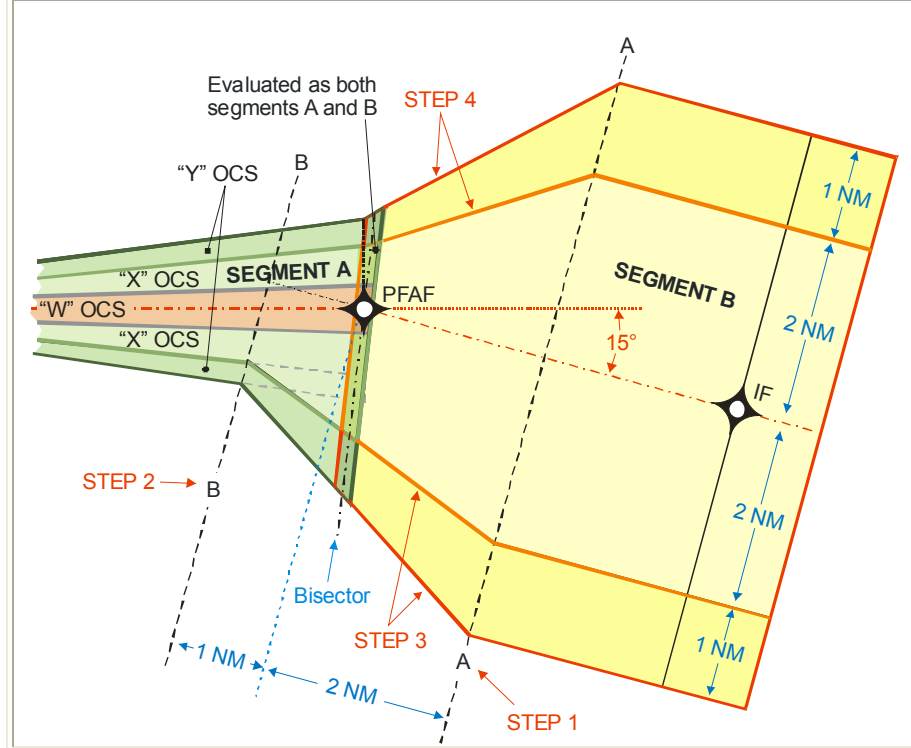
STEP 4: Connect lines from the point of intersection of line **A** and the outside primary and secondary intermediate segment boundaries to the final segment primary and secondary final segment lines at a point perpendicular to the final course at the *PFAF*.

The final segment evaluation extends to a point *ATT* prior to the angle bisector. The intermediate segment evaluation extends *ATT* past the angle bisector. Therefore, the area within *ATT* of the angle bisector is evaluated for both the final and intermediate segments.

Figure 2-13f. Offset LP Construction.



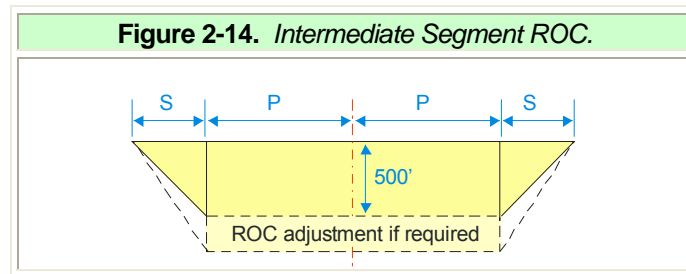
Offset LPV Construction.



2.9.3 c. **RF intermediate segments.** Locate the intermediate leg's **RF** segment's terminating fix at least 2 **NM** outside the **PFAF**.

2.9.4 **Obstacle Clearance.**

Apply 500 ft of **ROC** over the highest obstacle in the primary **OEA**. The **ROC** in the secondary area is 500 ft at the primary boundary tapering uniformly to zero at the outer edge (see figure 2-14).



Calculate the secondary **ROC** values using formula 2-11b.

Formula 2-11b. Secondary ROC.		
$ROC_{secondary} = (500 + adj) \cdot \left(1 - \frac{d_{primary}}{W_s}\right)$		
where $d_{primary}$ = perpendicular distance (ft) from edge of primary area W_s = Width of the secondary area adj = TERPS para 323 adjustments		
$(500+adj) \cdot (1-d_{primary}/W_s)$		
Calculator		
$d_{primary}$	<input type="text"/>	Click Here to Calculate
W_s	<input type="text"/>	
adj	<input type="text"/>	
$ROC_{secondary}$	<input type="text"/>	

2.9.5 Minimum IF to LTP Distance. (Applicable for LPV and LP procedures with no turn at PFAF)

Locate the **IF** at least d_{IF} (NM) from the **LTP** (see formula 2-12).

Formula 2-12. Min IF Distance.		
$d_{IF} = 0.3 \cdot \frac{d}{a} - d \cdot \frac{0.3048}{1852}$		
where d = distance (ft) from FPAP to LTP/FTP a = width (ft) of azimuth signal at LTP (table 2-7, column 5 value)		
$0.3 \cdot d/a - d \cdot 0.3048/1852$		
Calculator		
a		Click Here to Calculate
d		
d _{IF}		

Chapter 2. General Criteria

Section 3. Basic Vertically Guided Final Segment General Criteria

2.10 Authorized Glidepath Angles (GPAs).

The **optimum** (design standard) glidepath angle is 3 degrees. **GPAs** greater than 3 degrees that conform to *table 2-4* are authorized without Flight Standards/ military authority approval only when obstacles prevent use of 3 degrees. Flight Standards approval is required for angles less than 3 degrees or for angles greater than the minimum angle required for obstacle clearance.

Note: USAF only – apply guidance per AFI 11-230.

Category	θ
A**	5.7
B	4.2
C	3.6
D&E	3.1

* *LPV: Where $H_{ATh} < 250$, Cat A-C Max 3.5 degrees, Cat D/E Max 3.1 degrees.*

** *Cat A 6.4 degrees if V_{KIAS} limited to 80 knots maximum. Apply the **TERPS**, Volume 1, chapter 3 minimum H_{ATh} values based on glidepath angle where they are higher than the values in this order.*

2.11 Threshold Crossing Height (TCH).

Select the appropriate **TCH** from *table 2-5*. Publish a note indicating **VGSI** not coincident with the procedures designed descent angle (**VDA** or **GPA**, as appropriate) when the **VGSI** angle differs by more than 0.2 degrees or when the **VGSI TCH** is more than 3 ft from the designed **TCH**.

*Note: If an **ILS** is published to the same runway as the **RNAV** procedure, it's **TCH** and glidepath angle values should be used in the **RNAV** procedure design. The **VGSI TCH/angle** should be used (if within *table 4-5* tolerances) where a vertically guided procedure does not serve the runway.*

Table 2-5. TCH Requirements.			
Representative Aircraft Type	Approximate Glidepath-to-Wheel Height	Recommended TCH \pm 5 Ft	Remarks
<u>HEIGHT GROUP 1</u> General Aviation, Small Commuters, Corporate turbojets: T-37, T-38, C-12, C-20, C-21, T-1, T-3, T-6, UC-35, Fighter Jets	10 ft or less	40 ft	Many runways less than 6,000 ft long with reduced widths and/or restricted weight bearing which would normally prohibit landings by larger aircraft.
<u>HEIGHT GROUP 2</u> F-28, CV-340/440/580, B-737, C-9, DC-9, C-130, T-43, B-2, S-3	15 ft	45 ft	Regional airport with limited air carrier service.
<u>HEIGHT GROUP 3</u> B-727/707/720/757, B-52, C-17, C-32, C-135, C-141, E-3, P-3, E-8	20 ft	50 ft	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 ft.
<u>HEIGHT GROUP 4</u> B-747/767/777, L-1011, DC-10, A-300, B-1, KC-10, E-4, C-5, VC-25	25 ft	55 ft	Most primary runways at major airports.

Notes:

- 1: To determine the minimum allowable **TCH**, add 20 ft to the glidepath-to-wheel height.
- 2: To determine the maximum allowable **TCH**, add 50 ft to the glidepath-to-wheel height.
- 3: Maximum **LPV TCH** is 60 ft.

2.12 Determining FPAP Coordinates (LPV and LP only).

The positional relationship between the **LTP** and the **FPAP** determines the final approach ground track. Geodetically calculate the latitude and longitude of the **FPAP** using the **LTP** as a starting point, the desired final approach course (**optimum** course is the runway bearing) as a forward true azimuth value, and an appropriate distance (see formulas 2-13, 2-14, and 2-15). Apply table 2-7 to determine the appropriate distance from **LTP** to **FPAP**, signal splay, and course width at **LTP**.

Table 2-6. FPAP Location.					
1		2	3	4	5
ILS Serves Runway		ILS Does Not Serve Runway	± Slay	± Width	Offset Length
LTP Dist to LOC	FPAP Dist from LTP	FPAP Dist from LTP			
≤ 10,023' ≤ 9,023'	9023	9023	2.0° **	350 ft (106.75 m)* **	Formula 2-15 **
> 10,023' and ≤ 13,366'	to DER		Formula 2-13* **		
> 13,366 and ≤ 17,185'			to DER or as specified by approving agency	1.5° **	Formula 2-14* **
> 17,185' (AFS or Appropriate Military Agency Approval)					

* Round result to the nearest 0.25 meter.

** Use the *ILS* database values if applying column 1.

Formula 2-13. Signal Splay.		
$\text{splay} = \arctan\left(\frac{350}{\text{RWY}_{\text{length}} + 1000}\right) \cdot \frac{180}{\pi}$		
$\text{atan}(350/(\text{RWY}_{\text{length}}+1000))*180/\pi$		
Calculator		
RWY _{length}	<input type="text"/>	Click Here to Calculate
splay	<input type="text"/>	

Formula 2-14. Width at LTP.

$$\text{width} = \tan\left(1.5 \cdot \frac{\pi}{180}\right) \cdot (\text{RWY}_{\text{length}} + 1000) \cdot 0.3048$$

Round result to the nearest 0.25 meters

$$\tan(1.5 \cdot \pi / 180) \cdot (\text{RWY}_{\text{length}} + 1000) \cdot 0.3048$$

Calculator

RWY _{length}		Click Here to Calculate
width		

Formula 2-15. Offset Length.

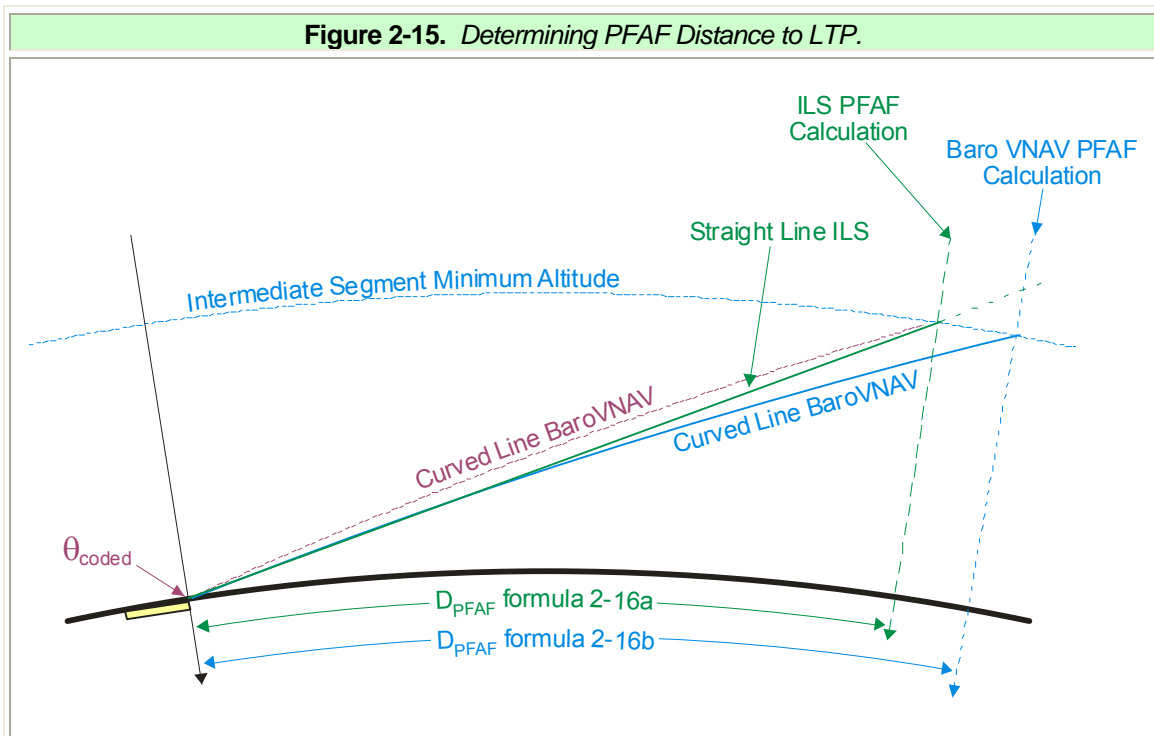
$$\text{offset}_{\text{length}} = \text{FPAP}_{\text{distance}} - \text{RWY}_{\text{length}}$$

$$\text{FPAP}_{\text{distance}} - \text{RWY}_{\text{length}}$$

Calculator

FPAP _{distance}		Click Here to Calculate
RWY _{length}		
offset _{length}		

2.13 Determining Precise Final Approach Fix/Final Approach Fix (PFAF/FAF) Coordinates (see figure 2-15).



Geodetically calculate the latitude and longitude of the **PFAF** using the true bearing from the landing threshold point (**LTP**) to the **PFAF** and the horizontal distance (**D_{PFAF}**) from the **LTP** to the point the glidepath intercepts the intermediate segment altitude. The **ILS/LPV** glidepath is assumed to be a straight line in space. The **LNAV/VNAV (BaroVNAV)** glidepath is a curved line (logarithmic spiral) in space. The calculation of **PFAF** distance from the **LTP** for a straight line is different than the calculation for a curved line. Therefore, two formulas are provided for determining this distance. *Formula 2-16a* calculates the glide slope intercept point (**GPIP**, **ILS nomenclature**; **PFAF**, **LPV nomenclature**) distance from **LTP**; i.e., the point that the straight line glide slope intersects the minimum intermediate segment altitude.) *Formula 2-16b* calculates the **LNAV/VNAV PFAF** distance from **LTP**; i.e., the point that the curved line **BaroVNAV** based glidepath intersects the minimum intermediate segment altitude. If **LNAV/VNAV** minimums are published on the chart, use *formula 2-16b*. If no **LNAV/VNAV** line of minima is published on the approach chart, use *formula 2-16a*, ($D_{GPIP} = D_{PFAF}$).

Note: Where an RNAV LNAV/VNAV procedure is published to an ILS runway, and the ILS PFAF must be used, publish the actual LNAV/VNAV glidepath angle (θ_{BVNAV}) calculated using formula 2-16c.

Formula 2-16a. ILS GPIP/LPV PFAF.		
$D_{GPIP} = r \cdot \left(\frac{\pi}{2} - \theta \cdot \frac{\pi}{180} - a \sin \left(\frac{\cos \left(\theta \cdot \frac{\pi}{180} \right) \cdot (r + LTP_{elev} + TCH)}{r + alt} \right) \right)$		
where alt = minimum intermediate segment altitude LTP _{elev} = LTP MSL elevation TCH = TCH value r = 20890537 θ = glidepath angle		
$r * (\pi/2 - \theta * \pi/180 - a \sin((\cos(\theta * \pi/180) * (r + LTP_{elev} + TCH)) / (r + alt)))$		
Calculator		
LTP _{elev}		Click Here to Calculate
θ		
TCH		
alt		
D _{GPIP}		

Formula 2-16b. LNAV/VNAV PFAF.

$$D_{PFAF} = \frac{\ln\left(\frac{r + \text{alt}}{r + LTP_{\text{elev}} + TCH}\right) \cdot r}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$$

where alt = minimum intermediate segment altitude
 LTP_{elev} = LTP MSL elevation
 TCH = TCH value
 r = 20890537
 θ = glidepath angle

(ln((r+alt)/(r+LTP_{elev}+TCH))*r)/tan(θ*π/180)

Calculator

LTP _{elev}		Click Here to Calculate
TCH		
θ		
alt		
D _{PFAF}		

Formula 2-16c. VNAV/VNAV Angle.

$$\theta_{BVNAV} = a \tan\left(\ln\left(\frac{r + PFAF_{\text{alt}}}{r + LTP_{\text{elev}} + TCH}\right) \cdot \frac{r}{D_{PFAF}}\right) \cdot \frac{180}{\pi}$$

where LTP_{elev} = LTP MSL elevation
 PFAF_{alt} = Minimum MSL altitude at PFAF
 D_{PFAF} = value from formula 2-14A or distance of existing PFAF
 TCH = TCH value
 r = 20890537

atan(ln((r+PFAF_{alt})/(r+LTP_{elev}+TCH))*r/D_{PFAF})*180/π

Calculator

PFAF _{alt}		Click Here to Calculate
LTP _{elev}		
TCH		
D _{PFAF}		
θ _{BVNAV}		

2.14 Determining Glidepath Altitude at a Fix.

Calculate the altitude ($Z_{glidepath}$) of the glidepath at any distance (D_z) from the **LTP** using *formula 2-17a* for **ILS** and **LPV**, and *formula 2-17b* for **LNAV/VNAV**.

Formula 2-17a. ILS/LPV.		
$Z_{glidepath} = \frac{(r + LTP_{elev} + TCH) \cdot \cos\left(\theta \cdot \frac{\pi}{180}\right)}{\cos\left(\frac{D_z}{r} + \theta \cdot \frac{\pi}{180}\right)} - r$		
where LTP_{elev} = LTP MSL elevation TCH = TCH value θ = glidepath angle $r = 20890537$ D_z = distance (ft) from LTP to fix		
$((r+LTP_{elev}+TCH)*\cos(\theta*\pi/180))/\cos(D_z/r+\theta*\pi/180)-r$		
Calculator		
LTP _{elev}	<input type="text"/>	Click Here to Calculate
TCH	<input type="text"/>	
θ	<input type="text"/>	
D _z	<input type="text"/>	
Z _{glidepath}	<input type="text"/>	

Formula 2-17b. LNAV/VNAV.		
$Z_{glidepath} = e^{\frac{D_z \cdot \tan\left(\theta \cdot \frac{\pi}{180}\right)}{r}} \cdot (r + LTP_{elev} + TCH) - r$		
where LTP_{elev} = LTP MSL elevation TCH = TCH value θ = glidepath angle $r = 20890537$ D_z = distance (ft) from LTP to fix		
$e^{((D_z*\tan(\theta*\pi/180))/r)*(r+LTP_{elev}+TCH)-r}$		
Calculator		
LTP _{elev}	<input type="text"/>	Click Here to Calculate
TCH	<input type="text"/>	
θ	<input type="text"/>	
D _z	<input type="text"/>	
Z _{glidepath}	<input type="text"/>	

2.15 Common Fixes.

Design all procedures published on the same chart to use the same sequence of charted fixes.

2.16 Clear Areas and Obstacle Free Zones (OFZ).

Airports Division is responsible for maintaining obstruction requirements in AC 150/5300-13, *Airport Design*. Appropriate military directives apply at military installations. For the purpose of this order, there are two **OFZs** that apply: the runway **OFZ** and the inner approach **OFZ**. The runway **OFZ** parallels the length of the runway and extends 200 ft beyond the runway threshold. The inner **OFZ** overlies the approach light system from a point 200 ft from the threshold to a point 200 ft beyond the last approach light. If approach lights are not installed or not planned, the inner **OFZ** does not apply. When obstacles penetrate either the runway or inner **OFZ**, visibility credit for lights is not authorized, and the lowest ceiling and visibility values are (*USAF/USN NA*):

- For $GPA \leq 4.2^\circ$: 300- $\frac{3}{4}$ (RVR 4000)
- For $GPA > 4.2^\circ$: 400-1 (RVR 5000)

2.17 Glidepath Qualification Surface (GQS).

The **GQS** extends from the runway threshold along the runway centerline extended to the **DA** point. It limits the height of obstructions between **DA** and runway threshold (**RWT**). When obstructions exceed the height of the **GQS**, an approach procedure with positive vertical guidance (**ILS**, **MLS**, **TLS**, **LPV**, Baro-**VNAV**, etc.) is not authorized.*

Note: Where obstructions penetrate the **GQS, vertically guided approach operations may be possible with aircraft groups restricted by wheel height. Contact the **FAA Flight Procedure Standards Branch**, AFS-420, (or appropriate military equivalent) for case-by-case analysis.*

2.17.1 Area.

2.17.1 a. **Origin and Length.** The **GQS** extends from the origin to the **DA**. The **OCS** origin is dependent on the **TCH** value (see figures 2-16a, b, and c).

- If the **TCH** > 50, the **GQS** originates at **z** feet above **LTP** elevation (see formula 2-18a).

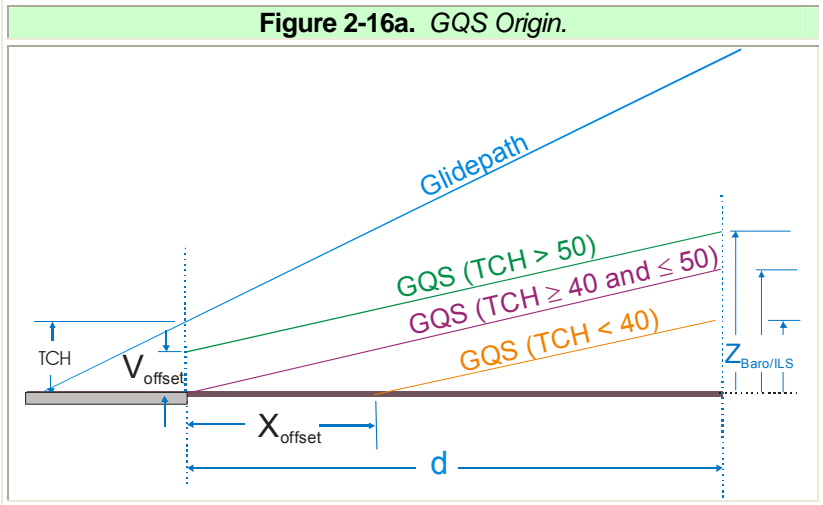
Formula 2-18a. OCS Origin height adjustment.		
$V_{\text{offset}} = \text{TCH} - 50$		
TCH-50		
Calculator		
TCH		Click Here to Calculate
V_{offset}		

- If the **TCH** ≥ 40 and ≤ 50, the **GQS** originates at **RWT** at **LTP** elevation.
- If the **TCH** < 40, the **GQS** originates **x** feet from (toward **PFAF**) **RWT** at **LTP** elevation. See formula 2-18b.

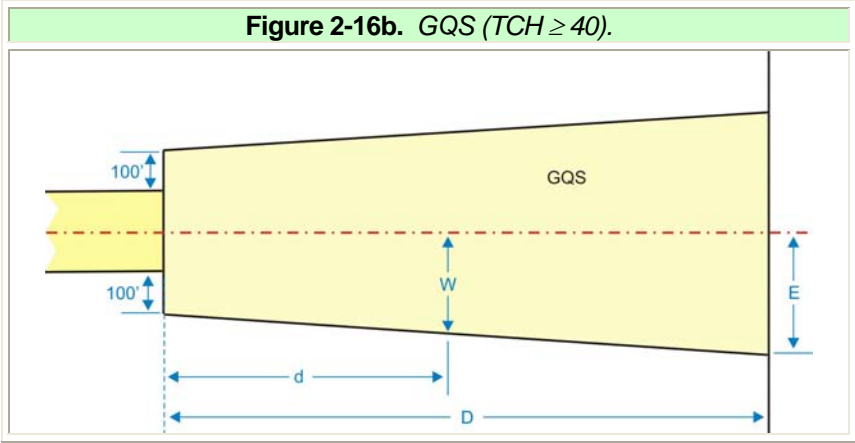
Formula 2-18b. OCS Origin along-track adjustment.		
$X_{\text{offset}} = \frac{40 - \text{TCH}}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$		
Where θ = glide slope angle TCH = threshold crossing height		
$(40 - \text{TCH}) / \tan(\theta * \pi / 180)$		
Calculator		
TCH		Click Here to Calculate
θ		
X_{offset}		

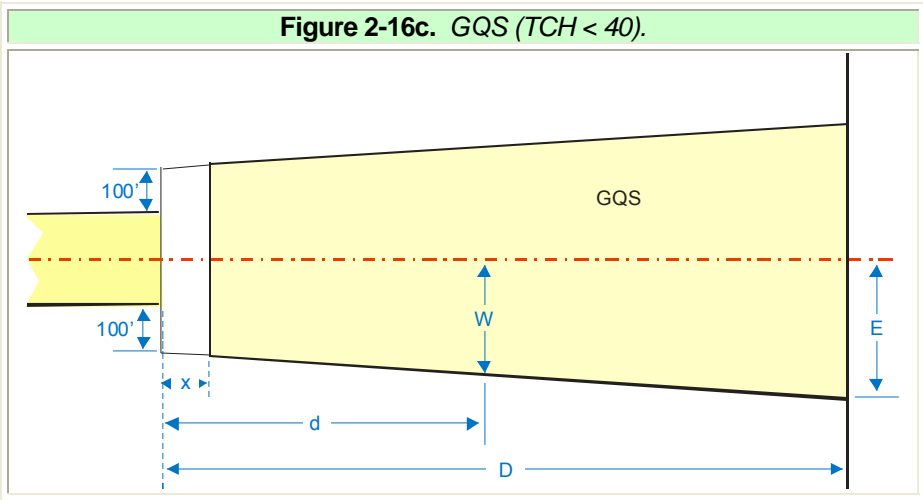
Where $X_{\text{offset}} > 200$ ft, the area between the end of the **POFZ** (see paragraph 2.18) and the **GQS** origin is $\pm \frac{\text{Rwy Width}}{2} + 100'$ wide, centered on the runway centerline extended.

Obstacles higher than the clearway plane (see paragraph 2.17.1e) that are not fixed by function for instrument landing operations are not allowed in this area.



2.17.1 b. **Width.** The GQS originates 100 ft from the runway edge at *RWT*.





Calculate the **GQS** half-width **E** at the **DA** point measured along the runway centerline extended using *formula 2-18c*:

Formula 2-18c. Half Width.	
$E = 0.036 \cdot D + 392.8$	
where D = distance (ft) measured along RCL extended from LTP to DA point	
$0.0036 \cdot D + 392.8$	
Calculator	
D	
E	
Click Here to Calculate	

Calculate the half-width of the **GQS** at any distance **d** from **RWT** using the *formula 2-19*:

Formula 2-19. GQS Half-width.		
$w = \frac{E - k}{D} \cdot d + k$		
where D = distance (ft) measured along RCL extended from LTP to DA point E = Result of formula 2-18c d = desired distance (ft) from LTP w = GQS half-width at distance "d" $k = \frac{\text{RWY}_{\text{width}}}{2} + 100$		
$d \cdot (E - k) / D + k$		
Calculator		
E		Click Here to Calculate
D		
d		
RWY _{width}		
w		

2.17.1

c. If the course is offset from the runway centerline, expand the **GQS** area on the side of the offset as follows referring to *figures 2-17 and 2-18*:

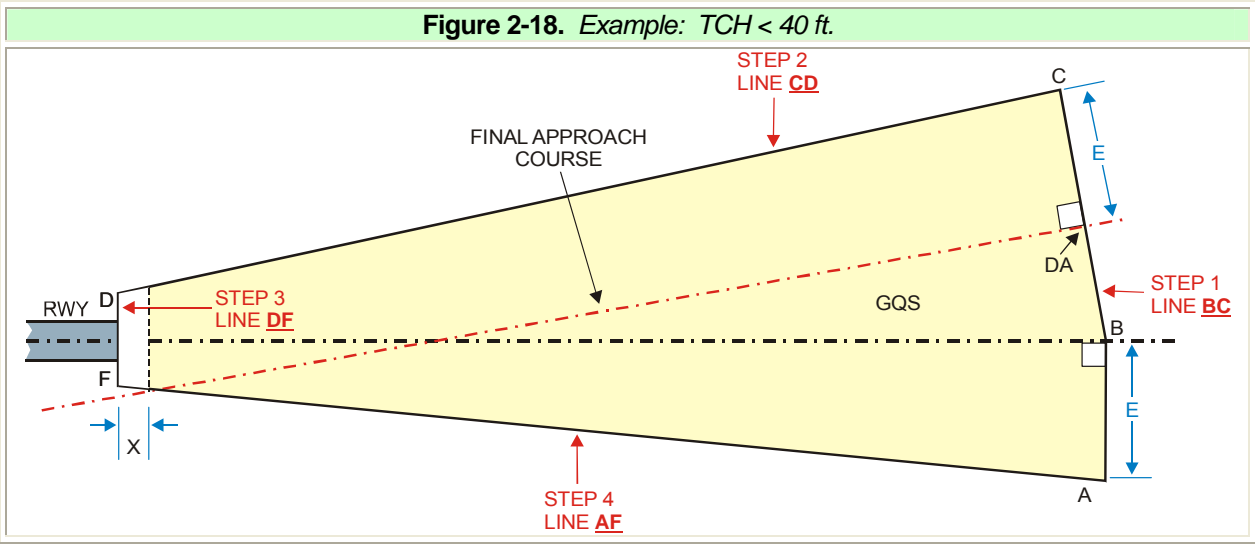
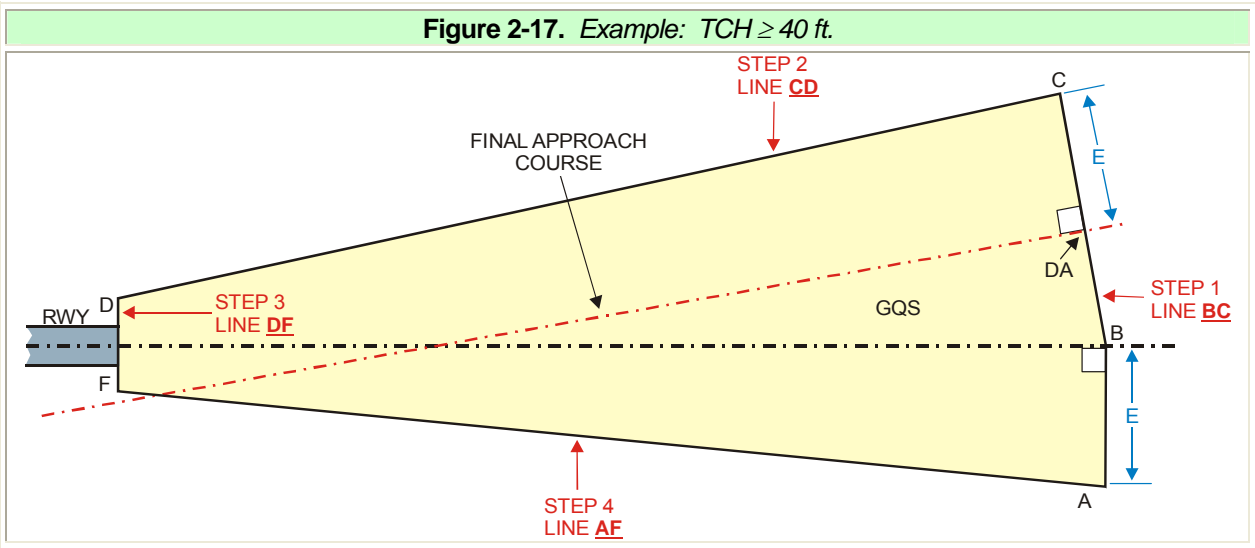
STEP 1: Construct line **BC**. Locate point **B** on the runway centerline extended perpendicular to course at the **DA** point. Calculate the half-width (**E**) of the **GQS** for the distance from point **B** to the **RWT**. Locate point **C** perpendicular to the course distance **E** from the course line. Connect points **B** and **C**.

STEP 2: Construct line **CD**. Locate point **D** 100 ft from the edge of the runway perpendicular to the **LTP**. Draw a line connecting point **C** to point **D**.

STEP 3: Construct line **DF**. Locate point **F** 100 ft from the edge of the runway perpendicular to the **LTP**. Draw a line connecting point **D** to point **F**.

STEP 4: Construct line **AF**. Locate point **A** distance **E** from point **B** perpendicular to the runway centerline extended. Connect point **A** to point **F**.

STEP 5: Construct line **AB**. Connect point **A** to point **B**.



Calculate the half-width of the offset side of the **GQS** trapezoid using *formula 2-20*.

Formula 2-20. Offset Side Half-width.

$$W_{\text{offset}} = d \cdot \left(\frac{\cos\left(\phi \cdot \frac{\pi}{180}\right) \cdot \left(\sin\left(\phi \cdot \frac{\pi}{180}\right) \cdot (D-i) + E\right) - k}{D - \sin\left(\phi \cdot \frac{\pi}{180}\right) \cdot \left(\sin\left(\phi \cdot \frac{\pi}{180}\right) \cdot (D-i) + E\right)} \right) + k$$

where d = distance (ft) from LTP to point in question
 D = distance (ft) along RCL from LTP to point B
 i = distance (ft) from LTP to RWY centerline intersection
 φ = degree of offset
 E = 0.036D+392.8
 $k = \frac{\text{RWY}_{\text{width}}}{2} + 100$

$d \cdot \left(\frac{\cos(\phi \cdot \pi / 180) \cdot (\sin(\phi \cdot \pi / 180) \cdot (D-i) + E) - k}{D - \sin(\phi \cdot \pi / 180) \cdot (\sin(\phi \cdot \pi / 180) \cdot (D-i) + E)} \right) + k$

Calculator	
d	
D	
i	
φ	
E	
RWY _{width}	
W _{offset}	

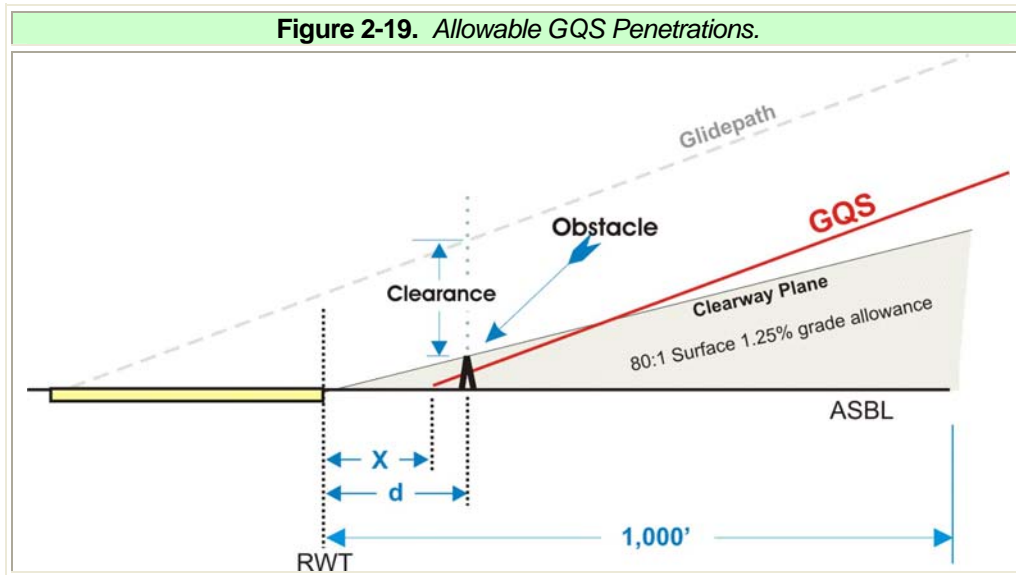
[Click Here to Calculate](#)

2.17.1

d. **OCS**. The **GQS** vertical characteristics reflect the glidepath characteristics of the procedure; i.e., the **ILS/MLS/TLS/LPV** based glidepath is a straight line in space, and the **Baro-VNAV** based glidepath (**LNAV/VNAV, RNP**) is a curved line in space. Obstructions must not penetrate the **GQS**. Calculate the **MSL** height of the **GQS** at any distance “**d**” measured from runway threshold (**RWT**) along runway centerline (**RCL**) extended to a point abeam the obstruction using the applicable version of *formula 2-21*.

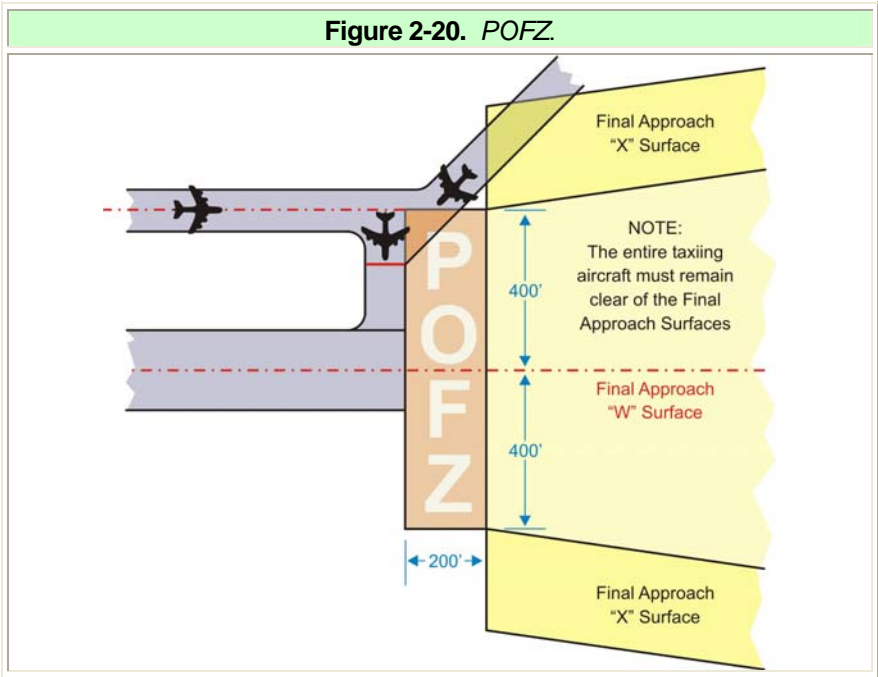
Formula 2-21. GQS Elevation.		
$Z_{GQS} = \frac{(r + LTP_{elev} + V_{offset}) \cos\left(\frac{2\theta}{3} \cdot \frac{\pi}{180}\right)}{\cos\left(\frac{d - X_{offset}}{r} + \frac{2\theta}{3} \cdot \frac{\pi}{180}\right)} - r$		
Where d = obstacle along RCL distance (ft) from RWT LTP _{elev} = LTP MSL elevation θ = Glidepath angle V _{offset} = see formula 2-18a X _{offset} = see formula 2-18b		
$(r + LTP_{elev} + V_{offset}) \cdot \cos\left(\frac{2\theta}{3} \cdot \frac{\pi}{180}\right) / \cos\left(\frac{d - X_{offset}}{r} + \frac{2\theta}{3} \cdot \frac{\pi}{180}\right) - r$		
$Z_{Baro} = e^{\frac{(d - X_{offset}) \cdot \tan\left(\frac{2\theta}{3} \cdot \frac{\pi}{180}\right)}{r}} \cdot (r + LTP_{elev} + V_{offset}) - r$		
Where d = obstacle along RCL distance (ft) from RWT LTP _{elev} = LTP MSL elevation θ = Glidepath angle V _{offset} = see formula 2-18a X _{offset} = see formula 2-18b		
$e^{\left(\frac{d - X_{offset}}{r}\right) \cdot \tan\left(\frac{2\theta}{3} \cdot \frac{\pi}{180}\right)} \cdot (r + LTP_{elev} + V_{offset}) - r$		
Calculator		
LTP _{elev}		Click Here to Calculate
X _{offset}		
V _{offset}		
d		
θ		
Z _{GQS}		
Z _{Baro}		

- 2.17.1** e. **Terrain under the clearway plane** (1st 1,000 ft off the approach end of the runway) is allowed to rise at a slope of 80:1 (grade of 1.25%) or appropriate military equivalent (*see figure 2-19*). Terrain and obstacles under the 80:1 slope (grade of 1.25 percent) are not considered obstructions; i.e., for the first 1,000 ft of the **GQS**, only obstacles that penetrate the clearway plane are evaluated.



- 2.18** **Precision Obstacle Free Zone (POFZ).** (Effective when reported ceiling is less than 300 ft and/or visibility less than $\frac{3}{4}$ statute miles (SM) while an aircraft on a vertically-guided approach is within 2 NM of the threshold.)

The tail and/or fuselage of a taxiing aircraft must not penetrate the **POFZ** when an aircraft flying a vertically guided approach (**ILS, MLS, LPV, TLS, RNP, LNAV/VNAV, PAR**) reaches 2 NM from threshold. The wing of aircraft holding on a perpendicular taxiway waiting for runway clearance may penetrate the **POFZ**; however, the fuselage or tail must not infringe the area. The **minimum** authorized **HATh** and visibility for the approach is 250 ft and $\frac{3}{4}$ SM where the **POFZ** is not clear (*see figure 2-20*).

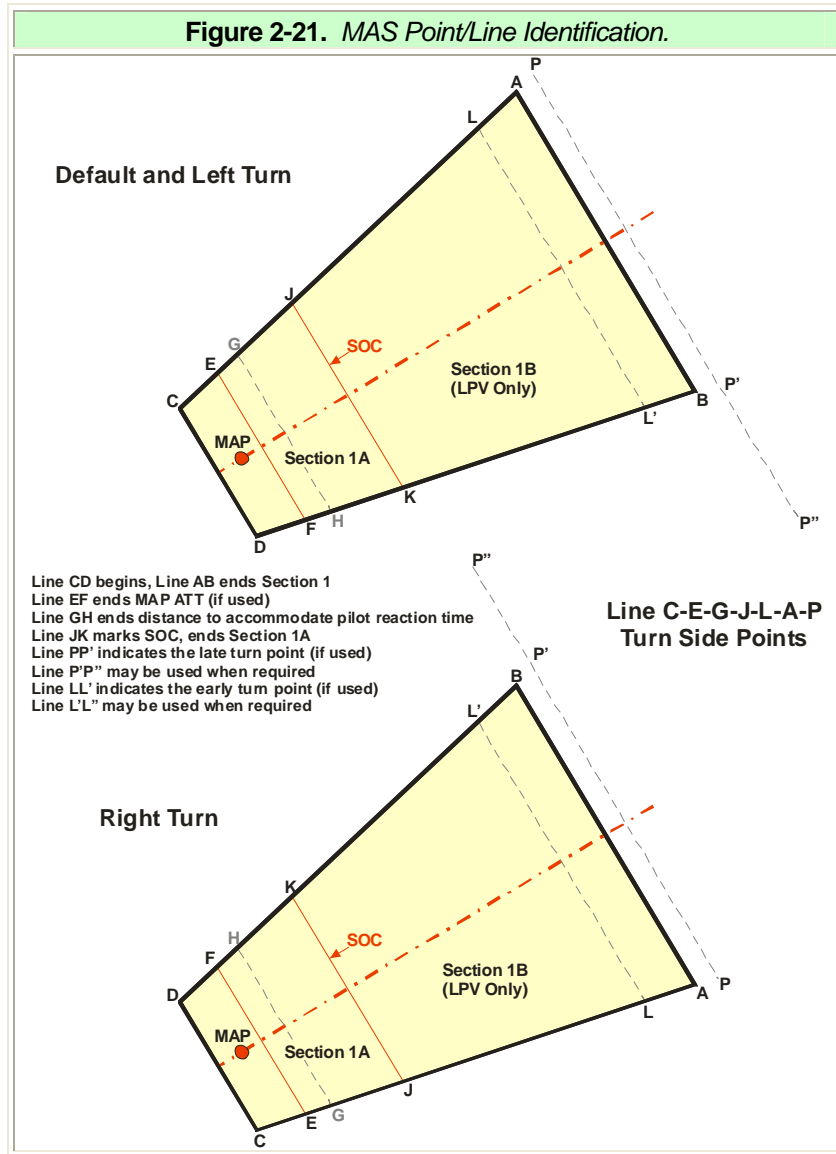


Chapter 2. General Criteria

Section 4. Missed Approach General Information

2.19 Missed Approach Segment (MAS) Conventions.

Figure 2-21 defines the **MAP** point **OEA** construction line terminology and convention for *section 1*.



The missed approach obstacle clearance standard is based on a minimum aircraft climb gradient of 200 ft/*NM*, protected by a **ROC** surface that rises at 152 ft/*NM*. The **MA ROC** value is based on a requirement for a 48 ft/*NM* ($200-152 = 48$) increase in **ROC** value from the start-of-climb (**SOC**) point located at the ***JK*** line (***AB*** line for ***LPV***). The actual slope of the **MA** surface is (1 *NM* in feet)/152 \approx 39.974. In manual application of **TERPS**, the rounded value of 40:1 has traditionally been applied. However, this order is written for automated application; therefore, the full value (to 15 significant digits) is used in calculations. The nominal **OCS** slope (***MA_{OCSslope}***) associated with any given missed approach climb gradient is calculated using *formula 2-22*.

Formula 2-22. Missed Approach OCS Slope.		
$MA_{OCSslope} = \frac{1852}{0.3048 \cdot (CG - 48)}$		
where CG = Climb Gradient (nominally 200 ft/ <i>NM</i>)		
$1852 / (0.3048 * (CG - 48))$		
Calculator		
CG		Click Here to Calculate
MA _{OCSslope}		

2.19.1 Charted Missed Approach Altitude.

Apply **TERPS** Volume 1, paragraphs 277d and 277f to establish the preliminary and charted missed approach altitudes.

2.19.2 Climb-In-Holding.

Apply **TERPS** Volume 1, paragraph 277e for climb-in-holding guidance.

Chapter 3. Non-Vertically Guided Procedures

3.0 General.

This chapter contains obstacle evaluation criteria for Lateral Navigation (*LNAV*), and Localizer Performance (*LP*) non-vertically guided approach procedures. For *RNAV* transition to Localizer (*LOC*) final, use *LP* criteria to evaluate the final and missed approach when *RNAV* is used for missed approach navigation. When constructing a “stand-alone” non-vertically guided procedure, locate the *PFAF* using *formula 2-16b*, nominally based on a 3-degree vertical path angle. The *PFAF* location for circling procedures that do not meet straight-in alignment are based on the position of the MAP instead of the *LTP* (substitute Airport elevation + 50 for *LTP* elevation + *TCH*).

3.1 Alignment.

Optimum non-vertically guided procedure final segment alignment is with the runway centerline extended through the *LTP*. When published in conjunction with a vertically guided procedure, alignment must be identical with the vertically guided final segment.

3.1.1 When the final course must be offset, it may be offset up to 30 degrees (published separately) when the following conditions are met:

3.1.1 a. For offset ≤ 5 degrees, align the course through *LTP*.

3.1.1 b. For offset > 5 degrees and ≤ 10 degrees, the course must cross the runway centerline extended at least 1,500 ft prior to *LTP* (5,200 ft maximum).

3.1.1 c. For offset > 10 degrees and ≤ 20 degrees, the course must cross the runway centerline extended at least 3,000 ft prior to *LTP* (5,200 ft maximum). (Offsets > 15 degrees, Category C/D minimum published visibility 1 *SM*, minimum *HATh* of 300)

3.1.1 d. For offset > 20 to 30 degrees (Cat A/B only), the course must cross the runway centerline extended at least 4,500 ft prior to the *LTP* (5,200 ft maximum).

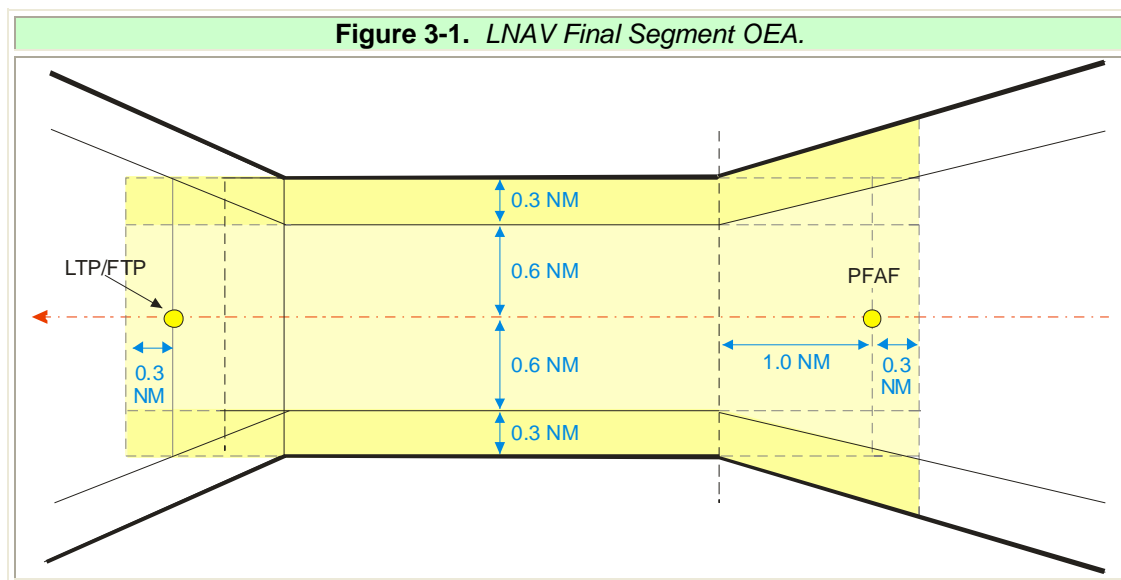
Note: Where a-d above cannot be attained or the final course does not intersect the runway centerline or intersects the centerline more than 5,200 ft from *LTP*, and an operational advantage can be achieved, the final may be aligned to lie laterally within 500 ft of the extended runway centerline at a point 3,000 ft outward from *LTP*. This option requires Flight Standards approval.

3.1.2 Circling.

The OPTIMUM final course alignment is to the center of the landing area, but may be to any portion of the usable landing surface. The latest point the **MAP** can be located is abeam the nearest usable landing surface.

3.2 Area - LNAV Final Segment.

The intermediate segment primary and secondary areas taper from initial segment **OEA** width (1-2-2-1) to the width of the final segment **OEA**. The taper begins at a point 2 **NM** prior to the **PFAF** and ends 1.0 **NM** past the **PFAF**. The final segment **OEA** primary and secondary areas follow the tapering boundaries of the intermediate segment from **ATT** prior to the **PFAF** to the point 1 **NM** past the **PFAF**, and then are a constant width to 0.3 **NM** past the **MAP**. See figure 3-1.



3.2.1 Length.

The **OEA** begins 0.3 **NM** prior to the **PFAF** and ends 0.3 **NM** past the **LTP**. Segment length is the distance from the **PFAF** location to the **LTP/FTP** location. Determine the **PFAF** location per *paragraph 2.13*. The **maximum** length is 10 **NM**.

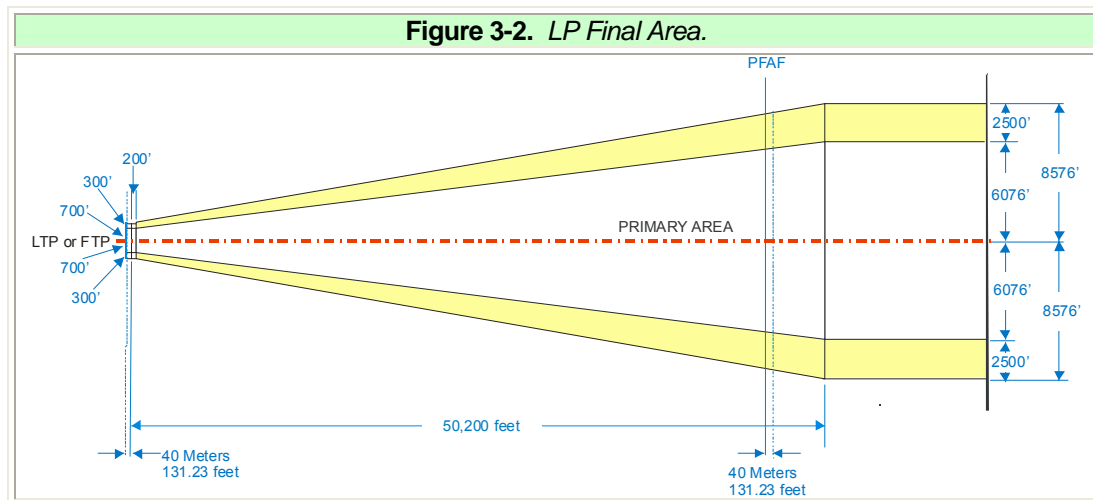
3.2.2 Width.

The final segment **OEA** primary and secondary boundaries are coincident with the intermediate segment boundaries (*see paragraph 2.9*) from a point 0.3 **NM** prior to the **PFAF** to a point 1 **NM** past the **PFAF**. See *formula 3-1*. From this point, the Primary **OEA** boundary is ± 0.6 **NM** ($\approx 3,646$ ft) from course centerline. A 0.3 **NM** ($\approx 1,823$ ft) secondary area is

Formula 3-1. Tapering Segment Width.		
$\frac{1}{2} wp = \frac{1.4d}{3} + 0.6$		
$ws = \frac{0.7d}{3} + 0.3$		
where d = along-track distance from line "B"		
$\frac{1}{2} wp = 1.4*d/3+0.6$		
$ws = 0.7*d/3+0.3$		
Calculator		
d		Click Here to Calculate
1/2wp		
ws		

3.3 Area – LP Final Segment.

The intermediate segment primary and secondary areas taper from initial segment *OEA* width (1-2-2-1) to the width of the final segment *OEA*. The taper begins at a point 2 NM prior to the *PFAF* and ends abeam the *PFAF*. The final segment *OEA* primary and secondary areas are linear (constant width) at distances greater than 50,200 ft from *LTP*. Inside this point, they taper uniformly until reaching a distance of 200 ft from *LTP*. From this point the area is linear to the *OEA* end 131.23 ft (40 m) past the *LTP*. See figure 3-2.



3.3.1 Length.

The *OEA* begins 131.23 ft (40 m) prior to the *PFAF* and ends 131.23 ft (40 m) past the *LTP*. Segment length is the distance from the *PFAF* location to the *LTP/FTP* location. Determine the *PFAF* location per *paragraph 2.13*. The *maximum* length is 10 *NM*.

3.3.2 Width. (See figure 3-2)

The perpendicular distance (W_p) from the course centerline to the outer boundary of the *primary area* is a constant 700 ft from a point 131.23 ft (40 m) past (inside) the *LTP* to a point 200 prior to (outside) the *LTP*. It expands from this point in a direction toward the *PFAF*. Calculate W_p from the 200 ft point to a point 50,200 from *LTP* using *formula 3-2*. The value of W_p beyond the 50,200-ft point is 6,076 ft.

Formula 3-2. Primary Area Width.		
$W_p = 0.10752 \cdot D + 678.5$		
where D = Along-track distance (> 200 ≤ 50,200) from LTP/FTP		
0.10752*D+678.5		
Calculator		
D		Click Here to Calculate
W_p		

The perpendicular distance (W_s) from the course centerline to the outer boundary of the *secondary area* is a constant 1,000 ft from a point 40 meters past (inside) the *LTP* to a point 200 prior to (outside) the *LTP*. It expands from this point in a direction toward the *PFAF*. Calculate W_s from the 200 ft point to a point 50,200 from *LTP* using *formula 3-3*. The value of W_s beyond the 50,200-ft point is 8,576 ft.

Formula 3-3. Secondary Area Width.		
$W_s = 0.15152 \cdot D + 969.7$		
where D = Along-track distance (> 200 ≤ 50,200) from LTP/FTP		
0.15152*D+969.7		
Calculator		
D		Click Here to Calculate
W_s		

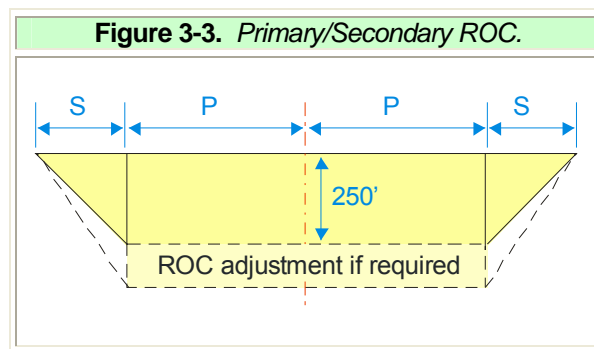
3.4 Obstacle Clearance.

3.4.1 Primary Area.

Apply 250 ft of **ROC** to the highest obstacle in the primary area. **TERPS** Volume 1, chapter 3 precipitous terrain, remote altimeter, and excessive length of final adjustments apply.

3.4.2 Secondary Area.

Secondary **ROC** tapers uniformly from 250 ft (plus adjustments) at the primary area boundary to zero at the outer edge. See figure 3-3.



Calculate the secondary **ROC** value using formula 3-4.

Formula 3-4. Secondary Area ROC.

$$ROC_{secondary} = (250 + adj) \cdot \left(1 - \frac{d_{primary}}{W_s}\right)$$

where $d_{primary}$ = perpendicular (relative to course centerline) distance (ft) from edge of primary area
 W_s = Width of the secondary area (s)
 adj = TERPS para 323 adjustments

$(250+adj) \cdot (1-d_{primary}/W_s)$

Calculator

$d_{primary}$	<input type="text"/>	Click Here to Calculate
W_s	<input type="text"/>	
adj	<input type="text"/>	
$ROC_{secondary}$	<input type="text"/>	

3.5 Final Segment Stepdown Fixes (SDF).

Where the **MDA** can be lowered at least 60 ft or a reduction in visibility can be achieved, **SDFs** may be established in the final approach segment.

3.5.1 **TERPS**, Volume 1, paragraph 289 applies, with the following:

3.5.1 a. **Establish step-down fix locations** in 0.10 *NM* increments from the *LTP/FTP*.

3.5.1 b. **The minimum distance** between stepdown fixes is 1 *NM*.

3.5.1 c. **For step-down fixes** published in conjunction with vertically-guided minimums, the published altitude at the fix must be equal to or less than the computed glidepath altitude at the fix.

Note: Glidepath altitude is calculated using the formula associated with the basis of the PFAF calculation.

3.5.1 d. **The altitude at any stepdown fix** may be established in 20 ft increments and shall be rounded to the next HIGHER 20-ft increment. For example, 2104 becomes 2120.

3.5.1 e. **Where a RASS adjustment is in use**, the published stepdown fix altitude must be established no lower than the altitude required for the greatest amount of adjustment (i.e., the published minimum altitude must incorporate the greatest amount of **RASS** adjustment required).

3.5.1 f. **TERPS, Volume 1**, paragraph 252 applies to *LNAV* and *LP* descent gradient.

Note: Where turns are designed at the PFAF, the 7:1 OIS starts ATT prior to the angle bisector, and extends 1 NM parallel to the final approach centerline. See figure 2-13e (LNAV) and figure 2-13f (LP).

3.5.1 g. **Obstacles eliminated from consideration** under this paragraph must be noted in the procedure documentation.

3.5.1 h. **Use the following formulas** to determine *OIS* elevation (*OIS_Z*) at an obstacle and minimum fix altitude (*MFA*) based on an obstacle height.

Formula 3-5. OIS elevation & Minimum Fix Altitude.

$$OIS_z = a - c - \frac{O_x}{7}$$

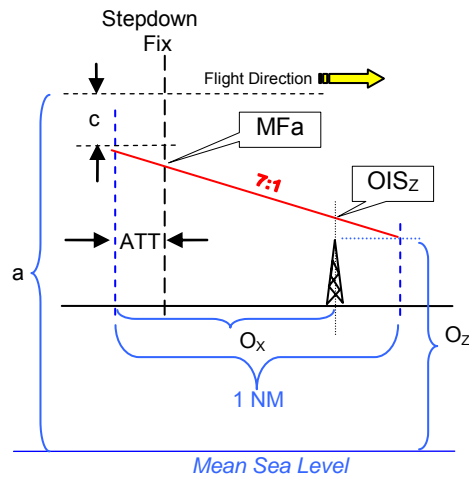
$$MFa = O_z + c + \frac{O_x}{7}$$

where c = ROC plus adjustments (TERPS Vol 1, para 3.2.2)

a = MSL fix altitude

O_x = Obstacle along-track distance (ft) from ATT prior to fix (1 NM max)

O_z = MSL obstacle elevation



$$OIS_z = a - c - O_x/7$$

$$MFa = O_z + c + O_x/7$$

Calculator

a	<input type="text"/>	Click Here to Calculate
c	<input type="text"/>	
O _x (1 NM Max)	<input type="text"/>	
O _z	<input type="text"/>	
OIS _z	<input type="text"/>	
MFa	<input type="text"/>	

3.6 Minimum Descent Altitude (*MDA*).

The *MDA* value is the sum of the controlling obstacle elevation *MSL* (including vertical error value when necessary) and the *ROC* + adjustments. Round the sum to the next higher 20-ft increment; e.g., 623 rounds to 640. The minimum *HATh* value is 250 ft.

3.7 Missed Approach Section 1. (*MAS-1*).

Section 1 begins *ATT* prior to the *MAP* and extends to the start-of-climb (*SOC*) or the point where the aircraft is projected to cross 400 ft above airport elevation, whichever is the greatest distance from *MAP*. See figure 3-4.

3.7.1 Length.

3.7.1 a. Flat Surface Length (*FSL*).

3.7.1 a. (1) *LNAV*. Section 1 flat surface begins at the cd line (0.3 *NM* prior to the *MAP*) and extends (distance *FSL* feet) to the jk line.

3.7.1 a. (2) *LP*. Section 1 flat surface begins at the cd line (40 meters prior to the *MAP*) and extends (distance *FSL* feet) to the jk line.

Calculate the value of *FSL* using formula 3-6.

3.7.1 b. Location of end of section 1 (ab line).

3.7.1 b. (1) $MDA \geq 400$ ft above airport elevation. The ab line is coincident with the jk line.

3.7.1 b. (2) $MDA < 400$. The ab line is located $\frac{1852}{(0.3048 \cdot CG)}$ feet beyond the jk line for each foot of altitude needed to reach 400 ft above airport elevation. The surface between the jk and ab lines is a rising surface with a slope commensurate with the rate of climb (nominally 40:1).

Formula 3-6. Flat Surface Length.		
$FSL = 20.2537 \cdot \left(\left(V_{KIAS} \cdot \frac{171233 \cdot \sqrt{(288 + 15) - 0.00198 \cdot MDA}}{(288 - 0.00198 \cdot MDA)^{2.628}} \right) + 10 \right) + 2 \cdot ATT$		
$20.2537 * (V_{KIAS} * (171233 * ((288 + 15) - 0.00198 * MDA)^{0.5}) / (288 - 0.00198 * MDA)^{2.628} + 10) + 2 * ATT$		
Calculator		
V _{KIAS}		Click Here to Calculate
ATT		
MDA		
FSL		

3.7.2 Width. LNAV and LP.

3.7.2 a. LNAV. The primary area boundary splays uniformly outward from the edge of the primary area at the cd line until it reaches a point 2 **NM** from course centerline. The secondary area outer boundary lines splay outward 15 degrees relative to the missed approach course from the outer edge of the secondary areas at the cd line (0.3 **NM** prior to **MAP**) until it reaches a point 3 **NM** from course centerline. Calculate the distance from course centerline to the primary and outer secondary boundary of the **MAS-1 OEA** at any distance from the *cd* line using *formula 3-7a*.

Formula 3-7a. LNAV Primary & Secondary Width.		
$MAS_{Y_{primary}} = d \cdot \frac{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot 1.4 \cdot NM}{2.1 \cdot NM} + 0.6 \cdot NM$		
$MAS_{Y_{secondary}} = d \cdot \tan\left(15 \cdot \frac{\pi}{180}\right) + 0.9 \cdot NM$		
where d = along-track distance (ft) from the cd line ≤ 47620.380 NM = 1852/0.3048		
$MAS_{Y_{primary}} = d * ((\tan(15 * \pi / 180) * 1.4 * 1852 / 0.3048)) / (2.1 * 1852 / 0.3048) + 0.6 * 1852 / 0.3048$ $MAS_{Y_{secondary}} = d * \tan(15 * \pi / 180) + 0.9 * 1852 / 0.3048$		
Calculator		
d		Click Here to Calculate
LNAV MAS _{Y_{primary}}		
LNAV MAS _{Y_{secondary}}		

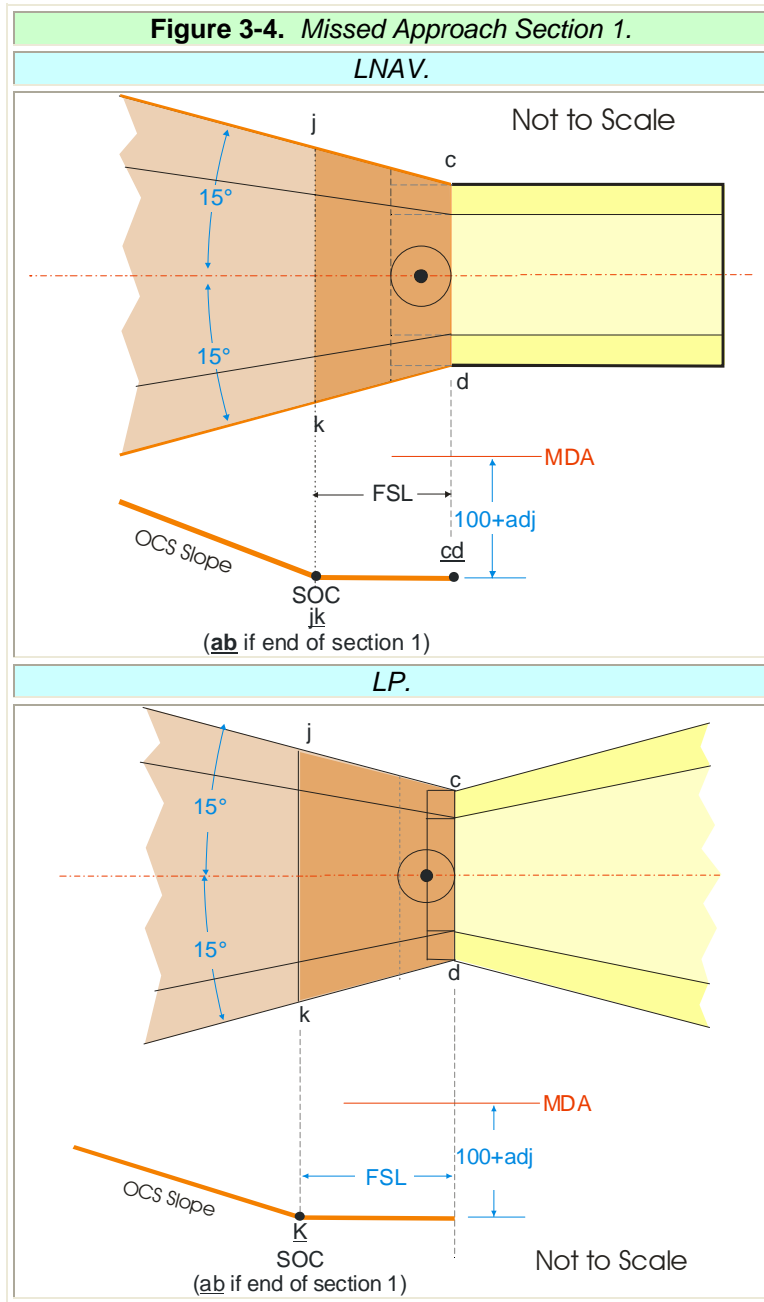
3.7.2 b. LP. The primary area boundary splays uniformly outward from the edge of the primary area at the cd line until it reaches a point 2 *NM* from course centerline. The secondary area outer boundary lines splay outward 15 degrees relative to the missed approach course from the outer edge of the secondary areas at the cd line (0.3 *NM* prior to *MAP*) until it reaches a point 3 *NM* from course centerline. Calculate the distance from course centerline to the primary and outer secondary boundary of the *MAS-1 OEA* at any distance from the cd line using *formula 3-7b*.

Formula 3-7b. LP Primary & Secondary Width.		
$MAS_{Y_{primary}} = d \cdot \frac{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot (2 \cdot NM - W_p)}{3 \cdot NM - W_s} + W_p$ $MAS_{Y_{secondary}} = d \cdot \tan\left(15 \cdot \frac{\pi}{180}\right) + W_s$ <p>where d = along-track distance (ft) from the cd line ≤ 64297.064 NM = 1852/0.3048</p>		
$MAS_{Y_{primary}} = d \cdot ((\tan(15 \cdot \pi / 180) \cdot (2 \cdot 1852 / 0.3048 - W_p)) / (3 \cdot 1852 / 0.3048 - W_s)) + W_p$ $MAS_{Y_{secondary}} = d \cdot \tan(15 \cdot \pi / 180) + W_s$		
Calculator		
d		Click Here to Calculate
W _p		
W _s		
LP MAS _{Y_{primary}}		
LP MAS _{Y_{secondary}}		

3.7.3 Obstacle Clearance. LNAV and LP.

The *MAS-1 OCS* is a flat surface. The *MSL* height of the surface (*HMAS*) is equal to the *MDA* minus 100 ft plus precipitous terrain, remote altimeter (only if full time), and excessive length of final adjustments. See *formula 3-8*.

Formula 3-8. HMAS.		
$HMAS = MDA - (100 + adj)$ <p>where adj = precipitous terrain, remote altimeter (only if full time), and excessive length of final adjustments</p>		
MDA-(100+adj)		
Calculator		
MDA		Click Here to Calculate
adj		
HMAS		



Chapter 4. Lateral Navigation with Vertical Guidance (*LNAV/VNAV*)

4.0 General.

An *LNAV/VNAV* approach is a vertically-guided approach procedure using *Baro-VNAV* or *WAAS VNAV* for the vertical guidance. Obstacle evaluation is based on the *LNAV OEA* dimensions and *Baro-VNAV OCS*. The actual vertical path provided by *Baro-VNAV* is influenced by temperature variations; i.e., during periods of cold temperature, the effective glidepath may be lower than published and during periods of hot weather, the effective glidepath may be higher than published. Because of this phenomenon, minimum and maximum temperature limits (for aircraft that are not equipped with temperature compensating systems) are published on the approach chart. Additionally, *LNAV/VNAV* approach procedures at airports where remote altimeter is in use or where the final segment overlies precipitous terrain must be annotated to indicate the approach is not authorized for *Baro-VNAV* systems. *TERPS ROC* adjustments for excessive length of final do not apply to *LNAV/VNAV* procedures. *LNAV/VNAV* minimum *HAT_h* value is 250 ft.

4.1 Final Approach Course Alignment.

Optimum final segment alignment is with the runway centerline ($\pm 0.03^\circ$) extended through the *LTP*.

- 4.1.1 Where lowest minimums can only be achieved by offsetting the final course, it may be offset up to 15 degrees when the following conditions are met:
- 4.1.1 a. For offset ≤ 5 degrees, align the course through *LTP*.
- 4.1.1 b. For offset > 5 degrees and ≤ 10 degrees, the course must cross the runway centerline extended at least 1,500 ft (5,200 ft maximum) prior to *LTP*. ($d_1=1,500$) Determine the minimum *HAT_h* value using *formula 4-1*.
- 4.1.1 c. For offset > 10 degrees and ≤ 15 degrees, the course must cross the runway centerline extended at least 3,000 ft (5,200 ft maximum) prior to *LTP* ($d_1=3,000$). Determine the minimum *HAT_h* value (*MIN_{HAT_h}*) using *formula 4-1*.

Formula 4-1. Offset Alignment Minimum DA.

$$d2 = \frac{V_{KIAS}^2 \cdot \tan\left(\frac{\alpha}{2} \cdot \frac{\pi}{180}\right)}{68625.4 \cdot \tan\left(18 \cdot \frac{\pi}{180}\right)} \cdot \frac{1852}{0.3048}$$

$$Min_{HATH} = e^{\frac{(d1+d2) \cdot \tan\left(\theta \cdot \frac{\pi}{180}\right)}{r}} \cdot (r + LTP_{elev} + TCH) - (r + LTP_{elev})$$

Where α = degree of offset
 θ = glidepath angle
 r = 20890537 feet
 LTP_{elev} = LTP MSL elevation
 $d1$ = value from paragraph 4.1b/c as appropriate

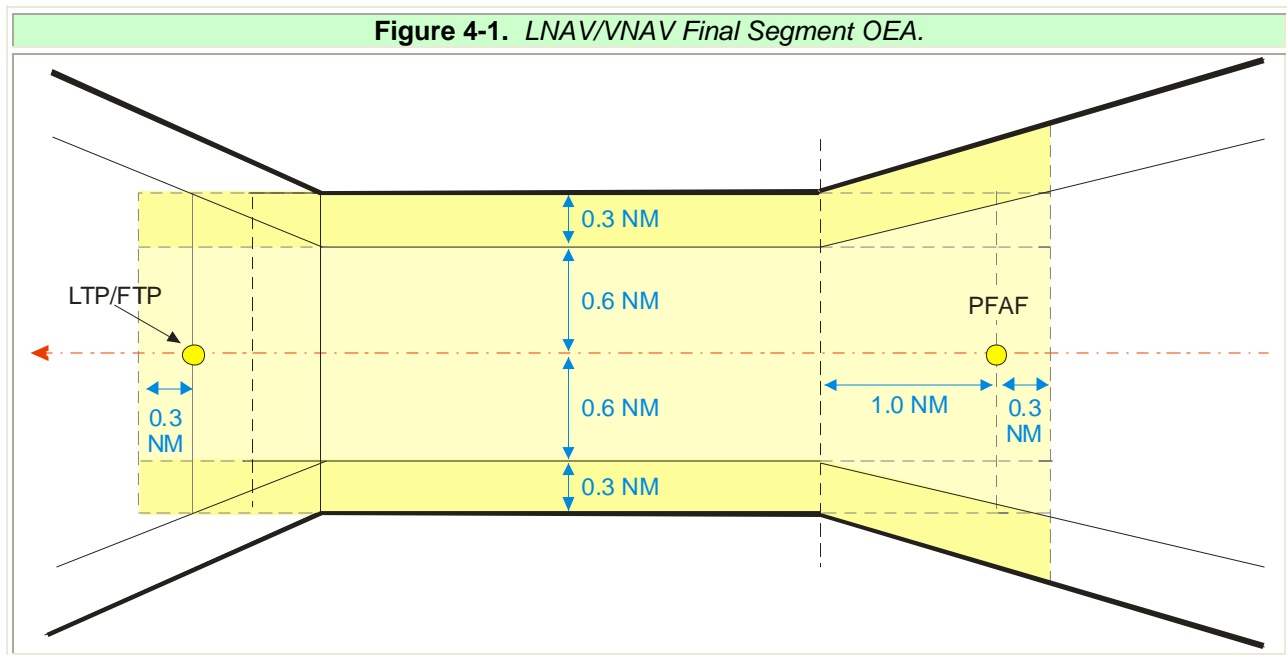
$d2 = (V_{KIAS}^2 \cdot \tan(\alpha/2 \cdot \pi/180)) / (68625.4 \cdot \tan(18 \cdot \pi/180)) \cdot 1852 / 0.3048$
 $Min_{HATH} = e^{(((d1+d2) \cdot \tan(\theta \cdot \pi/180)) / r) \cdot (r + LTP_{elev} + TCH) - (r + LTP_{elev})}$

Calculator	
d1	
α	
V_{KIAS}	
θ	
LTP_{elev}	
TCH	
d2	
Min_{HATH}	

Click Here
to
Calculate

4.2 Area.

The intermediate segment primary and secondary areas taper from initial segment **OEA** width (1-2-2-1) to the width of the final segment **OEA** width (0.3-0.6-0.6-0.3). The taper begins at a point 2 **NM** prior to the **PFAF** and ends 1.0 **NM** following (past) the **PFAF**. The final segment **OEA** primary and secondary areas follow the tapering boundaries of the intermediate segment from **ATT** prior to the **PFAF** to the point 1 **NM** past the **PFAF**, and then are a constant width to 0.3 **NM** past the **MAP**. See figure 4-1.



4.2.1 Length.

The *OEA* begins 0.3 *NM* prior to the *PFAF* and ends 0.3 *NM* past the *LTP*. Segment length is determined by *PFAF* location. Determine the *PFAF* location per *paragraph 2.12*. The **maximum** length is 10 *NM*.

4.2.2 Width.

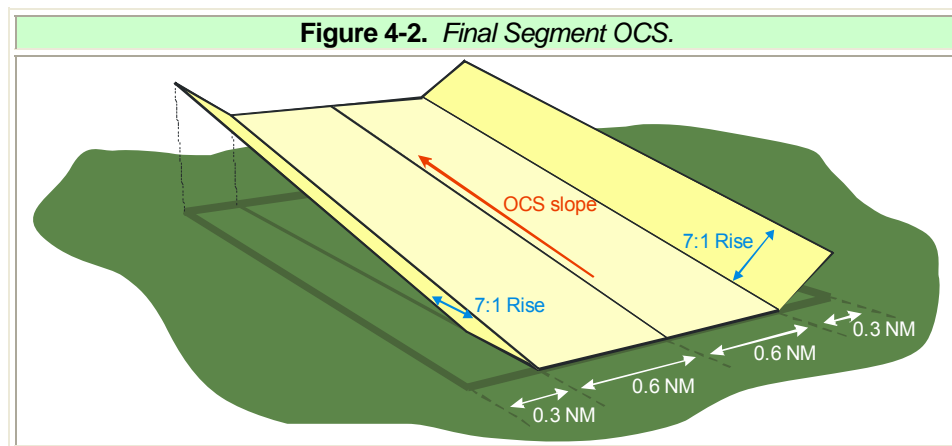
The final segment primary and secondary boundaries are coincident with the intermediate segment boundaries (*see paragraph 2.9*) from a point 0.3 *NM* prior to the *PFAF* to a point 1 *NM* past the *PFAF*. From this point, the Primary *OEA* boundary is ± 0.6 *NM* ($\approx 3,646$ ft) from course centerline. A 0.3 *NM* ($\approx 1,823$ ft) secondary area is located on each side of the primary area. Where the intermediate segment is not aligned with the final segment, the segment boundaries are constructed under chapter 2, *paragraph 2.9.3a*.

4.3 Obstacle Clearance Surface (OCS).

Obstacle clearance is provided by application of the *Baro-VNAV OCS*. The *OCS* originates at *LTP* elevation at distance D_{origin} from *LTP* as calculated by *formula 4-2*.

Formula 4-2. OCS Origin.		
$D_{\text{origin}} = \frac{250 - \text{TCH}}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$		
where θ = glidepath angle		
$(250 - \text{TCH}) / \tan(\theta * \pi / 180)$		
Calculator		
TCH		Click Here to Calculate
θ		
D_{origin}		

The **OCS** is a sloping plane in the primary area, rising along the course centerline from its origin toward the **PFAF**. The **OCS** slope ratio calculated under *paragraph 4.3.3*. In the primary area, the elevation of the **OCS** at any point is the elevation of the **OCS** at the course centerline abeam it. The **OCS** in the secondary areas is a 7:1 surface sloping upward from the edge of the primary area **OCS** perpendicular to the flight track. See *figure 4-2*.



The primary area **OCS** slope varies with the designed glidepath angle. The effective glidepath angle (actual angle flown) depends on the deviation from International Standard Atmosphere (**ISA**) temperature associated with airport elevation. Calculate the **ISA** temperature for the airport using *formula 4-3*.

Formula 4-3. Airport ISA.		
$ISA_{\text{airportC}} = 15 - 0.00198 \cdot \text{airport elevation}$ $ISA_{\text{airportF}} = 1.8 \cdot ISA_{\text{airportC}} + 32$		
$ISA_{\text{airportC}} = 15 - 0.00198 \cdot \text{Airport Elevation}$ $ISA_{\text{airportF}} = (1.8 \cdot ISA_{\text{airportC}}) + 32$		
Calculator		
Airport elevation		Click Here to Calculate
ISA _{airportC}		
ISA _{airportF}		

4.3.1 Low Temperature Limitation.

The *OCS* slope ratio (run/rise) provides obstacle protection within a temperature range that can reasonably be expected to exist at the airport. The slope ratio is based on the temperature spread between the airport ISA and the temperature to which the procedure is protected. This value is termed ΔISA_{LOW} . To calculate ΔISA_{LOW} , determine the average coldest temperature (*ACT*) for which the procedure will be protected. There are two recommended methods for determining *ACT* listed below in order of precedence.

- Average the lowest temperature for the coldest month of the year for the last 5 years, or...
- Assume a generalized standard ΔISA value based on geographic area; subtract this value from the airport ISA value to determine the generalized *ACT*. *Table 4-1* lists the standard values.

Table 4-1. Standard ΔISA Values.	
Location	Value below airport ISA°C / °F
Conus	-30°C / -86°F
Alaska	-40°C / -104°F
Hawaii	-20°C / -68°F

To convert the **ACT** from a Fahrenheit value to a Celsius value, use *formula 4-4*.

Formula 4-4. Convert ACT from °F to °C.		
$ACT^{\circ}C = \frac{ACT^{\circ}F - 32}{1.8}$		
(ACT°F-32)/1.8		
Calculator		
ACT °F		Click Here to Calculate
ACT °C		

Annotate the approach chart indicating the procedure is not available for **Baro-VNAV** based systems when the reported temperature is below the **ACT**.

4.3.2 High Temperature Limitation.

The maximum allowable descent rate (**MDR**) is 1,000 ft per minute from the minimum **HAT_h** to touchdown. The published glidepath angle should not result in a descent rate greater than the **MDR**. Higher than **ISA** temperatures may induce effective glidepath angles that are steep enough to result in a descent rate that exceeds the **MDR**. Publish a high temperature limitation for **Baro-VNAV** approaches that prevents descent rates exceeding the **MDR** at the maximum speed for the fastest published aircraft category assuming a 10 knot tailwind. Determine the published high temperature limitation as follows:

STEP 1: Calculate the glidepath angle that results in the **MDR** (**MDR_{angle}**) using *formula 4-5*.

Formula 4-5. Maximum Descent Rate Angle.

$$V_{KTAS} = V_{KIAS} \cdot \frac{171233 \cdot \sqrt{288 - 0.00198 \cdot (LTP_{elev} + 250)}}{(288 - 0.00198 \cdot (LTP_{elev} + 250))^{2.628}}$$

$$MDR_{angle} = \frac{180}{\pi} \cdot \text{asin} \left(\frac{60 \cdot 1000}{(V_{KTAS} + 10) \cdot \frac{1852}{0.3048}} \right)$$

where V_{KIAS} = indicated airspeed
 LTP_{elev} = LTP MSL elevation

$$MDR_{angle} = 180/\pi * \text{asin}(60000/((V_{KTAS}+10)*1852/0.3048))$$

$$V_{KTAS} = V_{KIAS} * (171233 * (288 - 0.00198 * (LTP_{elev} + 250))^{0.5}) / (288 - 0.00198 * (LTP_{elev} + 250))^{2.628}$$

Calculator

LTP_{elev}		Click Here to Calculate
V_{KIAS}		
V_{KTAS}		
MDR_{angle}		

STEP 2: Calculate the **Baro-VNAV** altitude (c) over the **PFAF** at **MDR** using *formula 4-6*.

Formula 4-6. High Temp PFAF Alt.

$$c = e^{ \frac{D_{PFAF} \cdot \tan \left(\frac{MDR_{angle} \cdot \pi}{180} \right)}{r + LTP_{elev}} } \cdot (r + LTP_{elev} + TCH) - r$$

where D_{PFAF} = value from paragraph 2.13
 LTP_{elev} = LTP MSL elevation
TCH = threshold crossing height
 MDR_{angle} = result of *formula 4-5*
 $r = 20890537$

$$e^{((D_{PFAF} * \tan(MDR_{angle} * \pi / 180)) / (r + LTP_{elev})) * (r + LTP_{elev} + TCH) - r}$$

Calculator

LTP_{elev}		Click Here to Calculate
TCH		
D_{PFAF}		
c		

STEP 3: Calculate ΔISA_{high} temperature based on High Temp *PFAF* Altitude using *formula 4-7*.

Formula 4-7. ΔISA_{high} Calculation.		
$\Delta ISA_{high} = \frac{c - PFAF_{alt} + 0.032 \cdot (PFAF_{alt} - LTP_{elev}) + 4.9}{0.19 + 0.0038 \cdot (PFAF_{alt} - LTP_{elev})}$		
$(c - PFAF_{alt} + 0.032 \cdot (PFAF_{alt} - LTP_{elev}) + 4.9) / (0.19 + 0.0038 \cdot (PFAF_{alt} - LTP_{elev}))$		
Calculator		
PFAF _{alt}		Click Here to Calculate
LTP _{elev}		
c		
ΔISA_{high}		

STEP 4: Calculate the published high temperature limit [$NA_{above}(C^\circ)$ and $NA_{above}(F^\circ)$] using *formula 4-8*.

Formula 4-8. Published HighTemp Limit.		
$NA_{above}(C^\circ) = Airport_{ISA} + \Delta ISA_{high}$		
$NA_{above}(F^\circ) = NA_{above}(C^\circ) \cdot 1.8 + 32$		
$NA_{above}(C^\circ) = Airport_{ISA} + \Delta ISA_{high}$ $NA_{above}(F^\circ) = NA_{above}(C^\circ) \cdot 1.8 + 32$		
Calculator		
Airport _{ISA}		Click Here to Calculate
ΔISA_{high}		
$NA_{above}(C^\circ)$		
$NA_{above}(F^\circ)$		

Note: If the calculated Fahrenheit value is greater than 130°, publish 130°F or 54°C as appropriate.

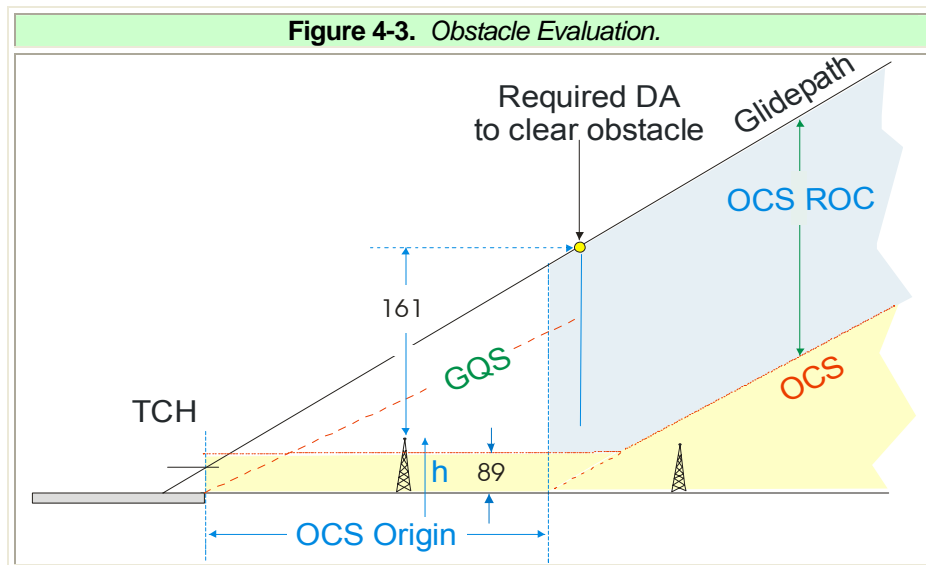
4.3.3 OCS Slope.

The **OCS** slope is dependent upon the published glidepath angle (θ), airport **ISA**, and the **ACT** temperatures. Determine the **OCS** slope value using *formula 4-9*.

Formula 4-9. OCS Slope.		
$OCS_{\text{slope}} = \frac{1}{\tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot (0.928 + 0.0038 \cdot (ACT^{\circ}C - ISA^{\circ}C))}$ <p>where θ = glidepath angle ISA$^{\circ}$C = Airport ISA from formula 4-3 ACT$^{\circ}$C = Value from paragraph 4.3.1</p>		
$1/(\tan(\theta * \pi / 180) * (0.928 + 0.0038 * (ACT^{\circ}C - ISA^{\circ}C)))$		
Calculator		
<input type="text" value="θ"/>	<input type="text"/>	Click Here to Calculate
<input type="text" value="ISA<math>^{\circ}</math>C"/>	<input type="text"/>	
<input type="text" value="ACT<math>^{\circ}</math>C"/>	<input type="text"/>	
<input type="text" value="OCS<math>_{\text{slope}}</math>"/>	<input type="text"/>	

4.3.4 Final Segment Obstacle Evaluation.

The final segment **OEA** is evaluated by application of an **ROC** and an **OCS**. **ROC** is applied from the LTP to the point the **OCS** reaches 89 ft above **LTP** elevation. The **OCS** is applied from this point to a point 0.3 **NM** outside the **PFAF**. See *figure 4-3*.

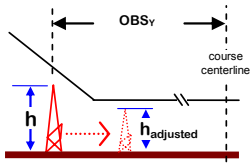


If an obstacle is in the secondary area (transitional surface), adjust the height of the obstacle using *formula 4-10*, then evaluate it at the adjusted height as if it is in the primary area.

**Formula 4-10. Secondary Area
Adjusted Obstacle Height.**

$$h_{\text{adjusted}} = h - \frac{\text{OBS}_Y - \text{Width}_{\text{primary}}}{7}$$

where h = obstacle MSL elevation
 $\text{Width}_{\text{primary}}$ = perpendicular distance (ft) of primary boundary from course centerline
 OBS_Y = obstacle perpendicular distance (ft) from course centerline



$h - (\text{OBS}_Y - \text{Width}_{\text{primary}}) / 7$

Calculator

h	<input type="text"/>	Click Here to Calculate
$\text{Width}_{\text{primary}}$	<input type="text"/>	
OBS_Y	<input type="text"/>	
h_{adjusted}	<input type="text"/>	

4.3.4

a. **ROC application.** Apply 161 ft of **ROC** to the higher of the follow:

- height of the obstacle exclusion area or
- highest obstacle above the exclusion area.

Calculate the **DA** based on **ROC** application (DA_{ROC}) using *formula 4-11*. Round the result to the next higher foot value.

Formula 4-11. DA Based on ROC Application.		
$DA_{ROC} = h + 161$		
where h = higher of: Obstacle MSL elevation ($h_{adjusted}$ if in secondary) or height of obstacle exclusion surface (89 ft above LTP elevation)		
$h+161$		
Calculator		
h		Click Here to Calculate
DA_{ROC}		

4.3.4 b. OCS Evaluation.

The *OCS* begins D_{ORIGIN} from *LTP* at *LTP* elevation. Application of the *OCS* begins at the point the *OCS* reaches 89 ft above *LTP* elevation. Determine the distance from *LTP* that the *OCS* reaches 89 ft above *LTP* using formula 4-12a. The *MSL* elevation of the *OCS* (OCS_{elev}) at any distance (OBS_X) from *LTP* ($OBS_X > D_{origin}$) is determined using formula 4-12b.

