CHANGE **U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION

8260.42B
CHG 1

National Policy

Effective Date:
11/20/2012

SUBJ: United States Standard for Helicopter Area Navigation (RNAV)

1. Purpose. This change incorporates new Helicopter Departure and Localizer Precision with Vertical (HLPV) criteria. Order 8260.42B contains criteria for the formulation, review, approval, and publication of area navigation (RNAV) helicopter instrument procedures based on Global Positioning System (GPS) and Wide Area Augmentation System (WAAS) navigation.

2. Audience. The primary audience for this Order is the Air Traffic Organization (ATO), Mission Support Services (MSS), Aeronautical Navigation Products Office (AeroNav Products), who has the responsibility to develop instrument flight procedures. The secondary audience includes the ATO MSS Aeronautical Information Management (AIM) Office (AJV-2), ATO Service Areas' Operational Support Group, Flight Procedures Team (OSG-FPT), Air Traffic's Technical Operations Aviation System Standards Office (AJW-3); Flight Standards headquarters, and regional office Divisions/Branches.

3. Where You Can Find This Change. You can find this order on the Directives Management System (DMS) Website: http://www.faa.gov/regulations_policies/orders_notices.

4. Explanation of Changes. Significant areas of new direction, guidance, policy, and criteria as follows:

Note: General. All references to FAA Orders 8260.52, United States Standard for Required Navigation Performance (RNP) Approach Procedures with Special Aircraft and Aircrew Authorization Required (SAAAR), and 8260.54A, The United States Standard for Area Navigation, are now found in FAA Order 8260.58, United States Standard for Performance Based Navigation (PBN) Instrument Procedure Design.

a. Table of Contents. Updated Table of Contents to coincide with the pages changed.

b. Chapter 1. Added further explanation regarding “automation” to include the use of the calculators embedded in this order and the geodetic calculator available on the AFS-420 web site, or CompSys 21 geodetic calculator available on the AeroNav Products web site, or Instrument Approach Procedure Automation/Instrument Procedures Development System (IAPA/IPDS), or other AFS-420 approved geodetic calculator.

c. Chapter 2.

(1) Paragraph 2. Added use of "rounding."

(2) Paragraph 2b. Updated Mathematics Convention to include feet per nautical mile (fpnm).

d. Chapter 6. Added Helicopter Departure criteria. This chapter describes RNAV departure criteria describing a visual departure from a non-instrument flight rules (IFR) departure location to an Initial Departure Fix to join with the IFR portion of the departure. This includes both public and special departure criteria.

e. Chapter 8. Added Helicopter Localizer Precision with Vertical (HLPV) criteria. This chapter describes the development of the HLPV Approach to a Point in Space and the initial missed approach segment.

f. Appendix C. Added new definitions to support new criteria in chapters 6 and 8.

John M. Allen

John M. Allen
Director, Flight Standards Service

PAGE CONTROL CHART

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
National Policy

ORDER 8260.42B

Effective Date:
March 10, 2009

SUBJ: United States Standard for Helicopter Area Navigation (RNAV)

These criteria are the Federal Aviation Administration (FAA) standards for developing helicopter area navigation (RNAV) instrument procedure construction based on Global Positioning System (GPS). This revision adds definitions, changes procedure identification from GPS to RNAV, provides specific holding pattern leg lengths, helicopter en route criteria, decreases navigation system error tolerance for along-track distance in the terminal area, and adds departure criteria, minimums, and requirements. The types of final approaches have been revised. They are Instrument Flight Rules (IFR) to an IFR heliport, IFR to a Visual Flight Rules (VFR) heliport (Proceed Visually), Point-in-Space (PinS) approach (Proceed VFR), and IFR to Runways with separate criteria for each.

The first step to increase helicopter IFR utility is the development of helicopter RNAV instrument procedures. Ongoing testing and criteria development by the FAA for application of the Wide Area Augmentation System (WAAS) will provide the next major step. WAAS with its increased integrity and 3-dimensional (3D) approach capability will allow narrower route widths and approaches with vertical guidance (APV).

Original Signed by

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Director
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Initiated By: AFS-420

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Chapter 1. General Information

1. Purpose of This Order. This order contains criteria for the formulation, review, approval, and publication of area navigation (RNAV) helicopter instrument procedures based on Global Positioning System (GPS) and Wide Area Augmentation System (WAAS) navigation.

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

3. Where Can I Find This Order? This information is also available on the FAA's Web site at http://www.faa.gov/regulations_policies/orders_notices

4. What This Order Cancels. Order 8260.42A, Helicopter Global Positioning System (GPS) Nonprecision Approach Criteria.

5. Explanation of Policy Changes. This document has been completely revised for harmonization with FAA Order 8260.54, The United States Standard for Area Navigation (RNAV), incorporation of criteria policy documents, and to meet FAA Order 1320.1, FAA Directives Management, formatting requirements. These criteria were written for automated implementation through the use of the calculators embedded in the document, AFS-420 geodetic calculator, Compsys 21 geodetic calculator, Instrument Approach Procedure Automation/ Instrument Procedures Development System (IAPA/IPDS), or other AFS-400 approved geodetic calculation products. 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.

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Chapter 2. General Criteria

Section 1. Basic Criteria Information

2-1. General. These criteria assume use of Global Positioning System (GPS) or Wide Area Augmentation System (WAAS) receivers approved for approach operations, in accordance with Advisory Circular (AC) 20-138, Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment; Technical Standard Order (TSO) C-129 Class A (1) systems; and AC 20-130, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, for GPS as part of a multi-sensor system meeting TSO-C129 Class C (1) System or pertinent military guidance. Advisory Circular (AC) 20-138C, Airworthiness Approval of Positioning and Navigation Systems, and Technical Standard Order (TSO) C196A, Airborne Supplemental Navigation Sensors for Global Positioning System Equipment using Aircraft-Based Augmentation, contain updated Airworthiness guidance. WAAS navigation equipment must be approved in accordance with the requirements specified in TSO-C145, Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS), or TSO-C146, Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).

Unless otherwise specified, Order 8260.3, United States Standard for Terminal Instrument Procedures (TERPS), applies. For public use procedures, the heliport must meet the guidance contained in AC 150/5390-2, Heliport Design. Obstacle clearance area dimensions are based on 90 knots indicated airspeed (KIAS) maximum in the initial and intermediate segments and 70 KIAS maximum in the final and missed approach segments until passing the missed approach holding fix. USA/USAF/USN/USCG only: procedures are designed for 90 KIAS in the final and missed approach segments.

The following FAA orders apply:

- 7130.3, Holding Pattern Criteria.
- 8260.3, United States Standard for Terminal Instrument Procedures (TERPS).
- 8260.19, Flight Procedures and Airspace.

Apply chapter 2, section 3 of Order 7130.3, Holding Pattern Criteria. Use pattern 4 for all helicopter holding (including climb-in-hold) up to and including 10,000 ft. Chart 4 nautical mile (NM) leg lengths.

The feeder, initial, intermediate, final, and missed approach criteria described in this order supersede the other publications listed above. See Order 8260.3, Volume 1, chapter 3 to determine visibility minima.

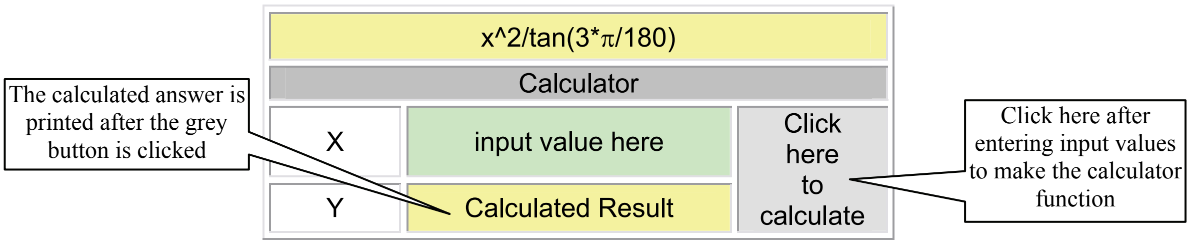
Formulas are numbered by chapter and depicted in standard mathematical notation and in standard text to aid in computer programming. Each formula contains a java script functional calculator.

Formula X-X. Formula Title

$$Y = \frac{X^2}{\tan\left(3 \cdot \frac{\pi}{180}\right)}$$

Formula in math notation

where X = variable value



2-2. 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. Unless otherwise noted, 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.

a. Documentation Accuracy:

(1) 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) Flight Path Alignment Point (FPAP) mean sea level (MSL) elevation to the nearest foot;

(3) FPAP height above ellipsoid (HAE) to the nearest tenth (0.1) meter;

(4) Glidepath angle to the next higher one hundredth (0.01) degree;

(5) Courses to the nearest one hundredth (0.01) degree;

(6) Course width at threshold to the nearest quarter (0.25) meter; and

(7) 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].

b. 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:

$$fpnm = \frac{1852}{0.3048}$$

(1) 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) Definition of Mathematical Functions and Constants:

a+b indicates addition

a-b indicates subtraction

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

In(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 2.718281828459045235360287471352662497757...

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

(3) 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

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

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

Notes on calculator usage:

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

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

c. Geospatial Standards. The following standards apply to the evaluation of obstacle and terrain position and elevation data relative to RNAV OEAs and OCSs. 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.

(1) 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 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) 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).

d. OEA Construction and Obstacle Evaluation Methodology.

(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 B).

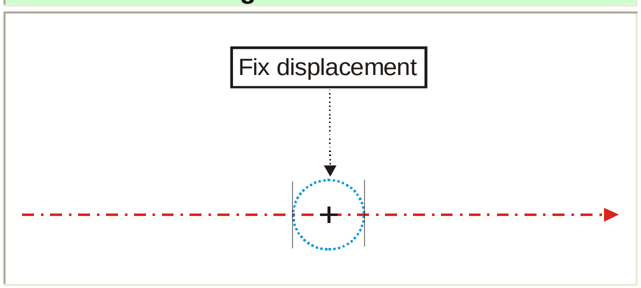
(2) Elevations (vertical dimension). Evaluate obstacles, terrain, and airport data using their elevation relative to their orthometric height above the geoid (for our purposes, MSL) referenced to the NAVD-88 vertical datum. The elevations of OCSs are determined spherically relative to their origin MSL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

e. 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 the FAA regional Flight Procedures Office (FPO**)** to verify the height value to use.

f. 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** Feeder, Initial, Intermediate, Missed Approach > 30 NM)	2.0 NM
	Terminal Feeder, Initial, Intermediate, Missed Approach ≤ 30 NM)	1.0 NM
	Approach (final)	0.3 NM
WAAS* (LP)	**Approach** (final)	40 meters

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

3. Procedure Identification. GPS and WAAS are considered to be RNAV systems. The procedure identification begins with "COPTER RNAV (GPS)." The remainder of the identification is based on whether the landing site is a heliport or a runway.

a. U.S. Army (USA) Helicopter Runways. USA heliports that have helicopter runways chart the procedure with the letter H and the runway number. To differentiate between parallel runways, use the letter "L" or "R"; i.e., COPTER RNAV (GPS) RWY H22R.

b. IFR Approach to an IFR Runway (within 30 degrees alignment). Use the abbreviation "RWY" followed by the runway number. Examples: COPTER RNAV (GPS) RWY 22.

c. Point-in-Space (PinS) or IVH procedures to a VFR Runway. Use the magnetic bearing of the final approach course. Example: COPTER RNAV (GPS) 160°.

d. Multiple Procedures to the Same Runway. Where more than one approach, using the same final approach guidance is developed to the same location, identify each location/guidance combination with an alphabetical suffix beginning at the end of the alphabet; e.g., COPTER RNAV (GPS) Z RWY 22 (first procedure), COPTER RNAV (GPS) Y RWY 22 (second procedure), COPTER RNAV (GPS) X RWY 22 (third procedure). Identify the procedure with the lowest minimums will be identified with "Z" and the next lowest "Y."

e. Special Approach Procedures. A procedure requires special authorization when it is an instrument flight rules (IFR) approach to a visual flight rules (VFR) heliport, reference chapter 4, paragraph 5, or one of the following conditions exists: (USAF/USA/USCG/USN not applicable).

(1) A track change at the precise final approach fix (PFAF) exceeds 30 degrees.

(2) Descent Gradient/Angle exceeds 600 ft/NM (5.64 degrees) on any IFR segment.

(3) When raising the helipoint crossing height (HCH) to greater than 10 ft in the visual segment.

(4) When a V_{mini} less than 70 knots indicated airspeed (KIAS) is applied.

(5) Where a bank angle other than the standard is used.

(6) When the missed approach point (MAP) to helipoint distance is less than 3,342 ft (0.55 NM).

Note: This criterion applies only to an IFR to a VFR heliport (IVH) procedure.

4. 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 (HRP), segment primary area width increases (expansion) or decreases (taper) at a rate of 30 degrees relative to course to the appropriate width. 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. 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 HRP is “1-3-3-1.” See figures 2-2b and 2-2c. For distances ≤ 30 NM, the width is “0.5-1.5-1.5-0.5.” See table 2-2 and figure 2-2a.

***Note:** Feeder segment width is 1-3-3-1 at all distances greater than 30 NM from HRP. A segment designed to cross within 30 NM of the HRP 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 HRP more than once expands when it crosses the boundary the first time and remains expanded.

<table>
<tr><th colspan="4">Table 2-2. RNAV Linear Segment Width (NM) Values.</th></tr>
<tr><th colspan="2">Segment</th><th>Primary Area Half-Width (p)</th><th>Secondary Area (s)</th></tr>
<tr><td rowspan="2">En Route, Feeder, Initial & Missed Approach</td><td rowspan="2">> 30 NM from ARP</td><td>± 3.00</td><td>1.00</td></tr>
<tr><td colspan="2">1-3-3-1</td></tr>
<tr><td rowspan="2">Feeder, Initial, Missed Approach</td><td rowspan="2">≤ 30 NM from ARP</td><td>± 1.50</td><td>0.5</td></tr>
<tr><td colspan="2">0.5-1.5-1.5-0.5</td></tr>
<tr><td colspan="2">Intermediate</td><td>Continues initial segment width until 2 NM prior to PFAF. Then tapers uniformly to final segment width.</td><td>Continues initial segment width until 2 NM prior to PFAF. Then tapers to final segment width.</td></tr>
</table>

Figure 2-2a. Segment Width Variables.

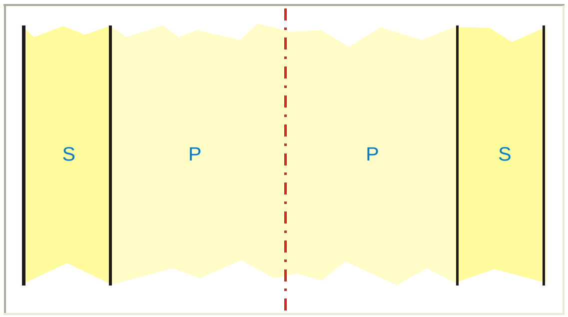


Figure 2-2b. En Route/Feeder/Initial Segment Cross Section (> 30 NM).

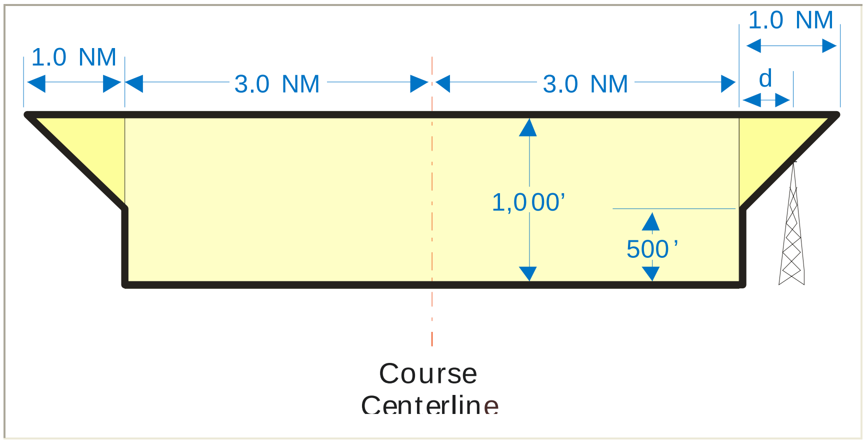
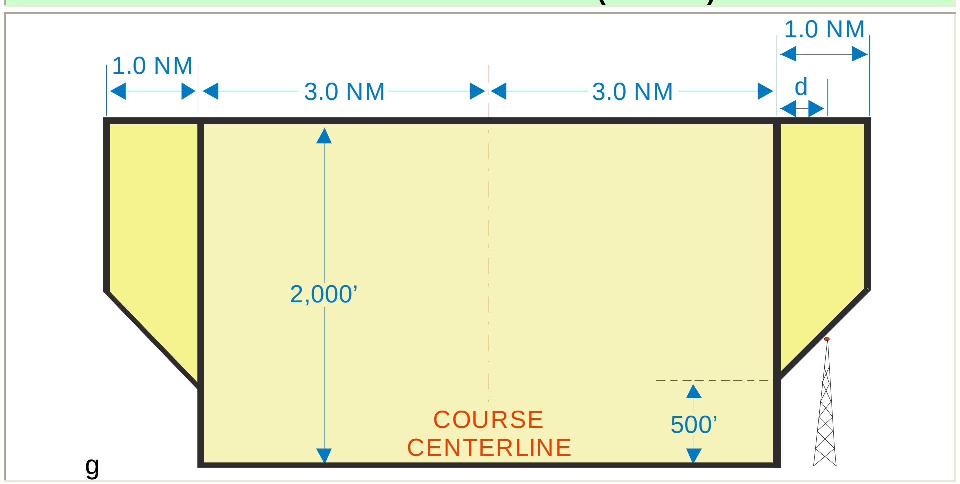


Figure 2-2c. En Route/Feeder/Initial Segment Cross Section Mountainous (> 30 NM).

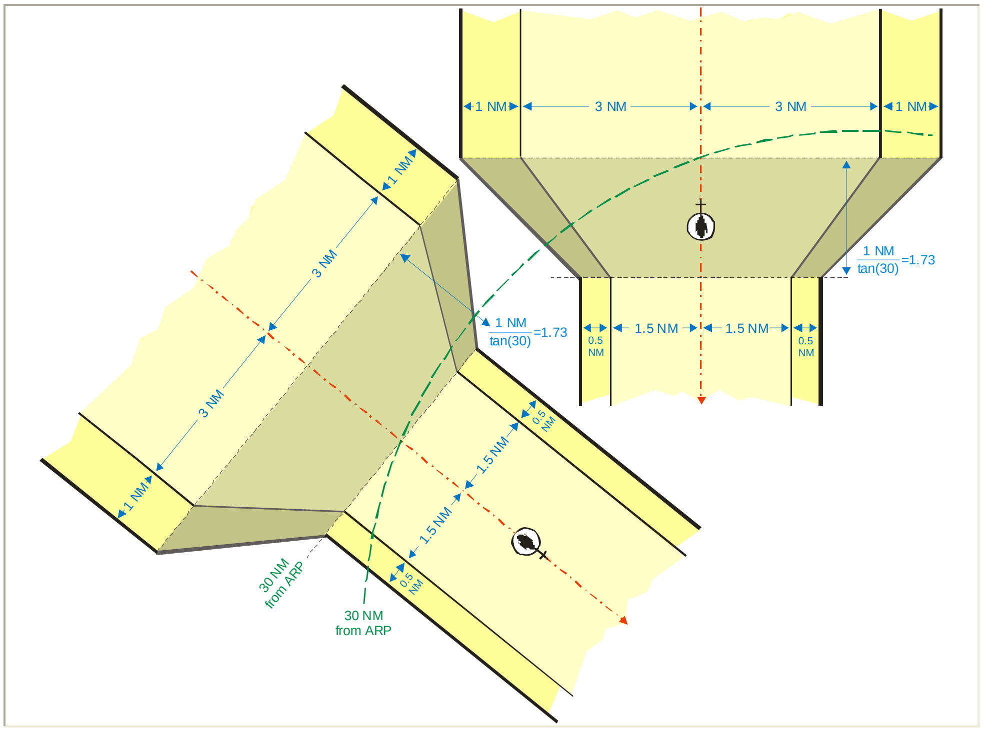


a. Width Changes at 30 NM from HRP/ARP.

(1) Width Changes at 30 NM from HRP (non-RF). Receiver sensitivity changes at 30 NM from HRP. From the point the designed course crosses 30 NM from HRP, the primary

OEA can taper inward at a rate of 30 degrees relative to course from ± 3 NM to ± 1.5 NM. The secondary area tapers from a 1 NM width when the 30 NM point is crossed to a 0.5 NM width abeam the point the primary area reaches the ± 1.5 NM width. The total along-track distance required to complete the taper is approximately 1.73 NM (10,524.14 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 (see figure 2-3a).

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



(2) Width Changes at 30 NM from HRP/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 1-3-3-1 prior to the 30 NM point and taper to 0.5-1.5-1.5-0.5 NM width inside 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, apply formula 2-3c to find the RF arc radius).

Formula 2-1. RF Segment Taper Width.

$$D=\frac{3-1.5}{\tan\left(30\cdot\frac{\pi}{180}\right)} \qquad \alpha=\frac{180\cdot D}{\pi\cdot R}$$

Calculates degrees of arc (α) to complete taper

$$B_{primary}=3-1.5\cdot\frac{\phi\cdot\pi\cdot R}{180\cdot D}$$

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

Where:

D = taper distance
R = RF leg radius
ϕ = degrees of arc (RF track)

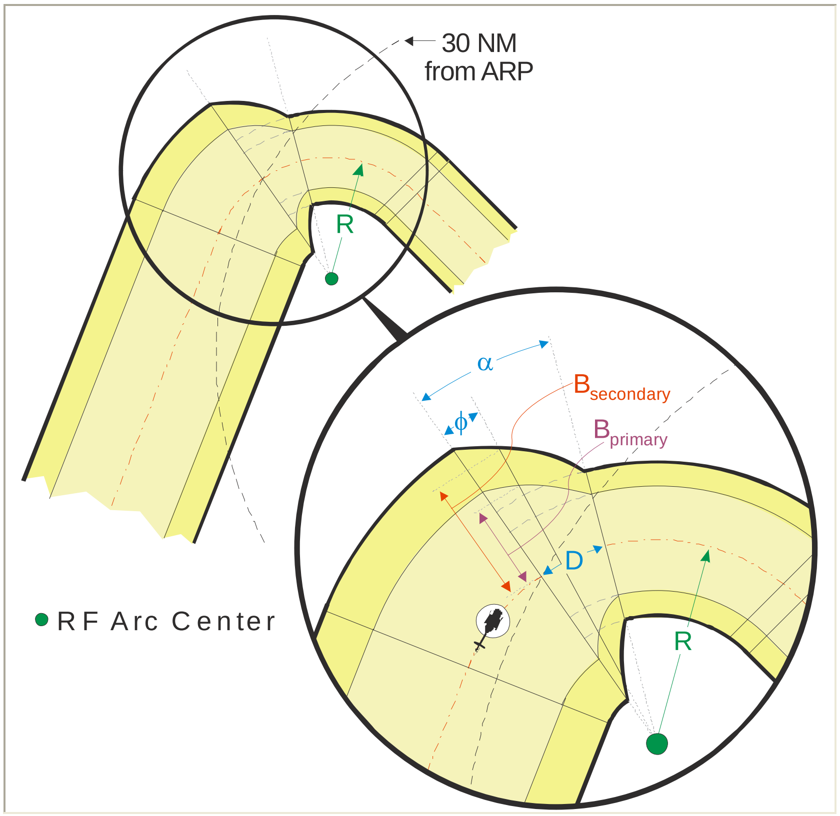
Note: "D" will be in the same units as "R"

D=(3-1.5)/tan(30*π/180)
α = (180*D)/(π*R)
$B_{primary}$ = 3-1.5*(ϕ*π*R)/(180*D)
$B_{secondary}$ = 4-2*(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.



5. Calculating the Turn Radius (R). The design turn radius value is based on four variables: indicated airspeed, assumed tailwind, altitude, and bank angle. Calculate R using formula 2-3c. Apply the indicated airspeed from table 2-3 for the highest speed helicopter category that will be published on the approach procedure. Apply the highest expected turn altitude value. Apply the appropriate bank angle from table 2-4 and formula 2-2 to determine the vertical path altitude (VP_{alt}).

Formula 2-2. Vertical Path Altitude.

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

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^((D$_Z$*tan(θ*π/180))/r)*(r+PFAF$_{alt}$)-r

Calculator		
$PFAF_{alt}$		Click here to calculate
θ	°	
D_Z		
VP_{alt}		

Note: Determine the highest altitude within a turn by:

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

For missed approach highest altitude in a turn, apply (a) or (b), and (c).

(a) Turn-At-A-Fix, 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 400 ft/NM (Helicopter) or a higher rate if a steeper climb gradient is specified. Compare the vertical path altitude at the fix to the minimum published fix altitude, apply the higher of the two;

(b) Turn-At-An-Altitude, apply the climb-to-altitude;

(c) Plus an additive, (Turn-At-A-Fix (FO) and Turn-At-An-Altitude) based on a continuous climb of 400 ft per 12 degrees of turn [ϕ*400/12]). The turn altitude must not be higher than the published missed approach altitude.

Helicopter example: 900 ft would be added for a turn of 27 degrees, 767 ft would be added for 23 degrees, 333 ft for 10 degrees of turn.

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. Helicopter Indicated Airspeeds (Knots).		
Segment	**Indicated Airspeed**	
	Civil	**Military**
Feeder, Initial, Intermediate	140	140
Final, Missed Approach	70	90

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 2,000 or less above airport elevation, then V_{KTW} = 30		
0.00198*alt+47		
Calculator		
alt		Click here to calculate
V_{KTW}		

Note: 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 11° or 14° for Helicopter)		
$(V_{KTAS}+V_{KTW})$^2/(tan($bank_{angle}$*π/180)*68625.4)		
Calculator		
V_{KTAS}		Click here to calculate
V_{KTW}		
$bank_{angle}$	°	
R		

Note: Use formula 2-8 to verify the required bank angle does not exceed the design bank angle (11 or 14 degrees), see table 2-4.

Table 2-4. Bank Angles.		
Knots True Airspeed (KTAS)	< 90	≥ 90
Bank Angle (In degrees)	11.0	14.0

6. Turn Construction. If the outbound course from a fix differs by more than 0.03 degrees from the inbound course to the fix (courses measured at the fix), a turn is indicated.

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

(1) 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 2-4a (terminal) or formula 2-4b (feeder and en route).

Formula 2-4a. Reaction & Roll Dist. (Terminal).		
$rr = 6 \cdot \frac{\frac{1852}{0.3048}}{3600} \cdot V_{KTAS}$		
6*1852/0.3048/3600*V_{KTAS}		
Calculator		
V_{KTAS}		Click here to calculate
rr		

Note: 6 second delay

Formula 2-4b. Turn Delay (En Route, Feeder).		
$rr = 8 \cdot \frac{\frac{1852}{0.3048}}{3600} \cdot (V_{KTAS} + V_{KTW})$		
8*(1852/0.3048/3600)*(V_{KTW}+V_{KTAS})		
Calculator		
V_{KTW}		Click here to calculate
V_{KTAS}		
rr (ft)		

Note: 8 second delay

Step 1: Determine **R**. See formula 2-3c.

Step 2: Determine **rr**. See formula 2-4a or formula 2-4b.

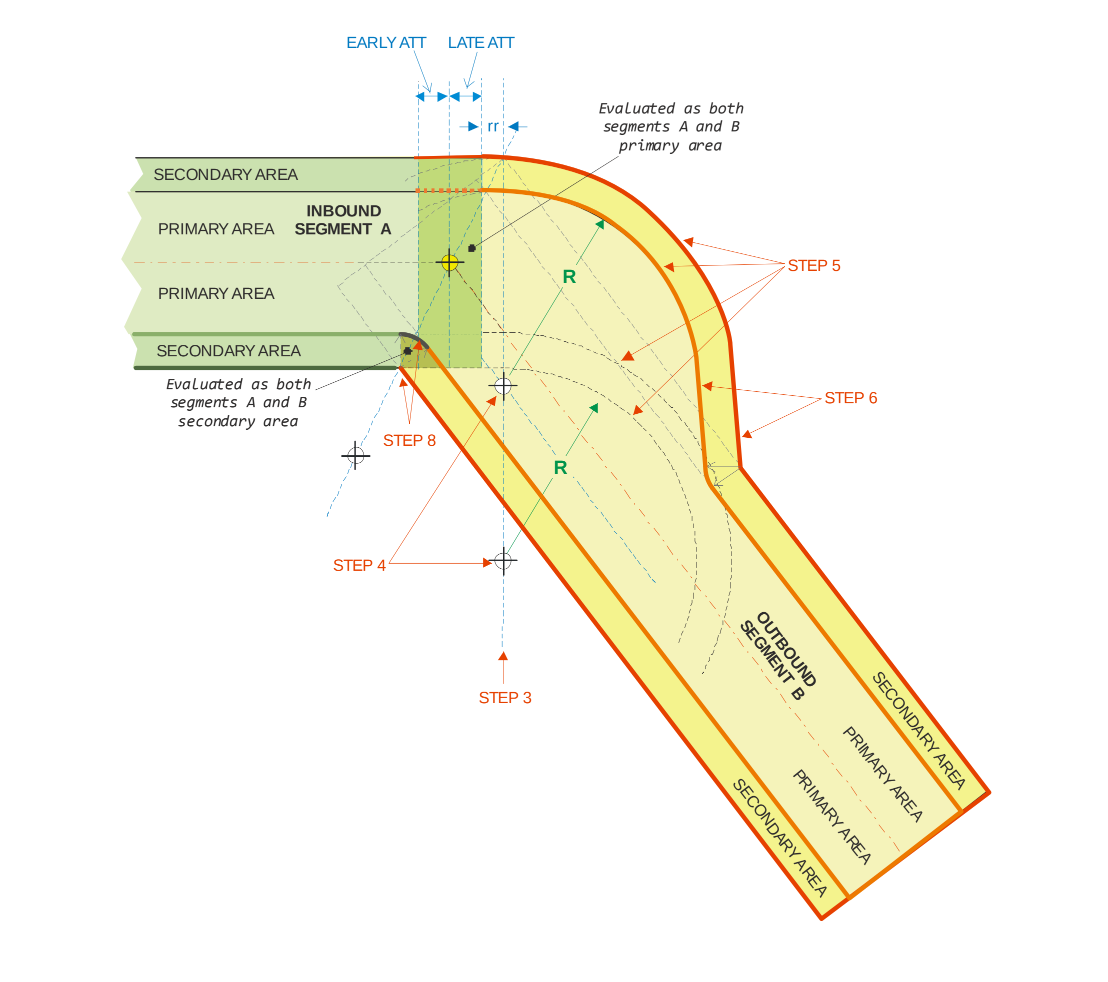
Step 3: Establish the baseline for construction of the turn expansion area as the line perpendicular to the inbound track at a distance past the turn fix equal to (ATT+rr).

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. If both the inner and outer arcs lie outside subsequent segment boundary lines, but the resulting tapering line tangent points lie inside the subsequent segment boundary lines, consider the expanded boundary connection points to be the intersection of the arc and the subsequent segment boundary lines. 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.

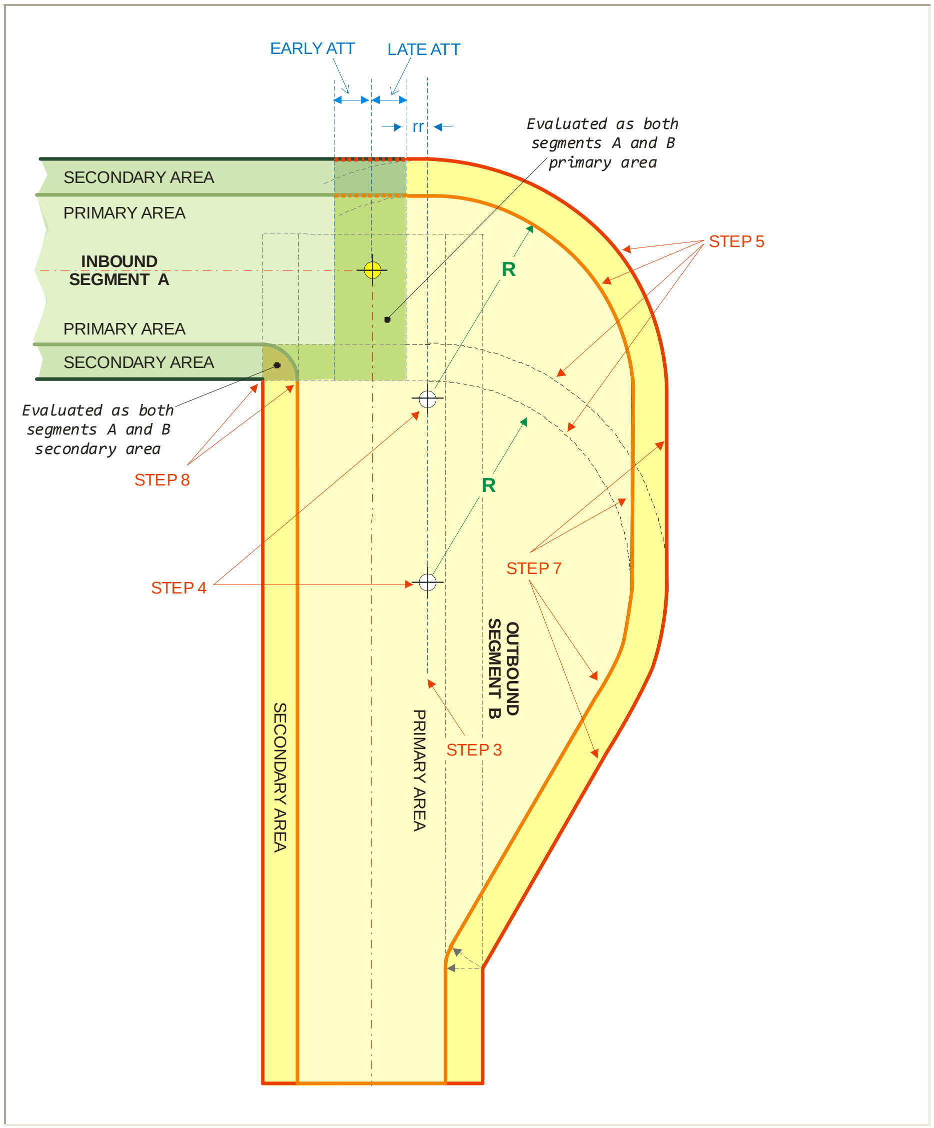


Step 7: If both the inner and outer arcs lie outside the tapering lines constructed in step 6, connect the respective inner and outer arcs with tangent lines and then construct the tapering lines from the arcs centered on the second center point as shown in figure 2-5.

Step 8: The inside turn secondary boundary is the intersection of the preceding and succeeding segment secondary boundaries. The inside turn primary boundary is an arc of secondary-width radius joining the preceding and succeeding segment primary boundaries.

Evaluate the inbound-segment secondary area truncated by the arc as primary area by both segments. Both segments also evaluate the secondary area inside the arc (see figures 2-4 and 2-5)

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



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

(2) 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 DTA distance from formula 2-5 and formula 2-6.

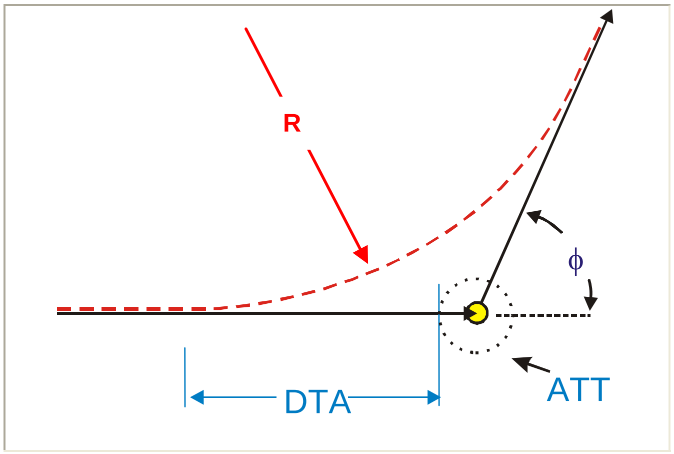
Formula 2-5. Distance of Turn Anticipation.

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

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.

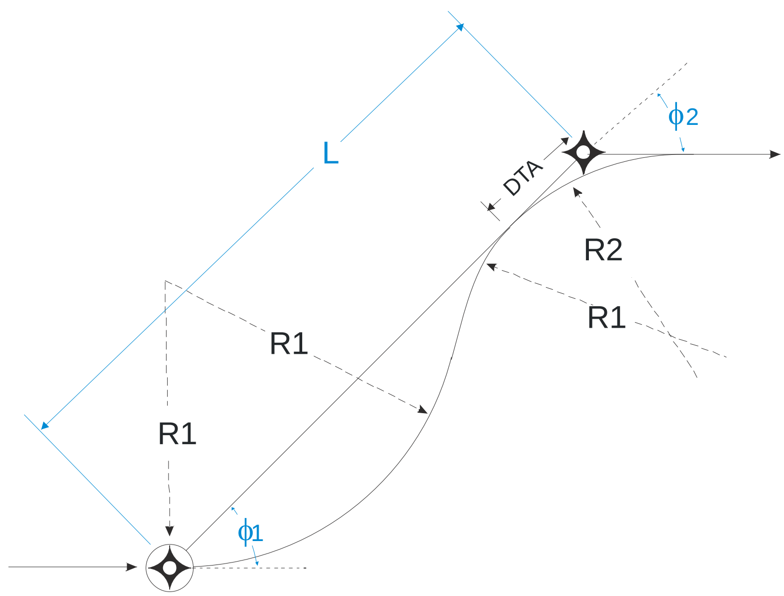
If $\phi 1 < \frac{180}{\pi} \bullet \operatorname{acos}(3^{0.5}-1)$, then

$$L = R1 \bullet \left(\sin(\phi 1) + 2 \bullet \sin\left(\operatorname{acos}\left(\frac{(1+\cos(\phi 1))}{2}\right)\right)\right) + R2 \bullet \tan\left(\frac{\phi 2}{2}\right)\text{, else}$$

$$L = R1 \bullet \left(\sin(\phi 1) + 4 - 3^{0.5} - 3^{0.5} \bullet \cos(\phi 1)\right) + R2 \bullet \tan\left(\frac{\phi 2}{2}\right)$$

Where:

R1 = turn radius (NM) at the segment initial fix (formula 2-3c)
R2 = turn radius (NM) at the segment termination fix (zero if no fly-by turn)
$\phi 1$ = turn magnitude at the segment initial fix
$\phi 2$ = turn magnitude at the segment termination fix



If ϕ1 <180/π*acos(3^0.5-1), then
R1*(sin(ϕ1*π/180)+2*sin(acos((1+cos(ϕ1*π/180))/2)))+R2*tan((ϕ2/2)*π/180), else
R1*(sin(ϕ1*π/180)+4-3^0.5-3^0.5*cos(ϕ1*π/180))+R2*tan((ϕ2/2)*π/180)

Calculator

R1		Click here to calculate
R2		
ϕ1	°	
ϕ2	°	
L		

b. 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.

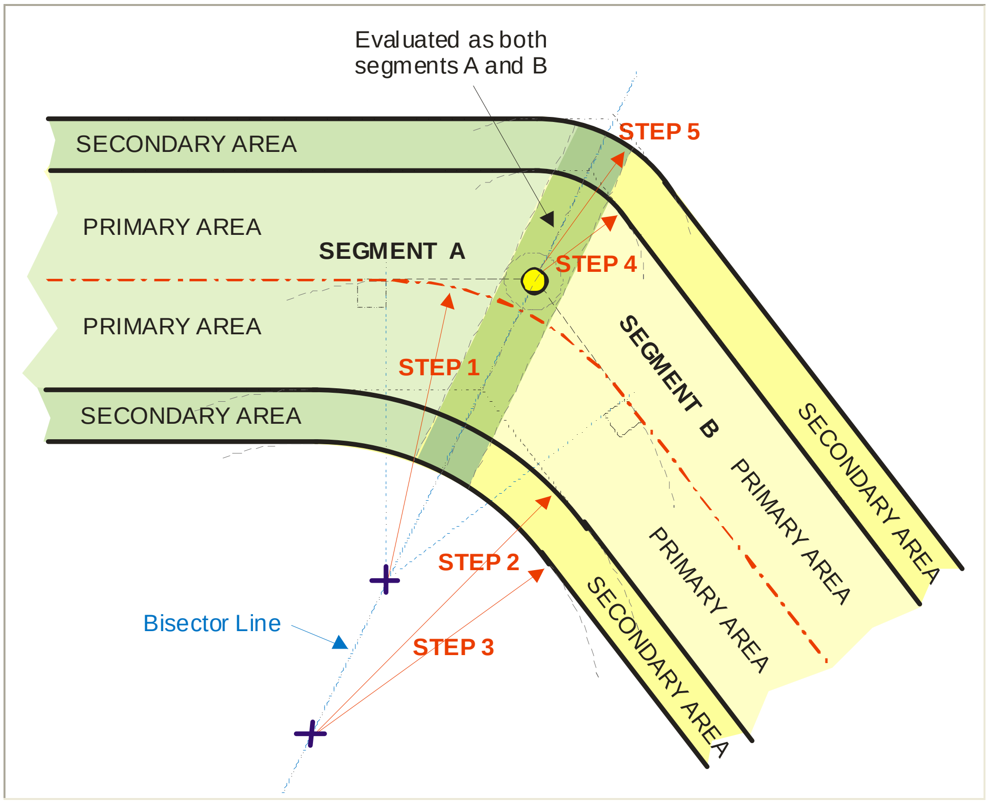
Step 2: Scribe an arc tangent to the inner primary boundaries of the two segment legs with a radius equal to $R+\frac{\text{Primary Area Half-width}}{2}$ (example: half width of 2 NM, the radius would be R+1.0 NM).

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.



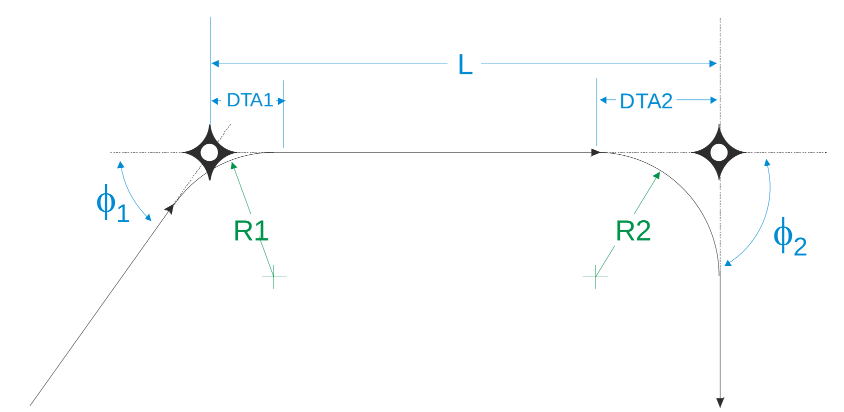
(1) Minimum length of track-to-fix (TF) leg following a fly-by turn. Calculate the minimum length for a TF leg following a fly-by turn using formula 2-7.

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

$$L = R1 \cdot \tan\left(\frac{\phi 1}{2}\right) + R2 \cdot \left(\frac{\phi 2}{2}\right)$$

Where:

R1 = Turn radius at the segment initial fix (formula 2-3c)
R2 = Turn radius at the segment termination (formula 2-3c)
Note: Zero when no turn
ϕ_1 = turn magnitude at the segment initial fix
ϕ_2 = turn magnitude, if any at the segment termination fix



R1*tan(ϕ1/2*π/180)+R2*tan(ϕ2/2*π/180)

Calculator		
R1		Click here to calculate
R2		
ϕ1	°	
ϕ2	°	
L		

c. 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 standard 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		
$bank_{angle}$	°	

Calculate RF segment length 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.

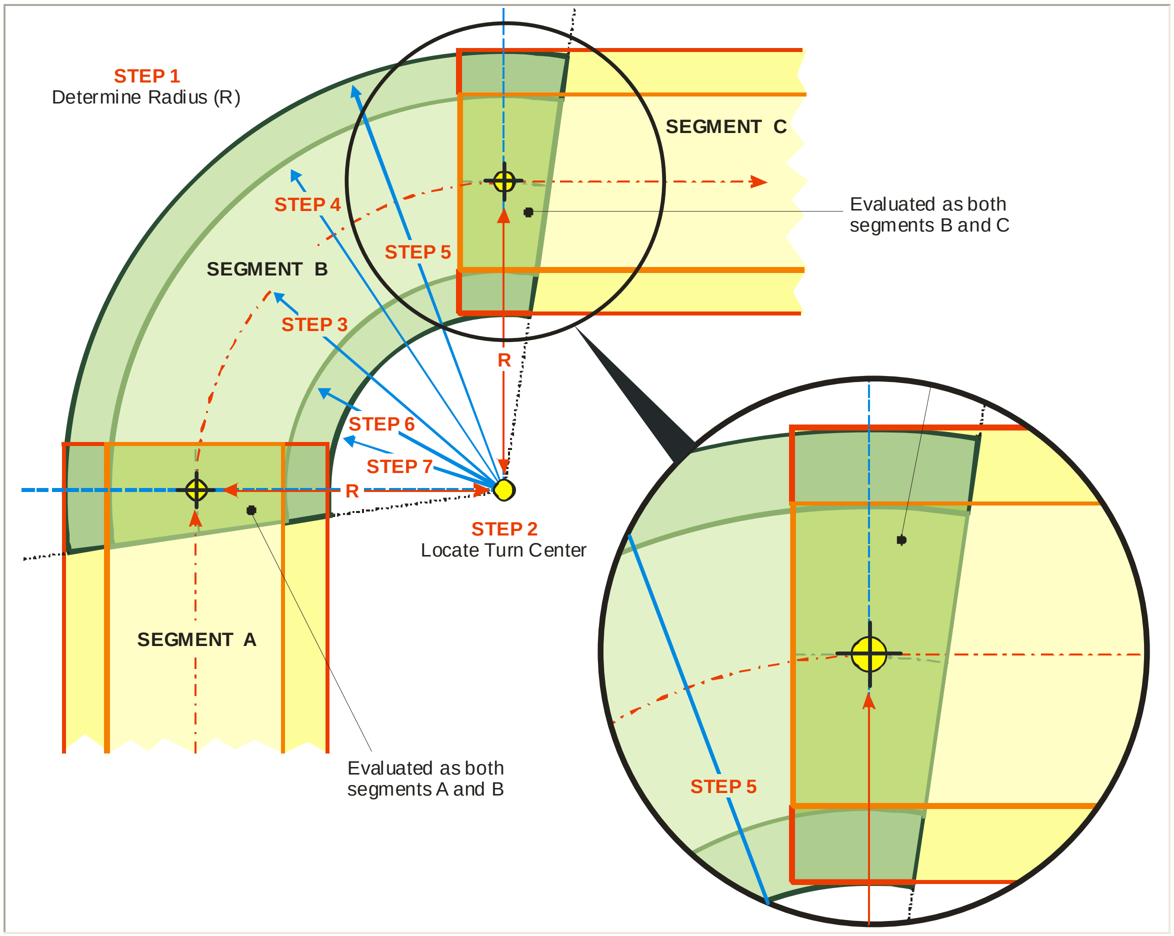
Step 4: Primary area outer boundary. Construct an arc of radius R+Primary area half-width from the tangent point on the preceding segment primary area outer boundary to the tangent point on the following course primary area outer boundary.

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.



d. RNAV TF/VA/VI/CF leg followed by a DF Leg. Calculate minimum DF segment length using formula 2-9b.

Formula 2-9b. RNAV DF Leg Minimum Length following TF/VA/VI/CF Legs.

If $\phi > 30$ then

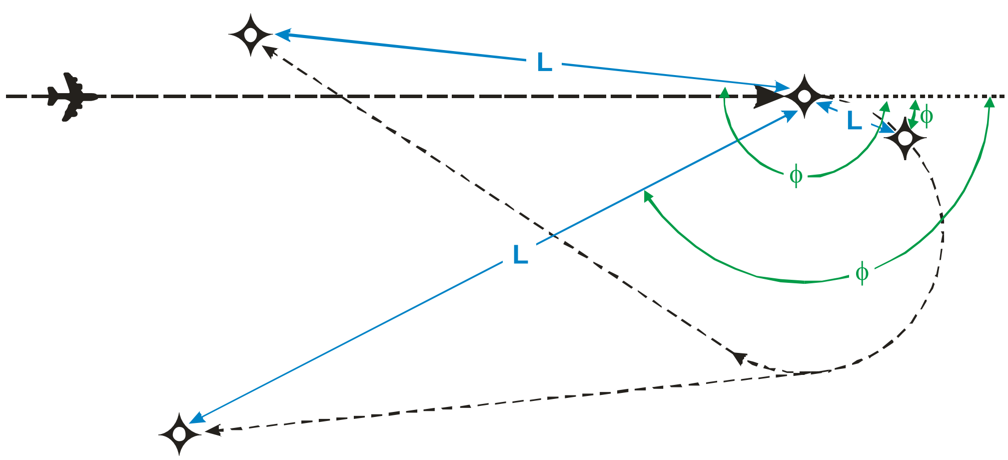
$$L = 4 \cdot R \cdot \left(\sin\left(\frac{\phi + 30}{2}\right)\right)^2, \text{ else}$$

$$L = 2 \cdot R \cdot \sin(\phi)$$

Where:

R = turn radius (NM) at the segment initial fix (formula 2-3c)

ϕ = turn magnitude at the segment initial fix



If ϕ>30 then
L= 4*R*(sin((ϕ+30)/2*π/180))^2, else
L=2*R*sin(ϕ*π/180)

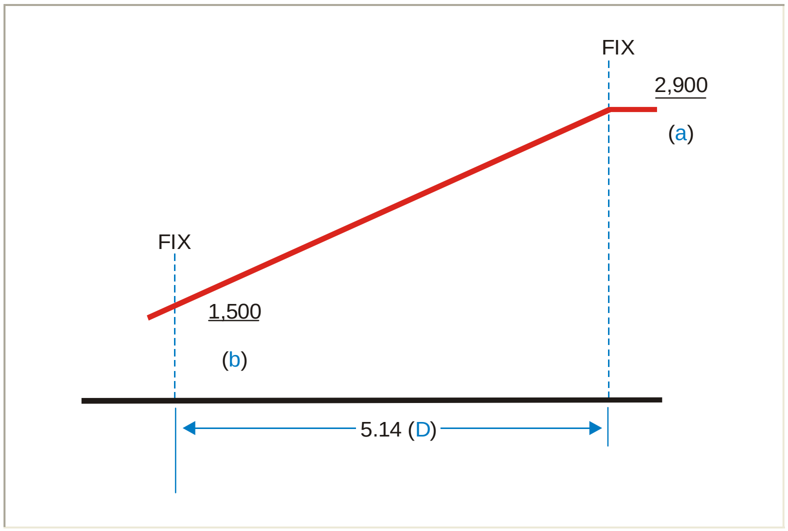
Calculator

R		Click here to calculate
ϕ		
L		

7. Helicopter Initial and Intermediate Descent Gradient. The optimum descent gradient in the initial and intermediate segment is 400 ft/NM (6.58%, 3.77°); maximum is 600 ft/NM (9.87%, 5.64°). Where higher descent gradients are required, Order 8260.3, Volume 1, paragraph 1110 applies.

a. 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 using formula 2-10 (see figure 2-8).

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

Calculator		
a		Click here to calculate
b		
D		
DG		

8. 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 90 degrees (70 degrees preferred). Formula 2-3c note applies. Chapter 2, paragraph 6 turn construction applies. The feeder segment terminates at the IAF (see chapter 2, figures 2-4, 2-5, and 2-6 for construction).

a. Length. The **minimum** length of a sub-segment is determined under chapter 2, paragraph 6a(2) or 6b(1) as appropriate. The **maximum** length of a sub-segment is 50 miles. The total length of the feeder segment should be as short as operationally possible.

b. Width. Primary area width is ± 3.0 NM from course centerline; secondary area width is 1.0 NM (1-3-3-1). These widths apply from the feeder segment initial fix to the approach IAF/termination fix.

c. Obstacle Clearance. The feeder segment OEA begins at the beginning fix early ATT and ends at the ending fix late ATT. 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. Order 8260.3, Volume 1, paragraphs 1720b(1), 1720b(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. (Refer to figures 2-2a, 2-2b **and** apply formula 2-12a for standard secondary ROC.) Apply formula 2-12b for designated mountainous area calculations (formulas are applicable for en route, feeder, and initial).

Note: ROC additive, see 8260.3, Volume 1, paragraph 1720.

d. Descent Gradient, Helicopter (feeder, initial, intermediate segments)**.** The optimum descent gradient in feeder, initial, and intermediate segments is 400 ft/NM (6.58%, 3.77°); maximum is 600 ft/NM (9.87%, 5.64°). Where higher descent gradients are required, Order 8260.3, Volume 1, paragraph 1110 applies.

e. Minimum Crossing Altitude (MCA). Establish an MCA when an obstacle prevents a normal climb to a higher minimum en route altitude (MEA). The normal climb gradient is shown in table 2-5. When a MCA is required, chart the required climb gradient and rate of climb on the procedure.

Table 2-5. Normal Helicopter En Route Climb Gradient.

Gradient Level (MSL)	Gradient	OCS Slope
at or below 5,000 ft	300 ft per NM	20.25:1
5,001 ft through 10,000 ft	240 ft per NM	25.3:1

The MCA computation is based on the distance from the nearest fix displacement tolerance line to the obstacle. The computation is rounded to the next higher 100-ft increment (see figure 2-9 for an example MCA computation).

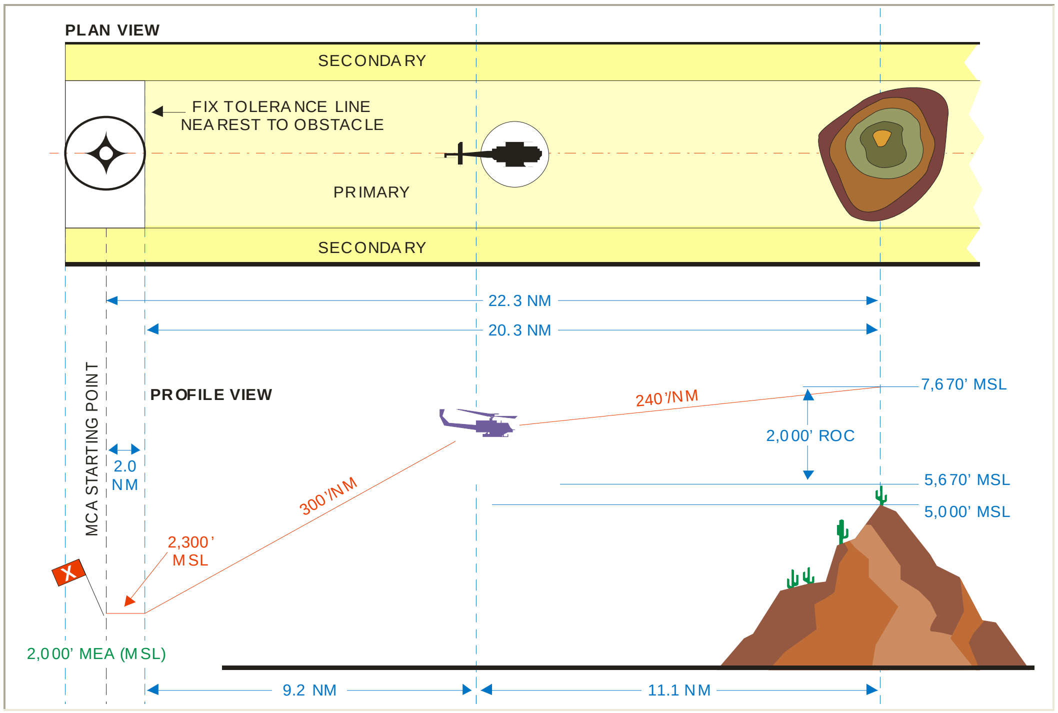
Note: The USA standard climb gradient is 400 ft/NM for all altitudes.

f. Determine MCA. Apply formula 2-11a, or 2-11b to determine MCA.

Formula 2-11a. MCA Sea Level to 5,000 ft MSL.		
$MCA = A\text{-}300 \cdot L$ Where: A = "Climb to" MSL Altitude L = Length of segment (NM)		
A-300*L		
Calculator		
A		Click here to calculate
L		
MCA		

Formula 2-11b. MCA 5,000 - 10,000 ft MSL.		
$MCA = 5000 - 300(L\text{-}\frac{A\text{-}5000}{240})$ Where: A = "Climb to" MSL Altitude L = Length of segment (NM)		
5000-300*(L-(A-5000)/240)		
Calculator		
A		Click here to calculate
L		
MCA		

Figure 2-9. Minimum Crossing Altitude (MCA).



Step 1: Add 2,000 ft mountainous ROC to MSL height of obstacle.

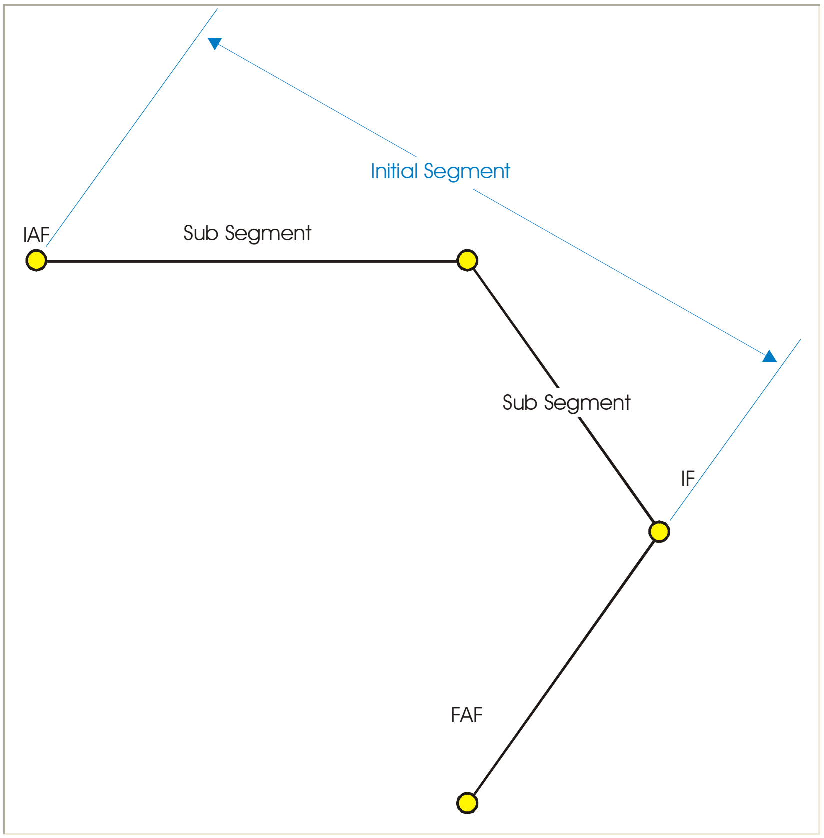
Step 2: Apply formula 2-11a or 2-11b to determine the MCA**.**

Chapter 2. General Criteria

Section 2. Terminal Segments

9. 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). Chapter 2, paragraphs 9b, 9c, 9d, and 9e apply to all sub segments individually. The total length of all sub segments must not exceed 50 NM. For descent gradient limits, see chapter 2, paragraph 8d.

Figure 2-10. Initial Sub Segments.



a. Course Reversal. The optimum design incorporates either the basic Y or T configuration (see AIM or FHP for further BASIC T/Y information). 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 chapter 2, paragraph 9f(2). The maximum course change at the fix (IAF/IF) is to 90 degrees (70 degrees above FL 190).

b. 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.

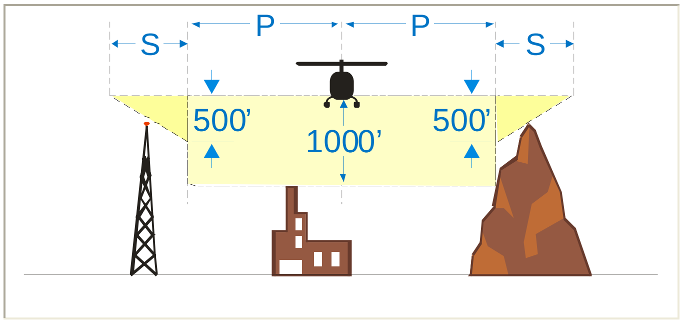
Note: For USA, limit initial segment turn to a MAXIMUM of 60 degrees with a basic "Y" approach configuration for COPTER RNAV (GPS) procedures.

c. Area – <u>Length</u>. The **maximum** segment length (total of sub segments) is 50 NM. Minimum length of sub segments is determined as described in chapter 2, paragraphs 6a(2) and 6b(1).

d. Area – <u>Width</u> (see table 2-2)**.**

e. Obstacle Clearance. The initial OEA begins at the segment beginning fix early ATT and ends at the segment ending fix late ATT. 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. En route/Feeder/Initial Segment ROC.



