U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

National Policy

ORDER 8260.54A

Effective Date:
12/07/07

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
Carol Giles

James J. Ballough
Director
Flight Standards Service

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Initiated By: AFS-420

RECORD OF CHANGES

8260.54A

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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 (***BaroVNAV***) 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

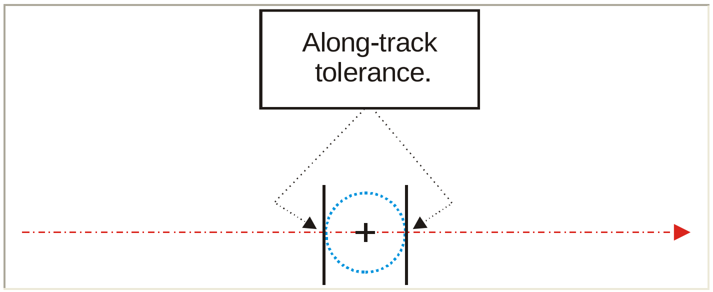
1.7 Definitions.

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 ± value (*see figure 1-1*).

Figure 1-1. *ATT.*



*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.*

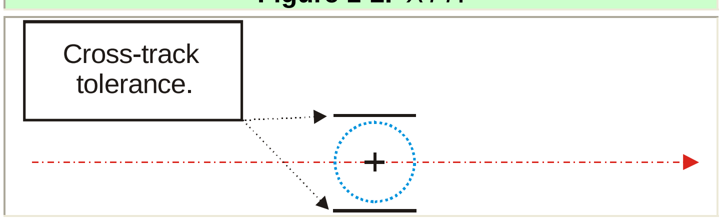
1.7.3 Barometric Altitude.

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 ± value (*see figure 1-2*).

Figure 1-2. *XTT.*



*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.

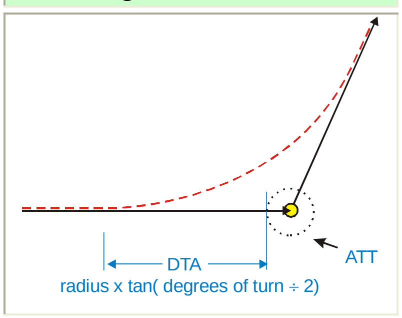
1.7.6 Departure End of Runway (*DER*).

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*).

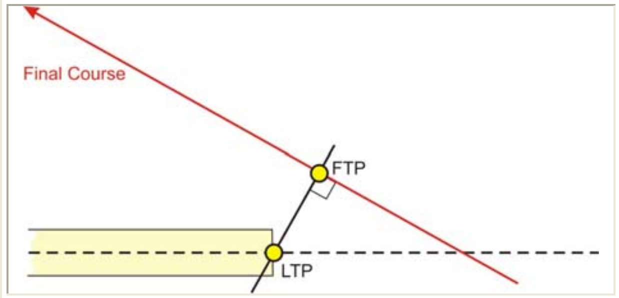
Figure 1-3. *DTA*.



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.

Figure 1-4. *FTP.*



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		
Click Here to Calculate	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. *HATh Example.*

$$HATh = DA - LTP_{elev}$$

$DA - LTP_{elev}$

Calculator

LTP_{elev}		Click Here to Calculate
DA		
HATh		

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*.

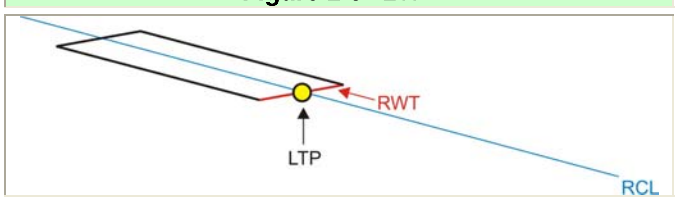
The inner-transitional ***OFZ*** is the airspace above the surfaces located on the outer edges of the runway ***OFZ*** and the inner-approach ***OFZ***. It applies to runways with approach visibility minimums less than ¾ statute miles (***SM***). (*USAF NA*)

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**).*

Figure 1-5. *LTP.*



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.

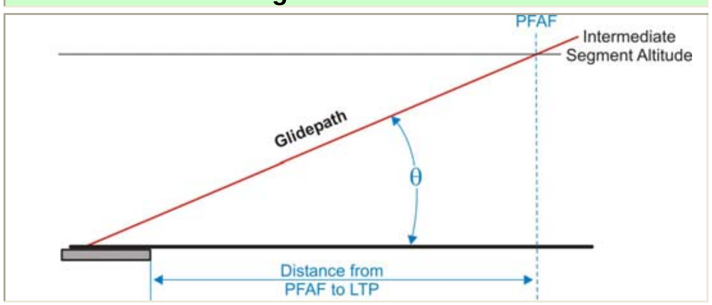
1.7.25 Obstacle Positions (*OBS*$_{X,Y,Z}$).

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.

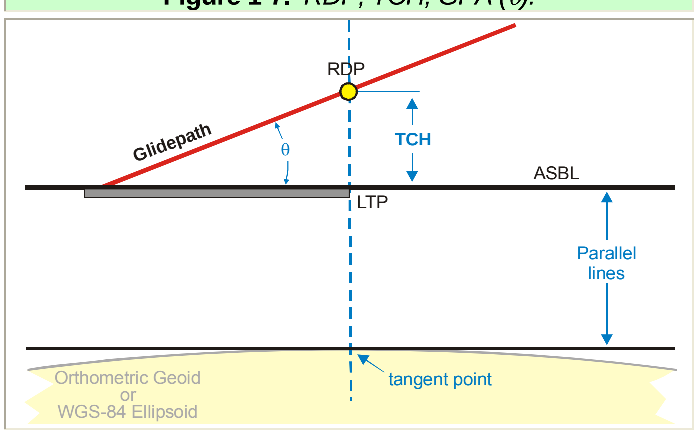
Figure 1-6. *PFAF.*



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*).

Figure 1-7. *RDP, TCH, GPA (θ).*



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.

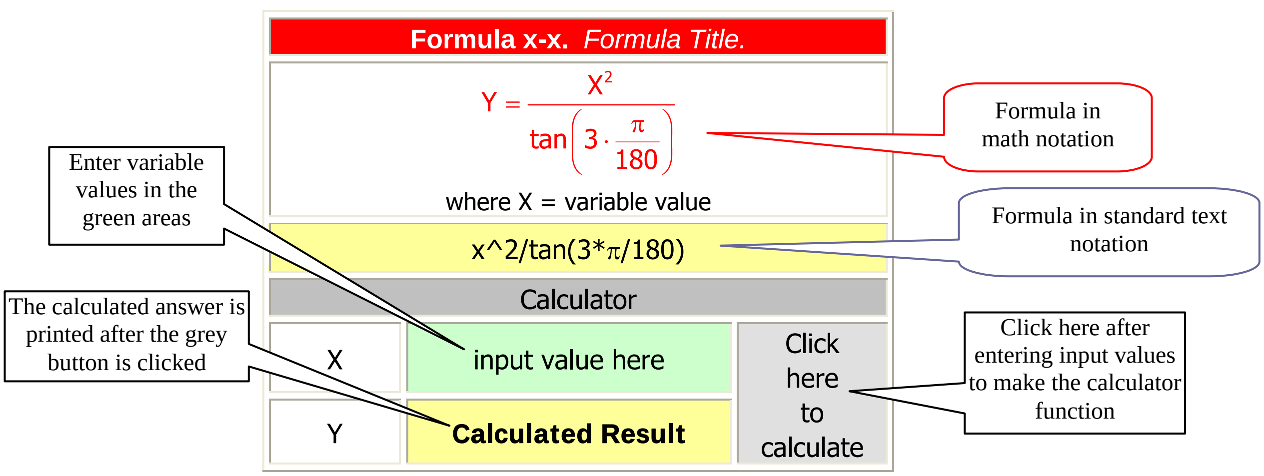
8260.3, *United States Standard for Terminal Instrument Procedures (**TERPS**).*

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.



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:

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

- Radian measure to degree measure:

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

- Feet to meters:

$$meters = feet \cdot 0.3048$$

- Meters to feet

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

- Feet to Nautical Miles (***NM***)

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

- ***NM*** to feet:

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

- ***NM*** to meters

$$meters = NM \cdot 1852$$

- Meters to ***NM***

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

- Temperature Celsius to Fahrenheit:

$$T_{Fahrenheit} = 1.8 \cdot T_{Celcius} + 32$$

- Temperature Fahrenheit to Celsius

$$T_{Celcius} = \frac{T_{Fahrenheit} - 32}{1.8}$$

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^0.5 indicates the square root of quantity "a"
a^2 or a^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 $atan(a)$ indicates the arc tangent of "a"
$\sin(a)$ indicates the sine of "a" degrees
$\sin^{-1}(a)$ or $asin(a)$ indicates the arc sine of "a"
$\cos(a)$ indicates the cosine of "a" degrees
$\cos^{-1}(a)$ or $acos(a)$ 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 2.7182818284590452353602874713526624977757...

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

<u>Notes on calculator usage</u>:

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 I'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*).

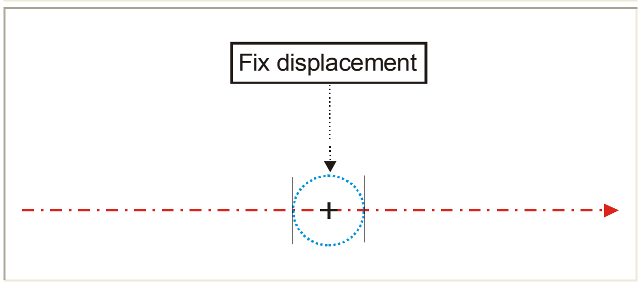
Apply the vertical and horizontal accuracy standards in Order 8260.19, paragraphs 272, 273, 274, and appendix 3. (USAF, apply guidance per AFI 11-230)

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*).

Figure 2-1. *ATT.*



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.

Figure 2-2. *Segment Width Variables.*

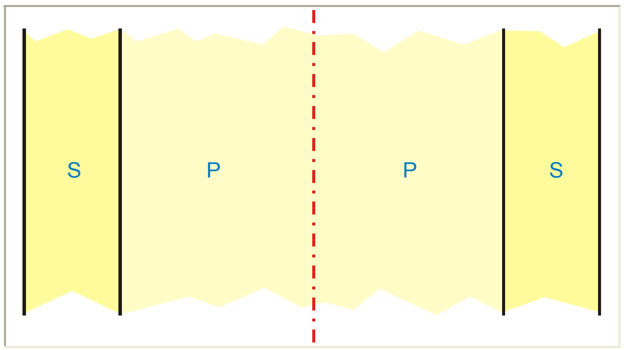
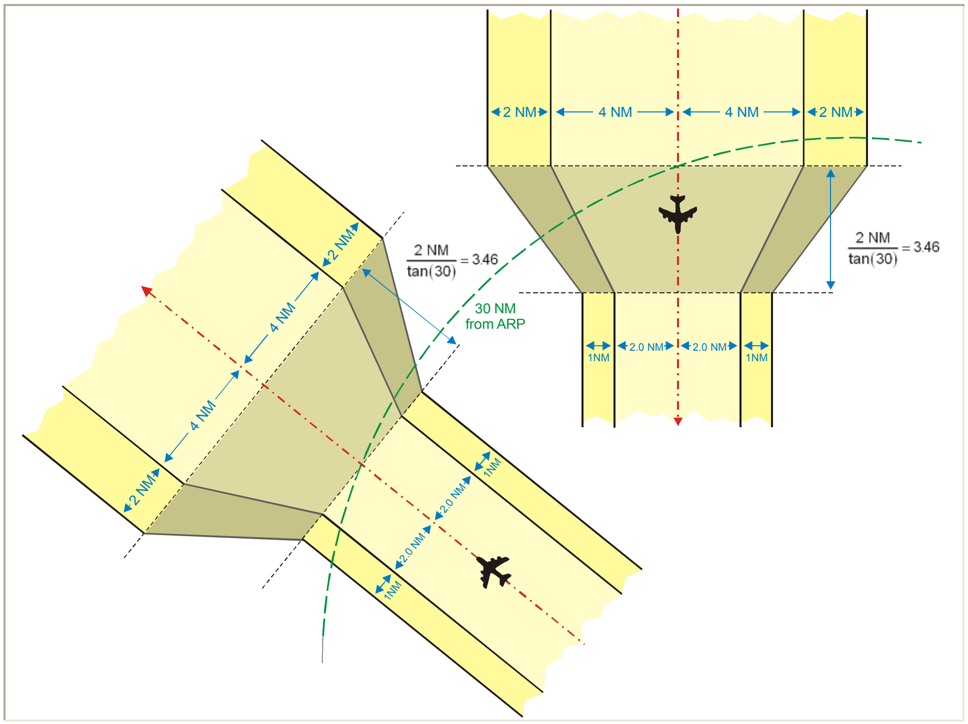


Figure 2-3a. *Segment Width Changes at 30 NM.*



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 (**$B_{primary}$**, **$B_{secondary}$**) 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.*

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

Calculates degrees of arc (α) to complete taper

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

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

where R = RF leg radius

ϕ = degrees of arc (RF track)

Note: "D" will be in the same units as "R"

α = (180*D)/(π*R)

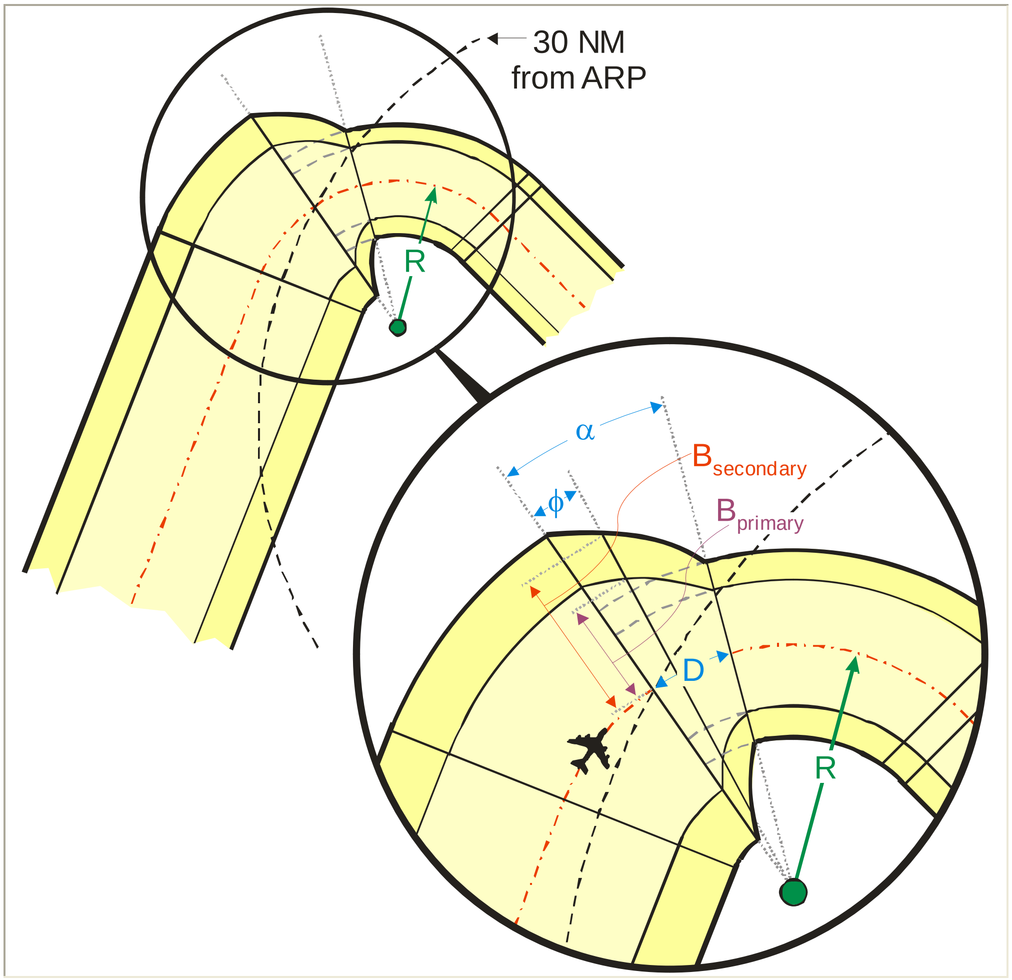
$B_{primary}$ = 4-2*(ϕ*π*R)/(180*D)

$B_{secondary}$ = 6-3*(ϕ*π*R)/(180*D)

Calculator

R		Click Here to Calculate
ϕ	°	
α	°	
D		
$B_{primary}$		
$B_{secondary}$		

Figure 2-3b. *Segment Width Changes in RF Leg (advanced avionics required).*



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.

<u>Note</u>: *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.*

$$VP_{alt} = e^{\frac{D_Z \cdot \tan\left(3 \cdot \frac{\pi}{180}\right)}{r}} \cdot \left(r + PFAF_{alt}\right) - r$$

where $PFAF_{alt}$ = Designed PFAF MSL altitude
θ = glidepath angle
D_Z = distance (ft) from PFAF to fix

Note: If D_Z is a NM value, convert to feet by multiplying NM by 1852/0.3048

e^((DD_Z*tan(3*π/180))/r)*(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 [ϕ*250/12 or ϕ*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.*

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

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.***		
$V_{KTW} = 0.00198 \cdot alt + 47$ where alt = highest turn altitude *Note: If "alt" is 2000 or less above airport elevation, then V_{KTW} = 30*		
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.*		
$$R = \frac{(V_{KTAS} + V_{KTW})^2}{\tan\left(bank_{angle} \cdot \frac{\pi}{180}\right) \cdot 68625.4}$$ where $bank_{angle}$ = assumed bank angle (normally 14° for Cat A, 18° for Cats B-D)		
$(V_{KTAS}+V_{KTW})$^2/(tan($bank_{angle}$*π/180)*68625.4)		
Calculator		
V_{KTAS}		Click Here to Calculate
V_{KTW}		
$bank_{angle}$	°	
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* $R = \dfrac{20}{\tan\left(\dfrac{\phi}{2} \cdot \dfrac{\pi}{180}\right)}$ *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.*

$$rr = 6 \cdot \frac{\frac{1852}{0.3048}}{3600} \cdot V_{KTAS}$$

6*1852/0.3048/3600*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*.

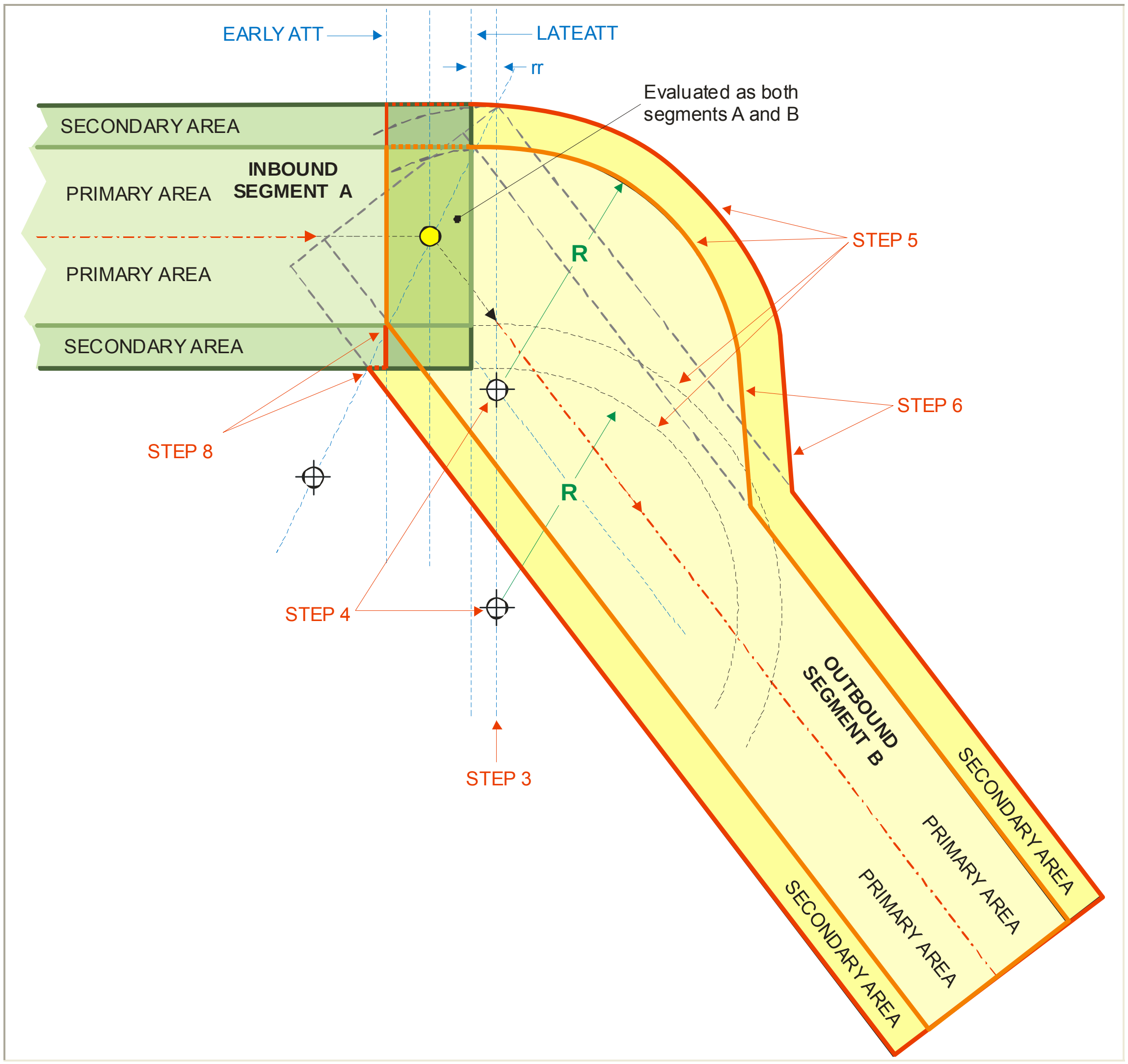
STEP 3: Establish the baseline for construction of the turn expansion area as the line perpendicular to the inbound track at a distance past the turn fix equal to (***ATT***+***rr***).

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.

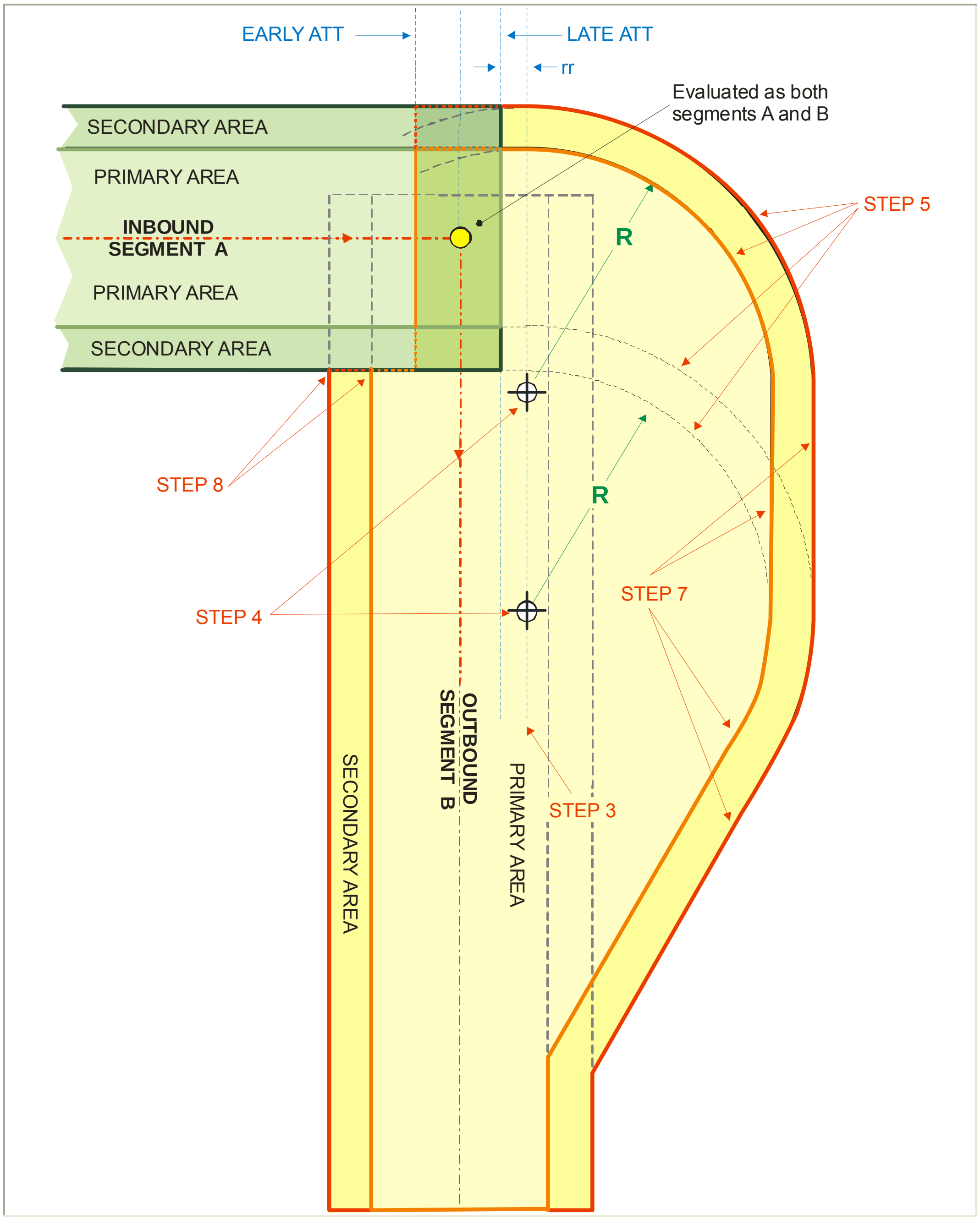
Figure 2-4. *Fly-Over with No Second Arc Expansion.*



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.

Figure 2-5. *Fly-Over with Second Arc Expansion.*



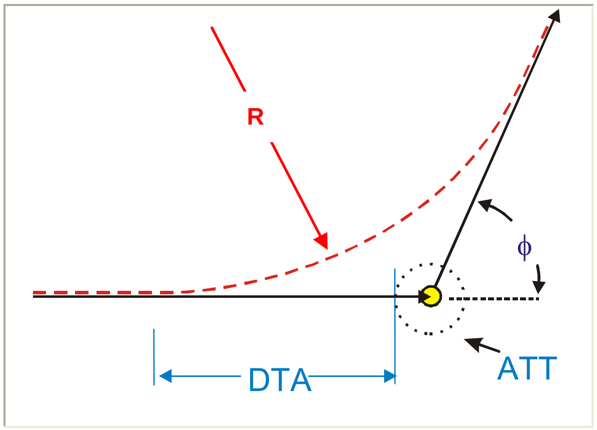
The inbound ***OEA*** end (± ***ATT***) is evaluated for both inbound and outbound segments.

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.*

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

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



R*tan(ϕ/2*π/180)

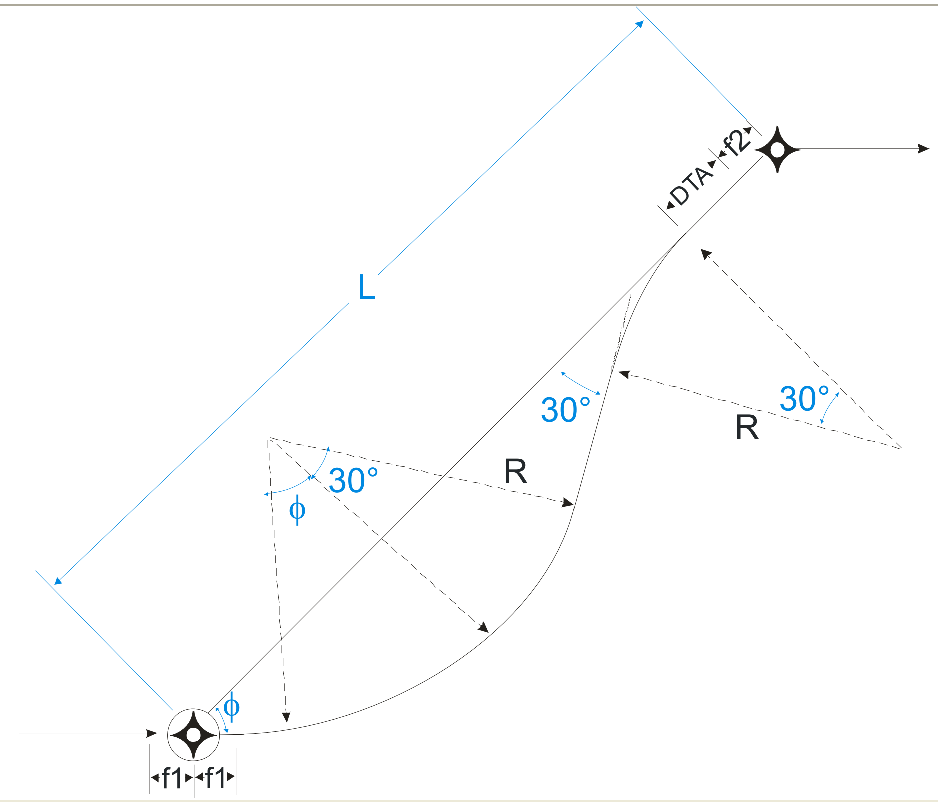
Calculator

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(ϕ*π/180)+3^0.5*sin(ϕ*π/180))+R*(sin(ϕ*π/180)+4-3^0.5-3^0.5*cos(ϕ*π/180))+DTA+f2

Calculator

f1		Click Here to Calculate
f2		
ϕ	°	
R		
DTA		
L		

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.

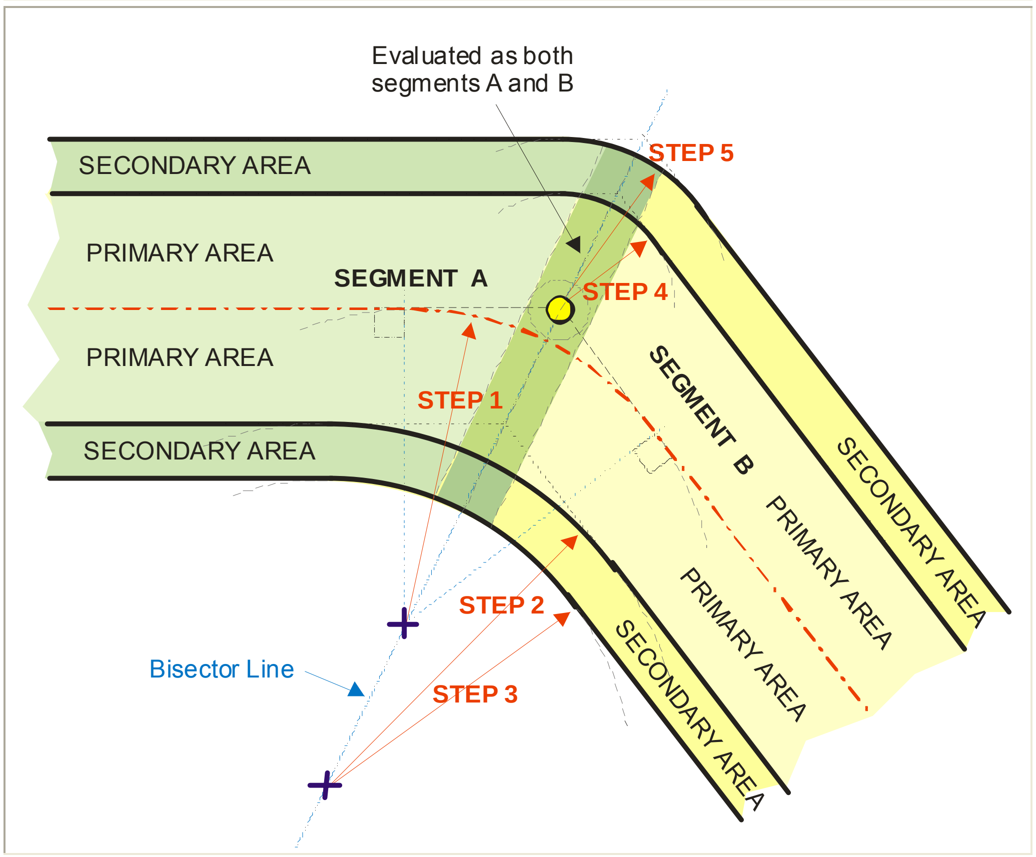
STEP 2: Scribe an arc (with origin on bisector line) that is tangent to the inner primary boundaries of the two segment legs with a radius equal to $\frac{\text{Primary Area Half-width}}{2}$ (example: half width of 2 ***NM***, the radius would be ***R***+1.0 ***NM***).

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.

Figure 2-6. *Fly-By Turn Construction.*



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*.

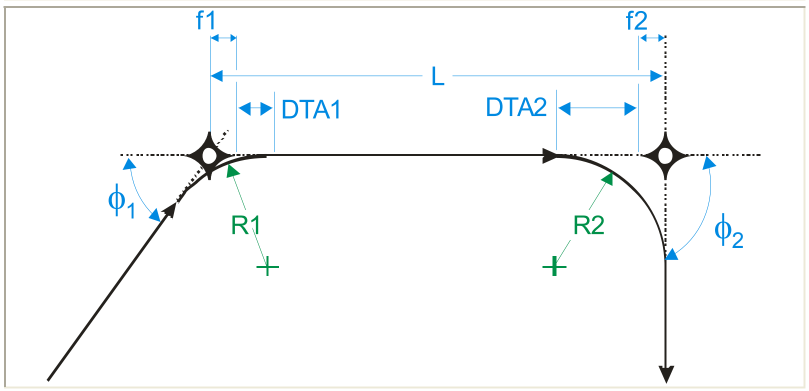
Formula 2-7. *TF Leg Minimum Length Following Fly-by Turn.*

$$L = f1 + DTA1 + DTA2 + f2$$

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 $\phi 2$ 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 $\phi 2$ is fly-over*



F1+DTA1+DTA2+F2

Calculator

f1		Click Here to Calculate
f2		
R1		
R2		
ϕ1	°	
ϕ2	°	
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.*

$$bank_{angle} = a\tan\left(\frac{(V_{KTAS} + V_{KTW})^2}{R \cdot 68625.4}\right) \cdot \frac{180}{\pi}$$

where V_{KTAS} = value from *formula 2-3a*
V_{KTW} = value from *Order 8260.52, table 1-3*
R = required radius

atan((V_KTAS+V_KTW)^2/(R*68625.4))*180/π

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.*

$$Segment_{length} = \frac{\pi \cdot R \cdot \phi}{180}$$

where R = RF segment radius (answer will be in the units entered)
ϕ = # of degrees of ARC (heading change)

π*R*ϕ/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.

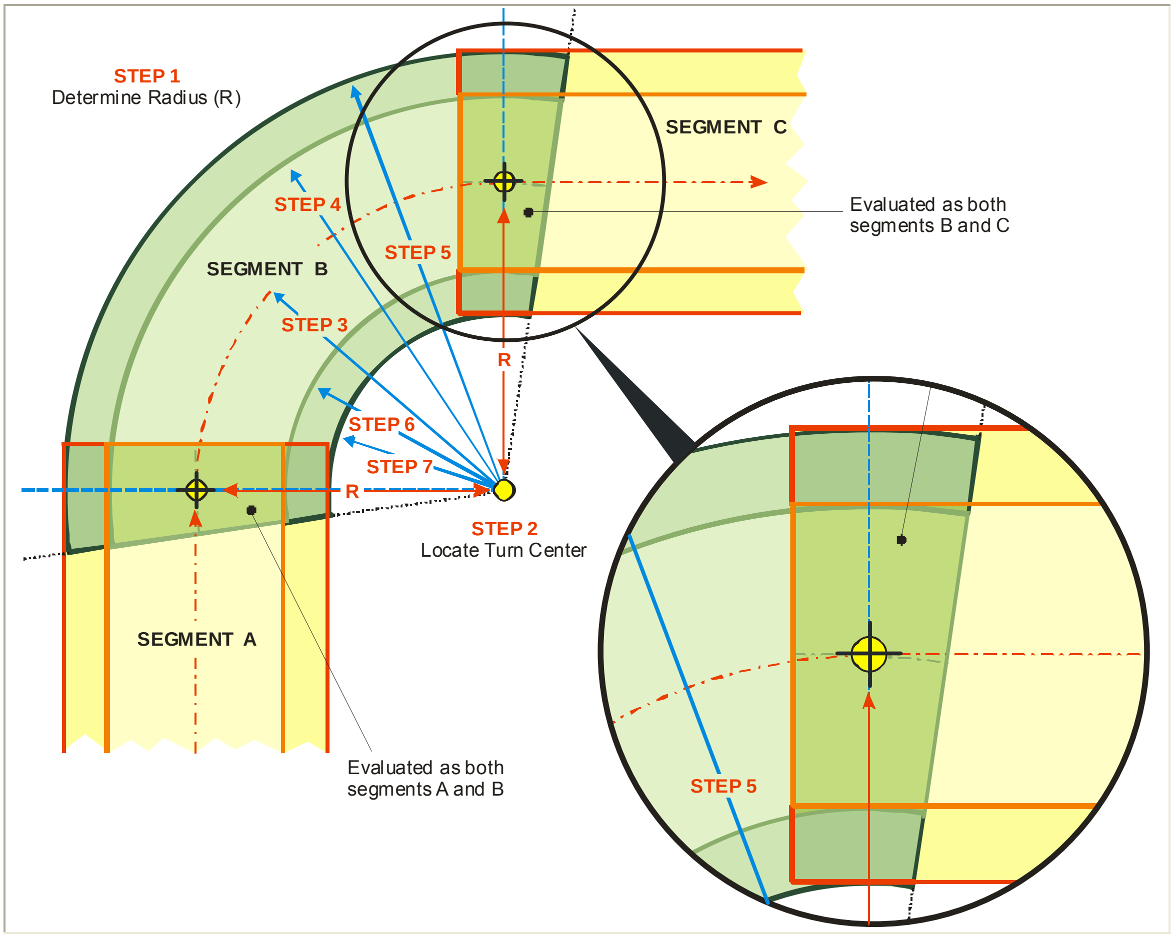
STEP 4: Primary area outer boundary. Construct an arc of radius **R**+*Primary area half-width* from the tangent point on the preceding segment primary area outer boundary to the tangent point on the following course primary area outer boundary.

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.

Figure 2-7. *RF Turn Construction.*



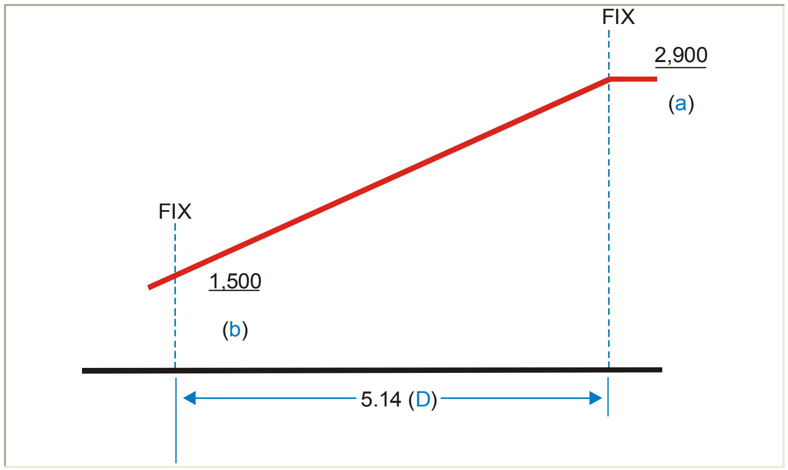
2.6 Descent Gradient.

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*).

Figure 2-8. *Calculating Descent Gradient.*



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		Click Here to Calculate
b		
D		
DG		

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).*

Figure 2-9a. *Feeder route (fly-by protection).*

See paragraph 2.5 for turn construction details

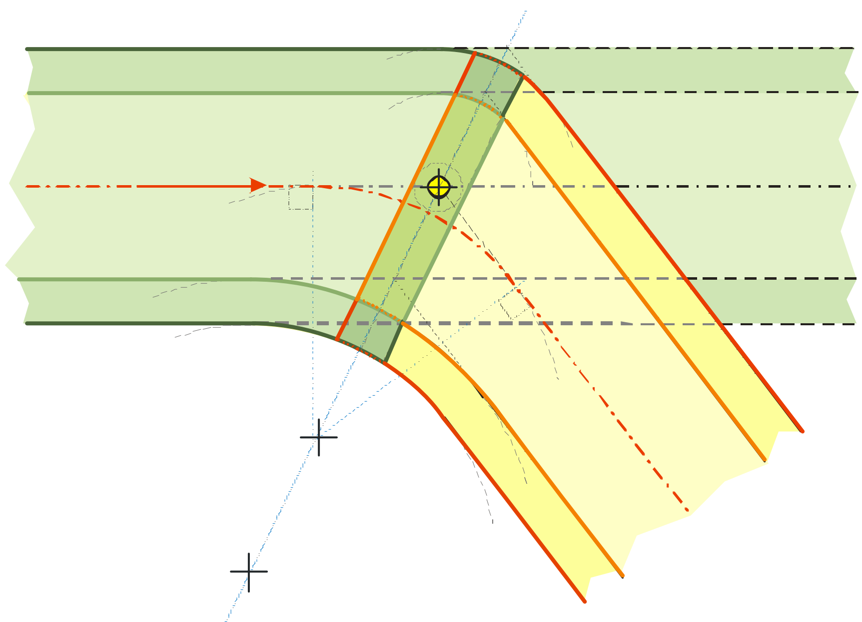
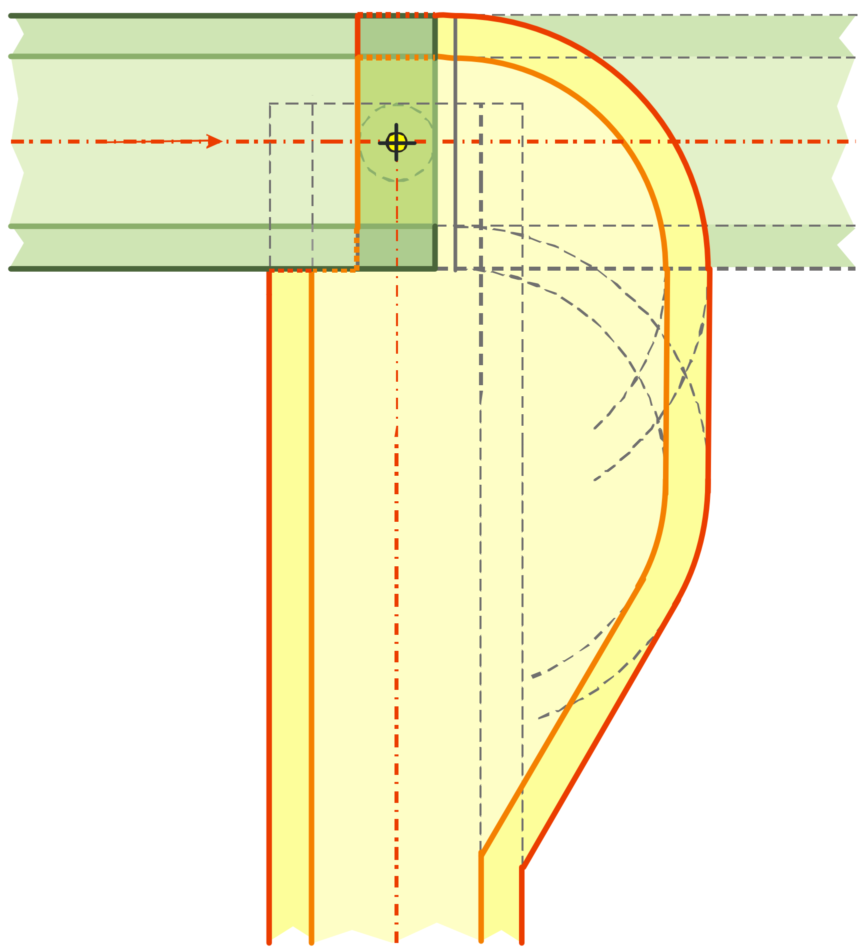


Figure 2-9b. *Feeder Route (Fly-over Protection).*



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°*).

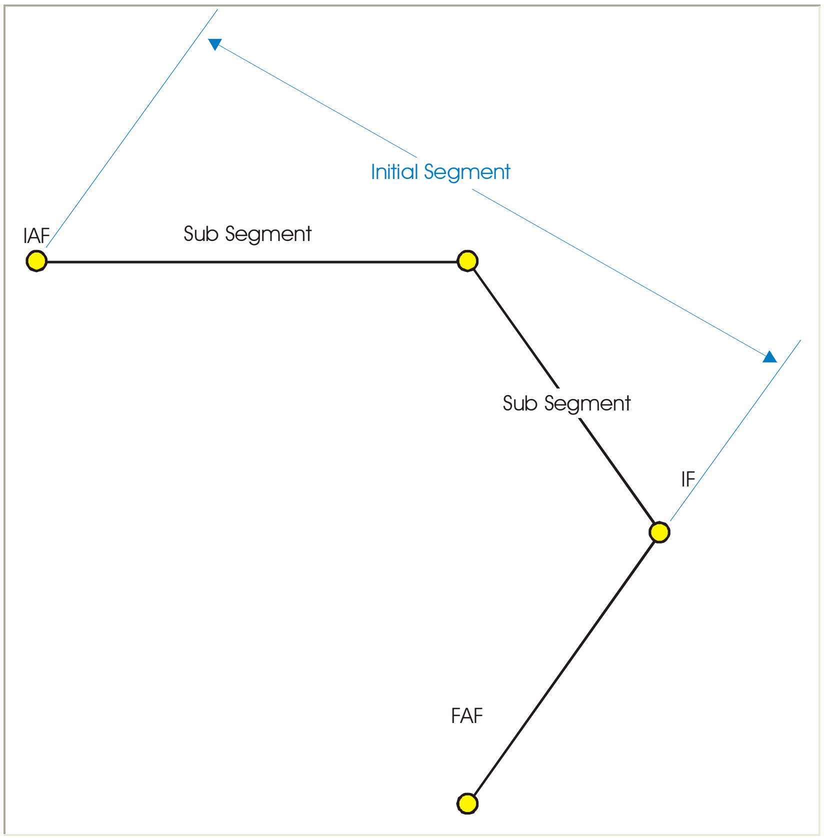
Chapter 2. General Criteria

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*.

Figure 2-10. *Initial Sub Segments.*



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.

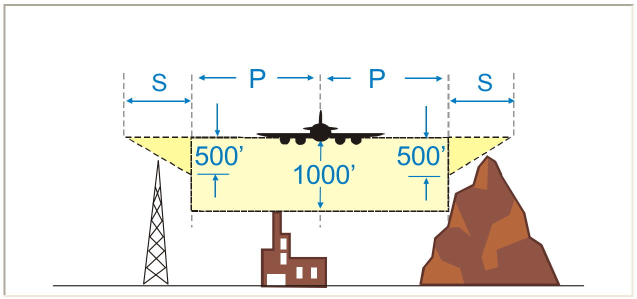
The **maximum** segment length (total of sub segments) is 50 ***NM***. Minimum length of sub segments is determined as described in *paragraphs 2.5.1b* and *2.5.2a*.

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*).

Figure 2-11. *Initial Segment ROC.*



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

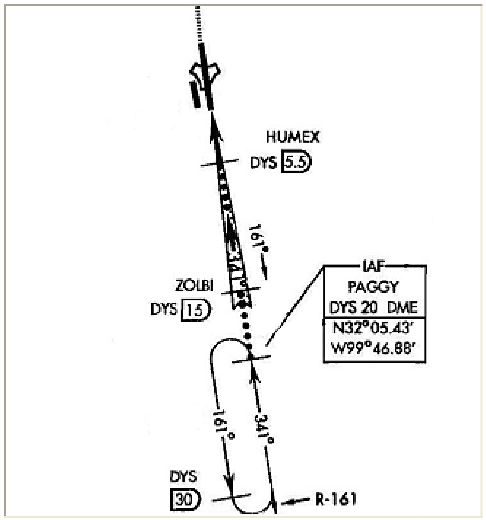
Formula 2-11a. *Secondary ROC.*		
$ROC_{secondary} = 500 \cdot \left(1 - \frac{d}{D}\right)$ where D = width (ft) of secondary d = distance (ft) from edge of primary area measured perpendicular to boundary		
500*(1-d/D)		
Calculator		
d		Click Here to Calculate
D		
$ROC_{secondary}$		

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.

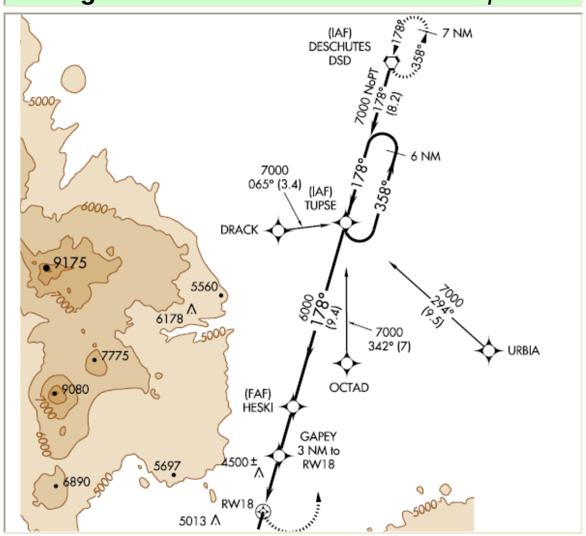
2.8.6 **a. Arrival Holding.** Ideally, the holding pattern inbound course should be aligned with the subsequent ***TF*** leg segment (tangent to course at the initial fix of the subsequent ***RF*** segment). *See figure 2-12a.* If the pattern is offset from the subsequent ***TF*** segment course, the 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.

Figure 2-12a. *Arrival Holding Example.*



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.

Figure 2-12b. *Course Reversal Example.*



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.*

Figure 2-13a. *RNAV Intermediate Segment (LPV, ILS, LP).*

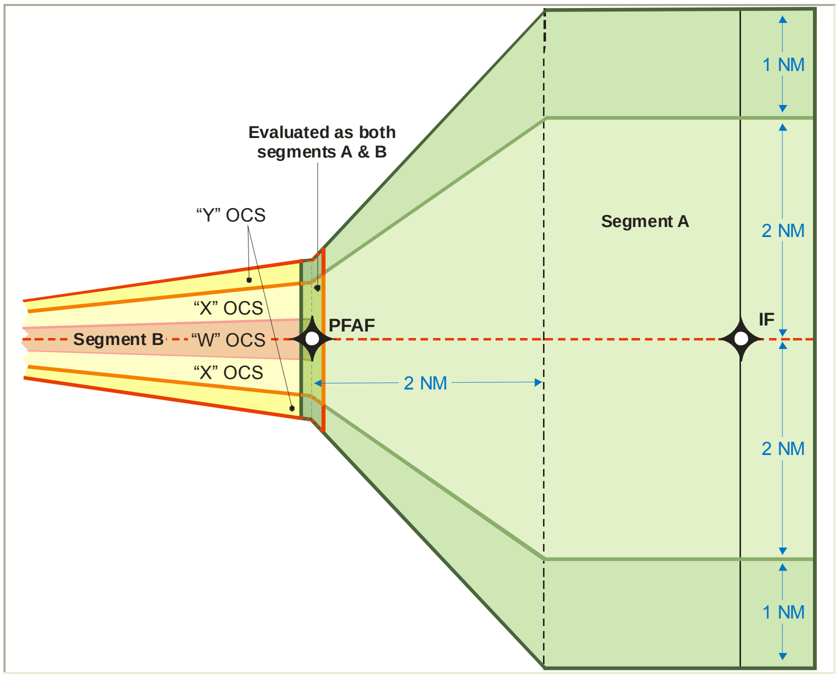
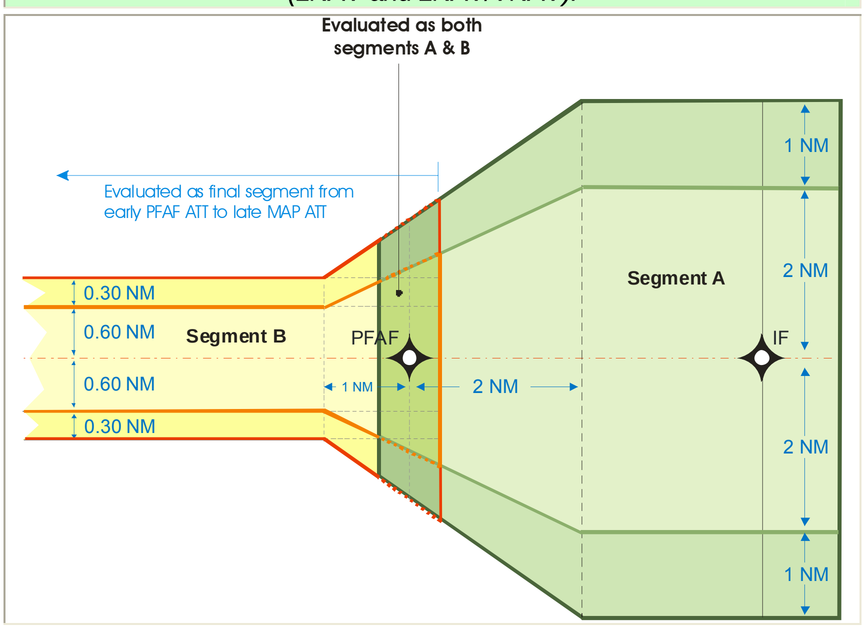


Figure 2-13b. *RNAV Intermediate Segment (LNAV and LNAV/VNAV).*



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*.