Formula 4-12a. Distance From LTP That OCS Application Begins.		
$D_{OCS} = D_{origin} + r \cdot OCS_{slope} \cdot \ln\left(\frac{LTP_{elev} + 89 + r}{r + LTP_{elev}}\right)$		
where LTP_{elev} = LTP MSL elevation D_{origin} = distance from formula 4-2 OCS_{slope} = slope from formula 4-9 $r = 20890537$ $e \approx 2.7182818284$		
$D_{origin} + r \cdot OCS_{slope} \cdot \ln((LTP_{elev} + 89 + r) / (r + LTP_{elev}))$		
Calculator		
LTP _{elev}		Click Here To Calculate
OCS _{slope}		
D _{origin}		
D _{OCS}		

Formula 4-12b. OCS Elevation.

$$OCS_{elev} = (r + LTP_{elev}) \cdot e^{\frac{OBS_x - D_{origin}}{r \cdot OCS_{slope}}} - r$$

where LTP_{elev} = LTP MSL elevation
 D_{origin} = distance (ft) from LTP to OCS origin
 OCS_{slope} = OCS slope ration (run/rise; e.g., 34)
 OBS_x = distance (ft) measured along course from LTP
 $r = 20890537$
 $e \approx 2.7182818284$

$$(r + LTP_{elev}) \cdot e^{((OBS_x - D_{origin}) / (r \cdot OCS_{slope}))} - r$$

Calculator

LTP _{elev}	<input type="text"/>	Click Here to Calculate
OCS _{slope}	<input type="text"/>	
D _{origin}	<input type="text"/>	
OBS _x	<input type="text"/>	
OCS _{elev}	<input type="text"/>	

Where obstacles penetrate the **OCS**, determine the minimum **DA** value (**DA_{OCS}**) based on the **OCS** evaluation by applying *formula 4-13* using the penetrating obstacle with the highest **MSL** value (*see figure 4-4*).

Formula 4-13. DA Based On OCS.

$$d = (r + LTP_{\text{elev}}) \cdot OCS_{\text{slope}} \cdot \ln\left(\frac{r + O_{\text{MSL}}}{r + LTP_{\text{elev}}}\right) + D_{\text{origin}}$$

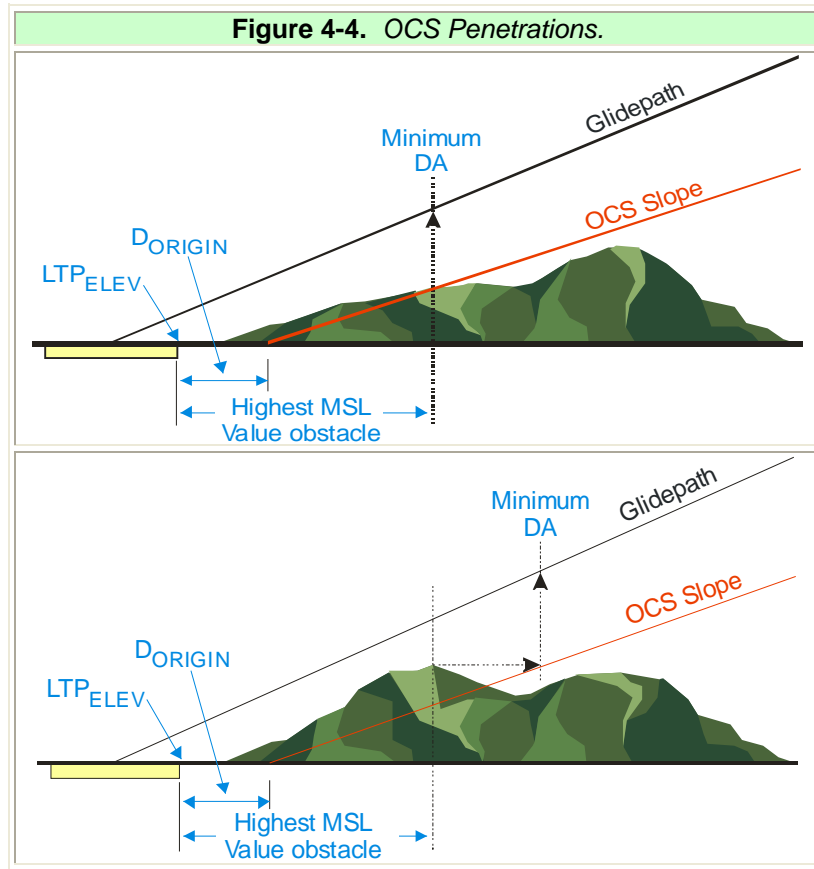
$$DA_{\text{OCS}} = e^{\frac{d \cdot \tan\left(\frac{\theta - \pi}{180}\right)}{r}} \cdot (r + LTP_{\text{elev}} + TCH) - r$$

where θ = glidepath angle
 O_{MSL} = obstacle MSL elevation
 D_{origin} = value from formula 4-2
 LTP_{elev} = LTP MSL elevation
 OCS_{slope} = value from formula 4-9
 TCH = threshold crossing height
 $r = 20890537$
 $e \approx 2.7182818284$

$d = (r + LTP_{\text{elev}}) \cdot OCS_{\text{slope}} \cdot \ln\left(\frac{r + O_{\text{MSL}}}{r + LTP_{\text{elev}}}\right) + D_{\text{origin}}$
 $DA_{\text{OCS}} = e^{\left(\frac{d \cdot \tan(\theta \cdot \pi / 180)}{r}\right)} \cdot (r + LTP_{\text{elev}} + TCH) - r$

Calculator

LTP _{elev}		Click Here to Calculate
TCH		
θ		
OCS _{slope}		
O _{MSL}		
D _{origin}		
DA _{OCS}		



4.3.4 c. **Final Segment DA.** The published *DA* is the higher of *DA_{LS}* or *DA_{OCS}*.

4.3.4 d. **Calculating DA to LTP distance.** Calculate the distance from *LTP* to *DA* using formula 4-14.

Formula 4-14. Distance to DA.

$$D_{DA} = \frac{\ln\left(\frac{r + DA}{r + LTP_{elev} + TCH}\right) \cdot (r + LTP_{elev})}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$$

where LTP_{elev} = LTP MSL elevation
 TCH = Threshold crossing height in feet
 r = 20890537
 θ = glidepath angle

$(\ln((r+DA)/(r+LTP_{elev}+TCH)) \cdot (r+LTP_{elev})) / \tan(\theta \cdot \pi / 180)$

Calculator	
LTP _{elev}	
TCH	
θ	
DA	
D _{DA}	

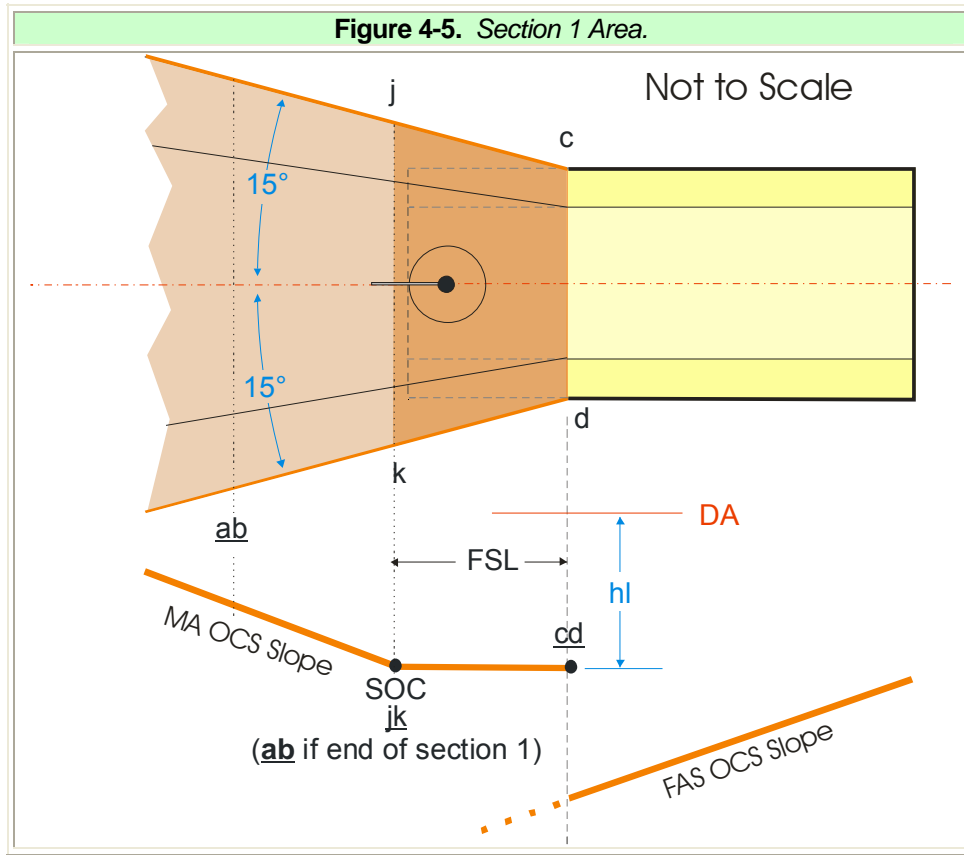
Click Here
to
Calculate

4.4 **Missed Approach Section 1.**

Section 1 extends from *DA* along a continuation of the final course to the start-of-climb (*SOC*) point or the point where the aircraft reaches 400 ft above airport elevation, whichever is farther. Turns are not allowed in section 1. See figure 4-6.

4.4.1 **Area.**

Section 1 provides obstacle protection allowing the aircraft to arrest descent, and configure the aircraft to climb. It begins at a line (**CD** line) perpendicular to the final approach track at *DA* (*D_{DA}* prior to threshold) and extends along the missed approach track to the **AB** line (the *SOC* point or the point the aircraft reaches 400 ft above airport elevation, whichever is farther from the *DA* point). The *OE*A contains a flat **ROC** surface, and a rising **OCS** (40:1 standard) if climb to 400 ft above airport elevation is necessary. See figure 4-5 and 4-6.



4.4.1 a. Length.

The area from the *DA* point to *SOC* is termed the “Flat Surface.” Calculate the Flat Surface Length (*FSL*) using *formula 4-15a*.

Formula 4-15a. Flat Surface Length.

$$FSL = 25.317 \cdot \left(\left(V_{KIAS} \cdot \frac{171233 \cdot \sqrt{(288 + 15) - 0.00198 \cdot DA}}{(288 - 0.00198 \cdot DA)^{2.628}} \right) + 10 \right)$$

where V_{KIAS} = knots indicated airspeed
 DA = Decision altitude

$$25.317 \cdot ((V_{KIAS} \cdot (171233 \cdot ((288 + 15) - 0.00198 \cdot DA)^{0.5}) / (288 - 0.00198 \cdot DA)^{2.628}) + 10)$$

Calculator

V_{KIAS}		Click Here to Calculate
DA		
FSL		

The end of the flat surface is **SOC** marked by the **JK** construction line. If the published **DA** is lower than 400 ft above airport, a 40:1 rising surface extension is added to section 1. Calculate the length (in feet) $sI_{extension}$ of the extension using *formula 4-15b*.

Formula 4-15b. Calculation of extension for climb to 400 ft.		
$sI_{extension} = \frac{Z}{CG} \cdot \frac{1852}{0.3048}$		
where Z = number of feet to climb to reach 400' above airport CG = climb gradient (standard 200)		
Z/CG*1852/0.3048		
Calculator		
CG		Click Here to Calculate
Z		
$sI_{extension}$		

4.4.1 b. Width.

The **OEA** splays at an angle of 15 degrees relative to the **FAC** from the outer edge of the final segment secondary area (perpendicular to the final approach course 5,468.5 ft from **FAC**) at the **DA** point. The splay ends when it reaches a point 3 **NM** from the missed approach course centerline (47,620.38 ft [7.8 **NM**] from **DA** point).

4.4.1 c. OCS.

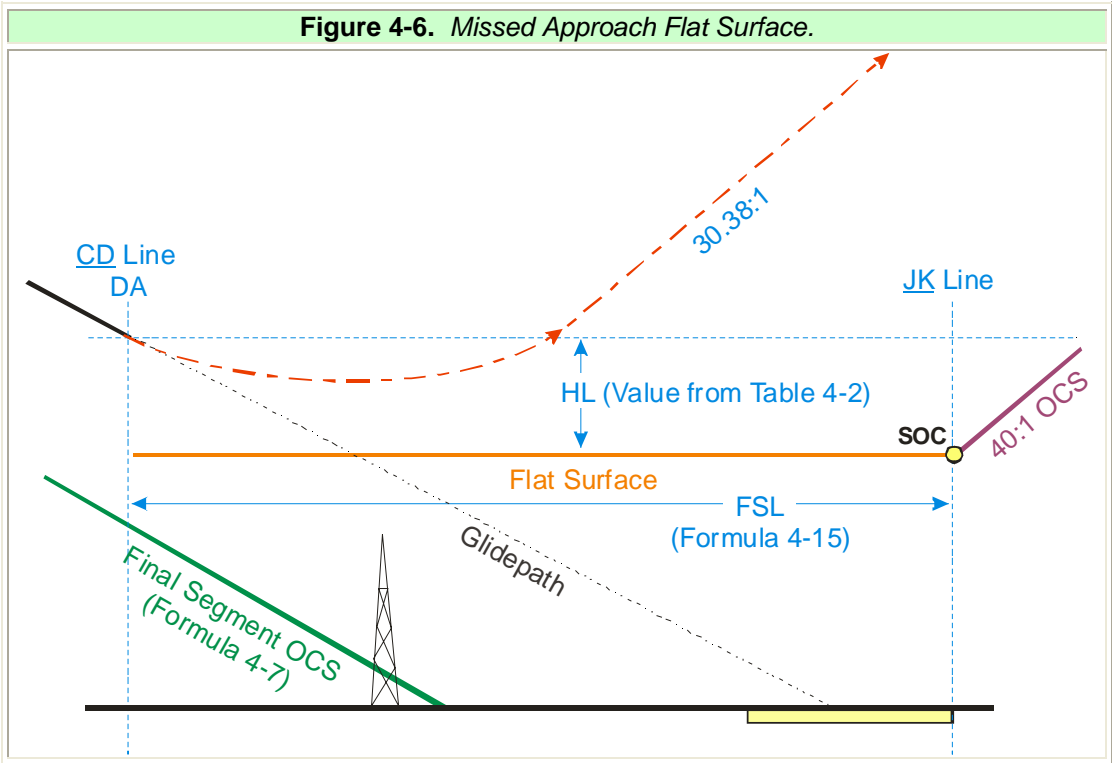
The height of the missed approach surface (**HMAS**) below the **DA** point is determined by *formula 4-16* using the **ROC** value (**hl**) from *table 4-2*. Select the **hl** value for the fastest aircraft category for which minimums are published.

Table 4-2. Level Surface ROC Values (hl).	
Aircraft Category	hl (ft)
A	131
B	142
C	150
D/E	161

Formula 4-16. HMAS Elevation.		
$HMAS = DA - hl$ <p>where hl = level surface ROC from table 4-2</p>		
DA-hl		
Calculator		
DA	<input type="text"/>	Click Here to Calculate
hl	<input type="text"/>	
HMAS	<input type="text"/>	

- 4.4.1 c. (1) The missed approach surface remains level (flat)** from the *DA* (*CD*) line point to the *SOC* point (*JK* line). Obstacles must not penetrate the flat surface. Where obstacles penetrate the flat surface, raise the *DA* by the amount of penetration and re-evaluate the missed approach segment. See figure 4-6.
- 4.4.1 c. (2) At *SOC* the surface begins to rise** along the missed approach course centerline at a slope ratio (40:1 standard) commensurate with the minimum required rate of climb (200 ft/NM standard); therefore, the *OCS* surface rise at any obstacle position is equal to the along-track distance from *SOC* (*JK* line) to a point abeam the obstacle. Obstacles must not penetrate the 40:1 surface. Where obstacles penetrate the 40:1 *OCS*, adjust *DA* by the amount (ΔDA) calculated by formula 4-17 and re-evaluate the missed approach segment.

Formula 4-17. DA Adjustment Value.		
$\Delta DA = e \frac{p \cdot \frac{MA_{slope} \cdot \tan\left(\theta - \frac{\pi}{180}\right)}{1 + MA_{slope} \cdot \tan\left(\theta - \frac{\pi}{180}\right)}}{r} \cdot r - r$ <p>where p = amount of penetration θ = glidepath angle MA_{slope} = MA OCS slope (nominally 40:1) $r = 20890537$</p>		
$e^{((p \cdot (MA_{slope} \cdot \tan(\theta \cdot \pi / 180)) / (1 + MA_{slope} \cdot \tan(\theta \cdot \pi / 180))) / r)} \cdot r - r$		
Calculator		
p	<input type="text"/>	Click Here to Calculate
θ	<input type="text"/>	
MA_{slope}	<input type="text"/>	
ΔDA	<input type="text"/>	



Chapter 5. LPV Final Approach Segment (FAS) Evaluation

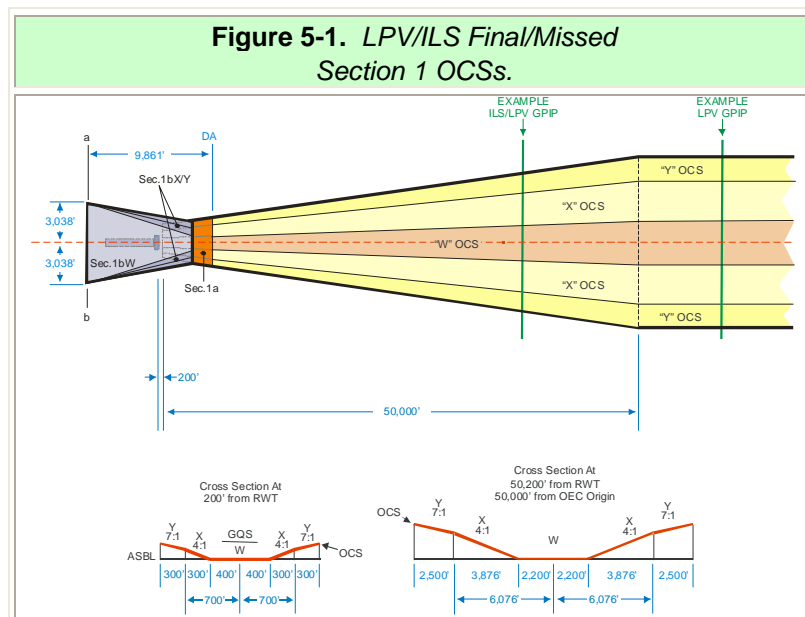
5.0 General.

The obstruction evaluation area (*OEA*) and associated obstacle clearance surfaces (*OCSs*) are applicable to *LPV* final approach segments. These criteria may also be applied to construction of an *RNAV* transition to an *ILS* final segment where the glidepath intercept point (*GPIP*) is located within 50,200 ft of the *LTP*. For *RNAV* transition to *ILS* final, use *LPV* criteria to evaluate the final and missed approach section 1.

5.1 Final Segment Obstruction Evaluation Area (*OEA*).

The *OEA* originates 200 ft from *LTP* or *FTP* as appropriate, and extends to a point ≈ 131 ft (40 meters *ATT*) beyond the *GPIP* (*GPIP* is determined using formula 2-14a). It is centered on the final approach course and expands uniformly from its origin to a point 50,000 ft from the origin where the outer boundary of the **X** surface is 6,076 ft perpendicular to the course centerline. Where the *GPIP* must be located more than 50,200 ft from *LTP*, the *OEA* continues linearly (boundaries parallel to course centerline) to the *GPIP* (see figure 5-1)*. The primary area *OCS* consists of the **W** and **X** surfaces. The **Y** surface is an early missed approach transitional surface. The **W** surface slopes longitudinally along the final approach track, and is level perpendicular to track. The **X** and **Y** surfaces slope upward from the edge of the **W** surface perpendicular to the final approach track. Obstacles located in the **X** and **Y** surfaces are adjusted in height to account for perpendicular surface rise and evaluated under the **W** surface.

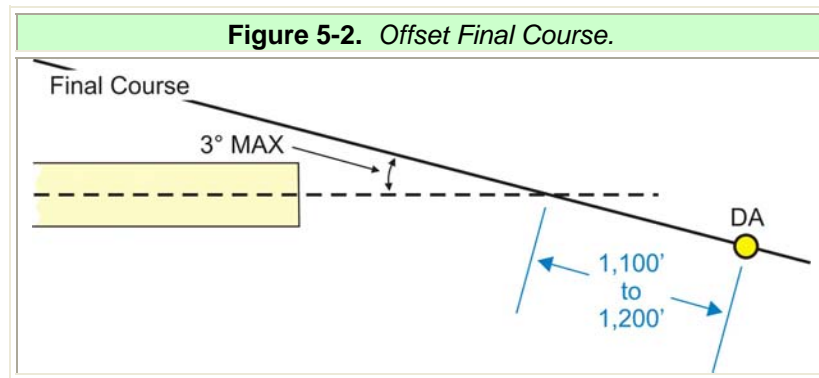
Note: ILS continues the splay, only LPV is linear outside 50,200 ft.



5.1.1 OEA Alignment.

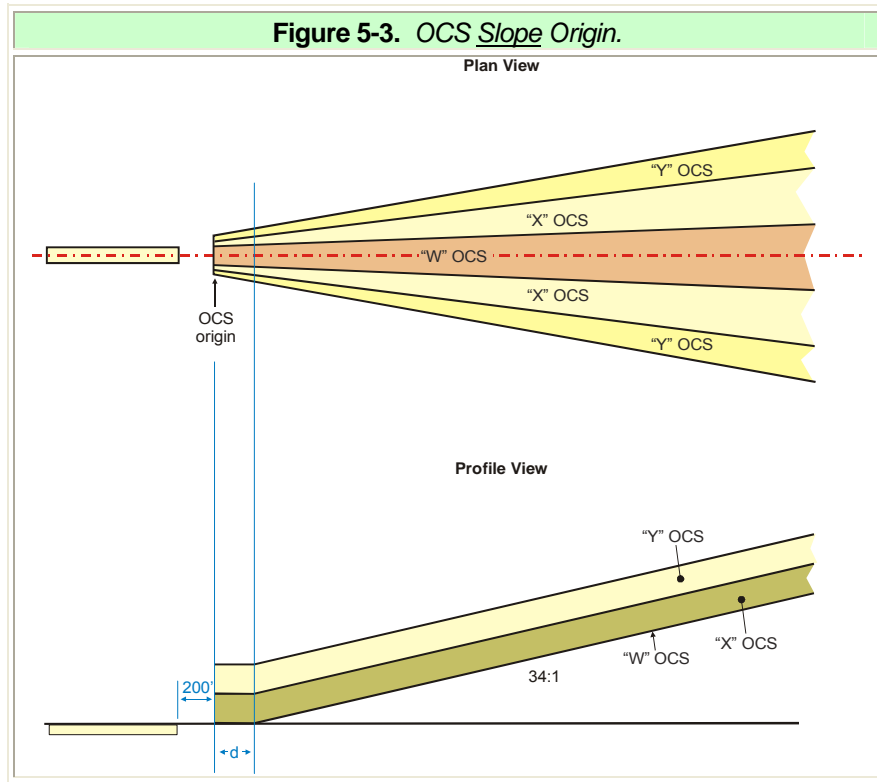
The final course is normally aligned with the runway centerline (**RCL**) extended ($\pm 0.03^\circ$) through the **LTP** (± 5 ft). Where a unique operational requirement indicates a need to offset the course from **RCL**, the offset must not exceed 3 degrees measured geodetically* at the point of intersection. If the course is offset, it must intersect the **RCL** at a point 1,100 to 1,200 ft inside the decision altitude (**DA**) point (see figure 5-2). Where the course is not aligned with **RCL**, the minimum **HATh** value is 250.

* *Note: Geodetic measurements account for the convergence of lines of longitude. Plane geometry calculations are not compatible with geodetic measurements. See appendix 1 for geodetic calculation explanation. A geodetic calculator (MS Excel) is available on the AFS-420 website. See appendix 2 for the calculator explanation.*



5.1.2 OCS Slope(s) (see figure 5-3).

In this document, slopes are expressed as run over rise; e.g., 34:1. Determine the **OCS** slope (**S**) associated with a specific glidepath angle (θ) using formula 5-1.



Formula 5-1. OCS Slope.		
$S = \frac{102}{\theta}$		
$S = 102/\theta$		
Calculator		
θ		Click Here to Calculate
S		

5.1.3 OCS Origin.

The *OEA* (all *OCS* surfaces) originates from *LTP* elevation at a point 200 ft from *LTP* (see figure 5-3) measured along course centerline and extends to the *GPIP*. The longitudinal (along-track) rising *W* surface slope begins at a point 200+*d* feet from *OEA* origin. The value of *d* is dependent on the *TCH*/glidepath angle relationship.

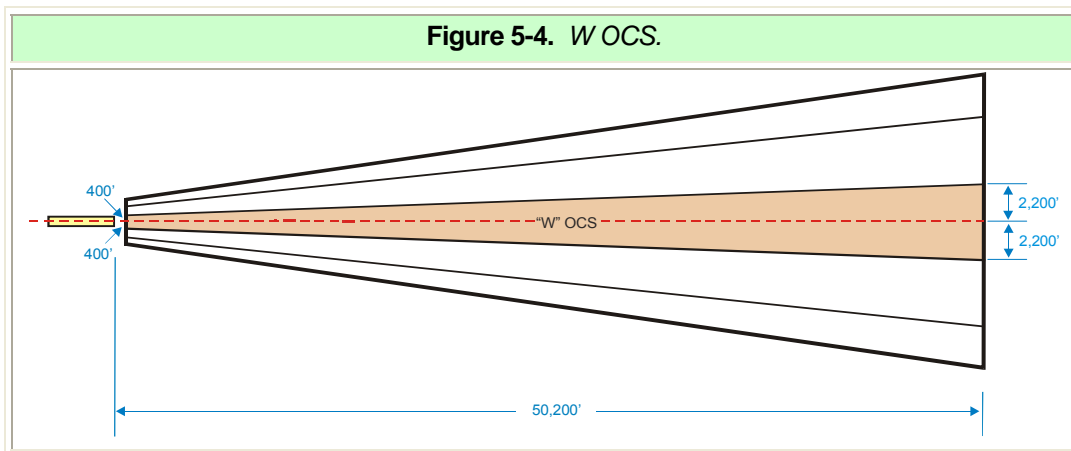
Where $\frac{TCH}{\tan(\theta \frac{\pi}{180})} \geq 954$, *d* equals zero [0].

Where $\frac{TCH}{\tan(\theta \frac{\pi}{180})} < 954$, calculate the value of *d* using formula 5-2.

Formula 5-2. Slope Origin Δ .		
$d = 954 - \frac{TCH}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$		
954-TCH/tan($\theta \cdot \pi/180$)		
Calculator		
TCH	<input type="text"/>	Click Here to Calculate
θ	<input type="text"/>	
d	<input type="text"/>	

5.2 W OCS. (See figure 5-4)

All final segment **OCS** (W,X, and Y) obstacles are evaluated relative to the height of the **W** surface based on their along-track distance (**OBS_X**) from the **LTP**, perpendicular distance (**OBS_Y**) from the course centerline, and **MSL** elevation (**OBS_{MSL}**) adjusted for earth curvature and **X/Y** surface rise if appropriate. This adjusted elevation is termed obstacle evaluation elevation (**O_{EE}**) and is covered in paragraph 5.2.2.



5.2.1 Width. (Perpendicular distance from course centerline to surface boundary)

The perpendicular distance (**W_{boundary}**) from course centerline to the boundary is 400 ft at the origin, and expands uniformly to 2,200 ft at a point 50,200 ft from **LTP/FTP**. Calculate **W_{boundary}** for any distance from **LTP** using formula 5-3. For obstacle evaluation purposes, the distance from **LTP** is termed **OBS_X**.

Formula 5-3. W OCS ½ Width.		
$W_{\text{boundary}} = 0.036 \cdot \text{OBS}_x + 392.8$		
where OBS_x = along-track distance (ft) from LTP to obstacle		
$0.036 \cdot \text{OBS}_x + 392.8$		
Calculator		
OBS _x		Click Here to Calculate
W _{boundary}		

5.2.2 Height.

Calculate the **MSL** height (ft) of the **W OCS** (W_{MSL}) at any distance OBS_x from **LTP** using *formula 5-4*.

Formula 5-4. W OCS MSL Elevation.		
$W_{\text{MSL}} = \frac{\left(r + \text{LTP}_{\text{elev}} - \frac{\theta \cdot (200 + d)}{102} \right) \cdot \cos \left(\text{atan} \left(\frac{\theta}{102} \right) \right)}{\cos \left(\frac{\text{OBS}_x - (200 + d)}{r} + \text{atan} \left(\frac{\theta}{102} \right) \right)} - r$		
where OBS_x = obstacle along-track distance (ft) from LTP/FTP LTP_{elev} = LTP MSL elevation θ = glidepath angle d = value from paragraph 5.1.3 $r = 20890537$		
$\left((r + \text{LTP}_{\text{elev}} - (\theta \cdot (200 + d)) / 102) \cdot \cos(\text{atan}(\theta / 102)) \right) / \cos((\text{OBS}_x - (200 + d)) / r + \text{atan}(\theta / 102)) - r$		
Calculator		
LTP _{elev}		Click Here to Calculate
θ		
d		
OBS _x		
W _{MSL}		

The **LPV** (and **ILS**) glidepath is considered to be a straight line in space extending from **TCH**. The **OCS** is; therefore, a flat plane (does not follow earth curvature) to protect the straight-line glidepath. The elevation of the **OCS** at any point is the elevation of the **OCS** at the course centerline abeam it. Since the earth’s surface curves away from these surfaces as distance from **LTP** increases, the **MSL** elevation (OBS_{MSL}) of an obstacle is reduced to account for earth curvature. This reduced value is termed the obstacle effective **MSL** elevation (O_{EE}). Calculate O_{EE} using *formula 5-5*.

Formula 5-5. EC Adjusted Obstacle MSL Elevation.

$$O_{EE} = OBS_{MSL} - \left((r + LTP_{elev}) \cdot \left(\frac{1}{\cos\left(\frac{OBS_Y}{r}\right)} - 1 \right) + Q \right)$$

where OBS_{MSL} = obstacle MSL elevation
 OBS_Y = perpendicular distance (ft) from course centerline to obstacle
 LTP_{elev} = LTP MSL elevation
 $r = 20890537$
 Q = adjustment for "X" or "Y" surface rise (0 if in W Surface)
See formula 5-7

$OBS_{MSL} - ((r + LTP_{elev}) * (1 / \cos(OBS_Y / r) - 1) + Q)$

Calculator

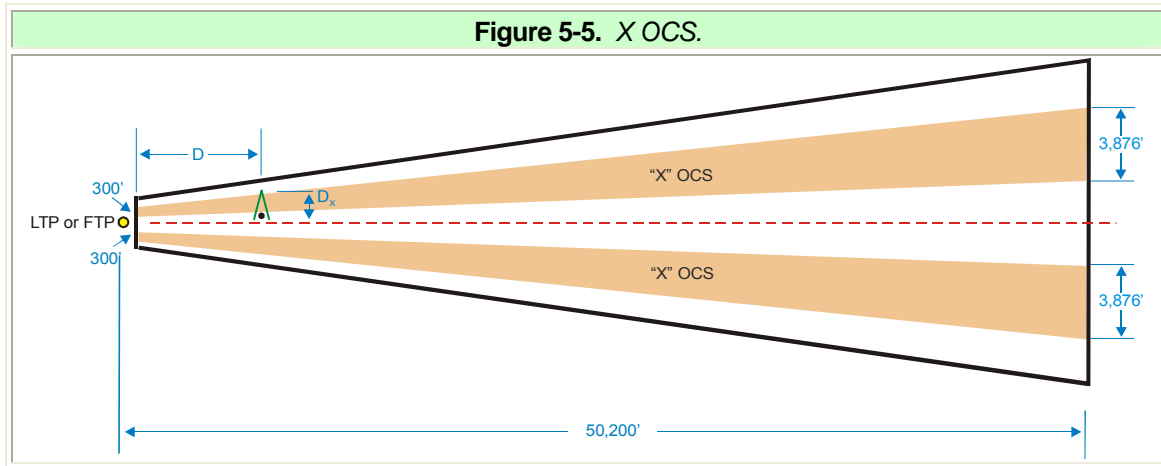
LTP _{elev}		Click Here to Calculate
Q		
OBS _{MSL}		
OBS _Y		
O _{EE}		

5.2.3 W OCS Evaluation.

Compare the obstacle O_{EE} to W_{MSL} at the obstacle location. Lowest minimums are achieved when the **W** surface is clear. To eliminate or avoid a penetration, take one or more of the following actions listed in the order of preference.

- 5.2.3 a. Remove or adjust the obstruction location and/or height.**
- 5.2.3 b. Displace the *RWT*.**
- 5.2.3 c. Raise the *GPA* (see paragraph 5.6) within the limits of table 2-5.**
- 5.2.3 d. Adjust *DA* (for existing obstacles only) see paragraph 5.5.2.**
- 5.2.3 e. Raise *TCH* (see paragraph 5.7).**

5.3 **X OCS.** (See figure 5-5)



5.3.1 **Width.**

The perpendicular distance from the course centerline to the outer boundary of the **X OCS** is 700 ft at the origin and expands uniformly to 6,076 ft at a point 50,200 ft from **LTP/FTP**. Calculate the perpendicular distance ($X_{boundary}$) from the course centerline to the **X** surface boundary using *formula 5-6*.

Formula 5-6. Perpendicular Dist to X Boundary.

$X_{boundary} = 0.10752 \cdot OBS_x + 678.5$

where OBS_x = obstacle along-track distance
(ft) from LTP/FTP

0.10752*OBS_x+678.5

Calculator

OBS _x		Click Here to Calculate
X _{boundary}		

Note: Where the intermediate segment is **NOT** aligned with the **FAC**, take into account the expansion of the final based on the intermediate segment taper.

5.3.2 **X Surface Obstacle Elevation Adjustment (Q).**

The **X OCS** begins at the height of the **W** surface and rises at a slope of 4:1 in a direction perpendicular to the final approach course. The **MSL** elevation of an obstacle in the **X** surface is adjusted (reduced) by the amount of surface rise. Use *formula 5-7* to determine the obstacle height adjustment (**Q**) for use in *formula 5-5*. Evaluate the obstacle under *paragraphs 5.2.2 and 5.2.3*.

Formula 5-7. X OCS Obstacle Height Adjustment.

$$Q = \frac{OBS_Y - W_{boundary}}{4}$$

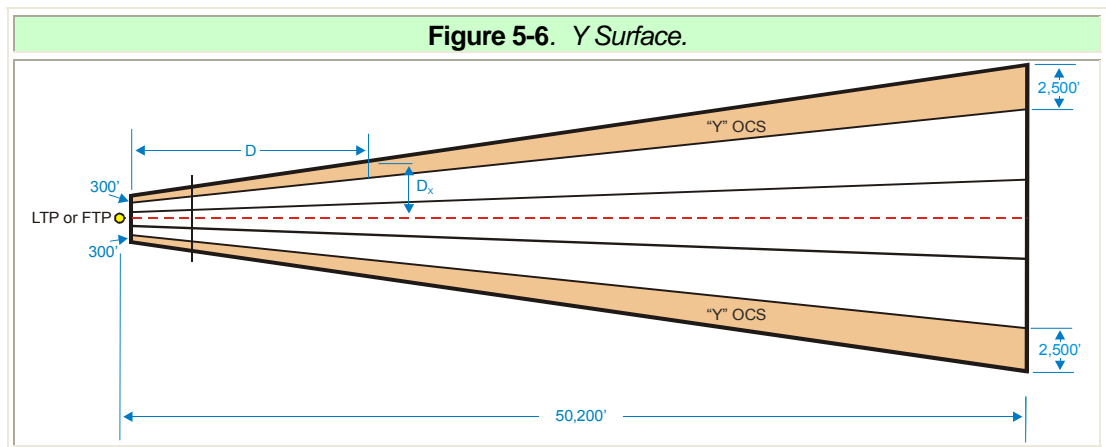
where OBS_Y = perpendicular distance (ft) from course centerline to obstacle
W_{boundary} = half-width of W surface abeam obstacle (*formula 5-3*)

(OBS_Y-W_{boundary})/4

Calculator

OBS _Y		Click Here to Calculate
W _{boundary}		
Q		

5.4 Y OCS. (See figure 5-6)



5.4.1 Width.

The perpendicular distance from the course centerline to the outer boundary of the **Y OCS** is 1,000 ft at the origin and expands uniformly to 8,576 ft at a point 50,200 ft from **LTP/FTP**. Calculate the perpendicular distance (**Y_{boundary}**) from the course centerline to the **Y** surface boundary using *formula 5-8*.

Formula 5-8. Perpendicular Distance to Y Boundary.

$$Y_{boundary} = 0.15152 \cdot OBS_X + 969.7$$

where OBS_X = obstacle along-track distance (ft) from LTP/FTP

0.15152*OBS_X+969.7

Calculator

OBS _X		Click Here to Calculate
Y _{boundary}		

Note: Take into account the expansion of the final based on the intermediate segment taper.

5.4.2 Y Surface Obstacle Elevation Adjustment (Q).

The **Y OCS** begins at the height of the **X** surface and rises at a slope of 7:1 in a direction perpendicular to the final approach course. The **MSL** elevation of an obstacle in the **Y** surface is adjusted (reduced) by the amount of **X** and **Y** surface rise. Use *formula 5-9* to determine the obstacle height adjustment (**Q**) for use in *formula 5-5*. Evaluate the obstacle under *paragraphs 5.2.2 and 5.2.3*.

Formula 5-9. Y OCS Obstacle Height Adjustment.		
$Q = \frac{X_{\text{boundary}} - W_{\text{boundary}}}{4} + \frac{\text{OBS}_Y - X_{\text{boundary}}}{7}$		
where W_{boundary} = perpendicular distance (ft) from course centerline to the W surface boundary X_{boundary} = perpendicular distance (ft) from course centerline to the X surface outer boundary OBS_Y = perpendicular distance (ft) from course centerline to the obstacle in the Y surface		
$(X_{\text{boundary}} - W_{\text{boundary}}) / 4 + (\text{OBS}_Y - X_{\text{boundary}}) / 7$		
Calculator		
X_{boundary}		Click Here to Calculate
W_{boundary}		
OBS_Y		
Q		

5.5 HATH and DA.

The **DA** value may be derived from the **HATH**. Where the **OCS** is clear, the *minimum HATH* for **LPV** operations is the greater of 200 ft or the limitations noted on *table 2-4*. If the **OCS** is penetrated, minimum **HATH** is 250. Round the **DA** result to the next higher whole foot.

5.5.1 DA Calculation (Clear OCS).

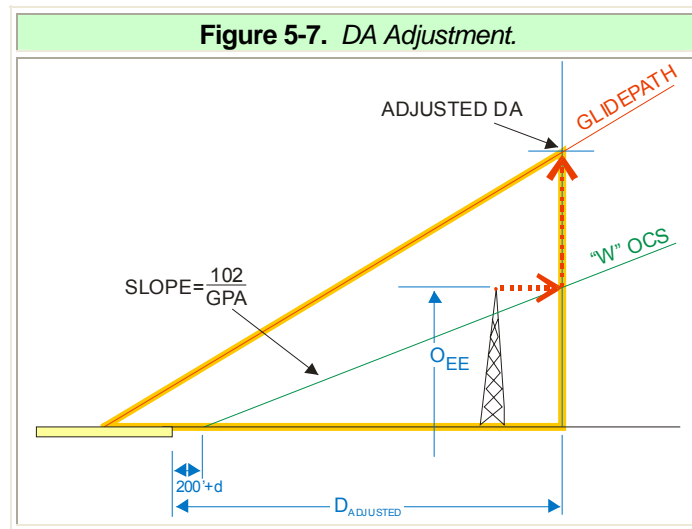
Calculate the **DA** using *formula 5-10*.

Formula 5-10. DA Calculation.		
$DA = HATH + LTP_{elev}$ where HATH = height above threshold LTP _{elev} = LTP MSL elevation		
HATH+LTP _{elev}		
Calculator		
HATH	<input type="text"/>	Click Here to Calculate
LTP _{elev}	<input type="text"/>	
DA	<input type="text"/>	

Calculate the along-course distance in feet from **DA** to **LTP/FTP** (X_{DA}) using *formula 5-11*.

Formula 5-11. Distance LTP to DA.		
$X_{DA} = r \cdot \left(\frac{\pi}{2} - \theta \cdot \frac{\pi}{180} - \text{asin} \left(\frac{\cos \left(\theta \cdot \frac{\pi}{180} \right) \cdot (r + LTP_{elev} + TCH)}{r + DA} \right) \right)$		
$r * (\pi/2 - \theta * \pi/180 - \text{asin}((\cos(\theta * \pi/180) * (r + LTP_{elev} + TCH)) / (r + DA)))$		
Calculator		
LTP _{elev}	<input type="text"/>	Click Here to Calculate
TCH	<input type="text"/>	
θ	<input type="text"/>	
DA	<input type="text"/>	
X _{DA}	<input type="text"/>	

5.5.2 **DA Calculation (OCS Penetration).** (See figure 5-7)



Calculate the adjusted *DA* for an obstacle penetration of the *OCS* using formula 5-12.

Formula 5-12. Adjusted DA.

$$D_{\text{adjusted}} = r \cdot \left(\frac{\pi}{2} - a \tan \left(\frac{\theta}{102} \right) - a \sin \left(\frac{\cos \left(a \tan \left(\frac{\theta}{102} \right) \right) \cdot \left(r + LTP_{\text{elev}} - \frac{\theta \cdot (200 + d)}{102} \right)}{r + O_{\text{EE}}} \right) \right)$$

$$DA_{\text{adjusted}} = \frac{(r + LTP_{\text{elev}} + TCH) \cdot \cos \left(\theta \cdot \frac{\pi}{180} \right)}{\cos \left(\frac{D_{\text{adjusted}}}{r} + \theta \cdot \frac{\pi}{180} \right)} - r$$

where $r = 20890537$
 $d =$ value from paragraph 5.1.3
 $\theta =$ glidepath angle
 $O_{\text{EE}} =$ from formula 5-5

$$D_{\text{adjusted}} = r \cdot \left(\frac{\pi}{2} - a \tan \left(\frac{\theta}{102} \right) - a \sin \left(\frac{\cos \left(a \tan \left(\frac{\theta}{102} \right) \right) \cdot \left(r + LTP_{\text{elev}} - \frac{\theta \cdot (200 + d)}{102} \right)}{r + O_{\text{EE}}} \right) \right)$$

$$DA_{\text{adjusted}} = \left(\frac{(r + LTP_{\text{elev}} + TCH) \cdot \cos \left(\theta \cdot \frac{\pi}{180} \right)}{\cos \left(\frac{D_{\text{adjusted}}}{r} + \theta \cdot \frac{\pi}{180} \right)} - r \right)$$

Calculator

LTP _{elev}		Click Here to Calculate
TCH		
θ		
d		
O _{EE}		
DA _{adjusted}		

5.6 Revising Glidepath Angle (GPA) for OCS Penetrations.

Raising the **GPA** may eliminate **OCS** penetrations. To determine the revised minimum **GPA**, use *formula 5-13*.

Formula 5-13. <i>Glidepath Angle Adjustment.</i>		
$SRD = \sqrt{(r + O_{EE})^2 + (r + LTP_{elev})^2 - 2 \cdot (r + O_{EE}) \cdot (r + LTP_{elev}) \cdot \cos\left(\frac{OBS_x - (200 + d)}{r}\right)}$ $RS = \frac{1}{\tan\left(a \cos\left(\frac{SRD^2 + (r + LTP_{elev})^2 - (r + O_{EE})^2}{2 \cdot SRD \cdot (r + LTP_{elev})}\right) - \frac{\pi}{2}\right)}$ $\theta_{required} = \frac{102}{RS}$ <p>where r = 20890537 O_{EE} = value from formula 5-5 OBS_x = along-track distance (ft) from LTP to penetrating obstacle d = value from paragraph 5.1.3</p>		
$SRD = \sqrt{(r + O_{EE})^2 + (r + LTP_{elev})^2 - 2 \cdot (r + O_{EE}) \cdot (r + LTP_{elev}) \cdot \cos((OBS_x - (200 + d))/r)}$ $RS = 1 / \tan(\text{acos}((SRD^2 + (r + LTP_{elev})^2 - (r + O_{EE})^2) / (2 * SRD * (r + LTP_{elev}))) - \pi/2)$ $\theta_{required} = 102 / RS$		
Calculator		
LTP _{elev}		Click Here to Calculate
d		
O _{EE}		
OBS _x		
θ _{required}		

5.7 Adjusting *TCH* to Reduce/Eliminate *OCS* Penetrations.

This paragraph is applicable ONLY where **d** from *paragraph 5.1.3, formula 5-2*, is greater than zero. Adjusting *TCH* is the equivalent to relocating the glide slope antenna in *ILS* criteria. The goal is to move the *OCS* origin toward the *LTP/FTP* (no closer than 200 ft) sufficiently to raise the *OCS* at the obstacle location. To determine the maximum **W** surface vertical relief (**Z**) that can be achieved by adjusting *TCH*, apply *formula 5-14*. If the value of **Z** is greater than the penetration (**p**), you may determine the amount to increase *TCH* by applying *formula 5-15*. If this option is selected, re-evaluate the final segment using the revised *TCH* value.

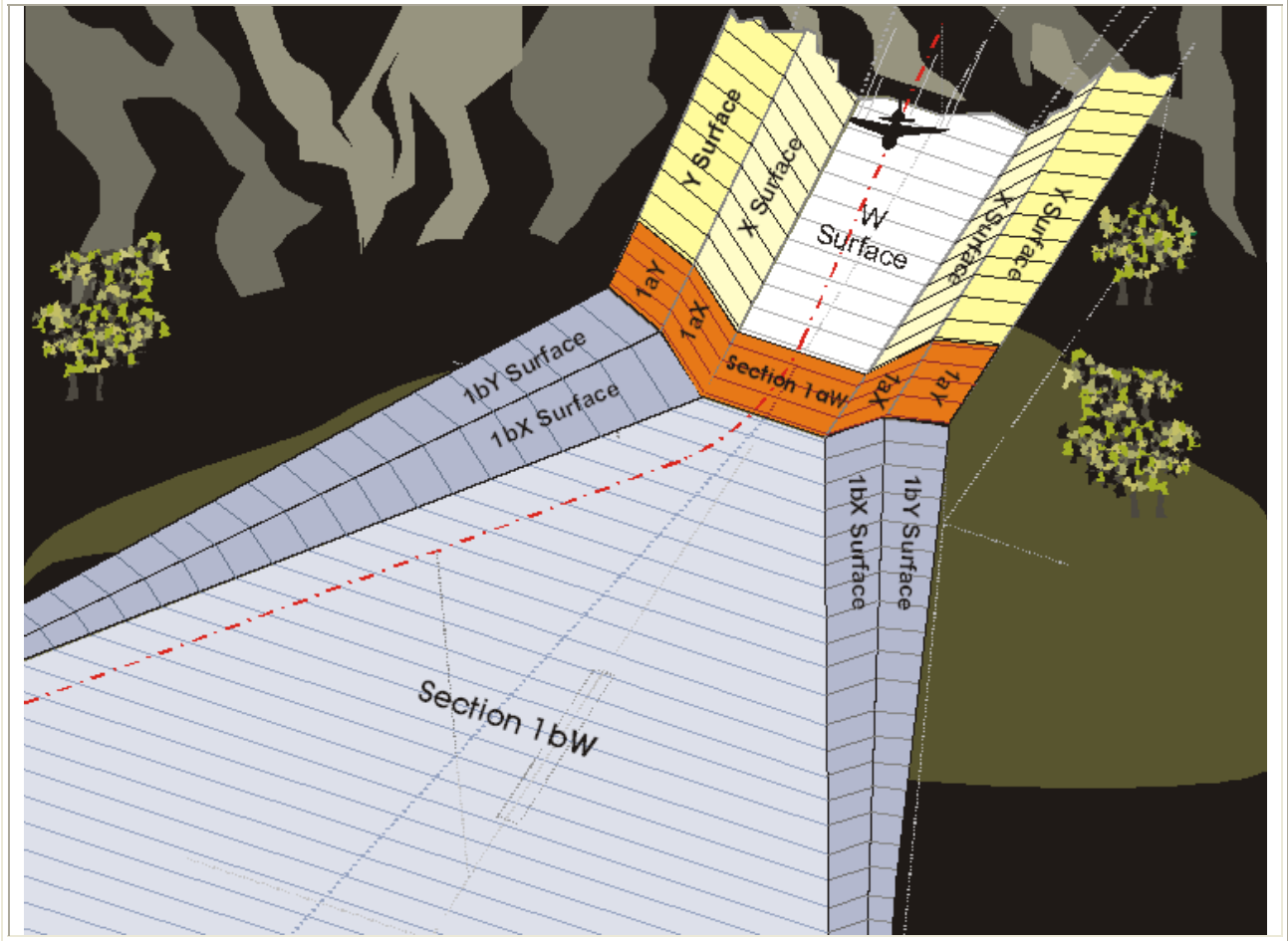
Formula 5-14. Vertical Relief.		
$Z = \frac{d \cdot \theta}{102}$		
where d = "d" from <i>paragraph 5.1.3, formula 5-2</i> θ = glidepath angle		
(d*θ)/102		
Calculator		
θ	<input type="text"/>	Click Here to Calculate
d	<input type="text"/>	
Z	<input type="text"/>	

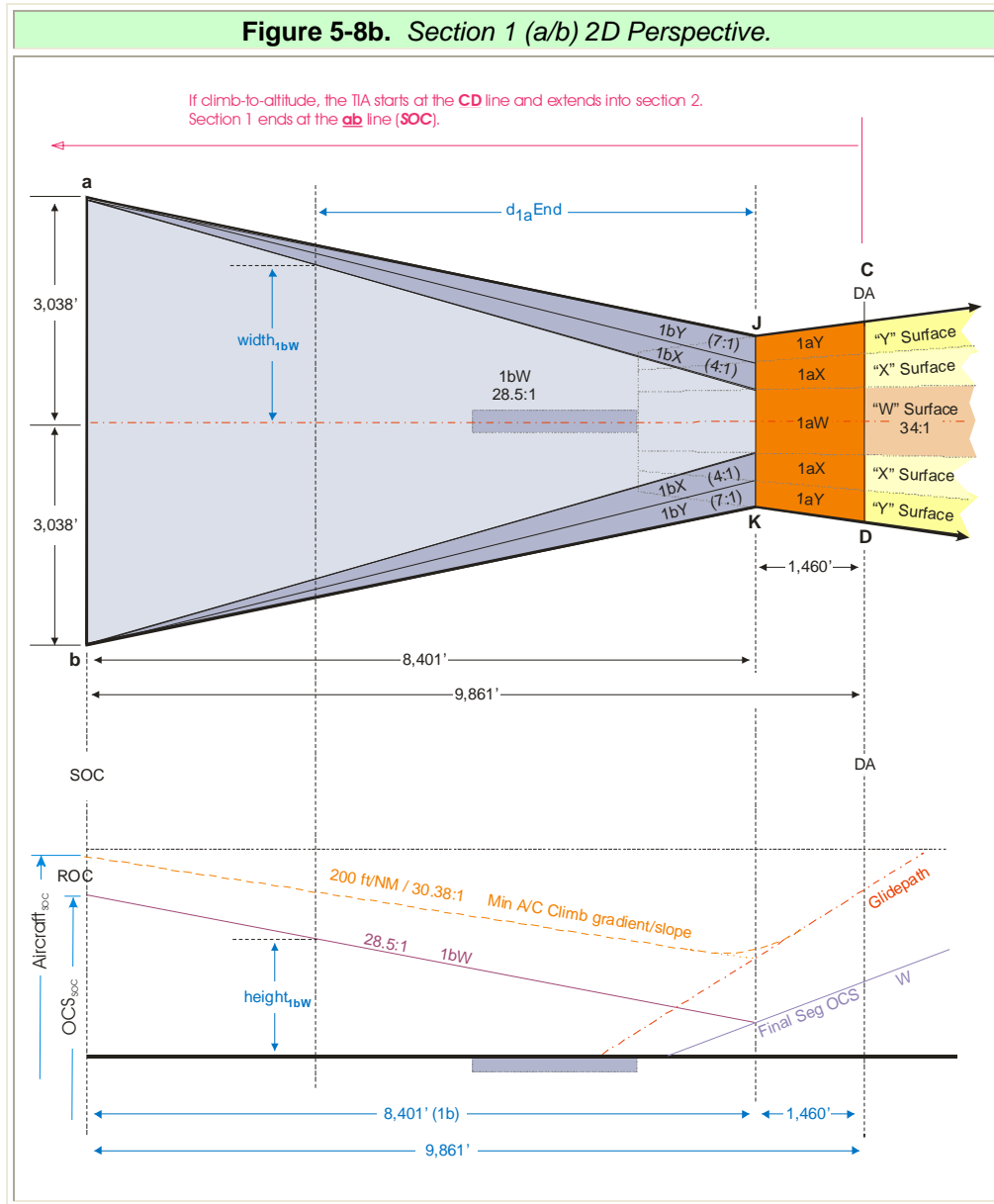
Formula 5-15. TCH Adjustment.		
$TCH_{\text{adjustment}} = \tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot \frac{102 \cdot p}{\theta}$		
where p = penetration (ft) [p ≤ Z] θ = glidepath angle		
$\tan(\theta * \pi / 180) * (102 * p) / \theta$		
Calculator		
θ	<input type="text"/>	Click Here to Calculate
p	<input type="text"/>	
TCH _{adjustment}	<input type="text"/>	

5.8 Missed Approach Section 1 (Height Loss and Initial Climb).

Section 1 begins at *DA* (*CD* line) and ends at the *AB* line. It accommodates height loss and establishment of missed approach climb gradient. Obstacle protection is based on an assumed minimum climb gradient of 200 ft/*NM* (≈30.38:1 slope). Section 1 is centered on a continuation of the final approach track and is subdivided into sections 1a and 1b (*see figures 5-8a and 5-8b*).

Figure 5-8a. Section 1 3D Perspective.





5.8.1 Section 1a.

Section **1a** is a 1,460 ft continuation of the *FAS OCS* beginning at the *DA* point to accommodate height loss. The portion consisting of the continuation of the *W* surface is identified as section **1aW**. The portions consisting of the continuation of the *X* surfaces are identified as section **1aX**. The portions consisting of the continuation of the *Y* surfaces are identified as section **1aY**. Calculate the width and elevation of the section **1aW**, **1aX**, and **1aY** surfaces at any distance from *LTP* using the final segment formulas.

5.8.2 Section 1b.

The section **1b** surface extends from the **JK** line at the end of section 1a as an up-sloping surface for a distance of 8,401 ft to the **AB** line. Section **1b** is subdivided into sections **1bW**, **1bX**, and **1bY** (see figure 5-8b).

5.8.2 a. Section 1bW. Section **1bW** extends from the end of section **1aW** for a distance of 8,401 ft. Its lateral boundaries splay from the width of the end of the **1aW** surface to a width of ± 3,038 ft either side of the missed approach course at the 8,401 ft point. Calculate the width of the **1bW** surface (*width_{1bW}*) at any distance **d_{1aEnd}** from the end of section **1a** using formula 5-16.

Formula 5-16. Section 1bW Boundary Perpendicular Distance.		
$\text{width}_{1bW} = \frac{d_{1aEnd} \cdot (3038 - C_W)}{8401} + C_W$		
where d_{1aEnd} = along-track distance (ft) from end of section 1a C_W = half-width of 1aW surface at section 1a end		
$D_{1aEnd} \cdot (3038 - C_W) / 8401 + C_W$		
Calculator		
d_{1aEnd}	<input type="text"/>	Click Here to Calculate
C_W	<input type="text"/>	
width_{1bW}	<input type="text"/>	

Calculate the elevation of the end of the **1aW** surface (*elev_{1aEnd}*) using formula 5-17.

Formula 5-17. W OCS End Elevation.		
$\text{elev}_{1aEnd} = \frac{\left(r + \text{LTP}_{\text{elev}} - \frac{\theta \cdot (200 + d)}{102} \right) \cdot \cos \left(a \tan \left(\frac{\theta}{102} \right) \right)}{\cos \left(\frac{X_{DA} - d - 1660}{r} + a \tan \left(\frac{\theta}{102} \right) \right)} - r$		
where X_{DA} = along-track distance (ft) from LTP to DA d = value from paragraph 5.1.3		
$\left((r + \text{LTP}_{\text{elev}} - (\theta \cdot (200 + d)) / 102) \cdot \cos(a \tan(\theta / 102)) \right) / \cos((X_{DA} - d - 1660) / r + a \tan(\theta / 102)) - r$		
Calculator		
LTP_{elev}	<input type="text"/>	Click Here to Calculate
θ	<input type="text"/>	
d	<input type="text"/>	
X_{DA}	<input type="text"/>	
elev_{1aEnd}	<input type="text"/>	

The surface rises from the elevation of the **1aW** surface at the end of section 1a at a slope ratio of 28.5:1. Calculate the elevation of the surface (*elev_{1bW}*) using *formula 5-18*.

Formula 5-18. Section 1bW OCS Elevation.		
$elev_{1bW} = (r + elev_{1aEnd}) \cdot e^{\left(\frac{d_{1aEnd}}{28.5 \cdot r}\right)} - r$		
where d_{1aEnd} = along-track distance (ft) from end of section 1a		
$(r + elev_{1aEnd}) \cdot e^{(d_{1aEnd} / (28.5 \cdot r))} - r$		
Calculator		
elev _{1aEnd}		Click Here to Calculate
d _{1aEnd}		
elev _{1bW}		

5.8.2

b. Section 1bX. Section **1bX** extends from the end of section **1aX** for a distance of 8,401 ft. Its inner boundary is the outer boundary of the **1bW** surface. Its outer boundary splays from the end of the **1aX** surface to a width of ± 3,038 ft either side of the missed approach course at the 8,401 ft point. Calculate the distance from the missed approach course centerline to the surface outer boundary (*width_{1bX}*) using *formula 5-19*.

Formula 5-19. Section 1bX Boundary Perpendicular Distance.		
$width_{1bX} = \frac{d_{1aEnd} \cdot (3038 - C_x)}{8401} + C_x$		
where d_{1aEnd} = along-track distance (ft) from end of section 1a C_x = perpendicular distance (ft) from course centerline to 1aX outer edge at section 1a end		
$d_{1aEnd} \cdot (3038 - C_x) / 8401 + C_x$		
Calculator		
d _{1aEnd}		Click Here to Calculate
C _x		
width _{1bX}		

The surface rises at a slope ratio of 4:1 perpendicular to the missed approach course from the edge of the **1bW** surface. Calculate the elevation of the **1bX** missed approach surface (*elev_{1bX}*) using *formula 5-20*.

Formula 5-20. Section 1bX OCS Elevation.		
$elev_{1bX} = elev_{1bW} + \frac{a - width_{1bW}}{4}$		
where a = perpendicular distance (ft) from the MA course		
$elev_{1bW} + (a - width_{1bW}) / 4$		
Calculator		
elev _{1bW}		Click Here to Calculate
a		
width _{1bW}		
elev _{1bX}		

5.8.2

c. Section 1bY. Section **1bY** extends from the end of section **1aY** for a distance of 8,401 ft. Its inner boundary is the outer boundary of the **1bX** surface. Its outer boundary splays from the outer edge of the **1aY** at the surface at the end of section **1a** to a width of ± 3,038 ft either side of the missed approach course at the 8,401 ft point. Calculate the distance from the missed approach course centerline to the surface outer boundary (*width_{1bY}*) using *formula 5-21*.

Formula 5-21. Section 1bY Boundary Perpendicular Distance.		
$width_{1bY} = \frac{d_{1aEnd} \cdot (3038 - C_Y)}{8401} + C_Y$		
where d _{1aEnd} = along-track distance (ft) from end of section 1a C _Y = perpendicular distance (ft) from course centerline to 1aY outer edge at section 1a end		
$d_{1aEnd} \cdot (3038 - C_Y) / 8401 + C_Y$		
Calculator		
d _{1aEnd}		Click Here to Calculate
C _Y		
width _{1bY}		

The surface rises at a slope ratio of 7:1 perpendicular to the missed approach course from the edge of the **1bX** surface. Calculate the elevation of the **1bY** missed approach surface ($elev_{1bY}$) using *formula 5-22*.

Formula 5-22. Section 1bY OCS Elevation.		
$elev_{1bY} = elev_{1bX} + \frac{a - width_{1bX}}{7}$ where a = perpendicular distance (ft) from the MA course		
$elev_{1bX} + (a - width_{1bX}) / 7$		
Calculator		
elev _{1bX}		Click Here to Calculate
a		
width _{1bX}		
elev _{1bY}		

5.9 Surface Height Evaluation.

5.9.1 Section 1a.

Obstacles that penetrate these surfaces are mitigated during the final segment **OCS** evaluation. However in the missed approach segment, penetrations are not allowed; therefore, penetrations must be mitigated by:

- Raising **TCH** (if **GPI** is less than 954 ft).
- Removing or reducing obstruction height.
- Raising glidepath angle.
- Adjusting **DA** (*for existing obstacles*).

5.9.2 DA Adjustment for a Penetration of Section 1b Surface.

The **DA** is adjusted (raised and consequently moved further away from **LTP**) by the amount necessary to raise the **1b** surface above the penetration. For a **1b** surface penetration of **p** ft, the **DA** point must move ΔX_{DA} feet farther from the **LTP** as determined by *formula 5-23*.

Formula 5-23. Along-track DA adjustment.		
$\Delta X_{DA} = \frac{2907 \cdot p}{28.5 \cdot \theta + 102}$		
where p = amount of penetration (ft) θ = glidepath angle		
$2907 \cdot p / (28.5 \cdot \theta + 102)$		
Calculator		
θ		Click Here to Calculate
p		
ΔX _{DA}		

This increase in the **DA** to **LTP** distance raises the **DA** (and **HATH**). Calculate the adjusted **DA** ($DA_{adjusted}$) using *formula 5-24*. Round up the result to the next 1-ft increment.

Formula 5-24. Adjusted DA.		
$DA_{adjusted} = \tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot (X_{DA} + \Delta X_{DA}) + LTP_{elev} + TCH$		
where θ = glidepath angle ΔX _{DA} = from formula 5-23 X _{DA} = from formula 5-11		
$\tan(\theta \cdot \pi / 180) \cdot (X_{DA} + \Delta X_{DA}) + LTP_{elev} + TCH$		
Calculator		
LTP _{elev}		Click Here to Calculate
TCH		
θ		
X _{DA}		
ΔX _{DA}		
DA _{adjusted}		

5.9.3 End of Section 1 Values.

Calculate the assumed *MSL* altitude of an aircraft on missed approach, the *OCS MSL* elevation, and the *ROC* at the end of section 1 (ab line) using *formula 5-25*. The end of section 1 (ab line) is considered *SOC*.

Formula 5-25. Section 1 End (SOC) Values.		
$\text{Aircraft}_{\text{SOC}} = \text{DA} - \tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot 1460 + 276.525$ $\text{OCS}_{\text{SOC}} = (r + \text{elev}_{1\text{Aend}}) e^{\left(\frac{8401}{28.5 \cdot r}\right)} - r$ $\text{ROC}_{\text{SOC}} = \text{Aircraft}_{\text{SOC}} - \text{OCS}_{\text{SOC}}$		
where $r = 20890537$ θ = glidepath angle DA = Published decision altitude (MSL) $\text{elev}_{1\text{Aend}}$ = value from formula 5-17 d = value from paragraph 5.1.3		
$\frac{\text{DA} - \tan(\theta \cdot \pi / 180) \cdot 1460 + 276.525 - (r + \text{elev}_{1\text{Aend}}) \cdot e^{(8401 / (28.5 \cdot r))} + r}{\text{Aircraft}_{\text{SOC}} - \text{OCS}_{\text{SOC}}}$		
Calculator		
DA		Click Here to Calculate
θ		
$\text{elev}_{1\text{Aend}}$		
$\text{Aircraft}_{\text{SOC}}$		
OCS_{SOC}		
ROC_{SOC}		

Chapter 6. Missed Approach Section 2

6.0 General.

6.0 a. Word Usage.

- **Nominal** refers to the designed/standard value, whether course/track or altitude, etc.
- **Altitude** refers to elevation (*MSL*).
- **Height** refers to the vertical distance from a specified reference (geoid, ellipsoid, runway threshold, etc.).

6.0 b. These criteria cover two basic missed approach (*MA*) constructions:

- Straight missed approach
- Turning missed approach

Note: These two construction methods accommodate traditional combination straight and turning missed approaches.

Refer to individual final chapters for *MA* section 1 information. The section 2 *OE*A begins at the end of section 1 (**AB** line), and splays at 15 degrees relative to the nominal track to reach full width (1-2-2-1 within 30 *NM*) (see figure 6-1). See chapter 2, paragraph 2.3 for segment width and expansion guidance. The section 2 standard *OCS* slope begins at the **AB** line. (See paragraph 2.19 and formula 2-22 for information and to calculate precise *OCS* values).

Note: All references to 'standard OCS slope' and use of '40:1' or the '40:1 ratio' refer to the output of formula 2-22 with an input CG of 200ft/NM.

Where a higher climb gradient (*CG*) than the standard *OCS* slope is required, apply the *CG* and its associated *OCS* from *SOC* (See *LPV* chapter for the section 1 *OCS* exception). Apply secondary areas as specified in this chapter. Measure the 12:1 secondary *OCS* perpendicular to the nominal track. In expansion areas, the slope rises in a direction perpendicular from the primary boundary (arc, diagonal corner-cutter, etc.), except where obstacles cannot be measured perpendicularly to a boundary, measure to the closest primary boundary. See figures 6-1 through 6-16 at the end of this chapter. Multiple higher-than-standard *CG*s require Flight Standards approval.

6.1 Straight Missed Approach.

The straight missed approach course is a continuation of the final approach course (*FAC*). The straight *MA* section 2 *OEA* begins at the end of section 1, (the **AB** line) and splays at 15 degrees relative to the nominal track until reaching full primary and secondary width (1-2-2-1 within 30 *NM*). Apply the section 2 standard *OCS*, (calculated for automation), (or the *OCS* associated with a higher *CG*) beginning at the **AB** line from the section 1 end *OCS* elevation. (*Revert to the calculated standard OCS when the increased CG is no longer required*). To determine primary *OCS* elevation at an obstacle, measure the along-track distance from the **AB** line to a point at/abeam the obstacle. Where the obstacle is located in the secondary area, apply the primary *OCS* slope to a point abeam the obstacle, then apply the 12:1 secondary slope (perpendicular to the track), from the primary boundary to the obstacle. *See figure 6-1.*

6.2 Turning Missed Approach (First Turn).

Apply turning criteria when requiring a turn at or beyond *SOC*. Where secondary areas exist in section 1, they continue, (splaying if necessary to reach full width) into section 2, including non-turn side secondary areas into the first-turn wind spiral and outside arc construction (see *figures 6-2, and 6-4 to 6-13*). Terminate turn-at-fix turn-side secondary areas not later than the early turn point. Do not apply turn-side secondary areas for turn-at-altitude construction.

There are two types of turn construction for the first missed approach turn:

- Turn at an altitude (see *paragraph 6.2.1*)
 - Always followed by a *DF* leg ending with a *DF/TF* connection.
- Turn at a fix (see *paragraph 6.2.2*)
 - Always followed by a *TF* leg ending with a *TF/TF* connection, (or *TF/RF*, which requires advanced avionics) when the initial straight leg is less than full width.
 - May be followed by an *RF* leg (which requires advanced avionics) when the initial straight leg has reached full width, ending with an *RF/TF* or *RF/RF* connection.

Following a turn, the minimum segment length (except *DF* legs) must be the greater of:

- The minimum length calculated using the chapter 2 formulas (2-6 and 2-7); or,
- The distance from previous fix to the intersection of the 30 degrees converging outer boundary line extension and the nominal track, (plus segment end fix *DTA* and *ATT*).

Minimum **DF** leg length must accommodate 6 seconds (minimum) of flight time based on the fastest aircraft category (K_{TAS}) expected to use the procedure, applied between the **WS**/direct-to-fix-line tangent point, and the earliest maneuvering point (early turn point) for the **DF/TF** fix. Convert to **TAS** using the **TIA** turn altitude plus the altitude gained at 250 ft/**NM** (Cat A/B), or 500 ft/**NM** (Cat C/D) from the **TIA** end center point to the **DF** fix.

6.2.1 Turn At An Altitude.

Apply turn-at-an-altitude construction unless the first missed approach turn is at a fix. Since pilots may commence a missed approach at altitudes higher than the **DA/MDA** and aircraft climb rates differ, turn-at-an-altitude construction protects the large area where turn initiation is expected. This construction also provides protection for ‘turn as soon as practicable’ and combination straight and tuning operations.

When a required aircraft turning altitude exceeds the minimum turning altitude (typically 400 ft above the airport), specify the turning altitude.

6.2.1 a. Turn Initiation Area (**TIA**).

Construct the **TIA** as a straight missed approach to the climb-to altitude, beginning from the earliest **MA** turn point (**CD** line) and ending where the specified minimum turning altitude (**STEP 1**) is reached (**AB** or **LL'** line, as appropriate). Base the **TIA** length on the climb distance required to reach the turning altitude (see appropriate **STEP 2** below). The **TIA** minimum length must place the aircraft at an altitude from which obstacle clearance is provided in section 2 outside of the **TIA**. The **TIA** boundary varies with length, the shortest **B-A-C-D**, where **AB** overlies **JK**. Where the **TIA** is contained within section 1, **B-A-J-C-D-K** defines the boundary. Where the required turn altitude exceeds that supported by section 1, the **TIA** extends into section 2, (see figure 6-2) and points **L'-L-A-J-C-D-K-B** define its boundary. In this case, **L-L'** is the early turn point based on the aircraft climbing at the prescribed **CG**. Calculate **TIA** length using the appropriate formula, 6-2a, 6-2b, or 6-2c.

*Note: Points **E** and **F** may not be used or may be overridden by the **JK** line.*

STEP 1: Turn altitude. The turn altitude is either operationally specified (must be at or above altitude required by obstacles) or determined by obstacle evaluation. Evaluate the nominal standard **OCS** slope (40:1). If the **OCS** is penetrated, mitigate the penetration with one or a combination of the following:

- a. Raise **DA/MDA**
- b. Establish a climb gradient that clears the obstacle
- c. Move **MAP**
- d. If penetration is outside **TIA**, consider raising the climb-to altitude

6.2.1

a. (1) Determine the aircraft required minimum turning altitude based on obstacle evaluation:

- Identify the most significant obstacle in section **2** (straight **MA**)
 - For straight **OCS/CG/length** options
- Identify the most significant/controlling obstacle outside the **TIA**, (typically turn-side).
- Find the shortest distance from the **TIA** lateral boundary to the obstacle
- Apply this distance and the standard **OCS** slope, (or higher **CG** associated slope) to find the **TIA**-to-obstacle **OCS** rise.
- The minimum **TIA OCS** boundary elevation, (and **OCS** end elevation) equals the obstacle elevation minus **OCS** rise.
- The minimum turn altitude is the sum of **TIA OCS** boundary elevation and:
 - 100 ft for non-vertically guided procedures, or
 - The *table 4-2 ROC* value for vertically guided procedures, rounded to the next higher 100-ft increment.

Note 1: TIA lateral boundary is the straight segment (portion) lateral boundary until the required minimum turn altitude and TIA length are established.

Note 2: Repeat step 1 until acceptable results are obtained.

The specified turn altitude must equal or exceed the section **1** end aircraft altitude. Apply *formula 5-25* to find **LPV** section **1** end altitude ($Aircraft_{SOC}$), and section **1** **OCS** end elevation (OCS_{SOC}). Find non-**LPV** section **1** end altitude using *formula 6-1*.

Formula 6-1. Section 1 End Aircraft Altitude (Non-LPV).

$$\text{Aircraft}_{\text{SOC}} = (r + \text{MDA or DA}) \cdot e^{\frac{\text{AB}_{\text{NM}} \cdot \text{CG}}{r}} - r$$

Where AB_{NM} = SOC to AB distance (NM)
 r = Earth radius (20890537 ft)
 CG = applied climb gradient (ft/NM)

$$(r + (\text{MDA or DA})) \cdot e^{((\text{AB}_{\text{NM}} \cdot \text{CG})/r)} - r$$

MDA or DA		Click Here To Calculate
SOC to AB distance NM		
CG		
Aircraft _{SOC}		

The section 2 standard **OCS** slope, (or the higher slope associated with the prescribed climb (**CG**)) begins at the **AB** line **OCS** elevation. See figures 6-2 through 6-7. See appropriate final chapters for the variable values associated with each final type.

STEP 2 (LPV): Calculate LPV **TIA** length using formula 6-2a1/6.2a2 (see paragraph 5.8 for further section 1 details). Apply **TIA** calculated lengths from the **CD** line.

Where an increased **CG** terminates prior to the **TIA** turn altitude, apply formula 6-2a1, otherwise apply formula 6-2a2.

Formula 6-2a1. TIA Length Multi-CG (LPV).

$$\text{TIA}_{\text{length}} = 9861 + \frac{r}{\text{CG1}} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + \text{CG1}_{\text{termalt}}}{r + \text{Aircraft}_{\text{SOC}}}\right) + \frac{r}{\text{CG2}} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + \text{turn}_{\text{alt}}}{r + \text{CG1}_{\text{termalt}}}\right)$$

where $\text{CG1}_{\text{termalt}}$ = Initial CG termination altitude
 r = Earth Radius (20890537 ft)
 turn_{alt} = required turn altitude
 $\text{Aircraft}_{\text{SOC}}$ = SOC Aircraft Altitude (formula 5-25)
 CG1 = Initial Climb Gradient (\geq Standard 200)
 CG2 = Second Climb Gradient (Standard 200)

$$9861 + r/\text{CG1} \cdot 1852/0.3048 \cdot \ln((r + \text{CG1}_{\text{termalt}})/(r + \text{Aircraft}_{\text{SOC}})) + r/\text{CG2} \cdot 1852/0.3048 \cdot \ln((r + \text{turn}_{\text{alt}})/(r + \text{CG1}_{\text{termalt}}))$$

Calculator

turn _{alt}		Click Here To Calculate
Aircraft _{SOC}		
CG1 _{termalt}		
CG1 (ft/NM)		
CG2 (ft/NM)		
TIA _{length} (ft)		

Formula 6-2a2. TIA Length Single-CG (LPV).		
$TIA_{length} = 9861 + \frac{r}{CG} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + turn_{alt}}{r + Aircraft_{SOC}}\right)$		
where $turn_{alt}$ = required turn altitude r = Earth Radius (20890537 ft) $Aircraft_{SOC}$ = SOC Aircraft Altitude (formula 5-25) CG = Climb Gradient (Standard 200)		
$9861+r/CG*1852/0.3048*\ln((r+turn_{alt})/(r+Aircraft_{SOC}))$		
Calculator		
turn _{alt}		Click Here To Calculate
Aircraft _{SOC}		
CG		
TIA _{length} (ft)		

STEP 2 (LNAV/LP): Calculate **LNAV** and **LP TIA** length using *formula 6-2b* and the appropriate **FSL** value (see *paragraph 3.7* for further section 1 details).

Where an increased **CG** terminates prior to the **TIA** turn altitude, apply *formula 6-2b1*, otherwise apply *formula 6-2b2*.

Formula 6-2b1. TIA Length Multi-CG (LNAV/LP).		
$TIA_{length} = FSL \cdot \frac{r}{(r + MDA)} + \frac{r}{CG1} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + CG1_{termalt}}{r + MDA}\right) + \frac{r}{CG2} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + turn_{alt}}{r + CG1_{termalt}}\right)$		
where $CG1_{termalt}$ = Initial CG termination altitude r = Earth Radius (20890537 ft) MDA = Aircraft Final MDA $CG1$ = Initial Climb Gradient (Standard 200) $CG2$ = Second Climb Gradient (Standard 200)		
$FSL*r/(r+MDA)+r/CG1*1852/0.3048*\ln((r+CG1_{termalt})/(r+MDA))+r/CG2*1852/0.3048*\ln((r+turn_{alt})/(r+CG1_{termalt}))$		
Calculator		
FSL (<i>formula 3-5</i>)(ft)		Click here to Calculate
turn _{alt}		
MDA		
CG1 _{termalt}		
CG1 (ft/NM)		
CG2 (ft/NM)		
TIA _{length} (ft)		

Formula 6-2b2. TIA Length Single-CG (LNAV/LP).

$$TIA_{length} = FSL \cdot \frac{r}{(r + MDA)} + \frac{r}{CG} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + turn_{alt}}{r + MDA}\right)$$

where $turn_{alt}$ = required turn altitude
 r = Earth Radius (20890537 ft)
 DA = Final DA
 CG = Climb Gradient (Standard 200)

FSL*(r/(r+MDA))+r/CG*1852/0.3048*ln((r+turn_{alt})/(r+MDA))

Calculator

FSL (formula 3-5)(ft)		Click Here to Calculate
turn _{alt}		
MDA		
CG		
TIA _{length} (ft)		

STEP 2 (LNAV/VNAV): Calculate **LNAV/VNAV TIA** length using *formula 6-2c* (see *paragraph 4.4* for further section 1 details).

Where an increased **CG** terminates prior to the **TIA** turn altitude, apply *formula 6-2c1*, otherwise apply *formula 6-2c2*.

Formula 6-2c1. TIA Length Multi-CG (LNAV/VNAV).

$$TIA_{length} = FSL \cdot \frac{r}{(r + DA)} + \frac{r}{CG1} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + CG1_{termalt}}{r + DA}\right) + \frac{r}{CG2} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + turn_{alt}}{r + CG1_{termalt}}\right)$$

where $CG1_{termalt}$ = Initial CG termination altitude
 r = Earth Radius (20890537 ft)
 DA = Aircraft Final DA
 CG1 = Initial Climb Gradient (≥Standard 200)
 CG2 = Second Climb Gradient (Standard 200)

FSL*r/(r+DA)+r/CG1*1852/0.3048*ln((r+CG1_{termalt})/(r+DA))+r/CG2*1852/0.3048*ln((r+turn_{alt})/(r+CG1_{termalt}))

Calculator

FSL (formula 4-15a)(ft)		Click Here to Calculate
turn _{alt}		
DA		
CG1 _{termalt}		
CG1 (ft/NM)		
CG2 (ft/NM)		
TIA _{length} (ft)		

Formula 6-2c2. TIA Length (LNAV / VNAV).		
$TIA_{length} = FSL \cdot \frac{r}{(r + DA)} + \frac{r}{CG} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + turn_{alt}}{r + DA}\right)$		
where turn _{alt} = required turn altitude r = Earth Radius (20890537 ft) DA = Final DA CG = Climb Gradient (Standard 200)		
$FSL \cdot r / (r + DA) + r / CG \cdot 1852 / 0.3048 \cdot \ln((r + turn_{alt}) / (r + DA))$		
Calculator		
FSL (<i>formula 4-15a</i>) (ft)		Click Here to Calculate
turn _{alt}		
DA		
CG		
TIA _{length} (ft)		

STEP 3: Locate the **TIA** end at a distance **TIA** length beyond **CD** (from **STEP 2**) (**LL'**). See figure 6-2.

The **OEA** includes areas to protect the earliest and latest direct tracks from the **TIA** to the fix. Construct the obstacle areas about each of the tracks as described below. See figures 6-2 through 6-9 for various turn geometry construction illustrations.

6.2.1 b. OEA Construction after TIA.

6.2.1 b. (1) Early Turn Track and OEA Construction.

Where the early track from the **FAC/CD** intersection defines a turn less than or equal to 75 degrees relative to the **FAC**, the tie-back point is point **C** (see figure 6-3); if the early track defines a turn greater than 75 degrees relative to the **FAC**, the tie-back point is point **D** (see figure 6-4). Where the early track represents a turn greater than 165 degrees, begin the early turn track and the 15 degrees splay from the non-turn side **TIA** end + **rr** (*formula 2-4*) (**PP'**) (see figure 6-5).

STEP 1: Construct a line (representing the earliest-turn flight track) from the tie back point, to the fix. See figure 6-2.

STEP 2: Construct the outer primary and secondary **OEA** boundary lines parallel to this line (1-2-2-1 segment width). See figure 6-2.

STEP 3: From the tie-back point, construct a line splaying at 15 degrees to intersect the parallel boundary lines or segment end, whichever occurs earlier (see figure 6-2 and 6-3).

Apply secondary areas only after the 15 degrees splay line intersects the primary boundary line.

6.2.1 b. (2) Late Turn Track and OEA Construction.

Apply wind spirals for late-turn outer boundary construction using the following calculations, construction techniques, and 15-degree bank angles. Calculate **WS** construction parameters for the appropriate aircraft category.

STEP 1: Find the no-wind turn radius (**R**) using *formula 6-3*.

Note: Apply the category's indicated airspeed from table 2-3 and the minimum assigned turn altitude when converting to true airspeed for this application.

Formula 6-3. No Wind Turn Radius (R).		
$R = \frac{(V_{KTAS} + 0)^2}{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot 68625.4}$		
$(V_{KTAS}+0)^2/(\tan(15*\pi/180)*68625.4)$		
Calculator		
V _{KTAS}		Click Here to Calculate
R		

STEP 2: Calculate the Turn Rate (**TR**) using *formula 6-3*. Maximum **TR** is 3 degrees per second. Apply the lower of 3 degrees per second or *formula 6-3a* output.

Formula 6-3a. TR.		
$TR = \frac{3431 \cdot \tan\left(15 \cdot \frac{\pi}{180}\right)}{\pi \cdot V_{KTAS}}$		
$(3431*\tan(15*\pi/180))/(\pi*V_{KTAS})$		
Calculator		
V _{KTAS}		Click Here to Calculate
TR		

STEP 2a: Calculate the Turn Magnitude (**TMAG**) using the appropriate no-wind turn radius and the arc distance (in degrees) from start of turn (at **PP'**) to the point of tangency with a line direct to the fix.

STEP 2b: Calculate the highest altitude in the turn using *formula 2-2* (see Missed Approach note following the formula). Determine altitude at subsequent fixes using fix-to-fix direct measurement and 500 ft per *NM* climb rate.

STEP 3: Find the omni-directional wind component (V_{KTW}) for the highest altitude in the turn using *formula 2-3b*.

STEP 4: Apply this common wind value (STEP 3) to all first-turn wind spirals.

Note: Apply 30 knots for turn altitudes $\leq 2,000$ ft above airport elevation.

STEP 5: Calculate the wind spiral radius increase (ΔR) (relative R), for a given turn magnitude (ϕ) using *formula 6-4*.

Formula 6-4. WS ΔR .		
$\Delta R = \frac{V_{KTW} \cdot \phi}{3600 \cdot TR}$		
Where ϕ = Degrees of turn TR = <i>Formula 6-3</i> (Max 3 degrees/second) V_{KTW} = <i>Formula 2-3b</i> Wind Speed		
$\phi * V_{KTW} / 3600 * TR$		
Calculator		
V_{KTW}		Click Here to Calculate
ϕ		
ΔR (NM)		
ΔR (ft)		

Note: See ΔR examples in figures 6-2 to 6-5.

STEP 6: Wind Spiral Construction (*see paragraph 6.4*).

6.2.2 Turn-At-A-Fix.

The first **MA** turn-at-a-fix may be a fly-by or fly-over fix. Use fly-by unless a fly-over is required for obstacle avoidance or where mandated by specific operational requirements. The turn fix early-turn-point must be at or beyond section 1 end.

6.2.2 a. Early/Late Turn Points.

The fly-by fix early-turn-point is located at (**FIX-ATT-DTA**) prior to the fix.

The fly-by fix late-turn-point is located at a distance (**FIX + ATT – DTA + rr**) from the fix.

The fly-over early-turn-point is located at a distance ($FIX - ATT$) prior to the fix.

The fly-over late-turn-point is located at a distance ($FIX + ATT + rr$) beyond the fix.

Fly-by fixes (see figure 6-10).

$$Early_{TP} = Fix - ATT - DTA$$

$$Late_{TP} = Fix + ATT - DTA + rr$$

Fly-over fixes (see figure 6-10).

$$Early_{TP} = Fix - ATT$$

$$Late_{TP} = Fix + ATT + rr$$

6.2.2

b. Turn-at-a-Fix (First MA turn) Construction.

The recommended maximum turn is 70 degrees; the absolute maximum is 90 degrees. The first turn fix must be located on the final approach track extended.

STEP 1: Calculate aircraft altitude at the **AB** line using formula 6-1.

STEP 2: Calculate fix distance based on minimum fix altitude. Where the first fix must be located at the point the aircraft reaches or exceeds a specific altitude, apply formula 6-5 (using the assigned/applied **CG**), to calculate fix distance (D_{fix}) (**NM**) from the **AB** line.

Formula 6-5. Fix Distance (D_{fix}).		
$D_{fix} = \ln\left(\frac{Alt_{fix} + r}{Aircraft_{SOC} + r}\right) \cdot \frac{r}{CG}$		
where Alt_{fix} = Minimum altitude required at fix $Aircraft_{SOC}$ = Aircraft AB line (SOC) altitude CG = Climb Gradient (Standard 200 ft/NM)		
$\ln((Alt_{fix}+r)/(Aircraft_{soc}+r))*r/CG$		
Calculator		
Alt_{fix}		Click Here to Calculate
$Aircraft_{SOC}$		
CG		
D_{fix} (NM)		

STEP 3: Calculate the altitude an aircraft climbing at the assigned **CG** would achieve over an established fix using *formula 6-6*.

Formula 6-6. Altitude Achieved at Fix.		
$Alt_{fix} = (r + Aircraft_{SOC}) \cdot e^{\left(\frac{CG \cdot D_{fix}}{r}\right)} - r$		
where D_{fix} = Distance (ft) from <u>AB</u> line to fix Aircraft _{SOC} = Aircraft <u>AB</u> line (SOC) altitude CG = Climb Gradient (Standard 200 ft/NM)		
$(r+Aircraft_{SOC}) * e^{(CG*D_{fix}/r)-r}$		
Calculator		
D_{fix} (NM)		Click Here to Calculate
Aircraft _{SOC}		
CG		
Alt _{fix}		

6.2.2 c. Fly-By Turn Calculations and Construction.
 (Consider direction-of-flight-distance positive, opposite-flight-direction distance negative).

6.2.2 c. (1) Fly-By Turn Calculations.

STEP 1: Calculate the fix to early-turn distance ($D_{earlyTP}$) using *formula 6-7*.

Formula 6-7. Early Turn Distance.		
$D_{earlyTP} = ATT + DTA$		
where ATT = along-track tolerance DTA = distance of turn anticipation		
$ATT+DTA$		
Calculator		
ATT		Click Here to Calculate
$DTA_{(FORMULA\ 2-5)}$		
$D_{earlyTP}$		

6.2.2 c. (2) **Early Turn Area Construction.**

Table 6-1. Inside Turn Expansion Guide.	
OB Segment Boundary Relative ETP Connections	Expansion Line Required
Secondary & Primary PRIOR ETP	15° Line
Secondary Prior ETP	15° Line
Primary Beyond ETP	A/2
Secondary & Primary Beyond ETP	A/2

Note: ETP = LL' early turn point connection, 15-degree line relative OB segment, A/2 = half turn-angle

6.2.2 c. (3) **Inside turn (Fly-By) Construction** is predicated on the location of the **LL'** and primary/secondary boundary intersections (early turn connections), relative the outbound segment, *see table 6-1. See figures 6-11a, 6-11b, 6-11c, and 6-12.*

See similar construction *figure 6-6.*

Where no inside turn secondary area exists in section **1**, apply secondary areas only after the turn expansion line/s intersect the outbound segment boundaries.

Apply the same technique to primary and secondary area connections when both inbound segment connection points fall either outside the outbound segment, or inside the outbound segment primary area. When both inbound connection points are within the outbound segment secondary area, or its extension, *table 6-1* displays a connection method for each point.

Note: Where half-turn-angle construction is indicated, apply a line splaying at the larger of, half-turn-angle, or 15 degrees relative the outbound track. Where a small angle turn exists and standard construction is suitable for one, but not both splays; connect the uncommon splay, normally primary, to the outbound primary boundary at the same along-track distance as the secondary connection. Maintain or increase primary area as required.

STEP 1: Construct a baseline (**LL'**) perpendicular to the inbound track at distance D_{earlyTP} (*formula 6-6*) prior to the fix.

CASE 1: The outbound segment boundary, or its extension, is **beyond** the baseline (early-turn connection points are **prior** to the outbound segment boundary).

STEP 1: Construct the inside turn expansion area with a line, drawn at one-half the turn angle from the inbound segment primary early turn connection point, to intercept the outbound segment primary boundary (*see figures 6-11a, 6-6*).

STEP 2 (if required): Construct the inside turn expansion area with a line, drawn at one-half the turn angle, from the inbound segment secondary early turn connection point, to intercept the outbound segment secondary boundary (*see figure 6-11a*).

CASE 2: The outbound segment secondary boundary or its extension is **prior** to the **LL'** baseline and outbound segment primary boundary or its extension is beyond the **LL'** baseline, (early-turn connection points are both **within** the outbound segment secondary area or its extension).

STEP 1: Construct the inside-turn expansion area with a line splaying at 15 degrees, (relative the outbound track) from the inbound segment secondary early turn connection point to intersect the outbound segment boundary.

STEP 1 Alt: Begin the splay from **L'** when the turn angle exceeds 75 degrees.

STEP 2: Construct the primary boundary with a line, drawn at one-half the turn angle, from the inbound segment primary early turn connection point to intercept the outbound segment primary boundary (*see figure 6-11b*).

CASE 3: The outbound segment secondary and primary boundaries, or their extensions, are **prior** to the **LL'** baseline (early-turn connection points are **inside** the outbound segment primary area).

STEP 1: Construct the inside turn expansion area with a line, splaying at 15 degrees (relative the outbound track) from the more conservative point, (**L'**) or (the intersection of **LL'** and the inbound segment inner primary boundary), to intersect the outbound segment boundaries.

STEP 1 Alt: Begin the splay from **L'** when the turn angle exceeds 75 degrees.

In this case, the inside turn secondary area is terminated at the outbound segment primary boundary, as it falls before the early turn points, **LL'** (*see figure 6-11c* for **L'** connection).

6.2.2

c. (4) Outside Turn (Fly-By) Construction.

STEP 1: Construct the outer primary boundary using a radius of one-half primary width (2 NM), centered on the plotted fix position, drawn from the inbound segment extended primary boundary until tangent to the outbound segment primary boundary (*see figures 6-11a through 6-11c*). *See figure 6-7.*

STEP 2: Construct the secondary boundary using a radius of one-half segment width ($3 NM$), centered on the plotted fix position, drawn from the inbound segment extended outer boundary until tangent to the outbound segment outer boundary (see figures 6-11a through 6-11c). See figure 6-7.