Note: Allowance for precipitous terrain should be made as specified in Order 8260.3, Volume 1, paragraph 3.2.2b.

Calculate the secondary ROC values using formula 2-12a.

Formula 2-12a. En route/Feeder/Initial Secondary ROC (Standard).

$$ROC_{secondary} = 500 \cdot \left(1 - \frac{d}{D}\right)$$

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		
$ROC_{secondary}$		

Calculate the secondary ROC values for designated mountainous areas using formula 2-12b. Consult Order 8260.3 para 1720 b (1) for possible adjustments to formula output.

Formula 2-12b. En Route/Feeder/Initial Secondary ROC (Mountainous).

$$ROC_{secondary} = 500 \cdot \left(1 - \frac{d}{D}\right) + 1000$$

Where:

D = width (ft) of secondary

d = distance (ft) from edge of primary area measured perpendicular to boundary

500*(1-d/D)+1000

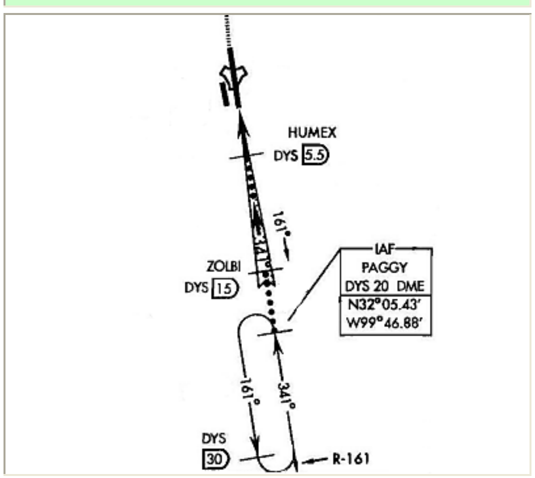
Calculator

d		Click here to calculate
D		
$ROC_{secondary}$		

f. 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.

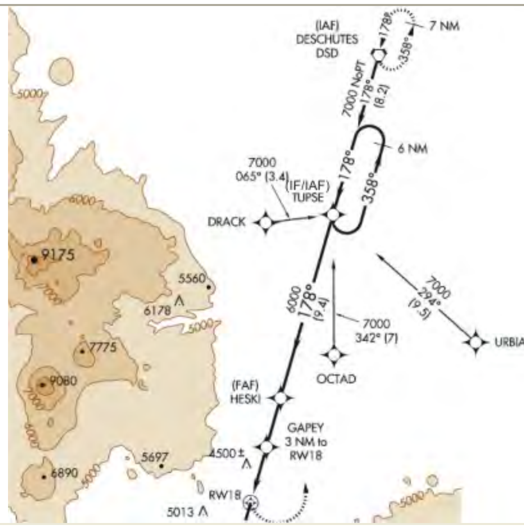
(1) Arrival Holding. Ideally, the holding pattern inbound course should be aligned with the subsequent TF leg segment (tangent to course at the initial fix of the subsequent RF segment). See figure 2-12a. If the pattern is offset from the subsequent TF segment course, the subsequent segment length must accommodate the resulting DTA requirement. 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) 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 descent gradient in the initial and intermediate segment is 400 ft/NM (6.58%, 3.77°); maximum is 600 ft/NM (9.87%, 5.64°). 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.



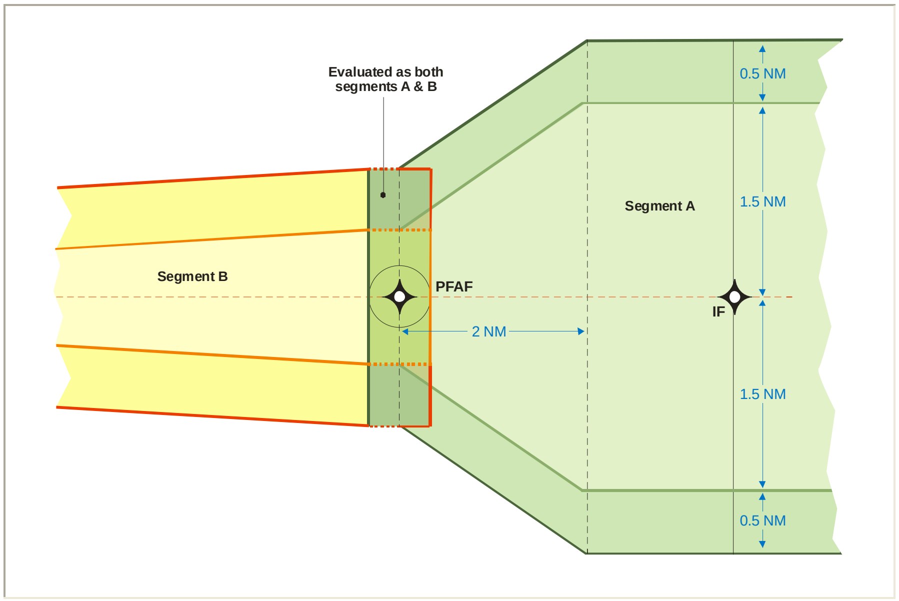
10. Intermediate Segment. The intermediate segment primary and secondary boundary lines connect abeam the plotted position of the PFAF at the appropriate primary and secondary final segment beginning widths.

a. Alignment (Maximum Course Change at the PFAF)**.** LNAV & LP. Align the intermediate course within 30 degrees of the final approach course (30 degrees maximum course change).

b. Length (Fix to Fix)**.** The **minimum** Helicopter category segment length is 2 NM. Where turns over 30 degrees at the IF are required, the minimum is 3 NM. Where turns to and from the intermediate segment are necessary, determine minimum segment length using formula 2-6 or formula 2-7, as appropriate.

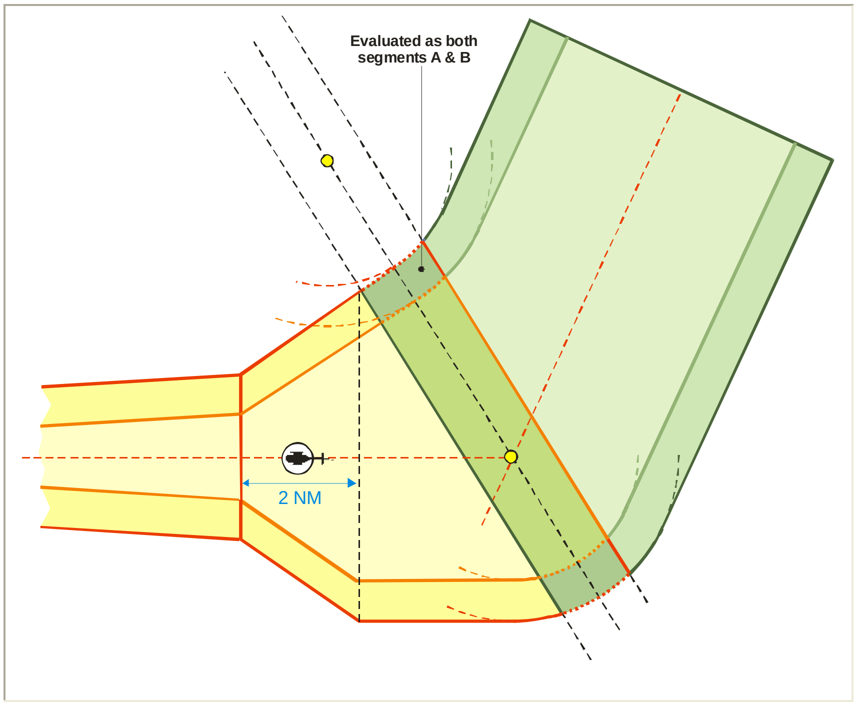
c. Width. The intermediate segment primary area tapers uniformly from ± 1.5 NM at a point 2 NM prior to the PFAF to the outer boundary of the X OCS abeam the PFAF (1 NM past the PFAF for LNAV). The secondary boundary tapers uniformly from 1 NM at a point 2 NM prior to the PFAF to the outer boundary of the Y OCS abeam the PFAF (1 NM past the PFAF for LNAV). See figure 2-13a.

Figure 2-13a. RNAV Intermediate Segment (LNAV Final).



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 connections as illustrated in figure 2-13b.

Figure 2-13b. RNAV Turn at IF (LNAV Final).



Maximum turn at the PFAF is 30 degrees. When a PFAF turn is constructed, **minimum** FAS length is 3 NM for turns greater than 15 degrees. Where the RNAV or LP intermediate course is not an extension of the FAC, use the following construction (see figure 2-13c).

(1) LNAV Offset Construction. Where LNAV intermediate course is not an extension of the final course, use the following construction (see figure 2-13c, upper graphic).

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 1.5 NM radius on the non-turn side of the fix.

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

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

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

(2) LP Offset Construction. Where LP intermediate course is not an extension of the final course, use the following construction (see figure 2-13c, lower graphic).

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.

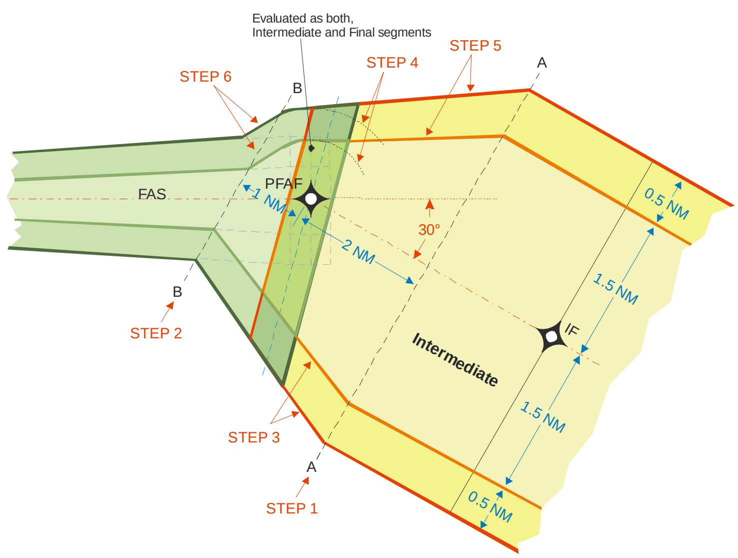
Step 3: Construct the inside turn boundaries by connecting the points of intersection of line A with the turn side intermediate segment boundaries with the intersection of line B with the turn side final segment boundaries.

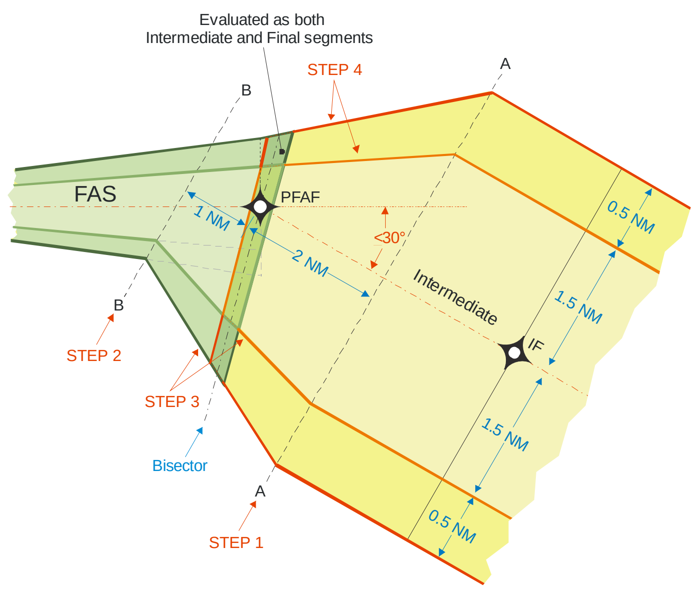
Step 4: Connect lines from the point of intersection of line **A** and the outside primary and secondary intermediate segment boundaries to the final segment primary and secondary final segment lines at a point perpendicular to the final course at the PFAF.

Note: DA must not occur at a greater distance from HRP than the turn-side point of intersection of the expanded outer boundary line with the final segment secondary boundary (intersection of line "B" with secondary boundary in figure 2-13c lower graphic). If a higher DA is required, then the degree of offset must be less.

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 2-13c. Offset LNAV/LP Turn at PFAF Construction.

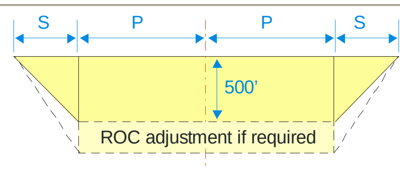




(3) RF intermediate segments. **Reserved.**

d. Obstacle Clearance. The intermediate OEA begins at the segment beginning fix early ATT and ends at the segment ending fix late ATT. 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 intermediate secondary ROC values using formula 2-13.

Formula 2-13. Intermediate 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 (ft) of the secondary area
adj = TERPS para 3.2.2 adjustments

$(500+adj)*(1-d_{primary}/W_S)$

Calculator

$d_{primary}$		Click here to calculate
W_S		
Adj		
$ROC_{secondary}$		

e. Minimum IF to FHP Distance (applicable for LP procedures with no turn at PFAF)**.** Locate the IF at least d_{IF} (NM) from the FHP (see formula 2-14).

Formula 2-14. Minimum IF Distance.		

$$d_{IF} = 0.3 \cdot \frac{d}{a} - d \cdot \frac{0.3048}{1852}$$

Where:

d = distance (ft) from FPAP to FHP
a = width (ft) of azimuth signal at FHP

Note: See chapter 4, table 4-1, column 3

0.3*d/a-d*0.3048/1852

Calculator

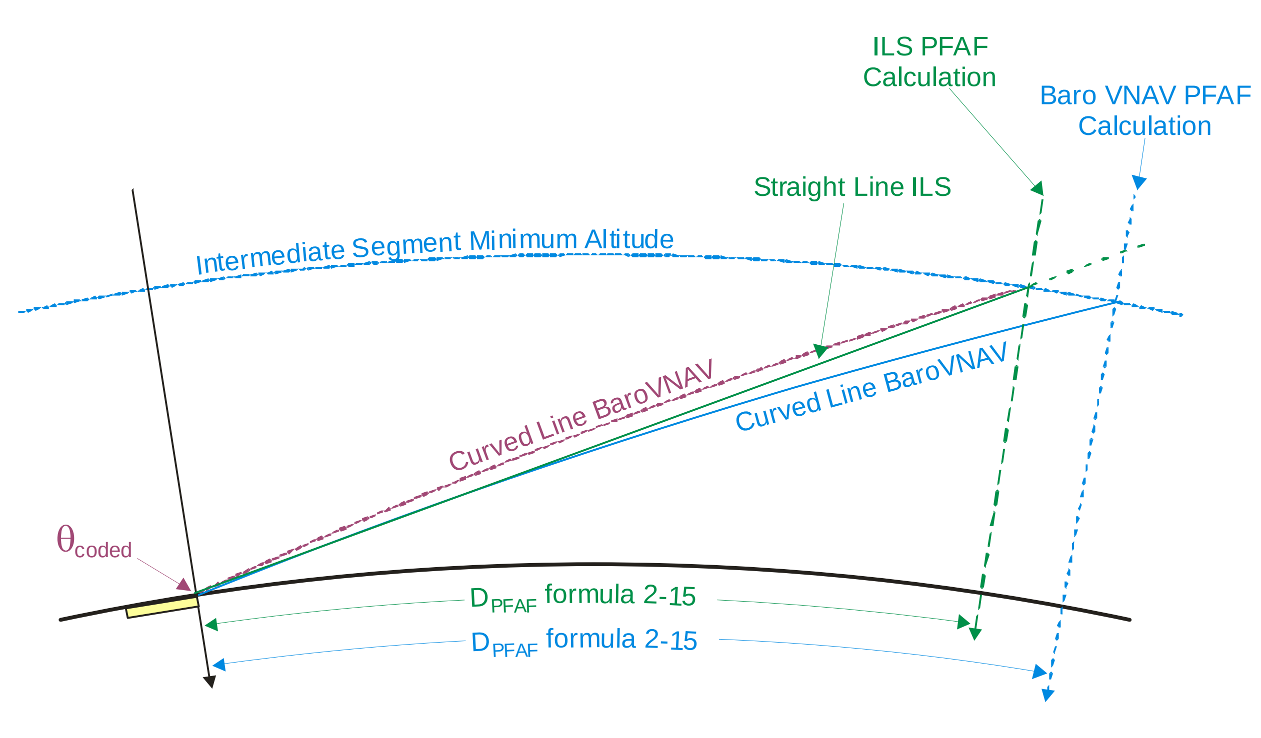
a		Click here to calculate
d		
d_{IF}		

Chapter 2. General Criteria

Section 3. Basic Vertically Guided Final Segment General Criteria

11. Determining Precise Final Approach Fix/Final Approach Fix (PFAF/FAF) Coordinates (see figure 2-15 fixed-wing example)**.**

Figure 2-15. Determining PFAF Distance to LTP (Example).



Geodetically calculate the latitude and longitude of the PFAF using the true bearing from the Heliport Reference Point (HRP) to the PFAF and the horizontal distance (D_{PFAF}) from the HRP to the point the glidepath intercepts the intermediate segment altitude. The LNAV (BaroVNAV) glidepath is a curved line (logarithmic spiral) in space. Calculation the PFAF distance from the HRP using formula 2-15 (calculates the LNAV PFAF distance from HRP; i.e., the point the curved line BaroVNAV based vertical path intersects the minimum intermediate segment altitude (see Order 8260.54A, chapter 2 for additional information).

Formula 2-15. LNAV PFAF.

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

where alt = minimum intermediate segment altitude
HRP_{elev} = HRP MSL elevation
HCH = Heliport Crossing Height value
r = 20890537
θ = glidepath angle

(ln((r+alt)/(r+HRP_{elev}+HCH))*r)/tan(θ*π/180)

Calculator

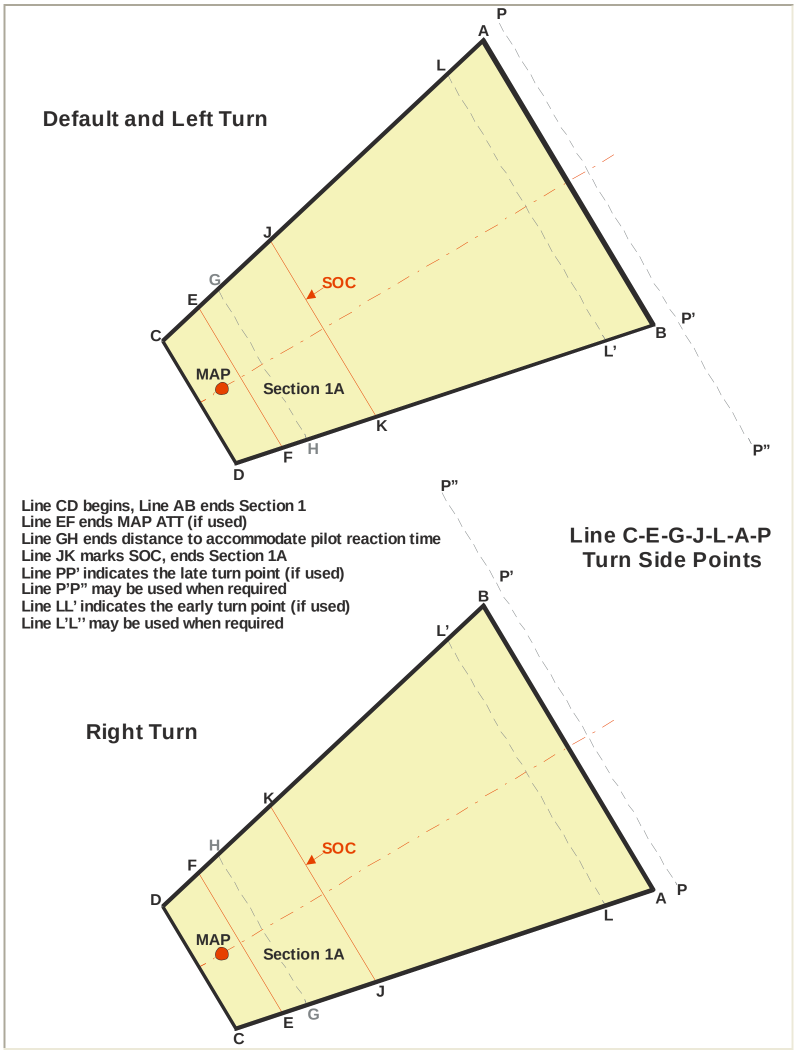
HRP_{elev}		Click here to calculate
HCH		
θ	°	
alt		
D_{PFAF}		

12-15. Reserved.

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

17. Missed Approach Segment (MAS) Conventions. Figure 2-16 defines the MAP point OEA construction line terminology and convention for section 1.

Figure 2-15. MAS Point/Line Identification.



The missed approach obstacle clearance standard is based on a minimum helicopter climb gradient of 400 ft/NM, protected by a ROC surface that rises at 304 ft/NM. The MA ROC value is based on a requirement for a 96 ft/NM (400-304 = 96) increase in ROC value from the start-of-climb (SOC) point located at JK. The actual slope of the MA surface is (1 NM in feet)/304≈ 19.987. In manual application of TERPS, the rounded value of 20:1 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 2-16.

Formula 2-16. Helicopter Missed Approach OCS Slope.		
$$MA_{OCSslope} = r \bullet \ln\left(\frac{\frac{1852}{0.3048 \cdot (CG - 96)} + r}{r}\right)$$ Where: CG = Climb Gradient (nominally 400 ft/NM)		
r*ln((1852/(.3048*(CG-96))+r)/r)		
Calculator		
CG		Click here to calculate
$MA_{OCSslope}$		

a. Charted Missed Approach Altitude. Apply Order 8260.3, Volume 1, paragraphs 277d and 277f to establish the preliminary and charted missed approach altitudes.

b. Climb-In-Holding. Apply Order 8260.3, Volume 1, paragraph 277e for climb-in-holding guidance.

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Chapter 3. Terminal Operations

1. Approach Configuration. The BASIC “Y” or “T” approach configuration should be the basis of procedure design. Segment length is affected by altitude to be lost, fix tolerances, and turn magnitude at the fixes. The **optimum** design incorporates a 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. Public procedures should not deviate from these shape and dimension configurations unless there is an operational advantage. Construct IAFs within 25 NM of the airport reference point/heliport reference point (ARP/HRP). See chapter 2, paragraph 9 for construction methods.

Note 1: Allowance for precipitous terrain should be made as specified in Order 8260.3, Volume 1, paragraph 3.2.2b.

Note 2: For USA, limit initial segment turn to a MAXIMUM of 60 degrees with a basic “Y” approach configuration for COPTER RNAV (GPS) procedures.

Table 3-1. Helicopter GPS MINIMUM Initial/Intermediate/Final Segment Lengths.

Course Intercept Angle (Degrees)	Minimum Leg Length (NM)
00 – 30	2.0
> 30 - 90 *	3.0

* Final segment 30-degree MAXIMUM intercept angle for Global Positioning System (GPS) and Wide Area Augmentation System (WAAS) public procedures. Final segment 60-degree MAXIMUM intercept angle for GPS and WAAS special procedures. A turn exceeding 30 degrees at the precise final approach fix (PFAF) requires documentation of equipment capability.

a. Initial Approach Segment. The initial approach segment begins at the IAF and ends at the IF. The initial segment/subsegment obstacle evaluation area (OEA) begins at the early ATT of the segment beginning fix and ends at the late ATT of the segment/subsegment ending fix. If a special procedure requires a course change at the IAF that exceeds 90 degrees, a waiver is required and is noted on FAA Form 8260-9 (no course change exceeding 120 degrees is allowed). The IF may be identified as an along-track distance (ATD) from the PFAF. Course change at the IF must not exceed 90 degrees for public and special procedures. Construct the inbound leg of course reversal holding patterns within 30 degrees of the intermediate course (IF/IAF). Apply chapter 2, paragraph 9 for course reversal using holding pattern criteria. Do not establish a holding pattern in lieu of procedure turn at the PFAF. See chapter 2 for construction methods.

(1) Length. The initial segment begins at IAF and ends at the IF. The length should not exceed 10 NM unless operational requirements mandate a longer segment. Determine the **minimum** length using the greater distance from formulas 2-7, 2-8, and table 3-1.

(2) Width.

(a) Primary Area. 1.5 NM each side of the course centerline.

(b) Secondary Area. 0.5 NM on each side of the primary area.

(3) Obstacle Clearance. Provide a **minimum** of 1,000 ft of required obstacle clearance (ROC) in the primary area. In the secondary area, provide 500 ft of ROC at the inner edge, tapering uniformly to zero at the outer edge (see chapter 2, figure 2-12). Calculate the secondary ROC using chapter 2, formula 2-12a or formula 2-12b. Establish initial segment altitudes in 100-ft increments that meet or exceed minimum ROC.

(4) Descent Gradient for Initial Segments (see chapter 2, paragraph 7).

b. Intermediate Segment. The intermediate segment begins at the IF and ends at the PFAF. The intermediate segment OEA begins at the early ATT of the segment beginning fix and ends at the late ATT of the segment ending fix. The intermediate segment is used to prepare the helicopter speed and configuration for final approach segment entry; therefore, the gradient should be as flat as possible. At a point beginning 2.0 NM from the PFAF, construct a taper to join the final approach segment (FAS).

(1) Alignment. The **maximum** course change at the PFAF is 30 degrees. Course change more than 30 degrees requires Flight Standards approval.

(2) Area.

(a) Length. The intermediate segment begins at the IF and ends at the PFAF. The length should not exceed 5.0 NM (**optimum** length is 3.0 NM). Determine the **minimum** length using the greater distance from formulas 2-7, 2-8, and table 3-1.

(b) Width.

1 Primary Area. 1.5 NM each side of the segment centerline, beginning at the earliest IF position. The segment taper begins 2.0 NM prior to the plotted position of the PFAF to reach a ± 0.55 NM width at the PFAF plotted position (see chapter 2, figures 2-13a, 2-13b, and 2-13c).

2 Secondary Area. 0.50 NM on each side of the primary area.

Note: USAF/USA/USCG/USN operating at 90 KIAS: Change 0.55 NM to 0.70 NM.

(3) Obstacle Clearance. Provide a MINIMUM of 500 ft of ROC in the primary area. In the secondary area, provide 500 ft of ROC at the inner edge tapering to zero feet at the outer edge. Establish altitudes for each intermediate segment in 100-ft increments, and round to the

next higher 100-ft increment. Calculate the secondary ROC using chapter 2, formula 2-13 (see chapter 2, figure 2-14).

(4) Descent Gradient for Intermediate Segments (see chapter 2, paragraph 7).

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Chapter 4. IFR Final and Visual Segments

1. General. The approach procedure type is determined by the visual segment. The instrument flight rule (IFR) final approach segment (FAS) applies to all five types of procedures. Use the criteria in chapter 3 for the construction of the initial and intermediate segments up to the precise final approach fix (PFAF), and chapter 5 criteria for the missed approach segment construction. Apply chapter 4, paragraph 3 criteria to LNAV IFR final segments, and chapter 4, paragraph 9 to WAAS LP IFR final segments.

Note: Chapter 4 graphics are not drawn to scale

a. Final Segment Stepdown Fix (SDF). An SDF may be applied where the MDA can be lowered 60 ft, or a visibility reduction can be achieved. Order 8260.3, Volume 1, paragraph 289 applies, with the following exceptions:

(1) Establish step-down fix locations in 0.10 NM increments.

(2) The minimum distance between stepdown fixes is 1 NM.

(3) Establish stepdown fix altitudes using 20-ft increments, rounded to the next **higher** 20-ft increment. For example, 2104 becomes 2120.

(4) Where a Remote Altimeter Setting Source (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).

(5) Descent gradient: Chapter 4, paragraphs 3a(3), 3a(4), and 3a(5) apply.

(6) Obstacles eliminated from consideration (3.5:1 area) under this paragraph must be noted in the procedure documentation (see Order 8260.19).

(7) Use formula 4-4 in chapter 4, paragraph 3a(6) concerning Order 8260.3, Volume 1, paragraph 289 to determine the OIS elevation at an obstacle and minimum fix altitude based on an obstacle height.

(8) To mitigate surface penetrations:

- Remove obstruction, or
- Reduce obstruction height, or
- Adjust the MDA, or
- Combination of options.

2. Missed Approach. Construct the missed approach for all procedures using chapter 5 criteria.

3. The five procedure types are:

- IFR to an IFR Heliport
- IFR to a VFR Heliport (IVH) (Proceed Visually)
- IFR to a VFR Runway (IVR) (Proceed Visually)
- Point-in-Space (PinS) Approach (Proceed VFR)
- IFR to an IFR Runway

a. LNAV IFR Final Approach Segment (FAS). The IFR FAS begins at the PFAF and ends at the missed approach point (MAP) (see figure 4-1). This FAS construction is unique to helicopters. It applies trapezoidal rather than the linear construction used for fixed-wing applications. Locate LNAV PFAF using chapter 2, formula 2-15. MAP location should provide the best compromise of lowest visibility and visual segment descent angle (VSDA). The **optimum** distance for the "Proceed Visually" MAP is 0.65 nautical mile (NM) [3/4 statute mile (SM) visibility] from the heliport. For public procedures, the preferred approach paths should be aligned with the prevailing wind direction to avoid downwind and minimize crosswind operations. Other approach/departure paths should be based on the assessment of the prevailing winds or when this information is not available, the separation between such flight paths and the preferred flight path should be at least 135 degrees.

(1) Alignment. The IFR final segment connects the PFAF to the MAP. The course change at the PFAF from the intermediate course to the final approach course (FAC) must not exceed 30 degrees. The MAP is located on the FAC between the PFAF and a point no closer to the helipoint than 0.3 NM from the visual segment reference line (VSRL). For a straight-in approach, the course change at the MAP must not exceed 30 degrees to an IFR heliport helipoint **or** 30 degrees from a runway centerline (RCL) extended to an IFR runway threshold (RWT). Optimum alignment is coincident with the RCL. When the alignment exceeds 5 degrees the optimum alignment point is 1,500 ft from the RWT on RCL. Where circling approaches are required, apply Order 8260.3 Category A criteria.

(2) Area. The obstacle evaluation area (OEA) begins at the earliest PFAF along-track tolerance (ATT) and ends at the latest MAP ATT (see figure 4-1).

(a) Length. The IFR final approach segment begins at the PFAF and ends at the MAP. The length should not exceed 10 NM (**optimum** length is 3 NM). Determine the **minimum** length using the greater of descent distance, formula 2-7 or 2-8, and table 3-1.

(b) Width.

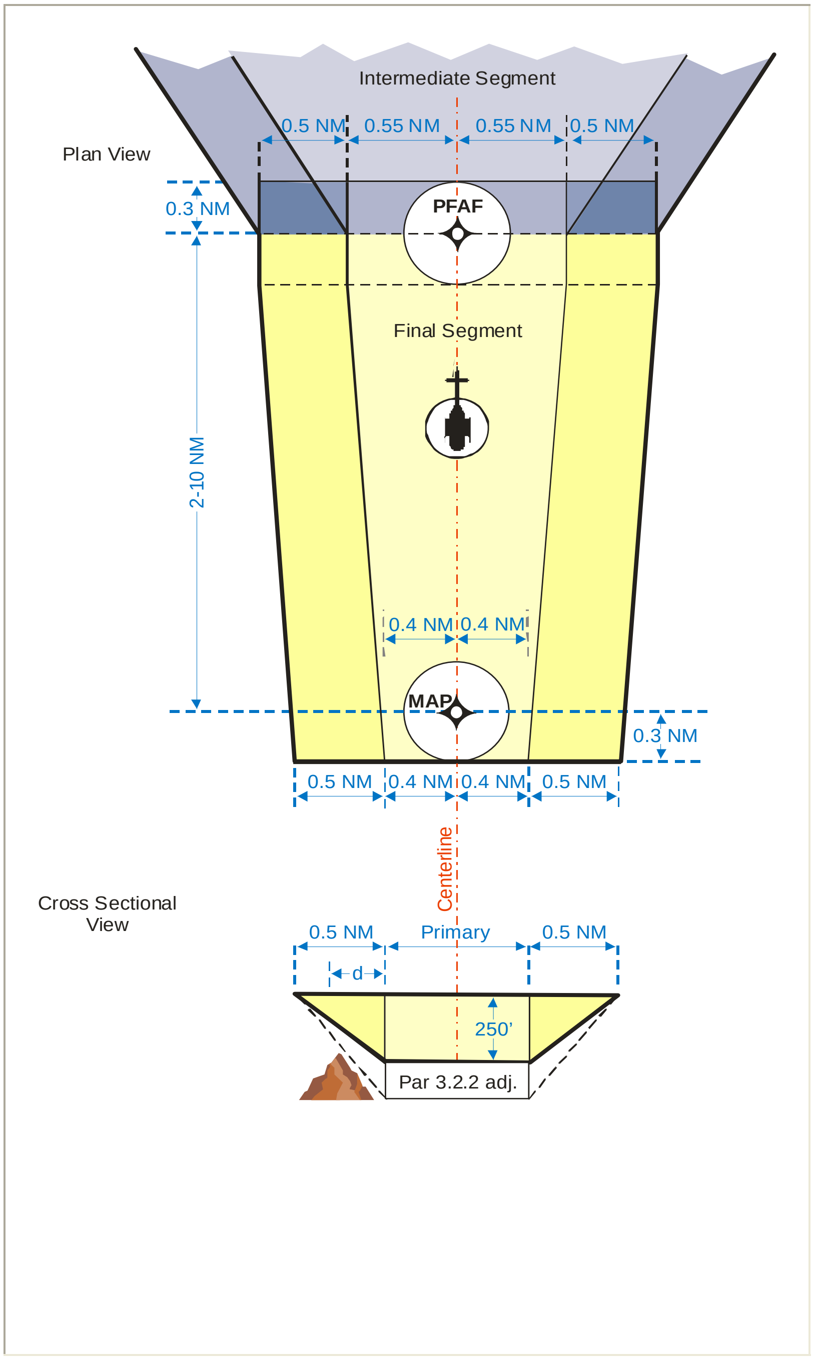
1 Primary Area. The primary area boundary begins 0.55 NM***** each side of the final segment centerline at the earliest PFAF ATT. The width remains constant until the latest PFAF ATT. It then tapers to 0.40 NM***** at the latest MAP ATT.

Note: USAF/USA/USCG/USN operating at 90 KIAS: Change 0.55 NM to 0.70 NM and 0.40 NM to 0.50 NM (primary area).

2 Secondary Area. The secondary area boundary is constant, 0.50 NM each side of the primary area. Calculate the primary half-width at any distance from latest MAP ATT using formula 4-1a.

(c) Required Obstacle Clearance. Primary area required obstacle clearance (ROC) is 250 ft. Secondary ROC is 250 ft at the edge of the primary area, tapering uniformly to zero at the outer edge. Calculate secondary ROC using formula 4-1b.

Figure 4-1. LNAV Final Segment Construction.



Formula 4-1a. Final Area Half-Width.(W_P)		
$$W_P = P_{W2} + \left(\frac{P_{W1} - P_{W2}}{D_1}\right) \cdot D_2$$ Where P_{W1} = Primary Width, PFAF, (0.55 or 0.7) NM P_{W2} = Primary Width, latest MAP ATT, (0.4 or 0.5) NM D_1 = PFAF to MAP distance (NM) D_2 = Latest MAP ATT to desired point (NM) W_T = Final Total Width (ft) (WP+0.5NM)		
P_{W2}+((P_{W1}- P_{W2})/D_1)*D_2		
Calculator		
P_{W1}		Click here to calculate
P_{W2}		
D_1		
D2		
W_P (NM)		
W_P (ft)		
W_T(ft)		

Formula 4-1b. Secondary Area ROC ($ROC_{secondary}$).		
$$ROC_{secondary} = (250 + adj) \cdot \left(1 - \frac{d_{primary}}{W_S}\right)$$ Where adj = TERPS para 3.2.2 adjustments (ft) $d_{primary}$ = distance (perpendicular to C/L from primary area (ft)) W_S = Secondary area width (ft)		
(250+adj)*(1-$d_{primary}$/W_S)		
Calculator		
adj		Click here to calculate
$d_{primary}$		
W_S		
$ROC_{secondary}$		

(3) Descent Gradient/Angle [IVH, PinS , and IVR] (R). The descent gradient/angle is measured from the plotted positions of the PFAF at PFAF altitude to the MAP at MDA. Calculate the final segment descent angle using formula 4-2. (Where required, calculate descent gradient using chapter 2, formula 2-10).

Formula 4-2. Final Approach Angle to MAP (DescentAngle).		
$$\text{DescentAngle} = \text{atan}\left(\frac{r}{c}\cdot\ln\left(\frac{r+a}{r+b}\right)\right)\cdot\frac{180}{\pi}$$ Where: c = PFAF to MAP distance (ft) a = PFAF altitude MSL b = MDA at MAP MSL		
atan(r/c*ln((r+a)/(r+b))*180/π		
Calculator		
c		Click here to calculate
a		
b		
DescentAngle		

Note 1: USA **maximum** descent gradient/angle is 478 ft/NM (4.5 degrees) without a waiver. Descent gradient/angle waivers may be granted up to 800 ft/NM (7.5 degrees).

Note 2: The visual segment descent gradient is considered separately in approaches to VFR heliports or VFR runways.

(4) Descent Gradient/Angle to an IFR Runway or an IFR Heliport. Apply the same descent gradient/angle in chapter 4, paragraph 3a(3) for an IFR approach to an IFR runway, but the distance/elevation calculations begin at the PFAF and end at RWT/TCH elevation (see figure 4-2b). For an IFR approach to an IFR Heliport, the distance/elevation calculations begin at the PFAF and end at HCH (see figure 4-2c). Apply formula 4-3 for descent angle, and chapter 2, formula 2-10 for descent gradient:

Formula 4-3. Descent Angle to Runway or HCH (DescentAngle).

$$DescentAngle = \operatorname{atan}\left(\frac{r}{c}\cdot\ln\left(\frac{r+a}{r+b}\right)\right)\cdot\frac{180}{\pi}$$

Where:

c = PFAF to RWT/helipoint distance (ft)
a = PFAF Altitude MSL
b = TCH/HCH elevation at RWT or HCH

atan(r/c*ln((r+a)/(r+b))*180/π

Calculator		
c		Click here to calculate
a		
b		
DescentAngle	°	

Figure 4-2a. Descent Angle, PFAF to MAP for IVH/PinS/IVR Procedures.

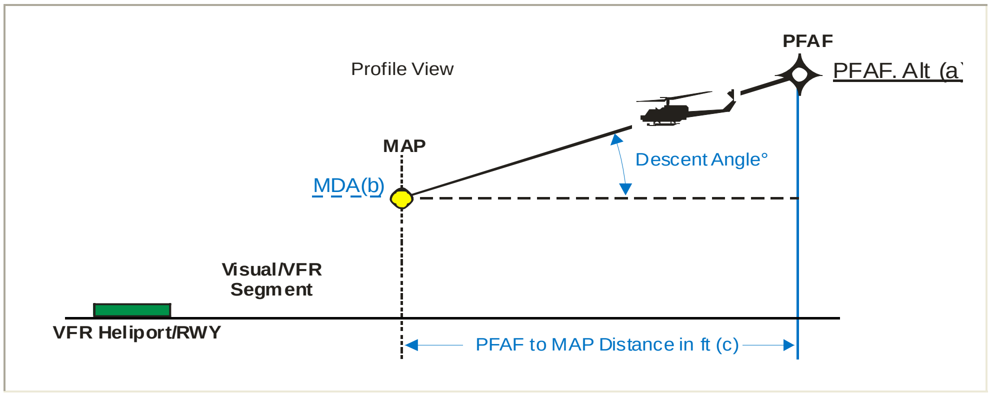


Figure 4-2b. Descent Angle, PFAF to TCH for IFR Approach to IFR Runway.

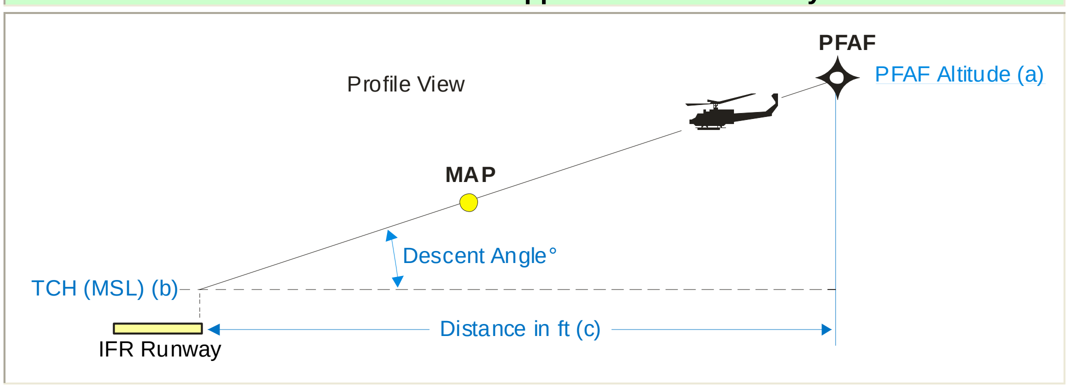
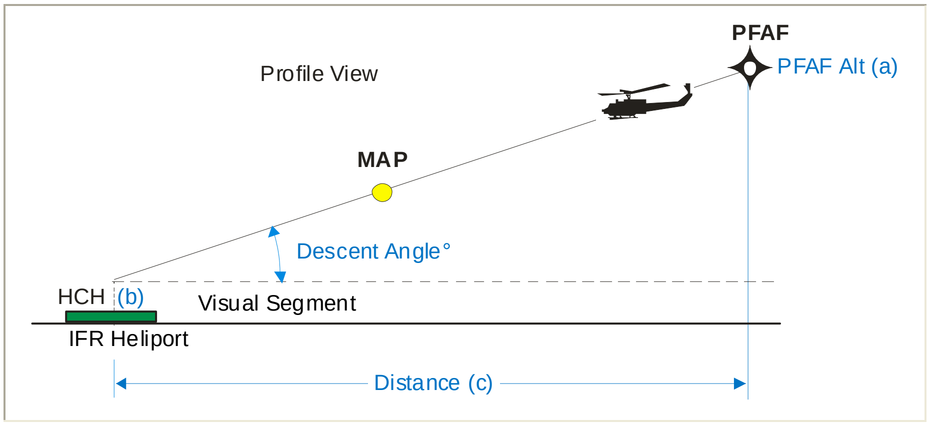


Figure 4-2c. Descent Angle, PFAF to HCH for IFR Approach to IFR Heliport.



(5) Stepdown Descent Gradient/Angle. When a stepdown fix is used, measure the descent gradient/angle from the PFAF at the PFAF altitude to the stepdown fix at the minimum fix altitude, then to the MAP at the MDA. For a stabilized approach, provide a constant gradient/angle from the PFAF to the MAP, (may require raising the PFAF altitude). A stepdown fix must be located no closer than 0.6 NM to the PFAF or MAP.

(6) Existing Obstacles Close to the PFAF or Stepdown Fix. If the segment descent gradient/angle is less than 800 ft/NM (7.5 degrees), Order 8260.3B, Volume 1, paragraph 289 may be applied substituting an OIS slope of 3.5:1 vice 7:1. Calculate the OIS Elevation and Minimum fix altitude using formula 4-4.

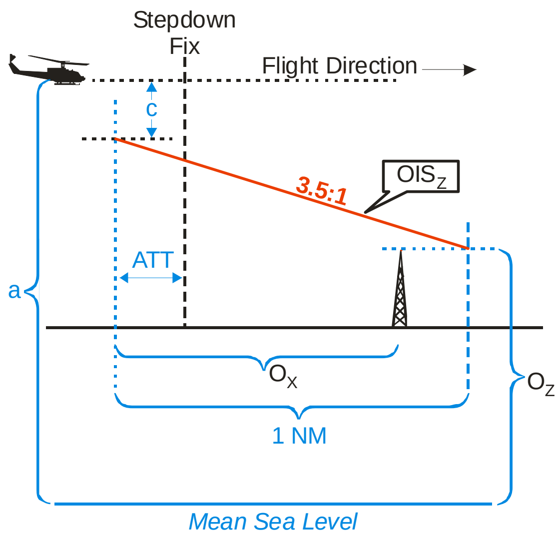
Formula 4-4. OIS Elevation & Minimum Fix Altitude (OIS_z & MFa).

$$OIS_z = (r + a - c) \cdot e^{\frac{-O_x}{3.5 \cdot r}} - r$$

$$MFa = (r + O_z + c) \cdot e^{\frac{O_x}{3.5 \cdot r}} - r$$

Where:

a = MSL fix altitude (ft)
c = ROC plus adjustments (Order 8260.3, Volume 1, para 3.2.2)
O_X = Obstacle along-track distance (ft) from ATT prior to fix (1 NM max)
O_Z = MSL obstacle elevation (ft)
MFa = Minimum Fix Altitude (rounded to next higher 100-ft increments)



OISZ=(r+a-c)*e^(-O_X/(3.5*r))-r
MFa=(r+O_Z+c)*e^(O_X/(3.5*r))-r

Calculator

a		Click here to calculate
c		
O_X		
O_Z		
OIS_Z		
MFa		

4. IFR Heliport Visual Segment. The IFR Heliport visual segment connects the MAP to the helipoint. The visual segment OCS starts at the VSRL and extends to the later of a point 250 ft below the MDA or the latest MAP ATT (see figures 4-3 and 4-4).

a. Alignment. The IFR Heliport visual segment connects the MAP to the helipoint. The course change at the MAP from the FAC must not exceed 30 degrees.

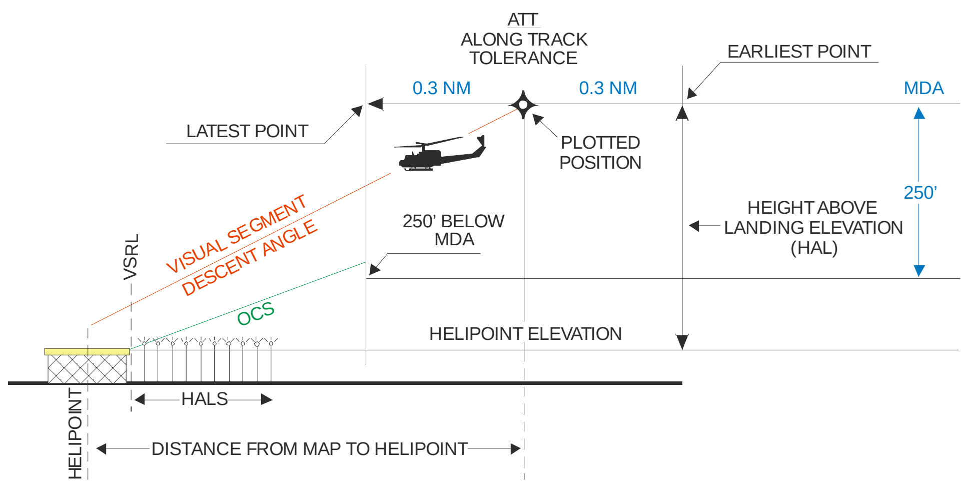
b. Area. The obstacle evaluation area (OEA) begins at the Visual Segment Reference Line (VSRL) and extends toward the MAP as defined below:

(1) Length. The IFR Heliport Visual segment begins at the MAP and ends at the Heliport (see profile figures 4-3 and 4-4).

(2) Width. The visual segment splay begins at the Visual Segment Reference Line (VSRL). It splays from the VSRL endpoints relative to the FAC to the latest FAS primary area width at the latest MAP ATT (see plan view figure 4-6 (right)). Where the OCS surface extends to a point 250 ft below the MDA, the boundary follows the primary area to its end point (see plan view figures 4-4 and 4-6 (left)).

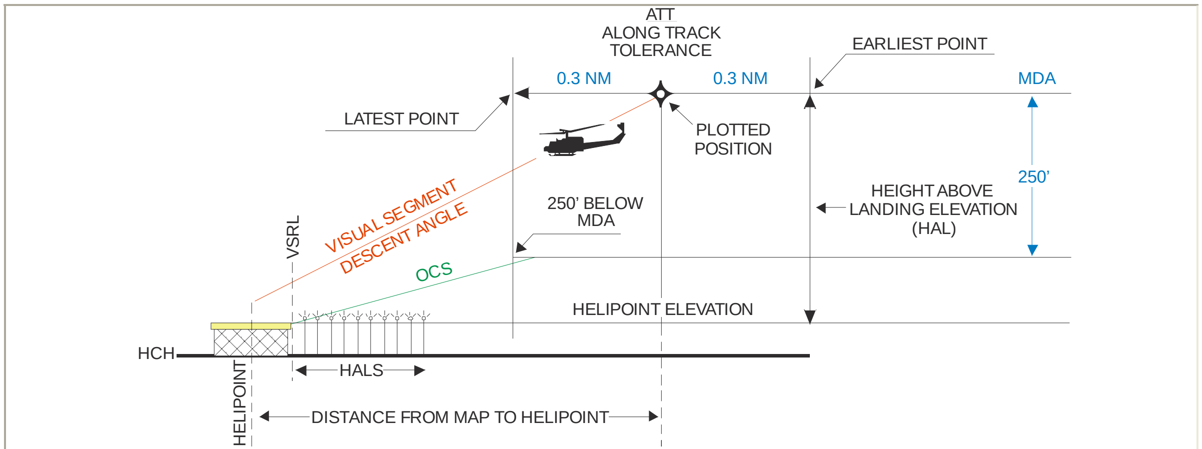
c. Obstacle Clearance Surface. The OCS begins at the VSRL and extends 1.0 degree below the VSDA (see figures 4-3 and 4-4).

Figure 4-3. IFR Heliport Visual Segment OCS Terminating at Latest MAP Position.



OCS REACHES MDA MINUS 250' FIRST THEN ENDS AT THE LATEST MAP POSITION
See Figure 4-6 (Right) .

Figure 4-4. IFR Heliport Visual Segment OCS Terminating at an Altitude 250 ft Below MDA.



OCS REACHES THE LATEST MAP POSITION FIRST THEN ENDS AT MDA MINUS 250' (VSL 250)
See Figure 4-6 (Left)

Figure 4-5. IFR Heliport Visual Segment Area.

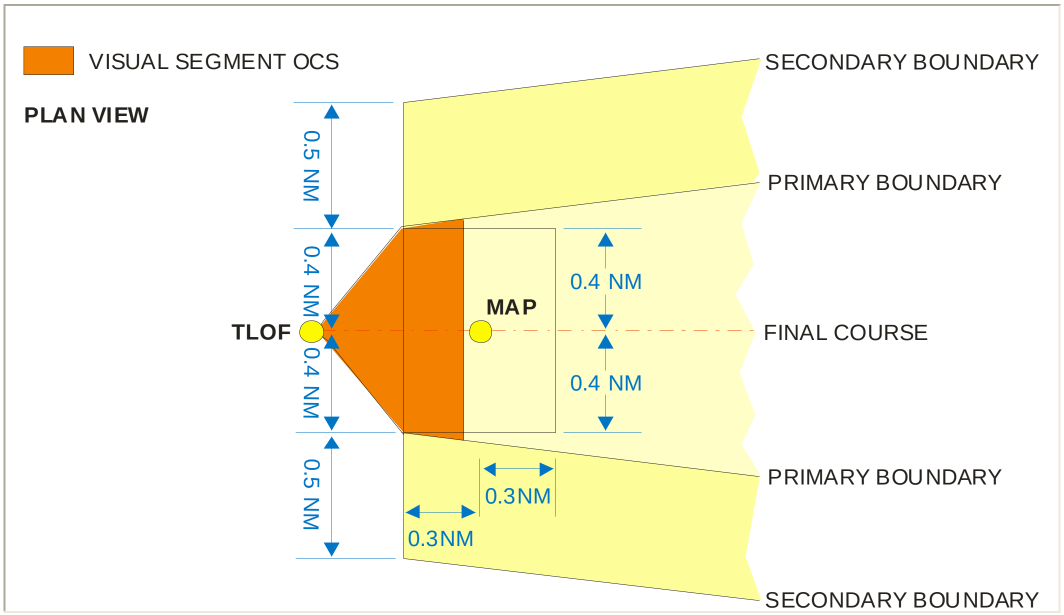
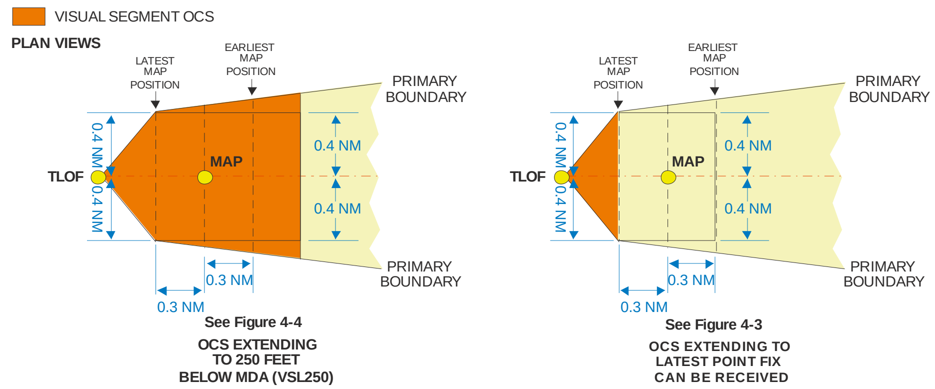


Figure 4-6. IFR Heliport Visual Segment Area Splays.



d. IFR Heliport with Visual Segment Descent Point (VSDP). A VSDP may be established for straight-in helicopter GPS procedures. Apply the VDP concepts in Order 8260.3, Volume 1, paragraph 253, except use helipoint elevation vice RWT elevation and HCH vice TCH. The recommended descent angle from the VSDP is 6.0 degrees. The **maximum** angle is 7.5 degrees. Locate the VSDP on the FAC at the point where the visual glide slope indicator (VGSI) on-glide slope beam intersects the MDA. Publish the VSDP as an ATD from the MAP. Do not publish a VSDP where the VSDP falls between the MAP and the helipoint. Where a VGSI is not established, calculate the VSDP to helipoint distance along the FAC using formula 4-5:

Note: Where **no** VSDP has been established, refer to chapter 4, paragraph 4e, then proceed from chapter 4, paragraph 4d(1).

Formula 4-5. VSDP to Heliport Distance ($VSDP_{dist}$).

$$VSDP_{dist} = \frac{\left(r \cdot \ln\left(\frac{r + MDA}{r + HE + HCH}\right)\right)}{\tan\left(VSDA \cdot \frac{\pi}{180}\right)}$$

Where:

MDA = Final Minimum Descent Altitude (MDA)
HE = Heliport Elevation
HCH = Heliport Crossing Height
VSDA = descent angle (see formula 4-8)

(r*ln((r+MDA)/(r+HE+HCH))/tan(VSDA*π/180)))

Calculator

MDA		Click here to calculate
HE		
HCH		
VSDA	°	
$VSDP_{dist}$		

(1) Alignment. The VSDP-based visual segment connects the FAC/VSDP to the helipoint. No course change is allowed at the VSDP.

(2) Area. The obstacle evaluation area (OEA) begins at the VSDP and ends at the helipoint/VSRL (see figure 4-7).

(a) Length. The VSDP-based visual segment begins at the VSDP and ends at the helipoint/VSRL. Determine the VSDP-based visual segment length, VSDP-based descent angle, HAL, and VSRL to a point 250 ft below MDA (VSL_{250}) using the following steps (see figure 4-7).

(b) Width. The VSDP-based visual segment begins at the VSRL. It splays from the VSRL ends at a 10-degree angle relative the FAC until reaching the VSDP.

(3) Obstacle Clearance. No obstacle may penetrate the VSDP-based visual segment OCS (see figure 4-7). Calculate the OCS MSL elevation at any point between the VSRL and the VSDP using formula 4-6. Evaluate obstacles based on the shortest obstacle to surface origin distance (VSRL), measured parallel to the visual segment centerline. Calculate the OCS MSL elevation at a specified obstacle location using formula 4-6.

Formula 4-6. OCS Elevation (OCS_{elev}).

$$OCS_{elev} = (r + HE) \cdot e^{\frac{D \cdot Tan\left(\beta \cdot \frac{\pi}{180}\right)}{r}} - r$$

Where:

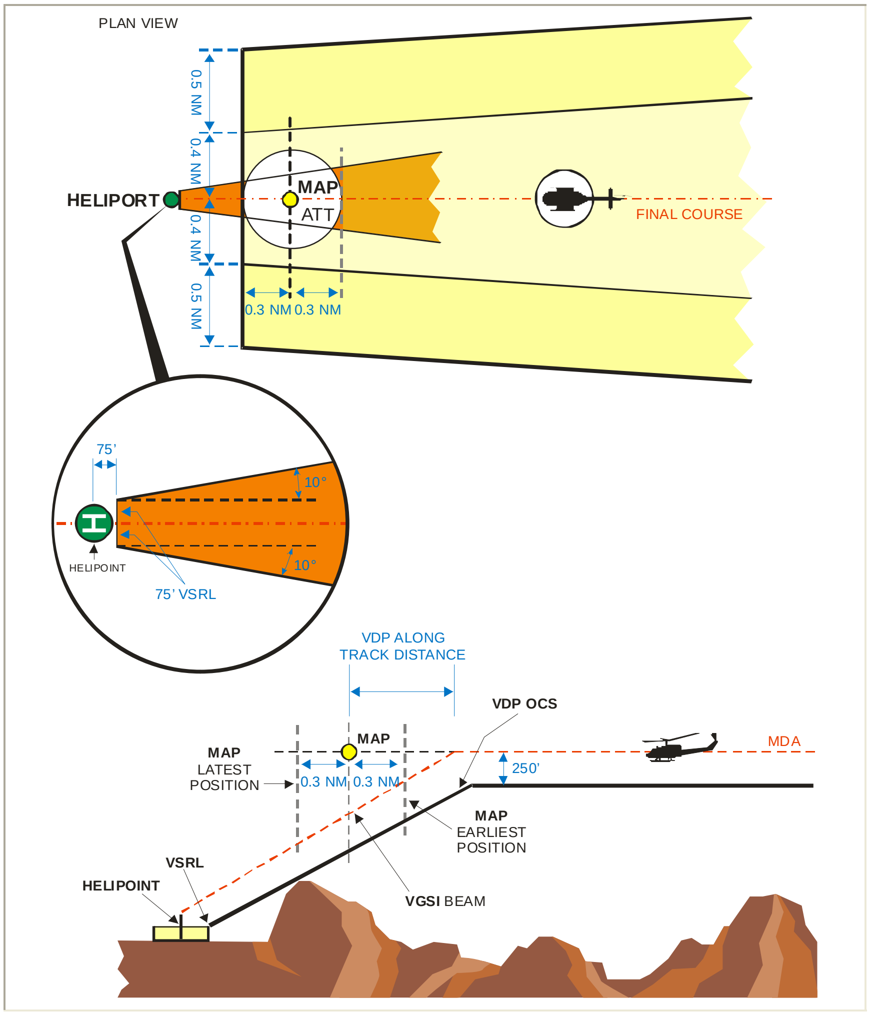
HE = Helipoint elevation MSL
D = Distance obstacle to VSRL(ft)
β = OCS Angle

(r+HE)*e^(D*Tan(β*π/180)/r)-r

Calculator

HE		Click here to calculate
D		
β	°	
OCS_{elev}		

Figure 4-7. IFR Heliport VSDP OCS.



(4) IFR Heliport HAL, VSDA-based Visual Segment Length (VSL250), and Visual Segment Descent Angle (VSDA) Computations. Calculate HAL, VSRL to a point 250 ft below MDA (VSL_{250}), and VSDA using the following steps (see figure 4-7):

(a) Calculate HAL using formula 4-7:

Formula 4-7. OCS Elevation (HAL).		
HAL= MDA-Helipoint Elevation (HE)		
MDA-HE		
Calculator		
MDA		Click here to calculate
HE		
HAL		

(b) Calculate VSDA using formula 4-8:

Formula 4-8. Visual Segment Descent Angle (VSDA).		
$$VSDA = \operatorname{atan}\left(\frac{r}{c}\cdot \ln\left(\frac{r+HAL+HCH}{r+HCH}\right)\right)\cdot\frac{180}{\pi}$$ Where: c = MAP to Helipoint Distance (ft); HAL = Formula 4-7 output; HCH = Heliport Crossing Height		
atan(r/c*ln((r+HAL+HCH)/(r+HCH))*180/π		
Calculator		
c		Click here to calculate
HAL		
HCH		
VSDA	°	

(c) Calculate visual segment length from the VSRL to a point 250 ft below MDA (VSL_{250}) using formula 4-9.