Figure 2-13c. *LNAV, LNAV/VNAV Example.*

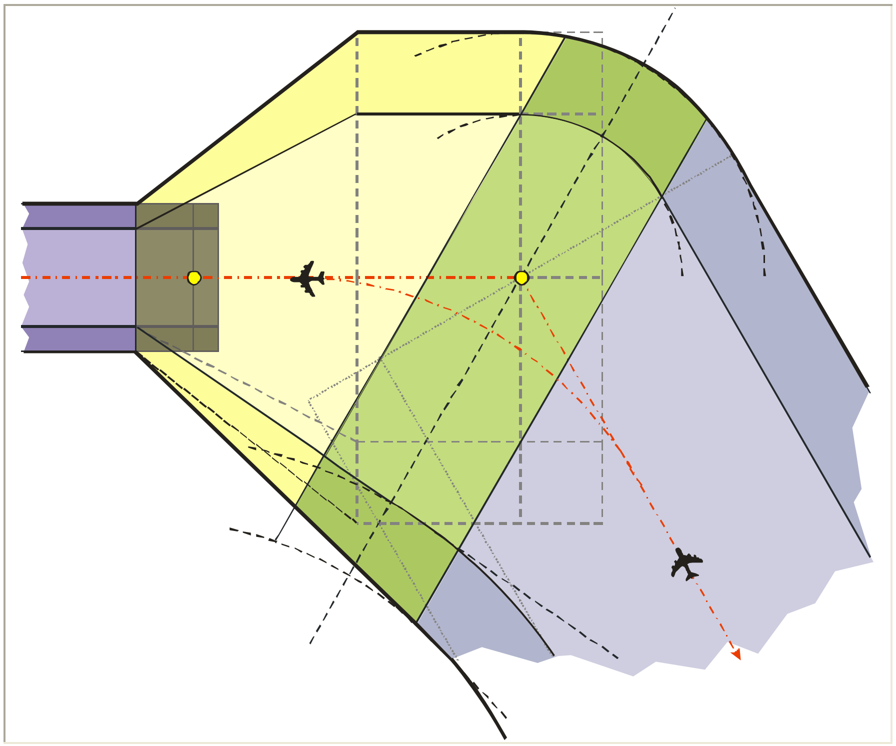
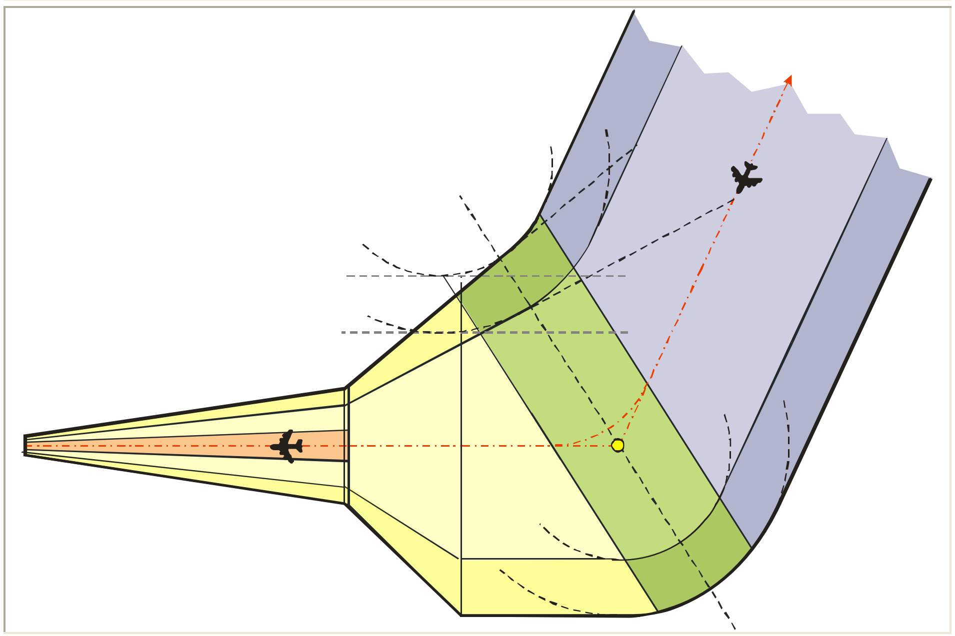


Figure 2-13d. *LP, LPV Example.*



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.

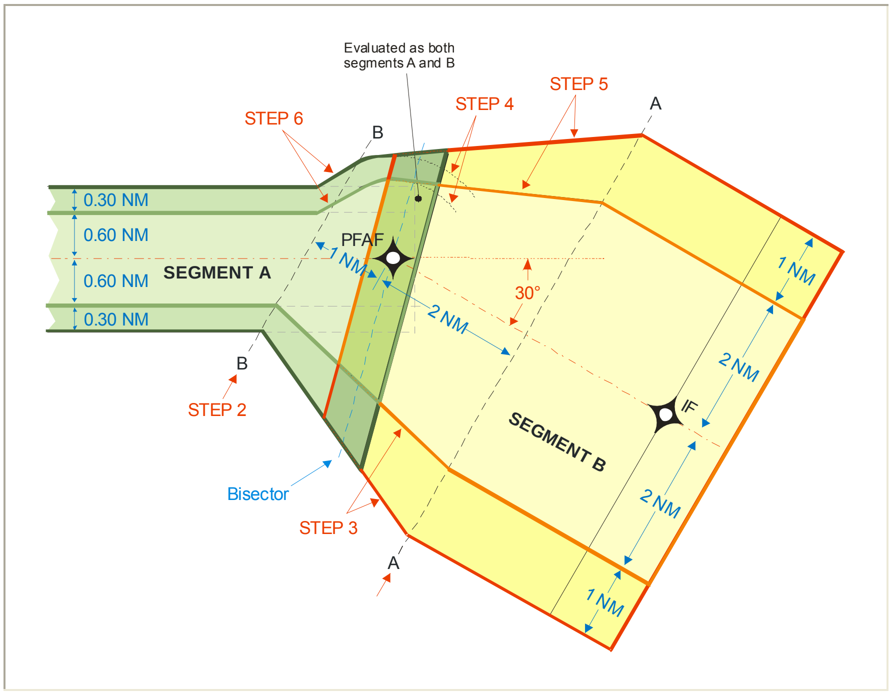
STEP 4: Construct arcs centered on the ***PFAF*** of 1 ***NM*** and 1.3 ***NM*** radius on the non-turn side of the fix.

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.

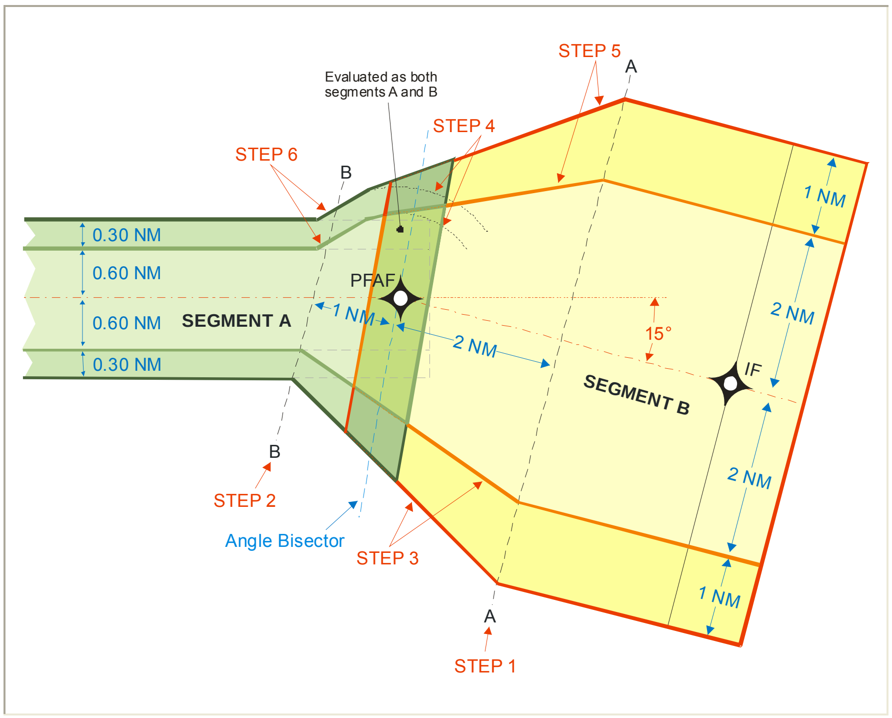
STEP 6: Connect lines tangent to the arcs created in *step 4* that taper inward at 30 degrees relative to the ***FAC*** to intersect the primary and secondary final segment boundaries as appropriate.

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.

Figure 2-13e. *Offset LNAV Construction.*



Offset LNAV/VNAV Construction.



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***.

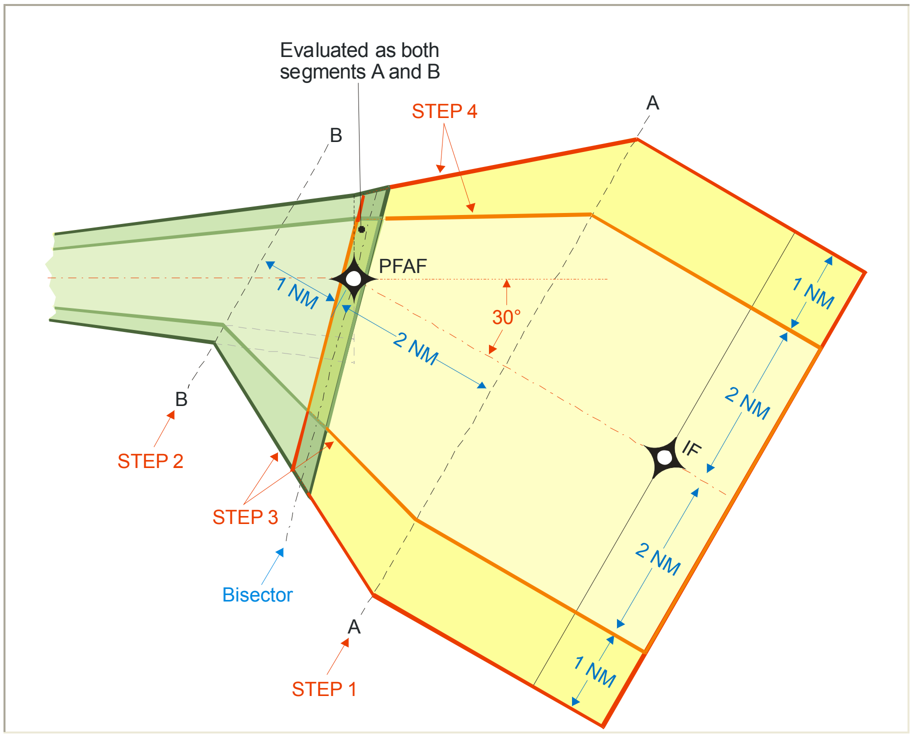
STEP 2: Construct line **B** perpendicular to the intermediate course extended 1 ***NM*** past the ***PFAF***.

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.

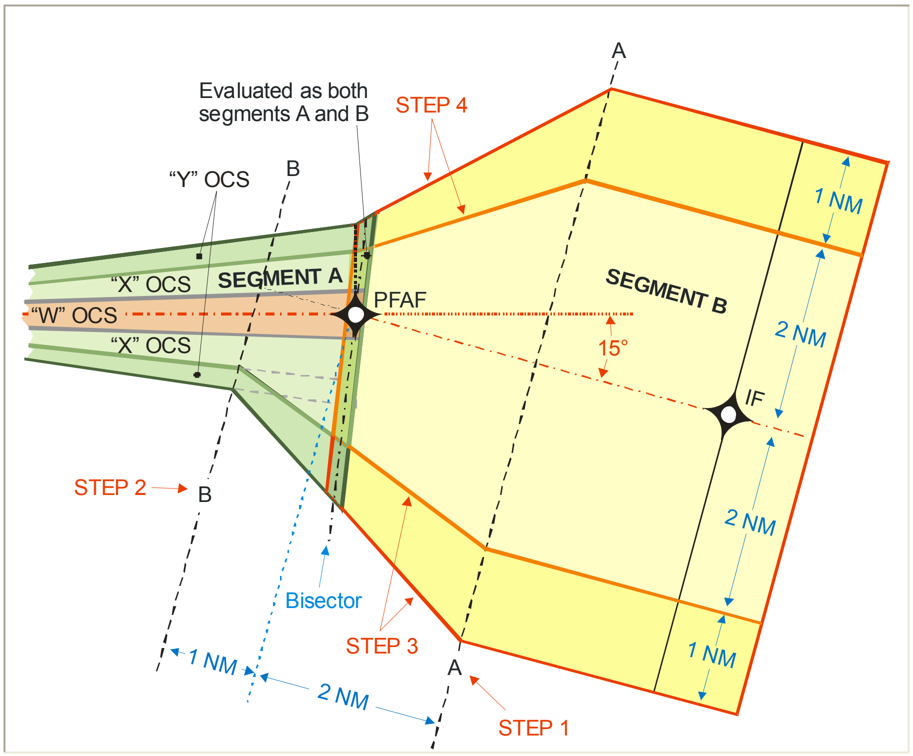
STEP 4: Connect lines from the point of intersection of line **A** and the outside primary and secondary intermediate segment boundaries to the final segment primary and secondary final segment lines at a point perpendicular to the final course at the ***PFAF***.

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.

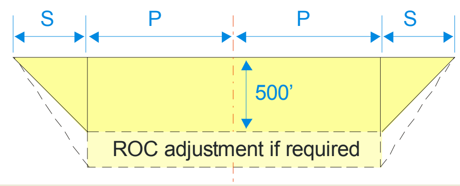


2.9.3 c. ***RF* intermediate segments.** Locate the intermediate leg's ***RF*** segment's terminating fix at least 2 ***NM*** outside the ***PFAF.***

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*).

Figure 2-14. *Intermediate Segment ROC.*



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)*(1-$d_{primary}$/W_S)

Calculator

$d_{primary}$		Click Here to Calculate
W_S		
adj		
$ROC_{secondary}$		

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

Locate the ***IF*** <u>at least</u> $\mathbf{d_{IF}}$ (***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*d/a-d*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. ***GPA*s** 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.

Table 2-4. *Maximum Allowable GPAs*.*	
Category	θ
A**	5.7
B	4.2
C	3.6
D&E	3.1

** LPV: Where **HATh** < 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 **HATh** 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 ± 5 Ft**	**Remarks**
HEIGHT GROUP 1 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.
HEIGHT GROUP 2 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.
HEIGHT GROUP 3 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.
HEIGHT GROUP 4 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>
<tr><th colspan="6">**Table 2-6.** *FPAP Location.*</th></tr>
<tr><td colspan="2">1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="2">ILS Serves Runway</td><td>ILS Does Not Serve Runway</td><td rowspan="2">± Slay</td><td rowspan="2">± Width</td><td rowspan="2">Offset Length</td></tr>
<tr><td>LTP Dist to LOC</td><td>FPAP Dist from LTP</td><td>FPAP Dist from LTP</td></tr>
<tr><td>≤ 10,023' ≤ 9,023'</td><td>9023</td><td rowspan="4">9023</td><td>2.0°
**</td><td rowspan="2">350 ft
(106.75 m)*
**</td><td>Formula 2-15
**</td></tr>
<tr><td>> 10,023' and ≤ 13,366'</td><td rowspan="2">to DER</td><td>Formula 2-13*
**</td><td rowspan="3">0
**</td></tr>
<tr><td>> 13,366 and ≤ 17,185'</td><td rowspan="2">1.5°
**</td><td rowspan="2">Formula 2-14*
**</td></tr>
<tr><td>> 17,185' (AFS or Appropriate Military Agency Approval)</td><td>to DER or as specified by approving agency</td></tr>
</table>

* Round result to the nearest 0.25 meter.
** Use the ***ILS*** database values if applying column 1.

Formula 2-13. *Signal Splay.*

$$splay = a\tan\left(\frac{350}{RWY_{length}+1000}\right)\cdot\frac{180}{\pi}$$

$atan(350/(RWY_{length}+1000))*180/\pi$

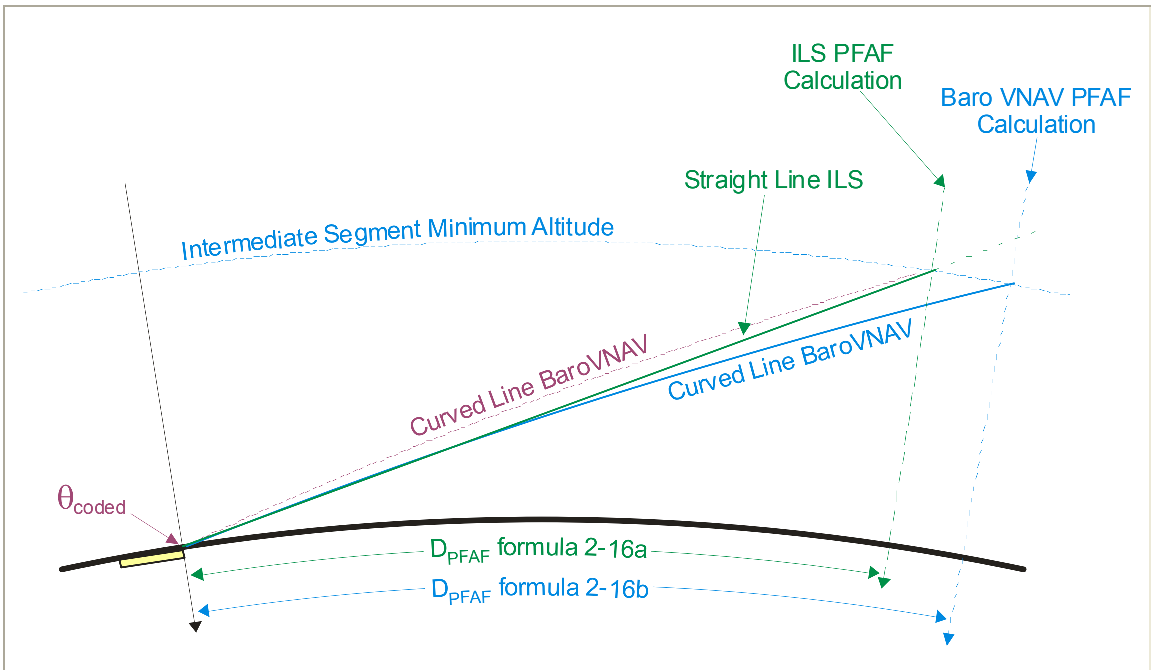
Calculator		
RWY_{length}	10,000.000	Click Here to Calculate
splay	1.822	

Formula 2-14. *Width at LTP.*		
$width = \tan\left(1.5 \cdot \frac{\pi}{180}\right) \cdot \left(RWY_{length} + 1000\right) \cdot 0.3048$ Round result to the nearest 0.25 meters		
$\tan(1.5*\pi/180)*(RWY_{length}+1000)*0.3048$		
Calculator		
RWY_{length}	10,000.000	Click Here to Calculate
width	87.75	

Formula 2-15. *Offset Length.*		
$offset_{length} = FPAP_{distance} - RWY_{length}$		
$FPAP_{Distance}-RWY_{length}$		
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)*.

Figure 2-15. *Determining PFAF Distance to LTP.*



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.*

$$D_{GPIP} = r \cdot \left(\frac{\pi}{2} - \theta \cdot \frac{\pi}{180} - \operatorname{asin}\left(\frac{\cos\left(\theta \cdot \frac{\pi}{180}\right) \cdot \left(r + LTP_{elev} + TCH\right)}{r + alt} \right) \right)$$

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

r*(π/2-θ*π/180-asin((cos(θ*π/180)*(r+LTPelev+TCH))/(r+alt)))

Calculator

LTP_{elev}	667.000	Click Here to Calculate
θ	3.05°	
TCH	40.000	
alt	2,500.000	
D_{GPIP}	33,152.857	

Formula 2-16b. *LNAV/VNAV PFAF.*

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

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}	567.000	Click Here to Calculate
TCH	45.000	
θ	3.03°	
alt	2,400.000	
D_{PFAF}	33,776.223	

Formula 2-16c. *VNAV/VNAV Angle.*

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

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

$PFAF_{alt}$	2,400.000	Click Here to Calculate
LTP_{elev}	567.000	
TCH	45.000	
D_{PFAF}	33,776.000	
θ_{BVNAV}	3.036°	

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+LTPelev+TCH)*cos(θ*π/180))/cos(DZ/r+θ*π/180)-r

Calculator

LTP_{elev}	567.000	Click Here to Calculate
TCH	45.000	
θ	3.03°	
D_Z	33,830.000	
$Z_{glidepath}$	2,430.320	

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^((DZ*tan(θ*π/180))/r)*(r+LTPelev+TCH)-r

Calculator

LTP_{elev}	567.000	Click Here to Calculate
TCH	45.000	
θ	3.03°	
D_Z	33,830.000	
$Z_{glidepath}$	2,402.847	

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 ***OFZ***s 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*** ≤ 4.2°: 300-¾ (RVR 4000)
- For ***GPA*** > 4.2°: 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.*		
$V_{offset} = TCH - 50$		
TCH-50		
Calculator		
TCH		Click Here to Calculate
V_{offset}		

- If the ***TCH*** ≥ 40 and ≤ 50, the ***GQS*** originates at ***RWT*** at ***LTP*** elevation.

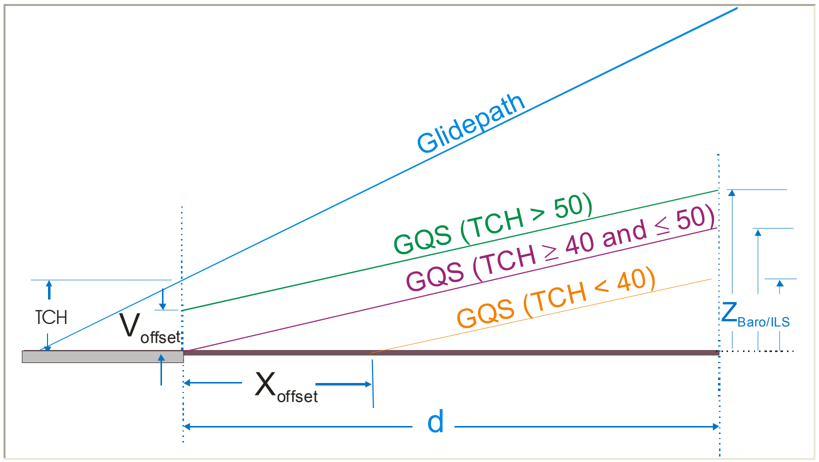
- If the ***TCH*** < 40, the ***GQS*** originates **x** feet from (toward ***PFAF***) ***RWT*** at ***LTP*** elevation. *See formula 2-18b*.

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

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

Figure 2-16a. *GQS Origin.*



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

Figure 2-16b. *GQS (TCH ≥ 40).*

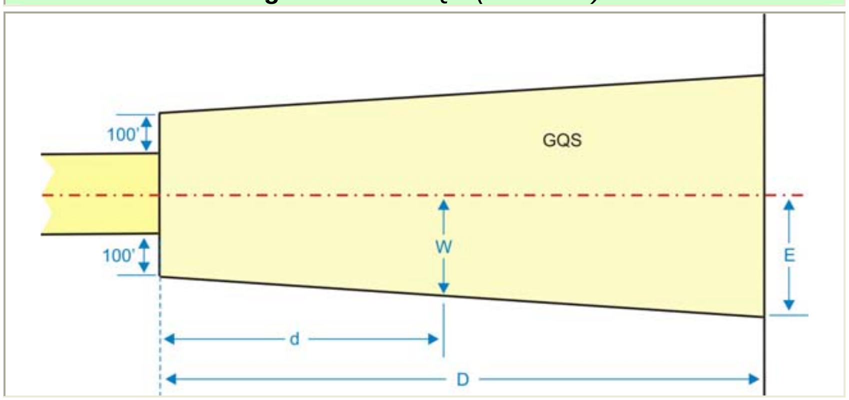
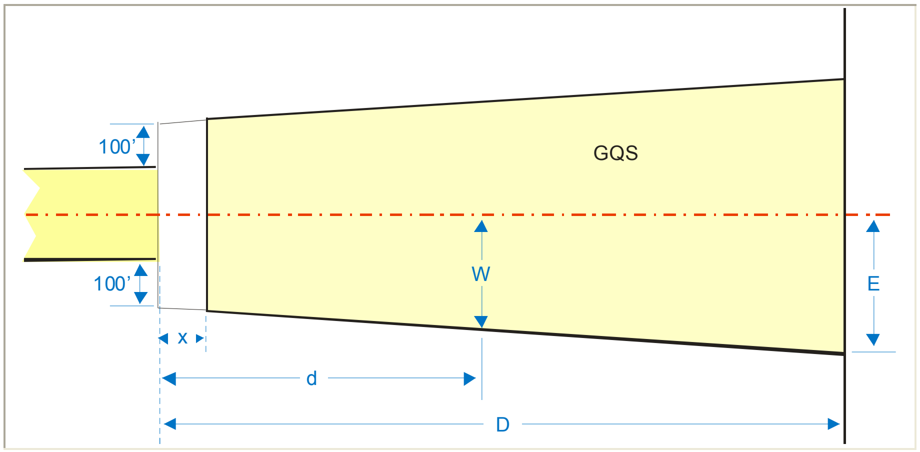


Figure 2-16c. *GQS (TCH < 40).*



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*D+392.8

Calculator		
D		Click Here to Calculate
E		

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" $k = \frac{RWY_{width}}{2} + 100$		
d*(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**.

Figure 2-17. *Example: TCH ≥ 40 ft.*

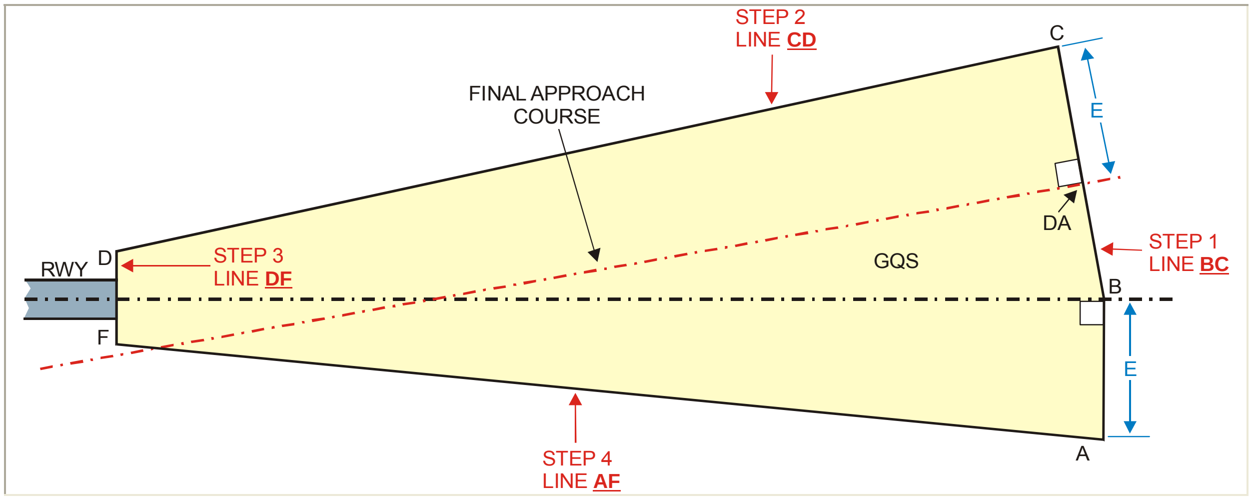
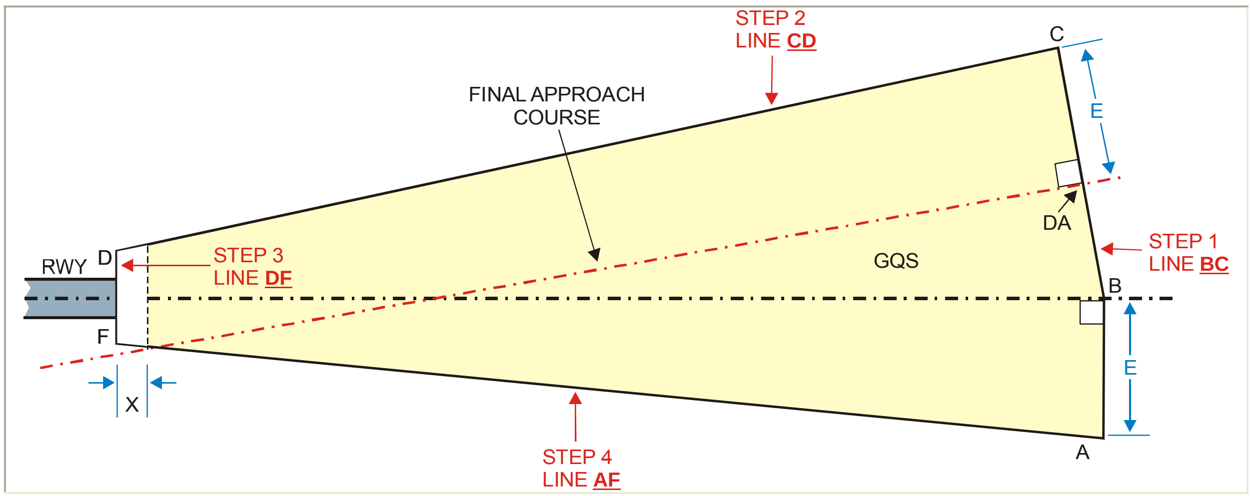


Figure 2-18. *Example: TCH < 40 ft.*



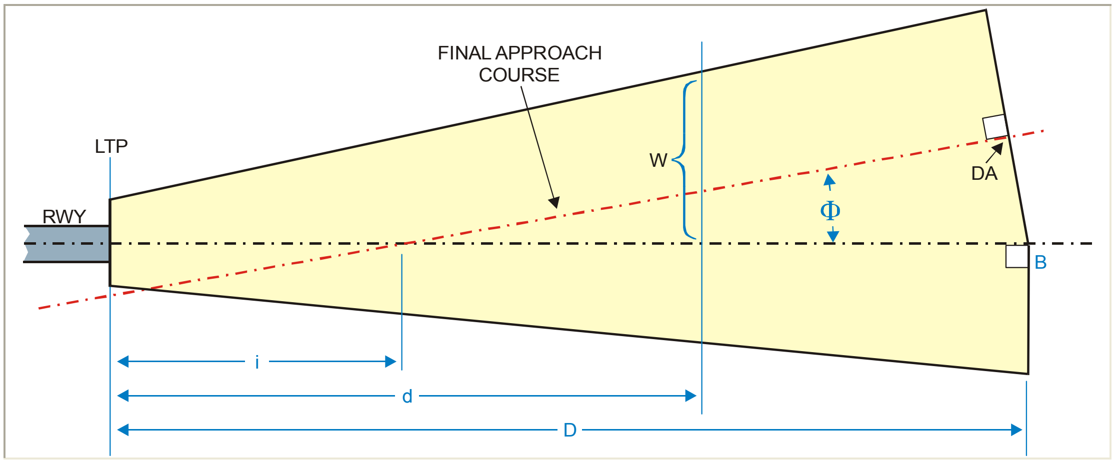
Calculate the half-width of the offset side of the ***GQS*** trapezoid using *formula 2-20*.

Formula 2-20. *Offset Side Half-width.*

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

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

$$k = \frac{RWY_{width}}{2} + 100$$



d*((cos(ϕ*π/180)*(sin(ϕ*π/180)*(D-i)+E)-k)/(D-sin(ϕ*π/180)*(sin(ϕ*π/180)*(D-i)+E)))+k

Calculator

d		Click Here to Calculate
D		
i		
ϕ	°	
E		
RWY_{width}		
W_{offset}		

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.*

$$Z_{GQS} = \frac{\left(r + LTP_{elev} + V_{offset}\right)\cos\left(\frac{2\theta}{3}\cdot\frac{\pi}{180}\right)}{\cos\left(\frac{d - X_{offset}}{r} + \frac{2\theta}{3}\cdot\frac{\pi}{180}\right)} - r$$

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

$(r+LTP_{elev}+V_{offset})*\cos((2*\theta/3)*\pi/180)/\cos((d-X_{offset})/r+(2*\theta/3)*\pi/180)-r$

$$Z_{Baro} = e^{\frac{(d - X_{offset})\cdot\tan\left(\frac{2\theta}{3}\cdot\frac{\pi}{180}\right)}{r}}\cdot\left(r + LTP_{elev} + V_{offset}\right) - r$$

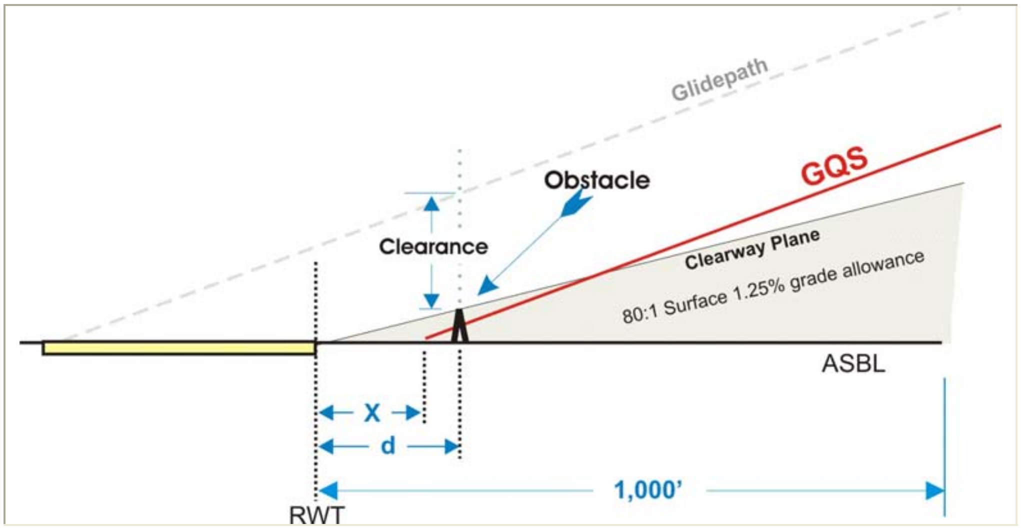
Where d = obstacle along RCL distance (ft) from RWT
LTP_{elev} = LTP MSL elevation
θ = Glidepath angle
V_{offset} = see formula 2-18a
X_{offset} = see formula 2-18b $_{lev}$ = LTP MSL elevation

$e^\wedge((d-X_{offset})*\tan((2*\theta/3)*\pi/180)/r)*(r+LTP_{elev}+V_{offset})-r$

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.

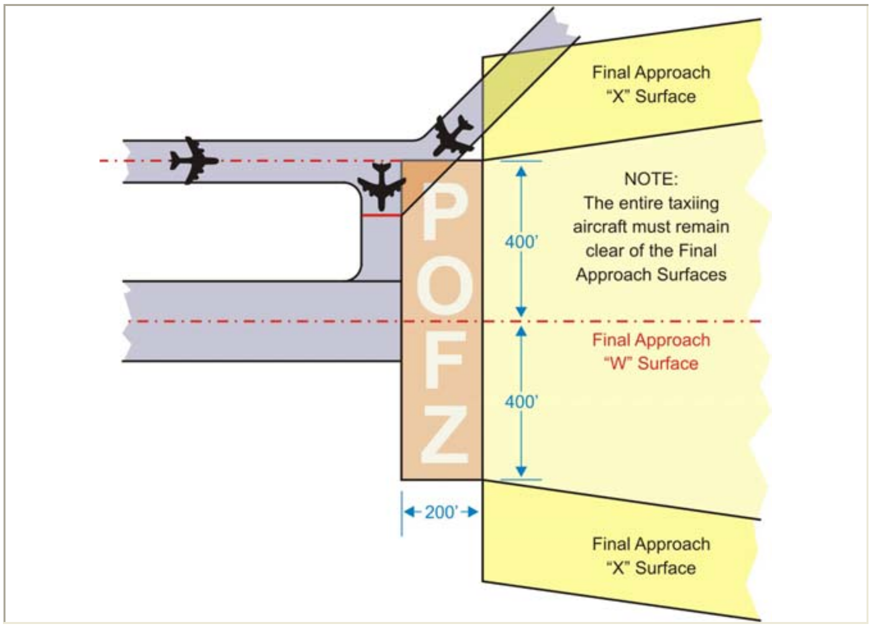
Figure 2-19. *Allowable GQS Penetrations.*



2.18 **Precision Obstacle Free Zone (*POFZ*).** (*Effective when reported ceiling is less than 300 ft and/or visibility less than ¾ 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 ¾ ***SM*** where the ***POFZ*** is not clear (*see figure 2-20*).

Figure 2-20. *POFZ.*



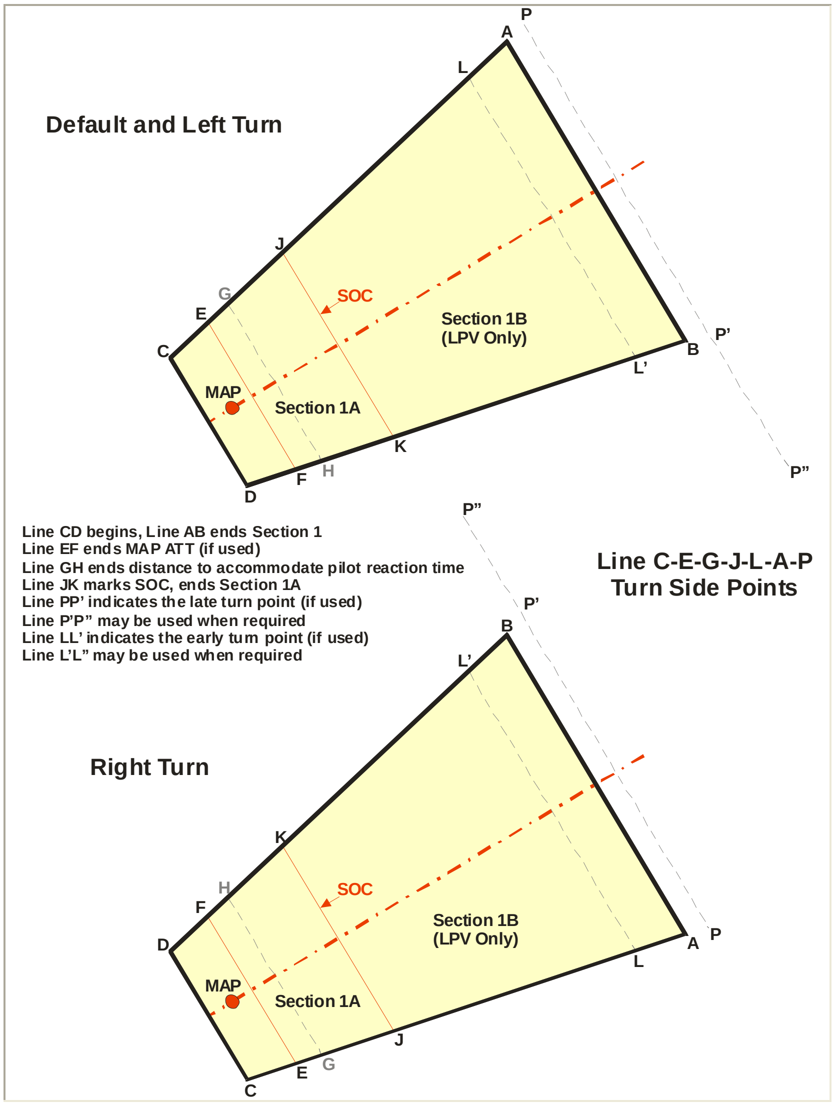
Chapter 2. General Criteria

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*.

Figure 2-21. *MAS Point/Line Identification.*



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 ≈ 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/NM)		
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.*

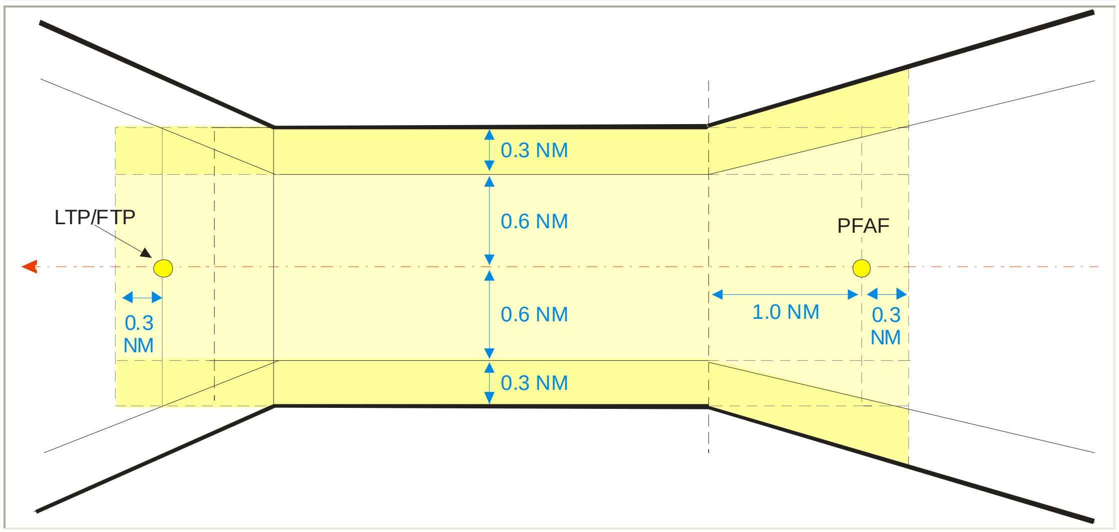
3.1.2 Circling.

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*.

Figure 3-1. *LNAV Final Segment OEA.*



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*** (≈ 3,646 ft) from course centerline. A 0.3 ***NM*** (≈ 1,823 ft) secondary area is

Formula 3-1. *Tapering Segment Width.*

$$\tfrac{1}{2}wp = \frac{1.4d}{3} + 0.6$$

$$ws = \frac{0.7d}{3} + 0.3$$

where d = along-track distance from line "B"

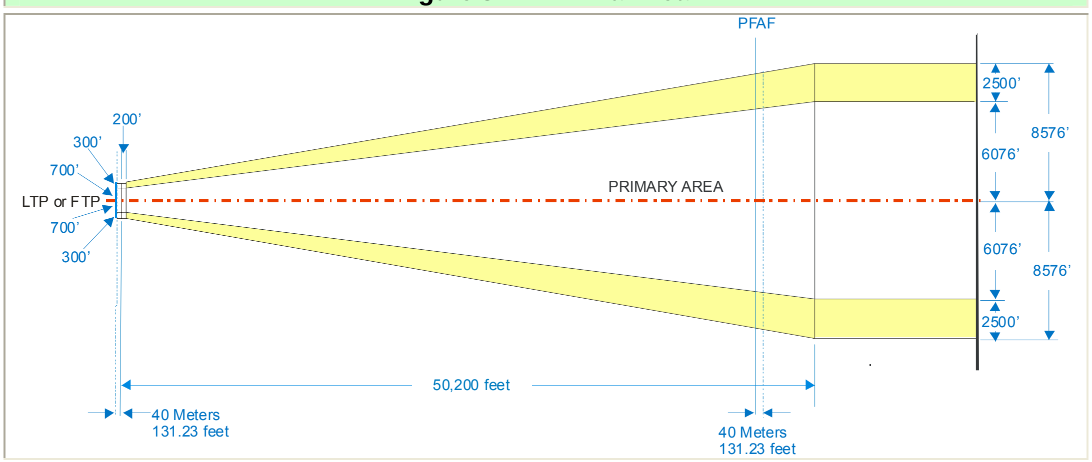
½wp = 1.4*d/3+0.6
ws = 0.7*d/3+0.3

Calculator		
d		Click Here to Calculate
½wp		
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.*

Figure 3-2. *LP Final Area.*



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 <u>secondary area</u> 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.

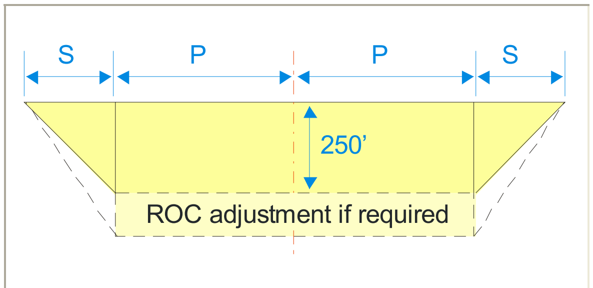
3.4.1 Primary Area.

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.*

Figure 3-3. *Primary/Secondary ROC.*



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

$(250+adj)*(1-d_{primary}/W_S)$

Calculator

$d_{primary}$		Click Here to Calculate
W_S		
adj		
$ROC_{secondary}$		

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, ***SDF***s 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.

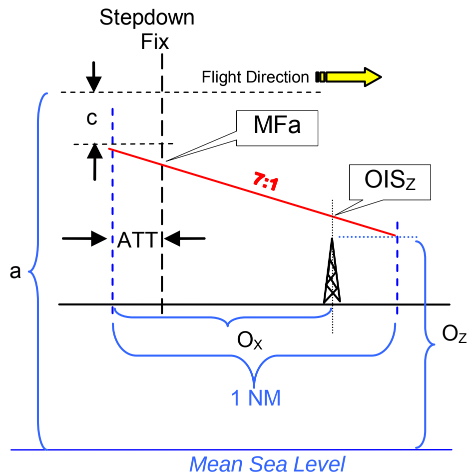
3.5.1 **h. Use the following formulas** to determine ***OIS*** elevation (OIS_Z) at an obstacle and minimum fix altitude (***MFa***) based on an obstacle height.

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		Click Here to Calculate
c		
O_X *(1 NM Max)*		
O_Z		
OIS_Z		
MFa		

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 ≥ 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.*		
$$MAS_{Yprimary} = d \cdot \frac{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot 1.4 \cdot NM}{2.1 \cdot NM} + 0.6 \cdot NM$$ $$MAS_{Ysecondary} = d \cdot \tan\left(15 \cdot \frac{\pi}{180}\right) + 0.9 \cdot NM$$ where d = along-track distance (ft) from the cd line ≤ 47620.380 NM = 1852/0.3048		
MAS$_{Yprimary}$=d*((tan(15*π/180)*1.4*1852/0.3048))/(2.1*1852/0.3048)+0.6*1852/0.3048 MAS$_{Ysecondary}$=d*tan(15*π/180)+0.9*1852/0.3048		
Calculator		
d		Click Here to Calculate
LNAV $MAS_{Yprimary}$		
LNAV $MAS_{Ysecondary}$		

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.*

$$MAS_{Yprimary} = d \cdot \frac{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot (2 \cdot NM - W_P)}{3 \cdot NM - W_S} + W_P$$

$$MAS_{Ysecondary} = d \cdot \tan\left(15 \cdot \frac{\pi}{180}\right) + W_S$$

where d = along-track distance (ft) from the cd line ≤ 64297.064
NM = 1852/0.3048

$MAS_{Yprimary}$= d*((tan(15*π/180)*(2*1852/0.3048-W_P))/(3*1852/0.3048-W_S))+W_P
$MAS_{Ysecondary}$= d*tan(15*π/180)+W_S

Calculator

d		Click Here to Calculate
W_P		
W_S		
LP $MAS_{Yprimary}$		
LP $MAS_{Ysecondary}$		

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.*

$$HMAS = MDA - (100 + adj)$$

where adj = precipitous terrain, remote altimeter (only if full time), and excessive length of final adjustments

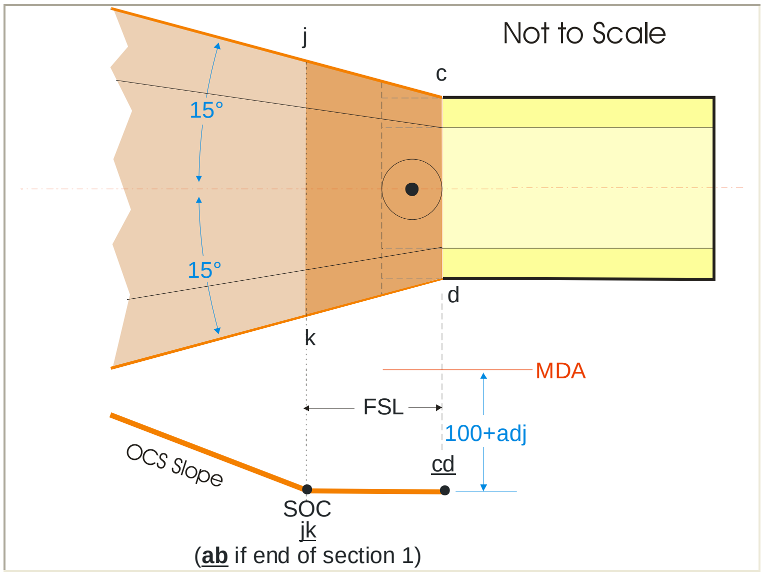
MDA-(100+adj)

Calculator

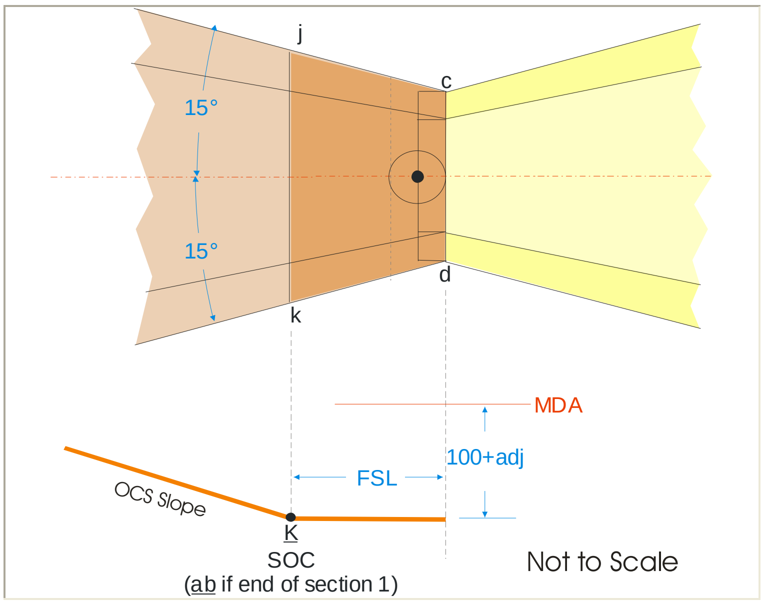
MDA		Click Here to Calculate
adj		
HMAS		

Figure 3-4. *Missed Approach Section 1.*

LNAV.



LP.



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 ***HATh*** value is 250 ft.