6.2.2 d. Fly-Over Turn Construction.

6.2.2 d. (1) Inside Turn (Fly-Over) Construction.

STEP 1: Construct the early-turn baseline (LL') at distance **ATT** prior to the fix, perpendicular to the inbound nominal track.

STEP 2: Refer to paragraph 6.2.2.c(3), (skip STEP 1).

6.2.2 d. (2) Outside Turn (Fly-Over) Construction.

STEP 1: Construct the late-turn baseline (PP') at distance ($ATT + rr$) beyond the fix, perpendicular to the inbound nominal track. Calculate late turn distance using formula 6-7.

STEP 2: Apply wind spiral outer boundary construction for the first **MA** fly-over turn. See paragraph 6.2.1b.(2) for necessary data, using the higher of formula 6-6 output, or the assigned fix crossing altitude for TAS and turn radius calculations. Apply paragraph 6.4 for wind spiral construction. A non-turn side secondary area may extend into the **WSI** area.

6.2.2 d. (3) Obstacle Evaluations. See paragraph 6.2.3.

6.2.3 Section 2 Obstacle Evaluations.

6.2.3 a. Turn at an Altitude Section 2.

Apply the standard **OCS** slope, (or the assigned **CG** associated slope) slope to section 2 obstacles (during and after the turn) based on the shortest primary area distance (**do**) from the **TIA** boundary to the obstacle. *Shortest primary area distance is the length of the shortest line kept within primary segments that passes through the early turn baseline of all preceding segments.*

STEP 1: Measure and apply the **OCS** along the shortest primary area distance (**do**) from the **TIA** boundary to the obstacle (single and multiple segments). See figures 6-2 through 6-13, (skip 6-10) for various obstacle measurement examples.

STEP 2: For obstacles located in secondary areas, measure and apply the **OCS** along the shortest primary area distance (**do**) from the **TIA** boundary to the primary boundary abeam the obstacle, then the 12:1 slope along the shortest distance to the obstacle, (taken perpendicular to the nominal track or in expansion

areas, to the primary arc, the primary corner-cutter, corner apex, or other appropriate primary boundary). Where an obstacle requires multiple measurements (*an obstacle is equidistant from multiple primary boundary points, or lies along perpendiculars from multiple primary boundary points, etc.*), apply the more adverse result from each of the combined primary/secondary measurements. *See figures 6-1 and 6-2 through 6-11c.*

6.2.3 b. Turn at Fix Section 2.

Apply the standard **OCS** slope, (or the assigned **CG** associated slope) beginning at the **AB** line at the inbound-segment end **OCS** height.

STEP 1: Measure and apply the **OCS** along the shortest distance (**do**) from the **AB** line (parallel to track) to **LL'**, the shortest primary distance to the obstacle (single and multiple segments). *See figures 6-2 through 6-13, (skip 6-10) for various obstacle measurement examples.*

STEP 2: For obstacles located in secondary areas, measure and apply the **OCS** along the shortest primary area distance (**do**) from the **TIA** boundary to the primary boundary abeam the obstacle, then the 12:1 slope along the shortest distance to the obstacle, (taken perpendicular to the nominal track or in expansion areas, to the primary arc, the primary corner-cutter, corner apex, or other appropriate primary boundary). Where an obstacle requires multiple measurements (*where an obstacle is equidistant from multiple primary boundary points, or lies along perpendiculars from multiple primary boundary points, etc.*), apply the more adverse result from each of the combined primary/secondary measurements (*see figures 6-6 through 6-8*). Additional obstacle measurement examples appear in *figures 6-1 through 6-11c*.

6.3 Turning Missed Approach (Second Turn).

6.3.1 DF/TF Turn (Second Turn, following turn-at-altitude).

Turns at the **DF** path terminator fix will be fly-by or fly-over to a **TF** leg. In either case, the outer boundary provides fly-over protection, and the inner boundary provides fly-by protection. Maximum turn angle is 90 degrees (applicable to both tracks within the **DF** segment). This application provides that construction under *chapter 2*, or this chapter will apply, including cases where the inside and outside turn construction differs.

6.3.1 a. DF/TF (Fly-By) Turn.

6.3.1 a. (1) Inside DF/TF (Fly-By) construction.

CASE 1: Full width inside secondary exists at the early turn point (**LL'**).

STEP 1: Construct a baseline (**LL'**) perpendicular to the inbound track nearer the turn side boundary at distance D_{earlyTP} (*formula 6-6*) prior to the fix.

STEP 2: Apply chapter 2, *paragraph 2.5.2* criteria.

CASE 2: Less than full width inside secondary exists at (**LL'**).

STEP 1: Apply *paragraph 6.2.2.c(3)* criteria.

6.3.1

a. (2) Outside *DF/TF* (Fly-By) construction.

CASE 1: Full width outside secondary exists at the early turn point (**L'L''**).

STEP 1: Construct a baseline (**L'L''**) perpendicular to the inbound track nearer the non-turn side boundary at distance D_{earlyTP} (*formula 6-6*) prior to the fix.

STEP 2: Apply chapter 2, *paragraph 2.5.2* criteria. See *figures 6-6 through 6-8*.

CASE 2: Less than full width outside secondary exists at (**L'L''**).

STEP 1: Apply *paragraph 6.2.2.c(4)* criteria.

6.3.1

b. *DF/TF* (Fly-Over) Turn.

6.3.1

b. (1) Inside *DF/TF* (Fly-Over) Turn Construction.

STEP 1: Construct a baseline (**LL'**) perpendicular to the inbound track nearer the turn side boundary at distance *ATT* prior to the fix (*see figure 6-9*).

Note: Where half-turn-angle construction is specified, apply a line splaying at the larger of half-turn-angle or 15 degrees relative the outbound track.

CASE 1: No inside secondary area exists at **LL'**.

STEP 1: Create the *OEA* early-turn protection by constructing a line, splaying at the larger of one-half (1/2) the turn angle, or 15 degrees relative the outbound track, from the intersection of **LL'** and the inbound segment inner primary boundary to connect with the outbound *TF* segment boundaries.

The *TF* secondary area begins at the intersection of this diagonal line and the outbound segment boundary.

CASE 2: Partial width inside secondary area exists at LL'.

STEP 1: Create the *OEA* early-turn primary area protection by constructing a line, splaying at the larger of one-half (1/2) the turn angle, or 15 degrees relative the outbound track, from the intersection of LL' and the inbound segment inner primary boundary to connect with the *TF* segment primary boundary.

STEP 2: Create the *OEA* early-turn secondary protection by constructing a line, splaying at the larger of one-half (1/2) the turn angle, or 15 degrees relative the outbound track, from the intersection of LL' and the inbound segment inner boundary to connect with the *TF* segment boundary.

CASE 3: Full width inside secondary area exists at LL'.

STEP 1: Apply chapter 2 criteria. *See figure 6-9.*

6.3.1 b. (2) Outside DF/TF (Fly-Over) Turn Construction.

STEP 1: Construct the late-turn baseline for each inbound track, (PP') for the track nearer the inside turn boundary, and (P'P'') for the outer track at distance (*ATT + rr*) beyond the fix, perpendicular to the appropriate inbound track. *See figure 6-9.*

Note: A DF/TF Fly-Over turn is limited to 90 degrees (both inbound tracks) and should require no more than one WS per baseline. Construct the outside track WS (WS1) on base line P'P'', then construct WS2 on baseline PP'.

STEP 2: Apply wind spiral construction, see *paragraph 6.2.1.b(2)* for necessary data, and *paragraph 6.4* for wind spiral construction *See figure 6-9.*

6.3.2 TF/TF Turn (Second Turn, following turn-at-fix).

Turns at the *TF* path terminator fix will be fly-by or fly-over to a *TF* leg. In either case, the outer boundary provides fly-over protection, and the inner boundary provides fly-by protection. Maximum turn angle is 90 degrees. This application provides that construction under *chapter 2*, or this chapter will apply, including cases where the inside and outside turn construction differs.

6.3.2 a. TF/TF (Fly-By) Turn.**6.3.2 a. (1) Inside TF/TF (Fly-By) construction.**

STEP 1: Apply chapter 2, *paragraph 2.5.2* criteria.

6.3.2 a. (2) Outside *TF/TF* (Fly-By) construction.

STEP 1: Apply chapter 2, *paragraph 2.5.1* criteria.

6.3.2 b. *TF/TF* (Fly-Over) Turn.

6.3.2 b. (1) Inside *TF/TF* (Fly-Over) Turn Construction.

STEP 1: Apply chapter 2, *paragraph 2.5.2* criteria.

6.3.2 b. (2) Outside *TF/TF* (Fly-Over) Turn Construction.

STEP 1: Apply chapter 2, *paragraph 2.5.1* criteria.

6.4 Wind Spiral Cases.

Wind Spiral (*WS*) construction applies to turn-at-an-altitude, turn-at-a-fix (Fly-Over) for the first *MA* turn, and *DF/TF* (Fly-Over) for the second turn. The late-turn line **P'** designator is typically placed where the baselines cross. Where baseline extension is required, mark each baseline inner end with **P'**.

Each *WS* has several connection options along its boundary. The chosen connection/s must provide the more reasonably conservative, (larger area) track and protection areas (*see figures 6-14a, 6-14b, and 6-14c* for examples).

- A 15-degree, (or greater*) splay line to join outbound segment outer boundaries, from:
 - *WS*/direct-to-fix tangent point
 - *WS* to *WS* tangent line origin
 - *WS* to *WS* tangent line end
 - *WS*/outbound segment parallel point (*DF* segment *NA*)
- A tangent line to join the next *WS*
- A tangent line direct to the next fix (*DF* segment)
- A tangent line, converging at 30 degrees to the segment track (*TF* segment)

**Note: See paragraph 6.4.1.a and b for alternate connection details.*

Outbound segment type and turn magnitude are primary factors in *WS* application. Refer to *table 6-2* for basic application differences. Calculate *rr* using *formula 2-4*.

Table 6-2. MA First Turn Wind Spiral Application Comparison.		
	Turn At Fix (FO)	Turn At Altitude
WS1 Baseline (PP')	Fix + $ATT + rr$	$TIA + rr$
WS2 Baseline (PP')	Fix + $ATT + rr$	$TIA + rr$
WS Number	1 or 2	1, 2, or 3 *
Final WS Connection (Tangent line)	30 degrees to outbound track	Direct to Fix

* Where a required turn exceeds that served by three wind spirals, consider adding fixes to avoid prohibitively large protection areas resulting from further wind spiral application.

6.4 a. Turn-at-Fix (FO) and Turn-at-Altitude WS Comparison.

Three cases for outer-boundary wind spirals commonly exist:

- (Case 1), Small angle turns use one wind spiral (**WS1**);
- (Case 2), Turns near/exceeding 90° ~ use a second wind spiral (**WS2**); and
- (Case 3), turns near/exceeding 180° ~ use a third wind spiral (**WS3**).

6.4 a. (1) Turn-at-Altitude WS application concludes with a line tangent to the final WS direct to the next fix.

6.4 a. (2) Turn-at-Fix (FO) WS application concludes with a line tangent to the final WS converging at a 30-degree angle to the outbound segment nominal track. The intersection of this line with the nominal track establishes the earliest maneuvering point for the next fix. The minimum segment length is the greater of:

- The minimum length calculated using the *chapter 2 formulas (2-6 and 2-7)*; or,
- The distance from previous fix to the intersection of the 30-degree converging outer boundary line extension and the nominal track, (plus **DTA** and **ATT**). See paragraph 6.2.2.c.3.

6.4 a. (3) Second MA Turn DF/TF Turn-at-Fix (FO) WS application concludes with a line tangent to the final WS converging at a 30-degree angle to the outbound segment nominal track. This construction requires two WS baselines, one for each inbound track. Each late turn baseline is located ($ATT + rr$) beyond the fix, oriented perpendicular to the specific track. The baseline for the inbound track nearer the inside turn boundary is designated **PP'**, the baseline associated

with the outside turn track is designated **P'P''**. For convenience **P'** is often placed at the intersection of the two baselines, but a copy properly goes with each baseline inner end where baseline extensions are required.

6.4.1 First MA Turn WS Construction.

Find late turn point distance (D_{lateTP}) using *formula 6-8*.

Formula 6-8. Late Turn Point Distance.		
$D_{lateTP} = ATT + rr$ where ATT = along-track tolerance rr = delay/roll-in <i>formula 2-4</i>		
ATT+rr		
Calculator		
ATT		Click Here to Calculate
rr (<i>formula 2-4</i>)		
D_{lateTP}		

6.4.1 a. CASE 1: Small angle turn using 1 WS.

STEP 1: Construct the **WSI** baseline, (**PP'**) perpendicular to the straight missed approach track at the late-turn-point (see *table 6-2* for line **PP'** location). See *figures 6-3, 6-12*.

STEP 2: Locate the wind spiral center on **PP'** at distance **R** (no-wind turn radius, using *formula 6-2a*; see *figure 6-2*) from the intersection of **PP'** and the inbound-segment outer-boundary extension. See *figures 6-4, 6-12*.

STEP 3: Construct **WSI** from this outer boundary point in the direction of turn until tangent to the **WS/Segment** connecting line from *table 6-2*. See *figure 6-4, 6-12*.

CASE 1-1: Turn-altitude (**WSI** ends when tangent to a line direct to fix)

STEP 1: Construct the **OEA** outer primary and secondary boundary lines parallel to this track (1-2-2-1 segment width). See *figure 6-3*.

STEP 2: Construct a line from the **WSI** tangent point, splaying at 15 degrees from the **WSI-to- fix** track until it intersects the parallel boundary lines or reaches the segment end (see *figures 6-2 through 6-6*).

Note: Consider 'full-width protection at the fix' to exist where the splay line is tangent to a full-width- radius- circle about the fix.

STEP 2alt-1: Where STEP 2 construction provides less than full-width protection at the **DF** fix, construct the **OEA** outer boundary with a line splaying from the **WSI**/direct-to-fix tangent point at 15 degrees relative the direct-to-fix line, (or greater where required to provide full-width protection at the **DF** fix), until it intersects the parallel boundary lines (not later than tangent/tangent-extension to the full-width-arc about the fix), and provides full-width protection at or before the **DF** fix. **DF** secondary areas begin/exist only where full width primary exists. See figures 14a, and 14b.

Note: Where excessive splay (dependent upon various conditions but generally in the 35-40 degree range), consider lengthening the segment, restricting the speed, category, etc. to avoid protection and/or construction difficulties.

CASE 1-2: Turn-at-Fix (FO) (WSI ends when tangent to a 30-degree line converging to nominal track).

STEP 1: Construct the **OEA** outer boundary line using **WSI** and the tangent 30-degree converging line until it crosses the outbound segment boundaries (see figure 6-12).

STEP 1a: Where **WSI** lies within the outbound segment primary boundary, construct the **OEA** boundary using **WSI** and a line (from the point **WSI** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary lines.

STEP 1b: Where **WSI** lies within the outbound segment secondary boundary, construct the **OEA** boundary using **WSI** and a line (from the point **WSI** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary line. Continue **WSI** and the tangent 30-degree converging line to establish the inner primary/secondary boundary.

6.4.1

b. CASE 2: Larger turn using more than 1 WS. For turns nearing or greater than 90 degrees, **WS2** may be necessary. See figures 6-4, 6-13.

STEP 1: To determine **WS2** necessity, locate its center on baseline **PP'**, at distance **R** from the inbound-segment inner-boundary extension.

STEP 2: Construct **WS2** from this inner boundary point in the direction of turn until tangent to the **WS**/Segment connecting line from table 6-2. See figure 6-13.

STEP 3: Where **WS2** intersects **WSI** construction, (including the connecting and expansion lines where appropriate), include **WS2** in the **OEA** construction. Otherwise revert to the single **WS** construction.

STEP 3a: Connect **WS1** and **WS2** with a line tangent to both (*see figures 6-4, 6-13*).

Note: The **WS1/ WS2** tangent line should parallel a line between the **WS** center points.

CASE 2-1: Turn-at-Altitude: (**WS2** ends when tangent to a line direct to fix)

STEP 1: Construct the **OEA** outer primary and secondary boundary lines parallel to this track (1-2-2-1 segment width).

STEP 2: Construct a line from the **WS2** tangent point, splaying at 15 degrees from the **WS2**-to-fix track until it intersects the parallel boundary lines or reaches the segment end (*see figure 6-4*).

Note: Consider 'full-width protection at the fix' exists where the splay line is tangent to a full-width- radius- circle about the fix.

STEP 2alt-1: Where **STEP 2** construction provides less than full-width protection at the **DF** fix, construct the **OEA** outer boundary with a line splaying from the **WS2**/direct-to-fix tangent point at 15 degrees relative the direct-to-fix line, (or greater where required to provide full-width protection at the **DF** fix), until it intersects the parallel boundary lines (not later than tangent/tangent-extension to the full-width-arc about the fix), and provides full-width protection at or before the **DF** fix. Where the turn angle is ≤ 105 degrees, or the divergence angle between the **WS/WS** tangent line and the direct-to-fix line is ≤ 15 degrees, apply the splay line form the **WS1/WS2** tangent line origin. **DF** secondary areas begin/exist only where full width primary exists (*see figures 6-14a and 6-14c*).

Note: Where excessive splay (dependent upon various conditions but generally in the 35-40 degree range), consider using an earlier splay origin point, lengthening the segment, restricting the speed, category, etc. to avoid protection or construction difficulties (*see paragraph 6.4 for origin points*).

CASE 2-2: Turn-at-Fix (FO): (**WS2** ends when tangent to a 30-degree line converging to nominal track).

STEP 1: Construct the **OEA** outer boundary line using **WS2** and the 30-degree converging line until it crosses the outbound segment boundaries (*see figure 6-13*).

STEP 1a: Where **WS2** lies within the outbound segment primary boundary, construct the **OEA** boundary using **WS1**, **WS2** and a line (from the point **WS1** or **WS2** is parallel to the outbound segment nominal track, the more conservative),

splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary lines.

STEP 1b: Where **WS2** lies within the outbound segment secondary boundary, construct the **OEA** boundary using **WS1**, **WS2** and a line (from the point **WS2** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary line. Continue **WS2** and the tangent 30-degree converging line to establish the inner primary/secondary boundary.

6.4.1

c. CASE 3: Larger turn using more than 2 WSs. (Not applicable to Turn-at-Fix due to 90° turn limit). For turns nearing or greater than 180 degrees ~ (such as a missed approach to a holding fix at the **IF**),

STEP 1: Construct the **WS3** baseline perpendicular to the straight missed approach track along the **CD** line-extended toward the turn side. *See figure 6-5.*

STEP 2: To determine **WS3** necessity, locate its center on the **WS3** baseline at distance **R** from point **C**. *See figure 6-5.*

STEP 3: Construct **WS3** from point **C** in the direction of turn until tangent to the WS/Segment connecting line from *table 6-2*. *See figure 6-5.*

STEP 4: Where **WS3** intersects **WS2** construction, include **WS3** in the **OEA** construction. Otherwise revert to the dual **WS** construction. *See figure 6-5.*

STEP 5: Connect **WS2** and **WS3** with a line tangent to both (*see figure 6-4, 6-5*).

*Note: The **WS2** & **WS3** tangent line should parallel a line between the **WS** center points.*

CASE 3-1: Turn-at-Altitude: (**WS3** ends when tangent to a line direct to fix)

STEP 1: Construct the **OEA** outer primary and secondary boundary lines parallel to this track (1-2-2-1 segment width). *See figure 6-5.*

STEP 2: Construct a line from the **WS3** tangent point, splaying at 15 degrees from the **WS3**-to- fix track until it intersects the parallel boundary lines or reaches the segment end. *See figure 6-5.*

6.4.1

d. Outside Turn Secondary Area. Outbound segment secondary areas following wind spirals begin where either the 30-degree converging line crosses the secondary and primary boundaries from outside the segment, or the 15-degree splay line crosses the primary boundary from inside the segment.

6.4.2 Second MA Turn WS Construction (DF/TF FO).

To accommodate the two inbound tracks in the *DF* leg, the second *MA* turn *DF/TF* (fly-over) construction uses two *WS* baselines, PP' and P'P''.

Note: Apply table 6-2 PP' location information for each baseline (formula is identical).

6.4.2 a. CASE 1: Small angle turn using 1 *WS* for each inbound *DF* track.

STEP 1: Construct the *WS1* baseline, (P'P'') perpendicular to the *DF* track nearer the outside of the *DF/TF* turn, at the late-turn-point (*see table 6-2* for line PP' location).

STEP 1a: Construct the *WS2* baseline, (PP') perpendicular to the *DF* track nearer the inside of the *DF/TF* turn, at the late-turn-point (*see table 6-2* for line PP' location).

STEP 2: Locate the *WS1* center on P'P'' at distance *R* (no-wind turn radius, *using formula 6-2a; see figure 6-2*) from the intersection of P'P'' and the inbound-segment outer-boundary extension.

STEP 2a: Locate the *WS2* center on PP' at distance *R* (no-wind turn radius, *using formula 6-2a; see figure 6-9*) from the intersection of PP' and the inbound-segment inner-boundary extension.

STEP 3: Construct *WS1* from this outer boundary point in the direction of turn until tangent to the *WS/Segment* connecting line from *table 6-2*.

STEP 3a: Construct *WS2* from this inner boundary point in the direction of turn until tangent to the *WS/Segment* connecting line from *table 6-2*.

STEP 4: Where *WS2* intersects *WS1* construction, include *WS2* in the *OEA* construction, and connect *WS1* to *WS2* with a tangent line. Otherwise revert to the single *WS* construction.

CASE 1-1: *WS1* and/or *WS2* lie outside the outbound segment boundary.

STEP 1: Construct the *OEA* outer boundary using *WS1* and/or *WS2* and the tangent 30-degree converging line until it crosses the outbound segment boundaries (*see figure 6-9*).

CASE 1-2: *WS1* and *WS2* lie inside the outbound segment boundary.

STEP 1: Where *WS1* and/or *WS2* lie inside the outbound segment primary boundary, construct the *OEA* outer boundary using *WS1* and/or *WS2* and a line

(from the point **WS1** or **WS2** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary lines.

STEP 1a: Where **WS1** and/or **WS2** lie inside the outbound segment secondary boundary, construct the **OEA** outer boundary using **WS1** and/or **WS2** and a line (from the point **WS1** or **WS2** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary line. Continue the final **WS** and 30-degree converging line to establish the primary/secondary boundary.

6.5 Missed Approach Climb Gradient.

Where the standard **OCS** slope is penetrated and the lowest **HAT_h** (final segment evaluation) is required, specify a missed approach **CG** to clear the penetrating obstruction. **MA** starting **ROC** is 100 ft for Non-Vertically-Guided-Procedures (**NVGP**), *formula 5-25* output for **LPV**, or *table 4-2* values for other Vertically-Guided-Procedures, plus appropriate **TERPS** chapter 3 **ROC** adjustments. **ROC** increases at 48 ft per **NM**, measured parallel to the missed approach track to **TIA** end (Turn-at-Altitude), or early-turn point (Turn-at-Fix), then shortest primary distance to the next fix. Apply fix-to-fix distance for subsequent segments. Where a part-time altimeter is in use, consider the aircraft **SOC** altitude to be the **MDA** associated with the local altimeter (ensures adequate **CG** is applied).

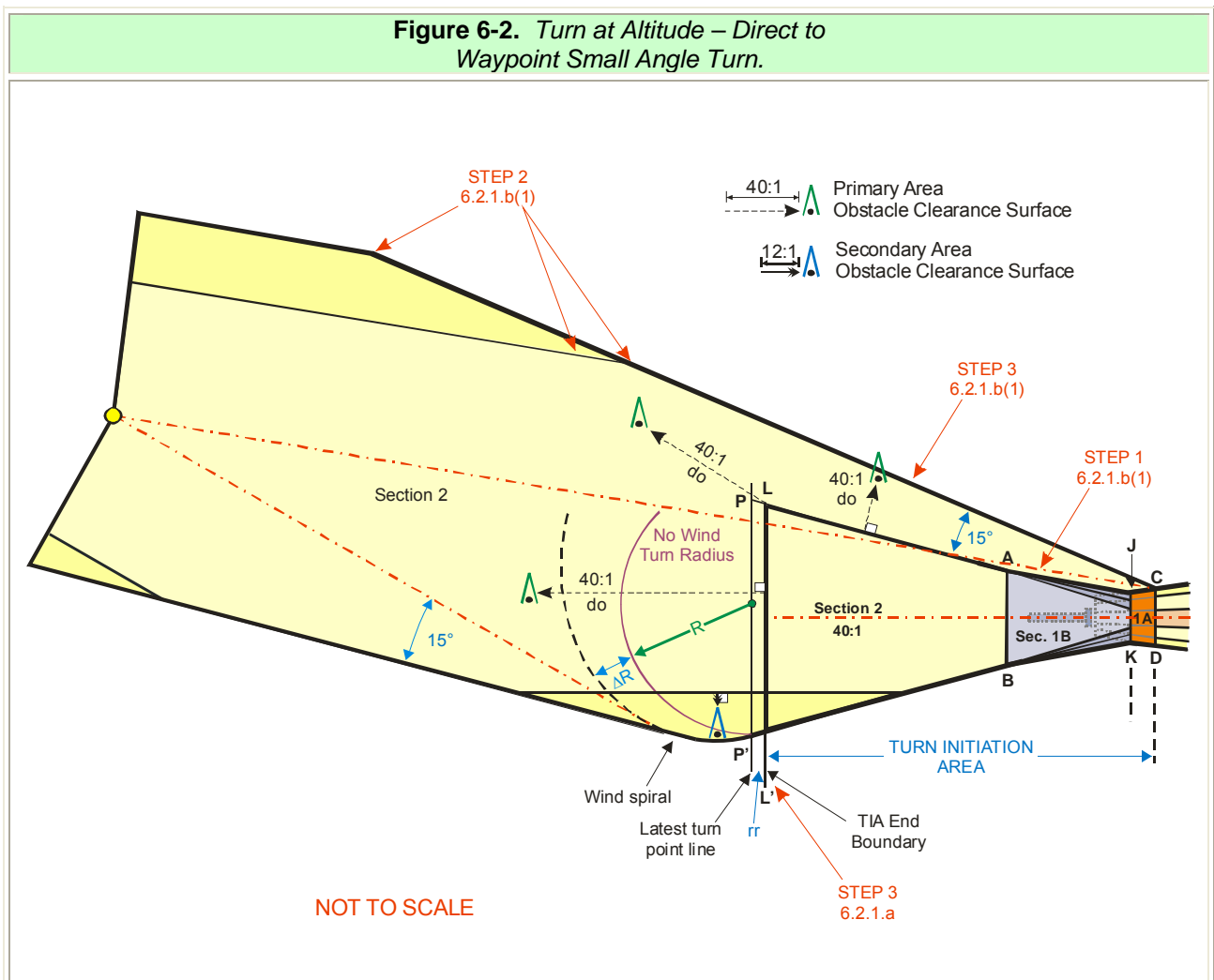
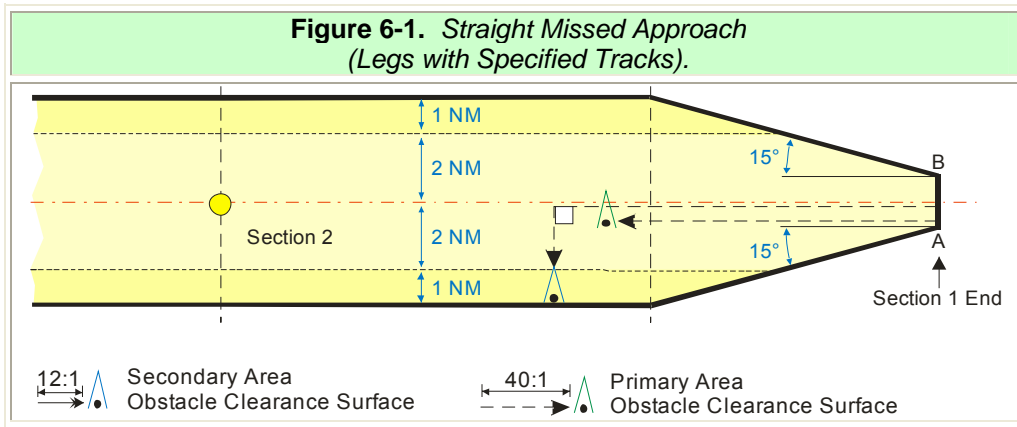
STEP 1: Calculate the **ROC**, the altitude at which the **ROC** for the obstacle is achieved, and the required **CG** (ft/**NM**) using *formula 6-9*. See *formula 2-22* for **MA** Slope calculations.

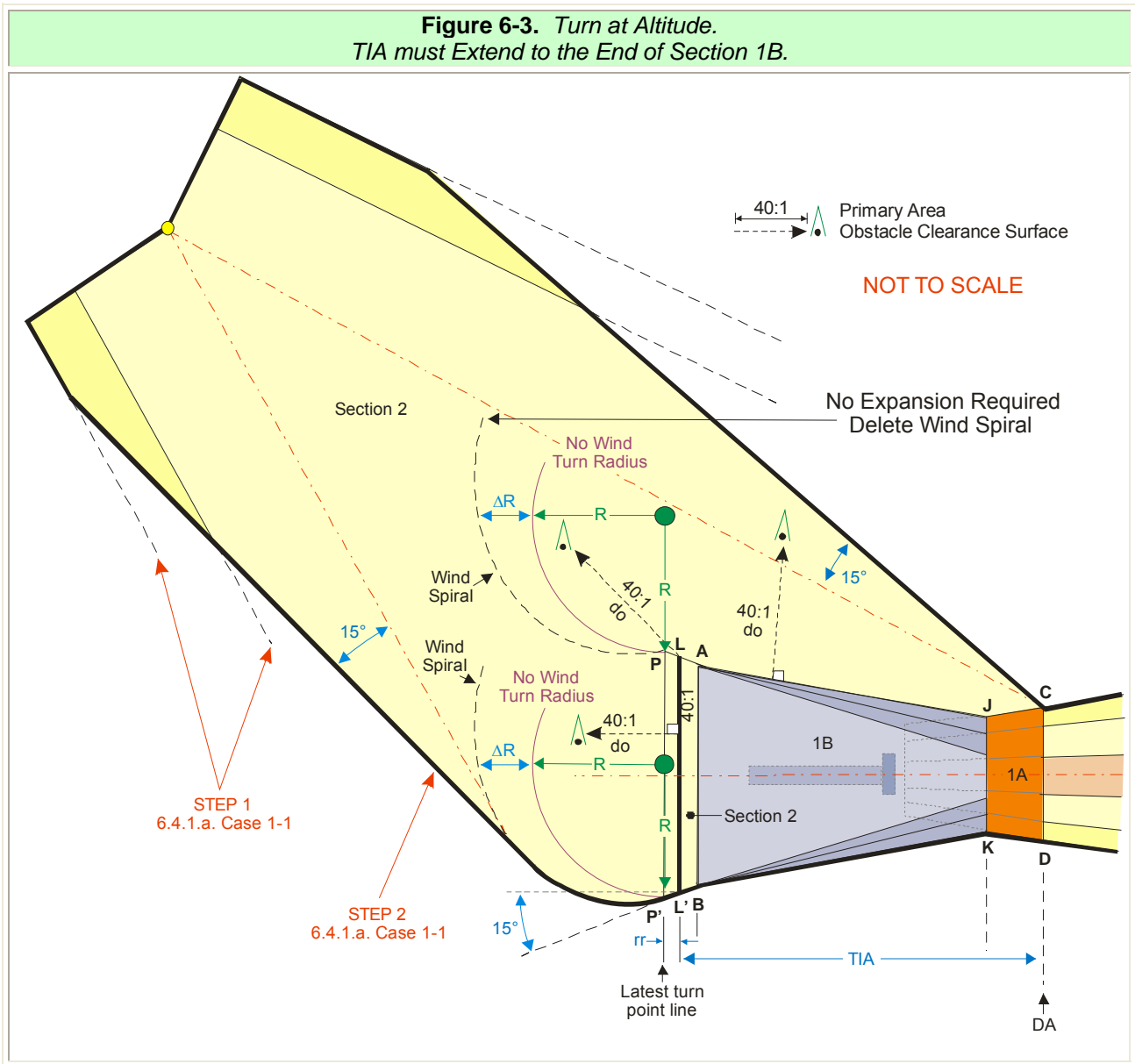
STEP 2: Apply the **CG** to:

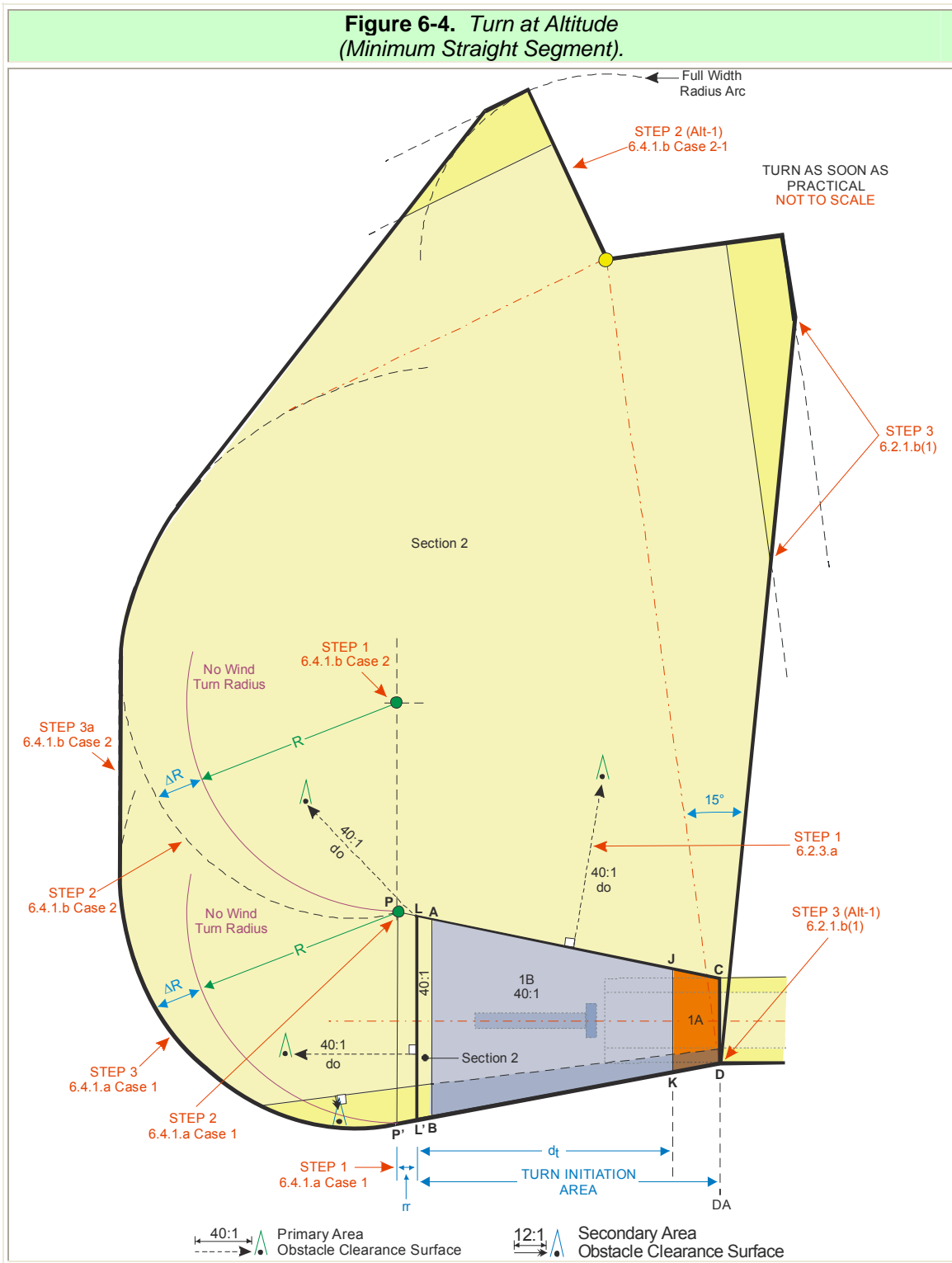
- The altitude which provides appropriate **ROC**, or
- The point/altitude where the subsequent standard **OCS** slope clears all obstacles.

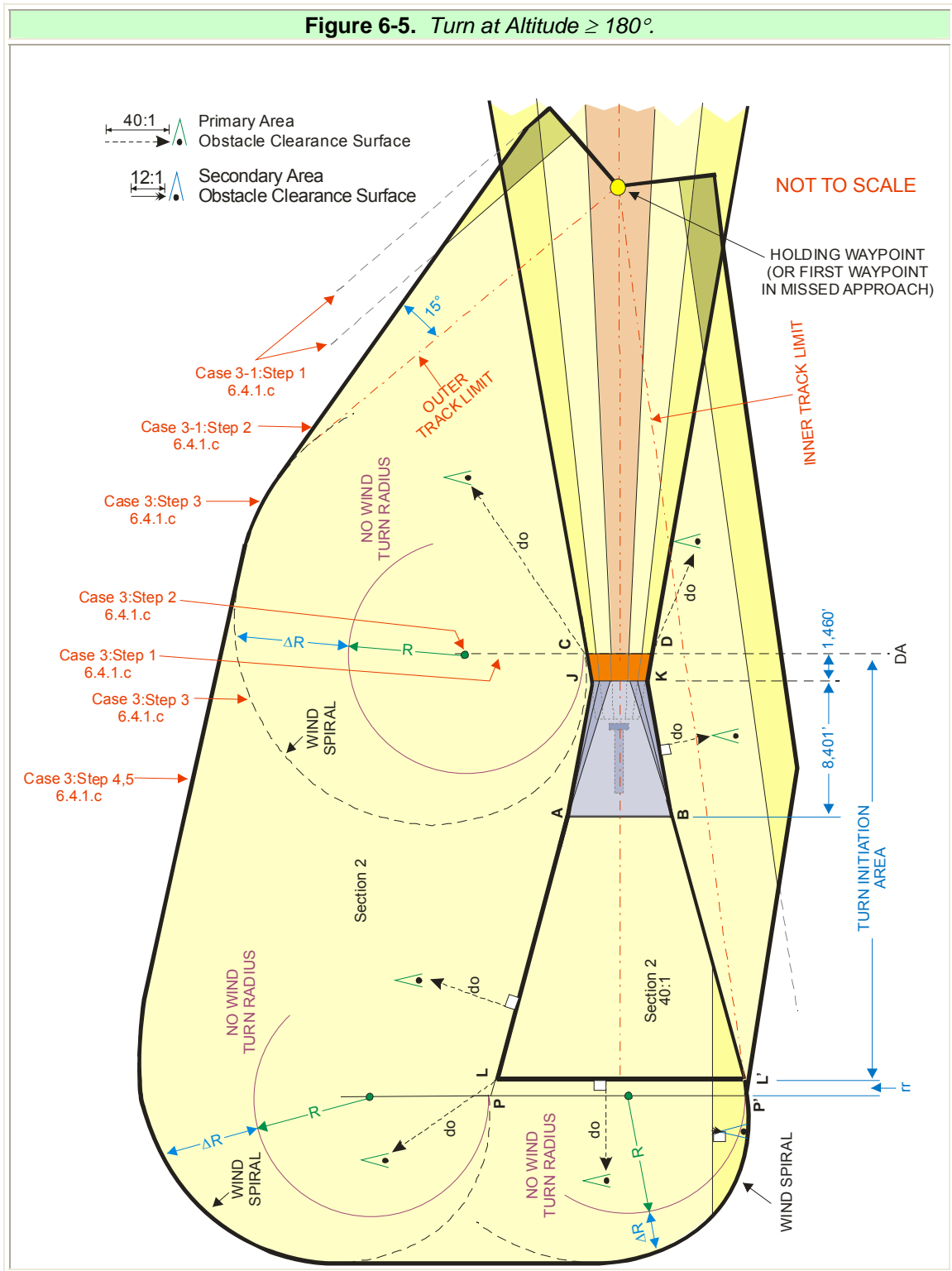
STEP 2a: Where a **RASS** adjustment is applicable for climb-to-altitude operations (prior to turn, terminate **CG**, etc.), apply the **CG** associated with the lower **MDA/DA** (*formula 6-9*). To establish the **RASS**-based climb-to-altitude, add the difference between the Local altimeter-based **MDA** and the **RASS**-based **MDA** to the climb-to-altitude and round to the next higher 100-ft increment (see **TERPS** chapter 3 for further details).

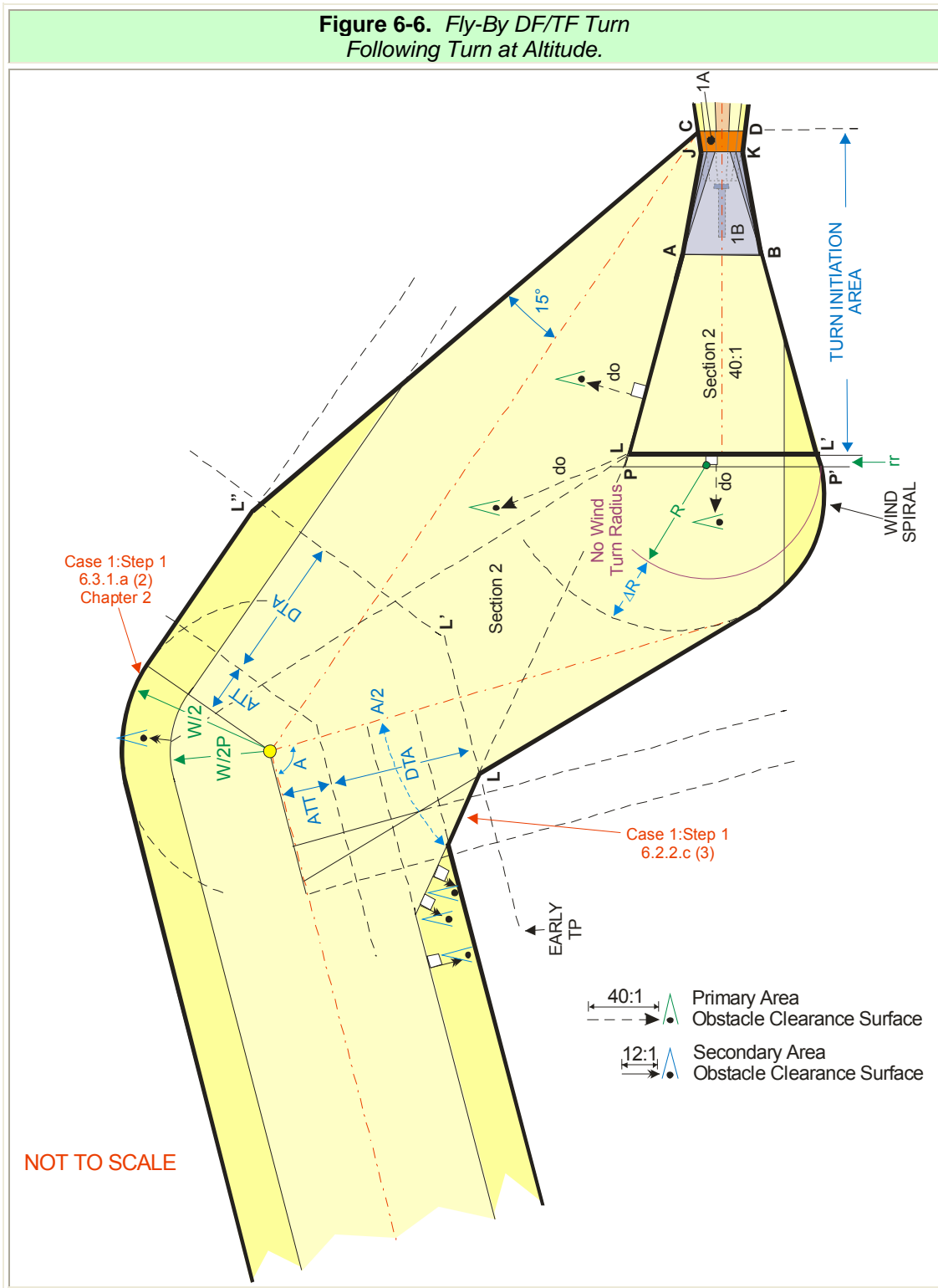
Formula 6-9. ROC/CG/Minimum Altitude/OCS.		
STEP 1	<p style="text-align: center;">$ROC_{obs} = ROC_{start} + 48 \cdot d$</p> <p style="text-align: center;">Where ROC_{start} = SOC ROC (<i>Table 4-2 value</i>) or (100 ft for NVGP)</p> <p style="text-align: center;">d = distance (<i>NM</i>) CG origin (<i>SOC</i>) to obstacle</p>	
$ROC_{start} + 48 \cdot d$		
STEP 2	<p style="text-align: center;">$Alt_{min} = O_{elev} + ROC_{obs}$</p> <p style="text-align: center;">Where ROC_{obs} = <i>Step 1 result</i> O_{elev} = Obstacle Elevation (<i>MSL</i>)</p>	
$O_{elev} + ROC_{obs}$		
STEP 3	<p style="text-align: center;">$CG = \frac{r}{d} \cdot \ln \left(\frac{(r + Alt_{min})}{(r + Aircraft_{soc})} \right)$</p> <p style="text-align: center;">Where Alt_{min} = <i>Step 2 result</i> $Aircraft_{soc}$ = aircraft altitude (<i>MSL</i>) at CG origin d = distance (<i>NM</i>), CG origin (<i>SOC</i>) to obstacle</p>	
$r/d \cdot \ln((r + ALT_{min}) / (r + Aircraft_{soc}))$		
Calculator		
ROC _{start}		Click Here to Calculate
O _{elev}		
d (<i>NM</i>)		
Aircraft _{soc}		
ROC _{obs}		
Alt _{min}		
CG		

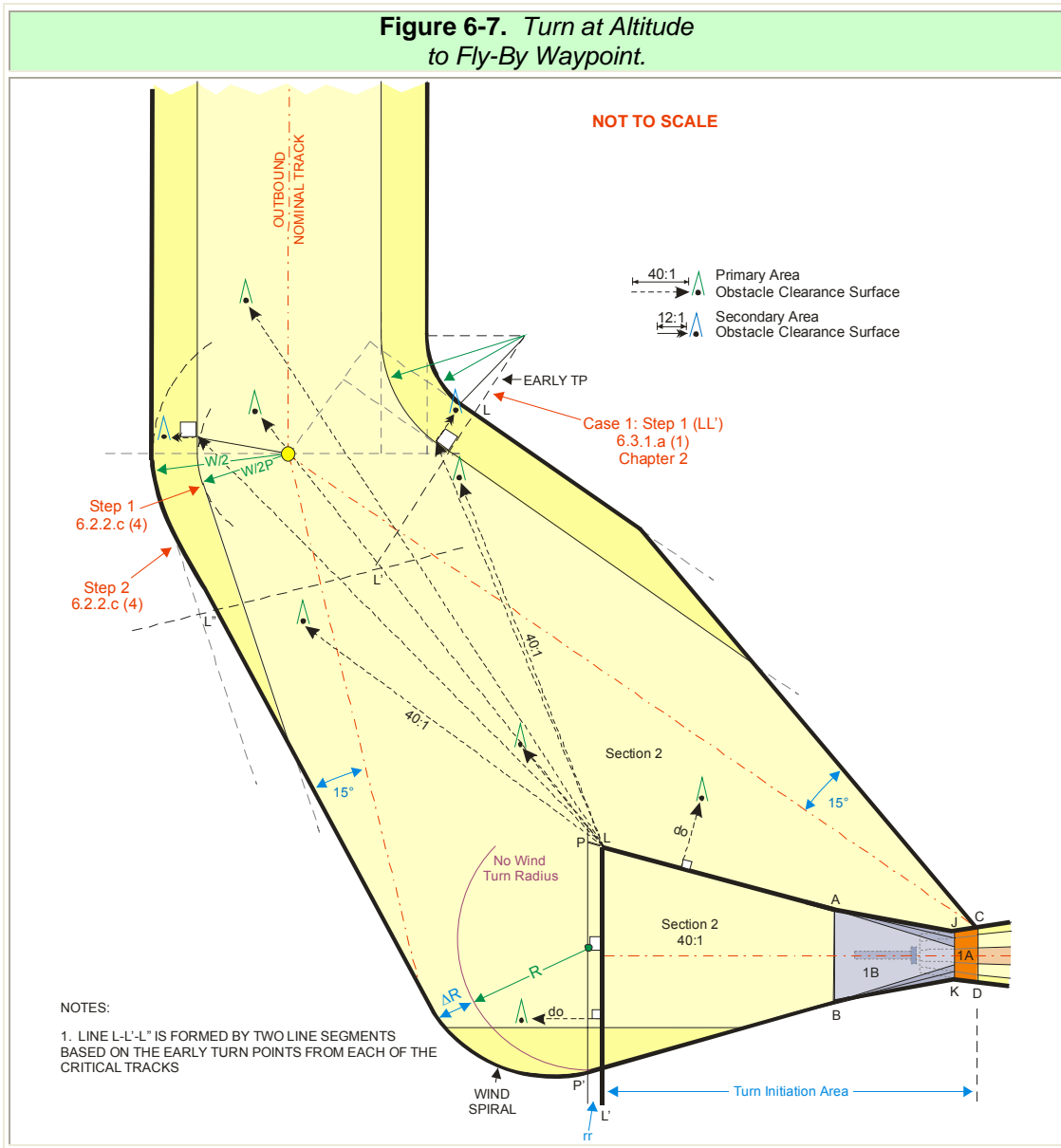


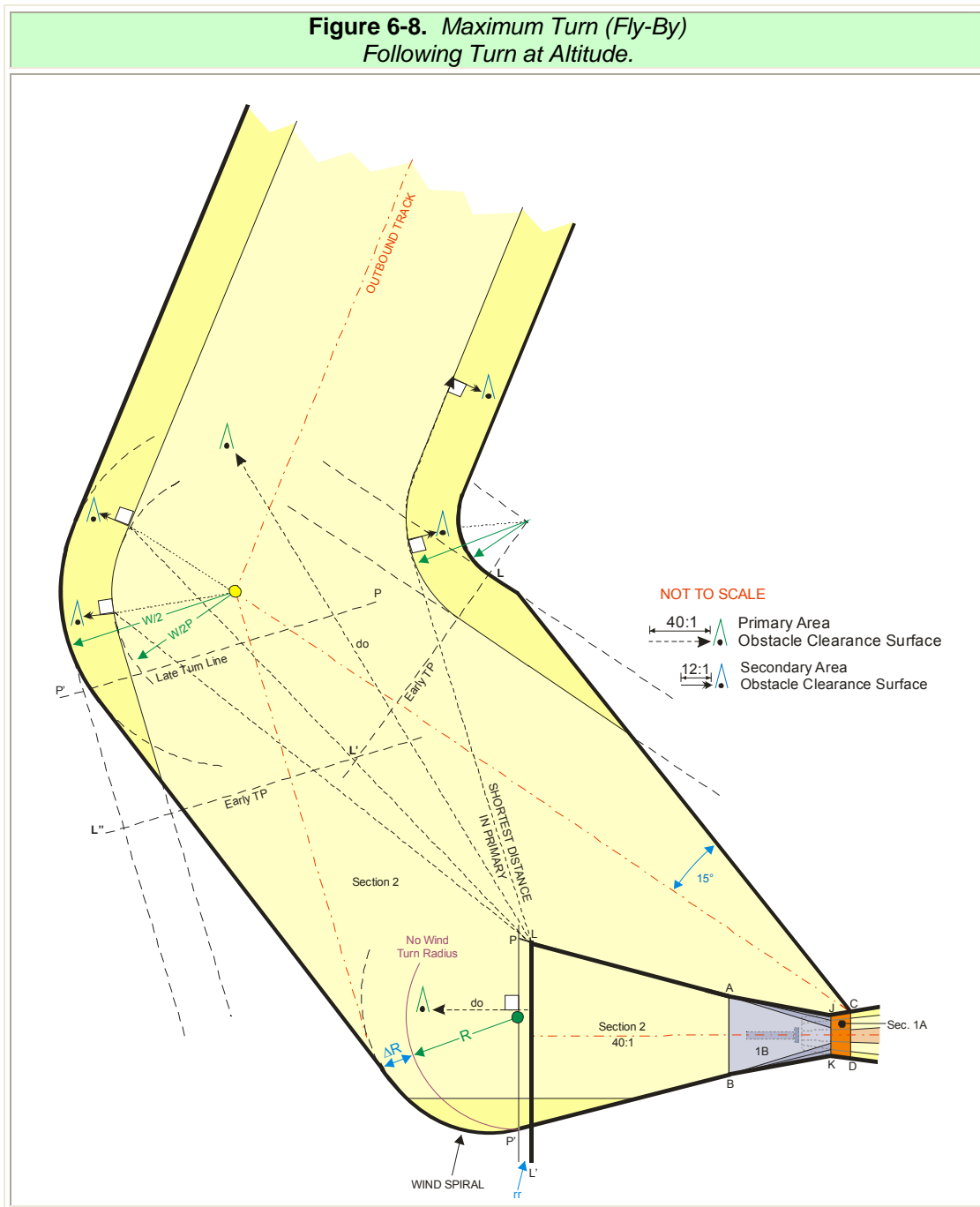


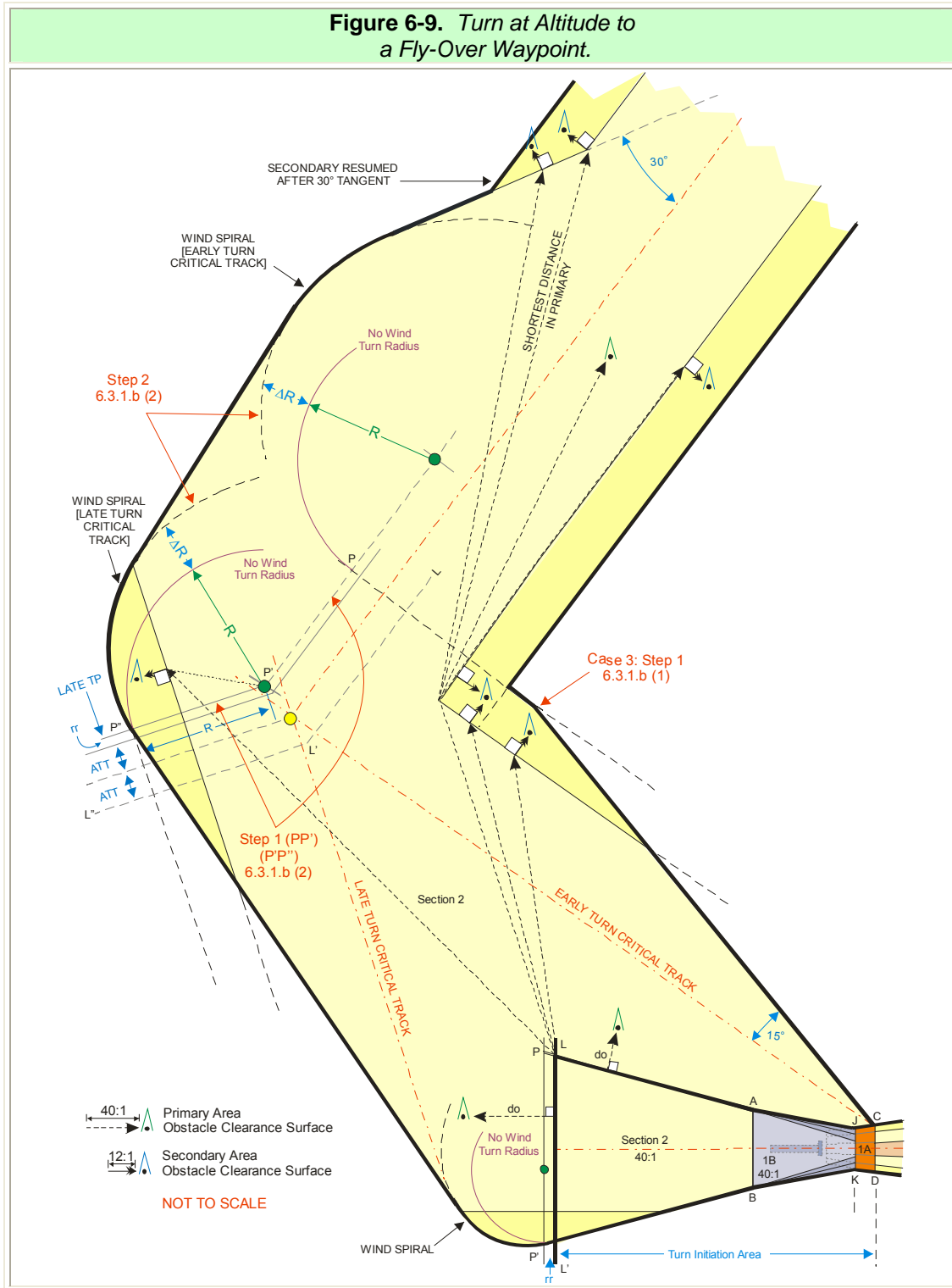


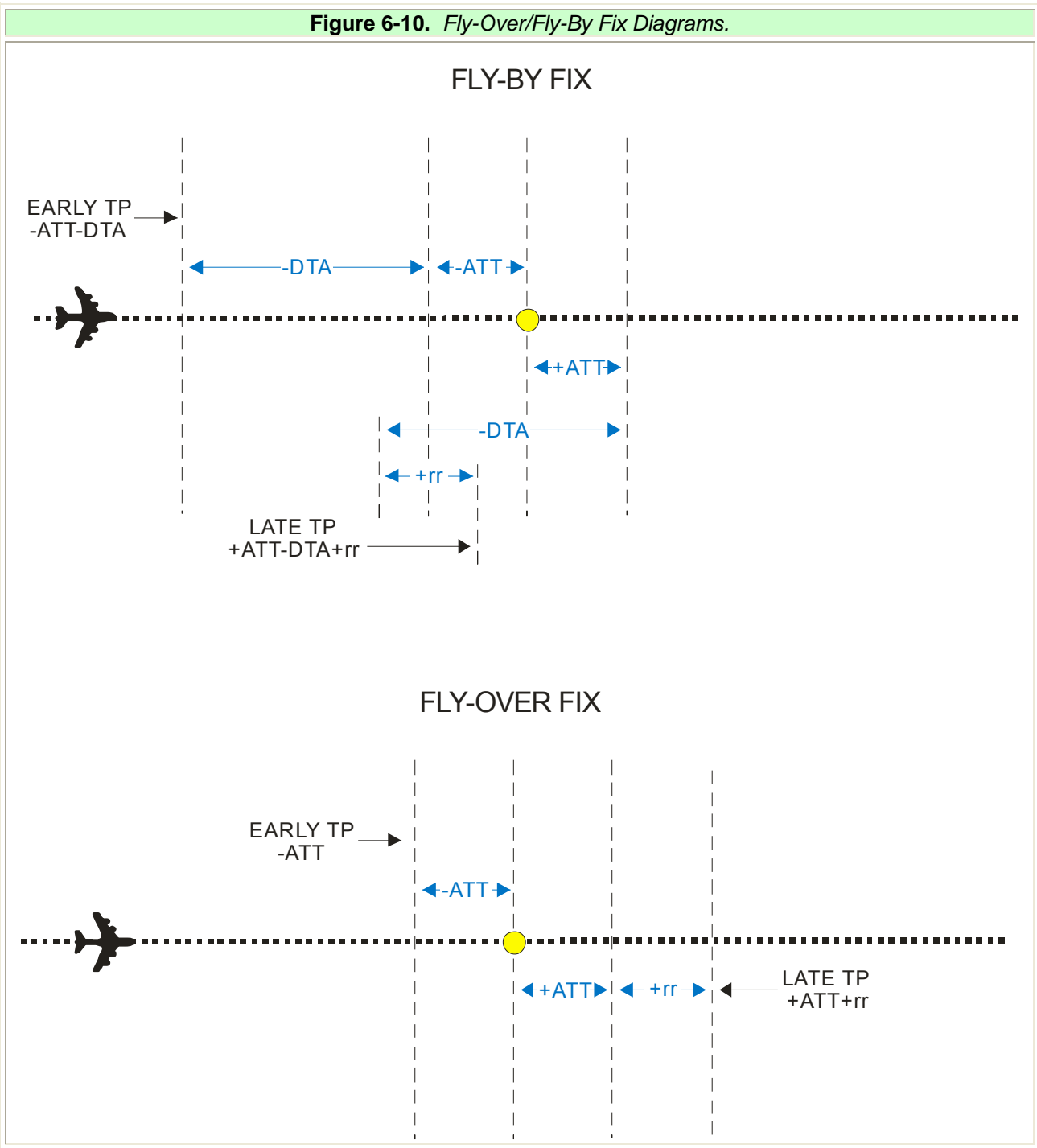


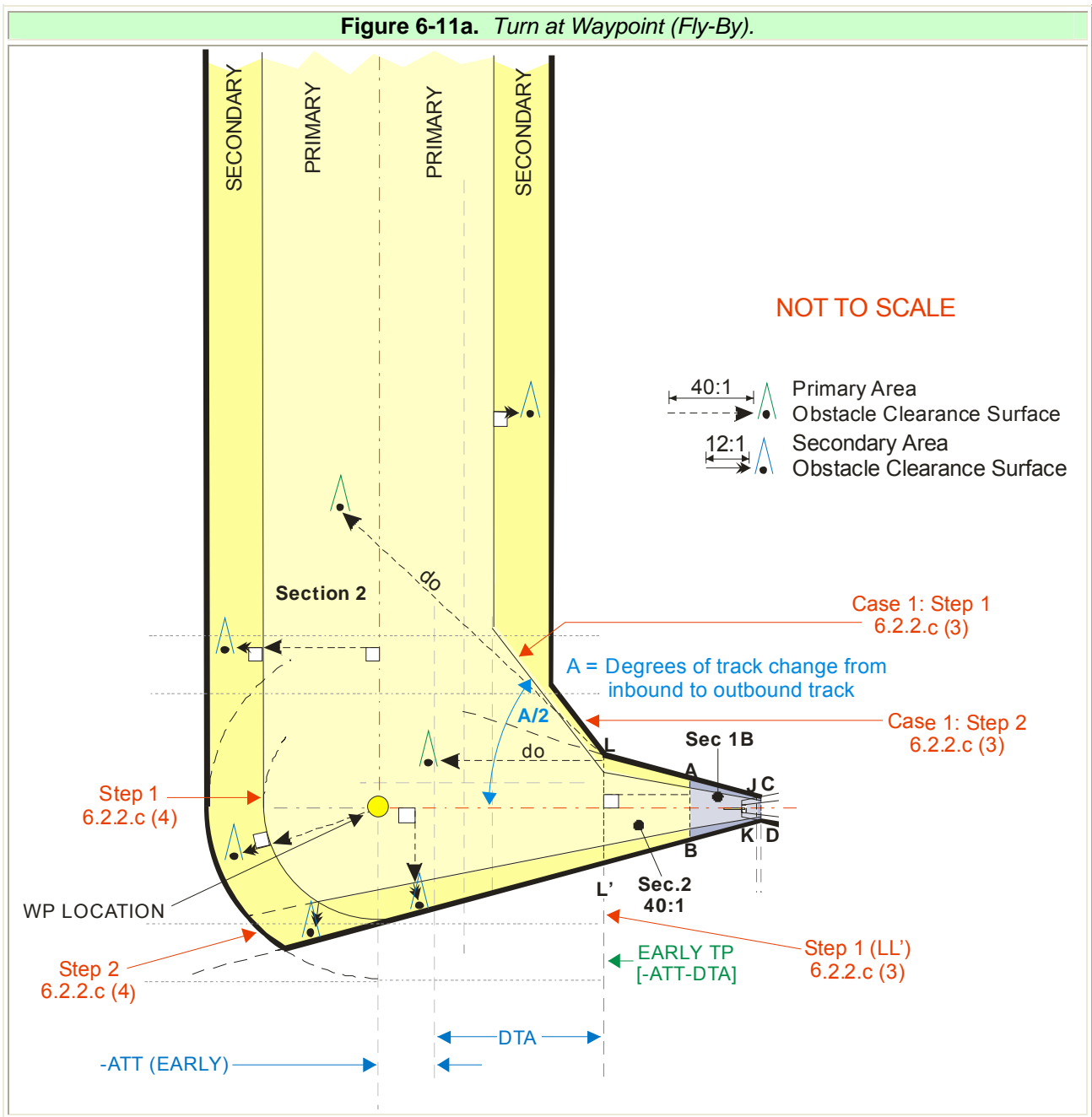


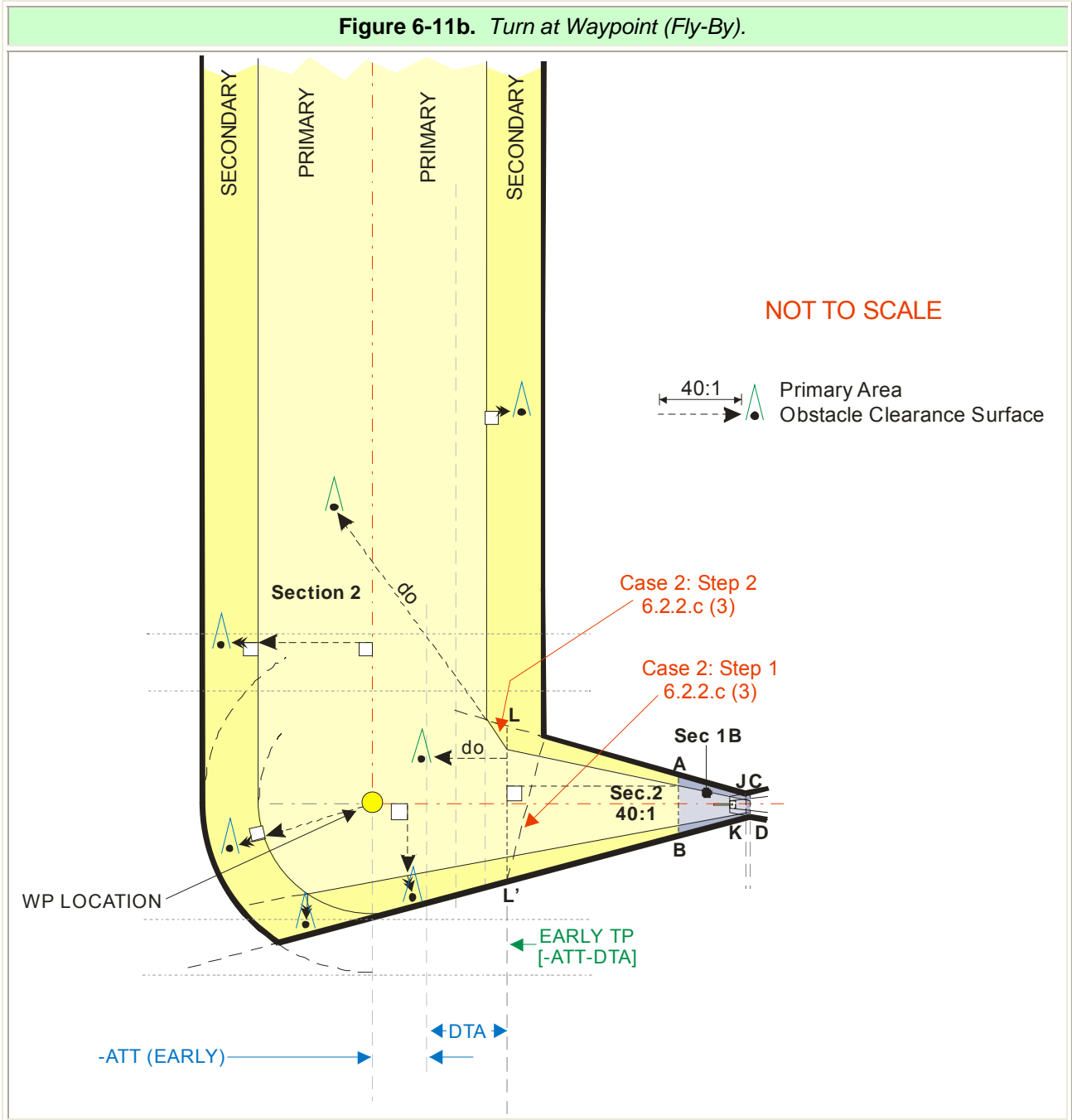


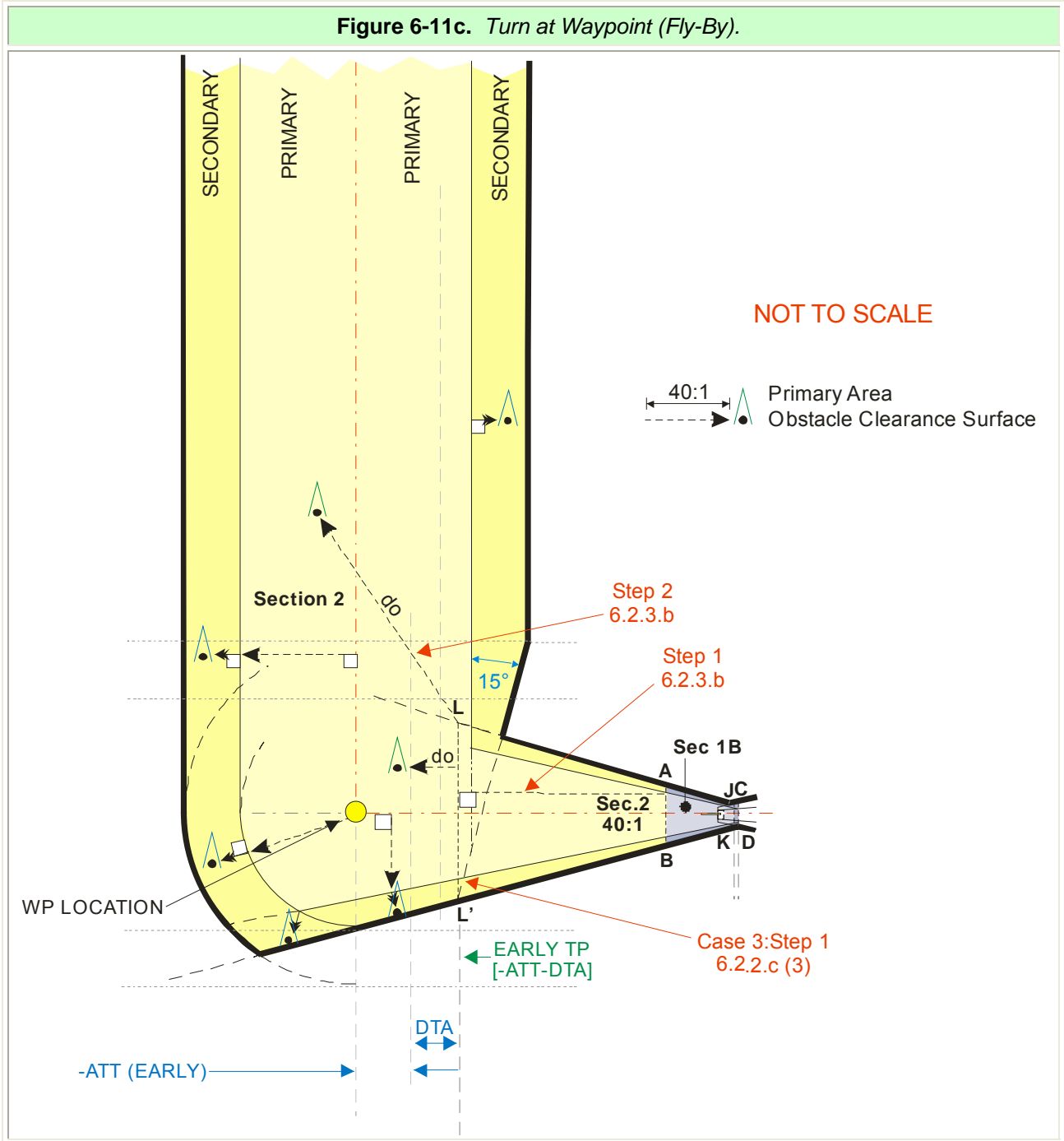












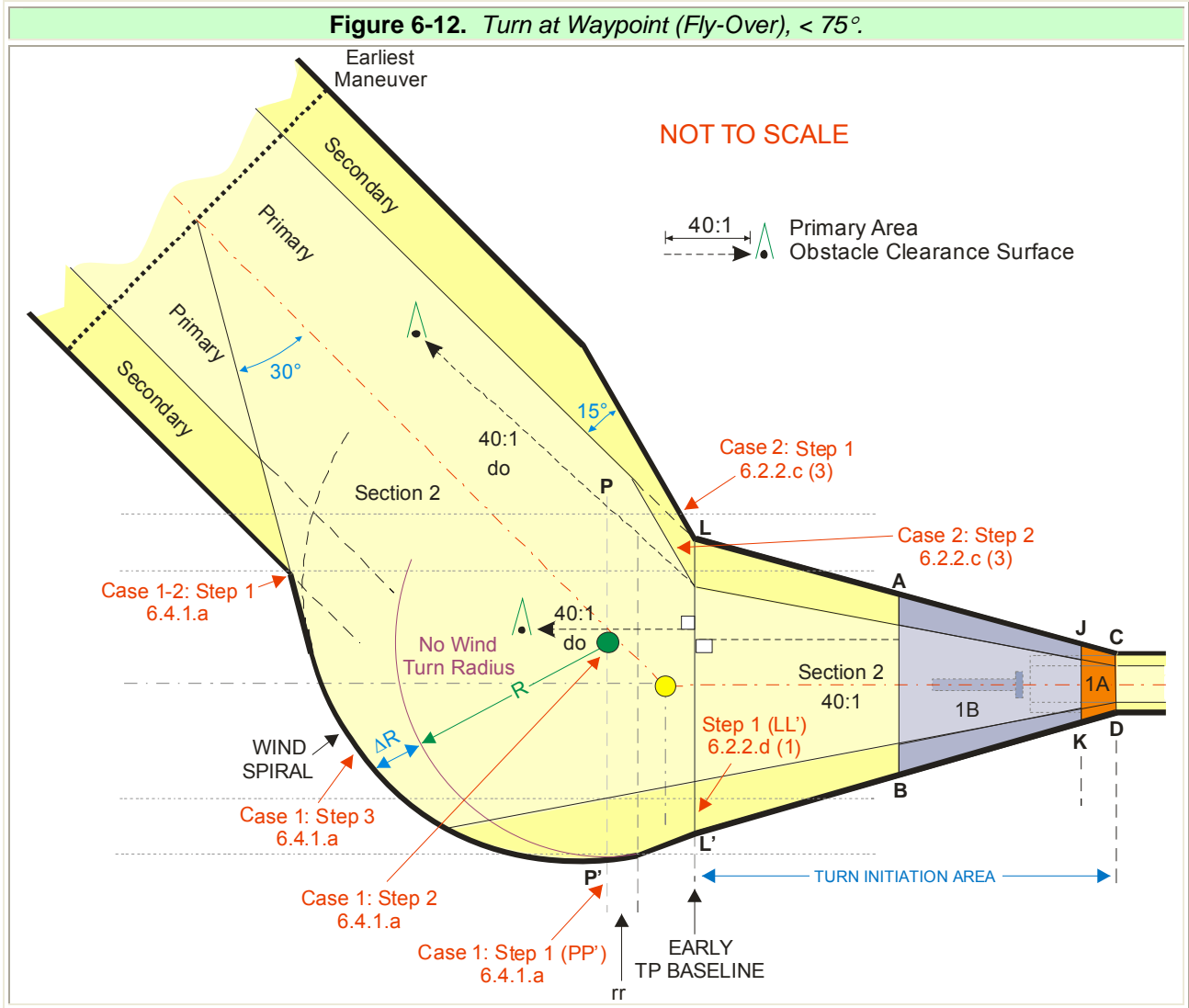
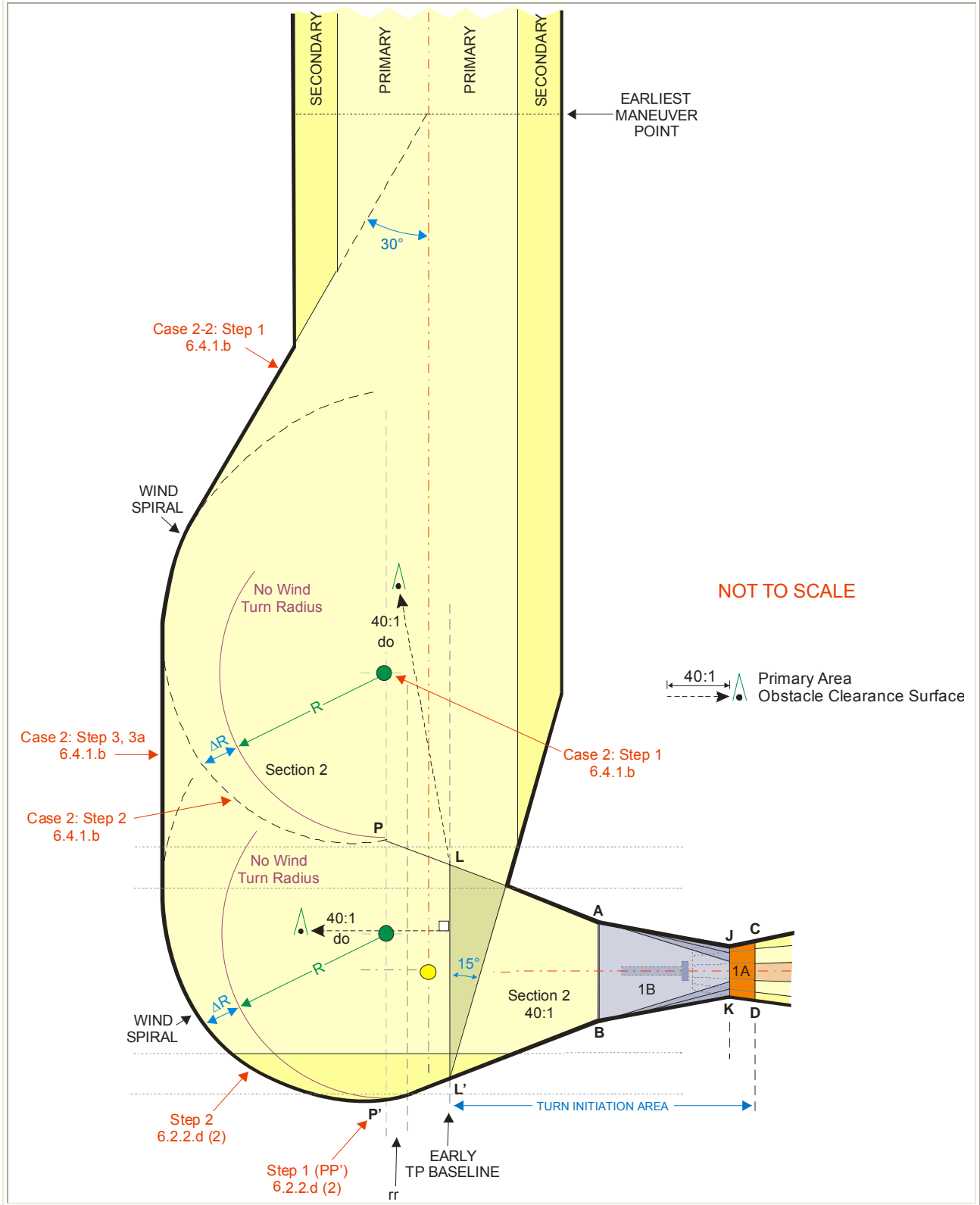
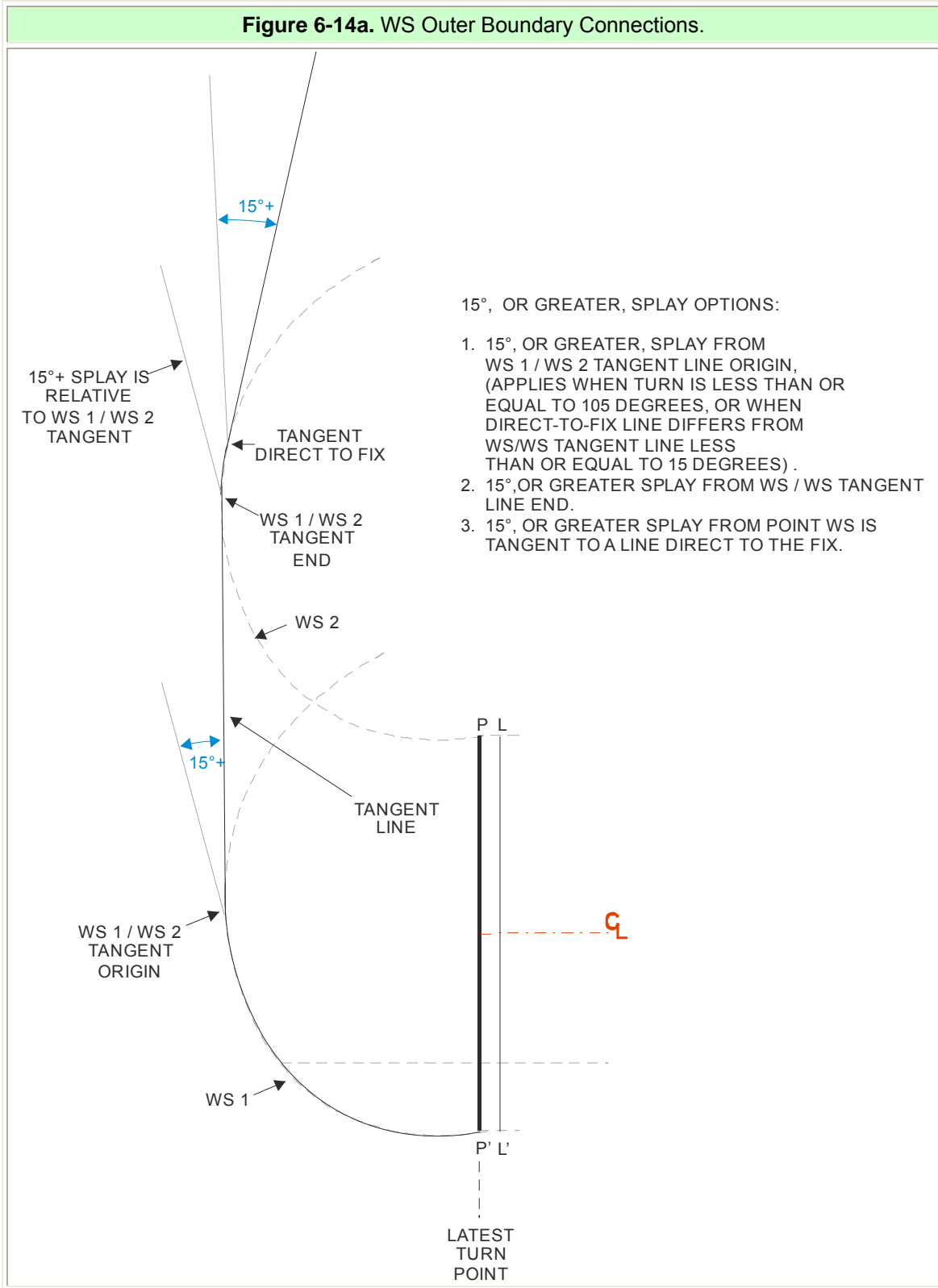
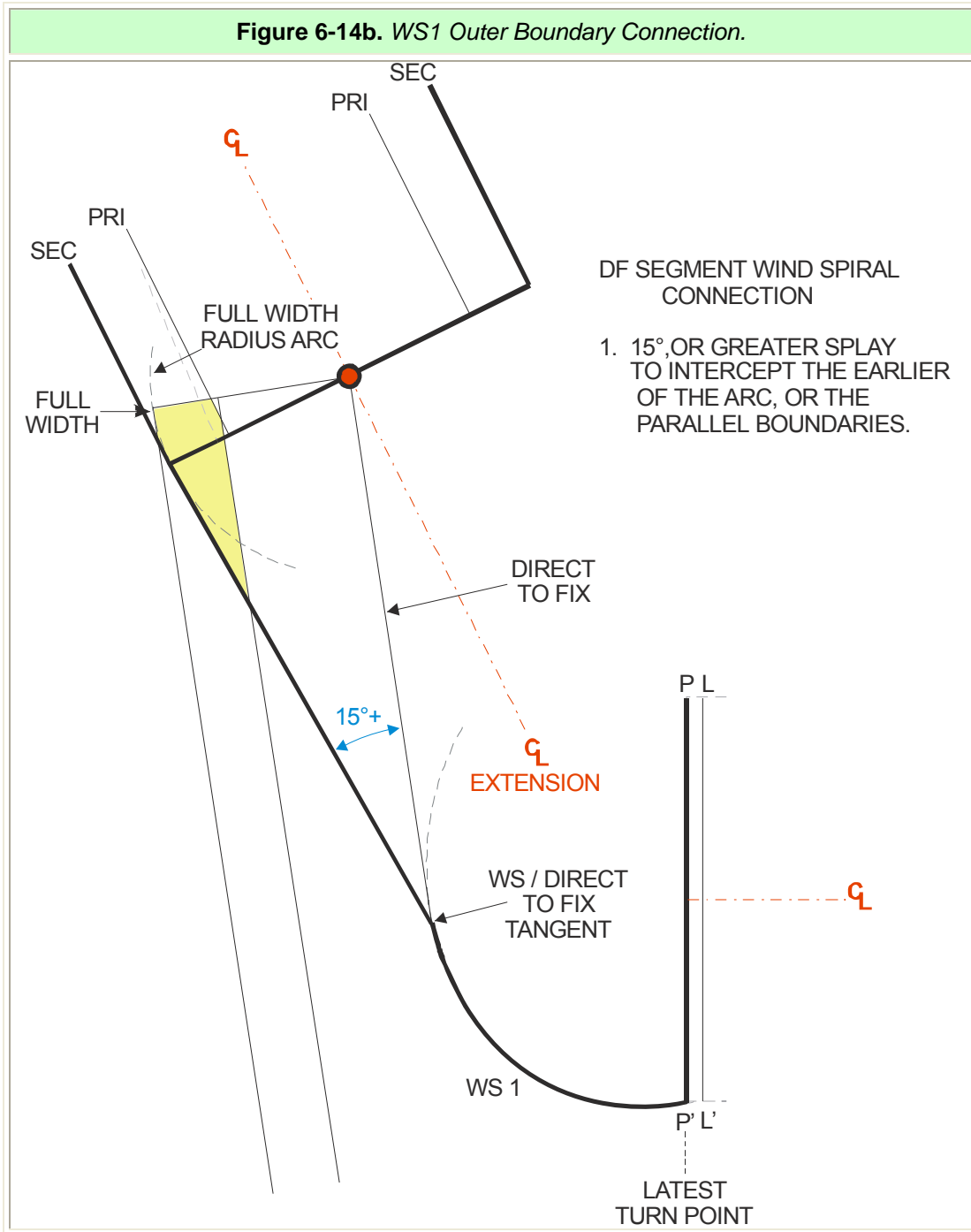
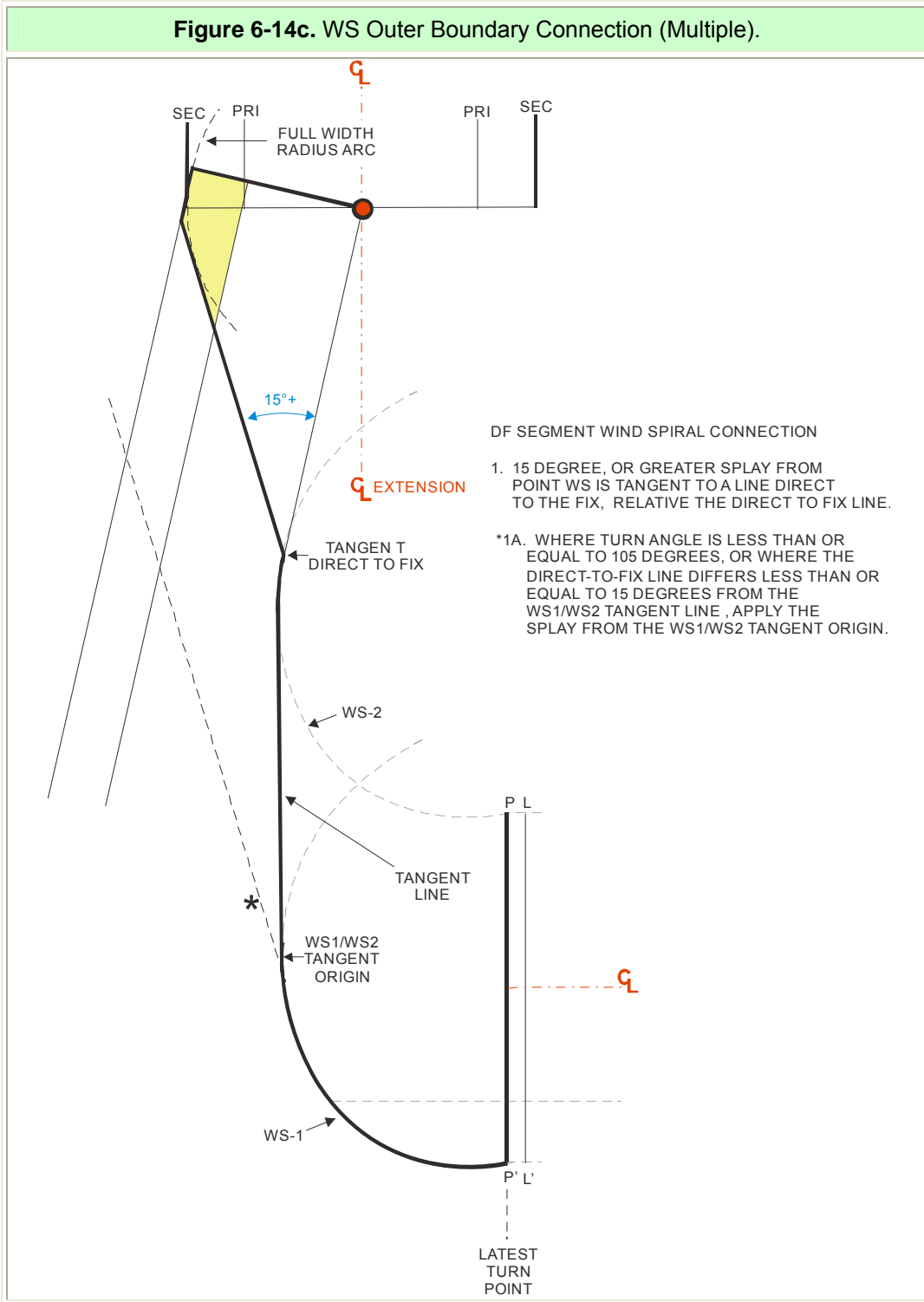


Figure 6-13. Turn at Waypoint (Fly-Over), 90°.