Formula 4-9. Visual Segment Length (VSL_{250}).		
$$VSL_{250} = \frac{\left(r\cdot \ln\left(\frac{r+a}{r+HE}\right)\right)}{\tan\left((VSDA-1)\cdot\frac{\pi}{180}\right)}$$ Where: HAL = Formula 4-7 output; a = HAL-250 (MSL); HE = Heliport elevation; VSDA = Formula 4-8 output		
(r*ln((r+a)/(r+HE)))/tan((VSDA-1)*(π/180))		
Calculator		
HAL		Click here to calculate
HE		
VSDA	°	
VSL_{250} (ft)		

e. No Established VSDP. Where no VSDP has been established, apply the principles of Order 8260.3, Volume 1, paragraph 253. Locate the VSDP on the FAC at the point where the VGSI on-glide-slope beam intersects the MDA. The recommended VSDP on-glide-slope descent gradient/angle is 639 ft/NM (6 degrees). The **maximum** angle is 7.5 degrees (USA

maximum descent gradient/angle is 478 ft/NM (4.5 degrees) without a waiver). Where a VGSI facility is installed, the VSDP OCS inclines upward from the VSRL at an angle 1.0 degree below the aiming angle of the on-glide-slope beam. Where no VGSI facility is installed, the VSDP OCS rises 1 degree below the VSDA. Publish the VSDP as an ATD from the MAP. The **minimum** HCH is 5 ft. The **maximum** HCH is 20 ft unless approved by Flight Standards. Calculate the VSDP distance (D) from the helipoint using formula 4-10.

Formula 4-10. Distance from Helipoint (D).

$$D = \frac{\left(r \cdot \ln\left(\frac{r + HAL + HE}{r + HE}\right)\right)}{\tan\left(VSDA \cdot \frac{\pi}{180}\right)}$$

Where:

HAL = Formula 4-7 output

HE = Heliport elevation

VSDA = Formula 4-8 output

(r*ln((r+HAL+HE)/(r+HE)))/tan(VSDA*(π/180))

Calculator		
HAL		Click here to calculate
HE		
VSDA	°	
D (ft)		

5. Special IFR Approach to a VFR Heliport (IVH) (Proceed Visually). The special procedure provides a measure of obstruction protection/ identification along the visual track from a MAP to a specific VFR heliport. The visual segment is based on the premise that the pilot will maintain level flight at the MDA until the helicopter is in a position to initiate a descent to the helipoint. Where obstacles preclude an immediate descent at the MAP to the FATO, establish an ATD fix to provide a descent point to the FATO. When an amended procedure no longer meets the criteria in this paragraph, a PinS procedure applying the criteria in chapter 4, paragraph 7 may be published. Compute the distance for the Remote Altimeter Setting Source (RASS) adjustment for the MDA and stepdown altitudes for the IVH approach procedures from the source to the MAP.

a. Alignment. The IVH visual segment connects the MAP to the helipoint. The **optimum** IVH visual segment is aligned with the FAC. The course change at the MAP must not exceed 30 degrees.

b. Area.

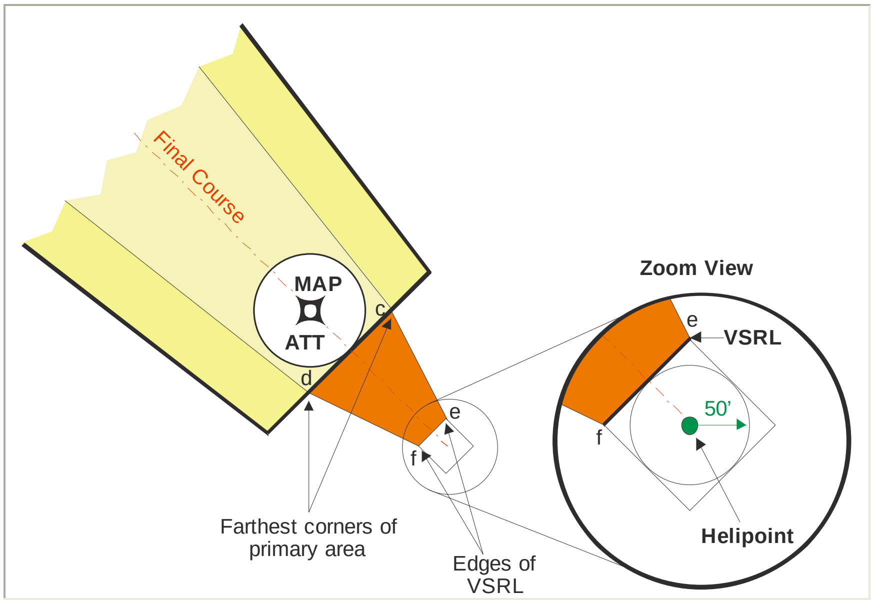
(1) Length. The IVH visual segment OEA begins at the earliest MAP ATT and ends at the VSRL. The IVH visual segment OEA **maximum** length is 10,560 ft (2 SM), measured from the MAP plotted position to the helipoint. The **optimum** MAP/ATD fix to helipoint distance is

3,949 ft (0.65 NM). The **minimum** distance from the MAP/ATD fix to the helipoint is 3,342 ft (0.55 NM).

(2) Width. The IVH visual segment splay begins at the VSRL. It splays from the VSRL endpoints toward the MAP until the visual segment OEA reaches the appropriate construction width [see chapter 4, paragraph 5b(2)(a) or 5b(2)(b)].

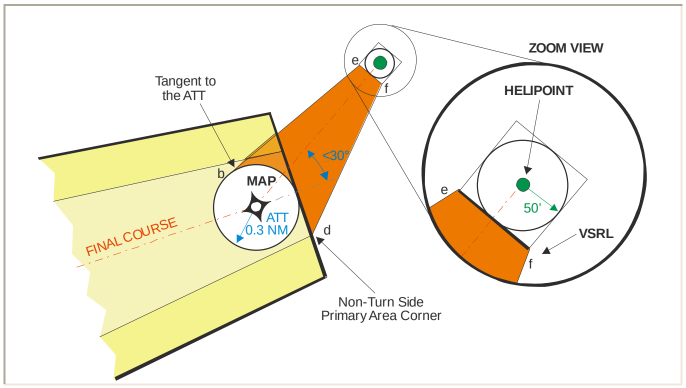
(a) Straight Course Construction. Connect the final primary area outer edges (cd) to the VSRL outer edges (ef) (see figure 4-8).

Figure 4-8. Straight Visual Segment OEA.



(b) Turn at the MAP Construction. Refer to figure 4-9, and connect the tangent on the turn side (b) of the MAP nearest the heliport to the VSRL at point (e). This connection extends the turn-side area and identifies whether final secondary areas lie within the visual OEA (The MDA must provide primary ROC within this area). Connect the non-turn-side primary area corner (d) to the VSRL at point (f).

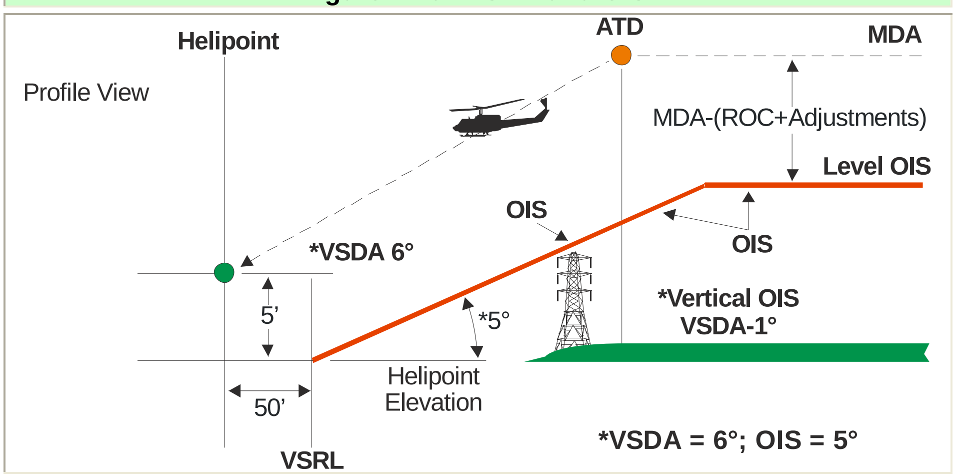
Figure 4-9. Visual Segment with Turn at MAP OEA.



(3) Visual Segment OIS Evaluation. Apply chapter 4, paragraph 3a for the IFR segment OCA and ROC. Apply chapter 4, paragraph 3a(3) in constructing the descent gradient/angle in the IFR segment.

c. Visual Segment Descent Angle (VSDA). The VSDA is a developer-specified angle extending from a point 5 to 20 ft directly above the helipoint to the MDA. The VSDA must cross the MDA between the helipoint and the MAP. The **maximum** VSDA is 7.5 degrees, **optimum** is 6.0 degrees, VSDA angles higher than 7.5 degrees require Flight Standards Service approval. (see figure 4-10).

Figure 4-10. VSDA and OIS.



d. Visual Segment OIS. The OIS begins at the VSRL and extends upward toward the MAP at an angle of (VSDA – 1 degree). The OIS rises to the point it reaches an altitude equal to the MDA minus the ROC and adjustments. Where the MAP is beyond this point, the OIS becomes a level surface to the MAP plotted position. Measure obstacles using the shortest distance to the VSRL. Obstacles should not penetrate the OIS; if they penetrate in the initial evaluation, take one of the following actions, listed in preferential order (see figure 4-11):

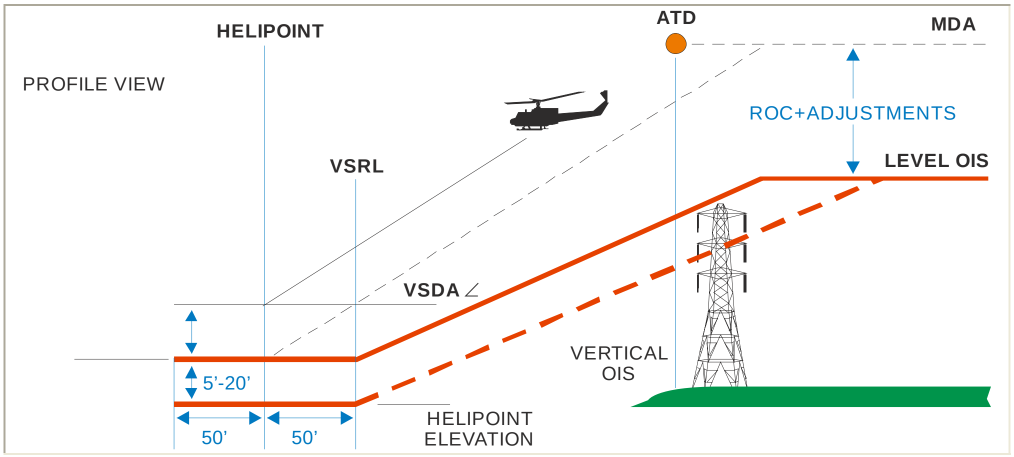
(1) Remove or adjust obstacle location and/or height to eliminate the penetration, or

(2) Raise the VSDA to achieve an OIS angle that clears the obstacle, (7.5 degrees **maximum** without Flight Standards Service approval), or

(3) Identify the obstacle with the greatest penetration. Raise the MDA the penetration amount and round to the next higher 20-ft increment. Initiate action to have the obstacle marked and lighted, if feasible. Depict all obstacles on the approach chart that penetrate the OIS and include in required training.

(4) Raise the HCH to ≤ 20 ft provided the height is consistent with the helicopter's ability to hover out of ground effect. When this procedure is applied, raise the OIS origin above the helipoint elevation by the amount that the HCH is increased (see figure 4-11).

Figure 4-11. VSDA and OIS.



6. Special IFR Approach to A VFR Runway (IVR) (Proceed Visually). This special procedure provides protection/identification along a visual track from the MAP to a specific point on a VFR runway (see figure 4-12 example). This procedure requires the training and equipment contained/specified in an OpSpec or letter of authorization (LOA). This procedure must meet all IVH (Proceed Visually) procedure requirements and the following additional requirements:

a. Location on the runway. The helipoint (aiming point) may be located at any point on a runway centerline, but should be at least a distance of (1.5 * Rotor Diameter) from the end of the usable runway on centerline. The runway is not required to be marked with heliport markings. The visual track from the MAP to the final approach area helipoint must be charted.

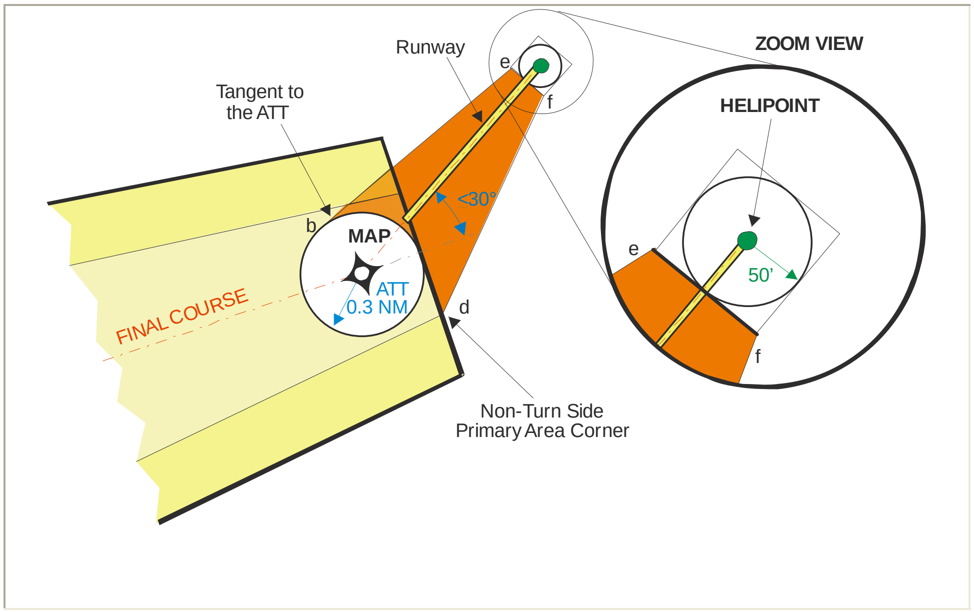
b. Alignment. The **optimum** FAC and visual flight path is aligned with the extended runway centerline, with the MAP at the threshold. The FAC must be aligned within 30 degrees of the extended runway centerline. See paragraph 5 and figures 4-8, 4-9 and 4-12 for OEA construction examples.

c. Day operations. An **'acceptable'** visual segment day flight evaluation for flyability and OIS obstacle penetration must be completed.

d. Night operations. An '**acceptable**' visual segment night flight evaluation for flyability must be completed. This evaluation must confirm the runway lighting system is visible from the MAP.

e. Helipoint Location. The runway final approach area about the heliport must be clearly viewable from the MAP.

Figure 4-12. IFR to a VFR Runway.



7. PinS Approach (Proceed VFR). The VFR segment on a PinS (Proceed VFR) approach procedure provides a measure of obstacle protection/identification to allow a safe transition from IFR to VFR flight. The area is not intended to support IFR descent.

Apply Order 8260.3, Volume 1, chapter 11 pertaining to PinS approach criteria, except no requirement exists for a MAP to be located beyond 2,600 ft of the helipoint. A PinS (Proceed VFR) procedure may be developed to a heliport, multiple heliports, or a geographical area not associated with a specific heliport. Refer to chapter 2, paragraph 3 to determine whether procedures are 'Specials.' Compute the distance for the Remote Altimeter Setting Source (RASS) adjustment for the MDA and stepdown altitudes for the PinS approach procedures from the source to the MAP.

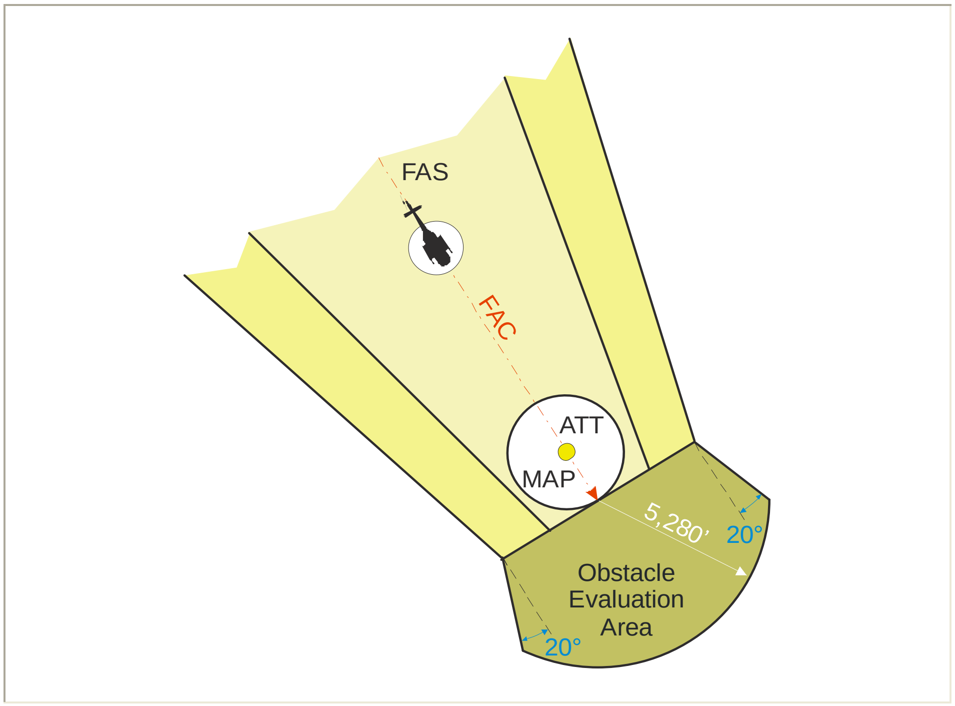
a. Alignment. The PinS visual segment is a 5,280 ft-radius arc segment centered at the FAC and the latest MAP ATT intersection.

b. Area. The PinS OEA is a 5,280 ft-radius arc segment centered at the FAC and the latest MAP ATT intersection. The arc segment is laterally bounded by 20 degree splay lines (relative the FAC-extended), originating at the FAS secondary boundaries and the latest MAP ATT (see figure 4-13).

c. Length. A 5,280 ft radius as described above.

d. PinS visual segment OIS (see chapter 4, paragraph 7e**).** This surface **must not** be penetrated **except** when a 'special approach procedure' MDA, not providing obstacle clearance in this area, is **mandatory** for mission completion. Obstacles that penetrate the special procedure surface must be charted and included in the required training (AAOs are not charted).

Figure 4-13. PinS (Proceed VFR)
VFR Transition Area Obstacle Evaluation (OEA).



e. Obstacle Clearance in the PinS VFR Segment. Add 250 ft of ROC (minus adjustments) to the highest obstacle/terrain within the VFR area and (round to the next higher 20-ft increment). The final MDA is the higher of the MDAs calculated for the final and VFR segments. This does not apply to special approaches (see chapter 4, paragraph 7d).

f. Visibility. The **minimum** final segment visibility is ¾ SM for a height above surface (HAS) of 800 ft and below. Where a HAS exceeds 800 ft, the MINIMUM visibility is 1.0 SM.

8. IFR to an IFR Runway.

a. Configuration and Alignment. The MAP location should provide the best compromise of lowest visibility and VSDA. Except where the alignment is to the RWT, the mandatory MAP location is at the FAC and RCL intersection. Where the alignment is to the RCL, the optimum MAP location is at the RWT, with optional MAP location along the FAC between the PFAF and the RWT.

b. Area. The final OEA begins at the earliest PFAF ATT and ends at the latest MAP ATT, RWT, or a point abeam the RWT, whichever is farthest. Apply chapter 4, paragraph 3a criteria for the IFR segment OEA and ROC (see figure 4-1).

c. Descent Gradient/Angle. Calculate the FAS descent angle from the PFAF altitude at the plotted position of the PFAF to the TCH at RWT. Apply chapter 4, paragraph 3a(4).

d. Visual Segment. Apply Order 8260.3, Volume 1, paragraph 3.3.2.d. Establish a 40 ± 5 ft TCH for runways where no VGSI is installed. Where a VGSI is installed, a final descent gradient and VSDA may be established to coincide with the established gradients/angles for angles of 3.0 angles or more. If the descent gradient/angle cannot be published coincident (within ± 0.20 degrees) and TCH values within 3 ft of the published VGSI glide slope angle, publish a note on the chart.

e. Visibility. See chapter 7, paragraph 1b. Apply Order 8260.3, Volume 1, paragraph 1127. Where obstacles penetrate Order 8260.3, Volume 1 paragraph 3.3.2.d. surfaces, add the chart note: Visibility Reduction by helicopters NA. See Order 8260.19, paragraph 854(i)(3).

> **Note:** When a special procedure has a GPA greater than 5.7 degrees and a TCH higher than 45 ft, Order 8260.3, Volume 1, paragraph 1127 may be applied. Table 25 application is required.

9. WAAS LP Criteria. The WAAS LP criteria apply to the final approach only. For all other segments apply GPS criteria except where noted for a turn at the PFAF, and missed approach constructions that are different. This implementation of WAAS does not include a glidepath function for these procedures. Criteria in this chapter provide a narrower OEA in the IFR FAS and OIS in the visual segment. The segment lengths and descent rate/gradients are the same as chapter 4, paragraph 3. The intermediate segment begins with the same width at the GPS intermediate fix (IF), reference chapter 3, paragraph 1b, tailored to the beginning WAAS FAS width, reference chapter 4, paragraph 9d at the PFAF. Apply chapter 4, paragraph 5 through 7 to design approaches in the visual/visual flight rule (VFR) segments, and apply chapter 4, paragraphs 8 and 9 for the IFR FAS OEA and ROC. Apply an OIS, reference chapter 4, paragraph 5d, with the reduced width, reference chapter 4, paragraph 8d. Apply chapter 4, paragraph 5 for the analysis of the VFR area of a Point in Space (PinS) (Proceed VFR) approach.

Figure 4-17 depicts the basic configuration for determining the Flight Path Alignment Point (FPAP) and fictitious helipoint (FHP) coordinates. Locate the FHP 2,600 ft from the MAP. The FPAP is a point defined by the World Geodetic System 1984 (WGS-84) latitude, longitude, and is located 9,023 ft from the FHP.

a. Minimums. Apply chapter 7.

b. Use The Following Steps for WAAS LP Procedure Construction:

Step 1: Determine the FAS course alignment, MAP, FHP, and FPAP coordinates.

Step 2: Calculate the distance (ft) from the FHP to the PFAF (D_{PFAF}) using formula 4-11. Calculate the primary and secondary area widths at any distance from FHP to the earliest point the PFAF can be received using formulas 4-11 and 4-13 (see figure 4-14).

Formula 4-11. LP PFAF (D_{PFAF}).

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

Where:

alt = minimum intermediate segment altitude
FHP_{elev} = FHP MSL elevation
HCH = HCH value
θ = glidepath angle

$(\ln((r+alt)/(r+FHP_{elev}+HCH))*r)/\tan(\theta*\pi/180)$

Calculator

FHP_{elev}		Click here to calculate
HCH		
θ	°	
alt		
D_{PFAF} (ft)		

Step 3: After constructing the IFR final trapezoid area, analyze the FAS by determining the controlling obstacle within the IFR final segment by applying the ROC in chapter 4, paragraph 9b and determining the minimum descent altitude (MDA).

Step 4: When constructing an IFR to a VFR heliport procedure (IVH, Proceed Visually), or an IFR approach to a VFR runway procedure (IVR, proceed visualy), apply chapter 4 criteria for the visual segment, but construct the narrower OIS in accordance with chapter 4, paragraph 9g.

Step 5: When constructing a PinS (Proceed VFR) approach, apply chapter 4 criteria for the VFR segment and adjust the MDA of the IFR segment after an analysis of the VFR segment if required.

Step 6: Construct the missed approach using chapter 5.

c. Determine FAS Course Alignment, FPAP and FHP Coordinates. The FAS course determines the positional relationship between the FPAP and the FHP. Calculate the FPAP latitude and longitude coordinates using the MAP as a starting point after determining the procedure final approach course (FAC). Use the direct program and extend the FAS course as an azimuth at a distance of 2,600 ft from the MAP to determine the FHP coordinates. Extend this course 9,023 ft beyond the FHP to calculate the FPAP coordinates (see figure 4-14 and table 4-1).

Figure 4-14. FPAP and FHP Coordinates.

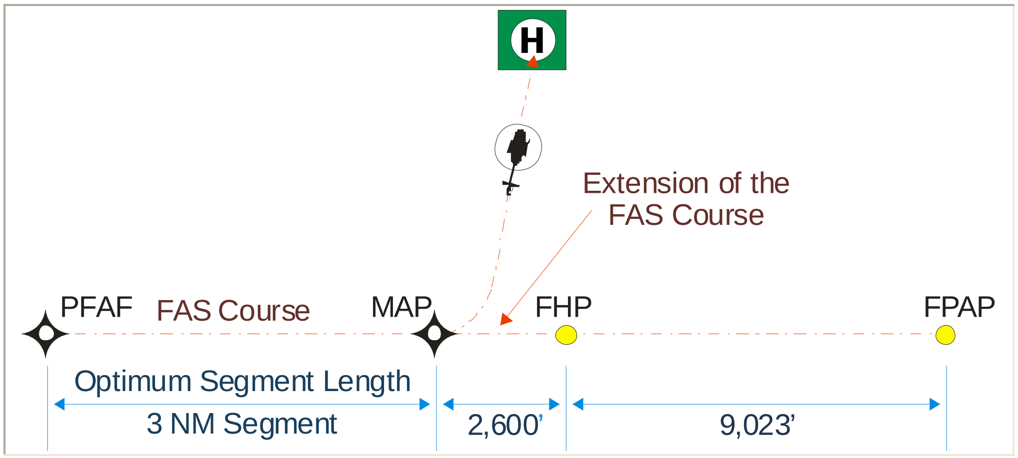


Table 4-1. FPAP Information.			
FPAP Distance from FHP	**± Splay**	**± Width**	**Length Offset**
9,023 ft	**2.0°**	**350 ft (106.75 m)***	**0**

*Round result to the nearest 0.25 m.

d. Area. The FAS OEA begins at the earliest PFAF position and ends at the MAP latest ATT (see figure 4-16). The PFAF and MAP ATT is ±40 m. Apply 250 ft of ROC in the primary area. The secondary area ROC is 250 ft at the primary boundary tapering uniformly to zero at the outer edge. The beginning primary area width nearest the FHP is 867.79 ft, and the secondary areas are 468.60 ft (see figures 4-15b and 4-16). Calculate the primary and secondary widths at any point between FHP and PFAF using formulas 4-12 (primary) and 4-13 (secondary).

(1) Length. The **standard** IFR final segment length PFAF to MAP is 3 NM but is also determined by descent gradient. The **minimum** length is 2 NM and the **maximum** length is 50,000 ft. (see figure 4-15a).

Figure 4-15a. WAAS LP Final Segment.

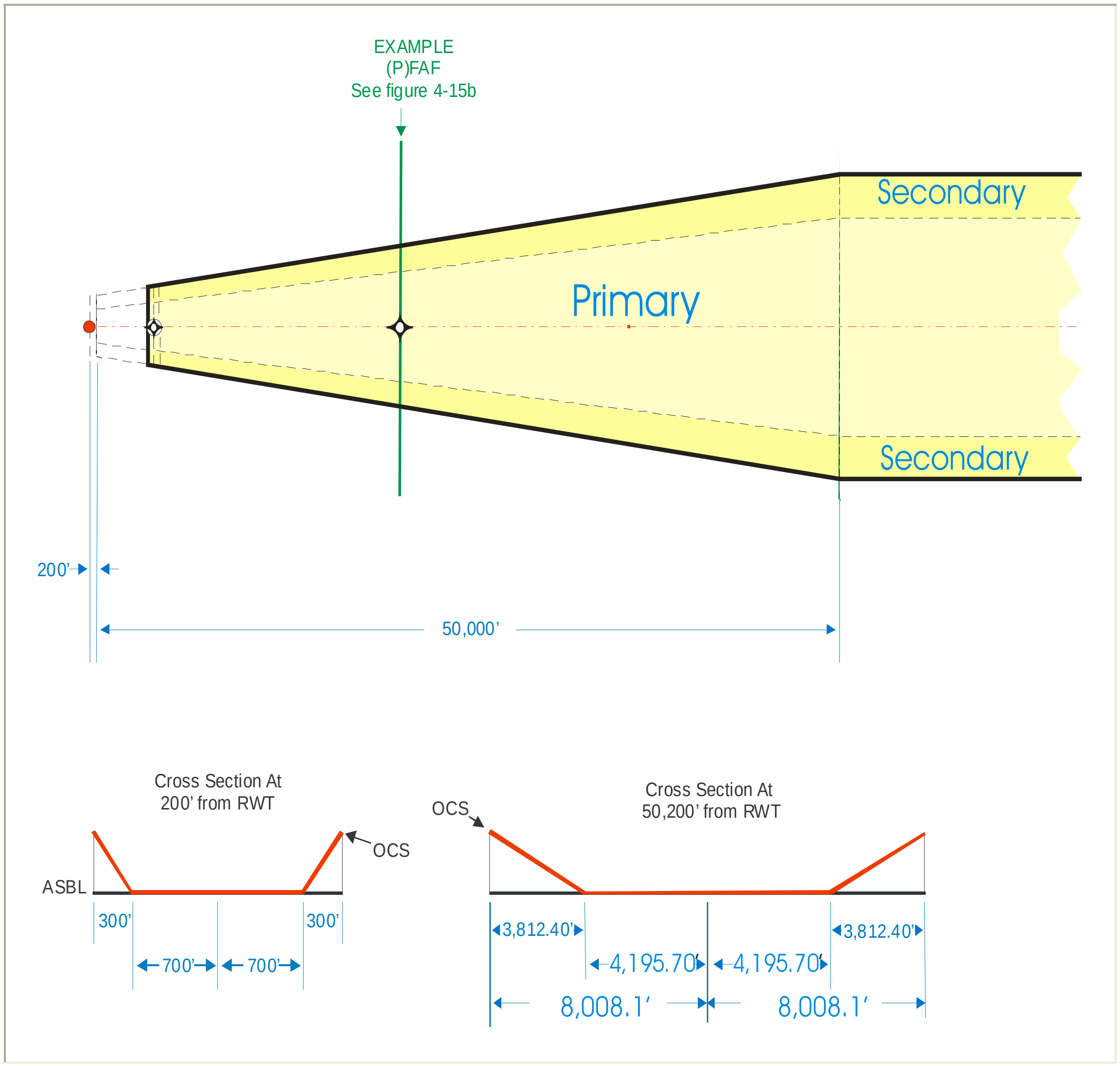


Figure 4-15b. WAAS LP Final Segment Construction.

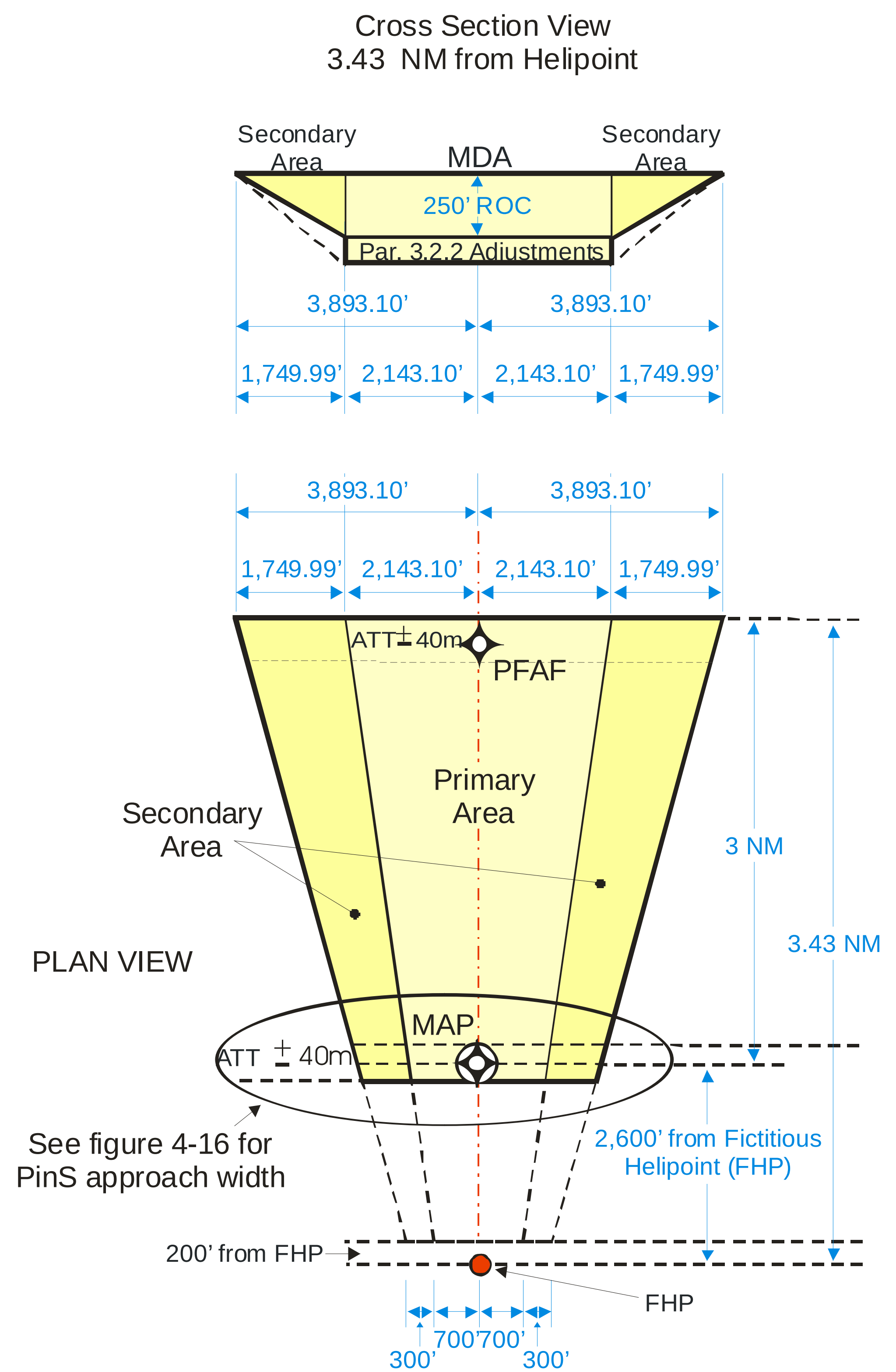
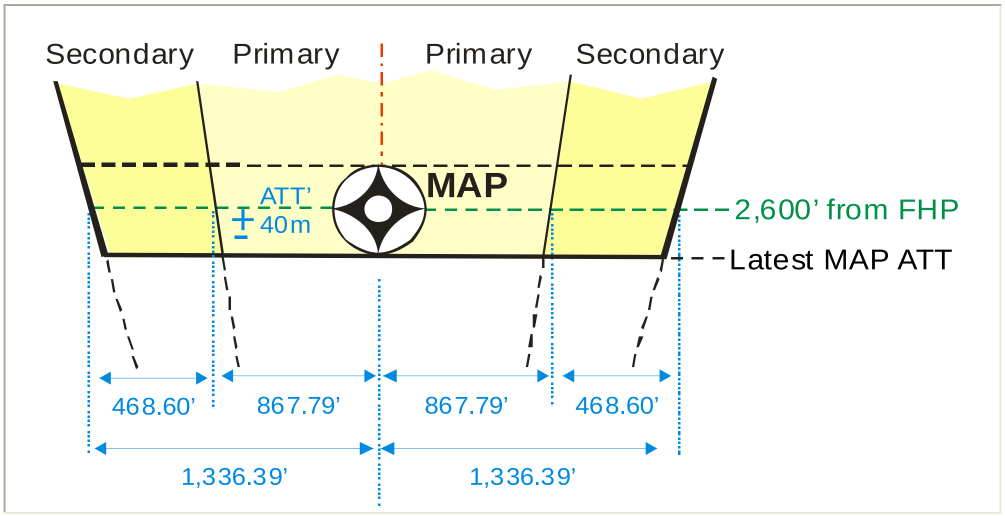


Figure 4-16. OCS Beginning Width, IFR to VFR Heliport and Copter PinS FAS at 2,600 ft from FHP.



(2) The primary area width (D_P) each side of FAC at its origin (2,600 ft from FHP) is 867.79 ft. The primary area expands uniformly to 3,495.70 ft from FAC at a point 50,200 ft from FHP. From 50,200 ft outward, the OEA is linear (boundaries parallel the centerline). The OEA begins at the earliest PFAF ATT and ends 2,600 ft from the FHP (MAP latest ATT). Calculate primary area half-width at any point in final using formula 4-12 (see figures 4-15a, 4-15b, and 4-16).

Calculate the perpendicular distance (ft) D_p from FAC to the primary area boundary at any distance (d_{FHP}) using formula 4-12:

Formula 4-12. ½ Width of Primary (D_p).		
D_P =1/2 Primary Area Width (ft) = 0.0699139 (d_{FHP} - 200) + 700 d_{FHP} = Distance (ft) from FHP, along course		
0.0699139*(d_{FHP}-200)+700		
Calculator		
d_{FHP}		Click here to calculate
D_P (ft)		

(3) The perpendicular distance from FAC to outer secondary boundary (D_s) is 1,336.39 ft at the origin, and expands uniformly to 7,008.1 ft at 50,200 ft from the FHP (see figures 4-15a, 4-15b, and 4-16). Calculate D_S (ft) using formula 4-13.

Formula 4-13. Perpendicular Distance (D_S).		
D_S = Secondary Boundary Dist. (ft) = 0.140162 (d_{FHP} - 200) + 1000 Where: D_S = Course to Outer Secondary Distance (ft) d_{FHP}= Distance from FHP (ft), along course		
0.140162*(d_{FHP} – 200) + 1000		
Calculator		
d_{FHP}		Click here to calculate
D_S (ft)		

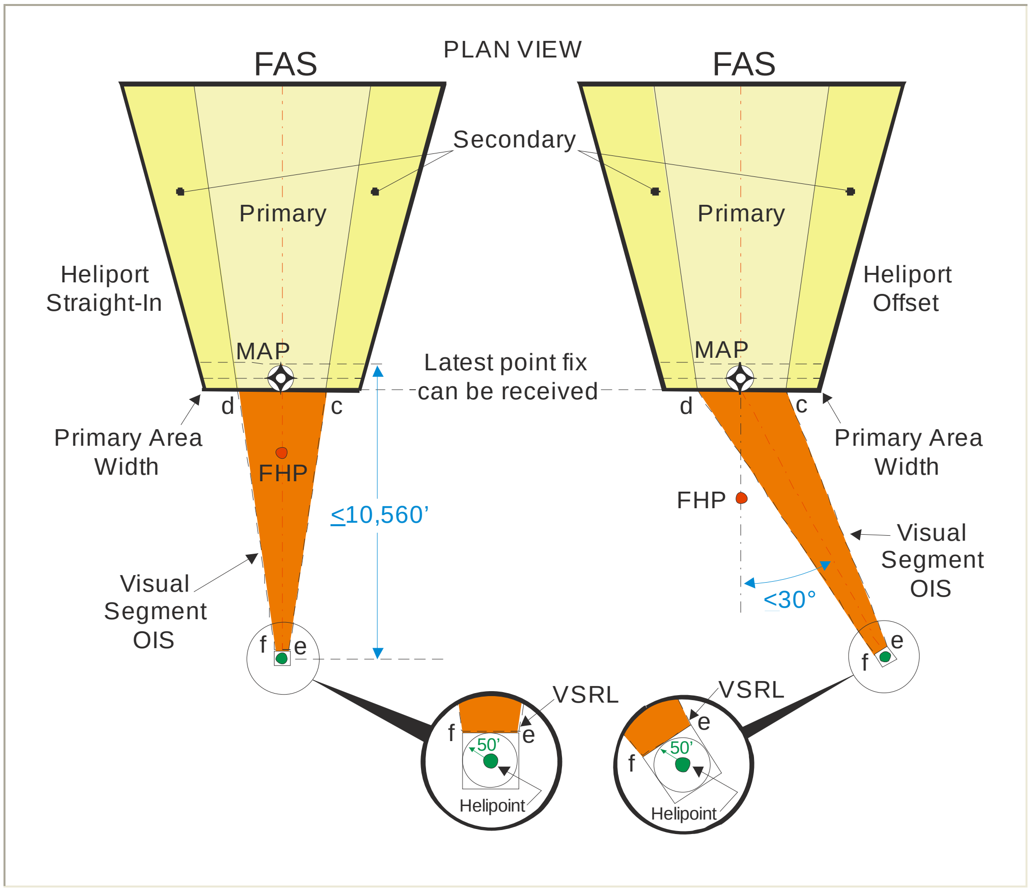
e. Required Obstacle Clearance (ROC). Primary ROC is 250 ft. The MDA can be no lower than the controlling obstacle height adjusted for obstacle accuracy tolerance (see Order 8260.19, appendix 2) plus the ROC value plus adjustments rounded to the next higher 20 ft-increment. Calculate secondary area ROC using formula 4-14.

Formula 4-14. Secondary Area ROC ($ROC_{secondary}$).		
$ROC_{secondary} = (250+adj) \cdot \left(1 - \frac{d_{primary}}{W_S}\right)$ Where: adj = TERPS para 3.2.2 adjustments $d_{primary}$ = perpendicular distance (ft) from primary area edge W_S = Secondary Area Width (ft)		
(250+adj)*(1-$d_{primary}$/W_s)		
Calculator		
adj		Click here to calculate
$d_{primary}$ (ft)		
W_s (ft)		
$ROC_{secondary}$		

f. FAS Descent Angle/Gradient. Apply chapter 4, paragraphs 3a(4) and 3a(5).

g. IFR Approach to a VFR Heliport (IVH) or IFR to a VFR Runway (IVR). Apply chapter 4, paragraphs 5 through 7 and the criteria in this chapter for the IFR final segment OEA. Construct the IFR FAS by applying chapter 4, paragraph 9. The OIS width is like the IFR final segment primary area width at the latest point the MAP can be received (± 867.79 ft) then narrows to the VSRL width (see figure 4-17).

Figure 4-17. Straight and Turn at the MAP OIS.



h. PinS Approach. Apply chapter 4, paragraph 9 to determine a preliminary MDA based on the FAS OEA. Apply chapter 4, paragraph 7 and 7e for the VFR segment analysis. The final MDA may require adjustment based on the VFR segment for a public procedure.

Chapter 5. Missed Approach

1. General.

a. Missed Approach (MA) Construction.

(1) Speed. Apply 70 KIAS for civil procedures (see chapter 2, paragraph 1) and 90 KIAS for military. Apply wind values (see chapter 2, formula 2-3b) and bank angles (see chapter 2, table 2-4).

(2) Optimum Flight Path. The missed approach segment ends at a holding point designated by a missed approach holding fix (MAHF). **Optimum** routing is straight ahead to a direct entry into holding at the MAHF. If the MA routing terminates at a "T" IAF, **optimum** MA holding pattern alignment is with the initial inbound course, with either a teardrop or direct entry into holding (see figure 5-1a).

Note: USA: Develop and annotate an alternate RNAV(GPS) MA procedure when requested.

b. Obstacle Clearance Standard. Calculate the nominal OCS slope ($MA_{OCSSLOPE}$) associated with a given missed approach climb gradient using chapter 2, formula 2-15. See chapter 2, paragraph 17 for Missed Approach Conventions.

c. Missed Approach Section 1 (MAS-1). Section 1 begins at earliest MAP along-track tolerance (ATT) and extends to the start-of-climb (SOC), or the point where the aircraft is projected to cross 400 ft above airport/heliport elevation, whichever is the greatest distance from MAP. See figure 5-1b for MA segment point and line designations. Figure 5-2 depicts the Section 1/Section 2 (partial), OCS plan and profile view beginning at an altitude of MDA minus 100 ft plus adjustments (see chapter 4 for greater final segment detail).

(1) Length.

(a) Flat Surface Length (FSL).

1 LNAV. Section 1 flat surface begins at CD (0.3 NM prior to the MAP) and extends (distance FSL feet) to JK.

2 LP. Section 1 flat surface begins at CD [40 meters prior to the MAP] and extends (distance FSL feet) to JK.

Step 1: Calculate the FSL value using formula 5-1. Use chapter 4, final segment formulas 4-1a, (LNAV primary and total), and 4-12 (LP primary), and 4-13 (LP Secondary distance) to determine MAS starting widths.

Formula 5-1. Flat Surface Length (FSL).		
$FSL = 8 \cdot \dfrac{\frac{1852}{0.3048}}{3600} \cdot \left(\left(V_{KIAS} \cdot \dfrac{171233 \cdot \sqrt{(288+15) - 0.00198 \cdot MDA}}{(288 - 0.00198 \cdot MDA)^{2.628}} \right) + 10 \right) + 2 \cdot ATT$		
8*(1852/0.3048/3600)*((VKIAS*(171233*((288+15)-0.00198*MDA)^0.5)/ (288-0.00198*MDA)^2.628)+10)+2*ATT		
Calculator		
V_{KIAS}		Click here to calculate
MDA		
ATT (ft)		
FSL(ft)		

Note: FSL time is 3 seconds reaction, and 5 seconds delay.

(2) Section 1 end location (AB).

(a) MDA ≥ 400 ft above airport/heliport elevation. Locate AB coincident with JK.

(b) MDA < 400 ft above airport/heliport elevation. Locate AB at $\dfrac{1852}{(0.3048 \cdot CG)}$ feet beyond JK for each foot of altitude needed to reach 400 ft above airport/heliport/surface elevation. The surface between JK and AB is a rising slope commensurate with the standard rate of climb (400 ft/NM). Find the appropriate CG-related slope using chapter 2, formula 2-15.

(c) Required/assigned turning altitude > 400 ft above airport/heliport elevation. Locate AB and apply the surface described in chapter 5, paragraph 1c(2)(b) until reaching the assigned turning altitude.

(3) Width. LNAV and LP.

(a) LNAV. Splay each secondary area outer boundary line outward 15 degrees relative to the missed approach course (MAC) from the secondary area outer edge at CD (0.3 NM prior to MAP) until it reaches a point 2 NM from MAC. Splay the primary area boundary uniformly outward from the primary area edge at CD to reach 1.5 NM from MAC at the same distance the secondary reaches full width. Calculate the distance from MAC to the MAS-1 OEA primary and outer secondary boundary at any distance from CD using formula 5-1a. Calculate final primary and secondary widths at CD using chapter 4, final formula 4-1a.

(b) LP. Splay each secondary area outer boundary line outward 15 degrees relative to the MAC from the secondary area outer edge at CD (40 meters prior to MAP) until it reaches a point 2 NM from MAC. Splay the primary area boundary uniformly outward from the primary area edge at CD to reach 1.5 NM from MAC at the same distance the secondary reaches full width. Calculate the distance (ft) from MAC to the MAS-1 OEA primary and outer secondary boundary at any distance from CD using formula 5-1a. Calculate final primary and secondary widths at CD using chapter 4, final segment formulas 4-12 and 4-13.

Formula 5-1a. LNAV/LP Section 1 Primary & Secondary Width.

$$MAS_{Yprimary} = d \cdot \frac{\tan\left(15 \cdot \frac{\pi}{180}\right) \cdot (1.5 \cdot NM - W_P)}{2 \cdot NM - W_S} + W_P$$

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

Where d = along-track distance (ft) from the cd line ≤ 45352.743
NM = 1852/0.3048
W_p = Primary Start Width (ft) (final formula)
W_s = Secondary Start Width (ft) (final formula)

$MAS_{Yprimary}$= d*((tan(15*π/180)*(1.5*1852/0.3048-W_P))/(2*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		
$MAS_{Yprimary}$		
$MAS_{Ysecondary}$		

(4) Obstacle Clearance Section 1.

(a) The nominal MAS-1 OCS is a flat surface. The MSL surface height (HMAS) is equal to the MDA minus 100 ft plus adjustments (see formula 5-1b). No obstacle may penetrate this surface.

(b) Where Section 1 extends beyond SOC (JK), no obstacle may penetrate the CG-associated OCS slope between SOC and AB. Find helicopter altitude at AB using formula 5-1c.

Formula 5-1b. 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		

Formula 5-1c. Section 1 End Helicopter Altitude ($Copter_{AB}$).

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

Where:

AB_{NM} = SOC to AB distance (NM)
CG = applied climb gradient (ft/NM)

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

MDA or DA		Click here to calculate
AB_{NM}		
CG		
$Copter_{AB}$		

d. These criteria cover two basic MA constructions:

- Straight missed approach
- Turning missed approach

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

(1) The section 2 obstacle evaluation area (OEA) splays 15 degrees relative to the nominal track to reach full width (see figure 5-3). The OEA ends at the MA Holding Fix (MAHF) latest ATT. Apply the Section 2 standard MA OCS slope beginning from AB . Calculate MA OCS slope values using chapter 2, formula 2-15.

Note: All references to 'standard MA OCS slope' and/or use of '20:1' refer to chapter 2, formula 2-15 output, with an input climb gradient (CG) of 400 ft/NM.

(2) Where a higher than standard CG (400 ft/NM) is required, apply the CG and the CG-related OCS from the SOC. Apply secondary areas as specified in this chapter. Measure the 4:1 secondary OCS perpendicular to the nominal track, measured from the primary boundary, or perpendicular to the primary boundary when considering arcs, diagonal corner-cutters, etc.

(3) Locate the MAHF within 25 NM of the ARP/HRP. Determine **minimum leg length** for course changes following the first fix after the MAP using the greater distance from chapter 2, formulas 2-7, 2-8, and 2-9, climb distance required, and chapter 3, table 3-1.

(4) Design MA holding for 90 KIAS, or the appropriate restricted speed.

2. Straight Missed Approach. The straight missed approach course (MAC) is a continuation of the final approach course (FAC). The straight MA section 2 OEA begins at secton 1 end (AB) and splays at 15 degrees relative to the nominal track until reaching full primary and secondary width (0.5-1.5-1.5-0.5). Apply the section 2 standard OCS, or the OCS associated with a higher CG, beginning at AB from the section 1 end OCS elevation. (When the increased CG is no longer required, revert to the section 2 standard OCS). Determine primary OCS elevation at an obstacle by measuring the along-track distance from AB 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 4:1 secondary slope (perpendicular to the track) from the primary boundary to the obstacle (see chapter 5, figures 5-3, 5-4).

3. Turning Missed Approach. Apply turning criteria when requiring a turn at or beyond SOC. Where secondary areas exist in section 1, they continue to full width in section 2. 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. The terms ‘inside turn’ and ‘outside turn’ are used to reduce verbiage in describing turn associated construction and relationships. Where required, alternate construction steps (indicated by Step #ALT) are provided to supplement or replace the primary step.

There are two types of turn construction for the first MA turn:

- Turn at an altitude (see chapter 5, paragraph 3a):
    - Always followed by a DF leg ending with a DF/TF connection

- Turn at a fix (see chapter 5, paragraph 3b):
    - Always followed by a TF leg ending with a TF/TF connection.
    - 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. RF turn initial fix must be located where the aircraft is at least 500 ft above airport elevation.

Following a turn, the minimum segment length must be the greater of:

- The minimum length calculated using chapter 2, formulas 2-7, 2-8 and 2-9.

- The distance from previous fix to the intersection of the 30-degree converging outer boundary line extension and the nominal track, (plus segment end fix DTA).

Minimum DF leg length must accommodate 6 seconds (minimum) of flight time based on either 70 KIAS or 90 KIAS, as appropriate, applied between the wind spiral (WS)/direct-to-fix-line tangent point, and the earliest maneuvering point of the DF/TF fix. Convert to TAS using chapter 2, formula 2-3a and the MAHF altitude.

a. Turn At An Altitude. Apply turn-at-an-altitude construction unless the first MA turn is at a fix. Since pilots may commence the MA at altitudes higher than the MDA and helicopter 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 turning operations. When a required turning altitude exceeds the minimum turning altitude (typically 400 ft above the airport, heliport, or height above surface), specify the turning altitude in a 100-ft increment. Where operationally required, 20-ft increments may be applied.

Note: 'Turn as soon as practicable' includes, but is not limited to operational suitability, flight characteristics/capability, appropriate altitude, positioned at or beyond the MA early ATT, as well as the feasibility, workability, and viability of the intended maneuver.

When a turn at altitude MA, (low MDA, turn at less than 400 ft above airport/heliport or height above surface, etc.) is required, Flight Standards Approval is required.

Track guidance is assumed throughout the operation; therefore, dead reckoning (DR) segments are not considered. Apply turning MA criteria whenever the MAC differs from the FAC. The following applies:

- Section 1/Section 2 connection is depicted in chapter 5, figure 5-5 for a minimum altitude turn-at-altitude MA. The CD is the earliest the MAP can be received. AB is the SOC (chapter 5, figure 5-6 depicts higher than minimum altitude turns).

- Section 2 and section 1 connect at AB.

- Construct section 2 outside-turn boundaries using WS vice specified radii. Construct outside boundaries in relation to these WS and late turn track (see chapter 5, figures 5-9, 5-13, 5-15).

- Construct inside-turn boundaries in relation to the early turn track (see chapter 5, figures 5-5, 5-6).

- Apply the standard OCS slope (or the assigned CG-associated slope) beginning at AB at AB OCS height. The secondary 4:1 surface rises from the primary OCS.

(1) Turn Initiation Area (TIA). Construct the TIA, a portion of a straight MA, beginning from the earliest MA turn point (CD), and ending where the specified minimum turning altitude is reached, (AB or LL'). Base the TIA length on the climb distance required to reach the turning altitude. The TIA minimum length must place the aircraft at an altitude from which obstacle clearance is provided in section 2 outside 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 5-8 and Order 8260.54 for construction examples) 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 helicopter climbing at the prescribed CG. Calculate TIA length using chapter 5, formula 5-2a. A 4:1 secondary is depicted on the non-turning side of the primary (see chapter 5, figures 5-6, 5-8, and 5-9).

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 OCS. If the OCS is penetrated, mitigate the penetration with one or a combination of the following:

- Raise MDA
- Establish a climb gradient that clears the obstacle
- Move MAP
- If the penetration is outside the TIA, consider raising the climb-to altitude

(a) Determine the helicopter required minimum turning altitude:

- Identify the controlling obstacle in section 2 (straight MA)
  - For straight OCS/CG/length options
- Identify the controlling obstacle in section 2, (typically turn-side)
- Find the shortest distance from the TIA lateral boundary to the obstacle
- Apply this distance and the MA OCS slope to find the TIA-to-obstacle OCS rise
- The minimum TIA boundary, (and OCS end elevation) equals the obstacle elevation minus OCS rise
- The minimum turn altitude is the sum of (TIA OCS boundary elevation) and (final ROC), rounded to the next higher 100 ft-increment (where operationally required, 20-ft increments may be applied)

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 altitude must equal or exceed the section 1 end altitude. Find section 1 end altitude using chapter 5, formula 5-1c.

Step 2: Calculate TIA length (ft) using chapter 5, formula 5-2a (see chapter 5, figures 5-6 and 5-8).

Formula 5-2a. TIA_{length}.

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

Where MDA = Final MDA
CG = Climb Gradient (Standard 400 ft/NM)
$turn_{alt}$ = required turn altitude

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

Calculator

FSL (formula 5-1)		Click here to calculate
MDA		
CG		
$turn_{alt}$		
TIA_{length} (ft)		

Step 3: Locate the TIA end at a distance TIA length beyond CD (from **Step 2**) (LL') where the applied OCS reaches the required TIA end surface elevation (from **Step 1**).

Step 4: Locate the latest turn point, (PP') at distance rr (from chapter 2, formula 2-4a) beyond the TIA end (AB/LL'). See example chapter 5, figures 5-6 and 5-8.

(2) OEA Construction after TIA. 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 chapter 5, figures 5-9 through 5-15 for various turn geometry construction illustrations.

(a) Early Turn Track and OEA Construction. Where the early turn 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 C (see chapter 5, figure 5-5); if the early track defines a turn greater than 75 degrees relative to the FAC, tie-back to point D (see chapter 5, figure 5-7). Where the early track represents a turn greater than 165 degrees (see chapter 5, figures 5-12 and 5-15), begin the early turn track and the 15-degree splay from the non-turn side TIA end + rr (chapter 2, formula 2-4a) (PP').

Step 1: Construct a line (defines the earliest-turn flight track), from the tie-back point to the fix. See chapter 5, figures 5-9, 5-10, 5-14, and 5-15.

Step 2: Construct the outer primary and secondary OEA boundary lines parallel to this line (0.5-1.5-1.5-0.5 segment width). See chapter 5, figures 5-9 and 5-10.

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 chapter 5, figures 5-9 and 5-10).

Note: Apply secondary areas only after the 15-degree splay line intersects the primary boundary line (see chapter 5, figures 5-9, 5-10, 5-13, etc).

Step 3Alt: Where **Step 3** construction provides less than full-width protection at the DF fix, construct the OEA inner boundary with a line splaying from the tie-back 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 chapter 5, figures 5-10, 5-14, and 5-15.

Note: Where excessive splay results (dependent upon various conditions but generally in the 20-25 degree range), consider modifying the segment to avoid protection and/or construction difficulties.

(b) Late Turn Track and OEA Construction. Apply WSs for late-turn outer boundary construction using the following calculations, construction techniques, and bank angles of 11 degrees or 14 degrees, as appropriate.

Step 1: Find the no-wind turn radius (R) using chapter 5, formula 5-2b.

Formula 5-2b. No-Wind Turn Radius (R).		
$R = \dfrac{(V_{KTAS}+0)^2}{\tan\left(Bank_{ANGLE}\cdot\left(\dfrac{\pi}{180}\right)\right)\cdot 68625.4}$ Where: V_{KTAS} = True Airspeed, formula 2-3a $Bank_{ANGLE}$ = Table 2-4 value		
$(V_{KTAS}+0)$^2/(tan($Bank_{ANGLE}$*π/180)*68625.4)		
Calculator		
V_{KTAS}		Click here to calculate
$Bank_{ANGLE}$	°	
R (NM)		

Note: Apply the appropriate indicated airspeed and minimum assigned turn altitude when converting to true airspeed for this application.

Step 2: Calculate the Turn Rate (TR) using chapter 5, formula 5-2c. Maximum TR is 3 degrees per second.

Formula 5-2c. Turn Rate (TR).		
$TR = \dfrac{3431\cdot\tan\left(Bank_{ANGLE}\cdot\dfrac{\pi}{180}\right)}{\pi\cdot V_{KTAS}}$ Where: $Bank_{ANGLE}$ = Table 2-4 V_{KTAS} = Formula 2-3a		
(3431*tan($Bank_{ANGLE}$*π/180))/(π*V_{KTAS})		
Calculator		
$Bank_{ANGLE}$	°	Click here to calculate
V_{KTAS}		
TR (˚/Sec)		

Step 2a: Calculate the Turn Magnitude ($Turn_{Magnitude}$) using the appropriate no-wind turn radius and the arc distance (degrees) from turn start (at PP') to the point of tangency with a line direct to the fix.

Step 2b: Calculate the highest altitude in the turn using chapter 5, formula 5-2d (MAHF altitude may be used). Determine subsequent fix altitudes using fix-to-fix direct measurement and 400 ft/NM, (or higher assigned) climb rate.

Formula 5-2d. Highest Altitude Gained ($Total_{ALT}$).		
$$HighestTurn = MDA_{ALT} + (2R \cdot \pi \cdot \frac{Turn_{Magnitude}}{360} \cdot CG)$$ Where: MDA_{ALT} = Procedure MDA; R = No-wind turn radius (NM), Formula 5-2b; $Turn_{Magnitude}$ = Turn start to rollout (deg); CG = Standard 400 ft/NM		
MDA_{ALT}+(2*R*π*$Turn_{Magnitude}$/360*CG)		
Calculator		
MDA_{ALT}		Click here to calculate
R		
$Turn_{Magnitude}$	°	
CG		
$Total_{ALT}$		

Step 3: Find the omni-directional wind component (V_{KTW}) for the highest altitude in the turn applying chapter 2, paragraph 5.

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 heliport/airport elevation.

Step 5: Calculate the wind spiral radius increase (ΔR) (relative R), for a given turn magnitude (ϕ) using chapter 5, formulas 5-2c and 5-2e.

Formula 5-2e. WS (ΔR).		
$$\Delta R = \frac{V_{KTW} \cdot \phi}{3600 \cdot TR}$$ Where: V_{KTW} = Windspeed, formula 2-3b; ϕ = Degrees of turn; TR = Turn Rate, formula 5-2c		
$(V_{KTW} * \phi)/(3600 * TR)$		
Calculator		
V_{KTW}		Click here to calculate
ϕ	°	
TR		
ΔR (NM)		
ΔR (ft)		

b. 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.

(1) Early/Late Turn Points.

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

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

Fly-by fixes (see chapter 5, figure 5-16).

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

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

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

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

Fly-over fixes (see chapter 5, figure 5-16).

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

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

(2) 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 AB using chapter 5, formula 5-1c.

Step 2: Calculate fix distance based on minimum fix altitude. Where the first fix must be located at the point the helicopter reaches or exceeds a specific altitude, apply chapter 5, formula 5-2f (using the assigned/applied CG), to calculate fix distance (D_{fix}) (NM) from SOC (AB/JK) (see chapter 5, figures 5-17 through 5-20).