4.1 Final Approach Course Alignment.

Optimum final segment alignment is with the runway centerline (± 0.03°) 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 (5200 ft maximum) prior to ***LTP***. (d1=1,500) Determine the minimum ***HATh*** 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*** (d1=3,000). Determine the minimum ***HATh*** value (MIN_{HATh}) 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*tan(α/2*π/180))/(68625.4*tan(18*π/180))*1852/0.3048
Min_{HATh}=e^(((d1+d2)*tan(θ*π/180))/r)*(r+LTP_{elev}+TCH)-(r+LTPelev)

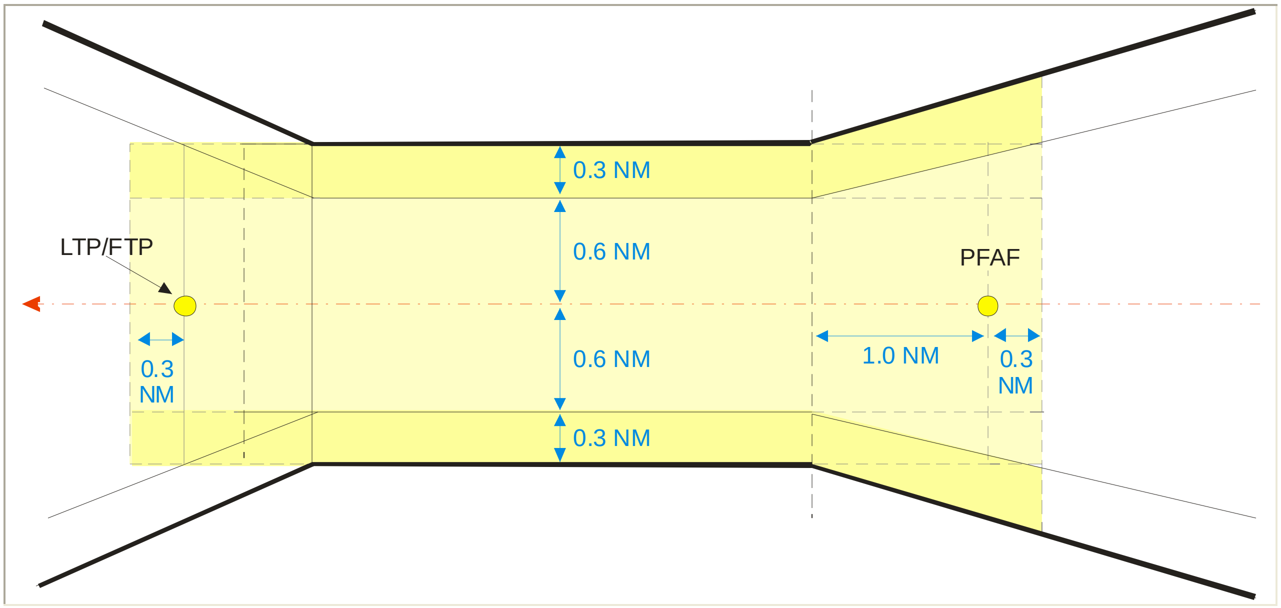
Calculator

d1	1,500.000	Click Here to Calculate
α	°	
V_{KIAS}		
θ	°	
LTP_{elev}		
TCH		
d2		
Min_{HATh}		

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.*

Figure 4-1. *LNAV/VNAV Final Segment OEA.*



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*** (≈ 3,646 ft) from course centerline. A 0.3 ***NM*** (≈ 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.*

$$D_{origin} = \frac{250 - TCH}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$$

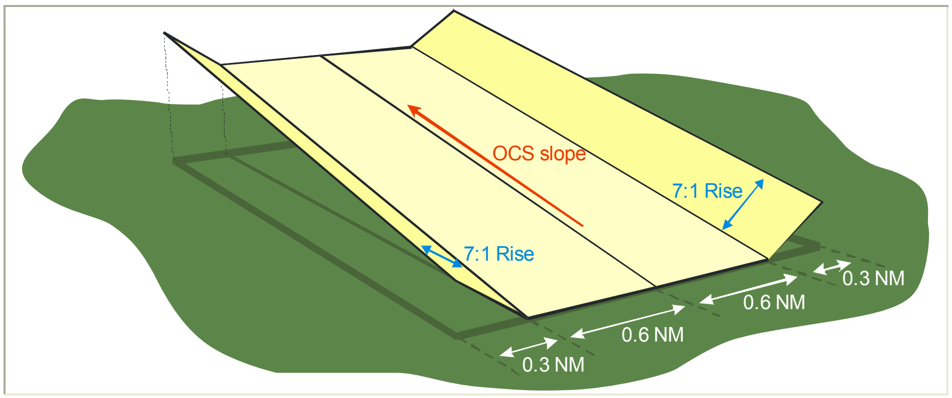
where θ = glidepath angle

(250-TCH)/tan(θ*π/180)

Calculator		
TCH	45.000	Click Here to Calculate
θ	°	
D_{origin}	3,911.633	

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.*

Figure 4-2. *Final Segment OCS.*



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.*		
$ISA_{airportC} = 15 - 0.00198 \cdot \text{airport elevation}$ $ISA_{airportF} = 1.8 \cdot ISA_{airportC} + 32$		
ISA$_{airportC}$=15-0.00198*Airport Elevation ISA$_{airportF}$=(1.8*ISA°$_{airportC}$)+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.*		
$ACT°C = \frac{ACT°F - 32}{1.8}$		
(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 ***HATh*** 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.*

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

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

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

MDR_{angle}=180/π*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.*

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

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}*π/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*(PFAF$_{alt}$-LTP$_{elev}$)+4.9)/(0.19+0.0038*(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°) and NA$_{above}$(F°)] 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°)=Airport$_{ISA}$+ΔISA$_{high}$ NA$_{above}$(F°)=NA$_{above}$(C°)*1.8+32		
Calculator		
Airport$_{ISA}$		Click Here to Calculate
ΔISA$_{high}$		
NA$_{above}$(C°)		
NA$_{above}$(F°)		

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 ($\boldsymbol{\theta}$), airport ***ISA***, and the ***ACT*** temperatures. Determine the **OCS** slope value using *formula 4-9*.

Formula 4-9. *OCS Slope.*

$$OCS_{slope} = \frac{1}{\tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot \left(0.928 + 0.0038 \cdot \left(ACT°C - ISA°C\right)\right)}$$

where θ = glidepath angle
ISA°C = Airport ISA from formula 4-3
ACT°C = Value from paragraph 4.3.1

1/(tan(θ*π/180)*(0.928+0.0038*(ACT°C- ISA°C)))

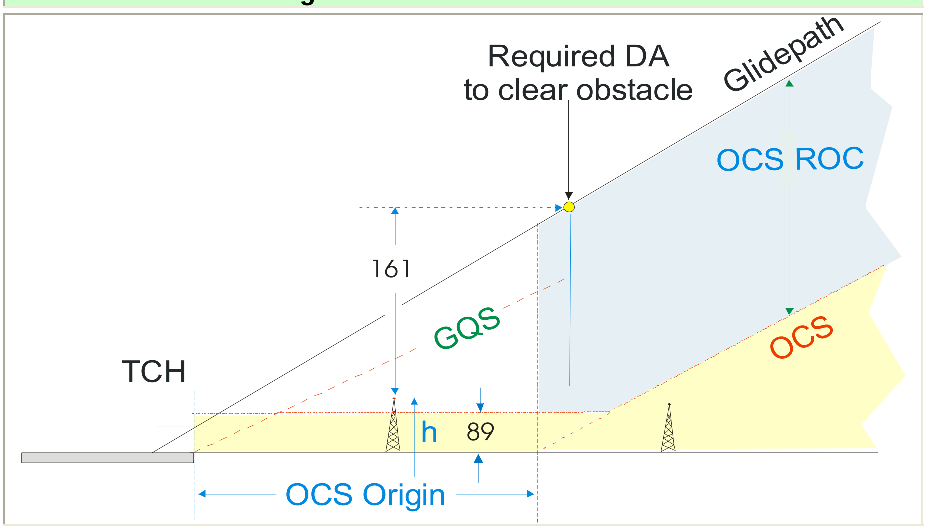
Calculator

θ	°	Click Here to Calculate
ISA°C		
ACT°C		
OCS_{slope}		

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.*

Figure 4-3. *Obstacle Evaluation.*



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.

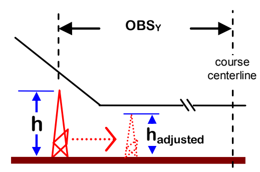
Formula 4-10. *Secondary Area Adjusted Obstacle Height.*

$$h_{adjusted} = h - \frac{OBS_Y - Width_{primary}}{7}$$

where h = obstacle MSL elevation

$Width_{primary}$ = perpendicular distance (ft) of primary boundary from course centerline

OBS_Y = obstacle perpendicular distance (ft) from course centerline



$h-(OBS_Y-Width_{primary})/7$

Calculator

h		Click Here to Calculate
$Width_{primary}$		
OBS_Y		
$h_{adjusted}$		

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 ($\boldsymbol{DA_{ROC}}$) 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.

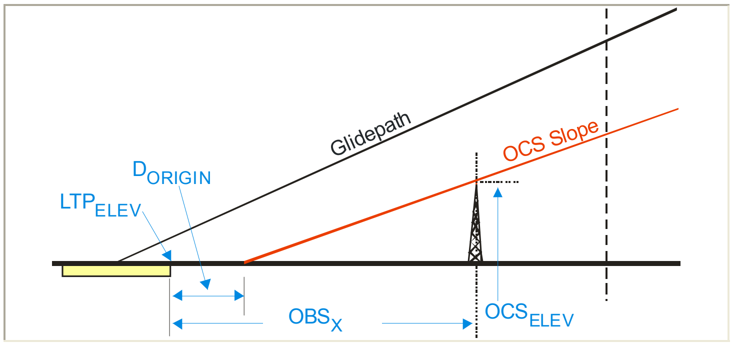
The ***OCS*** begins $\boldsymbol{D_{ORIGIN}}$ from ***LTP*** at ***LTP*** elevation. Application of the ***OCS*** begins at the point the ***OCS*** reaches 89 ft above ***LTP*** elevation. Determine the distance from ***LTP*** that the ***OCS*** reaches 89 ft above ***LTP*** using *formula 4-12a*. The ***MSL*** elevation of the ***OCS*** ($\boldsymbol{OCS_{elev}}$) at any distance ($\boldsymbol{OBS_X}$) from ***LTP*** ($\boldsymbol{OBS_X > D_{origin}}$) 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 ≈ 2.7182818284		
D_{origin}+r*OCS_{slope}*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 ≈ 2.7182818284



(r+LTP$_{elev}$)*e^((OBS$_X$-D$_{origin}$)/(r*OCS$_{slope}$))-r

Calculator

LTP_{elev}		Click Here to Calculate
OCS_{slope}		
D_{origin}		
OBS_X		
OCS_{elev}		

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.*		

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

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

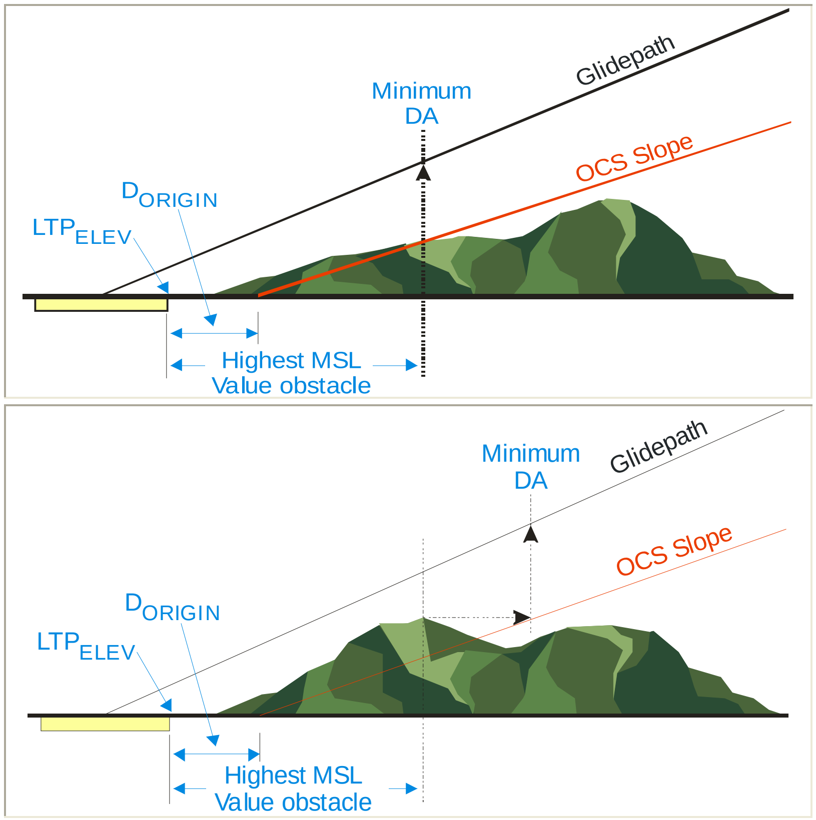
where θ = glidepath angle
O_{MSL} = obstacle MSL elevation
D_{origin} = *value from formula 4-2*
LTP_{elev} = LTP MSL elevation
OCS_{slope} = *value from formula 4-9*
TCH = threshold crossing height
r = 20890537
e ≈ 2.7182818284

d = (r+LTP_{elev})*OCS_{slope}*LN((r+O_{MSL})/(r+LTP_{elev}))+D_{origin}
DA_{OCS} = e^((d*tan(θ*π/180))/r)*(r+LTP_{elev}+TCH)-r

Calculator

LTP_{elev}		Click Here to Calculate
TCH		
θ	°	
OCS_{slope}		
O_{MSL}		
D_{origin}	3,911.633	
DA_{OCS}		

Figure 4-4. *OCS Penetrations.*



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))*(r+LTP_{elev}))/tan(θ*π/180)		
Calculator		
LTP_{elev}		Click Here to Calculate
TCH		
θ	°	
DA		
D_{DA}		

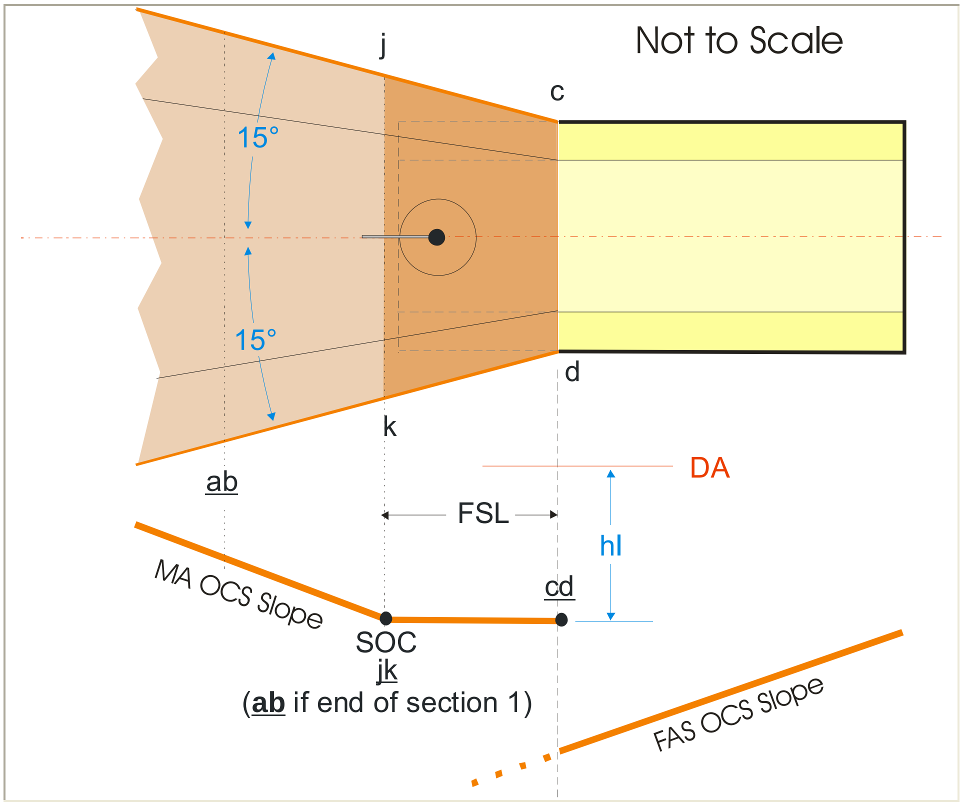
4.4 **Missed Approach Section 1.**

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 ***OEA*** 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.*

Figure 4-5. *Section 1 Area.*



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*((V_{KIAS}*(171233*((288+15)-0.00198*DA)^0.5)/(288-0.00198*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) $s1_{extension}$ of the extension using *formula 4-15b*.

Formula 4-15b. *Calculation of extension for climb to 400 ft.*		
$s1_{extension} = \frac{Z}{CG} \cdot \frac{1852}{0.3048}$ 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		
$s1_{extension}$		

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.*

$$HMAS = DA - hl$$

where hl = level surface ROC
from table 4-2

DA-hl

Calculator

DA		Click Here to Calculate
hl		
HMAS		

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.*

$$\Delta DA = e^{\frac{p \cdot \frac{MA_{slope} \cdot \tan\left(\theta \cdot \frac{\pi}{180}\right)}{1 + MA_{slope} \cdot \tan\left(\theta \cdot \frac{\pi}{180}\right)}}{r}} \cdot r - r$$

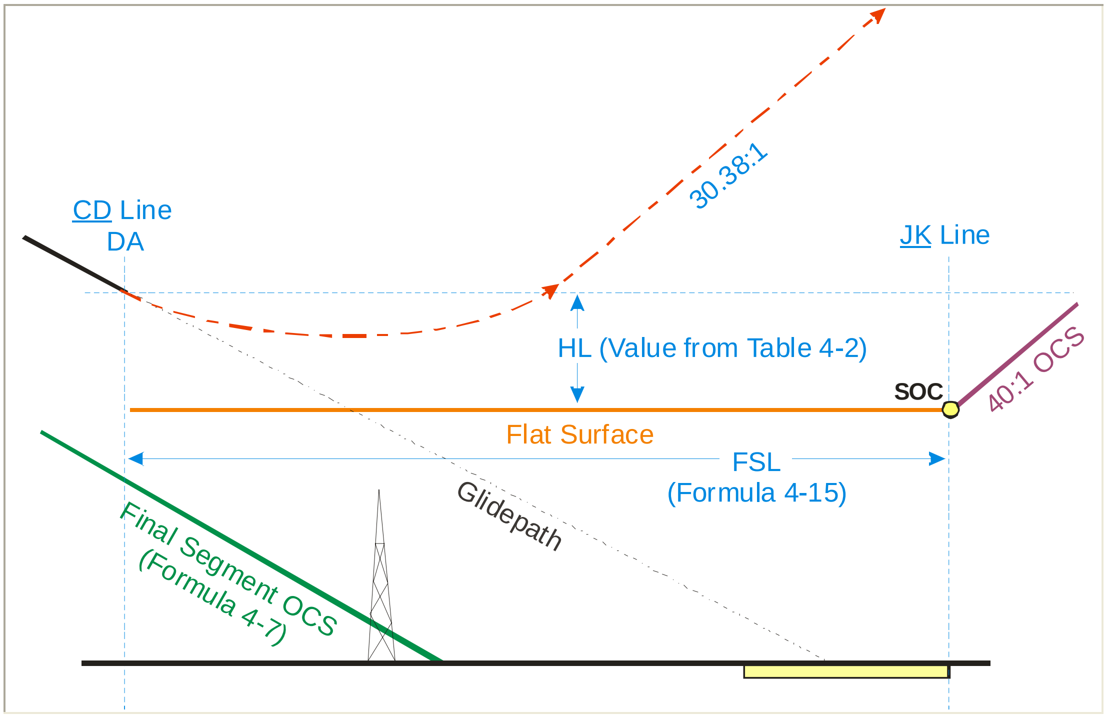
where p = amount of penetration
θ = glidepath angle
MA_{slope} = MA OCS slope (nominally 40:1)
r = 20890537

e^((p*(MA_{slope}*tan(θ*π/180))/(1+MA_{slope}*tan(θ*π/180))/r))*r-r

Calculator

p		Click Here to Calculate
θ	°	
MA_{slope}		
ΔDA		

Figure 4-6. *Missed Approach Flat Surface.*



Chapter 5. *LPV* Final Approach Segment (*FAS*) Evaluation

5.0 General.

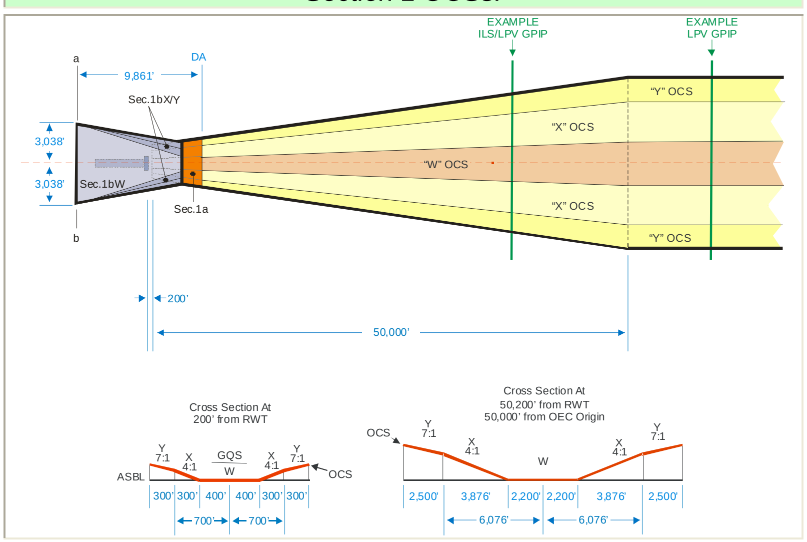
The obstruction evaluation area (***OEA***) and associated obstacle clearance surfaces (***OCSs***) are applicable to ***LPV*** final approach segments. These criteria may also be applied to construction of an ***RNAV*** transition to an ***ILS*** final segment where the glidepath intercept point (***GPIP)*** 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.

*<u>Note</u>: **ILS** continues the splay, only **LPV** is linear outside 50,200 ft.*

Figure 5-1. *LPV/ILS Final/Missed Section 1 OCSs.*

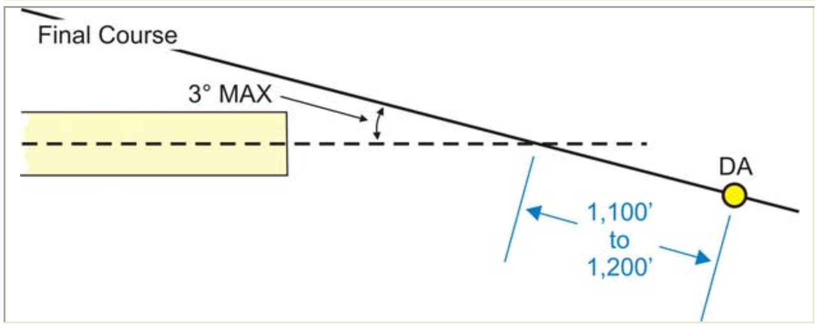


5.1.1 ***OEA* Alignment.**

The final course is normally aligned with the runway centerline (***RCL***) extended (± 0.03°) 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.*

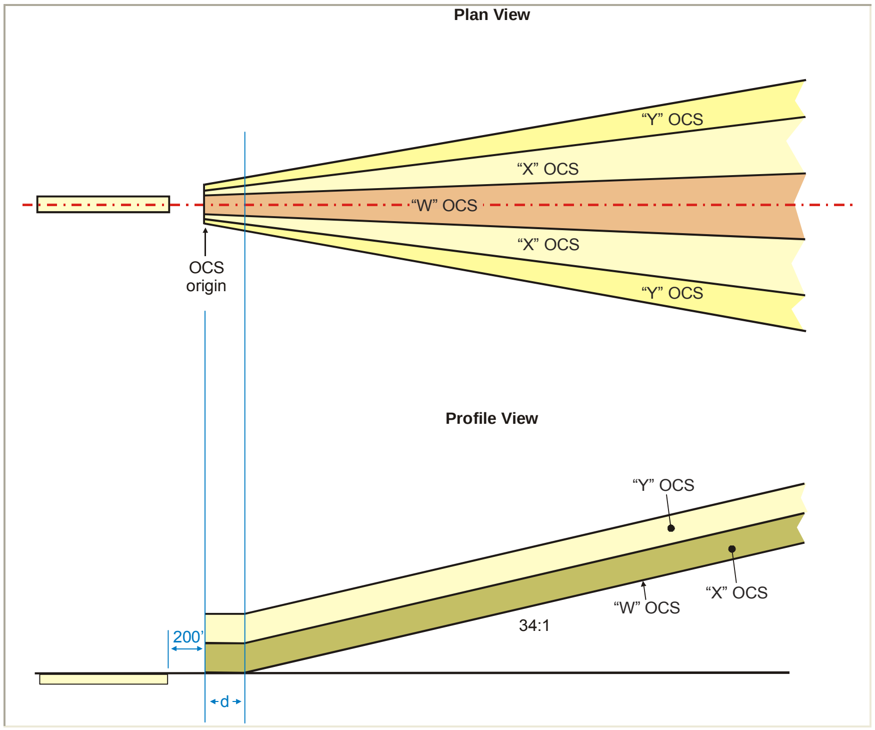
Figure 5-2. *Offset Final Course.*



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*.

Figure 5-3. *OCS Slope Origin.*



Formula 5-1. *OCS Slope.*

$$S = \frac{102}{\theta}$$

S = 102/θ

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

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

Formula 5-2. *Slope Origin Δ.*

$$d = 954 - \frac{TCH}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$$

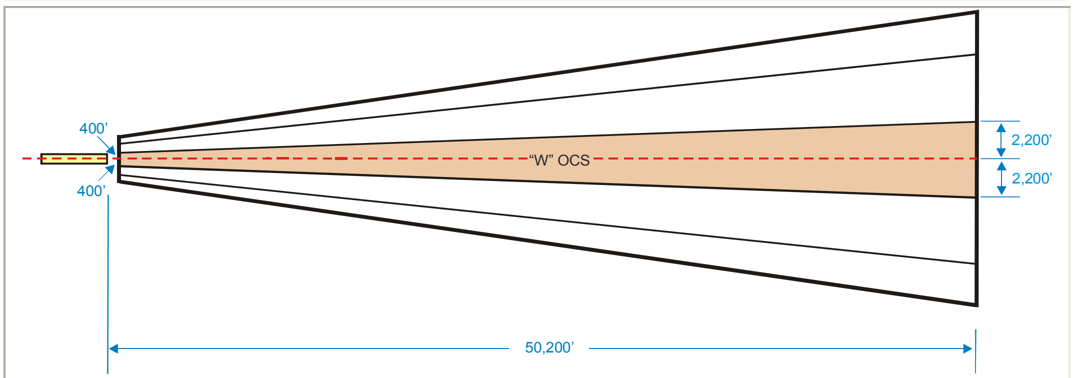
954-TCH/tan(θ*π/180)

Calculator		
TCH		Click Here to Calculate
θ	°	
d		

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*.

Figure 5-4. *W OCS.*



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.*		
$W_{boundary} = 0.036 \cdot OBS_X + 392.8$ where OBS_X = along-track distance (ft) from LTP to obstacle		
0.036*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.*		
$$W_{MSL} = \frac{\left(r + LTP_{elev} - \frac{\theta \cdot (200+d)}{102}\right) \cdot \cos\left(a\tan\left(\frac{\theta}{102}\right)\right)}{\cos\left(\frac{OBS_X - (200+d)}{r} + a\tan\left(\frac{\theta}{102}\right)\right)} - r$$ 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		
((r+LTP$_{elev}$-(θ*(200+d))/102)*cos(atan(θ/102)))/cos((OBS$_X$-(200+d))/r+atan(θ/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 $\boldsymbol{O_{EE}}$ to $\boldsymbol{W_{MSL}}$ 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*.**

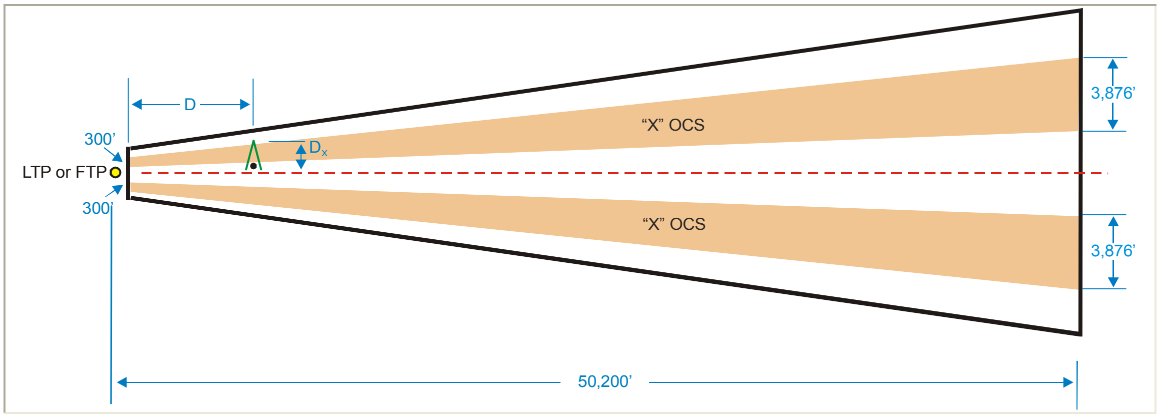
5.2.3 **c. Raise the *GPA*** (*see paragraph* 5.6) within the limits of *table* 2-5.

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*)

Figure 5-5. *X OCS.*



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

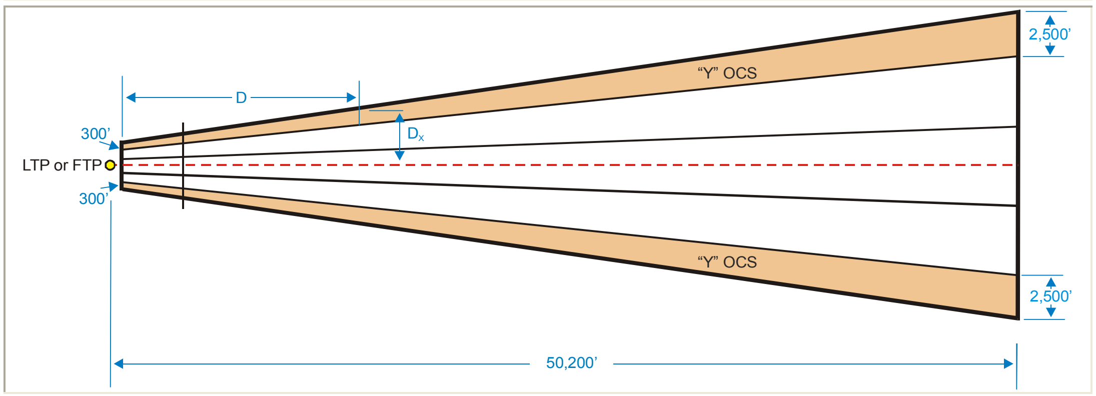
$W_{boundary}$ = half-width of W surface abeam obstacle (*formula 5-3*)

$(OBS_Y - W_{boundary})/4$

Calculator		
OBS_Y		Click Here to Calculate
$W_{boundary}$		
Q		

5.4 **Y *OCS*.** (*See figure 5-6*)

Figure 5-6. *Y Surface.*



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.*		
$$Q = \frac{X_{boundary} - W_{boundary}}{4} + \frac{OBS_Y - X_{boundary}}{7}$$ 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		
$(X_{boundary}-W_{boundary})/4+(OBS_Y-X_{boundary})/7$		
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*.

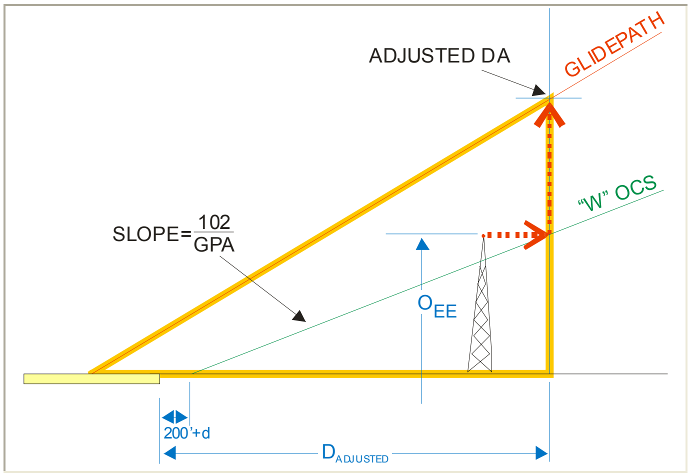
Formula 5-10. *DA Calculation.*		
$DA = HATh + LTP_{elev}$ where HATh = height above threshold LTP_{elev} = LTP MSL elevation		
$HATh+LTP_{elev}$		
Calculator		
HATh		Click Here to Calculate
LTP_{elev}		
DA		

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.*		
$$X_{DA} = r \cdot \left(\frac{\pi}{2} - \theta \cdot \frac{\pi}{180} - \operatorname{asin}\left(\frac{\cos\left(\theta \cdot \frac{\pi}{180}\right) \cdot (r + LTP_{elev} + TCH)}{r + DA} \right) \right)$$		
r*(π/2-θ*π/180-asin((cos(θ*π/180)*(r+LTP_{elev}+TCH))/(r+DA)))		
Calculator		
LTP_{elev}		Click Here to Calculate
TCH		
θ	°	
DA		
X_{DA}		

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

Figure 5-7. *DA Adjustment.*



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

Formula 5-12. *Adjusted DA.*

$$D_{adjusted} = r \cdot \left(\frac{\pi}{2} - \operatorname{atan}\left(\frac{\theta}{102}\right) - \operatorname{asin}\left(\frac{\cos\left(\operatorname{atan}\left(\frac{\theta}{102}\right)\right) \cdot \left(r + LTP_{elev} - \frac{\theta \cdot (200 + d)}{102} \right)}{r + O_{EE}} \right) \right)$$

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

where r = 20890537
d = *value from paragraph 5.1.3*
θ = glidepath angle
O_{EE} = *from formula 5-5*

$D_{adjusted}$=r*(π/2-atan(θ/102)-asin((cos(atan(θ/102))*((r+LTP_{elev})-(θ*(200+d))/102))/(r+O_{EE})))
$DA_{adjusted}$=((r+LTPelev+TCH)*cos(θ*π/180))/cos($D_{adjusted}$/r+θ*π/180)-r

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. *Glidepath Angle Adjustment.*

$$SRD = \sqrt{(r + O_{EE})^2 + (r + LTP_{elev})^2 - 2 \cdot (r + O_{EE}) \cdot (r + LTP_{elev}) \cdot \cos\left(\frac{OBS_X - (200 + d)}{r}\right)}$$

$$RS = \frac{1}{\tan\left(a\cos\left(\frac{SRD^2 + (r + LTP_{elev})^2 - (r + O_{EE})^2}{2 \cdot SRD \cdot (r + LTP_{elev})}\right) - \frac{\pi}{2}\right)}$$

$$\theta_{required} = \frac{102}{RS}$$

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*

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(acos((SRD^2+(r+LTP_{elev})^2-(r+O_{EE})^2)/(2*SRD*(r+LTP_{elev})))-π/2)
$\theta_{required}$=102/RS

Calculator

LTP_{elev}		Click Here to Calculate
d		
O_{EE}		
OBS_X		
$\theta_{required}$		

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 *paragraph 5.1.3, formula 5-2*
θ = glidepath angle

(d*θ)/102

Calculator		
θ	°	Click Here to Calculate
d		
Z		

Formula 5-15. *TCH Adjustment.*

$$TCH_{adjustment} = \tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot \frac{102 \cdot p}{\theta}$$

where p = penetration (ft) [$p \le Z$]
θ = glidepath angle

tan(θ*π/180)*(102*p)/θ

Calculator		
θ	°	Click Here to Calculate
p		
$TCH_{adjustment}$		

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.*

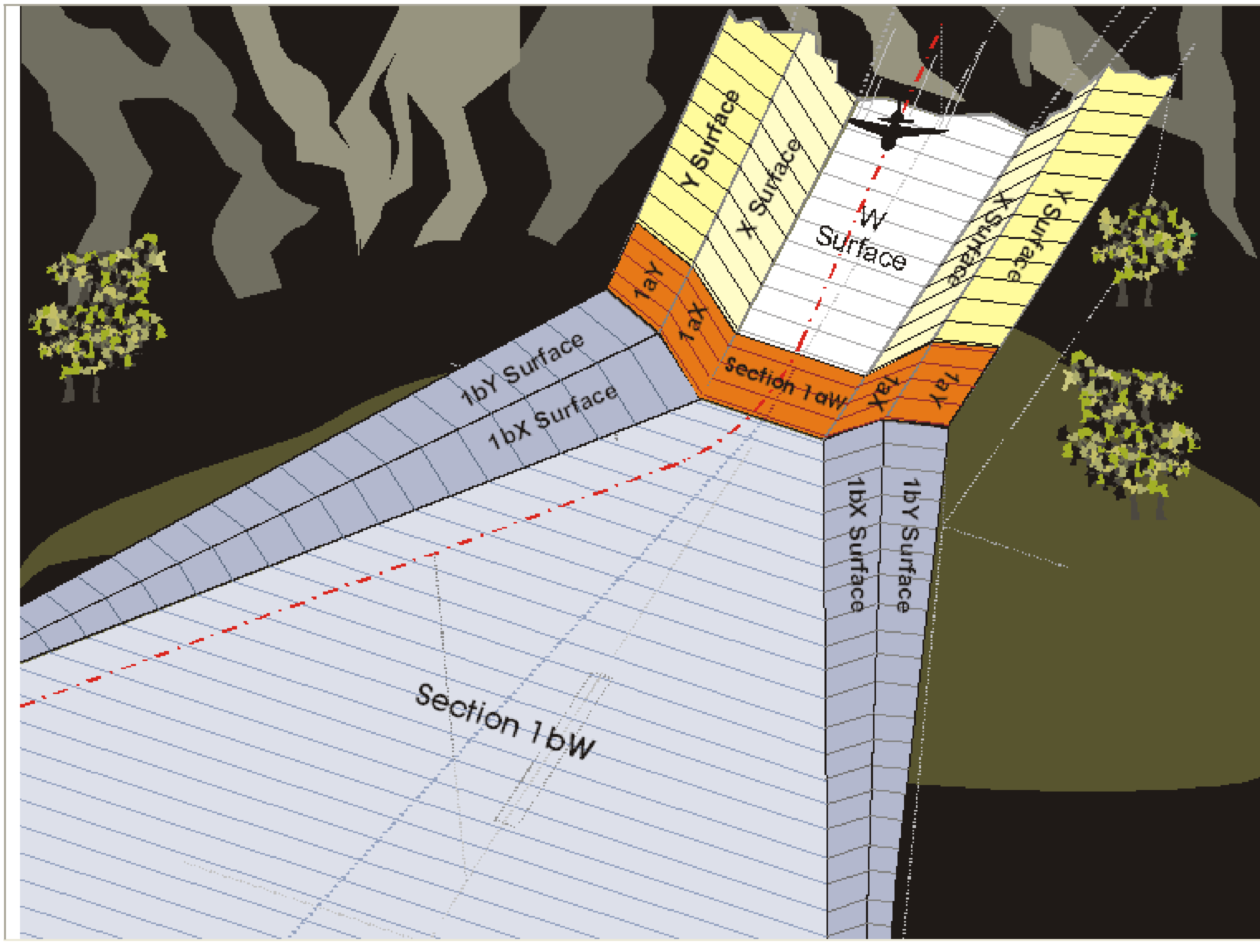
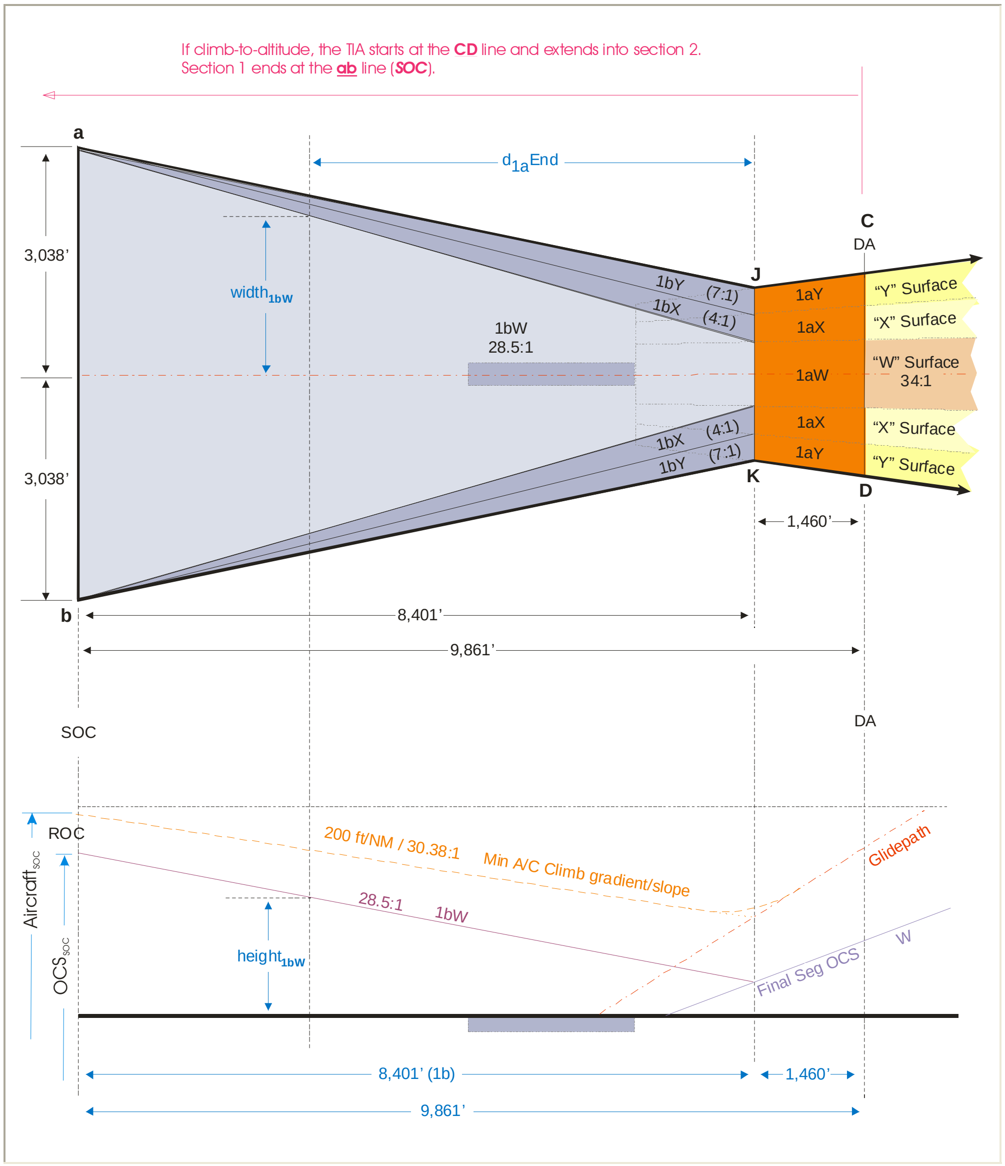


Figure 5-8b. *Section 1 (a/b) 2D Perspective.*



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 BoundaryPerpendicular Distance.*		
$$width_{1bW} = \frac{d_{1aEnd} \cdot (3038 - C_W)}{8401} + C_W$$ 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}*(3038-C_W)/8401+C_W		
Calculator		
d_{1aEnd}		Click Here to Calculate
C_W		
$width_{1bW}$		

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

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

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.*		
$elev_{1bW} = (r + elev_{1aEnd}) \cdot e^{\left(\frac{d1_{aEnd}}{28.5 \cdot r}\right)} - r$ where d_{1aEnd} = along-track distance (ft) from end of section 1a		
(r+elev1aEnd)*e^(d1aEnd/(28.5*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 BoundaryPerpendicular 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		
d1aEnd*(3038-CX)/8401+CX		
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.*		
$elev_{1bX} = elev_{1bW} + \dfrac{a - width_{1bW}}{4}$ 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 BoundaryPerpendicular Distance.*		
$width_{1bY} = \dfrac{d_{1aEnd} \cdot (3038 - C_Y)}{8401} + C_Y$ 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		
$d_{1aEnd}*(3038-C_Y)/8401+C_Y$		
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*p/(28.5*θ+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(θ*π/180)*(X_{DA}+ΔX_{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.*

$$Aircraft_{SOC} = DA - \tan\left(\theta \cdot \frac{\pi}{180}\right) \cdot 1460 + 276.525$$

$$OCS_{SOC} = \left(r + elev_{1Aend}\right) e^{\left(\frac{8401}{28.5 \cdot r}\right)} - r$$

$$ROC_{SOC} = Aircraft_{SOC} - OCS_{SOC}$$

where $r = 20890537$
θ = glidepath angle
DA = Published decision altitude (MSL)
$elev_{1Aend}$ = *value from formula 5-17*
d = *value from paragraph 5.1.3*

DA-tan(θ*π/180)*1460+276.525
(r+$elev_{1aEnd}$)*e^(8401/(28.5*r))-r
$Aircraft_{SOC}$-OCS_{SOC}

Calculator

DA		Click Here to Calculate
θ	°	
$elev_{1Aend}$		
$Aircraft_{SOC}$		
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** ***OEA*** 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 ***CGs*** 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).*		
$Aircraft_{SOC} = (r+\text{MDA or DA}) \cdot e^{\frac{AB_{NM} \cdot CG}{r}} - r$ Where AB_{NM} = SOC to AB distance (NM) r = Earth radius (20890537 ft) CG = applied climb gradient (ft/NM)		
(r+(MDA or DA))*e^((AB_{NM}*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).*		
$TIA_{length} = 9861 + \frac{r}{CG1} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + CG1_{termalt}}{r + Aircraft_{SOC}}\right) + \frac{r}{CG2} \cdot \frac{1852}{0.3048} \cdot \ln\left(\frac{r + turn_{alt}}{r + CG1_{termalt}}\right)$ where $CG1_{termalt}$ = Initial CG termination altitude r = Earth Radius (20890537 ft) $turn_{alt}$ = required turn altitude $Aircraft_{SOC}$ = SOC Aircraft Altitude *(formula 5-25)* CG1 = Initial Climb Gradient (≥ Standard 200) CG2 = Second Climb Gradient (Standard 200)		
9861+r/CG1*1852/0.3048*ln((r+$CG1_{termalt}$)/(r+$Aircraft_{SOC}$))+ r/CG2*1852/0.3048*ln((r+$turn_{alt}$)/(r+ $CG1_{termalt}$))		
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 (*formula 3-5*)(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		
$TIA_{length\ (ft)}$		

<u>STEP 2 (***LNAV/VNAV***)</u>: 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*r/(r+DA)+r/CG*1852/0.3048*ln((r+$turn_{alt}$)/(r+DA))		
Calculator		
FSL (*formula 4-15a*) (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).*		
$$R = \frac{(V_{KTAS} + 0)^2}{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot 68625.4}$$		
$(V_{KTAS}+0)\text{^}2/(\tan(15*\pi/180)*68625.4)$		
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 ≤ 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 = *Formula 6-3* (Max 3 degrees/second); V_{KTW} = *Formula 2-3b* 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((Altfix+r)/(Aircraftsoc+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 AB line to fix $Aircraft_{SOC}$ = Aircraft AB line (SOC) altitude CG = Climb Gradient (Standard 200 ft/NM)		
(r+Aircraft$_{SOC}$) *e^(CG*Dfix/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$_{(FORMULA\ 2\text{-}5)}$		
$D_{earlyTP}$		

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

<u>Note</u>: 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 **<u>LL'</u>** 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.

<u>Note</u>: 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.

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

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

<u>STEP 1</u>: 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*).

<u>STEP 2 *(if required)*</u>: 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*).

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

<u>STEP 1</u>: 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.

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

<u>STEP 2</u>: 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*).

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

<u>STEP 1</u>: 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 <u>**LL'**</u> and the inbound segment inner primary boundary), to intersect the outbound segment boundaries.

<u>STEP 1 Alt</u>: 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, <u>**LL'**</u> (*see figure 6-11c* for **L'** connection).

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

<u>STEP 1</u>: 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 ***WS1*** 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 measurements 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.

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

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

<u>STEP 2</u>: Apply chapter 2, *paragraph 2.5.2* criteria.

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

<u>STEP 1</u>: Apply *paragraph 6.2.2.c(3)* criteria.

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

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

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

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

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

<u>STEP 1</u>: 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.

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

<u>Note</u>: 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.

<u>CASE 1</u>: **No inside secondary area exists at <u>LL'</u>.**

<u>STEP 1</u>: 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 **<u>LL'</u>** 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 **<u>P'P''</u>**. 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 *formula 2-4*		
ATT+rr		
Calculator		
ATT		Click Here to Calculate
rr (*formula 2-4*)		
D_{lateTP}		

6.4.1 **a.** **<u>CASE 1</u>**: Small angle turn using 1 ***WS***.

<u>STEP 1</u>: Construct the ***WS1*** baseline, **(<u>PP'</u>)** 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.*

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

<u>STEP 3</u>: Construct ***WS1*** 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.*

<u>CASE 1-1</u>: **Turn-altitude** (***WS1*** ends when tangent to a line direct to fix)

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

<u>STEP 2</u>: Construct a line from the ***WS1*** tangent point, splaying at 15 degrees from the ***WS1***-to- fix track until it intersects the parallel boundary lines or reaches the segment end (*see figures 6-2 through 6-6*).

<u>Note</u>: 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 ***WS1/***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)** (***WS1*** ends when tangent to a 30-degree line converging to nominal track).