Appendix 1. Formulas by Chapter, Formatted For an Aid to Programming

Chapter 1	
1-1	$Z+GH$
HATH	$DA-LTP_{elev}$
Chapter 2	
2-1	$\alpha = (180*D)/(\pi*R)$
	$B_{primary} = 4-2*(\phi*\pi*R)/(180*D)$
	$B_{secondary} = 6-3*(\phi*\pi*R)/(180*D)$
2-2	$e^{((D_z*\tan(\theta*\pi/180))/r)*(r+PFAF_{alt})}-r$
2-3a	$(V_{KIAS}*171233*((288+15)-0.00198*alt)^{0.5})/(288-0.00198*alt)^{2.628}$
2-3b	$0.00198*alt+47$
2-3c	$(V_{KTAS}+V_{KTW})^2/(\tan(\text{bank}_{angle}*\pi/180)*68625.4)$
2-4	$6*1852/0.3048/3600*V_{KTAS}$
2-5	$R*\tan(\phi/2*\pi/180)$
2-6	$f1*(\cos(\phi*\pi/180)+3^{0.5}*\sin(\phi*\pi/180))+R*(\sin(\phi*\pi/180)+4-3^{0.5}-3^{0.5}*\cos(\phi*\pi/180))+DTA+f2$
2-7	$F1+DTA1+DTA2+F2$
2-8	$\text{atan}((V_{KTAS}+V_{KTW})^2/(R*68625.4))*180/\pi$
2-9	$\pi*R*\phi/180$
2-10	$(r*\ln((r+a)/(r+b)))/D$
2-11a	$500*(1-d/D)$
2-11b	$(500+adj)*(1-d_{primary}/WS)$
2-12	$0.3*d/a-d*0.3048/1852$
2-13	$\text{atan}(350/(RWY_{length}+1000))*180/\pi$
2-14	$\tan(1.5*\pi/180)*(RWY_{length}+1000)*0.3048$
2-15	$FPAP_{Distance}-RWY \text{ length}$
2-16a	$r*(\pi/2-\theta*\pi/180-\text{asin}((\cos(\theta*\pi/180)*(r+LTP_{elev}+TCH))/(r+alt)))$
2-16b	$(\ln((r+alt)/(r+LTP_{elev}+TCH))*r)/\tan(\theta*\pi/180)$
2-16c	$\text{atan}(\ln((r+PFAF_{alt})/(r+LTP_{elev}+TCH))*r/D_{PFAF})*180/\pi$
2-17a	$((r+LTP_{elev}+TCH)*\cos(\theta*\pi/180))/\cos(D_z/r+\theta*\pi/180)-r$
2-17b	$e^{((D_z*\tan(\theta*\pi/180))/r)*(r+LTP_{elev}+TCH)}-r$

2-18a	TCH-50
2-18b	$(40-TCH)/\tan(\theta*\pi/180)$
2-18c	$0.0036*D+392.8$
2-19	$d*(E-k)/D+k$
2-20	$d*((\cos(\phi*\pi/180)*(\sin(\phi*\pi/180)*(D-i)+E)-k)/(D-\sin(\phi*\pi/180)*(\sin(\phi*\pi/180)*(D-i)+E)))+k$
2-21	$(r+LTP_{elev}+V_{offset})*\cos((2*\theta/3)*\pi/180)/\cos((d-X_{offset})/r+(2*\theta/3)*\pi/180)-r$
	$e^{((d-X_{offset})*\tan((2*\theta/3)*\pi/180)/r)*(r+LTP_{elev}+V_{offset})}-r$
	$LTP_{elev}+(c-x)*\tan((2*\theta/3)*\pi/180)$
2-22	$1852/(0.3048*(CG-48))$
Chapter 3	
3-1	$\frac{1}{2}wp = 1.4*d/3+0.6$
	$ws = 0.7*d/3+0.3$
3-2	$0.10752*D+678.5$
3-3	$0.15152*d+969.7$
3-4	$(250+adj)*(1-d_{primary}/W_S)$
3-5	$OIS_z=a-c-O_x/7$
	$MFa=O_z+c+O_x/7$
3-6	$20.2537*((V_{KIAS}*(171233*((288+15)-0.00198*MDA)^{0.5}))/((288-0.00198*MDA)^{2.628}+10)+2*ATT$
3-7a	$MAS_{Y_{primary}}=d*((\tan(15*\pi/180)*1.4*1852/0.3048))/(2.1*1852/0.3048)+0.6*1852/0.3048$
	$MAS_{Y_{secondary}}=d*\tan(15*\pi/180)+0.9*1852/0.3048$
3-7b	$MAS_{Y_{primary}}=d*((\tan(15*\pi/180)*(2*1852/0.3048-W_p))/(3*1852/0.3048-W_s))+W_p$
	$MAS_{Y_{secondary}}=d*\tan(15*\pi/180)+W_s$
3-8	$MDA-(100+adj)$
Chapter 4	
4-1	$d2=(V_{KIAS}^2*\tan(\alpha/2*\pi/180))/(68625.4*\tan(18*\pi/180))*1852/0.3048$
	$Min_{HATH}=e^{(((d1+d2)*\tan(\theta*\pi/180))/r)*(r+LTP_{elev}+TCH)}-(r+LTP_{elev})$
4-2	$(250-TCH)/\tan(\theta*\pi/180)$
4-3	$ISA_{airportC}=15-0.00198*Airport\ Elevation$
	$ISA_{airportF}=(1.8*ISA^{\circ}C)+32$
4-4	$(ACT^{\circ}F-32)/1.8$

4-5	$\text{MDR}_{\text{angle}} = 180/\pi * \text{asin}(60000/((V_{\text{KTAS}} + 10) * 1852/0.3048))$
	$V_{\text{KTAS}} = V_{\text{KIAS}} * (171233 * (288 - 0.00198 * (\text{LTP}_{\text{elev}} + 250))^{0.5}) / (288 - 0.00198 * (\text{LTP}_{\text{elev}} + 250))^{2.628}$
4-6	$e^{((D_{\text{PFAF}} * \tan(\text{MDR}_{\text{angle}} * \pi/180)) / (r + \text{LTP}_{\text{elev}})) * (r + \text{LTP}_{\text{elev}} + \text{TCH}) - r}$
4-7	$(c - \text{PFAF}_{\text{alt}} + 0.032 * (\text{PFAF}_{\text{alt}} - (\text{LTP}_{\text{elev}} + 250)) + 4.9) / (0.19 + 0.0038 * (\text{PFAF}_{\text{alt}} - \text{LTP}_{\text{elev}} + 250))$
4-8	$\text{NA}_{\text{above}} \text{C}^\circ = \text{Airport}_{\text{ISA}} + \Delta \text{ISA}_{\text{high}}$
	$\text{NA}_{\text{above}}(\text{F}^\circ) = \text{NA}_{\text{above}}(\text{C}^\circ) * 1.8 + 32$
4-9	$1 / (\tan(\theta * \pi/180) * (0.928 + 0.0038 * (\text{ACT}^\circ \text{C} - \text{ISA}^\circ \text{C})))$
4-10	$h - (\text{OBS}_Y - \text{Width}_{\text{primary}} * 1852/0.3048) / 7$
4-11	$h + 161$
4-12a	$D_{\text{origin}} + r * \text{OCS}_{\text{slope}} * \ln((\text{LTP}_{\text{elev}} + 89 + r) / (r + \text{LTP}_{\text{elev}}))$
4-12b	$(r + \text{LTP}_{\text{elev}}) * e^{((\text{OBS}_X - D_{\text{origin}}) / (r * \text{OCS}_{\text{slope}})) - r}$
4-13	$d = (r + \text{LTP}_{\text{elev}}) * \text{OCS}_{\text{slope}} * \ln((r + \text{O}_{\text{MSL}}) / (r + \text{LTP}_{\text{elev}})) + D_{\text{origin}}$
	$\text{DA}_{\text{OCS}} = e^{((d * \tan(\theta * \pi/180)) / r) * (r + \text{LTP}_{\text{elev}} + \text{TCH}) - r}$
4-14	$(\ln((r + \text{DA}) / (r + \text{LTP}_{\text{elev}} + \text{TCH})) * (r + \text{LTP}_{\text{elev}})) / \tan(\theta * \pi/180)$
4-15a	$25.317 * ((V_{\text{KIAS}} * (171233 * ((288 + 15) - 0.00198 * \text{DA})^{0.5}) / (288 - 0.00198 * \text{DA})^{2.628}) + 10)$
4-15b	$Z / \text{CG} * 1852/0.3048$
4-16	$\text{DA} - \text{hl}$
4-17	$e^{((p * (\text{MA}_{\text{slope}} * \tan(\theta * \pi/180)) / (1 + \text{MA}_{\text{slope}} * \tan(\theta * \pi/180))) / r) * r - r}$
Chapter 5	
5-1	$S = 102/\theta$
5-2	$954 - \text{TCH} / \tan(\theta * \pi/180)$
5-3	$0.036 * \text{OBS}_X + 392.8$
5-4	$((r + \text{LTP}_{\text{elev}} - (\theta * (200 + d)) / 102) * \cos(\text{atan}(\theta/102))) / \cos((\text{OBS}_X - (200 + d)) / r + \text{atan}(\theta/102)) - r$
5-5	$\text{OBS}_{\text{MSL}} - ((r + \text{LTP}_{\text{elev}}) * (1 / \cos(\text{OBS}_Y/r) - 1) + Q)$
5-6	$0.10752 * \text{OBS}_X + 678.5$
5-7	$(\text{OBS}_Y - W_{\text{boundary}}) / 4$
5-8	$0.15152 * \text{OBS}_X + 969.7$
5-9	$(X_{\text{boundary}} - W_{\text{boundary}}) / 4 + (\text{OBS}_Y - X_{\text{boundary}}) / 7$
5-10	$\text{HATH} + \text{LTP}_{\text{elev}}$
5-11	$r * (\pi/2 - \theta * \pi/180 - \text{asin}((\cos(\theta * \pi/180) * (r + \text{LTP}_{\text{elev}} + \text{TCH})) / (r + \text{DA})))$
5-12	$D_{\text{adjusted}} = r * (\pi/2 - \text{atan}(\theta/102) - \text{asin}((\cos(\text{atan}(\theta/102)) * ((r + \text{LTP}_{\text{elev}}) - (\theta * (200 + d)) / 102)) / (r + \text{O}_{\text{EE}})))$
	$\text{DA}_{\text{adjusted}} = ((r + \text{LTP}_{\text{elev}} + \text{TCH}) * \cos(\theta * \pi/180)) / \cos(D_{\text{adjusted}} / r + \theta * \pi/180) - r$

5-13	$SRD = ((r + O_{EE})^2 + (r + LTP_{elev})^2 - 2 * (r + O_{EE}) * (r + LTP_{elev}) * \cos((OBS_x - (200 + d)) / r))^{0.5}$
	$RS = 1 / \tan(\arccos((SRD^2 + (r + LTP_{elev})^2 - (r + O_{EE})^2) / (2 * SRD * (r + LTP_{elev}))) - \pi / 2)$
	$\theta_{required} = 102 / RS$
5-14	$(d * \theta) / 102$
5-15	$\tan(\theta * \pi / 180) * (102 * p) / \theta$
5-16	$D_{1aEnd} * (3038 - C_W) / 8401 + C_W$
5-17	$((r + LTP_{elev} - (\theta * (200 + d)) / 102) * \cos(\arctan(\theta / 102))) / \cos((X_{DA} - d - 1660) / r + \arctan(\theta / 102)) - r$
5-18	$(r + elev_{1aEnd}) * e^{(d_{1aEnd} / (28.5 * r))} - r$
5-19	$d_{1aEnd} * (3038 - C_X) / 8401 + C_X$
5-20	$elev_{1bW} + (a - width_{1bW}) / 4$
5-21	$d_{1aEnd} * (3038 - C_Y) / 8401 + C_Y$
5-22	$elev_{1bX} + (a - width_{1bX}) / 7$
5-23	$2907 * p / (28.5 * \theta + 102)$
5-24	$\tan(\theta * \pi / 180) * (X_{DA} + \Delta X_{DA}) + LTP_{elev} + TCH$
5-25	$DA - \tan(\theta * \pi / 180) * 1460 + 276.525$
	$(r + elev_{1aEnd}) * e^{(8401 / (28.5 * r))} - r$
	$Aircraft_{SOC} - OCS_{SOC}$
Chapter 6	
6-1	$(r + (MDA \text{ or } DA)) * e^{((AB_{NM} * CG) / r)} - r$
6-2a1	$9861 + r / CG1 * 1852 / 0.3048 * \ln((r + CG1_{termalt}) / (r + Aircraft_{SOC})) + r / CG2 * 1852 / 0.3048 * \ln((r + turn_{alt}) / (r + CG1_{termalt}))$
6-2a2	$9861 + r / CG * 1852 / 0.3048 * \ln((r + turn_{alt}) / (r + Aircraft_{SOC}))$
6-2b1	$FSL * r / (r + MDA) + r / CG1 * 1852 / 0.3048 * \ln((r + CG1_{termalt}) / (r + MDA)) + r / CG2 * 1852 / 0.3048 * \ln((r + turn_{alt}) / (r + CG1_{termalt}))$
6-2b2	$FSL * r / (r + MDA) + r / CG * 1852 / 0.3048 * \ln((r + turn_{alt}) / (r + MDA))$
6-2c1	$FSL * r / (r + DA) + r / CG1 * 1852 / 0.3048 * \ln((r + CG1_{termalt}) / (r + DA)) + r / CG2 * 1852 / 0.3048 * \ln((r + turn_{alt}) / (r + CG1_{termalt}))$
6-2c2	$FSL * r / (r + DA) + r / CG * 1852 / 0.3048 * \ln((r + turn_{alt}) / (r + DA))$
6-3	$(V_{KTAS} + 0)^2 / (\tan(15 * \pi / 180) * 68625.4)$
6-3a	$(3431 * \tan(15 * \pi / 180)) / (\pi * V_{KTAS})$
6-4	$\phi * V_{KTW} / 3600 * TR$
6-5	$\ln((Alt_{fix} + r) / (Aircraft_{SOC} + r)) * r / CG$
6-6	$(r + Aircraft_{SOC}) * e^{(CG * D_{fix} / r)} - r$

6-7	ATT+DTA
6-8	ATT+rr
6-9	$ROC_{obs} = ROC_{start} + 48 * d$
	$Alt_{min} = O_{elev} + ROC_{obs}$
	$CG = (Alt_{min} - Acft_{elev}) / d$

Appendix 2. TERPS Standard Formulas for Geodetic Calculations

1.0 Purpose.

The ellipsoidal formulas contained in this document must be used in determining **RNAV** flight path (**GPS, RNP, WAAS, LAAS**) fixes, courses, and distance between fixes.

Notes:

Algorithms and methods are described for calculating geodetic locations (latitudes and longitudes) on the World Geodetic System of 1984 (**WGS-84**) ellipsoid, resulting from intersections of geodesic and non-geodesic paths. These algorithms utilize existing distance and azimuth calculation methods to compute intersections and tangent points needed for area navigation procedure construction. The methods apply corrections to an initial spherical approximation until the error is less than the maximum allowable error, as specified by the user.

Several constants are required for ellipsoidal calculations. First, the ellipsoidal parameters must be specified. For the **WGS-84** ellipsoid, these are:

$$\begin{aligned} a &= \text{semi-major axis} = 6,378,137.0 \text{ m} \\ b &= \text{semi-minor axis} = 6,356,752.314245 \text{ m} \\ 1/f &= \text{inverse flattening} = 298.257223563 \end{aligned}$$

Note that the semi-major axis is derived from the semi-minor axis and flattening parameters using the relation $b = a(1 - f)$.

Second, an earth radius is needed for spherical approximations. The appropriate radius is the geometric mean of the **WGS-84** semi-major and semi-minor axes. This gives

$$\text{SPHERE_RADIUS (r)} = \sqrt{ab} = 6,367,435.679716 \text{ m .}$$

Perform calculations with at least 15 significant digits.

For the purpose of determining geodetic positions, perform sufficient iterations to converge within 1 cm in distance and 0.002 arc seconds in bearing.

2.0 Introduction.

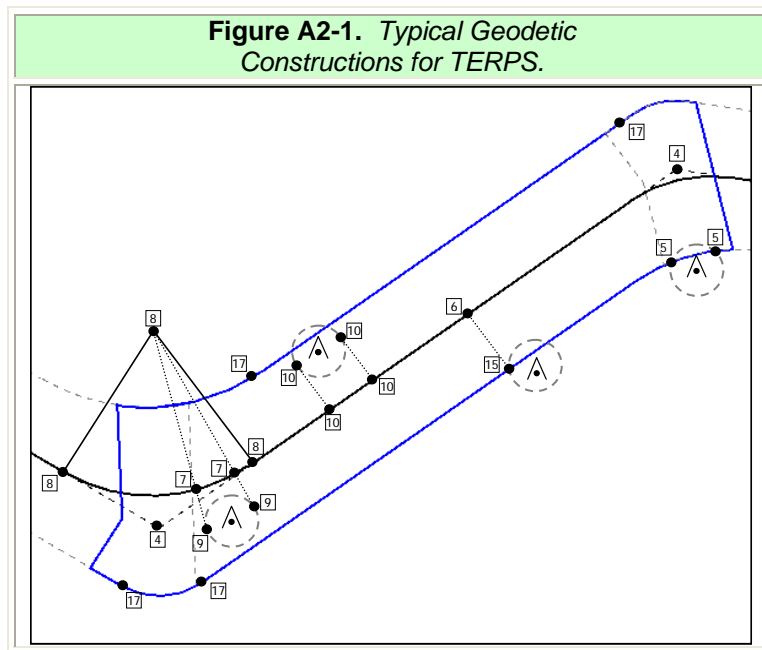
The algorithms needed to calculate geodetic positions on the earth for the purpose of constructing and analyzing Terminal Instrument Procedures (*TERPS*) require the following geodetic calculations, some of which are illustrated in *figure A2-1*:

- 1: Find the destination latitude and longitude, given starting latitude and longitude as well as distance and starting azimuth (often referred to as the “direct” or “forward” calculation).
- 2: Compute the geodesic arc length between two points, along with the azimuth of the geodesic at either point (often referred to as the “inverse” calculation).
- 3: Given a point on a geodesic, find a second geodesic that is perpendicular to the given geodesic at that point.
- 4: Given two geodesics, find their intersection point. (Labeled “4”)
- 5: Given two constant-radius arcs, find their intersection point(s). (Labeled “5”)
- 6: Given a geodesic and a separate point, find the point on the geodesic nearest the given point. (Labeled “6”)
- 7: Given a geodesic and an arc, find their intersection point(s). (Labeled “7”)
- 8: Given two geodesics and a radius value, find the arc of the given radius that is tangent to both geodesics and the points where tangency occurs. (Labeled “8”)
- 9: Given an arc and a point, determine the geodesic(s) tangent to the arc through the point and the point(s) where tangency occurs. (Labeled “9”)
- 10: Given an arc and a geodesic, determine the geodesic(s) that are tangent to the arc and perpendicular to the given geodesic and the point(s) where tangency occurs. (Labeled “10”)
- 11: Compute the length of an arc.
- 12: Determine whether a given point lies on a particular geodesic.
- 13: Determine whether a given point lies on a particular arc.

The following algorithms have been identified as required for analysis of *TERPS* procedures that use locus of points curves:

- 14: Given a geodesic and a locus, find their intersection point.
- 15: Given a fixed-radius arc and a locus, find their intersection point(s). (Labeled “15”)
- 16: Given two loci, find their intersection.
- 17: Given two loci and a radius, find the center of the arc tangent to both loci and the points of tangency. (Labeled “17”)

The algorithm prototypes and parameter descriptions are given below using a C-like syntax. However, the algorithm steps are described in pseudo-code to maintain clarity and readability.



Numbers refer to the algorithm in the list above that would be used to solve for the point.

2.1 Data Structures.

2.1.1 Geodetic Locations.

For convenience, one structure is used for both components of a geodetic coordinate. This is referred to as an `LLPoint`, which is declared as follows using C syntax:

```
typedef struct {
    latitude;
    longitude;
} LLPoint;
```

2.1.2 Geodesic Curves.

A geodesic curve is the minimal-length curve connecting two geodetic locations. Since the planar geodesic is a straight line, we will often informally refer to a geodesic as a “line.” Geodesics will be represented in data using two LLPoint structures.

2.1.3 Fixed Radius Arc.

A geodetic arc can be defined by a center point and radius distance. The circular arc is then the set (or locus) of points whose distance from the center point is equal to the radius. If an arc subtends an angle of less than 360 degrees, then its start azimuth, end azimuth, and orientation must be specified. The orientation is represented using a value of ± 1 , with +1 representing a counterclockwise arc and -1 representing a clockwise arc. The distance between the start and end points must be checked. If it is less than a predetermined tolerance value, then the arc will be treated like a complete circle.

2.1.4 Locus of Points Relative to a Geodesic.

A locus of points relative to a geodesic is the set of all points such that the perpendicular distance from the geodesic is defined by a continuous function $w(P)$ which maps each point P on the geodesic to a real number. For the purposes of procedure design, $w(P)$ will be either a constant value or a linear function of the distance from P to geodesic start point. In the algorithms that follow, a locus of points is represented using the following C structure:

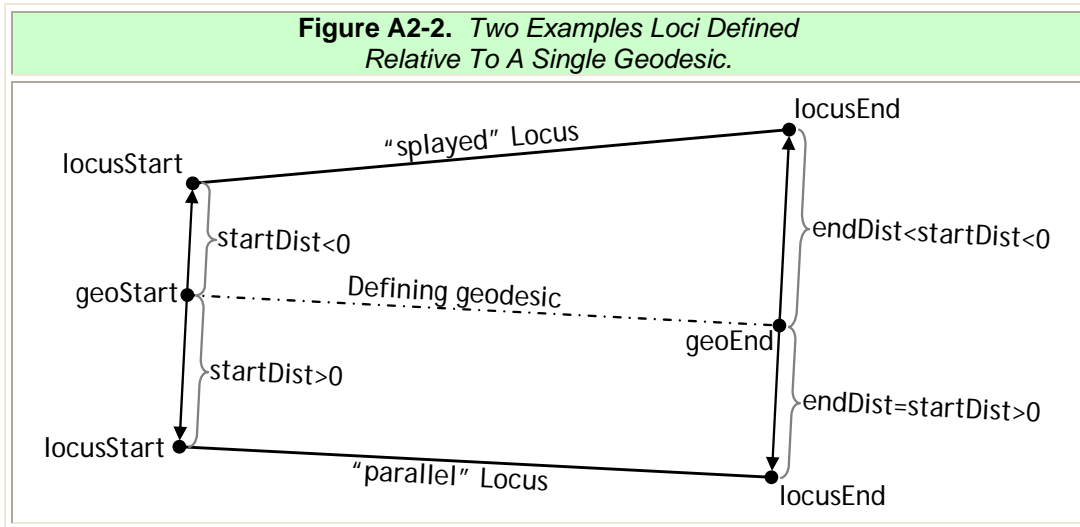
```
typedef struct {
    LLPoint geoStart; /* start point of geodesic */
    LLPoint geoEnd; /* end point of geodesic */
    LLPoint locusStart; /* start point of locus */
    LLPoint locusEnd; /* end point of locus */
    double startDist; /* distance from geodesic *
                       * to locus at geoStart */
    double endDist; /* distance from geodesic *
                    * to locus at geoEnd */
    int lineType; /* 0, 1 or 2 */
} Locus;
```

The startDist and endDist parameters define where the locus lies in relation to the defining geodesic. If endDist=startDist, then the locus will be described as being “parallel” to the geodesic, while if endDist≠startDist, then the locus is “splayed.” Furthermore, the sign of the distance parameter determines which side of the geodesic the locus is on. The algorithms described in this paper assume the following convention: if the distance to the locus is positive, then the locus lies to the

right of the geodesic; if the distance is negative, then the locus lies to the left. These directions are relative to the direction of the geodesic as viewed from the `geoStart` point. See *figure A2-2* for an illustration.

If memory storage is limited, then either the `startDist/endDist` or `locusStart/locusEnd` elements may be omitted from the structure, since one may be calculated from the other. However, calculating them once upon initialization and then storing them will reduce computation time.

The `lineType` attribute is used to specify the locus's extent. If it is set to 0 (zero), then the locus exists only between `geoStart` and `geoEnd`. If `lineType=1`, then the locus begins at `geoStart` but extends beyond `geoEnd`. If `lineType=2`, then the locus extends beyond both `geoStart` and `geoEnd`.



3.0 Basic Calculations.

3.1 Iterative Approach.

For most of the intersection and projection methods listed below, an initial approximation is iteratively improved until the calculated error is less than the required accuracy. The iterative schemes employ a basic secant method, relying upon a linear approximation of the error as a function of one adjustable parameter.

To begin the iteration, two starting solutions are found and used to initialize a pair of two-element arrays. The first array stores the two most recent values of the parameter being adjusted in the solution search. This array is named `distarray` when the search parameter is the distance from a known point. It is named `crsarray` when the search parameter is an angle measured against the azimuth of a known geodesic. The second array (named `errarray` in the algorithms below) stores the error values corresponding to the two most recent parameter values. Thus, these arrays store a linear representation of the error function. The next solution in each iteration is found by solving for the root of that linear function using the `findLinearRoot` function:

```
void findLinearRoot(double x[2], double y[2],
                  double* root) {
    if (x[0] == x[1]) {
        /* function has duplicate x values, no root */
        /* NOTE: NAN is a macro defined in math.h. It
         is required for any IEEE-compliant C
         environment */
        root = NAN;
    } else if (y[0] == y[1]) {
        if (y[0]*y[1] == 0.0) {
            *root = x[0];
        } else {
            /* function is non-zero constant, no root */
            root = NAN;
        }
    } else {
        *root = -y[0]*(x[1]-x[0])/(y[1]-y[0]) + x[0];
    }
}
```

This function returns the value of the search parameter for which the linear error approximation is zero. The returned root is used as the next value in the adjustable parameter and the corresponding error value is calculated. Then the parameter and error arrays are updated and another new root is found.

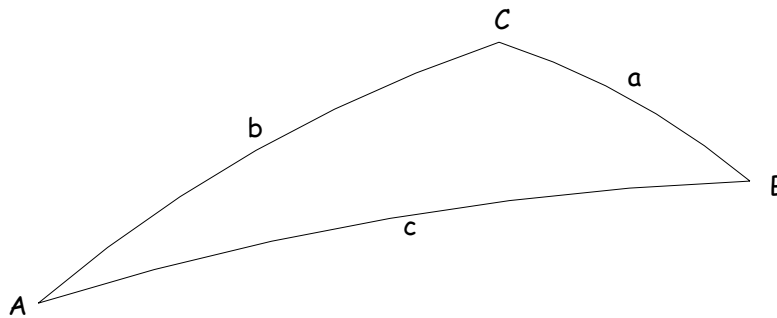
This iteration scheme works well for the algorithms described in this paper. Convergence is achieved very quickly because each starting solution is very close to the final solution, where the error is well approximated by a linear function.

3.2 Starting Solutions.

Starting solutions must be provided to start iterating toward a precise solution. Initial solutions may be found in all cases by using spherical triangles to approximate the geodetic curves being analyzed, and then solve for unknown distance and azimuth values using spherical trigonometry formulas.

3.2.1 Spherical Direction Intersect.

Given two points A and B and two bearings A to C and B to C, find C.



Run *Inverse* to find arc length from A to B and bearings A to B and B to A.

Compute differences of bearings to find angles A and B of the spherical triangle ABC.

More than one valid solution may result. Choose the solution closest to the original points.

Apply the spherical triangle formulas to find the angle C and arc lengths from A to C and from B to C:

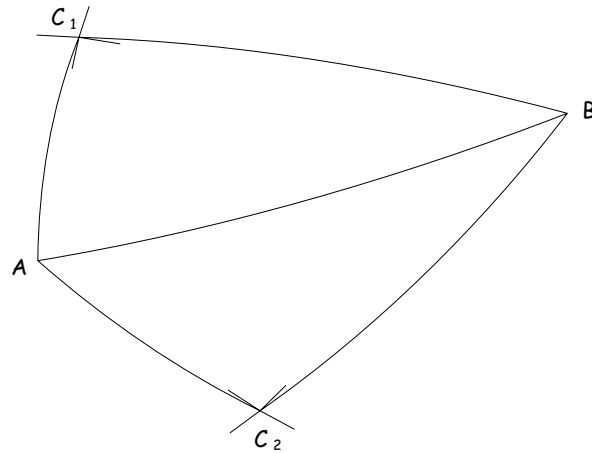
$$C = \cos^{-1} \left(-\cos(A) \cdot \cos(B) + \sin(A) \cdot \sin(B) \cos \left(\frac{c}{R} \right) \right),$$

$$a = R \cdot \cos^{-1} \left(\frac{\cos(A) + \cos(B) \cdot \cos(C)}{\sin(B) \cdot \sin(C)} \right), \quad b = R \cdot \cos^{-1} \left(\frac{\cos(B) + \cos(A) \cdot \cos(C)}{\sin(A) \cdot \sin(C)} \right).$$

Note: If distances *a* or *b* result from a reciprocal bearing, assign appropriate negative sign(*s*).

Run *Direct* from A to find C. Use given bearing and computed length b.

3.2.2 Spherical Distance Intersection.



Given A, B and distances AC and BC, find C_1 and C_2 .

Run *Inverse* to find length and bearings between A and B.

Use spherical triangles to find angles $A = \angle BAC_1 = \angle BAC_2$, $B = \angle ABC_1 = \angle ABC_2$, and $C = \angle BC_1A = \angle BC_2A$:

$$A = \cos^{-1} \left(\frac{\cos\left(\frac{a}{R}\right) - \cos\left(\frac{b}{R}\right)\cos\left(\frac{c}{R}\right)}{\sin\left(\frac{b}{R}\right)\sin\left(\frac{c}{R}\right)} \right), \quad B = \cos^{-1} \left(\frac{\cos\left(\frac{b}{R}\right) - \cos\left(\frac{a}{R}\right)\cos\left(\frac{c}{R}\right)}{\sin\left(\frac{a}{R}\right)\sin\left(\frac{c}{R}\right)} \right),$$

$$\text{and } C = \cos^{-1} \left(\frac{\cos\left(\frac{c}{R}\right) - \cos\left(\frac{a}{R}\right)\cos\left(\frac{b}{R}\right)}{\sin\left(\frac{a}{R}\right)\sin\left(\frac{b}{R}\right)} \right).$$

Run *Direct* from A to find C_1 and C_2 .

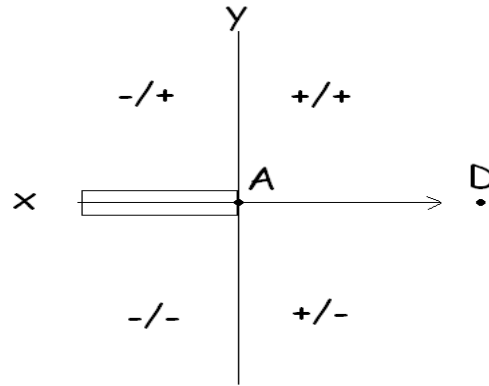
To compute the bearing from A to C_1 , start with the bearing from A to B and subtract angle A.

To compute the bearing from A to C_2 , start with the bearing from A to B and add angle A.

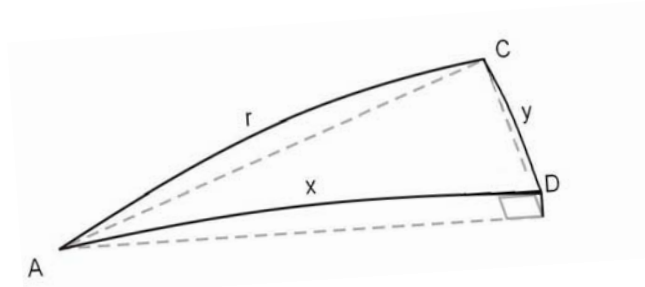
Use *Inverse* and spherical triangle formulas to get remaining bearings.

3.2.3 Spherical Tangent Point.

In both cases of the tangent point, distances are signed according to the following sign legend:



Where the arrow indicates the bearing from the first point A to the target point D.

3.2.4 Two Points and a Bearing Case.

Given two points, A and C, and a bearing from the first point (A). Find the point D along the given bearing extended which is closest to C.

Run *Inverse* to find length and bearings between A and C.

Find difference in bearings to compute angle A.

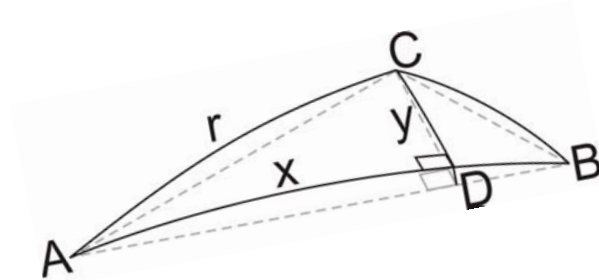
Use right spherical triangles to calculate y and x:

$$y = R \sin^{-1} \left(\sin\left(\frac{r}{R}\right) \sin(A) \right),$$

$$x = R \cos^{-1} \left(\cos\left(\frac{r}{R}\right) / \cos\left(\frac{y}{R}\right) \right).$$

Run *Direct* from A to find D using given bearing and computed length x.

3.2.5 Given Three Points Case.



Given three points (A, B, C), find the point (D) on the geodesic line from the first two points which is the perpendicular foot from the third point.

Use *Inverse* to determine bearing from A to B.

Use *Inverse* to determine bearing and length from A to C.

Find the difference in bearings to determine angle A.

Use right spherical triangles to find the lengths x and y:

$$y = R \sin^{-1} \left(\sin\left(\frac{r}{R}\right) \sin(A) \right),$$

$$x = R \cos^{-1} \left(\cos\left(\frac{r}{R}\right) / \cos\left(\frac{y}{R}\right) \right).$$

Use *Direct* to calculate D from A using the computed bearing from A to B and computed distance x.

3.3 Tolerances.

Two different convergence tolerances must be supplied so that the algorithms cease iterating once the error becomes sufficiently small. The first tolerance parameter is used in the forward and inverse routines; it is referred to as `eps` in the algorithm descriptions. The second parameter, labeled `tol`, is used in the intersection and projection routines to limit the overall error in the solution. Since the intersection and projection routines make multiple calls to the inverse and forward algorithms, the `eps` parameter should be several orders of magnitude smaller than the `tol` parameter to ensure that the iteration methods return correct results. Empirical studies have shown that `eps = 0.5e-13` and `tol = 1.0e-9` work well.

Finally, a maximum iteration count and convergence tolerances must be supplied to ensure that no algorithms can remain in an infinite loop if convergence is not reached. This parameter can be set by the programmer, but should be greater than five to ensure that all of the algorithms can reach convergence.

3.4 Direct and Inverse Algorithms.

The Direct and Inverse cases utilize formulae from T. Vincenty's, *Survey Review XXIII, No. 176, April 1975: Direct and Inverse Solutions of Geodesics on the Ellipsoid with Application of Nested Equations.*

Vincenty's notation is annotated below:

a, b , major and minor semi axes of the ellipsoid.

f , flattening = $\frac{a-b}{a}$.

ϕ , geodetic latitude, positive north of the equator.

L , difference in longitude, positive east.

s , length of the geodesic.

α_1, α_2 , bearings of the geodesic, clockwise from north; α_2 in the direction P_1P_2 produced.

α , bearing of the geodesic at the equator.

$u^2 = \frac{a^2 - b^2}{b^2} \cos^2 \alpha$.

U , reduced latitude, defined by $\tan U = (1 - f) \tan \phi$.

λ , difference in longitude on the auxiliary sphere.

σ , angular distance P_1P_2 , on the sphere.

σ_1 , angular distance on the sphere from the equator to P_1 .

σ_m , angular distance on the sphere from the equator to the midpoint of the line.

3.4.1 Vincenty's Direct Formula.

$$\tan \sigma_1 = \frac{\tan U_1}{\cos \alpha_1} \quad (1)$$

$$\sin \alpha = \cos U_1 \sin \alpha_1. \quad (2)$$

$$A = 1 + \frac{u^2}{16384} \left\{ 4096 + u^2 \left[-768 + u^2 (320 - 175u^2) \right] \right\} \quad (3)$$

$$B = \frac{u^2}{1024} \left\{ 256 + u^2 \left[-128 + u^2 (74 - 47u^2) \right] \right\} \quad (4)$$

$$2\sigma_m = 2\sigma_1 + \sigma \quad (5)$$

$$\Delta\sigma = B \sin \sigma \left\{ \cos(2\sigma_m) + \frac{1}{4} B \left[\cos(\sigma) (2 \cos^2(2\sigma_m) - 1) - \frac{1}{6} B \cos(2\sigma_m) (4 \sin^2 \sigma - 3) (4 \cos^2(2\sigma_m) - 3) \right] \right\} \quad (6)$$

$$\sigma = \frac{s}{bA} + \Delta\sigma \quad (7)$$

Equations (5), (6), and (7) are iterated until there is a negligible change in σ . The first approximation of σ is the first term of (7).

Note 1: For 1 cm accuracy, σ can change no more than $1.57e-009$.

$$\tan \phi_2 = \frac{\sin U_1 \cos \sigma + \cos U_1 \sin \sigma \cos \alpha_1}{(1-f) \left[\sin^2 \alpha + (\sin U_1 \sin \sigma - \cos U_1 \cos \sigma \cos \alpha_1)^2 \right]^{\frac{1}{2}}} \quad (8)$$

$$\tan \lambda = \frac{\sin \sigma \sin \alpha_1}{\cos U_1 \cos \sigma - \sin U_1 \sin \sigma \cos \alpha_1} \quad (9)$$

$$C = \frac{f}{16} \cos^2 \alpha \left[4 + f (4 - 3 \cos^2 \alpha) \right] \quad (10)$$

$$L = \lambda - (1-C) f \sin \alpha \left\{ \sigma + C \sin \sigma \left[\cos(2\sigma_m) + C \cos \sigma (2 \cos^2(2\sigma_m) - 1) \right] \right\} \quad (11)$$

$$\tan \alpha_2 = \frac{\sin \alpha}{-\sin U_1 \sin \sigma + \cos U_1 \cos \sigma \cos \alpha_1} \quad (12)$$

The latitude is found by computing the arctangent of (8) and α_2 is found by computing the arctangent of (12).

3.4.2 Vincenty's Inverse Formula.

$$\lambda = L \text{ (first approximation)} \quad (13)$$

$$\sin^2 \sigma = (\cos U_2 \sin \lambda)^2 + (\cos U_1 \sin U_2 - \sin U_1 \cos U_2 \cos \lambda)^2 \quad (14)$$

$$\cos \sigma = \sin U_1 \sin U_2 + \cos U_1 \cos U_2 \cos \lambda \quad (15)$$

$$\tan \sigma = \frac{\sin \sigma}{\cos \sigma} \quad (16)$$

$$\sin \alpha = \frac{\cos U_1 \cos U_2 \sin \lambda}{\sin \sigma} \quad (17)$$

$$\cos(2\sigma_m) = \cos \sigma - \frac{2 \sin U_1 \sin U_2}{\cos^2 \alpha} \quad (18)$$

λ is obtained by equations (10) and (11). This procedure is iterated starting with equation (14) until the change in λ is negligible. *See Note 1.*

$$s = bA(\sigma - \Delta\sigma) \quad (19)$$

Where $\Delta\sigma$ comes from equations (3), (4), and (6)

$$\tan \alpha_1 = \frac{\cos U_2 \sin \lambda}{\cos U_1 \sin U_2 - \sin U_1 \cos U_2 \cos \lambda} \quad (20)$$

$$\tan \alpha_2 = \frac{\cos U_1 \sin \lambda}{\cos U_1 \sin U_2 \cos \lambda - \sin U_1 \cos U_2} \quad (21)$$

The inverse formula may give no solution over a line between two nearly antipodal points. This will occur when λ , as computed by (11), is greater than π in absolute value. To find α_1, α_2 , compute the arctangents of (20) and (21).

3.5 Geodesic Oriented at Specified Angle.

In *TERPS* procedure design, it is often required to find a geodesic that lies at a prescribed angle to another geodesic. For instance, the end lines of an obstacle evaluation area (*OEA*) are typically projected from the flight path at a prescribed angle. Since the azimuth of a geodesic varies over the length of the curve, the angle between two geodesics must be measured by comparing the azimuth of each geodesic at the point where they intersect. Keeping that in mind, the following pseudo code represents an algorithm that will calculate the correct azimuth at the intersection. The desired geodesic is then defined by the azimuth returned and the given intersection point.

3.5.1 Input/Output.

double azimuthAtAngle(LLPoint **startPt**, LLPoint **intxPt**,
double **angle**, double **eps**)
returns a double representing the azimuth of the intersecting geodesic, where the
inputs are:

LLPoint startPt	=	Coordinates of start point of given geodesic
LLPoint intxPt	=	Coordinates of intersection of given and desired geodesics
double angle	=	Angle between given geodesic and desired geodesic at intersection point ($\pm\pi/2$ for perpendicular lines)
double eps	=	Convergence parameter for forward/inverse algorithms

3.5.2 Algorithm Steps.

See *figure A2-3* for an illustration of quantities.

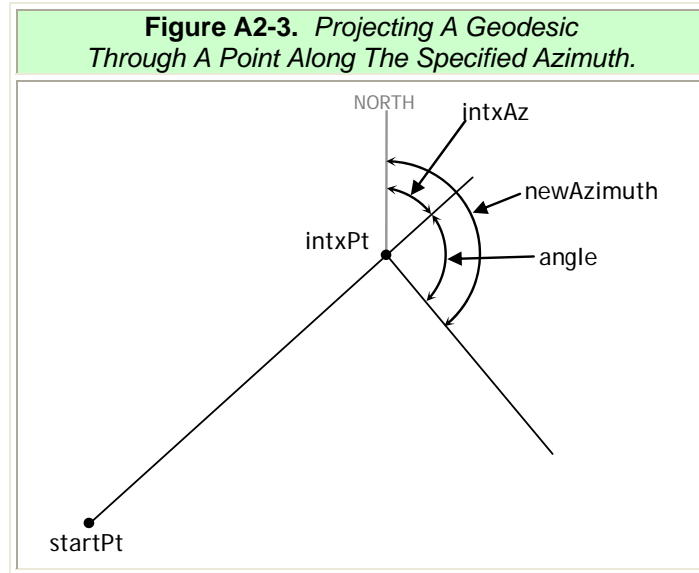
STEP 1: Use the *inverse algorithm* to calculate the azimuth required to follow the given geodesic from **intxPt** to **startPt**. Use **intxPt** as the starting point and **startPt** as the destination point. Denote the computed azimuth by **intxAz**.

STEP 2: Convert the **intxAz** to its reciprocal: $\text{intxAz} = \text{intxAx} + \pi$.

STEP 3: Add the desired change in azimuth to get the azimuth of the new geodesic:
 $\text{newAzimuth} = \text{intxAz} + \text{angle}$.

STEP 4: Return the calculated azimuth.

Note that if **angle** is positive, then the new geodesic will lie to the right of the given geodesic (from the perspective of standing at the start point and facing toward the end point); otherwise, the new geodesic will lie to the left.



3.6 Determine If Point Lies on Geodesic.

This algorithm returns a non-zero (true) value if a point lies on and within the bounds of a given geodesic. The bounds of the geodesic are specified by two pieces of information: the end point coordinates and an integer length code. If the length code is set to 0, then the geodesic is understood to exist only between its start and end points, so a value of true will be returned only if the test point also lies between the start and end points. If the length code is set to 1, then the geodesic is understood to extend beyond its end point to a distance of one half of earth's circumference from its end point. If the length code is set to 2, then the geodesic is understood to extend clear around the globe.

3.6.1 Input/Output.

`int WGS84PtIsOnGeodesic(LLPoint startPt, LLPoint endPt, LLPoint testPt, int lengthCode, double tol)` returns an integer value indicating whether `testPt` lies on geodesic, where the inputs are:

<code>LLPoint startPt</code>	=	Geodetic coordinate of line start point
<code>LLPoint endPt</code>	=	Geodetic coordinate of line end point
<code>LLPoint testPt</code>	=	Geodetic coordinate of point to test
<code>int lengthCode</code>	=	Integer that specifies extent of line. 0: geodesic exists only between <code>startPt</code> and <code>endPt</code> . 1: geodesic extends beyond <code>endPt</code> .

double tol = Maximum difference allowed in distance

double eps = Convergence parameter for forward/inverse algorithms

3.6.2 Algorithm Steps.

See *figure A2-4* for an illustration of the variables.

STEP 1: Use *inverse algorithm* to calculate the distance from `startPt` to `testPt`. Denote this value by `dist13`.

STEP 2: Use *inverse algorithm* to calculate the azimuth and distance from `startPt` to `endPt`. Denote these values by `crs12` and `dist12`, respectively.

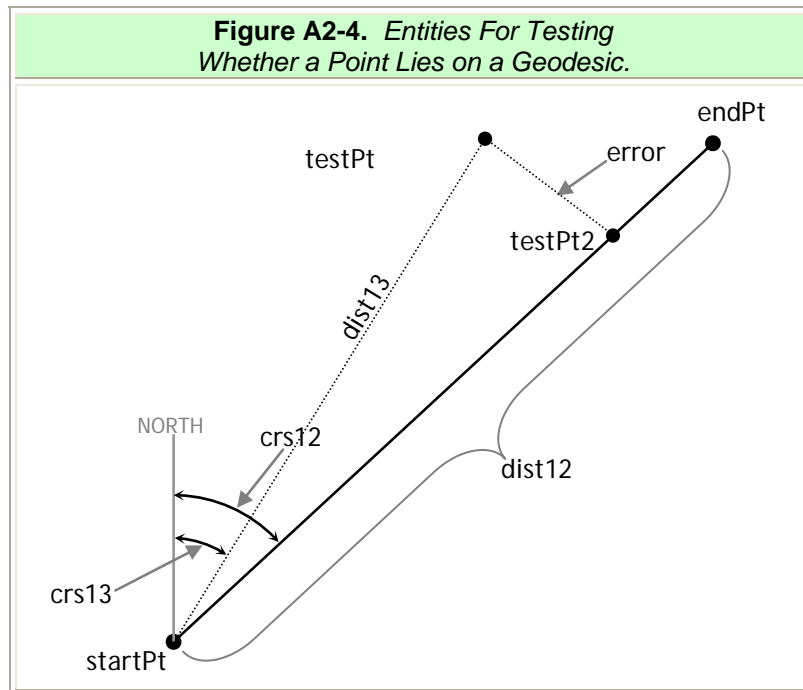
STEP 3: Use *direct algorithm* to project a point from `startPt`, along `crs12`, a distance equal to `dist13`. Denote this point by `testPt2`.

STEP 4: Use *inverse algorithm* `WGS84InvDist` to calculate distance from `testPt` to `testPt2`. This distance is the error.

STEP 5: Examine error to determine whether `testPt` lies on the geodesic within `tol` as follows:

- a. If (`error ≤ tol`) then
 - i. If (`lengthCode > 0`) or (`dist13-dist12 ≤ tol`) then
 1. `onLine = true`
 - ii. else
 1. `onLine = false`
 - iii. end if
- b. Else if (`lengthCode = 2`)
 - i. Use the *direct algorithm* to project point from `startPt`, along `crs12+π` a distance `dist13`. Again, denote this point again by `testPt2`.
 - ii. Use the *inverse algorithm* to recalculate error, which is the distance from `testPt` to `testPt2`.

- iii. If $(\text{error} \leq \text{tol})$ then $\text{onLine} = \text{true}$.
 - iv. Else $\text{onLine} = \text{false}$.
 - v. End if.
- c. Else.
- i. $\text{onLine} = \text{false}$.
- d. End if.



3.7 Determine If Point Lies on Arc.

This algorithm returns a non-zero (true) value if the sample point lies on and between the bounds of the given arc. The arc is defined by its center point, radius, start azimuth, end azimuth, and orientation. A positive orientation parameter indicates that the arc is traversed in a counterclockwise sense, while a negative orientation parameter indicates that the arc is traversed clockwise. This algorithm is used in conjunction with the arc intersection functions (*Algorithms 4.2, 4.3, and 4.6*) to determine whether the computed intersections lie within the bounds of the desired arc.

3.7.1 Input/Output.

`int WGS84PtIsOnArc(LLPoint center, double radius, double startCrs, double endCrs, int orient, LLPoint testPt, double tol)` returns an integer value indicating whether `testPt` lies on arc, where the inputs are:

<code>LLPoint center</code>	=	Geodetic coordinates of arc center
<code>double radius</code>	=	Arc radius
<code>double startCrs</code>	=	True azimuth from center to start of arc
<code>double endCrs</code>	=	True azimuth from center to end of arc
<code>int orient</code>	=	Orientation of the arc [+1 for counter-clockwise; -1 for clockwise]
<code>LLPoint testPt</code>	=	Geodetic coordinate of point to test
<code>double tol</code>	=	Maximum error allowed in solution
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

3.7.2 Algorithm Steps.

See *figure A2-5* for an illustration of the variables.

STEP 1: Use *inverse algorithm* to calculate distance and azimuth from center to `testPt`. Denote values as `dist` and `crs`, respectively.

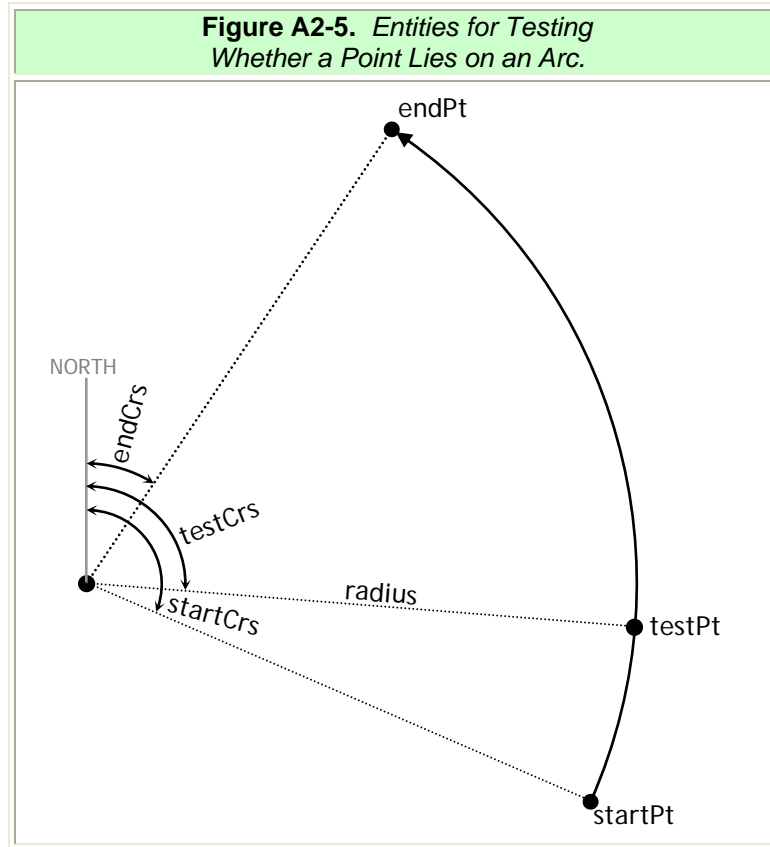
STEP 2: If $(\text{abs}(\text{dist} - \text{radius}) > \text{tol})$ then `testPt` is not correct distance from center.

a. `onArc = false`.

STEP 3: else.

- a. Use *Algorithm Attachment A.1* to calculate the angle subtended by the full arc. Denote this value by `arcExtent`.
- b. If (`arcExtent = 360°`) then
 - i. `onArc = true`.
- c. else.
 - i. Use the *inverse algorithm* to calculate the azimuth from center to `testPt`. Denote this value by `testCrS`.
 - ii. Use *Algorithm Attachment A.1* to calculate the angle subtended by and arc starting at `startCrS`, but ending at `testCrS`, with the same orientation. Denote this value by `subExtent`.
 - iii. If (`subExtent ≤ arcExtent`) then traversing arc from `startCrS` to `endCrS`, one would encounter `testPt`, so it must lie on arc.
 1. `onArc = true`.
- d. end if.

STEP 4: end if.



3.8 Calculate Length of Fixed Radius Arc.

A fixed radius arc on an ellipsoid does not generally lie in a plane. Therefore, the length of the arc cannot be computed using the usual formula for the circumference of a circle. The following algorithm takes the approach of dividing the arc into many sub-arcs. Three points are then calculated on each sub-arc. Since any three points in space uniquely determine both a plane and an arc, the three points on each sub-arc are used to calculate the radius and subtended angle of the planar arc that contains all three points. The length of the approximating planar arc is then calculated for each sub-arc. The sum of the sub-arc lengths approaches the length of the original arc as the number of sub-arc increases (and each sub-arc's length decreases).

A simpler method that is sufficiently accurate for arcs with radius less than about 300 nautical miles (*NM*) is described in *section 6.4*.

3.8.1 Input/Output.

```
double WGS84DiscretizedArcLength (LLPoint center, double
radius, double startCrs, double endCrs, int orient, int
*n, double tol)
```

returns a double precision value representing the length of the arc, where the inputs are:

LLPoint center	=	Geodetic coordinates of arc center
double radius	=	Arc radius
double startCrs	=	True azimuth from center to start of arc
double endCrs	=	True azimuth from center to end of arc
int orient	=	Orientation of the arc [+1 for counter-clockwise; -1 for clockwise]
int *n	=	Reference to integer used to return number of steps in discretized arc
double tol	=	Maximum allowed error
double eps	=	Convergence parameter for forward/inverse algorithms

3.8.2 Algorithm Steps.

See *figure A2-6* for an illustration of the variables.

STEP 1: Set initial number of sub-arcs to use. The fixed value $n = 16$ has been found through trial-and-error to be a good starting value. Alternatively, the initial value of n may be calculated based on the arc's subtended angle and its radius (i.e., its approximate arc length).

STEP 2: Convert center point to Earth-Centered, Earth-Fixed (**ECEF**) coordinates, v_0 , according to *Algorithm 6.1*.

STEP 3: Compute subtended angle, $subtAngle$, using *Algorithm Attachment A.1*.

STEP 4: Set iteration count, $k = 0$.

STEP 5: Do while $k = 0$ or $((error > tol) \text{ and } (k \leq maximumIterationCount))$.

- a. Calculate subtended angle of each sub-arc, $\theta = \text{subtAngle}/n$.
- b. Use *direct algorithm* from `center`, using `startCrs` and distance `radius`, to project start point of arc. Denote this point by `p1`.
- c. Convert `p1` to **ECEF** coordinates. Denote this vector by `v1`.
- d. Initialize `arcLength = 0`.
- e. For `i = 0` to `n`.
 - i. Compute azimuth from arc center to end point of sub-arc number `i`:
 $\theta = \text{startCrs} + i * d\theta$.
 - ii. Use *direct algorithm* from `center`, using azimuth $\theta + 0.5 * d\theta$ and distance `radius`, to project middle point of sub-arc. Denote this point by `p2`.
 - iii. Convert `p2` to **ECEF** coordinate `v2`.
 - iv. Use *direct algorithm* from `center`, using azimuth $\theta + d\theta$ and distance `radius`, to project endpoint of sub-arc. Denote this point by `p2`.
 - v. Convert `p2` to **ECEF** coordinate `v2`.
 - vi. Subtract `v2` from `v1` to find chord vector between `p1` and `p2`. Denote this vector by `chord1`. Compute $x1 = |\text{chord1}|$.
 - vii. Subtract `v2` from `v3` to find chord vector between `p3` and `p2`. Denote this vector by `chord2`. Compute $x2 = |\text{chord2}|$.
 - viii. Compute dot product of `chord1` and `chord2`. Denote this value as `d`.
 - ix. Use the following calculation to compute the length `L` of the sub-arc: (*see figure A2-7*)

$$\xi = \frac{d}{x_1 x_2}$$

$$\sigma = \sqrt{1 - \xi^2}$$

$$R = \frac{x_2 \sqrt{(x_1/x_2 - \xi)^2 + \sigma^2}}{2\sigma}$$

$$A = 2(\pi - \cos^{-1} \xi)$$

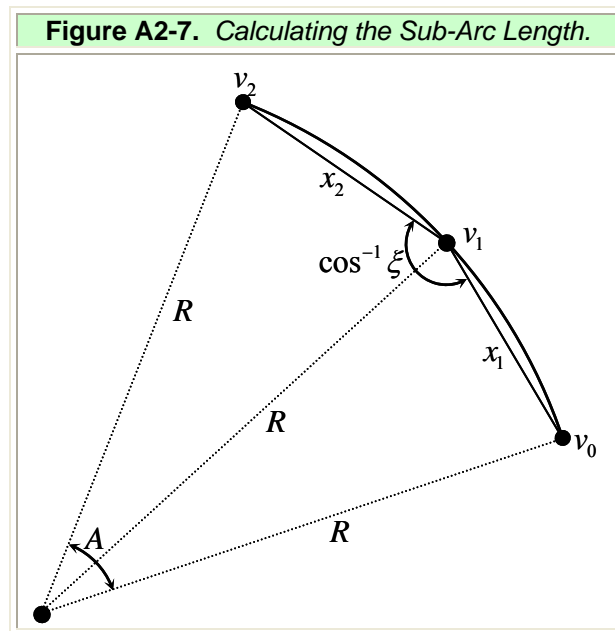
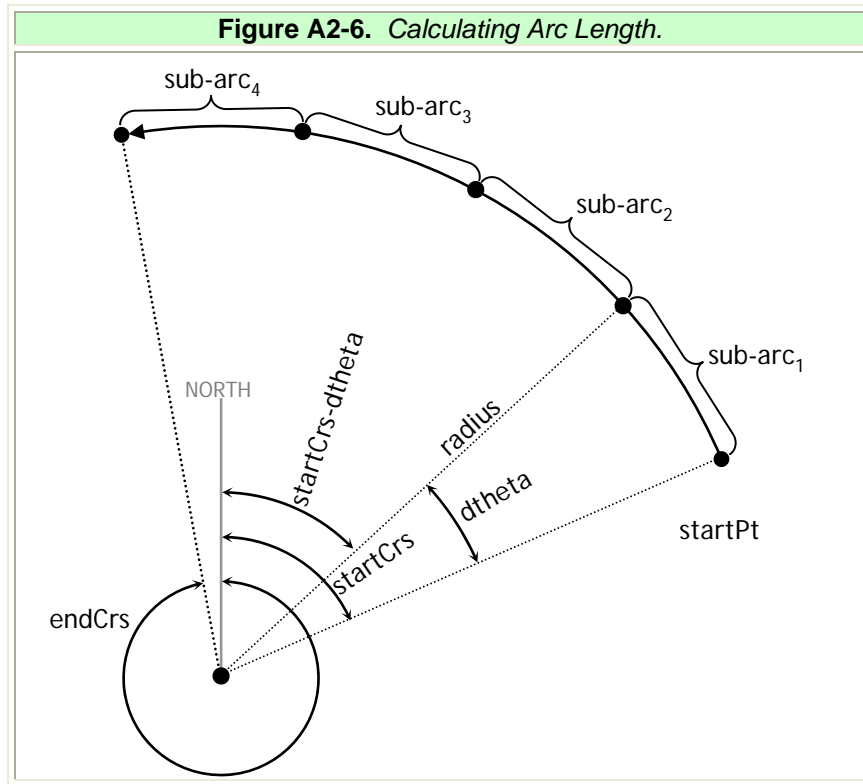
$$L = R \cdot A$$

Note that since the arc length is a planar (not geodetic) calculation, the subtended angle A is not equal to d theta.

- x. Add L to cumulative `arcLength` to get total length of sub-arcs through sub-arc number i : `arcLength = arcLength + L`.
- f. end for loop.
- g. Compute error, which is the change in length calculation between this iteration and the last: `error = abs(arcLength - oldLength)`.
- h. Increment the iteration count: `k = k + 1`.
- i. Double the number of sub-arcs: `n = 2*n`.
- j. Save the current length for comparison with the next iteration: `oldLength = arcLength`.

STEP 6: End while loop.

STEP 7: Return `arcLength`.



3.9 Find Distance from Defining Geodesic to Locus.

When computing a position on a locus of points, it is necessary to solve for the distance from the defining geodesic to the locus. This distance is constant if the locus is designed to be “parallel” to the defining geodesic. However, it is necessary to allow the locus distance to vary linearly with distance along the geodesic, since in some cases the locus will splay away from the defining geodesic. To account for this, we have included `startDist` and `endDist` attributes in the `Locus` structure defined above. For a given point on the geodesic (or given distance from the geodesic start point), the distance to the locus can then be calculated.

The two algorithms described below carry out the computation of locus distance for different input parameters. If the distance from the geodesic start point to the point of interest is known, then `WGS84DistToLocusD` may be used to calculate the locus distance. If instead a point on the defining geodesic is given, the `WGS84DistToLocusP` may be used. The latter algorithm simply computes the distance from the geodesic start point to the given point and then invokes the former algorithm. Therefore, steps are described for `WGS84DistToLocusD` only.

3.9.1 Input/Output.

`double WGS84DistToLocusD (Locus loc, double distance, double eps)` returns the distance from the defining geodesic to the locus at the given distance from `loc.geoStart`, where the inputs are:

<code>Locus loc</code>	=	Locus of interest
<code>double distance</code>	=	Distance from locus start point to point where distance is to be computed
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

`double WGS84DistToLocusP (Locus loc, LLPoint geoPt, double tol, double eps)` returns the distance from the defining geodesic to the locus at the given point, where the inputs are:

<code>Locus loc</code>	=	Locus of interest
<code>LLPoint geoPt</code>	=	Point on defining geodesic
<code>double tol</code>	=	Maximum allowable error
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithm

3.9.2 Algorithm Steps.

The following steps are followed if the distance from `loc.geoStart` is given. If a point on the geodesic (`geoPt`) is given instead, then first use the inverse algorithm to compute the distance from `geoPt` to `loc.geoStart` and then follow the following steps (note that distance must be signed negative if the locus's line type is 2 and `geoPt` is farther from `geoEnd` than it is from `geoStart`):

STEP 1: Use the *inverse function* to compute the length of the locus's defining geodesic. Denote this value as `geoLen`.

STEP 2: If (`geoLen = 0`) then `distToLoc = 0.0`

STEP 3: Else: $\text{distToLoc} = \text{loc.startDist} + \frac{\text{distance}}{\text{geoLen}} * (\text{loc.endDist} - \text{loc.startDist})$

STEP 4: End if

STEP 5: Return `distToLoc`

3.10 Project Point on Locus from Point on Defining Geodesic.

Given a point on the defining geodesic, this algorithm computes the corresponding point on the locus.

3.10.1 Input/Output.

`LLPoint WGS84PointOnLocusP (Locus loc, LLPoint geoPt, double tol, double eps)` returns the point on the locus that is abeam the given point, where the inputs are:

<code>Locus loc</code>	=	Locus of Interest
<code>LLPoint geoPt</code>	=	Point on defining geodesic
<code>double tol</code>	=	Maximum allowable error
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

3.10.2 Algorithm Steps.

STEP 1: Use *Algorithm 3.9* (with point input) to determine the distance from `geoPt` to the locus. Denote this distance as `distp`.

STEP 2: If (`distp = 0`) return `geoPt`

STEP 3: Use the *inverse algorithm* to compute the course from `geoPt` to the start point of the defining geodesic. Denote this value as `fcrs`.

STEP 4: If (`distp > 0.0`) then the locus lies to the right of the geodesic. Let

$$\text{tempcrs} = \text{fcrs} - \frac{\pi}{2}$$

STEP 5: Else, the locus lies to the left of the geodesic. Let $\text{tempcrs} = \text{fcrs} + \frac{\pi}{2}$

STEP 6: End if

STEP 7: Use the *direct algorithm* to project a point along `tempcrs`, distance `abs(distp)` from `geoPt`. Denote the point as `ptOnLoc`.

STEP 8: Return `ptOnLoc`.

3.11 Determine if Point Lies on Locus.

This algorithm compares the position of a given point with the position of the corresponding point on the locus. The corresponding point on the locus is found by projecting the given point onto the locus's defining geodesic curve, computing the correct distance from there to the locus, and then projecting a point at that distance perpendicular to the geodesic. If distance from the corresponding point to the given point is less than the error tolerance, then a reference to the projected point on the geodesic is returned. Otherwise a null reference is returned.

An alternative implementation could simply return true or false, rather than references. However, it is more efficient to return the projected point as this is often needed in subsequent calculations.

3.11.1 Input/Output.

LLPoint* WGS84PtIsOnLocus (Locus **loc**, LLPoint **testPt**, double **tol**) returns a reference to the projection of **testPt** on the locus's defining geodesic if **testPt** lies on the locus and NULL otherwise, where the inputs are:

Locus loc	=	Locus of Interest
LLPoint testPt	=	Point to test against locus
Double tol	=	Maximum allowable error
Double eps	=	Convergence parameter for forward/inverse algorithms

3.11.2 Algorithm Steps.

See *figure A2-8* for an illustration of the variables.

STEP 1: Use the *inverse algorithm* to calculate the course from the start point (**geoStart**) of the locus's defining geodesic to its end point (**geoEnd**). Denote this value as **fcrs**.

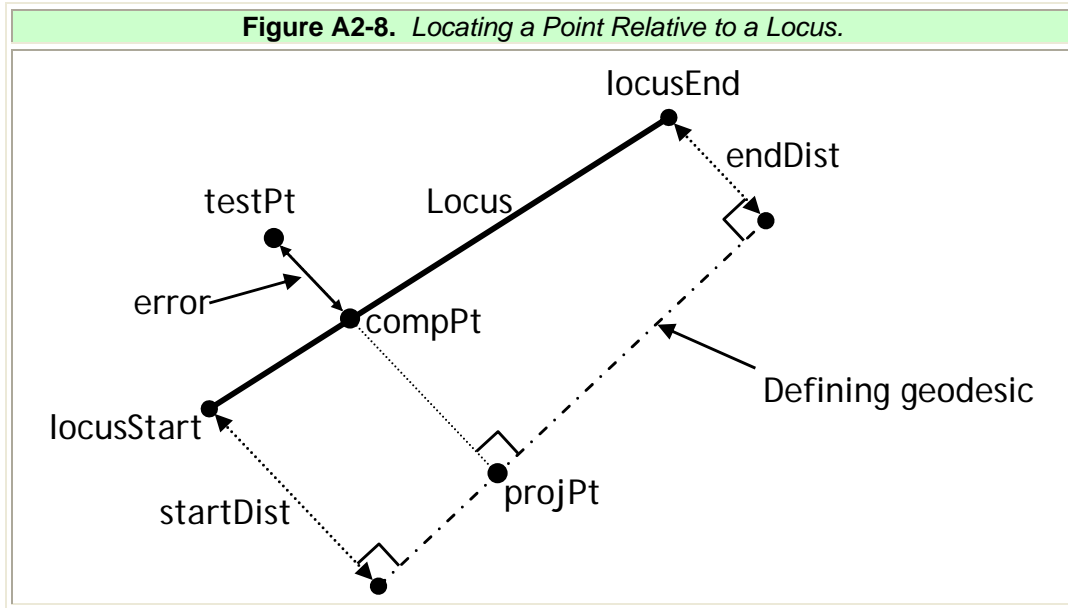
STEP 2: Use *Algorithm 5.1* to project **testPt** onto the locus's defining geodesic. Denote the projected point as **projPt**.

STEP 3: Use *Algorithm 3.6* to determine whether **projPt** lies on the locus's defining geodesic. If it does not, then return 0 (false).

STEP 4: Use *Algorithm 3.11* to compute the point on the locus corresponding to **projPt**. Denote this point by **compPt**.

STEP 5: Use the *inverse algorithm* to calculate **error**, the distance between **projPt** and **compPt**.

STEP 6: If (**error** < **tol**) then return reference to **projPt**. Otherwise, return NULL.



3.12 Compute Course of Locus

This algorithm is analogous to the inverse algorithm for a geodesic. It is used by other locus algorithms when the direction of the locus is needed.

3.12.1 Input/Output.

`double WGS84LocusCrsAtPoint (Locus loc, LLPoint testPt, LLPoint* geoPt, double* perpCrs, double tol)` returns the course of the locus at the given point. Also sets values of calculation byproducts, including the corresponding point on the locus's geodesic and the course from the given point toward the geodesic point, where the inputs are:

<code>Locus loc</code>	=	Locus of Interest
<code>LLPoint testPt</code>	=	Point at which course will be calculated
<code>LLPoint* geoPt</code>	=	Projection of <code>testPt</code> on defining geodesic
<code>double* perpCrs</code>	=	Course for <code>testPt</code> to <code>geoPt</code>
<code>double tol</code>	=	Maximum allowable error
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

3.12.2 Algorithm Steps.

See *figure A2-9* for an illustration of the variables.

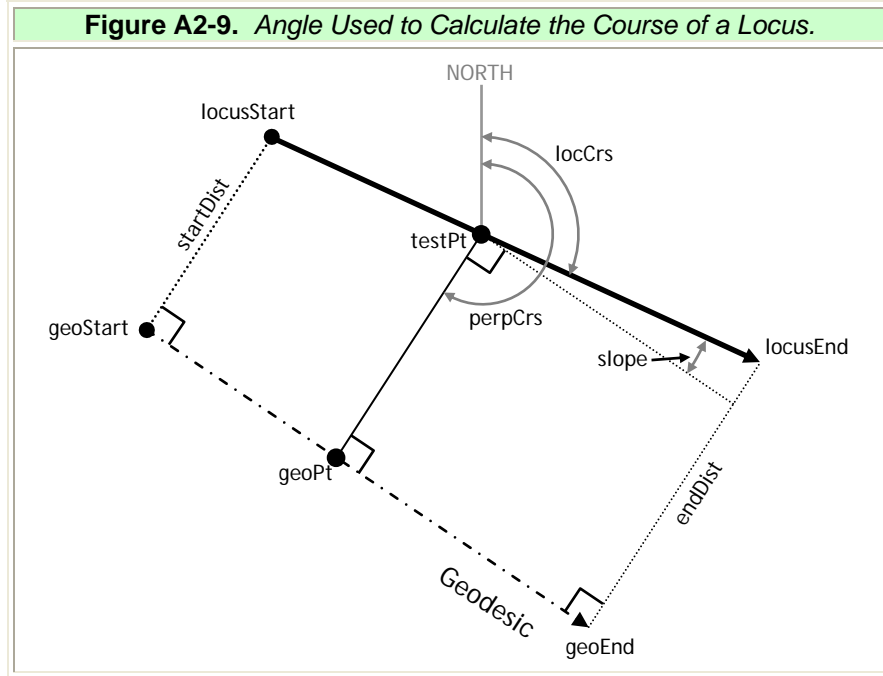
- STEP 1: Use *Algorithm 3.11* to determine whether `testPt` lies on `loc`. This same step will return a reference to the projection of `testPt` onto the defining geodesic. Denote this reference as `geoPt`.
- STEP 2: If (`geoPt = NULL`) then `testPt` is not a valid point at which to calculate the locus's course. Return -1.0. (Valid course values are in the range $[0, 2\pi]$.)
- STEP 3: Use the *inverse algorithm* to calculate the course and distance from `testPt` to `geoPt`, denoted by `perpCrS` and `perpDist`, respectively.
- STEP 4: Use *Algorithm 3.9* to calculate `distToLoc`, the distance from the geodesic to the locus at `geoPt`. This step is required to determine which side of the geodesic the locus lies on because `perpDist` will always be positive.
- STEP 5: Calculate the slope of the locus relative to the geodesic:

$$\text{slope} = \frac{(\text{loc.endDist} - \text{loc.startDist})}{\text{geoLen}}$$
- STEP 6: Convert the slope to angular measure in radians:

$$\text{slope} = \text{atan}(\text{slope})$$
- STEP 7: Adjust the value of the perpendicular course by `slope`. This accounts for how the locus is approaching or receding from the geodesic:

$$\text{perpCrS} = \text{perpCrS} + \text{slope}$$
- STEP 8: If (`distToLoc < 0`), then `testPt` lies to the left of the geodesic, so `perpCrS` points to the right of the locus's course:

$$\text{locCrS} = \text{perpCrS} - \pi/2$$
- STEP 9: Else, `testPt` lies to the right of the geodesic so `perpCrS` points to the left of the locus's course: $\text{locCrS} = \text{perpCrS} + \pi/2$
- STEP 10: Return `locCrS`



4.0 Intersections.

4.1 Intersection of Two Geodesics.

The following algorithm computes the coordinates where two geodesic curves intersect. Each geodesic is defined by its starting coordinates and azimuth at that coordinate. The algorithm returns a single set of coordinates if the geodesics intersect and returns a null solution (no coordinates) if they do not.

4.1.1 Input/Output.

`LLPoint* WGS84CrsIntersect(LLPoint point1, double az13, double* az31, double* dist13, LLPoint point2, double az23, double* az32, double* dist23, double tol)` returns a reference to an `LLPoint` structure that contains the intersection coordinates, where the inputs are:

<code>LLPoint point1</code>	=	Start point of first geodesic
<code>double az13</code>	=	Azimuth of first geodesic at point1
<code>double* az31</code>	=	Reference to reverse azimuth of first geodesic at point3 (this is calculated and returned)
<code>double* dist13</code>	=	Reference to distance between point1 and point3 (calculated and returned)
<code>LLPoint point2</code>	=	Start point of second geodesic
<code>double az23</code>	=	Azimuth of second geodesic at point2
<code>double* az32</code>	=	Reference to reverse azimuth of second geodesic at point3 (this is calculated and returned)
<code>double* dist23</code>	=	Reference to distance between point2 and point3 (calculated and returned)
<code>double tol</code>	=	Maximum error allowed in solution
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

4.1.2 Algorithm Steps.

See *figure A2-10* for an illustration of the variables.

STEP 1: Use *inverse algorithm* to calculate distance, azimuth and reverse azimuth from point1 to point2. Denote these values by `dist12`, `crs12` and `crs21`, respectively.

- STEP 2: Calculate the difference in angle between crs_{12} and crs_{13} , denoted by $angle_1$.
- STEP 3: Calculate the difference in angle between crs_{21} and crs_{23} , denoted by $angle_2$.
- STEP 4: If $(\sin(angle_1) * \sin(angle_2) < 0)$ then the courses lay on opposite sides of the $point_1$ - $point_2$ line and cannot intersect in this hemisphere.
- Return no intersection.
- STEP 5: Else if $(angle_2 < tol)$ or $(angle_1 < tol)$ then the two geodesics are identical and there is no single unique intersection (there are infinite intersections).
- Return no intersection.
- STEP 6: End if.
- STEP 7: Locate the approximate intersection point, $point_3$, using a spherical earth model. See the documents referenced in *section 3.2* methods to accomplish this.
- STEP 8: Use the *inverse algorithm* to calculate $dist_{13}$, the distance from $point_1$ to $point_3$.
- STEP 9: Use the *inverse algorithm* to calculate $dist_{23}$, the distance from $point_2$ to $point_3$.
- STEP 10: If $dist_{13} < tol$, then the intersection point is very close to $point_1$. Calculation errors may lead to treating the point as if it were beyond the end of the geodesic. Therefore, it is helpful to move $point_1$ a small distance along the geodesic.
- Use the *direct algorithm* to move $point_1$ from its original coordinates, 1 NM along azimuth $crs_{13} + \pi$.
 - Use the *inverse algorithm* to calculate the azimuth crs_{13} for the geodesic from the new $point_1$.
- STEP 11: Repeat steps 10, 10(a), and 10(b) for $point_2$ and crs_{23} .
- STEP 12: If $(dist_{23} < dist_{13})$ then the intersection point is closer to $point_2$ than $point_1$. In this case, the iterative scheme will be more accurate if we swap $point_1$ and $point_2$. This is because we iterate by projecting the

approximate point onto the geodesic from `point1` and then calculating the error in azimuth from `point2`. If the distance from `point2` to the intersection is small, then small errors in distance can correspond to large errors in azimuth, which will lead to slow convergence. Therefore, we swap the points so that we are always measuring azimuth errors farther from the geodesic starting point.

- a. `newPt = point1`
- b. `point1 = point2`
- c. `point2 = newPt`
- d. `acrs13 = crs13`
- e. `crs13 = crs23`
- f. `crs23 = acrs13`
- g. `dist13 = dist23`; We only need one distance so the other is not saved.
- h. `swapped = 1`; This is a flag that is set so that the solutions can be swapped back after they are found.

STEP 13: End if

STEP 14: Initialize the distance array: `distarray[0] = dist13`. Errors in azimuth from `point2` will be measured as a function of distance from `point1`. The two most recent distances from `point1` are stored in a two element array. This array is initialized with the distance from `point1` to `point3`:

STEP 15: Use the *direct algorithm* to project `point3` onto the geodesic from `point1`. Use `point1` as the starting point, and a distance of `distarray[0]` and azimuth of `crs13`.

STEP 16: Use the *inverse algorithm* to measure the azimuth `acrs23` from `point2` to `point3`.

STEP 17: Initialize the error array:
`errarray[0] = signedAzimuthDifference(acrs23, crs23)`.

See *Algorithm 6.1* for an explanation of the `signedAzimuthDifference` function; `errarray[0]` will be in the range $(-\pi, \pi]$.

- STEP 18: Initialize the second element of the distance array using a logical guess:
`distarray[1]=1.01*dist13.`
- STEP 19: Use the *direct algorithm* to project the second approximation of `point3` onto the geodesic from `point1`. Use `point1` as the starting point, and a distance of `distarray[1]` and azimuth of `crs13`.
- STEP 20: Use the *inverse algorithm* to measure the azimuth `acrs23` from `point2` to `point3`.
- STEP 21: Initialize the error array (*see Algorithm 6.1*):
`errarray[1] = signedAzimuthDifference(acrs23, crs23).`
- STEP 22: Initialize `k = 0`
- STEP 23: Do while (`k=0`) or (`(error > tol)` and (`k ≤ maximumIterationCount`))
- a. Use *linear approximation* to find root of `errarray` as a function of `distarray`. This gives an improved approximation to `dist13`.
 - b. Use the *direct algorithm* to project the next approximation of the intersection point, `newPt`, onto the geodesic from `point1`. Use `point1` as the starting point, and a distance of `dist13` (calculated in previous step) and azimuth of `crs13`.
 - c. Use *inverse algorithm* to calculate the azimuth `acrs23` from `point2` to `newPt`.
 - d. Use the *inverse algorithm* to compute the distance from `newPt` to `point3` (the previous estimate). Denote this value as the error for this iteration.
 - e. Update `distarray` and `errarray` with new values:
`distarray[0] = distarray[1]`
`distarray[1] = dist13`
`errarray[0] = errarray[1]`
`errarray[1] = signedAzimuthDifference(acrs23, crs23)`
(See Algorithm 6.1)
 - f. Increment `k`: `k = k + 1`

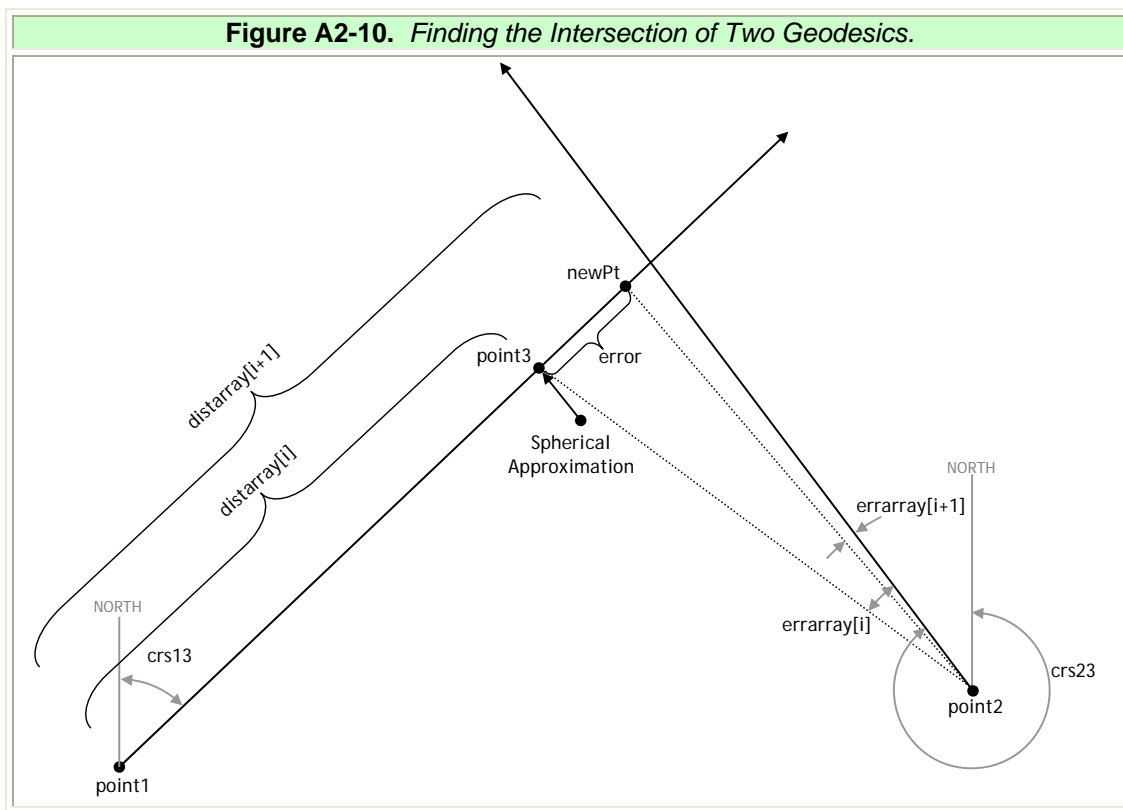
g. Set `point3 = newPt`.

STEP 24: End while loop.

STEP 25: Check if `k` reached `maximumIterationCount`. If so, then the algorithm may not have converged, so an error message should be displayed.

STEP 26: The distances and azimuths from `point1` and `point2` to `point3` are available at the end of this function, since they were calculated throughout the iteration. It may be beneficial to return them with the `point3` coordinates, since they may be needed by the calling function. If this is done, and if `swapped = 1`, then the original identities of `point1` and `point2` were exchanged and the azimuths and distances must be swapped again before they are returned.

STEP 27: Return `point3`.



4.2 Intersection of Two Arcs.

The following algorithm computes the intersection points of two arcs. Each arc is defined by its center point coordinates and radius. The algorithm will return a null solution (no points) if the arcs do not intersect; it will return a single set of coordinates

if the arcs intersect tangentially; and it will return two sets of coordinates if the arcs overlap.

4.2.1 Input/Output.

LLPoint* WGS84ArcIntersect(LLPoint **center1**, double **radius1**, LLPoint **center2**, double **radius2**, int* **n**, double **tol**) returns a reference to an LLPoint structure array that contains the coordinates of the intersection(s), where the inputs are:

LLPoint center1	=	Geodetic coordinates of first arc center
double radius1	=	Radius of first arc in nautical miles
LLPoint center2	=	Geodetic coordinates of second arc center
double radius2	=	Radius of second arc in nautical miles
int* n	=	Reference to integer number of intersection points returned
double tol	=	Maximum error allowed in solution
double eps	=	Convergence parameter for forward/inverse algorithms

4.2.2 Algorithm Steps.

See *figure A2-11* for an illustration of the variables.

This algorithm treats the arcs as full circles. Once the intersections of the circles are found, then each intersection point may be tested and discarded if it does not lie within the bounds of the arc.

STEP 1: Use *inverse algorithm* to calculate the distance and azimuth between center1 and center2. Denote these values as *dist12* and *crs12*, respectively.

STEP 2: If $(\text{radius1} + \text{radius2} - \text{dist12} + \text{tol} < 0)$ or $(\text{abs}(\text{radius1} - \text{radius2}) > \text{dist12})$ then the circles are spaced such that they do not intersect. If the first conditional is true, then the arcs are too far apart. If the second conditional is true, then one arc is contained within the other.

a. Return no intersections.

STEP 3: Else if $(\text{abs}(\text{radius1} + \text{radius2} - \text{dist12}) \leq \text{tol})$ then the circles are tangent to each other and intersect in exactly one point.

- a. Use *direct algorithm* to project point from center1, along crs12, distance radius1.
- b. Return projected point.

STEP 4: End if

STEP 5: Calculate approximate intersection points, point1 and point2, according to *section 3.2*.

STEP 6: Iterate to improve approximation to point1:

- a. $k = 0$
- b. Use *inverse algorithm* to find azimuth from center2 to point1, denote this value as crs2x.
- c. Use *direct algorithm* to move point1 along crs2x to circumference of circle 2. Use center2 as starting point, crs2x as azimuth, radius2 as distance.
- d. Use *inverse algorithm* to compute distance and azimuth from center1 to point1. Denote these values as dist1x and crs1x, respectively.
- e. Compute error at this iteration step: $error = radius1 - dist1x$.
- f. Initialize arrays to store error as function of course from center1:
 $errarray[1] = error$
 $crsarray[1] = crs1x$
- g. While ($k \leq maximumIterationCount$) and ($abs(error) > tol$), improve approximation
 - i. Use *direct function* to move point1 along crs1x to circumference of circle1. Use center1 as starting point, crs1x as azimuth, and radius1 as distance. Note that crs1x was calculated as last step in previous iteration.
 - ii. Use *inverse function* to find azimuth from center2 to point1, crs2x.
 - iii. Use *direct function* to move point1 along crs2x to circumference of circle2. Use center2 as starting point, crs2x as azimuth, and radius2 as distance.

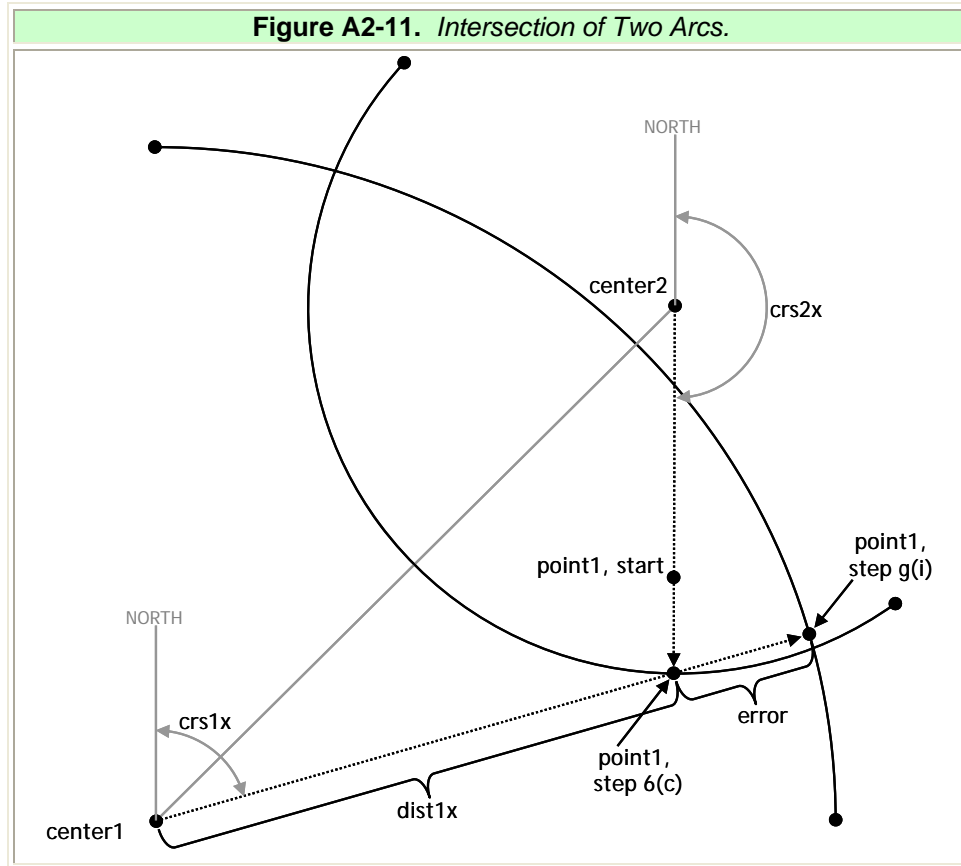
- iv. Use *inverse algorithm* to compute distance and azimuth from center1 to point1. Denote these values as `dist1x` and `crs1x`, respectively.
- v. Update function arrays:
`crsarray[0] = crsarray[1]`
`crsarray[1] = crs1x`
`errarray[0] = errarray[1]`
`errarray[1] = r1 - dist1x`
- vi. Use *linear root finder* to find the azimuth value that corresponds to zero error. Update the variable `crs1x` with this root value.
- vii. Increment `k`: `k = k + 1`
- h. End while loop.

STEP 7: Store `point1` in array to be returned: `intx[0] = point1`.

STEP 8: Repeat step 6 for approximation `point2`.

STEP 9: Store `point2` in array to be returned: `intx[1] = point2`.

STEP 10: Return array `intx`.



4.3 Intersections of Arc and Geodesic.

The following algorithm computes the point where a geodesic intersects an arc. The geodesic is defined by its starting coordinates and azimuth. The arc is defined by its center point coordinates and radius. The algorithm will return a null solution (no points) if the arc and geodesic do not intersect; it will return a single set of coordinates if the arc and geodesic intersect tangentially; and it will return two sets of coordinates if the arc and geodesic overlap.

4.3.1 Input/Output.

`LLPoint* WGS84GeodesicArcIntersect(LLPoint pt1, double crs1, LLPoint center, double radius, int* n, double tol)`
 returns a reference to an `LLPoint` structure array that contains the coordinates of the intersection(s), where the inputs are:

<code>LLPoint pt1</code>	=	Geodetic coordinates of start point of geodesic
<code>double crs1</code>	=	Initial azimuth of geodesic at start point
<code>LLPoint center</code>	=	Geodetic coordinates of arc center point
<code>double radius</code>	=	Arc radius in nautical miles

`int* n` = Reference to number of intersection points returned
`double tol` = Maximum error allowed in solution
`double eps` = Convergence parameter for forward/inverse algorithms

4.3.2 Algorithm Steps.

This algorithm treats the arc and geodesic as unbounded. Once intersection points are found, they must be tested using *Algorithms 3.6 and 3.7* to determine which, if any, lie within the curves' bounds. This algorithm fails if the arc and geodesic describe the same great circle. A test for this case is embedded in step 7. See *figure A2-12* for an illustration of the variable names.

STEP 1: Use *Algorithm 5.1* to find the perpendicular projection point from arc center point (`center`) to the geodesic defined by starting point `pt1` and azimuth `crs1`. Denote this point by `perpPt`.