Formula 5-2f. Fix Distance (D_{fix}).

$$D_{fix} = \ln\left(\frac{Alt_{fix} + r}{Copter_{SOC} + r}\right) \cdot \frac{r}{CG}$$

Where:

Alt_{fix} = Minimum altitude required at fix
$Copter_{SOC}$ = Copter AB (SOC) altitude
CG = Climb Gradient (Standard 400 ft/NM)

ln((Altfix+r)/(Copter$_{soc}$+r))*r/CG

Calculator

Alt_{fix}		Click here to calculate
$Copter_{SOC}$		
CG		
D_{fix} (NM)		

Step 3: Calculate the altitude a helicopter climbing at the assigned CG would achieve over an established fix using chapter 5, formula 5-2g.

Formula 5-2g Altitude Achieved at Fix (Alt_{fix}).

$$Alt_{fix} = (r + Copter_{SOC}) \cdot e^{\left(\frac{CG \cdot D_{fix}}{r}\right)} - r$$

Where:

$Copter_{SOC}$ = Copter AB (SOC) altitude
CG = Climb Gradient (Standard 400 ft/NM)
D_{fix} = Distance (NM) from AB to fix

(r+Copter$_{SOC}$)*e^(CG*D$_{fix}$/r)-r

Calculator

$Copter_{SOC}$		Click here to calculate
CG		
D_{fix} (NM)		
Alt_{fix}		

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

(a) Fly-By Turn Calculations.

Step 1: Apply chapter 5, formula 5-2h for distance turn anticipation (DTA).

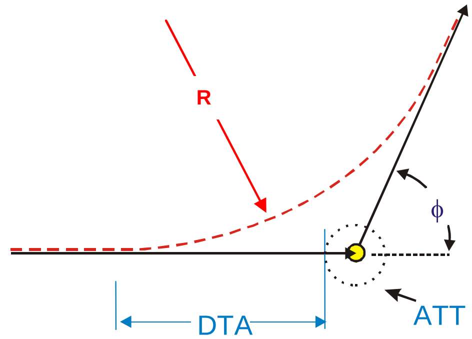
Formula 5-2h. Distance Turn Anticipation.

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

Where:

ϕ = Turn/Heading Change (Degrees)

R = No-Wind Turn Radius, formula 5-2b



R*tan(ϕ/2*π/180)

Calculator

R		Click here to calculate
ϕ (Degrees)	°	
DTA (NM)		

Calculate the fix to early-turn distance ($D_{early\ TP}$) using chapter 5, formula 5-2i.

Formula 5-2i. Early Turn Distance ($D_{earlyTP}$).

$$D_{earlyTP} = ATT + DTA$$

Where:

ATT = along-track tolerance (NM)

DTA = Turn anticipation distance (NM), formula 5-2h

ATT+DTA

Calculator

ATT		Click here to calculate
DTA		
$D_{earlyTP}$ (NM)		

(b) Early Turn Point (ETP) and Area construction.

Table 5-1. Inside Turn Expansion Guide.	
Outbound Segment Boundary Relative ETP Connections	**Expansion Line Required**
Secondary & Primary **PRIOR** ETP	15-Degree Line
Secondary **Prior** ETP	15-Degree Line
Primary **Beyond** ETP	$\phi/2$
Secondary & Primary **Beyond** ETP	$\phi/2$

Note: ETP = LL' early turn point connection, 15-degree line relative the outbound segment, $\phi/2$ = half turn-angle

(c) Inside turn (Fly-By) Construction is predicated on the location of LL' and primary/secondary boundary intersections (early turn connections), relative the outbound segment, see chapter 5, table 5-1. (See chapter 5, figures 5-17 and 5-18).

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 5-1 provides a connection method for each point.

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

Step 1: Construct a baseline (LL') perpendicular to the inbound track at distance $D_{earlyTP}$ (chapter 5, formula 5-2h) prior to the fix (see chapter 5, figures 5-17 and 5-18).

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

Step 1: Construct the inside turn expansion area with a line, drawn at one-half the turn angle from the inbound segment primary early turn connection point, to intercept the outbound segment primary boundary (see chapter 5, figure 5-18).

Step 2 (if required): Construct the inside turn expansion area with a line, drawn at one-half the turn angle, from the inbound segment secondary early turn connection point, to intercept the outbound segment secondary boundary (see chapter 5, figure 5-18).

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

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

Step 1Alt: Where the turn angle exceeds 75 degrees, begin the splay from L'.

Step 2: Construct the primary boundary with a line, drawn at one-half the turn angle, from the inbound segment primary early turn connection point to intercept the outbound segment primary boundary (see chapter 5, figure 5-17).

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

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

Step 1Alt: Where the turn angle exceeds 75 degrees, begin the splay from L'.
In this case, terminate the inside turn secondary area at the outbound segment primary boundary, since it falls before the early turn points, LL' (see chapter 5, figure 5-18a).

(d) Outside Turn (Fly-By) Construction.

Step 1: Construct the outer primary boundary using a radius of 1/2 primary width (1.5 NM), centered on the plotted fix position, drawn from the inbound segment extended primary boundary until tangent to the outbound segment primary boundary. See chapter 5, figure 5-17.

Step 2: Construct the secondary boundary using a radius of one-half segment width (2 NM), centered on the plotted fix position, drawn from the inbound segment extended outer boundary until tangent to the outbound segment outer boundary (see chapter 5, figures 5-17, 5-18, and 5-18a). Where no inbound secondary exists, use an arc of radius one-half segment width from tangent to the outbound segment secondary boundary to terminate at the inbound segment boundary.

(3) Fly-Over Turn Construction.

(a) Inside Turn (Fly-Over) Construction.

Step 1: Construct the early-turn baseline (<u>LL'</u>) at distance ATT prior to the fix, perpendicular to the inbound nominal track.

Step 2: Refer to chapter 5, paragraph 3b(3)(c), (skip **Step 1**).

(b) Outside Turn (Fly-Over) Construction.

Step 1: Construct the late-turn baseline (<u>PP'</u>) at distance (ATT + rr) beyond the fix, perpendicular to the inbound nominal track. Calculate late turn distance using chapter 5, formula 5-2j (see chapter 5, figure 5-19).

Formula 5-2j. Late Turn Point Distance (D_{lateTP}).

$$D_{lateTP} = ATT + \left(rr \cdot \frac{0.3048}{1852}\right)$$

Where:

ATT = along-track tolerance (NM)
rr = delay/roll-in formula 2-4a

ATT+(rr*0.3048/1852)

Calculator		
ATT (NM)		Click here to calculate
rr (ft)		
D_{lateTP} (NM)		

Step 2: Apply wind spiral outer boundary construction for the first MA fly-over turn. See chapter 5, paragraph 3a(2)(b) for necessary data, using the higher of chapter 5, formula 5-2g output, or the assigned fix crossing altitude for TAS and turn radius calculations and chapter 5, paragraph 5 for wind spiral construction. A non-turn side secondary area may extend into the WS1 area.

(c) Obstacle Evaluations. See chapter 5, paragraph 3b(4)

(4) Section 2 Obstacle Evaluations.

(a) Turn at an Altitude Section 2. Apply the standard MA OCS slope, (or the assigned CG slope) to section 2 obstacles based on the shortest primary area distance (do) from the TIA boundary to the obstacle. <u>Shortest primary area distance</u> 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 various obstacle measurement examples in chapter 5, figures 5-19 through 5-22.

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 4:1 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 chapter 5, figures 5-19 through 5-22.

(b) Turn at Fix Section 2. Apply an inclined OCS (MA OCS) slope, beginning at SOC at the inbound-segment end OCS height.

Step 1: Measure and apply the OCS along the shortest distance (do) from AB (parallel to track) to LL', the shortest primary distance to the obstacle (single and multiple segments). See chapter 5, figures 5-19 and 5-20, 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 4:1 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 chapter 5, figure 5-21).

4. Turning Missed Approach (Second Turn).

a. 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.

(1) DF/TF (Fly-By) Turn.

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

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

Step 1: Construct a baseline (LL') perpendicular to the inbound track nearer the turn side boundary at distance $D_{earlyTP}$ (chapter 5, formula 5-2h) prior to the fix.

Step 2: Apply chapter 2 criteria.

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

Step 1: Apply chapter 5, paragraph 3b(3)(c) criteria.

(b) Outside DF/TF (Fly-By) construction.

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

Step 1: Construct a baseline (L'L'') perpendicular to the inbound track nearer the non-turn side boundary at distance $D_{earlyTP}$ (chapter 5, formula 5-2h) prior to the fix.

Step 2: Apply chapter 2 criteria. See chapter 5, figures 5-21 through 5-22.

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

Step 1: Apply chapter 5, paragraph 3b(3)(d) criteria.

(2) DF/TF (Fly-Over) Turn.

(a) Inside DF/TF (Fly-Over) Turn Construction.

Step 1: Construct a baseline (LL') perpendicular to the inbound track nearer the turn side boundary at distance ATT prior to the fix (see chapter 5, figure 5-22).

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

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

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

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

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

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

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

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

Step 1: Apply chapter 2 criteria. See chapter 5, figure 5-21.

(b) 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 chapter 5, figure 5-22.

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 chapter 5, paragraph 3a(2)(b) for necessary data, and chapter 5, paragraph 5 for wind spiral construction See chapter 5, figure 5-22.

b. 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.

(1) TF/TF (Fly-By) Turn.

(a) Inside TF/TF (Fly-By) construction.

Step 1: Apply chapter 2 criteria.

(b) Outside TF/TF (Fly-By) construction.

Step 1: Apply chapter 2 criteria.

(2) TF/TF (Fly-Over) Turn.

(a) Inside TF/TF (Fly-Over) Turn Construction.

Step 1: Apply chapter 2 criteria.

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

Step 1: Apply chapter 2 criteria.

5. 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'. Additional WS examples are available in Order 8260.54.

Each WS has several connection options along its boundary. The chosen connection(s) must provide the more conservative reasonable track and protection areas (see chapter 5, figures 5-23 through 5-25 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 (see chapter 5, figure 5-25)
- A tangent line direct to the next fix (DF segment) (see chapter 5, figure 5-24)
- A tangent line, converging at 30 degrees to the segment track (TF segment) (see chapter 5, figure 5-20)

  ***Note:** See chapter 5, paragraphs 5b(1) and 5b(2) for alternate connection details.

  Note: Where multiple WSs exist, a line from the earlier WS splaying at 15 degrees relative the tangent line between WSs may produce the more conservative construction.

Outbound segment type and turn magnitude are primary factors in WS application. Refer to chapter 5, table 5-2 for basic application differences. Calculate rr using chapter 2, formula 2-4a.

Table 5-2. 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
WS3 Baseline (CD Ext)	NA	TIA + rr
WS Number	1 or 2	1, 2, or 3 *
Final WS Connection (Tangent line)	30˚ 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.

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).

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

(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 or,
- The distance from previous fix to the intersection of the 30-degree converging outer boundary line extension and the nominal track, (plus DTA). See chapter 5, paragraph 4a.

(3) Second MA Turn DF/TF Turn-at-Fix (FO) WS application concludes with a line tangent to the final WS converging at a 30-degree angle to the outbound segment nominal track. This construction requires two WS baselines, one for each inbound track. Each late turn baseline is located (ATT + rr) beyond the fix, oriented perpendicular to the specific track. The baseline for the inbound track nearer the inside turn boundary is designated PP', the baseline associated with the outside turn track is designated P'P''. For convenience P' is often placed at the intersection of the two baselines, but a copy properly goes with each baseline inner end if baseline extensions are required (see chapter 5, figure 5-22).

b. First MA Turn WS Construction. Find late turn point distance ($D_{late\ TP}$) using chapter 5, formula 5-2j.

(1) CASE 1: Small angle turn using 1 WS.

Step 1: Construct the WS1 baseline, (PP') perpendicular to the straight MA track at the late-turn-point (see chapter 5, table 5-2 for line PP' location). See chapter 5, figures 5-5 and 5-8.

Step 2: Locate the wind spiral center on PP' at distance R (no-wind turn radius, using chapter 5, formula 5-2b; see chapter 5, figure 5-8) from the intersection of PP' and the inbound-segment outer-boundary extension (see chapter 5, figures 5-8 and 5-9).

Step 3: Construct WS1 from this outer boundary point in the direction of turn until tangent to the WS/Segment connecting line from chapter 5, table 5-2 (see chapter 5, figure 5-9).

CASE 1-1: Turn-at-Altitude (WS1 ends when tangent to a line direct to fix).

Step 1: Construct the OEA outer primary and secondary boundary lines parallel to this track (0.5-1.5-1.5-.0.5 segment width). See chapter 5, figure 5-9.

Step 2: 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 chapter 5, figure 5-9).

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

Step 2Alt: 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 chapter 5, figure 5-9).

Note: Where excessive splay (dependent upon various conditions 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 chapter 5, figure 5-19).

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 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 (see chapter 5, similar figure 5-24).

(2) CASE 2: Larger turn using more than 1 WS. For turns nearing or greater than 90 degrees, WS2 may be necessary. See chapter 5, figure 5-20.

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/WS, or WS/Segment connecting line from chapter 5, table 5-2. See chapter 5, figure 5-20.

Step 3: Where WS2 intersects, or is outside 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 chapter 5, figure 5-20).

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

<u>CASE 2-1</u>: 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 (0.5-1.5-1.5.0.5 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 chapter 5, figure 5-9).

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: 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), <u>and</u> 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 chapter 5, figure 5-9).

Note: Where excessive splay exists (dependent upon various conditions but generally greater than 30 degrees), consider using an earlier splay origin point, lengthening the segment, restricting the speed, category, etc. to avoid protection or construction difficulties (see chapter 5, paragraph 5 for origin points).

<u>CASE 2-2</u>: 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 chapter 5, figure 5-20).

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.

(3) <u>CASE 3</u>: Larger turn using more than 2 WSs. (Not applicable to Turn-at-Fix due to 90 degree 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 MA track along <u>CD</u>-extended toward the turn side. See chapter 5, figure 5-15.

Step 2: To determine WS3 necessity, locate its center on the WS3 baseline at distance R from point C. See chapter 5, figure 5-15.

Step 3: Construct WS3 from point C in the direction of turn until tangent to the WS/WS, or WS/Segment connecting line from chapter 5, table 5-2. See chapter 5, figure 5-15.

Step 4: Where WS3 intersects, or is outside WS2 construction, include WS3 in the OEA construction. Otherwise revert to the dual WS construction. See chapter 5, figure 5-15.

Step 5: Connect WS2 and WS3 with a line tangent to both. See chapter 5, figure 5-15.

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

<u>CASE 3-1</u>: 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 (0.5-1.5-1.5-0.5 segment width). See chapter 5, figure 5-15.

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 chapter 5, figure 5-15.

(4) 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.

c. 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 chapter 5, table 5-2 PP’ location information for each baseline (formula is identical).

(1) 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 chapter 5, table 5-2 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 chapter 5, table 5-2 for line PP’ location.

Step 2: Locate the WS1 center on P’P’’ at distance R (no-wind turn radius, using chapter 5, formula 5-2b; see chapter 5, figure 5-5) 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 chapter 5, formula 5-2b; see chapter 5, figure 5-5) 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 chapter 5, table 5-2.

Step 3a: Construct WS2 from this inner boundary point in the direction of turn until tangent to the WS/Segment connecting line from chapter 5, table 5-2.

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 chapter 5, figure 5-22.

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 degrees converging line to establish the primary/secondary boundary.

6. Missed Approach Climb Gradient. Where the MA standard OCS is penetrated and a CG is required, specify a missed approach CG to clear the penetrating obstruction. MA starting ROC is 100 ft (plus adjustments). ROC increases at 96 ft/NM, measured parallel to the MA 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 helicopter 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 chapter 5, formula 5-13.

Step 2: Apply the CG to:

- The altitude which provides appropriate ROC, or
- The point/altitude where the subsequent MA OCS 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 (chapter 5, formula 5-3). Where there is a local altimeter, 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 Order 8260.3, Volume 1, chapter 3 for further details).

Formula 5-3. ROC/CG/Minimum Altitude/OCS.	
STEP 1	$$ROC_{obs} = ROC_{start} + 96 \cdot d$$ Where: ROC_{start} = SOC ROC (100 ft for NVGP); d = distance (NM) CG origin (SOC) to obstacle
$ROC_{start}+96*d$	
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	$$CG = \frac{r}{d} \cdot \ln\left(\frac{(r + Alt_{min})}{(r + Copter_{SOC})}\right)$$ Where: Alt_{min} = Step 2 result; $Copter_{SOC}$ = Helicopter altitude (MSL) at CG origin; d = distance (NM), CG origin (SOC) to obstacle
$r/d*\ln((r+ALT_{min})/(r+Copter_{SOC}))$	

Calculator

ROC_{start}		Click here to calculate
O_{elev}		
d (NM)		
$Copter_{SOC}$		
ROC_{obs}		
Alt_{min}		
CG		

Note: Figures are NOT drawn to scale.

Figure 5-1a. Missed Approach Optimum Flight Paths.

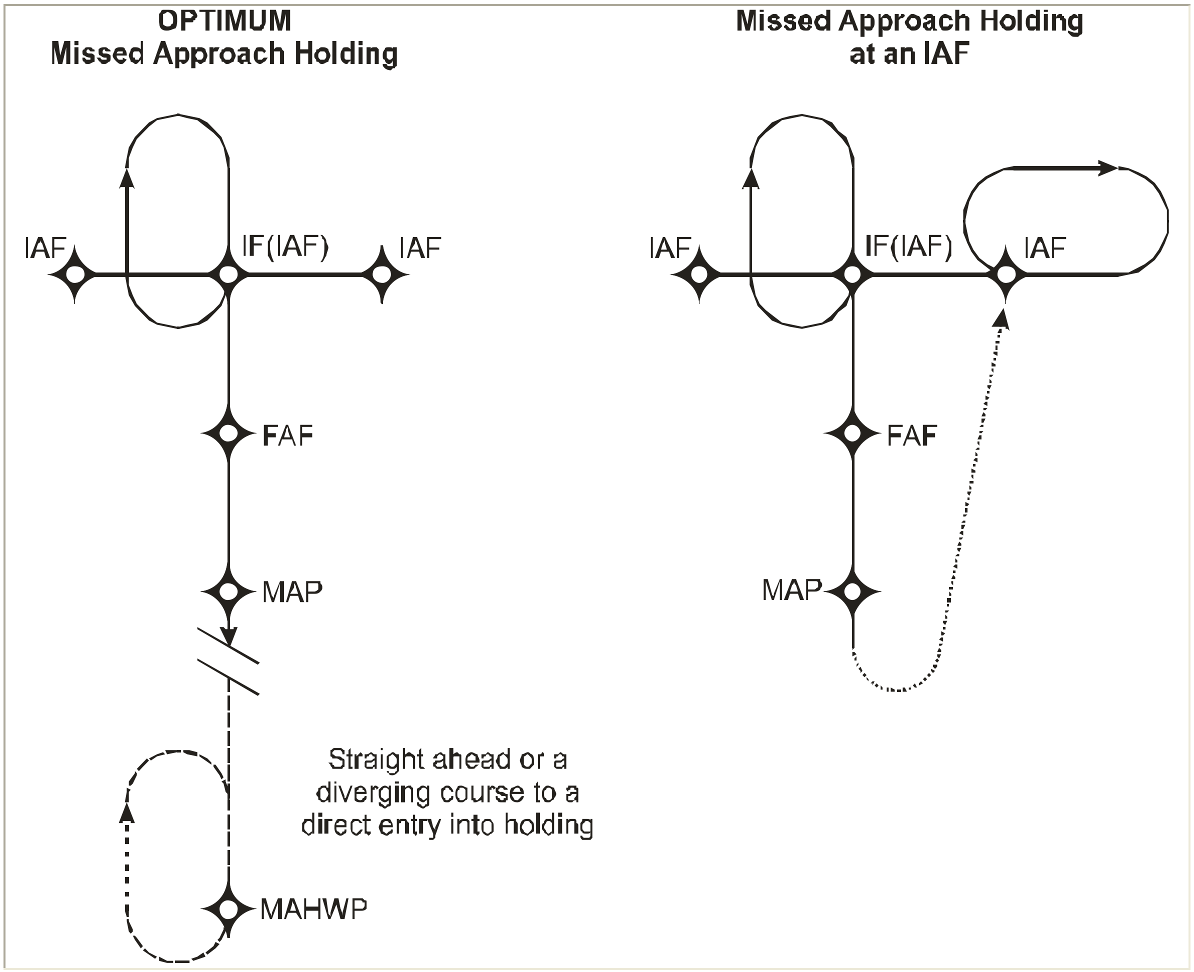


Figure 5-1b. MAS Point/Line Identification.

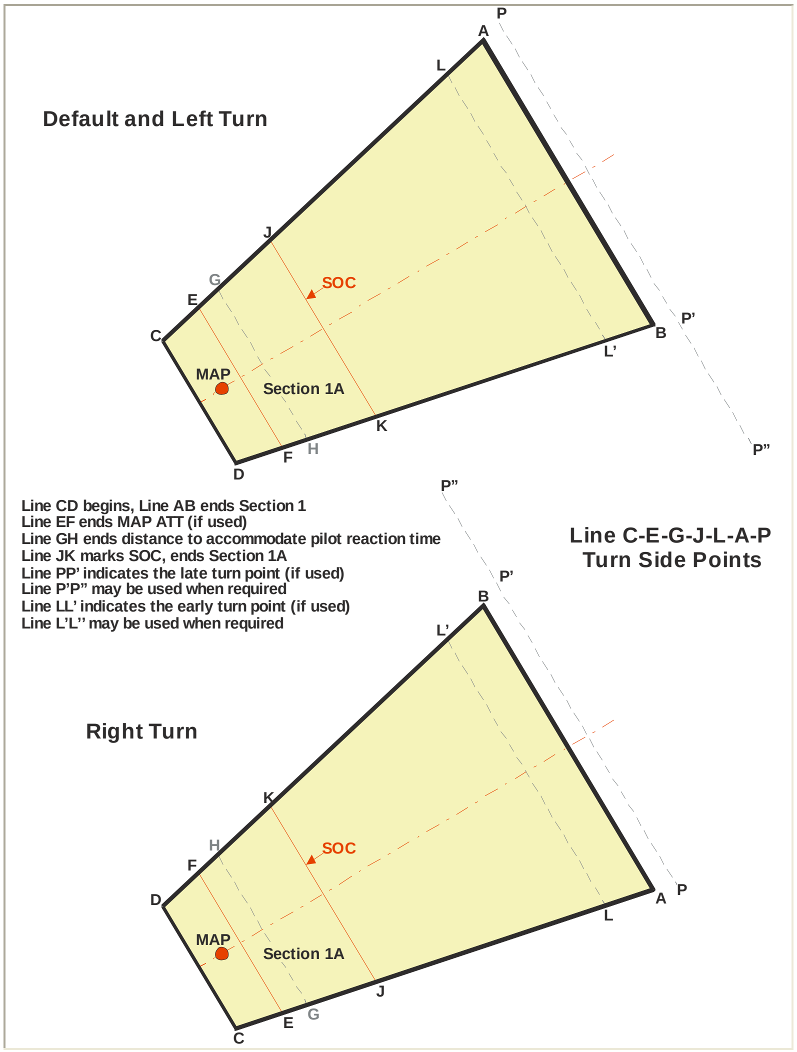


Figure 5-2. Missed Approach Section 1.

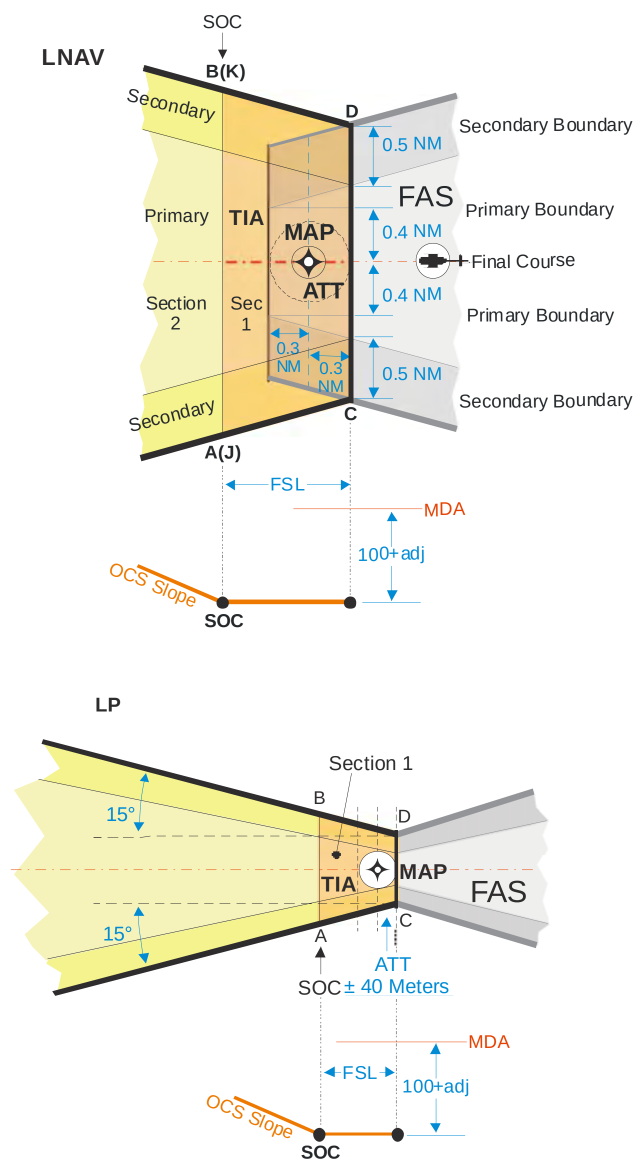


Figure 5-3. Straight Missed Approach.

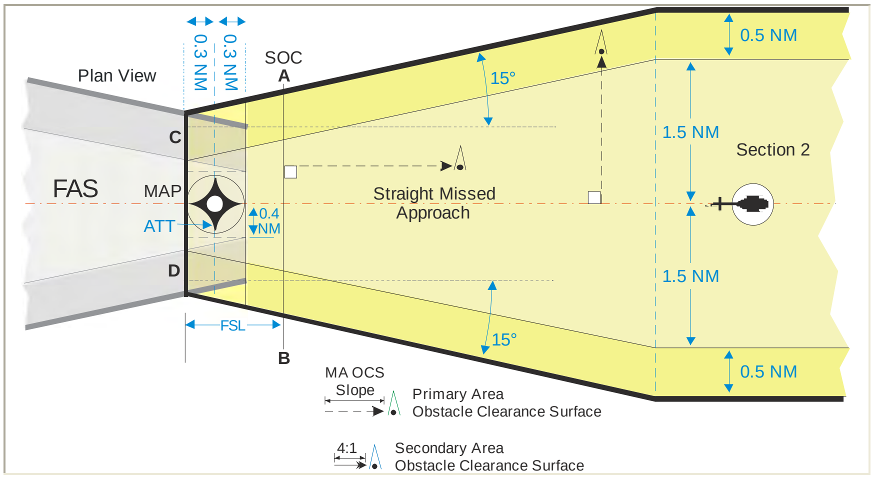


Figure 5-4. Straight Missed Approach (GPS/LNAV / LP).

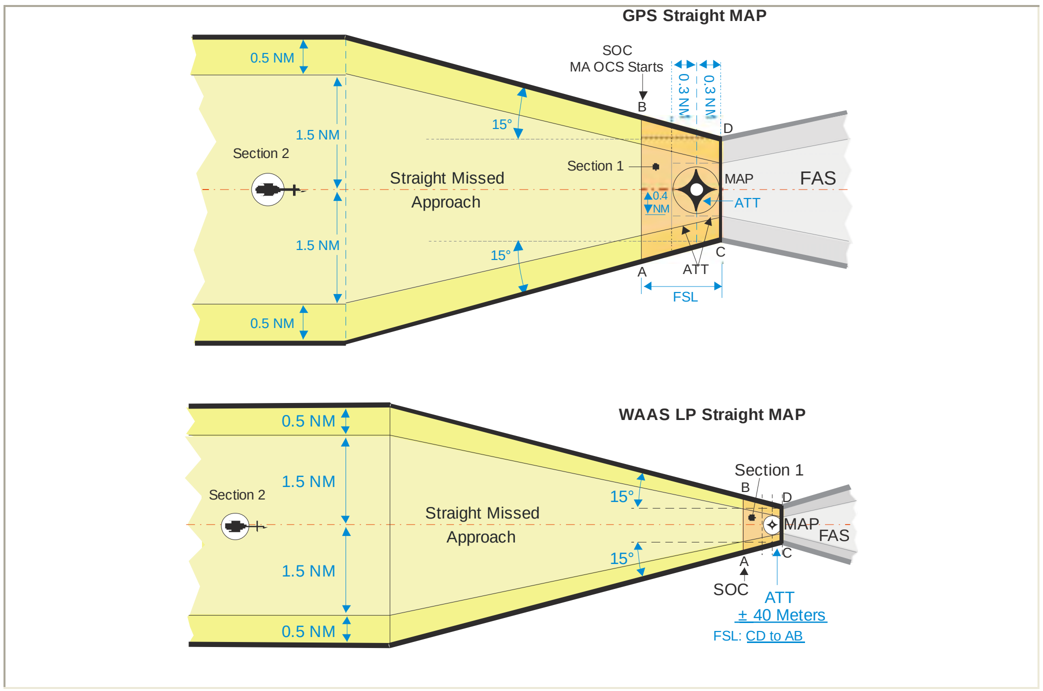


Figure 5-5. Turn at Altitude Missed Approach, ≤ 75° (Minimum Turning Altitude).

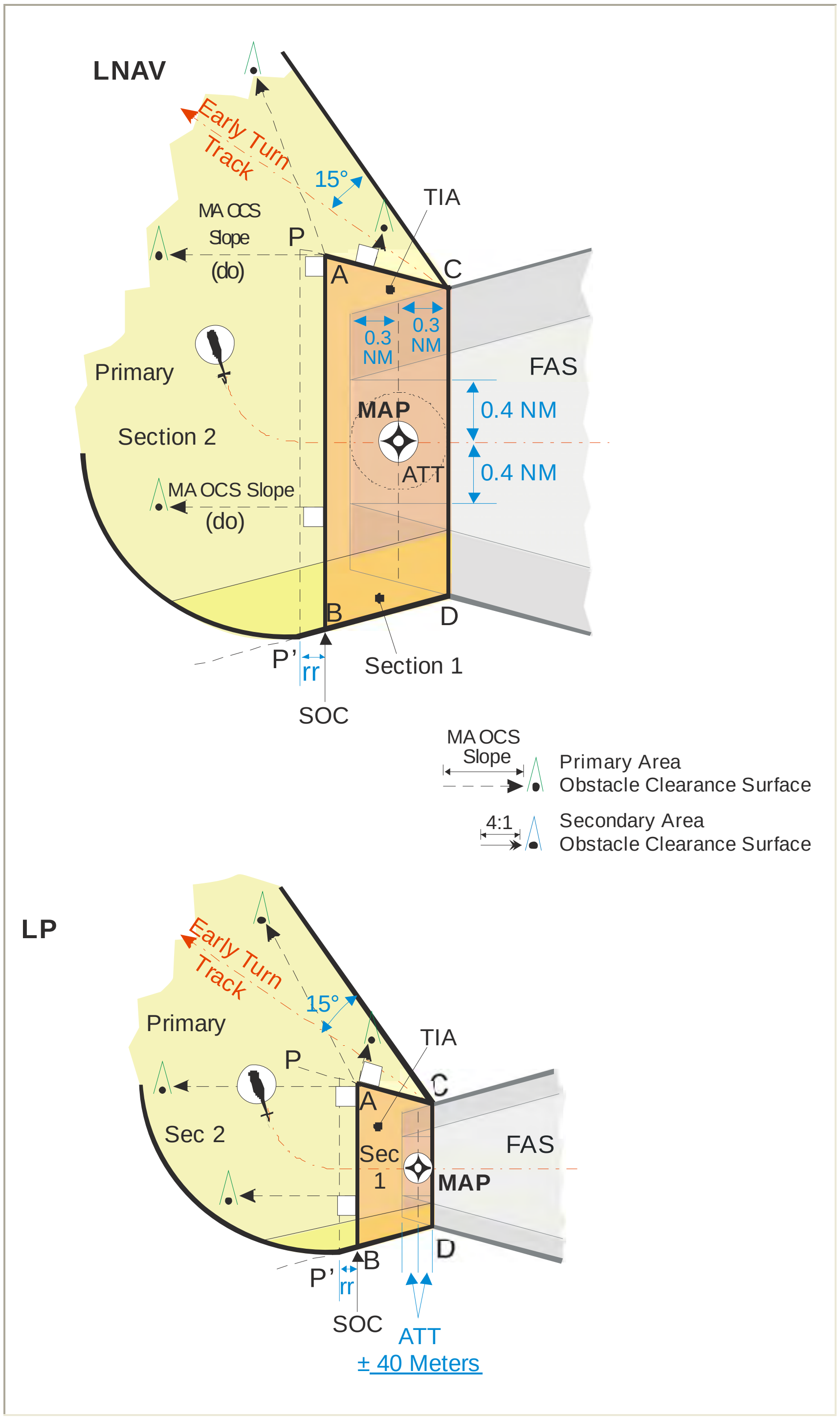


Figure 5-6. Turn at Altitude Missed Approach, ≤ 75° (> Minimum Turning Altitude).

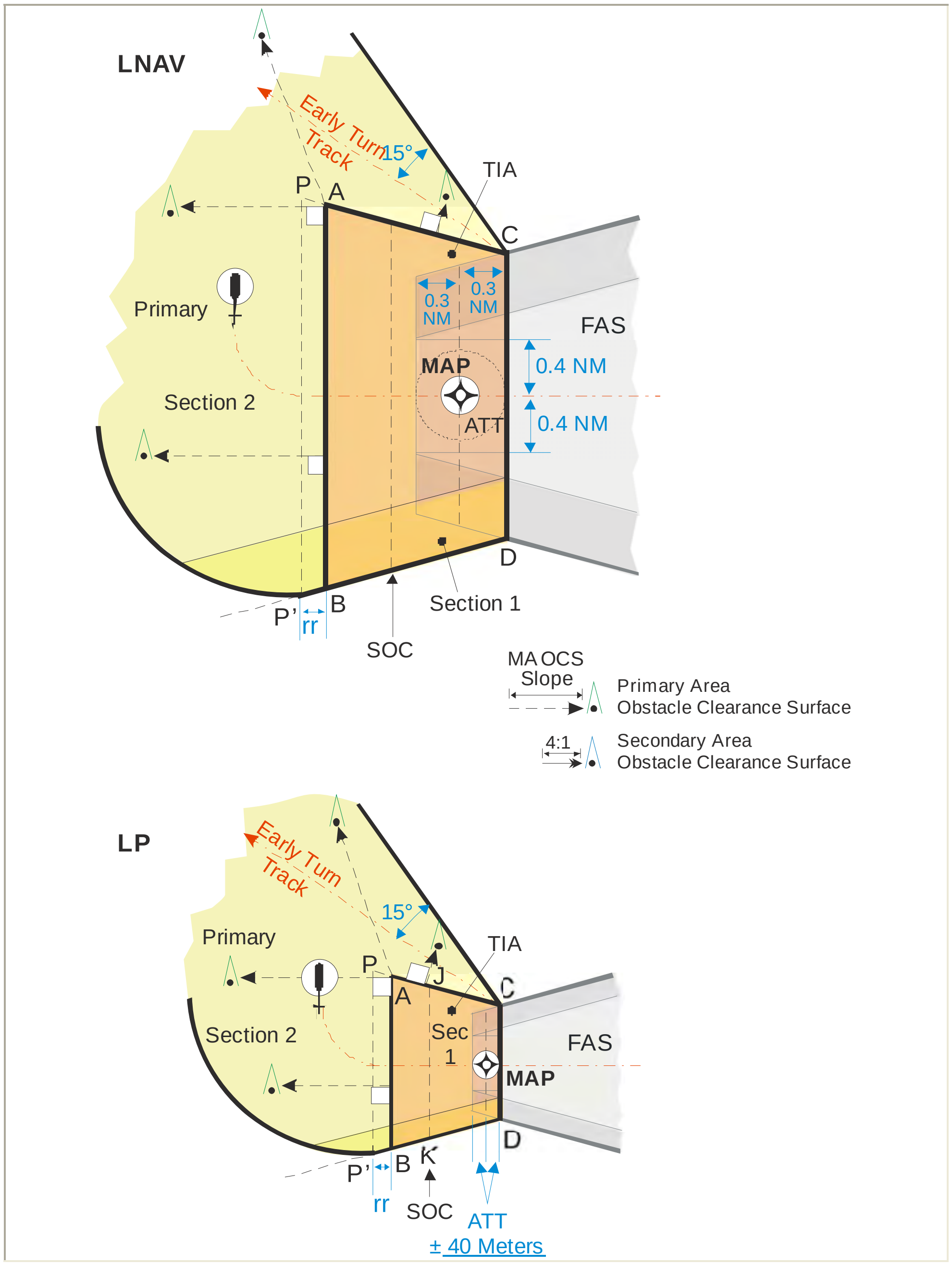


Figure 5-7. Turn at Altitude Missed Approach, > 75˚ (Minimum Turn Altitude).

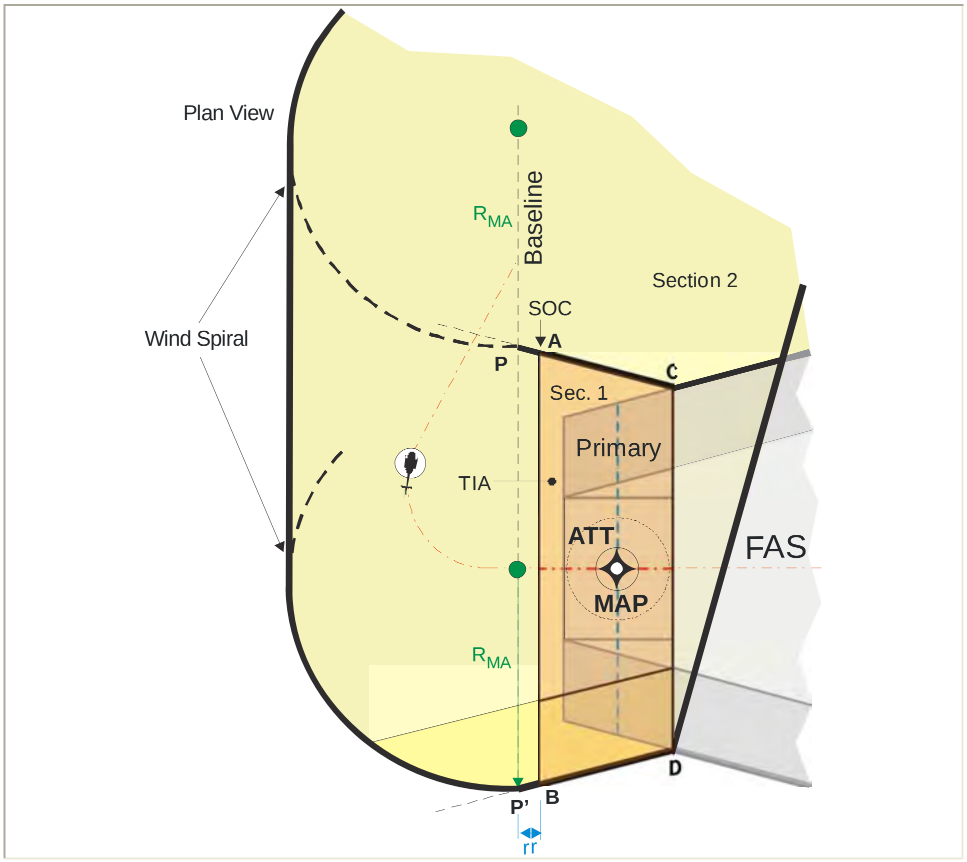


Figure 5-8. Turn at Altitude Missed Approach, ≤ 75˚ (Greater than Minimum Turn Altitude).

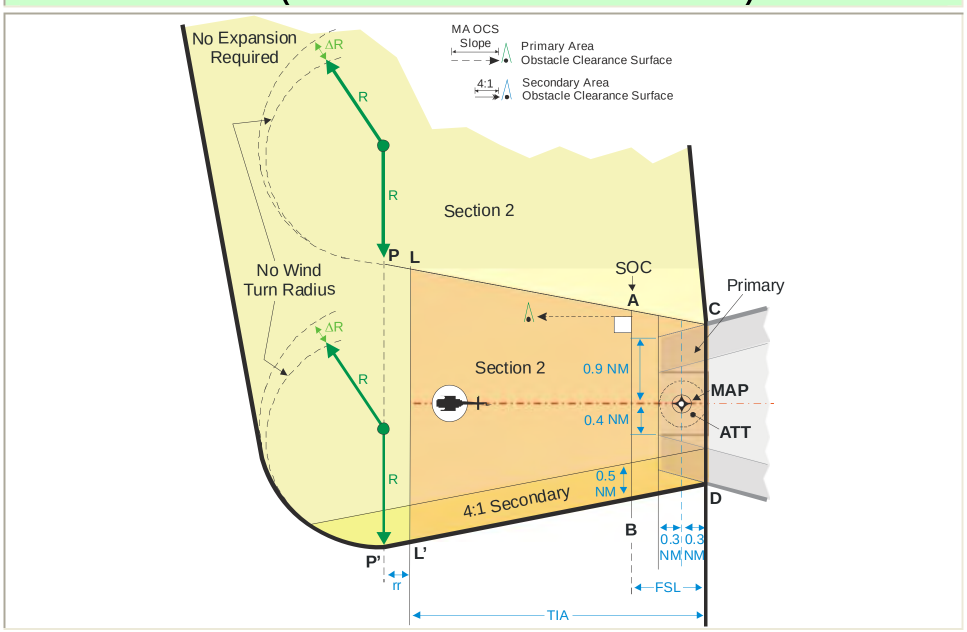


Figure 5-9. Turn at Altitude Missed Approach, ≤ 75 Degrees (Minimum Turn Altitude).

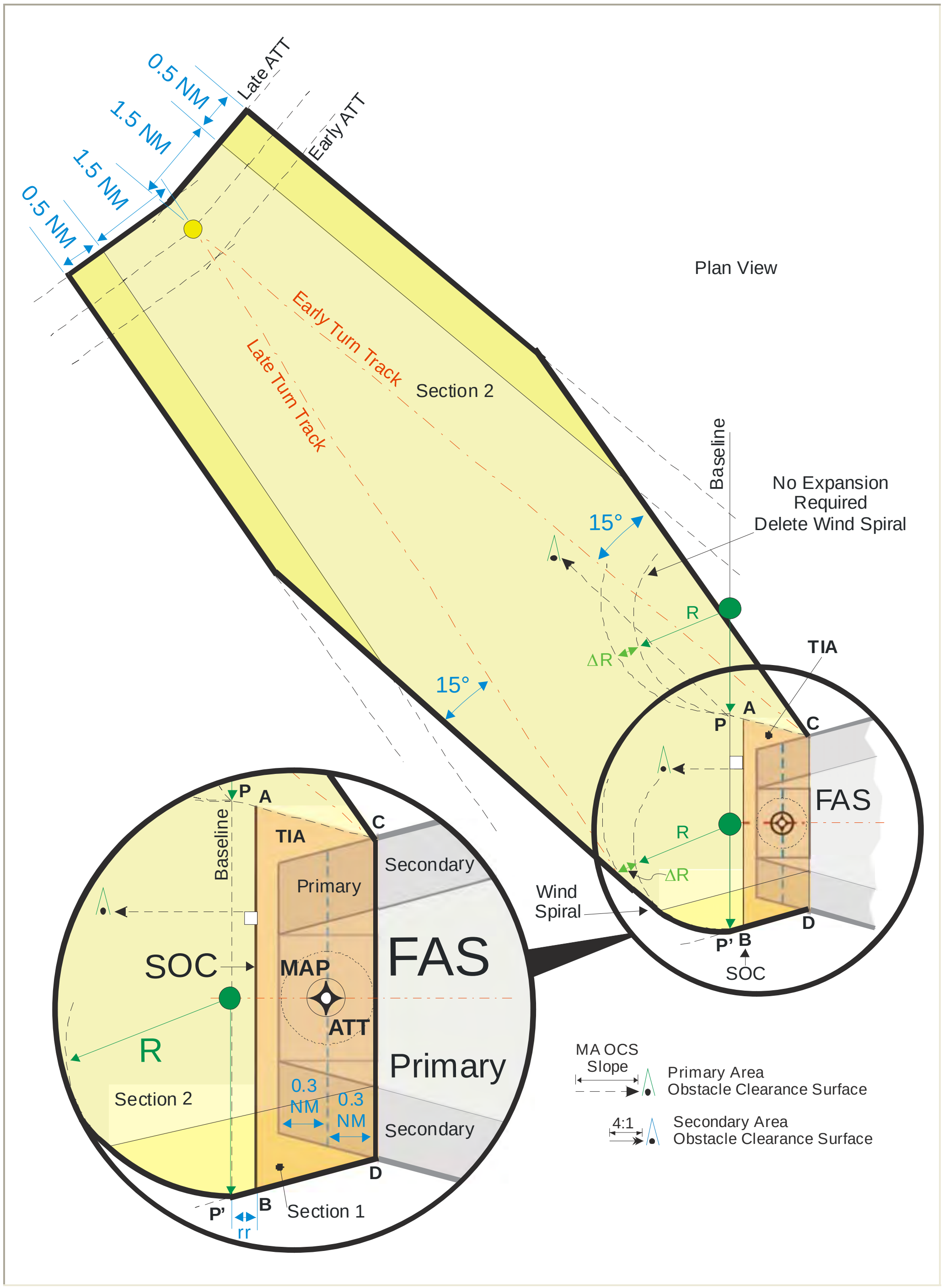


Figure 5-10. Turn at Altitude Missed Approach, >75 degrees (Minimum Turn Altitude).

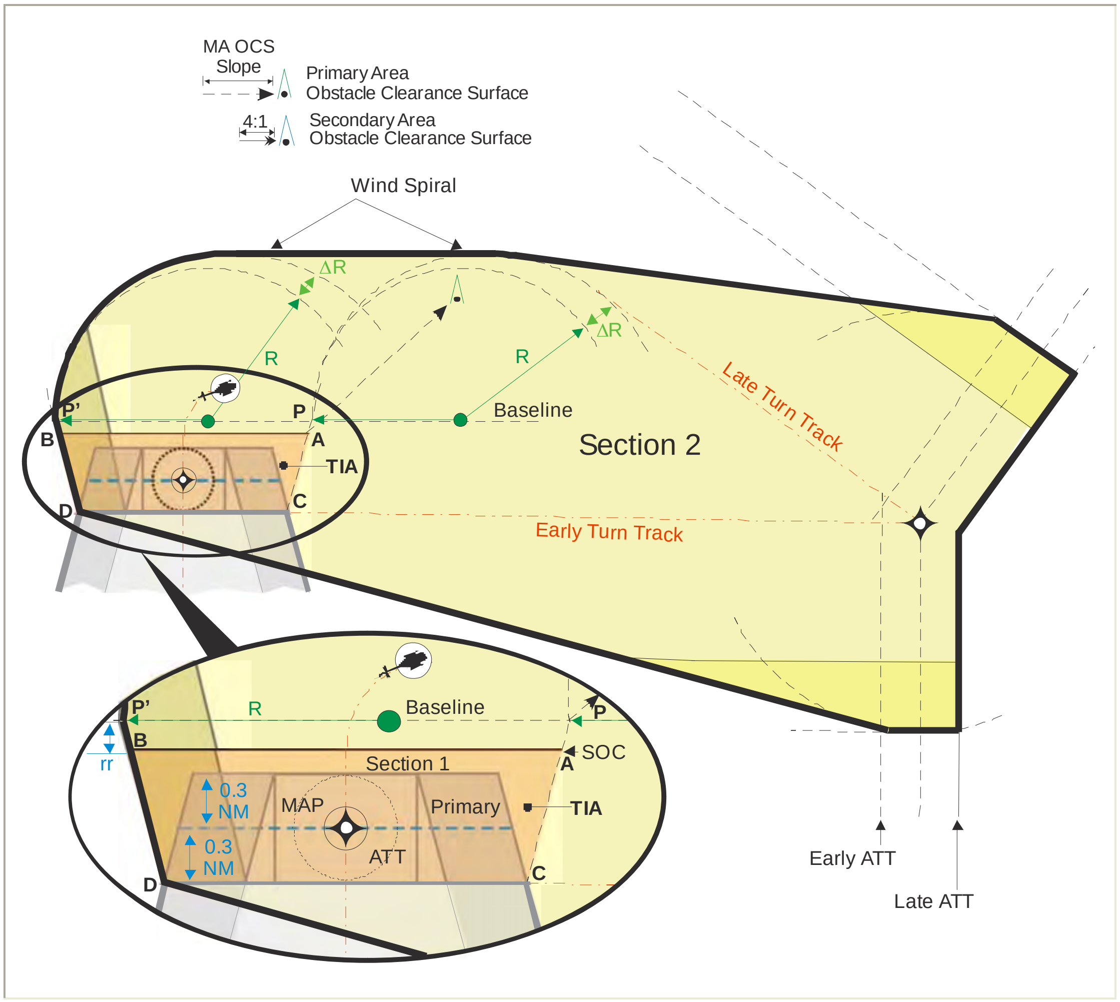
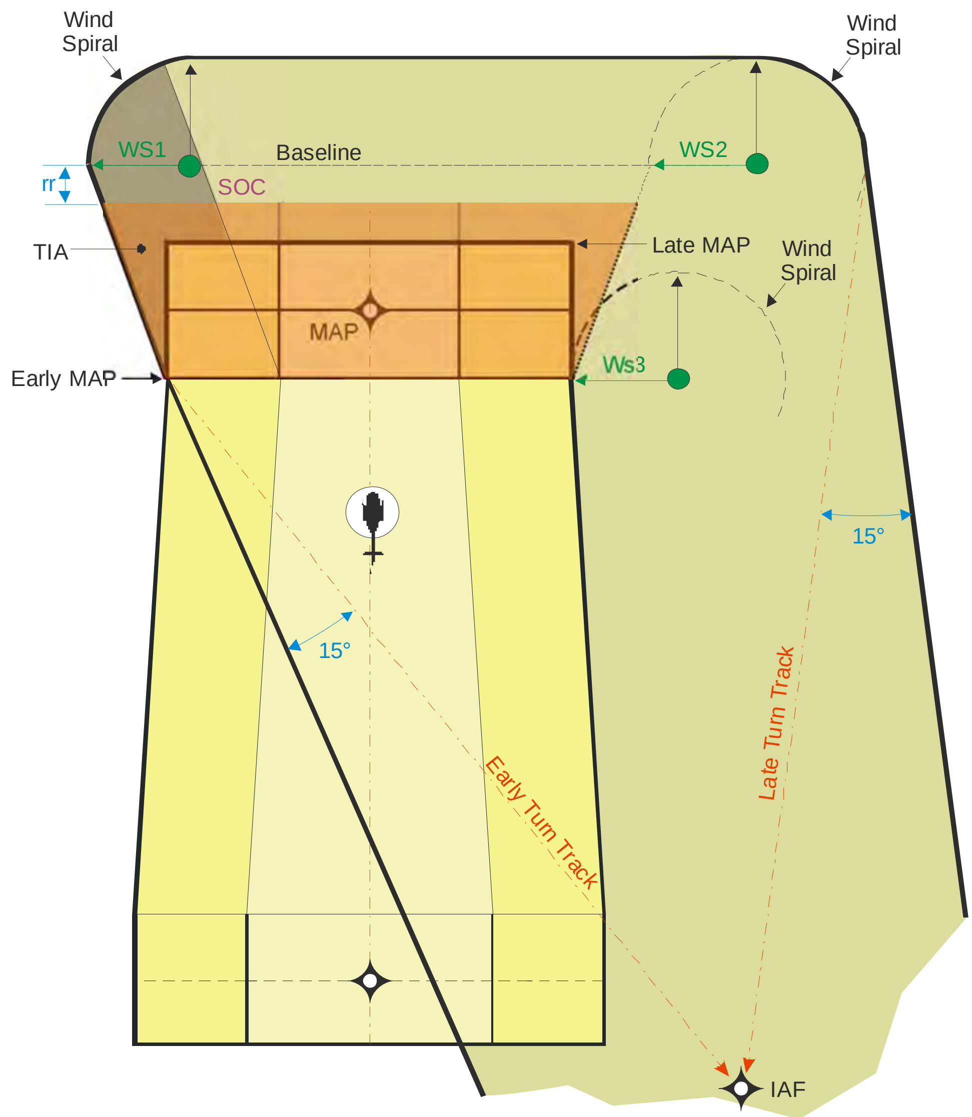


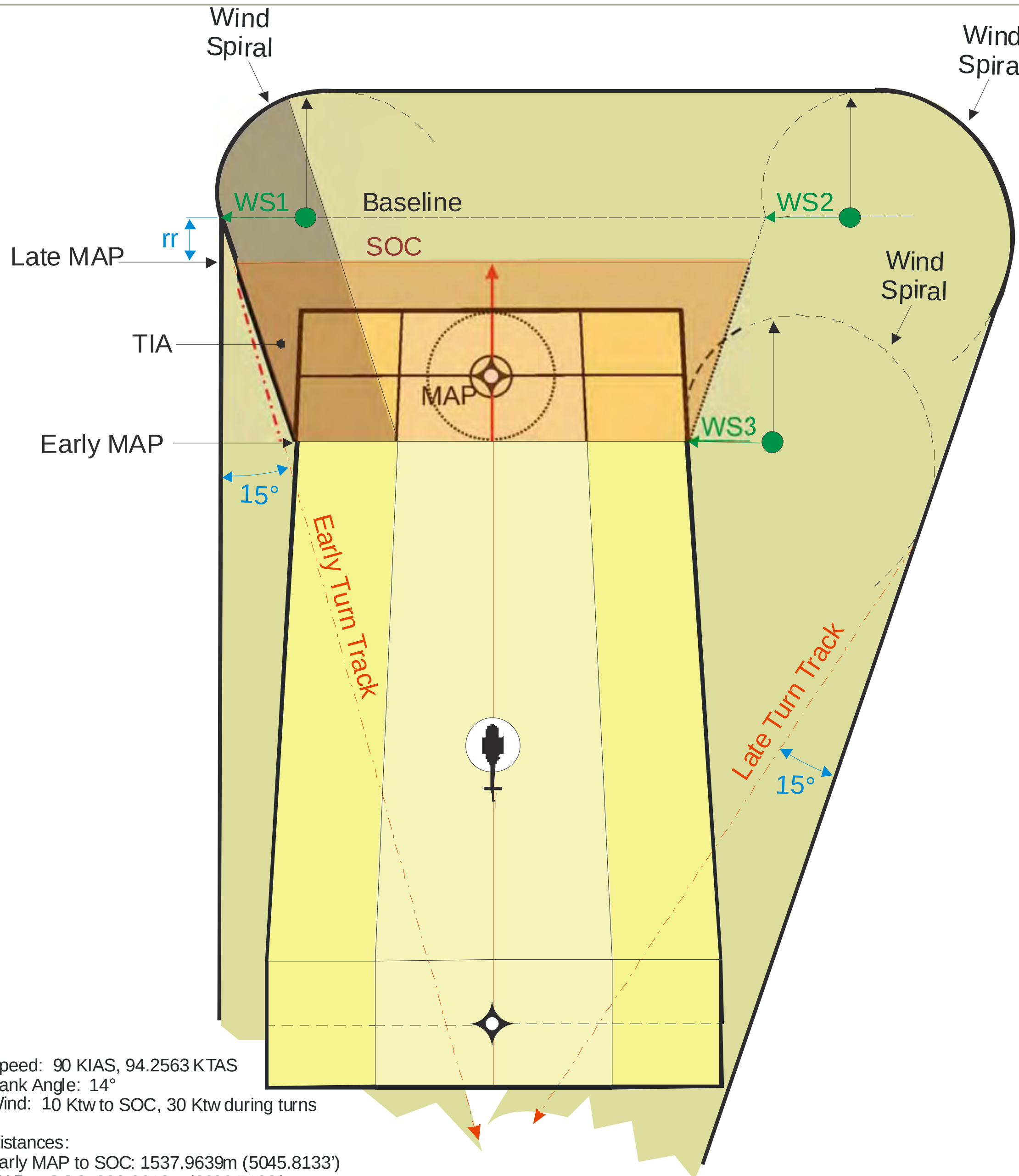
Figure 5-11. 70 KIAS Missed Approach Segment, >75 degrees, ≤ 165 degrees (Minimum Turn Altitude) 2 WS.



Speed: 70 KIAS, 73.31 KTAS
Bank Angle: 11°
Wind: 10 Ktw to SOC, 30 Ktw during turns

Distances:
Early MAP to SOC: 1452.2731m (4764.6755')
MAP to SOC: 892.0613m (2926.7103')
Late MAP to SOC: 341.0644m (1118.9777')

Figure 5-12. 90 KIAS Missed Approach Segment, > 165 degrees (Minimum Turn Altitude) 3 WS.



Speed: 90 KIAS, 94.2563 KTAS
Bank Angle: 14°
Wind: 10 Ktw to SOC, 30 Ktw during turns

Distances:
Early MAP to SOC: 1537.9639m (5045.8133')
MAP to SOC: 892.0613m (2926.7103')
Late MAP to SOC: 426.7639m (1400.1440')

Early MAP to W/S Limit (90°): 3006.3146m (9863.2369')
SOC to WS Baseline: 383.5364m (1258.3215') (rr)

No Wind Turn Radius: 959.1922m (3146.9560')

Figure 5-13. Direct to Fix Segment Following a TIA completion ≤ 75 Degrees (One WS).

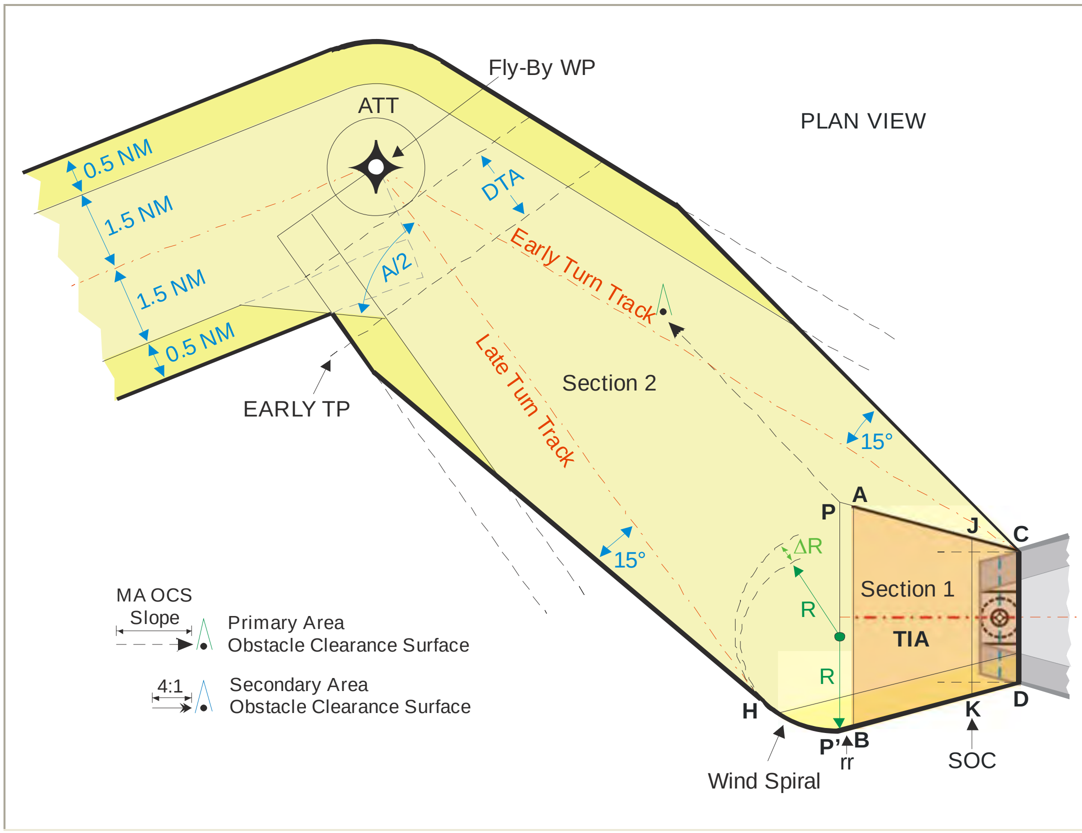


Figure 5-14. Direct to Fix Segment Following a TIA completion >75 degrees (Two WS).