STEP 1: Construct the ***OEA*** outer boundary line using ***WS1*** and the tangent 30-degree converging line until it crosses the outbound segment boundaries (*see figure 6-12).*

STEP 1a: Where ***WS1*** lies within the outbound segment primary boundary, construct the ***OEA*** boundary using ***WS1*** and a line (from the point ***WS1*** 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 ***WS1*** lies within the outbound segment secondary boundary, construct the e ***OEA*** boundary using ***WS1*** and a line (from the point ***WS1*** 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 ***WS1*** 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 ***WS1*** 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 ***HATh*** (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	$$ROC_{obs} = ROC_{start} + 48 \cdot d$$ Where ROC_{start} = SOC ROC (*Table 4-2 value*) or (100 ft for NVGP) d = distance (*NM*) *CG* origin (*SOC*) to obstacle
ROC_{start}+48*d	
STEP 2	$$Alt_{min} = O_{elev} + ROC_{obs}$$ Where ROC_{obs} = *Step 1 result* O_{elev} = Obstacle Elevation (*MSL*)
O_{elev}+ROC_{obs}	
STEP 3	$$CG = \frac{r}{d} \cdot \ln\left(\frac{(r + Alt_{min})}{(r + Aircraft_{SOC})}\right)$$ Where Alt_{min} = *Step 2 result* $Airfraft_{SOC}$ = aircraft altitude (*MSL*) at *CG* origin d = distance (*NM*), *CG* origin (*SOC*) to obstacle
r/d*ln((r+ALT_{min})/(r+$Aircraft_{SOC}$))	

Calculator

ROC_{start}		Click Here to Calculate
O_{elev}		
d (*NM*)		
$Aircraft_{SOC}$		
ROC_{obs}		
Alt_{min}		
CG		

Figure 6-1. *Straight Missed Approach (Legs with Specified Tracks).*

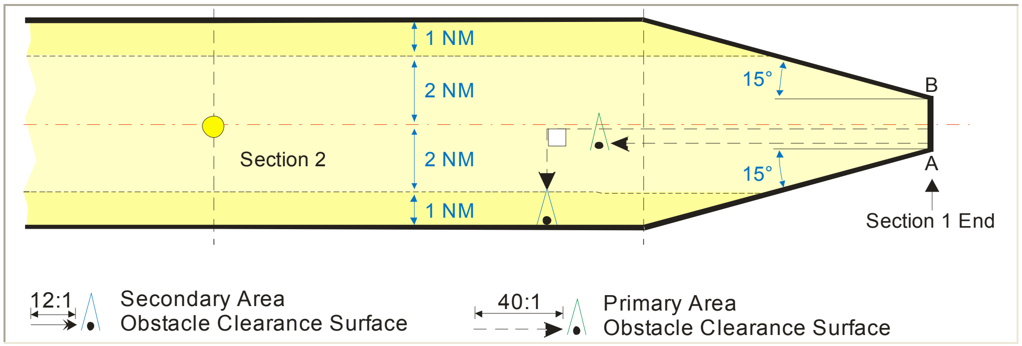


Figure 6-2. *Turn at Altitude – Direct to Waypoint Small Angle Turn.*

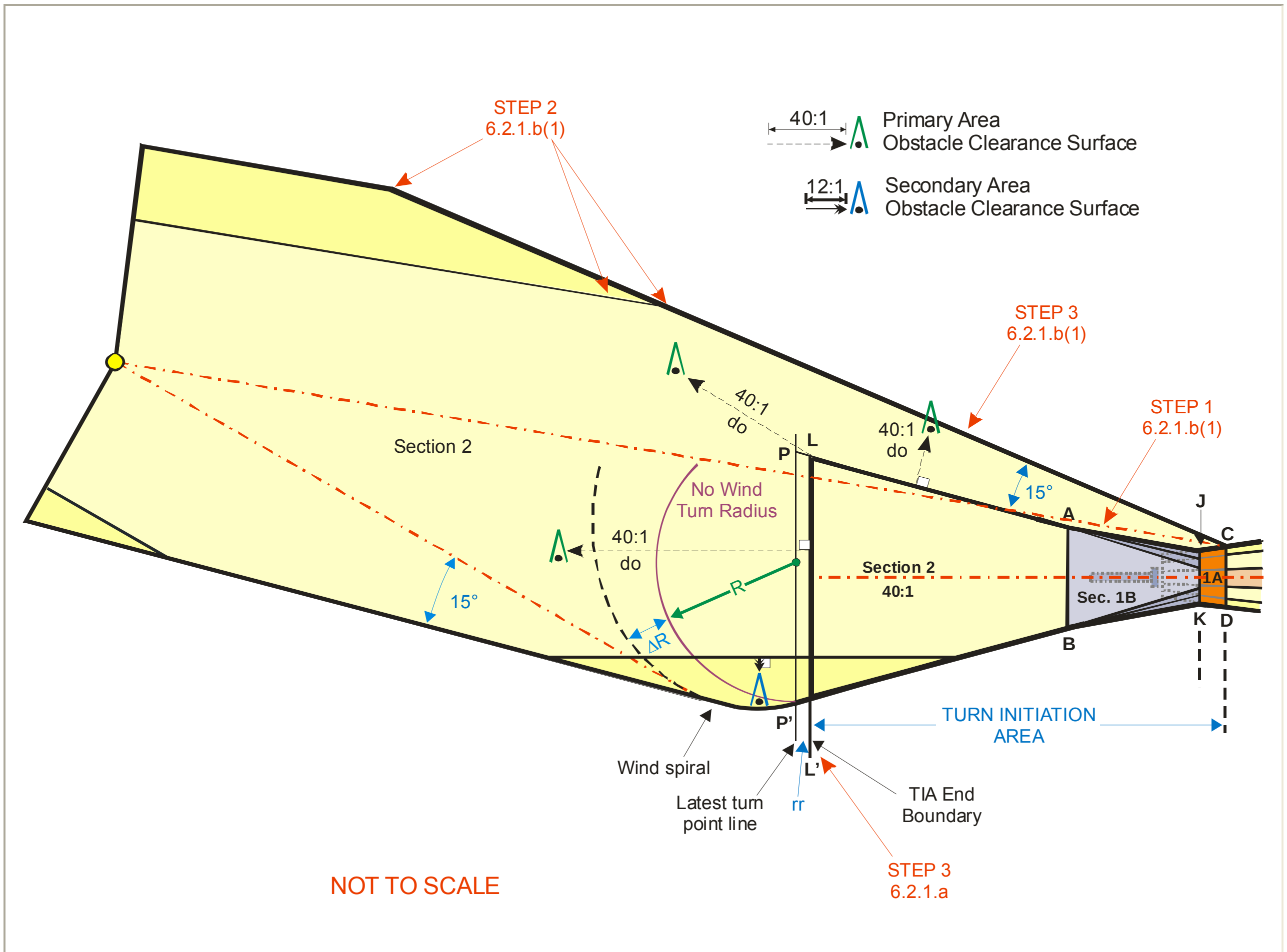


Figure 6-3. *Turn at Altitude.*
TIA must Extend to the End of Section 1B.

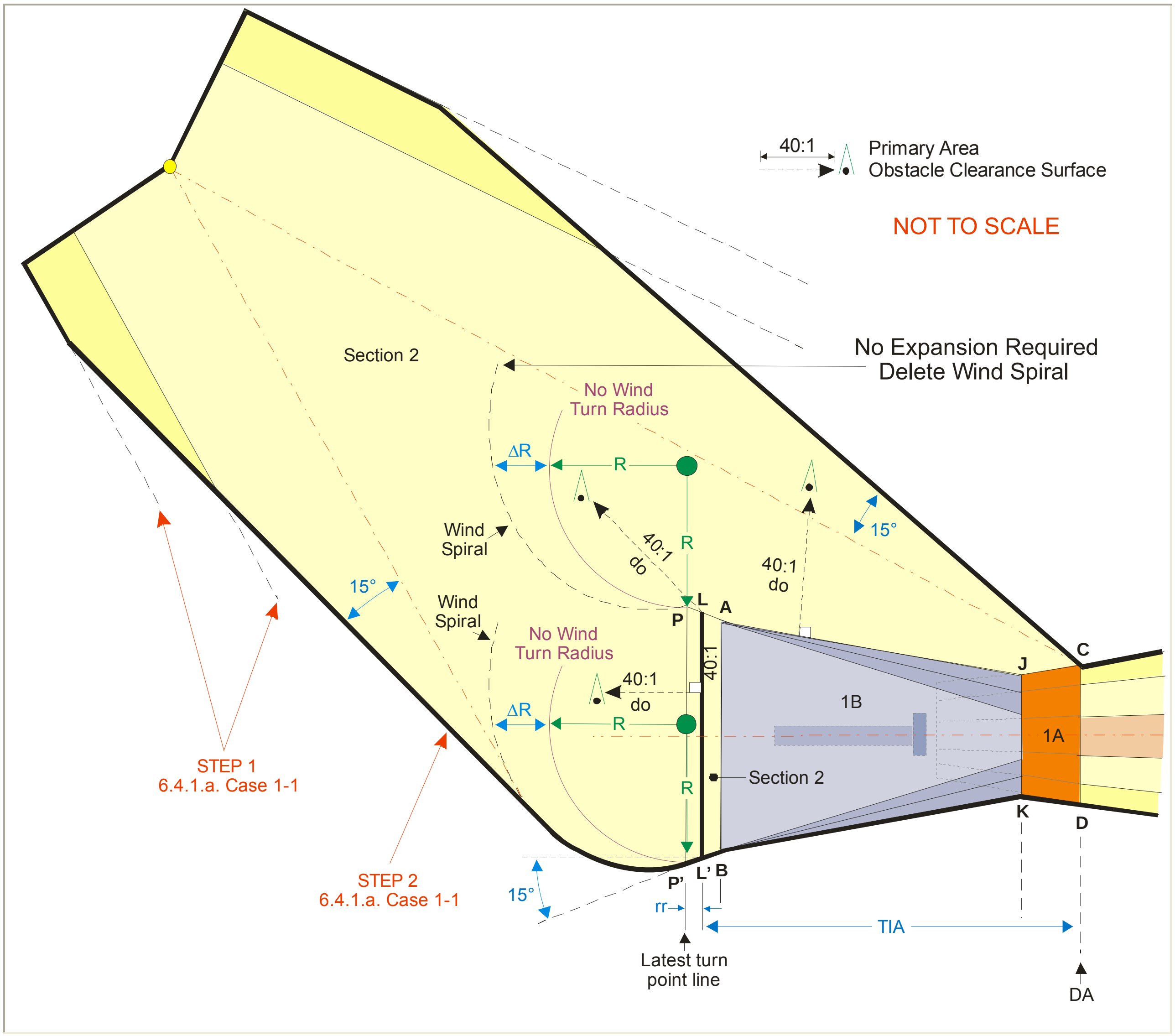


Figure 6-4. *Turn at Altitude (Minimum Straight Segment).*

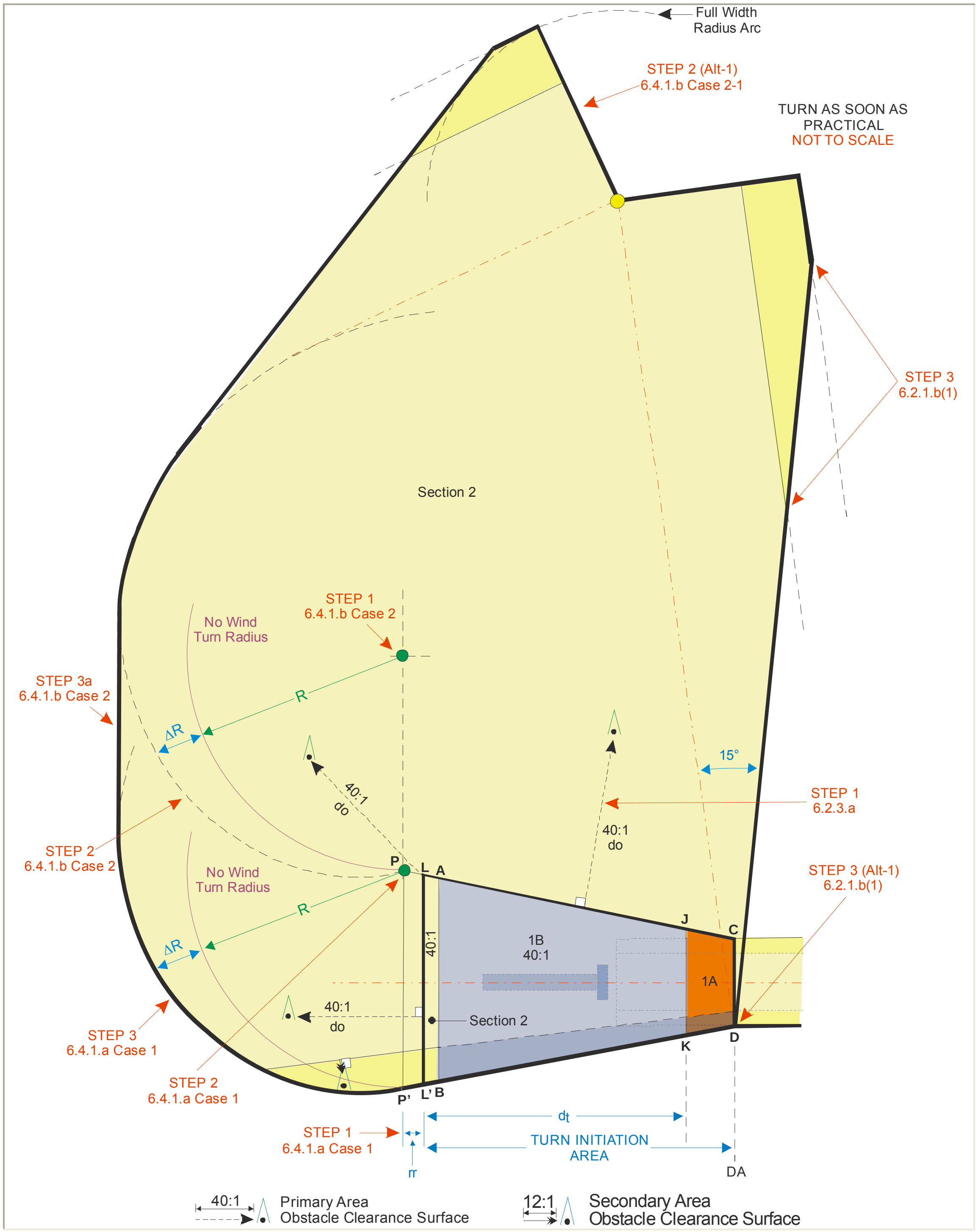


Figure 6-5. *Turn at Altitude ≥ 180°.*

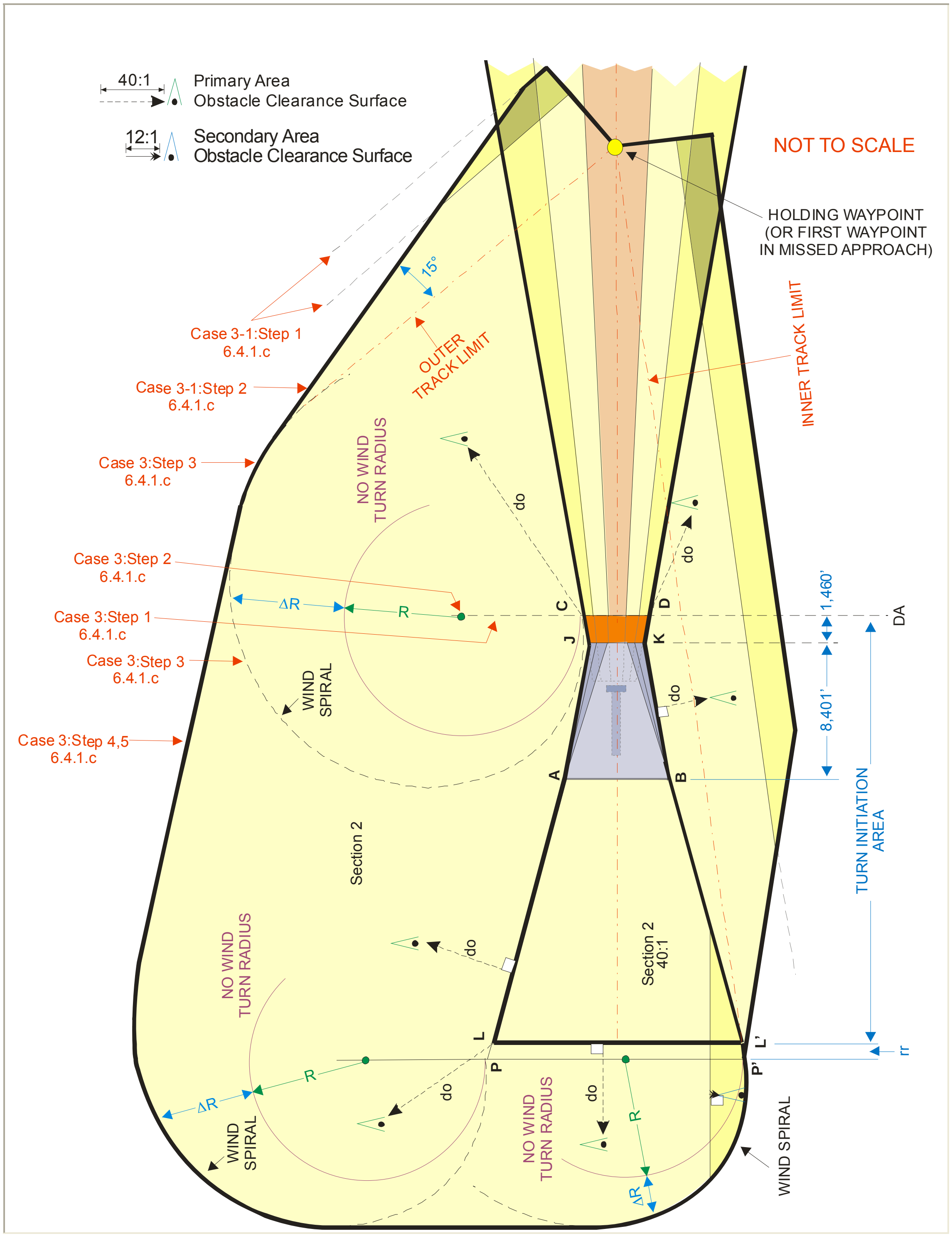


Figure 6-6. *Fly-By DF/TF Turn Following Turn at Altitude.*

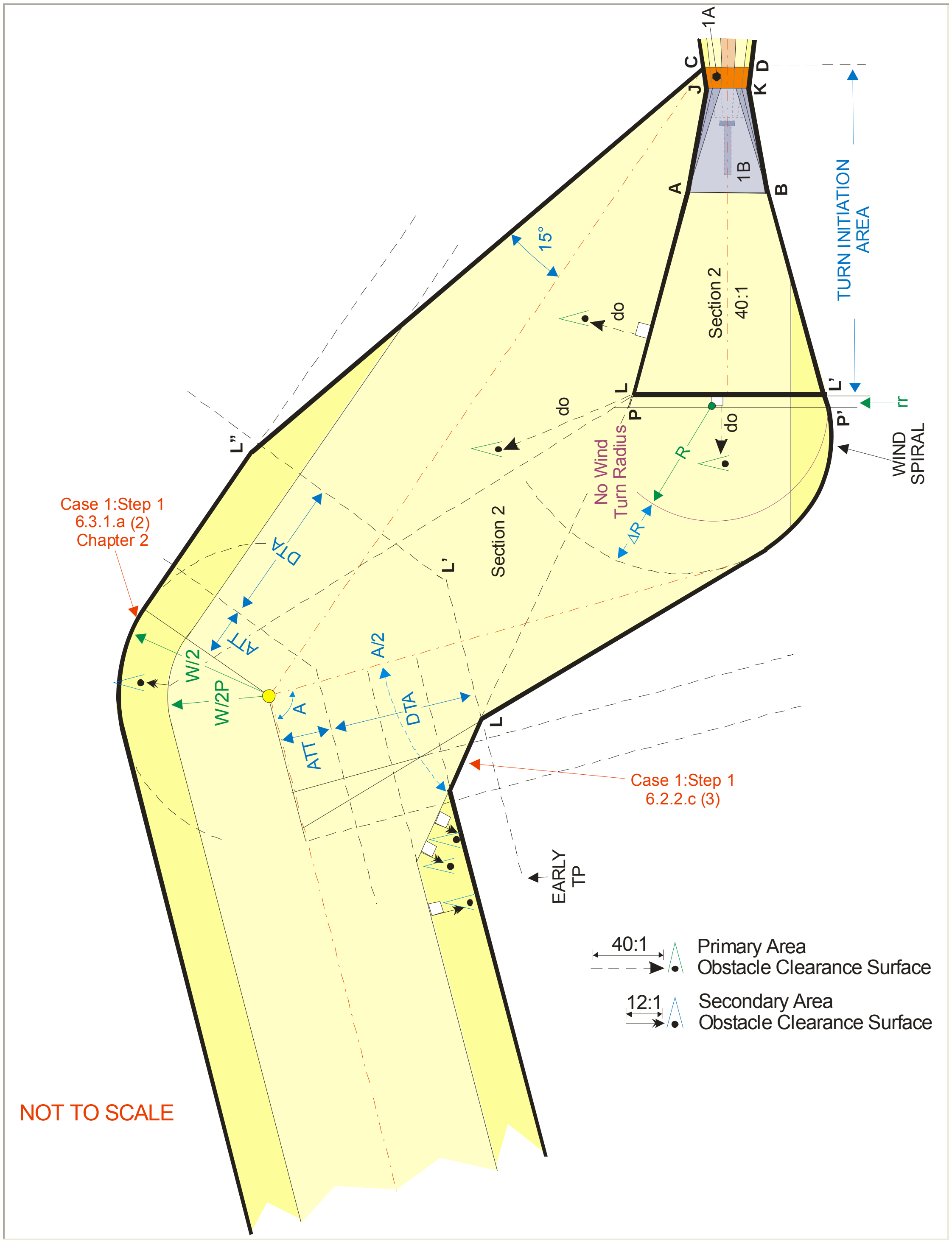


Figure 6-7. *Turn at Altitude to Fly-By Waypoint.*

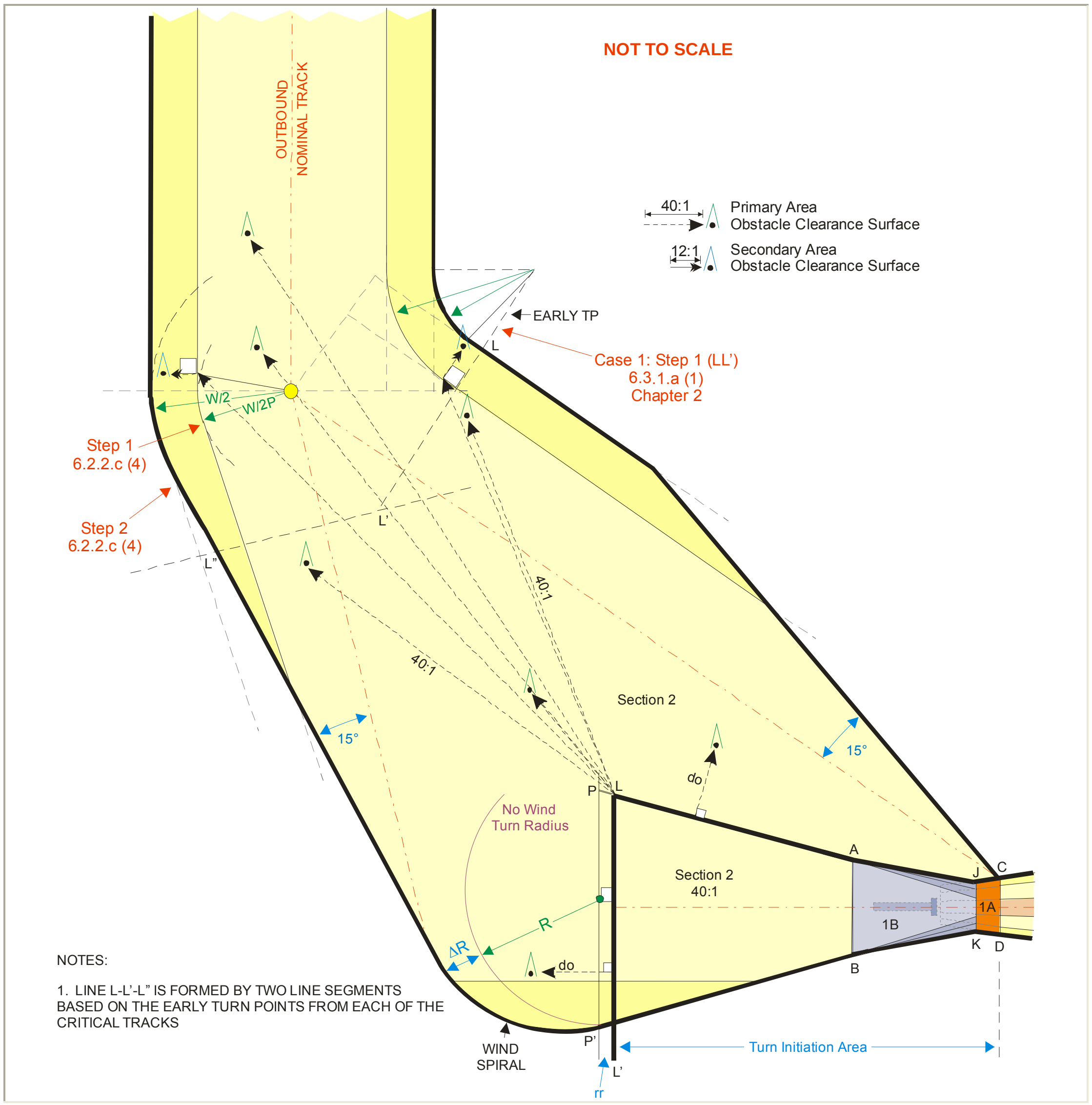


Figure 6-8. *Maximum Turn (Fly-By)*
Following Turn at Altitude.

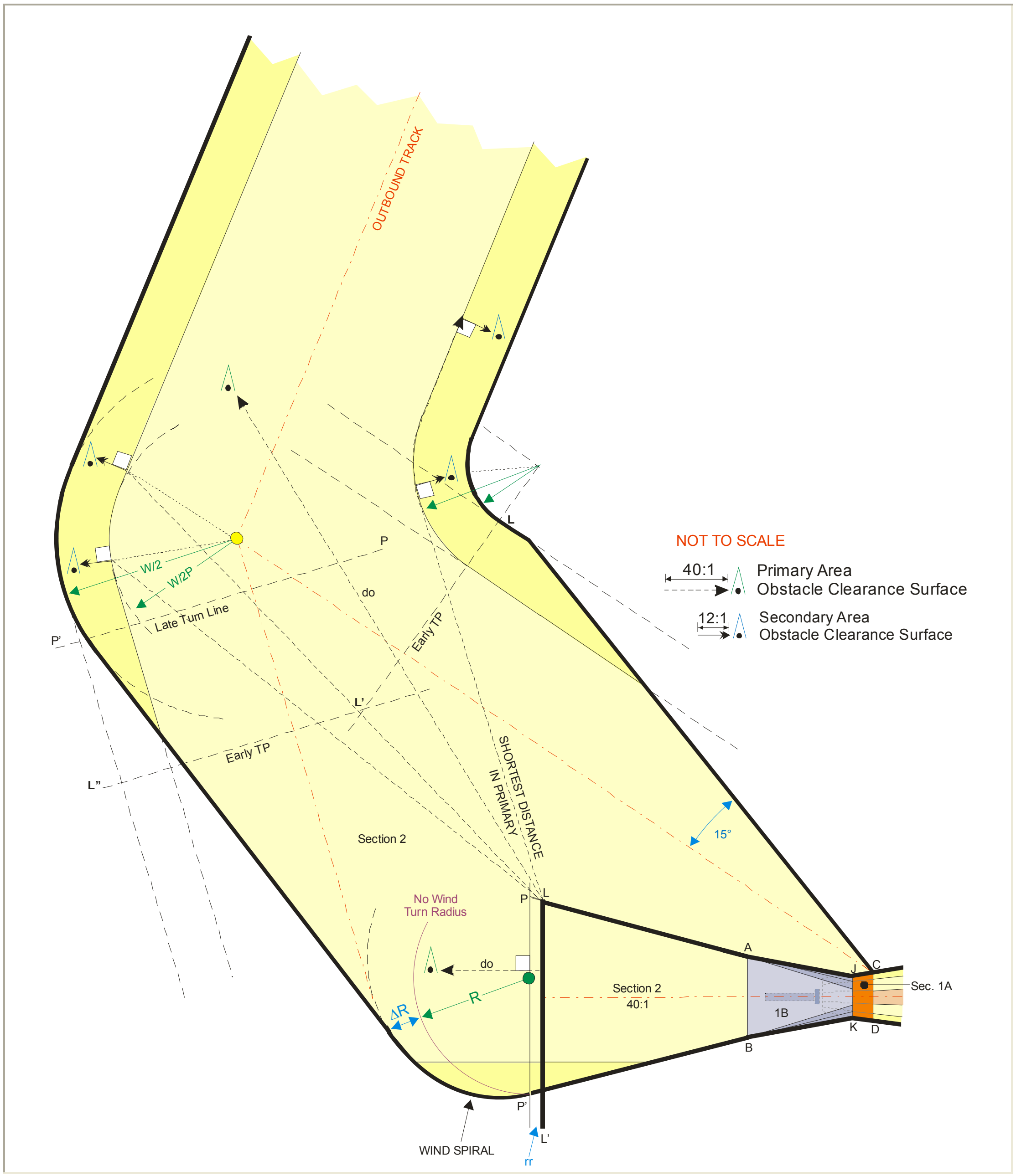


Figure 6-9. *Turn at Altitude to a Fly-Over Waypoint.*

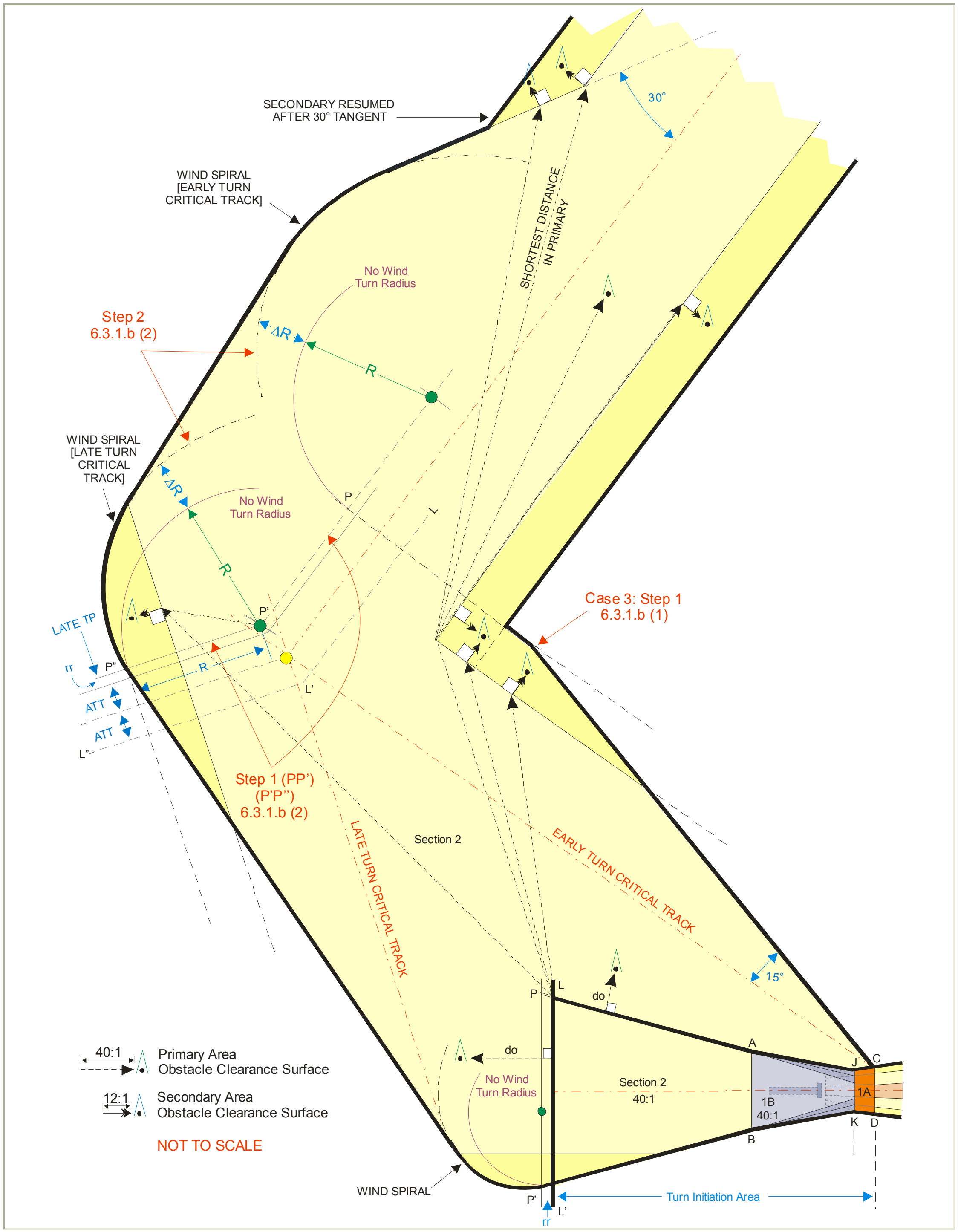


Figure 6-10. *Fly-Over/Fly-By Fix Diagrams.*

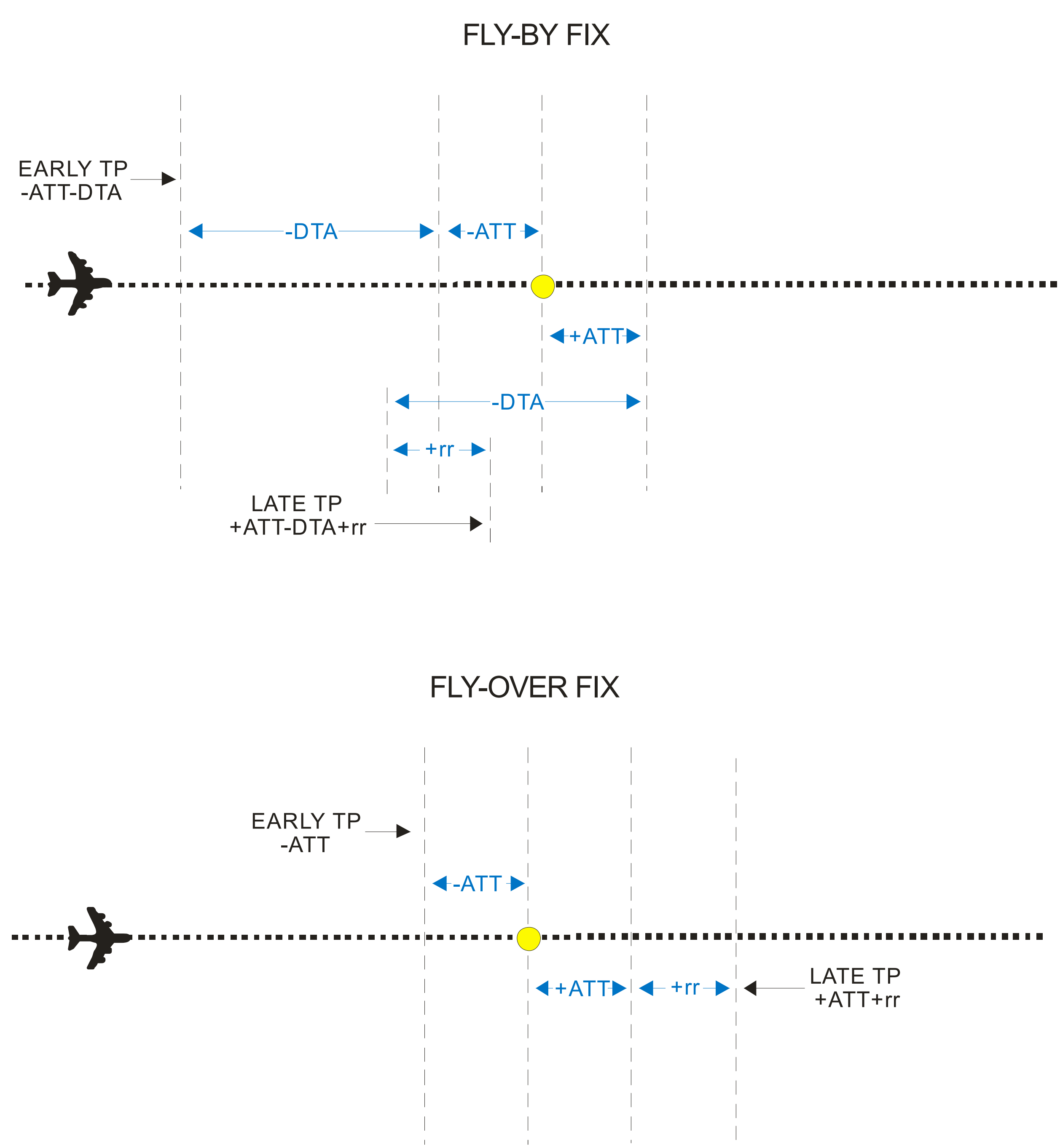


Figure 6-11a. *Turn at Waypoint (Fly-By).*

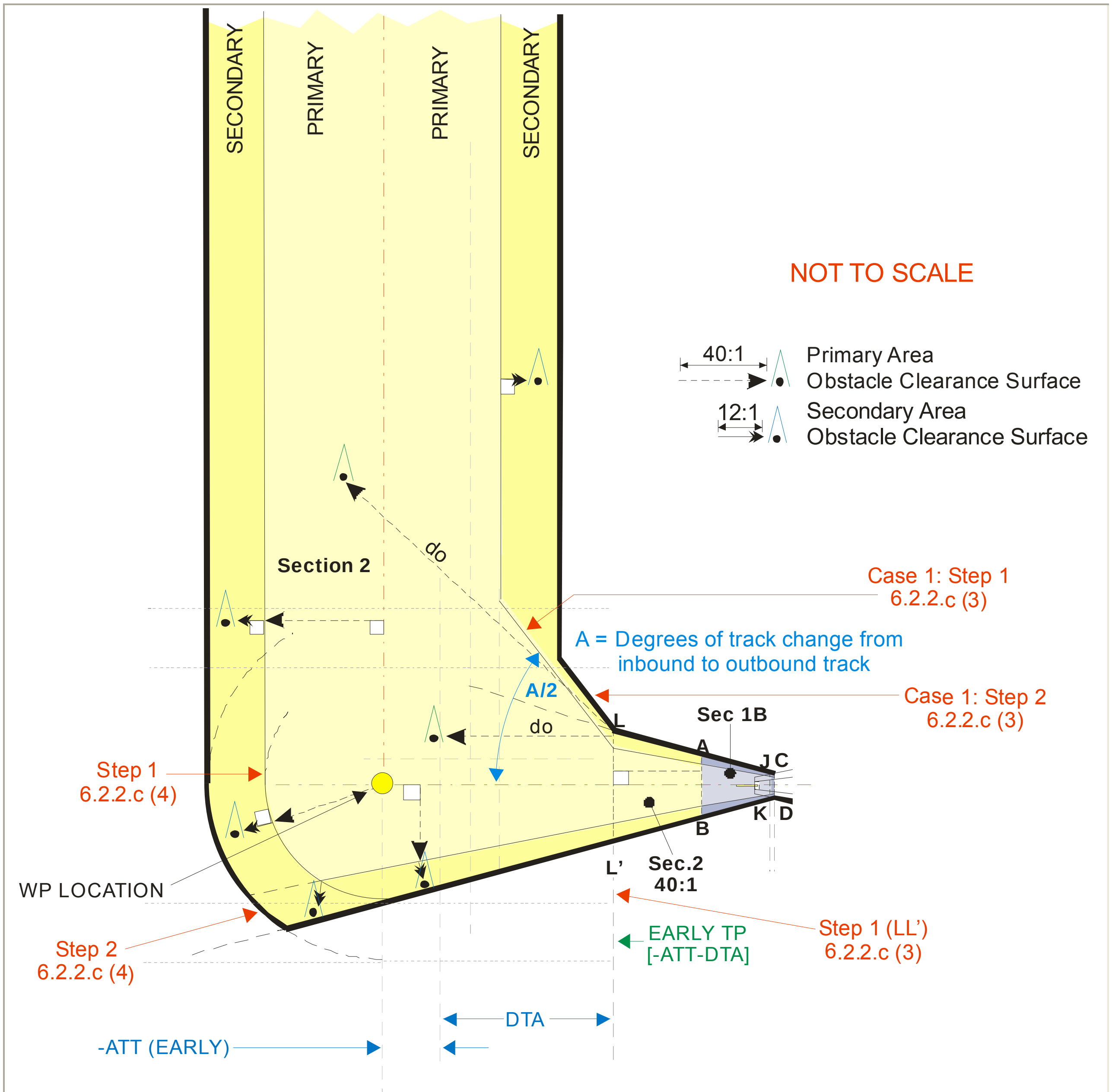


Figure 6-11b. *Turn at Waypoint (Fly-By).*

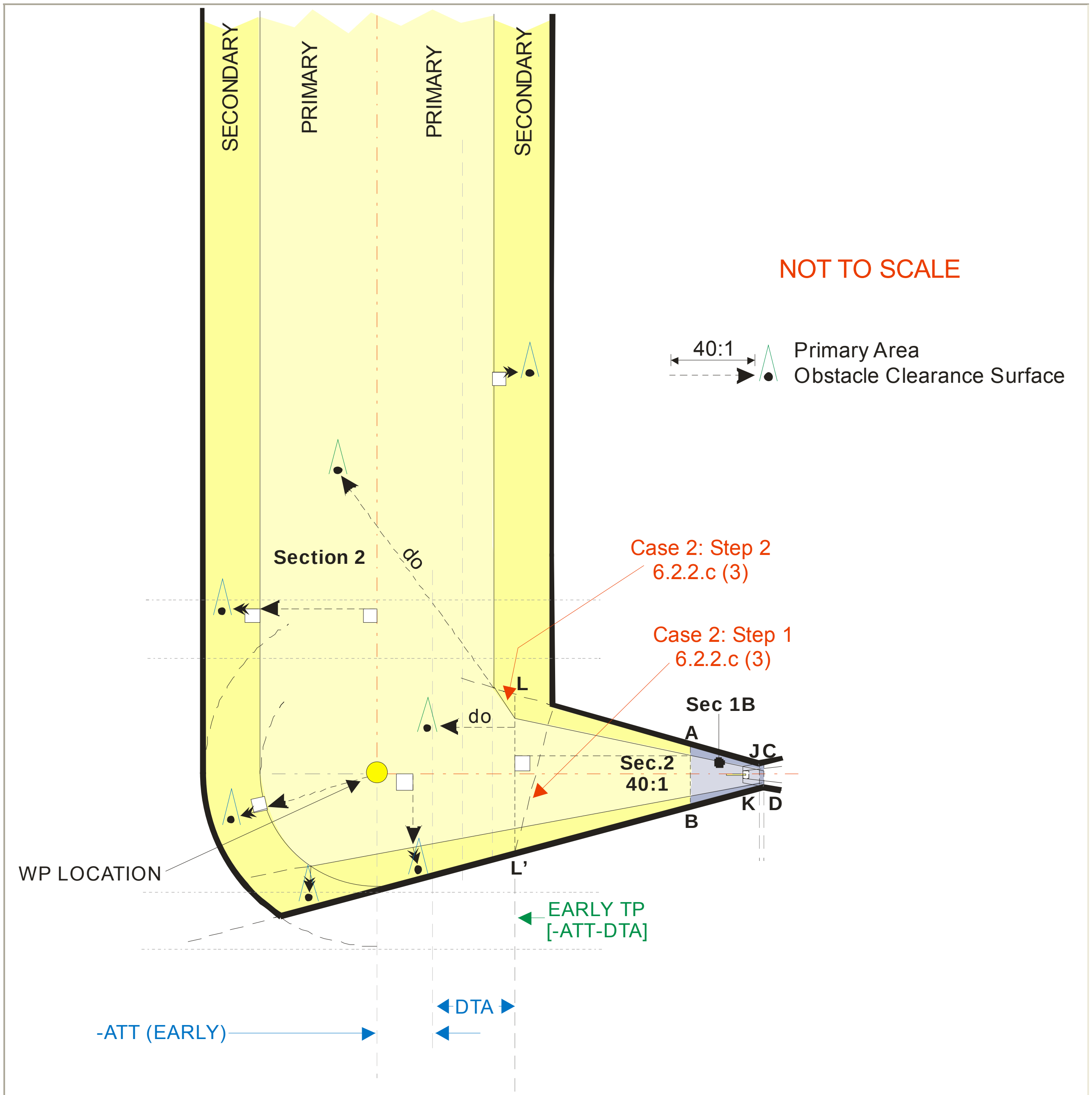


Figure 6-11c. *Turn at Waypoint (Fly-By).*

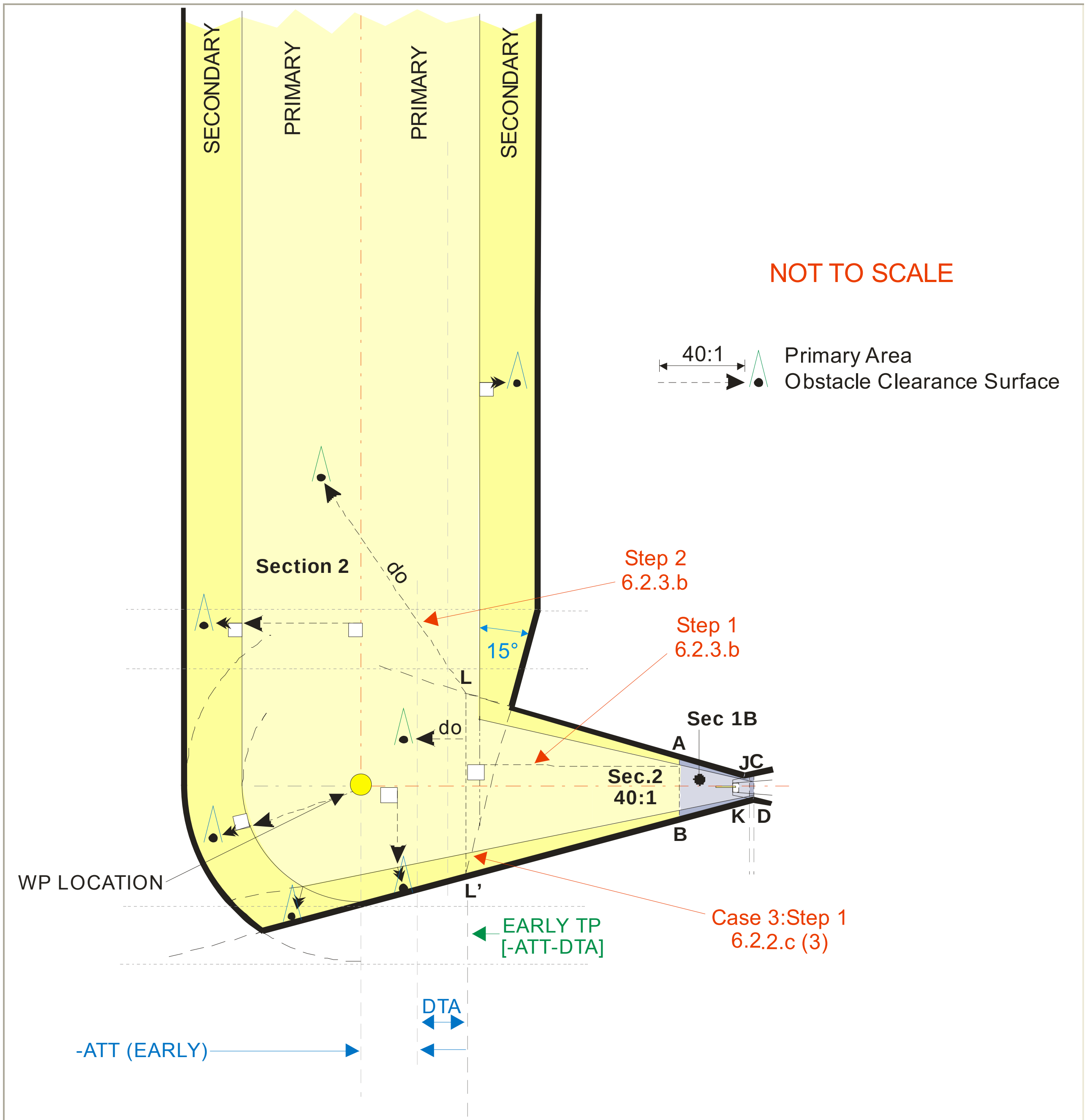


Figure 6-12. *Turn at Waypoint (Fly-Over), < 75°.*

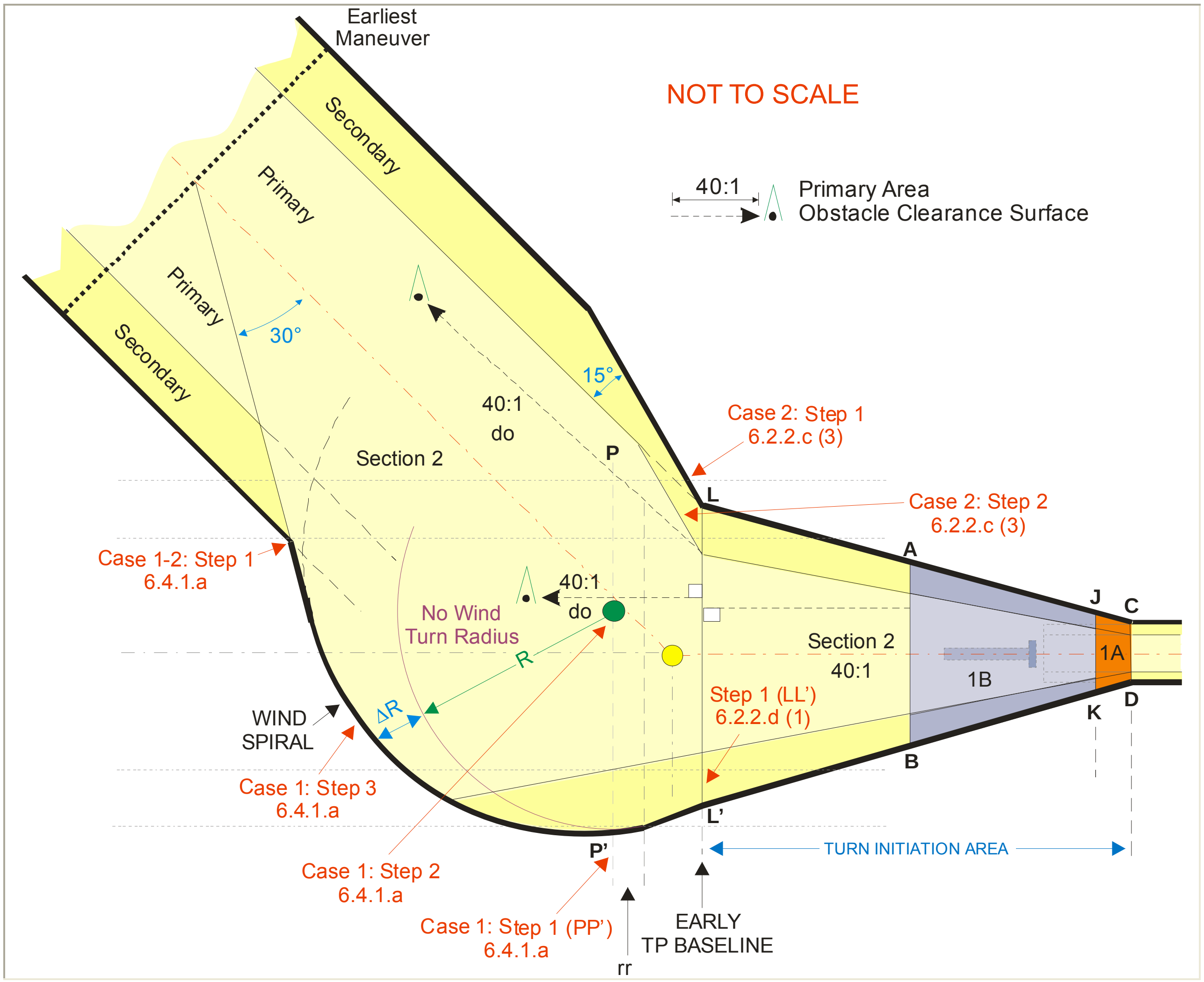


Figure 6-13. *Turn at Waypoint (Fly-Over), 90°.*

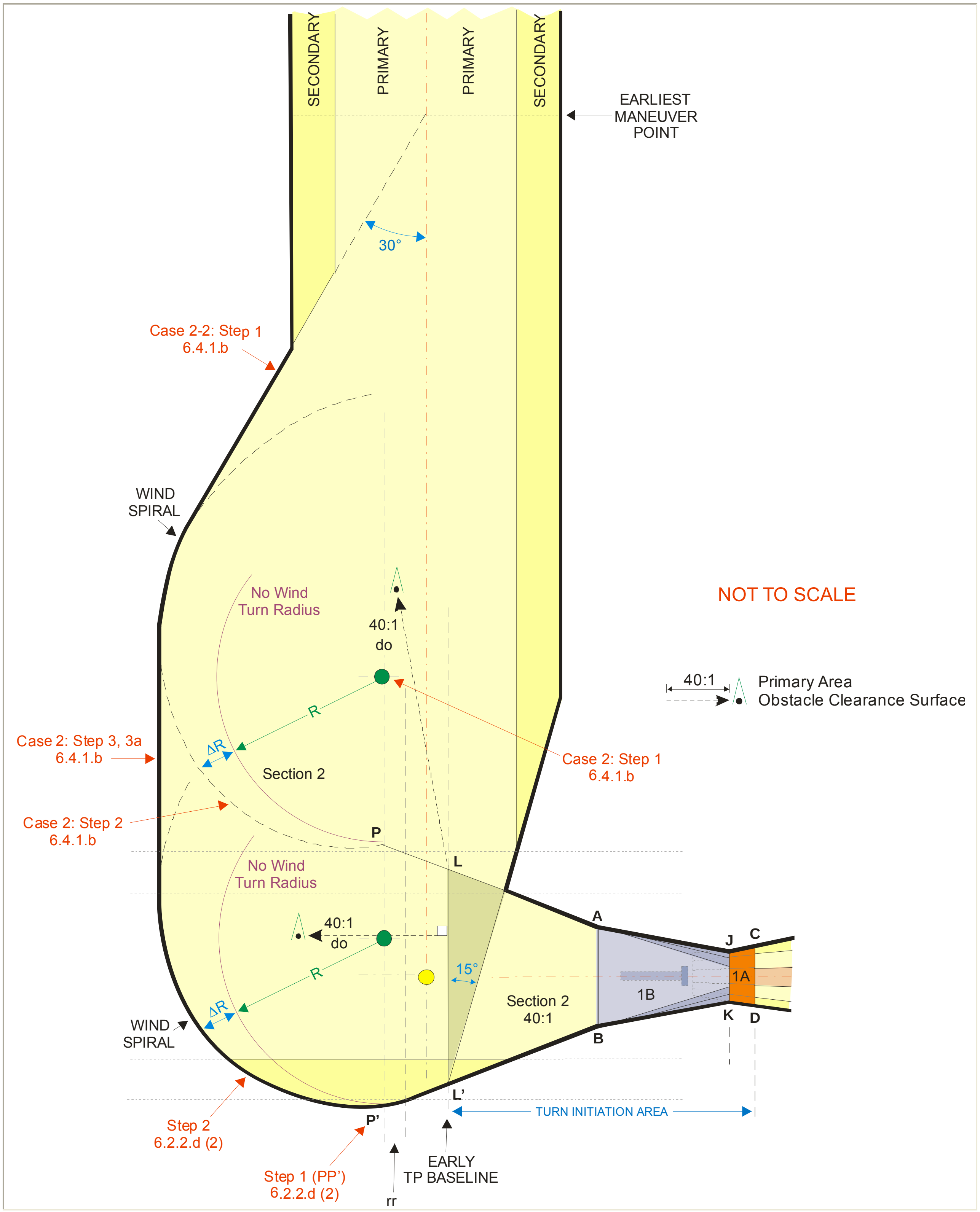


Figure 6-14a. WS Outer Boundary Connections.