STEP 2: Use the *inverse algorithm* to calculate the distance from `center` to `perpPt`. Denote this value by `perpDist`.

STEP 3: If (`abs(perpDist - radius) < tol`), then the geodesic is tangent to the arc and intersection point is at `perpPt`.

a. Return `intx[0] = perpPt`

STEP 4: Else if (`perpDist > radius`) then geodesic passes too far from center of circle; there is no intersection.

a. Return empty array.

STEP 5: End if

STEP 6: Use *inverse algorithm* to calculate azimuth of the geodesic at `perpPt`. Denote the azimuth from `perpPt` to `pt1` as `crs`.

STEP 7: Use *spherical triangle approximation* to find distance from `perpPt` to one intersection points. Since the spherical triangle formed from `center`, `perpPt`, and either intersection point has a right angle at the `perpPt` vertex, the distance from `perpPt` to either intersection is:

$$\text{dist} = \text{SPHERE_RADIUS} * \text{acos}(\text{cos}(\text{radius} / \text{SPHERE_RADIUS}) / \text{cos}(\text{perpDist} / \text{SPHERE_RADIUS}))$$

where SPHERE_RADIUS is the radius of the spherical earth approximation. Note that a test must be performed so that if $\cos(\text{perpDist}/\text{SPHERE_RADIUS}) = 0$, then no solution is returned

STEP 8: Find ellipsoidal approximation $\text{intx}[0]$ to first intersection by starting at perpPt and using direct algorithm with distance dist and azimuth crs . This will place $\text{intx}[0]$ on the geodesic.

STEP 9: Initialize iteration count $k = 0$.

STEP 10: Use *inverse algorithm* to calculate the distance from center to $\text{intx}[0]$. Denote this value by radDist . In the same calculation, calculate azimuth from $\text{intx}[0]$ to center . Denote this value by rcrs ; it will be used to improve the solution.

STEP 11: Calculate error for this iteration: $\text{error} = \text{radius} - \text{radDist}$

STEP 12: Initialize arrays that will hold distance and error function values so that linear interpolation may be used to improve approximation:
 $\text{distarray}[0] = \text{dist}$
 $\text{errarray}[0] = \text{error}$

STEP 13: Do one iterative step using spherical approximation near intersection point (see figure A2-13).

- a. Use the *inverse algorithm* to calculate the azimuth from $\text{intx}[0]$ to perpPt . Denote this value by bcrs .
- b. Compute the angle between the arc's radial line and the geodesic at $\text{intx}[0]$. This is depicted by B in A2-13:

$$B = \text{abs}(\text{signedAzimuthDifference}(\text{bcrs}, \text{rcrs}) + \pi - \theta)$$

See *Algorithm 6.1* for an explanation of "signedAzimuthDifference."

- c. Calculate the angle opposite the radial error:

$$A = \text{acos}\left(\sin(B) \cos\left(\frac{\text{abs}(\text{error})}{\text{SPHERE_RADIUS}}\right)\right)$$

- d. If $(\text{abs}(\sin(A)) < \text{tol})$ then the triangle is nearly isosceles, so use simple formula for correction term c : $c = \text{error}$
- e. Else, if $(\text{abs}(A) < \text{tol})$ then the error is very small, so use flat approximation: $c = \text{error}/\cos(B)$

- f. Else, use a spherical triangle approximation for c :

$$c = \text{SPHERE_RADIUS} * \text{asin} \left(\frac{\sin(\text{error}/\text{SPHERE_RADIUS})}{\sin(A)} \right)$$
- g. End if
- h. If ($\text{error} > 0$), then $\text{intx}[0]$ is inside the circle, so approximation must be moved away from perpPt : $\text{dist} = \text{dist} + c$
- i. Else $\text{dist} = \text{dist} - c$
- j. End if
- k. Use the *direct algorithm* to move $\text{intx}[0]$ closer to solution. Use perpPt as the starting point with distance dist and azimuth crs .
- l. Use the *inverse algorithm* to calculate the distance from center to $\text{intx}[0]$. Denote this value again radDist .
- m. Initialize second value of distarray and errarray :

$$\begin{aligned} \text{distarray}[1] &= \text{dist} \\ \text{errarray}[1] &= \text{radius} - \text{radDist} \end{aligned}$$

STEP 14: Do while ($\text{abs}(\text{error}) > \text{tol}$) and ($k < \text{maximumIterationCount}$)

- a. Use a *linear root finder* to find the distance value that corresponds to zero error. Update the variable dist with this root value.
- b. Use the *direct algorithm* again to move $\text{intx}[0]$ closer to solution. Use perpPt as the starting point with distance dist and azimuth crs .
- c. Use the *inverse algorithm* to calculate the distance from center to $\text{intx}[0]$. Denote this value radDist .
- d. Update distarray and errarray with the new values:

$$\begin{aligned} \text{distarray}[0] &= \text{distarray}[1] \\ \text{errarray}[0] &= \text{errarray}[1] \\ \text{distarray}[1] &= \text{dist} \\ \text{errarray}[1] &= \text{radius} - \text{radDist} \end{aligned}$$
- e. Increment the iteration count: $k = k + 1$

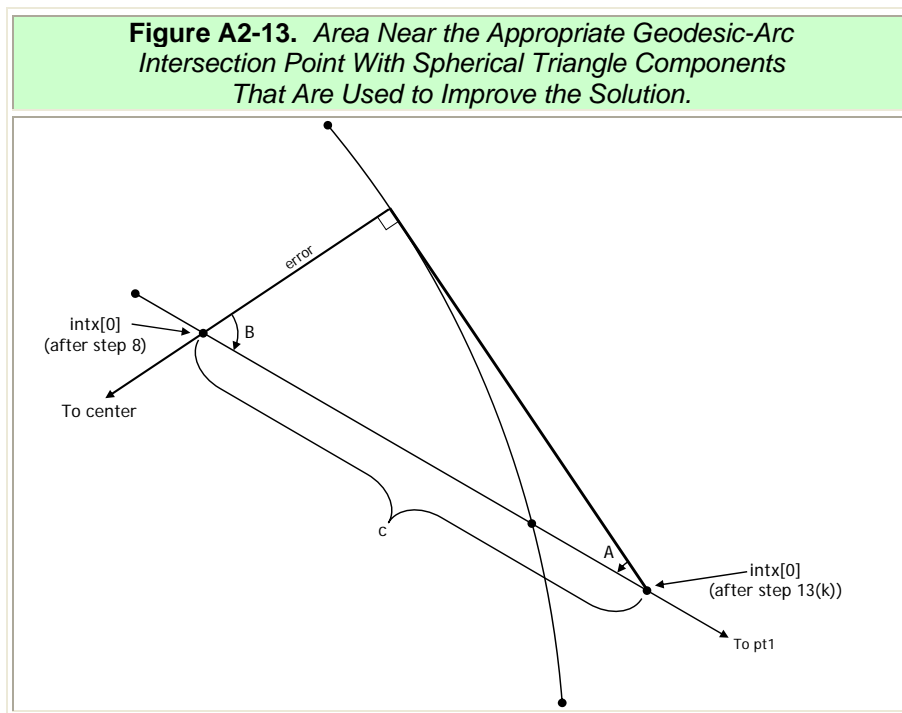
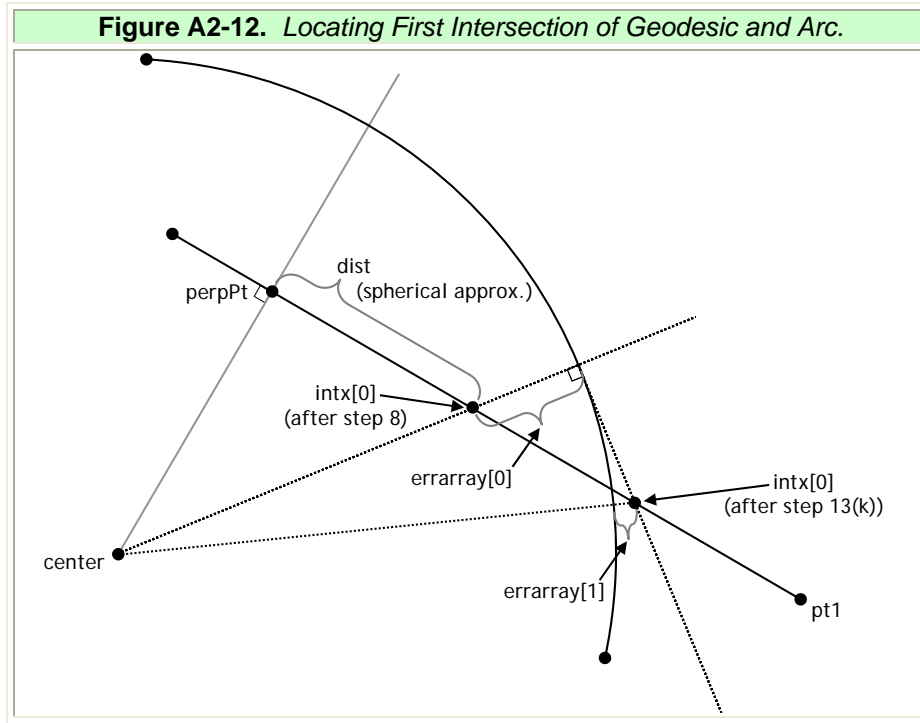
STEP 15: End while loop

STEP 16: Prepare variables to solve for second solution, `intx[1]`.

- a. Second solution lies on other side of `perpPt`, so set `crs = crs + π` .
- b. Use *direct algorithm* to find `intx[1]`. Start at `perpPt`, using `crs` for the azimuth and `dist` for the distance, since the distance from `perpPt` to `intx[0]` is a very good approximation to the distance from `perpPt` to `intx[1]`.
- c. Use *inverse algorithm* to calculate `radDist`, the distance from center to `intx[1]`.
- d. Initialize the error function array:
`errarray[0] = radius - radDist`.

STEP 17: Repeat steps 13 through 15 to improve solution for `intx[1]`

STEP 18: Return `intx[0]` and `intx[1]`



4.4 Arc Tangent to Two Geodesics.

This algorithm is useful for finding flight path arcs, such as fitting a fly-by turn or radius-to-fix (RF) leg between two track-to-fix (TF) legs. Note that for the arc to be

tangent to both the incoming and the outgoing geodesics, the two tangent points must be different distances from the geodesics' intersection point.

4.4.1 Input/Output.

LLPoint* WGS84TangentFixedRadiusArc(LLPoint **pt1**, double **crs12**, LLPoint **pt3**, double **crs3**, double **radius**, int* **dir**, double **tol**) returns a reference to an LLPoint structure array that contains the coordinates of the center point and both tangent points of the arc that is tangent to both given geodesic, where the inputs are:

LLPoint pt1	=	Geodetic coordinates of start point of first geodesic
double crs12	=	Azimuth of first geodesic at pt1
LLPoint pt3	=	Geodetic coordinates of end point of second geodesic
double crs3	=	Azimuth of second geodesic at pt3
double radius	=	Radius of desired arc
int* dir	=	Reference to an integer that represents direction of turn. dir = 1 for left hand turn dir = -1 for right hand turn
double tol	=	Maximum error allowed in solution
double eps	=	Convergence parameter for forward/inverse algorithms

4.4.2 Algorithm Steps.

See *figure A2-14* for an illustration of the variable names.

STEP 1: Use *Algorithm 4.1* to locate the intersection point of the given geodesics. The first geodesic has azimuth *crs12* at *pt1*, while the second geodesic has azimuth *crs3* at *pt3*. Denote their intersection point by *pt2*.

STEP 2: If intersection point *pt2* is not found, then no tangent arc can be found.

a. Return empty array.

STEP 3: End if

STEP 4: Use the *inverse algorithm* to calculate the distance from *pt1* to *pt2* (denoted by *dist12*). Also calculate the azimuth at *pt2* to go from *pt2* to *pt1*. Denote this value by *crs21*.

STEP 5: Use the *inverse algorithm* to compute the azimuth at pt2 to go from pt2 to pt3. Denote this value by `crs23`.

STEP 6: Calculate angle between courses at pt2 (see Algorithm 6.1). Denote this value by `vertexAngle`:

`vertexAngle = signedAzimuthDifference(crs21, crs23)`

STEP 7: If `abs(sin(vertexAngle)) < tol`, then either there is no turn or the turn is 180 degrees. In either case, no tangent arc can be found.

a. Return empty array.

STEP 8: Else if `vertexAngle > 0` then course changes direction to the right:
`dir = -1`

STEP 9: Else, the course changes direction to the left: `dir = 1`

STEP 10: End if

STEP 11: Use spherical triangle calculations to compute the approximate distance from pt2 to the points where the arc is tangent to either geodesic. Denote this distance by `DTA`:

a. `A = vertexAngle/2`

b. If `(radius > SPHERE_RADIUS * A)` then no arc of the required radius will fit between the given geodesics

i. Return empty array

c. End if

d.
$$DTA = SPHERE_RADIUS \times \text{asin} \left(\frac{\tan \left(\frac{\text{radius}}{SPHERE_RADIUS} \right)}{\tan(A)} \right)$$

STEP 12: Use the calculated `DTA` value to calculate the distance from pt1 to the approximate tangent point on the first geodesic:

`distToStart = dist12 - DTA`

STEP 13: Initialize the iteration count: `k = 0`

STEP 14: Initialize the error measure: `error = 0.0`

STEP 15: Do while (k = 0) or ((abs(error) > tol) and (k ≤ maximumIterationCount))

- a. Adjust the distance to tangent point based on current error value (this has no effect on first pass through, because error = 0):

$$\text{distToStart} = \text{distToStart} - \frac{\text{error}}{\sin(\text{vertexAngle})}$$

- b. Use the *direct algorithm* to project startPt distance distToStart from pt1. Use pt1 as the starting point with azimuth of crs12 and distance of distToStart.
- c. Use the *inverse algorithm* to compute azimuth of geodesic at startPt. Denote this value by perpCrs.
- d. If (dir < 0), then the tangent arc must curve to the right. Add $\pi/2$ to perpCrs to get the azimuth from startPt to center of arc:

$$\text{perpCrs} = \text{perpCrs} + \frac{\pi}{2}$$

- e. Else, the tangent arc must curve to the left. Subtract $\pi/2$ from perpCrs to get the azimuth from startPt to center of arc:

$$\text{perpCrs} = \text{perpCrs} - \frac{\pi}{2}$$

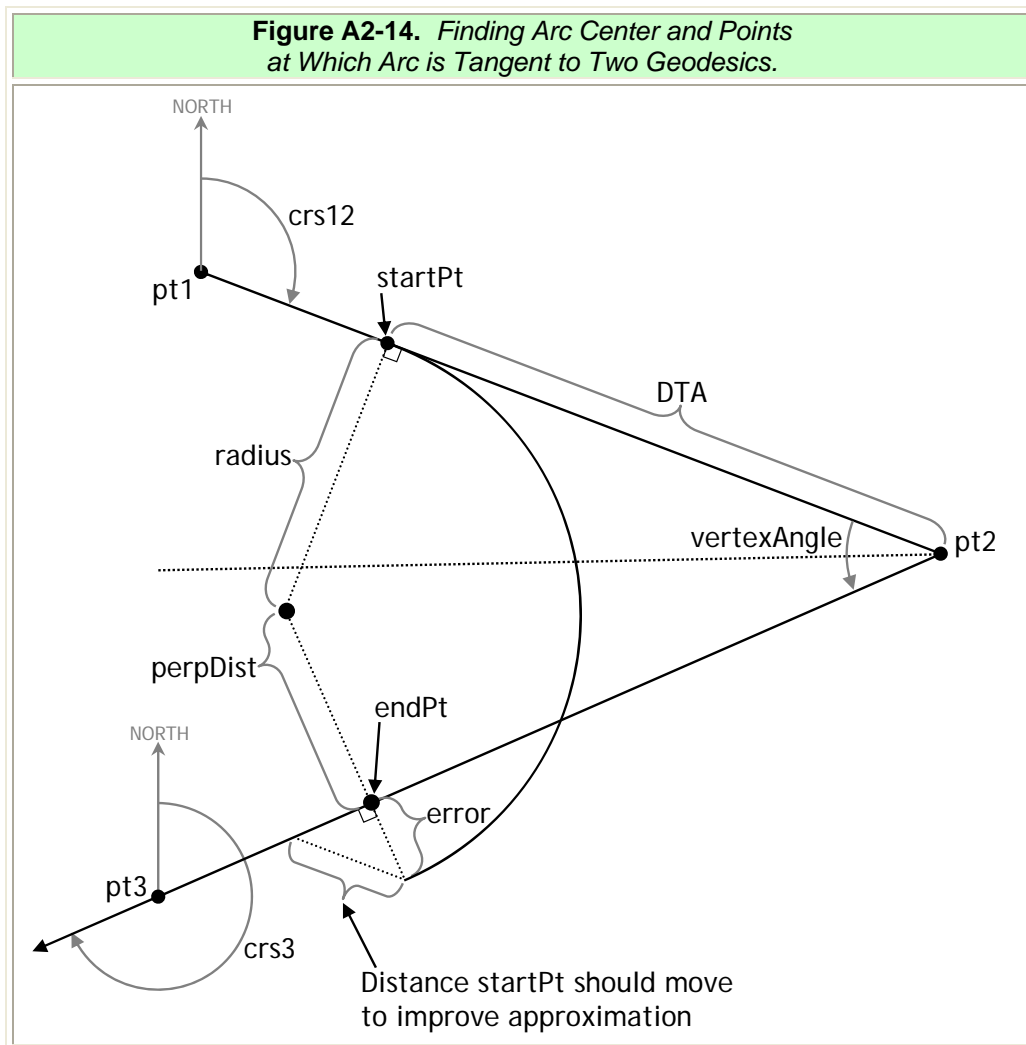
- f. End if.
- g. Use the *direct algorithm* to locate the arc center point, centerPt. Use startPt as the starting point, perpCrs for the azimuth, and radius for the distance.
- h. Use *Algorithm 5.1* to project centerPt to the second geodesic. Denote the projected point by endPt. This is approximately where the arc will be tangent to the second geodesic.
- i. Use the *inverse algorithm* to calculate the distance from centerPt to endPt. Denote this distance by perpDist.
- j. Calculate the tangency error: error = radius - perpDist. This error value will be compared against the required tolerance parameter. If its magnitude is greater than tol, then it will be used to adjust the position of startPt until both startPt and endPt are the correct distance from centerPt.

STEP 16: End while.

STEP 17: Assign the calculated points to output array

```
intx[0] = centerPt
intx[1] = startPt
intx[2] = endPt
```

STEP 18: Return intx.



4.5 Intersections of Geodesic and Locus.

This algorithm is useful for finding the corner points of *TF* subsegment's *OEA*, where a parallel (represented as a locus of points) intersects the geodesic end line.

4.5.1 Input/Output.

`LLPoint* WGS84GeoLocusIntersect(LLPoint gStart, LLPoint gEnd, Locus loc, double tol)` returns a reference to an `LLPoint` structure array that contains the coordinates of the intersection point., where the inputs are:

<code>LLPoint gStart</code>	=	Geodetic coordinates of start point of geodesic
<code>LLPoint gEnd</code>	=	Geodetic coordinates of end point of geodesic
<code>Locus loc</code>	=	Structure defining locus of points
<code>double tol</code>	=	Maximum error allowed in solution
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

4.5.2 Algorithm Steps.

See *figure A2-15* for an illustration of the variable names.

STEP 1: Use the *geodesic intersection algorithm (Algorithm 4.1)* to find a first approximation to the point where the given geodesic and locus intersect. Use the start and end coordinates of the locus along with the start and end coordinates of given geodesic as inputs to the geodesic intersection algorithm. This will erroneously treat the locus as a geodesic; however, the calculated intersection will be close to the desired intersection. The geodesic intersection algorithm will return the approximate intersection point, `pt1`, along with the courses and distances from the `pt1` to the start points of the locus and given geodesic. Denote these courses and distances as `crs31`, `dist13`, `crs32`, `dist23`, respectively.

STEP 2: If `pt1` is not found, then the locus and geodesic do not intersect.

a. Return empty point.

STEP 3: End if

STEP 4: Use the *inverse algorithm* to calculate the course from `gStart` to `gEnd`. Denote this value as `fcrs`. This value is needed by the direct algorithm to locate new points on the given geodesic.

- STEP 5: Use the *inverse algorithm* to calculate the distance and course from `pt1` to `gStart`. Denote these value as `distBase` and `crsBase`, respectively.
- STEP 6: Use the *inverse algorithm* to calculate the forward course for the locus's defining geodesic. Denote this value as `tcrs`. This value is needed to project the approximate point onto the defining geodesic in order to calculate the appropriate locus distance.
- STEP 7: Use *Algorithm 5.1* to project `pt1` onto the locus's defining geodesic. Use `pt1`, `loc.geoStart`, and `tcrs` as inputs. Denote the returned point as `pInt`, the returned course as `crsFromPt`, and the returned distance as `distFromPt`.
- STEP 8: Use *Algorithm 3.9* to calculate the distance from the defining geodesic to the locus at `pInt`. Denote this value as `distLoc`. Note that `distLoc` may be positive or negative, depending on which side of defining geodesic the locus lies.
- STEP 9: Calculate the distance from `pt1` to the locus. This is the initial error:
`errarray[1] = distFromPt - abs(distLoc)`.
- STEP 10: Save the initial distance from `gStart` to the approximate point:
`distarray[1] = distBase`. We will iterate to improve the approximation by finding a new value for `distBase` that makes `errarray` zero.
- STEP 11: Calculate a new value of `distBase` that will move `pt1` closer to the locus. This is done by approximating the region where the given geodesic and locus intersect as a right Euclidean triangle and estimating the distance from the current `pt1` position to the locus (*see figure A2-16*).
- a. Calculate the angle between the geodesic from `pt1` to `pInt` and the geodesic from `pt1` to `gStart`:
`theta = abs(signedAzimuthDifference(crsFromPt,crsBase))`

- b. Calculate a new value for `distBase`:

$$\text{distBase} = \text{distBase} - \frac{\text{errarray}[1]}{\cos(\text{theta})}$$

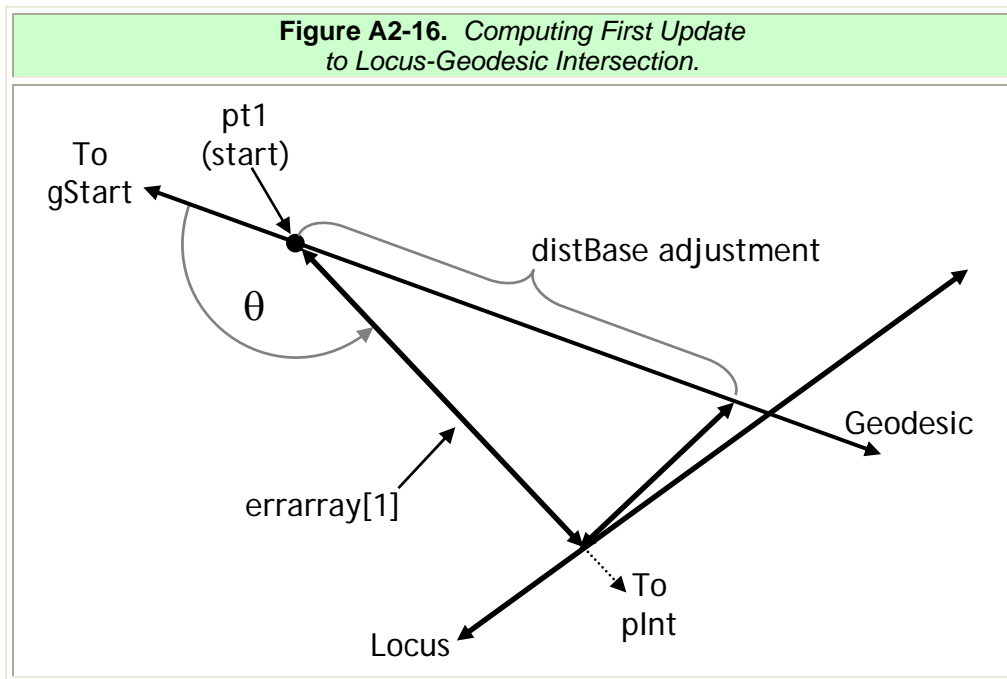
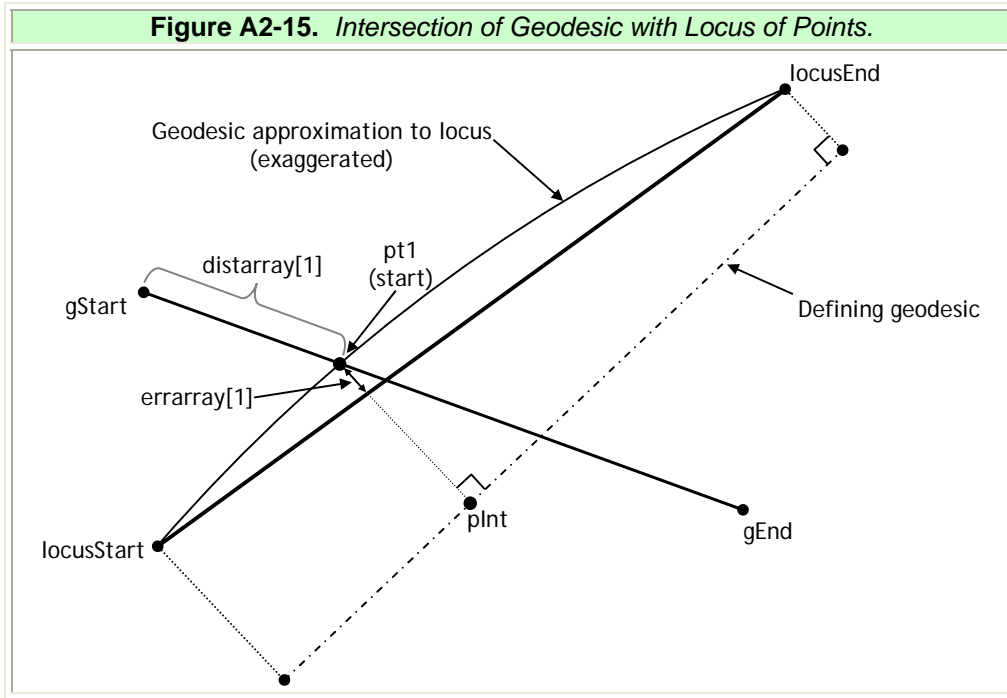
STEP 12: Initialize the iteration count: `k = 0`.

STEP 13: Do while (`abs(errarray[1] > tol)` and (`k < maxIterationCount`))

- a. Use `gStart`, `fcrs`, and the updated value of `distBase` in the direct algorithm to update the value of `pt1`.
- b. Save the current values of `errarray` and `distarray`:
`errarray[0] = errarray[1]`
`distarray[0] = distarray[1]`
- c. Set `distarray[1] = distBase`.
- d. Repeat steps 7, 8, and 9 to calculate the distance from `pt1` to the locus, `distloc`, and the corresponding update to `errarray[1]`.
- e. Use a linear root finder with `distarray` and `errarray` to find the distance value that makes the error zero. Update `distBase` with this root value.

STEP 14: End while

STEP 15: Return `pt1`.



4.6 Intersections of Arc and Locus.

This algorithm solves for the intersection of a fixed radius arc and a locus. It is very similar to Algorithm 4.3, which computes the intersections of an arc and a geodesic. It begins by treating the locus as a geodesic and applying Algorithm 4.3 to find approximate intersection points. The approximation is improved by traveling along the locus, measuring the distance to the arc center at each point. The difference between this distance and the given arc radius is the error. The error is modeled as a series of linear functions of position on the locus. The root of each function gives the next approximation to the intersection. Iteration stops when the error is less than the specified tolerance.

4.6.1 Input/Output.

`LLPoint* WGS84LocusArcIntersect(Locus loc, LLPoint center, double radius, int* n, double tol)` returns a reference to an `LLPoint` structure array that contains the coordinates of the intersection(s), where the inputs are:

<code>Locus loc</code>	=	Locus of interest
<code>LLPoint center</code>	=	Geodetic coordinates of arc
<code>double radius</code>	=	Arc radius
<code>int* n</code>	=	Number of intersections found
<code>double tol</code>	=	Maximum error allowed in solution
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

4.6.2 Algorithm Steps.

See *figure A2-17* for an illustration of the variables.

STEP 1: Initialize number of intersections: `n = 0`

STEP 2: Use the inverse algorithm to compute the course from `loc.locusStart` to `loc.locusEnd`. Denote this value as `fcrs`.

STEP 3: Use *Algorithm 4.3* to find the point(s) where the arc intersects the geodesic joining `loc.locusStart` and `loc.locusEnd`. Denote the set of intersections as `intx` and the count of these intersections as `n1`. This gives a first approximation to the intersections of the arc and the locus.

STEP 4: If (`n1 = 0`), then no approximate intersections were found. Return `NULL`.

STEP 5: Use the inverse algorithm to compute the course and distance from `loc.geoStart` to `loc.geoEnd`. Store these values as `gcrs` and `gdist`, respectively.

STEP 6: For `i=0, i<n1`

- a. Use *Algorithm 5.1* to project `intx[0]` to the locus's defining geodesic. Denote the projected point as `perpPt`.
- b. Use the *inverse algorithm* to calculate `distbase`, the distance from `perpPt` to `loc.geoStart`.
- c. Use *Algorithm 3.10* to project `locPt` onto the locus from `perpPt`.
- d. Use the *inverse algorithm* to calculate `distCenter`, the distance from `locPt` to center.
- e. Calculate the error and store it in an array:
`errarray[1] = distCenter - radius`
- f. If `(abs(errarray[1]) < tol)`, then `locPt` is close enough to the circle. Set `intx[n] = locPt`, `n = n+1`, and continue to the end of the for loop, skipping steps g through l below.
- g. Save the current value of `distbase` to an array: `distarray[1] = distbase`
- h. Initialize the iteration count: `k = 0`
- i. Perturb `distbase` by a small amount to generate a second point at which to measure the error: `newDistbase = 1.001*distbase`.
- j. Do while `(k < maxIterationCount)` and `(abs(errarray[1]) > tol)`
 - i. Project `perpPt` on the defining geodesic a distance `newDistbase` along course `gcrs` from `loc.geoStart`.
 - ii. Use *Algorithm 3.10* to project `locPt` onto the locus from `perpPt`.
 - iii. Use the inverse algorithm to calculate `distCenter`, the distance from `locPt` to center.
 - iv. Calculate the error: `error = distCenter - radius`

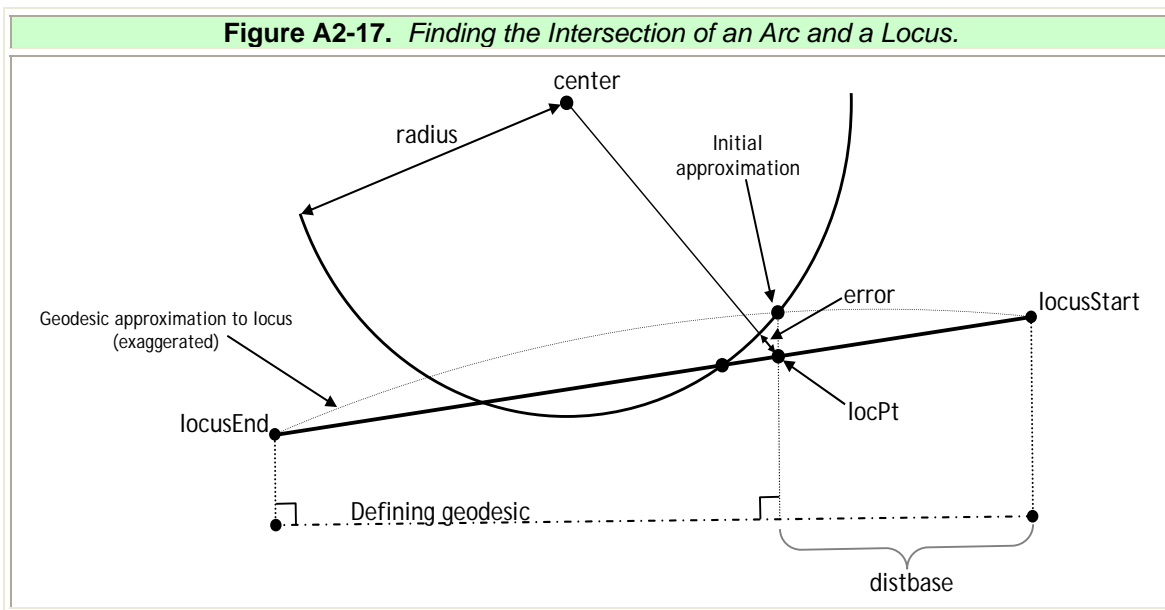
- v. Update the distance and error arrays:


```

      distarray[0] = distarray[1]
      distarray[1] = newDistbase
      errarray[0] = errarray[1]
      errarray[1] = error
      
```
- vi. Use a linear root finder with `distarray` and `errarray` to find the distance value that makes the error zero. Update `newDistbase` with this root value.
- k. End while
- l. If `locPt` is on the locus according to *Algorithm 3.11*, then
 - i. copy `locPt` to the output array: `intx[n] = locPt`.
 - ii. Update the count of intersection points found: `n = n + 1`.

STEP 7: End for loop

STEP 8: Return `intx`



4.7 Intersections of Two Loci.

4.7.1 Input/Output.

LLPoint* WGS84LocusIntersect(Locus **loc1**, Locus **loc2**, double **tol**) returns a reference to an LLPoint structure array that contains the intersection coordinates, where the inputs are:

Locus **loc1** = First locus of interest
 Locus **loc2** = Second locus of interest
 Double **tol** = Maximum error allowed in solution
 Double **eps** = Convergence parameter for forward/inverse algorithms

4.7.2 Algorithm Steps.

See *figure A2-18* for an illustration of the variables and calculation steps.

STEP 1: Use the *inverse algorithm* to calculate the course of the geodesic approximation to **loc1**. Use **loc1.locusStart** and **loc1.locusEnd** as start and end points. Denote this course as **crs1**.

STEP 2: Use the *inverse algorithm* to calculate the course of the geodesic approximation to **loc2**. Use **loc2.locusStart** and **loc2.locusEnd** as start and end points. Denote this course as **crs2**.

STEP 3: Use **loc1.locusStart**, **crs1**, **loc2.locusStart**, and **crs2** as input to *Algorithm 4.1* to calculate an approximate solution to the locus intersection. Denote the approximate intersection point at **p1**.

STEP 4: If (**p1** = NULL), then the loci do not intersect, so return NULL.

STEP 5: Use the *inverse algorithm* to calculate the course of **loc1**'s defining geodesic. Use **loc1.geoStart** and **loc1.geoEnd** as the start and end points, and denote the course as **tcrs1**.

STEP 6: Project **p1** to the geodesic of **loc1** using *Algorithm 5.1* with **loc1.geoStart** and **tcrs1** as input parameters. Store the projected point as **pint1**.

STEP 7: If (**pint1** = NULL), then no projected point was found so return NULL.

STEP 8: Use the *inverse algorithm* to calculate **distbase**, the distance from **loc1.geoStart** to **pint1**.

STEP 9: Initialize iteration counter: **k** = 0

STEP 10: Do while (**k** = 0) or ((**k** < **maxIterationCount**) and (**fabs(error)** > **tol**))

- a. If ($k > 0$) then apply direct algorithm to project new `pint1` on `loc1`. Use starting point `loc1.geoStart`, course `tcrs1`, and distance `distbase`.
- b. Use *Algorithm 3.10* to project a point on `loc1` from the current `pint1`. Denote the projected point as `ploc1`.
- c. Project `ploc1` to the geodesic of `loc2` using *Algorithm 5.1* with `loc2.geoStart` and `tcrs2` as input parameters. Store the projected point as `pint2`.
- d. Use *Algorithm 3.10* to project a point on `loc2` from `pint2`. Denote the projected point as `ploc2`. If `ploc1` were truly at the intersection of the `loci`, then `ploc2` and `ploc1` would be the same point. The distance between them measures the error at this calculation step.
- e. Compute the error by using the inverse algorithm to calculate the distance between `ploc1` and `ploc2`.
- f. Update the error and distance arrays and store the current values:

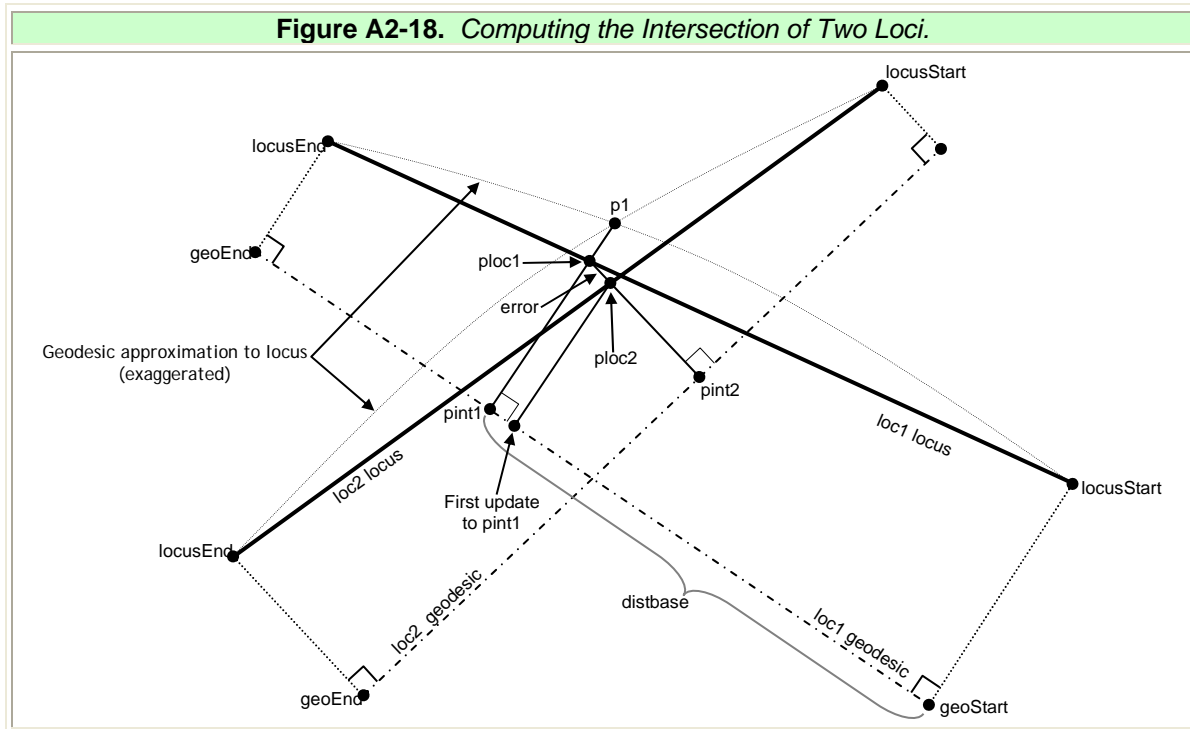

```
errarray[0] = errarray[1]
errarray[1] = error
distarray[0] = distarray[1]
distarray[1] = distbase
```
- g. If ($k = 0$), then project `ploc2` onto `loc1` to get a new estimate of `distbase`:
 - i. Project `ploc2` to the geodesic of `loc1` using *Algorithm 5.1* with `loc1.geoStart` and `tcrs1` as input parameters. Store the projected point as `pint1`.
 - ii. Use the *inverse algorithm* to calculate `distbase`, the distance from `loc1.geoStart` to `pint1`.
- h. Else,
 - i. Use a *linear root finder* with `distarray` and `errarray` to find the distance value that makes the error zero. Update `distbase` with this root value. This is possible only after the first update step because two values are required in each array.
- i. End if
- j. Increment iteration count: $k = k + 1$

STEP 11: End while

STEP 12: Use *Algorithm 3.11* with inputs of `loc1` and `ploc1` to determine if `ploc1` lies on the `loc1`. If not, return NULL.

STEP 13: Use *Algorithm 3.11* with inputs of `loc2` and `ploc1` to determine if `ploc1` lies on the `loc2`. If not, return NULL.

STEP 14: Return `ploc1`.



4.8 Arc Tangent to Two Loci.

Computing a tangent arc of a given radius to two loci is very similar to fitting an arc to two geodesics. The following algorithm uses the same basic logic as *Algorithm 4.4*.

4.8.1 Input/Output.

`LLPoint*` `WGS84LocusTanFixedRadiusArc(Locus loc1, Locus loc2, double radius, int* dir, double tol)` returns a reference to an `LLPoint` structure array that contains the coordinates of the center point and both tangent points of the arc that is tangent to both given loci, where the inputs are:

`Locus loc1` = Structure defining first locus
`Locus loc2` = Structure defining second locus

double radius	=	Radius of desired arc
int* dir	=	Reference to an integer that represents direction of turn. dir = 1 for left hand turn dir = -1 for right hand turn
double tol	=	Maximum error allowed in solution
double eps	=	Convergence parameter for forward/inverse algorithms

4.8.2 Algorithm Steps.

See *figure A2-19*.

STEP 1: Use *inverse algorithm* to calculate `crs12`, the course from `loc1.locusStart` to `loc1.locusEnd`.

STEP 2: Use *inverse algorithm* to calculate `gcrs1` and `geoLen1`, the course and distance from `loc1.geoStart` to `loc1.geoEnd`.

STEP 3: Use *inverse algorithm* to calculate `crs32`, the course from `loc2.locusEnd` to `loc2.locusStart`. Convert `crs32` to its reciprocal: $crs32 = crs32 + \pi$.

STEP 4: Apply *Algorithm 4.4* to find the arc tangent to the geodesic approximations to `loc1` and `loc2`. Use `loc1.locusStart`, `crs12`, `loc2.locusEnd`, `crs32`, and `radius` as input parameter. Denote the array of points returned as `intx`. `intx[0]` will be the approximate arc center point, `intx[1]` will be the tangent point near `loc1`, and `intx[2]` will be the tangent point near `loc2`. Also returned will be the direction of the arc, `dir`.

STEP 5: If (`intx = NULL`) then there is no tangent arc. Return `NULL`.

STEP 6: Calculate the approximate angle at the vertex where `loc1` and `loc2` intersect. This will be used only to estimate the first improvement to the tangent point `intx[1]`. Thus we use an efficient spherical triangles approximation (see *figure A2-20*):

- a. Use the *spherical inverse function* to calculate the `rcrs1`, the course from `intx[0]` (the approximate arc center) to `intx[1]` (the approximate tangent point on `loc1`).

- b. Use the *spherical inverse function* to calculate the `rcrs2`, the course from `intx[0]` to `intx[2]` (the other approximate tangent point).
- c. Calculate the angle difference between `rcrs1` and `rcrs2`:

$$\text{angle} = \text{abs}(\text{signedAzimuthDifference}(\text{rcrs1}, \text{rcrs2}))$$
- d.
$$\text{vertexAngle} = 2 * \text{acos} \left(\sin \left(\frac{\text{angle}}{2} \right) \cos \left(\frac{\text{radius}}{\text{SPHERE_RADIUS}} \right) \right)$$

STEP 7: Calculate the inclination angle of `loc1` relative to its geodesic:

$$\text{locAngle} = \text{atan} \left[\frac{(\text{loc1.endDist} - \text{loc1.startDist})}{\text{geoLen1}} \right]$$

STEP 8: Apply *Algorithm 5.1* to project `intx[1]` onto the defining geodesic of `loc1`. Use `loc1.geoStart` and `gcrs1` as input parameters. Denote the projected point as `geoPt1`.

STEP 9: Use the *inverse algorithm* to compute `distbase`, the distance from `loc1.geoStart` to `geoPt1`.

STEP 10: Initialize the iteration count: `k = 0`

STEP 11: Do while (`k = 0`) or (`(k < maxIterationCount) and (fabs(error) > tol)`)

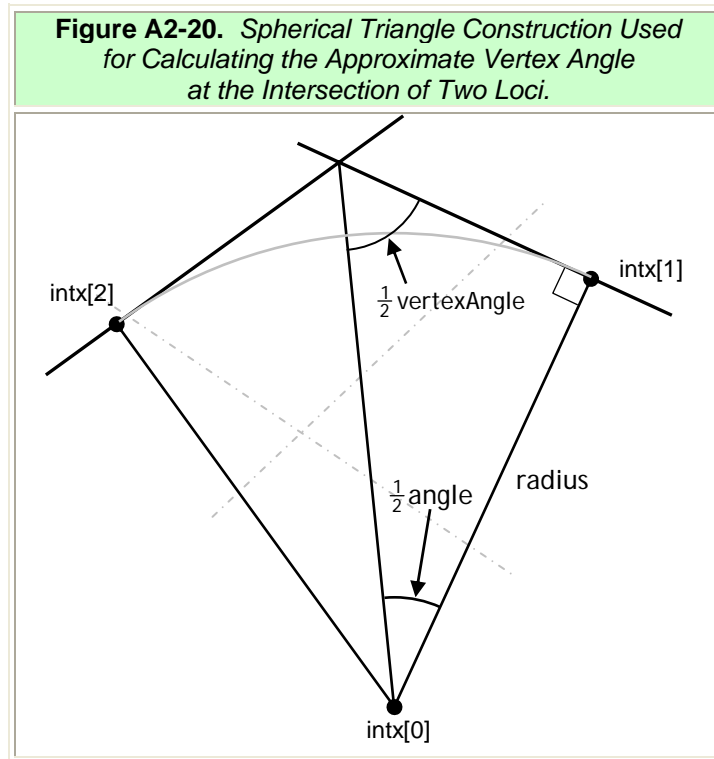
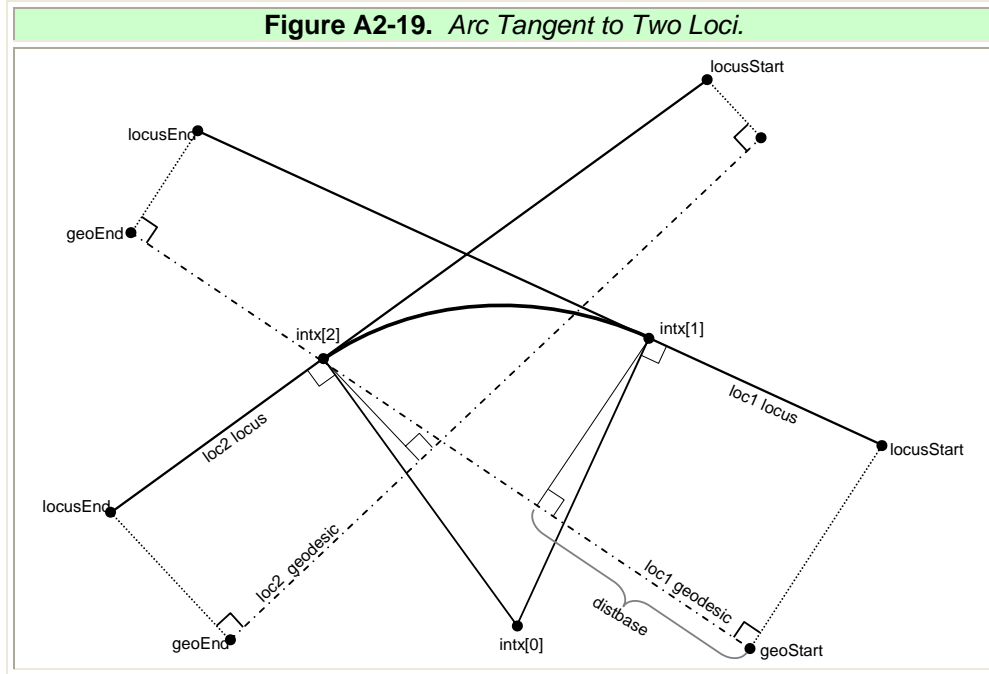
- a. If (`k > 0`), then we need to find new `intx[1]` from current value of `distbase`:
 - i. Use *direct algorithm* with starting point `loc1.geoStart`, course `gcrs1`, and distance `distbase` to project point `geoPt1`
- b. End If
- c. Use *Algorithm 3.10* to project a point on `loc1` from the current `geoPt1`. Denote the projected point as `intx[1]`.
- d. Use *Algorithm 3.12* to calculate `lcrs1`, the course of `loc1` at `intx[1]`.
- e. Convert `lcrs1` into the correct perpendicular course toward the arc center (note that `dir > 0` indicates a left-hand turn): $\text{lcrs1} = \text{lcrs1} - \text{dir} * \frac{\pi}{2}$

- f. Use the *direct algorithm* with starting point `intx[1]`, course `lcrs1`, and distance `radius` to project the arc center point, `intx[0]`.
- g. Use *Algorithm 5.2* to project `intx[0]` onto `loc2`. Reassign `intx[2]` as the projected point.
- h. Use the *inverse algorithm* to calculate `r2`, the distance from `intx[0]` to `intx[2]`
- i. Calculate the error: `error = r2 - radius`
- j. Update the distance and error function arrays:
`distarray[0] = distarray[1]`
`distarray[1] = distbase`
`errarray[0] = errarray[1]`
`errarray[1] = error`
- k. If (`k = 0`), then estimate better `distbase` value using spherical approximation and calculated error:

$$\text{distbase} = \text{distbase} + \text{error} * \frac{\cos(\text{locAngle})}{\sin(\text{vertexAngle})}$$
- l. Else, use a linear root finder with `distarray` and `errarray` to find the distance value that makes the error zero. Update `distbase` with this root value.
- m. End if

STEP 12: End while

STEP 13: Return `intx`.



5.0 Projections.

5.1 Project Point to Geodesic.

This algorithm is used to determine the shortest distance from a point to a geodesic. It also locates the point on the geodesic that is nearest the given point.

5.1.1 Input/Output.

`LLPoint* WGS84PerpIntercept(LLPoint pt1, double crs13, LLPoint pt2, double* crsFromPoint, double* distFromPoint, double tol)` returns a reference to an `LLPoint` structure that contains the coordinates of the projected point, where the inputs are:

<code>LLPoint pt1</code>	=	Coordinates of geodesic start point
<code>double crs13</code>	=	Initial azimuth of geodesic at start point
<code>LLPoint pt2</code>	=	Coordinates of point to be projected to geodesic
<code>double* crsFromPoint</code>	=	Reference to value that will store the course from pt2 to projected point
<code>double* distFromPoint</code>	=	Reference to value that will store the distance from pt2 to projected point
<code>double tol</code>	=	Maximum error allowed in solution
<code>double eps</code>	=	Convergence parameter for forward/inverse algorithms

5.1.2 Algorithm Steps.

This algorithm treats the geodesic as unbounded, so that projected points that lie “behind” the geodesic starting point `pt1` will be returned. If it is desired to limit solutions to those that lie along the forward direction of the given geodesic, then *step 5* may be modified to return a null solution (see *figure A2-21*).

STEP 1: Use the inverse algorithm to calculate the distance, azimuth, and reverse azimuth from point1 to point2. Denote these values as `dist12`, `crs12`, and `crs21`, respectively.

- STEP 2: Calculate the angle between the given geodesic and the geodesic between $pt1$ and $pt2$. This is accomplished using signedAzimuthDifference function (see *Algorithm 6.1*)
- $$angle = \text{abs}(\text{signedAzimuthDifference}(crs13, crs12)).$$
- STEP 3: If ($dist12 \leq tol$), then $pt2$, $pt1$, and projected point $pt3$ are all the same point.
- STEP 4: Calculate $dist13$, the approximate distance from $pt1$ to the projected point $pt3$, using a spherical triangles approximation (see *figure A2-22*):
- $a = dist12 / SPHERE_RADIUS$
 - $dist13 = SPHERE_RADIUS \cdot \text{atan}[(\tan a) \cdot \text{abs}(\cos(angle))]$.
(Note, the $\text{abs}()$ function handles the case when $angle > \pi/2$, and should be faster than checking the sign of $angle$ using a conditional.)
- STEP 5: If $angle > \pi/2$, then $pt3$ is behind $pt1$, so we need to move $pt1$ back along the geodesic (redefining the geodesic parameters in the process) so that the projected point will fall forward of $pt1$.
- Use the direct algorithm to place a point behind $pt1$ on the given geodesic. Use $pt1$ as the starting point, $dist13 + 1.0$ nautical miles as the distance, and $crs13 + \pi$ as the azimuth. Denote this new point as $newPt1$.
 - Redefine $dist13$ as the distance from $newPt1$ to the approximate projection point. Since we moved $newPt1$ to $dist13 + 1.0$ nautical miles behind $pt1$, the new approximation to $dist13$ is simply 1.0 nautical miles, so set $dist13 = 1.0$.
 - Use the inverse algorithm to recalculate the initial azimuth of the geodesic at $newPt1$. Use $newPt1$ as the start point and $pt1$ as the end point. Update $crs13$ with this value.
 - Set $pt1 = newPt1$.
- STEP 6: Else, if $\text{abs}(dist13) < 1.0$, then the projected point is less than 1.0 nautical miles from $pt1$. In this case, numerical accuracy may be limited and it is beneficial to move the start point of the geodesic backwards a significant distance. We have achieved good results using 1.0 nautical miles.
- Use the direct algorithm to place a point behind $pt1$ on the given geodesic. Use $pt1$ as the starting point, 1.0 nautical miles as the

distance, and $\text{crs13} + \pi$ as the azimuth. Denote this new point as newPt1 .

- b. Redefine dist13 as the distance from newPt1 to the approximate projection point. Since we moved newPt1 1.0 nautical miles behind pt1 , the new approximation to dist13 is 1.0 nautical miles greater than the original approximation, so set $\text{dist13} = \text{dist13} + 1.0$.
- c. Use the inverse algorithm to recalculate the initial azimuth of the geodesic at newPt1 . Use newPt1 as the start point and pt1 as the end point. Update crs13 with this value.
- d. Set $\text{pt1} = \text{newPt1}$.

STEP 7: End If

STEP 8: Use the direct algorithm to project a point on the given geodesic distance dist13 from pt1 . Use pt1 for the starting point, dist13 for distance, and crs13 for azimuth. Denote the computed point by pt3 .

STEP 9: Use the inverse algorithm to calculate the azimuth crs31 from pt3 to pt1 .

STEP 10: Use the inverse algorithm to calculate the azimuth crs32 and distance dist23 from pt3 to pt2

STEP 11: Calculate the angle between the geodesics that intersect at pt3 , and cast that angle into the range $[0, \pi]$ using the following formula (see Algorithm 6.1): $\text{angle} = \text{abs}(\text{signedAzimuthDifference}(\text{crs31}, \text{crs32}))$

STEP 12: Calculate the error and store it as the first element in the error function array: $\text{errarray}[0] = \text{angle} - \pi$

STEP 13: Store the current distance from pt1 to pt3 in the distance function array: $\text{distarray}[0] = \text{dist13}$

STEP 14: A second distance/error value must be calculated before linear interpolation may be used to improve the solution. The following formula may be used: $\text{distarray}[1] = \text{distarray}[0] + \text{errarray}[0] \cdot \text{dist23}$

STEP 15: Use direct algorithm to project point on the given geodesic distance $\text{distarray}[1]$ from pt1 . Use pt1 for the starting point, $\text{distarray}[1]$ for distance, and crs13 for azimuth. Denote the computed point by pt3 .

STEP 16: Use the inverse algorithm to calculate the azimuth $crs31$ from $pt3$ to $pt1$.

STEP 17: Use the inverse algorithm to calculate the azimuth $crs32$ from $pt3$ to $pt2$.

STEP 18: Calculate the error in angle (see Algorithm 06.1):

$$errarray[1] = \text{abs}(\text{signedAzimuthDifference}(crs31, crs32)) - \frac{\pi}{2}$$

STEP 19: Initialize the iteration count: $k = 0$

STEP 20: Do while ($k = 0$) or ($(\text{error} > \text{tol})$ and ($k < \text{maxIterationCount}$))

- a. Use linear approximation to find root of $errarray$ as a function of $distarray$. This gives an improved approximation to $dist13$.
- b. Use direct algorithm to project point on the given geodesic distance $dist13$ from $pt1$. Use $pt1$ for the starting point, $dist13$ for distance, and $crs13$ for azimuth. Denote the computed point by $pt3$.
- c. Use the inverse algorithm to calculate the azimuth $crs31$ from $pt3$ to $pt1$.
- d. Use the inverse algorithm to calculate the distance $dist23$, azimuth $crs32$, and reverse azimuth $crs23$ from $pt3$ to $pt2$.
- e. Update $distarray$ and $errarray$ with the new values:

$$\begin{aligned} distarray[0] &= distarray[1] \\ errarray[0] &= errarray[1] \\ distarray[1] &= dist13 \\ errarray[1] &= \text{abs}(\text{signedAzimuthDifference}(crs31, crs32)) - \frac{\pi}{2} \end{aligned}$$
 (see Algorithm 6.1 for and explanation of "signedAzimuthDifference")
- f. Calculate the difference between the two latest distance values. This serves as the error function for measuring convergence:

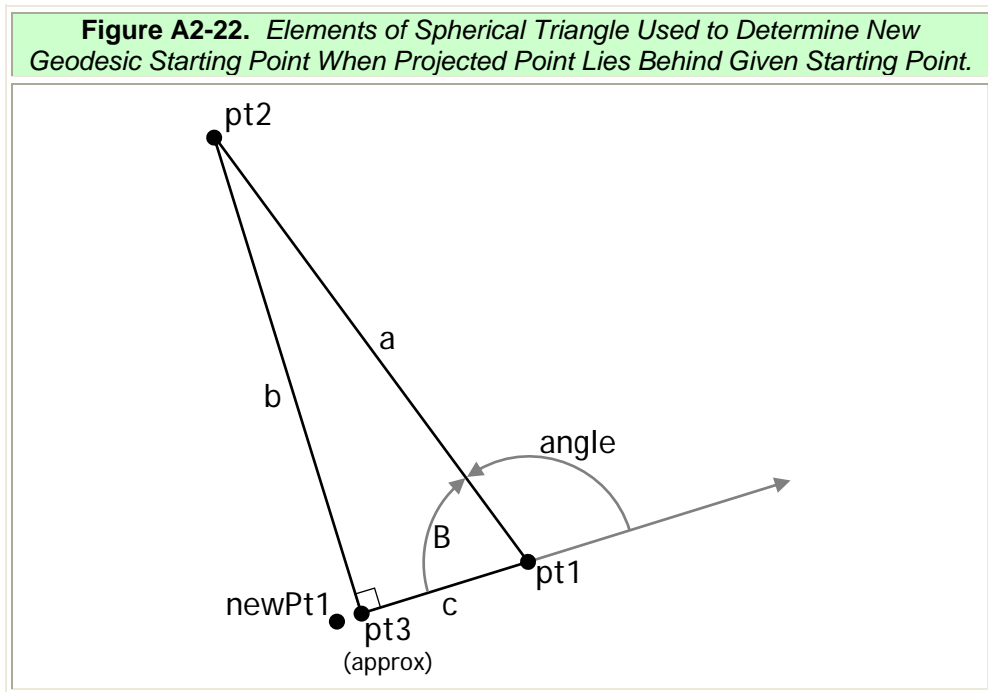
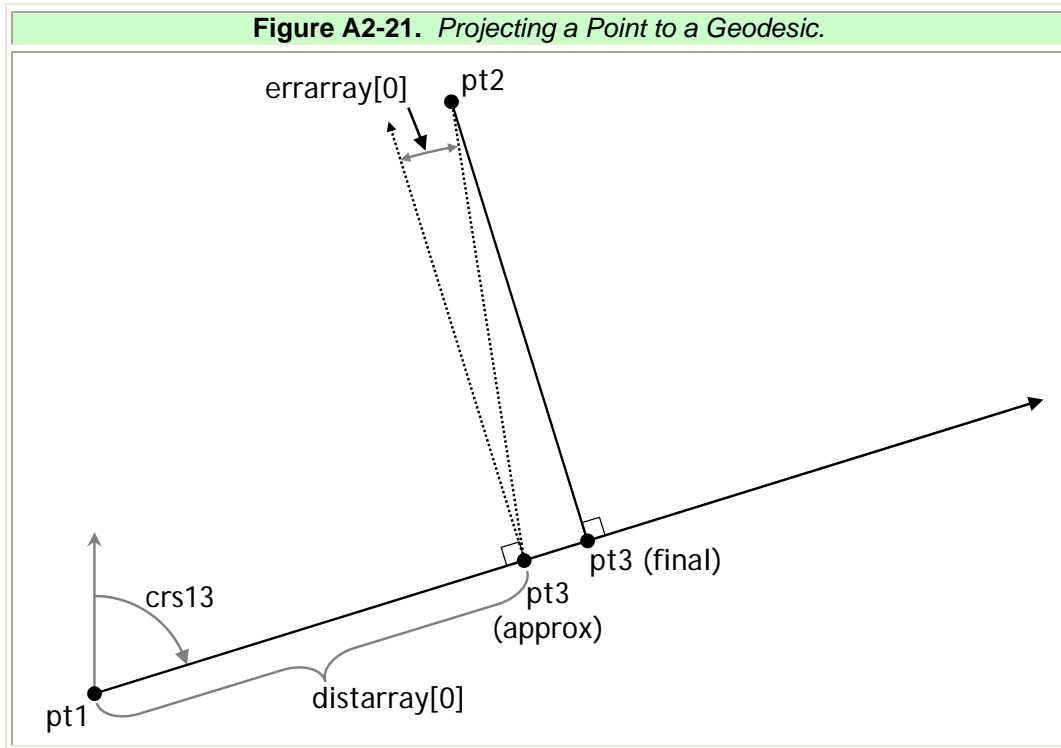
$$\text{error} = \text{abs}(distarray[1] - distarray[0])$$

STEP 21: End while

STEP 22: Set $crsToPoint = crs32$

STEP 23: Set $distToPoint = dist23$

STEP 24: Return pt3



5.2 Project Point to Locus.

This algorithm returns the point on a locus nearest the given sample point. It is used in *Algorithm 4.8* to calculate an arc tangent to two loci.

5.2.1 Input/Output.

LLPoint* WGS84LocusPerpIntercept(Locus loc, LLPoint pt2, double* crsFromPoint, double* distFromPoint, double tol)
returns a reference to an LLPoint structure that contains the coordinates of the projected point, where the inputs are:

Locus loc	=	Locus structure to which point will be projected
LLPoint pt2	=	Coordinates of point to be projected to locus
double* crsFromPoint	=	Reference to value that will store the course from pt2 to projected point
double* distFromPoint	=	Reference to value that will store the distance from pt2 to projected point
double tol	=	Maximum error allowed in solution
double eps	=	Convergence parameter for forward/inverse algorithms

5.2.2 Algorithm Steps.

See *figure A2-23* for an illustration of the variables.

STEP 1: Use the *inverse algorithm* to compute *gcrs* and *gdist*, the course and distance from *loc.geoStart* to *loc.geoEnd*.

STEP 2: If $(\text{abs}(\text{loc.startDist} - \text{loc.endDist}) < \text{tol})$, then the locus is “parallel” to its defining geodesic. In this case, the projected point on the locus will lie on the geodesic joining *pt2* with its projection on the defining geodesic, and the calculation is simplified:

- a. Apply *Algorithm 5.1* to project *pt2* onto the defining geodesic of *loc*. Use *loc.geoStart*, *gcrs*, and *pt2* as input parameters. The intersection point, *geoPt*, will be returned along with the course and distance from *pt2* to *geoPt*. Denote the course and distance values as *crsFromPoint* and *distFromPoint*, respectively.
- b. Use *Algorithm 3.10* to project a point *locPt* on the locus from *perpPt* on the geodesic.

- c. Use the *inverse algorithm* to recalculate `distFromPoint` as the distance between `pt2` and `locPt`.
- d. Return `locPt`.

STEP 3: End If

STEP 4: Use the *inverse algorithm* to compute `lcrs`, the course from `loc.locusStart` to `loc.locusEnd`.

STEP 5: Use *Algorithm 5.1* to project `pt2` onto the geodesic approximation of the locus. Pass `loc.locusStart`, `lcrs`, and `pt2` as parameters. Denote the computed point as `locPt`. (In general, this point will not exactly lie on the locus. We will adjust its position so that it is on the locus in a subsequent step.)

STEP 6: Calculate the locus inclination angle, relative to its geodesic:

$$\text{locAngle} = \text{atan}\left(\frac{\text{loc.startDist} - \text{loc.endDist}}{\text{gdist}}\right)$$

STEP 7: Use *Algorithm 5.1* to project `locPt` onto the locus's defining geodesic. Pass `loc.geoStart`, `gcrs`, and `locPt` as parameters. Denote the computed point as `geoPt`.

STEP 8: Use the *inverse function* to calculate the distance from `loc.geoStart` to `geoPt`. Store this value as `distarray[1]`.

STEP 9: Initialize the iteration count: `k=0`

STEP 10: Do while (`k = 0`) or (`abs(errarray[1]) > tol`) and (`k < maxIterationCount`)

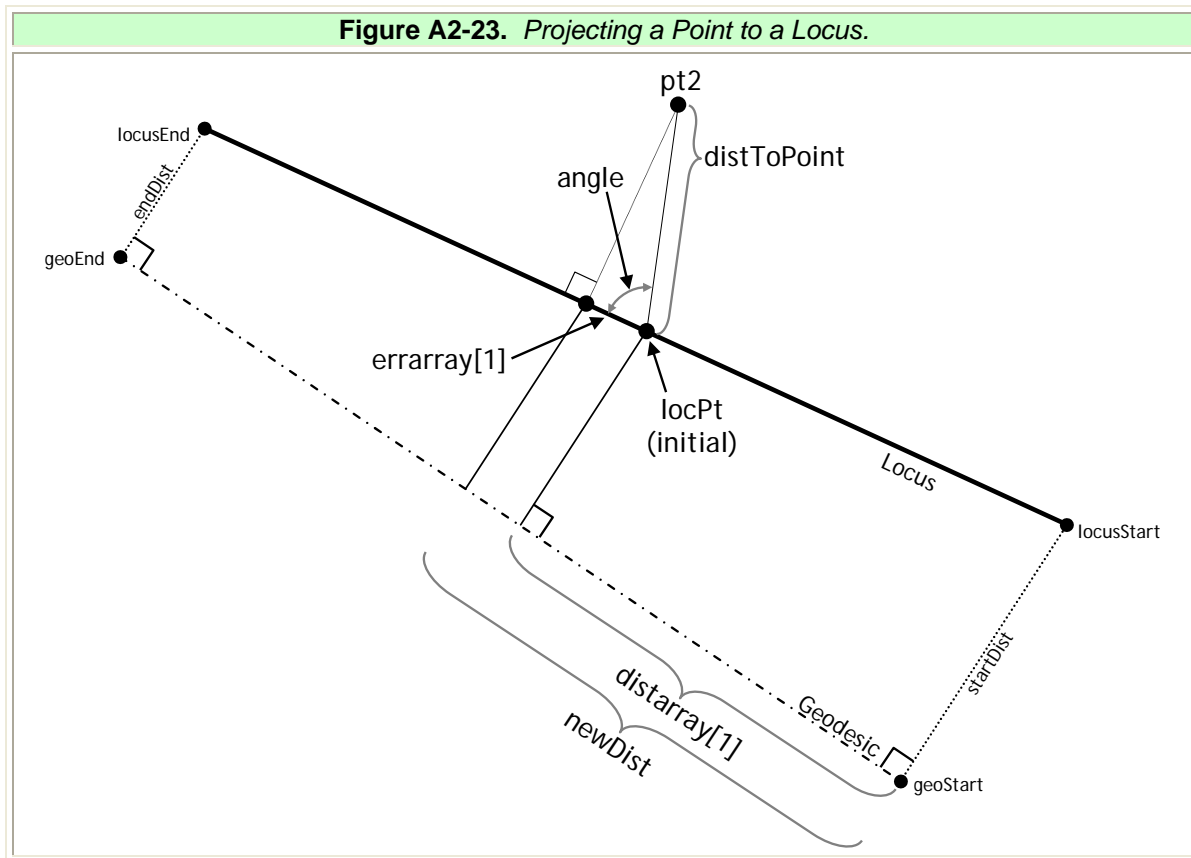
- a. Use *Algorithm 3.10* with `distarray[1]` to project a point onto the locus. Reassign `locPt` as this point.
- b. Use *Algorithm 3.12* to recompute `lcrs`, the course of the locus at `locPt`.
- c. Use the *inverse algorithm* to compute `crsToPoint` and `distToPoint`, the course and distance from `locPt` to `pt2`.
- d. Compute the signed angle between the locus and the geodesic from `locPt` to `pt2`:

$$\text{angle} = \text{abs}(\text{signedAzimuthDifference}(\text{lcrs}, \text{crsToPoint}))$$

- e. Store the approximate error as $errarray[1] = -distToPoint * \cos(\text{angle})$
This converts the error in angle into an error in distance which can be compared to `tol`.
- f. If $(\text{abs}(errarray[1]) < \text{tol})$, then the approximation is close enough, so return `locPt`.
- g. If $(k = 0)$ then a direct calculation is used to improve the approximation: $\text{newDist} = \text{distarray}[1] + errarray[1] * \cos(\text{locAngle})$
- h. Else, use a *linear root finder* with `distarray` and `errarray` to solve for the distance value that makes the error zero. Denote this value as `newDist`.
- i. End If
- j. Update the distance and error arrays:
 $\text{distarray}[0] = \text{distarray}[1]$
 $\text{errarray}[0] = \text{errarray}[1]$
 $\text{distarray}[1] = \text{newDist}$

STEP 11: End while

STEP 12: Return `locPt`



5.3 Tangent Projection from Point to Arc.

This projection is used in obstacle evaluation when finding the point on an **RF** leg or fly-by turn path where the distance to an obstacle must be measured.

5.3.1 Input/Output.

LLPoint* WGS84PointToArcTangents(LLPoint **point**, LLPoint **center**, double **radius**, int* **n**, double **tol**) returns a reference to an LLPoint structure that contains the coordinates of the points where geodesics through **point** are tangent to arc, where the inputs are:

LLPoint **point** = Point from which lines will be tangent to arc

LLPoint **center** = Geodetic centerpoint coordinates of arc

double **radius** = Radius of arc

int* **n** = Reference to number of tangent points found (0, 1, or 2)

double **tol** = Maximum error allowed in solution

double eps = Convergence parameter for forward/inverse algorithms

5.3.2 Algorithm Steps.

This algorithm treats the arc as a complete circle, so either zero or two tangent points will be returned. If the arc is bounded and two tangent points are found, then each point must be tested using *Algorithm 3.7* to determine whether they lie within the arc's bounds. (See figure A2-24)

STEP 1: Use the *inverse algorithm* to calculate the distance, azimuth, and reverse azimuth from point to center. Denote these values by `crsToCenter`, `crsFromCenter`, and `distToCenter`, respectively.

STEP 2: If $\text{abs}(\text{distToCenter} - \text{radius}) < \text{tol}$, then point lies on the arc and is a tangent point.

- a. Set `n = 1`
- b. Return `tanPt = point`

STEP 3: Else, if $\text{distToCenter} < \text{radius}$, then point lies inside of the arc and no tangent points exist.

- a. Return no solution.

STEP 4: End if

STEP 5: There must be two tangent points on the circle, so set `n = 2`

STEP 6: Use spherical trigonometry to compute approximate tangent points.

- a. $a = \text{distToCenter} / \text{SPHERE_RADIUS}$
- b. $b = \text{radius} / \text{SPHERE_RADIUS}$
- c. $c = \text{acos}(\tan(b) / \tan(a))$.

This is the approximate angle between the geodesic that joins point with center and the geodesic that joins center with either tangent point.

STEP 7: Initialize iteration count: `k = 0`

STEP 8: Do while (`k = 0`) or ($\text{abs}(\text{error}) > \text{tol}$ and `k < maxIterationCount`)

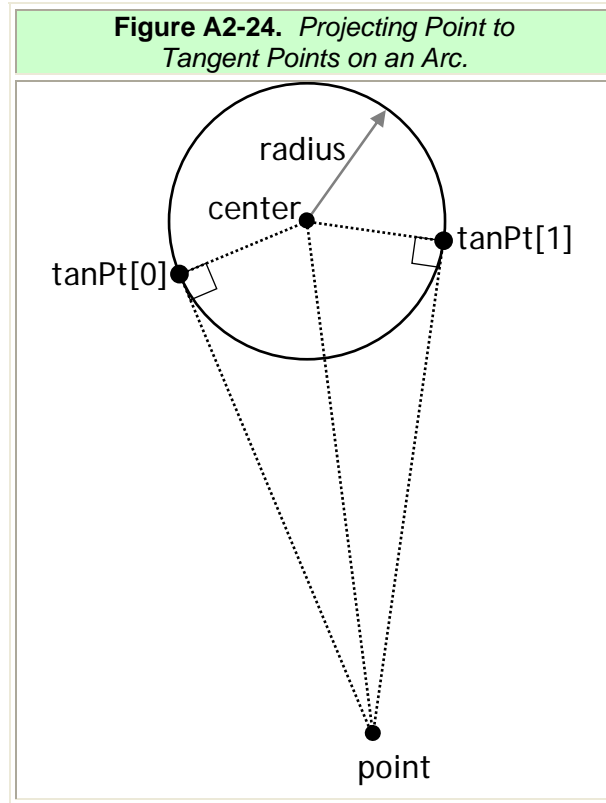
- a. Use the *direct algorithm* to locate `tanPt [0]` on arc. Use `center` as the starting point, `radius` as the distance, and `courseFromCenter+C` as the azimuth.
- b. Use the inverse algorithm to calculate the azimuth from `tanPt [0]` to `center`. Denote this value as `radCrs`.
- c. Use the *inverse algorithm* to calculate the azimuth from `tanPt [0]` to `point`. Denote this value as `tanCrs`.
- d. Use the function in *Algorithm 6.1* to calculate the angle between the two courses and cast it into the range $(-\pi, \pi]$:

$$\text{diff} = \text{signedAzimuthDifference}(\text{radCrs}, \text{tanCrs})$$
- e. Compute the error: $\text{error} = \text{abs}(\text{diff}) - \frac{\pi}{2}$
- f. Adjust the value of `C` to improve the approximation: $C = C + \text{error}$
- g. Increment the iteration count: $k = k + 1$

STEP 9: End while loop.

STEP 10: Repeat steps 7-9 to solve for `tanPt [1]`. In each iteration; however, use `crsFromPoint-C` for azimuth in step 8(a).

STEP 11: Return `tanPt [0]` and `tanPt [1]`



5.4 Project Arc to Geodesic.

This algorithm is used for obstacle evaluation when finding a point on the straight portion of *TF* leg where distance to an obstacle must be measured.

5.4.1 Input/Output.

`void WGS84PerpTangentPoints(LLPoint lineStart, double crs, LLPoint center, double radius, LLPoint linePts[2], LLPoint tanPts[2], double tol)` returns no output, where input values are:

<code>LLPoint lineStart</code>	=	Start point of geodesic to which arc tangent points will be projected
<code>double crs</code>	=	Initial course of geodesic
<code>LLPoint center</code>	=	Geodetic coordinates of arc center
<code>double radius</code>	=	Arc radius
<code>LLPoint linePts</code>	=	Array of projected points on geodesic
<code>LLPoint tanPts</code>	=	Array of tangent points on arc

double tol = Maximum error allowed in solution

double eps = Convergence parameter for forward/inverse algorithms

5.4.2 Algorithm Steps.

See *figure A2-25* for an illustration of the variable names.

STEP 1: Use the *inverse algorithm* to calculate the distance, azimuth, and reverse azimuth from `lineStart` to `center`. Denote these values as `distStartToCenter`, `crsStartToCenter`, and `crsCenterToStart`, respectively.

STEP 2: Compute the angle between the given geodesic and the geodesic that joins `lineStart` to `center` (see *Algorithm 6.1*):
 $\text{angle1} = \text{signedAzimuthDifference}(\text{crs}, \text{crsStartToCenter})$

STEP 3: If $\text{abs}(\text{distStartToCenter} * (\text{crsStartToCenter} - \text{crs})) < \text{tol}$, then `center` lies on the given geodesic, which is a diameter of the circle. In this case, the tangent points and project points are the same.

- a. Use the *direct algorithm* to compute `tanPts[0]`. Use `lineStart` as the starting point, `crs` as the azimuth, and `distStartToCenter - radius` as the distance.
- b. Use the *direct algorithm* to compute `tanPts[0]`. Use `lineStart` as the starting point, `crs` as the azimuth, and `distStartToCenter + radius` as the distance.
- c. Set `linePts[0] = tanPts[0]`
- d. Set `linePts[1] = tanPts[1]`
- e. Return all four points.

STEP 4: End if

STEP 5: Use *Algorithm 5.1* to project `center` to the geodesic defined by `lineStart` and `crs`. Denote the projected point by `perpPt`.

STEP 6: Use the *inverse algorithm* to calculate the distance, azimuth, and reverse azimuth from `perpPt` to `lineStart`. Denote these values by `dist12` and `crs21`, respectively.

STEP 7: Set `delta = radius`

STEP 8: Initialize iteration count: $k = 0$

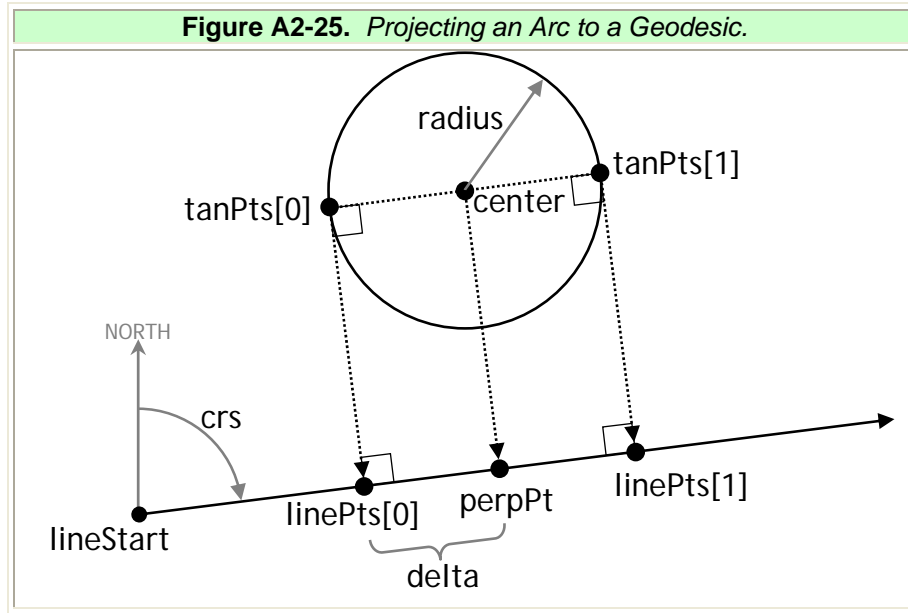
STEP 9: Do while ($k = 0$) or ($\text{abs}(\text{error}) > \text{tol}$ and $k < \text{maxIterationCount}$)

- a. Use the *direct algorithm* to compute $\text{linePts}[0]$. Use perpPt as the starting point, delta as the distance, and $\text{crs21} + \pi$ as the azimuth.
- b. Use the *inverse algorithm* to calculate the course from $\text{linePts}[0]$ to perpPt . Denote this value by strCrs .
- c. Calculate the azimuth, perpCrs , from $\text{linePts}[0]$ to the desired position of $\text{tanPts}[0]$. The azimuth depends upon which side of the line the circle lies, which is given by the sign of angle1 :
 $\text{perpCrs} = \text{strCrs} - \text{sign}(\text{angle1}) * \pi / 2$.
- d. Use *Algorithm 5.1* to project center onto the geodesic passing through $\text{linePts}[0]$ at azimuth perpCrs . Algorithm 5.1 will return the projected point, $\text{tanPts}[0]$, along with the distance from center to $\text{tanPts}[0]$. Denote this distance by radDist .
- e. Calculate the error, the amount that radDist differs from radius:
 $\text{error} = \text{radDist} - \text{radius}$
- f. Adjust the distance from lineStart to $\text{linePts}[0]$:
 $\text{delta} = \text{delta} - \text{error}$
- g. Increment the iteration count: $k = k + 1$

STEP 10: End while loop.

STEP 11: Repeat steps 7-10 to solve for $\text{linePts}[1]$ and $\text{tanPts}[1]$. In each iteration; however, use crs21 for azimuth in step a). Note that using the final delta value for the first iteration in the search for $\text{linePts}[1]$ will make the code more efficient (i.e., don't repeat *step 7*).

STEP 12: Return $\text{linePts}[0]$, $\text{linePts}[1]$, $\text{tanPts}[0]$, and $\text{tanPts}[1]$.



Attachment A - Useful Functions.

Attachment B - Calculate Angular Arc Extent.

When calculating the angle subtended by an arc, one must take into account the possibility that the arc crosses the northern branch cut, where $0^\circ = 360^\circ$. The following algorithm accounts for this case.

5.4.3 Input/Output.

`double WGS84GetArcExtent(double startCrs, double endCrs, int orientation, double tol)` returns a double precision value containing the arc's subtended angle, where the input values are:

`double startCrs` = Azimuth from center to start point of arc

`double endCrs` = Azimuth from center to end point of arc

`int orientation` = Integer that indicates the direction in which the arc is traversed to go from `startCrs` to `endCrs`.
`orientation = 1` if the arc is traversed counter-clockwise,
`orientation = -1` if the arc is traversed clockwise.

`double tol` = Maximum error allowed in calculations

`double eps` = Convergence parameter for forward/inverse algorithms

5.4.4 Algorithm Steps.

STEP 1: If `(abs(startCrs-endCrs) < tol)` return $2*\pi$

STEP 2: If `orientation < 0`, then orientation is clockwise. Cast the arc into a positive orientation so only one set of calculations is required

- a. `temp = startCrs`
- b. `startCrs = endCrs`
- c. `endCrs = temp`

STEP 3: End if

STEP 4: If `startCrs > endCrs`, then `angle = startCrs - endCrs`

STEP 5: Else `angle = 2*\pi + startCrs - endCrs`

STEP 6: End if

STEP 7: If `orientation < 0`, then `angle = -angle`

STEP 8: Return angle

6.0 Converting Geodetic Latitude/Longitude to *ECEF* Coordinates.

Geodetic coordinates may be converted to rectilinear *ECEF* coordinates using the following formulae¹. Given geodetic latitude φ , geodetic longitude θ , semi-major axis a and flattening parameter f , calculate the square of the eccentricity

$$e^2 = f(2 - f)$$

and the curvature in the prime vertical:

$$N = \frac{a}{\sqrt{1 - e^2 \sin^2 \varphi}}$$

The *ECEF* coordinates are then

$$\begin{aligned} x &= N \cos \varphi \cos \theta \\ y &= N \cos \varphi \sin \theta \\ z &= N(1 - e^2) \sin \varphi \end{aligned}$$

6.1 Signed Azimuth Difference.

It is often necessary to calculate the signed angular difference in azimuth between two geodesics at the point where they intersect. The following functions casts the difference between two geodesics into the range $[-\pi, \pi)$:

$$\text{signedAzimuthDifference}(a_1, a_2) = \text{mod}(a_1 - a_2 + \pi, 2\pi) - \pi$$

This function returns the angle between the two geodesics as if the geodesic that is oriented along azimuth a_1 were on the positive x -axis and the geodesic oriented along azimuth a_2 passed through the origin. In other words, if

$\text{signedAzimuthDifference}(a_1, a_2) > 0$ azimuth a_2 is to the left when standing at the geodesics' intersection point and facing in the direction of azimuth a_1 .

The mod function in the definition of `signedAzimuthDifference` must always return a non-negative value. Note that the C language's built in `fmod` function does not have this behavior, so a replacement must be supplied. The following code suffices:

```
double mod(double a, double b) {
  a = fmod(a, b);
  if (a < 0.0) a = a + b;
  return a;
}
```

6.2 Approximate Fixed Radius Arc Length.

Algorithm 3.8 describes a method for computing the length of an arc to high precision. The following algorithm provides a solution accurate to 1 centimeter for an arc whose radius is less than about 300 nautical miles (*NM*). This algorithm approximates the ellipsoid at the center of the arc in question with a “best fit” sphere, whose radius is

¹ Dana, Peter H., “Coordinate Conversion Geodetic Latitude, Longitude, and Height to ECEF, X, Y, Z”, <http://www.colorado.edu/geography/gcraft/notes/datum/gif/llhxyz.gif>, 11 February, 2003

computed as the geometric mean of the meridional and prime-vertical curvatures at the arc's center.

Given the arc center's latitude θ , the ellipsoidal semi-major axis a and flattening f , compute the local radius of curvature R as follows:

$$e^2 = f(2 - f)$$

$$M = \frac{a(1 - e^2)}{(1 - e^2 \sin^2 \theta)^{\frac{3}{2}}}$$

$$N = \frac{a}{\sqrt{1 - e^2 \sin^2 \theta}}$$

$$R = \sqrt{MN}$$

If the radius and subtended angle of the of the constant radius arc are r and A , respectively, then the length of the arc is given by:

$$L = AR \sin\left(\frac{r}{R}\right)$$

Test results for this formula and comparisons to *Algorithm 3.8* are given in *section 7.7*.

Attachment C**7.0 Sample Function Test Results.**

The following pages provide test inputs with expected outputs. This data is included here to make it easy to verify that an independent implementation of these algorithms produces the same results. All of these results were obtained using the tolerance parameter $\text{tol} = 1.0e-9$ and forward/inverse convergence parameter $\text{eps} = 0.5e-13$.

Test results are not included for those algorithms that are fairly straightforward applications of other algorithms, such as 3.9, 3.10, and 3.11.