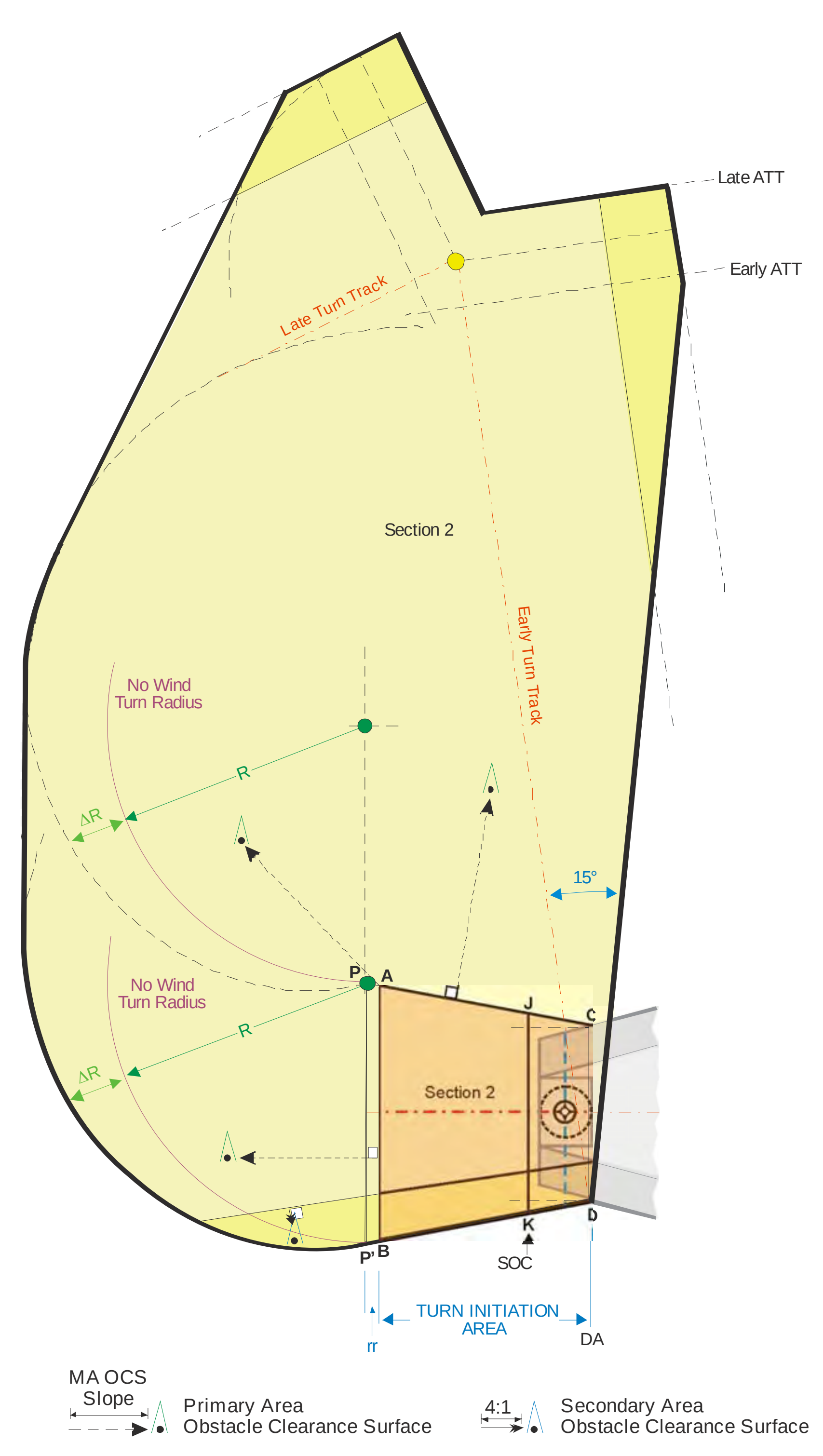


Figure 5-15. Direct to Fix Segment
Following a TIA completion > 165 degrees 3 WS.

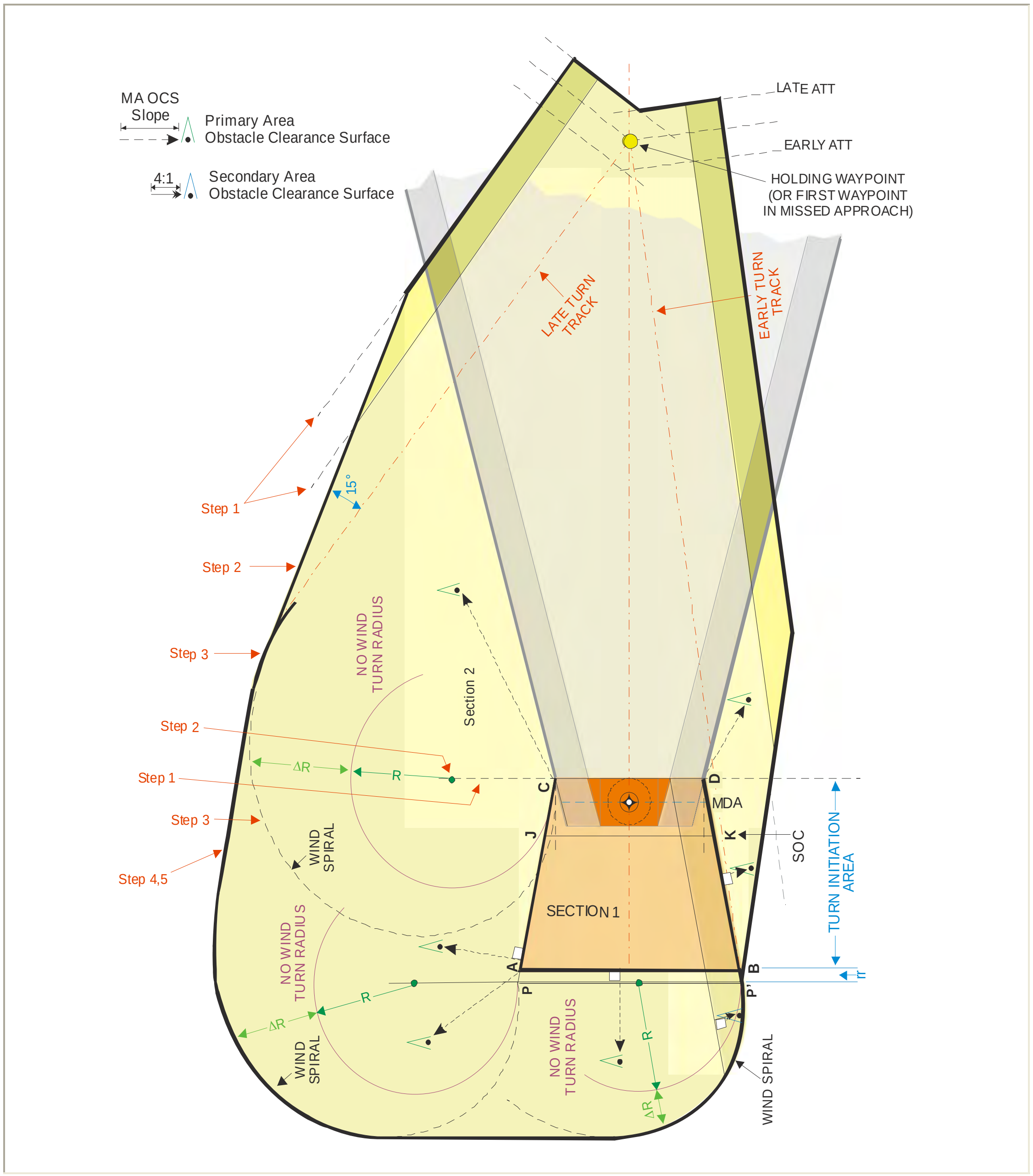


Figure 5-16. Fly-Over/Fly-By Diagrams.

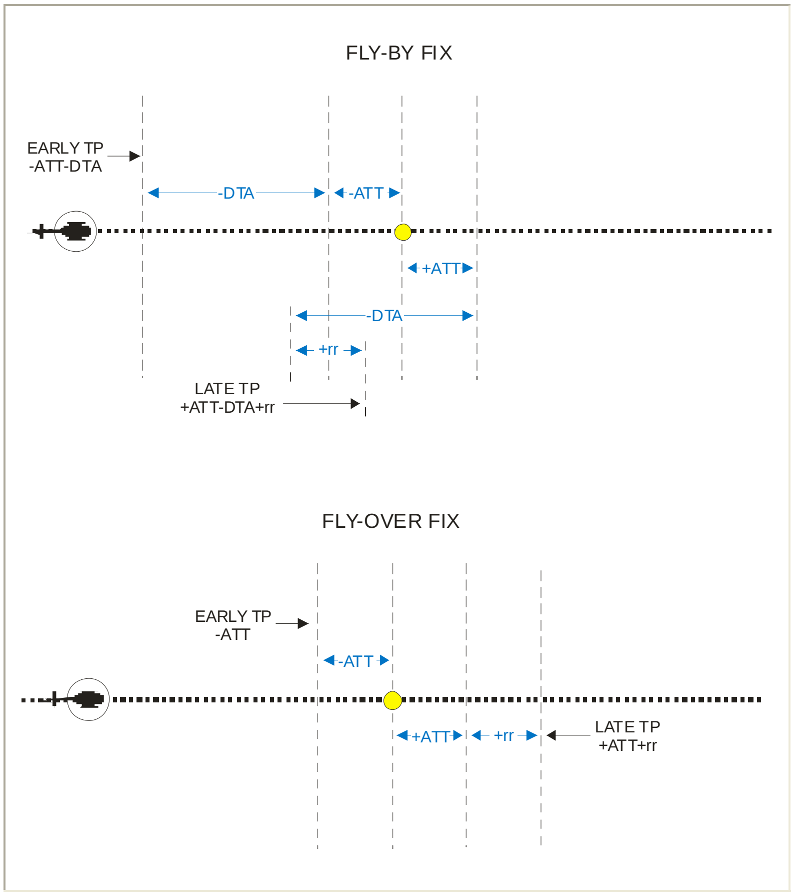


Figure 5-17. Turn at a Waypoint (fly-by).

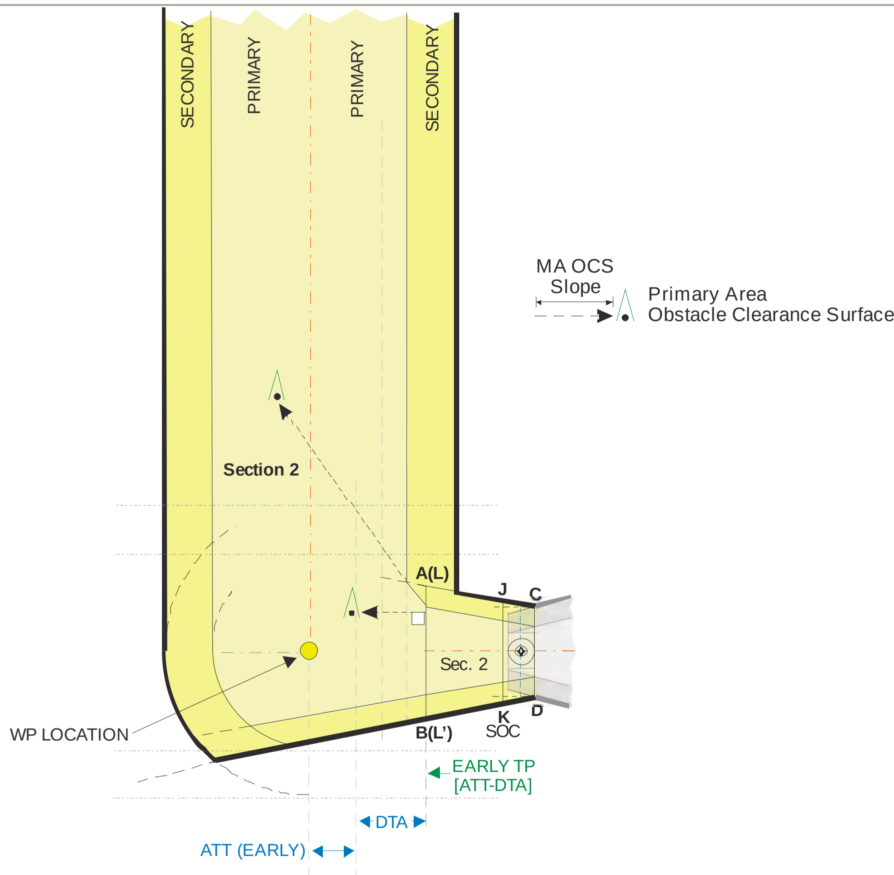


Figure 5-18a Turn at a Waypoint (fly-by).

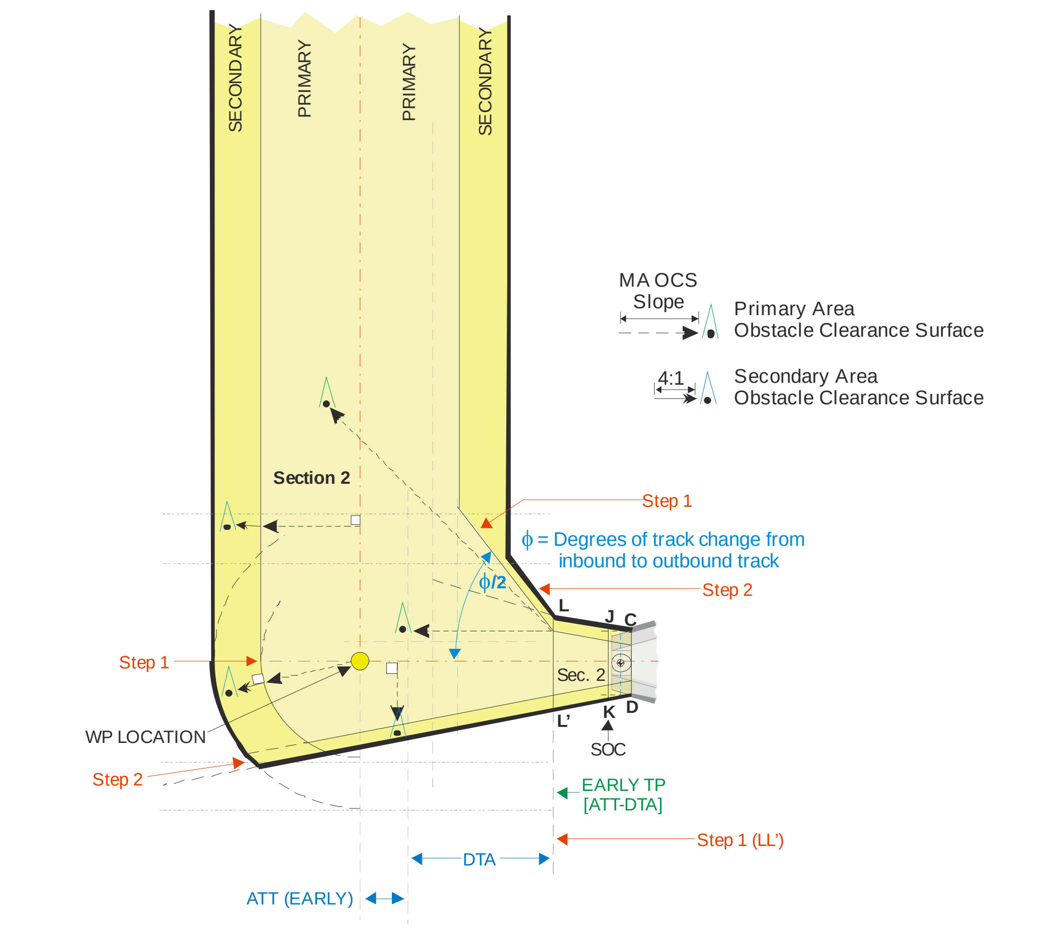


Figure 5-18b. Turn at a Waypoint (fly-by).

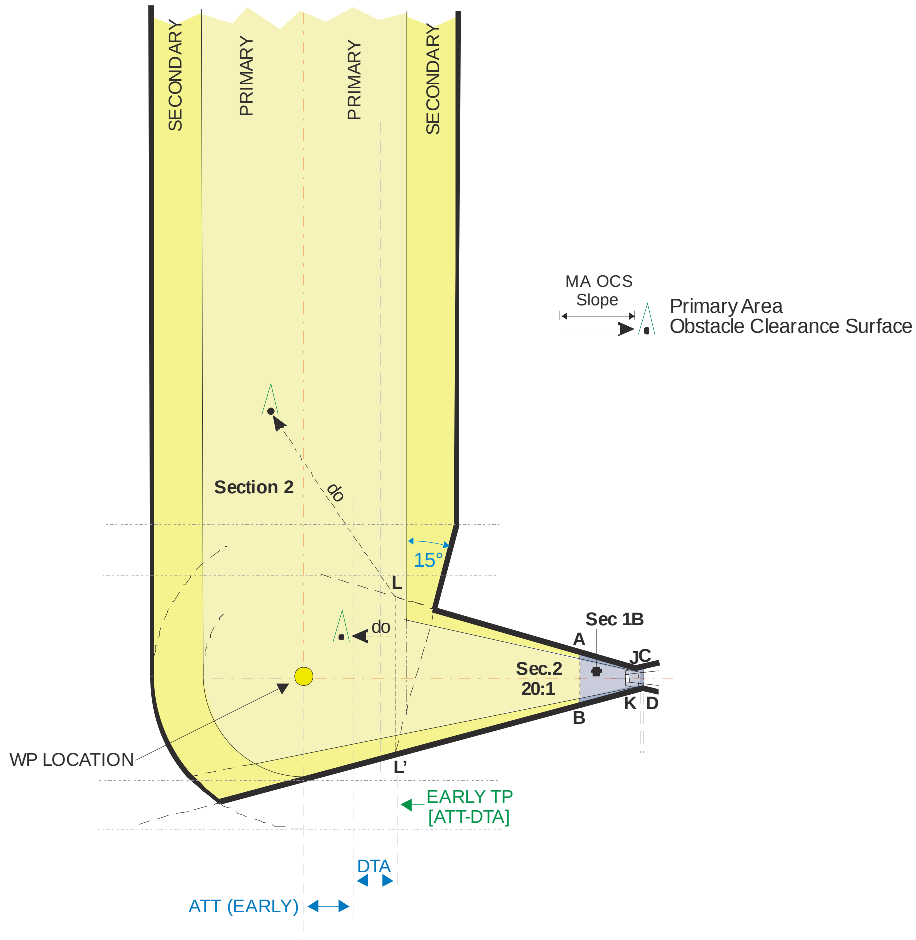


Figure 5-19. Turn at a Waypoint (fly-over) ≤ 75 Degrees.

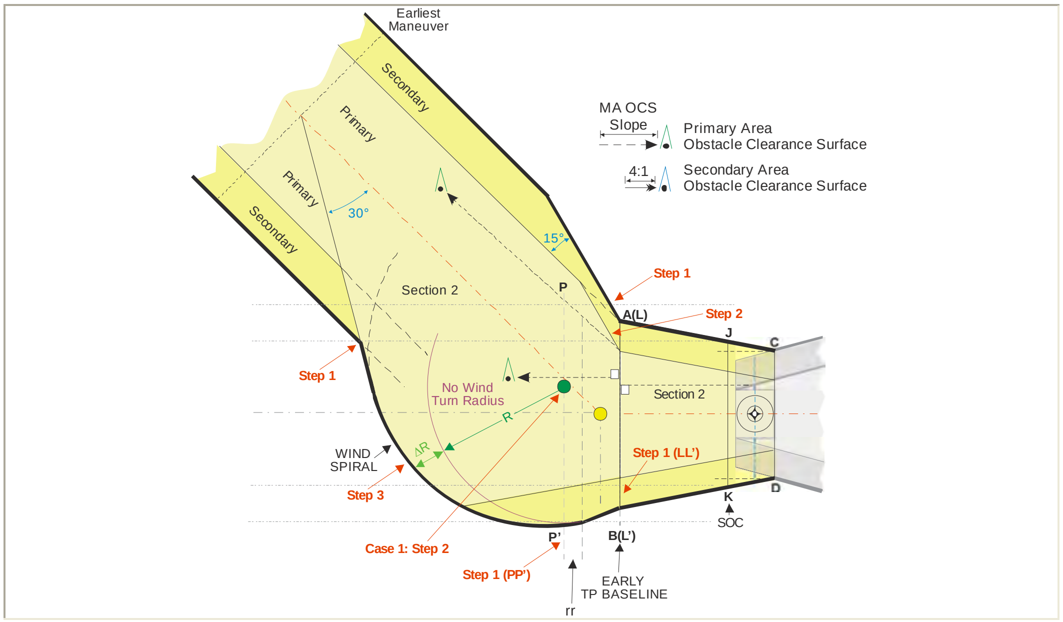


Figure 5-20. Turn at a Waypoint (fly-over) > 75 Degrees.

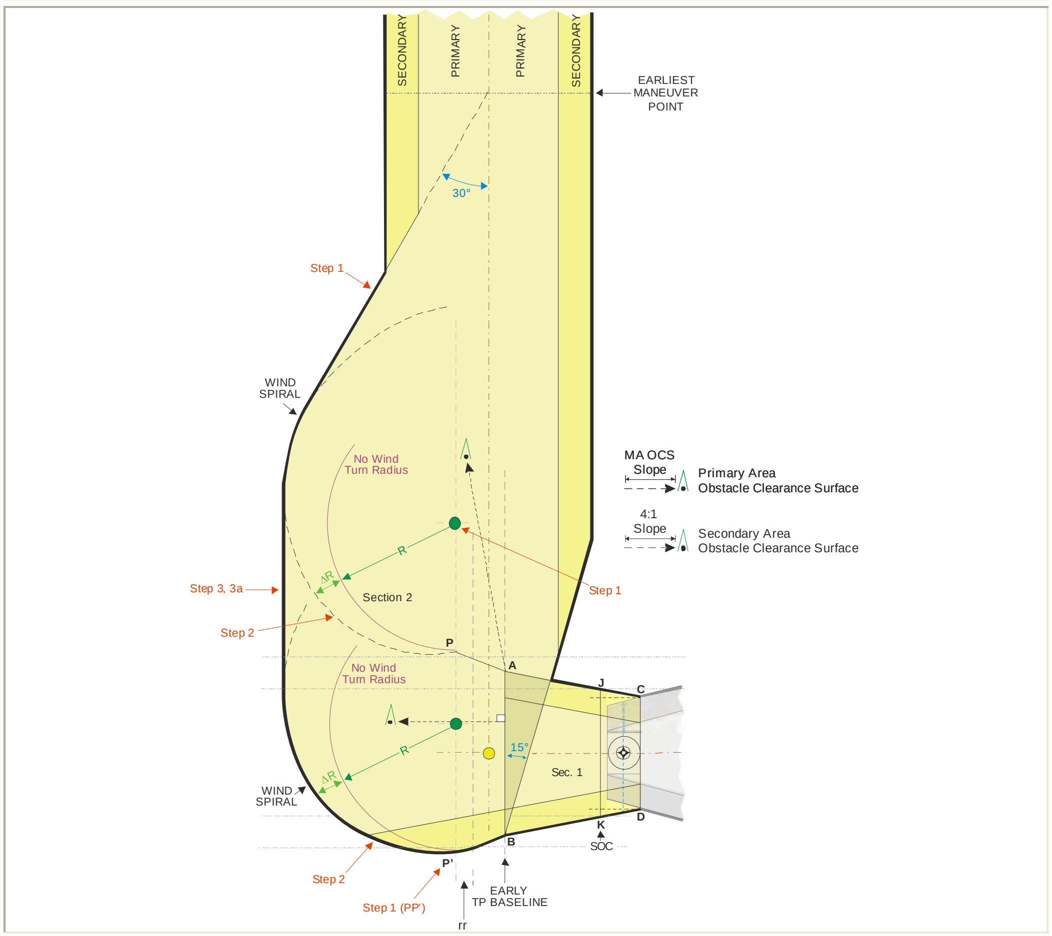


Figure 5-21. Second Turn Fly-By Construction.

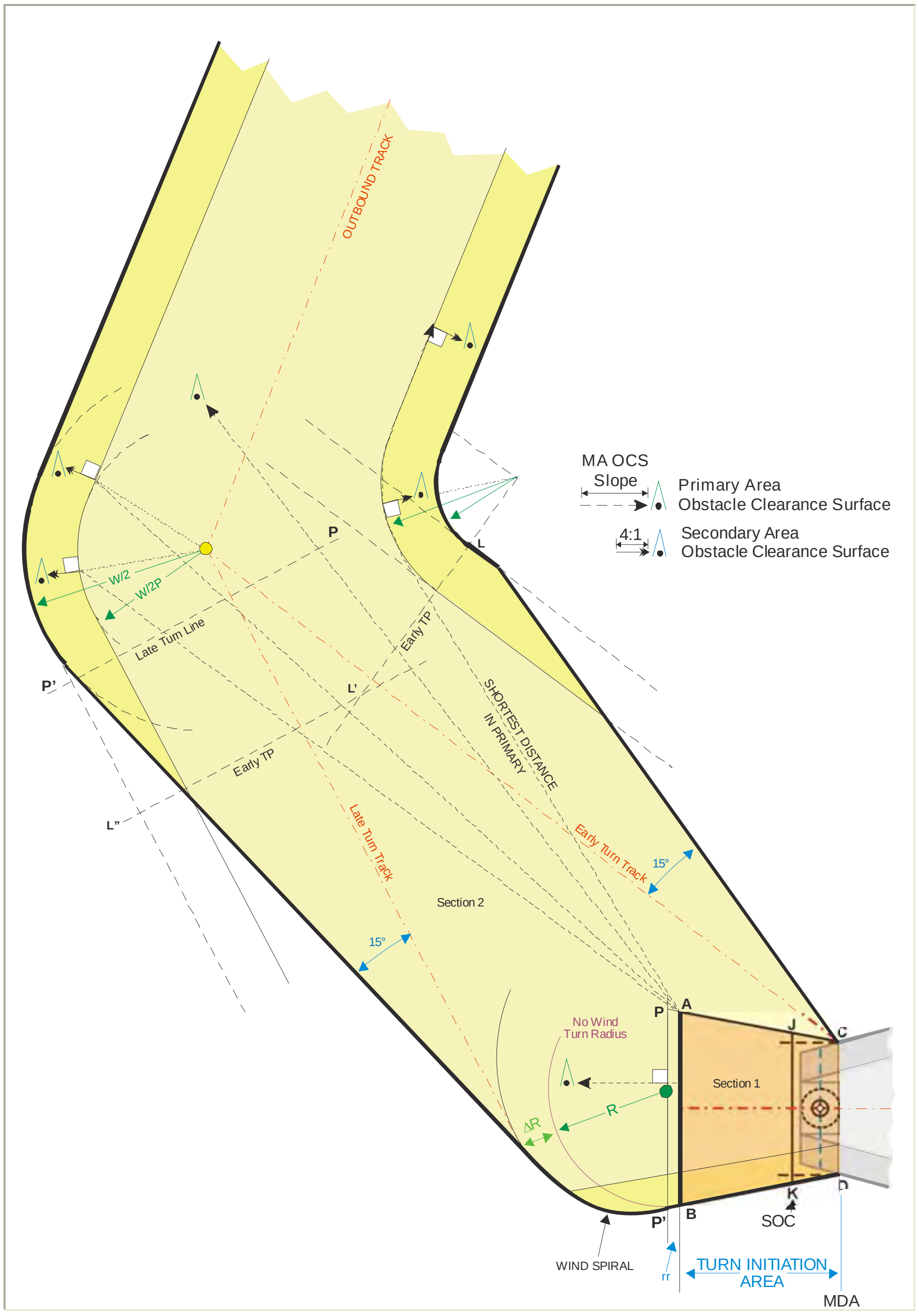


Figure 5-22. Second Turn Fly-Over Construction.

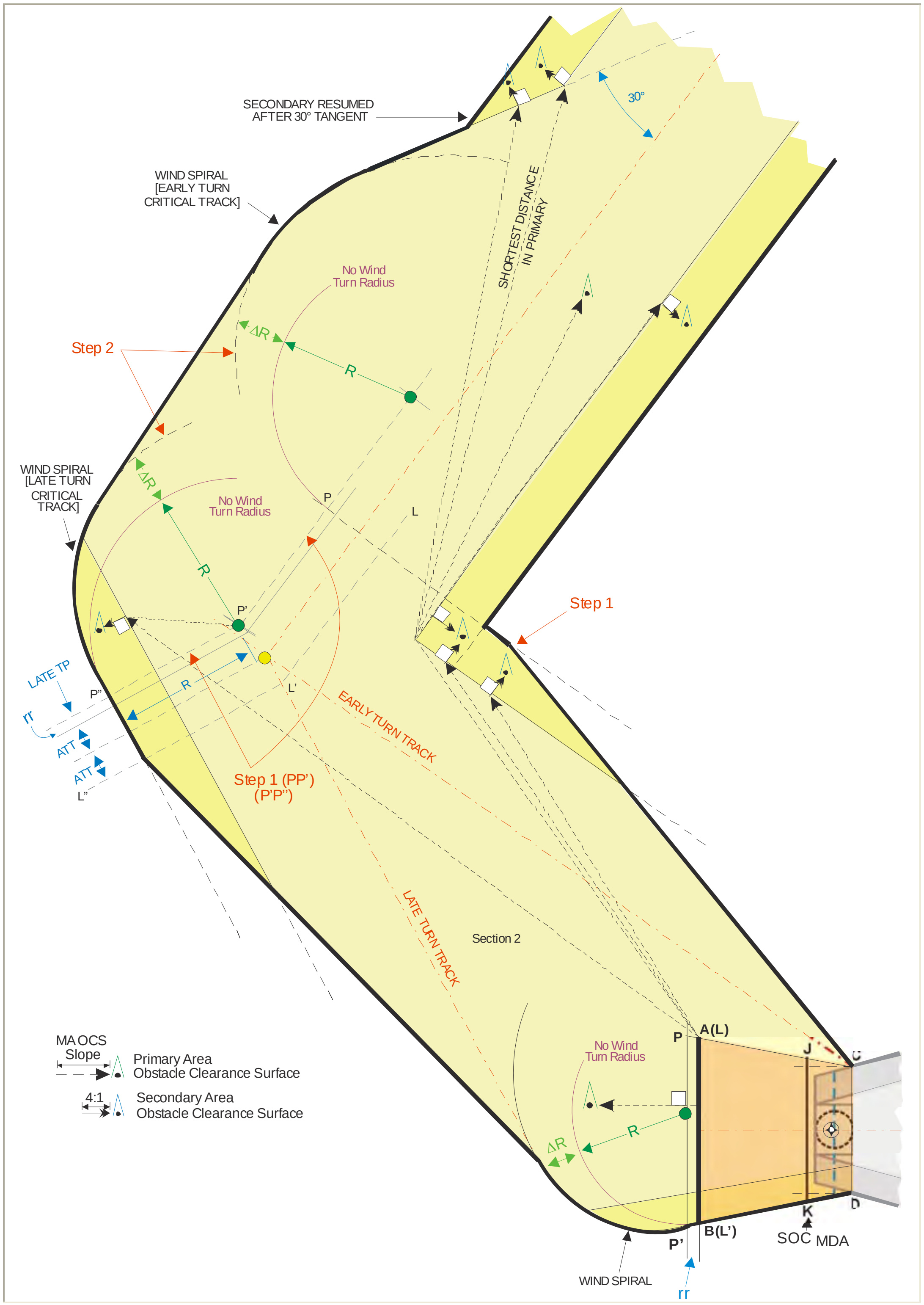
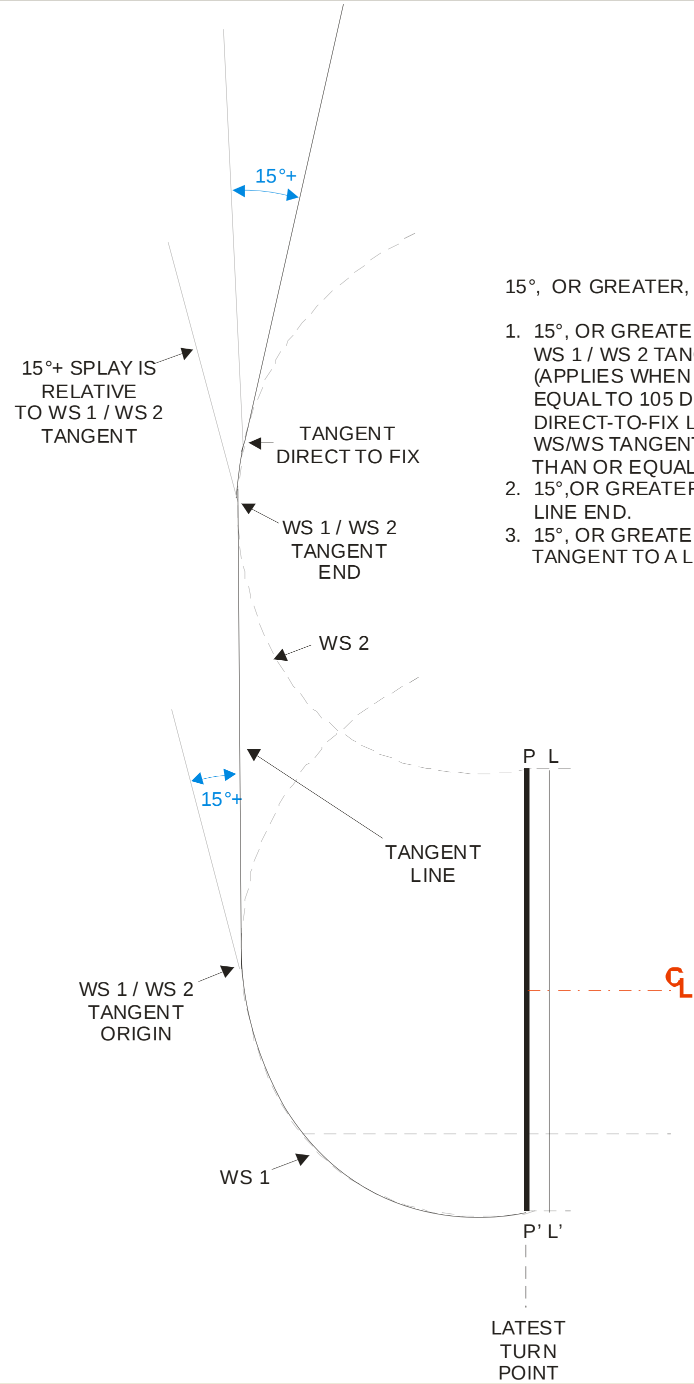


Figure 5-23. WS Connection (Inside Outbound Segment Primary Boundary).



15°, OR GREATER, SPLAY OPTIONS:

1. 15°, OR GREATER, SPLAY FROM WS 1 / WS 2 TANGENT LINE ORIGIN, (APPLIES WHEN TURN IS LESS THAN OR EQUAL TO 105 DEGREES, OR WHEN DIRECT-TO-FIX LINE DIFFERS FROM WS/WS TANGENT LINE LESS THAN OR EQUAL TO 15 DEGREES) .
2. 15°,OR GREATER SPLAY FROM WS / WS TANGENT LINE END.
3. 15°, OR GREATER SPLAY FROM POINT WS IS TANGENT TO A LINE DIRECT TO THE FIX.

Figure 5-24. WS Connection
(Inside Outbound Segment Primary Boundary).

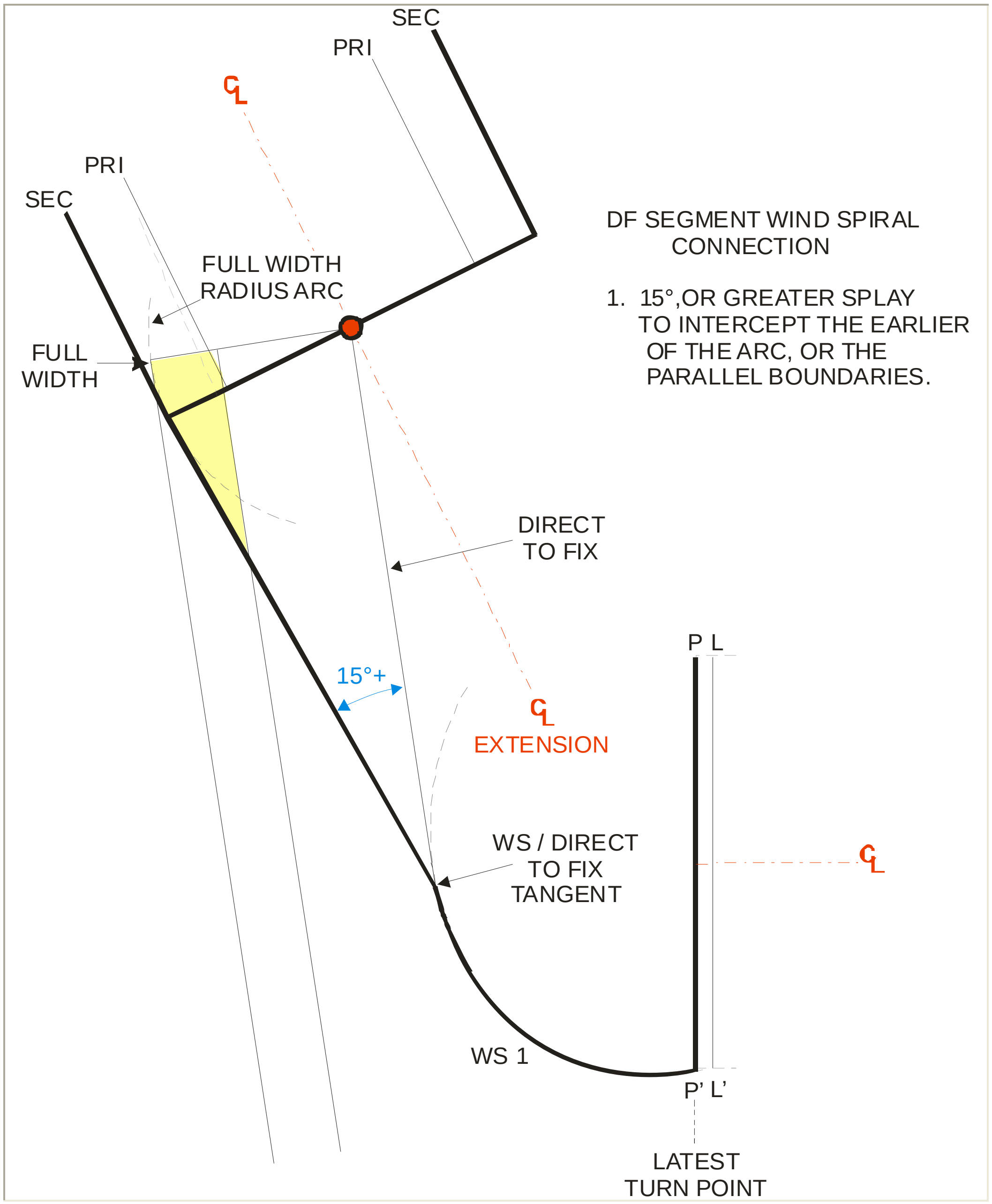
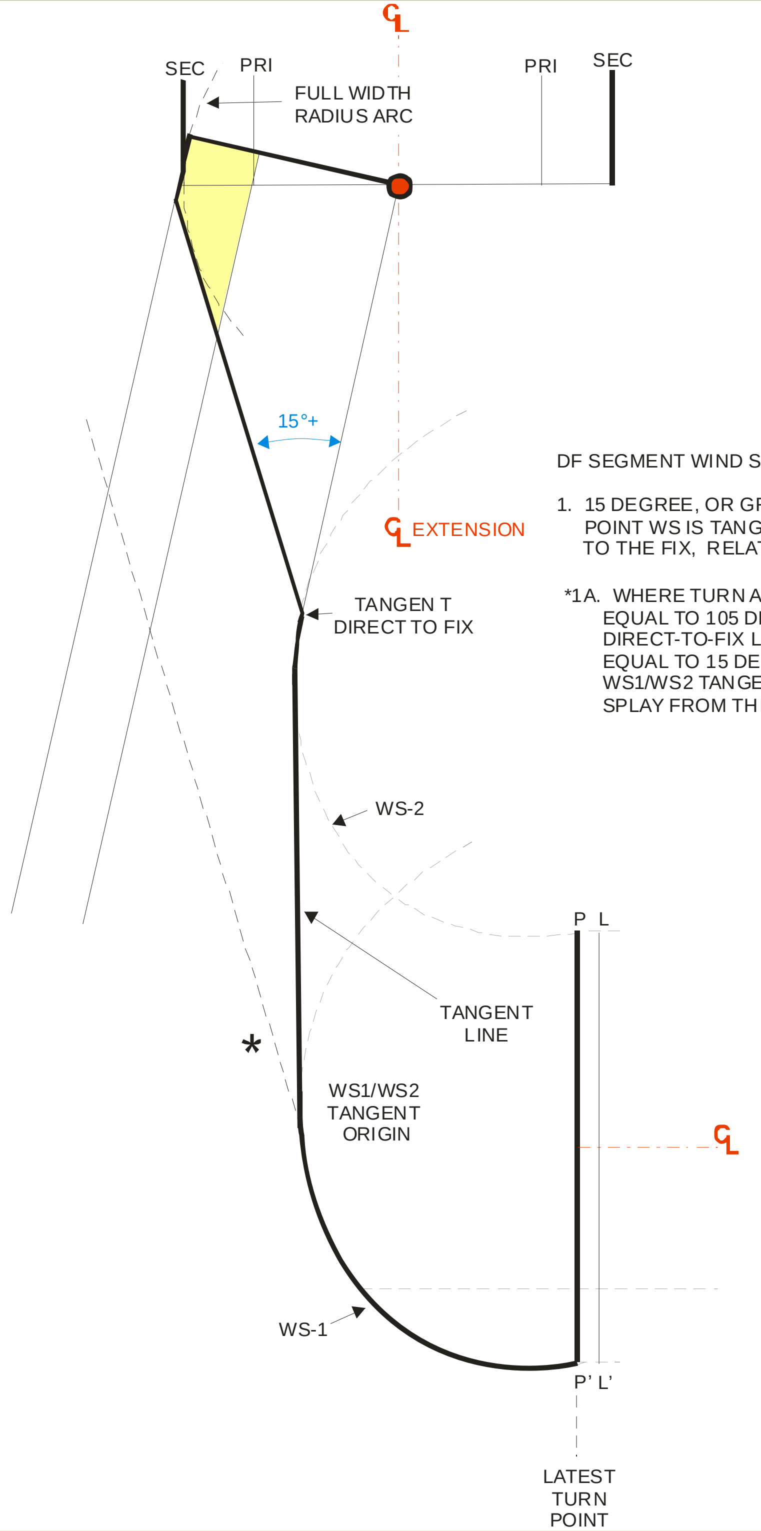


**Figure 5-25. WS Connection
(Inside Outbound Segment Secondary Boundary).**



DF SEGMENT WIND SPIRAL CONNECTION

1. 15 DEGREE, OR GREATER SPLAY FROM POINT WS IS TANGENT TO A LINE DIRECT TO THE FIX, RELATIVE THE DIRECT TO FIX LINE.

*1A. WHERE TURN ANGLE IS LESS THAN OR EQUAL TO 105 DEGREES, OR WHERE THE DIRECT-TO-FIX LINE DIFFERS LESS THAN OR EQUAL TO 15 DEGREES FROM THE WS1/WS2 TANGENT LINE , APPLY THE SPLAY FROM THE WS1/WS2 TANGENT ORIGIN.

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Chapter 6. Helicopter Instrument Departure Design Criteria

6-1. General. See chapter 2, paragraph 1, section 1.

6-2. Terms. These terms/variables are common to all formulas:

β is magnitude of heading change in degrees
θ is glidepath angle in degrees
alt is altitude AMSL
ATT is along-track tolerance
DA is decision altitude specified AMSL
$\mathbf{d_{FauxOrigin}}$ is the distance from RDP to the phantom LTP for OEA construction
FTE means "Flight Technical Error"
HAS is the height in feet above the surface beneath (within 5,200 radius of) RDP
LTP means "landing threshold point"
MSL in this document is synonymous with AMSL
$\mathbf{OBS_{elev}}$ is the obstacle AMSL elevation
$\mathbf{OBS_x}$ is the along-track distance from reference datum point
$\mathbf{PFAF_{alt}}$ is the minimum AMSL altitude at the PFAF
RDP means "reference datum point"

$$\text{Functions and Constants}\left\{\begin{array}{l}\cdot\mathbf{deg}=\times\dfrac{\pi}{180}\\ \mathbf{fpnm}=\dfrac{1852}{0.3048}\\ \mathbf{max(a,b)}=\text{maximum value of a and b}\\ \mathbf{round(a,b)}=\text{rounds a to b decimal places}\\ \mathbf{ceiling(a)}=\text{rounds a to next integer toward positive infinity}\end{array}\right\}$$

6-3. Obstacle Departure Procedures. Reserved.

6-4. PinS Departures.

a. Background operational information for procedure designers. The PinS Departure Procedures (DPs) described in this criteria allow a pilot to depart a heliport and visually navigate and avoid obstacles to the Initial Departure Fix (IDF) where IFR obstruction clearance begins. The IDF is a FB WP. IFR helicopter departure procedures will consist of a defined route in graphic form, published/charted as a standard instrument departure (SID) and comply with design and documentation guidelines as specified in this chapter and FAA Order 8260.46 chapter 2, appendices A, C, D, and E.

b. General Procedure Design. Establish the IDF at a distance from 1.5 NM to 5.0 NM from HRP for Public DPs, and 0.55 NM to 2.0 NM for Special DPs. PCG and obstruction clearance must be provided from the earliest ATT at the IDF to the latest ATT at the last DP WP

(DP termination fix) where the DP joins the en route structure and an altitude that permits en route flight.

(1) Public DP Construction. Optimum leg length is 3.0 NM. If the magnitude (β) of the first turn is ≤ 70 degrees, the minimum leg length allowed is 3.0 NM. If β of the first turn is > 70 degrees the minimum leg length is 3.5 NM. Maximum turn magnitude is 90 degrees and leg length is 10.0 NM.

(2) Special DP Construction. The **optimum** leg length for Special helicopter DP construction is 3.0 NM. If β of the first turn angle is ≤ 30 degrees, the minimum leg length is 2.0 NM, if β of the first turn angles are > 30 degrees the minimum leg length increases to 3.0 NM. Maximum value for β is 90 degrees and maximum leg length is 10.0 NM.

(3) After the first turn fix, and expanding to full width, apply standard RNAV initial segment OEA construction for Category "A" aircraft. Minimum leg length is the greater of the current RNAV minimum leg length criteria or as construction requires after the first turn fix.

(4) Use Formula 6-1 to determine turn radius (R) and DTA appropriate for β. For a Public DP, use a design climb airspeed of 80 KIAS and a 13-degree bank angle until the climb trajectory reaches the target departure altitude. After the target departure altitude is reached, design for 140 KIAS and 15-degree bank angle. For a Special DP, use the best rate of climb airspeed (V_y), the cruising airspeed (V_c), and the design bank angle for V_y and V_c applicable to the specific design helicopter.

(5) If lower or higher airspeeds are required because of design helicopter performance or equipment operating limitations, publish a speed restriction.

Formula 6-1. Turn Radius/DTA

$$(1)\quad input\ V_{KIAS},\ bank_{angle},\ turn_{alt},\ \beta,\ HRP_{elev}$$

$$(2)\quad \mathbf{case}(turn_{alt} - HRP_{elev} > 2000):\ V_{KTW} = round(0.00198 \cdot turn_{alt} + 47, 0)$$
$$\mathbf{case}(turn_{alt} - HRP_{elev} \le 2000):\ V_{KTW} = 30$$

$$(3)\quad V_{KTAS} = \mathbf{round}\left[\frac{V_{KIAS} \cdot 171233 \cdot \sqrt{303 - 0.00198 \times turn_{alt}}}{(288 - 0.00198 \cdot turn_{alt})^{2.628}}, 0\right]$$

$$(4)\quad R = \mathbf{round}\left[\frac{(V_{KTAS} + V_{KTW})^2}{\tan(bank_{angle}°) \cdot 68625.4}, 2\right]$$

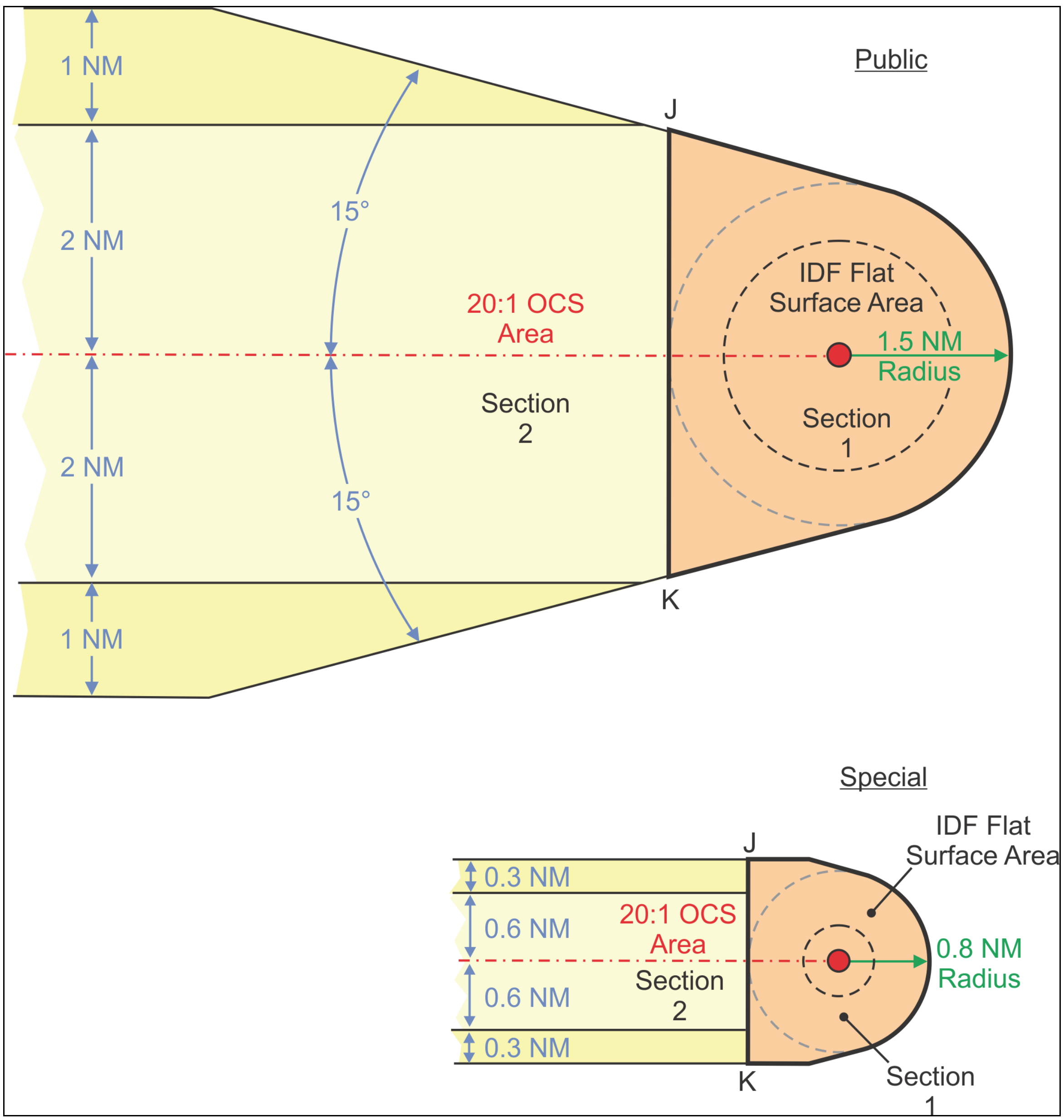
$$(5)\quad DTA_{NM} = \mathbf{round}\left[R \cdot \tan\left(\frac{\beta°}{2}\right), 2\right]$$

if ($turn_{alt}$-HRP_{elev}>2000) then 0.00198*$turn_{alt}$+47 else 30 round((V_{KIAS}*171233*(303-0.00198*$turn_{alt}$)^0.5)/(288-0.00198*$turn_{alt}$)^2.628,0) round((V_{KTAS}+V_{KTW})^2/(tan($bank_{angle}$*π/180)*68625.4),2) round(R*tan(β/2*π/180),2)

Calculator		
V_{KIAS}		Click Here to calculate
$bank_{angle}$		
$turn_{alt}$		
β		
HRP_{elev}		
V_{KTW}		
R		
DTA		

6-5. Obstacle Evaluation Area. The OEA consists of Section 1 (the IDF flat surface area), and Section 2 (the 20:1 sloping OCS), as shown in Figure 6-1. The JK line (end of section 1/ beginning of section 2) is a line perpendicular to the initial departure course that is a specified distance from the IDF: 1.5 NM (1 NM ATT + 0.5 NM FTE) for public DPs and 0.8 NM (0.3 NM ATT + 0.5 NM FTE) for Specials the construction radius around the IDF is 1 NM ATT + 0.5 NM FTE = 1.5 NM for a Public DP and 0.3 NM + 0.5 NM FTE = 0.8 NM for a Special DP. A 15-degree splay defines the Section 1 and Section 2 outer boundaries as shown in Figure 6-1 below. The OEA entry is centered on the IDF and the route is constructed as a series of TF legs to the DP termination fix.

Figure 6-1. Section 1 Flat Surface, Section 2 OCS Areas



6-6. General Public PinS Departure Construction. For Public DP construction, OEA configuration is dependent on the course change angle at the first turn fix, and the length of the first segment. Some examples are illustrated in Figure 6-2 thru Figure 6-4. Instructions on how to define these cases (creating the specific OEAs and turn boundaries) are located in steps below:

Figure 6-2. Public OEA Area Plan View (90-Degree Turn)

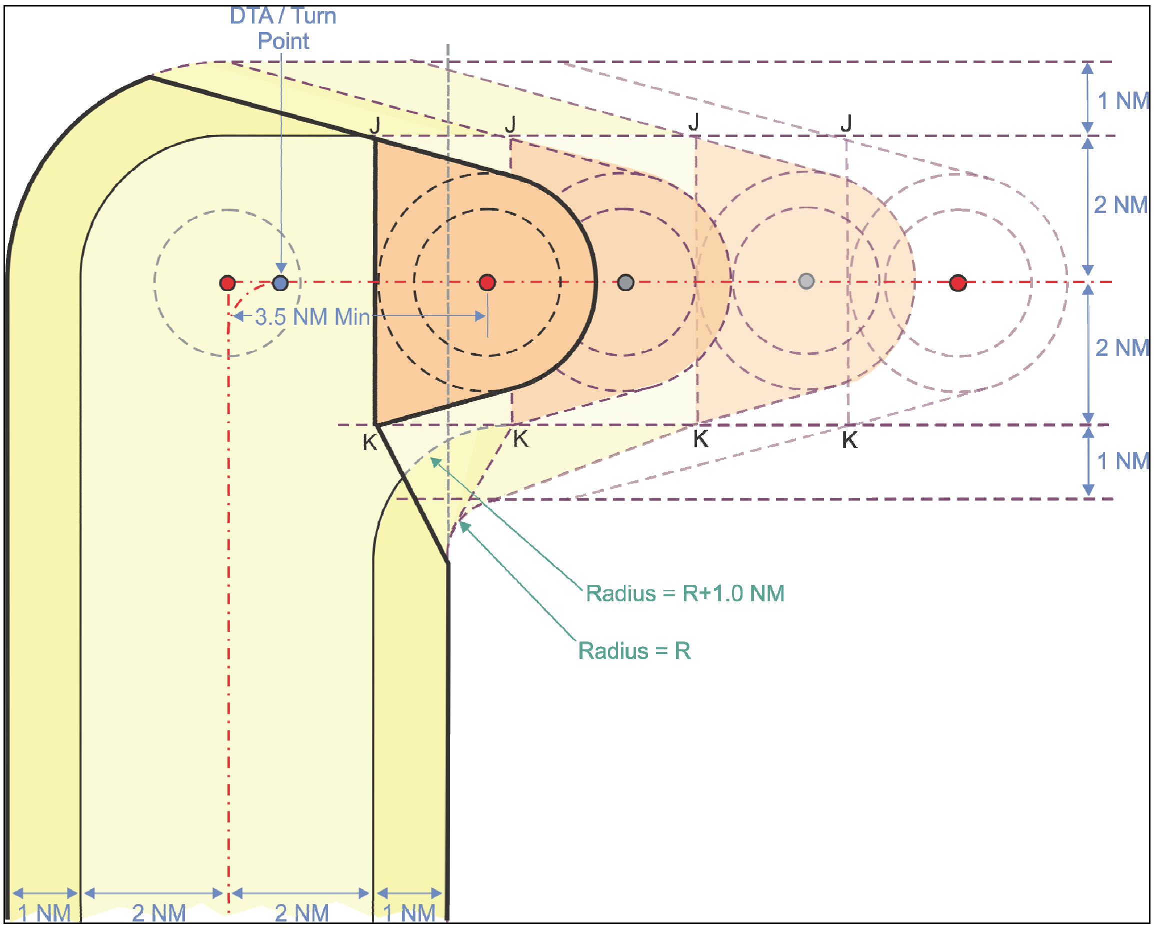


Figure 6-3. Public OEA Area Plan View (15- and 30-Degree Turns)

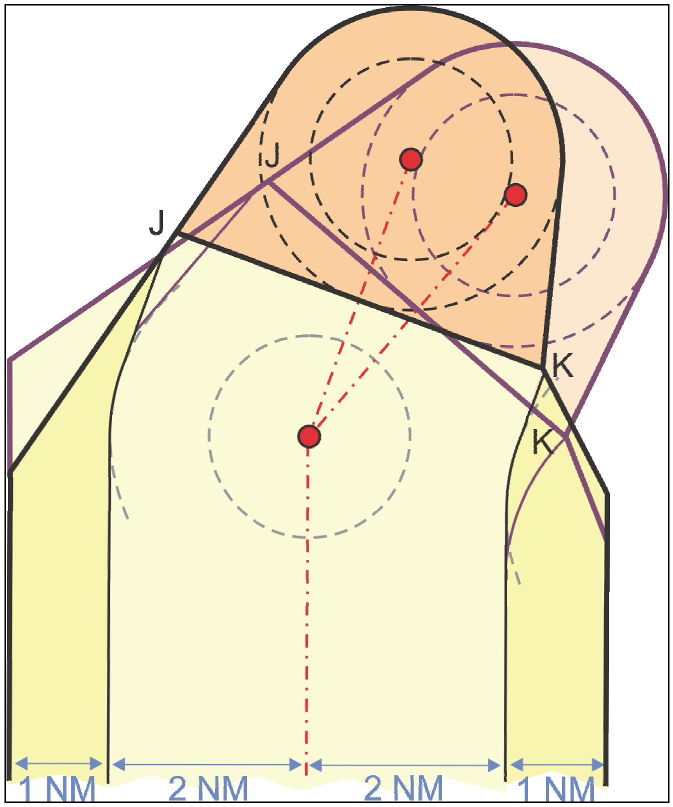
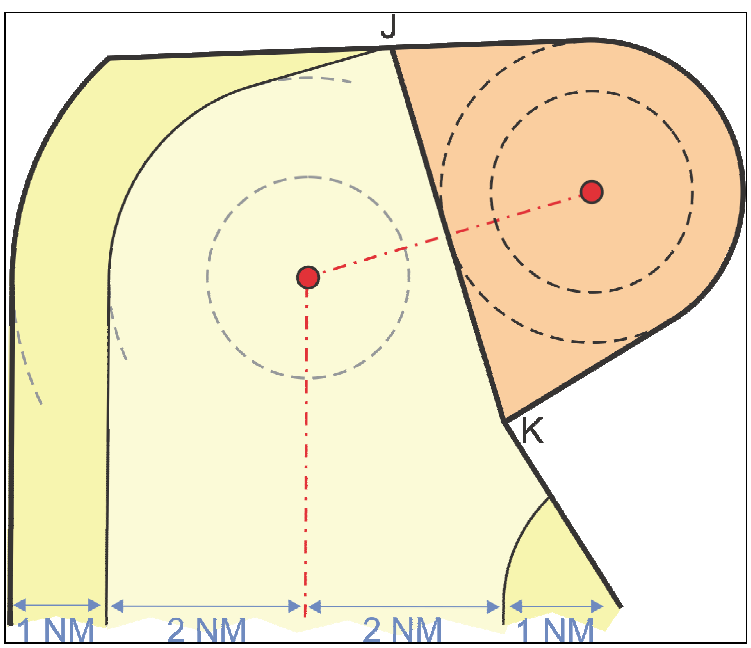


Figure 6-4. Public OEA Area Plan View (70-Degree Turn)



Step 1: Position the IDF as a FB fix. Use a fix-to-fix distance that is in accordance with chapter 2, paragraph 2b(1).

Step 2: Construct the IDF Circle as an arc with a 1.5 NM radius centered at the IDF fix.

Step 3: Construct the Designed Turning Flight Path.