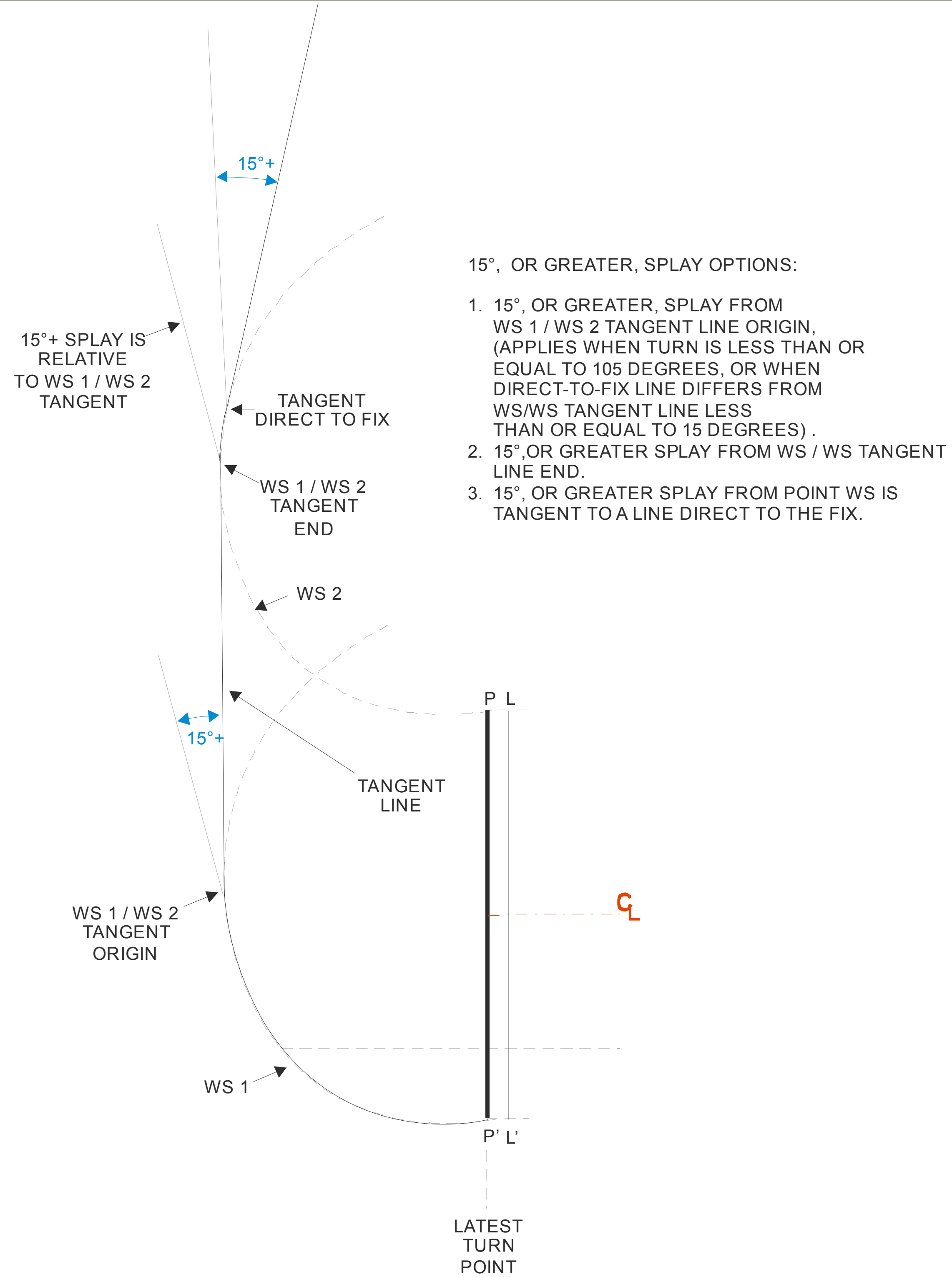


Figure 6-14b. *WS1 Outer Boundary Connection.*

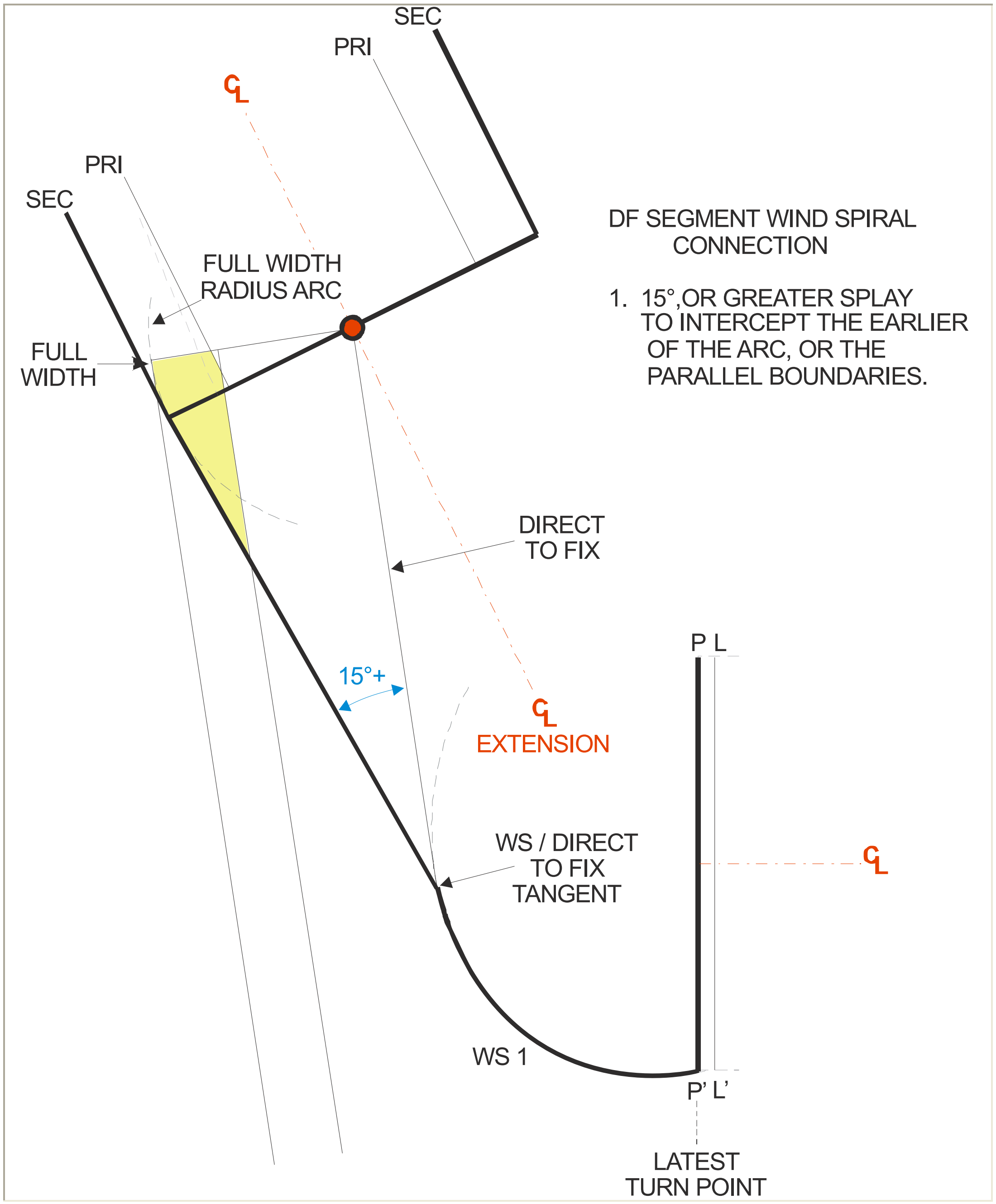
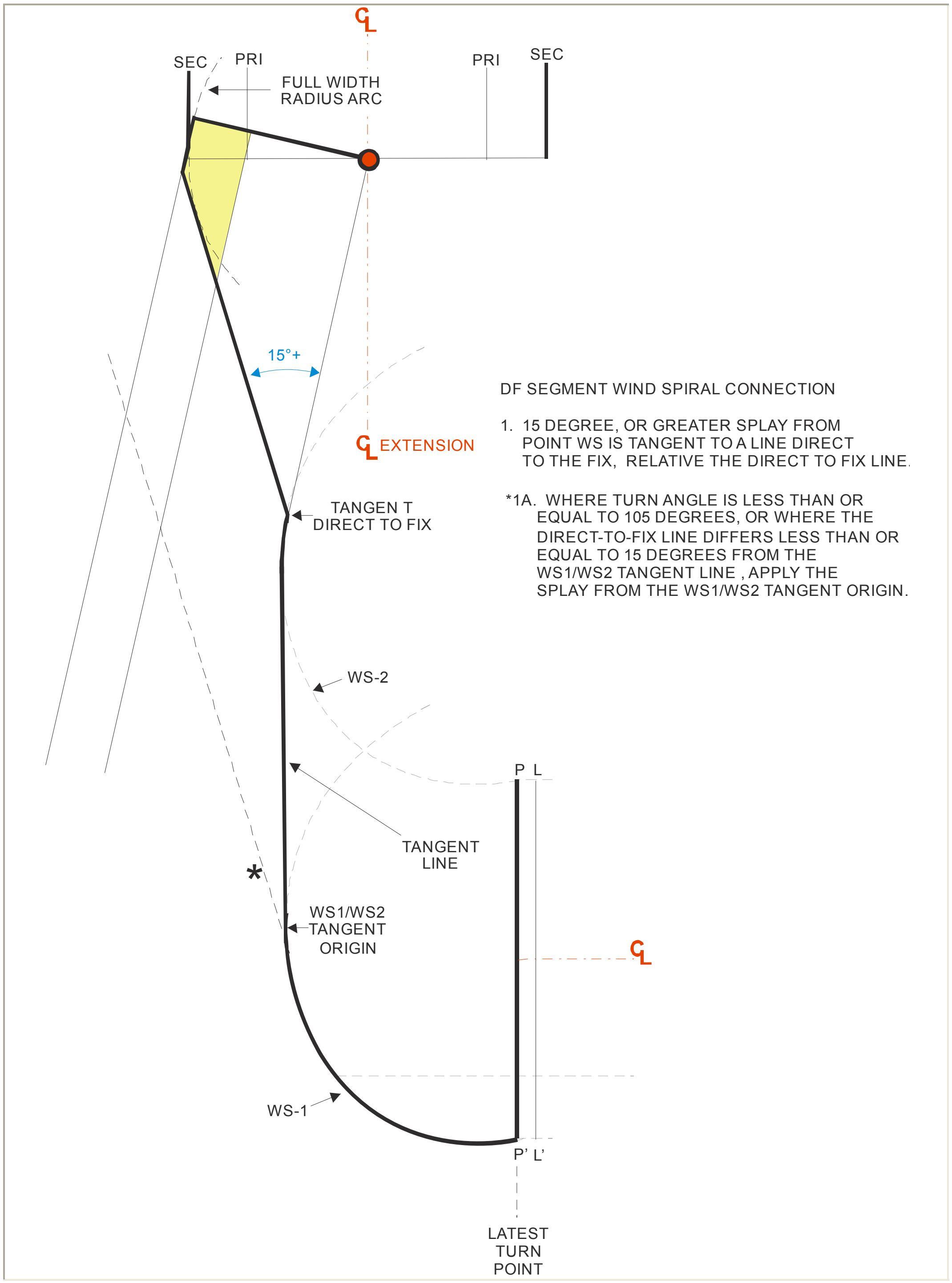


Figure 6-14c. WS Outer Boundary Connection (Multiple).



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	α = (180*D)/(π*R)
	$B_{primary}$ = 4-2*(ϕ*π*R)/(180*D)
	$B_{secondary}$ = 6-3*(ϕ*π*R)/(180*D)
2-2	e^((D_Z*tan(θ*π/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($bank_{angle}$*π/180)*68625.4)
2-4	6*1852/0.3048/3600*V_{KTAS}
2-5	R*tan(ϕ/2*π/180)
2-6	f1*(cos(ϕ*π/180)+3^0.5*sin(ϕ*π/180))+R*(sin(ϕ*π/180)+4-3^0.5-3^0.5*cos(ϕ*π/180))+DTA+f2
2-7	F1+DTA1+DTA2+F2
2-8	atan((V_{KTAS}+V_{KTW})^2/(R*68625.4))*180/π
2-9	π*R*ϕ/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	atan(350/(RWY_{Length}+1000))*180/π
2-14	tan(1.5*π/180)*(RWY_{length}+1000)*0.3048
2-15	$FPAP_{Distance}$-RWY length
2-16a	r*(π/2-θ*π/180-asin((cos(θ*π/180)*(r+LTP_{elev}+TCH))/(r+alt)))
2-16b	(ln((r+alt)/(r+LTP_{elev}+TCH))*r)/tan(θ*π/180)
2-16c	atan(ln((r+$PFAF_{alt}$)/(r+LTP_{elev}+TCH))*r/D_{PFAF})*180/π
2-17a	((r+LTP_{elev}+TCH)*cos(θ*π/180))/cos(D_Z/r+θ*π/180)-r
2-17b	e^((D_Z*tan(θ*π/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	$(r+LTP_{elev}+V_{offset})*cos((2*\theta/3)*\pi/180)/cos((d-X_{offset})/r+(2*\theta/3)*\pi/180)-r$
	$e\hat{}((d-X_{offset})*tan((2*\theta/3)*\pi/180)/r)*(r+LTP_{elev}+V_{offset})-r$
	$LTP_{elev}+(c-x)*tan((2*\theta/3)*\pi/180)$
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	$20.2537*((V_{KIAS}*(171233*((288+15)-0.00198*MDA)\hat{}0.5)/(288-0.00198*MDA)\hat{}2.628)+10)+2*ATT$
3-7a	$MAS_{Yprimary}=d*((tan(15*\pi/180)*1.4*1852/0.3048))/(2.1*1852/0.3048)+0.6*1852/0.3048$
	$MAS_{Ysecondary}=d*tan(15*\pi/180)+0.9*1852/0.3048$
3-7b	$MAS_{Yprimary}= d*((tan(15*\pi/180)*(2*1852/0.3048-W_P))/(3*1852/0.3048-W_S))+W_P$
	$MAS_{Ysecondary}= d*tan(15*\pi/180)+W_S$
3-8	$MDA-(100+adj)$
Chapter 4	
4-1	$d2=(V_{KIAS}\hat{}2*tan(\alpha/2*\pi/180))/(68625.4*tan(18*\pi/180))*1852/0.3048$
	$Min_{HATh}=e\hat{}(((d1+d2)*tan(\theta*\pi/180))/r)*(r+LTP_{elev}+TCH)-(r+LTP_{elev})$
4-2	$(250-TCH)/tan(\theta*\pi/180)$
4-3	$ISA_{airportC}=15-0.00198*Airport\ Elevation$
	$ISA_{airportF}= (1.8*ISA°C)+32$
4-4	$(ACT°F-32)/1.8$

4-5	MDR_{angle}=180/π*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
4-6	e^((D_{PFAF}*tan(MDR_{angle}*π/180))/(r+LTP_{elev}))*(r+LTP_{elev}+TCH)-r
4-7	(c-$PFAF_{alt}$+0.032*($PFAF_{alt}$-(LTP_{elev}+250))+4.9)/(0.19+0.0038*($PFAF_{alt}$-LTP_{elev}+250)))
4-8	NA_{above}C°=$Airport_{ISA}$+ΔISA_{high}
	NA_{above}(F°)=$NA_{above(C°)}$*1.8+32
4-9	1/(tan(θ*π/180)*(0.928+0.0038*(ACT°C- ISA°C)))
4-10	h-(OBS_Y-$Width_{primary}$*1852/0.3048)/7
4-11	h+161
4-12a	D_{origin}+r*OCS_{slope}*ln((LTP_{elev}+89+r)/(r+LTP_{elev}))
4-12b	(r+LTP_{elev})*e^((OBS_X-D_{origin})/(r*OCS_{slope}))-r
4-13	d = (r+LTP_{elev})*OCS_{slope}*ln((r+O_{MSL})/(r+LTP_{elev}))+D_{origin}
	DA_{OCS} = e^((d*tan(θ*π/180))/r)*(r+LTP_{elev}+TCH)-r
4-14	(ln((r+DA)/(r+LTP_{elev}+TCH))*(r+LTP_{elev}))/tan(θ*π/180)
4-15a	25.317*((V_{KIAS}*(171233*((288+15)-0.00198*DA)^0.5)/(288-0.00198*DA)^2.628)+10)
4-15b	Z/CG*1852/0.3048
4-16	DA-hl
4-17	e^((p*(MA_{slope}*tan(θ*π/180))/(1+MA_{slope}*tan(θ*π/180))/r))*r-r
Chapter 5	
5-1	S = 102/θ
5-2	954-TCH/tan(θ*π/180)
5-3	0.036*OBS_X+392.8
5-4	((r+LTP_{elev}-(θ*(200+d))/102)*cos(atan(θ/102)))/cos((OBS_X-(200+d))/r+atan(θ/102))-r
5-5	OBS_{MSL}-((r+LTP_{elev})*(1/cos(OBS_Y/r)-1)+Q)
5-6	0.10752*OBS_X+678.5
5-7	(OBS_Y-$W_{boundary}$)/4
5-8	0.15152*OBS_X+969.7
5-9	($X_{boundary}$-$W_{boundary}$)/4+(OBS_Y-$X_{boundary}$)/7
5-10	HATh+LTP_{elev}
5-11	r*(π/2-θ*π/180-asin((cos(θ*π/180)*(r+LTP_{elev}+TCH))/(r+DA)))
5-12	$D_{adjusted}$=r*(π/2-atan(θ/102)-asin((cos(atan(θ/102))*((r+LTP_{elev})-(θ*(200+d))/102))/(r+O_{EE})))
	$DA_{adjusted}$=((r+LTPelev+TCH)*cos(θ*π/180))/cos($D_{adjusted}$/r+θ*π/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(acos((SRD^2+(r+LTP_{elev})^2-(r+O_{EE})^2)/(2*SRD*(r+LTP_{elev})))-π/2)
	$\theta_{required}$=102/RS
5-14	(d*θ)/102
5-15	tan(θ*π/180)*(102*p)/θ
5-16	D_{1aEnd}*(3038-C_W)/8401+C_W
5-17	((r+LTP_{elev}-(θ*(200+d))/102)*cos(atan(θ/102)))/cos((X_{DA}-d-1660)/r+atan(θ/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*θ+102)
5-24	tan(θ*π/180)*(X_{DA}+ΔX_{DA})+LTP_{elev}+TCH
5-25	DA-tan(θ*π/180)*1460+276.525
	(r+$elev_{1aEnd}$)*e^(8401/(28.5*r))-r
	$Aircraft_{SOC}$-OCS_{SOC}
Chapter 6	
6-1	(r+(MDA 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*π/180)*68625.4)
6-3a	(3431*tan(15*π/180))/(π*V_{KTAS})
6-4	ϕ*V_{KTW}/3600*TR
6-5	ln((Alt_{fix}+r)/($Aircraft_{SOC}$+r))*r/CG
6-6	(r+$Aircraft_{SOC}$) *e^(CG*Dfix/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.

<u>Notes</u>:

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:

$$a = \text{ semi-major axis} = 6{,}378{,}137.0 \text{ m}$$
$$b = \text{ semi-minor axis} = 6{,}356{,}752.314245 \text{ m}$$
$$1/f = \text{ inverse flattening} = 298.257223563$$

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:

<u>14</u>: Given a geodesic and a locus, find their intersection point.

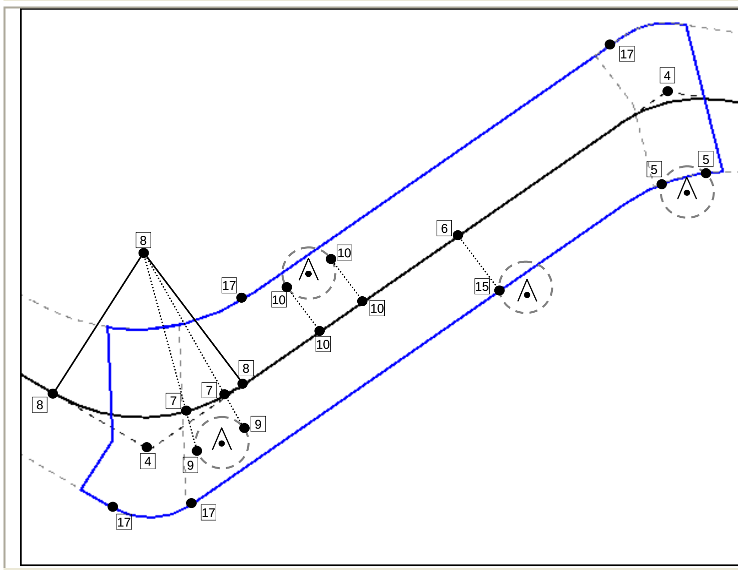
<u>15</u>: Given a fixed-radius arc and a locus, find their intersection point(s). (Labeled “15”)

<u>16</u>: Given two loci, find their intersection.

<u>17</u>: 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.

Figure A2-1. *Typical Geodetic Constructions for TERPS.*



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:

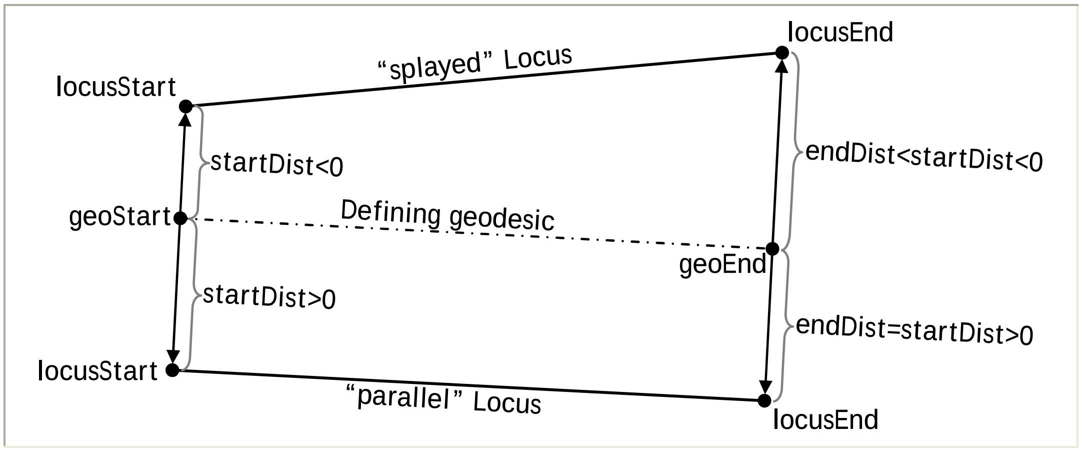
```
typedef struct {
   LLPoint geoStart;   /* start point of geodesic */
   LLPoint geoEnd;     /* end point of geodesic   */
   LLPoint locusStart; /* start point of locus    */
   LLPoint locusEnd;   /* end point of locus      */
   double startDist;   /* distance from geodesic  *
                        * 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`.

Figure A2-2. *Two Examples Loci Defined Relative To A Single Geodesic.*



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.

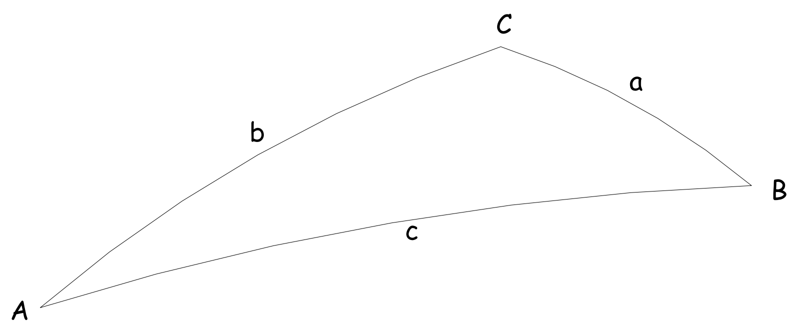
This iteration scheme works well for the algorithms described in this paper. Convergence is achieved very quickly because each starting solution is very close to the final solution, where the error is well approximated by a linear function.

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:

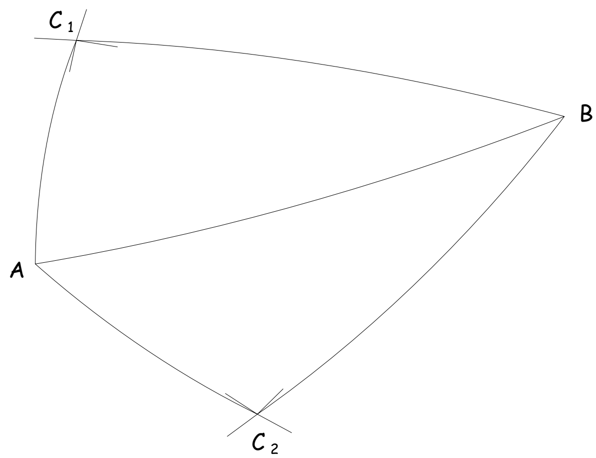
$$C = \cos^{-1}\left(-\cos(A)\cdot\cos(B) + \sin(A)\cdot\sin(B)\cos\left(\frac{c}{R}\right)\right),$$

$$a = R\cdot\cos^{-1}\left(\frac{\cos(A)+\cos(B)\cdot\cos(C)}{\sin(B)\cdot\sin(C)}\right),\ b = R\cdot\cos^{-1}\left(\frac{\cos(B)+\cos(A)\cdot\cos(C)}{\sin(A)\cdot\sin(C)}\right).$$

<u>Note</u>: 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 =BAC_1 = BAC_2, B =ABC_1 = ABC_2, and C = BC_1A = BC_2A:

$$A = \cos^{-1}\left(\frac{\cos\left(\frac{a}{R}\right) - \cos\left(\frac{b}{R}\right)\cos\left(\frac{c}{R}\right)}{\sin\left(\frac{b}{R}\right)\sin\left(\frac{c}{R}\right)}\right),\ B = \cos^{-1}\left(\frac{\cos\left(\frac{b}{R}\right) - \cos\left(\frac{a}{R}\right)\cos\left(\frac{c}{R}\right)}{\sin\left(\frac{a}{R}\right)\sin\left(\frac{c}{R}\right)}\right),$$

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.

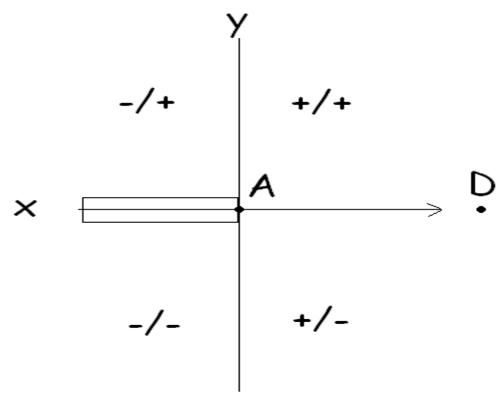
To compute the bearing from A to $C_{1,}$ start with the bearing from A to B and subtract angle A.

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.

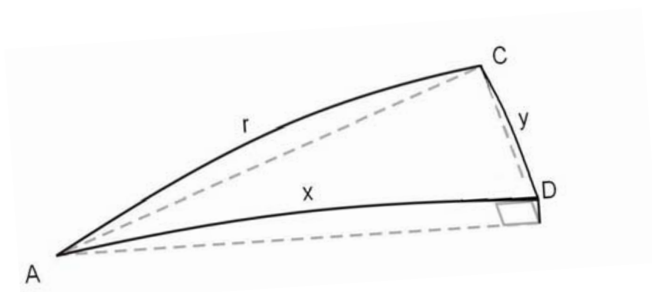
3.2.3 Spherical Tangent Point.

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.

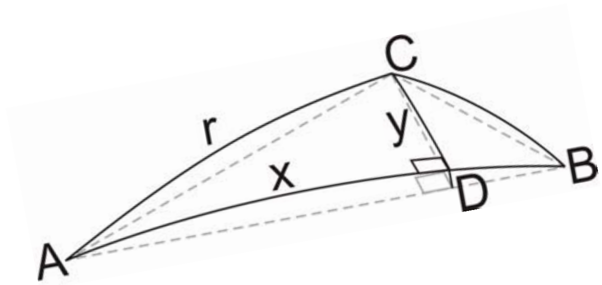
Use right spherical triangles to calculate y and x:

$$y = R\sin^{-1}\left(\sin(\frac{r}{R})\sin(A)\right),$$

$$x = R\cos^{-1}\left(\cos(\frac{r}{R})/\cos(\frac{y}{R})\right).$$

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:

$$y = R\sin^{-1}\left(\sin(\frac{r}{R})\sin(A)\right),$$

$$x = R\cos^{-1}\left(\cos(\frac{r}{R})/\cos(\frac{y}{R})\right).$$

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 $= \dfrac{a-b}{a}$.

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.

$u^2 = \dfrac{a^2 - b^2}{b^2}\cos^2\alpha$.

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.

$$\tan\sigma_1 = \frac{\tan U_1}{\cos\alpha_1} \quad (1)$$

$$\sin\alpha = \cos U_1 \sin\alpha_1 . \quad (2)$$

$$A = 1 + \frac{u^2}{16384}\left\{4096 + u^2\left[-768 + u^2\left(320 - 175u^2\right)\right]\right\} \quad (3)$$

$$B = \frac{u^2}{1024}\left\{256 + u^2\left[-128 + u^2\left(74 - 47u^2\right)\right]\right\} \quad (4)$$

$$2\sigma_m = 2\sigma_1 + \sigma \quad (5)$$

$$\Delta\sigma = B\sin\sigma\left\{\cos(2\sigma_m) + \frac{1}{4}B\left[\cos(\sigma)\left(2\cos^2(2\sigma_m) - 1\right) - \frac{1}{6}B\cos(2\sigma_m)\left(4\sin^2\sigma - 3\right)\left(4\cos^2(2\sigma_m) - 3\right)\right]\right\} \quad (6)$$

$$\sigma = \frac{s}{bA} + \Delta\sigma \quad (7)$$

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).

<u>Note 1</u>: *For 1 cm accuracy, σ can change no more than 1.57e-009.*

$$\tan\phi_2 = \frac{\sin U_1 \cos\sigma + \cos U_1 \sin\sigma\cos\alpha_1}{(1-f)\left[\sin^2\alpha + \left(\sin U_1 \sin\sigma - \cos U_1 \cos\sigma\cos\alpha_1\right)^2\right]^{\frac{1}{2}}} \quad (8)$$

$$\tan\lambda = \frac{\sin\sigma\sin\alpha_1}{\cos U_1 \cos\sigma - \sin U_1 \sin\sigma\cos\alpha_1} \quad (9)$$

$$C = \frac{f}{16}\cos^2\alpha\left[4 + f\left(4 - 3\cos^2\alpha\right)\right] \quad (10)$$

$$L = \lambda - (1-C)f\sin\alpha\left\{\sigma + C\sin\sigma\left[\cos(2\sigma_m) + C\cos\sigma\left(2\cos^2(2\sigma_m) - 1\right)\right]\right\} \quad (11)$$

$$\tan\alpha_2 = \frac{\sin\alpha}{-\sin U_1 \sin\sigma + \cos U_1 \cos\sigma\cos\alpha_1} \quad (12)$$

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.

$$\lambda = L \text{ (first approximation)} \quad (13)$$

$$\sin^2\sigma = \left(\cos U_2 \sin\lambda\right)^2 + \left(\cos U_1 \sin U_2 - \sin U_1 \cos U_2 \cos\lambda\right)^2 \quad (14)$$

$$\cos\sigma = \sin U_1 \sin U_2 + \cos U_1 \cos U_2 \cos\lambda \quad (15)$$

$$\tan\sigma = \frac{\sin\sigma}{\cos\sigma} \quad (16)$$

$$\sin\alpha = \frac{\cos U_1 \cos U_2 \sin\lambda}{\sin\sigma} \quad (17)$$

$$\cos(2\sigma_m) = \cos\sigma - \frac{2\sin U_1 \sin U_2}{\cos^2\alpha} \quad (18)$$

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 (±π/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`.

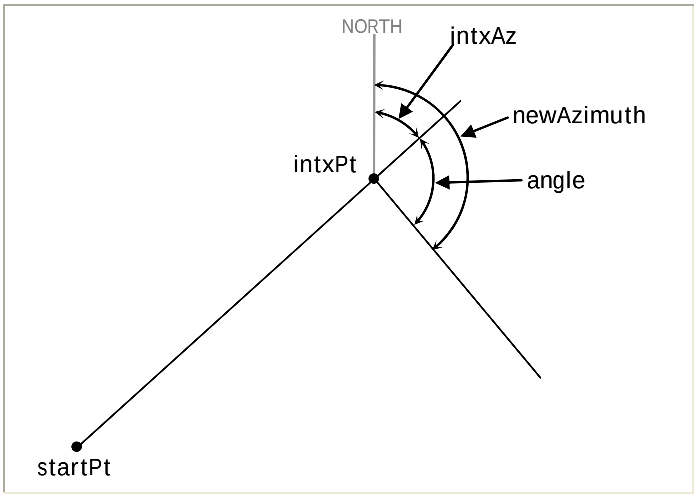
STEP 2: Convert the `intxAz` to its reciprocal: `intxAz = intxAx + π`.

STEP 3: Add the desired change in azimuth to get the azimuth of the new geodesic:
`newAzimuth = intxAz + 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.

Figure A2-3. *Projecting A Geodesic Through A Point Along The Specified Azimuth.*



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:

`LLPoint startPt`	=	Geodetic coordinate of line start point
`LLPoint endPt`	=	Geodetic coordinate of line end point
`LLPoint testPt`	=	Geodetic coordinate of point to test
`int lengthCode`	=	Integer that specifies extent of line. 0: geodesic exists only between `startPt` and `endPt`. 1: geodesic extends beyond `endPt`.

`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 `(error ≤ tol)` then `onLine = true`.

iv. Else `onLine = false`.

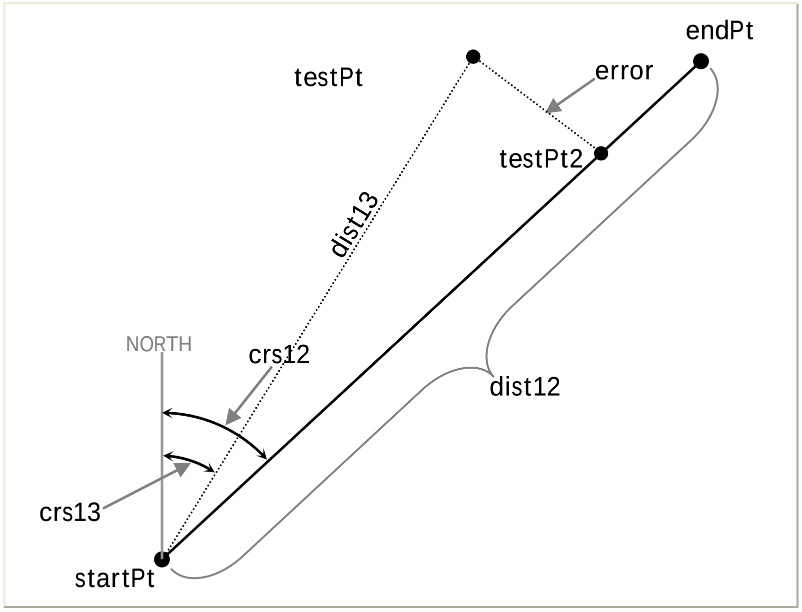
v. End if.

c. Else.

i. `onLine = false`.

d. End if.

Figure A2-4. *Entities For Testing Whether a Point Lies on a Geodesic.*



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:

`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]
`LLPoint testPt`	=	Geodetic coordinate of point to test
`double tol`	=	Maximum error allowed in solution
`double eps`	=	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 `(abs(dist-radius) > 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`.

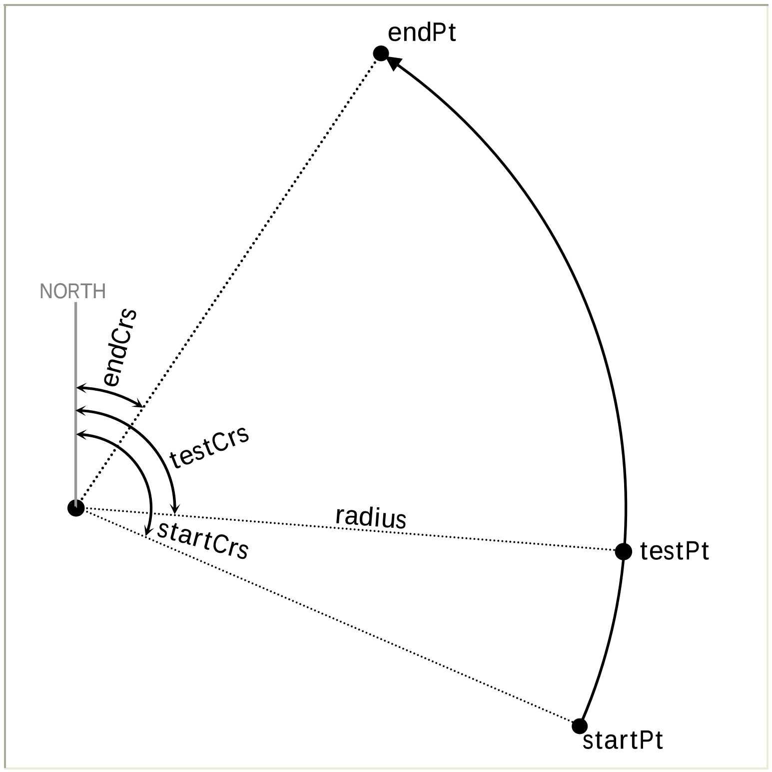
   iii. If `(subExtent ≤ arcExtent)` then traversing arc from `startCrs` to `endCrs`, one would encounter `testPt`, so it must lie on arc.

      1. `onArc = true`.

d. end if.

STEP 4: end if.

Figure A2-5. *Entities for Testing Whether a Point Lies on an Arc.*



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, `v0`, 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`) and (`k` ≤ `maximumIterationCount`)).

a. Calculate subtended angle of each sub-arc, `theta = 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 = startCrs + i*dtheta.`

   ii. Use *direct algorithm* from `center`, using azimuth `theta+0.5*dtheta` 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+dtheta` 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 = |chord1|`.

   vii. Subtract `v2` from `v3` to find chord vector between `p3` and `p2`. Denote this vector by `chord2`. Compute `x2 = |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*)

$$\xi = \frac{d}{x_1 x_2}$$
$$\sigma = \sqrt{1-\xi^2}$$
$$R = \frac{x_2\sqrt{\left(x_1/x_2-\xi\right)^2+\sigma^2}}{2\sigma}$$
$$A = 2\left(\pi - \cos^{-1}\xi\right)$$
$$L = R \cdot A$$

Note that since the arc length is a planar (not geodetic) calculation, the subtended angle A is not equal to `dtheta`.

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`.

<u>STEP 6</u>: End while loop.

<u>STEP 7</u>: Return `arcLength`.

Figure A2-6. *Calculating Arc Length.*

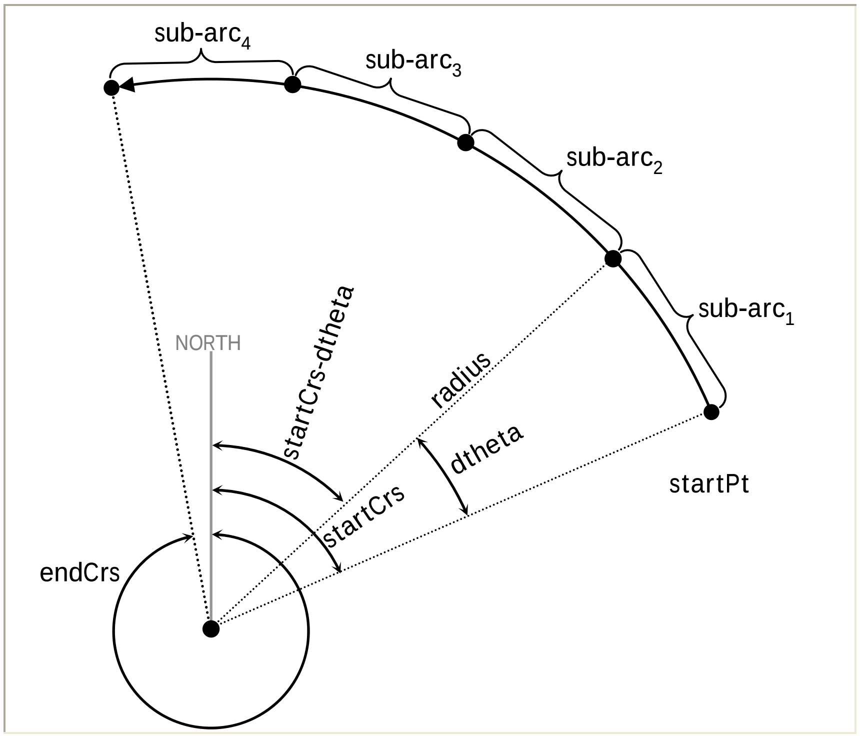
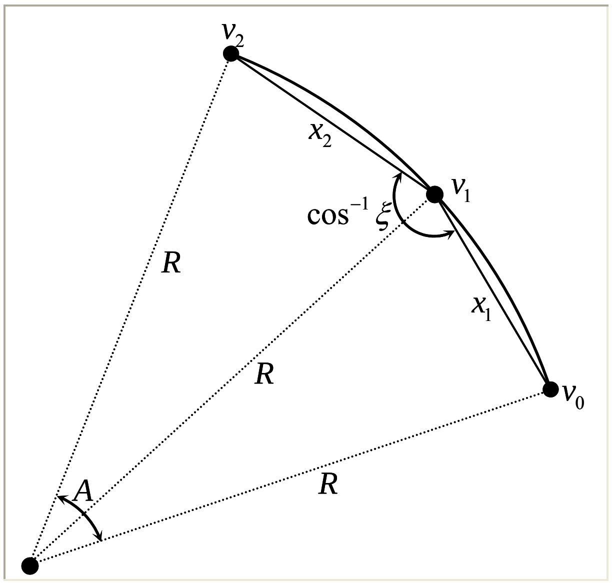


Figure A2-7. *Calculating the Sub-Arc Length.*



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:

`Locus loc`	=	Locus of interest
`double distance`	=	Distance from locus start point to point where distance is to be computed
`double eps`	=	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:

`Locus loc`	=	Locus of interest
`LLPoint geoPt`	=	Point on defining geodesic
`double tol`	=	Maximum allowable error
`double eps`	=	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: $\text{distToLoc=loc.startDist+}\frac{\text{distance}}{\text{geoLen}}*\left(\text{loc.endDist-loc.startDist}\right)$

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:

`Locus loc`	=	Locus of Interest
`LLPoint geoPt`	=	Point on defining geodesic
`double tol`	=	Maximum allowable error
`double eps`	=	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`.

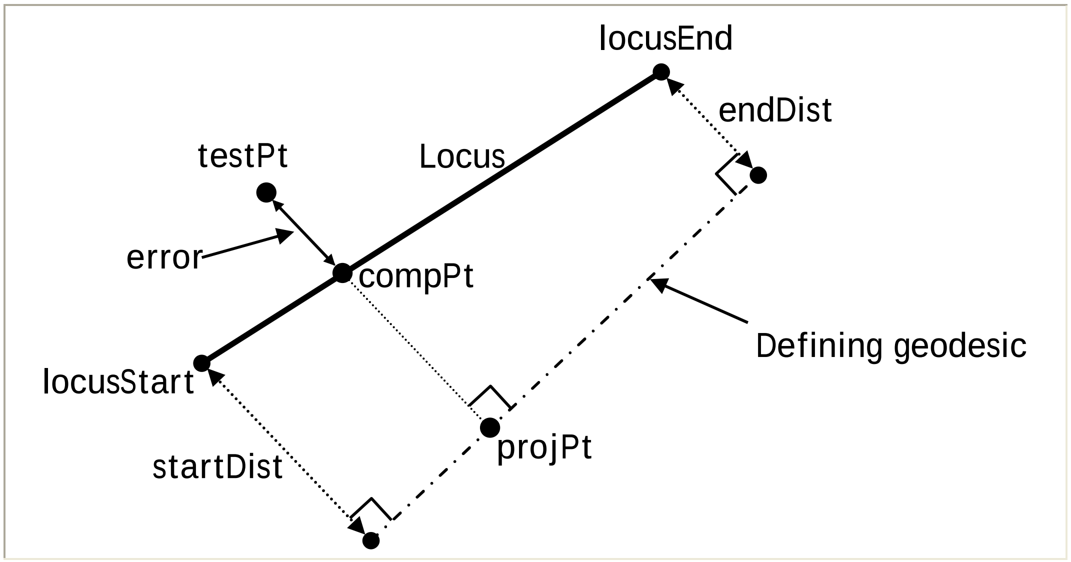
STEP 3: Use *Algorithm 3.6* to determine whether `projPt` lies on the locus's defining geodesic. If it does not, then return 0 (false).

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`.

Figure A2-8. *Locating a Point Relative to a Locus.*



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:

`Locus loc`	=	Locus of Interest
`LLPoint testPt`	=	Point at which course will be calculated
`LLPoint* geoPt`	=	Projection of `testPt` on defining geodesic
`double* perpCrs`	=	Course for `testPt` to `geoPt`
`double tol`	=	Maximum allowable error
`double eps`	=	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:

$$\text{slope} = \left(\text{loc.endDist-loc.startDist}\right) / \text{geoLen}$$

STEP 6: Convert the slope to angular measure in radians:

$$\texttt{slope} = \text{atan}\left(\texttt{slope}\right)$$

STEP 7: Adjust the value of the perpendicular course by `slope`. This accounts for how the locus is approaching or receding from the geodesic:

$$\text{perpCrs} = \text{perpCrs} + \text{slope}$$

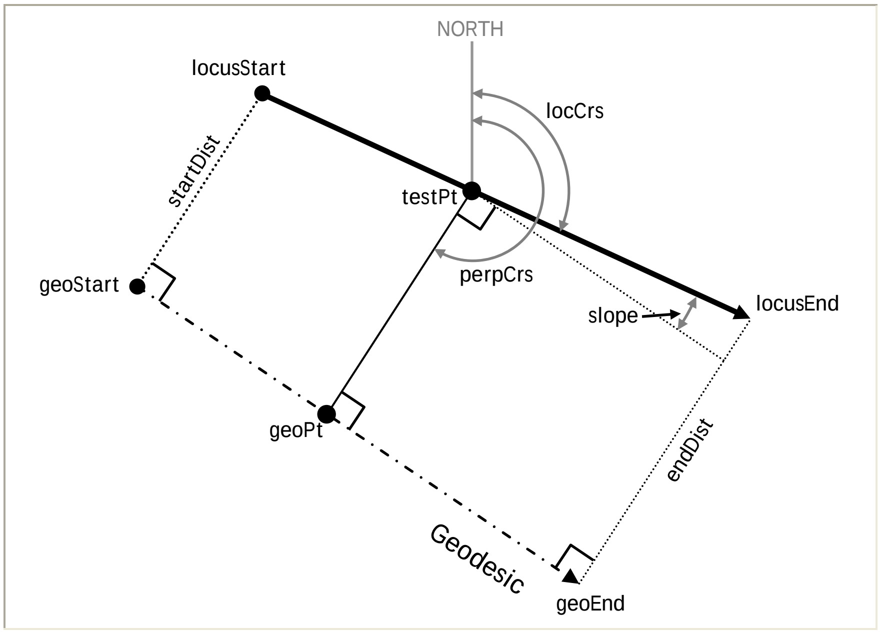
STEP 8: If (`distToLoc < 0`), then `testPt` lies to the left of the geodesic, so `perpCrs` points to the right of the locus's course:

$$\texttt{locCrs} = \texttt{perpCrs} - \pi/2$$

STEP 9: Else, `testPt` lies to the right of the geodesic so `perpCrs` points to the left of the locus's course: $\texttt{locCrs} = \texttt{perpCrs} + \pi/2$

STEP 10: Return `locCrs`

Figure A2-9. *Angle Used to Calculate the Course of a Locus.*



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:

`LLPoint point1`	=	Start point of first geodesic
`double az13`	=	Azimuth of first geodesic at `point1`
`double* az31`	=	Reference to reverse azimuth of first geodesic at `point3` (this is calculated and returned)
`double* dist13`	=	Reference to distance between `point1` and `point3` (calculated and returned)
`LLPoint point2`	=	Start point of second geodesic
`double az23`	=	Azimuth of second geodesic at `point2`
`double* az32`	=	Reference to reverse azimuth of second geodesic at `point3` (this is calculated and returned)
`double* dist23`	=	Reference to distance between `point2` and `point3` (calculated and returned)
`double tol`	=	Maximum error allowed in solution
`double eps`	=	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 `crs12` and `crs13`, denoted by `angle1`.

STEP 3: Calculate the difference in angle between `crs21` and `crs23`, denoted by `angle2`.

STEP 4: If (sin(`angle1`)*sin(`angle2`) < 0) then the courses lay on opposite sides of the `point1-point2` line and cannot intersect in this hemisphere.

a. Return no intersection.

STEP 5: Else if (`angle2 < tol`) or (`angle2 < tol`) then the two geodesics are identical and there is no single unique intersection (there are infinite intersections).

a. Return no intersection.

STEP 6: End if.

STEP 7: Locate the approximate intersection point, `point3`, 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 `dist13`, the distance from `point1` to `point3`.

STEP 9: Use the *inverse algorithm* to calculate `dist23`, the distance from `point2` to `point3`.

STEP 10: If `dist13 < tol`, then the intersection point is very close to `point1`. Calculation errors may lead to treating the point as if it were beyond the end of the geodesic. Therefore, it is helpful to move `point1` a small distance along the geodesic.

a. Use the *direct algorithm* to move point1 from its original coordinates, 1 ***NM*** along azimuth `crs13`+π.

b. Use the *inverse algorithm* to calculate the azimuth `crs13` for the geodesic from the new `point1`.

STEP 11: Repeat steps 10, 10(a), and 10(b) for `point2` and `crs23`.

STEP 12: If (`dist23 < dist13`) then the intersection point is closer to `point2` than `point1`. In this case, the iterative scheme will be more accurate if we swap `point1` and `point2`. 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`.

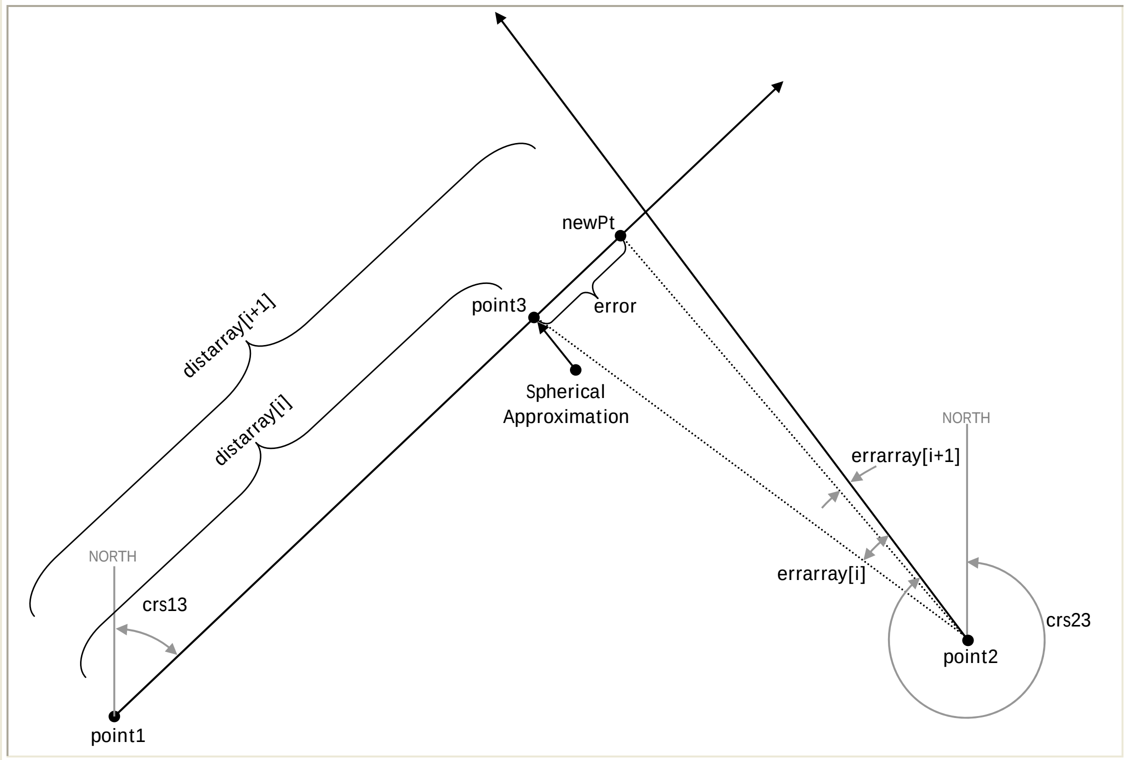
STEP 24: End while loop.

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`.

Figure A2-10. *Finding the Intersection of Two Geodesics.*



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 (`radius1 + radius2 –dist12 + tol < 0`) or (abs(`radius1-radius2) > 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 (abs`(radius1+radius2-dist12) ≤ 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.

<u>STEP 4</u>: End if

<u>STEP 5</u>: Calculate approximate intersection points, `point1` and `point2`, according to *section 3.2*.

<u>STEP 6</u>: 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` ≤ `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.

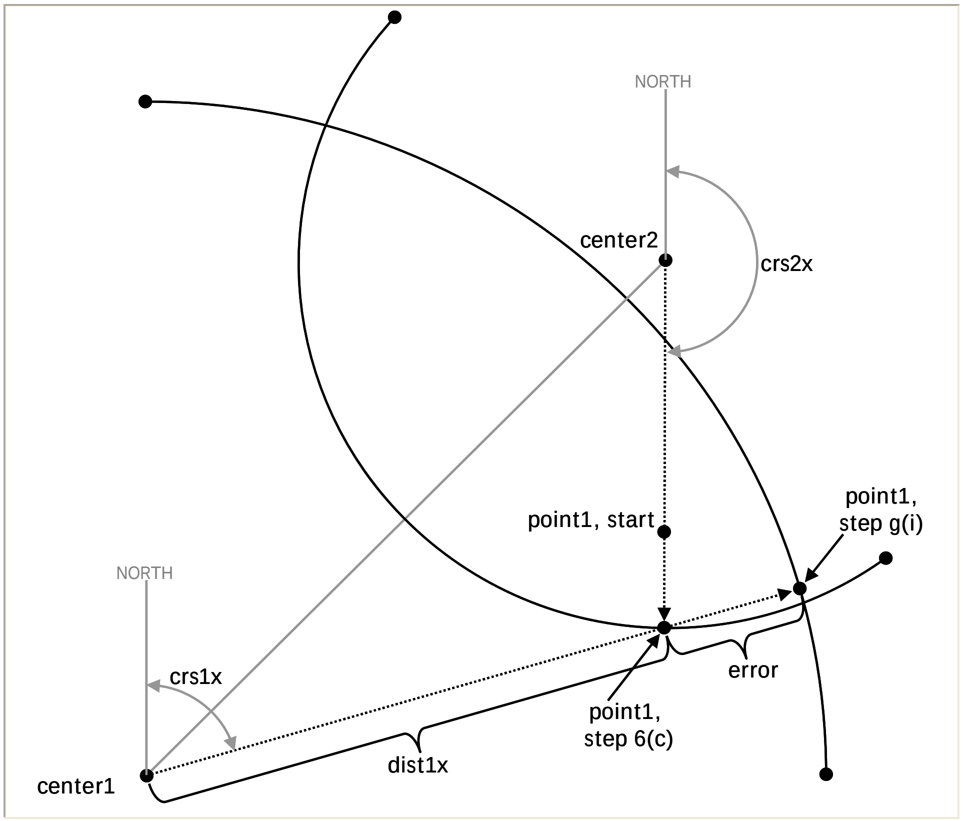
<u>STEP 7</u>: Store `point1` in array to be returned: `intx[0] = point1`.

<u>STEP 8</u>: Repeat step 6 for approximation `point2`.

<u>STEP 9</u>: Store `point2` in array to be returned: `intx[1] = point2`.

<u>STEP 10</u>: Return array `intx`.

Figure A2-11. *Intersection of Two Arcs.*



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:

`LLPoint pt1`	=	Geodetic coordinates of start point of geodesic
`doulbe crs1`	=	Initial azimuth of geodesic at start point
`LLPoint center`	=	Geodetic coordinates of arc center point
`double radius`	=	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:

`dist = SPHERE_RADIUS*`acos(cos(`radius/SPHERE_RADIUS)/`
cos(`perpDist/SPHERE_RADIUS`))

where SPHERE_RADIUS is the radius of the spherical earth approximation. Note that a test must be performed so that if cos(perpDist/SPHERE_RADIUS) = 0, then no solution is returned

STEP 8: Find ellipsoidal approximation intx[0] to first intersection by starting at perpPt and using direct algorithm with distance dist and azimuth crs. This will place intx[0] on the geodesic.

STEP 9: Initialize iteration count k = 0.

STEP 10: Use *inverse algorithm* to calculate the distance from center to intx[0]. Denote this value by radDist. In the same calculation, calculate azimuth from intx[0] to center. Denote this value by rcrs; it will be used to improve the solution.

STEP 11: Calculate error for this iteration: error = radius – radDist

STEP 12: Initialize arrays that will hold distance and error function values so that linear interpolation may be used to improve approximation:

```
distarray[0] = dist
errarray[0] = 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 intx[0] to perpPt. Denote this value by bcrs.

b. Compute the angle between the arc's radial line and the geodesic at intx[0]. This is depicted by B in A2-13:

$$B = \text{abs}\left(\text{signedAzimuthDifference}\left(\texttt{bcrs},\texttt{rcrs}\right)+\pi-\theta\right)$$

See *Algorithm 6.1* for an explanation of "signedAzimuthDifference."

c. Calculate the angle opposite the radial error:

$$A = \text{acos}\left(\sin\left(B\right)\cos\left(\frac{\text{abs}\left(\texttt{error}\right)}{\texttt{SPHERE\_RADIUS}}\right)\right)$$

d. If (abs(sin(A)) < tol) then the triangle is nearly isosceles, so use simple formula for correction term c: c = error

e. Else, if (abs(A) < tol) then the error is very small, so use flat approximation: c = error/cos(B)

f. Else, use a spherical triangle approximation for c:

$$c = SPHERE\_RADIUS * asin\left(\frac{\sin(error/SPHERE\_RADIUS)}{\sin(A)}\right)$$

g. End if

h. If (error > 0), then intx[0] is inside the circle, so approximation must be moved away from perpPt: dist = dist + c

i. Else dist = dist - c

j. End if

k. Use the *direct algorithm* to move 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 intx[0]. Denote this value again radDist.

m. Initialize second value of distarray and errarray:
```
distarray[1] = dist
errarray[1] = radius-radDist
```

STEP 14: Do while (abs(error) > tol) and (k < 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 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 intx[0]. Denote this value radDist.

d. Update distarray and errarray with the new values:
```
distarray[0] = distarray[1]
errarray[0] = errarray[1]
distarray[1] = dist
errarray[1] = radius-radDist
```

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]`

Figure A2-12. *Locating First Intersection of Geodesic and Arc.*

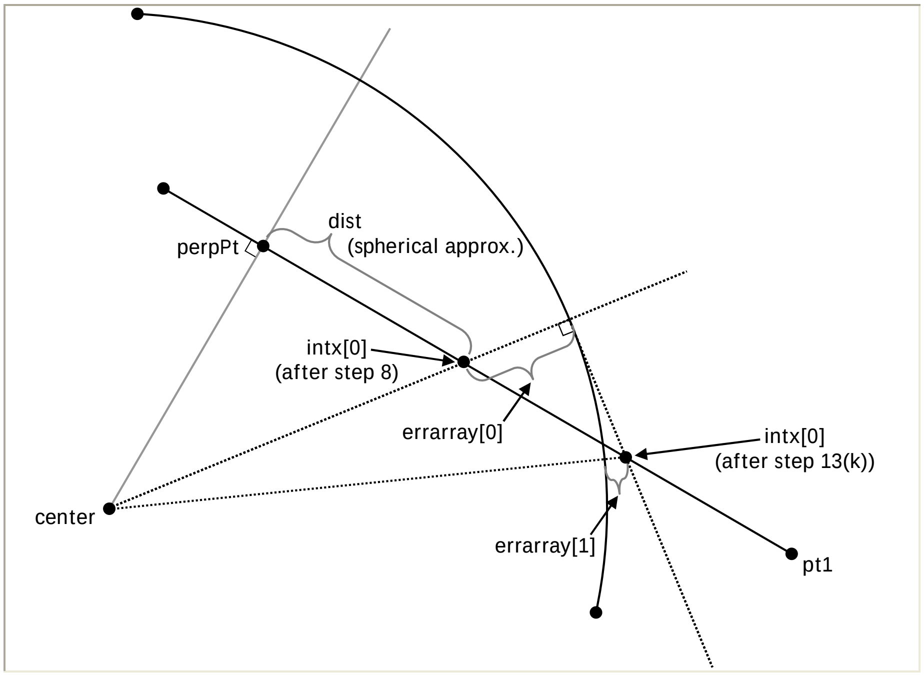
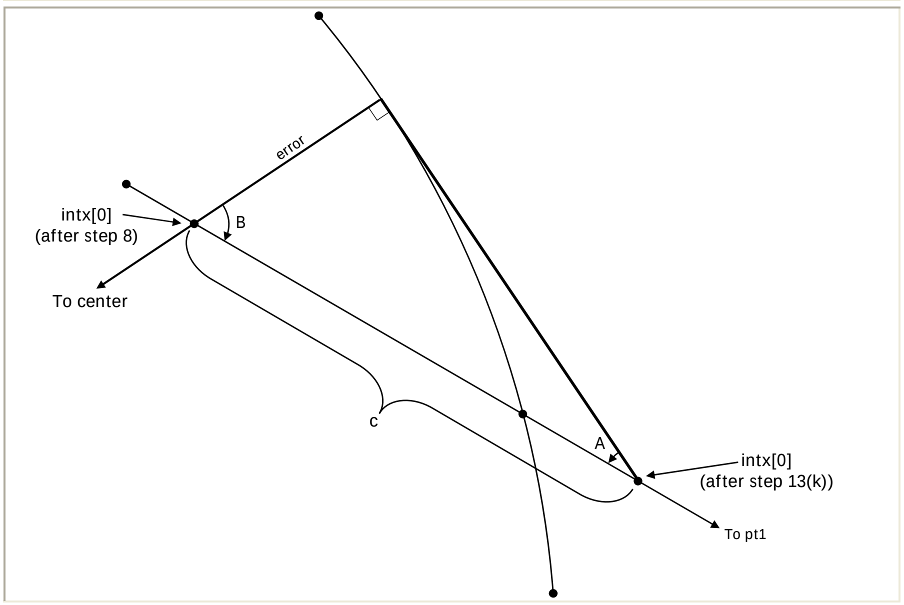


Figure A2-13. *Area Near the Appropriate Geodesic-Arc Intersection Point With Spherical Triangle Components That Are Used to Improve the Solution.*



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`:

$$\texttt{vertexAngle} = \text{signedAzimuthDifference}(\texttt{crs21},\texttt{crs23})$$

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. $\text{A} = \text{vertexAngle}/2$

b. If $(\texttt{radius} > \texttt{SPHERE\_RADIUS} * \texttt{A})$ then no arc of the required radius will fit between the given geodesics

i. Return empty array

c. End if

d. $$\text{DTA} = \text{SPHERE\_RADIUS} \times \text{asin}\left(\frac{\tan\left(\text{radius}/\text{SPHERE\_RADIUS}\right)}{\tan(\text{A})}\right)$$

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`

<u>STEP 15</u>: 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`):

$$\mathtt{distToStart} = \mathtt{distToStart} - \frac{\mathtt{error}}{\sin(\mathtt{vertexAngle})}$$

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:

$$\mathtt{perpCrs} = \mathtt{perpCrs} + \frac{\pi}{2}$$

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:

$$\mathtt{perpCrs} = \mathtt{perpCrs} - \frac{\pi}{2}$$

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`.

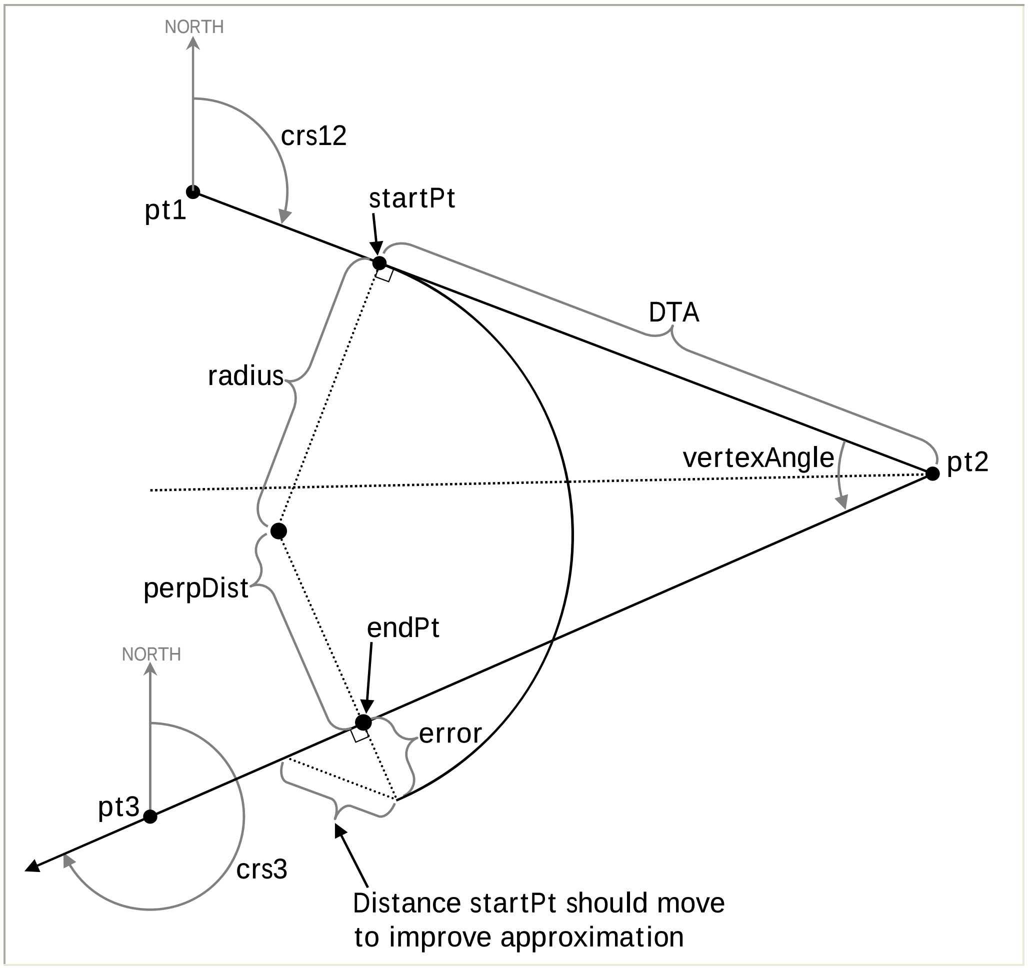
STEP 16: End while.

STEP 17: Assign the calculated points to output array

```
intx[0] = centerPt
intx[1] = startPt
intx[2] = endPt
```

STEP 18: Return `intx`.

Figure A2-14. *Finding Arc Center and Points at Which Arc is Tangent to Two Geodesics.*



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:

`LLPoint gStart`	=	Geodetic coordinates of start point of geodesic
`LLPoint gEnd`	=	Geodetic coordinates of end point of geodesic
`Locus loc`	=	Structure defining locus of points
`double tol`	=	Maximum error allowed in solution
`double eps`	=	Convergence parameter for forward/inverse algorithms

4.5.2 Algorithm Steps.

See *figure A2-15* for an illustration of the variable names.

<u>STEP 1</u>: 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.

<u>STEP 2</u>: If `pt1` is not found, then the locus and geodesic to not intersect.

a. Return empty point.

<u>STEP 3</u>: End if

<u>STEP 4</u>: 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`:

$$\texttt{theta} = \text{abs}\left(\text{signedAzimuthDifference}\left(\texttt{crsFromPt},\texttt{crsBase}\right)\right)$$

b. Calculate a new value for `distBase`:

$$\texttt{distBase} = \texttt{distBase} - \frac{\texttt{errarray[1]}}{\cos(\texttt{theta})}$$

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`.

Figure A2-15. *Intersection of Geodesic with Locus of Points.*

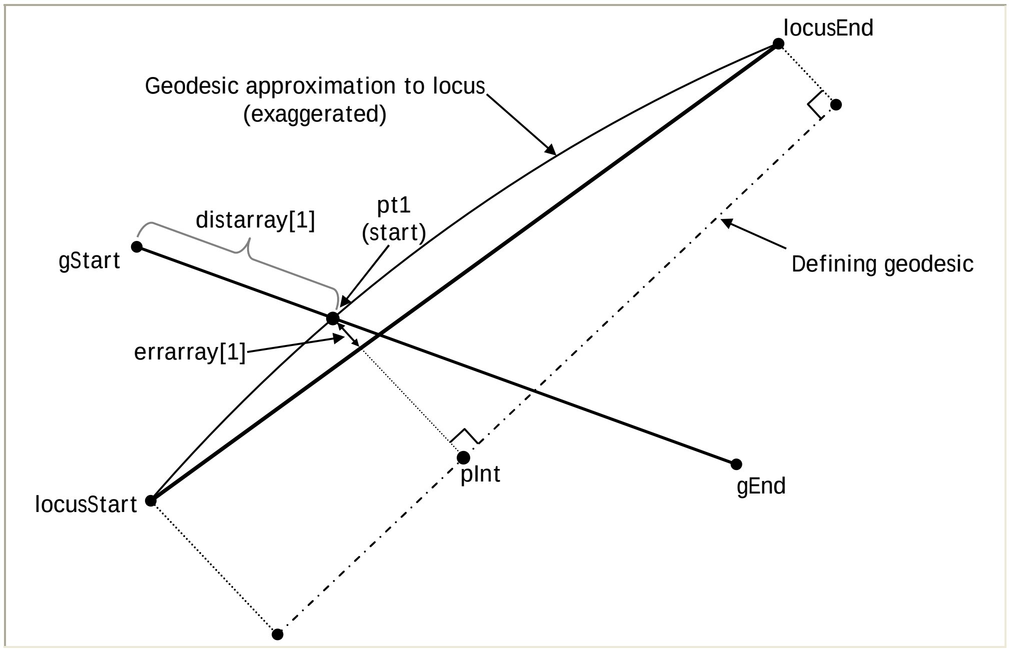
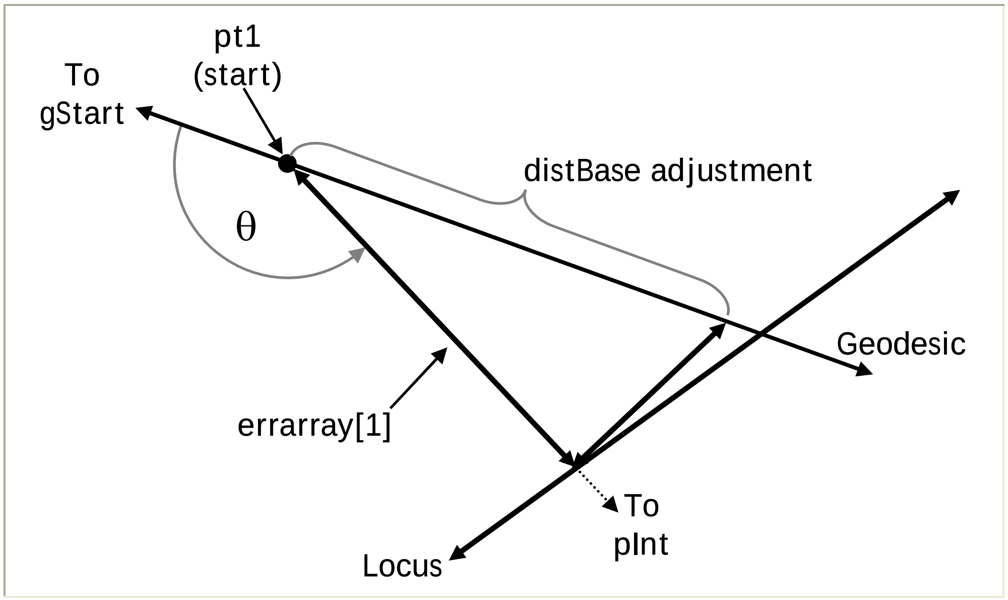


Figure A2-16. *Computing First Update to Locus-Geodesic Intersection.*



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:

`Locus loc`	=	Locus of interest
`LLPoint center`	=	Geodetic coordinates of arc
`double radius`	=	Arc radius
`int* n`	=	Number of intersections found
`double tol`	=	Maximum error allowed in solution
`double eps`	=	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

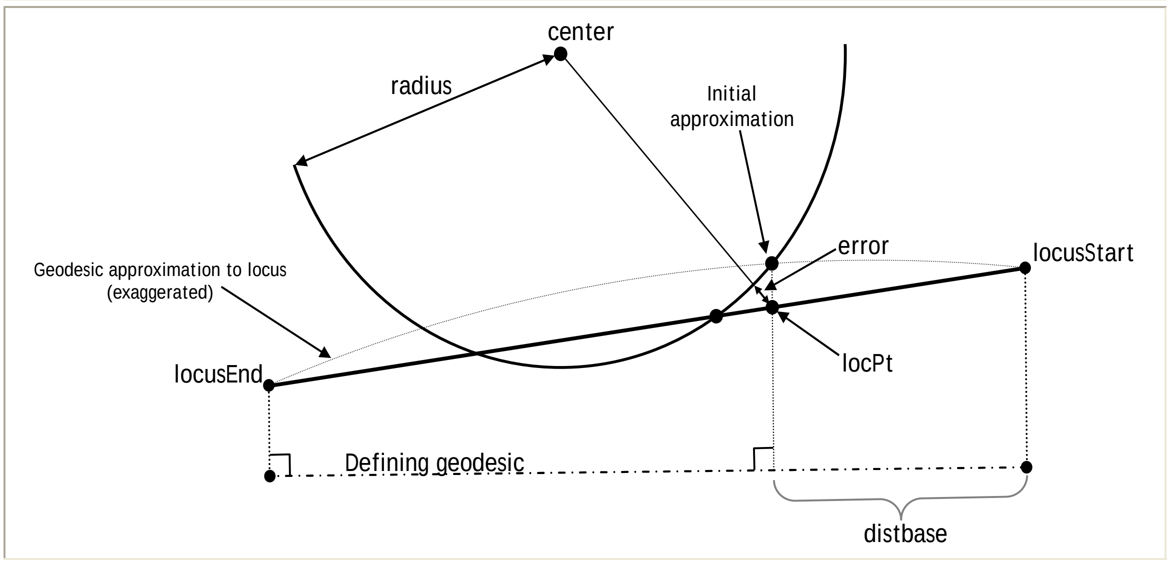
i. copy `locPt` to the output array: `intx[n] = locPt`.

ii. Update the count of intersection points found: `n = n + 1`.

STEP 7: End for loop

STEP 8: Return `intx`

Figure A2-17. *Finding the Intersection of an Arc and a Locus.*



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`

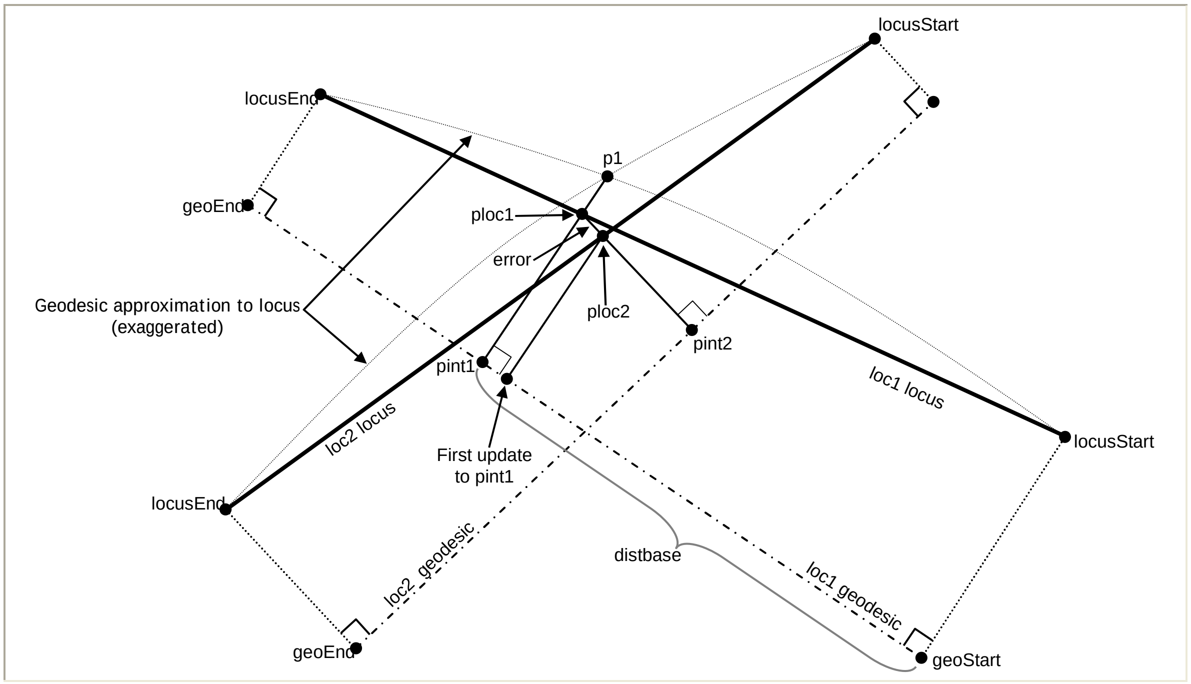
STEP 11: End while

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`.

Figure A2-18. *Computing the Intersection of Two Loci.*



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`:

$$\mathtt{angle} = \text{abs}\left(\text{signedAzimuthDifference}\left(\mathtt{rcrs1},\mathtt{rcrs2}\right)\right)$$

d. $$\mathtt{vertexAngle} = 2 * \text{acos}\left(\sin\left(\frac{\mathtt{angle}}{2}\right)\cos\left(\frac{\mathtt{radius}}{\mathtt{SPHERE\_RADIUS}}\right)\right)$$

STEP 7: Calculate the inclination angle of loc1 relative to its geodesic:

$$\mathtt{locAngle} = \text{atan}\left[\left(\mathtt{loc1.endDist} - \mathtt{loc1.startDist}\right) / \mathtt{geoLen1}\right]$$

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:

$$\mathtt{distbase} = \mathtt{distbase} + \mathtt{error} * \frac{\cos(\mathtt{locAngle})}{\sin(\mathtt{vertexAngle})}$$

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

<u>STEP 12</u>: End while

<u>STEP 13</u>: Return `intx`.

Figure A2-19. *Arc Tangent to Two Loci.*

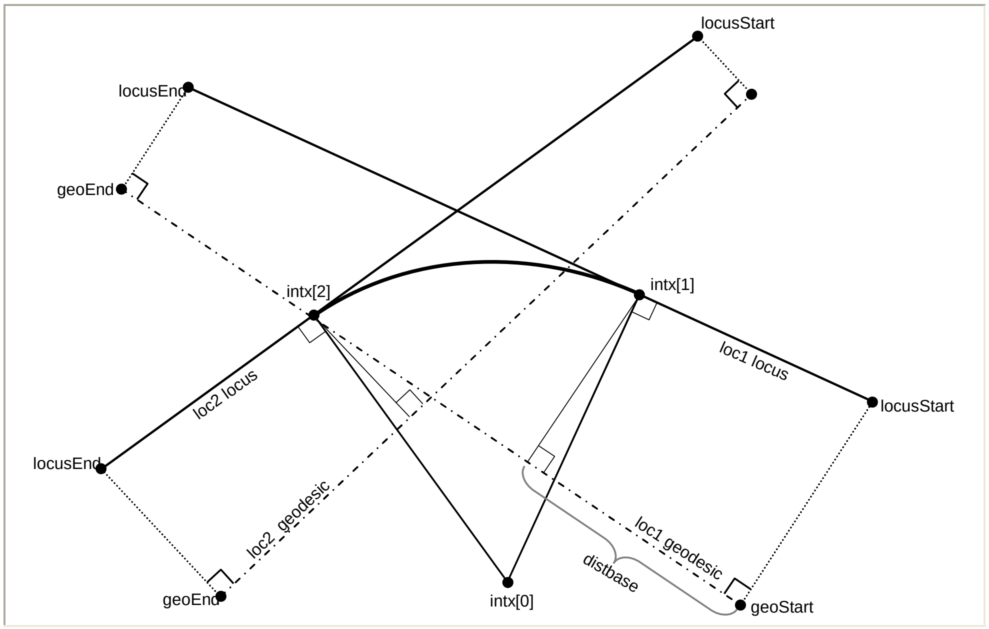
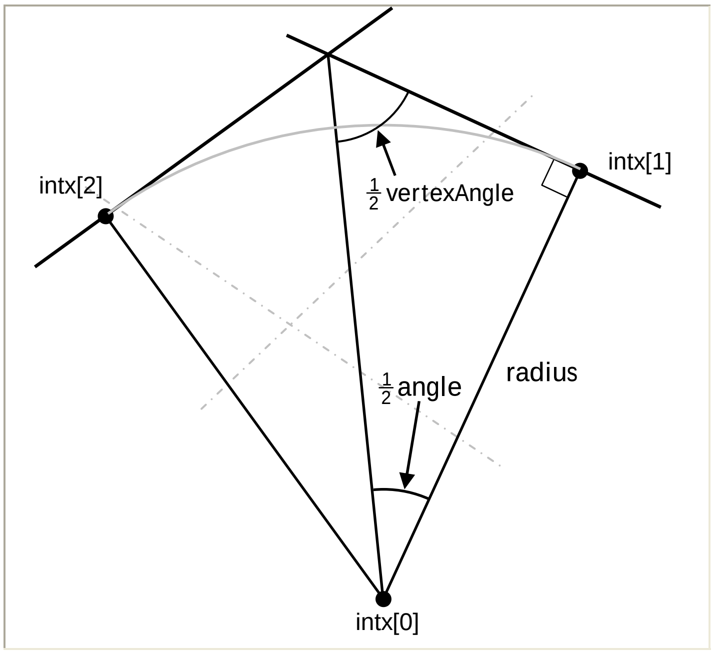


Figure A2-20. *Spherical Triangle Construction Used for Calculating the Approximate Vertex Angle at the Intersection of Two Loci.*



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:

`LLPoint pt1`	=	Coordinates of geodesic start point
`double crs13`	=	Initial azimuth of geodesic at start point
`LLPoint pt2`	=	Coordinates of point to be projected to geodesic
`double* crsFrom Point`	=	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

5.1.2 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*)

$$\texttt{angle} = \text{abs}\left(\text{signedAzimuthDifference}\left(\texttt{crs13}, \texttt{crs12}\right)\right).$$

STEP 3: If (`dist12 <= 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. $\texttt{a} = \texttt{dist12} / \texttt{SPHERE\_RADIUS}$

b. $\texttt{dist13} = \texttt{SPHERE\_RADIUS} \cdot \text{atan}\left[\left(\tan \texttt{a}\right) \cdot \text{abs}\left(\cos\left(\texttt{angle}\right)\right)\right].$

(Note, the abs() function handles the case when $\texttt{angle} > \pi/2$, and should be faster than checking the sign of `angle` using a conditional.)

STEP 5: If $\texttt{angle} > \pi/2$, 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`.

a. 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 $\texttt{crs13} + \pi$ 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` to `dist13`+1.0 nautical miles behind `pt1`, the new approximation to `dist13` is simply 1.0 nautical miles, so set `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 `pt1` = `newPt1`.

STEP 6: Else, if 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.

a. 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 $\texttt{crs13} + \pi$ 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 `dist13` = `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 `pt1` = `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): $\texttt{angle} = \text{abs}\left(\text{signedAzimuthDifference}\left(\texttt{crs31}, \texttt{crs32}\right)\right)$

STEP 12: Calculate the error and store it as the first element in the error function array: `errarray[0] = angle - π`

STEP 13: Store the current distance from `pt1` to `pt3` in the distance function array: `distarray[0] = 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:

$$\texttt{distarray}[1] = \texttt{distarray}[0] + \texttt{errarray[0]} \cdot \texttt{dist23}$$

STEP 15: Use direct algorithm to project point on the given geodesic distance `distarray[1]` from `pt1`. Use `pt1` for the starting point, `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):

$$\texttt{errarray[1]} = \text{abs}\left(\text{signedAzimuthDifference}\left(\texttt{crs31},\texttt{crs32}\right)\right) - \pi/2$$

STEP 19: Initialize the iteration count: `k = 0`

STEP 20: Do while (`k = 0`) or ((`error > tol`) and (`k < 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:

```
distarray[0] = distarray[1]
errarray[0] = errarray[1]
distarray[1] = dist13
```

$$\texttt{errarray[1]} = \text{abs}\left(\text{signedAzimuthDifference}\left(\texttt{crs31},\texttt{crs32}\right)\right) - \pi/2$$

(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:

$$\texttt{error} = \text{abs}\left(\texttt{distarray[1]-distrray[0]}\right)$$

STEP 21: End while

STEP 22: Set `crsToPoint = crs32`

STEP 23: Set `distToPoint = dist23`

STEP 24: Return `pt3`

Figure A2-21. *Projecting a Point to a Geodesic.*

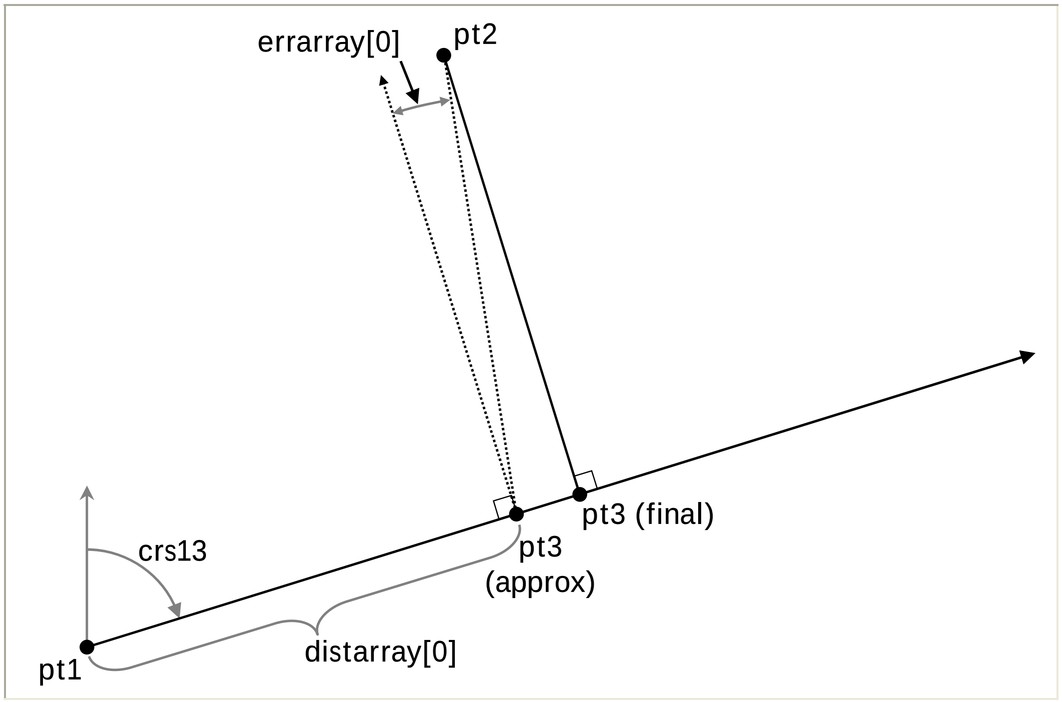
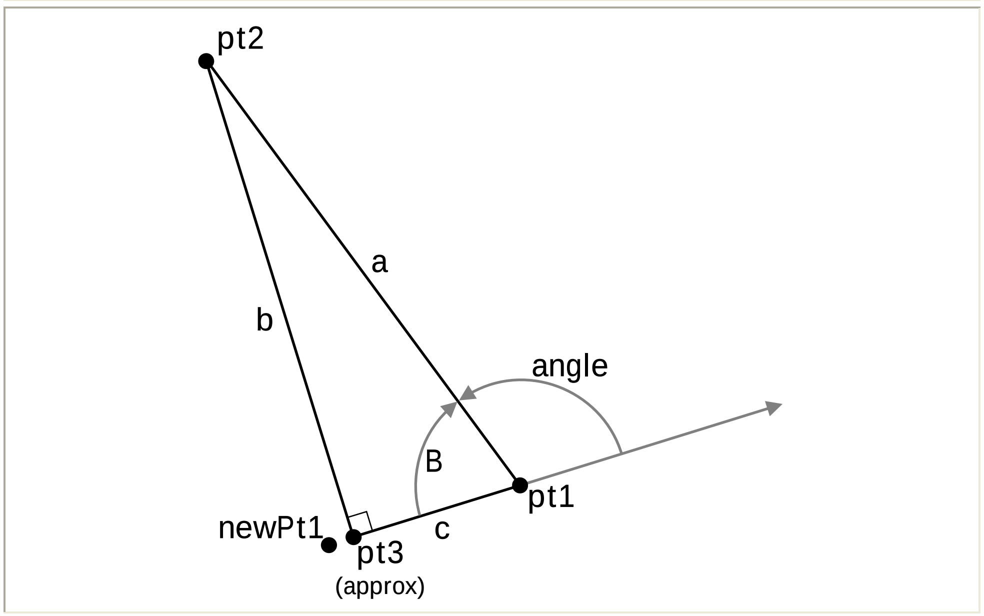


Figure A2-22. *Elements of Spherical Triangle Used to Determine New Geodesic Starting Point When Projected Point Lies Behind Given Starting Point.*



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 (abs(`loc.startDist-loc.endDist) < 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:

$$\texttt{locAngle} = \operatorname{atan}\left(\frac{\texttt{loc.startDist} - \texttt{loc.endDist}}{\texttt{gdist}}\right)$$

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`:

$$\texttt{angle} = \operatorname{abs}\left(\text{signedAzimuthDifference}\left(\texttt{lcrs}, \texttt{crsToPoint}\right)\right)$$

e. Store the approximate error as $errarray[1] = -distToPoint * \cos(angle)$ This converts the error in angle into an error in distance which can be compared to `tol`.

f. If (abs(errarray[1]) < tol), then the approximation is close enough, so return `locPt`.

g. If (`k = 0`) then a direct calculation is used to improve the approximation: $newDist = distarray[1] + errarray[1] * \cos(locAngle)$

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`.

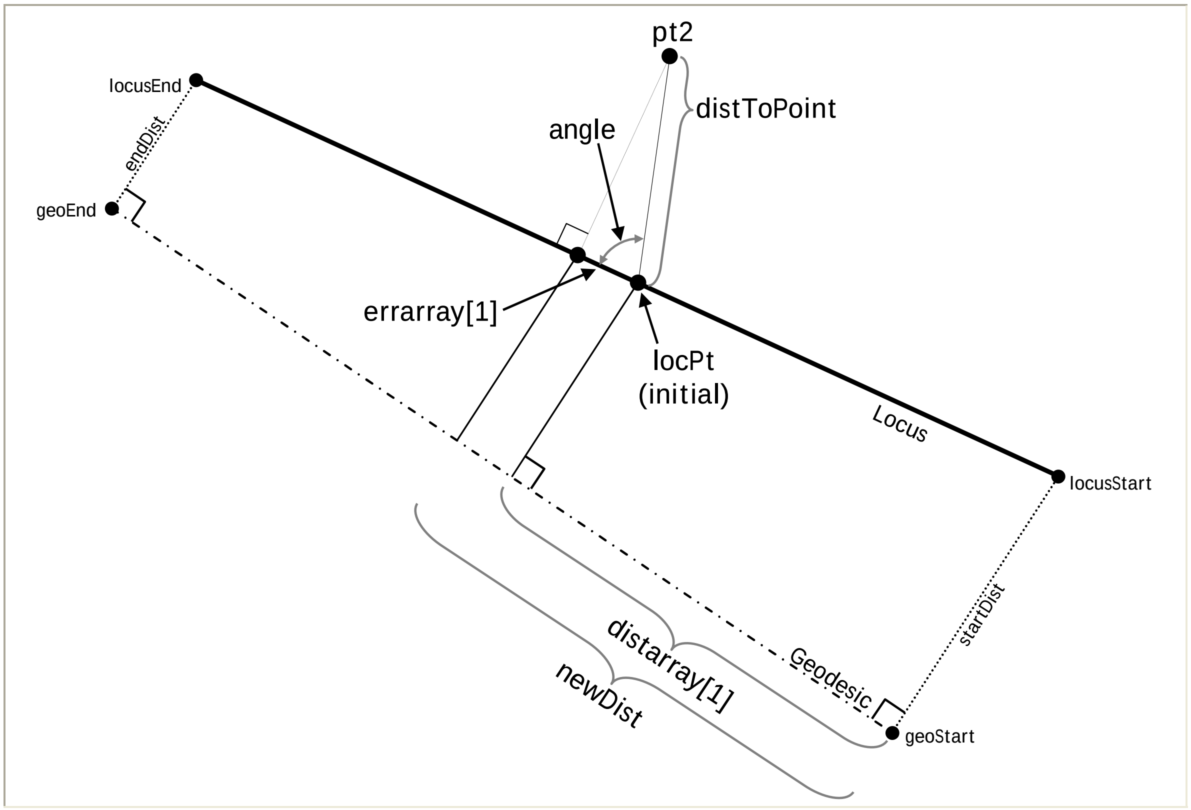
i. End If

j. Update the distance and error arrays:
```
distarray[0] = distarray[1]
errarray[0] = errarray[1]
distarray[1] = newDist
```

<u>STEP 11</u>: End while

<u>STEP 12</u>: Return `locPt`

Figure A2-23. *Projecting a Point to a Locus.*



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 abs(`distToCenter - radius) < tol`, then point lies on the arc and is a tangent point.

a. Set `n` = 1

b. Return `tanPt = point`

STEP 3: Else, if `distToCenter < 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. $C = \operatorname{acos}\left(\tan(b)/\tan(a)\right)$.

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 (abs(`error) > 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 $(-\pi, \pi]$:

$$\texttt{diff} = \text{signedAzimuthDifference}(\texttt{radCrs},\texttt{tanCrs})$$

e. Compute the error: $\texttt{error} = \text{abs}(\texttt{diff}) - \frac{\pi}{2}$

f. Adjust the value of `C` to improve the approximation: `C = C + error`

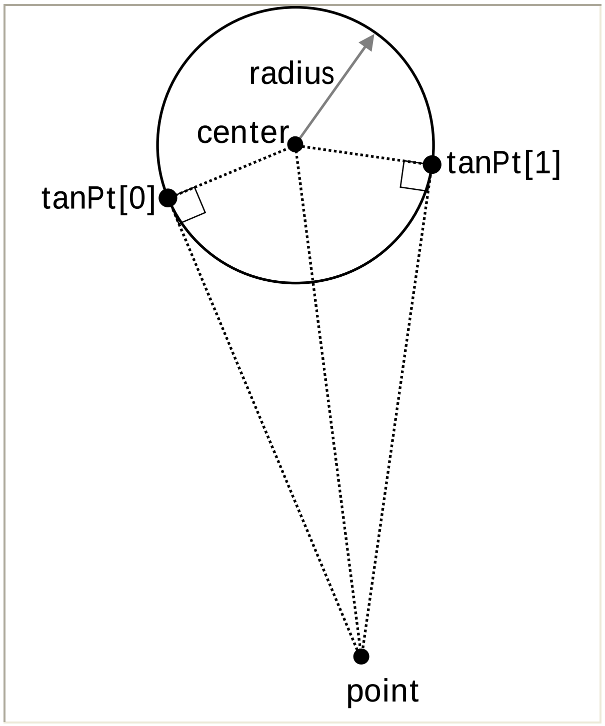
g. Increment the iteration count: `k = k + 1`

<u>STEP 9</u>: End while loop.

<u>STEP 10</u>: Repeat steps 7-9 to solve for `tanPt[1]`. In each iteration; however, use `crsFromPoint-C` for azimuth in step 8(a).

<u>STEP 11</u>: Return `tanPt[0]` and `tanPt[1]`

Figure A2-24. *Projecting Point to Tangent Points on an Arc.*



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:

`LLPoint lineStart`	=	Start point of geodesic to which arc tangent points will be projected
`double crs`	=	Initial course of geodesic
`LLPoint center`	=	Geodetic coordinates of arc cetner
`double radius`	=	Arc radius
`LLPoint linePts`	=	Array of projected points on geodesic
`LLPoint tanPts`	=	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*):
$$\texttt{angle1} = \text{signedAzimuthDifference}(\texttt{crs}, \texttt{crsStartToCenter})$$

STEP 3: If abs(distStartToCenter*(crsStartToCenter-crs)) < 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 (abs(`error`) `> tol` and `k < maxIterationCount`)

a. Use the *direct algorithm* to compute `linePts[0]`. Use `perpPt` as the starting point, `delta` as the distance, and `crs21`+π as the azimuth.

b. Use the *inverse algorithm* to calculate the course from `linePts[0]` to `perpPt`. Denote this value by `strCrs`.

c. Calculate the azimuth, `perpCrs`, from `linePts[0]` to the desired position of tanPts[0]. The azimuth depends upon which side of the line the circle lies, which is given by the sign of `angle1`:
`perpCrs = strCrs` – sign(angle1)*π/2.

d. Use *Algorithm 5.1* to project `center` onto the geodesic passing through `linePts[0]` at azimuth `perpCrs`. Algorithm 5.1 will return the projected point, `tanPts[0]`, along with the distance from `center` to `tanPts[0]`. Denote this distance by `radDist`.

e. Calculate the error, the amount that `radDist` differs from `radius`:
`error = radDist - radius`

f. Adjust the distance from `lineStart` to `linePts[0]`:
`delta = delta - error`

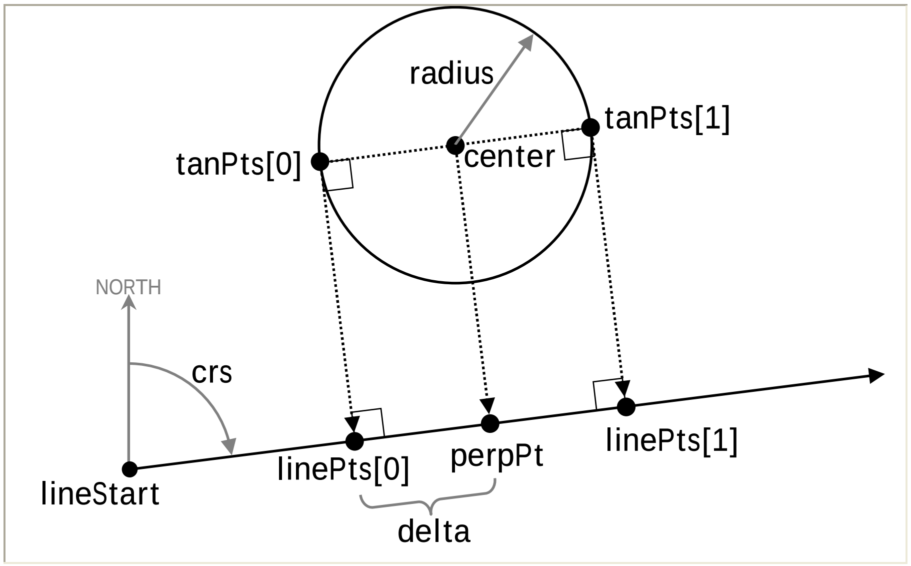
g. Increment the iteration count: `k = k + 1`

STEP 10: End while loop.

STEP 11: Repeat steps 7-10 to solve for `linePts[1]` and `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 `linePts[1]` will make the code more efficient (i.e., don't repeat *step 7*).

STEP 12: Return `linePts[0], linePts[1], tanPts[0]`, and `tanPts[1]`.

Figure A2-25. *Projecting an Arc to a Geodesic.*



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° = 360°. 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*π

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*π + 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 formulae[1]. 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

$$x = N\cos\varphi\cos\theta$$
$$y = N\cos\varphi\sin\theta$$
$$z = N(1-e^2)\sin\varphi$$

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:

$$e^2 = f\left(2 - f\right)$$

$$M = \frac{a\left(1 - e^2\right)}{\left(1 - e^2 \sin^2\theta\right)^{\frac{3}{2}}}$$

$$N = \frac{a}{\sqrt{1 - e^2 \sin^2\theta}}$$

$$R = \sqrt{MN}$$

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 $\texttt{tol} = 1.0\mathrm{e}-9$ and forward/inverse convergence parameter $\texttt{eps} = 0.5\mathrm{e}-13$.