WGS84 Direct Test Results

Test Identifier	Starting Latitude	Starting Longitude	Distance (NM)	Initial Azimuth (degrees)	Computed Destination Latitude	Computed Destination Longitude
test1	40:10:24.50000N	70:12:45.60000W	200.0	90.0	40:05:30.77099N	65:52:03.22158W
test2	40:10:24.50000N	70:12:45.60000W	200.0	0.0	43:30:29.87690N	70:12:45.60000W
test3	40:10:24.50000N	70:12:45.60000W	200.0	180.0	36:50:12.19034N	70:12:45.60000W
test4	40:10:24.50000N	70:12:45.60000W	200.0	270.0	40:05:30.77099N	74:33:27.97842W
test5	40:10:24.50000N	70:12:45.60000W	200.0	46.0	42:26:44.93817N	66:58:26.80185W
test6	40:10:24.50000N	70:12:45.60000W	200.0	127.0	38:06:56.47029N	66:50:21.71131W
test7	40:10:24.50000N	70:12:45.60000W	200.0	199.0	37:00:37.63806N	71:34:01.15378W
test8	40:10:24.50000N	70:12:45.60000W	200.0	277.0	40:29:56.05779N	74:33:04.77416W
test9	40:10:24.50000N	70:12:45.60000W	2.0	90.0	40:10:24.47060N	70:10:09.05140W
test10	40:10:24.50000N	70:12:45.60000W	2.0	0.0	40:12:24.58831N	70:12:45.60000W
test11	40:10:24.50000N	70:12:45.60000W	2.0	180.0	40:08:24.41100N	70:12:45.60000W
test12	40:10:24.50000N	70:12:45.60000W	2.0	270.0	40:10:24.47060N	70:15:22.14860W
test13	40:10:24.50000N	70:12:45.60000W	2.0	46.0	40:11:47.90520N	70:10:52.95004W
test14	40:10:24.50000N	70:12:45.60000W	2.0	127.0	40:09:12.20998N	70:10:40.61155W
test15	40:10:24.50000N	70:12:45.60000W	2.0	199.0	40:08:30.95052N	70:13:36.54366W
test16	40:10:24.50000N	70:12:45.60000W	2.0	277.0	40:10:39.10616N	70:15:20.99098W
test17	40:10:24.50000N	70:12:45.60000W	3000.0	90.0	24:30:24.17902N	13:01:17.08239W
test18	40:10:24.50000N	70:12:45.60000W	3000.0	0.0	89:58:28.94717N	109:47:14.40000E
test19	40:10:24.50000N	70:12:45.60000W	3000.0	180.0	10:00:44.08298S	70:12:45.60000W
test20	40:10:24.50000N	70:12:45.60000W	3000.0	270.0	24:30:24.17902N	127:24:14.11761W
test21	40:10:24.50000N	70:12:45.60000W	3000.0	46.0	55:17:03.30750N	4:30:00.21623E
test22	40:10:24.50000N	70:12:45.60000W	3000.0	127.0	3:28:31.38990N	32:28:57.95936W
test23	40:10:24.50000N	70:12:45.60000W	3000.0	199.0	8:09:04.17050S	84:46:29.97795W
test24	40:10:24.50000N	70:12:45.60000W	3000.0	277.0	29:06:16.65778N	130:30:47.88401W
test25	50:10:52.50000N	123:06:57.10000W	200.0	90.0	50:03:56.42973N	117:56:18.19536W
test26	50:10:52.50000N	123:06:57.10000W	200.0	0.0	53:30:36.93183N	123:06:57.10000W
test27	50:10:52.50000N	123:06:57.10000W	200.0	180.0	46:51:01.16657N	123:06:57.10000W
test28	50:10:52.50000N	123:06:57.10000W	200.0	270.0	50:03:56.42973N	128:17:36.00464W
test29	50:10:52.50000N	123:06:57.10000W	200.0	46.0	52:25:49.36941N	119:11:51.80053W
test30	50:10:52.50000N	123:06:57.10000W	200.0	127.0	48:06:24.18375N	119:08:33.75213W
test31	50:10:52.50000N	123:06:57.10000W	200.0	199.0	47:01:13.78683N	124:42:04.78016W
test32	50:10:52.50000N	123:06:57.10000W	200.0	277.0	50:28:19.21956N	128:17:55.21964W
test33	50:10:52.50000N	123:06:57.10000W	2.0	90.0	50:10:52.45833N	123:03:50.41132W
test34	50:10:52.50000N	123:06:57.10000W	2.0	0.0	50:12:52.37823N	123:06:57.10000W
test35	50:10:52.50000N	123:06:57.10000W	2.0	180.0	50:08:52.62108N	123:06:57.10000W
test36	50:10:52.50000N	123:06:57.10000W	2.0	270.0	50:10:52.45833N	123:10:03.78868W
test37	50:10:52.50000N	123:06:57.10000W	2.0	46.0	50:12:15.75291N	123:04:42.74250W
test38	50:10:52.50000N	123:06:57.10000W	2.0	127.0	50:09:40.32859N	123:04:28.06612W
test39	50:10:52.50000N	123:06:57.10000W	2.0	199.0	50:08:59.14786N	123:07:57.83998W
test40	50:10:52.50000N	123:06:57.10000W	2.0	277.0	50:11:07.06846N	123:10:02.41284W
test41	50:10:52.50000N	123:06:57.10000W	3000.0	90.0	29:37:18.55208N	61:31:12.91277W
test42	50:10:52.50000N	123:06:57.10000W	3000.0	0.0	80:00:57.51620N	56:53:02.90000E
test43	50:10:52.50000N	123:06:57.10000W	3000.0	180.0	0:02:43.03479N	123:06:57.10000W
test44	50:10:52.50000N	123:06:57.10000W	3000.0	270.0	29:37:18.55208N	175:17:18.71277E

test45	50:10:52.50000N	123:06:57.10000W	3000.0	46.0	56:40:22.79938N	33:42:20.71403W
test46	50:10:52.50000N	123:06:57.10000W	3000.0	127.0	11:23:14.37898N	84:34:26.55554W
test47	50:10:52.50000N	123:06:57.10000W	3000.0	199.0	1:35:14.22889N	137:32:13.52544W
test48	50:10:52.50000N	123:06:57.10000W	3000.0	277.0	33:39:39.03338N	171:08:27.87014E
test49	42:44:32.10000N	66:27:19.60000E	200.0	90.0	42:39:10.81410N	70:58:29.15259E
test50	42:44:32.10000N	66:27:19.60000E	200.0	0.0	46:04:32.07438N	66:27:19.60000E
test51	42:44:32.10000N	66:27:19.60000E	200.0	180.0	39:24:25.11928N	66:27:19.60000E
test52	42:44:32.10000N	66:27:19.60000E	200.0	270.0	42:39:10.81410N	61:56:10.04741E
test53	42:44:32.10000N	66:27:19.60000E	200.0	46.0	45:00:33.43147N	69:50:07.10761E
test54	42:44:32.10000N	66:27:19.60000E	200.0	127.0	40:40:50.71563N	69:57:17.17656E
test55	42:44:32.10000N	66:27:19.60000E	200.0	199.0	39:34:47.61048N	65:03:08.96220E
test56	42:44:32.10000N	66:27:19.60000E	200.0	277.0	43:03:35.51327N	61:56:24.98803E
test57	42:44:32.10000N	66:27:19.60000E	2.0	90.0	42:44:32.06784N	66:30:02.45101E
test58	42:44:32.10000N	66:27:19.60000E	2.0	0.0	42:46:32.13452N	66:27:19.60000E
test59	42:44:32.10000N	66:27:19.60000E	2.0	180.0	42:42:32.06478N	66:27:19.60000E
test60	42:44:32.10000N	66:27:19.60000E	2.0	270.0	42:44:32.06784N	66:24:36.74899E
test61	42:44:32.10000N	66:27:19.60000E	2.0	46.0	42:45:55.46641N	66:29:16.78884E
test62	42:44:32.10000N	66:27:19.60000E	2.0	127.0	42:43:19.84058N	66:29:29.61668E
test63	42:44:32.10000N	66:27:19.60000E	2.0	199.0	42:42:38.60108N	66:26:26.60774E
test64	42:44:32.10000N	66:27:19.60000E	2.0	277.0	42:44:46.69688N	66:24:37.95230E
test65	42:44:32.10000N	66:27:19.60000E	3000.0	90.0	25:52:49.48262N	124:39:55.85184E
test66	42:44:32.10000N	66:27:19.60000E	3000.0	0.0	87:25:13.54228N	113:32:40.40000W
test67	42:44:32.10000N	66:27:19.60000E	3000.0	180.0	7:25:57.78702S	66:27:19.60000E
test68	42:44:32.10000N	66:27:19.60000E	3000.0	270.0	25:52:49.48262N	8:14:43.34816E
test69	42:44:32.10000N	66:27:19.60000E	3000.0	46.0	55:52:47.54426N	144:47:50.12500E
test70	42:44:32.10000N	66:27:19.60000E	3000.0	127.0	5:30:44.95719N	104:18:35.77997E
test71	42:44:32.10000N	66:27:19.60000E	3000.0	199.0	5:39:14.93608S	51:58:13.27568E
test72	42:44:32.10000N	66:27:19.60000E	3000.0	277.0	30:21:08.45258N	4:52:35.40656E
test73	31:12:52.30000N	125:28:47.50000E	200.0	90.0	31:09:21.00038N	129:21:55.26637E
test74	31:12:52.30000N	125:28:47.50000E	200.0	0.0	34:33:15.83037N	125:28:47.50000E
test75	31:12:52.30000N	125:28:47.50000E	200.0	180.0	27:52:22.52362N	125:28:47.50000E
test76	31:12:52.30000N	125:28:47.50000E	200.0	270.0	31:09:21.00038N	121:35:39.73363E
test77	31:12:52.30000N	125:28:47.50000E	200.0	46.0	33:30:10.60726N	128:20:48.89100E
test78	31:12:52.30000N	125:28:47.50000E	200.0	127.0	29:10:03.77133N	128:31:13.43437E
test79	31:12:52.30000N	125:28:47.50000E	200.0	199.0	28:02:57.01708N	124:15:14.09016E
test80	31:12:52.30000N	125:28:47.50000E	200.0	277.0	31:33:48.07660N	121:36:24.04854E
test81	31:12:52.30000N	125:28:47.50000E	2.0	90.0	31:12:52.27886N	125:31:07.43524E
test82	31:12:52.30000N	125:28:47.50000E	2.0	0.0	31:14:52.56685N	125:28:47.50000E
test83	31:12:52.30000N	125:28:47.50000E	2.0	180.0	31:10:52.03253N	125:28:47.50000E
test84	31:12:52.30000N	125:28:47.50000E	2.0	270.0	31:12:52.27886N	125:26:27.56476E
test85	31:12:52.30000N	125:28:47.50000E	2.0	46.0	31:14:15.83349N	125:30:28.18558E
test86	31:12:52.30000N	125:28:47.50000E	2.0	127.0	31:11:39.90782N	125:30:39.23361E
test87	31:12:52.30000N	125:28:47.50000E	2.0	199.0	31:10:58.58265N	125:28:01.95668E
test88	31:12:52.30000N	125:28:47.50000E	2.0	277.0	31:13:06.93605N	125:26:28.60187E
test89	31:12:52.30000N	125:28:47.50000E	3000.0	90.0	19:27:03.05786N	179:41:20.83695E
test90	31:12:52.30000N	125:28:47.50000E	3000.0	0.0	81:07:29.93181N	125:28:47.50000E
test91	31:12:52.30000N	125:28:47.50000E	3000.0	180.0	18:59:46.09922S	125:28:47.50000E
test92	31:12:52.30000N	125:28:47.50000E	3000.0	270.0	19:27:03.05786N	71:16:14.16305E

test93	31:12:52.30000N	125:28:47.50000E	3000.0	46.0	52:04:30.90569N	171:09:46.53647W
test94	31:12:52.30000N	125:28:47.50000E	3000.0	127.0	3:37:54.96189S	163:12:50.99996E
test95	31:12:52.30000N	125:28:47.50000E	3000.0	199.0	16:50:15.39672S	110:24:43.33889E
test96	31:12:52.30000N	125:28:47.50000E	3000.0	277.0	24:24:11.81091N	69:01:02.24210E
test97	49:10:24.50000S	75:12:45.60000W	200.0	90.0	49:03:42.87631S	70:08:25.93407W
test98	49:10:24.50000S	75:12:45.60000W	200.0	0.0	45:50:31.05302S	75:12:45.60000W
test99	49:10:24.50000S	75:12:45.60000W	200.0	180.0	52:30:11.00366S	75:12:45.60000W
test100	49:10:24.50000S	75:12:45.60000W	200.0	270.0	49:03:42.87631S	80:17:05.26593W
test101	49:10:24.50000S	75:12:45.60000W	200.0	46.0	46:48:17.31010S	71:43:18.85029W
test102	49:10:24.50000S	75:12:45.60000W	200.0	127.0	51:06:09.21946S	70:59:16.31551W
test103	49:10:24.50000S	75:12:45.60000W	200.0	199.0	52:18:31.88478S	76:58:48.10816W
test104	49:10:24.50000S	75:12:45.60000W	200.0	277.0	48:39:31.53843S	80:12:23.46911W
test105	49:10:24.50000S	75:12:45.60000W	2.0	90.0	49:10:24.45978S	75:09:42.72995W
test106	49:10:24.50000S	75:12:45.60000W	2.0	0.0	49:08:24.60011S	75:12:45.60000W
test107	49:10:24.50000S	75:12:45.60000W	2.0	180.0	49:12:24.39920S	75:12:45.60000W
test108	49:10:24.50000S	75:12:45.60000W	2.0	270.0	49:10:24.45978S	75:15:48.47005W
test109	49:10:24.50000S	75:12:45.60000W	2.0	46.0	49:09:01.18981S	75:10:34.11555W
test110	49:10:24.50000S	75:12:45.60000W	2.0	127.0	49:11:36.63156S	75:10:19.49448W
test111	49:10:24.50000S	75:12:45.60000W	2.0	199.0	49:12:17.86267S	75:13:45.17447W
test112	49:10:24.50000S	75:12:45.60000W	2.0	277.0	49:10:09.84830S	75:15:47.09213W
test113	49:10:24.50000S	75:12:45.60000W	3000.0	90.0	29:08:15.41939S	14:06:51.81153W
test114	49:10:24.50000S	75:12:45.60000W	3000.0	0.0	0:58:06.24146N	75:12:45.60000W
test115	49:10:24.50000S	75:12:45.60000W	3000.0	180.0	81:01:11.20478S	104:47:14.40000E
test116	49:10:24.50000S	75:12:45.60000W	3000.0	270.0	29:08:15.41939S	136:18:39.38847W
test117	49:10:24.50000S	75:12:45.60000W	3000.0	46.0	7:52:38.83544S	41:28:29.05694W
test118	49:10:24.50000S	75:12:45.60000W	3000.0	127.0	52:04:51.42106S	7:52:24.35518E
test119	49:10:24.50000S	75:12:45.60000W	3000.0	199.0	73:51:36.66725S	168:08:53.56896E
test120	49:10:24.50000S	75:12:45.60000W	3000.0	277.0	25:11:20.18815S	132:13:38.05215W
test121	43:10:45.70000S	123:42:43.40000W	200.0	90.0	43:05:19.50216S	119:09:38.75232W
test122	43:10:45.70000S	123:42:43.40000W	200.0	0.0	39:50:39.63379S	123:42:43.40000W
test123	43:10:45.70000S	123:42:43.40000W	200.0	180.0	46:30:44.75296S	123:42:43.40000W
test124	43:10:45.70000S	123:42:43.40000W	200.0	270.0	43:05:19.50216S	128:15:48.04768W
test125	43:10:45.70000S	123:42:43.40000W	200.0	46.0	40:49:05.78329S	120:33:14.53881W
test126	43:10:45.70000S	123:42:43.40000W	200.0	127.0	45:07:29.89631S	119:57:05.47191W
test127	43:10:45.70000S	123:42:43.40000W	200.0	199.0	46:19:13.99376S	125:16:37.84869W
test128	43:10:45.70000S	123:42:43.40000W	200.0	277.0	42:41:04.43281S	128:11:59.62018W
test129	43:10:45.70000S	123:42:43.40000W	2.0	90.0	43:10:45.66735S	123:39:59.39209W
test130	43:10:45.70000S	123:42:43.40000W	2.0	0.0	43:08:45.67398S	123:42:43.40000W
test131	43:10:45.70000S	123:42:43.40000W	2.0	180.0	43:12:45.72532S	123:42:43.40000W
test132	43:10:45.70000S	123:42:43.40000W	2.0	270.0	43:10:45.66735S	123:45:27.40791W
test133	43:10:45.70000S	123:42:43.40000W	2.0	46.0	43:09:22.30610S	123:40:45.46715W
test134	43:10:45.70000S	123:42:43.40000W	2.0	127.0	43:11:57.91229S	123:40:32.37455W
test135	43:10:45.70000S	123:42:43.40000W	2.0	199.0	43:12:39.18273S	123:43:36.82325W
test136	43:10:45.70000S	123:42:43.40000W	2.0	277.0	43:10:31.04038S	123:45:26.17463W
test137	43:10:45.70000S	123:42:43.40000W	3000.0	90.0	26:06:37.08296S	65:19:15.88930W
test138	43:10:45.70000S	123:42:43.40000W	3000.0	0.0	6:59:37.06995N	123:42:43.40000W
test139	43:10:45.70000S	123:42:43.40000W	3000.0	180.0	86:59:08.38590S	56:17:16.60000E
test140	43:10:45.70000S	123:42:43.40000W	3000.0	270.0	26:06:37.08296S	177:53:49.08930E

test141	43:10:45.70000S	123:42:43.40000W	3000.0	46.0	2:51:33.84923S	90:17:19.02340W
test142	43:10:45.70000S	123:42:43.40000W	3000.0	127.0	50:58:42.47481S	48:01:25.22327W
test143	43:10:45.70000S	123:42:43.40000W	3000.0	199.0	75:32:45.23169S	140:44:35.89858E
test144	43:10:45.70000S	123:42:43.40000W	3000.0	277.0	21:49:17.43560S	178:34:03.34260W
test145	30:13:55.50000S	54:53:17.40000E	200.0	90.0	30:10:32.24599S	58:44:04.46955E
test146	30:13:55.50000S	54:53:17.40000E	200.0	0.0	26:53:23.96278S	54:53:17.40000E
test147	30:13:55.50000S	54:53:17.40000E	200.0	180.0	33:34:20.90547S	54:53:17.40000E
test148	30:13:55.50000S	54:53:17.40000E	200.0	270.0	30:10:32.24599S	51:02:30.33045E
test149	30:13:55.50000S	54:53:17.40000E	200.0	46.0	27:52:57.82170S	57:35:36.72392E
test150	30:13:55.50000S	54:53:17.40000E	200.0	127.0	32:12:18.30198S	58:01:31.85506E
test151	30:13:55.50000S	54:53:17.40000E	200.0	199.0	33:23:02.92727S	53:35:33.92865E
test152	30:13:55.50000S	54:53:17.40000E	200.0	277.0	29:46:10.92312S	51:05:09.54001E
test153	30:13:55.50000S	54:53:17.40000E	2.0	90.0	30:13:55.47966S	54:55:35.92341E
test154	30:13:55.50000S	54:53:17.40000E	2.0	0.0	30:11:55.21431S	54:53:17.40000E
test155	30:13:55.50000S	54:53:17.40000E	2.0	180.0	30:15:55.78508S	54:53:17.40000E
test156	30:13:55.50000S	54:53:17.40000E	2.0	270.0	30:13:55.47966S	54:50:58.87659E
test157	30:13:55.50000S	54:53:17.40000E	2.0	46.0	30:12:31.93209S	54:54:57.02201E
test158	30:13:55.50000S	54:53:17.40000E	2.0	127.0	30:15:07.87646S	54:55:08.05224E
test159	30:13:55.50000S	54:53:17.40000E	2.0	199.0	30:15:49.22963S	54:52:32.28676E
test160	30:13:55.50000S	54:53:17.40000E	2.0	277.0	30:13:40.82086S	54:50:59.91478E
test161	30:13:55.50000S	54:53:17.40000E	3000.0	90.0	18:52:29.86498S	108:49:20.15190E
test162	30:13:55.50000S	54:53:17.40000E	3000.0	0.0	19:58:48.22673N	54:53:17.40000E
test163	30:13:55.50000S	54:53:17.40000E	3000.0	180.0	80:08:58.44983S	54:53:17.40000E
test164	30:13:55.50000S	54:53:17.40000E	3000.0	270.0	18:52:29.86498S	0:57:14.64810E
test165	30:13:55.50000S	54:53:17.40000E	3000.0	46.0	7:58:13.96628N	88:37:37.35172E
test166	30:13:55.50000S	54:53:17.40000E	3000.0	127.0	46:16:23.75384S	116:51:12.92431E
test167	30:13:55.50000S	54:53:17.40000E	3000.0	199.0	71:41:54.15847S	2:36:27.57861E
test168	30:13:55.50000S	54:53:17.40000E	3000.0	277.0	14:01:56.87883S	3:23:24.56420E
test169	71:03:45.50000S	155:13:37.40000E	200.0	90.0	70:47:04.46404S	165:21:13.27121E
test170	71:03:45.50000S	155:13:37.40000E	200.0	0.0	67:44:32.20108S	155:13:37.40000E
test171	71:03:45.50000S	155:13:37.40000E	200.0	180.0	74:22:54.50904S	155:13:37.40000E
test172	71:03:45.50000S	155:13:37.40000E	200.0	270.0	70:47:04.46404S	145:06:01.52879E
test173	71:03:45.50000S	155:13:37.40000E	200.0	46.0	68:37:38.70618S	161:47:11.03268E
test174	71:03:45.50000S	155:13:37.40000E	200.0	127.0	72:51:42.35787S	164:14:58.08728E
test175	71:03:45.50000S	155:13:37.40000E	200.0	199.0	74:09:55.67082S	151:16:06.01068E
test176	71:03:45.50000S	155:13:37.40000E	200.0	277.0	70:23:23.03906S	145:22:23.31016E
test177	71:03:45.50000S	155:13:37.40000E	2.0	90.0	71:03:45.39916S	155:19:45.39068E
test178	71:03:45.50000S	155:13:37.40000E	2.0	0.0	71:01:45.98931S	155:13:37.40000E
test179	71:03:45.50000S	155:13:37.40000E	2.0	180.0	71:05:45.01026S	155:13:37.40000E
test180	71:03:45.50000S	155:13:37.40000E	2.0	270.0	71:03:45.39916S	155:07:29.40932E
test181	71:03:45.50000S	155:13:37.40000E	2.0	46.0	71:02:22.42883S	155:18:01.80054E
test182	71:03:45.50000S	155:13:37.40000E	2.0	127.0	71:04:57.35874S	155:18:31.58931E
test183	71:03:45.50000S	155:13:37.40000E	2.0	199.0	71:05:38.48847S	155:11:37.40237E
test184	71:03:45.50000S	155:13:37.40000E	2.0	277.0	71:03:30.83602S	155:07:32.22736E
test185	71:03:45.50000S	155:13:37.40000E	3000.0	90.0	37:33:28.76348S	130:07:28.60879W
test186	71:03:45.50000S	155:13:37.40000E	3000.0	0.0	21:04:35.11214S	155:13:37.40000E
test187	71:03:45.50000S	155:13:37.40000E	3000.0	180.0	59:09:32.80147S	24:46:22.60000W
test188	71:03:45.50000S	155:13:37.40000E	3000.0	270.0	37:33:28.76348S	80:34:43.40879E

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Appendix 2

test189	71:03:45.50000S	155:13:37.40000E	3000.0	46.0	25:50:57.88581S	167:05:40.45264W
test190	71:03:45.50000S	155:13:37.40000E	3000.0	127.0	49:25:34.58238S	94:31:25.79851W
test191	71:03:45.50000S	155:13:37.40000E	3000.0	199.0	57:40:40.95961S	2:56:35.65351E
test192	71:03:45.50000S	155:13:37.40000E	3000.0	277.0	35:23:25.31483S	86:40:04.05968E

WGS84 Inverse Test Results

Test Identifier	Starting Latitude	Starting Longitude	Destination Latitude	Destination Longitude	Computed Azimuth (degrees)	Computed Reverse Azimuth (degrees)	Computed Distance (NM)
test1	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	90.00000	272.80147	200.00000
test2	40:10:24.50000N	70:12:45.60000W	43:30:29.87690N	70:12:45.60000W	0.00000	180.00000	200.00000
test3	40:10:24.50000N	70:12:45.60000W	36:50:12.19034N	70:12:45.60000W	180.00000	0.00000	200.00000
test4	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	74:33:27.97842W	270.00000	87.19853	200.00000
test5	40:10:24.50000N	70:12:45.60000W	42:26:44.93817N	66:58:26.80185W	46.00000	228.13861	200.00000
test6	40:10:24.50000N	70:12:45.60000W	38:06:56.47029N	66:50:21.71131W	127.00000	309.13021	200.00000
test7	40:10:24.50000N	70:12:45.60000W	37:00:37.63806N	71:34:01.15378W	199.00000	18.15487	200.00000
test8	40:10:24.50000N	70:12:45.60000W	40:29:56.05779N	74:33:04.77416W	277.00000	94.19092	200.00000
test9	40:10:24.50000N	70:12:45.60000W	40:10:24.47060N	70:10:09.05140W	90.00000	270.02805	2.00000
test10	40:10:24.50000N	70:12:45.60000W	40:12:24.58831N	70:12:45.60000W	0.00000	180.00000	2.00000
test11	40:10:24.50000N	70:12:45.60000W	40:08:24.41100N	70:12:45.60000W	180.00000	0.00000	2.00000
test12	40:10:24.50000N	70:12:45.60000W	40:10:24.47060N	70:15:22.14860W	270.00000	89.97195	2.00000
test13	40:10:24.50000N	70:12:45.60000W	40:11:47.90520N	70:10:52.95004W	46.00000	226.02019	2.00000
test14	40:10:24.50000N	70:12:45.60000W	40:09:12.20998N	70:10:40.61155W	127.00000	307.02239	2.00000
test15	40:10:24.50000N	70:12:45.60000W	40:08:30.95052N	70:13:36.54366W	199.00000	18.99087	2.00000
test16	40:10:24.50000N	70:12:45.60000W	40:10:39.10616N	70:15:20.99098W	277.00000	96.97215	2.00000
test17	40:10:24.50000N	70:12:45.60000W	24:30:24.17902N	13:01:17.08239W	90.00000	302.81413	3000.00000
test18	40:10:24.50000N	70:12:45.60000W	89:58:28.94717N	109:47:14.40000E	0.00000	0.00000	3000.00000
test19	40:10:24.50000N	70:12:45.60000W	10:00:44.08298S	70:12:45.60000W	180.00000	0.00000	3000.00000
test20	40:10:24.50000N	70:12:45.60000W	24:30:24.17902N	127:24:14.11761W	270.00000	57.18587	3000.00000
test21	40:10:24.50000N	70:12:45.60000W	55:17:03.30750N	4:30:00.21623E	46.00000	285.35933	3000.00000
test22	40:10:24.50000N	70:12:45.60000W	3:28:31.38990N	32:28:57.95936W	127.00000	322.25100	3000.00000
test23	40:10:24.50000N	70:12:45.60000W	8:09:04.17050S	84:46:29.97795W	199.00000	14.57444	3000.00000
test24	40:10:24.50000N	70:12:45.60000W	29:06:16.65778N	130:30:47.88401W	277.00000	60.28734	3000.00000
test25	50:10:52.50000N	123:06:57.10000W	50:03:56.42973N	117:56:18.19536W	90.00000	273.97445	200.00000
test26	50:10:52.50000N	123:06:57.10000W	53:30:36.93183N	123:06:57.10000W	0.00000	180.00000	200.00000
test27	50:10:52.50000N	123:06:57.10000W	46:51:01.16657N	123:06:57.10000W	180.00000	0.00000	200.00000
test28	50:10:52.50000N	123:06:57.10000W	50:03:56.42973N	128:17:36.00464W	270.00000	86.02555	200.00000
test29	50:10:52.50000N	123:06:57.10000W	52:25:49.36941N	119:11:51.80053W	46.00000	229.05914	200.00000
test30	50:10:52.50000N	123:06:57.10000W	48:06:24.18375N	119:08:33.75213W	127.00000	310.00613	200.00000
test31	50:10:52.50000N	123:06:57.10000W	47:01:13.78683N	124:42:04.78016W	199.00000	17.81022	200.00000
test32	50:10:52.50000N	123:06:57.10000W	50:28:19.21956N	128:17:55.21964W	277.00000	93.00968	200.00000
test33	50:10:52.50000N	123:06:57.10000W	50:10:52.45833N	123:03:50.41132W	90.00000	270.03983	2.00000
test34	50:10:52.50000N	123:06:57.10000W	50:12:52.37823N	123:06:57.10000W	0.00000	180.00000	2.00000
test35	50:10:52.50000N	123:06:57.10000W	50:08:52.62108N	123:06:57.10000W	180.00000	0.00000	2.00000
test36	50:10:52.50000N	123:06:57.10000W	50:10:52.45833N	123:10:03.78868W	270.00000	89.96017	2.00000
test37	50:10:52.50000N	123:06:57.10000W	50:12:15.75291N	123:04:42.74250W	46.00000	226.02867	2.00000
test38	50:10:52.50000N	123:06:57.10000W	50:09:40.32859N	123:04:28.06612W	127.00000	307.03179	2.00000
test39	50:10:52.50000N	123:06:57.10000W	50:08:59.14786N	123:07:57.83998W	199.00000	18.98704	2.00000
test40	50:10:52.50000N	123:06:57.10000W	50:11:07.06846N	123:10:02.41284W	277.00000	96.96046	2.00000
test41	50:10:52.50000N	123:06:57.10000W	29:37:18.55208N	61:31:12.91277W	90.00000	312.48202	3000.00000
test42	50:10:52.50000N	123:06:57.10000W	80:00:57.51620N	56:53:02.90000E	0.00000	360.00000	3000.00000
test43	50:10:52.50000N	123:06:57.10000W	0:02:43.03479N	123:06:57.10000W	180.00000	0.00000	3000.00000
test44	50:10:52.50000N	123:06:57.10000W	29:37:18.55208N	175:17:18.71277E	270.00000	47.51798	3000.00000

test45	50:10:52.50000N	123:06:57.10000W	56:40:22.79938N	33:42:20.71403W	46.00000	303.05928	3000.00000
test46	50:10:52.50000N	123:06:57.10000W	11:23:14.37898N	84:34:26.55554W	127.00000	328.48986	3000.00000
test47	50:10:52.50000N	123:06:57.10000W	1:35:14.22889N	137:32:13.52544W	199.00000	12.06222	3000.00000
test48	50:10:52.50000N	123:06:57.10000W	33:39:39.03338N	171:08:27.87014E	277.00000	49.84895	3000.00000
test49	42:44:32.10000N	66:27:19.60000E	42:39:10.81410N	70:58:29.15259E	90.00000	273.06555	200.00000
test50	42:44:32.10000N	66:27:19.60000E	46:04:32.07438N	66:27:19.60000E	360.00000	180.00000	200.00000
test51	42:44:32.10000N	66:27:19.60000E	39:24:25.11928N	66:27:19.60000E	180.00000	0.00000	200.00000
test52	42:44:32.10000N	66:27:19.60000E	42:39:10.81410N	61:56:10.04741E	270.00000	86.93445	200.00000
test53	42:44:32.10000N	66:27:19.60000E	45:00:33.43147N	69:50:07.10761E	46.00000	228.34339	200.00000
test54	42:44:32.10000N	66:27:19.60000E	40:40:50.71563N	69:57:17.17656E	127.00000	309.32917	200.00000
test55	42:44:32.10000N	66:27:19.60000E	39:34:47.61048N	65:03:08.96220E	199.00000	18.07623	200.00000
test56	42:44:32.10000N	66:27:19.60000E	43:03:35.51327N	61:56:24.98803E	277.00000	93.92550	200.00000
test57	42:44:32.10000N	66:27:19.60000E	42:44:32.06784N	66:30:02.45101E	90.00000	270.03070	2.00000
test58	42:44:32.10000N	66:27:19.60000E	42:46:32.13452N	66:27:19.60000E	360.00000	180.00000	2.00000
test59	42:44:32.10000N	66:27:19.60000E	42:42:32.06478N	66:27:19.60000E	180.00000	0.00000	2.00000
test60	42:44:32.10000N	66:27:19.60000E	42:44:32.06784N	66:24:36.74899E	270.00000	89.96930	2.00000
test61	42:44:32.10000N	66:27:19.60000E	42:45:55.46641N	66:29:16.78884E	46.00000	226.02210	2.00000
test62	42:44:32.10000N	66:27:19.60000E	42:43:19.84058N	66:29:29.61668E	127.00000	307.02451	2.00000
test63	42:44:32.10000N	66:27:19.60000E	42:42:38.60108N	66:26:26.60774E	199.00000	18.99001	2.00000
test64	42:44:32.10000N	66:27:19.60000E	42:44:46.69688N	66:24:37.95230E	277.00000	96.96952	2.00000
test65	42:44:32.10000N	66:27:19.60000E	25:52:49.48262N	124:39:55.85184E	90.00000	305.21226	3000.00000
test66	42:44:32.10000N	66:27:19.60000E	87:25:13.54228N	113:32:40.40000W	360.00000	0.00000	3000.00000
test67	42:44:32.10000N	66:27:19.60000E	7:25:57.78702S	66:27:19.60000E	180.00000	0.00000	3000.00000
test68	42:44:32.10000N	66:27:19.60000E	25:52:49.48262N	8:14:43.34816E	270.00000	54.78774	3000.00000
test69	42:44:32.10000N	66:27:19.60000E	55:52:47.54426N	144:47:50.12500E	46.00000	289.76179	3000.00000
test70	42:44:32.10000N	66:27:19.60000E	5:30:44.95719N	104:18:35.77997E	127.00000	323.83257	3000.00000
test71	42:44:32.10000N	66:27:19.60000E	5:39:14.93608S	51:58:13.27568E	199.00000	13.92399	3000.00000
test72	42:44:32.10000N	66:27:19.60000E	30:21:08.45258N	4:52:35.40656E	277.00000	57.70460	3000.00000
test73	31:12:52.30000N	125:28:47.50000E	31:09:21.00038N	129:21:55.26637E	90.00000	272.01250	200.00000
test74	31:12:52.30000N	125:28:47.50000E	34:33:15.83037N	125:28:47.50000E	0.00000	180.00000	200.00000
test75	31:12:52.30000N	125:28:47.50000E	27:52:22.52362N	125:28:47.50000E	180.00000	360.00000	200.00000
test76	31:12:52.30000N	125:28:47.50000E	31:09:21.00038N	121:35:39.73363E	270.00000	87.98750	200.00000
test77	31:12:52.30000N	125:28:47.50000E	33:30:10.60726N	128:20:48.89100E	46.00000	227.53504	200.00000
test78	31:12:52.30000N	125:28:47.50000E	29:10:03.77133N	128:31:13.43437E	127.00000	308.52956	200.00000
test79	31:12:52.30000N	125:28:47.50000E	28:02:57.01708N	124:15:14.09016E	199.00000	18.39361	200.00000
test80	31:12:52.30000N	125:28:47.50000E	31:33:48.07660N	121:36:24.04854E	277.00000	94.98210	200.00000
test81	31:12:52.30000N	125:28:47.50000E	31:12:52.27886N	125:31:07.43524E	90.00000	270.02014	2.00000
test82	31:12:52.30000N	125:28:47.50000E	31:14:52.56685N	125:28:47.50000E	0.00000	180.00000	2.00000
test83	31:12:52.30000N	125:28:47.50000E	31:10:52.03253N	125:28:47.50000E	180.00000	360.00000	2.00000
test84	31:12:52.30000N	125:28:47.50000E	31:12:52.27886N	125:26:27.56476E	270.00000	89.97986	2.00000
test85	31:12:52.30000N	125:28:47.50000E	31:14:15.83349N	125:30:28.18558E	46.00000	226.01450	2.00000
test86	31:12:52.30000N	125:28:47.50000E	31:11:39.90782N	125:30:39.23361E	127.00000	307.01608	2.00000
test87	31:12:52.30000N	125:28:47.50000E	31:10:58.58265N	125:28:01.95668E	199.00000	18.99345	2.00000
test88	31:12:52.30000N	125:28:47.50000E	31:13:06.93605N	125:26:28.60187E	277.00000	96.98000	2.00000
test89	31:12:52.30000N	125:28:47.50000E	19:27:03.05786N	179:41:20.83695E	90.00000	294.84102	3000.00000
test90	31:12:52.30000N	125:28:47.50000E	81:07:29.93181N	125:28:47.50000E	0.00000	180.00000	3000.00000
test91	31:12:52.30000N	125:28:47.50000E	18:59:46.09922S	125:28:47.50000E	180.00000	360.00000	3000.00000
test92	31:12:52.30000N	125:28:47.50000E	19:27:03.05786N	71:16:14.16305E	270.00000	65.15898	3000.00000

test93	31:12:52.30000N	125:28:47.50000E	52:04:30.90569N	171:09:46.53647W	46.00000	271.27816	3000.00000
test94	31:12:52.30000N	125:28:47.50000E	3:37:54.96189S	163:12:50.99996E	127.00000	316.76433	3000.00000
test95	31:12:52.30000N	125:28:47.50000E	16:50:15.39672S	110:24:43.33889E	199.00000	16.92311	3000.00000
test96	31:12:52.30000N	125:28:47.50000E	24:24:11.81091N	69:01:02.24210E	277.00000	68.81857	3000.00000
test97	49:10:24.50000S	75:12:45.60000W	49:03:42.87631S	70:08:25.93407W	90.00000	266.16411	200.00000
test98	49:10:24.50000S	75:12:45.60000W	45:50:31.05302S	75:12:45.60000W	0.00000	180.00000	200.00000
test99	49:10:24.50000S	75:12:45.60000W	52:30:11.00366S	75:12:45.60000W	180.00000	0.00000	200.00000
test100	49:10:24.50000S	75:12:45.60000W	49:03:42.87631S	80:17:05.26593W	270.00000	93.83589	200.00000
test101	49:10:24.50000S	75:12:45.60000W	46:48:17.31010S	71:43:18.85029W	46.00000	223.40538	200.00000
test102	49:10:24.50000S	75:12:45.60000W	51:06:09.21946S	70:59:16.31551W	127.00000	303.75602	200.00000
test103	49:10:24.50000S	75:12:45.60000W	52:18:31.88478S	76:58:48.10816W	199.00000	20.36902	200.00000
test104	49:10:24.50000S	75:12:45.60000W	48:39:31.53843S	80:12:23.46911W	277.00000	100.76518	200.00000
test105	49:10:24.50000S	75:12:45.60000W	49:10:24.45978S	75:09:42.72995W	90.00000	269.96156	2.00000
test106	49:10:24.50000S	75:12:45.60000W	49:08:24.60011S	75:12:45.60000W	0.00000	180.00000	2.00000
test107	49:10:24.50000S	75:12:45.60000W	49:12:24.39920S	75:12:45.60000W	180.00000	0.00000	2.00000
test108	49:10:24.50000S	75:12:45.60000W	49:10:24.45978S	75:15:48.47005W	270.00000	90.03844	2.00000
test109	49:10:24.50000S	75:12:45.60000W	49:09:01.18981S	75:10:34.11555W	46.00000	225.97237	2.00000
test110	49:10:24.50000S	75:12:45.60000W	49:11:36.63156S	75:10:19.49448W	127.00000	306.96929	2.00000
test111	49:10:24.50000S	75:12:45.60000W	49:12:17.86267S	75:13:45.17447W	199.00000	19.01253	2.00000
test112	49:10:24.50000S	75:12:45.60000W	49:10:09.84830S	75:15:47.09213W	277.00000	97.03815	2.00000
test113	49:10:24.50000S	75:12:45.60000W	29:08:15.41939S	14:06:51.81153W	90.00000	228.53270	3000.00000
test114	49:10:24.50000S	75:12:45.60000W	0:58:06.24146N	75:12:45.60000W	0.00000	180.00000	3000.00000
test115	49:10:24.50000S	75:12:45.60000W	81:01:11.20478S	104:47:14.40000E	180.00000	180.00000	3000.00000
test116	49:10:24.50000S	75:12:45.60000W	29:08:15.41939S	136:18:39.38847W	270.00000	131.46730	3000.00000
test117	49:10:24.50000S	75:12:45.60000W	7:52:38.83544S	41:28:29.05694W	46.00000	208.40144	3000.00000
test118	49:10:24.50000S	75:12:45.60000W	52:04:51.42106S	7:52:24.35518E	127.00000	238.15368	3000.00000
test119	49:10:24.50000S	75:12:45.60000W	73:51:36.66725S	168:08:53.56896E	199.00000	130.11219	3000.00000
test120	49:10:24.50000S	75:12:45.60000W	25:11:20.18815S	132:13:38.05215W	277.00000	134.10803	3000.00000
test121	43:10:45.70000S	123:42:43.40000W	43:05:19.50216S	119:09:38.75232W	90.00000	266.88737	200.00000
test122	43:10:45.70000S	123:42:43.40000W	39:50:39.63379S	123:42:43.40000W	0.00000	180.00000	200.00000
test123	43:10:45.70000S	123:42:43.40000W	46:30:44.75296S	123:42:43.40000W	180.00000	0.00000	200.00000
test124	43:10:45.70000S	123:42:43.40000W	43:05:19.50216S	128:15:48.04768W	270.00000	93.11263	200.00000
test125	43:10:45.70000S	123:42:43.40000W	40:49:05.78329S	120:33:14.53881W	46.00000	223.88618	200.00000
test126	43:10:45.70000S	123:42:43.40000W	45:07:29.89631S	119:57:05.47191W	127.00000	304.37967	200.00000
test127	43:10:45.70000S	123:42:43.40000W	46:19:13.99376S	125:16:37.84869W	199.00000	20.10232	200.00000
test128	43:10:45.70000S	123:42:43.40000W	42:41:04.43281S	128:11:59.62018W	277.00000	100.05767	200.00000
test129	43:10:45.70000S	123:42:43.40000W	43:10:45.66735S	123:39:59.39209W	90.00000	269.96883	2.00000
test130	43:10:45.70000S	123:42:43.40000W	43:08:45.67398S	123:42:43.40000W	0.00000	180.00000	2.00000
test131	43:10:45.70000S	123:42:43.40000W	43:12:45.72532S	123:42:43.40000W	180.00000	0.00000	2.00000
test132	43:10:45.70000S	123:42:43.40000W	43:10:45.66735S	123:45:27.40791W	270.00000	90.03117	2.00000
test133	43:10:45.70000S	123:42:43.40000W	43:09:22.30610S	123:40:45.46715W	46.00000	225.97759	2.00000
test134	43:10:45.70000S	123:42:43.40000W	43:11:57.91229S	123:40:32.37455W	127.00000	306.97509	2.00000
test135	43:10:45.70000S	123:42:43.40000W	43:12:39.18273S	123:43:36.82325W	199.00000	19.01016	2.00000
test136	43:10:45.70000S	123:42:43.40000W	43:10:31.04038S	123:45:26.17463W	277.00000	97.03094	2.00000
test137	43:10:45.70000S	123:42:43.40000W	26:06:37.08296S	65:19:15.88930W	90.00000	234.37420	3000.00000
test138	43:10:45.70000S	123:42:43.40000W	6:59:37.06995N	123:42:43.40000W	0.00000	180.00000	3000.00000
test139	43:10:45.70000S	123:42:43.40000W	86:59:08.38590S	56:17:16.60000E	180.00000	180.00000	3000.00000
test140	43:10:45.70000S	123:42:43.40000W	26:06:37.08296S	177:53:49.08930E	270.00000	125.62580	3000.00000

test141	43:10:45.70000S	123:42:43.40000W	2:51:33.84923S	90:17:19.02340W	46.00000	211.73748	3000.00000
test142	43:10:45.70000S	123:42:43.40000W	50:58:42.47481S	48:01:25.22327W	127.00000	247.60161	3000.00000
test143	43:10:45.70000S	123:42:43.40000W	75:32:45.23169S	140:44:35.89858E	199.00000	108.26051	3000.00000
test144	43:10:45.70000S	123:42:43.40000W	21:49:17.43560S	178:34:03.34260W	277.00000	128.69292	3000.00000
test145	30:13:55.50000S	54:53:17.40000E	30:10:32.24599S	58:44:04.46955E	90.00000	268.06441	200.00000
test146	30:13:55.50000S	54:53:17.40000E	26:53:23.96278S	54:53:17.40000E	0.00000	180.00000	200.00000
test147	30:13:55.50000S	54:53:17.40000E	33:34:20.90547S	54:53:17.40000E	180.00000	360.00000	200.00000
test148	30:13:55.50000S	54:53:17.40000E	30:10:32.24599S	51:02:30.33045E	270.00000	91.93559	200.00000
test149	30:13:55.50000S	54:53:17.40000E	27:52:57.82170S	57:35:36.72392E	46.00000	224.68558	200.00000
test150	30:13:55.50000S	54:53:17.40000E	32:12:18.30198S	58:01:31.85506E	127.00000	305.37336	200.00000
test151	30:13:55.50000S	54:53:17.40000E	33:23:02.92727S	53:35:33.92865E	199.00000	19.68306	200.00000
test152	30:13:55.50000S	54:53:17.40000E	29:46:10.92312S	51:05:09.54001E	277.00000	98.90168	200.00000
test153	30:13:55.50000S	54:53:17.40000E	30:13:55.47966S	54:55:35.92341E	90.00000	269.98063	2.00000
test154	30:13:55.50000S	54:53:17.40000E	30:11:55.21431S	54:53:17.40000E	0.00000	180.00000	2.00000
test155	30:13:55.50000S	54:53:17.40000E	30:15:55.78508S	54:53:17.40000E	180.00000	360.00000	2.00000
test156	30:13:55.50000S	54:53:17.40000E	30:13:55.47966S	54:50:58.87659E	270.00000	90.01937	2.00000
test157	30:13:55.50000S	54:53:17.40000E	30:12:31.93209S	54:54:57.02201E	46.00000	225.98607	2.00000
test158	30:13:55.50000S	54:53:17.40000E	30:15:07.87646S	54:55:08.05224E	127.00000	306.98452	2.00000
test159	30:13:55.50000S	54:53:17.40000E	30:15:49.22963S	54:52:32.28676E	199.00000	19.00631	2.00000
test160	30:13:55.50000S	54:53:17.40000E	30:13:40.82086S	54:50:59.91478E	277.00000	97.01923	2.00000
test161	30:13:55.50000S	54:53:17.40000E	18:52:29.86498S	108:49:20.15190E	90.00000	246.00043	3000.00000
test162	30:13:55.50000S	54:53:17.40000E	19:58:48.22673N	54:53:17.40000E	0.00000	180.00000	3000.00000
test163	30:13:55.50000S	54:53:17.40000E	80:08:58.44983S	54:53:17.40000E	180.00000	0.00000	3000.00000
test164	30:13:55.50000S	54:53:17.40000E	18:52:29.86498S	0:57:14.64810E	270.00000	113.99957	3000.00000
test165	30:13:55.50000S	54:53:17.40000E	7:58:13.96628N	88:37:37.35172E	46.00000	218.90713	3000.00000
test166	30:13:55.50000S	54:53:17.40000E	46:16:23.75384S	116:51:12.92431E	127.00000	265.83428	3000.00000
test167	30:13:55.50000S	54:53:17.40000E	71:41:54.15847S	2:36:27.57861E	199.00000	63.35732	3000.00000
test168	30:13:55.50000S	54:53:17.40000E	14:01:56.87883S	3:23:24.56420E	277.00000	117.80900	3000.00000
test169	71:03:45.50000S	155:13:37.40000E	70:47:04.46404S	165:21:13.27121E	90.00000	260.42680	200.00000
test170	71:03:45.50000S	155:13:37.40000E	67:44:32.20108S	155:13:37.40000E	360.00000	180.00000	200.00000
test171	71:03:45.50000S	155:13:37.40000E	74:22:54.50904S	155:13:37.40000E	180.00000	360.00000	200.00000
test172	71:03:45.50000S	155:13:37.40000E	70:47:04.46404S	145:06:01.52879E	270.00000	99.57320	200.00000
test173	71:03:45.50000S	155:13:37.40000E	68:37:38.70618S	161:47:11.03268E	46.00000	219.84014	200.00000
test174	71:03:45.50000S	155:13:37.40000E	72:51:42.35787S	164:14:58.08728E	127.00000	298.41826	200.00000
test175	71:03:45.50000S	155:13:37.40000E	74:09:55.67082S	151:16:06.01068E	199.00000	22.77938	200.00000
test176	71:03:45.50000S	155:13:37.40000E	70:23:23.03906S	145:22:23.31016E	277.00000	106.30428	200.00000
test177	71:03:45.50000S	155:13:37.40000E	71:03:45.39916S	155:19:45.39068E	90.00000	269.90331	2.00000
test178	71:03:45.50000S	155:13:37.40000E	71:01:45.98931S	155:13:37.40000E	360.00000	180.00000	2.00000
test179	71:03:45.50000S	155:13:37.40000E	71:05:45.01026S	155:13:37.40000E	180.00000	0.00000	2.00000
test180	71:03:45.50000S	155:13:37.40000E	71:03:45.39916S	155:07:29.40932E	270.00000	90.09669	2.00000
test181	71:03:45.50000S	155:13:37.40000E	71:02:22.42883S	155:18:01.80054E	46.00000	225.93054	2.00000
test182	71:03:45.50000S	155:13:37.40000E	71:04:57.35874S	155:18:31.58931E	127.00000	306.92270	2.00000
test183	71:03:45.50000S	155:13:37.40000E	71:05:38.48847S	155:11:37.40237E	199.00000	19.03153	2.00000
test184	71:03:45.50000S	155:13:37.40000E	71:03:30.83602S	155:07:32.22736E	277.00000	97.09595	2.00000
test185	71:03:45.50000S	155:13:37.40000E	37:33:28.76348S	130:07:28.60879W	90.00000	204.21144	3000.00000
test186	71:03:45.50000S	155:13:37.40000E	21:04:35.11214S	155:13:37.40000E	360.00000	180.00000	3000.00000
test187	71:03:45.50000S	155:13:37.40000E	59:09:32.80147S	24:46:22.60000W	180.00000	180.00000	3000.00000
test188	71:03:45.50000S	155:13:37.40000E	37:33:28.76348S	80:34:43.40879E	270.00000	155.78856	3000.00000

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test189	71:03:45.50000S	155:13:37.40000E	25:50:57.88581S	167:05:40.45264W	46.00000	195.07128	3000.00000
test190	71:03:45.50000S	155:13:37.40000E	49:25:34.58238S	94:31:25.79851W	127.00000	203.51009	3000.00000
test191	71:03:45.50000S	155:13:37.40000E	57:40:40.95961S	2:56:35.65351E	199.00000	168.59567	3000.00000
test192	71:03:45.50000S	155:13:37.40000E	35:23:25.31483S	86:40:04.05968E	277.00000	156.67990	3000.00000

WGS84PtsOnGeodesic Test Results

Test Identifier	Geodesic Start Point Latitude	Geodesic Start Point Longitude	Geodesic End Point Latitude	Geodesic End Point Longitude	Test Point Latitude	Test Point Longitude	Length Code	Result
test1	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	41:32:28.56417N	68:47:19.47018W	0	1
test2	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	42:04:35.80000N	68:12:34.70000W	0	1
test3	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	41:47:53.25338N	68:30:44.96922W	0	1
test4	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	41:26:00.91053N	68:54:13.28237W	0	1
test5	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	41:09:22.65915N	69:11:50.60000W	0	1
test6	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	0	1
test7	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	0	1
test8	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:09:22.65915N	69:11:50.60000W	0	1
test9	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	40:10:24.50000N	70:12:45.60000W	0	1
test10	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	38:47:17.80000N	69:11:50.60000W	0	0
test11	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	39:35:17.80000N	69:11:50.60000W	0	0
test12	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	44:47:17.80000N	69:11:50.60000W	0	0
test13	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	41:47:17.80000N	68:11:50.60000E	0	0
test14	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	42:04:35.80000N	70:12:34.70000E	0	1
test15	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	41:47:18.13124N	69:53:49.92815E	0	1
test16	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:29:59.59453N	68:32:40.35274E	0	1
test17	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:29:10.95567N	68:31:50.60000E	0	1
test18	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	0	1
test19	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	40:43:56.24806N	68:47:00.28971E	0	1
test20	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:07:48.28268N	69:11:50.60000E	0	1
test21	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	40:10:24.50000N	68:12:45.60000E	0	1
test22	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	40:27:32.30453N	68:30:09.76991E	0	1
test23	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	38:47:17.80000N	72:11:50.60000E	0	0
test24	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	43:47:17.80000N	72:11:50.60000E	0	0
test25	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	40:12:17.80000S	69:11:50.60000W	0	0
test26	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	39:55:35.80000S	68:12:34.70000W	0	1
test27	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	40:12:53.41991S	68:30:06.40714W	0	1
test28	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	40:34:15.03903S	68:52:01.67681W	0	1
test29	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	40:53:18.36384S	69:11:50.60000W	0	1
test30	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	0	1
test31	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	41:50:24.50000S	70:12:45.60000W	0	1
test32	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:53:18.36384S	69:11:50.60000W	0	1
test33	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	41:50:24.50000S	70:12:45.60000W	0	1
test34	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	42:12:17.80000S	69:11:50.60000W	0	0
test35	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	38:12:17.80000S	69:11:50.60000W	0	0
test36	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	43:12:17.80000S	69:11:50.60000W	0	0
test37	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	40:12:17.80000S	68:11:50.60000E	0	0
test38	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	39:55:35.80000S	70:12:34.70000E	0	1
test39	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	40:13:19.06538S	69:54:40.06070E	0	1
test40	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	40:11:49.41238S	69:56:11.14294E	0	1

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test41	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	40:54:53.06605S	69:11:50.60000E	0	1
test42	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	0	1
test43	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	0	1
test44	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	41:47:33.72993S	68:15:50.60000E	0	1
test45	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	41:50:24.50000S	68:12:45.60000E	0	1
test46	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	43:29:17.80000S	69:11:50.60000E	0	0
test47	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	38:29:17.80000S	69:11:50.60000E	0	0
test48	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	41:49:17.80000S	69:11:50.60000E	0	0

WGS84PtsOnArc Test Results

Test Identifier	Arc Center Latitude	Arc Center Longitude	Arc Radius	Arc Start Azimuth	Arc End Azimuth	Arc Direction	Test Point Latitude	Test Point Longitude	Result
test1	40:10:24.50000N	70:12:45.60000W	100.0	90.0	100.0	-1	39:55:12.84696N	68:04:03.03796W	1
test2	40:10:24.50000N	70:12:45.60000W	100.0	100.0	90.0	1	40:04:24.98785N	68:02:37.73455W	1
test3	40:10:24.50000N	70:12:45.60000W	100.0	100.0	90.0	1	40:27:01.27947N	68:03:50.83114W	0
test4	40:10:24.50000N	70:12:45.60000W	100.0	20.0	120.0	-1	39:39:01.64315N	68:09:21.02760W	1
test5	40:10:24.50000N	70:12:45.60000W	100.0	355.0	10.0	-1	41:50:27.82240N	70:11:34.70000W	1
test6	40:10:24.50000N	70:12:45.60000W	100.0	15.0	350.0	1	41:50:27.82240N	70:11:34.70000W	1
test7	40:10:24.50000N	70:12:45.60000W	100.0	15.0	350.0	-1	41:50:27.82240N	70:11:34.70000W	0
test8	40:10:24.50000N	70:12:45.60000W	100.0	250.0	300.0	-1	40:22:32.07141N	72:22:27.11102W	1
test9	40:10:24.50000N	70:12:45.60000W	100.0	330.0	200.0	1	41:12:48.70166N	71:55:32.15119W	1
test10	40:10:24.50000N	70:12:45.60000W	100.0	200.0	230.0	-1	38:51:33.35407N	68:53:10.34405W	0
test11	40:10:24.50000N	70:12:45.60000E	100.0	90.0	100.0	-1	39:57:28.59246N	72:21:55.36432E	1
test12	40:10:24.50000N	70:12:45.60000E	100.0	100.0	90.0	1	40:04:25.10140N	72:22:53.47612E	1
test13	40:10:24.50000N	70:12:45.60000E	100.0	100.0	90.0	1	40:26:53.80980N	72:21:41.88661E	0
test14	40:10:24.50000N	70:12:45.60000E	100.0	20.0	120.0	-1	39:39:10.70047N	72:16:14.18085E	1
test15	40:10:24.50000N	70:12:45.60000E	100.0	355.0	10.0	-1	41:50:27.82240N	70:11:34.70000E	1
test16	40:10:24.50000N	70:12:45.60000E	100.0	15.0	350.0	1	41:50:27.82240N	70:11:34.70000E	1
test17	40:10:24.50000N	70:12:45.60000E	100.0	15.0	350.0	-1	41:50:27.82240N	70:11:34.70000E	0
test18	40:10:24.50000N	70:12:45.60000E	100.0	250.0	300.0	-1	40:22:28.60052N	68:03:03.59248E	1
test19	40:10:24.50000N	70:12:45.60000E	100.0	330.0	200.0	1	41:13:31.30530N	68:30:43.58125E	1
test20	40:10:24.50000N	70:12:45.60000E	100.0	200.0	230.0	-1	39:05:41.34977N	71:51:29.95766E	0
test21	40:10:24.50000S	70:12:45.60000E	100.0	90.0	100.0	-1	40:12:40.39213S	72:23:13.39076E	1
test22	40:10:24.50000S	70:12:45.60000E	100.0	100.0	90.0	1	40:04:25.10140S	72:22:53.47612E	0
test23	40:10:24.50000S	70:12:45.60000E	100.0	100.0	90.0	1	39:39:10.70047S	72:16:14.18085E	0
test24	40:10:24.50000S	70:12:45.60000E	100.0	20.0	120.0	-1	40:26:53.80980S	72:21:41.88661E	1
test25	40:10:24.50000S	70:12:45.60000E	100.0	355.0	10.0	-1	38:30:19.45513S	70:11:34.70000E	1
test26	40:10:24.50000S	70:12:45.60000E	100.0	15.0	350.0	1	38:30:19.45513S	70:11:34.70000E	1
test27	40:10:24.50000S	70:12:45.60000E	100.0	15.0	350.0	-1	38:30:19.45513S	70:11:34.70000E	0
test28	40:10:24.50000S	70:12:45.60000E	100.0	250.0	300.0	-1	40:23:20.88344S	68:03:11.35606E	1
test29	40:10:24.50000S	70:12:45.60000E	100.0	330.0	200.0	1	39:47:33.58163S	68:06:05.87892E	1
test30	40:10:24.50000S	70:12:45.60000E	100.0	200.0	230.0	-1	41:45:30.73148S	70:53:47.69121E	0
test31	40:10:24.50000S	70:12:45.60000W	100.0	90.0	100.0	-1	40:12:32.98018S	68:02:17.71481W	1
test32	40:10:24.50000S	70:12:45.60000W	100.0	100.0	90.0	1	40:04:11.30750S	68:02:39.04105W	0
test33	40:10:24.50000S	70:12:45.60000W	100.0	100.0	90.0	1	39:23:12.36192S	68:18:22.61369W	0
test34	40:10:24.50000S	70:12:45.60000W	100.0	20.0	120.0	-1	40:39:21.80200S	68:07:26.05449W	1
test35	40:10:24.50000S	70:12:45.60000W	100.0	355.0	10.0	-1	38:30:19.45513S	70:11:34.70000W	1
test36	40:10:24.50000S	70:12:45.60000W	100.0	15.0	350.0	1	38:30:19.45513S	70:11:34.70000W	1
test37	40:10:24.50000S	70:12:45.60000W	100.0	15.0	350.0	-1	38:30:19.45513S	70:11:34.70000W	0
test38	40:10:24.50000S	70:12:45.60000W	100.0	250.0	300.0	-1	40:23:44.12558S	72:22:16.19656W	1
test39	40:10:24.50000S	70:12:45.60000W	100.0	330.0	200.0	1	39:54:28.73386S	72:21:18.43758W	1
test40	40:10:24.50000S	70:12:45.60000W	100.0	200.0	230.0	-1	41:29:48.15752S	68:52:34.09229W	0

WGS84PtsOnLocus Test Results

Test Identifier	Geodesic Start Latitude	Geodesic Start Longitude	Geodesic End Latitude	Geodesic End Longitude	Locus Start Latitude	Locus Start Longitude	Locus End Latitude	Locus End Longitude	Locus Start Distance (nm)	Locus End Distance (mm)	Test Point Latitude	Test Point Longitude	Result
test1	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:55:05.0078 2N	70:51:34.00000 W	42:55:01.7725 9N	70:24:20.8836 8N	-0.5	-0.5	42:55:05.0017 5N	70:50:23.28330 W	1
test2	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:55:05.0078 2N	70:51:34.00000 W	42:55:01.7725 9N	70:24:20.8836 8N	-0.5	-0.5	42:55:05.0077 1N	70:51:24.71201 W	1
test3	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:55:35.0155 9N	70:51:34.00000 W	42:55:31.7799 3N	70:24:20.6635 6N	-1.0	-1.0	42:55:35.0077 6N	70:50:13.66761 W	1
test4	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:52:34.9683 0N	70:51:34.00000 W	42:52:19.7321 9N	70:24:22.0712 7N	2.0	2.2	42:52:34.0141 3N	70:49:26.93090 W	1
test5	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:57:35.0462 4N	70:51:34.00000 W	42:53:31.7503 1N	70:24:21.5436 7N	-3.0	1.0	42:56:58.6919 6N	70:47:27.05896 W	1
test6	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:50:34.9359 0N	70:51:34.00000 W	42:50:31.7045 5N	70:24:22.8620 5N	4.0	4.0	42:50:34.8184 3N	70:46:22.99515 W	1
test7	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:59:35.0761 8N	70:51:34.00000 W	42:59:01.8300 8N	70:24:19.1210 9N	-5.0	-4.5	42:59:28.7760 9N	70:45:58.16124 W	1
test8	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:48:34.9027 9N	70:51:34.00000 W	42:48:07.6668 0N	70:24:23.9152 2N	6.0	6.4	42:48:27.5379 7N	70:43:32.97138 W	1
test9	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	43:01:35.1054 3N	70:51:34.00000 W	43:01:31.8645 9N	70:24:18.0175 4N	-7.0	-7.0	43:01:34.9363 5N	70:45:20.32134 W	1
test10	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:46:34.8689 9N	70:51:34.00000 W	42:53:31.7503 1N	70:24:21.5436 7N	8.0	1.0	42:48:36.3742 8N	70:43:41.44040 W	1
test11	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:55:05.0078 2N	70:51:34.00000 W	42:55:01.7725 9N	70:24:20.8836 8N	-0.5	-0.5	42:53:60.0000 0N	70:50:23.28330 W	0
test12	42:54:35.0000 0N	70:51:34.00000 W	42:54:31.7652 1N	70:24:21.10373 W	42:46:34.8689 9N	70:51:34.00000 W	42:46:31.6410 8N	70:24:24.6165 8N	8.0	8.0	42:42:00.0000 0N	70:43:42.62942 W	0
test13	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:54:04.9921 4S	70:51:34.00000 W	42:54:01.7577 8S	70:24:21.3237 3S	-0.5	-0.5	42:54:04.9860 8S	70:50:23.30236 W	1
test14	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:54:04.9921 4S	70:51:34.00000 W	42:54:01.7577 8S	70:24:21.3237 3S	-0.5	-0.5	42:54:04.9920 4S	70:51:24.70232 W	1
test15	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:55:35.0155 9S	70:51:34.00000 W	42:55:31.7799 3S	70:24:20.6635 6S	1.0	1.0	42:55:35.0077 6S	70:50:13.66761 W	1
test16	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:52:34.9683 0S	70:51:34.00000 W	42:52:19.7321 9S	70:24:22.0712 7S	-2.0	-2.2	42:52:34.0141 3S	70:49:26.93090 W	1
test17	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:57:35.0462 4S	70:51:34.00000 W	42:53:31.7503 1S	70:24:21.5436 7S	3.0	-1.0	42:56:58.6919 6S	70:47:27.05896 W	1
test18	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:50:34.9359 0S	70:51:34.00000 W	42:50:31.7045 5S	70:24:22.8620 5S	-4.0	-4.0	42:50:34.8184 3S	70:46:22.99515 W	1
test19	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:59:35.0761 8S	70:51:34.00000 W	42:59:01.8300 8S	70:24:19.1210 9S	5.0	4.5	42:59:28.7760 9S	70:45:58.16124 W	1
test20	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:48:34.9027 9S	70:51:34.00000 W	42:48:07.6668 0S	70:24:23.9152 2S	-6.0	-6.4	42:48:27.5379 7S	70:43:32.97138 W	1
test21	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	43:01:35.1054 3S	70:51:34.00000 W	43:01:31.8645 9S	70:24:18.0175 4S	7.0	7.0	43:01:34.9363 5S	70:45:20.32134 W	1
test22	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:46:34.8689 9S	70:51:34.00000 W	42:53:31.7503 1S	70:24:21.5436 7S	-8.0	-1.0	42:48:36.3742 8S	70:43:41.44040 W	1

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test23	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:54:04.9921 4S	70:51:34.00000 W	42:54:01.7577 8S	70:24:21.3237 3S	-0.5	-0.5	42:53:60.0000 0S	70:50:23.30236 W	0
test24	42:54:35.0000 0S	70:51:34.00000 W	42:54:31.7652 1S	70:24:21.10373 W	42:46:34.8689 9S	70:51:34.00000 W	42:46:31.6410 8S	70:24:24.6165 8S	-8.0	-8.0	42:42:00.0000 0S	70:43:42.62942 W	0

WGS84LocusCrsAtPoint Test Results

Test Identifier	Input	Geodesic Start Latitude	Geodesic Start Longitude	Geodesic End Latitude	Geodesic End Longitude	Locus Start Latitude	Locus Start Longitude	Locus End Latitude	Locus End Longitude	Locus Start Distance (nm)	Locus End Distance (nm)	Test Point Latitude	Test Point Longitude
	Output	Geodesic Point Latitude	Geodesic Point Longitude	Locus Azimuth at Test Point (degrees)	Azimuth from Test Point to Geodesic Point (degrees)								
Test1	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.0000W	42:55:01.77259N	70:24:20.88368N	-0.5	-0.5	42:55:05.00175N	70:50:23.28330W
	Output	42:54:34.99393N	70:50:23.29283W	180.01337	90.01337								
Test2	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.0000W	42:55:01.77259N	70:24:20.88368N	-0.5	-0.5	42:55:05.00771N	70:51:24.71201W
	Output	42:54:34.9990N	70:51:24.71327W	180.00176	90.00176								
Test3	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:55:35.01559N	70:51:34.0000W	42:55:31.77993N	70:24:20.66356N	-1.0	-1.0	42:55:35.00776N	70:50:13.66761W
	Output	42:54:34.99218N	70:50:13.68926W	180.01519	90.01519								
Test4	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:52:34.96830N	70:51:34.0000W	42:52:19.73219N	70:24:22.07127N	2.0	2.2	42:52:34.01413N	70:49:26.93090W
	Output	42:54:34.98039N	70:49:26.86188W	0.59697	90.59697								
Test5	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:57:35.04624N	70:51:34.0000W	42:53:31.75031N	70:24:21.54367N	-3.0	1.0	42:56:58.69196N	70:47:27.05896W
	Output	42:54:34.92612N	70:47:27.21838W	191.35663	101.35663								
Test6	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:50:34.93590N	70:51:34.0000W	42:50:31.70455N	70:24:22.86205N	4.0	4.0	42:50:34.81843N	70:46:22.99515W
	Output	42:54:34.88240N	70:46:22.65989W	0.05882	90.05882								
Test7	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:59:35.07618N	70:51:34.0000W	42:59:01.83008N	70:24:19.12109N	-5.0	-4.5	42:59:28.77609N	70:45:58.16124W
	Output	42:54:34.86353N	70:45:58.60448W	181.49561	91.49561								
Test8	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	42:48:34.90279N	70:51:34.0000W	42:48:07.66680N	70:24:23.91522N	6.0	6.4	42:48:27.53797N	70:43:32.97138W
	Output	42:54:34.71836N	70:43:32.17826W	1.23674	91.23674								
test9	Input	42:54:35.0000N	70:51:34.0000W	42:54:31.76521N	70:24:21.10373W	43:01:35.10543N	70:51:34.0000W	43:01:31.86459N	70:24:18.01754N	-7.0	-7.0	43:01:34.93635N	70:45:20.32134W
	Output	42:54:34.83124N	70:45:21.02628W	180.07067	90.07067								

Test10	Input	42:54:35.00 000N	70:51:34.000 00W	42:54:31.76 521N	70:24:21.103 73W	42:46:34.86 899N	70:51:34.000 00W	42:53:31.75 031N	70:24:21.54 367N	8.0	1.0	42:48:36.37 428N	70:43:41.440 40W
	Output	42:54:34.72 821N	70:43:40.679 98W	-19.20067	70.79933								
Test11	Input	42:54:35.00 000N	70:51:34.000 00W	42:54:31.76 521N	70:24:21.103 73W	42:55:05.00 782N	70:51:34.000 00W	42:55:01.77 259N	70:24:20.88 368N	-0.5	-0.5	42:55:05.00 175N	70:50:23.283 30W
	Output	42:54:34.99 393N	70:50:23.292 83W	180.01337	90.01337								
Test12	Input	42:54:35.00 000N	70:51:34.000 00W	42:54:31.76 521N	70:24:21.103 73W	42:46:34.86 899N	70:51:34.000 00W	42:46:31.64 108N	70:24:24.61 658N	8.0	8.0	42:46:34.59 884N	70:43:42.629 42W
	Output	42:54:34.72 928N	70:43:41.613 15W	0.08915	90.08915								
Test13	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:54:04.99 214S	70:51:34.000 00W	42:54:01.75 778S	70:24:21.32 373S	-0.5	-0.5	42:54:04.98 608S	70:50:23.302 36W
	Output	42:54:34.99 393S	70:50:23.292 83W	179.98663	89.98663								
Test14	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:54:04.99 214S	70:51:34.000 00W	42:54:01.75 778S	70:24:21.32 373S	-0.5	-0.5	42:54:04.99 204S	70:51:24.702 32W
	Output	42:54:34.99 990S	70:51:24.701 07W	179.99824	89.99824								
Test15	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:55:35.01 559S	70:51:34.000 00W	42:55:31.77 993S	70:24:20.66 356S	1.0	1.0	42:55:35.00 776S	70:50:13.667 61W
	Output	42:54:34.99 218S	70:50:13.689 26W	359.98481	89.98481								
Test16	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:52:34.96 830S	70:51:34.000 00W	42:52:19.73 219S	70:24:22.07 127S	-2.0	-2.2	42:52:34.01 413S	70:49:26.930 90W
	Output	42:54:34.98 039S	70:49:26.861 88W	179.40303	89.40303								
Test17	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:57:35.04 624S	70:51:34.000 00W	42:53:31.75 031S	70:24:21.54 367S	3.0	-1.0	42:56:58.69 196S	70:47:27.058 96W
	Output	42:54:34.92 612S	70:47:27.218 38W	348.64337	78.64337								
Test18	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:50:34.93 590S	70:51:34.000 00W	42:50:31.70 455S	70:24:22.86 205S	-4.0	-4.0	42:50:34.81 843S	70:46:22.995 15W
	Output	42:54:34.88 240S	70:46:22.659 89W	179.94118	89.94118								
Test19	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:59:35.07 618S	70:51:34.000 00W	42:59:01.83 008S	70:24:19.12 109S	5.0	4.5	42:59:28.77 609S	70:45:58.161 24W
	Output	42:54:34.86 353S	70:45:58.604 48W	358.50439	88.50439								
Test20	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:48:34.90 279S	70:51:34.000 00W	42:48:07.66 680S	70:24:23.91 522S	-6.0	-6.4	42:48:27.53 797S	70:43:32.971 38W
	Output	42:54:34.71 836S	70:43:32.178 26W	178.76326	88.76326								
Test21	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	43:01:35.10 543S	70:51:34.000 00W	43:01:31.86 459S	70:24:18.01 754S	7.0	7.0	43:01:34.93 635S	70:45:20.321 34W
	Output	42:54:34.83 124S	70:45:21.026 28W	359.92933	89.92933								
Test22	Input	42:54:35.00	70:51:34.000	42:54:31.76	70:24:21.103	42:46:34.86	70:51:34.000	42:53:31.75	70:24:21.54	-8.0	-1.0	42:48:36.37	70:43:41.440

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	t	000S	00W	521S	73W	899S	00W	031S	367S			428S	40W
	Output	42:54:34.72 821S	70:43:40.679 98W	199.20067	109.20067								
Test23	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:54:04.99 214S	70:51:34.000 00W	42:54:01.75 778S	70:24:21.32 373S	-0.5	-0.5	42:54:04.98 608S	70:50:23.302 36W
	Output	42:54:34.99 393S	70:50:23.292 83W	179.98663	89.98663								
Test24	Input	42:54:35.00 000S	70:51:34.000 00W	42:54:31.76 521S	70:24:21.103 73W	42:46:34.86 899S	70:51:34.000 00W	42:46:31.64 108S	70:24:24.61 658S	-8.0	-8.0	42:46:34.59 884S	70:43:42.629 42W
	Output	42:54:34.72 928S	70:43:41.613 15W	179.91085	89.91085								

WGS84DiscretizedArcLength Test Results

Test Identifier	Arc Center Latitude	Arc Center Longitude	Arc Radius	Start Azimuth	End Azimuth	Direction	Computed Arc Length (Algorithm 0) (nm)	Direct Computation Result (Section 6.4) (nm)	Difference (meters)
test1	38:13:25.10000N	77:54:23.40000W	5.0	91.0	226.0	-1	11.780968	11.780968	1.60e-007
test2	38:13:25.10000N	77:54:23.40000W	5.0	91.0	226.0	1	19.634947	19.634947	2.60e-008
test3	38:13:25.10000N	77:54:23.40000W	5.0	0.0	0.0	1	31.415915	31.415915	2.17e-007
test4	38:13:25.10000N	77:54:23.40000W	50.0	0.0	0.0	1	314.148211	314.148211	2.83e-006
test5	38:13:25.10000N	77:54:23.40000W	100.0	0.0	0.0	1	628.230102	628.230102	4.62e-005
test6	38:13:25.10000N	77:54:23.40000W	150.0	0.0	0.0	1	942.179365	942.179365	3.33e-004
test7	38:13:25.10000N	77:54:23.40000W	200.0	0.0	0.0	1	1255.929721	1255.929722	1.39e-003
test8	38:13:25.10000N	77:54:23.40000W	250.0	0.0	0.0	1	1569.414934	1569.414936	4.23e-003
test9	38:13:25.10000N	77:54:23.40000W	300.0	0.0	0.0	1	1882.568820	1882.568826	1.05e-002
test10	38:13:25.10000N	77:54:23.40000W	350.0	0.0	0.0	1	2195.325269	2195.325282	2.27e-002
test11	38:13:25.10000N	77:54:23.40000W	400.0	0.0	0.0	1	2507.618252	2507.618275	4.42e-002
test12	38:13:25.10000N	77:54:23.40000W	450.0	0.0	0.0	1	2819.381836	2819.381879	7.95e-002
test13	38:13:25.10000N	77:54:23.40000W	500.0	0.0	0.0	1	3130.550201	3130.550274	1.34e-001
test14	30:34:17.18000N	105:40:50.70000W	4.0	30.0	340.0	1	3.490658	3.490658	1.27e-008
test15	30:34:17.18000N	105:40:50.70000W	4.0	30.0	340.0	-1	21.642078	21.642078	7.24e-008
test16	30:34:17.18000N	105:40:50.70000W	4.0	0.0	0.0	1	25.132736	25.132736	7.62e-008
test17	30:34:17.18000N	105:40:50.70000W	4.0	0.0	0.0	-1	25.132736	25.132736	7.63e-008
test18	30:34:17.18000N	105:40:50.70000E	4.0	30.0	340.0	1	3.490658	3.490658	1.23e-008
test19	30:34:17.18000N	105:40:50.70000E	4.0	30.0	340.0	-1	21.642078	21.642078	7.28e-008
test20	30:34:17.18000N	105:40:50.70000E	4.0	0.0	0.0	1	25.132736	25.132736	7.63e-008
test21	30:34:17.18000N	105:40:50.70000E	4.0	0.0	0.0	-1	25.132736	25.132736	7.62e-008
test22	30:34:17.18000S	105:40:50.70000E	4.0	30.0	340.0	1	3.490658	3.490658	2.65e-008
test23	30:34:17.18000S	105:40:50.70000E	4.0	30.0	340.0	-1	21.642078	21.642078	7.89e-008
test24	30:34:17.18000S	105:40:50.70000E	4.0	0.0	0.0	1	25.132736	25.132736	7.62e-008
test25	30:34:17.18000S	105:40:50.70000E	4.0	0.0	0.0	-1	25.132736	25.132736	7.62e-008
test26	30:34:17.18000S	105:40:50.70000W	4.0	30.0	340.0	1	3.490658	3.490658	2.65e-008
test27	30:34:17.18000S	105:40:50.70000W	4.0	30.0	340.0	-1	21.642078	21.642078	7.89e-008
test28	30:34:17.18000S	105:40:50.70000W	4.0	0.0	0.0	1	25.132736	25.132736	7.62e-008
test29	30:34:17.18000S	105:40:50.70000W	4.0	0.0	0.0	-1	25.132736	25.132736	7.62e-008
test30	30:34:17.18000N	105:40:50.70000W	40.0	30.0	340.0	1	34.905798	34.905798	9.65e-005
test31	30:34:17.18000N	105:40:50.70000W	40.0	30.0	340.0	-1	216.415945	216.415946	9.71e-005
test32	30:34:17.18000N	105:40:50.70000W	40.0	0.0	0.0	1	251.321743	251.321743	5.82e-007
test33	30:34:17.18000N	105:40:50.70000W	40.0	0.0	0.0	-1	251.321743	251.321743	5.82e-007
test34	00:04:00.00000N	90:33:72.0000W	11.1	136.0	380.0	1	22.472820	22.472820	7.34e-008
test35	00:04:00.00000N	90:33:72.0000W	11.1	136.0	380.0	-1	47.270415	47.270415	3.17e-007
test36	00:04:00.00000N	90:33:72.0000W	11.1	0.0	0.0	1	69.743235	69.743235	4.14e-007
test37	00:04:00.00000N	90:33:72.0000W	11.1	136.0	20.0	1	22.472820	22.472820	7.34e-008
test38	00:04:00.00000N	90:33:72.0000W	11.1	136.0	20.0	-1	47.270415	47.270415	3.17e-007
test39	00:04:00.00000N	90:33:72.0000W	11.1	0.0	0.0	1	69.743235	69.743235	4.14e-007
test40	80:00:00.00000N	90:33:72.0000W	11.1	136.0	20.0	1	22.472821	22.472821	2.25e-007
test41	80:00:00.00000N	90:33:72.0000W	11.1	136.0	20.0	-1	47.270416	47.270416	7.27e-007
test42	80:00:00.00000N	90:33:72.0000W	11.1	0.0	0.0	1	69.743237	69.743237	9.51e-007

WGS84CrsIntersect Test Results

Test Identifier	Point 1 Latitude	Point 1 Longitude	Point 2 Latitude	Point 2 Longitude	Azimuth at Point 2 (degrees)	Azimuth from Intersection to Point 1 (degrees)	Distance to Point 1 from Intersection (nm)	Azimuth at Point 2 (degrees)	Azimuth from Intersection to Point 2 (degrees)	Distance to Point 2 from Intersection (nm)	Intersection Latitude	Intersection Longitude
test1	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	90.0	271.09328	77.96062	187.0	6.79842	115.70425	40:09:39.8358 8N	68:31:04.02698 W
test2	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	90.0	273.49211	249.49410	127.0	309.24501	197.11484	40:02:47.6253 9N	64:47:40.82715 W
test3	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	180.0	0.00000	2400.88568	183.0	2.22965	2517.34979	0:01:16.52501 N	70:12:45.60000 W
test4	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	175.0	355.32391	298.99250	190.0	9.07914	417.80313	35:12:07.9008 0N	69:41:00.06384 W
test5	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	175.0	173.09453	979.39618	170.0	166.54243	877.94705	56:24:04.1050 2N	72:44:22.05038 W
test6	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	170.0	352.06299	1472.94791	175.0	356.13925	1574.29532	15:50:52.8475 8N	65:55:13.50649 W
test7	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	140.0	321.55556	182.84945	175.0	355.30205	256.71971	37:48:35.7038 7N	67:44:28.20017 W
test8	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	35.0	216.45257	170.25572	200.0	200.13304	25.67248	42:28:43.1818 6N	68:00:48.75631 W
test9	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	35.0	215.81864	98.37315	225.0	44.50036	47.79193	41:30:38.3729 1N	68:57:39.59637 W
test10	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	40.0	221.23764	131.59286	200.0	19.92283	15.13463	41:50:21.9114 3N	68:19:36.20912 W
test11	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	40.0	221.33298	141.28719	170.0	350.01830	7.04762	41:57:39.1815 7N	68:11:02.27771 W
test12	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	190.0	9.32285	315.31940	200.0	18.05830	449.41589	34:59:10.9227 0N	71:19:18.57958 W
test13	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	230.0	232.66774	233.26393	250.0	251.36850	95.79181	42:36:17.8566 5N	66:10:46.71710 W
test14	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	300.0	117.24240	217.12520	270.0	85.84998	277.49771	41:54:31.9685 6N	74:24:39.29939 W
test15	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	320.0	135.96039	394.31108	300.0	114.50787	390.41454	45:03:45.8575 4N	76:10:13.00551 W
test16	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	30.0	211.06420	143.97676	300.0	119.74072	19.87930	42:14:30.0763 0N	68:35:51.38889 W
test17	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	30.0	211.32507	177.09156	0.0	180.00000	38.22767	42:42:50.2660 2N	68:12:40.70000 W
test18	40:10:24.5000 0N	70:12:45.60000 W	42:04:35.8000 0N	68:12:40.70000 W	20.0	202.00674	361.27463	10.0	190.65118	226.90835	45:47:51.2680 0N	67:16:23.97908 W
test19	40:10:24.5000 0S	70:12:45.60000 W	38:04:35.8000 0S	68:12:40.70000 W	90.0	268.92420	76.71333	187.0	7.21051	125.94256	40:09:41.2534 3S	68:32:41.62303 W
test20	40:10:24.5000 0S	70:12:45.60000 W	38:04:35.8000 0S	68:12:40.70000 W	90.0	266.46490	252.57903	127.0	304.80422	200.97896	40:02:36.2730 6S	64:43:40.26353 W
test21	40:10:24.5000	70:12:45.60000	38:04:35.8000	68:12:40.70000	180.0	0.00000	1101.097	183.0	4.51831	1229.277	58:30:33.9088	70:12:45.60000

	OS	W	OS	W			25			14	3S	W
test22	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	175.0	354.6684 0	244.3791 2	190.0	10.99389	375.3399 1	44:13:53.4208 OS	69:43:09.64545 W
test23	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	175.0	176.0715 0	1613.099 44	170.0	171.9168 5	1500.622 55	13:17:28.7861 3S	72:31:44.37321 W
test24	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	170.0	346.5975 7	915.3811 8	175.0	353.1172 0	1027.966 38	55:06:51.9932 3S	65:38:55.06563 W
test25	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	140.0	318.3463 2	173.4655 1	175.0	354.6736 1	258.0259 7	42:21:45.9161 9S	67:42:22.30757 W
test26	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	35.0	213.6247 4	181.7958 0	200.0	199.8852 0	26.04680	37:40:05.0377 1S	68:01:27.49821 W
test27	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	35.0	214.0330 0	125.4253 2	225.0	45.29430	31.67886	38:26:57.8047 3S	68:41:11.55669 W
test28	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	40.0	218.8389 1	134.4067 5	200.0	20.10452	23.26402	38:26:28.4278 8S	68:22:48.33817 W
test29	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	40.0	218.7115 5	149.8818 4	170.0	349.9774 4	9.94061	38:14:23.7925 3S	68:10:29.24046 W
test30	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	190.0	10.58888	220.3768 9	200.0	21.89034	366.6713 0	43:47:20.0839 7S	71:05:33.40366 W
test31	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	230.0	227.5691 6	241.3832 4	250.0	248.8525 0	95.09771	37:31:08.1738 1S	66:20:20.79110 W
test32	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	300.0	123.0199 6	262.8714 0	270.0	94.18427	322.4826 2	37:52:47.6582 0S	75:00:21.64521 W
test33	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	320.0	143.7337 6	481.8931 0	300.0	124.8185 5	472.5686 9	33:50:26.3510 1S	76:24:08.89427 W
test34	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	30.0	208.9666 1	155.7949 4	300.0	120.2223 3	19.80226	37:54:39.0707 1S	68:34:20.89766 W
test35	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	30.0	208.7459 9	191.4541 0	0.0	180.0000 0	41.16601	37:23:22.9781 6S	68:12:40.70000 W
test36	40:10:24.5000 OS	70:12:45.60000 W	38:04:35.8000 OS	68:12:40.70000 W	20.0	198.1775 7	450.5605 9	10.0	189.3900 6	304.5480 2	33:03:55.9155 5S	67:09:49.72585 W
test37	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	90.0	268.9259 6	76.58779	187.0	7.21051	125.9449 3	40:09:41.3948 5S	69:52:39.75365 E
test38	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	90.0	266.4665 0	252.4636 0	127.0	304.8040 8	200.9914 3	40:02:36.7003 OS	73:41:41.93617 E
test39	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	180.0	360.0000 0	1100.012 45	183.0	4.51599	1228.188 96	58:29:28.9764 5S	68:12:45.60000 E
test40	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	175.0	354.6690 2	243.9689 6	190.0	10.99261	374.9238 9	44:13:28.9171 2S	68:42:18.37446 E
test41	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	175.0	176.0709 1	1610.923 21	170.0	171.9156 3	1498.429 64	13:19:39.6265 8S	65:53:56.00212 E
test42	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	170.0	346.6021 0	914.5607 8	175.0	353.1195 0	1027.162 53	55:06:04.1975 9S	72:46:16.27258 E
test43	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	140.0	318.3483 7	173.2619 8	175.0	354.6738 3	257.8732 4	42:21:36.7885 4S	70:42:57.94500 E
test44	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	35.0	213.6283 9	181.2824 0	200.0	199.8871 8	25.59220	37:40:30.7171 2S	70:23:42.21581 E
test45	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	35.0	214.0295 9	125.8876 1	225.0	45.28920	31.13428	38:26:34.7941 OS	69:44:39.40243 E

test46	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	40.0	218.8420 1	134.0315 8	200.0	20.10593	23.57520	38:26:45.9790 4S	70:02:24.89276 E
test47	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	40.0	218.7129 3	149.7132 6	170.0	349.9771 3	10.07419	38:14:31.6935 3S	70:14:53.93008 E
test48	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	190.0	10.58725	219.8166 0	200.0	21.88681	366.0777 6	43:46:47.0357 7S	67:20:06.32333 E
test49	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	230.0	227.5679 5	241.5124 0	250.0	248.8496 2	95.33926	37:31:02.9386 E	72:05:17.59883 E
test50	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	300.0	123.0197 5	262.8518 4	270.0	94.18239	322.3365 2	37:52:48.2984 0S	63:25:10.79761 E
test51	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	320.0	143.7321 8	481.6535 0	300.0	124.8154 6	472.2303 3	33:50:37.9632 2S	62:01:32.51590 E
test52	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	30.0	208.9670 2	155.7298 6	300.0	120.2210 6	19.68914	37:54:42.4907 5S	69:51:07.91279 E
test53	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	30.0	208.7476 4	191.1834 6	0.0	180.0000 0	40.92873	37:23:37.2326 5S	70:12:40.70000 E
test54	40:10:24.5000 OS	68:12:45.60000 E	38:04:35.8000 OS	70:12:40.70000 E	20.0	198.1805 7	449.6742 8	10.0	189.3915 7	303.6945 1	33:04:46.5374 0S	71:15:21.73045 E
test55	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	90.0	271.0915 3	77.83566	187.0	6.79843	115.7018 5	40:09:39.9789 3N	69:54:17.39524 E
test56	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	90.0	273.4902 2	249.3582 9	127.0	309.2448 7	197.1017 6	40:02:48.1219 7N	73:37:39.78188 E
test57	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	180.0	360.0000 0	2396.683 05	183.0	2.22965	2513.143 98	0:05:29.92696 N	68:12:45.60000 E
test58	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	175.0	355.3233 8	298.4366 8	190.0	9.08018	417.2421 3	35:12:41.1916 1N	68:44:27.81826 E
test59	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	175.0	173.0968 5	978.6223 8	170.0	166.5470 2	877.1571 7	56:23:18.1079 9N	65:41:19.19227 E
test60	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	170.0	352.0615 5	1470.738 41	175.0	356.1385 5	1572.102 01	15:53:04.6965 2N	72:29:58.69976 E
test61	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	140.0	321.5537 0	182.6172 4	175.0	355.3018 6	256.5372 3	37:48:46.6282 6N	70:40:52.06822 E
test62	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	35.0	216.4489 2	169.8518 3	200.0	200.1312 3	25.32646	42:28:23.6827 5N	70:24:22.98760 E
test63	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	35.0	215.8236 2	98.95285	225.0	44.50715	47.13287	41:31:06.5899 3N	69:28:18.70067 E
test64	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	40.0	221.2345 5	131.2770 7	200.0	19.92155	15.38722	41:50:07.6564 1N	70:05:38.28221 E
test65	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	40.0	221.3314 7	141.1334 4	170.0	350.0186 0	7.16484	41:57:32.2517 0N	70:14:20.75633 E
test66	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	190.0	9.32443	314.4794 1	200.0	18.06144	448.5440 4	35:00:00.7367 3N	67:06:22.55872 E
test67	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	230.0	232.6692 0	233.3841 0	250.0	251.3718 0	96.01994	42:36:22.2305 8N	72:14:52.24641 E
test68	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	300.0	117.2421 8	217.1421 4	270.0	85.85158	277.3905 3	41:54:32.4340 3N	64:00:50.69032 E
test69	40:10:24.5000 ON	68:12:45.60000 E	42:04:35.8000 ON	70:12:40.70000 E	320.0	135.9619 1	394.1797 6	300.0	114.5113 2	390.1869 8	45:03:40.1939 4N	62:15:25.92213 E
test70	40:10:24.5000	68:12:45.60000	42:04:35.8000	70:12:40.70000	30.0	211.0637	143.9165	300.0	119.7420	19.77535	42:14:26.9810	69:49:37.30186

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Appendix 2

	0N	E	0N	E		3	6		8		6N	E
test71	40:10:24.5000 0N	68:12:45.60000 E	42:04:35.8000 0N	70:12:40.70000 E	30.0	211.3232 2	176.8599 4	0.0	180.0000 0	38.02981	42:42:38.3910 8N	70:12:40.70000 E
test72	40:10:24.5000 0N	68:12:45.60000 E	42:04:35.8000 0N	70:12:40.70000 E	20.0	202.0030 9	360.7041 5	10.0	190.6494 9	226.3701 5	45:47:19.5403 5N	71:08:48.89165 E

WGS84ArcIntersect Test Results

Test Identifier	Arc 1 Center Latitude	Arc 1 Center Longitude	Arc 1 Radius	Arc 2 Center Latitude	Arc 2 Center Longitude	Arc 2 Radius	Intersection 1 Latitude	Intersection 1 Longitude	Intersection 2 Latitude	Intersection 2 Longitude
test1	40:10:24.50000N	70:12:45.60000W	100.0	52:04:35.80000N	68:12:40.70000W	270.0	N/A	N/A	N/A	N/A
test2	40:10:24.50000N	70:12:45.60000W	500.0	42:04:35.80000N	68:12:40.70000W	10.0	N/A	N/A	N/A	N/A
test3	0:00:00.00000N	0:00:00.00000E	150.0	0:00:00.00000N	4:59:27.60000W	150.0	0:00:36.09395S	2:29:43.80000W	0:00:36.09395N	2:29:43.80000W
test4	40:10:24.50000N	70:12:45.60000W	500.0	52:04:35.80000N	68:12:40.70000W	270.0	48:22:59.73249N	72:12:38.32104W	47:52:02.19529N	65:45:38.36390W
test5	40:10:24.50000N	70:12:45.60000W	500.0	52:04:35.80000N	68:12:40.70000W	500.0	46:29:29.71744N	77:40:33.97739W	45:10:28.61546N	61:09:37.26553W
test6	40:10:24.50000N	70:12:45.60000W	500.0	52:04:35.80000N	68:12:40.70000W	1000.0	36:14:44.69990N	60:52:32.48344W	37:48:21.06721N	80:28:07.28278W
test7	40:10:24.50000N	70:12:45.60000W	500.0	52:04:35.80000N	68:12:40.70000W	1200.0	32:04:17.90465N	67:44:28.29488W	32:37:16.67926N	74:36:44.61637W
test8	40:10:24.50000N	70:12:45.60000W	500.0	52:04:35.80000N	68:12:40.70000W	1300.0	N/A	N/A	N/A	N/A
test9	40:10:24.50000N	70:12:45.60000W	500.0	52:04:35.80000N	68:12:40.70000W	10.0	N/A	N/A	N/A	N/A
test10	40:10:24.50000S	70:12:45.60000W	500.0	52:04:35.80000S	68:12:40.70000W	270.0	47:52:02.19529S	65:45:38.36390W	48:22:59.73249S	72:12:38.32104W
test11	40:10:24.50000S	70:12:45.60000W	500.0	52:04:35.80000S	68:12:40.70000W	500.0	45:10:28.61546S	61:09:37.26553W	46:29:29.71744S	77:40:33.97739W
test12	40:10:24.50000S	70:12:45.60000W	500.0	52:04:35.80000S	68:12:40.70000W	1000.0	37:48:21.06721S	80:28:07.28278W	36:14:44.69990S	60:52:32.48344W
test13	40:10:24.50000S	70:12:45.60000W	500.0	52:04:35.80000S	68:12:40.70000W	1200.0	32:37:16.67926S	74:36:44.61637W	32:04:17.90465S	67:44:28.29488W
test14	40:10:24.50000S	70:12:45.60000W	500.0	52:04:35.80000S	68:12:40.70000W	1300.0	N/A	N/A	N/A	N/A
test15	40:10:24.50000S	70:12:45.60000W	500.0	52:04:35.80000S	68:12:40.70000W	10.0	N/A	N/A	N/A	N/A
test16	40:10:24.50000S	70:12:45.60000E	500.0	52:04:35.80000S	68:12:40.70000E	270.0	48:22:59.73249S	72:12:38.32104E	47:52:02.19529S	65:45:38.36390E
test17	40:10:24.50000S	70:12:45.60000E	500.0	52:04:35.80000S	68:12:40.70000E	500.0	46:29:29.71744S	77:40:33.97739E	45:10:28.61546S	61:09:37.26553E
test18	40:10:24.50000S	70:12:45.60000E	500.0	52:04:35.80000S	68:12:40.70000E	1000.0	36:14:44.69990S	60:52:32.48344E	37:48:21.06721S	80:28:07.28278E
test19	40:10:24.50000S	70:12:45.60000E	500.0	52:04:35.80000S	68:12:40.70000E	1200.0	32:04:17.90465S	67:44:28.29488E	32:37:16.67926S	74:36:44.61637E
test20	40:10:24.50000S	70:12:45.60000E	500.0	52:04:35.80000S	68:12:40.70000E	1300.0	N/A	N/A	N/A	N/A
test21	40:10:24.50000S	70:12:45.60000E	500.0	52:04:35.80000S	68:12:40.70000E	10.0	N/A	N/A	N/A	N/A
test22	40:10:24.50000N	70:12:45.60000E	500.0	52:04:35.80000N	68:12:40.70000E	270.0	47:52:02.19529N	65:45:38.36390E	48:22:59.73249N	72:12:38.32104E
test23	40:10:24.50000N	70:12:45.60000E	500.0	52:04:35.80000N	68:12:40.70000E	500.0	45:10:28.61546N	61:09:37.26553E	46:29:29.71744N	77:40:33.97739E
test24	40:10:24.50000N	70:12:45.60000E	500.0	52:04:35.80000N	68:12:40.70000E	1000.0	37:48:21.06721N	80:28:07.28278E	36:14:44.69990N	60:52:32.48344E
test25	40:10:24.50000N	70:12:45.60000E	500.0	52:04:35.80000N	68:12:40.70000E	1200.0	32:37:16.67926N	74:36:44.61637E	32:04:17.90465N	67:44:28.29488E
test26	40:10:24.50000N	70:12:45.60000E	500.0	52:04:35.80000N	68:12:40.70000E	1300.0	N/A	N/A	N/A	N/A
test27	40:10:24.50000N	70:12:45.60000E	500.0	52:04:35.80000N	68:12:40.70000E	10.0	N/A	N/A	N/A	N/A
test28	6:10:24.50000S	70:12:45.60000E	500.0	6:04:35.80000N	68:12:40.70000E	500.0	0:57:26.91899S	63:41:24.65688E	0:51:39.75573N	74:44:00.46476E
test29	90:00:00.00000N	70:12:45.60000E	500.0	78:04:35.80000N	68:12:40.70000E	500.0	81:42:32.06863N	112:26:25.42164E	81:42:32.06863N	23:58:55.97836E
test30	90:00:00.00000S	70:12:45.60000E	500.0	78:04:35.80000S	68:12:40.70000E	500.0	81:42:32.06863S	23:58:55.97836E	81:42:32.06863S	112:26:25.42164E