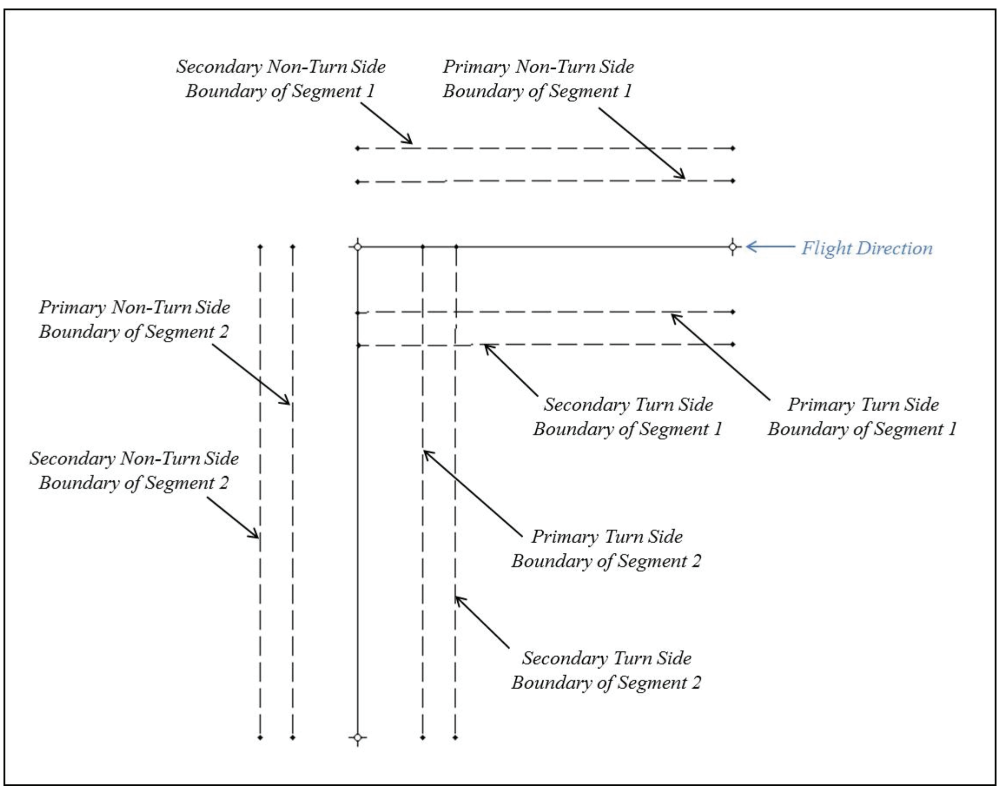
Step 3a: Determine the turn radius (R) utilizing Formula 6-1.

Step 3b: Construct an arc of radius R that lays tangent to Segments 1 and 2.

Step 4: Construct Segment 1 Boundaries. Construct Boundaries of half-widths 1-2-2-1 in reference to Segment 1. They will hereby be referred to as the Secondary Turn Side Boundary of Segment 1, the Primary Turn Side Boundary of Segment 1, the Primary Non-Turn Side Boundary of Segment 1, and the Secondary Non-Turn Side Boundary of Segment 1. These boundaries are depicted in Figure 6-5.

Step 5: Construct Segment 2 Boundaries. Construct Boundaries of half-widths 1-2-2-1 in reference to Segment 2. They will hereby be referred to as the Secondary Turn Side Boundary of Segment 2, the Primary Turn Side Boundary of Segment 2, the Primary Non-Turn Side Boundary of Segment 2, and the Secondary Non-Turn Side Boundary of Segment 2. These boundaries are depicted in Figure 6-5.

Figure 6-5. Construction of the Segment 1 and Segment 2 Boundaries



Step 6: Construct the Turn Side Splay Line (see Figure 6-6).

Step 6a: Locate the Splay End Reference Point a distance of 1.5/tan(15°) NM from the IDF along the Segment 1 Course Line.

Step 6b: Locate the Turn Side Splay Line End Point as the Splay End Reference Point projected onto the Secondary Turn Side Boundary of Segment 1.

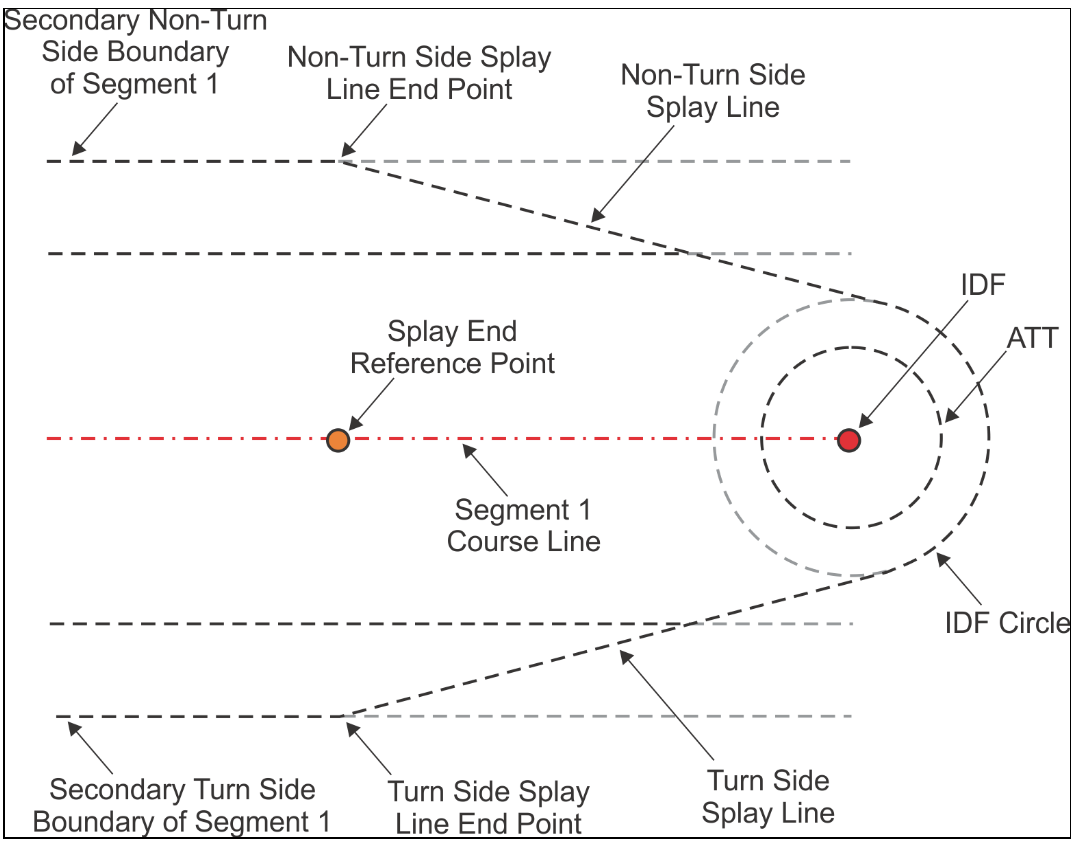
Step 6c: Construct the Turn Side Splay Line as a line that is tangent to the IDF Circle passing through the Turn Side Splay Line End Point.

Step 7: Construct the Non-Turn Side Splay Line (see Figure 6-6).

Step 7a: Locate the Non-Turn Side Splay Line End Point as the Splay End Reference Point projected onto the Secondary Non-Turn Side Boundary of Segment 1.

Step 7b: Construct the Non-Turn Side Splay Line as a line that is tangent to the IDF Circle passing through the Non-Turn Side Splay Line End Point.

Figure 6-6. Construction of the Splay Lines



Step 8: Construct the IDF Flat Surface Area (see Figure 6-7).

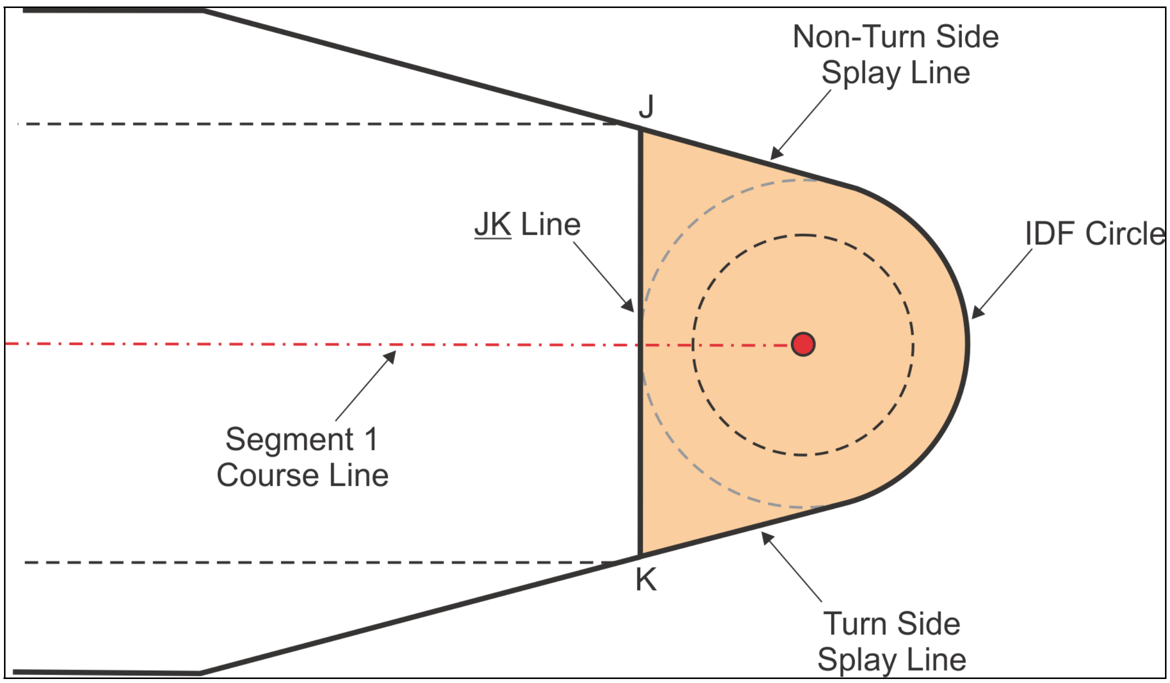
Step 8a: Construct the JK line as a line that lays tangent to the IDF Circle at a point intersecting the Segment 1 Course Line.

Step 8b: Truncate the JK line where it intersects the Turn Side Splay Line and the Non-Turn Side Splay Line.

Step 8c: The IDF Flat Surface Area is the area bounded by the IDF Circle, the Turn Side and Non-Turn Side Splay Lines, and the JK line.

Step 8d: The Turn Side end of the JK line will hereby be referred to as Point J and the Non-Turn Side end of the JK line will hereby be referred to as Point K.

Figure 6-7. Construction of the IDF Flat Surface Area

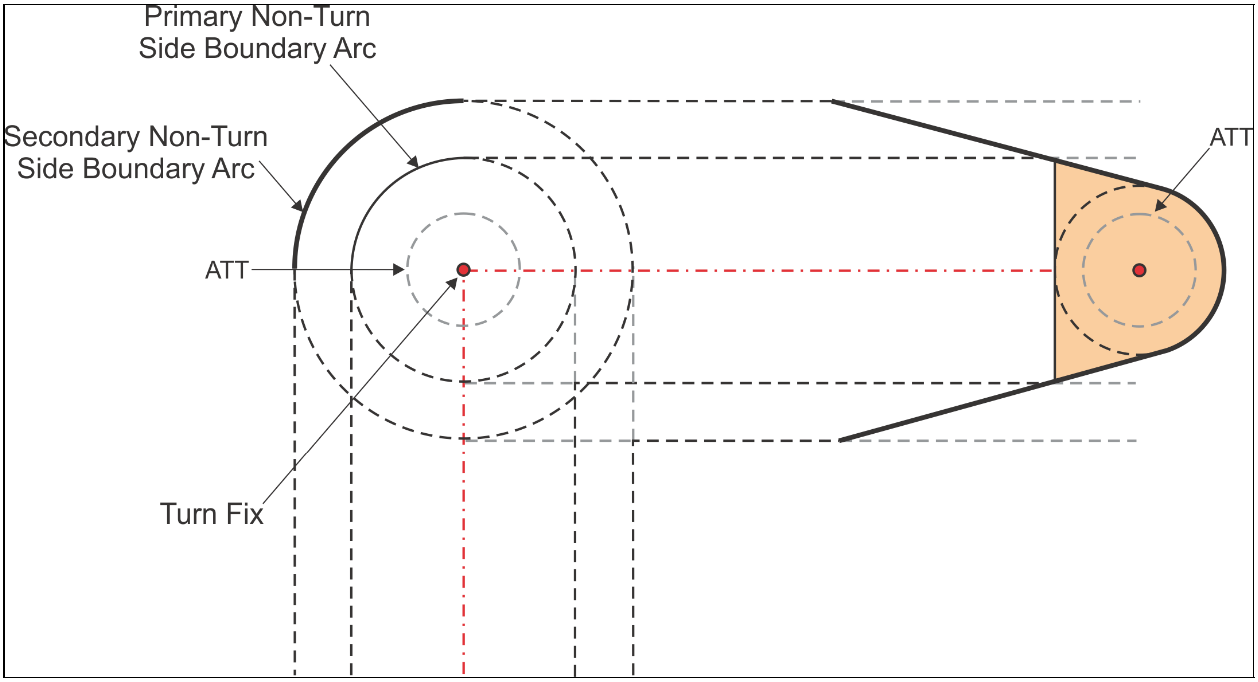


Step 9: Construct Non-Turn Side Boundary Arcs (see Figure 6-8).

Step 9a: Construct the Primary Non-Turn Side Boundary Arc centered on the turn fix with a radius equal to the Segment 1 primary half-width.

Step 9b: Construct the Secondary Non-Turn Side Boundary Arc centered on the turn fix with a radius equal to the Segment 1 primary half-width plus the segment secondary width.

Figure 6-8. Construction of the Non-Turn Side Boundary Arcs

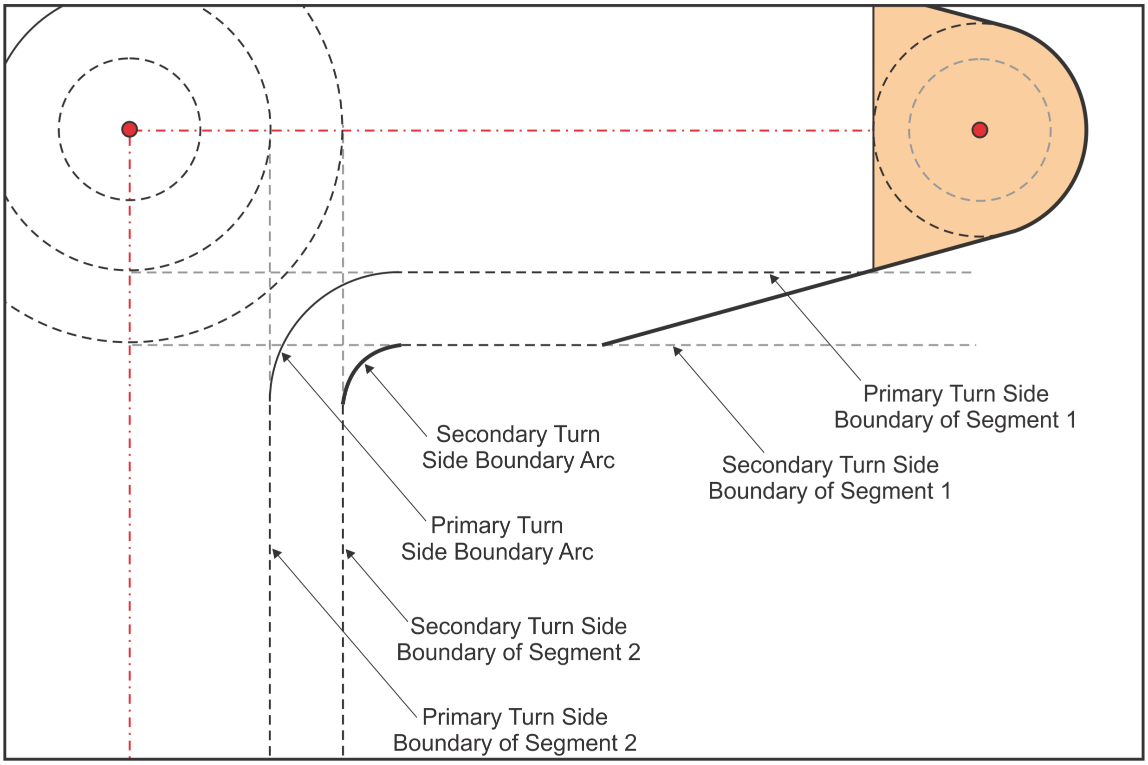


Step 10: Construct Turn Side Boundary Arcs (see Figure 6-9).

Step 10a: Construct the Primary Turn Side Boundary Arc tangent to the Primary Turn Side Boundaries of Segments 1 and 2 with a radius equal to R + 1 NM.

Step 10b: Construct the Secondary Turn Side Boundary Arc tangent to the Secondary Turn Side Boundaries of Segments 1 and 2 with a radius equal to R.

Figure 6-9. Construction of the Turn Side Boundary Arcs



Step 11: Define and Construct the Non-Turn Side Boundary.

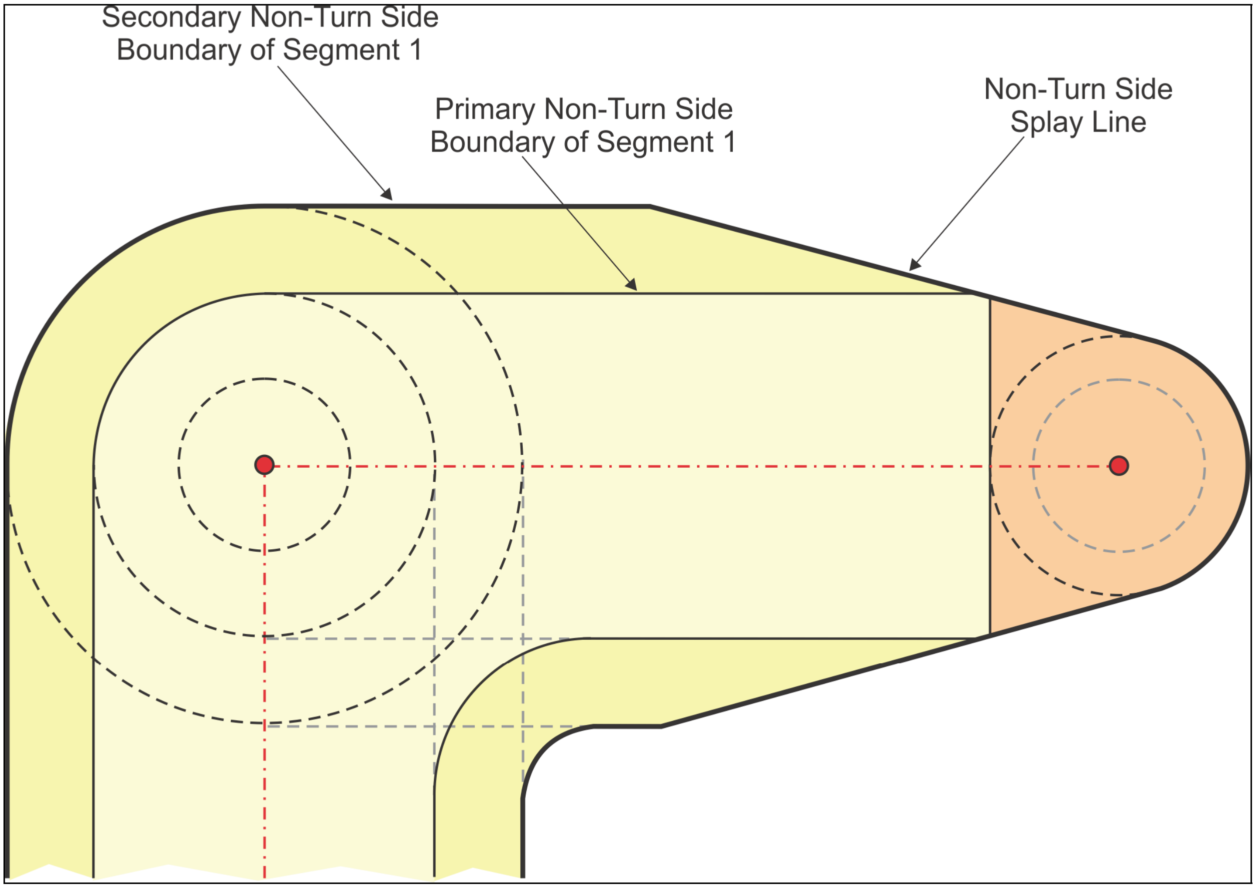
Step 11a: Depending on the course change at the second waypoint and the length of Segment 1, the Non-Turn Side Splay Line will either intersect the Secondary Non-Turn Side Boundary of Segment 1, the Secondary Non-Turn Side Boundary Arc, or the Secondary Non-Turn Side Boundary of Segment 2.

Step 11b: If the Non-Turn Side Splay Line intersects the Secondary Non-Turn Side Boundary of Segment 1 (see Figure 6-10), then:

Step 11b (1): Truncate the Secondary Non-Turn Side Boundary of Segment 1 at the intersection, and,

Step 11b (2): Truncate the Primary Non-Turn Side Boundary of Segment 1 where it intersects the Non-Turn Side Splay Line.

Figure 6-10. Construction of the Non-Turn Side Boundary, Case 1



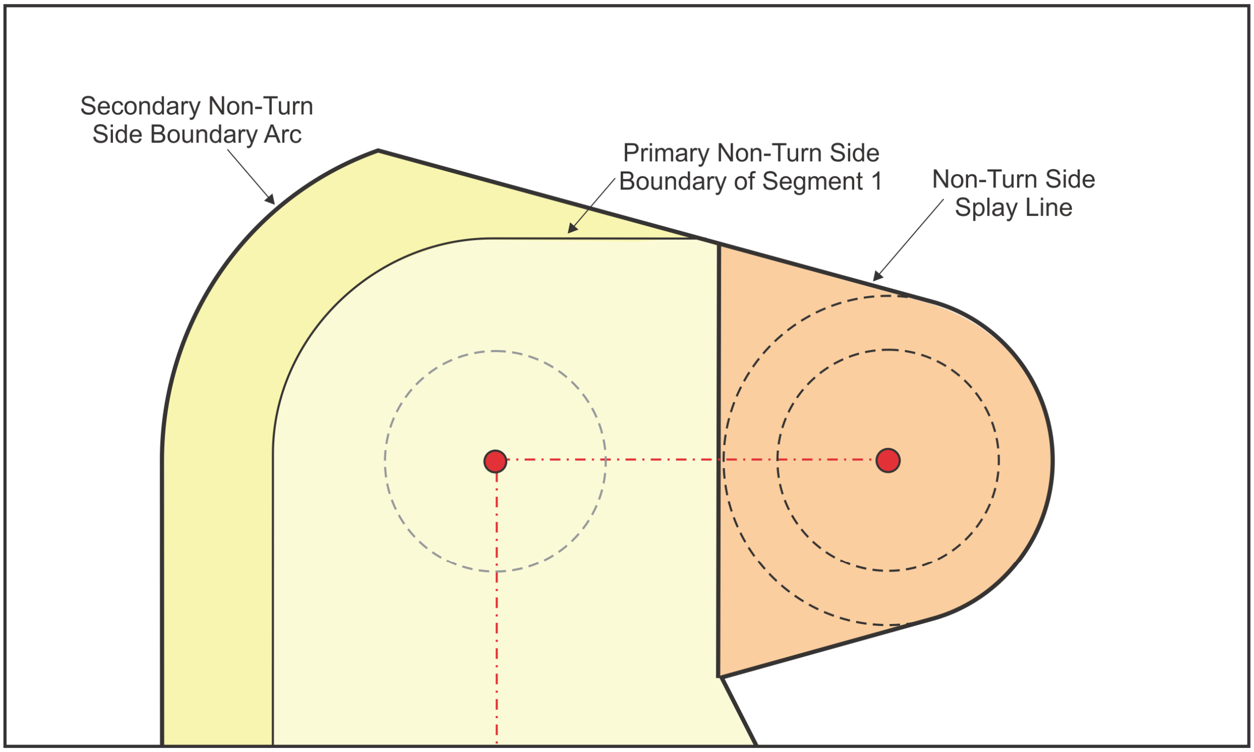
Step 11c: If the Non-Turn Side Splay Line intersects the Secondary Non-Turn Side Boundary Arc (see Figure 6-2) then,

Step 11c (1): Remove the Secondary Non-Turn Side Boundary of Segment 1,

Step 11c (2): Truncate the Secondary Non-Turn Side Boundary Arc at the intersection and,

Step 11c (3): Truncate the Primary Non-Turn Side Boundary of Segment 1 where it intersects the Non-Turn Side Splay Line.

Figure 6-11. Construction of the Non-Turn Side Boundary, Case 2



Step 11d: If the Non-Turn Side Splay Line intersects the Secondary Non-Turn Side Boundary of Segment 2 (see Figure 6-12) then,

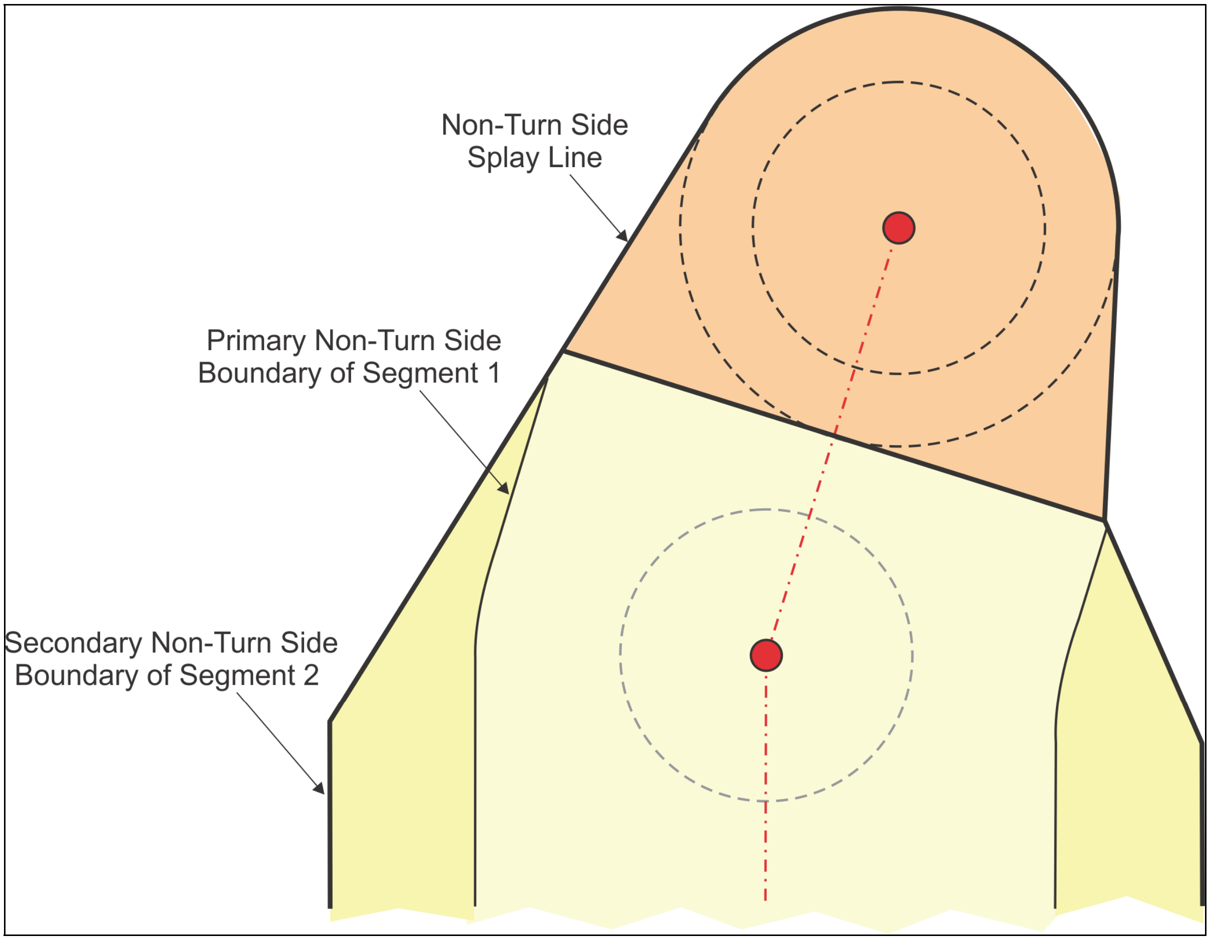
Step 11d (1): Remove the Secondary Non-Turn Side Boundary of Segment 1,

Step 11d (2): Remove the Secondary Non-Turn Side Boundary Arc,

Step 11d (3): Truncate the Secondary Non-Turn Side Boundary of Segment 2 at the intersection and,

Step 11d (4): Truncate the Primary Non-Turn Side Boundary of Segment 1 where it intersects the Non-Turn Side Splay Line.

Figure 6-12. Construction of the Non-Turn Side Boundary, Case 3



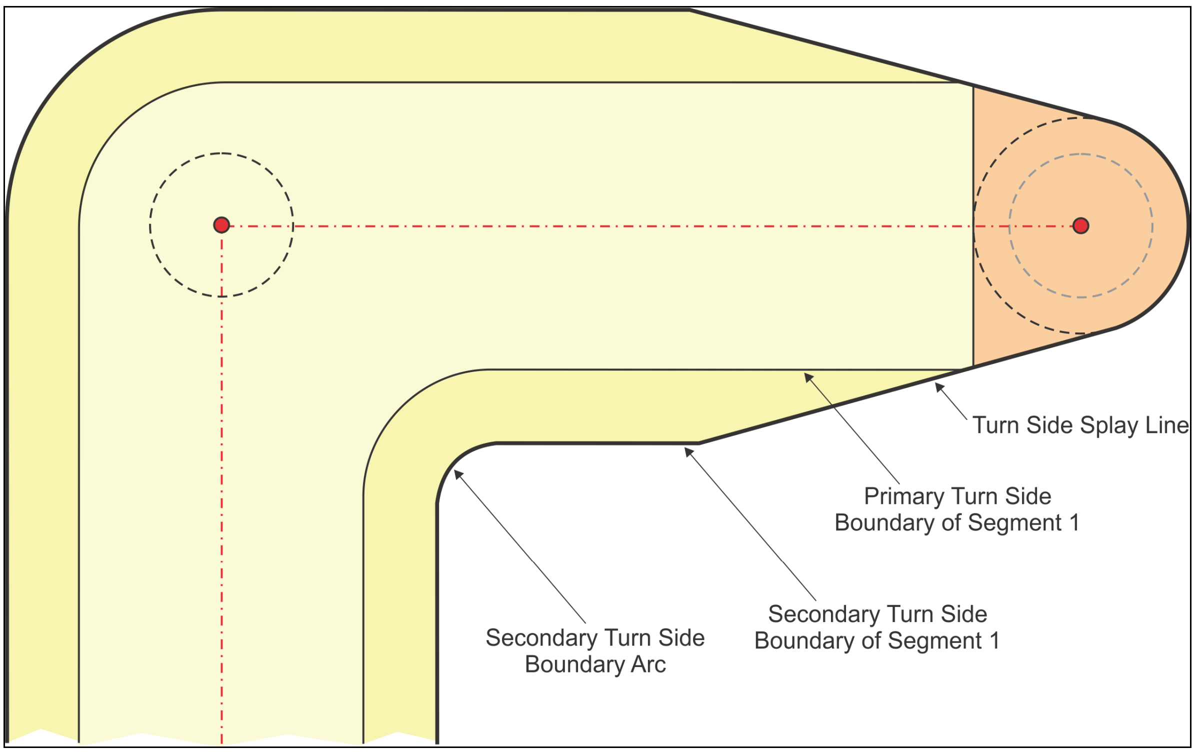
Step 12: Define and Construct the Turn Side Boundary.

Step 12a: If the Turn Side Splay Line intersects the Secondary Turn Side Boundary of Segment 1 before the start of the Secondary Turn Side Boundary Arc (see Figure 6-13) then,

Step 12a (1): Truncate the Primary Turn Side Boundary of Segment 1 at its intersection with the Turn Side Splay Line and,

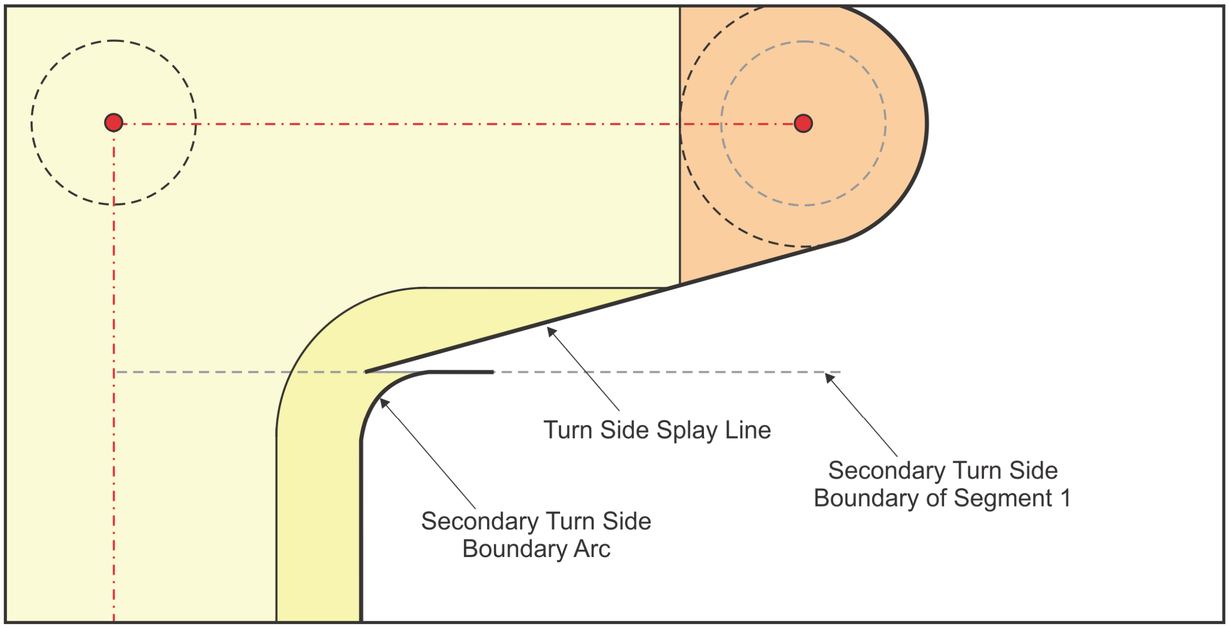
Step 12a (2): Truncate the Secondary Turn Side Boundary of Segment 1 at its intersection with the Turn Side Splay Line.

Figure 6-13. Construction of the Turn Side Boundary, Case 1



Step 12b: If the Turn Side Splay Line intersects the Secondary Turn Side Boundary of Segment 1 after the start of the Secondary Turn Side Boundary Arc (see Figure 6-14) then,

Figure 6-14. Construction of the Turn Side Boundary, Case 2 Determination



Step 12b (1): Construct the Turn Side Boundary Line as a line that lays tangent to the Secondary Turn Side Boundary Arc and passes through Point K.

Step 12b (1)(a): If the configuration of the procedure is such that this step cannot be performed, forego this step and proceed to Step 12c.

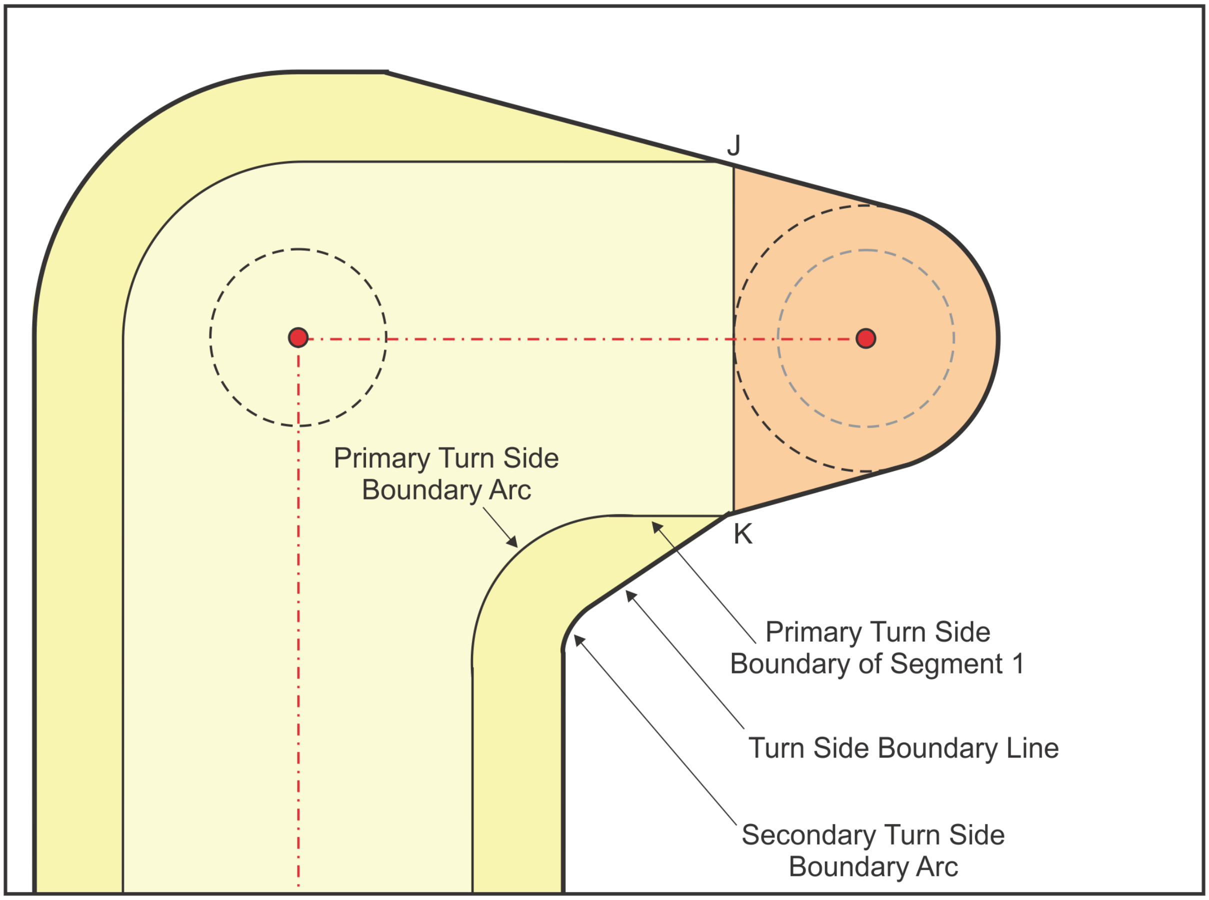
Step 12b (2): If the Turn Side Boundary Line intersects the Primary Turn Side Boundary of Segment 1 (see Figure 6-15) then,

Step 12b (2)(a): Truncate the Primary Turn Side Boundary of Segment 1 at its intersection with the Turn Side Boundary Line,

Step 12b (2)(b): Remove the Secondary Turn Side Boundary of Segment 1, and

Step 12b (2)(c): Truncate the Secondary Turn Side Boundary Arc at its point of tangency with the Turn Side Boundary Line.

Figure 6-15. Construction of the Turn Side Boundary, Case 2a



Step 12b (3): If the Turn Side Boundary Line intersects the Primary Turn Side Boundary Arc (see Figure 6-16) then,

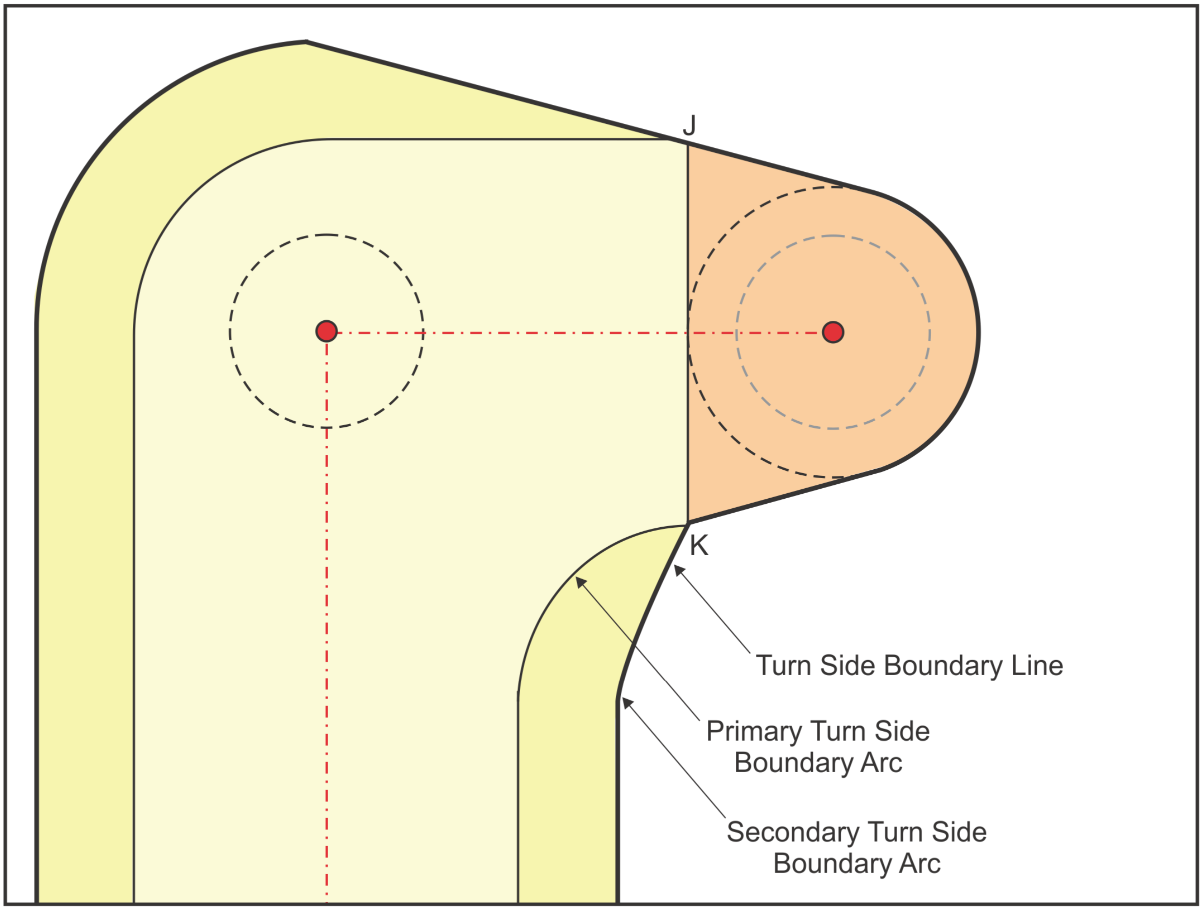
Step 12b (3)(a): Truncate the Primary Turn Side Boundary Arc at its intersection with the Turn Side Boundary Line,

Step 12b (3)(b): Truncate the Secondary Turn Side Boundary Arc at its point of tangency with the Turn Side Boundary Line,

Step 12b (3)(c): Remove the Primary Turn Side Boundary of Segment 1, and

Step 12b (3)(d): Remove the Secondary Turn Side Boundary of Segment 1.

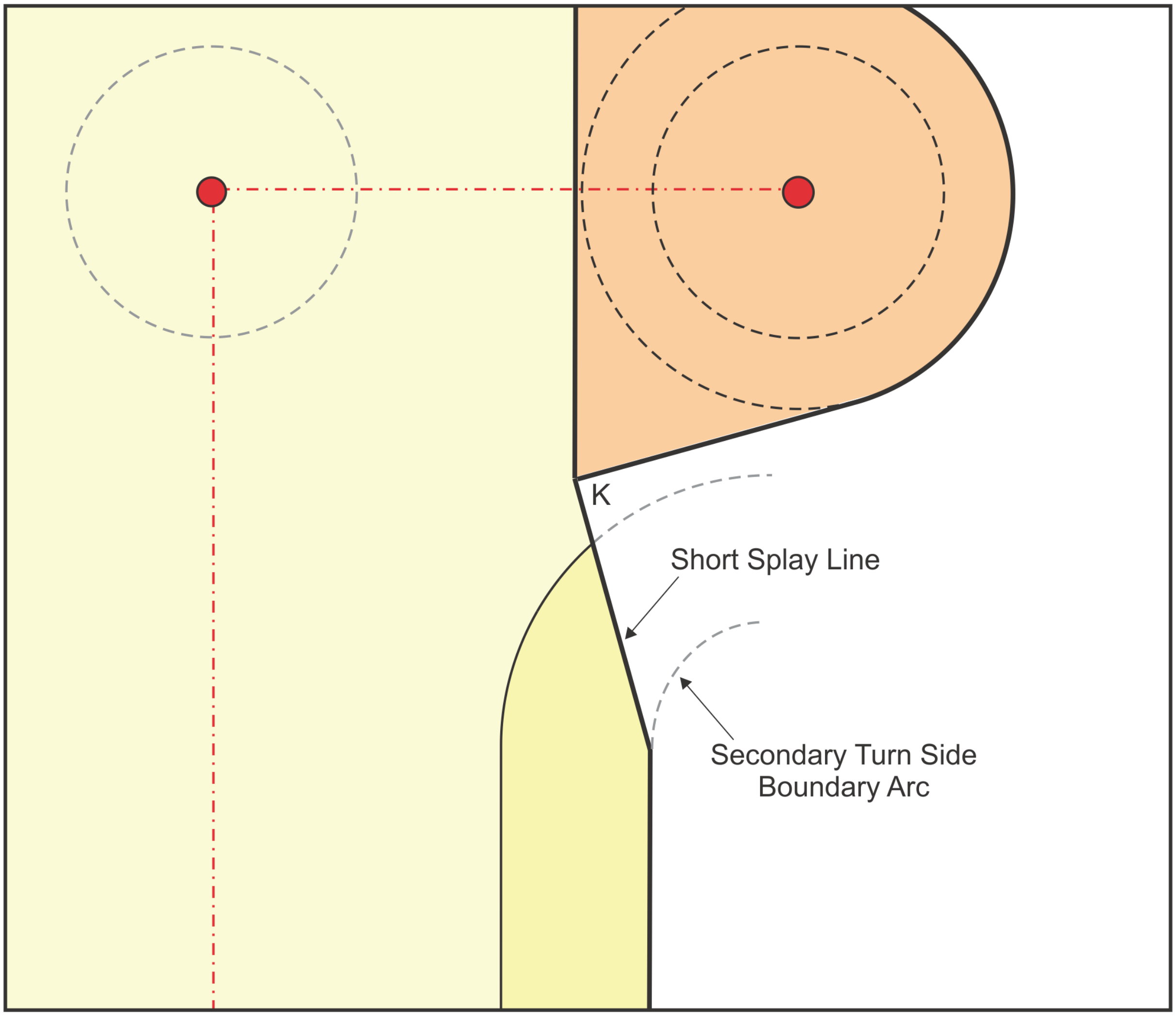
Figure 6-16. Construction of the Turn Side Boundary, Case 2b



Step 12c: If full width cannot be achieved in the initial segment [as described in Step 12a], and a tangent line cannot be drawn between Point K and the Secondary Turn Side Boundary Arc [as described in Step 12b(1)(a)],

Step 12c (1): Construct the Short Splay Line as a line that starts at Point K and ends at the end of the Secondary Turn Side Boundary Arc (see Figure 6-9).

Figure 6-17. Construction of the Turn Side Boundary, Case 3 Determination



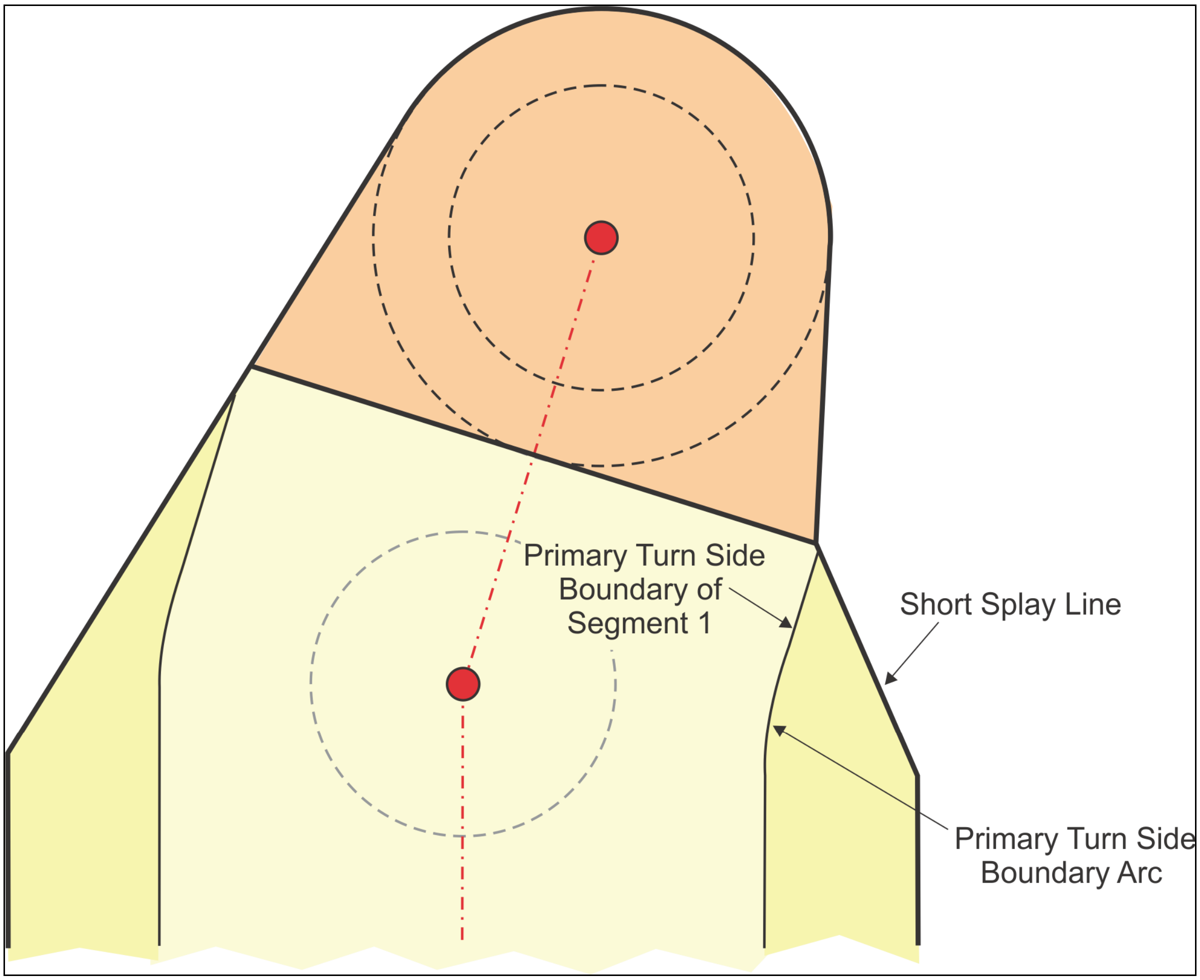
Step 12c (2): If the Short Splay Line intersects the Primary Turn Side Boundary of Segment 1 (see Figure 6-18) then,

Step 12c (2)(a): Remove the Secondary Turn Side Boundary of Segment 1,

Step 12c (2)(b): Remove the Secondary Turn Side Boundary Arc, and

Step 12c (2)(c): Truncate the Primary Turn Side Boundary of Segment 1 at its intersection with the Short Splay Line.

Figure 6-18. Construction of the Turn Side Boundary, Case 3a



Step 12c (3): If the Short Splay Line intersects the Primary Turn Side Boundary Arc (see Figure 6-19) then,

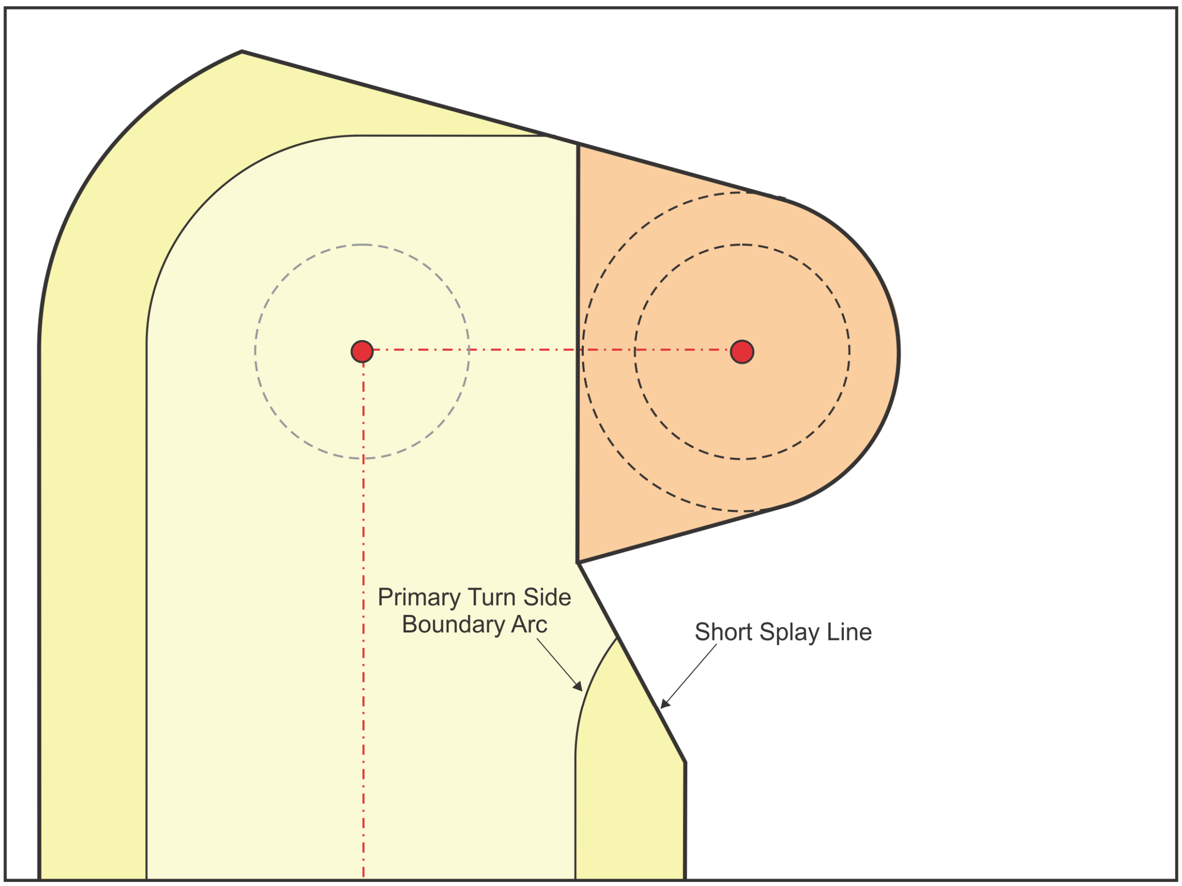
Step 12c (3)(a): Remove the Primary Turn Side Boundary of Segment 1,

Step 12c (3)(b): Remove the Secondary Turn Side Boundary of Segment 1,

Step 12c (3)(c): Remove the Secondary Turn Side Boundary Arc, and

Step 12c (3)(d): Truncate the Primary Turn Side Boundary Arc at its point of intersection with the Short Splay Line.

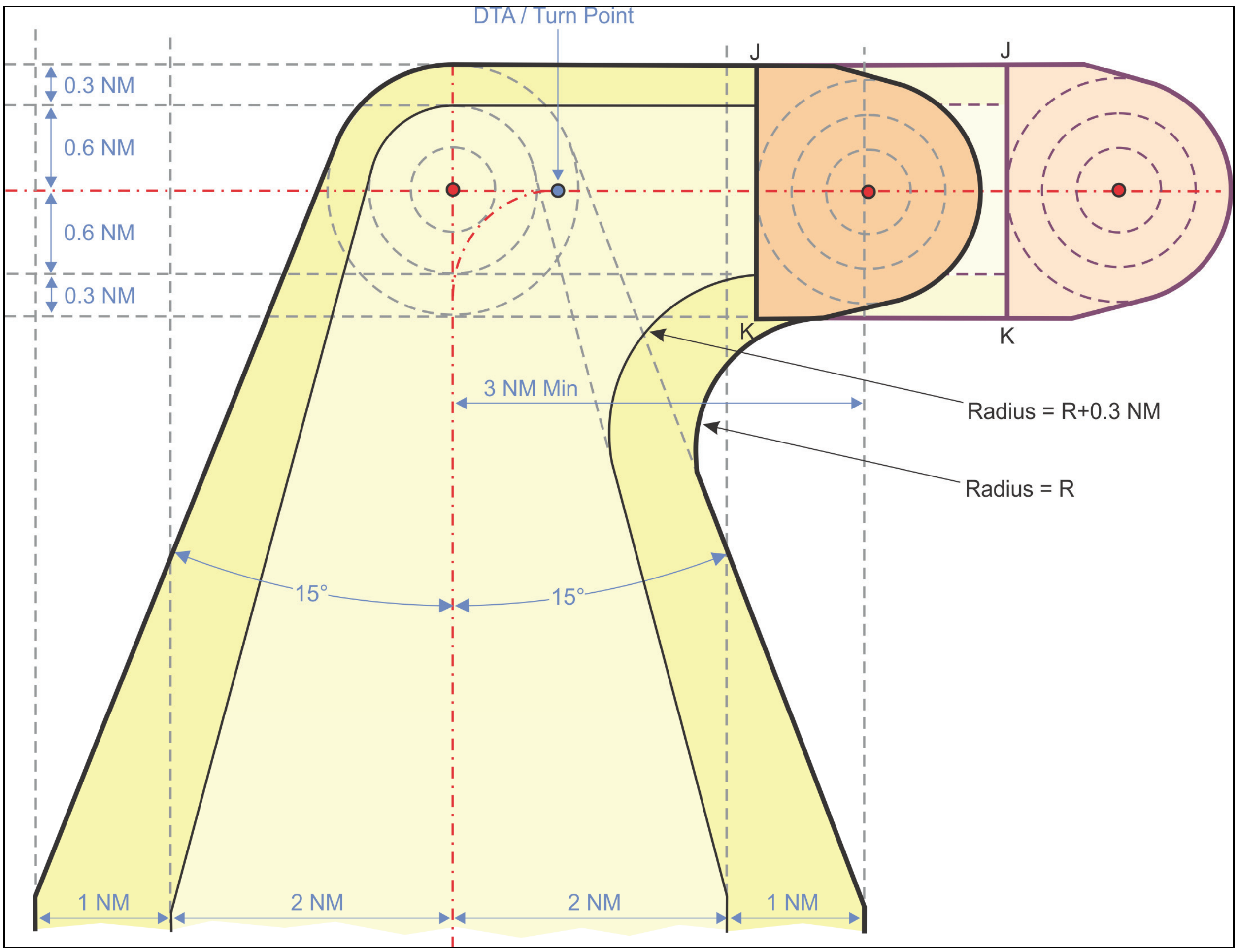
Figure 6-19. Construction of the Turn Side Boundary, Case 3b



6-7. Special PinS Departure Construction. When necessary to avoid obstacles, a Special DP may be constructed where the initial departure leg (only) is designed with an ATT value of 0.3 NM (RNP/RNAV 0.3).

For this construction, multiple OEA configurations can occur that are greatly affected by the course change angle and the length of the first departure segment. Some examples of these different scenarios are illustrated in Figure 6-20. Instructions on how to define these cases and create the resulting OEAs are located in this paragraph.

Figure 6-20. Special OEA Area Plan View (90 Degree Turn)



Step 1: Position the IDF as an FB fix. Use a fix-to-fix distance that is in accordance with chapter 2, paragraph 2b.

Step 2: Construct the IDF Circle as an arc with a 0.8 NM radius centered at the IDF fix.

Step 3: Construct the Designed Turning Flight Path.