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

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

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

WGS84PtIsOnGeodesic 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

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

WGS84PtIsOnArc 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

WGS84PtIsOnLocus 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 E nd Distance (mn)	Test Point Latitude	Test Point Longitude	Result
test1	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.00000W	42:55:01.77259N	70:24:20.88368N	-0.5	-0.5	42:55:05.00175N	70:50:23.28330W	1
test2	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.00000W	42:55:01.77259N	70:24:20.88368N	-0.5	-0.5	42:55:05.00771N	70:51:24.71201W	1
test3	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:35.01559N	70:51:34.00000W	42:55:31.77993N	70:24:20.66356N	-1.0	-1.0	42:55:35.00776N	70:50:13.66761W	1
test4	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:52:34.96830N	70:51:34.00000W	42:52:19.73219N	70:24:22.07127N	2.0	2.2	42:52:34.01413N	70:49:26.93090W	1
test5	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:57:35.04624N	70:51:34.00000W	42:53:31.75031N	70:24:21.54367N	-3.0	1.0	42:56:58.69196N	70:47:27.05896W	1
test6	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:50:34.93590N	70:51:34.00000W	42:50:31.70455N	70:24:22.86205N	4.0	4.0	42:50:34.81843N	70:46:22.99515W	1
test7	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:59:35.07618N	70:51:34.00000W	42:59:01.83008N	70:24:19.12109N	-5.0	-4.5	42:59:28.77609N	70:45:58.16124W	1
test8	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:48:34.90279N	70:51:34.00000W	42:48:07.66680N	70:24:23.91522N	6.0	6.4	42:48:27.53797N	70:43:32.97138W	1
test9	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	43:01:35.10543N	70:51:34.00000W	43:01:31.86459N	70:24:18.01754N	-7.0	-7.0	43:01:34.93635N	70:45:20.32134W	1
test10	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:46:34.86899N	70:51:34.00000W	42:53:31.75031N	70:24:21.54367N	8.0	1.0	42:48:36.37428N	70:43:41.44040W	1
test11	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.00000W	42:55:01.77259N	70:24:20.88368N	-0.5	-0.5	42:53:60.00000N	70:50:23.28330W	0
test12	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:46:34.86899N	70:51:34.00000W	42:46:31.64108N	70:24:24.61658N	8.0	8.0	42:42:00.00000N	70:43:42.62942W	0
test13	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:54:04.99214S	70:51:34.00000W	42:54:01.75778S	70:24:21.32373S	-0.5	-0.5	42:54:04.98608S	70:50:23.30236W	1
test14	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:54:04.99214S	70:51:34.00000W	42:54:01.75778S	70:24:21.32373S	-0.5	-0.5	42:54:04.99204S	70:51:24.70232W	1
test15	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:55:35.01559S	70:51:34.00000W	42:55:31.77993S	70:24:20.66356S	1.0	1.0	42:55:35.00776S	70:50:13.66761W	1
test16	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:52:34.96830S	70:51:34.00000W	42:52:19.73219S	70:24:22.07127S	-2.0	-2.2	42:52:34.01413S	70:49:26.93090W	1
test17	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:57:35.04624S	70:51:34.00000W	42:53:31.75031S	70:24:21.54367S	3.0	-1.0	42:56:58.69196S	70:47:27.05896W	1
test18	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:50:34.93590S	70:51:34.00000W	42:50:31.70455S	70:24:22.86205S	-4.0	-4.0	42:50:34.81843S	70:46:22.99515W	1
test19	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:59:35.07618S	70:51:34.00000W	42:59:01.83008S	70:24:19.12109S	5.0	4.5	42:59:28.77609S	70:45:58.16124W	1
test20	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:48:34.90279S	70:51:34.00000W	42:48:07.66680S	70:24:23.91522S	-6.0	-6.4	42:48:27.53797S	70:43:32.97138W	1
test21	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	43:01:35.10543S	70:51:34.00000W	43:01:31.86459S	70:24:18.01754S	7.0	7.0	43:01:34.93635S	70:45:20.32134W	1
test22	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:46:34.86899S	70:51:34.00000W	42:53:31.75031S	70:24:21.54367S	-8.0	-1.0	42:48:36.37428S	70:43:41.44040W	1

test23	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:54:04.99214S	70:51:34.00000W	42:54:01.75778S	70:24:21.32373S	-0.5	-0.5	42:53:60.00000S	70:50:23.30236W	0
test24	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:46:34.86899S	70:51:34.00000W	42:46:31.64108S	70:24:24.61658S	-8.0	-8.0	42:42:00.00000S	70:43:42.62942W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.00000W	42:55:01.77259N	70:24:20.88368N	-0.5	-0.5	42:55:05.00771N	70:51:24.71201W
	Output	42:54:34.99990N	70:51:24.71327W	180.00176	90.00176								
Test3	Input	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:35.01559N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:52:34.96830N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:57:35.04624N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:50:34.93590N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:59:35.07618N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:48:34.90279N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	43:01:35.10543N	70:51:34.00000W	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:46:34.86899N	70:51:34.00000W	42:53:31.75031N	70:24:21.54367N	8.0	1.0	42:48:36.37428N	70:43:41.44040W
	Output	42:54:34.72821N	70:43:40.67998W	-19.20067	70.79933								
Test11	Input	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:55:05.00782N	70:51:34.00000W	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								
Test12	Input	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:46:34.86899N	70:51:34.00000W	42:46:31.64108N	70:24:24.61658N	8.0	8.0	42:46:34.59884N	70:43:42.62942W
	Output	42:54:34.72928N	70:43:41.61315W	0.08915	90.08915								
Test13	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:54:04.99214S	70:51:34.00000W	42:54:01.75778S	70:24:21.32373S	-0.5	-0.5	42:54:04.98608S	70:50:23.30236W
	Output	42:54:34.99393S	70:50:23.29283W	179.98663	89.98663								
Test14	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:54:04.99214S	70:51:34.00000W	42:54:01.75778S	70:24:21.32373S	-0.5	-0.5	42:54:04.99204S	70:51:24.70232W
	Output	42:54:34.99990S	70:51:24.70107W	179.99824	89.99824								
Test15	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:55:35.01559S	70:51:34.00000W	42:55:31.77993S	70:24:20.66356S	1.0	1.0	42:55:35.00776S	70:50:13.66761W
	Output	42:54:34.99218S	70:50:13.68926W	359.98481	89.98481								
Test16	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:52:34.96830S	70:51:34.00000W	42:52:19.73219S	70:24:22.07127S	-2.0	-2.2	42:52:34.01413S	70:49:26.93090W
	Output	42:54:34.98039S	70:49:26.86188W	179.40303	89.40303								
Test17	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:57:35.04624S	70:51:34.00000W	42:53:31.75031S	70:24:21.54367S	3.0	-1.0	42:56:58.69196S	70:47:27.05896W
	Output	42:54:34.92612S	70:47:27.21838W	348.64337	78.64337								
Test18	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:50:34.93590S	70:51:34.00000W	42:50:31.70455S	70:24:22.86205S	-4.0	-4.0	42:50:34.81843S	70:46:22.99515W
	Output	42:54:34.88240S	70:46:22.65989W	179.94118	89.94118								
Test19	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:59:35.07618S	70:51:34.00000W	42:59:01.83008S	70:24:19.12109S	5.0	4.5	42:59:28.77609S	70:45:58.16124W
	Output	42:54:34.86353S	70:45:58.60448W	358.50439	88.50439								
Test20	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:48:34.90279S	70:51:34.00000W	42:48:07.66680S	70:24:23.91522S	-6.0	-6.4	42:48:27.53797S	70:43:32.97138W
	Output	42:54:34.71836S	70:43:32.17826W	178.76326	88.76326								
Test21	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	43:01:35.10543S	70:51:34.00000W	43:01:31.86459S	70:24:18.01754S	7.0	7.0	43:01:34.93635S	70:45:20.32134W
	Output	42:54:34.83124S	70:45:21.02628W	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

	t	000S	00W	521S	73W	899S	00W	031S	367S			428S	40W
	Output	42:54:34.72821S	70:43:40.67998W	199.20067	109.20067								
Test23	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:54:04.99214S	70:51:34.00000W	42:54:01.75778S	70:24:21.32373S	-0.5	-0.5	42:54:04.98608S	70:50:23.30236W
	Output	42:54:34.99393S	70:50:23.29283W	179.98663	89.98663								
Test24	Input	42:54:35.00000S	70:51:34.00000W	42:54:31.76521S	70:24:21.10373W	42:46:34.86899S	70:51:34.00000W	42:46:31.64108S	70:24:24.61658S	-8.0	-8.0	42:46:34.59884S	70:43:42.62942W
	Output	42:54:34.72928S	70:43:41.61315W	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	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	90.0	271.09328	77.96062	187.0	6.79842	115.70425	40:09:39.83588N	68:31:04.02698W
test2	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	90.0	273.49211	249.49410	127.0	309.24501	197.11484	40:02:47.62539N	64:47:40.82715W
test3	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	180.0	0.00000	2400.88568	183.0	2.22965	2517.34979	0:01:16.52501N	70:12:45.60000W
test4	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	175.0	355.32391	298.99250	190.0	9.07914	417.80313	35:12:07.90080N	69:41:00.06384W
test5	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	175.0	173.09453	979.39618	170.0	166.54243	877.94705	56:24:04.10502N	72:44:22.05038W
test6	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	170.0	352.06299	1472.94791	175.0	356.13925	1574.29532	15:50:52.84758N	65:55:13.50649W
test7	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	140.0	321.55556	182.84945	175.0	355.30205	256.71971	37:48:35.70387N	67:44:28.20017W
test8	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	35.0	216.45257	170.25572	200.0	200.13304	25.67248	42:28:43.18186N	68:00:48.75631W
test9	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	35.0	215.81864	98.37315	225.0	44.50036	47.79193	41:30:38.37291N	68:57:39.59637W
test10	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	40.0	221.23764	131.59286	200.0	19.92283	15.13463	41:50:21.91143N	68:19:36.20912W
test11	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	40.0	221.33298	141.28719	170.0	350.01830	7.04762	41:57:39.18157N	68:11:02.27771W
test12	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	190.0	9.32285	315.31940	200.0	18.05830	449.41589	34:59:10.92270N	71:19:18.57958W
test13	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	230.0	232.66774	233.26393	250.0	251.36850	95.79181	42:36:17.85665N	66:10:46.71710W
test14	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	300.0	117.24240	217.12520	270.0	85.84998	277.49771	41:54:31.96856N	74:24:39.29939W
test15	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	320.0	135.96039	394.31108	300.0	114.50787	390.41454	45:03:45.85754N	76:10:13.00551W
test16	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	30.0	211.06420	143.97676	300.0	119.74072	19.87930	42:14:30.07630N	68:35:51.38889W
test17	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	30.0	211.32507	177.09156	0.0	180.00000	38.22767	42:42:50.26602N	68:12:40.70000W
test18	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:40.70000W	20.0	202.00674	361.27463	10.0	190.65118	226.90835	45:47:51.26800N	67:16:23.97908W
test19	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	90.0	268.92420	76.71333	187.0	7.21051	125.94256	40:09:41.25343S	68:32:41.62303W
test20	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	90.0	266.46490	252.57903	127.0	304.80422	200.97896	40:02:36.27306S	64:43:40.26353W
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

	0S	W	0S	W			25			14	3S	W
test22	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	175.0	354.66840	244.37912	190.0	10.99389	375.33991	44:13:53.42080S	69:43:09.64545W
test23	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	175.0	176.07150	1613.09944	170.0	171.91685	1500.62255	13:17:28.78613S	72:31:44.37321W
test24	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	170.0	346.59757	915.38118	175.0	353.11720	1027.96638	55:06:51.99323S	65:38:55.06563W
test25	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	140.0	318.34632	173.46551	175.0	354.67361	258.02597	42:21:45.91619S	67:42:22.30757W
test26	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	35.0	213.62474	181.79580	200.0	199.88520	26.04680	37:40:05.03771S	68:01:27.49821W
test27	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	35.0	214.03300	125.42532	225.0	45.29430	31.67886	38:26:57.80473S	68:41:11.55669W
test28	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	40.0	218.83891	134.40675	200.0	20.10452	23.26402	38:26:28.42788S	68:22:48.33817W
test29	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	40.0	218.71155	149.88184	170.0	349.97744	9.94061	38:14:23.79253S	68:10:29.24046W
test30	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	190.0	10.58888	220.37689	200.0	21.89034	366.67130	43:47:20.08397S	71:05:33.40366W
test31	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	230.0	227.56916	241.38324	250.0	248.85250	95.09771	37:31:08.17381S	66:20:20.79110W
test32	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	300.0	123.01996	262.87140	270.0	94.18427	322.48262	37:52:47.65820S	75:00:21.64521W
test33	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	320.0	143.73376	481.89310	300.0	124.81855	472.56869	33:50:26.35101S	76:24:08.89427W
test34	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	30.0	208.96661	155.79494	300.0	120.22233	19.80226	37:54:39.07071S	68:34:20.89766W
test35	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	30.0	208.74599	191.45410	0.0	180.00000	41.16601	37:23:22.97816S	68:12:40.70000W
test36	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	20.0	198.17757	450.56059	10.0	189.39006	304.54802	33:03:55.91555S	67:09:49.72585W
test37	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	90.0	268.92596	76.58779	187.0	7.21051	125.94493	40:09:41.39485S	69:52:39.75365E
test38	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	90.0	266.46650	252.46360	127.0	304.80408	200.99143	40:02:36.70030S	73:41:41.93617E
test39	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	180.0	360.00000	1100.01245	183.0	4.51599	1228.18896	58:29:28.97645S	68:12:45.60000E
test40	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	175.0	354.66902	243.96896	190.0	10.99261	374.92389	44:13:28.91712S	68:42:18.37446E
test41	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	175.0	176.07091	1610.92321	170.0	171.91563	1498.42964	13:19:39.62658S	65:53:56.00212E
test42	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	170.0	346.60210	914.56078	175.0	353.11950	1027.16253	55:06:04.19759S	72:46:16.27258E
test43	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	140.0	318.34837	173.26198	175.0	354.67383	257.87324	42:21:36.78854S	70:42:57.94500E
test44	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	35.0	213.62839	181.28240	200.0	199.88718	25.59220	37:40:30.71712S	70:23:42.21581E
test45	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	35.0	214.02959	125.88761	225.0	45.28920	31.13428	38:26:34.79410S	69:44:39.40243E

test46	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	40.0	218.84201	134.03158	200.0	20.10593	23.57520	38:26:45.97904S	70:02:24.89276E
test47	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	40.0	218.71293	149.71326	170.0	349.97713	10.07419	38:14:31.69353S	70:14:53.93008E
test48	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	190.0	10.58725	219.81660	200.0	21.88681	366.07776	43:46:47.03577S	67:20:06.32333E
test49	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	230.0	227.56795	241.51240	250.0	248.84962	95.33926	37:31:02.93863S	72:05:17.59883E
test50	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	300.0	123.01975	262.85184	270.0	94.18239	322.33652	37:52:48.29840S	63:25:10.79761E
test51	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	320.0	143.73218	481.65350	300.0	124.81546	472.23033	33:50:37.96322S	62:01:32.51590E
test52	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	30.0	208.96702	155.72986	300.0	120.22106	19.68914	37:54:42.49075S	69:51:07.91279E
test53	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	30.0	208.74764	191.18346	0.0	180.00000	40.92873	37:23:37.23265S	70:12:40.70000E
test54	40:10:24.50000S	68:12:45.60000E	38:04:35.80000S	70:12:40.70000E	20.0	198.18057	449.67428	10.0	189.39157	303.69451	33:04:46.53740S	71:15:21.73045E
test55	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	90.0	271.09153	77.83566	187.0	6.79843	115.70185	40:09:39.97893N	69:54:17.39524E
test56	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	90.0	273.49022	249.35829	127.0	309.24487	197.10176	40:02:48.12197N	73:37:39.78188E
test57	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	180.0	360.00000	2396.68305	183.0	2.22965	2513.14398	0:05:29.92696N	68:12:45.60000E
test58	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	175.0	355.32338	298.43668	190.0	9.08018	417.24213	35:12:41.19161N	68:44:27.81826E
test59	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	175.0	173.09685	978.62238	170.0	166.54702	877.15717	56:23:18.10799N	65:41:19.19227E
test60	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	170.0	352.06155	1470.73841	175.0	356.13855	1572.10201	15:53:04.69652N	72:29:58.69976E
test61	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	140.0	321.55370	182.61724	175.0	355.30186	256.53723	37:48:46.62826N	70:40:52.06822E
test62	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	35.0	216.44892	169.85183	200.0	200.13123	25.32646	42:28:23.68275N	70:24:22.98760E
test63	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	35.0	215.82362	98.95285	225.0	44.50715	47.13287	41:31:06.58993N	69:28:18.70067E
test64	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	40.0	221.23455	131.27707	200.0	19.92155	15.38722	41:50:07.65641N	70:05:38.28221E
test65	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	40.0	221.33147	141.13344	170.0	350.01860	7.16484	41:57:32.25170N	70:14:20.75633E
test66	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	190.0	9.32443	314.47941	200.0	18.06144	448.54404	35:00:00.73673N	67:06:22.55872E
test67	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	230.0	232.66920	233.38410	250.0	251.37180	96.01994	42:36:22.23058N	72:14:52.24641E
test68	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	300.0	117.24218	217.14214	270.0	85.85158	277.39053	41:54:32.43403N	64:00:50.69032E
test69	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	320.0	135.96191	394.17976	300.0	114.51132	390.18698	45:03:40.19394N	62:15:25.92213E
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

	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

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	40:10:24.50000N	70:12:45.60000W	90.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	90.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	180.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	175.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	140.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	35.0	42:04:35.80000N	68:12:34.70000W	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test7	40:10:24.50000N	70:12:45.60000W	35.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	40.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	40.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	190.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	300.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	320.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	30.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	30.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000N	70:12:45.60000W	20.0	42:04:35.80000N	68:12:34.70000W	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	40:10:24.50000S	70:12:45.60000W	90.0	38:04:35.80000S	68:12:34.70000W	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	40:10:24.50000S	70:12:45.60000W	90.0	38:04:35.80000S	68:12:34.70000W	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	40:10:24.50000S	70:12:45.60000W	180.0	38:04:35.80000S	68:12:34.70000W	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	40:10:24.50000S	70:12:45.60000W	175.0	38:04:35.80000S	68:12:34.70000W	10.0	20.0	1	41:53:23.08049S	69:33:48.78224W	41:55:13.61589S	70:00:29.02018W	41:57:06.70642S	69:07:29.45776W
test20	40:10:24.50000S	70:12:45.60000W	140.0	38:04:35.80000S	68:12:34.70000W	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	40:10:24.50000S	70:12:45.60000W	35.0	38:04:35.80000S	68:12:34.70000W	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test22	40:10:24.50	70:12:45.60	35.0	38:04:35.80	68:12:34.70	45.0	50.0	-1	38:59:07.56	67:51:47.61	38:31:17.23	68:44:54.62	38:23:43.49	68:36:56.20

	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	40:10:24.50000N	68:12:45.60000E	90.0	42:04:35.80000N	70:12:34.70000E	307.0	25.0	1	40:31:47.54306N	71:58:04.95738E	40:06:47.80578N	71:56:42.34739E	40:51:25.82191N	72:18:26.57839E
test48	40:10:24.50000N	68:12:45.60000E	180.0	42:04:35.80000N	70:12:34.70000E	10.0	25.0	1	37:51:10.80607N	68:44:19.53963E	37:51:15.03684N	68:12:45.60000E	37:47:09.94546N	69:15:28.10850E
test49	40:10:24.50000N	68:12:45.60000E	175.0	42:04:35.80000N	70:12:34.70000E	10.0	20.0	1	38:00:10.41235N	68:52:32.81783E	37:58:31.60944N	68:27:20.01909E	37:56:56.65308N	69:17:30.61773E
test50	40:10:24.50000N	68:12:45.60000E	140.0	42:04:35.80000N	70:12:34.70000E	355.0	30.0	1	39:24:56.40398N	69:51:43.36317E	39:05:59.95608N	69:21:45.17977E	39:27:33.77651N	70:30:17.81305E
test51	40:10:24.50000N	68:12:45.60000E	35.0	42:04:35.80000N	70:12:34.70000E	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test52	40:10:24.50000N	68:12:45.60000E	35.0	42:04:35.80000N	70:12:34.70000E	45.0	50.0	-1	40:58:50.90375N	70:19:10.81896E	41:28:19.01585N	69:25:37.89916E	41:34:06.34313N	69:32:08.06055E
test53	40:10:24.50000N	68:12:45.60000E	40.0	42:04:35.80000N	70:12:34.70000E	20.0	10.0	1	41:55:09.03646N	69:53:43.95858E	41:48:33.97658N	70:03:48.54891E	41:51:45.11040N	70:06:19.53131E
test54	40:10:24.50000N	68:12:45.60000E	40.0	42:04:35.80000N	70:12:34.70000E	350.0	5.0	1	41:58:57.74099N	70:07:06.10358E	41:55:39.73901N	70:12:08.27010E	41:59:49.98252N	70:13:42.26099E
test55	40:10:24.50000N	68:12:45.60000E	190.0	42:04:35.80000N	70:12:34.70000E	20.0	15.0	1	38:11:57.14712N	68:05:36.93299E	38:14:30.86947N	67:46:51.62699E	38:07:07.73150N	68:23:37.55015E
test56	40:10:24.50000N	68:12:45.60000E	300.0	42:04:35.80000N	70:12:34.70000E	90.0	15.0	-1	41:43:03.43894N	65:13:22.97799E	41:29:48.35505N	65:03:59.84075E	41:58:02.30748N	65:12:12.70228E
test57	40:10:24.50000N	68:12:45.60000E	320.0	42:04:35.80000N	70:12:34.70000E	120.0	50.0	-1	42:21:48.75747N	67:11:53.44646E	41:49:02.23303N	66:21:09.56547E	43:05:54.90302N	67:43:53.33289E
test58	40:10:24.50000N	68:12:45.60000E	30.0	42:04:35.80000N	70:12:34.70000E	120.0	15.0	-1	41:54:06.60769N	69:56:40.44962E	42:01:50.95973N	69:39:26.81837E	42:07:07.31140N	70:06:41.86897E
test59	40:10:24.50000N	68:12:45.60000E	30.0	42:04:35.80000N	70:12:34.70000E	180.0	10.0	-1	42:06:49.39078N	69:59:08.53808E	42:11:59.48512N	69:47:37.82330E	42:06:50.17739N	70:12:34.70000E
test60	40:10:24.50000N	68:12:45.60000E	20.0	42:04:35.80000N	70:12:34.70000E	190.0	20.0	-1	42:32:22.60485N	69:51:44.28487E	42:39:31.91024N	69:26:26.96605E	42:28:55.91068N	70:18:22.54478E

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	43:47:17.80000N	69:11:50.60000W	39:34:35.80000N	69:12:34.70000W						
	Locus Input	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:34:51.08997N	70:54:12.49358W	42:29:44.86980N	68:54:29.59541W	-40.0	-40.0
	Output	42:13:22.21447N	69:12:07.67540W								
test2	Geodesic Input	41:47:17.80000N	69:11:50.60000W	42:04:35.80000N	68:12:34.70000W						
	Locus Input	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:16:32.54683N	70:23:04.51876W	42:10:54.51067N	68:23:00.30232W	-10.0	-10.0
	Output	41:57:19.79045N	68:37:45.07858W								
test3	Geodesic Input	41:47:17.80000N	69:11:50.60000W	41:47:17.80000N	65:12:34.70000W						
	Locus Input	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:01:10.70138N	69:57:20.70132W	41:58:16.13817N	68:02:11.16321W	15.0	10.0
	Output	41:48:04.24394N	68:12:34.32299W								
test4	Geodesic Input	41:47:17.80000N	69:11:50.60000W	39:36:04.50000N	67:26:41.20000W						
	Locus Input	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:03:01.62624N	70:00:25.34804W	41:53:11.72828N	67:53:53.81471W	12.0	18.0
	Output	41:11:48.40128N	68:42:35.01577W								
test5	Geodesic Input	41:47:17.80000N	69:11:50.60000W	39:36:04.50000N	69:11:50.60000W						
	Locus Input	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:17:46.04493N	70:25:08.52603W	42:10:54.51067N	68:23:00.30232W	-12.0	-10.0
	Output	41:26:42.33213N	69:11:50.60000W								
test6	Geodesic Input	41:47:17.80000N	69:11:50.60000W	40:10:24.50000N	70:12:45.60000W						
	Locus Input	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:16:32.54683N	70:23:04.51876W	42:17:12.26361N	68:33:27.97949W	-10.0	-20.0
	Output	41:09:26.33503N	69:36:02.59565W								
test7	Geodesic Input	38:47:17.80000N	69:11:50.60000W	42:04:35.80000N	68:12:34.70000W						

	Locus Input	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:58:16.13817N	68:02:11.16322W	40:01:10.70138N	69:57:20.70132W	-10.0	-15.0
	Output	41:40:37.83025N	68:20:06.26330W								
test8	Geodesic Input	38:47:17.80000N	69:11:50.60000W	41:36:04.50000N	69:11:50.60000W						
	Locus Input	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	42:12:10.13809N	68:25:05.67147W	40:16:32.54683N	70:23:04.51876W	12.0	10.0
	Output	41:27:24.30947N	69:11:50.60000W								
test9	Geodesic Input	39:47:17.80000N	69:11:50.60000W	41:10:24.50000N	70:12:45.60000W						
	Locus Input	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:55:44.00859N	67:58:02.32477W	40:04:15.53037N	70:02:28.53823W	-14.0	-10.0
	Output	40:25:30.20295N	69:39:29.15454W								
test10	Geodesic Input	39:47:17.80000N	69:11:50.60000W	41:05:17.80000N	72:11:50.60000W						
	Locus Input	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:39:11.51094N	67:31:12.85281W	39:48:49.10840N	69:36:53.95760W	-40.0	-35.0
	Output	39:55:22.68250N	69:29:41.62067W								
test11	Geodesic Input	39:47:17.80000N	68:31:50.60000W	39:47:17.80000N	72:11:50.60000W						
	Locus Input	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:35:59.92546N	67:26:04.91588W	39:39:30.54353N	69:21:38.70685W	-45.0	-50.0
	Output	39:47:49.91827N	69:13:40.39367W								
test12	Geodesic Input	40:47:17.80000N	68:31:50.60000W	39:15:17.80000N	72:11:50.60000W						
	Locus Input	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:40:28.08041N	67:33:16.16949W	39:42:36.95607N	69:26:43.33456W	-38.0	-45.0
	Output	40:51:17.20232N	68:21:40.00231W								
test13	Geodesic Input	41:47:17.80000N	68:11:50.60000E	42:34:35.80000N	69:12:34.70000E						
	Locus Input	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:34:48.34098N	67:31:15.95275E	42:30:56.94337N	69:28:29.96911E	-40.0	-42.0
	Output	N/A	N/A								
test14	Geodesic Input	41:47:17.80000N	68:11:50.60000E	42:04:35.80000N	70:12:34.70000E						
	Locus Input	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:16:31.86263N	68:02:25.99064E	42:12:09.29285N	70:00:02.80815E	-10.0	-12.0
	Output	42:01:21.05406N	69:48:40.14334E								
test15	Geodesic Input	41:47:17.80000N	68:11:50.60000E	41:47:17.80000N	69:12:34.70000E						
	Locus Input	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:34:48.34098N	67:31:15.95275E	42:29:04.57278N	69:31:40.10061E	-40.0	-39.0

	Output	41:47:21.72812N	68:46:38.51557E								
test16	Geodesic Input	41:47:17.80000N	67:11:50.60000E	39:36:04.50000N	69:26:41.20000E						
	Locus Input	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:16:31.86263N	68:02:25.99064E	42:09:38.28182N	70:04:13.77003E	-10.0	-8.0
	Output	40:37:49.71683N	68:24:40.01729E								
test17	Geodesic Input	41:47:17.80000N	68:31:50.60000E	39:34:35.80000N	68:31:50.60000E						
	Locus Input	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:07:20.47150N	68:17:54.70834E	42:03:20.08407N	70:14:39.72588E	5.0	2.0
	Output	40:21:38.98519N	68:31:50.60000E								
test18	Geodesic Input	41:47:17.80000N	68:41:50.60000E	40:10:24.50000N	68:12:45.60000E						
	Locus Input	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:16:31.86263N	68:02:25.99064E	42:07:44.92286N	70:07:21.77389E	-10.0	-5.0
	Output	40:31:50.20654N	68:19:04.04752E								
test19	Geodesic Input	38:47:17.80000N	68:11:50.60000E	42:04:35.80000N	69:12:34.70000E						
	Locus Input	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:59:32.70797N	70:20:54.30885E	40:04:16.21255N	68:23:03.35373E	-8.0	-10.0
	Output	40:21:27.32287N	68:40:03.99226E								
test20	Geodesic Input	38:47:17.80000N	69:11:50.60000E	41:36:04.50000N	69:11:50.60000E						
	Locus Input	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	42:01:26.43878N	70:17:47.11005E	40:07:57.29566N	68:16:52.92374E	-5.0	-4.0
	Output	41:00:37.22699N	69:11:50.60000E								
test21	Geodesic Input	39:47:17.80000N	69:11:50.60000E	41:10:24.50000N	68:12:45.60000E						
	Locus Input	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	42:00:48.53800N	70:18:49.53023E	40:01:11.72389N	68:28:11.53713E	-6.0	-15.0
	Output	40:22:24.93524N	68:47:13.10535E								
test22	Geodesic Input	38:47:17.80000N	72:11:50.60000E	40:05:17.80000N	69:11:50.60000E						
	Locus Input	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:39:14.30455N	70:53:59.62806E	39:44:31.54766N	68:55:47.78511E	-40.0	-42.0
	Output	40:03:55.52616N	69:15:09.86384E								
test23	Geodesic Input	39:47:17.80000N	72:11:50.60000E	39:47:17.80000N	68:11:50.60000E						
	Locus Input	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:42:25.31152N	70:48:50.79796E	39:44:31.54766N	68:55:47.78511E	-35.0	-42.0
	Output	39:47:56.9679	68:58:57.6908								

		8N	7E								
test24	Geodesic Input	41:47:17.80000N	72:01:50.60000E	40:15:17.80000N	69:01:50.60000E						
	Locus Input	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:45:36.08581N	70:43:41.45993E	39:50:42.75433N	68:45:35.91786E	-30.0	-32.0
	Output	40:24:52.23963N	69:19:46.81959E								
test25	Geodesic Input	40:32:17.80000S	69:31:50.60000W	39:45:35.80000S	68:32:34.70000W						
	Locus Input	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:47:14.99172S	70:17:56.70673W	39:37:07.26246S	68:43:14.91695W	-5.0	-30.0
	Output	40:15:45.41972S	69:10:37.42061W								
test26	Geodesic Input	40:12:17.80000S	69:11:50.60000W	39:55:35.80000S	68:12:34.70000W						
	Locus Input	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:44:05.24805S	70:23:07.30456W	39:48:13.36527S	68:24:52.75546W	-10.0	-12.0
	Output	40:03:21.16483S	68:39:49.20815W								
test27	Geodesic Input	40:12:17.80000S	69:11:50.60000W	40:12:17.80000S	65:12:34.70000W						
	Locus Input	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:40:55.26981S	70:28:17.39464W	39:44:31.65649S	68:31:00.79721W	-15.0	-18.0
	Output	40:12:30.90626S	68:58:24.71946W								
test28	Geodesic Input	40:12:17.80000S	69:11:50.60000W	42:05:35.80000S	67:26:34.70000W						
	Locus Input	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:51:02.37334S	70:11:43.31749W	39:56:49.41116S	68:10:31.43442W	1.0	2.0
	Output	40:35:40.81313S	68:50:43.69996W								
test29	Geodesic Input	40:12:17.80000S	69:11:50.60000W	42:25:35.80000S	69:11:50.60000W						
	Locus Input	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:51:40.23723S	70:10:41.01456W	39:57:26.20299S	68:09:29.77411W	2.0	3.0
	Output	40:57:17.62289S	69:11:50.60000W								
test30	Geodesic Input	40:12:17.80000S	69:11:50.60000W	41:50:24.50000S	70:12:45.60000W						
	Locus Input	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:40:55.26981S	70:28:17.39464W	39:43:17.68107S	68:33:03.33213W	-15.0	-20.0
	Output	40:43:15.13120S	69:30:42.16309W								
test31	Geodesic Input	43:12:17.80000S	69:11:50.60000W	39:55:35.80000S	68:12:34.70000W						
	Locus Input	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	39:58:39.75911S	68:07:26.39841W	41:51:40.23723S	70:10:41.01456W	-5.0	-2.0
	Output	40:06:31.28916S	68:15:42.78110W								

test32	Geodesic Input	43:12:17.80000S	69:11:50.60000W	40:55:35.80000S	69:11:50.60000W						
	Locus Input	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:00:30.02435S	68:04:21.19705W	41:54:49.41461S	70:05:29.19346W	-8.0	-7.0
	Output	41:05:16.19670S	69:11:50.60000W								
test33	Geodesic Input	42:12:17.80000S	69:11:50.60000W	40:50:24.50000S	70:12:45.60000W						
	Locus Input	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	39:48:13.36527S	68:24:52.75546W	41:44:05.24805S	70:23:07.30456W	12.0	10.0
	Output	41:16:14.12186S	69:53:51.98283W								
test34	Geodesic Input	42:12:17.80000S	69:11:50.60000W	40:45:17.50000S	72:11:50.60000W						
	Locus Input	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:13:56.09360S	67:41:37.98194W	42:06:08.48229S	69:46:42.39287W	-30.0	-25.0
	Output	41:59:37.91453S	69:39:10.91231W								
test35	Geodesic Input	42:12:17.80000S	69:11:50.60000W	42:12:17.80000S	72:11:50.60000W						
	Locus Input	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:20:00.99821S	67:31:15.37383W	42:14:16.98565S	69:33:04.43858W	-40.0	-38.0
	Output	42:12:31.30889S	69:31:07.42859W								
test36	Geodesic Input	40:12:17.80000S	67:11:50.60000W	41:30:17.80000S	70:11:50.60000W						
	Locus Input	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:01:06.76102S	68:03:19.42649W	41:55:27.22164S	70:04:26.76787W	-9.0	-8.0
	Output	41:03:44.09408S	69:08:30.81544W								
test37	Geodesic Input	40:42:17.80000S	68:11:50.60000E	39:52:35.80000S	69:12:34.70000E						
	Locus Input	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:25:04.68264S	67:31:27.86642E	39:30:21.55001S	69:30:40.99953E	-40.0	-41.0
	Output	40:15:33.08735S	68:44:47.55891E								
test38	Geodesic Input	40:12:17.80000S	68:11:50.60000E	39:55:35.80000S	70:12:34.70000E						
	Locus Input	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:49:27.87799S	70:02:18.78242E	-15.0	-10.0
	Output	39:58:31.84128S	69:52:29.29742E								
test39	Geodesic Input	40:12:17.80000S	68:11:50.60000E	40:12:17.80000S	72:12:34.70000E						
	Locus Input	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:47:15.34302S	68:07:34.11126E	39:51:18.35063S	70:05:23.36577E	-5.0	-7.0
	Output	40:13:16.89179S	69:43:44.03190E								
test40	Geodes	38:01:17.8000	68:11:50.6000	40:12:17.8000	69:56:34.7000						

	ic Input	0S	0E	0S	0E						
	Locus Input	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:44:32.88343S	69:54:07.36243E	-15.0	-18.0
	Output	39:55:56.20199S	69:43:03.93718E								
test41	Geodesic Input	38:01:17.80000S	69:11:50.60000E	41:12:17.80000S	69:11:50.60000E						
	Locus Input	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:43:19.04394S	69:52:04.68943E	-15.0	-20.0
	Output	40:25:31.95062S	69:11:50.60000E								
test42	Geodesic Input	38:01:17.80000S	69:11:50.60000E	41:50:24.50000S	68:12:45.60000E						
	Locus Input	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:44:32.88343S	69:54:07.36243E	-15.0	-18.0
	Output	41:17:14.59269S	68:21:44.54338E								
test43	Geodesic Input	43:29:17.80000S	68:11:50.60000E	39:55:35.80000S	70:12:34.70000E						
	Locus Input	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:10:51.57579S	70:38:22.52584E	42:09:14.44140S	68:44:05.27630E	-25.0	-30.0
	Output	41:34:33.35900S	69:18:28.69285E								
test44	Geodesic Input	42:29:17.80000S	69:11:50.60000E	38:55:35.80000S	68:11:50.60000E						
	Locus Input	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:00:29.47695S	70:20:48.75282E	41:56:04.38538S	68:22:07.56499E	-8.0	-9.0
	Output	41:26:23.00508S	68:53:29.08873E								
test45	Geodesic Input	42:29:17.80000S	69:11:50.60000E	40:50:24.50000S	68:12:45.60000E						
	Locus Input	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	39:57:25.99787S	70:15:39.83219E	41:53:33.42022S	68:17:57.59846E	-3.0	-5.0
	Output	41:34:00.90066S	68:38:24.24396E								
test46	Geodesic Input	40:29:17.80000S	70:11:50.60000E	38:45:07.50000S	67:11:50.60000E						
	Locus Input	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	39:58:02.71210S	70:16:41.57960E	41:52:17.88059S	68:15:52.73784E	-4.0	-3.0
	Output	40:19:41.24209S	69:54:30.11308E								

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	40:04:35.80000N	67:12:40.70000W	44:59:45.92088N	68:26:00.21137W	39:56:32.24583N	68:10:17.89287W	44:49:00.82197N	69:41:53.85880W	-45.0	-55.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	41:16:20.97483N	68:33:49.64706W	N/A	N/A						
test2	LocusInputs	40:04:35.80000N	67:12:40.70000W	35:21:11.74762N	69:17:59.12450W	40:19:46.76257N	68:07:58.28686W	35:38:35.67860N	70:21:53.80953W	45.0	55.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	38:52:37.32110N	68:51:25.92398W	N/A	N/A						
test3	LocusInputs	40:04:35.80000N	68:12:40.70000W	44:06:29.08145N	72:11:23.83279W	40:10:19.71054N	68:01:59.52680W	44:15:37.90140N	71:54:52.50907W	10.0	15.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	40:10:40.48392N	68:02:17.74643W	41:44:11.11144N	69:26:43.29973W						
test4	LocusInputs	40:04:35.80000N	67:12:40.70000W	39:53:37.86852N	73:42:48.01440W	39:24:33.84810N	67:12:40.70000W	39:13:42.17201N	73:39:02.85208W	-40.0	-40.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	39:24:15.45160N	68:17:38.63126W	39:18:24.79605N	72:03:32.01227W						
test5	LocusInputs	40:04:35.80000N	67:12:40.70000W	42:25:59.29666N	73:03:41.42140W	39:47:15.03035N	67:25:39.04894W	42:03:31.24636N	73:18:28.55441W	-20.0	-25.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	40:02:54.56086N	68:02:47.12641W	41:27:12.33255N	71:37:11.75223W						
test6	LocusInputs	40:04:35.80000N	67:12:40.70000W	37:26:38.49374N	72:39:00.04197W	40:24:30.80802N	67:27:43.97508W	37:47:30.86022N	72:56:21.95509W	23.0	25.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	40:09:14.29595N	68:02:19.62879W	38:40:57.69877N	71:10:40.22633W						
test7	LocusInputs	42:54:35.80000N	70:11:34.70000W	37:54:23.25449N	70:11:34.70000W	42:54:34.63546N	69:55:14.95265W	37:54:22.70515N	70:00:12.39331W	-12.0	-9.0
	ArcInputs	40:10:24.5000	70:12:45.6000	100.0							

		0N	0W								
	Outputs	41:49:41.81253N	69:56:23.66945W	38:30:50.35272N	69:59:38.85328W						
test8	LocusInputs	42:54:35.80000N	70:11:34.70000W	38:36:54.74970N	66:48:53.11210W	42:45:33.45879N	70:31:08.92001W	38:25:55.70018N	67:13:10.97191W	17.0	22.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	41:48:11.21428N	69:44:43.27879W	39:41:58.47789N	68:08:06.44802W						
test9	LocusInputs	42:54:35.80000N	70:11:34.70000W	38:34:20.92985N	73:28:27.37397W	42:47:21.88895N	69:55:16.82351W	38:30:28.69575N	73:19:31.79717W	-14.0	-8.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	41:47:15.33175N	70:45:57.13556W	39:49:26.30016N	72:19:59.93614W						
test10	LocusInputs	40:24:35.80000N	75:11:34.70000W	40:13:30.13260N	68:39:33.29289W	40:09:35.15249N	75:11:34.70000W	39:53:32.47781N	68:41:28.29400W	15.0	20.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	40:05:22.18528N	72:22:58.48688W	N/A	N/A						
test11	LocusInputs	40:24:35.80000N	75:11:34.70000W	41:52:02.63088N	68:51:37.82571W	40:17:01.57931N	75:08:10.50021W	41:46:14.44889N	68:49:34.67458W	8.0	
	ArcInputs	6.0	40:10:24.50000N								
	Outputs	70:12:45.60000W	100.0	41:03:30.88159N	72:04:03.66717W	41:40:47.06916N	69:16:07.93303W				
test12	LocusInputs	40:24:35.80000N	75:11:34.70000W	37:59:52.60403N	69:33:17.73371W	40:34:24.08080N	75:05:01.48924W	38:11:04.65506N	69:24:54.64598W	-11.0	-13.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	39:22:31.10917N	72:06:39.15758W	38:30:24.52137N	70:07:20.17531W						
test13	LocusInputs	37:09:35.80000N	70:21:34.70000W	42:09:50.66942N	70:21:34.70000W	37:09:34.10973N	70:01:33.74416W	42:09:49.71595N	70:06:47.22254W	16.0	11.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	38:30:36.75113N	70:02:54.77447W	41:50:21.16270N	70:06:25.67783W						
test14	LocusInputs	37:09:35.80000N	70:21:34.70000W	41:15:08.98180N	66:39:17.43518W	37:14:37.77298N	70:30:55.36855W	41:19:17.77892N	66:46:46.42762W	-9.0	-7.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							
	Outputs	38:40:34.86821N	69:15:50.39090W	39:59:51.92500N	68:03:11.54227W						
test15	LocusInputs	37:09:35.80000N	70:21:34.70000W	41:29:39.48761N	73:34:58.78500W	37:15:24.56960N	70:08:25.90396W	41:34:48.49958N	73:23:33.80854W	12.0	10.0
	ArcInputs	40:10:24.50000N	70:12:45.60000W	100.0							

	Outputs	38:40:27.45727N	71:09:21.24587W	40:18:13.26914N	72:22:56.80903W						
test16	LocusInputs	40:04:35.80000N	73:12:40.70000E	44:59:45.92088N	71:59:21.18863E	39:48:00.15827N	71:17:40.20472E	44:43:50.98219N	70:09:07.24848E	-90.0	-80.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	41:46:00.68336N	70:51:43.52402E	N/A	N/A						
test17	LocusInputs	40:04:35.80000N	73:12:40.70000E	35:21:11.74762N	71:07:22.27550E	40:36:07.65151N	71:15:28.17727E	35:49:22.22773N	69:22:33.06760E	95.0	90.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	38:30:43.20226N	70:24:16.36558E	N/A	N/A						
test18	LocusInputs	40:04:35.80000N	72:12:40.70000E	43:30:53.45685N	67:21:10.09784E	40:14:29.48962N	72:25:36.35111E	43:49:30.21672N	67:44:10.09926E	14.0	25.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	40:16:35.49023N	72:23:04.19012E	41:49:56.03913N	70:26:23.17962E						
test19	LocusInputs	40:04:35.80000N	73:12:40.70000E	39:53:37.86852N	66:42:33.38560E	39:32:34.26062N	73:12:40.70000E	39:28:40.60461N	66:44:54.61550E	-32.0	-25.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	39:33:23.20779N	72:13:25.35838E	39:31:28.71124N	68:13:08.42930E						
test20	LocusInputs	40:04:35.80000N	73:12:40.70000E	42:25:59.29666N	67:21:39.97860E	39:55:03.56268N	73:05:31.79786E	42:17:00.31604N	67:15:43.86529E	-11.0	-10.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	40:13:44.90572N	72:23:12.06451E	41:35:55.71369N	69:04:18.25538E						
test21	LocusInputs	40:04:35.80000N	73:12:40.70000E	37:26:38.49374N	67:46:21.35803E	40:15:51.48849N	73:04:11.23785E	37:39:10.22938N	67:35:57.37599E	13.0	15.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	39:57:08.54828N	72:21:51.60527E	38:36:13.70124N	69:29:05.91728E						
test22	LocusInputs	42:54:35.80000N	70:11:34.70000E	37:54:23.25449N	70:11:34.70000E	42:54:17.16834N	71:16:53.48450E	37:54:09.52152N	71:08:26.12075E	-48.0	-45.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	41:38:47.56150N	71:14:35.87008E	38:40:33.81918N	71:09:38.04827E						
test23	LocusInputs	42:54:35.80000N	70:11:34.70000E	38:36:54.74970N	73:34:16.28790E	42:45:33.45879N	69:52:00.47999E	38:26:55.82263N	73:12:10.65574E	17.0	20.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	41:48:29.4306	70:38:53.2169	39:41:45.9624	72:17:19.7266						

		6N	6E	1N	9E						
test24	LocusInputs	42:54:35.80000N	70:11:34.70000E	38:34:20.92985N	66:54:42.02603E	42:46:50.80632N	70:29:02.27938E	38:26:06.61768N	67:13:38.98386E	-15.0	-17.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	41:47:43.40196N	69:42:02.50041E	39:42:31.14816N	68:07:53.50977E						
test25	LocusInputs	40:24:35.80000N	65:11:34.70000E	40:13:30.13260N	71:43:36.10711E	39:57:34.60638N	65:11:34.70000E	39:41:33.83675N	71:40:32.63802E	27.0	32.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	39:53:11.08875N	68:04:30.93940E	N/A	N/A						
test26	LocusInputs	40:24:35.80000N	65:11:34.70000E	41:52:02.63088N	71:31:31.57429E	40:13:14.42778N	65:16:40.71507E	41:41:24.26479N	71:35:17.06907E	12.0	11.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	40:58:28.40606N	68:17:39.16683E	41:37:44.27698N	71:17:08.46322E						
test27	LocusInputs	40:24:35.80000N	65:11:34.70000E	37:59:52.60403N	70:49:51.66629E	40:38:51.35239N	65:21:07.27556E	38:11:56.32557N	70:58:53.55929E	-16.0	-14.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	39:25:51.87086N	68:16:33.76002E	38:30:27.42682N	70:19:30.21732E						
test28	LocusInputs	37:09:35.80000N	70:21:34.70000E	42:09:50.66942N	70:21:34.70000E	37:09:12.03214N	71:36:38.04189E	42:09:20.38191N	71:44:56.41786E	60.0	62.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	38:56:06.49229N	71:39:23.30959E	41:22:52.71681N	71:43:31.92819E						
test29	LocusInputs	37:09:35.80000N	70:21:34.70000E	41:24:05.81315N	73:46:45.59830E	37:14:44.72265N	70:10:50.58087E	41:28:28.20339N	73:37:51.07864E	-10.0	-8.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	38:45:47.16793N	71:21:43.16537E	40:00:12.62742N	72:22:22.79266E						
test30	LocusInputs	37:09:35.80000N	70:21:34.70000E	41:29:39.48761N	67:08:10.61500E	37:17:49.45718N	70:40:12.75662E	41:37:22.57804N	67:25:18.75938E	17.0	15.0
	ArcInputs	40:10:24.50000N	70:12:45.60000E	100.0							
	Outputs	38:32:19.44329N	69:47:05.36481E	40:42:42.10179N	68:08:47.23533E						
test31	LocusInputs	40:04:35.80000S	73:12:40.70000E	35:08:30.42508S	72:09:14.02356E	40:07:30.99907S	72:50:51.17492E	35:11:43.38567S	71:45:09.30741E	-17.0	-20.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	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		
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	41:39:29.00627S	71:12:51.34782E	N/A	N/A						
test33	LocusInputs	40:04:35.80000S	72:12:40.70000E	36:27:08.38182S	67:49:48.47323E	40:05:18.25476S	72:11:45.42067E	36:28:29.21623S	67:47:58.39809E	-1.0	-2.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	38:30:19.51072S	70:11:27.28055E	N/A	N/A						
test34	LocusInputs	40:04:35.80000S	73:12:40.70000E	39:53:37.86852S	66:42:33.38560E	39:09:33.04483S	73:12:40.70000E	39:08:42.68217S	66:46:46.39327E	55.0	45.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	39:11:05.72257S	71:57:05.49382E	39:11:02.25193S	68:28:29.05646E						
test35	LocusInputs	40:04:35.80000S	73:12:40.70000E	37:26:38.49374S	67:46:21.35803E	40:15:51.48849S	73:04:11.23785E	37:36:39.95775S	67:38:02.45124E	-13.0	-12.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	39:56:39.83307S	72:21:46.06481E	38:35:25.48014S	69:32:05.80065E						
test36	LocusInputs	40:04:35.80000S	73:12:40.70000E	42:25:59.29666S	67:21:39.97860E	39:48:07.10444S	73:00:21.11336E	42:10:42.83913S	67:11:35.58816E	19.0	17.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	40:04:47.04502S	72:22:55.48617E	41:31:16.72059S	68:55:09.20530E						
test37	LocusInputs	38:04:35.80000S	70:11:34.70000E	43:04:47.81441S	70:11:34.70000E	38:04:34.46263S	70:29:18.51824E	43:04:45.46340S	70:34:46.50160E	-14.0	-17.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	38:31:11.62401S	70:29:45.34652E	41:49:14.99630S	70:33:18.33807E						
test38	LocusInputs	38:04:35.80000S	70:11:34.70000E	42:16:02.95041S	73:45:33.85544E	38:24:06.71761S	69:31:39.73455E	42:32:52.83250S	73:12:02.21580E	37.0	30.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	38:33:41.56924S	69:39:34.02709E	41:11:49.98705S	71:56:32.15188E						
test39	LocusInputs	38:04:35.80000S	70:11:34.70000E	42:18:57.42808S	66:43:26.95968E	38:15:23.23243S	70:34:25.87614E	42:27:09.69405S	67:00:23.77562E	-21.0	-15.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	38:30:35.91066S	70:22:22.12255E	40:59:38.89521S	68:18:29.60201E						
test40	LocusInputs	40:24:35.80000S	65:51:34.70000E	40:13:30.13260S	72:23:36.10711E	41:39:38.45017S	65:51:34.70000E	41:23:21.12281S	72:30:27.67815E	75.0	70.0

	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	41:34:42.11106S	69:01:43.31833E	41:26:48.13779S	71:37:49.38289E						
test41	LocusInputs	40:24:35.80000S	65:51:34.70000E	38:37:15.53538S	71:53:43.64116E	40:27:26.10432S	65:52:51.47157E	38:39:06.23077S	71:54:43.10773E	3.0	
	ArcInputs	2.0	40:10:24.50000S								
	Outputs	70:12:45.60000E	100.0	39:50:38.66908S	68:05:10.58480E	38:48:21.65069S	71:26:44.41888E				
test42	LocusInputs	40:24:35.80000S	65:51:34.70000E	42:31:36.14552S	71:53:17.58283E	40:22:48.79823S	65:52:45.98838E	42:30:40.89788S	71:53:49.28758E	-2.0	-1.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	41:30:04.01423S	68:53:01.27732E	41:48:16.79755S	69:45:17.54741E						
test43	LocusInputs	43:09:35.80000S	70:21:34.70000E	38:09:24.03567S	70:21:34.70000E	43:09:34.98423S	70:35:14.47789E	38:09:23.48139S	70:32:59.33158E	10.0	
	ArcInputs	9.0	40:10:24.50000S	70:12:45.60000E							
	Outputs	100.0	41:49:05.47847S	70:34:35.62154E	38:31:34.72650S	70:33:08.46967E					
test44	LocusInputs	42:09:35.80000S	70:21:34.70000E	37:57:18.93348S	73:53:33.13110E	42:09:02.22981S	70:20:27.82742E	37:56:47.34314S	73:52:28.61147E	-1.0	-1.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	41:48:28.50199S	70:38:59.27618E	39:50:56.92924S	72:20:25.64340E						
test45	LocusInputs	43:09:35.80000S	70:21:34.70000E	38:35:33.30636S	67:40:00.75564E	43:11:17.14290S	70:16:37.37426E	38:36:20.67340S	67:37:40.08878E	-4.0	-2.0
	ArcInputs	40:10:24.50000S	70:12:45.60000E	100.0							
	Outputs	41:43:03.84950S	69:22:56.07645E	39:36:34.42863S	68:10:29.08623E						
test46	LocusInputs	40:04:35.80000S	67:12:40.70000W	35:08:30.42508S	68:16:07.37644W	40:11:50.97658S	68:07:56.58748W	35:15:37.84100S	69:10:20.62043W	-43.0	-45.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	39:22:25.63807S	68:18:55.98559W	N/A	N/A						
test47	LocusInputs	40:04:35.80000S	67:12:40.70000W	44:45:10.49519S	69:36:31.49688W	39:48:58.60203S	68:07:33.46836W	44:28:43.55420S	70:33:39.49919W	45.0	44.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	41:33:34.04010S	68:59:26.86286W	N/A	N/A						
test48	LocusInputs	40:04:35.80000S	68:12:40.70000W	36:27:08.38182S	72:35:32.92677W	39:55:23.21575S	68:00:43.79991W	36:19:43.28447S	72:25:28.64583W	13.0	11.0
	ArcInputs	40:10:24.5000	70:12:45.6000	100.0							