WGS84GeodesicArcIntersect Test Results

Test Identifier	Geodesic Start Latitude	Geodesic Start Longitude	Geodesic Azimuth	Arc Center Latitude	Arc Center Longitude	Arc Radius	Intersection 1 Latitude	Intersection 1 Longitude	Intersection 2 Latitude	Intersection 2 Longitude
test1	40:04:35.80000N	67:12:40.70000W	350.0	40:10:24.50000N	70:12:45.60000W	100.0	N/A	N/A	N/A	N/A
test2	40:04:35.80000N	67:12:40.70000W	200.0	40:10:24.50000N	70:12:45.60000W	100.0	N/A	N/A	N/A	N/A
test3	40:04:35.80000N	68:12:40.70000W	325.0	40:10:24.50000N	70:12:45.60000W	100.0	39:55:07.50121N	68:04:04.19322W	41:49:07.05128N	69:51:08.02313W
test4	40:04:35.80000N	67:12:40.70000W	270.0	40:10:24.50000N	70:12:45.60000W	100.0	40:04:25.03104N	68:02:37.73049W	39:57:42.51976N	72:21:57.92383W
test5	40:04:35.80000N	67:12:40.70000W	300.0	40:10:24.50000N	70:12:45.60000W	100.0	40:26:58.44233N	68:03:50.25317W	41:41:50.22946N	71:06:22.56112W
test6	40:04:35.80000N	67:12:40.70000W	240.0	40:10:24.50000N	70:12:45.60000W	100.0	39:39:05.08426N	68:09:19.50227W	38:31:25.09106N	70:31:48.24036W
test7	42:54:35.80000N	70:11:34.70000W	180.0	40:10:24.50000N	70:12:45.60000W	100.0	41:50:27.82240N	70:11:34.70000W	38:30:19.45513N	70:11:34.70000W
test8	42:54:35.80000N	70:11:34.70000W	148.0	40:10:24.50000N	70:12:45.60000W	100.0	41:37:21.88671N	69:07:30.61751W	40:14:53.46014N	68:02:21.53739W
test9	42:54:35.80000N	70:11:34.70000W	211.0	40:10:24.50000N	70:12:45.60000W	100.0	41:40:11.55047N	71:10:59.87403W	40:05:20.45327N	72:22:58.34527W
test10	40:24:35.80000N	75:11:34.70000W	90.0	40:10:24.50000N	70:12:45.60000W	100.0	40:22:32.07141N	72:22:27.11102W	40:11:17.30268N	68:02:17.43363W
test11	40:24:35.80000N	75:11:34.70000W	71.0	40:10:24.50000N	70:12:45.60000W	100.0	41:12:48.70166N	71:55:32.15119W	41:44:39.12385N	69:28:24.56005W
test12	40:24:35.80000N	75:11:34.70000W	117.0	40:10:24.50000N	70:12:45.60000W	100.0	38:58:10.68147N	71:42:17.04664W	38:34:08.21242N	70:48:01.94345W
test13	37:09:35.80000N	70:21:34.70000W	0.0	40:10:24.50000N	70:12:45.60000W	100.0	38:30:33.27210N	70:21:34.70000W	41:50:14.67279N	70:21:34.70000W
test14	37:09:35.80000N	70:21:34.70000W	34.0	40:10:24.50000N	70:12:45.60000W	100.0	38:51:33.35407N	68:53:10.34405W	39:40:46.86281N	68:08:35.72134W
test15	37:09:35.80000N	70:21:34.70000W	331.0	40:10:24.50000N	70:12:45.60000W	100.0	38:53:33.43923N	71:35:33.98874W	39:55:14.26604N	72:21:28.46764W
test16	40:04:35.80000N	73:12:40.70000E	350.0	40:10:24.50000N	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test17	40:04:35.80000N	73:12:40.70000E	200.0	40:10:24.50000N	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test18	40:04:35.80000N	72:12:40.70000E	315.0	40:10:24.50000N	70:12:45.60000E	100.0	39:57:28.59246N	72:21:55.36432E	41:49:06.70033N	69:51:05.23564E
test19	40:04:35.80000N	73:12:40.70000E	270.0	40:10:24.50000N	70:12:45.60000E	100.0	40:04:25.10140N	72:22:53.47612E	39:57:42.95307N	68:03:33.19723E
test20	40:04:35.80000N	73:12:40.70000E	300.0	40:10:24.50000N	70:12:45.60000E	100.0	40:26:53.80980N	72:21:41.88661E	41:41:48.45569N	69:19:03.39492E
test21	40:04:35.80000N	73:12:40.70000E	240.0	40:10:24.50000N	70:12:45.60000E	100.0	39:39:10.70047N	72:16:14.18085E	38:31:26.01350N	69:53:35.03132E
test22	42:54:35.80000N	70:11:34.70000E	180.0	40:10:24.50000N	70:12:45.60000E	100.0	41:50:27.82240N	70:11:34.70000E	38:30:19.45513N	70:11:34.70000E
test23	42:54:35.80000N	70:11:34.70000E	148.0	40:10:24.50000N	70:12:45.60000E	100.0	41:38:51.44804N	71:14:26.22964E	40:11:43.96597N	72:23:13.80920E
test24	42:54:35.80000N	70:11:34.70000E	211.0	40:10:24.50000N	70:12:45.60000E	100.0	41:38:52.66082N	69:11:07.98528E	40:08:17.38700N	68:02:21.75495E
test25	40:24:35.80000N	65:11:34.70000E	90.0	40:10:24.50000N	70:12:45.60000E	100.0	40:22:28.60052N	68:03:03.59248E	40:11:08.47196N	72:23:13.71817E
test26	40:24:35.80000N	65:11:34.70000E	71.0	40:10:24.50000N	70:12:45.60000E	100.0	41:13:31.30530N	68:30:43.58125E	41:44:55.52500N	70:56:05.26696E
test27	40:24:35.80000N	65:11:34.70000E	117.0	40:10:24.50000N	70:12:45.60000E	100.0	38:55:28.33410N	68:47:03.42056E	38:35:19.72896N	69:32:28.24986E
test28	37:09:35.80000N	70:21:34.70000E	0.0	40:10:24.50000N	70:12:45.60000E	100.0	38:30:33.27210N	70:21:34.70000E	41:50:14.67279N	70:21:34.70000E
test29	37:09:35.80000N	70:21:34.70000E	31.0	40:10:24.50000N	70:12:45.60000E	100.0	39:05:41.34977N	71:51:29.95766E	39:31:54.37145N	72:12:37.10649E
test30	37:09:35.80000N	70:21:34.70000E	331.0	40:10:24.50000N	70:12:45.60000E	100.0	38:39:57.65316N	69:17:30.06177E	40:20:03.37282N	68:02:45.21636E
test31	40:04:35.80000S	73:12:40.70000E	350.0	40:10:24.50000S	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test32	40:04:35.80000S	73:12:40.70000E	200.0	40:10:24.50000S	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test33	40:04:35.80000S	72:12:40.70000E	315.0	40:10:24.50000S	70:12:45.60000E	100.0	40:12:40.39213S	72:23:13.39076E	38:30:19.48047S	70:13:59.97421E
test34	40:04:35.80000S	73:12:40.70000E	270.0	40:10:24.50000S	70:12:45.60000E	100.0	40:04:25.10140S	72:22:53.47612E	39:57:42.95307S	68:03:33.19723E
test35	40:04:35.80000S	73:12:40.70000E	300.0	40:10:24.50000S	70:12:45.60000E	100.0	39:39:10.70047S	72:16:14.18085E	38:31:26.01350S	69:53:35.03132E
test36	40:04:35.80000S	73:12:40.70000E	240.0	40:10:24.50000S	70:12:45.60000E	100.0	40:26:53.80980S	72:21:41.88661E	41:41:48.45569S	69:19:03.39492E
test37	38:04:35.80000S	70:11:34.70000E	180.0	40:10:24.50000S	70:12:45.60000E	100.0	38:30:19.45513S	70:11:34.70000E	41:50:27.82240S	70:11:34.70000E
test38	38:04:35.80000S	70:11:34.70000E	148.0	40:10:24.50000S	70:12:45.60000E	100.0	38:31:34.10858S	70:33:03.48677E	40:38:16.13339S	72:18:29.56104E
test39	38:04:35.80000S	70:11:34.70000E	211.0	40:10:24.50000S	70:12:45.60000E	100.0	38:31:47.32219S	69:50:45.35130E	40:40:24.17522S	68:07:50.24284E
test40	40:24:35.80000S	65:51:34.70000E	90.0	40:10:24.50000S	70:12:45.60000E	100.0	40:23:20.88344S	68:03:11.35606E	40:13:31.47512S	72:23:12.41522E
test41	40:24:35.80000S	65:51:34.70000E	71.0	40:10:24.50000S	70:12:45.60000E	100.0	39:47:33.58163S	68:06:05.87892E	38:46:58.13955S	71:24:05.30746E
test42	40:24:35.80000S	65:51:34.70000E	117.0	40:10:24.50000S	70:12:45.60000E	100.0	41:34:54.09546S	69:02:08.00210E	41:46:21.53454S	69:35:18.59270E

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Appendix 2

test43	43:09:35.80000S	70:21:34.70000E	0.0	40:10:24.50000S	70:12:45.60000E	100.0	41:50:14.67279S	70:21:34.70000E	38:30:33.27210S	70:21:34.70000E
test44	43:09:35.80000S	70:21:34.70000E	34.0	40:10:24.50000S	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test45	43:09:35.80000S	70:21:34.70000E	335.0	40:10:24.50000S	70:12:45.60000E	100.0	41:44:46.94173S	69:28:53.61272E	39:33:21.66496S	68:12:06.66151E
test46	40:04:35.80000S	67:12:40.70000W	350.0	40:10:24.50000S	70:12:45.60000W	100.0	N/A	N/A	N/A	N/A
test47	40:04:35.80000S	67:12:40.70000W	200.0	40:10:24.50000S	70:12:45.60000W	100.0	N/A	N/A	N/A	N/A
test48	40:04:35.80000S	68:12:40.70000W	315.0	40:10:24.50000S	70:12:45.60000W	100.0	40:12:32.98018S	68:02:17.71481W	38:30:19.55929S	70:11:21.32978W
test49	40:04:35.80000S	67:12:40.70000W	270.0	40:10:24.50000S	70:12:45.60000W	100.0	40:04:25.03104S	68:02:37.73049W	39:57:42.51976S	72:21:57.92383W
test50	40:04:35.80000S	67:12:40.70000W	300.0	40:10:24.50000S	70:12:45.60000W	100.0	39:39:05.08426S	68:09:19.50227W	38:31:25.09106S	70:31:48.24036W
test51	40:04:35.80000S	67:12:40.70000W	240.0	40:10:24.50000S	70:12:45.60000W	100.0	40:26:58.44233S	68:03:50.25317W	41:41:50.22946S	71:06:22.56112W
test52	38:04:35.80000S	70:11:34.70000W	180.0	40:10:24.50000S	70:12:45.60000W	100.0	38:30:19.45513S	70:11:34.70000W	41:50:27.82240S	70:11:34.70000W
test53	38:04:35.80000S	70:11:34.70000W	148.0	40:10:24.50000S	70:12:45.60000W	100.0	38:31:55.04879S	69:49:49.11075W	40:36:19.17675S	68:06:20.78959W
test54	38:04:35.80000S	70:11:34.70000W	211.0	40:10:24.50000S	70:12:45.60000W	100.0	38:31:27.49080S	70:32:08.75118W	40:42:18.41652S	72:16:54.09843W
test55	40:24:35.80000S	74:11:34.70000W	90.0	40:10:24.50000S	70:12:45.60000W	100.0	40:23:44.12558S	72:22:16.19656W	40:14:45.41675S	68:02:21.20257W
test56	40:24:35.80000S	74:11:34.70000W	71.0	40:10:24.50000S	70:12:45.60000W	100.0	39:54:28.73386S	72:21:18.43758W	38:51:32.35724S	68:53:12.00023W
test57	40:24:35.80000S	74:11:34.70000W	117.0	40:10:24.50000S	70:12:45.60000W	100.0	41:17:23.70708S	71:50:29.04635W	41:50:26.40135S	70:15:52.05998W
test58	43:09:35.80000S	70:21:34.70000W	0.0	40:10:24.50000S	70:12:45.60000W	100.0	41:50:14.67279S	70:21:34.70000W	38:30:33.27210S	70:21:34.70000W
test59	43:09:35.80000S	70:21:34.70000W	34.0	40:10:24.50000S	70:12:45.60000W	100.0	41:29:48.15752S	68:52:34.09229W	40:34:48.23070S	68:05:51.32589W
test60	43:09:35.80000S	70:21:34.70000W	331.0	40:10:24.50000S	70:12:45.60000W	100.0	41:27:45.66110S	71:36:19.10893W	40:21:28.52278S	72:22:35.77672W

WGS84TangentFixedRadiusArc Test Results

Test Identifier	Geodesic 1 Start Latitude	Geodesic 1 Start Longitude	Geodesic 1 Azimuth	Geodesic 2 Start Latitude	Geodesic 2 Start Longitude	Geodesic 2 Azimuth	Arc Radius	Arc Direction	Arc Center Latitude	Arc Center Longitude	Tangent Point 1 Latitude	Tangent Point 1 Longitude	Tangent Point 2 Latitude	Tangent Point 2 Longitude
test1	40:10:24.5000N	70:12:45.6000W	90.0	42:04:35.8000N	68:12:34.7000W	7.0	75.0	1	41:25:26.56571N	69:59:17.04094W	40:10:23.74429N	69:59:31.88877W	41:17:07.03907N	68:20:18.39888W
test2	40:10:24.5000N	70:12:45.6000W	90.0	42:04:35.8000N	68:12:34.7000W	307.0	25.0	1	40:31:46.79892N	66:27:03.20189W	40:06:47.06612N	66:28:25.95221W	40:51:25.07414N	66:06:41.57854W
test3	40:10:24.5000N	70:12:45.6000W	180.0	42:04:35.8000N	68:12:34.7000W	10.0	25.0	1	37:49:18.52460N	69:41:12.45766W	37:49:22.75065N	70:12:45.60000W	37:45:17.76097N	69:10:04.65398W
test4	40:10:24.5000N	70:12:45.6000W	175.0	42:04:35.8000N	68:12:34.7000W	10.0	20.0	1	37:58:58.93078N	69:32:51.13441W	37:57:20.15294N	69:58:03.52834W	37:55:45.22180N	69:07:53.72716W
test5	40:10:24.5000N	70:12:45.6000W	140.0	42:04:35.8000N	68:12:34.7000W	355.0	30.0	1	39:24:32.81954N	68:33:23.26170W	39:05:36.47498N	69:03:21.38752W	39:27:10.17660N	67:54:49.02689W
test6	40:10:24.5000N	70:12:45.6000W	35.0	42:04:35.8000N	68:12:34.7000W	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test7	40:10:24.5000N	70:12:45.6000W	35.0	42:04:35.8000N	68:12:34.7000W	45.0	50.0	-1	40:57:48.66322N	68:07:20.87268W	41:27:16.30680N	69:00:53.40061W	41:33:03.54197N	68:54:23.62947W
test8	40:10:24.5000N	70:12:45.6000W	40.0	42:04:35.8000N	68:12:34.7000W	20.0	10.0	1	41:55:40.79274N	68:31:10.13947W	41:49:05.67932N	68:21:05.52942W	41:52:16.83907N	68:18:34.47631W
test9	40:10:24.5000N	70:12:45.6000W	40.0	42:04:35.8000N	68:12:34.7000W	350.0	5.0	1	41:59:13.16537N	68:18:06.96458W	41:55:55.15030N	68:13:04.79341W	42:00:05.41038N	68:11:30.78144W
test10	40:10:24.5000N	70:12:45.6000W	190.0	42:04:35.8000N	68:12:34.7000W	20.0	15.0	1	38:10:11.23560N	70:20:17.73040W	38:12:44.89584N	70:39:02.59725W	38:05:21.93366N	70:02:17.49744W
test11	40:10:24.5000N	70:12:45.6000W	300.0	42:04:35.8000N	68:12:34.7000W	90.0	15.0	-1	41:43:02.57956N	73:12:06.06904W	41:29:47.49856N	73:21:29.21152W	41:58:01.44478N	73:13:16.42120W
test12	40:10:24.5000N	70:12:45.6000W	320.0	42:04:35.8000N	68:12:34.7000W	120.0	50.0	-1	42:22:04.52412N	71:13:56.01200W	41:49:17.86811N	72:04:39.94655W	43:06:10.85660N	70:41:56.46903W
test13	40:10:24.5000N	70:12:45.6000W	30.0	42:04:35.8000N	68:12:34.7000W	120.0	15.0	-1	41:54:13.54118N	68:28:45.14229W	42:01:57.90713N	68:45:58.79336W	42:07:14.26829N	68:18:43.75999W
test14	40:10:24.5000N	70:12:45.6000W	30.0	42:04:35.8000N	68:12:34.7000W	180.0	10.0	-1	42:07:16.10426N	68:26:00.95597W	42:12:26.23456N	68:37:31.72202W	42:07:16.89107N	68:12:34.70000W
test15	40:10:24.5000N	70:12:45.6000W	20.0	42:04:35.8000N	68:12:34.7000W	190.0	20.0	-1	42:33:38.00509N	68:33:07.56179W	42:40:47.45417N	68:58:25.31418W	42:30:11.24393N	68:06:28.78422W
test16	40:10:24.5000S	70:12:45.6000W	90.0	38:04:35.8000S	68:12:34.7000W	7.0	75.0	1	38:55:19.66495S	69:57:30.23681W	40:10:23.45763S	69:57:13.42772W	39:05:15.38970S	68:22:08.10115W
test17	40:10:24.5000S	70:12:45.6000W	90.0	38:04:35.8000S	68:12:34.7000W	307.0	25.0	1	39:41:24.87800S	66:18:33.94822W	40:06:24.60062S	66:17:08.09870W	39:21:05.93754S	65:59:42.39589W
test18	40:10:24.5000S	70:12:45.6000W	180.0	38:04:35.8000S	68:12:34.7000W	10.0	25.0	1	41:48:21.64034S	69:39:19.85614W	41:48:26.50432S	70:12:45.60000W	41:53:01.81471S	69:06:28.19550W
test19	40:10:24.5000S	70:12:45.6000W	175.0	38:04:35.8000S	68:12:34.7000W	10.0	20.0	1	41:53:23.0849S	69:33:48.78224W	41:55:13.61589S	70:00:29.02018W	41:57:06.70642S	69:07:29.45776W
test20	40:10:24.5000S	70:12:45.6000W	140.0	38:04:35.8000S	68:12:34.7000W	355.0	30.0	1	40:53:21.50747S	68:32:50.30433W	41:13:01.31780S	69:02:47.99272W	40:50:44.90598S	67:53:26.70965W
test21	40:10:24.5000S	70:12:45.6000W	35.0	38:04:35.8000S	68:12:34.7000W	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test22	40:10:24.5000S	70:12:45.6000W	35.0	38:04:35.8000S	68:12:34.7000W	45.0	50.0	-1	38:59:07.56476S	67:51:47.61476W	38:31:17.23476S	68:44:54.62476W	38:23:43.49476S	68:36:56.20476W

	000S	000W		000S	000W				203S	082W	392S	547W	887S	242W
test23	40:10:24.50 000S	70:12:45.60 000W	40.0	38:04:35.80 000S	68:12:34.70 000W	20.0	10.0	1	38:21:17.65 803S	68:33:50.38 808W	38:27:34.84 485S	68:23:56.35 353W	38:24:44.64 049S	68:21:54.05 514W
test24	40:10:24.50 000S	70:12:45.60 000W	40.0	38:04:35.80 000S	68:12:34.70 000W	350.0	5.0	1	38:12:57.08 171S	68:17:09.17 935W	38:16:05.07 958S	68:12:12.22 289W	38:12:05.00 846S	68:10:54.32 298W
test25	40:10:24.50 000S	70:12:45.60 000W	190.0	38:04:35.80 000S	68:12:34.70 000W	20.0	15.0	1	41:21:05.57 583S	70:09:04.40 926W	41:18:28.19 792S	70:28:40.65 479W	41:26:30.42 675S	69:50:29.08 027W
test26	40:10:24.50 000S	70:12:45.60 000W	300.0	38:04:35.80 000S	68:12:34.70 000W	90.0	15.0	-1	38:11:39.46 782S	73:47:56.44 226W	38:24:20.78 704S	73:58:07.81 572W	37:56:40.09 827S	73:46:48.10 003W
test27	40:10:24.50 000S	70:12:45.60 000W	320.0	38:04:35.80 000S	68:12:34.70 000W	120.0	50.0	-1	37:18:22.45 450S	71:50:53.37 418W	37:49:40.64 492S	72:39:57.99 848W	36:35:56.07 395S	71:17:47.86 633W
test28	40:10:24.50 000S	70:12:45.60 000W	30.0	38:04:35.80 000S	68:12:34.70 000W	120.0	15.0	-1	38:15:18.86 600S	68:27:05.40 167W	38:08:02.37 874S	68:43:44.12 803W	38:02:19.38 377S	68:17:33.22 322W
test29	40:10:24.50 000S	70:12:45.60 000W	30.0	38:04:35.80 000S	68:12:34.70 000W	180.0	10.0	-1	38:02:17.85 831S	68:25:14.17 729W	37:57:27.29 149S	68:36:18.51 623W	38:02:18.53 972S	68:12:34.70 000W
test30	40:10:24.50 000S	70:12:45.60 000W	20.0	38:04:35.80 000S	68:12:34.70 000W	190.0	20.0	-1	37:17:13.88 439S	68:27:34.64 341W	37:10:42.09 265S	68:51:15.15 355W	37:20:43.05 501S	68:02:53.31 084W
test31	40:10:24.50 000S	68:12:45.60 000E	90.0	38:04:35.80 000S	70:12:34.70 000E	7.0	75.0	1	38:55:19.71 316S	68:27:39.15 441E	40:10:23.50 671S	68:27:55.56 302E	39:05:15.43 802S	70:03:01.29 112E
test32	40:10:24.50 000S	68:12:45.60 000E	90.0	38:04:35.80 000S	70:12:34.70 000E	307.0	25.0	1	39:41:25.57 535S	72:06:36.70 261E	40:06:25.30 217S	72:08:02.42 702E	39:21:06.63 156S	72:25:28.25 205E
test33	40:10:24.50 000S	68:12:45.60 000E	180.0	38:04:35.80 000S	70:12:34.70 000E	10.0	25.0	1	41:46:59.98 555S	68:46:10.63 681E	41:47:04.84 568S	68:12:45.60 000E	41:51:40.05 992S	69:19:01.62 673E
test34	40:10:24.50 000S	68:12:45.60 000E	175.0	38:04:35.80 000S	70:12:34.70 000E	10.0	20.0	1	41:52:26.37 245S	68:51:35.20 384E	41:54:16.88 004S	68:24:55.35 570E	41:56:09.94 304S	69:17:54.15 406E
test35	40:10:24.50 000S	68:12:45.60 000E	140.0	38:04:35.80 000S	70:12:34.70 000E	355.0	30.0	1	40:53:00.52 340S	69:52:16.78 699E	41:12:40.22 975S	69:22:19.13 720E	40:50:23.93 467S	70:31:40.17 600E
test36	40:10:24.50 000S	68:12:45.60 000E	35.0	38:04:35.80 000S	70:12:34.70 000E	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test37	40:10:24.50 000S	68:12:45.60 000E	35.0	38:04:35.80 000S	70:12:34.70 000E	45.0	50.0	-1	38:58:15.99 199S	70:34:27.34 186E	38:30:25.98 705S	69:41:20.68 237E	38:22:52.33 996S	69:49:18.75 679E
test38	40:10:24.50 000S	68:12:45.60 000E	40.0	38:04:35.80 000S	70:12:34.70 000E	20.0	10.0	1	38:21:56.65 274S	69:51:00.76 931E	38:28:13.89 538S	70:00:54.83 463E	38:25:23.66 587S	70:02:57.19 466E
test39	40:10:24.50 000S	68:12:45.60 000E	40.0	38:04:35.80 000S	70:12:34.70 000E	350.0	5.0	1	38:13:14.64 955S	70:08:04.12 833E	38:16:22.65 986S	70:13:01.09 183E	38:12:22.57 289S	70:14:19.00 895E
test40	40:10:24.50 000S	68:12:45.60 000E	190.0	38:04:35.80 000S	70:12:34.70 000E	20.0	15.0	1	41:19:48.53 358S	68:16:44.73 461E	41:17:11.20 581S	67:57:08.86 172E	41:25:13.27 841S	68:35:19.75 280E
test41	40:10:24.50 000S	68:12:45.60 000E	300.0	38:04:35.80 000S	70:12:34.70 000E	90.0	15.0	-1	38:11:40.61 138S	64:37:37.05 220E	38:24:21.93 390S	64:27:25.68 277E	37:56:41.23 801S	64:38:45.31 315E
test42	40:10:24.50 000S	68:12:45.60 000E	320.0	38:04:35.80 000S	70:12:34.70 000E	120.0	50.0	-1	37:18:44.79 574S	66:35:00.43 984E	37:50:03.14 293S	65:45:55.73 018E	36:36:18.21 450S	67:08:05.70 311E
test43	40:10:24.50 000S	68:12:45.60 000E	30.0	38:04:35.80 000S	70:12:34.70 000E	120.0	15.0	-1	38:15:26.42 644S	69:58:20.50 710E	38:08:09.92 689S	69:41:41.76 083E	38:02:26.92 225S	70:07:52.65 334E
test44	40:10:24.50 000S	68:12:45.60 000E	30.0	38:04:35.80 000S	70:12:34.70 000E	180.0	10.0	-1	38:02:49.25 073S	69:59:55.13 263E	37:57:58.65 008S	69:48:50.73 899E	38:02:49.93 235S	70:12:34.70 000E
test45	40:10:24.50 000S	68:12:45.60 000E	20.0	38:04:35.80 000S	70:12:34.70 000E	190.0	20.0	-1	37:19:00.32 748S	69:57:10.89 521E	37:12:28.38 650S	69:33:29.89 561E	37:22:29.58 087S	70:21:52.79 009E
test46	40:10:24.50 000N	68:12:45.60 000E	90.0	42:04:35.80 000N	70:12:34.70 000E	7.0	75.0	1	41:25:26.60 664N	68:25:52.36 461E	40:10:23.78 448N	68:25:37.91 699E	41:17:07.07 993N	70:04:51.00 769E

test47	40:10:24.50 000N	68:12:45.60 000E	90.0	42:04:35.80 000N	70:12:34.70 000E	307.0	25.0	1	40:31:47.54 306N	71:58:04.95 738E	40:06:47.80 578N	71:56:42.34 739E	40:51:25.82 191N	72:18:26.57 839E
test48	40:10:24.50 000N	68:12:45.60 000E	180.0	42:04:35.80 000N	70:12:34.70 000E	10.0	25.0	1	37:51:10.80 607N	68:44:19.53 963E	37:51:15.03 684N	68:12:45.60 000E	37:47:09.94 546N	69:15:28.10 850E
test49	40:10:24.50 000N	68:12:45.60 000E	175.0	42:04:35.80 000N	70:12:34.70 000E	10.0	20.0	1	38:00:10.41 235N	68:52:32.81 783E	37:58:31.60 944N	68:27:20.01 909E	37:56:56.65 308N	69:17:30.61 773E
test50	40:10:24.50 000N	68:12:45.60 000E	140.0	42:04:35.80 000N	70:12:34.70 000E	355.0	30.0	1	39:24:56.40 398N	69:51:43.36 317E	39:05:59.95 608N	69:21:45.17 977E	39:27:33.77 651N	70:30:17.81 305E
test51	40:10:24.50 000N	68:12:45.60 000E	35.0	42:04:35.80 000N	70:12:34.70 000E	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test52	40:10:24.50 000N	68:12:45.60 000E	35.0	42:04:35.80 000N	70:12:34.70 000E	45.0	50.0	-1	40:58:50.90 375N	70:19:10.81 896E	41:28:19.01 585N	69:25:37.89 916E	41:34:06.34 313N	69:32:08.06 055E
test53	40:10:24.50 000N	68:12:45.60 000E	40.0	42:04:35.80 000N	70:12:34.70 000E	20.0	10.0	1	41:55:09.03 646N	69:53:43.95 858E	41:48:33.97 658N	70:03:48.54 891E	41:51:45.11 040N	70:06:19.53 131E
test54	40:10:24.50 000N	68:12:45.60 000E	40.0	42:04:35.80 000N	70:12:34.70 000E	350.0	5.0	1	41:58:57.74 099N	70:07:06.10 358E	41:55:39.73 901N	70:12:08.27 010E	41:59:49.98 252N	70:13:42.26 099E
test55	40:10:24.50 000N	68:12:45.60 000E	190.0	42:04:35.80 000N	70:12:34.70 000E	20.0	15.0	1	38:11:57.14 712N	68:05:36.93 299E	38:14:30.86 947N	67:46:51.62 699E	38:07:07.73 150N	68:23:37.55 015E
test56	40:10:24.50 000N	68:12:45.60 000E	300.0	42:04:35.80 000N	70:12:34.70 000E	90.0	15.0	-1	41:43:03.43 894N	65:13:22.97 799E	41:29:48.35 505N	65:03:59.84 075E	41:58:02.30 748N	65:12:12.70 228E
test57	40:10:24.50 000N	68:12:45.60 000E	320.0	42:04:35.80 000N	70:12:34.70 000E	120.0	50.0	-1	42:21:48.75 747N	67:11:53.44 646E	41:49:02.23 303N	66:21:09.56 547E	43:05:54.90 302N	67:43:53.33 289E
test58	40:10:24.50 000N	68:12:45.60 000E	30.0	42:04:35.80 000N	70:12:34.70 000E	120.0	15.0	-1	41:54:06.60 769N	69:56:40.44 962E	42:01:50.95 973N	69:39:26.81 837E	42:07:07.31 140N	70:06:41.86 897E
test59	40:10:24.50 000N	68:12:45.60 000E	30.0	42:04:35.80 000N	70:12:34.70 000E	180.0	10.0	-1	42:06:49.39 078N	69:59:08.53 808E	42:11:59.48 512N	69:47:37.82 330E	42:06:50.17 739N	70:12:34.70 000E
test60	40:10:24.50 000N	68:12:45.60 000E	20.0	42:04:35.80 000N	70:12:34.70 000E	190.0	20.0	-1	42:32:22.60 485N	69:51:44.28 487E	42:39:31.91 024N	69:26:26.96 605E	42:28:55.91 068N	70:18:22.54 478E

WGS84GeoLocusIntersect Test Results

Test Identifier	Geodesic Input	Geodesic Start Latitude	Geodesic Start Longitude	Geodesic End Latitude	Geodesic End Longitude						
	Locus Input	Locus Geodesic Start Latitude	Locus Geodesic Start Longitude	Locus Geodesic End Latitude	Locus Geodesic End Longitude	Locus Start Latitude	Locus Start Longitude	Locus End Latitude	Locus End Longitude	Locus Start Distance (nm)	Locus End Distance (nm)
	Output	Intersection Latitude	Intersection Longitude								
test1	Geodesic Input	43:47:17.8000 0N	69:11:50.6000 0W	39:34:35.8000 0N	69:12:34.7000 0W						
	Locus Input	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:34:51.0899 7N	70:54:12.4935 8W	42:29:44.8698 0N	68:54:29.5954 1W	-40.0	-40.0
	Output	42:13:22.2144 7N	69:12:07.6754 0W								
test2	Geodesic Input	41:47:17.8000 0N	69:11:50.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W						
	Locus Input	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:16:32.5468 3N	70:23:04.5187 6W	42:10:54.5106 7N	68:23:00.3023 2W	-10.0	-10.0
	Output	41:57:19.7904 5N	68:37:45.0785 8W								
test3	Geodesic Input	41:47:17.8000 0N	69:11:50.6000 0W	41:47:17.8000 0N	65:12:34.7000 0W						
	Locus Input	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:01:10.7013 8N	69:57:20.7013 2W	41:58:16.1381 7N	68:02:11.1632 1W	15.0	10.0
	Output	41:48:04.2439 4N	68:12:34.3229 9W								
test4	Geodesic Input	41:47:17.8000 0N	69:11:50.6000 0W	39:36:04.5000 0N	67:26:41.2000 0W						
	Locus Input	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:03:01.6262 4N	70:00:25.3480 4W	41:53:11.7282 8N	67:53:53.8147 1W	12.0	18.0
	Output	41:11:48.4012 8N	68:42:35.0157 7W								
test5	Geodesic Input	41:47:17.8000 0N	69:11:50.6000 0W	39:36:04.5000 0N	69:11:50.6000 0W						
	Locus Input	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:17:46.0449 3N	70:25:08.5260 3W	42:10:54.5106 7N	68:23:00.3023 2W	-12.0	-10.0
	Output	41:26:42.3321 3N	69:11:50.6000 0W								
test6	Geodesic Input	41:47:17.8000 0N	69:11:50.6000 0W	40:10:24.5000 0N	70:12:45.6000 0W						
	Locus Input	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:16:32.5468 3N	70:23:04.5187 6W	42:17:12.2636 1N	68:33:27.9794 9W	-10.0	-20.0
	Output	41:09:26.3350 3N	69:36:02.5956 5W								
test7	Geodesic Input	38:47:17.8000 0N	69:11:50.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W						

	Locus Input	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:58:16.1381 7N	68:02:11.1632 2W	40:01:10.7013 8N	69:57:20.7013 2W	-10.0	-15.0
	Output	41:40:37.8302 5N	68:20:06.2633 0W								
test8	Geodesic Input	38:47:17.8000 0N	69:11:50.6000 0W	41:36:04.5000 0N	69:11:50.6000 0W						
	Locus Input	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	42:12:10.1380 9N	68:25:05.6714 7W	40:16:32.5468 3N	70:23:04.5187 6W	12.0	10.0
	Output	41:27:24.3094 7N	69:11:50.6000 0W								
test9	Geodesic Input	39:47:17.8000 0N	69:11:50.6000 0W	41:10:24.5000 0N	70:12:45.6000 0W						
	Locus Input	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:55:44.0085 9N	67:58:02.3247 7W	40:04:15.5303 7N	70:02:28.5382 3W	-14.0	-10.0
	Output	40:25:30.2029 5N	69:39:29.1545 4W								
test10	Geodesic Input	39:47:17.8000 0N	69:11:50.6000 0W	41:05:17.8000 0N	72:11:50.6000 0W						
	Locus Input	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:39:11.5109 4N	67:31:12.8528 1W	39:48:49.1084 0N	69:36:53.9576 0W	-40.0	-35.0
	Output	39:55:22.6825 0N	69:29:41.6206 7W								
test11	Geodesic Input	39:47:17.8000 0N	68:31:50.6000 0W	39:47:17.8000 0N	72:11:50.6000 0W						
	Locus Input	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:35:59.9254 6N	67:26:04.9158 8W	39:39:30.5435 3N	69:21:38.7068 5W	-45.0	-50.0
	Output	39:47:49.9182 7N	69:13:40.3936 7W								
test12	Geodesic Input	40:47:17.8000 0N	68:31:50.6000 0W	39:15:17.8000 0N	72:11:50.6000 0W						
	Locus Input	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:40:28.0804 1N	67:33:16.1694 9W	39:42:36.9560 7N	69:26:43.3345 6W	-38.0	-45.0
	Output	40:51:17.2023 2N	68:21:40.0023 1W								
test13	Geodesic Input	41:47:17.8000 0N	68:11:50.6000 0E	42:34:35.8000 0N	69:12:34.7000 0E						
	Locus Input	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:34:48.3409 8N	67:31:15.9527 5E	42:30:56.9433 7N	69:28:29.9691 1E	-40.0	-42.0
	Output	N/A	N/A								
test14	Geodesic Input	41:47:17.8000 0N	68:11:50.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E						
	Locus Input	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:16:31.8626 3N	68:02:25.9906 4E	42:12:09.2928 5N	70:00:02.8081 5E	-10.0	-12.0
	Output	42:01:21.0540 6N	69:48:40.1433 4E								
test15	Geodesic Input	41:47:17.8000 0N	68:11:50.6000 0E	41:47:17.8000 0N	69:12:34.7000 0E						
	Locus Input	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:34:48.3409 8N	67:31:15.9527 5E	42:29:04.5727 8N	69:31:40.1006 1E	-40.0	-39.0

	Output	41:47:21.7281 2N	68:46:38.5155 7E								
test16	Geodesic Input	41:47:17.8000 0N	67:11:50.6000 0E	39:36:04.5000 0N	69:26:41.2000 0E						
	Locus Input	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:16:31.8626 3N	68:02:25.9906 4E	42:09:38.2818 2N	70:04:13.7700 3E	-10.0	-8.0
	Output	40:37:49.7168 3N	68:24:40.0172 9E								
test17	Geodesic Input	41:47:17.8000 0N	68:31:50.6000 0E	39:34:35.8000 0N	68:31:50.6000 0E						
	Locus Input	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:07:20.4715 0N	68:17:54.7083 4E	42:03:20.0840 7N	70:14:39.7258 8E	5.0	2.0
	Output	40:21:38.9851 9N	68:31:50.6000 0E								
test18	Geodesic Input	41:47:17.8000 0N	68:41:50.6000 0E	40:10:24.5000 0N	68:12:45.6000 0E						
	Locus Input	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:16:31.8626 3N	68:02:25.9906 4E	42:07:44.9228 6N	70:07:21.7738 9E	-10.0	-5.0
	Output	40:31:50.2065 4N	68:19:04.0475 2E								
test19	Geodesic Input	38:47:17.8000 0N	68:11:50.6000 0E	42:04:35.8000 0N	69:12:34.7000 0E						
	Locus Input	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:59:32.7079 7N	70:20:54.3088 5E	40:04:16.2125 5N	68:23:03.3537 3E	-8.0	-10.0
	Output	40:21:27.3228 7N	68:40:03.9922 6E								
test20	Geodesic Input	38:47:17.8000 0N	69:11:50.6000 0E	41:36:04.5000 0N	69:11:50.6000 0E						
	Locus Input	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	42:01:26.4387 8N	70:17:47.1100 5E	40:07:57.2956 6N	68:16:52.9237 4E	-5.0	-4.0
	Output	41:00:37.2269 9N	69:11:50.6000 0E								
test21	Geodesic Input	39:47:17.8000 0N	69:11:50.6000 0E	41:10:24.5000 0N	68:12:45.6000 0E						
	Locus Input	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	42:00:48.5380 0N	70:18:49.5302 3E	40:01:11.7238 9N	68:28:11.5371 3E	-6.0	-15.0
	Output	40:22:24.9352 4N	68:47:13.1053 5E								
test22	Geodesic Input	38:47:17.8000 0N	72:11:50.6000 0E	40:05:17.8000 0N	69:11:50.6000 0E						
	Locus Input	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:39:14.3045 5N	70:53:59.6280 6E	39:44:31.5476 6N	68:55:47.7851 1E	-40.0	-42.0
	Output	40:03:55.5261 6N	69:15:09.8638 4E								
test23	Geodesic Input	39:47:17.8000 0N	72:11:50.6000 0E	39:47:17.8000 0N	68:11:50.6000 0E						
	Locus Input	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:42:25.3115 2N	70:48:50.7979 6E	39:44:31.5476 6N	68:55:47.7851 1E	-35.0	-42.0
	Output	39:47:56.9679	68:58:57.6908								

		8N	7E								
test24	Geodesic Input	41:47:17.8000 0N	72:01:50.6000 0E	40:15:17.8000 0N	69:01:50.6000 0E						
	Locus Input	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:45:36.0858 1N	70:43:41.4599 3E	39:50:42.7543 3N	68:45:35.9178 6E	-30.0	-32.0
	Output	40:24:52.2396 3N	69:19:46.8195 9E								
test25	Geodesic Input	40:32:17.8000 0S	69:31:50.6000 0W	39:45:35.8000 0S	68:32:34.7000 0W						
	Locus Input	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:47:14.9917 2S	70:17:56.7067 3W	39:37:07.2624 6S	68:43:14.9169 5W	-5.0	-30.0
	Output	40:15:45.4197 2S	69:10:37.4206 1W								
test26	Geodesic Input	40:12:17.8000 0S	69:11:50.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W						
	Locus Input	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:44:05.2480 5S	70:23:07.3045 6W	39:48:13.3652 7S	68:24:52.7554 6W	-10.0	-12.0
	Output	40:03:21.1648 3S	68:39:49.2081 5W								
test27	Geodesic Input	40:12:17.8000 0S	69:11:50.6000 0W	40:12:17.8000 0S	65:12:34.7000 0W						
	Locus Input	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:40:55.2698 1S	70:28:17.3946 4W	39:44:31.6564 9S	68:31:00.7972 1W	-15.0	-18.0
	Output	40:12:30.9062 6S	68:58:24.7194 6W								
test28	Geodesic Input	40:12:17.8000 0S	69:11:50.6000 0W	42:05:35.8000 0S	67:26:34.7000 0W						
	Locus Input	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:51:02.3733 4S	70:11:43.3174 9W	39:56:49.4111 6S	68:10:31.4344 2W	1.0	2.0
	Output	40:35:40.8131 3S	68:50:43.6999 6W								
test29	Geodesic Input	40:12:17.8000 0S	69:11:50.6000 0W	42:25:35.8000 0S	69:11:50.6000 0W						
	Locus Input	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:51:40.2372 3S	70:10:41.0145 6W	39:57:26.2029 9S	68:09:29.7741 1W	2.0	3.0
	Output	40:57:17.6228 9S	69:11:50.6000 0W								
test30	Geodesic Input	40:12:17.8000 0S	69:11:50.6000 0W	41:50:24.5000 0S	70:12:45.6000 0W						
	Locus Input	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:40:55.2698 1S	70:28:17.3946 4W	39:43:17.6810 7S	68:33:03.3321 3W	-15.0	-20.0
	Output	40:43:15.1312 0S	69:30:42.1630 9W								
test31	Geodesic Input	43:12:17.8000 0S	69:11:50.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W						
	Locus Input	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	39:58:39.7591 1S	68:07:26.3984 1W	41:51:40.2372 3S	70:10:41.0145 6W	-5.0	-2.0
	Output	40:06:31.2891 6S	68:15:42.7811 0W								

test32	Geodesic Input	43:12:17.8000 0S	69:11:50.6000 0W	40:55:35.8000 0S	69:11:50.6000 0W						
	Locus Input	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:00:30.0243 5S	68:04:21.1970 5W	41:54:49.4146 1S	70:05:29.1934 6W	-8.0	-7.0
	Output	41:05:16.1967 0S	69:11:50.6000 0W								
test33	Geodesic Input	42:12:17.8000 0S	69:11:50.6000 0W	40:50:24.5000 0S	70:12:45.6000 0W						
	Locus Input	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	39:48:13.3652 7S	68:24:52.7554 6W	41:44:05.2480 5S	70:23:07.3045 6W	12.0	10.0
	Output	41:16:14.1218 6S	69:53:51.9828 3W								
test34	Geodesic Input	42:12:17.8000 0S	69:11:50.6000 0W	40:45:17.5000 0S	72:11:50.6000 0W						
	Locus Input	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:13:56.0936 0S	67:41:37.9819 4W	42:06:08.4822 9S	69:46:42.3928 7W	-30.0	-25.0
	Output	41:59:37.9145 3S	69:39:10.9123 1W								
test35	Geodesic Input	42:12:17.8000 0S	69:11:50.6000 0W	42:12:17.8000 0S	72:11:50.6000 0W						
	Locus Input	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:20:00.9982 1S	67:31:15.3738 3W	42:14:16.9856 5S	69:33:04.4385 8W	-40.0	-38.0
	Output	42:12:31.3088 9S	69:31:07.4285 9W								
test36	Geodesic Input	40:12:17.8000 0S	67:11:50.6000 0W	41:30:17.8000 0S	70:11:50.6000 0W						
	Locus Input	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:01:06.7610 2S	68:03:19.4264 9W	41:55:27.2216 4S	70:04:26.7678 7W	-9.0	-8.0
	Output	41:03:44.0940 8S	69:08:30.8154 4W								
test37	Geodesic Input	40:42:17.8000 0S	68:11:50.6000 0E	39:52:35.8000 0S	69:12:34.7000 0E						
	Locus Input	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:25:04.6826 4S	67:31:27.8664 2E	39:30:21.5500 1S	69:30:40.9995 3E	-40.0	-41.0
	Output	40:15:33.0873 5S	68:44:47.5589 1E								
test38	Geodesic Input	40:12:17.8000 0S	68:11:50.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E						
	Locus Input	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:49:27.8779 9S	70:02:18.7824 2E	-15.0	-10.0
	Output	39:58:31.8412 8S	69:52:29.2974 2E								
test39	Geodesic Input	40:12:17.8000 0S	68:11:50.6000 0E	40:12:17.8000 0S	72:12:34.7000 0E						
	Locus Input	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:47:15.3430 2S	68:07:34.1112 6E	39:51:18.3506 3S	70:05:23.3657 7E	-5.0	-7.0
	Output	40:13:16.8917 9S	69:43:44.0319 0E								
test40	Geodesic Input	38:01:17.8000	68:11:50.6000	40:12:17.8000	69:56:34.7000						

	ic Input	OS	OE	OS	OE						
	Locus Input	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:44:32.8834 3S	69:54:07.3624 3E	-15.0	-18.0
	Output	39:55:56.2019 9S	69:43:03.9371 8E								
test41	Geodesic Input	38:01:17.8000 0S	69:11:50.6000 0E	41:12:17.8000 0S	69:11:50.6000 0E						
	Locus Input	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:43:19.0439 4S	69:52:04.6894 3E	-15.0	-20.0
	Output	40:25:31.9506 2S	69:11:50.6000 0E								
test42	Geodesic Input	38:01:17.8000 0S	69:11:50.6000 0E	41:50:24.5000 0S	68:12:45.6000 0E						
	Locus Input	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:44:32.8834 3S	69:54:07.3624 3E	-15.0	-18.0
	Output	41:17:14.5926 9S	68:21:44.5433 8E								
test43	Geodesic Input	43:29:17.8000 0S	68:11:50.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E						
	Locus Input	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:10:51.5757 9S	70:38:22.5258 4E	42:09:14.4414 0S	68:44:05.2763 0E	-25.0	-30.0
	Output	41:34:33.3590 0S	69:18:28.6928 5E								
test44	Geodesic Input	42:29:17.8000 0S	69:11:50.6000 0E	38:55:35.8000 0S	68:11:50.6000 0E						
	Locus Input	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:00:29.4769 5S	70:20:48.7528 2E	41:56:04.3853 8S	68:22:07.5649 9E	-8.0	-9.0
	Output	41:26:23.0050 8S	68:53:29.0887 3E								
test45	Geodesic Input	42:29:17.8000 0S	69:11:50.6000 0E	40:50:24.5000 0S	68:12:45.6000 0E						
	Locus Input	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	39:57:25.9978 7S	70:15:39.8321 9E	41:53:33.4202 2S	68:17:57.5984 6E	-3.0	-5.0
	Output	41:34:00.9006 6S	68:38:24.2439 6E								
test46	Geodesic Input	40:29:17.8000 0S	70:11:50.6000 0E	38:45:07.5000 0S	67:11:50.6000 0E						
	Locus Input	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	39:58:02.7121 0S	70:16:41.5796 0E	41:52:17.8805 9S	68:15:52.7378 4E	-4.0	-3.0
	Output	40:19:41.2420 9S	69:54:30.1130 8E								

WGS84LocusArcIntersect Test Results

Test Identifier	Locus Inputs	Locus Geodesic Start Latitude	Locus Geodesic Start Longitude	Locus Geodesic End Latitude	Locus Geodesic End Longitude	Locus Start Latitude	Locus Start Longitude	Locus End Latitude	Locus End Longitude	Locus Start Distance	Locus End Distance
	Arc Inputs	Arc Center Latitude	Arc Center Longitude	Arc Radius							
	Outputs	Intersection 1 Latitude	Intersection 1 Longitude	Intersection 2 Latitude	Intersection 2 Longitude						
test1	LocusInputs	40:04:35.8000 0N	67:12:40.7000 0W	44:59:45.9208 8N	68:26:00.2113 7W	39:56:32.2458 3N	68:10:17.8928 7W	44:49:00.821 97N	69:41:53.8588 0W	-45.0	-55.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	41:16:20.9748 3N	68:33:49.6470 6W	N/A	N/A						
test2	LocusInputs	40:04:35.8000 0N	67:12:40.7000 0W	35:21:11.7476 2N	69:17:59.1245 0W	40:19:46.7625 7N	68:07:58.2868 6W	35:38:35.678 60N	70:21:53.8095 3W	45.0	55.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	38:52:37.3211 0N	68:51:25.9239 8W	N/A	N/A						
test3	LocusInputs	40:04:35.8000 0N	68:12:40.7000 0W	44:06:29.0814 5N	72:11:23.8327 9W	40:10:19.7105 4N	68:01:59.5268 0W	44:15:37.901 40N	71:54:52.5090 7W	10.0	15.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	40:10:40.4839 2N	68:02:17.7464 3W	41:44:11.1114 4N	69:26:43.2997 3W						
test4	LocusInputs	40:04:35.8000 0N	67:12:40.7000 0W	39:53:37.8685 2N	73:42:48.0144 0W	39:24:33.8481 0N	67:12:40.7000 0W	39:13:42.172 01N	73:39:02.8520 8W	-40.0	-40.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	39:24:15.4516 0N	68:17:38.6312 6W	39:18:24.7960 5N	72:03:32.0122 7W						
test5	LocusInputs	40:04:35.8000 0N	67:12:40.7000 0W	42:25:59.2966 6N	73:03:41.4214 0W	39:47:15.0303 5N	67:25:39.0489 4W	42:03:31.246 36N	73:18:28.5544 1W	-20.0	-25.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	40:02:54.5608 6N	68:02:47.1264 1W	41:27:12.3325 5N	71:37:11.7522 3W						
test6	LocusInputs	40:04:35.8000 0N	67:12:40.7000 0W	37:26:38.4937 4N	72:39:00.0419 7W	40:24:30.8080 2N	67:27:43.9750 8W	37:47:30.860 22N	72:56:21.9550 9W	23.0	25.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	40:09:14.2959 5N	68:02:19.6287 9W	38:40:57.6987 7N	71:10:40.2263 3W						
test7	LocusInputs	42:54:35.8000 0N	70:11:34.7000 0W	37:54:23.2544 9N	70:11:34.7000 0W	42:54:34.6354 6N	69:55:14.9526 5W	37:54:22.705 15N	70:00:12.3933 1W	-12.0	-9.0
	Arclnputs	40:10:24.5000	70:12:45.6000	100.0							

		0N	0W								
	Outputs	41:49:41.8125 3N	69:56:23.6694 5W	38:30:50.3527 2N	69:59:38.8532 8W						
test8	LocusInp uts	42:54:35.8000 0N	70:11:34.7000 0W	38:36:54.7497 0N	66:48:53.1121 0W	42:45:33.4587 9N	70:31:08.9200 1W	38:25:55.700 18N	67:13:10.9719 1W	17.0	22.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	41:48:11.2142 8N	69:44:43.2787 9W	39:41:58.4778 9N	68:08:06.4480 2W						
test9	LocusInp uts	42:54:35.8000 0N	70:11:34.7000 0W	38:34:20.9298 5N	73:28:27.3739 7W	42:47:21.8889 5N	69:55:16.8235 1W	38:30:28.695 75N	73:19:31.7971 7W	-14.0	-8.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	41:47:15.3317 5N	70:45:57.1355 6W	39:49:26.3001 6N	72:19:59.9361 4W						
test10	LocusInp uts	40:24:35.8000 0N	75:11:34.7000 0W	40:13:30.1326 0N	68:39:33.2928 9W	40:09:35.1524 9N	75:11:34.7000 0W	39:53:32.477 81N	68:41:28.2940 0W	15.0	20.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	40:05:22.1852 8N	72:22:58.4868 8W	N/A	N/A						
test11	LocusInp uts	40:24:35.8000 0N	75:11:34.7000 0W	41:52:02.6308 8N	68:51:37.8257 1W	40:17:01.5793 1N	75:08:10.5002 1W	41:46:14.448 89N	68:49:34.6745 8W	8.0	
	Arclnputs	6.0	40:10:24.5000 0N								
	Outputs	70:12:45.6000 0W	100.0	41:03:30.8815 9N	72:04:03.6671 7W	41:40:47.0691 6N	69:16:07.9330 3W				
test12	LocusInp uts	40:24:35.8000 0N	75:11:34.7000 0W	37:59:52.6040 3N	69:33:17.7337 1W	40:34:24.0808 0N	75:05:01.4892 4W	38:11:04.655 06N	69:24:54.6459 8W	-11.0	-13.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	39:22:31.1091 7N	72:06:39.1575 8W	38:30:24.5213 7N	70:07:20.1753 1W						
test13	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0W	42:09:50.6694 2N	70:21:34.7000 0W	37:09:34.1097 3N	70:01:33.7441 6W	42:09:49.715 95N	70:06:47.2225 4W	16.0	11.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	38:30:36.7511 3N	70:02:54.7744 7W	41:50:21.1627 0N	70:06:25.6778 3W						
test14	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0W	41:15:08.9818 0N	66:39:17.4351 8W	37:14:37.7729 8N	70:30:55.3685 5W	41:19:17.778 92N	66:46:46.4276 2W	-9.0	-7.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	38:40:34.8682 1N	69:15:50.3909 0W	39:59:51.9250 0N	68:03:11.5422 7W						
test15	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0W	41:29:39.4876 1N	73:34:58.7850 0W	37:15:24.5696 0N	70:08:25.9039 6W	41:34:48.499 58N	73:23:33.8085 4W	12.0	10.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							

	Outputs	38:40:27.4572 7N	71:09:21.2458 7W	40:18:13.2691 4N	72:22:56.8090 3W						
test16	LocusInputs	40:04:35.8000 0N	73:12:40.7000 0E	44:59:45.9208 8N	71:59:21.1886 3E	39:48:00.1582 7N	71:17:40.2047 2E	44:43:50.982 19N	70:09:07.2484 8E	-90.0	-80.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	41:46:00.6833 6N	70:51:43.5240 2E	N/A	N/A						
test17	LocusInputs	40:04:35.8000 0N	73:12:40.7000 0E	35:21:11.7476 2N	71:07:22.2755 0E	40:36:07.6515 1N	71:15:28.1772 7E	35:49:22.227 73N	69:22:33.0676 0E	95.0	90.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:30:43.2022 6N	70:24:16.3655 8E	N/A	N/A						
test18	LocusInputs	40:04:35.8000 0N	72:12:40.7000 0E	43:30:53.4568 5N	67:21:10.0978 4E	40:14:29.4896 2N	72:25:36.3511 1E	43:49:30.216 72N	67:44:10.0992 6E	14.0	25.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	40:16:35.4902 3N	72:23:04.1901 2E	41:49:56.0391 3N	70:26:23.1796 2E						
test19	LocusInputs	40:04:35.8000 0N	73:12:40.7000 0E	39:53:37.8685 2N	66:42:33.3856 0E	39:32:34.2606 2N	73:12:40.7000 0E	39:28:40.604 61N	66:44:54.6155 0E	-32.0	-25.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	39:33:23.2077 9N	72:13:25.3583 8E	39:31:28.7112 4N	68:13:08.4293 0E						
test20	LocusInputs	40:04:35.8000 0N	73:12:40.7000 0E	42:25:59.2966 6N	67:21:39.9786 0E	39:55:03.5626 8N	73:05:31.7978 6E	42:17:00.316 04N	67:15:43.8652 9E	-11.0	-10.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	40:13:44.9057 2N	72:23:12.0645 1E	41:35:55.7136 9N	69:04:18.2553 8E						
test21	LocusInputs	40:04:35.8000 0N	73:12:40.7000 0E	37:26:38.4937 4N	67:46:21.3580 3E	40:15:51.4884 9N	73:04:11.2378 5E	37:39:10.229 38N	67:35:57.3759 9E	13.0	15.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	39:57:08.5482 8N	72:21:51.6052 7E	38:36:13.7012 4N	69:29:05.9172 8E						
test22	LocusInputs	42:54:35.8000 0N	70:11:34.7000 0E	37:54:23.2544 9N	70:11:34.7000 0E	42:54:17.1683 4N	71:16:53.4845 0E	37:54:09.521 52N	71:08:26.1207 5E	-48.0	-45.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	41:38:47.5615 0N	71:14:35.8700 8E	38:40:33.8191 8N	71:09:38.0482 7E						
test23	LocusInputs	42:54:35.8000 0N	70:11:34.7000 0E	38:36:54.7497 8N	73:34:16.2879 0E	42:45:33.4587 9N	69:52:00.4799 9E	38:26:55.822 63N	73:12:10.6557 4E	17.0	20.0
	ArclInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	41:48:29.4306	70:38:53.2169	39:41:45.9624	72:17:19.7266						

test24	LocusInp uts	42:54:35.8000 0N	70:11:34.7000 0E	38:34:20.9298 5N	66:54:42.0260 3E	42:46:50.8063 2N	70:29:02.2793 8E	38:26:06.617 68N	67:13:38.9838 6E	-15.0	-17.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	41:47:43.4019 6N	69:42:02.5004 1E	39:42:31.1481 6N	68:07:53.5097 7E						
test25	LocusInp uts	40:24:35.8000 0N	65:11:34.7000 0E	40:13:30.1326 0N	71:43:36.1071 1E	39:57:34.6063 8N	65:11:34.7000 0E	39:41:33.836 75N	71:40:32.6380 2E	27.0	32.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	39:53:11.0887 5N	68:04:30.9394 0E	N/A	N/A						
test26	LocusInp uts	40:24:35.8000 0N	65:11:34.7000 0E	41:52:02.6308 8N	71:31:31.5742 9E	40:13:14.4277 8N	65:16:40.7150 7E	41:41:24.264 79N	71:35:17.0690 7E	12.0	11.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	40:58:28.4060 6N	68:17:39.1668 3E	41:37:44.2769 8N	71:17:08.4632 2E						
test27	LocusInp uts	40:24:35.8000 0N	65:11:34.7000 0E	37:59:52.6040 3N	70:49:51.6662 9E	40:38:51.3523 9N	65:21:07.2755 6E	38:11:56.325 57N	70:58:53.5592 9E	-16.0	-14.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	39:25:51.8708 6N	68:16:33.7600 2E	38:30:27.4268 2N	70:19:30.2173 2E						
test28	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0E	42:09:50.6694 2N	70:21:34.7000 0E	37:09:12.0321 4N	71:36:38.0418 9E	42:09:20.381 91N	71:44:56.4178 6E	60.0	62.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:56:06.4922 9N	71:39:23.3095 9E	41:22:52.7168 1N	71:43:31.9281 9E						
test29	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0E	41:24:05.8131 5N	73:46:45.5983 0E	37:14:44.7226 5N	70:10:50.5808 7E	41:28:28.203 39N	73:37:51.0786 4E	-10.0	-8.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:45:47.1679 3N	71:21:43.1653 7E	40:00:12.6274 2N	72:22:22.7926 6E						
test30	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0E	41:29:39.4876 1N	67:08:10.6150 0E	37:17:49.4571 8N	70:40:12.7566 2E	41:37:22.578 04N	67:25:18.7593 8E	17.0	15.0
	Arclnputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:32:19.4432 9N	69:47:05.3648 1E	40:42:42.1017 9N	68:08:47.2353 3E						
test31	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	35:08:30.4250 8S	72:09:14.0235 6E	40:07:30.9990 7S	72:50:51.1749 2E	35:11:43.385 67S	71:45:09.3074 1E	-17.0	-20.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	N/A	N/A	N/A	N/A						
test32	LocusInp	40:04:35.8000	73:12:40.7000	44:45:10.4951	70:48:49.9031	39:47:12.8682	72:11:43.6127	44:24:55.275	69:38:47.3187	50.0	54.0

	uts	0S	0E	9S	2E	3S	1E	06S	9E		
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	41:39:29.0062 7S	71:12:51.3478 2E	N/A	N/A						
test33	LocusInp uts	40:04:35.8000 0S	72:12:40.7000 0E	36:27:08.3818 2S	67:49:48.4732 3E	40:05:18.2547 6S	72:11:45.4206 7E	36:28:29.216 23S	67:47:58.3980 9E	-1.0	-2.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:30:19.5107 2S	70:11:27.2805 5E	N/A	N/A						
test34	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	39:53:37.8685 2S	66:42:33.3856 0E	39:09:33.0448 3S	73:12:40.7000 0E	39:08:42.682 17S	66:46:46.3932 7E	55.0	45.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	39:11:05.7225 7S	71:57:05.4938 2E	39:11:02.2519 3S	68:28:29.0564 6E						
test35	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	37:26:38.4937 4S	67:46:21.3580 3E	40:15:51.4884 9S	73:04:11.2378 5E	37:36:39.957 75S	67:38:02.4512 4E	-13.0	-12.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	39:56:39.8330 7S	72:21:46.0648 1E	38:35:25.4801 4S	69:32:05.8006 5E						
test36	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	42:25:59.2966 6S	67:21:39.9786 0E	39:48:07.1044 4S	73:00:21.1133 6E	42:10:42.839 13S	67:11:35.5881 6E	19.0	17.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	40:04:47.0450 2S	72:22:55.4861 7E	41:31:16.7205 9S	68:55:09.2053 0E						
test37	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0E	43:04:47.8144 1S	70:11:34.7000 0E	38:04:34.4626 3S	70:29:18.5182 4E	43:04:45.463 40S	70:34:46.5016 0E	-14.0	-17.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:31:11.6240 1S	70:29:45.3465 2E	41:49:14.9963 0S	70:33:18.3380 7E						
test38	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0E	42:16:02.9504 1S	73:45:33.8554 4E	38:24:06.7176 1S	69:31:39.7345 5E	42:32:52.832 50S	73:12:02.2158 0E	37.0	30.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:33:41.5692 4S	69:39:34.0270 9E	41:11:49.9870 5S	71:56:32.1518 8E						
test39	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0E	42:18:57.4280 8S	66:43:26.9596 8E	38:15:23.2324 3S	70:34:25.8761 4E	42:27:09.694 05S	67:00:23.7756 2E	-21.0	-15.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:30:35.9106 6S	70:22:22.1225 5E	40:59:38.8952 1S	68:18:29.6020 1E						
test40	LocusInp uts	40:24:35.8000 0S	65:51:34.7000 0E	40:13:30.1326 0S	72:23:36.1071 1E	41:39:38.4501 7S	65:51:34.7000 0E	41:23:21.122 81S	72:30:27.6781 5E	75.0	70.0

	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	41:34:42.1110 6S	69:01:43.3183 3E	41:26:48.1377 9S	71:37:49.3828 9E						
test41	LocusInp uts	40:24:35.8000 0S	65:51:34.7000 0E	38:37:15.5353 8S	71:53:43.6411 6E	40:27:26.1043 2S	65:52:51.4715 7E	38:39:06.230 77S	71:54:43.1077 3E	3.0	
	Arclnputs	2.0	40:10:24.5000 0S								
	Outputs	70:12:45.6000 0E	100.0	39:50:38.6690 8S	68:05:10.5848 0E	38:48:21.6506 9S	71:26:44.4188 8E				
test42	LocusInp uts	40:24:35.8000 0S	65:51:34.7000 0E	42:31:36.1455 2S	71:53:17.5828 3E	40:22:48.7982 3S	65:52:45.9883 8E	42:30:40.897 88S	71:53:49.2875 8E	-2.0	-1.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	41:30:04.0142 3S	68:53:01.2773 2E	41:48:16.7975 5S	69:45:17.5474 1E						
test43	LocusInp uts	43:09:35.8000 0S	70:21:34.7000 0E	38:09:24.0356 7S	70:21:34.7000 0E	43:09:34.9842 3S	70:35:14.4778 9E	38:09:23.481 39S	70:32:59.3315 8E	10.0	
	Arclnputs	9.0	40:10:24.5000 0S	70:12:45.6000 0E							
	Outputs	100.0	41:49:05.4784 7S	70:34:35.6215 4E	38:31:34.7265 0S	70:33:08.4696 7E					
test44	LocusInp uts	42:09:35.8000 0S	70:21:34.7000 0E	37:57:18.9334 8S	73:53:33.1311 0E	42:09:02.2298 1S	70:20:27.8274 2E	37:56:47.343 14S	73:52:28.6114 7E	-1.0	-1.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	41:48:28.5019 9S	70:38:59.2761 8E	39:50:56.9292 4S	72:20:25.6434 0E						
test45	LocusInp uts	43:09:35.8000 0S	70:21:34.7000 0E	38:35:33.3063 6S	67:40:00.7556 4E	43:11:17.1429 0S	70:16:37.3742 6E	38:36:20.673 40S	67:37:40.0887 8E	-4.0	-2.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	41:43:03.8495 0S	69:22:56.0764 5E	39:36:34.4286 3S	68:10:29.0862 3E						
test46	LocusInp uts	40:04:35.8000 0S	67:12:40.7000 0W	35:08:30.4250 8S	68:16:07.3764 4W	40:11:50.9765 8S	68:07:56.5874 8W	35:15:37.841 00S	69:10:20.6204 3W	-43.0	-45.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	39:22:25.6380 7S	68:18:55.9855 9W	N/A	N/A						
test47	LocusInp uts	40:04:35.8000 0S	67:12:40.7000 0W	44:45:10.4951 9S	69:36:31.4968 8W	39:48:58.6020 3S	68:07:33.4683 6W	44:28:43.554 20S	70:33:39.4991 9W	45.0	44.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	41:33:34.0401 0S	68:59:26.8628 6W	N/A	N/A						
test48	LocusInp uts	40:04:35.8000 0S	68:12:40.7000 0W	36:27:08.3818 2S	72:35:32.9267 7W	39:55:23.2157 5S	68:00:43.7999 1W	36:19:43.284 47S	72:25:28.6458 3W	13.0	11.0
	Arclnputs	40:10:24.5000	70:12:45.6000	100.0							

		0S	0W								
	Outputs	39:52:21.9892 9S	68:04:43.1350 5W	38:32:16.8257 1S	69:47:22.0623 3W						
test49	LocusInp uts	40:04:35.8000 0S	67:12:40.7000 0W	39:53:37.8685 2S	73:42:48.0144 0W	39:52:35.2435 1S	67:12:40.7000 0W	39:43:38.981 59S	73:41:51.3189 0W	12.0	10.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	39:52:39.5690 3S	68:04:38.7058 4W	39:47:22.4378 0S	72:19:21.7385 6W						
test50	LocusInp uts	40:04:35.8000 0S	67:12:40.7000 0W	37:26:38.4937 4S	72:39:00.0419 7W	40:12:23.6530 5S	67:18:33.1054 1W	37:33:19.536 73S	72:44:32.3991 0W	-9.0	-8.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	39:51:22.1708 7S	68:04:58.7312 4W	38:33:52.8622 5S	70:46:51.0549 5W						
test51	LocusInp uts	40:04:35.8000 0S	67:12:40.7000 0W	42:25:59.2966 6S	73:03:41.4214 0W	39:54:11.5185 1S	67:20:28.4948 1W	42:17:54.228 55S	73:09:01.9993 6W	12.0	
	Arclnputs	9.0	40:10:24.5000 0S	70:12:45.6000 0W							
	Outputs	100.0	40:12:56.7452 6S	68:02:18.0598 0W	41:36:12.1797 0S	71:20:37.1459 8W					
test52	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0W	43:04:47.8144 1S	70:11:34.7000 0W	38:04:33.8280 6S	70:33:06.4772 2W	43:04:45.984 03S	70:32:02.7621 6W	17.0	15.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	38:31:33.7683 5S	70:33:00.7342 1W	41:49:21.9263 0S	70:32:18.7801 8W						
test53	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0W	42:16:02.9504 1S	66:37:35.5445 6W	38:08:18.3689 2S	70:19:06.1664 2W	42:18:51.947 05S	66:43:09.5742 2W	7.0	
	Arclnputs	5.0	40:10:24.5000 0S								
	Outputs	70:12:45.6000 0W	100.0	38:30:44.0931 5S	70:01:02.1551 2W	40:43:33.7987 1S	68:09:09.8591 4W				
test54	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0W	42:18:57.4280 8S	73:39:42.4403 2W	38:11:17.1184 4S	69:57:26.6712 6W	42:24:58.669 38S	73:27:17.2069 4W	-13.0	-11.0
	Arclnputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	38:30:19.2704 6S	70:12:08.8825 1W	40:55:39.9262 8S	72:09:46.0694 1W						
test55	LocusInp uts	40:24:35.8000 0S	74:11:34.7000 0W	40:13:30.1326 0S	67:39:33.2928 9W	40:31:36.0887 9S	74:11:34.7000 0W	40:18:29.530 53S	67:39:04.3669 0W	7.0	
	Arclnputs	5.0	40:10:24.5000 0S								
	Outputs	70:12:45.6000 0W	100.0	40:30:09.4866 7S	72:20:57.9109 9W	40:19:54.8752 3S	68:02:44.2857 5W				
test56	LocusInp uts	40:24:35.8000 0S	74:11:34.7000 0W	38:37:15.5353 8S	68:09:25.7588 4W	40:29:19.6318 8S	74:09:26.6875 4W	38:40:01.575 10S	68:07:56.5399 1W	5.0	
	Arclnputs	3.0	40:10:24.5000 0S								

	Outputs	70:12:45.6000 0W	100.0	39:59:27.5984 5S	72:22:15.8536 4W	38:53:50.9894 3S	68:49:29.9986 7W				
test57	LocusInputs	40:24:35.8000 0S	74:11:34.7000 0W	42:31:36.1455 2S	68:09:51.8171 7W	40:18:21.2380 9S	74:07:25.4644 6W	42:26:04.620 97S	68:06:41.8210 4W	-7.0	-6.0
	ArclInputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	41:05:49.4322 5S	72:02:08.1952 3W	41:49:47.0223 0S	69:57:20.4136 2W						
test58	LocusInputs	43:09:35.8000 0S	70:21:34.7000 0W	38:09:24.0356 7S	70:21:34.7000 0W	43:09:34.6253 0S	70:05:10.9676 0W	38:09:23.351 38S	70:08:53.9985 0W	12.0	10.0
	ArclInputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	41:50:20.7257 3S	70:06:13.8396 6W	38:30:22.2401 6S	70:08:39.6534 0W						
test59	LocusInputs	43:09:35.8000 0S	70:21:34.7000 0W	38:57:14.6046 1S	66:46:39.4688 2W	43:06:47.8649 6S	70:27:14.2560 0W	38:55:40.030 26S	66:49:55.8331 7W	-5.0	-3.0
	ArclInputs	40:10:24.5000 0S	70:12:45.6000 0W	100.0							
	Outputs	41:36:12.3850 7S	69:04:54.5032 6W	40:25:02.1678 4S	68:03:28.1370 5W						
test60	LocusInputs	43:09:35.8000 0S	70:21:34.7000 0W	38:44:26.1773 4S	73:27:19.4204 0W	43:06:11.8293 0S	70:13:13.2659 7W	38:42:09.850 51S	73:21:37.8696 1W	7.0	
	ArclInputs	5.0	40:10:24.5000 0S								
	Outputs	70:12:45.6000 0W	100.0	41:36:07.2264 7S	71:20:47.9604 4W	40:08:27.7810 7S	72:23:09.8858 2W				
test61	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:55:05.0078 2N	70:51:34.0000 0W	42:55:01.772 59N	70:24:20.8836 8W	-0.5	-0.5
	ArclInputs	42:54:35.0000 0N	70:51:34.0000 0W								
	Outputs	1.0	42:55:05.0017 5N	70:50:23.2833 0W	N/A	N/A					
test62	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:55:05.0078 2N	70:51:34.0000 0W	42:55:01.772 59N	70:24:20.8836 8W	-0.5	-0.5
	ArclInputs	42:54:35.0000 0N	70:50:14.0000 0W								
	Outputs	1.0	42:55:05.0077 1N	70:51:24.7120 1W	42:55:04.9802 6N	70:49:03.2664 4W					
test63	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:55:35.0155 9N	70:51:34.0000 0W	42:55:31.779 93N	70:24:20.6635 6W	-1.0	-1.0
	ArclInputs	42:55:35.0000 0N	70:48:52.0000 0W								
	Outputs	1.0	42:55:35.0077 6N	70:50:13.6676 1W	42:55:34.9435 8N	70:47:30.3324 4W					
test64	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:52:34.9683 0N	70:51:34.0000 0W	42:52:31.735 23N	70:24:21.9833 6W	2.0	
	ArclInputs	2.0	42:53:05.0000 0N								
	Outputs	70:47:32.0000	1.5	42:52:34.9488	70:49:27.3891	42:52:34.8133	70:45:36.6763				

		0W		4N	4W	2N	2W				
test65	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:57:35.0462 4N	70:51:34.0000 0W	42:57:31.808 85N	70:24:19.7825 1W	-3.0	-3.0
	ArclInputs	42:56:35.0000 0N	70:46:12.0000 0W								
	Outputs	1.0	42:57:34.9240 4N	70:46:16.5022 7W	42:57:34.9168 7N	70:46:07.3243 2W					
test66	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:50:34.9359 0N	70:51:34.0000 0W	42:50:31.704 55N	70:24:22.8620 5W	4.0	
	ArclInputs	4.0	42:51:35.0000 0N								
	Outputs	70:44:52.0000 0W	1.5	42:50:34.8184 3N	70:46:22.9951 5W	42:50:34.6409 8N	70:43:21.2222 5W				
test67	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:59:35.0761 8N	70:51:34.0000 0W	42:59:31.837 07N	70:24:18.9005 0W	-5.0	-5.0
	ArclInputs	42:58:35.0000 0N	70:43:32.0000 0W								
	Outputs	2.0	42:59:34.9358 4N	70:45:53.6482 1W	42:59:34.6045 8N	70:41:10.0928 1W					
test68	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:48:34.9027 9N	70:51:34.0000 0W	42:48:31.673 17N	70:24:23.7397 8W	6.0	
	ArclInputs	6.0	42:49:35.0000 0N								
	Outputs	70:42:12.0000 0W	1.5	42:48:34.6329 0N	70:43:42.7194 9W	42:48:34.3855 6N	70:40:41.5853 8W				
test69	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	43:01:35.1054 3N	70:51:34.0000 0W	43:01:31.864 59N	70:24:18.0175 4W	-7.0	-7.0
	ArclInputs	43:00:05.0000 0N	70:43:32.0000 0W								
	Outputs	2.0	43:01:34.9363 5N	70:45:20.3213 4W	43:01:34.6829 1N	70:41:43.2892 1W					
test70	LocusInputs	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:46:34.8689 9N	70:51:34.0000 0W	42:46:31.641 08N	70:24:24.6165 8W	8.0	
	ArclInputs	8.0	42:47:35.0000 0N								
	Outputs	70:42:12.0000 0W	1.5	42:46:34.5988 4N	70:43:42.6294 2W	42:46:34.3516 2N	70:40:41.6754 5W				

WGS84LocusIntersect Test Results

Test Identifier	Locus 1 Input s	Locus 1 Geodesic Start Latitude	Locus 1 Geodesic Start Longitude	Locus 1 Geodesic End Latitude	Locus 1 Geodesic End Longitude	Locus 1 Start Latitude	Locus 1 Start Longitude	Locus 1 End Latitude	Locus 1 End Longitude	Locus 1 Start Distance	Locus 1 End Distance
	Locus 2 Input s	Locus 2 Geodesic Start Latitude	Locus 2 Geodesic Start Longitude	Locus 2 Geodesic End Latitude	Locus 2 Geodesic End Longitude	Locus 2 Start Latitude	Locus 2 Start Longitude	Locus 2 End Latitude	Locus 2 End Longitude	Locus 2 Start Distance	Locus 2 End Distance
	Output	Intersection Latitude	Intersection Longitude								
test1	Locus 1 Input s	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:34:51.0899 7N	70:54:12.4935 8W	42:29:44.8698 0N	68:54:29.5954 1W	-40.0	-40.0
	Locus 2 Input s	43:47:17.8000 0N	69:11:50.6000 0W	39:34:35.8000 0N	69:12:34.7000 0W	43:47:17.1676 6N	69:39:27.2347 9W	39:34:35.4551 7N	69:38:26.6752 8W	20.0	20.0
	Output	41:48:06.5241 6N	69:38:56.6040 0W								
test2	Locus 1 Input s	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:16:32.5468 3N	70:23:04.5187 6W	42:10:54.5106 7N	68:23:00.3023 2W	-10.0	-10.0
	Locus 2 Input s	41:47:17.8000 0N	69:11:50.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	41:37:59.8802 5N	69:06:54.9891 8W	41:55:15.3956 3N	68:07:46.3891 7W	10.0	10.0
	Output	41:41:38.5201 9N	68:54:37.0039 0W								
test3	Locus 1 Input s	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:01:10.7013 8N	69:57:20.7013 2W	41:58:16.1381 7N	68:02:11.1632 1W	15.0	10.0
	Locus 2 Input s	41:47:17.8000 0N	69:11:50.6000 0W	41:47:17.8000 0N	65:12:34.7000 0W	41:37:17.6777 5N	69:11:32.0456 2W	41:32:17.6097 7N	65:13:02.4957 5W	10.0	15.0
	Output	41:36:57.4329 2N	68:23:48.5601 0W								
test4	Locus 1 Input s	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:03:01.6262 4N	70:00:25.3480 4W	41:53:11.7282 8N	67:53:53.8147 1W	12.0	18.0
	Locus 2 Input s	41:47:17.8000 0N	69:11:50.6000 0W	39:36:04.5000 0N	67:26:41.2000 0W	41:52:34.9417 4N	69:00:29.1444 3W	39:42:12.8489 4N	67:13:19.9927 3W	-10.0	-12.0

	Output	41:20:04.4625 8N	68:32:58.4065 5W								
test5	Locu s 1 Input s	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:17:46.0449 3N	70:25:08.5260 3W	42:10:54.5106 7N	68:23:00.3023 2W	-12.0	-10.0
	Locu s 2 Input s	41:47:17.8000 0N	69:11:50.6000 0W	39:36:04.5000 0N	69:11:50.6000 0W	41:47:16.0501 1N	68:51:47.4998 8W	39:36:03.6284 5N	68:57:36.7133 8W	-15.0	-11.0
	Output	41:44:55.2592 2N	68:51:53.9657 8W								
test6	Locu s 1 Input s	40:10:24.5000 0N	70:12:45.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	40:16:32.5468 3N	70:23:04.5187 6W	42:17:12.2636 1N	68:33:27.9794 9W	-10.0	-20.0
	Locu s 2 Input s	41:47:17.8000 0N	69:11:50.6000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:49:02.2422 2N	69:16:39.5521 7W	40:12:31.9150 0N	70:18:40.0683 8W	4.0	5.0
	Output	40:44:08.2182 5N	69:58:43.8293 7W								
test7	Locu s 1 Input s	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:58:16.1381 7N	68:02:11.1632 2W	40:01:10.7013 8N	69:57:20.7013 2W	-10.0	-15.0
	Locu s 2 Input s	38:47:17.8000 0N	69:11:50.6000 0W	42:04:35.8000 0N	68:12:34.7000 0W	38:50:20.0384 9N	69:29:19.7500 3W	42:09:21.4152 1N	68:40:03.6747 2W	-14.0	-21.0
	Output	41:03:48.9093 7N	68:56:49.9517 3W								
test8	Locu s 1 Input s	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	42:12:10.1380 9N	68:25:05.6714 7W	40:16:32.5468 3N	70:23:04.5187 6W	12.0	10.0
	Locu s 2 Input s	38:47:17.8000 0N	69:11:50.6000 0W	41:36:04.5000 0N	69:11:50.6000 0W	38:47:17.4570 7N	69:20:47.7572 6W	41:36:03.5650 7N	69:26:30.3233 2W	-7.0	-11.0
	Output	41:13:51.0104 3N	69:25:43.4742 2W								
test9	Locu s 1 Input s	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:55:44.0085 9N	67:58:02.3247 7W	40:04:15.5303 7N	70:02:28.5382 3W	-14.0	-10.0
	Locu s 2 Input s	38:47:17.8000 0N	69:11:50.6000 0W	40:10:24.5000 0N	70:12:45.6000 0W	38:59:28.6538 7N	68:43:52.4133 2W	40:20:21.2677 0N	69:50:05.4418 8W	25.0	20.0

	Output	40:17:45.1343 4N	69:47:54.6864 5W								
test10	Locu s 1 Input s	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:39:11.5109 4N	67:31:12.8528 1W	39:48:49.1084 0N	69:36:53.9576 0W	-40.0	-35.0
	Locu s 2 Input s	38:47:17.8000 0N	69:11:50.6000 0W	40:05:17.8000 0N	72:11:50.6000 0W	39:47:44.1723 0N	68:26:14.2059 5W	41:02:28.8540 6N	71:31:12.0259 2W	70.0	65.0
	Output	40:08:19.8280 5N	69:15:22.3249 8W								
test11	Locu s 1 Input s	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:35:59.9254 6N	67:26:04.9158 8W	39:39:30.5435 3N	69:21:38.7068 5W	-45.0	-50.0
	Locu s 2 Input s	38:47:17.8000 0N	68:31:50.6000 0W	38:47:17.8000 0N	72:11:50.6000 0W	40:22:21.4225 5N	68:29:21.1058 2W	40:07:20.9579 6N	72:13:56.0319 2W	95.0	80.0
	Output	40:21:46.0977 1N	68:40:43.7978 3W								
test12	Locu s 1 Input s	42:04:35.8000 0N	68:12:34.7000 0W	40:10:24.5000 0N	70:12:45.6000 0W	41:40:28.0804 1N	67:33:16.1694 9W	39:42:36.9560 7N	69:26:43.3345 6W	-38.0	-45.0
	Locu s 2 Input s	38:47:17.8000 0N	68:31:50.6000 0W	37:15:17.8000 0N	72:11:50.6000 0W	40:08:26.7293 9N	69:25:11.9334 6W	38:40:51.7713 9N	73:12:28.7597 3W	91.0	98.0
	Output	N/A	N/A								
test13	Locu s 1 Input s	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:34:48.3409 8N	67:31:15.9527 5E	42:30:56.9433 7N	69:28:29.9691 1E	-40.0	-42.0
	Locu s 2 Input s	41:47:17.8000 0N	68:11:50.6000 0E	42:34:35.8000 0N	69:12:34.7000 0E	41:17:38.5789 7N	68:53:19.8260 4E	42:03:10.5022 8N	69:56:00.7853 3E	43.0	45.0
	Output	N/A	N/A								
test14	Locu s 1 Input s	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:16:31.8626 3N	68:02:25.9906 4E	42:12:09.2928 5N	70:00:02.8081 5E	-10.0	-12.0
	Locu s 2 Input s	41:47:17.8000 0N	68:11:50.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	41:32:35.4823 1N	68:15:50.2484 6E	41:48:50.4711 7N	70:16:21.8070 9E	15.0	16.0

	Output	41:42:45.7526 0N	69:29:17.3042 9E								
test15	Locu s 1 Input s	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:34:48.3409 8N	67:31:15.9527 5E	42:29:04.5727 8N	69:31:40.1006 1E	-40.0	-39.0
	Locu s 2 Input s	41:47:17.8000 0N	68:11:50.6000 0E	41:47:17.8000 0N	69:12:34.7000 0E	41:57:18.0553 9N	68:11:45.8662 9E	41:56:18.0306 4N	69:12:38.9592 3E	-10.0	-9.0
	Output	41:56:37.0676 2N	68:56:31.2985 6E								
test16	Locu s 1 Input s	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:16:31.8626 3N	68:02:25.9906 4E	42:09:38.2818 2N	70:04:13.7700 3E	-10.0	-8.0
	Locu s 2 Input s	41:47:17.8000 0N	67:11:50.6000 0E	39:36:04.5000 0N	69:26:41.2000 0E	41:50:25.6189 4N	67:17:03.5345 1E	39:39:42.6864 8N	69:32:52.0080 0E	-5.0	-6.0
	Output	40:42:15.6690 2N	68:29:20.0061 3E								
test17	Locu s 1 Input s	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:07:20.4715 0N	68:17:54.7083 4E	42:03:20.0840 7N	70:14:39.7258 8E	5.0	2.0
	Locu s 2 Input s	41:47:17.8000 0N	68:31:50.6000 0E	39:34:35.8000 0N	68:31:50.6000 0E	41:47:17.7922 2N	68:30:30.3929 2E	39:34:35.7352 3N	68:27:57.8038 0E	1.0	3.0
	Output	40:18:31.3117 1N	68:28:47.2260 9E								
test18	Locu s 1 Input s	40:10:24.5000 0N	68:12:45.6000 0E	42:04:35.8000 0N	70:12:34.7000 0E	40:16:31.8626 3N	68:02:25.9906 4E	42:07:44.9228 6N	70:07:21.7738 9E	-10.0	-5.0
	Locu s 2 Input s	41:47:17.8000 0N	68:41:50.6000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:46:10.2267 8N	68:48:21.2823 7E	40:09:05.3082 9N	68:20:23.6852 4E	-5.0	-6.0
	Output	40:41:23.8055 8N	68:29:32.6277 4E								
test19	Locu s 1 Input s	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:59:32.7079 7N	70:20:54.3088 5E	40:04:16.2125 5N	68:23:03.3537 3E	-8.0	-10.0
	Locu s 2 Input s	38:47:17.8000 0N	68:11:50.6000 0E	42:04:35.8000 0N	69:12:34.7000 0E	38:45:43.5422 8N	68:20:33.9873 4E	42:02:42.6772 7N	69:23:00.9583 2E	7.0	8.0

	Output	40:36:11.7226 0N	68:54:48.3960 6E								
test20	Locu s 1 Input s	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	42:01:26.4387 8N	70:17:47.1100 5E	40:07:57.2956 6N	68:16:52.9237 4E	-5.0	-4.0
	Locu s 2 Input s	38:47:17.8000 0N	69:11:50.6000 0E	41:36:04.5000 0N	69:11:50.6000 0E	38:47:17.7720 1N	69:14:24.0736 3E	41:36:04.4304 6N	69:15:50.5251 4E	2.0	3.0
	Output	41:04:06.9429 7N	69:15:33.5551 7E								
test21	Locu s 1 Input s	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	42:00:48.5380 0N	70:18:49.5302 3E	40:06:06.7955 3N	68:19:58.2220 0E	-6.0	-7.0
	Locu s 2 Input s	38:47:17.8000 0N	69:11:50.6000 0E	40:10:24.5000 0N	68:12:45.6000 0E	38:49:41.1280 2N	69:17:27.8536 1E	40:13:19.8610 3N	68:19:36.0001 8E	5.0	6.0
	Output	40:08:53.2734 3N	68:22:44.4858 7E								
test22	Locu s 1 Input s	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:39:14.3045 5N	70:53:59.6280 6E	39:48:51.4871 6N	68:48:39.6699 5E	-40.0	-35.0
	Locu s 2 Input s	38:47:17.8000 0N	72:11:50.6000 0E	40:05:17.8000 0N	69:11:50.6000 0E	39:00:16.4273 8N	72:21:30.4059 5E	40:27:19.1913 8N	69:27:20.3440 9E	15.0	25.0
	Output	40:26:06.2537 5N	69:29:53.1140 3E								
test23	Locu s 1 Input s	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:42:25.3115 2N	70:48:50.7979 6E	39:48:14.3800 2N	68:49:40.8840 6E	-35.0	-36.0
	Locu s 2 Input s	39:47:17.8000 0N	72:11:50.6000 0E	39:47:17.8000 0N	69:11:50.6000 0E	40:27:19.2540 3N	72:12:43.2781 0E	40:25:19.1880 8N	69:11:00.5804 2E	40.0	38.0
	Output	40:25:42.0926 1N	69:27:47.1856 7E								
test24	Locu s 1 Input s	42:04:35.8000 0N	70:12:34.7000 0E	40:10:24.5000 0N	68:12:45.6000 0E	41:45:36.0858 1N	70:43:41.4599 3E	39:50:42.7543 3N	68:45:35.9178 6E	-30.0	-32.0
	Locu s 2 Input s	41:47:17.8000 0N	72:11:50.6000 0E	40:15:17.8000 0N	69:11:50.6000 0E	42:14:05.9248 1N	71:48:22.0642 0E	40:42:18.3300 9N	68:46:57.6206 2E	32.0	33.0