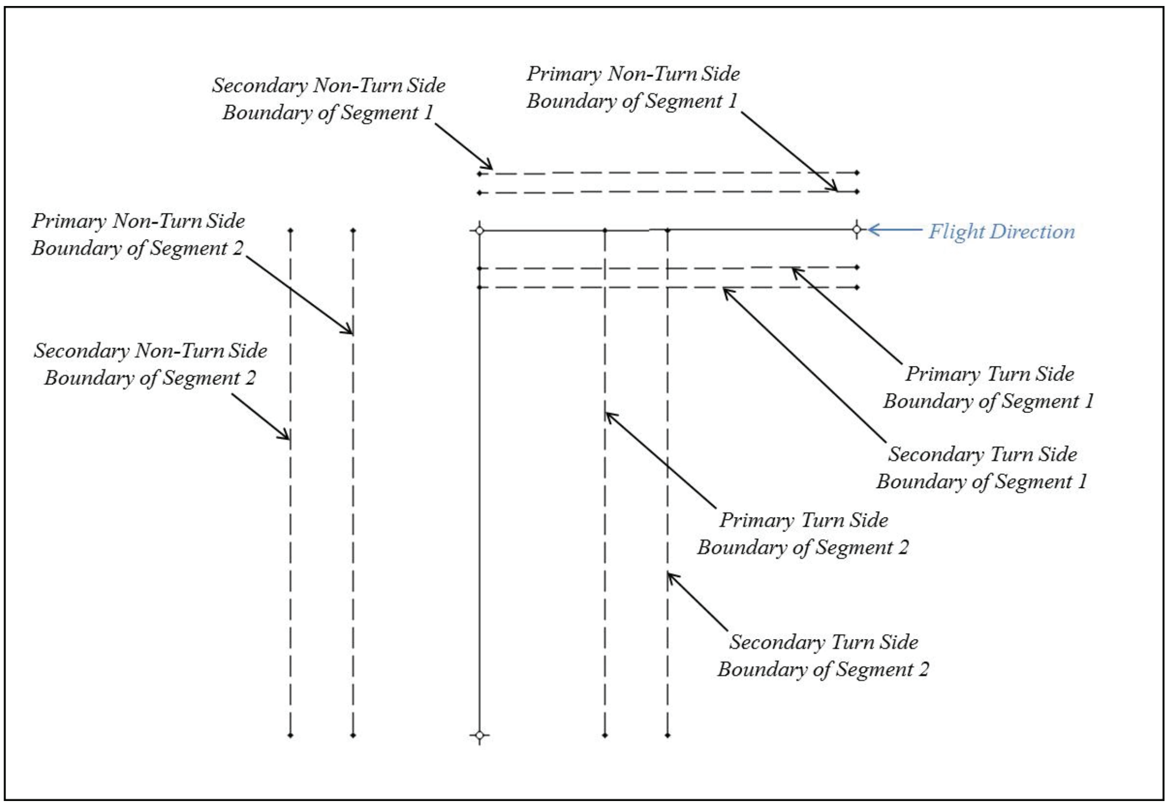
Step 3a: Determine the turn radius (R) utilizing Formula 6-1.

Step 3b: Construct an arc of radius R starting at the early turn point that lays tangent to Segments 1 and 2.

Step 4: Construct Segment 1 Boundaries. Construct Boundaries of half-widths 0.3-0.6-0.6-0.3 in reference to Segment 1. They will hereby be referred to as the Secondary Turn Side Boundary of Segment 1, the Primary Turn Side Boundary of Segment 1, the Primary Non-Turn Side Boundary of Segment 1, and the Secondary Non-Turn Side Boundary of Segment 1. These boundaries are depicted in Figure 6-21.

Step 5: Construct Segment 2 Boundaries. Construct Boundaries of half-widths 1-2-2-1 in reference to Segment 2. They will hereby be referred to as the Secondary Turn Side Boundary of Segment 2, the Primary Turn Side Boundary of Segment 2, the Primary Non-Turn Side Boundary of Segment 2, and the Secondary Non-Turn Side Boundary of Segment 2. These boundaries are depicted in Figure 6-21.

Figure 6-21. Construction of the Segment 1 and Segment 2 Boundaries



Step 6: Construct the Segment 1 Turn Side Splay Line (see Figure 6-22).

Step 6a: Locate the Segment 1 Splay End Reference Point a distance of 0.1/tan(15°) NM from the IDF along the Segment 1 Course Line.

Step 6b: Locate the Segment 1 Turn Side Splay Line End Point as the Segment 1 Splay End Reference Point projected onto the Secondary Turn Side Boundary of Segment 1.

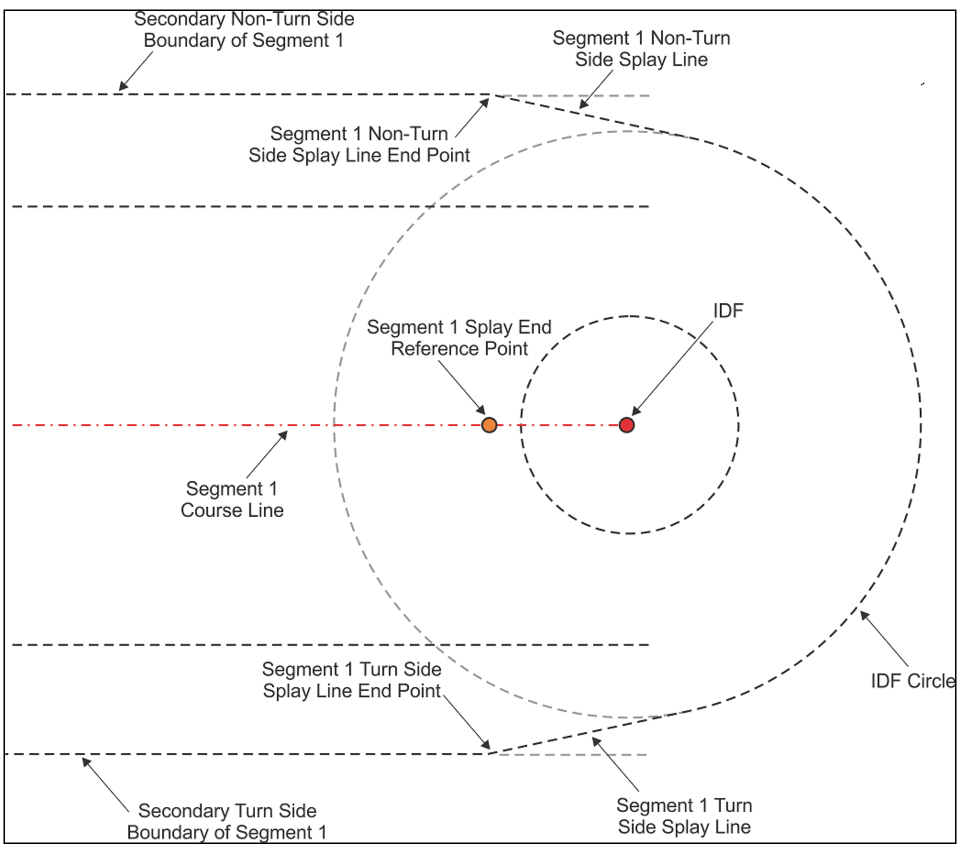
Step 6c: Construct the Segment 1 Turn Side Splay Line as a line that is tangent to the IDF Circle passing through the Segment 1 Turn Side Splay Line End Point.

Step 7: Construct the Segment 1 Non-Turn Side Splay Line (see Figure 6-22).

Step 7a: Locate the Segment 1 Non-Turn Side Splay Line End Point as the Segment 1 Splay End Reference Point projected onto the Secondary Non-Turn Side Boundary of Segment 1.

Step 7b: Construct the Segment 1 Non-Turn Side Splay Line as a line that is tangent to the IDF Circle passing through the Segment 1 Non-Turn Side Splay Line End Point.

Figure 6-22. Construction of the Splay Lines



Step 8: Construct the IDF Flat Surface Area (see Figure 6-23).

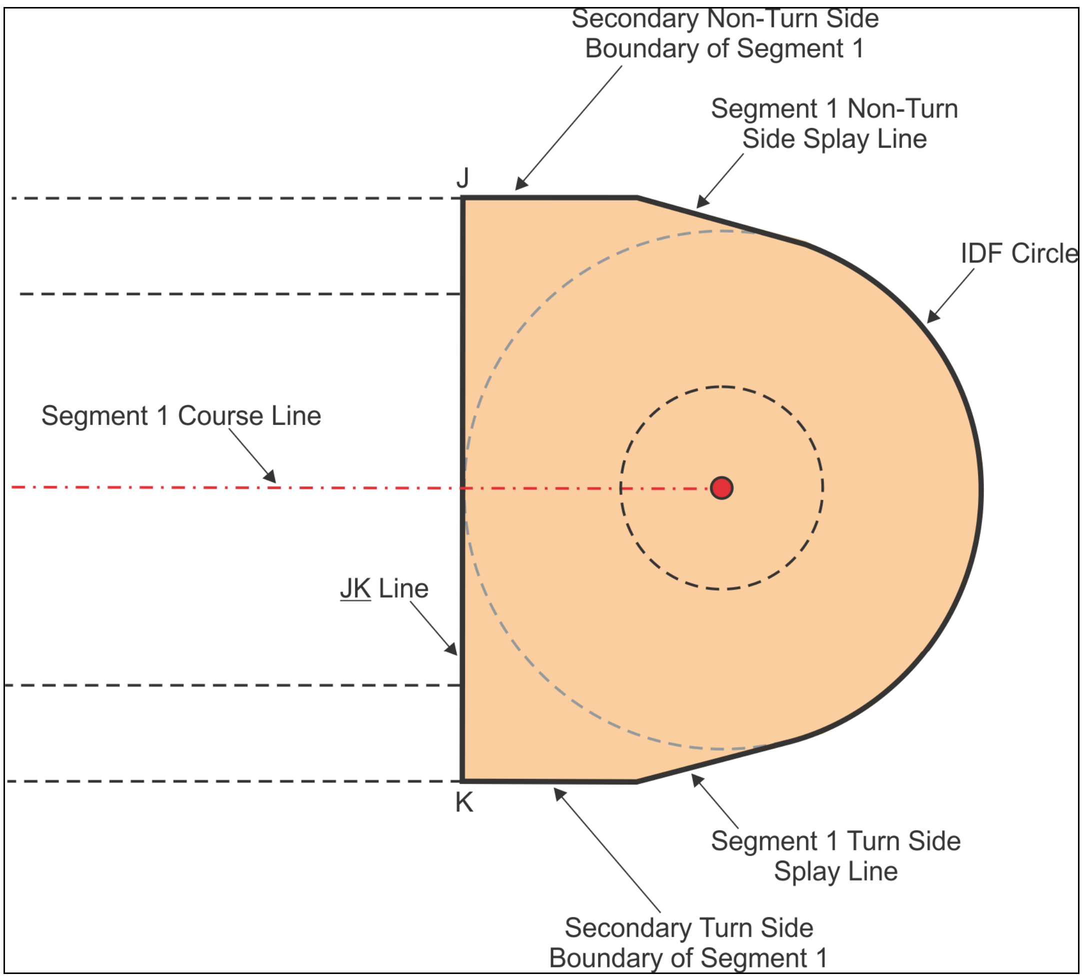
Step 8a: Construct the JK line as a line that lays tangent to the IDF Circle at a point intersecting the Segment 1 Course Line.

Step 8b: Truncate the JK line where it intersects the Secondary Non-Turn Side Boundary of Segment 1 and the Secondary Turn Side Boundary of Segment 1.

Step 8c: The IDF Flat Surface Area is the area bounded by the IDF Circle, the Segment 1 Turn Side and Non-Turn Side Splay Lines, the Secondary Turn Side and Non-Turn Side Boundaries of Segment 1, and the JK line.

Step 8d: The Turn Side end of the JK line will hereby be referred to as Point K and the Non-Turn Side end of the JK line will hereby be referred to as Point J.

Figure 6-23. Construction of the IDF Flat Surface Area

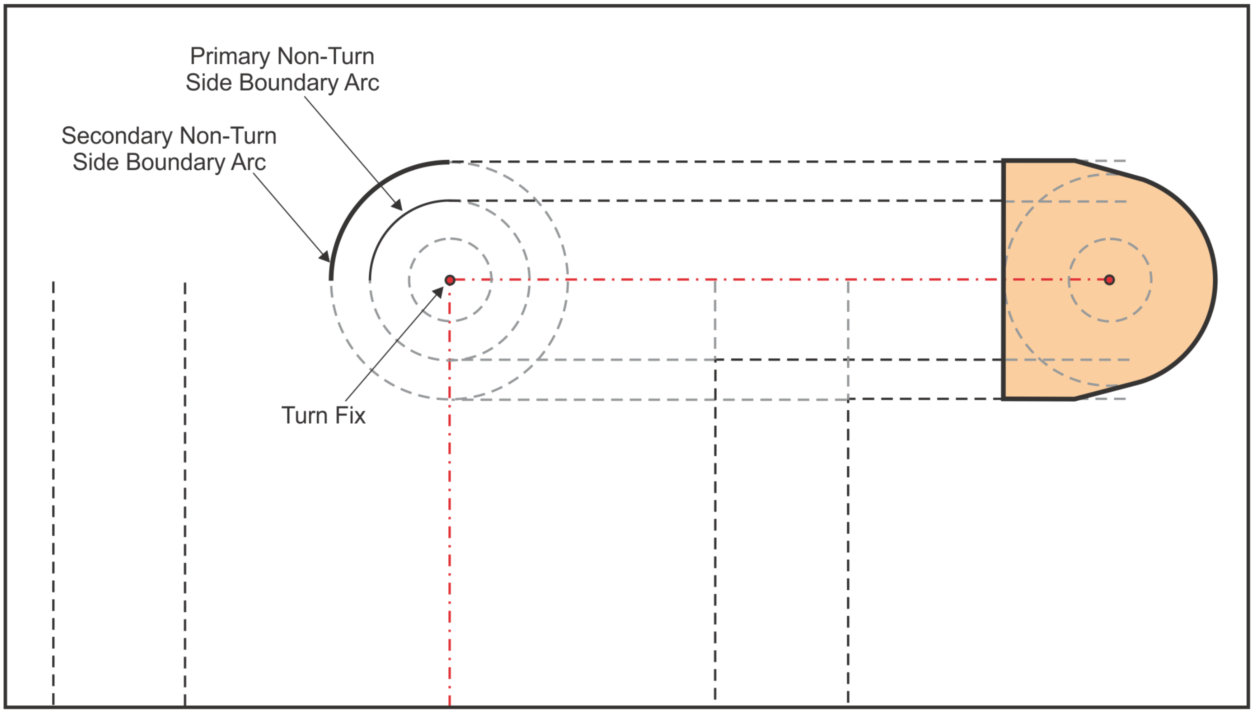


Step 9: Construct Non-Turn Side Boundary Arcs (see Figure 6-24).

Step 9a: Construct the Primary Non-Turn Side Boundary Arc centered on the turn fix with a radius equal to the Segment 1 primary half-width.

Step 9b: Construct the Secondary Non-Turn Side Boundary Arc centered on the turn fix with a radius equal to the Segment 1 primary half-width plus the segment secondary width.

Figure 6-24, Construction of the Non-Turn Side Boundary Arcs



Step 10: Construct Segment 2 Splay Lines.

Step 10a: Construct Segment 2 Secondary Non-Turn Side Splay Line (see Figure 6-25).

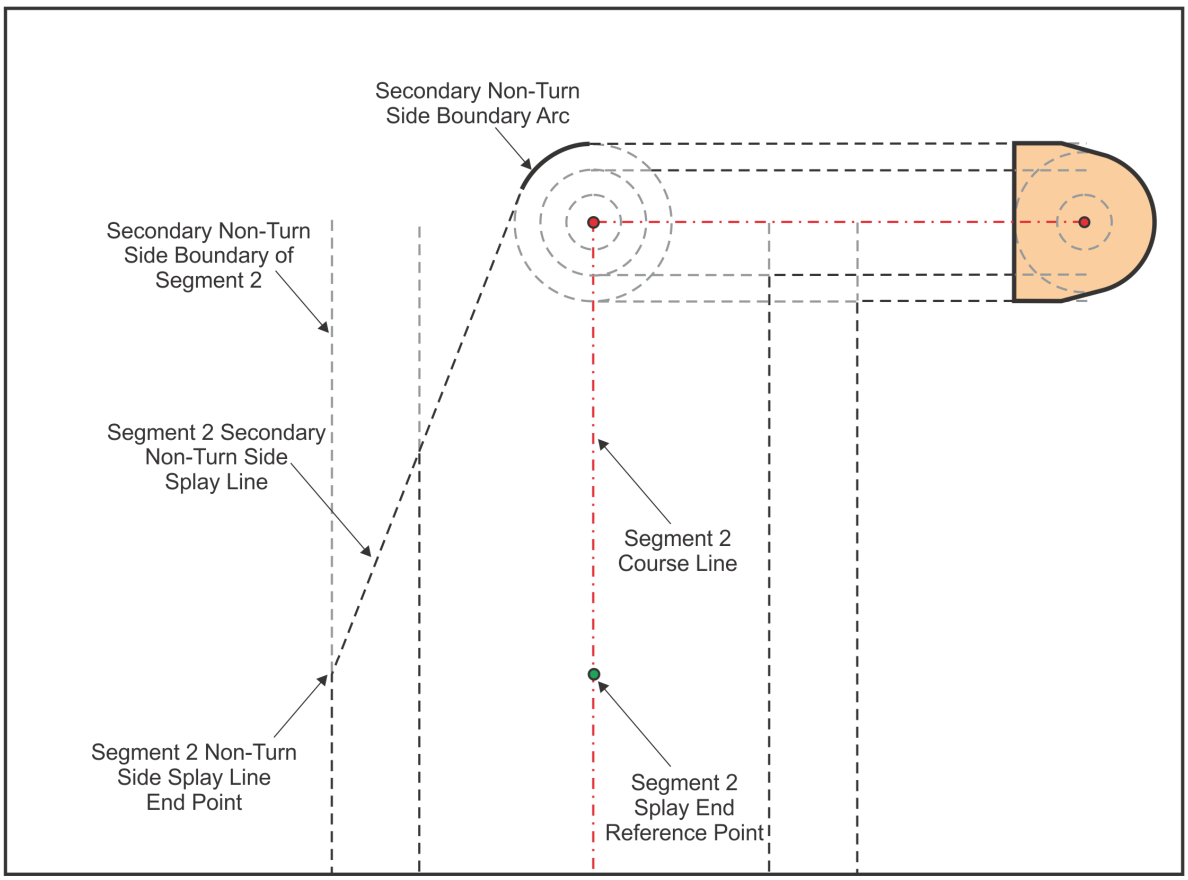
Step 10a (1): Locate the Segment 2 Splay End Reference Point a distance of 2.1/tan(15°) NM from the turn fix along the Segment 2 Course Line.

Step 10a (2): Locate the Segment 2 Non-Turn Side Splay Line End Point as the Segment 2 Splay End Reference Point projected onto the Secondary Non-Turn Side Boundary of Segment 2.

Step 10a (3): Construct the Segment 2 Secondary Non-Turn Side Splay Line as a line that is tangent to the Secondary Non-Turn Side Boundary Arc passing through the Segment 2 Non-Turn Side Splay Line End Point.

Step 10a (4): If Segment 2 is not long enough to allow for a full expansion with a 15-degree splay, utilize a splay angle ≥ 15 degrees as necessary to reach full expansion at the termination of Segment 2.

Figure 6-25. Construction of the Segment 2 Secondary Non-Turn Side Splay Line



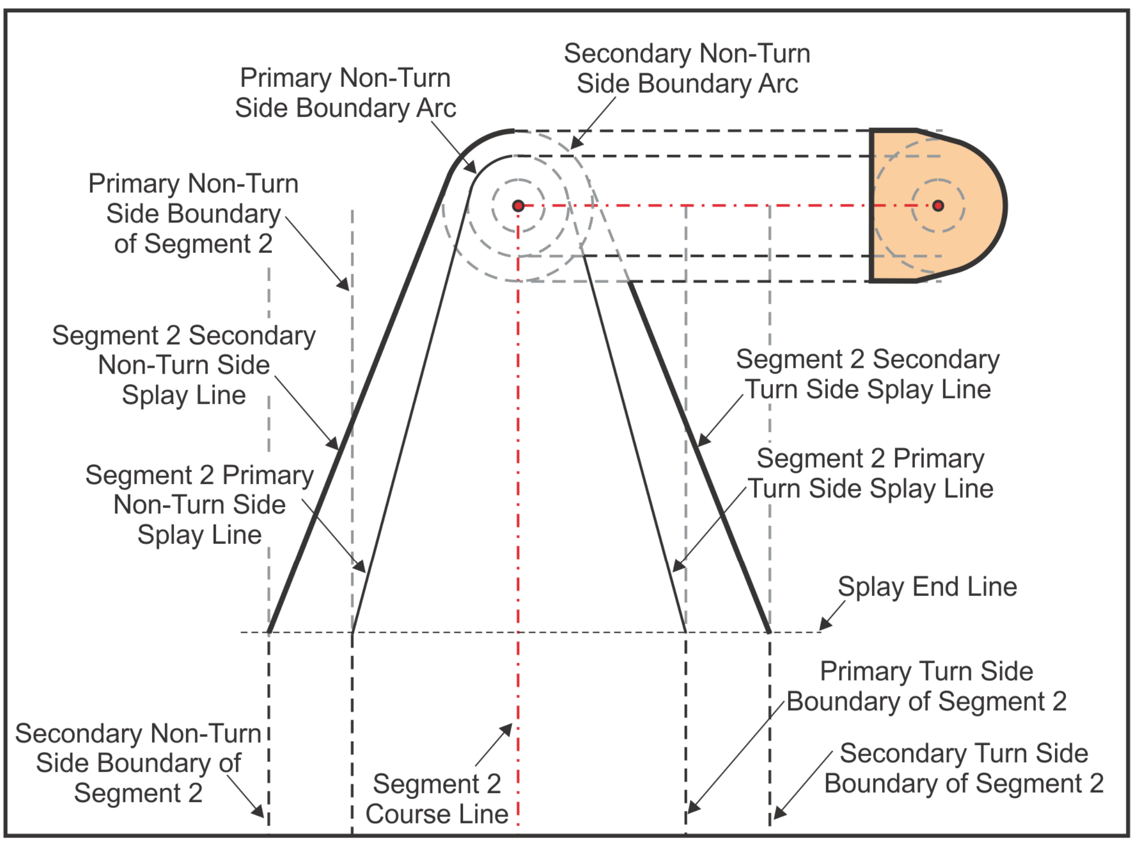
Step 10b: Construct the Splay End Line as an infinite line that is perpendicular to the Segment 2 Course Line and intersects at the end point of the Segment 2 Secondary Non-Turn Side Splay Line. The Splay End Line will be used to determine the end points of the remaining Segment 2 splay lines (see Figure 6-26).

Step 10c: Construct the Segment 2 Primary Non-Turn Side Splay Line as a line tangent to the Primary Non-Turn Side Boundary Arc and runs through the intersection of the Splay End Line and the Primary Non-Turn Side Boundary of Segment 2 (see Figure 6-26).

Step 10d: Construct the Segment 2 Primary Turn Side Splay Line as a line tangent to the Primary Non-Turn Side Boundary Arc and runs through the intersection of the Splay End Line and the Primary Turn Side Boundary of Segment 2 (see Figure 6-26).

Step 10e: Construct the Segment 2 Secondary Turn Side Splay Line as a line tangent to the Secondary Non-Turn Side Boundary Arc and runs through the intersection of the Splay End Line and the Secondary Turn Side Boundary of Segment 2 (see Figure 6-26).

Figure 6-26. Construction of the Segment 2 Splay Lines



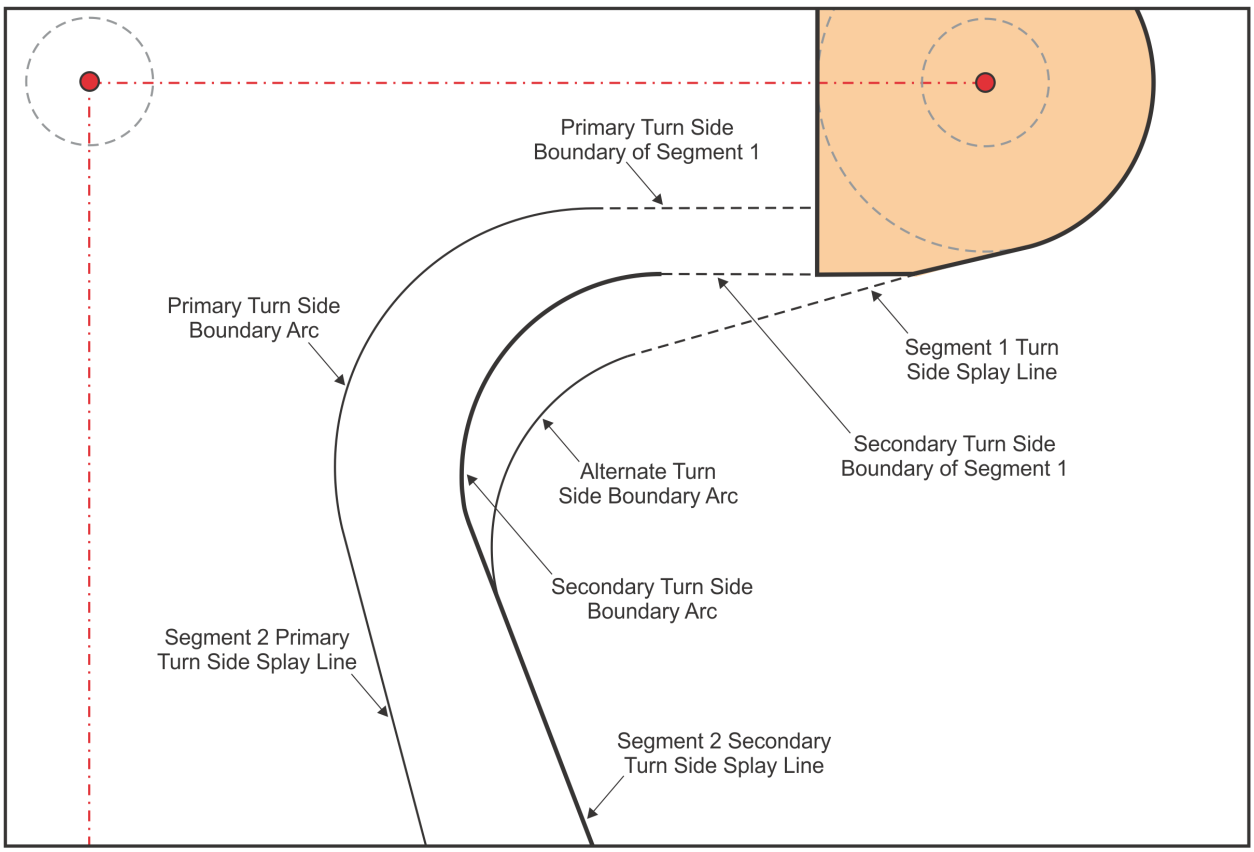
Step 11: Construct Turn Side Boundary Arcs (see Figure 6-27).

Step 11a: Construct the Primary Turn Side Boundary Arc as an arc that is tangent to both the Segment 2 Primary Turn Side Splay Line and the Primary Turn Side Boundary of Segment 1 with a radius equal to R + 0.3 NM.

Step 11b: Construct the Secondary Turn Side Boundary Arc an arc that is tangent to both the Segment 2 Secondary Turn Side Splay Line and the Secondary Turn Side Boundary of Segment 1 with a radius equal to R.

Step 11c: Construct the Alternate Turn Side Boundary Arc as an arc that is tangent to both the Segment 2 Secondary Turn Side Splay Line and the Segment 1 Turn Side Splay Line with a radius equal to R.

Figure 6-27. Construction of the Turn Side Boundary Arcs

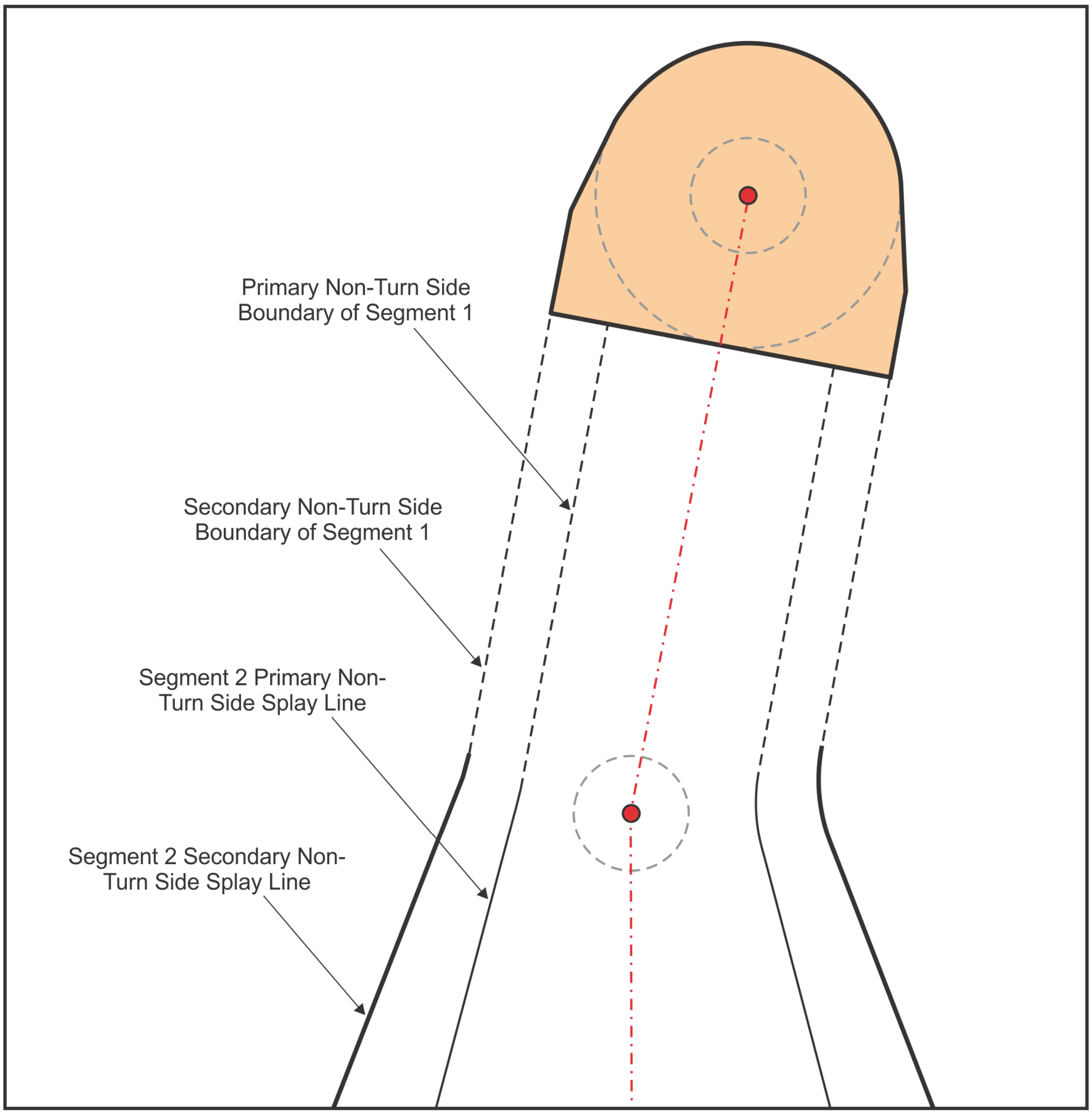


Step 12: Define and Construct the Secondary Non-Turn Side Boundary.

Step 12a: If the Secondary Non-Turn Side Boundary of Segment 1 intersects the Segment 2 Secondary Non-Turn Side Splay Line, as depicted in Figure 6-28, then remove the Secondary Non-Turn Side Boundary Arc and truncate the Secondary Non-Turn Side Boundary of Segment 1 and the Segment 2 Secondary Non-Turn Side Splay Line at their intersection.

Step 12b: Otherwise, truncate the Secondary Non-Turn Side Boundary of Segment 1 and the Segment 2 Secondary Non-Turn Side Splay Line at their point of tangency with the Secondary Non-Turn Side Boundary Arc (see Figure 6-29).

Figure 6-28. Construction of the Non-Turn Side Boundary, Case 1

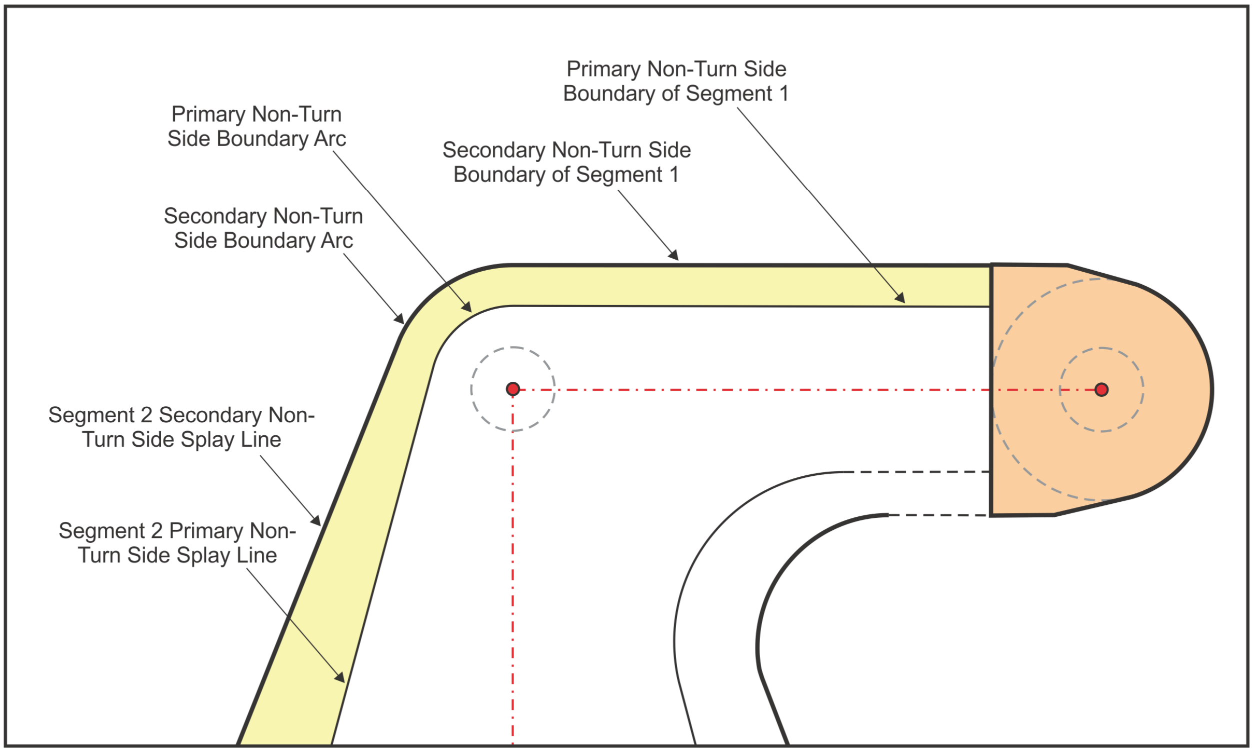


Step 13: Define and Construct the Primary Non-Turn Side Boundary.

Step 13a: If the Primary Non-Turn Side Boundary of Segment 1 intersects the Segment 2 Primary Non-Turn Side Splay Line, as depicted in Figure 6-28, then remove the Primary Non-Turn Side Boundary Arc and truncate the Primary Non-Turn Side Boundary of Segment 1 and the Segment 2 Primary Non-Turn Side Splay Line at their intersection.

Step 13b: Otherwise, truncate the Primary Non-Turn Side Boundary of Segment 1 and the Segment 2 Primary Non-Turn Side Splay Line at their point of tangency with the Primary Non-Turn Side Boundary Arc (see Figure 6-29).

Figure 6-29. Construction of the Non-Turn Side Boundary, Case 2



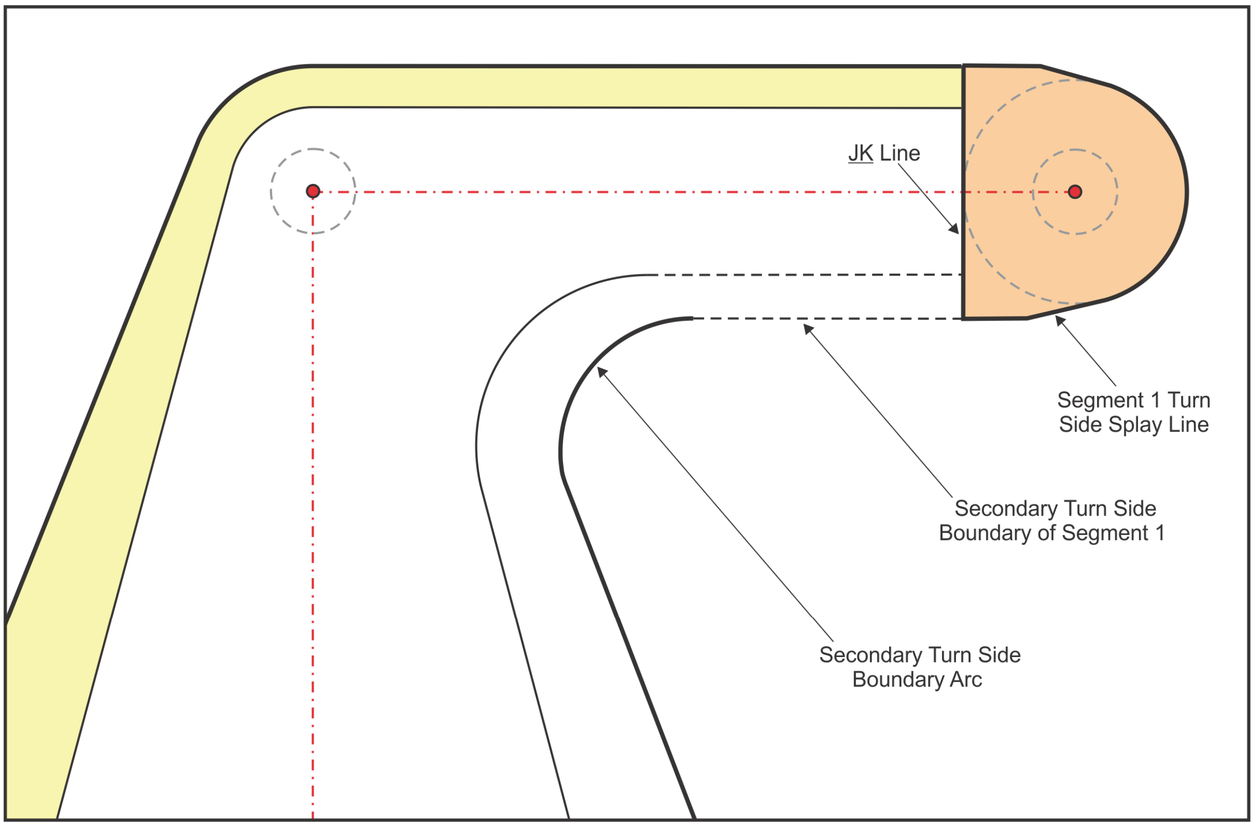
Step 14: Define and Construct the Secondary Turn Side Boundary

Step 14a: If the intersection of the Secondary Turn Side Boundary of Segment 1 and the Segment 1 Turn Side Splay Line occurs before the start of the Secondary Turn Side Boundary Arc (see Figure 6-30) then,

Step 14a (1): Remove the Alternate Turn Side Boundary Arc, and

Step 14a (2): Truncate the Secondary Turn Side Boundary of Segment 1 where it intersects the JK line.

Figure 6-30. Construction of the Secondary Turn Side Boundary, Case 1



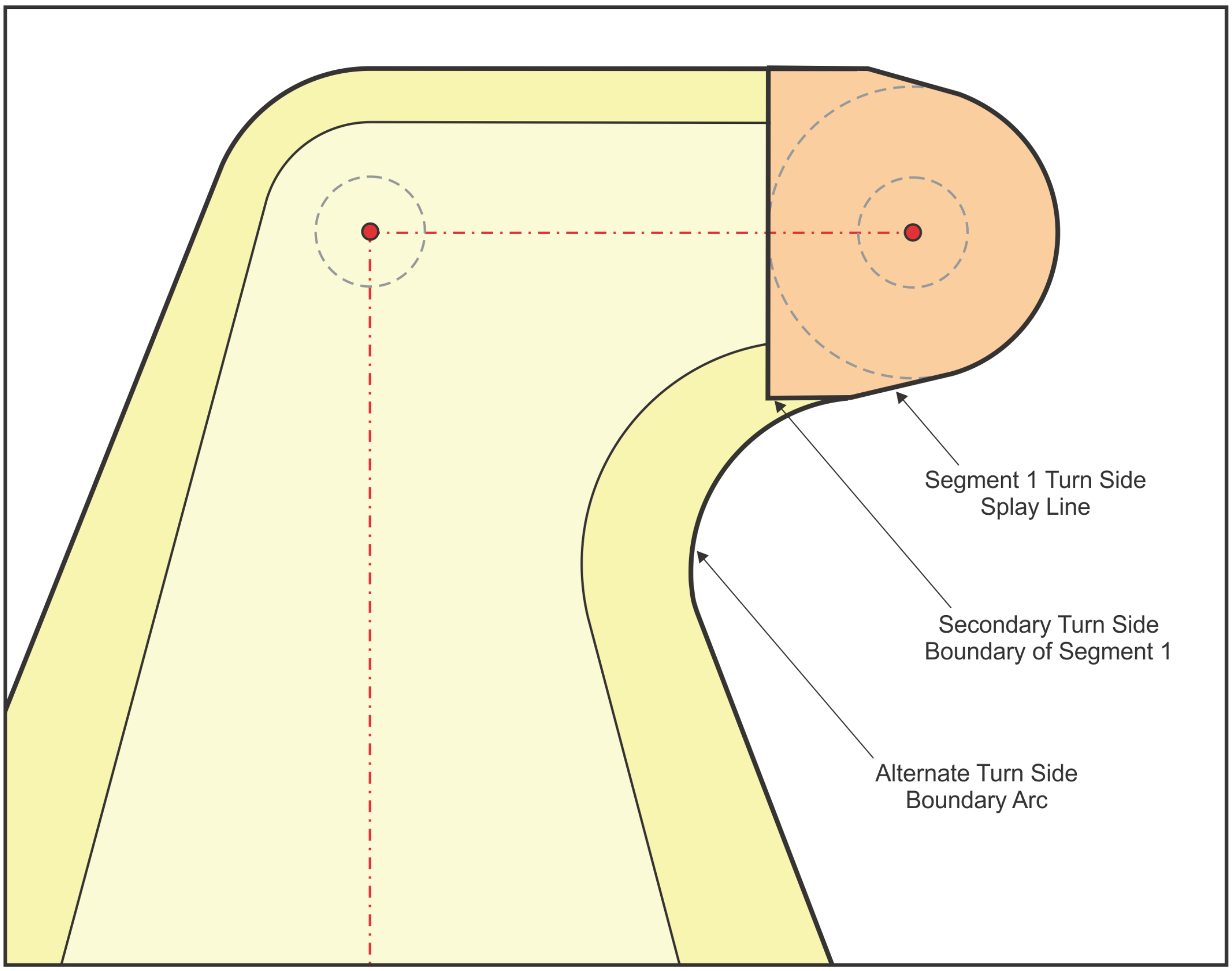
Step 14b: If the intersection of the Secondary Turn Side Boundary of Segment 1 and the Segment 1 Turn Side Splay Line occurs after the start of the Secondary Turn Side Boundary Arc (see Figure 6-31) then,

Step 14b (1): Remove the Secondary Turn Side Boundary Arc,

Step 14b (2): Remove the Secondary Turn Side Boundary of Segment 1, and

Step 14b (3): Extend the Segment 1 Turn Side Splay Line to the Alternate Turn Side Boundary Arc.

Figure 6-31. Construction of the Secondary Turn Side Boundary, Case 2

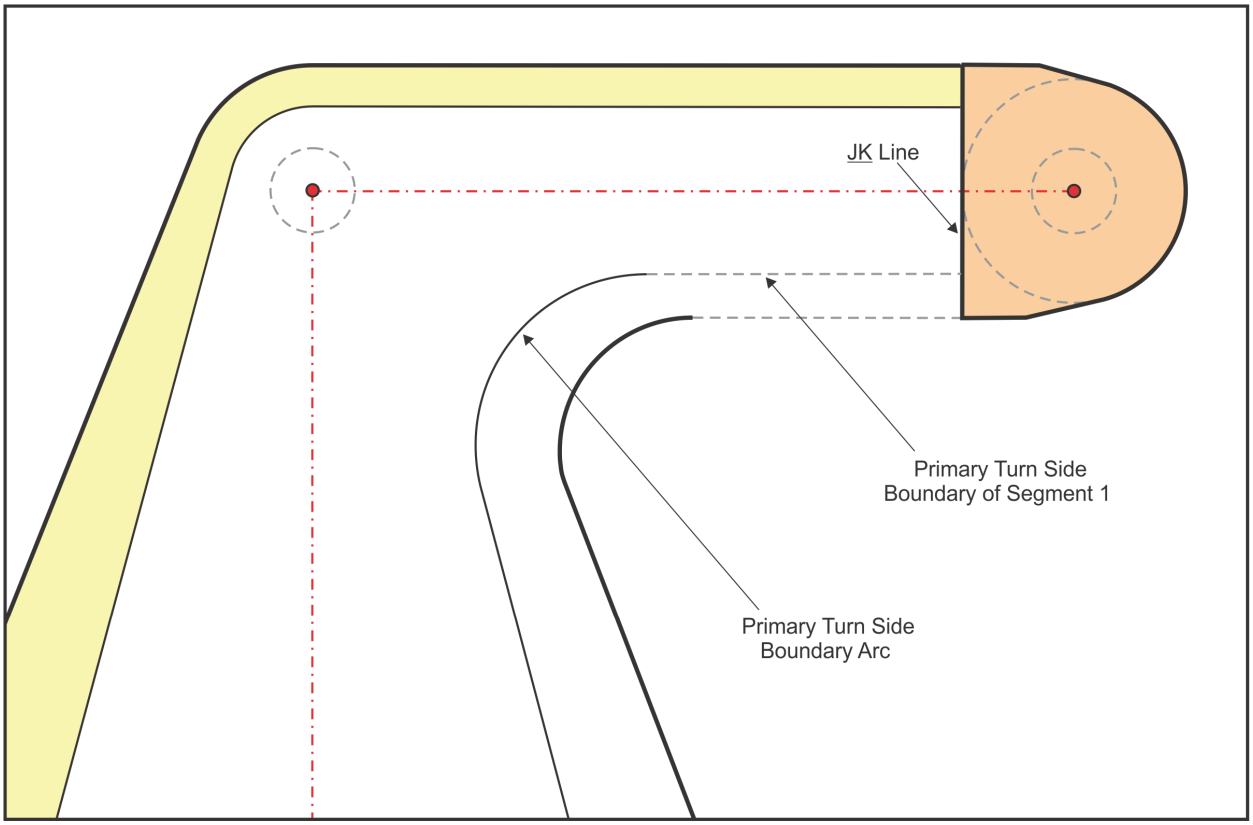


Step 15: Define and Construct the Primary Turn Side Boundary

Step 15a: If the JK line intersects the Primary Turn Side Boundary of Segment 1 (see Figure 6-32) then,

Step 15a (1): Truncate the Primary Turn Side Boundary of Segment 1 where it intersects the JK line.

Figure 6-32. Construction of the Primary Turn Side Boundary, Case 1

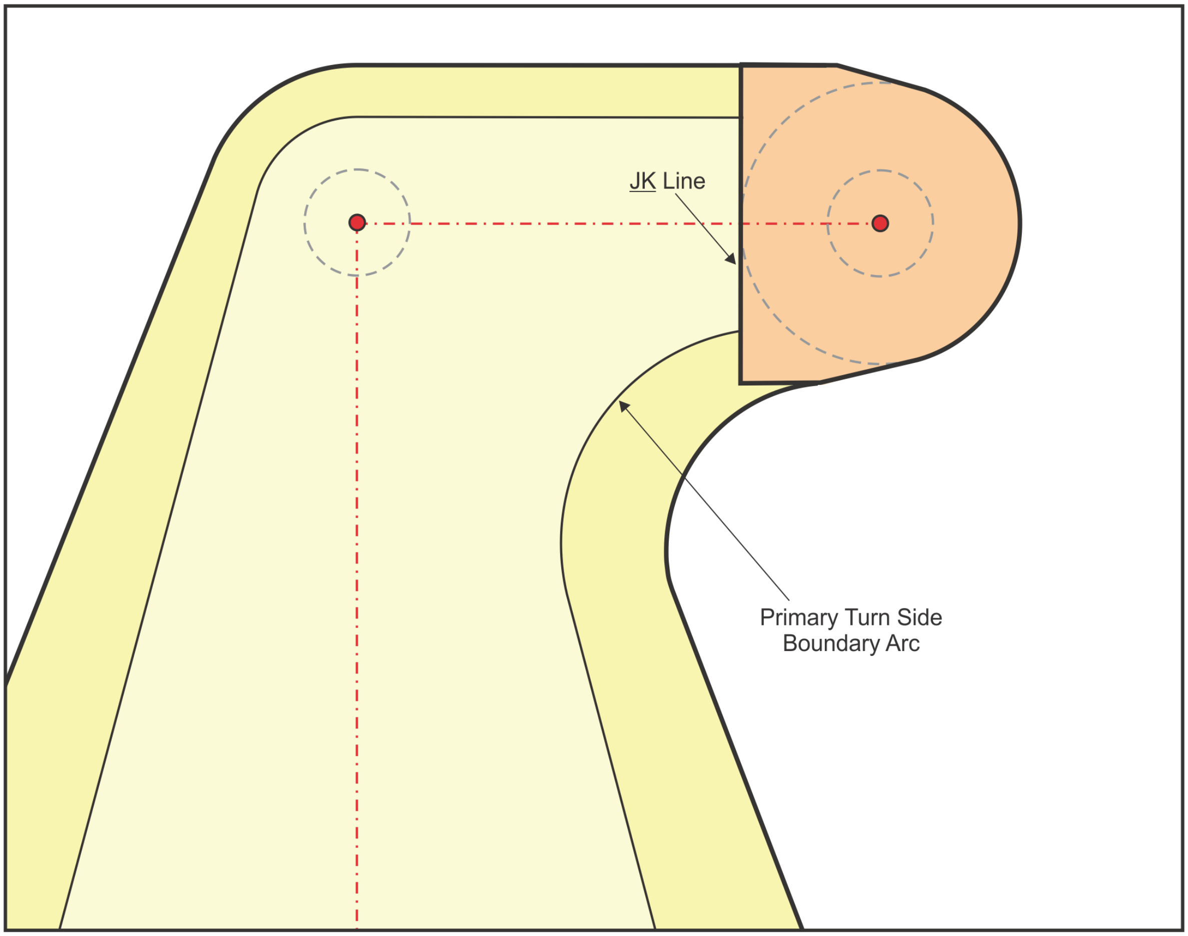


Step 15b: If the JK line intersects the Primary Turn Side Boundary Arc (see Figure 6-33) then,

Step 15b (1): Remove the Primary Turn Side Boundary of Segment 1, and

Step 15b (2): Truncate the Primary Turn Side Boundary Arc where it intersects the JK line.

Figure 6-33. Construction of the Primary Turn Side Boundary, Case 2



6-8. Obstacle Evaluation (OE). Starting at the JK line, apply a 20:1 OCS in the primary OEA, and a 6:1 OCS in the secondary OEA rising perpendicular from the edge of the primary area. Where an obstacle penetrates the primary OCS, or the *secondary OCS throughout the DP, calculate a minimum CG to clear the penetration(s) for all departure segments (legs) or raise the IDF crossing altitude. The highest required CG of all the departure legs is maintained until penetration(s) are cleared, and then the CG may be relaxed. See Figure 6-34 for a Climb Area Profile View and Figure 6-35/Figure 6-36 for a Climb Area Plan View. See paragraph 6-8 for assessing ROC, minimum altitude and CG.

* The elevation of obstacles in the secondary is reduced.

Figure 6-34. Climb Area Profile View

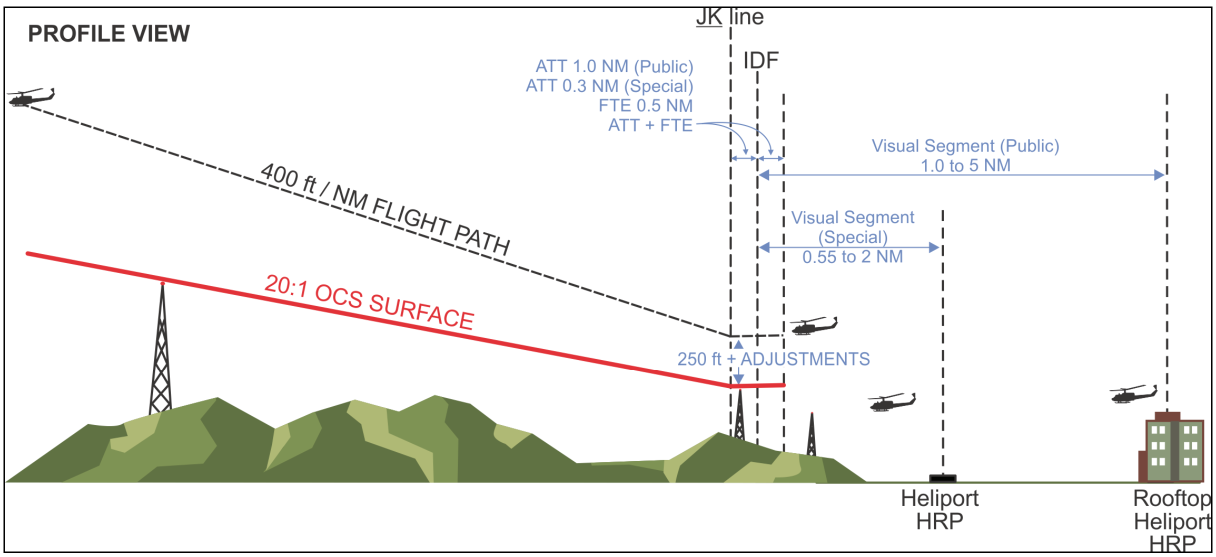


Figure 6-35. Departure Climb Area Plan View (Public)

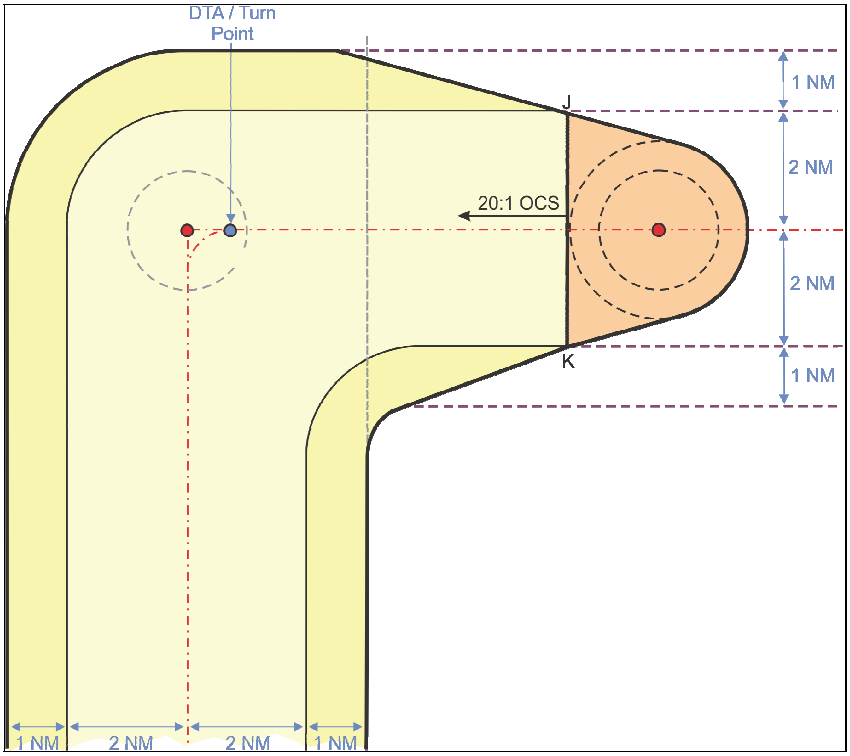
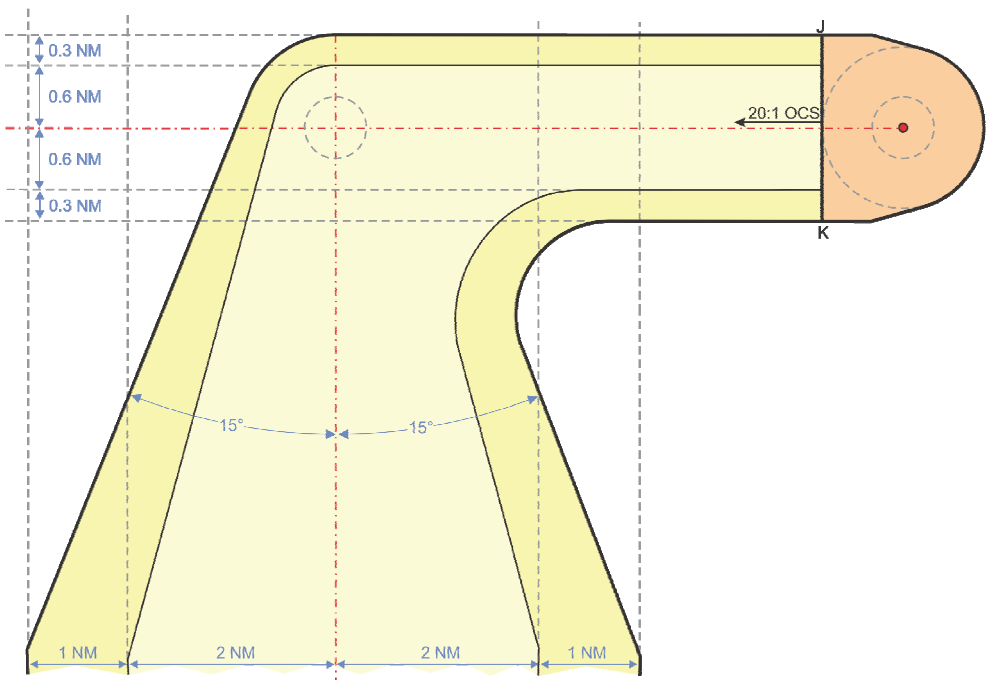


Figure 6-36. Departure Climb Area Plan View (Special)



6-9. Required Obstacle Clearance (ROC).

a. Section 1 Obstacle Clearance.

(1) The PinS DP minimum ROC at the IDF is 250 ft, plus any adjustments for RASS (when altimeter source greater than 5 NM from the IDF), precipitous terrain, and obstacle accuracy code.

Note 1: Precipitous terrain apply Section 1 only.

Note 2: IDF altitude must not be lower than the heliport elevation.

(2) ROC is applied within the IDF flat surface area (Section 1), and then rounded to the next higher 100-ft increment. For example, 500 ft remains 500 ft and 501 ft becomes 600 ft. The rounded altitude is the IDF crossing altitude.

(3) Accuracy Code. Obstacle accuracy code is 2C (50 ft horizontal/20 ft vertical) in the IDF flat surface area.

b. Section 2 Obstacle Clearance.

(1) Sloping OCS. ROC increases at 96 ft/NM for all climb gradients.

(2) Primary OEA. Apply a 20:1 OCS originating at the JK line in the direction of departure. The OCS origin elevation is equal to the IDF crossing altitude subtracting ROC and any adjustments.

(3) Secondary OEA. Apply a 6:1 OCS from the edge of the primary OEA. The OCS origin elevation is equal to the height of the primary OEA boundary directly abeam the obstacle and perpendicular to the segment track. For obstacles located within a turn OEA (see Figure 6-37).

(4) Obstacle evaluation. If the OCS is clear, then the standard CG (400 ft/NM) applies. If the OCS is not clear, then take the following actions:

(a) Publish a CG to clear the penetration(s). CGs in excess of 600 ft/NM requires Flight Standards approval.

(b) Alternatively, raise the IDF altitude to clear the penetration(s) to accommodate helicopters that cannot meet the non-standard climb gradient.

Note: This option will increase the ceiling value at the IDF.

(c) Lastly, design another DP over a different route to achieve a lower CG.

(5) Level Surface. The departure OCS continues to increase until reaching 1,000 ft of ROC for non-mountainous regions (2,000 ft for mountainous regions) to the highest obstacle

located within the primary OEA (or secondary equivalent), and round the result to the next higher 100-ft increment. For example, 5,700 ft remains 5,700 ft and 5,701 ft becomes 5,800 ft.

(6) Accuracy Code. The obstacle accuracy code for the 20:1 OCS area is 4D (250 ft horizontal/50 ft vertical).

(7) Calculate the ROC over an obstacle, the altitude at which the ROC is achieved, and the resulting required CG using Formula 6-2.