		0S	0W								
	Outputs	39:52:21.98929S	68:04:43.13505W	38:32:16.82571S	69:47:22.06233W						
test49	LocusInputs	40:04:35.80000S	67:12:40.70000W	39:53:37.86852S	73:42:48.01440W	39:52:35.24351S	67:12:40.70000W	39:43:38.98159S	73:41:51.31890W	12.0	10.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	39:52:39.56903S	68:04:38.70584W	39:47:22.43780S	72:19:21.73856W						
test50	LocusInputs	40:04:35.80000S	67:12:40.70000W	37:26:38.49374S	72:39:00.04197W	40:12:23.65305S	67:18:33.10541W	37:33:19.53673S	72:44:32.39910W	-9.0	-8.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	39:51:22.17087S	68:04:58.73124W	38:33:52.86225S	70:46:51.05495W						
test51	LocusInputs	40:04:35.80000S	67:12:40.70000W	42:25:59.29666S	73:03:41.42140W	39:54:11.51851S	67:20:28.49481W	42:17:54.22855S	73:09:01.99936W	12.0	
	ArcInputs	9.0	40:10:24.50000S	70:12:45.60000W							
	Outputs	100.0	40:12:56.74526S	68:02:18.05980W	41:36:12.17970S	71:20:37.14598W					
test52	LocusInputs	38:04:35.80000S	70:11:34.70000W	43:04:47.81441S	70:11:34.70000W	38:04:33.82806S	70:33:06.47722W	43:04:45.98403S	70:32:02.76216W	17.0	15.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	38:31:33.76835S	70:33:00.73421W	41:49:21.92630S	70:32:18.78018W						
test53	LocusInputs	38:04:35.80000S	70:11:34.70000W	42:16:02.95041S	66:37:35.54456W	38:08:18.36892S	70:19:06.16642W	42:18:51.94705S	66:43:09.57422W	7.0	
	ArcInputs	5.0	40:10:24.50000S								
	Outputs	70:12:45.60000W	100.0	38:30:44.09315S	70:01:02.15512W	40:43:33.79871S	68:09:09.85914W				
test54	LocusInputs	38:04:35.80000S	70:11:34.70000W	42:18:57.42808S	73:39:42.44032W	38:11:17.11844S	69:57:26.67126W	42:24:58.66938S	73:27:17.20694W	-13.0	-11.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	38:30:19.27046S	70:12:08.88251W	40:55:39.92628S	72:09:46.06941W						
test55	LocusInputs	40:24:35.80000S	74:11:34.70000W	40:13:30.13260S	67:39:33.29289W	40:31:36.08879S	74:11:34.70000W	40:18:29.53053S	67:39:04.36690W	7.0	
	ArcInputs	5.0	40:10:24.50000S								
	Outputs	70:12:45.60000W	100.0	40:30:09.48667S	72:20:57.91099W	40:19:54.87523S	68:02:44.28575W				
test56	LocusInputs	40:24:35.80000S	74:11:34.70000W	38:37:15.53538S	68:09:25.75884W	40:29:19.63188S	74:09:26.68754W	38:40:01.57510S	68:07:56.53991W	5.0	
	ArcInputs	3.0	40:10:24.50000S								

	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
	ArcInputs	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
	ArcInputs	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
	ArcInputs	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	
	ArcInputs	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
	ArcInputs	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
	ArcInputs	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
	ArcInputs	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	
	ArcInputs	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	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:57:35.04624N	70:51:34.00000W	42:57:31.80885N	70:24:19.78251W	-3.0	-3.0
	ArcInputs	42:56:35.00000N	70:46:12.00000W								
	Outputs	1.0	42:57:34.92404N	70:46:16.50227W	42:57:34.91687N	70:46:07.32432W					
test66	LocusInputs	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:50:34.93590N	70:51:34.00000W	42:50:31.70455N	70:24:22.86205W	4.0	
	ArcInputs	4.0	42:51:35.00000N								
	Outputs	70:44:52.00000W	1.5	42:50:34.81843N	70:46:22.99515W	42:50:34.64098N	70:43:21.22225W				
test67	LocusInputs	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:59:35.07618N	70:51:34.00000W	42:59:31.83707N	70:24:18.90050W	-5.0	-5.0
	ArcInputs	42:58:35.00000N	70:43:32.00000W								
	Outputs	2.0	42:59:34.93584N	70:45:53.64821W	42:59:34.60458N	70:41:10.09281W					
test68	LocusInputs	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:48:34.90279N	70:51:34.00000W	42:48:31.67317N	70:24:23.73978W	6.0	
	ArcInputs	6.0	42:49:35.00000N								
	Outputs	70:42:12.00000W	1.5	42:48:34.63290N	70:43:42.71949W	42:48:34.38556N	70:40:41.58538W				
test69	LocusInputs	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	43:01:35.10543N	70:51:34.00000W	43:01:31.86459N	70:24:18.01754W	-7.0	-7.0
	ArcInputs	43:00:05.00000N	70:43:32.00000W								
	Outputs	2.0	43:01:34.93635N	70:45:20.32134W	43:01:34.68291N	70:41:43.28921W					
test70	LocusInputs	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:46:34.86899N	70:51:34.00000W	42:46:31.64108N	70:24:24.61658W	8.0	
	ArcInputs	8.0	42:47:35.00000N								
	Outputs	70:42:12.00000W	1.5	42:46:34.59884N	70:43:42.62942W	42:46:34.35162N	70:40:41.67545W				

WGS84LocusIntersect Test Results

Test Identifier	Locus 1 Inputs	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 Inputs	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 Inputs	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:34:51.08997N	70:54:12.49358W	42:29:44.86980N	68:54:29.59541W	-40.0	-40.0
	Locus 2 Inputs	43:47:17.80000N	69:11:50.60000W	39:34:35.80000N	69:12:34.70000W	43:47:17.16766N	69:39:27.23479W	39:34:35.45517N	69:38:26.67528W	20.0	20.0
	Output	41:48:06.52416N	69:38:56.60400W								
test2	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:16:32.54683N	70:23:04.51876W	42:10:54.51067N	68:23:00.30232W	-10.0	-10.0
	Locus 2 Inputs	41:47:17.80000N	69:11:50.60000W	42:04:35.80000N	68:12:34.70000W	41:37:59.88025N	69:06:54.98918W	41:55:15.39563N	68:07:46.38917W	10.0	10.0
	Output	41:41:38.52019N	68:54:37.00390W								
test3	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:01:10.70138N	69:57:20.70132W	41:58:16.13817N	68:02:11.16321W	15.0	10.0
	Locus 2 Inputs	41:47:17.80000N	69:11:50.60000W	41:47:17.80000N	65:12:34.70000W	41:37:17.67775N	69:11:32.04562W	41:32:17.60977N	65:13:02.49575W	10.0	15.0
	Output	41:36:57.43292N	68:23:48.56010W								
test4	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:03:01.62624N	70:00:25.34804W	41:53:11.72828N	67:53:53.81471W	12.0	18.0
	Locus 2 Inputs	41:47:17.80000N	69:11:50.60000W	39:36:04.50000N	67:26:41.20000W	41:52:34.94174N	69:00:29.14443W	39:42:12.84894N	67:13:19.99273W	-10.0	-12.0

	Output	41:20:04.46258N	68:32:58.40655W								
test5	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:17:46.04493N	70:25:08.52603W	42:10:54.51067N	68:23:00.30232W	-12.0	-10.0
	Locus 2 Inputs	41:47:17.80000N	69:11:50.60000W	39:36:04.50000N	69:11:50.60000W	41:47:16.05011N	68:51:47.49988W	39:36:03.62845N	68:57:36.71338W	-15.0	-11.0
	Output	41:44:55.25922N	68:51:53.96578W								
test6	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:04:35.80000N	68:12:34.70000W	40:16:32.54683N	70:23:04.51876W	42:17:12.26361N	68:33:27.97949W	-10.0	-20.0
	Locus 2 Inputs	41:47:17.80000N	69:11:50.60000W	40:10:24.50000N	70:12:45.60000W	41:49:02.24222N	69:16:39.55217W	40:12:31.91500N	70:18:40.06838W	4.0	5.0
	Output	40:44:08.21825N	69:58:43.82937W								
test7	Locus 1 Inputs	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:58:16.13817N	68:02:11.16322W	40:01:10.70138N	69:57:20.70132W	-10.0	-15.0
	Locus 2 Inputs	38:47:17.80000N	69:11:50.60000W	42:04:35.80000N	68:12:34.70000W	38:50:20.03849N	69:29:19.75003W	42:09:21.41521N	68:40:03.67472W	-14.0	-21.0
	Output	41:03:48.90937N	68:56:49.95173W								
test8	Locus 1 Inputs	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	42:12:10.13809N	68:25:05.67147W	40:16:32.54683N	70:23:04.51876W	12.0	10.0
	Locus 2 Inputs	38:47:17.80000N	69:11:50.60000W	41:36:04.50000N	69:11:50.60000W	38:47:17.45707N	69:20:47.75726W	41:36:03.56507N	69:26:30.32332W	-7.0	-11.0
	Output	41:13:51.01043N	69:25:43.47422W								
test9	Locus 1 Inputs	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:55:44.00859N	67:58:02.32477W	40:04:15.53037N	70:02:28.53823W	-14.0	-10.0
	Locus 2 Inputs	38:47:17.80000N	69:11:50.60000W	40:10:24.50000N	70:12:45.60000W	38:59:28.65387N	68:43:52.41332W	40:20:21.26770N	69:50:05.44188W	25.0	20.0

	Output	40:17:45.13434N	69:47:54.68645W								
test10	Locus 1 Inputs	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:39:11.51094N	67:31:12.85281W	39:48:49.10840N	69:36:53.95760W	-40.0	-35.0
	Locus 2 Inputs	38:47:17.80000N	69:11:50.60000W	40:05:17.80000N	72:11:50.60000W	39:47:44.17230N	68:26:14.20595W	41:02:28.85406N	71:31:12.02592W	70.0	65.0
	Output	40:08:19.82805N	69:15:22.32498W								
test11	Locus 1 Inputs	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:35:59.92546N	67:26:04.91588W	39:39:30.54353N	69:21:38.70685W	-45.0	-50.0
	Locus 2 Inputs	38:47:17.80000N	68:31:50.60000W	38:47:17.80000N	72:11:50.60000W	40:22:21.42255N	68:29:21.10582W	40:07:20.95796N	72:13:56.03192W	95.0	80.0
	Output	40:21:46.09771N	68:40:43.79783W								
test12	Locus 1 Inputs	42:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	41:40:28.08041N	67:33:16.16949W	39:42:36.95607N	69:26:43.33456W	-38.0	-45.0
	Locus 2 Inputs	38:47:17.80000N	68:31:50.60000W	37:15:17.80000N	72:11:50.60000W	40:08:26.72939N	69:25:11.93346W	38:40:51.77139N	73:12:28.75973W	91.0	98.0
	Output	N/A	N/A								
test13	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:34:48.34098N	67:31:15.95275E	42:30:56.94337N	69:28:29.96911E	-40.0	-42.0
	Locus 2 Inputs	41:47:17.80000N	68:11:50.60000E	42:34:35.80000N	69:12:34.70000E	41:17:38.57897N	68:53:19.82604E	42:03:10.50228N	69:56:00.78533E	43.0	45.0
	Output	N/A	N/A								
test14	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:16:31.86263N	68:02:25.99064E	42:12:09.29285N	70:00:02.80815E	-10.0	-12.0
	Locus 2 Inputs	41:47:17.80000N	68:11:50.60000E	42:04:35.80000N	70:12:34.70000E	41:32:35.48231N	68:15:50.24846E	41:48:50.47117N	70:16:21.80709E	15.0	16.0

	Output	41:42:45.75260N	69:29:17.30429E								
test15	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:34:48.34098N	67:31:15.95275E	42:29:04.57278N	69:31:40.10061E	-40.0	-39.0
	Locus 2 Inputs	41:47:17.80000N	68:11:50.60000E	41:47:17.80000N	69:12:34.70000E	41:57:18.05539N	68:11:45.86629E	41:56:18.03064N	69:12:38.95923E	-10.0	-9.0
	Output	41:56:37.06762N	68:56:31.29856E								
test16	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:16:31.86263N	68:02:25.99064E	42:09:38.28182N	70:04:13.77003E	-10.0	-8.0
	Locus 2 Inputs	41:47:17.80000N	67:11:50.60000E	39:36:04.50000N	69:26:41.20000E	41:50:25.61894N	67:17:03.53451E	39:39:42.68648N	69:32:52.00800E	-5.0	-6.0
	Output	40:42:15.66902N	68:29:20.00613E								
test17	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:07:20.47150N	68:17:54.70834E	42:03:20.08407N	70:14:39.72588E	5.0	2.0
	Locus 2 Inputs	41:47:17.80000N	68:31:50.60000E	39:34:35.80000N	68:31:50.60000E	41:47:17.79222N	68:30:30.39292E	39:34:35.73523N	68:27:57.80380E	1.0	3.0
	Output	40:18:31.31171N	68:28:47.22609E								
test18	Locus 1 Inputs	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:34.70000E	40:16:31.86263N	68:02:25.99064E	42:07:44.92286N	70:07:21.77389E	-10.0	-5.0
	Locus 2 Inputs	41:47:17.80000N	68:41:50.60000E	40:10:24.50000N	68:12:45.60000E	41:46:10.22678N	68:48:21.28237E	40:09:05.30829N	68:20:23.68524E	-5.0	-6.0
	Output	40:41:23.80558N	68:29:32.62774E								
test19	Locus 1 Inputs	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:59:32.70797N	70:20:54.30885E	40:04:16.21255N	68:23:03.35373E	-8.0	-10.0
	Locus 2 Inputs	38:47:17.80000N	68:11:50.60000E	42:04:35.80000N	69:12:34.70000E	38:45:43.54228N	68:20:33.98734E	42:02:42.67727N	69:23:00.95832E	7.0	8.0

	Output	40:36:11.72260N	68:54:48.39606E								
test20	Locus 1 Inputs	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	42:01:26.43878N	70:17:47.11005E	40:07:57.29566N	68:16:52.92374E	-5.0	-4.0
	Locus 2 Inputs	38:47:17.80000N	69:11:50.60000E	41:36:04.50000N	69:11:50.60000E	38:47:17.77201N	69:14:24.07363E	41:36:04.43046N	69:15:50.52514E	2.0	3.0
	Output	41:04:06.94297N	69:15:33.55517E								
test21	Locus 1 Inputs	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	42:00:48.53800N	70:18:49.53023E	40:06:06.79553N	68:19:58.22200E	-6.0	-7.0
	Locus 2 Inputs	38:47:17.80000N	69:11:50.60000E	40:10:24.50000N	68:12:45.60000E	38:49:41.12802N	69:17:27.85361E	40:13:19.86103N	68:19:36.00018E	5.0	6.0
	Output	40:08:53.27343N	68:22:44.48587E								
test22	Locus 1 Inputs	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:39:14.30455N	70:53:59.62806E	39:48:51.48716N	68:48:39.66995E	-40.0	-35.0
	Locus 2 Inputs	38:47:17.80000N	72:11:50.60000E	40:05:17.80000N	69:11:50.60000E	39:00:16.42738N	72:21:30.40595E	40:27:19.19138N	69:27:20.34409E	15.0	25.0
	Output	40:26:06.25375N	69:29:53.11403E								
test23	Locus 1 Inputs	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:42:25.31152N	70:48:50.79796E	39:48:14.38002N	68:49:40.88406E	-35.0	-36.0
	Locus 2 Inputs	39:47:17.80000N	72:11:50.60000E	39:47:17.80000N	69:11:50.60000E	40:27:19.25403N	72:12:43.27810E	40:25:19.18808N	69:11:00.58042E	40.0	38.0
	Output	40:25:42.09261N	69:27:47.18567E								
test24	Locus 1 Inputs	42:04:35.80000N	70:12:34.70000E	40:10:24.50000N	68:12:45.60000E	41:45:36.08581N	70:43:41.45993E	39:50:42.75433N	68:45:35.91786E	-30.0	-32.0
	Locus 2 Inputs	41:47:17.80000N	72:11:50.60000E	40:15:17.80000N	69:11:50.60000E	42:14:05.92481N	71:48:22.06420E	40:42:18.33009N	68:46:57.62062E	32.0	33.0

	Output	41:38:45.61961N	70:36:24.07170E								
test25	Locus 1 Inputs	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:25:01.88807S	70:54:00.26901W	39:34:01.71595S	68:48:20.02988W	-40.0	-35.0
	Locus 2 Inputs	40:12:17.80000S	69:11:50.60000W	39:25:35.80000S	68:12:34.70000W	40:37:33.30027S	68:38:14.16936W	39:51:57.45011S	67:37:07.05316W	36.0	38.0
	Output	N/A	N/A								
test26	Locus 1 Inputs	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:44:05.24805S	70:23:07.30456W	39:48:13.36527S	68:24:52.75546W	-10.0	-12.0
	Locus 2 Inputs	40:12:17.80000S	69:11:50.60000W	39:55:35.80000S	68:12:34.70000W	40:07:35.34521S	69:14:03.22375W	39:49:58.20740S	68:15:18.03727W	-5.0	-6.0
	Output	39:54:52.24216S	68:31:25.59353W								
test27	Locus 1 Inputs	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:40:55.26981S	70:28:17.39464W	39:44:31.65649S	68:31:00.79721W	-15.0	-18.0
	Locus 2 Inputs	40:12:17.80000S	69:11:50.60000W	40:12:17.80000S	65:12:34.70000W	40:02:17.50254S	69:11:33.04859W	40:01:17.47180S	65:12:54.00184W	-10.0	-11.0
	Output	40:02:33.17060S	68:48:36.22812W								
test28	Locus 1 Inputs	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:51:02.37334S	70:11:43.31749W	39:56:49.41116S	68:10:31.43442W	1.0	2.0
	Locus 2 Inputs	40:12:17.80000S	69:11:50.60000W	42:05:35.80000S	67:26:34.70000W	40:10:35.71331S	69:08:37.07963W	42:03:15.74654S	67:22:12.94439W	-3.0	-4.0
	Output	40:33:04.17399S	68:47:59.71025W								
test29	Locus 1 Inputs	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:51:40.23723S	70:10:41.01456W	39:57:26.20299S	68:09:29.77411W	2.0	3.0
	Locus 2 Inputs	40:12:17.80000S	69:11:50.60000W	42:25:35.80000S	69:11:50.60000W	40:12:17.68228S	69:06:37.35813W	42:25:35.60119S	69:05:05.52129W	-4.0	-5.0

	Output	40:51:57.10883S	69:06:10.74013W								
test30	Locus 1 Inputs	41:50:24.50000S	70:12:45.60000W	39:55:35.80000S	68:12:34.70000W	41:40:55.26981S	70:28:17.39464W	39:43:17.68107S	68:33:03.33213W	-15.0	-20.0
	Locus 2 Inputs	40:12:17.80000S	69:11:50.60000W	41:50:24.50000S	70:12:45.60000W	40:11:27.30497S	69:14:12.68764W	41:49:06.86266S	70:16:22.84949W	2.0	3.0
	Output	40:52:52.40604S	69:40:09.58552W								
test31	Locus 1 Inputs	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	39:58:39.75911S	68:07:26.39841W	41:51:40.23723S	70:10:41.01456W	-5.0	-2.0
	Locus 2 Inputs	43:12:17.80000S	69:11:50.60000W	39:55:35.80000S	68:12:34.70000W	43:08:10.82604S	69:35:47.37235W	39:52:20.45272S	68:31:36.29102W	-18.0	-15.0
	Output	40:33:38.43603S	68:44:35.40196W								
test32	Locus 1 Inputs	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:00:30.02435S	68:04:21.19705W	41:54:49.41461S	70:05:29.19346W	-8.0	-7.0
	Locus 2 Inputs	43:12:17.80000S	69:11:50.60000W	40:55:35.80000S	69:11:50.60000W	43:12:17.59574S	69:05:00.40914W	40:55:35.52833S	69:03:55.66338W	5.0	6.0
	Output	40:57:49.85657S	69:03:56.69283W								
test33	Locus 1 Inputs	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:05:23.65941S	67:56:06.51681W	42:01:07.05660S	69:55:04.01517W	-16.0	-17.0
	Locus 2 Inputs	43:12:17.80000S	69:11:50.60000W	41:50:24.50000S	70:12:45.60000W	43:05:27.11300S	68:55:09.55756W	41:41:47.30664S	69:51:38.39963W	14.0	18.0
	Output	41:51:43.92702S	69:45:04.44818W								
test34	Locus 1 Inputs	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:32:07.98119S	67:10:24.55960W	42:24:53.32280S	69:15:09.51219W	-60.0	-55.0
	Locus 2 Inputs	43:12:17.80000S	69:11:50.60000W	41:45:17.50000S	72:11:50.60000W	42:12:48.71741S	68:21:45.17937W	40:42:57.94861S	71:16:28.51249W	70.0	75.0

	Output	42:00:18.17296S	68:47:07.75272W								
test35	Locus 1 Inputs	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:20:00.99821S	67:31:15.37383W	42:14:16.98565S	69:33:04.43858W	-40.0	-38.0
	Locus 2 Inputs	43:12:17.80000S	69:11:50.60000W	43:12:17.80000S	72:11:50.60000W	41:57:17.07312S	69:13:38.69558W	41:52:16.98865S	72:09:55.44922W	75.0	80.0
	Output	41:57:16.43557S	69:14:20.41022W								
test36	Locus 1 Inputs	39:55:35.80000S	68:12:34.70000W	41:50:24.50000S	70:12:45.60000W	40:50:11.29811S	66:38:54.23203W	42:51:30.15103S	68:29:23.51673W	-90.0	-98.0
	Locus 2 Inputs	41:12:17.80000S	67:11:50.60000W	42:30:17.80000S	70:11:50.60000W	40:07:50.59278S	68:02:20.22470W	41:21:13.00297S	71:02:42.74576W	75.0	78.8
	Output	N/A	N/A								
test37	Locus 1 Inputs	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:25:04.68264S	67:31:27.86642E	39:30:21.55001S	69:30:40.99953E	-40.0	-41.0
	Locus 2 Inputs	40:12:17.80000S	68:11:50.60000E	39:22:35.80000S	69:12:34.70000E	40:26:04.93621S	68:30:47.96796E	39:34:51.58798S	69:29:36.49340E	20.0	18.0
	Output	40:02:03.43498S	68:58:38.15474E								
test38	Locus 1 Inputs	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:49:27.87799S	70:02:18.78242E	-15.0	-10.0
	Locus 2 Inputs	40:12:17.80000S	68:11:50.60000E	39:55:35.80000S	70:12:34.70000E	40:10:19.37749S	68:11:24.60959E	39:52:38.87779S	70:11:50.67961E	-2.0	-3.0
	Output	39:55:03.75907S	69:56:15.20886E								
test39	Locus 1 Inputs	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:47:15.34302S	68:07:34.11126E	39:51:18.35063S	70:05:23.36577E	-5.0	-7.0
	Locus 2 Inputs	40:12:17.80000S	68:11:50.60000E	40:12:17.80000S	72:12:34.70000E	40:02:17.50440S	68:12:08.25927E	40:00:17.44311S	72:12:13.51920E	-10.0	-12.0

	Output	40:02:27.42225S	69:54:26.29229E								
test40	Locus 1 Inputs	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:44:32.88343S	69:54:07.36243E	-15.0	-18.0
	Locus 2 Inputs	38:01:17.80000S	68:11:50.60000E	40:12:17.80000S	69:56:34.70000E	38:01:49.06303S	68:10:45.76086E	40:13:22.25096S	69:54:22.52989E	1.0	2.0
	Output	39:57:32.74476S	69:41:29.82264E								
test41	Locus 1 Inputs	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:43:19.04394S	69:52:04.68943E	-15.0	-20.0
	Locus 2 Inputs	38:01:17.80000S	69:11:50.60000E	41:12:17.80000S	69:11:50.60000E	38:01:17.79319S	69:13:06.53044E	41:12:17.76952S	69:14:29.58125E	-1.0	-2.0
	Output	40:23:10.15763S	69:14:07.43973E								
test42	Locus 1 Inputs	41:50:24.50000S	68:12:45.60000E	39:55:35.80000S	70:12:34.70000E	41:40:56.32203S	67:57:12.65839E	39:44:32.88343S	69:54:07.36243E	-15.0	-18.0
	Locus 2 Inputs	38:01:17.80000S	69:11:50.60000E	41:50:24.50000S	68:12:45.60000E	38:00:55.02621S	69:09:21.49922E	41:49:48.38430S	68:08:49.69566E	2.0	3.0
	Output	41:22:22.77502S	68:16:27.47836E								
test43	Locus 1 Inputs	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:10:51.57579S	70:38:22.52584E	42:09:14.44140S	68:44:05.27630E	-25.0	-30.0
	Locus 2 Inputs	43:29:17.80000S	68:11:50.60000E	39:55:35.80000S	70:12:34.70000E	43:30:05.86262S	68:14:21.66324E	39:56:44.04610S	70:16:11.26613E	2.0	3.0
	Output	41:25:37.23971S	69:27:12.71895E								
test44	Locus 1 Inputs	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:00:29.47695S	70:20:48.75282E	41:56:04.38538S	68:22:07.56499E	-8.0	-9.0
	Locus 2 Inputs	43:29:17.80000S	68:11:50.60000E	39:55:35.80000S	68:11:50.60000E	43:29:16.97488S	68:25:34.80469E	39:55:34.91839S	68:26:08.51484E	10.0	11.0

	Output	41:52:35.54339S	68:25:50.12077E								
test45	Locus 1 Inputs	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:01:42.80403S	70:22:52.44969E	41:57:19.81081S	68:24:12.67104E	-10.0	-11.0
	Locus 2 Inputs	43:29:17.80000S	69:11:50.60000E	41:50:24.50000S	68:12:45.60000E	43:23:08.26920S	69:30:36.97906E	41:43:36.31250S	68:33:35.19449E	15.0	17.0
	Output	41:46:49.25922S	68:35:22.68060E								
test46	Locus 1 Inputs	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:44:05.62309S	71:35:48.62363E	42:39:04.17634S	69:34:51.53641E	-80.0	-78.0
	Locus 2 Inputs	43:29:17.80000S	69:11:50.60000E	41:45:07.50000S	66:11:50.60000E	42:55:41.16916S	69:46:17.72457E	41:10:04.65932S	66:49:24.86243E	42.0	45.0
	Output	N/A	N/A								
test47	Locus 1 Inputs	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:24:48.94167S	71:02:16.73937E	42:21:42.91321S	69:05:08.70917E	-48.0	-50.0
	Locus 2 Inputs	42:09:17.80000S	70:11:50.60000E	42:09:17.80000S	66:11:50.60000E	41:24:17.29349S	70:10:26.53430E	41:20:17.23054S	66:13:22.04429E	45.0	49.0
	Output	41:24:17.32470S	70:03:47.79505E								
test48	Locus 1 Inputs	39:55:35.80000S	70:12:34.70000E	41:50:24.50000S	68:12:45.60000E	40:50:05.06559S	71:46:21.29806E	42:51:59.99285S	69:57:19.49762E	-90.0	-99.0
	Locus 2 Inputs	42:29:17.80000S	69:11:50.60000E	44:01:17.80000S	66:11:50.60000E	41:48:42.56241S	68:32:33.37476E	43:15:31.54446S	65:29:49.92129E	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	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	40:11:24.54424N	70:12:45.60000W	40:06:30.74430N	65:51:59.39953W	-1.0	-1.0	
	Locus 2 Inputs	38:45:52.61565N	68:43:43.42897W	42:04:35.80000N	68:12:34.70000W	38:45:59.57764N	68:44:59.62433W	42:04:43.10740N	68:13:54.67112W	-1.0	-1.0	2.0
	Output	1	40:12:42.90980N	68:34:26.17064W	40:10:42.84203N	68:34:29.05890W	40:12:28.74286N	68:31:50.63189W				
test2	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	40:11:24.54424N	70:12:45.60000W	40:07:30.71740N	65:51:55.57562W	-1.0	-2.0	
	Locus 2 Inputs	38:45:52.61565N	68:43:43.42897W	42:04:35.80000N	68:12:34.70000W	38:46:06.52583N	68:46:15.82380W	42:04:43.10740N	68:13:54.67112W	-2.0	-1.0	2.0
	Output	1	40:13:05.94559N	68:35:07.04402W	40:11:05.86817N	68:35:09.12978W	40:12:51.19787N	68:32:31.58271W				
test3	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	40:09:24.45559N	70:12:45.60000W	40:04:30.79747N	65:52:07.04176W	1.0	1.0	
	Locus 2 Inputs	38:45:52.61565N	68:43:43.42897W	42:04:35.80000N	68:12:34.70000W	38:45:45.63986N	68:42:27.23774W	42:04:28.47712N	68:11:14.73398W	1.0	1.0	3.0
	Output	1	40:11:41.86765N	68:33:16.75939W	40:08:41.76592N	68:33:21.14059W	40:11:20.55656N	68:29:23.52219W				
test4	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	40:09:24.45559N	70:12:45.60000W	40:03:30.82374N	65:52:10.86008W	1.0	2.0	
	Locus 2 Inputs	38:45:52.61565N	68:43:43.42897W	42:04:35.80000N	68:12:34.70000W	38:45:38.65027N	68:41:11.05062W	42:04:28.47712N	68:11:14.73398W	2.0	1.0	2.0
	Outputs	1	40:10:16.88671N	68:31:25.71947W	40:08:16.83227N	68:31:29.47643W	40:10:03.24871N	68:28:50.19280W				
test5	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	40:11:24.54424N	70:12:45.60000W	40:06:30.74430N	65:51:59.39953W	-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	42:00:55.56489N	68:13:02.90937W	41:59:35.84742N	68:11:02.56225W	42:01:16.98268N	68:10:24.50096W				
test12	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	36:53:06.45688N	70:56:01.64236W	40:10:34.91946N	70:14:02.68842W	36:53:26.36762N	70:58:29.16009W	1.0	2.0	
	Locus 2 Inputs	37:29:19.58128N	71:54:04.49005W	40:04:35.80000N	69:12:34.70000W	37:28:05.07986N	71:52:06.21943W	40:03:57.19927N	69:11:34.83283W	2.0	1.0	2.0
	Outputs	1	38:53:33.20366N	70:29:18.12452W	38:53:54.26304N	70:31:49.44779W	38:52:17.75784N	70:27:18.54619W				
test13	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	41:46:39.60265N	74:04:18.29468W	40:08:40.49257N	70:14:03.84114W	41:45:46.34067N	74:04:55.27667W	-2.0	-1.0	
	Locus 2 Inputs	40:59:32.62580N	72:36:48.38318W	41:04:35.80000N	68:12:34.70000W	41:00:32.58502N	72:36:52.38181W	41:06:35.86947N	68:12:34.70000W	-1.0	-2.0	2.0
	Outputs	-1	40:59:45.33128N	72:06:21.69023W	40:58:00.36264N	72:07:38.62039W	41:01:45.25431N	72:06:29.56162W				
test14	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	43:02:23.57855N	67:56:26.25658W	40:09:24.43355N	70:10:30.05811W	43:01:52.20697N	67:55:16.51206W	2.0	1.0	
	Locus 2 Inputs	43:40:32.94322N	72:11:18.24139W	42:04:35.80000N	68:12:34.70000W	43:42:19.59129N	72:10:02.38529W	42:05:27.78065N	68:11:54.40631W	-2.0	-1.0	2.0
	Outputs	-1	42:12:06.97304N	68:32:37.78057W	42:13:08.44340N	68:34:56.48241W	42:13:50.86269N	68:31:16.86380W				
test15	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	39:30:57.68485N	65:58:09.51526W	40:11:23.63181N	70:12:32.00453W	39:32:54.83806N	65:57:35.35782W	-1.0	-2.0	
	Locus 2 Inputs	41:23:57.63585N	67:49:25.73753W	38:04:35.80000N	68:12:34.70000W	41:24:03.11784N	67:50:45.13238W	38:04:46.24310N	68:15:06.10222W	1.0	2.0	2.0
	Outputs	-1	39:51:21.55710N	68:04:58.82454W	39:53:19.41110N	68:04:28.85574W	39:51:10.29889N	68:02:23.68937W				
test16	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	40:05:30.77099S	65:52:03.22158W	40:11:24.54424S	70:12:45.60000W	40:07:30.71740S	65:51:55.57562W	1.0	2.0	
	Locus 2 Inputs	41:23:11.70467S	68:44:56.51207W	38:04:35.80000S	68:12:34.70000W	41:23:27.02365S	68:42:18.38698W	38:04:43.11348S	68:11:19.27704W	2.0	1.0	2.0
	Outputs	1	40:09:04.41861S	68:32:58.98277W	40:11:04.49607S	68:32:56.83433W	40:09:18.87549S	68:30:23.61882W				
test17	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	40:05:30.77099S	65:52:03.22158W	40:09:24.45559S	70:12:45.60000W	40:03:30.82374S	65:52:10.86008W	-1.0	-2.0	
	Locus 2	40:51:02.56824S	65:49:04.57909W	38:04:35.80000S	68:12:34.70000W	40:52:10.59442S	65:51:14.90408W	38:05:08.50946S	68:13:38.43618W	-2.0	-1.0	2.0

	Inputs											
	Outputs	1	40:03:14.47849S	66:37:33.38495W	40:05:14.44565S	66:37:26.29402W	40:02:07.80789S	66:35:23.42243W				
test18	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	43:30:29.87690S	70:12:45.60000W	40:10:24.47060S	70:10:09.05140W	43:30:29.86864S	70:11:23.15209W	-2.0	-1.0	
	Locus 2 Inputs	40:56:44.38623S	70:24:30.08251W	38:04:35.80000S	68:12:34.70000W	40:56:13.10174S	70:25:37.65728W	38:03:35.71346S	68:14:46.28392W	-1.0	-2.0	3.0
	Outputs	1	40:25:56.59723S	70:06:18.82840W	40:25:55.84892S	70:10:14.54714W	40:27:29.08986S	70:02:56.51901W				
test19	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	43:29:41.80326S	69:48:49.55137W	40:10:34.93724S	70:15:21.55954W	43:29:47.30291S	69:50:11.63525W	2.0	1.0	
	Locus 2 Inputs	40:46:58.96510S	70:43:33.36104W	38:04:35.80000S	68:12:34.70000W	40:47:34.75534S	70:42:29.93966W	38:05:44.68644S	68:10:30.17729W	1.0	2.0	2.0
	Outputs	1	40:13:25.07866S	70:12:23.80009W	40:13:36.12195S	70:14:59.80379W	40:14:36.57101S	70:10:17.90579W				
test20	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	42:41:33.37650S	67:18:27.47257W	40:09:07.29111S	70:10:45.71453W	42:40:53.27207S	67:17:26.94763W	-2.0	-1.0	
	Locus 2 Inputs	41:23:57.63585S	68:49:25.73753W	38:04:35.80000S	69:12:34.70000W	41:24:03.11784S	68:50:45.13238W	38:04:46.24310S	69:15:06.10222W	-1.0	-2.0	3.0
	Outputs	1	41:11:40.44578S	68:56:19.65774W	41:13:37.47945S	68:59:20.93278W	41:11:23.24899S	68:52:22.32154W				
test21	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	37:24:53.77602S	67:48:48.29235W	40:11:33.36017S	70:10:37.32686W	37:25:26.92444S	67:47:45.47885W	2.0	1.0	
	Locus 2 Inputs	40:23:45.26180S	71:17:39.82870W	38:04:35.80000S	68:12:34.70000W	40:22:17.49277S	71:19:27.00296W	38:03:53.32348S	68:13:28.42249W	-2.0	-1.0	2.0
	Outputs	-1	38:19:04.22608S	68:29:21.21374W	38:17:57.68753S	68:31:28.14715W	38:17:38.59151S	68:31:08.12837W				
test22	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	37:35:08.04987S	67:31:03.26743W	40:09:07.29111S	70:14:45.48547W	37:34:30.80862S	67:32:02.49205W	-2.0	-1.0	
	Locus 2 Inputs	41:21:34.31610S	67:26:28.97088W	38:04:35.80000S	68:12:34.70000W	41:21:12.42483S	67:23:52.29253W	38:04:25.36303S	68:11:19.87010W	2.0	1.0	2.0
	Outputs	1	38:11:04.15943S	68:12:22.74671W	38:12:19.77140S	68:10:24.46167W	38:10:42.67713S	68:09:53.00775W				
test23	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	43:27:18.01078S	71:00:24.95285W	40:10:14.06628S	70:14:02.68187W	43:26:56.04570S	71:03:06.91312W	1.0	2.0	
	Locus 2 Inputs	42:35:45.27780S	72:06:36.63038W	40:04:35.80000S	69:12:34.70000W	42:37:05.45079S	72:04:35.69054W	40:05:14.39206S	69:11:34.81405W	2.0	1.0	2.0

	Outputs	1	41:09:00.28976S	70:25:29.09105W	41:08:38.53506S	70:28:05.30341W	41:10:18.25757S	70:23:28.27022W				
test24	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	38:26:46.46774S	73:53:15.48461W	40:12:08.49221S	70:14:03.90752W	38:27:37.21779S	73:53:56.33533W	-2.0	-1.0	
	Locus 2 Inputs	38:59:53.21474S	73:29:12.95994W	39:04:35.80000S	69:12:34.70000W	38:58:53.22454S	73:29:09.34242W	39:02:35.68826S	69:12:34.70000W	-1.0	-2.0	2.0
	Outputs	-1	39:02:21.67793S	72:38:46.91955W	39:04:03.70982S	72:40:08.19904W	39:00:21.62999S	72:38:41.87165W				
test25	Locus 1 Inputs	40:10:24.50000S	70:12:45.60000W	37:15:52.75197S	68:07:31.78007W	40:11:24.52218S	70:10:29.99173W	37:16:21.59037S	68:06:25.83960W	2.0	1.0	
	Locus 2 Inputs	36:21:10.67774S	71:47:01.13406W	38:04:35.80000S	68:12:34.70000W	36:19:28.94358S	71:45:42.08355W	38:03:43.77956S	68:11:56.71384W	-2.0	-1.0	2.0
	Outputs	-1	37:57:02.69588S	68:31:21.63789W	37:56:05.07632S	68:33:34.74930W	37:55:19.15511S	68:30:04.71414W				
test26	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	40:05:30.77099S	72:33:27.97842E	40:11:24.54424S	68:12:45.60000E	40:07:30.71740S	72:33:35.62438E	1.0	2.0	
	Locus 2 Inputs	41:23:11.70467S	69:40:12.88793E	38:04:35.80000S	70:12:34.70000E	41:23:27.02365S	69:42:51.01302E	38:04:43.11348S	70:13:50.12296E	2.0	1.0	2.0
	Outputs	1	40:09:04.64798S	69:52:10.38091E	40:11:04.72555S	69:52:12.51866E	40:09:19.10487S	69:54:45.74500E				
test27	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	40:05:30.77099S	72:33:27.97842E	40:09:24.45559S	68:12:45.60000E	40:03:30.82374S	72:33:20.33992E	-1.0	-2.0	
	Locus 2 Inputs	40:51:02.56824S	72:36:04.82091E	38:04:35.80000S	70:12:34.70000E	40:52:10.59442S	72:33:54.49592E	38:05:08.50946S	70:11:30.96382E	-2.0	-1.0	2.0
	Outputs	1	40:03:15.21615S	71:47:36.65550E	40:05:15.18367S	71:47:43.73613E	40:02:08.54536S	71:49:46.61823E				
test28	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	43:30:29.87690S	68:12:45.60000E	40:10:24.47060S	68:15:22.14860E	43:30:29.86864S	68:14:08.04791E	-2.0	-1.0	
	Locus 2 Inputs	40:56:44.38623S	68:00:39.31749E	38:04:35.80000S	70:12:34.70000E	40:56:13.10174S	67:59:31.74272E	38:03:35.71346S	70:10:23.11608E	-1.0	-2.0	3.0
	Outputs	1	40:25:28.59897S	68:19:12.51023E	40:25:27.85071S	68:15:16.81863E	40:27:01.08104S	68:22:34.80466E				
test29	Locus 1 Inputs	40:10:24.50000S	68:12:45.60000E	43:29:41.80326S	68:36:41.64863E	40:10:34.93724S	68:10:09.64046E	43:29:47.30291S	68:35:19.56475E	2.0	1.0	
	Locus 2 Inputs	40:46:58.96510S	67:41:36.03896E	38:04:35.80000S	70:12:34.70000E	40:47:34.75534S	67:42:39.46034E	38:05:44.68644S	70:14:39.22271E	1.0	2.0	2.0
	Outpu	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
	Outpu ts	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
	Outpu ts	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
	Outpu ts	-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
	Outpu ts	-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

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	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	309.31753	0.64273	42:05:00.24258N	68:13:14.76673W								
test2	Inputs	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	129.31753	1.35727	42:03:44.17073N	68:11:10.11749W								
test3	Inputs	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	129.60401	2.08646	42:03:15.94272N	68:10:25.22603W								
test4	Inputs	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	309.03106	1.37192	42:05:27.64952N	68:14:00.58323W								
test5	Inputs	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	153.01195	57.96492	41:12:49.81350N	67:37:43.49832W								
test6	Inputs	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	65:52:03.22158W	40:08:24.41100N	70:12:45.60000W	40:04:30.79747N	65:52:07.04176W	2.0	1.0	42:04:35.80000N	68:12:34.70000W
	Outputs	181.00609	116.68342	40:07:51.80394N	68:15:14.93906W								
test7	Inputs	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	218.31689	143.82663	40:10:41.23180N	70:08:54.51269W								
test8	Inputs	40:10:24.50000N	70:12:45.60000W	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	40:04:35.80000N	69:12:34.70000W
	Outputs	240.93040	38.37214	39:45:48.10411N	69:56:04.27064W								
test9	Inputs	40:10:24.50000N	70:12:45.60000W	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	42:04:35.80000N	68:12:34.70000W
	Outputs	283.05132	65.25203	42:18:48.35558N	69:38:15.57457W								

test10	Inputs	40:10:24.50000N	70:12:45.60000W	43:30:29.87690N	70:12:45.60000W	40:10:24.47060N	70:10:09.05140W	43:30:29.86864N	70:11:23.15209W	2.0	1.0	42:04:35.80000N	68:12:34.70000W
	Outputs	271.05601	88.06612	42:05:12.28968N	70:10:50.66239W								
test11	Inputs	40:10:24.50000N	70:12:45.60000W	43:29:41.80326N	70:36:41.64863W	40:10:19.25950N	70:14:03.57478W	43:29:30.75486N	70:39:25.80395W	-1.0	-2.0	42:04:35.80000N	68:12:34.70000W
	Outputs	266.05671	100.72052	41:56:20.94047N	70:27:13.96006W								
test12	Inputs	40:10:24.50000N	70:12:45.60000W	42:10:25.78109N	73:44:43.81529W	40:11:11.81273N	70:11:57.40023W	42:11:14.53862N	73:43:56.74833W	1.0	1.0	42:04:35.80000N	69:12:34.70000W
	Outputs	218.66979	116.72692	40:32:44.27479N	70:48:14.72623W								
test13	Inputs	40:10:24.50000N	70:12:45.60000W	36:50:12.19034N	70:12:45.60000W	40:10:24.49265N	70:11:27.32569W	36:50:12.16424N	70:10:16.11397W	-1.0	-2.0	38:04:35.80000N	72:12:34.70000W
	Outputs	88.48154	96.22417	38:06:05.77988N	70:10:42.38354W								
test14	Inputs	40:10:24.50000N	70:12:45.60000W	37:58:59.08359N	73:26:32.36055W	40:11:56.48089N	70:14:26.26527W	37:59:43.69324N	73:27:23.18593W	2.0	1.0	38:04:35.80000N	72:12:34.70000W
	Outputs	318.44031	35.88843	38:31:24.84927N	72:42:54.95851W								
test15	Inputs	40:10:24.50000N	70:12:45.60000W	40:05:30.77099N	74:33:27.97842W	40:08:24.41100N	70:12:45.60000W	40:04:30.79747N	74:33:24.15824W	-2.0	-1.0	38:04:35.80000N	72:12:34.70000W
	Outputs	358.99772	123.10364	40:07:47.67496N	72:15:23.10907W								
test16	Inputs	20:10:24.50000N	70:12:45.60000W	22:47:42.88332N	67:59:32.62915W	20:11:01.57566N	70:13:35.86376W	22:48:20.61693N	68:00:23.22901W	-1.0	-1.0	22:04:35.80000N	68:12:34.70000W
	Outputs	308.72881	18.49323	22:16:11.68878N	68:28:07.95660W								
test17	Inputs	20:10:24.50000N	70:12:45.60000W	22:47:42.88332N	67:59:32.62915W	20:09:47.42031N	70:11:55.34284W	22:47:05.14519N	67:58:42.03703W	1.0	1.0	22:04:35.80000N	68:12:34.70000W
	Outputs	308.72881	16.49323	22:14:56.50252N	68:26:26.90385W								
test18	Inputs	20:10:24.50000N	70:12:45.60000W	22:47:42.88332N	67:59:32.62915W	20:09:47.42031N	70:11:55.34284W	22:46:27.40256N	67:57:51.45264W	1.0	2.0	22:04:35.80000N	68:12:34.70000W
	Outputs	309.01529	15.69835	22:14:30.29919N	68:25:43.56946W								
test19	Inputs	20:10:24.50000N	70:12:45.60000W	22:47:42.88332N	67:59:32.62915W	20:11:01.57566N	70:13:35.86376W	22:48:58.34604N	68:01:13.83660W	-1.0	-2.0	22:04:35.80000N	68:12:34.70000W
	Outputs	308.44233	19.28768	22:16:37.00430N	68:28:51.98766W								
test20	Inputs	20:10:24.50000N	70:12:45.60000W	21:42:55.04997N	67:03:07.16284W	20:11:17.67400N	70:13:15.54639W	21:44:42.47168N	67:04:05.42224W	-1.0	-2.0	22:04:35.80000N	68:12:34.70000W
	Outputs	152.41757	46.88028	21:22:52.16995N	67:49:19.19587W								
test21	Inputs	20:10:24.50000N	70:12:45.60000W	20:08:16.10563N	66:40:11.24376W	20:08:24.05152N	70:12:45.60000W	20:07:15.89488N	66:40:12.60255W	2.0	1.0	22:04:35.80000N	68:12:34.70000W
	Outputs	180.40439	115.88931	20:08:17.39840N	68:13:26.84791W								
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	19:59:44.51317N	69:54:16.80106W								
test23	Inputs	20:10:24.50000N	70:12:45.60000W	17:16:01.61500N	68:28:18.10827W	20:09:54.38551N	70:13:40.83341W	17:15:02.38476N	68:30:07.30583W	1.0	2.0	20:04:35.80000N	69:12:34.70000W
	Outputs	240.62790	47.41380	19:41:09.80503N	69:56:21.99784W								
test24	Inputs	20:10:24.50000N	70:12:45.60000W	23:26:37.86400N	69:27:33.93765W	20:10:37.01823N	70:13:47.98905W	23:27:03.45735N	69:29:41.45246W	-1.0	-2.0	22:04:35.80000N	68:12:34.70000W
	Outputs	282.46352	87.05417	22:23:01.23192N	69:44:17.95270W								
test25	Inputs	20:10:24.50000N	70:12:45.60000W	23:31:06.93560N	70:12:45.60000W	20:10:24.48716N	70:10:38.03712W	23:31:06.93179N	70:11:40.31639W	2.0	1.0	22:04:35.80000N	68:12:34.70000W
	Outputs	270.46647	110.19089	22:04:46.78090N	70:11:13.20586W								
test26	Inputs	20:10:24.50000N	70:12:45.60000W	23:30:20.06967N	70:31:42.81974W	20:10:19.24793N	70:13:49.13814W	23:30:09.31498N	70:33:52.85078W	-1.0	-2.0	22:04:35.80000N	68:12:34.70000W
	Outputs	265.46611	122.69379	21:53:59.00085N	70:24:06.45107W								
test27	Inputs	20:10:24.50000N	70:12:45.60000W	22:12:35.69228N	73:02:34.77881W	20:11:11.95601N	70:12:06.32892W	22:13:23.79135N	73:01:55.88211W	1.0	1.0	22:04:35.80000N	69:12:34.70000W
	Outputs	218.36943	123.21147	20:27:18.81236N	70:34:01.01617W								
test28	Inputs	20:10:24.50000N	70:12:45.60000W	16:49:37.49349N	70:12:45.60000W	20:10:24.49679N	70:11:41.81856W	16:49:37.48292N	70:10:40.49187W	-1.0	-2.0	18:04:35.80000N	72:12:34.70000W
	Outputs	89.09350	115.76556	18:05:47.86911N	70:11:03.51621W								
test29	Inputs	20:10:24.50000N	70:12:45.60000W	18:00:09.46178N	72:53:29.02106W	20:11:56.76327N	70:14:07.60925W	18:00:55.00817N	72:54:10.22384W	2.0	1.0	18:04:35.80000N	72:12:34.70000W
	Outputs	319.05008	23.26620	18:22:13.64861N	72:28:36.69646W								
test30	Inputs	20:10:24.50000N	70:12:45.60000W	20:08:16.10563N	73:45:19.95624W	20:08:24.05152N	70:12:45.60000W	20:07:15.89488N	73:45:18.59745W	-2.0	-1.0	18:04:35.80000N	72:12:34.70000W
	Outputs	359.59765	123.21213	20:08:16.82998N	72:13:29.86100W								

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 s 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
test2	40:04:35.	73:12:34.	240.0	40:10:24.	70:12:45.	50.	38:39:26.	70:09:47.	39:31:32.	71:59:30.	39:43:45.	69:17:44.	40:36:38.	71:08:28.

1	80000N	70000E		50000N	60000E	0	28959N	67412E	39864N	22696E	18199N	08525E	84939N	77660E
test22	42:54:35.80000N	70:11:34.70000E	180.0	40:10:24.50000N	70:12:45.60000E	50.0	39:20:22.07307N	70:11:34.70000E	41:00:26.50523N	70:11:34.70000E	39:20:22.06721N	70:12:44.75738E	41:00:26.49902N	70:12:46.49381E
test23	42:54:35.80000N	70:11:34.70000E	148.0	40:10:24.50000N	70:12:45.60000E	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
test24	42:54:35.80000N	70:11:34.70000E	211.0	40:10:24.50000N	70:12:45.60000E	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
test25	40:24:35.80000N	65:11:34.70000E	90.0	40:10:24.50000N	70:12:45.60000E	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
test26	40:24:35.80000N	65:11:34.70000E	71.0	40:10:24.50000N	70:12:45.60000E	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
test27	40:24:35.80000N	65:11:34.70000E	117.0	40:10:24.50000N	70:12:45.60000E	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
test28	37:09:35.80000N	70:21:34.70000E	0.0	40:10:24.50000N	70:12:45.60000E	50.0	41:00:26.84065N	70:21:34.70000E	39:20:22.39722N	70:21:34.70000E	41:00:26.49479N	70:12:38.92986E	39:20:22.07107N	70:12:51.88818E
test29	37:09:35.80000N	70:21:34.70000E	31.0	40:10:24.50000N	70:12:45.60000E	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
test30	37:09:35.80000N	70:21:34.70000E	331.0	40:10:24.50000N	70:12:45.60000E	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
test31	40:14:35.80000S	76:12:34.70000E	350.0	40:10:24.50000S	70:12:45.60000E	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
test32	40:04:35.80000S	75:12:34.70000E	200.0	40:10:24.50000S	70:12:45.60000E	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
test33	40:04:35.80000S	72:12:34.70000E	315.0	40:10:24.50000S	70:12:45.60000E	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
test34	40:04:35.80000S	73:12:34.70000E	270.0	40:10:24.50000S	70:12:45.60000E	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
test35	40:04:35.80000S	73:12:34.70000E	300.0	40:10:24.50000S	70:12:45.60000E	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
test36	40:04:35.80000S	73:12:34.70000E	240.0	40:10:24.50000S	70:12:45.60000E	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
test37	38:04:35.80000S	70:11:34.70000E	180.0	40:10:24.50000S	70:12:45.60000E	50.0	41:00:26.50523S	70:11:34.70000E	39:20:22.07307S	70:11:34.70000E	41:00:26.49902S	70:12:46.49381E	39:20:22.06721S	70:12:44.75738E
test38	38:04:35.80000S	70:11:34.70000E	148.0	40:10:24.50000S	70:12:45.60000E	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
test39	38:04:35.80000S	70:11:34.70000E	211.0	40:10:24.50000S	70:12:45.60000E	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
test40	40:24:35.80000S	65:51:34.70000E	90.0	40:10:24.50000S	70:12:45.60000E	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
test41	40:24:35.80000S	65:51:34.70000E	71.0	40:10:24.50000S	70:12:45.60000E	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
test42	40:24:35.80000S	65:51:34.70000E	117.0	40:10:24.50000S	70:12:45.60000E	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
test43	43:09:35.80000S	69:38:25.30000E	0.0	40:10:24.50000S	70:12:45.60000E	50.0	39:20:27.07217S	69:38:25.30000E	41:00:31.67824S	69:38:25.30000E	39:20:22.12663S	70:12:21.11372E	41:00:26.43381S	70:13:11.57361E
test44	43:09:35.80000S	69:38:25.30000E	34.0	40:10:24.50000S	70:12:45.60000E	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
test45	43:09:35.80000S	69:38:25.30000E	335.0	40:10:24.50000S	70:12:45.60000E	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

test46	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
test47	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
test48	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
test49	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
test50	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
test51	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
test52	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
test53	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
test54	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
test55	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
test56	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
test57	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
test58	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
test59	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
test60	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

The following individuals contributed to this Appendix:
Alan Jones, AFS-420
Dr. Michael Mills, The MITRE Corporation
Dr. Richard Snow, The MITRE Corporation
M. Jane Henry, Innovative Solutions International, Inc.
Dr. Dave Stapleton, Innovative Solutions International, Inc.

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: ________________

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