	Output	41:38:45.6196 1N	70:36:24.0717 0E								
test25	Locu s 1 Input s	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:25:01.8880 7S	70:54:00.2690 1W	39:34:01.7159 5S	68:48:20.0298 8W	-40.0	-35.0
	Locu s 2 Input s	40:12:17.8000 0S	69:11:50.6000 0W	39:25:35.8000 0S	68:12:34.7000 0W	40:37:33.3002 7S	68:38:14.1693 6W	39:51:57.4501 1S	67:37:07.0531 6W	36.0	38.0
	Output	N/A	N/A								
test26	Locu s 1 Input s	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:44:05.2480 5S	70:23:07.3045 6W	39:48:13.3652 7S	68:24:52.7554 6W	-10.0	-12.0
	Locu s 2 Input s	40:12:17.8000 0S	69:11:50.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	40:07:35.3452 1S	69:14:03.2237 5W	39:49:58.2074 0S	68:15:18.0372 7W	-5.0	-6.0
	Output	39:54:52.2421 6S	68:31:25.5935 3W								
test27	Locu s 1 Input s	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:40:55.2698 1S	70:28:17.3946 4W	39:44:31.6564 9S	68:31:00.7972 1W	-15.0	-18.0
	Locu s 2 Input s	40:12:17.8000 0S	69:11:50.6000 0W	40:12:17.8000 0S	65:12:34.7000 0W	40:02:17.5025 4S	69:11:33.0485 9W	40:01:17.4718 0S	65:12:54.0018 4W	-10.0	-11.0
	Output	40:02:33.1706 0S	68:48:36.2281 2W								
test28	Locu s 1 Input s	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:51:02.3733 4S	70:11:43.3174 9W	39:56:49.4111 6S	68:10:31.4344 2W	1.0	2.0
	Locu s 2 Input s	40:12:17.8000 0S	69:11:50.6000 0W	42:05:35.8000 0S	67:26:34.7000 0W	40:10:35.7133 1S	69:08:37.0796 3W	42:03:15.7465 4S	67:22:12.9443 9W	-3.0	-4.0
	Output	40:33:04.1739 9S	68:47:59.7102 5W								
test29	Locu s 1 Input s	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:51:40.2372 3S	70:10:41.0145 6W	39:57:26.2029 9S	68:09:29.7741 1W	2.0	3.0
	Locu s 2 Input s	40:12:17.8000 0S	69:11:50.6000 0W	42:25:35.8000 0S	69:11:50.6000 0W	40:12:17.6822 8S	69:06:37.3581 3W	42:25:35.6011 9S	69:05:05.5212 9W	-4.0	-5.0

	Output	40:51:57.1088 3S	69:06:10.7401 3W								
test30	Locu s 1 Input s	41:50:24.5000 0S	70:12:45.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	41:40:55.2698 1S	70:28:17.3946 4W	39:43:17.6810 7S	68:33:03.3321 3W	-15.0	-20.0
	Locu s 2 Input s	40:12:17.8000 0S	69:11:50.6000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:11:27.3049 7S	69:14:12.6876 4W	41:49:06.8626 6S	70:16:22.8494 9W	2.0	3.0
	Output	40:52:52.4060 4S	69:40:09.5855 2W								
test31	Locu s 1 Input s	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	39:58:39.7591 1S	68:07:26.3984 1W	41:51:40.2372 3S	70:10:41.0145 6W	-5.0	-2.0
	Locu s 2 Input s	43:12:17.8000 0S	69:11:50.6000 0W	39:55:35.8000 0S	68:12:34.7000 0W	43:08:10.8260 4S	69:35:47.3723 5W	39:52:20.4527 2S	68:31:36.2910 2W	-18.0	-15.0
	Output	40:33:38.4360 3S	68:44:35.4019 6W								
test32	Locu s 1 Input s	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:00:30.0243 5S	68:04:21.1970 5W	41:54:49.4146 1S	70:05:29.1934 6W	-8.0	-7.0
	Locu s 2 Input s	43:12:17.8000 0S	69:11:50.6000 0W	40:55:35.8000 0S	69:11:50.6000 0W	43:12:17.5957 4S	69:05:00.4091 4W	40:55:35.5283 3S	69:03:55.6633 8W	5.0	6.0
	Output	40:57:49.8565 7S	69:03:56.6928 3W								
test33	Locu s 1 Input s	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:05:23.6594 1S	67:56:06.5168 1W	42:01:07.0566 0S	69:55:04.0151 7W	-16.0	-17.0
	Locu s 2 Input s	43:12:17.8000 0S	69:11:50.6000 0W	41:50:24.5000 0S	70:12:45.6000 0W	43:05:27.1130 0S	68:55:09.5575 6W	41:41:47.3066 4S	69:51:38.3996 3W	14.0	18.0
	Output	41:51:43.9270 2S	69:45:04.4481 8W								
test34	Locu s 1 Input s	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:32:07.9811 9S	67:10:24.5596 0W	42:24:53.3228 0S	69:15:09.5121 9W	-60.0	-55.0
	Locu s 2 Input s	43:12:17.8000 0S	69:11:50.6000 0W	41:45:17.5000 0S	72:11:50.6000 0W	42:12:48.7174 1S	68:21:45.1793 7W	40:42:57.9486 1S	71:16:28.5124 9W	70.0	75.0

	Output	42:00:18.1729 6S	68:47:07.7527 2W								
test35	Locu s 1 Input s	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:20:00.9982 1S	67:31:15.3738 3W	42:14:16.9856 5S	69:33:04.4385 8W	-40.0	-38.0
	Locu s 2 Input s	43:12:17.8000 0S	69:11:50.6000 0W	43:12:17.8000 0S	72:11:50.6000 0W	41:57:17.0731 2S	69:13:38.6955 8W	41:52:16.9886 5S	72:09:55.4492 2W	75.0	80.0
	Output	41:57:16.4355 7S	69:14:20.4102 2W								
test36	Locu s 1 Input s	39:55:35.8000 0S	68:12:34.7000 0W	41:50:24.5000 0S	70:12:45.6000 0W	40:50:11.2981 1S	66:38:54.2320 3W	42:51:30.1510 3S	68:29:23.5167 3W	-90.0	-98.0
	Locu s 2 Input s	41:12:17.8000 0S	67:11:50.6000 0W	42:30:17.8000 0S	70:11:50.6000 0W	40:07:50.5927 8S	68:02:20.2247 0W	41:21:13.0029 7S	71:02:42.7457 6W	75.0	78.8
	Output	N/A	N/A								
test37	Locu s 1 Input s	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:25:04.6826 4S	67:31:27.8664 2E	39:30:21.5500 1S	69:30:40.9995 3E	-40.0	-41.0
	Locu s 2 Input s	40:12:17.8000 0S	68:11:50.6000 0E	39:22:35.8000 0S	69:12:34.7000 0E	40:26:04.9362 1S	68:30:47.9679 6E	39:34:51.5879 8S	69:29:36.4934 0E	20.0	18.0
	Output	40:02:03.4349 8S	68:58:38.1547 4E								
test38	Locu s 1 Input s	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:49:27.8779 9S	70:02:18.7824 2E	-15.0	-10.0
	Locu s 2 Input s	40:12:17.8000 0S	68:11:50.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	40:10:19.3774 9S	68:11:24.6095 9E	39:52:38.8777 9S	70:11:50.6796 1E	-2.0	-3.0
	Output	39:55:03.7590 7S	69:56:15.2088 6E								
test39	Locu s 1 Input s	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:47:15.3430 2S	68:07:34.1112 6E	39:51:18.3506 3S	70:05:23.3657 7E	-5.0	-7.0
	Locu s 2 Input s	40:12:17.8000 0S	68:11:50.6000 0E	40:12:17.8000 0S	72:12:34.7000 0E	40:02:17.5044 0S	68:12:08.2592 7E	40:00:17.4431 1S	72:12:13.5192 0E	-10.0	-12.0

	Output	40:02:27.4222 5S	69:54:26.2922 9E								
test40	Locu s 1 Input s	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:44:32.8834 3S	69:54:07.3624 3E	-15.0	-18.0
	Locu s 2 Input s	38:01:17.8000 0S	68:11:50.6000 0E	40:12:17.8000 0S	69:56:34.7000 0E	38:01:49.0630 3S	68:10:45.7608 6E	40:13:22.2509 6S	69:54:22.5298 9E	1.0	2.0
	Output	39:57:32.7447 6S	69:41:29.8226 4E								
test41	Locu s 1 Input s	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:43:19.0439 4S	69:52:04.6894 3E	-15.0	-20.0
	Locu s 2 Input s	38:01:17.8000 0S	69:11:50.6000 0E	41:12:17.8000 0S	69:11:50.6000 0E	38:01:17.7931 9S	69:13:06.5304 4E	41:12:17.7695 2S	69:14:29.5812 5E	-1.0	-2.0
	Output	40:23:10.1576 3S	69:14:07.4397 3E								
test42	Locu s 1 Input s	41:50:24.5000 0S	68:12:45.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	41:40:56.3220 3S	67:57:12.6583 9E	39:44:32.8834 3S	69:54:07.3624 3E	-15.0	-18.0
	Locu s 2 Input s	38:01:17.8000 0S	69:11:50.6000 0E	41:50:24.5000 0S	68:12:45.6000 0E	38:00:55.0262 1S	69:09:21.4992 2E	41:49:48.3843 0S	68:08:49.6956 6E	2.0	3.0
	Output	41:22:22.7750 2S	68:16:27.4783 6E								
test43	Locu s 1 Input s	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:10:51.5757 9S	70:38:22.5258 4E	42:09:14.4414 0S	68:44:05.2763 0E	-25.0	-30.0
	Locu s 2 Input s	43:29:17.8000 0S	68:11:50.6000 0E	39:55:35.8000 0S	70:12:34.7000 0E	43:30:05.8626 2S	68:14:21.6632 4E	39:56:44.0461 0S	70:16:11.2661 3E	2.0	3.0
	Output	41:25:37.2397 1S	69:27:12.7189 5E								
test44	Locu s 1 Input s	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:00:29.4769 5S	70:20:48.7528 2E	41:56:04.3853 8S	68:22:07.5649 9E	-8.0	-9.0
	Locu s 2 Input s	43:29:17.8000 0S	68:11:50.6000 0E	39:55:35.8000 0S	68:11:50.6000 0E	43:29:16.9748 8S	68:25:34.8046 9E	39:55:34.9183 9S	68:26:08.5148 4E	10.0	11.0

	Output	41:52:35.5433 9S	68:25:50.1207 7E								
test45	Locu s 1 Input s	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:01:42.8040 3S	70:22:52.4496 9E	41:57:19.8108 1S	68:24:12.6710 4E	-10.0	-11.0
	Locu s 2 Input s	43:29:17.8000 0S	69:11:50.6000 0E	41:50:24.5000 0S	68:12:45.6000 0E	43:23:08.2692 0S	69:30:36.9790 6E	41:43:36.3125 0S	68:33:35.1944 9E	15.0	17.0
	Output	41:46:49.2592 2S	68:35:22.6806 0E								
test46	Locu s 1 Input s	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:44:05.6230 9S	71:35:48.6236 3E	42:39:04.1763 4S	69:34:51.5364 1E	-80.0	-78.0
	Locu s 2 Input s	43:29:17.8000 0S	69:11:50.6000 0E	41:45:07.5000 0S	66:11:50.6000 0E	42:55:41.1691 6S	69:46:17.7245 7E	41:10:04.6593 2S	66:49:24.8624 3E	42.0	45.0
	Output	N/A	N/A								
test47	Locu s 1 Input s	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:24:48.9416 7S	71:02:16.7393 7E	42:21:42.9132 1S	69:05:08.7091 7E	-48.0	-50.0
	Locu s 2 Input s	42:09:17.8000 0S	70:11:50.6000 0E	42:09:17.8000 0S	66:11:50.6000 0E	41:24:17.2934 9S	70:10:26.5343 0E	41:20:17.2305 4S	66:13:22.0442 9E	45.0	49.0
	Output	41:24:17.3247 0S	70:03:47.7950 5E								
test48	Locu s 1 Input s	39:55:35.8000 0S	70:12:34.7000 0E	41:50:24.5000 0S	68:12:45.6000 0E	40:50:05.0655 9S	71:46:21.2980 6E	42:51:59.9928 5S	69:57:19.4976 2E	-90.0	-99.0
	Locu s 2 Input s	42:29:17.8000 0S	69:11:50.6000 0E	44:01:17.8000 0S	66:11:50.6000 0E	41:48:42.5624 1S	68:32:33.3747 6E	43:15:31.5444 6S	65:29:49.9212 9E	50.0	55.0
	Output	N/A	N/A								

WGS84LocusTanFixedRadiusArc Test Results

Test Identifier	Locus 1 Input	Locus 1 Geodesic Start Latitude	Locus 1 Geodesic Start Longitude	Locus 1 Geodesic End Latitude	Locus 1 Geodesic End Longitude	Locus 1 Start Latitude	Locus 1 Start Longitude	Locus 1 End Latitude	Locus 1 End Longitude	Locus 1 Start Distance (nm)	Locus 1 End Distance (nm)	
	Locus 2 Input	Locus 2 Geodesic Start Latitude	Locus 2 Geodesic Start Longitude	Locus 2 Geodesic End Latitude	Locus 2 Geodesic End Longitude	Locus 2 Start Latitude	Locus 2 Start Longitude	Locus 2 End Latitude	Locus 2 End Longitude	Locus 2 Start Distance (nm)	Locus 2 End Distance (nm)	Arc Radius (nm)
	Output	Arc Direction	Arc Center Latitude	Arc Center Longitude	Tangent Point 1 Latitude	Tangent Point 1 Longitude	Tangent Point 2 Latitude	Tangent Point 2 Longitude				
test1	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	40:05:30.770 99N	65:52:03.221 58W	40:11:24.544 24N	70:12:45.600 00W	40:06:30.744 30N	65:51:59.399 53W	-1.0	-1.0	
	Locus 2 Inputs	38:45:52.615 65N	68:43:43.428 97W	42:04:35.800 00N	68:12:34.700 00W	38:45:59.577 64N	68:44:59.624 33W	42:04:43.107 40N	68:13:54.671 12W	-1.0	-1.0	2.0
	Output	1	40:12:42.909 80N	68:34:26.170 64W	40:10:42.842 03N	68:34:29.058 90W	40:12:28.742 86N	68:31:50.631 89W				
test2	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	40:05:30.770 99N	65:52:03.221 58W	40:11:24.544 24N	70:12:45.600 00W	40:07:30.717 40N	65:51:55.575 62W	-1.0	-2.0	
	Locus 2 Inputs	38:45:52.615 65N	68:43:43.428 97W	42:04:35.800 00N	68:12:34.700 00W	38:46:06.525 83N	68:46:15.823 80W	42:04:43.107 40N	68:13:54.671 12W	-2.0	-1.0	2.0
	Output	1	40:13:05.945 59N	68:35:07.044 02W	40:11:05.868 17N	68:35:09.129 78W	40:12:51.197 87N	68:32:31.582 71W				
test3	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	40:05:30.770 99N	65:52:03.221 58W	40:09:24.455 59N	70:12:45.600 00W	40:04:30.797 47N	65:52:07.041 76W	1.0	1.0	
	Locus 2 Inputs	38:45:52.615 65N	68:43:43.428 97W	42:04:35.800 00N	68:12:34.700 00W	38:45:45.639 86N	68:42:27.237 74W	42:04:28.477 12N	68:11:14.733 98W	1.0	1.0	3.0
	Output	1	40:11:41.867 65N	68:33:16.759 39W	40:08:41.765 92N	68:33:21.140 59W	40:11:20.556 56N	68:29:23.522 19W				
test4	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	40:05:30.770 99N	65:52:03.221 58W	40:09:24.455 59N	70:12:45.600 00W	40:03:30.823 74N	65:52:10.860 08W	1.0	2.0	
	Locus 2 Inputs	38:45:52.615 65N	68:43:43.428 97W	42:04:35.800 00N	68:12:34.700 00W	38:45:38.650 27N	68:41:11.050 62W	42:04:28.477 12N	68:11:14.733 98W	2.0	1.0	2.0
	Outputs	1	40:10:16.886 71N	68:31:25.719 47W	40:08:16.832 27N	68:31:29.476 43W	40:10:03.248 71N	68:28:50.192 80W				
test5	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	40:05:30.770 99N	65:52:03.221 58W	40:11:24.544 24N	70:12:45.600 00W	40:06:30.744 30N	65:51:59.399 53W	-1.0	-1.0	

	Locus 2 Inputs	38:45:52.615 65N	68:43:43.428 97W	42:04:35.800 00N	68:12:34.700 00W	38:45:45.639 86N	68:42:27.237 74W	42:04:28.477 12N	68:11:14.733 98W	1.0	1.0	2.0
	Outputs	1	40:12:40.653 68N	68:31:48.782 39W	40:10:40.586 99N	68:31:51.747 66W	40:12:26.428 00N	68:29:13.254 21W				
test6	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	40:05:30.770 99N	65:52:03.221 58W	40:11:24.544 24N	70:12:45.600 00W	40:07:30.717 40N	65:51:55.575 62W	-1.0	-2.0	
	Locus 2 Inputs	39:01:03.206 12N	64:47:37.885 16W	41:04:35.800 00N	68:12:34.700 00W	38:59:30.112 07N	64:49:15.158 95W	41:03:47.851 19N	68:13:22.435 86W	-2.0	-1.0	2.0
	Outputs	1	40:11:11.478 12N	66:48:27.886 28W	40:09:11.456 03N	66:48:33.100 50W	40:12:45.838 78N	66:46:51.019 20W				
test7	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	36:50:12.190 34N	70:12:45.600 00W	40:10:24.470 60N	70:10:09.051 40W	36:50:12.183 82N	70:11:30.856 98W	-2.0	-1.0	
	Locus 2 Inputs	38:10:03.489 78N	71:19:20.313 30W	41:04:35.800 00N	69:12:34.700 00W	38:10:32.285 15N	71:20:27.085 81W	41:05:35.812 05N	69:14:52.148 42W	-1.0	-2.0	3.0
	Outputs	1	40:02:07.334 83N	70:06:18.248 80W	40:02:08.387 28N	70:10:12.593 88W	40:00:39.589 07N	70:02:53.618 27W				
test8	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	36:50:55.829 85N	69:51:03.262 40W	40:10:14.004 41N	70:15:21.546 23W	36:50:50.822 61N	69:52:17.756 45W	2.0	1.0	
	Locus 2 Inputs	38:02:20.089 09N	70:59:31.553 24W	41:04:35.800 00N	69:12:34.700 00W	38:01:55.782 14N	70:58:22.104 46W	41:03:45.031 32N	69:10:10.925 36W	1.0	2.0	2.0
	Outputs	1	39:33:03.947 33N	70:08:17.798 94W	39:32:52.952 67N	70:10:52.284 75W	39:32:13.764 21N	70:05:56.864 47W				
test9	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	37:35:08.049 87N	67:31:03.267 43W	40:11:41.674 10N	70:10:45.639 05W	37:35:45.282 80N	67:30:04.026 42W	-2.0	-1.0	
	Locus 2 Inputs	37:45:08.920 78N	67:50:36.686 93W	41:04:35.800 00N	68:12:34.700 00W	37:45:03.921 63N	67:51:52.078 35W	41:04:25.305 11N	68:15:12.760 89W	-1.0	-2.0	3.0
	Outputs	1	38:09:11.856 36N	67:58:23.767 23W	38:07:20.135 32N	68:01:22.776 21W	38:09:27.920 01N	67:54:36.468 55W				
test10	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	42:52:36.591 94N	67:36:46.624 23W	40:09:15.600 15N	70:10:37.398 89W	42:52:00.699 38N	67:35:41.228 61W	2.0	1.0	
	Locus 2 Inputs	39:55:58.224 92N	69:41:27.775 37W	43:04:35.800 00N	68:12:34.700 00W	39:56:37.332 95N	69:43:55.282 80W	43:04:56.318 78N	68:13:51.636 78W	-2.0	-1.0	2.0
	Outputs	1	41:21:07.174 87N	69:07:28.710 56W	41:19:57.562 77N	69:05:18.906 22W	41:20:26.728 78N	69:04:58.698 14W				
test11	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	42:41:33.376 50N	67:18:27.472 57W	40:11:41.674 10N	70:14:45.560 95W	42:42:13.471 96N	67:19:28.019 14W	-2.0	-1.0	
	Locus	38:47:21.082	67:28:11.049	42:04:35.800	68:12:34.700	38:47:40.921	67:25:39.675	42:04:46.215	68:11:15.351	2.0	1.0	2.0

	2 Inputs	27N	43W	00N	00W	31N	82W	51N	30W			
	Outputs	1	42:00:55.564 89N	68:13:02.909 37W	41:59:35.847 42N	68:11:02.562 25W	42:01:16.982 68N	68:10:24.500 96W				
test12	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	36:53:06.456 88N	70:56:01.642 36W	40:10:34.919 46N	70:14:02.688 42W	36:53:26.367 62N	70:58:29.160 09W	1.0	2.0	
	Locus 2 Inputs	37:29:19.581 28N	71:54:04.490 05W	40:04:35.800 00N	69:12:34.700 00W	37:28:05.079 86N	71:52:06.219 43W	40:03:57.199 27N	69:11:34.832 83W	2.0	1.0	2.0
	Outputs	1	38:53:33.203 66N	70:29:18.124 52W	38:53:54.263 04N	70:31:49.447 79W	38:52:17.757 84N	70:27:18.546 19W				
test13	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	41:46:39.602 65N	74:04:18.294 68W	40:08:40.492 57N	70:14:03.841 14W	41:45:46.340 67N	74:04:55.276 67W	-2.0	-1.0	
	Locus 2 Inputs	40:59:32.625 80N	72:36:48.383 18W	41:04:35.800 00N	68:12:34.700 00W	41:00:32.585 02N	72:36:52.381 81W	41:06:35.869 47N	68:12:34.700 00W	-1.0	-2.0	2.0
	Outputs	-1	40:59:45.331 28N	72:06:21.690 23W	40:58:00.362 64N	72:07:38.620 39W	41:01:45.254 31N	72:06:29.561 62W				
test14	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	43:02:23.578 55N	67:56:26.256 58W	40:09:24.433 55N	70:10:30.058 11W	43:01:52.206 97N	67:55:16.512 06W	2.0	1.0	
	Locus 2 Inputs	43:40:32.943 22N	72:11:18.241 39W	42:04:35.800 00N	68:12:34.700 00W	43:42:19.591 29N	72:10:02.385 29W	42:05:27.780 65N	68:11:54.406 31W	-2.0	-1.0	2.0
	Outputs	-1	42:12:06.973 04N	68:32:37.780 57W	42:13:08.443 40N	68:34:56.482 41W	42:13:50.862 69N	68:31:16.863 80W				
test15	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	39:30:57.684 85N	65:58:09.515 26W	40:11:23.631 81N	70:12:32.004 53W	39:32:54.838 06N	65:57:35.357 82W	-1.0	-2.0	
	Locus 2 Inputs	41:23:57.635 85N	67:49:25.737 53W	38:04:35.800 00N	68:12:34.700 00W	41:24:03.117 84N	67:50:45.132 38W	38:04:46.243 10N	68:15:06.102 22W	1.0	2.0	2.0
	Outputs	-1	39:51:21.557 10N	68:04:58.824 54W	39:53:19.411 10N	68:04:28.855 74W	39:51:10.298 89N	68:02:23.689 37W				
test16	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	40:05:30.770 99S	65:52:03.221 58W	40:11:24.544 24S	70:12:45.600 00W	40:07:30.717 40S	65:51:55.575 62W	1.0	2.0	
	Locus 2 Inputs	41:23:11.704 67S	68:44:56.512 07W	38:04:35.800 00S	68:12:34.700 00W	41:23:27.023 65S	68:42:18.386 98W	38:04:43.113 48S	68:11:19.277 04W	2.0	1.0	2.0
	Outputs	1	40:09:04.418 61S	68:32:58.982 77W	40:11:04.496 07S	68:32:56.834 33W	40:09:18.875 49S	68:30:23.618 82W				
test17	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	40:05:30.770 99S	65:52:03.221 58W	40:09:24.455 59S	70:12:45.600 00W	40:03:30.823 74S	65:52:10.860 08W	-1.0	-2.0	
	Locus 2 Inputs	40:51:02.568 24S	65:49:04.579 09W	38:04:35.800 00S	68:12:34.700 00W	40:52:10.594 42S	65:51:14.904 08W	38:05:08.509 46S	68:13:38.436 18W	-2.0	-1.0	2.0

	Inputs											
	Outputs	1	40:03:14.478 49S	66:37:33.384 95W	40:05:14.445 65S	66:37:26.294 02W	40:02:07.807 89S	66:35:23.422 43W				
test18	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	43:30:29.876 90S	70:12:45.600 00W	40:10:24.470 60S	70:10:09.051 40W	43:30:29.868 64S	70:11:23.152 09W	-2.0	-1.0	
	Locus 2 Inputs	40:56:44.386 23S	70:24:30.082 51W	38:04:35.800 00S	68:12:34.700 00W	40:56:13.101 74S	70:25:37.657 28W	38:03:35.713 46S	68:14:46.283 92W	-1.0	-2.0	3.0
	Outputs	1	40:25:56.597 23S	70:06:18.828 40W	40:25:55.848 92S	70:10:14.547 14W	40:27:29.089 86S	70:02:56.519 01W				
test19	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	43:29:41.803 26S	69:48:49.551 37W	40:10:34.937 24S	70:15:21.559 54W	43:29:47.302 91S	69:50:11.635 25W	2.0	1.0	
	Locus 2 Inputs	40:46:58.965 10S	70:43:33.361 04W	38:04:35.800 00S	68:12:34.700 00W	40:47:34.755 34S	70:42:29.939 66W	38:05:44.686 44S	68:10:30.177 29W	1.0	2.0	2.0
	Outputs	1	40:13:25.078 66S	70:12:23.800 09W	40:13:36.121 95S	70:14:59.803 79W	40:14:36.571 01S	70:10:17.905 79W				
test20	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	42:41:33.376 50S	67:18:27.472 57W	40:09:07.291 11S	70:10:45.714 53W	42:40:53.272 07S	67:17:26.947 63W	-2.0	-1.0	
	Locus 2 Inputs	41:23:57.635 85S	68:49:25.737 53W	38:04:35.800 00S	69:12:34.700 00W	41:24:03.117 84S	68:50:45.132 38W	38:04:46.243 10S	69:15:06.102 22W	-1.0	-2.0	3.0
	Outputs	1	41:11:40.445 78S	68:56:19.657 74W	41:13:37.479 45S	68:59:20.932 78W	41:11:23.248 99S	68:52:22.321 54W				
test21	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	37:24:53.776 02S	67:48:48.292 35W	40:11:33.360 17S	70:10:37.326 86W	37:25:26.924 44S	67:47:45.478 85W	2.0	1.0	
	Locus 2 Inputs	40:23:45.261 80S	71:17:39.828 70W	38:04:35.800 00S	68:12:34.700 00W	40:22:17.492 77S	71:19:27.002 96W	38:03:53.323 48S	68:13:28.422 49W	-2.0	-1.0	2.0
	Outputs	-1	38:19:04.226 08S	68:29:21.213 74W	38:17:57.687 53S	68:31:28.147 15W	38:17:38.591 51S	68:31:08.128 37W				
test22	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	37:35:08.049 87S	67:31:03.267 43W	40:09:07.291 11S	70:14:45.485 47W	37:34:30.808 62S	67:32:02.492 05W	-2.0	-1.0	
	Locus 2 Inputs	41:21:34.316 10S	67:26:28.970 88W	38:04:35.800 00S	68:12:34.700 00W	41:21:12.424 83S	67:23:52.292 53W	38:04:25.363 03S	68:11:19.870 10W	2.0	1.0	2.0
	Outputs	1	38:11:04.159 43S	68:12:22.746 71W	38:12:19.771 40S	68:10:24.461 67W	38:10:42.677 13S	68:09:53.007 75W				
test23	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	43:27:18.010 78S	71:00:24.952 85W	40:10:14.066 28S	70:14:02.681 87W	43:26:56.045 70S	71:03:06.913 12W	1.0	2.0	
	Locus 2 Inputs	42:35:45.277 80S	72:06:36.630 38W	40:04:35.800 00S	69:12:34.700 00W	42:37:05.450 79S	72:04:35.690 54W	40:05:14.392 06S	69:11:34.814 05W	2.0	1.0	2.0

	Outputs	1	41:09:00.289 76S	70:25:29.091 05W	41:08:38.535 06S	70:28:05.303 41W	41:10:18.257 57S	70:23:28.270 22W				
test24	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	38:26:46.467 74S	73:53:15.484 61W	40:12:08.492 21S	70:14:03.907 52W	38:27:37.217 79S	73:53:56.335 33W	-2.0	-1.0	
	Locus 2 Inputs	38:59:53.214 74S	73:29:12.959 94W	39:04:35.800 00S	69:12:34.700 00W	38:58:53.224 54S	73:29:09.342 42W	39:02:35.688 26S	69:12:34.700 00W	-1.0	-2.0	2.0
	Outputs	-1	39:02:21.677 93S	72:38:46.919 55W	39:04:03.709 82S	72:40:08.199 04W	39:00:21.629 99S	72:38:41.871 65W				
test25	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	37:15:52.751 97S	68:07:31.780 07W	40:11:24.522 18S	70:10:29.991 73W	37:16:21.590 37S	68:06:25.839 60W	2.0	1.0	
	Locus 2 Inputs	36:21:10.677 74S	71:47:01.134 06W	38:04:35.800 00S	68:12:34.700 00W	36:19:28.943 58S	71:45:42.083 55W	38:03:43.779 56S	68:11:56.713 84W	-2.0	-1.0	2.0
	Outputs	-1	37:57:02.695 88S	68:31:21.637 89W	37:56:05.076 32S	68:33:34.749 30W	37:55:19.155 11S	68:30:04.714 14W				
test26	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	40:05:30.770 99S	72:33:27.978 42E	40:11:24.544 24S	68:12:45.600 00E	40:07:30.717 40S	72:33:35.624 38E	1.0	2.0	
	Locus 2 Inputs	41:23:11.704 67S	69:40:12.887 93E	38:04:35.800 00S	70:12:34.700 00E	41:23:27.023 65S	69:42:51.013 02E	38:04:43.113 48S	70:13:50.122 96E	2.0	1.0	2.0
	Outputs	1	40:09:04.647 98S	69:52:10.380 91E	40:11:04.725 55S	69:52:12.518 66E	40:09:19.104 87S	69:54:45.745 00E				
test27	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	40:05:30.770 99S	72:33:27.978 42E	40:09:24.455 59S	68:12:45.600 00E	40:03:30.823 74S	72:33:20.339 92E	-1.0	-2.0	
	Locus 2 Inputs	40:51:02.568 24S	72:36:04.820 91E	38:04:35.800 00S	70:12:34.700 00E	40:52:10.594 42S	72:33:54.495 92E	38:05:08.509 46S	70:11:30.963 82E	-2.0	-1.0	2.0
	Outputs	1	40:03:15.216 15S	71:47:36.655 50E	40:05:15.183 67S	71:47:43.736 13E	40:02:08.545 36S	71:49:46.618 23E				
test28	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	43:30:29.876 90S	68:12:45.600 00E	40:10:24.470 60S	68:15:22.148 60E	43:30:29.868 64S	68:14:08.047 91E	-2.0	-1.0	
	Locus 2 Inputs	40:56:44.386 23S	68:00:39.317 49E	38:04:35.800 00S	70:12:34.700 00E	40:56:13.101 74S	67:59:31.742 72E	38:03:35.713 46S	70:10:23.116 08E	-1.0	-2.0	3.0
	Outputs	1	40:25:28.598 97S	68:19:12.510 23E	40:25:27.850 71S	68:15:16.818 63E	40:27:01.081 04S	68:22:34.804 66E				
test29	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	43:29:41.803 26S	68:36:41.648 63E	40:10:34.937 24S	68:10:09.640 46E	43:29:47.302 91S	68:35:19.564 75E	2.0	1.0	
	Locus 2 Inputs	40:46:58.965 10S	67:41:36.038 96E	38:04:35.800 00S	70:12:34.700 00E	40:47:34.755 34S	67:42:39.460 34E	38:05:44.686 44S	70:14:39.222 71E	1.0	2.0	2.0
	Outputs	1	40:13:05.036	68:13:04.979	40:13:16.079	68:10:28.987	40:14:16.523	68:15:10.868				

	ts		69S	01E	09S	97E	26S	66E				
test30	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	42:41:33.37650S	71:07:03.72743E	40:09:07.29111S	68:14:45.48547E	42:40:53.27207S	71:08:04.25237E	-2.0	-1.0	
	Locus 2 Inputs	41:23:57.63585S	69:35:43.66247E	38:04:35.80000S	69:12:34.70000E	41:24:03.11784S	69:34:24.26762E	38:04:46.24310S	69:10:03.29778E	-1.0	-2.0	3.0
	Outputs	1	41:11:18.77346S	69:28:47.00130E	41:13:15.79650S	69:25:45.73071E	41:11:01.57821S	69:32:44.31595E				
test31	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	37:24:53.77602S	70:36:42.90765E	40:11:33.36017S	68:14:53.87314E	37:25:26.92444S	70:37:45.72115E	2.0	1.0	
	Locus 2 Inputs	40:23:45.26180S	67:07:29.57130E	38:04:35.80000S	70:12:34.70000E	40:22:17.49277S	67:05:42.39704E	38:03:53.32348S	70:11:40.97751E	-2.0	-1.0	2.0
	Outputs	-1	38:18:15.29786S	69:56:51.27653E	38:17:08.77155S	69:54:44.35635E	38:16:49.67907S	69:55:04.36125E				
test32	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	37:35:08.04987S	70:54:27.93257E	40:09:07.29111S	68:10:45.71453E	37:34:30.80862S	70:53:28.70795E	-2.0	-1.0	
	Locus 2 Inputs	41:21:34.31610S	70:58:40.42912E	38:04:35.80000S	70:12:34.70000E	41:21:12.42483S	71:01:17.10747E	38:04:25.36303S	70:13:49.52990E	2.0	1.0	2.0
	Outputs	1	38:11:21.50667S	70:12:50.64310E	38:12:37.12356S	70:14:48.93082E	38:11:00.02297S	70:15:20.39160E				
test33	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	43:27:18.01078S	67:25:06.24715E	40:10:14.06628S	68:11:28.51813E	43:26:56.04570S	67:22:24.28688E	1.0	2.0	
	Locus 2 Inputs	42:35:45.27780S	66:18:32.76962E	40:04:35.80000S	69:12:34.70000E	42:37:05.45079S	66:20:33.70946E	40:05:14.39206S	69:13:34.58595E	2.0	1.0	2.0
	Outputs	1	41:08:35.70113S	68:00:08.09319E	41:08:13.94866S	67:57:31.89648E	41:09:53.66093S	68:02:08.91061E				
test34	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	38:26:46.46774S	64:32:15.71539E	40:12:08.49221S	68:11:27.29248E	38:27:37.21779S	64:31:34.86467E	-2.0	-1.0	
	Locus 2 Inputs	38:59:53.21474S	64:55:56.44006E	39:04:35.80000S	69:12:34.70000E	38:58:53.22454S	64:56:00.05758E	39:02:35.68826S	69:12:34.70000E	-1.0	-2.0	2.0
	Outputs	-1	39:02:22.26616S	65:46:45.49514E	39:04:04.29828S	65:45:24.21595E	39:00:22.21794S	65:46:50.53225E				
test35	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	37:15:52.75197S	70:17:59.41993E	40:11:24.52218S	68:15:01.20827E	37:16:21.59037S	70:19:05.36040E	2.0	1.0	
	Locus 2 Inputs	36:21:10.67774S	66:38:08.26594E	38:04:35.80000S	70:12:34.70000E	36:19:28.94358S	66:39:27.31645E	38:03:43.77956S	70:13:12.68616E	-2.0	-1.0	2.0
	Outputs	-1	37:57:10.38318S	69:54:04.25802E	37:56:12.76197S	69:51:51.14391E	37:55:26.83944S	69:55:21.17757E				

test36	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	40:05:30.77099N	72:33:27.97842E	40:09:24.45559N	68:12:45.60000E	40:03:30.82374N	72:33:20.33992E	1.0	2.0	
	Locus 2 Inputs	38:52:47.19234N	68:57:43.98857E	42:04:35.80000N	70:12:34.70000E	38:52:13.67562N	69:00:11.54546E	42:04:18.24336N	70:13:51.74273E	2.0	1.0	2.0
	Outputs	1	40:10:43.92255N	69:26:42.17253E	40:08:43.85504N	69:26:39.21907E	40:10:10.37031N	69:29:12.48839E				
test37	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	40:05:30.77099N	72:33:27.97842E	40:11:24.54424N	68:12:45.60000E	40:07:30.71740N	72:33:35.62438E	-1.0	-2.0	
	Locus 2 Inputs	39:13:29.53578N	72:28:55.25646E	42:04:35.80000N	70:12:34.70000E	39:12:28.52052N	72:26:42.26184E	42:04:03.98622N	70:11:26.38299E	-2.0	-1.0	2.0
	Outputs	1	40:11:08.56456N	71:38:56.66811E	40:09:08.54388N	71:38:51.39855E	40:12:09.97080N	71:41:11.24340E				
test38	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	36:50:12.19034N	68:12:45.60000E	40:10:24.47060N	68:15:22.14860E	36:50:12.18382N	68:14:00.34302E	-2.0	-1.0	
	Locus 2 Inputs	39:10:02.81529N	68:04:02.52380E	42:04:35.80000N	70:12:34.70000E	39:10:31.56185N	68:02:54.78528E	42:05:35.80077N	70:10:15.11366E	-1.0	-2.0	3.0
	Outputs	1	39:39:58.78561N	68:19:02.28704E	39:39:59.83137N	68:15:09.19344E	39:38:32.84035N	68:22:27.11164E				
test39	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	36:50:55.82985N	68:34:27.93760E	40:10:14.00441N	68:10:09.65377E	36:50:50.82261N	68:33:13.44355E	2.0	1.0	
	Locus 2 Inputs	39:19:02.15978N	67:44:48.14899E	42:04:35.80000N	70:12:34.70000E	39:18:29.10241N	67:45:52.68873E	42:03:26.92161N	70:14:46.65709E	1.0	2.0	2.0
	Outputs	1	39:55:11.69116N	68:14:35.29494E	39:55:00.63826N	68:11:59.99070E	39:54:04.52166N	68:16:44.57011E				
test40	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	37:35:08.04987N	70:54:27.93257E	40:11:41.67410N	68:14:45.56095E	37:35:45.28280N	70:55:27.17358E	-2.0	-1.0	
	Locus 2 Inputs	38:45:10.91527N	69:34:50.91008E	42:04:35.80000N	69:12:34.70000E	38:45:05.92527N	69:33:34.47694E	42:04:25.30587N	69:09:54.18228E	-1.0	-2.0	3.0
	Outputs	1	39:08:09.55199N	69:27:04.93864E	39:06:16.31747N	69:24:05.04175E	39:08:25.58999N	69:30:55.36592E				
test41	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:52:36.59194N	70:48:44.57577E	40:09:15.60015N	68:14:53.80111E	42:52:00.69938N	70:49:49.97139E	2.0	1.0	
	Locus 2 Inputs	39:40:36.03510N	67:09:25.73456E	42:04:35.80000N	70:12:34.70000E	39:41:57.92929N	67:07:32.03241E	42:05:18.23971N	70:11:37.71848E	-2.0	-1.0	2.0
	Outputs	-1	41:42:57.59835N	69:45:22.81427E	41:44:07.68026N	69:43:12.69417E	41:44:22.45121N	69:43:29.43785E				
test42	Locus	40:10:24.500	68:12:45.600	42:41:33.376	71:07:03.727	40:11:41.674	68:10:45.639	42:42:13.471	71:06:03.180	-2.0	-1.0	

	1 Inputs	00N	00E	50N	43E	10N	05E	96N	86E			
	Locus 2 Inputs	38:47:21.082 27N	70:56:58.350 57E	42:04:35.800 00N	70:12:34.700 00E	38:47:40.921 31N	70:59:29.724 18E	42:04:46.215 51N	70:13:54.048 70E	2.0	1.0	2.0
	Output s	1	42:00:40.360 69N	70:12:10.192 54E	41:59:20.648 42N	70:14:10.537 96E	42:01:01.777 07N	70:14:48.590 80E				
test43	Locus 1 Inputs	40:10:24.500 00N	68:12:45.600 00E	36:53:06.456 88N	67:29:29.557 64E	40:10:34.919 46N	68:11:28.511 58E	36:53:26.367 62N	67:27:02.039 91E	1.0	2.0	
	Locus 2 Inputs	37:29:19.581 28N	66:31:04.909 95E	40:04:35.800 00N	69:12:34.700 00E	37:28:05.079 86N	66:33:03.180 57E	40:03:57.199 27N	69:13:34.567 17E	2.0	1.0	2.0
	Output s	1	38:54:00.302 76N	67:56:19.259 60E	38:54:21.364 33N	67:53:47.920 86E	38:52:44.849 07N	67:58:18.842 32E				
test44	Locus 1 Inputs	40:10:24.500 00N	68:12:45.600 00E	41:46:39.602 65N	64:21:12.905 32E	40:08:40.492 57N	68:11:27.358 86E	41:45:46.340 67N	64:20:35.923 33E	-2.0	-1.0	
	Locus 2 Inputs	40:59:32.625 80N	64:48:21.016 82E	41:04:35.800 00N	69:12:34.700 00E	41:00:32.585 02N	64:48:17.018 19E	41:06:35.869 47N	69:12:34.700 00E	-1.0	-2.0	2.0
	Output s	-1	41:01:38.016 65N	66:14:41.465 26E	40:59:52.998 91N	66:13:24.616 88E	41:03:37.995 84N	66:14:35.281 50E				
test45	Locus 1 Inputs	40:10:24.500 00N	68:12:45.600 00E	43:02:23.578 55N	70:29:04.943 42E	40:09:24.433 55N	68:15:01.141 89E	43:01:52.206 97N	70:30:14.687 94E	2.0	1.0	
	Locus 2 Inputs	43:40:32.943 22N	66:13:51.158 61E	42:04:35.800 00N	70:12:34.700 00E	43:42:19.591 29N	66:15:07.014 71E	42:05:27.780 65N	70:13:14.993 69E	-2.0	-1.0	2.0
	Output s	-1	42:11:59.998 55N	69:52:47.824 75E	42:13:01.467 06N	69:50:29.125 65E	42:13:43.885 07N	69:54:08.746 43E				

WGS84PerpIntercept Test Results

Test Identifier	Geodesic Start Latitude	Geodesic Start Longitude	Geodesic Azimuth (degrees)	Test Point Latitude	Test Point Longitude	Azimuth From Test Point To Intercept (degrees)	Distance From Test Point To Intercept (nm)	Intercept Latitude	Intercept Longitude
test1	40:10:24.50000N	70:12:45.60000W	38.0	42:04:35.80000N	68:12:40.70000W	129.31642	0.41489	42:04:20.02035N	68:12:14.84062W
test2	40:10:24.50000N	70:12:45.60000W	62.0	42:04:35.80000N	68:12:40.70000W	153.29737	59.66462	41:11:10.62477N	67:37:10.15895W
test3	40:10:24.50000N	70:12:45.60000W	90.0	42:04:35.80000N	68:12:40.70000W	181.29165	115.13091	40:09:25.68132N	68:16:03.75475W
test4	40:10:24.50000N	70:12:45.60000W	127.0	42:04:35.80000N	68:12:40.70000W	218.31581	145.78046	40:09:07.48064N	70:10:32.43942W
test5	40:10:24.50000N	70:12:45.60000W	150.0	42:04:35.80000N	68:12:40.70000W	241.33453	135.01795	40:58:00.14293N	70:49:04.80560W
test6	40:10:24.50000N	70:12:45.60000W	0.0	42:04:35.80000N	68:12:40.70000W	271.34146	89.41691	42:05:38.63720N	70:12:45.60000W
test7	40:10:24.50000N	70:12:45.60000W	335.0	42:04:35.80000N	68:12:40.70000W	246.33745	129.70818	41:10:42.02846N	70:50:01.67112W
test8	40:10:24.50000N	70:12:45.60000W	305.0	42:04:35.80000N	68:12:40.70000W	216.31402	145.61723	40:06:15.57774N	70:05:03.11962W
test9	40:10:24.50000N	70:12:45.60000W	180.0	38:04:35.80000N	72:12:40.70000W	88.76710	94.68092	38:05:36.99418N	70:12:45.60000W
test10	40:10:24.50000N	70:12:45.60000W	230.0	38:04:35.80000N	72:12:40.70000W	318.72576	34.59985	38:30:34.10445N	72:41:45.37882W
test11	40:10:24.50000N	70:12:45.60000W	270.0	38:04:35.80000N	72:12:40.70000W	358.70998	124.63008	40:09:18.54080N	72:16:20.21715W
test12	40:10:24.50000S	70:12:45.60000W	38.0	38:04:35.80000S	68:12:40.70000W	126.73606	2.00964	38:05:47.98305S	68:10:38.28715W
test13	40:10:24.50000S	70:12:45.60000W	62.0	38:04:35.80000S	68:12:40.70000W	150.71427	65.51427	39:01:40.59903S	67:31:33.29933W
test14	40:10:24.50000S	70:12:45.60000W	90.0	38:04:35.80000S	68:12:40.70000W	178.70822	124.62717	40:09:18.36107S	68:09:00.88927W
test15	40:10:24.50000S	70:12:45.60000W	127.0	38:04:35.80000S	68:12:40.70000W	215.73655	156.61476	40:10:50.64448S	70:12:00.36233W
test16	40:10:24.50000S	70:12:45.60000W	150.0	38:04:35.80000S	68:12:40.70000W	238.75798	144.43973	39:17:48.31169S	70:51:45.99999W
test17	40:10:24.50000S	70:12:45.60000W	0.0	38:04:35.80000S	68:12:40.70000W	268.76542	94.80986	38:05:37.16104S	70:12:45.60000W
test18	40:10:24.50000S	70:12:45.60000W	335.0	38:04:35.80000S	68:12:40.70000W	243.76128	138.61172	39:04:08.70412S	70:52:19.87385W
test19	40:10:24.50000S	70:12:45.60000W	305.0	38:04:35.80000S	68:12:40.70000W	213.73448	156.49404	40:13:57.58564S	70:06:08.18853W
test20	40:10:24.50000S	70:12:45.60000W	180.0	42:04:35.80000S	72:12:40.70000W	91.33964	89.29531	42:05:38.46633S	70:12:45.60000W
test21	40:10:24.50000S	70:12:45.60000W	230.0	42:04:35.80000S	72:12:40.70000W	321.30417	30.78578	41:40:30.62405S	72:38:21.72071W
test22	40:10:24.50000S	70:12:45.60000W	270.0	42:04:35.80000S	72:12:40.70000W	1.28990	115.12817	40:09:25.84116S	72:09:17.92603W
test23	40:10:24.50000S	68:12:45.60000E	38.0	38:04:35.80000S	70:12:40.70000E	126.73774	2.11300	38:05:51.69739S	70:14:49.40745E
test24	40:10:24.50000S	68:12:45.60000E	62.0	38:04:35.80000S	70:12:40.70000E	150.71599	65.57735	39:01:43.94797S	70:53:50.37701E
test25	40:10:24.50000S	68:12:45.60000E	90.0	38:04:35.80000S	70:12:40.70000E	178.70998	124.63008	40:09:18.54080S	70:16:20.21715E
test26	40:10:24.50000S	68:12:45.60000E	127.0	38:04:35.80000S	70:12:40.70000E	215.73831	156.53943	40:10:46.85840S	68:13:24.28550E
test27	40:10:24.50000S	68:12:45.60000E	150.0	38:04:35.80000S	70:12:40.70000E	238.75971	144.32946	39:17:44.81540S	67:33:42.64546E
test28	40:10:24.50000S	68:12:45.60000E	0.0	38:04:35.80000S	70:12:40.70000E	268.76710	94.68092	38:05:36.99418S	68:12:45.60000E
test29	40:10:24.50000S	68:12:45.60000E	335.0	38:04:35.80000S	70:12:40.70000E	243.76299	138.49604	39:04:05.58767S	67:33:09.49758E
test30	40:10:24.50000S	68:12:45.60000E	305.0	38:04:35.80000S	70:12:40.70000E	213.73624	156.42241	40:13:53.89461S	68:19:16.11563E
test31	40:10:24.50000S	72:12:45.60000E	180.0	42:04:35.80000S	70:12:40.70000E	91.34146	89.41691	42:05:38.63720S	72:12:45.60000E
test32	40:10:24.50000S	72:12:45.60000E	230.0	42:04:35.80000S	70:12:40.70000E	321.30598	30.70974	41:40:34.16471S	69:47:03.52290E
test33	40:10:24.50000S	72:12:45.60000E	270.0	42:04:35.80000S	70:12:40.70000E	1.29165	115.13091	40:09:25.68132S	70:16:03.75475E
test34	40:10:24.50000N	68:12:45.60000E	38.0	42:04:35.80000N	70:12:40.70000E	129.31459	0.50899	42:04:16.44172N	70:13:12.42516E
test35	40:10:24.50000N	68:12:45.60000E	62.0	42:04:35.80000N	70:12:40.70000E	153.29558	59.71928	41:11:07.73298N	70:48:13.29934E
test36	40:10:24.50000N	68:12:45.60000E	90.0	42:04:35.80000N	70:12:40.70000E	181.28990	115.12817	40:09:25.84116N	70:09:17.92603E
test37	40:10:24.50000N	68:12:45.60000E	127.0	42:04:35.80000N	70:12:40.70000E	218.31405	145.70504	40:09:10.93426N	68:14:52.79291E
test38	40:10:24.50000N	68:12:45.60000E	150.0	42:04:35.80000N	70:12:40.70000E	241.33274	134.91123	40:58:03.16688N	67:36:24.05438E
test39	40:10:24.50000N	68:12:45.60000E	0.0	42:04:35.80000N	70:12:40.70000E	271.33964	89.29531	42:05:38.46633N	68:12:45.60000E
test40	40:10:24.50000N	68:12:45.60000E	335.0	42:04:35.80000N	70:12:40.70000E	246.33565	129.59677	41:10:44.67776N	67:35:27.86348E
test41	40:10:24.50000N	68:12:45.60000E	305.0	42:04:35.80000N	70:12:40.70000E	216.31226	145.54520	40:06:18.96327N	68:20:21.80300E

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Appendix 2

test42	40:10:24.50000N	72:12:45.60000E	180.0	38:04:35.80000N	70:12:40.70000E	88.76542	94.80986	38:05:37.16104N	72:12:45.60000E
test43	40:10:24.50000N	72:12:45.60000E	230.0	38:04:35.80000N	70:12:40.70000E	318.72407	34.51477	38:30:30.24106N	69:43:40.27830E
test44	40:10:24.50000N	72:12:45.60000E	270.0	38:04:35.80000N	70:12:40.70000E	358.70822	124.62717	40:09:18.36107N	70:09:00.88927E

WGS84LocusPerpIntercept Test Results

Test Identifier	Inputs	Locus Geodesic Start Latitude	Locus Geodesic Start Longitude	Locus Geodesic End Latitude	Locus Geodesic End Longitude	Locus Start Latitude	Locus Start Longitude	Locus End Latitude	Locus End Longitude	Locus Start Distance (nm)	Locus End Distance (nm)	Test Point Latitude	Test Point Longitude
	Outputs	Azimuth From Test Point To Intercept (degrees)	Distance From Test Point To Intercept (nm)	Intercept Latitude	Intercept Longitude								
test1	Inputs	40:10:24.5000N	70:12:45.6000W	42:46:07.45918N	67:25:36.90158W	40:11:01.46238N	70:13:47.29029W	42:46:45.90859N	67:26:39.45541W	-1.0	-1.0	42:04:35.8000N	68:12:34.7000W
	Outputs	309.31753	0.64273	42:05:00.24258N	68:13:14.76673W								
test2	Inputs	40:10:24.5000N	70:12:45.6000W	42:46:07.45918N	67:25:36.90158W	40:09:47.52843N	70:11:43.92830W	42:45:29.00021N	67:24:34.36924W	1.0	1.0	42:04:35.8000N	68:12:34.7000W
	Outputs	129.31753	1.35727	42:03:44.17073N	68:11:10.11749W								
test3	Inputs	40:10:24.5000N	70:12:45.6000W	42:46:07.45918N	67:25:36.90158W	40:09:47.52843N	70:11:43.92830W	42:44:50.53170N	67:23:31.85839W	1.0	2.0	42:04:35.8000N	68:12:34.7000W
	Outputs	129.60401	2.08646	42:03:15.94272N	68:10:25.22603W								
test4	Inputs	40:10:24.5000N	70:12:45.6000W	42:46:07.45918N	67:25:36.90158W	40:11:01.46238N	70:13:47.29029W	42:47:24.34843N	67:27:42.03074W	-1.0	-2.0	42:04:35.8000N	68:12:34.7000W
	Outputs	309.03106	1.37192	42:05:27.64952N	68:14:00.58323W								
test5	Inputs	40:10:24.5000N	70:12:45.6000W	41:40:24.61603N	66:17:03.91251W	40:11:17.51431N	70:13:22.35551W	41:42:13.03866N	66:18:12.69511W	-1.0	-2.0	42:04:35.8000N	68:12:34.7000W
	Outputs	153.01195	57.96492	41:12:49.81350N	67:37:43.49832W								
test6	Inputs	40:10:24.5000N	70:12:45.6000W	40:05:30.77099N	65:52:03.22158W	40:08:24.41100N	70:12:45.6000W	40:04:30.79747N	65:52:07.04176W	2.0	1.0	42:04:35.8000N	68:12:34.7000W
	Outputs	181.00609	116.68342	40:07:51.80394N	68:15:14.93906W								
test7	Inputs	40:10:24.5000N	70:12:45.6000W	38:06:56.47029N	66:50:21.71131W	40:12:00.39619N	70:11:11.34983W	38:08:29.64659N	66:48:45.71750W	-2.0	-2.0	42:04:35.8000N	68:12:34.7000W
	Outputs	218.31689	143.82663	40:10:41.23180N	70:08:54.51269W								
test8	Inputs	40:10:24.5000N	70:12:45.6000W	37:15:52.75197N	68:07:31.78007W	40:09:54.47230N	70:13:53.37924W	37:14:55.04445N	68:09:43.61910W	1.0	2.0	40:04:35.8000N	69:12:34.7000W
	Outputs	240.93040	38.37214	39:45:48.10411N	69:56:04.27064W								
test9	Inputs	40:10:24.5000N	70:12:45.6000W	43:25:53.95085N	69:15:43.32087W	40:10:36.97688N	70:14:02.16772W	43:26:20.17044N	69:18:24.04024W	-1.0	-2.0	42:04:35.8000N	68:12:34.7000W
	Outputs	283.05132	65.25203	42:18:48.35558N	69:38:15.57457W								

test1 0	Input s	40:10:24.5 0000N	70:12:45.60 000W	43:30:29.8 7690N	70:12:45.60 000W	40:10:24.4 7060N	70:10:09.05 140W	43:30:29.8 6864N	70:11:23.15 209W	2.0	1.0	42:04:35.8 0000N	68:12:34.70 000W
	Outp uts	271.05601	88.06612	42:05:12.2 8968N	70:10:50.66 239W								
test1 1	Input s	40:10:24.5 0000N	70:12:45.60 000W	43:29:41.8 0326N	70:36:41.64 863W	40:10:19.2 5950N	70:14:03.57 478W	43:29:30.7 5486N	70:39:25.80 395W	-1.0	-2.0	42:04:35.8 0000N	68:12:34.70 000W
	Outp uts	266.05671	100.72052	41:56:20.9 4047N	70:27:13.96 006W								
test1 2	Input s	40:10:24.5 0000N	70:12:45.60 000W	42:10:25.7 8109N	73:44:43.81 529W	40:11:11.8 1273N	70:11:57.40 023W	42:11:14.5 3862N	73:43:56.74 833W	1.0	1.0	42:04:35.8 0000N	69:12:34.70 000W
	Outp uts	218.66979	116.72692	40:32:44.2 7479N	70:48:14.72 623W								
test1 3	Input s	40:10:24.5 0000N	70:12:45.60 000W	36:50:12.1 9034N	70:12:45.60 000W	40:10:24.4 9265N	70:11:27.32 569W	36:50:12.1 6424N	70:10:16.11 397W	-1.0	-2.0	38:04:35.8 0000N	72:12:34.70 000W
	Outp uts	88.48154	96.22417	38:06:05.7 7988N	70:10:42.38 354W								
test1 4	Input s	40:10:24.5 0000N	70:12:45.60 000W	37:58:59.0 8359N	73:26:32.36 055W	40:11:56.4 8089N	70:14:26.26 527W	37:59:43.6 9324N	73:27:23.18 593W	2.0	1.0	38:04:35.8 0000N	72:12:34.70 000W
	Outp uts	318.44031	35.88843	38:31:24.8 4927N	72:42:54.95 851W								
test1 5	Input s	40:10:24.5 0000N	70:12:45.60 000W	40:05:30.7 7099N	74:33:27.97 842W	40:08:24.4 1100N	70:12:45.60 000W	40:04:30.7 9747N	74:33:24.15 824W	-2.0	-1.0	38:04:35.8 0000N	72:12:34.70 000W
	Outp uts	358.99772	123.10364	40:07:47.6 7496N	72:15:23.10 907W								
test1 6	Input s	20:10:24.5 0000N	70:12:45.60 000W	22:47:42.8 8332N	67:59:32.62 915W	20:11:01.5 7566N	70:13:35.86 376W	22:48:20.6 1693N	68:00:23.22 901W	-1.0	-1.0	22:04:35.8 0000N	68:12:34.70 000W
	Outp uts	308.72881	18.49323	22:16:11.6 8878N	68:28:07.95 660W								
test1 7	Input s	20:10:24.5 0000N	70:12:45.60 000W	22:47:42.8 8332N	67:59:32.62 915W	20:09:47.4 2031N	70:11:55.34 284W	22:47:05.1 4519N	67:58:42.03 703W	1.0	1.0	22:04:35.8 0000N	68:12:34.70 000W
	Outp uts	308.72881	16.49323	22:14:56.5 0252N	68:26:26.90 385W								
test1 8	Input s	20:10:24.5 0000N	70:12:45.60 000W	22:47:42.8 8332N	67:59:32.62 915W	20:09:47.4 2031N	70:11:55.34 284W	22:46:27.4 0256N	67:57:51.45 264W	1.0	2.0	22:04:35.8 0000N	68:12:34.70 000W
	Outp uts	309.01529	15.69835	22:14:30.2 9919N	68:25:43.56 946W								
test1 9	Input s	20:10:24.5 0000N	70:12:45.60 000W	22:47:42.8 8332N	67:59:32.62 915W	20:11:01.5 7566N	70:13:35.86 376W	22:48:58.3 4604N	68:01:13.83 660W	-1.0	-2.0	22:04:35.8 0000N	68:12:34.70 000W
	Outp uts	308.44233	19.28768	22:16:37.0 0430N	68:28:51.98 766W								
test2 0	Input s	20:10:24.5 0000N	70:12:45.60 000W	21:42:55.0 4997N	67:03:07.16 284W	20:11:17.6 7400N	70:13:15.54 639W	21:44:42.4 7168N	67:04:05.42 224W	-1.0	-2.0	22:04:35.8 0000N	68:12:34.70 000W
	Outp uts	152.41757	46.88028	21:22:52.1 6995N	67:49:19.19 587W								
test2 1	Input s	20:10:24.5 0000N	70:12:45.60 000W	20:08:16.1 0563N	66:40:11.24 376W	20:08:24.0 5152N	70:12:45.60 000W	20:07:15.8 9488N	66:40:12.60 255W	2.0	1.0	22:04:35.8 0000N	68:12:34.70 000W
	Outp uts	180.40439	115.88931	20:08:17.3 9840N	68:13:26.84 791W								
test2	Input	20:10:24.5	70:12:45.60	18:08:16.6	67:25:03.87	20:12:00.6	70:11:28.81	18:09:51.6	67:23:46.42	-2.0	-2.0	22:04:35.8	68:12:34.70

2	s	0000N	000W	0075N	343W	8945N	766W	3861N	707W			0000N	000W
	Outputs	217.71425	156.60521	19:59:44.5 1317N	69:54:16.80 106W								
test2 3	Inputs	20:10:24.5 0000N	70:12:45.60 000W	17:16:01.6 1500N	68:28:18.10 827W	20:09:54.3 8551N	70:13:40.83 341W	17:15:02.3 8476N	68:30:07.30 583W	1.0	2.0	20:04:35.8 0000N	69:12:34.70 000W
	Outputs	240.62790	47.41380	19:41:09.8 0503N	69:56:21.99 784W								
test2 4	Inputs	20:10:24.5 0000N	70:12:45.60 000W	23:26:37.8 6400N	69:27:33.93 765W	20:10:37.0 1823N	70:13:47.98 905W	23:27:03.4 5735N	69:29:41.45 246W	-1.0	-2.0	22:04:35.8 0000N	68:12:34.70 000W
	Outputs	282.46352	87.05417	22:23:01.2 3192N	69:44:17.95 270W								
test2 5	Inputs	20:10:24.5 0000N	70:12:45.60 000W	23:31:06.9 3560N	70:12:45.60 000W	20:10:24.4 8716N	70:10:38.03 712W	23:31:06.9 3179N	70:11:40.31 639W	2.0	1.0	22:04:35.8 0000N	68:12:34.70 000W
	Outputs	270.46647	110.19089	22:04:46.7 8090N	70:11:13.20 586W								
test2 6	Inputs	20:10:24.5 0000N	70:12:45.60 000W	23:30:20.0 6967N	70:31:42.81 974W	20:10:19.2 4793N	70:13:49.13 814W	23:30:09.3 1498N	70:33:52.85 078W	-1.0	-2.0	22:04:35.8 0000N	68:12:34.70 000W
	Outputs	265.46611	122.69379	21:53:59.0 0085N	70:24:06.45 107W								
test2 7	Inputs	20:10:24.5 0000N	70:12:45.60 000W	22:12:35.6 9228N	73:02:34.77 881W	20:11:11.9 5601N	70:12:06.32 892W	22:13:23.7 9135N	73:01:55.88 211W	1.0	1.0	22:04:35.8 0000N	69:12:34.70 000W
	Outputs	218.36943	123.21147	20:27:18.8 1236N	70:34:01.01 617W								
test2 8	Inputs	20:10:24.5 0000N	70:12:45.60 000W	16:49:37.4 9349N	70:12:45.60 000W	20:10:24.4 9679N	70:11:41.81 856W	16:49:37.4 8292N	70:10:40.49 187W	-1.0	-2.0	18:04:35.8 0000N	72:12:34.70 000W
	Outputs	89.09350	115.76556	18:05:47.8 6911N	70:11:03.51 621W								
test2 9	Inputs	20:10:24.5 0000N	70:12:45.60 000W	18:00:09.4 6178N	72:53:29.02 106W	20:11:56.7 6327N	70:14:07.60 925W	18:00:55.0 0817N	72:54:10.22 384W	2.0	1.0	18:04:35.8 0000N	72:12:34.70 000W
	Outputs	319.05008	23.26620	18:22:13.6 4861N	72:28:36.69 646W								
test3 0	Inputs	20:10:24.5 0000N	70:12:45.60 000W	20:08:16.1 0563N	73:45:19.95 624W	20:08:24.0 5152N	70:12:45.60 000W	20:07:15.8 9488N	73:45:18.59 745W	-2.0	-1.0	18:04:35.8 0000N	72:12:34.70 000W
	Outputs	359.59765	123.21213	20:08:16.8 2998N	72:13:29.86 100W								

WGS84PointToArcTangents

Test Identifier	Point Latitude	Point Longitude	Arc Center Latitude	Arc Center Longitude	Arc Radius	Tangent Point 1 Latitude	Tangent Point 1 Longitude	Tangent Point 2 Latitude	Tangent Point 2 Longitude
test1	40:04:35.80000 N	68:12:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	N/A	N/A	N/A	N/A
test2	40:04:35.80000 N	67:12:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	38:58:50.99979 N	68:42:19.92957 W	41:17:02.57149 N	68:34:37.49185 W
test3	40:04:35.80000 N	60:42:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	38:33:51.49399 N	69:38:46.59230 W	41:48:38.13537 N	69:47:36.01065 W
test4	40:04:35.80000 N	47:18:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	38:32:36.38289 N	69:45:21.56093 W	41:50:24.89752 N	70:17:02.95660 W
test5	42:54:35.80000 N	70:11:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	41:10:08.36776 N	68:27:18.83665 W	41:10:59.53083 N	71:57:22.47464 W
test6	64:54:35.80000 N	70:11:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	40:15:27.76756 N	68:02:23.12392 W	40:15:31.95981 N	72:23:07.86461 W
test7	52:54:35.80000 N	70:11:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	40:21:58.95584 N	68:02:59.46118 W	40:22:10.22316 N	72:22:30.19164 W
test8	40:24:35.80000 N	75:11:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	41:43:51.26621 N	70:59:57.14126 W	38:44:18.56935 N	71:18:35.69631 W
test9	40:24:35.80000 N	85:11:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	41:50:23.42412 N	70:17:57.13255 W	38:33:20.77969 N	70:44:13.68450 W
test10	40:24:35.80000 N	80:11:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	41:49:34.92720 N	70:30:17.76805 W	38:34:51.79348 N	70:51:10.47505 W
test11	37:09:35.80000 N	70:21:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	39:17:29.76121 N	72:02:47.41811 W	39:11:04.58987 N	68:28:26.79906 W
test12	30:09:35.80000 N	70:21:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	39:53:58.01340 N	72:21:11.40785 W	39:51:26.97905 N	68:04:57.44757 W
test13	25:09:35.80000 N	70:21:34.70000 W	40:10:24.50000 N	70:12:45.60000 W	100.0	39:59:12.99136 N	72:22:13.50689 W	39:57:25.86494 N	68:03:36.34196 W
test14	40:04:35.80000 N	72:12:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test15	40:04:35.80000 N	73:12:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	38:58:59.31128 N	71:43:22.32134E	41:16:52.48137 N	71:51:05.39764E
test16	40:04:35.80000 N	80:12:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	38:33:38.85748 N	70:45:44.00068E	41:48:54.91998 N	70:35:56.19986E
test17	40:04:35.80000 N	85:12:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	38:32:40.44989 N	70:40:33.55927E	41:50:14.09817 N	70:21:45.92010E
test18	42:54:35.80000 N	70:11:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	41:10:59.53083 N	71:57:22.47464E	41:10:08.36776 N	68:27:18.83666E
test19	52:54:35.80000 N	70:11:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	40:22:10.22315 N	72:22:30.19164E	40:21:58.95586 N	68:02:59.46118E
test20	57:54:35.80000 N	70:11:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	40:18:20.82175 N	72:22:56.15166E	40:18:13.61636 N	68:02:34.42092E
test21	40:24:35.80000 N	65:11:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	41:43:58.89962 N	69:26:00.45951E	38:44:06.31619 N	69:07:22.38700E
test22	40:24:35.80000 N	55:11:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	41:50:23.55695 N	70:07:38.55861E	38:33:20.46158 N	69:41:19.14594E

test23	40:24:35.80000 N	60:11:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	41:49:35.71820 N	69:55:21.25651E	38:34:50.41383 N	69:34:26.43627E
test24	37:09:35.80000 N	70:21:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	39:11:04.58989 N	68:28:26.79904E	39:17:29.76123 N	72:02:47.41812E
test25	32:09:35.80000 N	70:21:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	39:47:00.76207 N	68:06:16.51285E	39:50:03.52790 N	72:20:10.72389E
test26	27:09:35.80000 N	70:21:34.70000E	40:10:24.50000 N	70:12:45.60000E	100.0	39:55:34.77439 N	68:03:58.36606E	39:57:35.60852 N	72:21:56.65907E
test27	40:04:35.80000S	72:12:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test28	40:04:35.80000S	73:12:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	41:16:52.48137S	71:51:05.39763E	38:58:59.31128S	71:43:22.32134E
test29	40:04:35.80000S	83:12:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	41:49:55.55059S	70:26:29.37475E	38:32:53.74966S	70:41:49.38811E
test30	40:04:35.80000S	80:12:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	41:48:54.91998S	70:35:56.19985E	38:33:38.85748S	70:45:44.00069E
test31	38:04:35.80000S	70:11:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	38:49:55.28970S	71:29:33.42172E	38:50:48.30732S	68:54:26.10830E
test32	28:04:35.80000S	70:11:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	39:55:27.43830S	72:21:31.28285E	39:55:44.66533S	68:03:56.29379E
test33	33:04:35.80000S	70:11:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	39:45:36.78731S	72:18:46.32802E	39:46:03.95424S	68:06:35.51577E
test34	40:24:35.80000S	65:51:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	38:48:24.38501S	68:58:41.71027E	41:41:16.63837S	69:17:31.03298E
test35	40:24:35.80000S	60:51:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	38:35:16.36317S	69:32:41.49524E	41:49:20.73591S	69:53:01.97091E
test36	40:24:35.80000S	55:51:34.70000E	40:10:24.50000S	70:12:45.60000E	100.0	38:33:26.36693S	69:40:49.11846E	41:50:20.97633S	70:06:20.58405E
test37	43:09:35.80000S	69:38:25.30000E	40:10:24.50000S	70:12:45.60000E	100.0	40:52:32.16687S	68:13:48.41601E	41:16:01.63700S	71:52:03.48811E
test38	48:09:35.80000S	69:38:25.30000E	40:10:24.50000S	70:12:45.60000E	100.0	40:25:12.33606S	68:03:29.94912E	40:34:39.67829S	72:19:42.54233E
test39	53:09:35.80000S	69:38:25.30000E	40:10:24.50000S	70:12:45.60000E	100.0	40:19:08.92651S	68:02:39.52957E	40:24:28.22924S	72:22:08.94257E
test40	40:04:35.80000S	68:12:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	N/A	N/A	N/A	N/A
test41	40:04:35.80000S	66:47:25.30000 W	40:10:24.50000S	70:12:45.60000 W	100.0	41:26:06.94082S	68:46:38.84215 W	38:51:27.83161S	68:53:19.53080 W
test42	40:04:35.80000S	56:47:25.30000 W	40:10:24.50000S	70:12:45.60000 W	100.0	41:50:00.49059S	70:00:06.82169 W	38:32:50.15608S	69:44:01.95578 W
test43	40:04:35.80000S	59:47:25.30000 W	40:10:24.50000S	70:12:45.60000 W	100.0	41:49:07.32741S	69:51:10.22069 W	38:33:29.54331S	69:40:33.17198 W
test44	38:04:35.80000S	70:11:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	38:50:48.30732S	68:54:26.10830 W	38:49:55.28969S	71:29:33.42171 W
test45	28:04:35.80000S	70:11:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	39:55:44.66533S	68:03:56.29379 W	39:55:27.43828S	72:21:31.28285 W
test46	33:04:35.80000S	70:11:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	39:46:03.95424S	68:06:35.51577 W	39:45:36.78730S	72:18:46.32802 W
test47	40:24:35.80000S	74:11:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	38:51:54.10807S	71:32:55.13292 W	41:39:02.49151S	71:13:58.65781 W
test48	40:24:35.80000S	84:11:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	38:33:30.19485S	70:45:01.28168 W	41:50:19.19941S	70:19:56.15761 W
test49	40:24:35.80000S	80:11:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	38:34:51.79347S	70:51:10.47504 W	41:49:34.92720S	70:30:17.76806 W
test50	43:09:35.80000S	70:21:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	41:02:16.59197S	72:05:02.69299 W	41:08:20.56609S	68:25:37.35380 W
test51	48:09:35.80000S	70:21:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	40:28:45.82853S	72:21:17.78853 W	40:31:11.70040S	68:04:49.12313 W
test52	53:09:35.80000S	70:21:34.70000 W	40:10:24.50000S	70:12:45.60000 W	100.0	40:21:08.09707S	72:22:38.37153 W	40:22:30.13116S	68:03:03.81110 W

WGS84PerpTangentPoints Test Results

Test Identifier	Geodesic Start Latitude	Geodesic Start Longitude	Geodesic Azimuth (degrees)	Arc Center Latitude	Arc Center Longitude	Arc Radius	Intercept 1 Latitude	Intercept 1 Longitude	Intercept 2 Latitude	Intercept 2 Longitude	Tangent Point 1 Latitude	Tangent Point 1 Longitude	Tangent Point 2 Latitude	Tangent Point 2 Longitude
test1	40:04:35.80000N	65:12:40.70000W	350.0	40:10:24.50000N	70:12:45.60000W	50.0	41:45:15.42301N	65:36:23.05394W	40:06:32.80959N	65:13:07.57044W	40:59:04.91370N	70:27:57.32812W	39:21:40.43861N	69:58:02.47943W
test2	40:04:35.80000N	65:12:40.70000W	200.0	40:10:24.50000N	70:12:45.60000W	50.0	38:14:05.43205N	66:03:35.08024W	39:48:31.53705N	65:20:15.65454W	39:22:29.68372N	70:31:27.94338W	40:58:17.46091N	69:53:43.69995W
test3	40:04:35.80000N	68:12:40.70000W	325.0	40:10:24.50000N	70:12:45.60000W	100.0	42:13:23.37083N	70:14:57.87719W	39:30:24.62906N	67:41:50.28458W	41:30:34.37380N	71:31:37.17040W	38:49:17.65513N	68:57:04.57474W
test4	40:04:35.80000N	65:12:40.70000W	270.0	40:10:24.50000N	70:12:45.60000W	50.0	39:55:02.92066N	71:16:44.98301W	40:00:38.90564N	69:06:53.45783W	40:07:17.85127N	71:17:50.28392W	40:12:54.82728N	69:07:35.57088W
test5	40:04:35.80000N	65:12:40.70000W	300.0	40:10:24.50000N	70:12:45.60000W	50.0	42:06:05.22048N	70:09:48.79496W	41:20:00.99595N	68:11:12.42020W	40:32:38.56283N	71:11:21.28560W	39:47:38.67195N	69:14:49.94129W
test6	40:04:35.80000N	65:12:40.70000W	240.0	40:10:24.50000N	70:12:45.60000W	50.0	37:57:45.76917N	69:38:55.15062W	38:51:12.13212N	67:51:14.22782W	39:42:50.60770N	71:07:01.04721W	40:37:35.17545N	69:17:48.54937W
test7	44:54:35.80000N	70:11:34.70000W	180.0	40:10:24.50000N	70:12:45.60000W	50.0	39:20:22.07307N	70:11:34.70000W	41:00:26.50523N	70:11:34.70000W	39:20:22.06721N	70:12:44.75738W	41:00:26.49902N	70:12:46.49381W
test8	44:54:35.80000N	70:11:34.70000W	148.0	40:10:24.50000N	70:12:45.60000W	50.0	40:44:55.03008N	66:49:02.96925W	42:11:35.30495N	67:55:46.12774W	39:27:50.18529N	69:38:39.28546W	40:52:46.19633N	70:47:39.16449W
test9	44:54:35.80000N	70:11:34.70000W	211.0	40:10:24.50000N	70:12:45.60000W	50.0	40:39:20.90907N	73:30:31.26204W	42:06:51.06530N	72:25:51.03824W	39:27:22.55669N	70:45:52.63953W	40:53:14.53640N	69:38:52.20992W
test10	40:24:35.80000N	75:11:34.70000W	90.0	40:10:24.50000N	70:12:45.60000W	50.0	40:15:00.17740N	69:06:59.49277W	40:20:38.68482N	71:17:28.91405W	40:07:17.14968N	69:07:40.97872W	40:12:55.02357N	71:17:55.61784W
test11	40:24:35.80000N	75:11:34.70000W	71.0	40:10:24.50000N	70:12:45.60000W	50.0	41:42:40.03737N	69:38:05.90758W	41:14:59.29549N	71:45:59.60155W	40:23:40.58611N	69:09:45.81981W	39:56:32.34252N	71:15:19.64207W
test12	40:24:35.80000N	75:11:34.70000W	117.0	40:10:24.50000N	70:12:45.60000W	50.0	38:21:19.52582N	70:19:44.57750W	39:10:39.07842N	72:11:03.63508W	39:45:02.93329N	69:16:42.08956W	40:35:20.61719N	71:09:29.12730W
test13	37:09:35.80000N	70:21:34.70000W	0.0	40:10:24.50000N	70:12:45.60000W	50.0	41:00:26.84065N	70:21:34.70000W	39:20:22.39722N	70:21:34.70000W	41:00:26.49479N	70:12:38.92986W	39:20:22.07107N	70:12:51.88818W
test14	37:09:35.80000N	70:21:34.70000W	34.0	40:10:24.50000N	70:12:45.60000W	50.0	39:57:02.53883N	67:53:34.67323W	38:35:09.95589N	69:07:43.83953W	40:51:46.48176N	69:35:52.67111W	39:28:52.04803N	70:48:56.68220W
test15	37:09:35.80000N	70:21:34.70000W	331.0	40:10:24.50000N	70:12:45.60000W	50.0	40:07:42.80472N	72:30:57.33906W	38:41:00.31862N	71:26:24.86130W	40:54:09.57283N	70:44:34.61853W	39:26:31.66858N	69:41:34.39676W
test16	40:04:35.80000N	75:12:34.70000E	350.0	40:10:24.50000N	70:12:45.60000E	50.0	41:45:12.67315N	74:48:53.01070E	40:06:30.07882N	75:12:08.45696E	40:59:04.94944N	69:57:34.06882E	39:21:40.40510N	70:27:28.53420E
test17	40:04:35.80000N	75:12:34.70000E	200.0	40:10:24.50000N	70:12:45.60000E	50.0	38:14:08.75549N	74:21:41.80893E	39:48:34.82983N	75:05:01.29260E	39:22:29.72463N	69:54:03.08054E	40:58:17.41786N	70:31:47.68622E
test18	40:04:35.80000N	72:12:34.70000E	315.0	40:10:24.50000N	70:12:45.60000E	100.0	42:02:53.59978N	69:31:25.90082E	39:43:08.75530N	72:40:17.05485E	41:18:51.03968N	68:36:46.64551E	39:00:35.86938N	71:45:27.62796E
test19	40:04:35.80000N	73:12:34.70000E	270.0	40:10:24.50000N	70:12:45.60000E	50.0	40:00:17.63529N	69:08:04.99603E	40:03:39.33076N	71:18:12.14247E	40:08:25.20509N	69:07:35.90168E	40:11:47.29572N	71:17:58.51179E
test20	40:04:35.80000N	73:12:34.70000E	300.0	40:10:24.50000N	70:12:45.60000E	50.0	41:28:31.69569N	69:52:44.13264E	40:40:49.88638N	71:49:00.24598E	40:33:41.08619N	69:14:51.20890E	39:46:37.81172N	71:09:59.27305E
test22	40:04:35.80000N	73:12:34.70000E	240.0	40:10:24.50000N	70:12:45.60000E	50.0	38:39:26.700947	70:09:47.393132	39:31:32.715930	71:59:30.394345	39:43:45.691744	40:36:38.710828		

1	8000N	7000E		5000N	6000E	0	28959N	67412E	39864N	22696E	18199N	08525E	84939N	77660E
test2	42:54:35. 8000N	70:11:34. 7000E	180.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	39:20:22. 07307N	70:11:34. 7000E	41:00:26. 50523N	70:11:34. 7000E	39:20:22. 06721N	70:12:44. 75738E	41:00:26. 49902N	70:12:46. 49381E
test2	42:54:35. 8000N	70:11:34. 7000E	148.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	40:12:21. 71012N	72:22:44. 76027E	41:38:14. 00626N	71:14:56. 56898E	39:27:51. 50743N	70:46:54. 69271E	40:52:45. 72705N	69:37:51. 05930E
test2	42:54:35. 8000N	70:11:34. 7000E	211.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	40:10:13. 49744N	68:03:47. 64473E	41:36:57. 43421N	69:09:38. 18678E	39:27:25. 16505N	69:39:32. 86210E	40:53:12. 66240N	70:46:43. 04537E
test2	40:24:35. 8000N	65:11:34. 7000E	90.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	40:14:52. 70121N	71:18:31. 30185E	40:20:33. 87049N	69:08:02. 27516E	40:07:15. 81920N	71:17:50. 10192E	40:12:56. 35847N	69:07:35. 65928E
test2	40:24:35. 8000N	65:11:34. 7000E	71.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	41:43:07. 73081N	70:47:18. 27558E	41:15:29. 46607N	68:39:22. 65865E	40:23:39. 25925N	71:15:45. 84597E	39:56:33. 64852N	69:10:11. 05812E
test2	40:24:35. 8000N	65:11:34. 7000E	117.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	38:20:32. 33083N	70:05:08. 22153E	39:09:53. 57178N	68:13:51. 51407E	39:45:01. 83231N	71:08:48. 26146E	40:35:21. 75120N	69:16:02. 91762E
test2	37:09:35. 8000N	70:21:34. 7000E	0.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	41:00:26. 84065N	70:21:34. 7000E	39:20:22. 39722N	70:21:34. 7000E	41:00:26. 49479N	70:12:38. 92986E	39:20:22. 07107N	70:12:51. 88818E
test2	37:09:35. 8000N	70:21:34. 7000E	31.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	40:01:09. 54385N	72:36:33. 75760E	38:36:16. 81276N	71:28:10. 67923E	40:53:16. 92717N	70:46:33. 80034E	39:27:23. 36126N	69:39:36. 80041E
test3	37:09:35. 8000N	70:21:34. 7000E	331.0	40:10:24. 5000N	70:12:45. 6000E	50. 0	40:13:21. 86911N	68:07:53. 03613E	38:46:42. 27396N	69:12:35. 67163E	40:54:04. 71013N	69:40:45. 15677E	39:26:36. 29194N	70:44:07. 71534E
test3	40:14:35. 8000S	76:12:34. 7000E	350.0	40:10:24. 5000S	70:12:45. 6000E	40. 0	38:52:44. 97680S	75:54:07. 21038E	40:11:52. 39692S	76:11:57. 12656E	39:30:36. 53650S	70:07:10. 29772E	40:50:12. 39327S	70:18:21. 70242E
test3	40:04:35. 8000S	75:12:34. 7000E	200.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	42:16:12. 64050S	74:07:57. 72436E	40:42:17. 22780S	74:54:32. 53991E	40:56:18. 37182S	69:46:38. 66583E	39:24:22. 40493S	70:38:11. 32653E
test3	40:04:35. 8000S	72:12:34. 7000E	315.0	40:10:24. 5000S	70:12:45. 6000E	100. 0	38:09:45. 50471S	69:49:01. 12662E	40:32:44. 31824S	72:49:35. 77432E	38:57:32. 89527S	68:44:05. 92033E	41:22:09. 83417S	71:44:30. 08384E
test3	40:04:35. 8000S	73:12:34. 7000E	270.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	40:00:17. 63529S	69:08:04. 99603E	40:03:39. 33076S	71:18:12. 14247E	40:08:25. 20509S	69:07:35. 90168E	40:11:47. 29572S	71:17:58. 51179E
test3	40:04:35. 8000S	73:12:34. 7000E	300.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	38:39:26. 28959S	70:09:47. 67412E	39:31:32. 39864S	71:59:30. 22696E	39:43:45. 18199S	69:17:44. 08525E	40:36:38. 84939S	71:08:28. 77660E
test3	40:04:35. 8000S	73:12:34. 7000E	240.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	41:28:31. 69569S	69:52:44. 13264E	40:40:49. 88638S	71:49:00. 24598E	40:33:41. 08619S	69:14:51. 20890E	39:46:37. 81172S	71:09:59. 27305E
test3	38:04:35. 8000S	70:11:34. 7000E	180.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	41:00:26. 50523S	70:11:34. 7000E	39:20:22. 07307S	70:11:34. 7000E	41:00:26. 49902S	70:12:46. 49381E	39:20:22. 06721S	70:12:44. 75738E
test3	38:04:35. 8000S	70:11:34. 7000E	148.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	40:17:07. 13084S	72:00:20. 55877E	38:52:56. 85946S	70:50:18. 83964E	40:52:45. 70508S	70:47:40. 18638E	39:27:53. 54845S	69:38:32. 22868E
test3	38:04:35. 8000S	70:11:34. 7000E	211.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	40:18:46. 00666S	68:25:41. 54164E	38:53:38. 70009S	69:33:47. 56507E	40:53:14. 02637S	69:38:51. 10513E	39:27:25. 77604S	70:45:59. 66955E
test4	40:24:35. 8000S	65:51:34. 7000E	90.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	40:16:52. 78726S	71:18:36. 57794E	40:21:48. 85747S	69:08:01. 28224E	40:07:38. 35059S	71:17:52. 01922E	40:12:33. 75700S	69:07:34. 45828E
test4	40:24:35. 8000S	65:51:34. 7000E	71.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	38:59:21. 92563S	70:45:28. 67998E	39:36:03. 21874S	68:45:36. 55313E	39:51:34. 97299S	71:13:03. 49121E	40:28:43. 60957S	69:11:55. 38110E
test4	40:24:35. 8000S	65:51:34. 7000E	117.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	42:01:19. 14270S	70:19:39. 19192E	41:19:26. 82819S	68:18:23. 75678E	40:30:35. 82765S	71:12:35. 50340E	39:49:40. 20801S	69:13:32. 78935E
test4	43:09:35. 8000S	69:38:25. 3000E	0.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	39:20:27. 07217S	69:38:25. 3000E	41:00:31. 67824S	69:38:25. 3000E	39:20:22. 12663S	70:12:21. 11372E	41:00:26. 43381S	70:13:11. 57361E
test4	43:09:35. 8000S	69:38:25. 3000E	34.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	40:10:58. 21027S	72:13:54. 61283E	41:35:13. 91157S	71:02:44. 04238E	39:28:37. 32353S	70:48:27. 91118E	40:51:59. 02911S	69:36:16. 97478E
test4	43:09:35. 8000S	69:38:25. 3000E	335.0	40:10:24. 5000S	70:12:45. 6000E	50. 0	40:06:15. 66891S	67:47:39. 73289E	41:37:39. 92668S	68:41:26. 00208E	39:25:07. 21618S	69:45:10. 03499E	40:55:33. 61492S	70:41:01. 20850E

test4 6	40:24:35. 80000S	65:12:40. 70000W	350.0	40:10:24. 50000S	70:12:45. 60000W	40. 0	38:58:11. 44004S	65:32:11. 35937W	40:17:14. 24083S	65:14:22. 36760W	39:30:39. 49061S	70:18:54. 59385W	40:50:09. 33911S	70:06:34. 13853W
test4 7	40:04:35. 80000S	67:12:40. 70000W	200.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	41:43:04. 52714S	68:00:35. 08875W	40:09:08. 86953S	67:14:50. 23285W	40:56:45. 65430S	70:37:27. 46544W	39:23:56. 63322S	69:48:40. 85141W
test4 8	40:04:35. 80000S	68:12:40. 70000W	315.0	40:10:24. 50000S	70:12:45. 60000W	100. .0	38:09:39. 42011S	70:36:21. 58383W	40:32:38. 43897S	67:35:47. 44055W	38:57:32. 70200S	71:41:25. 01247W	41:22:10. 04449S	68:41:01. 39841W
test4 9	40:04:35. 80000S	66:47:19. 30000W	270.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	39:59:20. 91374S	71:17:19. 47416W	40:03:11. 27515S	69:07:15. 00811W	40:08:10. 83970S	71:17:54. 39452W	40:12:01. 69154S	69:07:33. 13622W
test5 0	40:04:35. 80000S	66:47:19. 30000W	300.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	38:30:35. 82998S	70:08:06. 75040W	39:22:59. 34750S	68:18:50. 55549W	39:43:33. 42333S	71:07:37. 37083W	40:36:50. 98023S	69:17:12. 16414W
test5 1	40:04:35. 80000S	66:47:19. 30000W	240.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	41:36:36. 30412S	70:27:37. 90336W	40:49:14. 86902S	68:30:52. 22885W	40:33:27. 89443S	71:10:48. 90600W	39:46:50. 64641S	69:15:22. 88056W
test5 2	38:04:35. 80000S	70:11:34. 70000W	180.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	41:00:26. 50523S	70:11:34. 70000W	39:20:22. 07307S	70:11:34. 70000W	41:00:26. 49902S	70:12:46. 49381W	39:20:22. 06721S	70:12:44. 75738W
test5 3	38:04:35. 80000S	70:11:34. 70000W	148.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	40:16:18. 90281S	68:23:29. 95567W	38:52:08. 17125S	69:33:30. 08556W	40:52:46. 41906S	69:37:52. 49907W	39:27:52. 86878S	70:46:57. 54788W
test5 4	38:04:35. 80000S	70:11:34. 70000W	211.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	40:19:33. 41765S	71:58:06. 74176W	38:54:26. 53851S	70:49:59. 19702W	40:53:13. 33180S	70:46:41. 59808W	39:27:26. 43690S	69:39:30. 09147W
test5 5	40:24:35. 80000S	74:11:34. 70000W	90.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	40:17:53. 93865S	69:06:53. 05426W	40:22:24. 75464S	71:17:31. 47355W	40:07:50. 95861S	69:07:38. 20443W	40:12:21. 11411S	71:17:57. 31644W
test5 6	40:24:35. 80000S	74:11:34. 70000W	71.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	39:05:20. 87464S	69:36:38. 15858W	39:41:42. 34805S	71:36:49. 98435W	39:51:46. 35643S	69:12:21. 64904W	40:28:31. 97625S	71:13:41. 67519W
test5 7	40:24:35. 80000S	74:11:34. 70000W	117.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	41:54:54. 96618S	70:02:37. 71975W	41:12:42. 82714S	72:03:28. 17431W	40:30:47. 80049S	69:13:02. 54949W	39:49:28. 51990S	71:11:51. 36671W
test5 8	43:09:35. 80000S	70:21:34. 70000W	0.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	39:20:22. 39722S	70:21:34. 70000W	41:00:26. 84065S	70:21:34. 70000W	39:20:22. 07107S	70:12:51. 88818W	41:00:26. 49479S	70:12:38. 92986W
test5 9	43:09:35. 80000S	70:21:34. 70000W	34.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	40:20:09. 24057S	67:53:40. 37644W	41:44:20. 61162S	69:05:11. 16171W	39:28:45. 24018S	69:36:47. 75179W	40:51:50. 71125S	70:49:30. 38048W
test6 0	43:09:35. 80000S	70:21:34. 70000W	331.0	40:10:24. 50000S	70:12:45. 60000W	50. 0	40:10:21. 52153S	72:30:11. 26250W	41:38:48. 88727S	71:28:25. 57541W	39:26:35. 31407S	70:44:05. 41422W	40:54:03. 53921S	69:40:42. 41911W

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Appendix 2

The following individuals contributed to this Appendix:

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Dr. Richard Snow, The MITRE Corporation

M. Jane Henry, Innovative Solutions International, Inc.

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Directive Feedback Information

Please submit any written comments or recommendation for improving this directive, or suggest new items or subjects to be added to it. Also, if you find an error, please tell us about it.

Subject: Order

To: Directive Management Officer, _____

(Please check all appropriate line items)

- An error (procedural or typographical) has been noted in paragraph _____ on page _____ .
- Recommend paragraph _____ on page _____ be changed as follows:
(attached separate sheet if necessary)

- In a future change to this order, please include coverage on the following subject
(briefly describe what you want added):

Other comments:

I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____

Telephone Number: _____ Routing Symbol: _____