Formula 6-2. ROC/Min Alt/CG

(1) $input\ d,\ d_{secondary},\ OBS_{elev},\ adj,\ aircraft_{SOC}$

(2) $ROC_{OBS} = (250+adj)+\frac{96 \cdot d}{fpnm}$

(3) $OBS_{elev} = if\left[\left(OBS_{elev} - aircraft_{SOC} - \frac{d_{secondary}}{6}\right) \le 0, 0, OBS_{elev} - \frac{d_{secondary}}{6}\right]$

(4) $alt_{min} = OBS_{elev} + ROC_{OBS}$

(5) $CG_{minimum} = \text{ceiling}\left[\frac{r}{d} \cdot \ln\left(\frac{r + alt_{min}}{r + aircraft_{SOC}}\right) \cdot fpnm\right]$

(6) $CG_{required} = \max[400,\ CG_{minimum}]$

(250+adj)+96*d/fpnm if OBS in secondary, OBS_{elev}= OBS_{elev}- $d_{secondary}$/6 OBS_{elev}+ROC_{OBS} ceiling(r/d*ln((r+alt_{min})/(r+$aircraft_{SOC}$))*fpnm) max(400,$CG_{minimum}$)

Calculator		
d		Click here to calculate
$d_{secondary}$		
OBS_{elev}		
adj		
$aircraft_{SOC}$		
ROC_{OBS}		
alt_{min}		
$CG_{minimum}$		
$CG_{required}$		

6-10. Obstacle Distance Measurement. Obstacle distance (d) is measured using the shortest distance from each primary area obstacle to the JK line as illustrated in Figure 6-37 and Figure 6-38. Secondary area obstacles that occur during turn expansions have an obstacle distance that begins at the JK line and ends at the point on the edge of the primary boundary closest to the obstacle. Secondary area obstacles that do not occur during turn expansion have an obstacle distance that begins at the JK line and ends at the point of intersection of a line perpendicular to the flight path passing through the obstacle and boundary of the primary area. Secondary area obstacle evaluations are further reduced based on their distances to the primary edge boundary as shown in Formula 6-2. Detailed steps for obstacle distance measurements and calculations are found below:

a. Obstacle in the Primary evaluation. Determine obstacle evaluation distance (d), as the shortest distance within the primary area from the obstacle to the JK line.

b. Obstacle in the Secondary evaluation.

(1) Determine the intersecting element of a line drawn from the obstacle to the closest point on the flight path.

(a) If the intersecting element is an arc, determine the Obstacle Primary Point as the closest point on the primary boundary to the obstacle.

(b) If the intersecting element is not an arc, determine the Obstacle Primary Point as the point of intersection between a line drawn from the obstacle perpendicular to the flight path and the Primary Boundary.

(2) Determine obstacle evaluation distance (d), as the shortest distance within the primary area to from the Obstacle Primary Point to the JK line.

(3) Determine distance into the secondary ($d_{secondary}$) as the distance from the obstacle to the Obstacle Primary Point.

Figure 6-37. Measuring Obstacle Distance (Public)

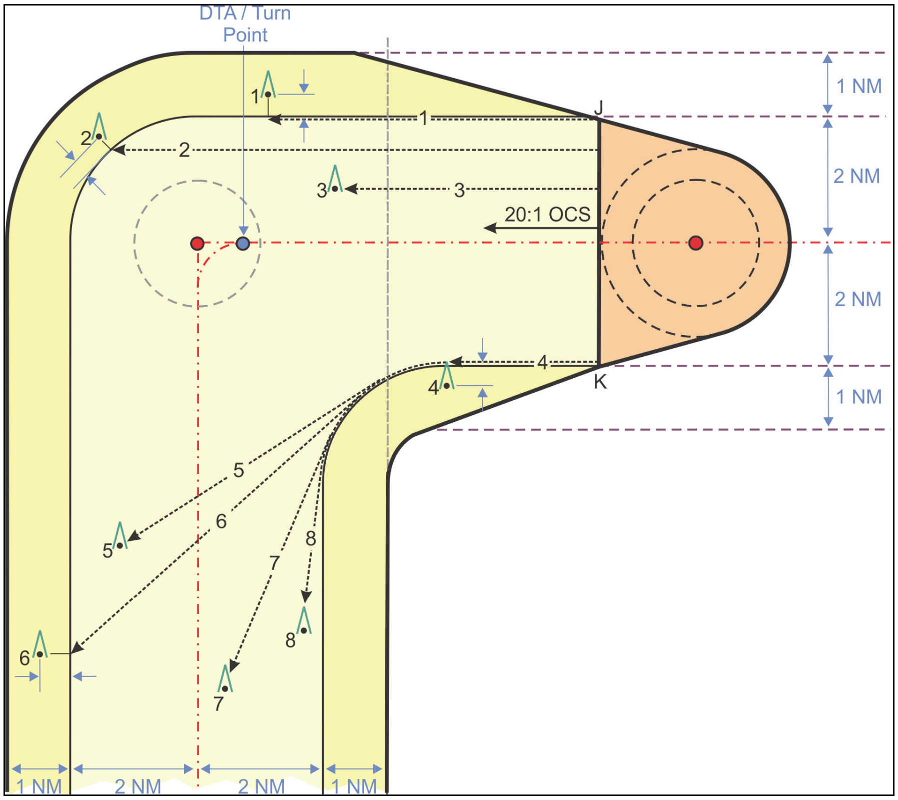
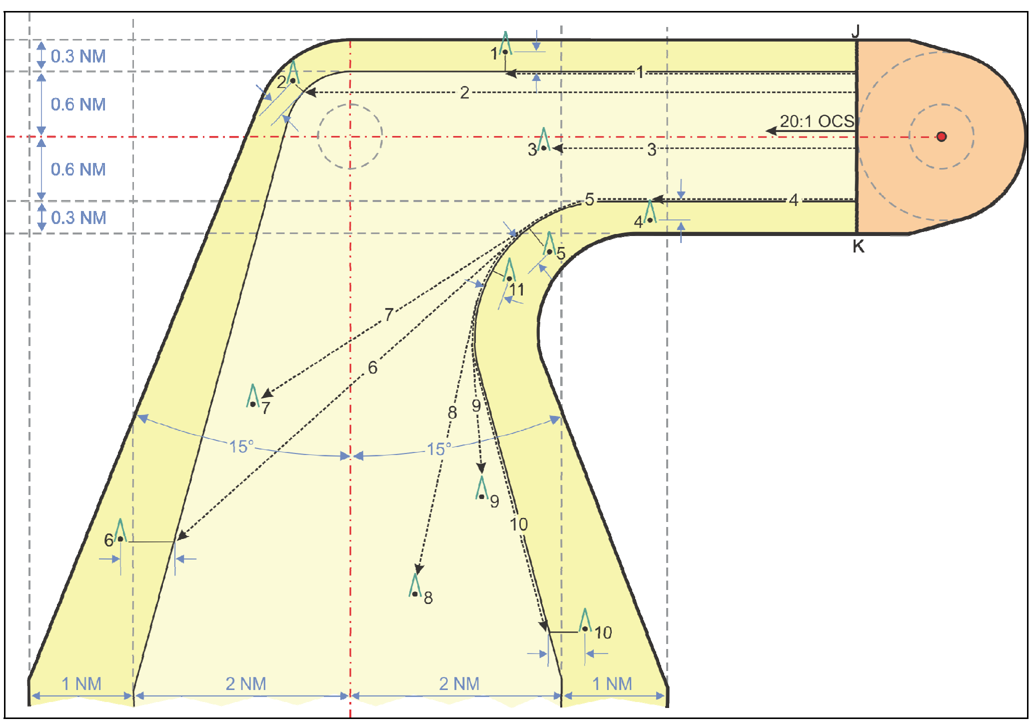


Figure 6-38. Measuring Obstacle Distance (Special)



6-11. Visual Segment (Specials only). To ensure a safe IFR operation from a heliport, it is essential to establish the acceptability of the landing site, to design a safe, flyable departure procedure, and to provide a flight inspection evaluation consistent with the type of operation. This paragraph provides the construction guidance for the visual segment of this type of procedure.

a. Procedure design. The special procedure provides a measure of obstruction protection/ identification along the visual track from a specific VFR heliport to the IDF.

Note: In most cases the DP will be developed to utilize the waypoints of a corresponding Approach Procedure, resulting in the IDF being in the same location as the MAP.

(1) Alignment. The visual segment connects the helipoint to the IDF. The optimum visual segment is aligned with the FAC. The course change at the IDF must not exceed 30 degrees.

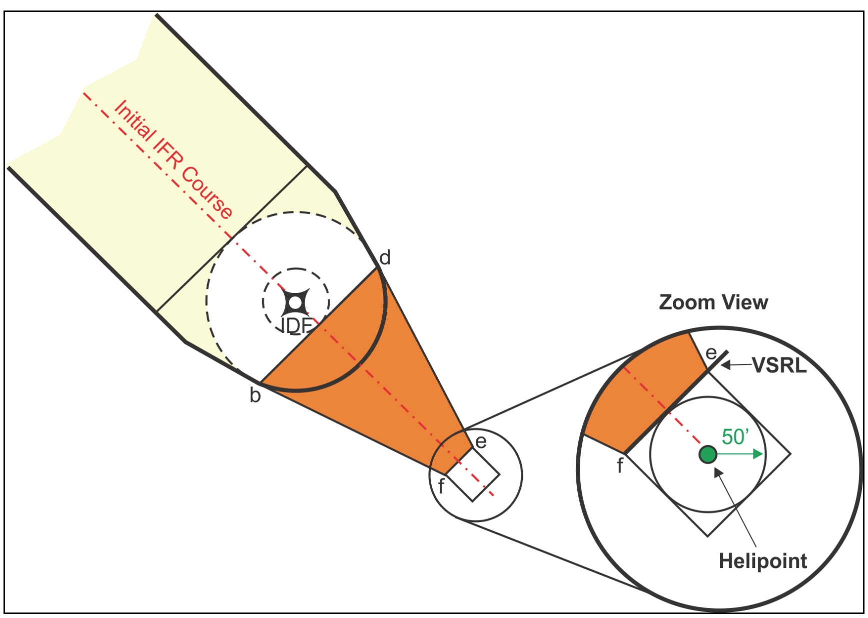
(2) Area.

(a) Length. The visual segment OEA begins at the VSRL and ends at the IDF. The visual segment OEA maximum length is 2 NM, measured from the helipoint to the IDF plotted position. The optimum helipoint to the ATD/IDF fix distance is 0.65 NM.

(b) Width. The visual segment splay begins at the VSRL. It splays from the VSRL endpoints to 0.6 NM either side of the IDF, perpendicular to the Initial IFR course.

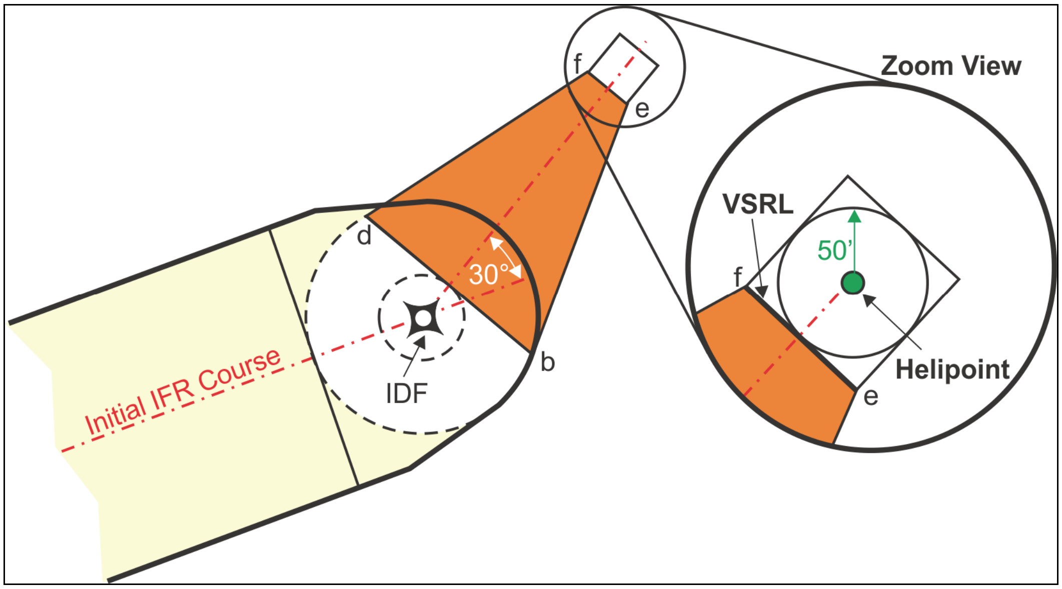
1. Straight Course Construction. Connect the VSRL outer edges (EF) to points B and D - 0.6 NM either side of the IDF, perpendicular to the Initial IFR course (see Figure 6-39).

Figure 6-39. Straight Visual Segment OEA



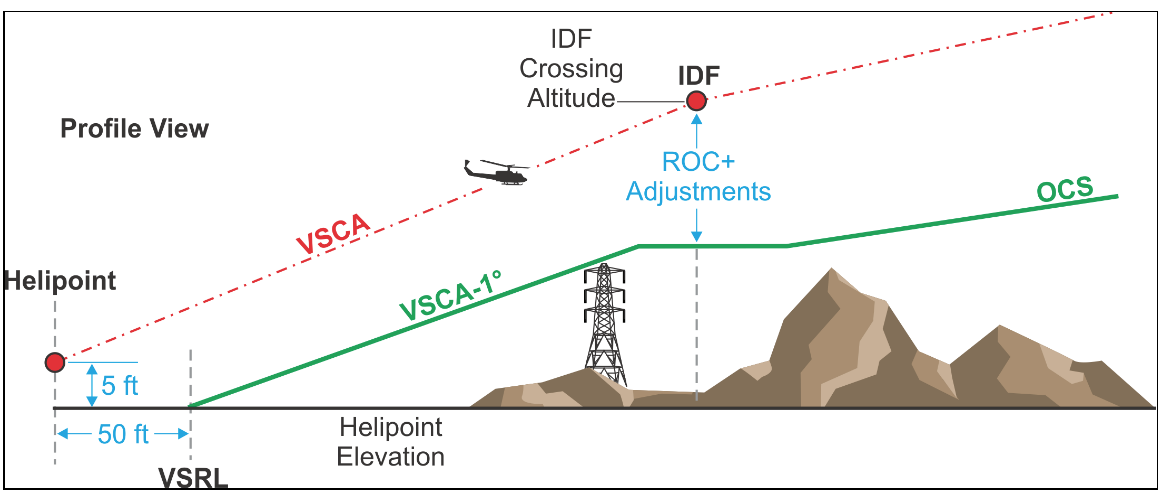
2. Turn at the IDF Construction. Connect the VSRL outer edges (EF) to points B and D - 0.6 NM either side of the IDF, perpendicular to the Initial IFR course (see Figure 6-40).

Figure 6-40. Visual Segment with Turn at IDF OEA



(c) Visual Segment Climb Angle (VSCA). The VSCA is a developer-specified angle extending from a point 5 to 20 ft directly above the helipoint to the IDF altitude (see Figure 6-41).

Figure 6-41. VSCA and OIS



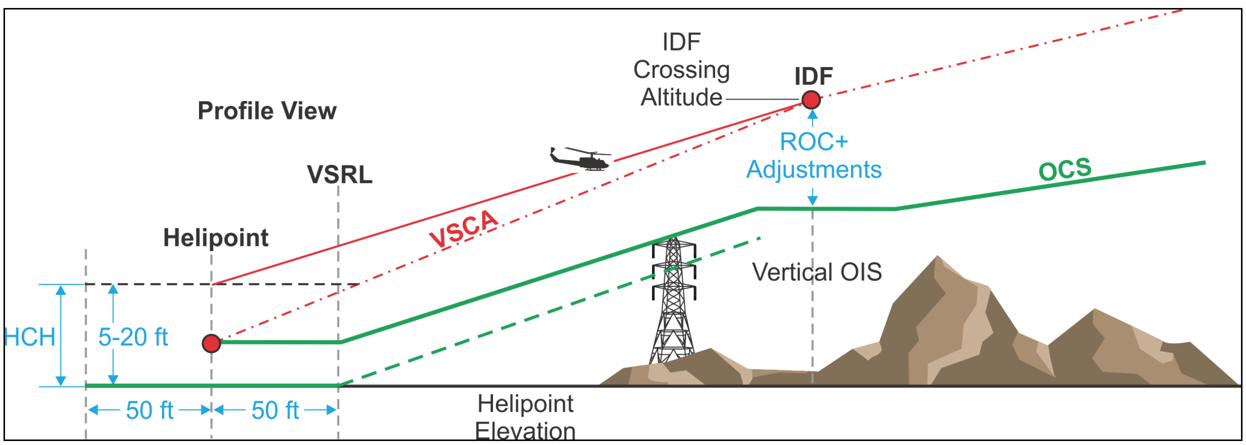
(d) Visual Segment OIS. The OIS begins at the VSRL and extends upward toward the IDF at an angle of (VSCA – 1 degree). The OIS rises to the point it reaches an altitude equal to the IDF altitude minus the ROC and adjustments, after which it becomes a level surface to the end of the IDF area. Measure obstacles using the shortest distance to the VSRL. Obstacles should not penetrate the OIS; if they penetrate in the initial evaluation; take one of the following actions, listed in preferential order (see Figure 6-42):

1. Remove or adjust obstacle location and/or height to eliminate the penetration, or

2. Raise the VSCA (Maximum 8.13°) to achieve an OIS angle that clears the obstacle, (verify that the helicopter meets this new climb performance), or

3. Raise the HCH to ≤ 20 ft. Consult with the operator to determine ability of the helicopter fleet to hover at the adjusted HCH. When this procedure is applied, raise the OIS origin above the helipoint elevation by the amount that the HCH is increased (see Figure 6-42).

Figure 6-42. VSCA and OIS Evaluation



b. Charting requirements.

(1) Publish the VSCA and climb gradient to the IDF.

(2) Chart the obstructions required by the application of the attached criteria.

(3) If the procedure is determined to be unusable at night, or night operations are not requested, annotate the procedure: "Procedure NA at night."

6-12. Weather Minimums. Calculate ceiling and visibility weather minimums required for documenting the RNAV PinS DP on FAA Form 8260-15.

a. The minimum ceiling will correspond with the IFR MSL altitude required at the IDF rounded up to the next higher 100-ft increment, or the highest HRP elevation rounded up to the next higher 100-ft increment, whichever is higher. For example, 500 ft remains 500 ft and 501 ft becomes 600 ft.

b. The visibility for a DP without a visual segment is in accordance with standard VFR minima. See FAA Form 8260-15 examples in FAA Order 8260.46, appendix F.

c. The visibility for a Special DP with a visual segment is the greater of ¾ SM or the distance between the HRP and the IDF. Conduct an obstacle evaluation of the visual segment area, ensure that a satisfactory day/night flight validation is accomplished, and obtain Flight Standards approval of the Special DP.

Chapter 7. Minimums for Helicopter Nonprecision RNAV amd WAAS Approaches

1. Application. Minimums specified for Category "A" aircraft in Order 8260.3, Volume 1, chapter 3, apply to helicopter RNAV procedures, except as follows: For helicopter procedures to heliports or helipoints, substitute "helipoint elevation" for "airport elevation" and "height above threshold (HATh)" for "heliport crossing height (HCH)."

a. Altitudes for IFR Approaches to IFR Heliports. Heliport minimums are referenced to the helipoint elevation (HE).

b. Visibilities for IFR Approaches to IFR Heliports and Runways.

(1) Approaches to Lighted Heliports with a Heliport Approach Lighting System (HALS). Apply Order 8260.37, table 3. Apply Order 8260.3, Volume 1, chapter 3, table 3-5b for DoD helicopters.

(2) Approaches to Runways. Apply Order 8260.3, Volume 1, chapter 3, table 3-6 for civilian helicopters. The minimum visibility may be ½ the computed values in table 3-6 but not less than ¼ sm/1.200 RVR. Apply Order 8260.3, Volume 1, chapter 3, table 3-5b for DoD helicopters.

> **Note 1:** For all procedures where obstacles penetrate Order 8260.3, Volume 1, chapter 3, paragraph 3.3.2 visual surfaces, visibility credit for approach lighting systems must not reduce visibility to values less than the values specified by paragraph 3.3.2 (3/4 or 1 SM as appropriate).

> **Note 2:** For USA, when analyzing the visual position of the final approach segment and a penalty is encountered when applying the basic criteria in Order 8260.3, Volume 1, paragraph 3.3.2, apply 20:1 vice 34:1 and 10:1 vice 20:1.

c. IFR to a VFR Heliport (IVH) IFR to a VFR Runway (IVR). (Proceed Visually). The **minimum** visibility is ¾ SM. If the height above surface (HAS) exceeds 800 ft, the **minimum** visibility is 1 SM. The **minimum** visibility must not be less than the distance from the plotted position of the MAP to the helipoint. Nighttime Operations must be flight inspected and approved (see appendix A).

d. PinS Approach (Proceed VFR). The **minimum** visibility is ¾ SM. If the height above surface (HAS) exceeds 800 ft, the **minimum** visibility is 1 SM.

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Chapter 8. HLPV PinS Final Approach Segment (FAS) Evaluation

8-1. General. Helicopter specific LPV PinS criteria are based on chapter 2 OEA concepts; however, the LPV and LNAV procedure follows the same ground track and fixes and the along-track location of DA and the LNAV MAP are the same. For procedures annotated "Proceed VFR," DA must be at least 250 ft above the terrain/surface and obstacles within a radius of 5,280 ft of the latest ATT point of the LNAV/LPV MAP/DA (see Figure 8-1 and Figure 8-2). For procedures annotated "Proceed Visually" DA must be at least 250 ft HAL.

Figure 8-1. Pins LPV Reference Datum Point (RDP)

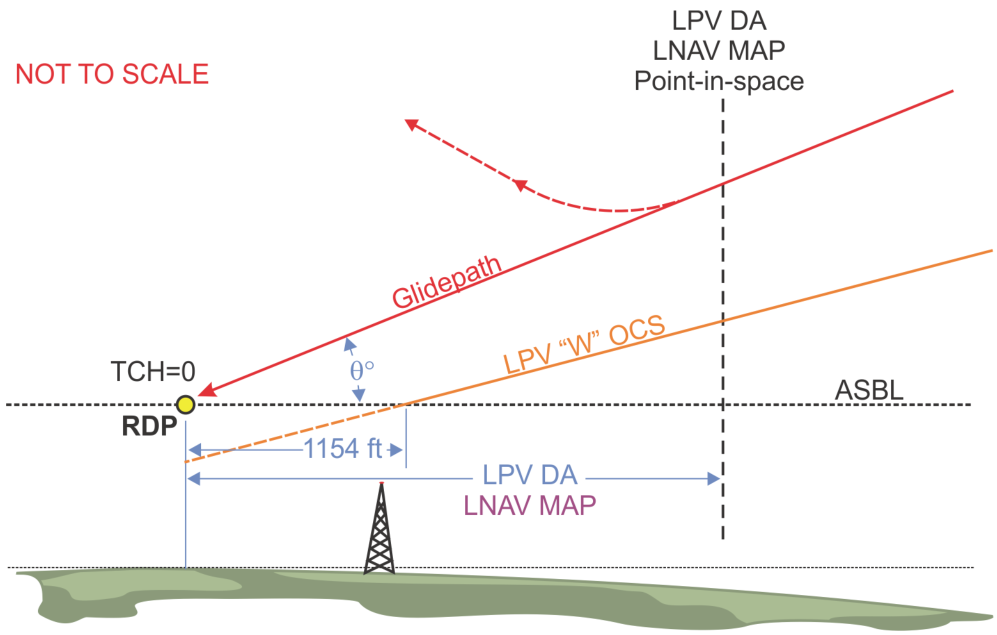
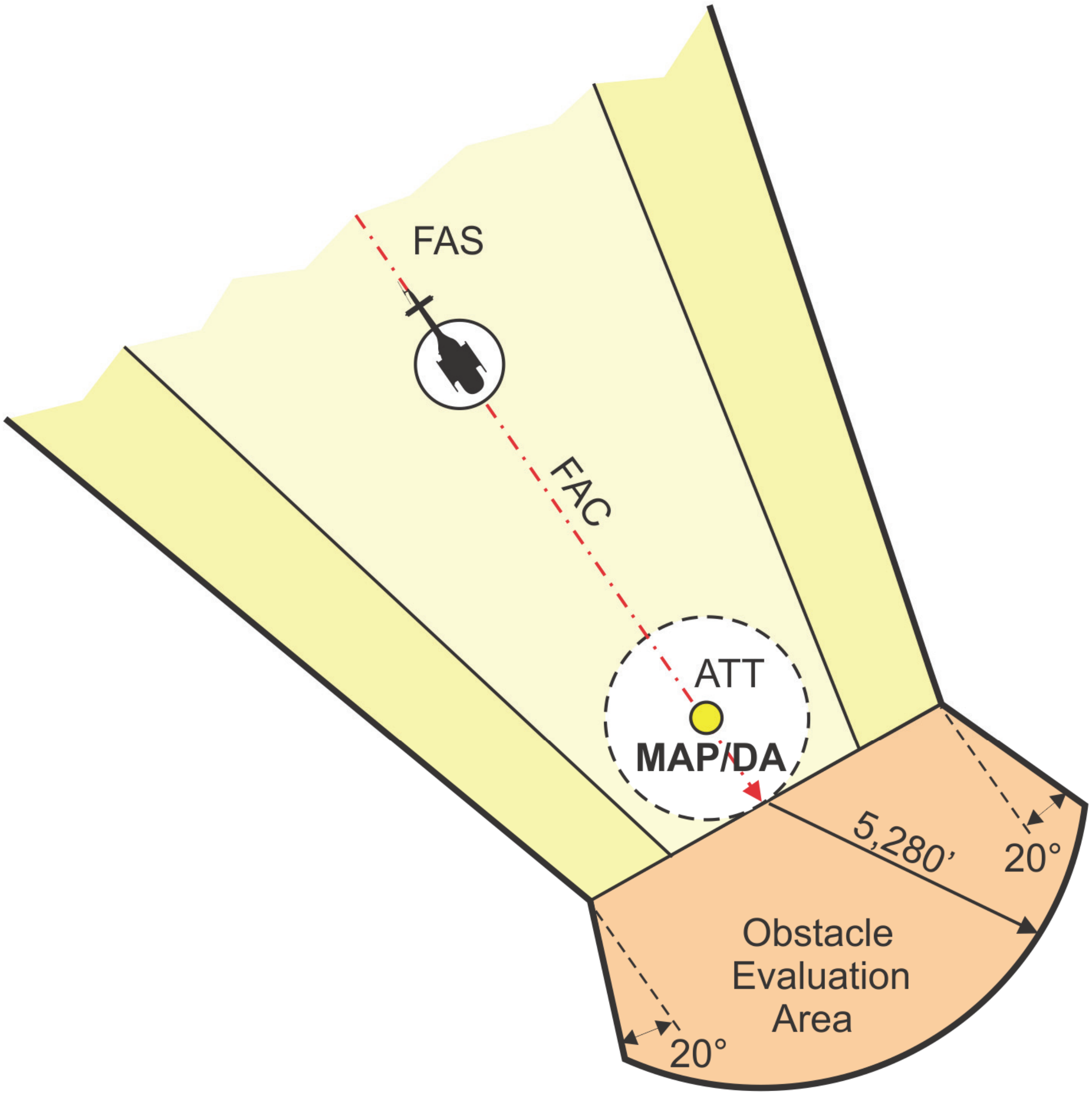


Figure 8-2. PinS VFR Area



8-2. Final Segment Obstruction Evaluation Area (OEA). The HLPV PinS final segment begins at the distance 1,154 ft from the RDP and extends to GPIP. The OEA protection extends the along-track segment dimension by the ATT value (40 m, 131.234 ft) at each end (see Figure 8-3 and Figure 8-4).

Figure 8-3. PinS OEA Plan View

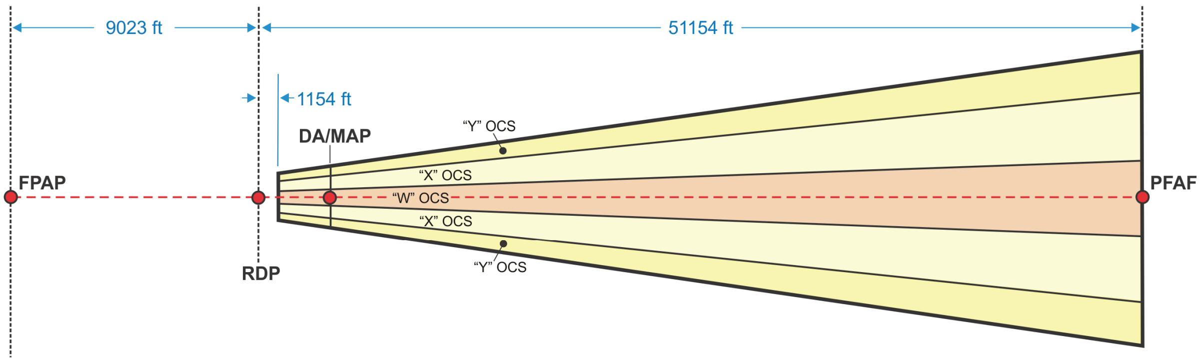
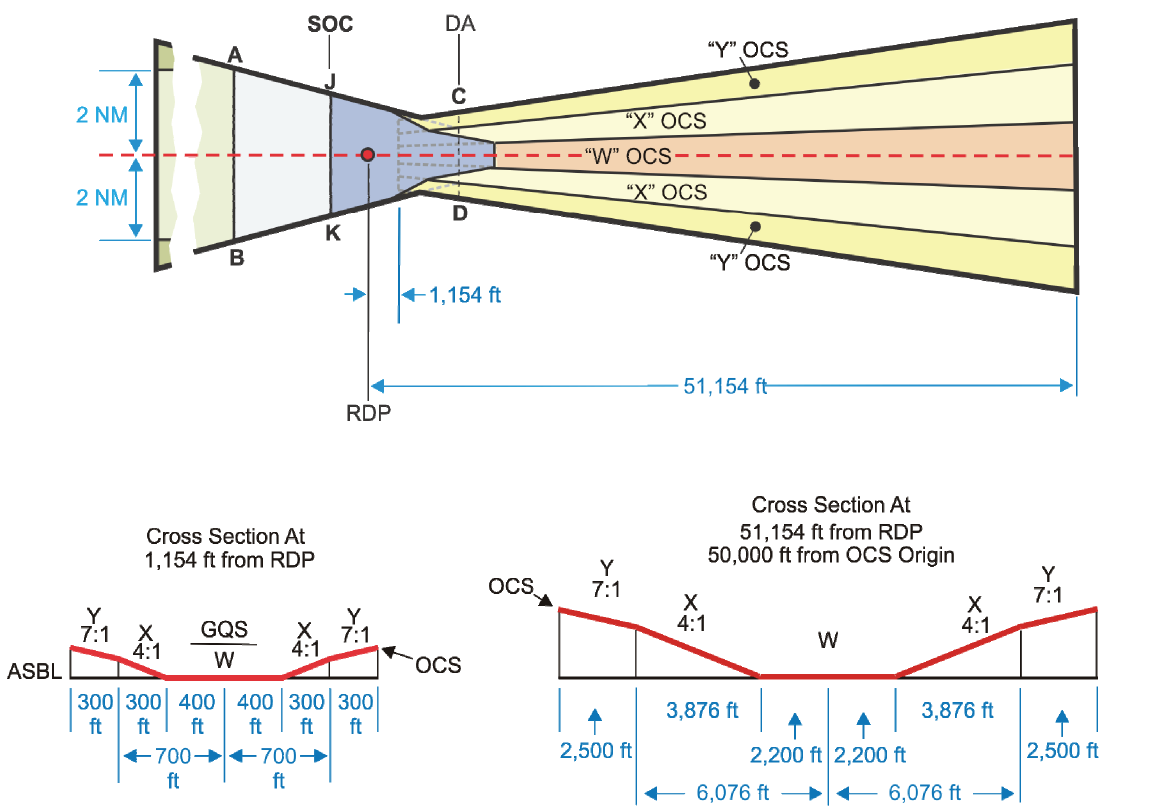


Figure 8-4. GPIP

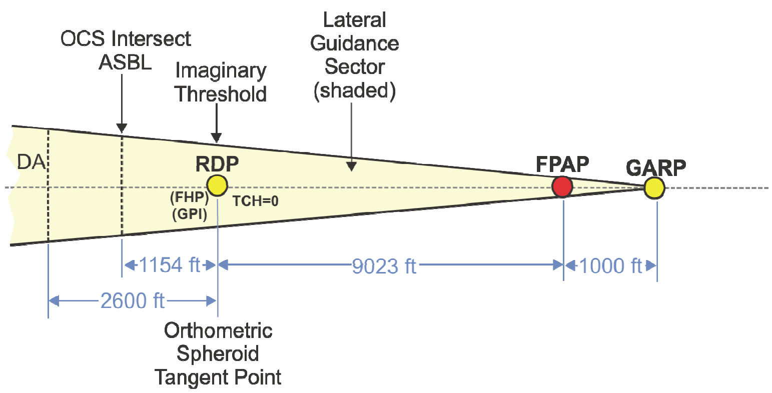


a. Calculate the distance from RDP to PFAF using Formula 2-15 (coincident with LNAV PFAF). Minimum length is 3 NM and maximum 10 NM. When using Formula 2-15 replace HCH with 0, and HRP_{elev} with RDP_{elev}.

b. Locate the FPAP 9,023 ft from RDP on a continuation of the final approach course (FAC), see Figure 8-5. The following are values entered into the procedure FAS data block (see paragraph 8-11).

Distance RDP to FPAP = 9,023 ft
Distance FPAP to GARP = 304.8 m (1,000 ft)
Course Width at RDP = 106.75 m (350 ft)

Figure 8-5. FPAP



c. OEA Alignment. The FAC is nominally aligned with landing site approach track extended (± 0.03°). Where a unique operational requirement indicates a need to offset the track from DA/MAP to the landing site from the track of the FAC, the offset must not exceed 30 degrees measured at DA.

d. OCS Slope. In this document, OCS slope is expressed as run over rise; e.g., 22.667:1. Determine the OCS slope (OCS_{slope}) associated with a specific θ° using Formula 8-1.

Formula 8-1. OCS Slope

$$(1)\ \text{input } \theta°$$

$$(2)\ OCS_{slope} = \textbf{round}\left[\frac{102}{\theta°}, 3\right]$$

round(102/θ°,3)		
Calculator		
θ°		Click Here to Calculate
OCS_{slope}		

e. OCS Origin and Elevation. For obstacle evaluation, the OCS originates 1,154 ft from (prior to) the RDP at the same elevation. Along-track distance measurements in the final segment OEA are from RDP.

8-3. W OCS. All final segment OCS (W, X, and Y surfaces) obstacles are evaluated relative to the height of the W surface based on their along-track distance (OBS_X) from RDP, perpendicular distance (OBS_Y) from the FAC centerline, and MSL elevation (OBS_{elev}) adjusted for earth curvature and X/Y surface rise if appropriate. This adjusted elevation is termed obstacle effective elevation (O_{EE}) and is covered in paragraph 8-3b.

a. Half-Width. (Perpendicular distance from FAC centerline to surface boundary.) The perpendicular distance ($W_{boundary}$) from FAC centerline to the boundary is 400 ft at the point 1,154 ft from RDP and expands uniformly to 2,200 ft at a point 51,154 ft from RDP then remains constant. Calculate $W_{boundary}$ for any distance from RDP using Formula 8-2.

Formula 8-2. W OCS Half-Width

(1) input OBS_X

(2) $W_{boundary} = 0.036 \cdot (OBS_X - 954) + 392.8$

Where OBS_X = any along-track distance from RDP $\leq$ 51,154 ft

0.036*(OBSX-954)+392.8		
Calculator		
OBS_X		Click Here to Calculate
$W_{boundary}$		

b. Height. Calculate the MSL height (ft) of the W OCS (W_{elev}) at any distance from RDP using Formula 8-3.

Formula 8-3. W OCS MSL Elevation

(1) input DA, $\theta°$, OBS_X

(2) $$W_{elev} = \frac{(r + DA) \cdot \cos\left(\operatorname{atan}\left(\frac{\theta}{102}\right)\right)}{\cos\left(\frac{OBS_X - 1154}{r} + \operatorname{atan}\left(\frac{\theta}{102}\right)\right)} - r$$

(r+DA)*cos(atan(θ°/102))/cos((OBS$_X$-1154)/r+atan(θ°/102))-r		
Calculator		
DA		Click Here to Calculate
$\theta°$		
OBS_X		
W_{elev}		

The glide path is a straight line in space extending from RDP. The OCS is; therefore, a flat plane (does not follow earth curvature) to protect the straight-line glide path. The elevation of the OCS at any point is the elevation of the OCS at the FAC centerline abeam it. Since the earth's surface curves away from these surfaces as distance from RDP increases, the MSL elevation (OBS_{elev}) of an obstacle is reduced to account for earth curvature. This reduced value is termed the obstacle effective elevation (O_{EE}). Calculate O_{EE} using Formula 8-4 with adjustment "Q" for "X" or "Y" surface rise (0 if in W Surface).

Formula 8-4. Calculation of O_{EE}

$$(1)\ input\ OBS_{elev},\ DA,\ OBS_Y,\ Q$$

$$(2)\ O_{EE} = OBS_{elev} - \left((r+DA) \cdot \left(\frac{1}{\cos\left(\frac{OBS_Y}{r}\right)} - 1 \right) + Q \right)$$

OBS$_{elev}$-((r+DA)*(1/cos(OBS$_Y$/r)-1)+Q)		
Calculator		
OBS_{elev}		Click Here to Calculate
DA		
OBS_Y		
Q		
O_{EE}		

c. W OCS Evaluation. Compare the obstacle O_{EE} to W_{elev} 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.

(1) Remove or adjust the obstruction location and/or height.

(2) Raise the GPA (see paragraph 8-7) up to a maximum GPA of 9 degrees.

(3) Adjust DA (for existing obstacles only) see paragraph 8-6.

(4) Raise RDP elevation

(5) Adjust Final Approach Course.

8-4. X OCS.

a. Width. Calculate the perpendicular distance ($X_{boundary}$) from the FAC centerline to the X surface boundary using Formula 8-5.

Formula 8-5. Perpendicular Distance to "X" Boundary

$$(1)\ input\ OBS_X$$

$$(2)\ X_{boundary} = 0.10752 \cdot (OBS_X - 954) + 678.496$$

0.10752*(OBS$_X$-954)+678.496		
Calculator		
OBS_X		Click Here to Calculate
$X_{boundary}$		

b. 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 FAC. The MSL elevation of an obstacle in the X surface is adjusted (reduced) by the amount of surface rise. Use Formula 8-6 to determine the obstacle height adjustment (Q) for use in Formula 8-4. Evaluate the obstacle under paragraphs 8-3b and 8-3c.

Formula 8-6. X OCS Obstacle Height Adjustment

$$(1)\ input\ OBS_Y,\ W_{boundary}$$

$$(2)\ Q = \frac{OBS_Y - W_{boundary}}{4}$$

(OBS$_y$-W$_{boundary}$)/4		
Calculator		
OBS_y		Click Here to Calculate
$W_{boundary}$		
Q		

8-5. Y OCS.

a. Width. Calculate the perpendicular distance ($Y_{boundary}$) from the FAC centerline to the Y surface boundary using Formula 8-7.

Formula 8-7. Perpendicular Distance to "Y" Boundary

$$(1)\quad input\ \ OBS_X$$

$$(2)\quad Y_{boundary} = 0.15152 \cdot (OBS_X - 954) + 969.696$$

0.15152*(OBS$_X$-954)+969.696		
Calculator		
OBS_X		Click Here to Calculate
$Y_{boundary}$		

b. 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 FAC. The MSL elevation of an obstacle in the Y surface is adjusted (reduced) by the amount of X and Y surface rise. Use Formula 8-8 to determine the obstacle height adjustment (Q) for use in Formula 8-4. Evaluate the obstacle under paragraphs 8-3b and 8-3c.

Formula 8-8. Y OCS Obstacle Height Adjustment

$$(1)\quad input\ \ X_{boundary},\ W_{boundary},\ OBS_Y$$

$$(2)\quad Q = \frac{X_{boundary} - W_{boundary}}{4} + \frac{OBS_Y - X_{boundary}}{7}$$

($X_{boundary}$-$W_{boundary}$)/4+(OBS_y-$X_{boundary}$)/7		
Calculator		
$X_{boundary}$		Click Here to Calculate
$W_{boundary}$		
OBS_Y		
Q		

8-6. HAS and DA. Where the OCS is clear, the minimum HAS is the greater of 250 ft.

a. DA Calculation (Clear OCS). The minimum DA value is 250 ft above the highest obstruction (terrain+obstacle or vegetation) rounded to the next higher 1-ft increment.

b. DA Adjustment to mitigate OCS Penetration. Calculate the adjusted DA for an obstacle penetration of the OCS using Formula 8-9.

Formula 8-9. Adjusted DA

$$(1)\quad input\ \ \theta°,\ DA,\ O_{EE}$$

$$(2)\quad D_{adjusted} = r\cdot\left(\frac{\pi}{2} - \mathbf{atan}\left(\frac{\theta°}{102}\right) - \mathbf{asin}\left(\frac{\mathbf{cos}\left(\mathbf{atan}\left(\frac{\theta°}{102}\right)\right)\cdot\left(r + DA - 954 - \frac{\theta°\cdot 954}{102}\right)}{r + O_{EE}}\right)\right)$$

$$(3)\quad DA_{adjusted} = \mathbf{ceiling}\left[\frac{(r + DA - 954)\cdot\mathbf{cos}\left(\theta°\cdot\frac{\pi}{180}\right)}{\mathbf{cos}\left(\frac{D_{adjusted}}{r} + \theta°\cdot\frac{\pi}{180}\right)} - r\right]$$

r*(π/2-atan(θ°/102)-asin(cos(atan(θ°/102))*(r+DA-954-θ°*954/102)/(r+O_{EE}))) ceiling((r+DA-954)*cos(θ°*π/180)/cos($D_{adjusted}$/r+θ°*π/180)-r)		
Calculator		
$\theta°$		Click Here to Calculate
DA		
O_{EE}		
$D_{adjusted}$		
$DA_{adjusted}$		

8-7. Revising Glide Path Angle ($\theta°_{adjusted}$) for OCS Penetrations. Raising the θ° may eliminate OCS penetrations. To determine $\theta°_{adjusted}$, use Formula 8-10.

Formula 8-10. Glide Path Angle Adjustment

(1) input OBS_X, OBS_{elev}, RDP_{elev}

(2) $s=(r+RDP_{elev})^2+(r+OBS_{elev})^2-2\cdot(r+RDP_{elev})\cdot(r+OBS_{elev})\cdot\cos\left(\frac{OBS_X-1154}{r}\right)$

(3) $b=\mathrm{acos}\left(\frac{(r+RDP_{elev})^2+s-(r+OBS_{elev})^2}{2\cdot(r+RDP_{elev})\cdot\sqrt{s}}\right)-\frac{\pi}{2}$

(4) $OCS_{adjusted\_slope}=\mathrm{round}\left(\frac{1}{\tan(b)},2\right)$

(5) $\theta_{adjusted}=\mathrm{round}\left(\frac{102}{OCS_{adjusted\_slope}},2\right)$

(r+RDP$_{elev}$)^2+(r+OBS$_{elev}$)^2-2*(r+RDP$_{elev}$)*(r+OBS$_{elev}$)*cos((OBS$_X$-1154)/r) acos(((r+RDP$_{elev}$)^2+s-(r+OBS$_{elev}$)^2)/(2*(r+RDP$_{elev}$)*sqrt(s)))-π/2 OCS$_{adjusted_slope}$=round(1/tan(b),2) θ$_{adjusted}$=round(102/OCS$_{adjusted_slope}$,2)		
Calculator		
OBS_X		Click Here to Calculate
OBS_{elev}		
RDP_{elev}		
$OCS_{adjusted\_slope}$		
$\theta°_{adjusted}$		

The descent rate of the adjusted glidepath angle should not exceed 800 ft/min. Descent rate is heavily dependent on airspeed. Determine the airspeed that yields 800 ft/min ($V_{KIAS\_800ft\_min}$) for the adjusted glidepath angle using Formula 8-11. If $V_{KIAS\_800ft\_min}$ is less than the normal approach speed, publish a final approach airspeed restriction of $V_{KIAS\_800ft\_min}$. The minimum adjusted glidepath angle should not be less than three degrees. If operationally required, with AFS approval, the maximum descent rate can be increased to 1,000 ft/min.

Formula 8-11. Descent Rate Indicated Airspeed

$$(1)\quad input\quad \theta^{\circ}_{adjusted},\ DA$$

$$(2)\quad V_{KIAS\_800*ft/min} = \mathbf{round}\left[\left(\frac{800*}{101.26859\cdot\sin\left(\theta^{\circ}_{adjusted}\cdot\frac{\pi}{180}\right)}-10\right)\cdot\frac{(288-0.00198\cdot DA)^{2.628}}{171233\cdot\sqrt{303-0.00198\cdot DA}},0\right]$$

*1000 when the airspeed limit is required for 1000 ft/min

round[(800/(101.26859*sin(θ°adjusted*π/180))-10)*((288-0.00198*DA)^2.628)/(171233*sqrt(303-0.00198*DA)),0]		
Calculator		
$\theta^{\circ}_{adjusted}$		Click Here to Calculate
DA		
$V_{KIAS\_800ft/min}$		
$V_{KIAS\_1000ft/min}$ (with AFS approval)		

8-8. Adjusting TCH to Reduce/Eliminate OCS Penetrations. NA for PinS LPV procedures.

8-9. Missed Approach Section 1 (Height Loss and Initial Climb). Section 1 begins at DA (<u>CD</u> line) and ends at the <u>AB</u> line. It accommodates height loss and establishment of missed approach climb gradient. Obstacle protection is based on an assumed minimum climb gradient of 400 ft/NM (≈15.19:1 slope). Section 1 is centered on a continuation of the FAC and is subdivided into sections 1a and 1b (see Figures 8-6 and 8-7).

Figure 8-6. Section 1 3D Perspective

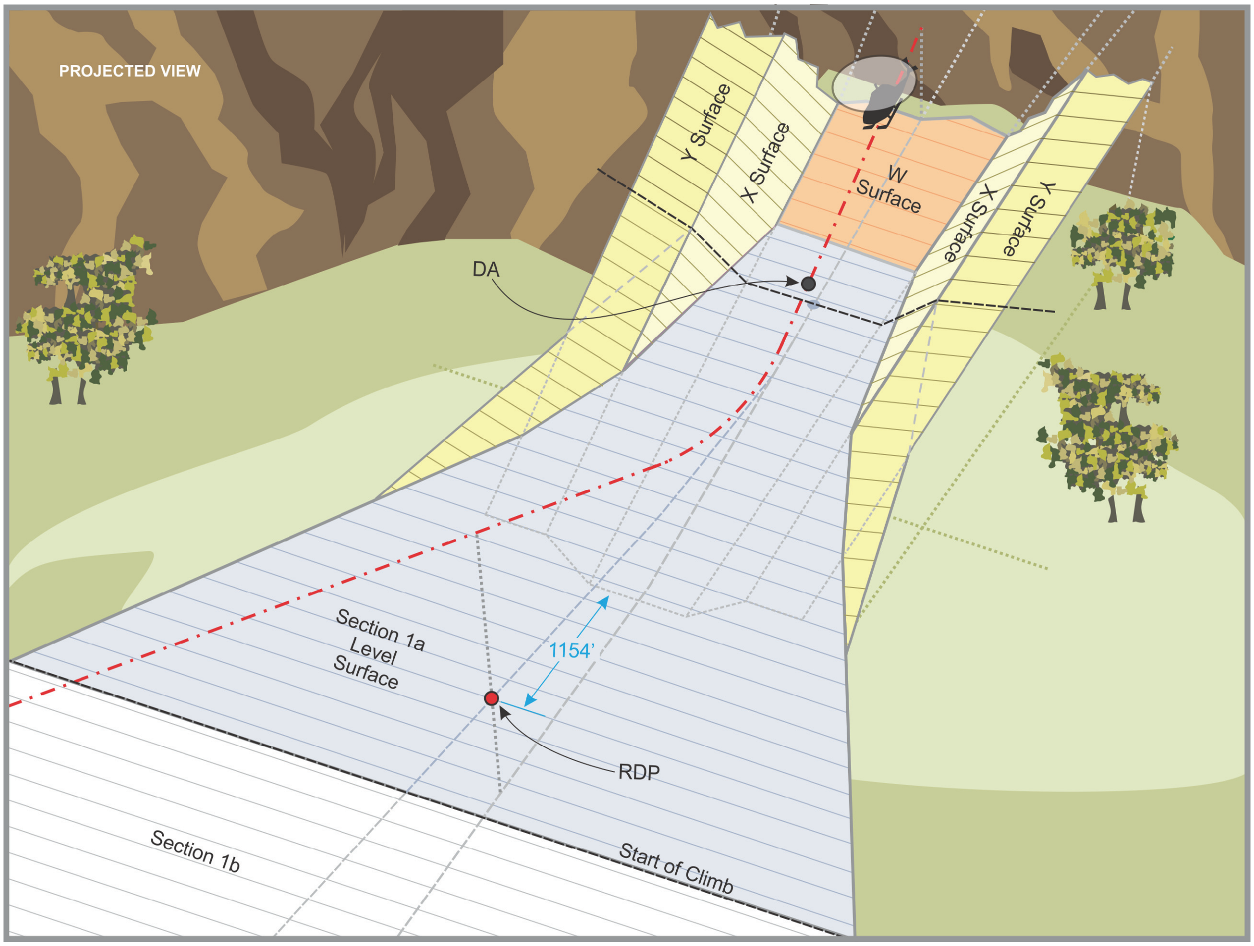
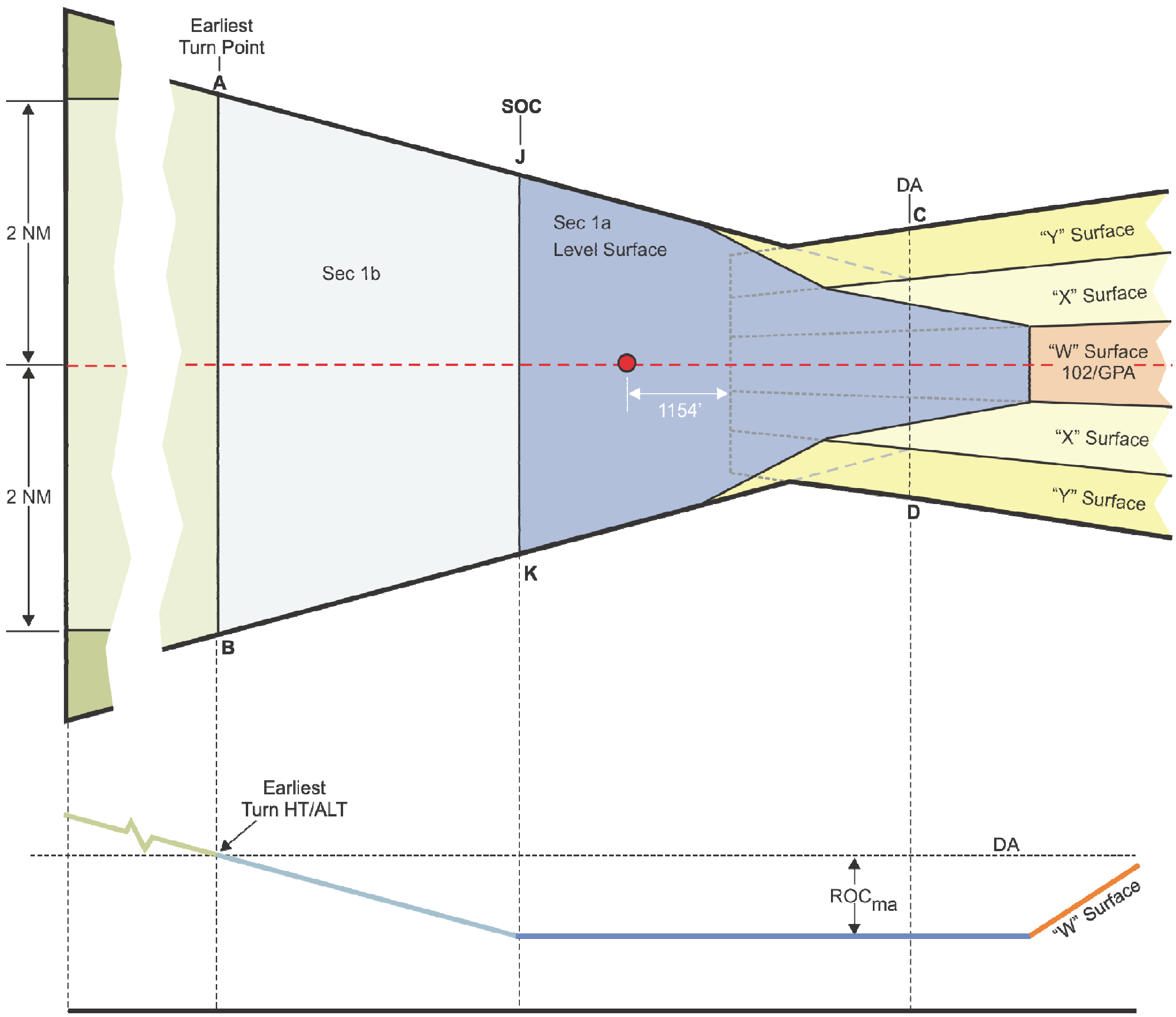


Figure 8-7. Section 1 (a/b) 2D Perspective



a. Missed Approach Section 1. Section 1 begins at DA (<u>CD</u> line) and ends at the <u>JK</u> line which is the Start-Of-Climb (SOC) point. It accommodates reconfiguration, inherent height loss, and establishing required missed approach climb gradient (CG_{MA}) of 400 ft/NM (20:1 slope), unless higher climb gradients and the appropriate slope adjustments are authorized. Section 1 is subdivided into sections 1a and 1b, and is centered on a continuation of the FAC. These surfaces must not be penetrated. Section 1a, is protected by a level surface that provides required ROC (ROC_{sec_1a}) based on glide path angle and airspeed. ROC is 115 ft for glide path angles up to 3.2 degrees. Apply ROC adjustments for glide path angles exceeding 3.2 degrees, for RDP elevations greater than 3,000 ft., and for final indicated airspeed. Calculate section 1a ROC (ROC_{sec_1a}) and the level surface MSL elevation (sec_1a_{elev}) using Formula 8-12.

Formula 8-12. MA Beginning ROC

(1) input $DA,\ RDP_{elev},\ \theta°,\ V_{KIAS}$

(2) **if** $(\theta° > 3.2°)$ **then**

$$\theta°_{adjustment} = 0.05 \cdot 25 \cdot \frac{\theta° - 3.2}{0.1}$$

else

$$\theta°_{adjustment} = 0$$

end if

(3) **if** $(RDP_{elev} > 3000)$ **then**

$$Elev_{adjustment} = 0.02 \cdot 25 \cdot \frac{RDP_{elev}}{1000}$$

else

$$Elev_{adjustment} = 0$$

end if

(4) $$ROC_{sec\_1a} = 115 + \theta°_{adjustment} + Elev_{adjustment} - 25 \cdot \frac{90 - V_{KIAS}}{90}$$

(5) $$Level\_sfc_{elev} = DA - ROC_{sec\_1a}$$

0.05*25*(θ° -3.2)/0.1 0.02*25*RDP_{elev}/1000 115+$θ°_{adjustment}$+$Elev_{adjustment}$-25*(90-V_{KIAS})/90 DA- ROC_{sec_1a}		
Calculator		
DA		Click Here to Calculate
RDP_{elev}		
θ°		
V_{KIAS}		
ROC_{sec_1a}		
$Level\_sfc_{elev}$		

(1) Section 1a. Section 1a length varies with altitude, airspeed, and glide path angle. The 1a surface splays at 15 degrees relative the FAC extension, from X boundary at its beginning (CD line) until reaching the JK line. Calculate X width at section 1a start point using the final segment X width. Calculate section 1a length ($Length_{sec1a}$) using Formula 8-13.

Formula 8-13. Section 1a Length

(1) input $\theta°$, V_{KTAS} °

(2) $anpe = 1.225 \cdot \frac{40}{0.3048}$

(3) $wpr = 60 \cdot \tan\left(\theta \cdot \frac{\pi}{180}\right)$

(4) $fte = \frac{75}{\tan\left(\theta \cdot \frac{\pi}{180}\right)}$

(5) $d1 = 10 \cdot \frac{(V_{KTAS} + 10) \cdot fpnm}{3600}$

(6) $Length_{sec1a} = \mathbf{round}\left[d1 + \frac{4}{3} \cdot \sqrt{anpe^2 + wpr^2 + fte^2}, 0\right]$

1.225*40/0.3048 60*tan(θ°*π/180) 75/tan(θ°*π/180) 10*(V_{KTAS}+10)*fpnm/3600 round(d1+(4/3)*(anpe^2+wpr^2+fte^2)^0.5,0)		
Calculator		
$\theta°$		Click Here to Calculate
V_{KTAS}		
$Length_{sec1a}$		

(a) Calculate the 1a surface half-width (½width$_{sec1a}$) at any along-track distance (d$_{1a}$) from DA assuming a beginning half-width of the final segment "X" surface at DA (½X$_{sfc_DA}$) using Formula 8-14.

Formula 8-14. Section 1a Width

(1) input d_{1a}, DA, RDP_{elev}, $\theta°$

(2) $$\tfrac{1}{2}width_{sec1a} = d_{1a} \cdot \tan\left(15 \cdot \frac{\pi}{180}\right) + 0.036 \cdot \left(\frac{DA - RDP_{elev}}{\tan\left(\theta° \cdot \frac{\pi}{180}\right)} - 954\right) + 398.2$$

d$_{1a}$*tan(15*π/180)+0.036*((DA-RDP$_{elev}$)/tan(θ°*π/180)-954)+398.2		
Calculator		
d_{1a}		Click Here to Calculate
DA		
RDP_{elev}		
$\theta°$		
½$width_{sec1a}$		

(b) Obstacles within the lateral boundaries of the flat surface that underlie the X or Y surfaces may be evaluated against the higher of: (1) the W surface abeam the obstacle, or (2) the flat surface elevation. Conduct the evaluation using the "Obstacle Effective Elevation" (O$_{EE}$).

(2) Section 1b. Section 1b provides initial climb protection from SOC at the specified CG$_{MA}$ until minimum turn height/altitude (alt$_{turn}$) is attained. Its lateral boundaries continue the section 1a splay until alt$_{turn}$ is reached or until reaching full width, whichever occurs first. Calculate section 1b length using Formula 8-15.

Formula 8-15. Section 1b Length

$$(1) \quad input \quad alt_{turn},\ Level\_sfc_{elev},\ CG_{MA}$$

$$(2) \quad Length_{sec1b} = \frac{r \cdot fpnm \cdot \ln\left[\frac{r + alt_{turn}}{r + Level\_sfc_{elev}}\right]}{CG_{MA}}$$

r*fpnm*ln((r+alt$_{turn}$)/(r+Level_sfc$_{elev}$))/CG$_{MA}$		
Calculator		
alt_{turn}		Click Here to Calculate
$Level\_sfc_{elev}$		
CG_{MA}		
$Length_{sec1b}$		

(a) Calculate the width of the section 1b surface (½width$_{sec1b}$) at any distance d$_{sec1a_end}$ from the end of section 1a using Formula 8-16.

Formula 8-16. Section 1b Width

$$(1) \quad input \ d_{sec1a\_end},\ \tfrac{1}{2}width_{sec1a}$$

$$(2) \quad \tfrac{1}{2}width_{sec1b} = d_{sec1a\_end} \cdot \tan\left(15 \cdot \tfrac{\pi}{180}\right) + \tfrac{1}{2}width_{sec1a}$$

d$_{sec1a_end}$*tan(15*π/180)+1/2width$_{sec1a}$		
Calculator		
d$_{sec1a_end}$		Click Here to Calculate
½width$_{sec1a}$		
½width$_{sec1b}$		

(b) The surface rises at a rate related to the assigned CG$_{MA}$ from sec_1a$_{elev}$. Determine the 1b MA surface elevation (OCS_1b$_{OBS_x}$) at any section 1b obstacle distance (d), and the elevation of the OCS at section 1b end (OCS_1b$_{end_elev}$) using Formula 8-17.

Formula 8-17. MA Slope and Section 1b Elevation

$$(1)\ \text{input } CG_{MA},\ d_{sec1b\_end},\ Level\_sfc_{elev},\ OBS_x$$

$$(2)\ MA_{slope}=\frac{fpnm}{CG_{MA}-96}$$

$$(3)\ OCS\_1b_{end\_elev}=\frac{d_{sec1b\_end}}{MA_{slope}}+Level\_sfc_{elev}$$

$$(4)\ OCS\_1b_{OBS\_x}=\frac{OBS_x}{MA_{slope}}$$

fpnm/(CG_{MA}-96) d_{sec1b_end}/MA_{slope}+$Level\_sfc_{elev}$ OBS_x/MA_{slope}		
Calculator		
CG_{MA}		Click Here to Calculate
d_{sec1b_end}		
$Level\_sfc_{elev}$		
OBS_x		
MA_{slope}		
$OCS\_1b_{end\_elev}$		
$OCS\_1b_{OBS\_X}$		

b. Section 2. See chapter 5.

8-10. Surface Height Evaluation.

a. Section 1a. Obstacles that penetrate these surfaces are mitigated during the final segment OCS evaluation. However, missed approach segment penetrations are not allowed and must be mitigated by:

(1) Removing or reducing obstruction height.

(2) Adjusting RDP elevation.

(3) Adjusting the FAC.

(4) Adjusting DA (for existing obstacles).

(5) A combination of the above mitigations.

b. Section 1b/Section 2 Surface Penetration. The CG_{MA} may be increased, (if operationally feasible) in addition to the options listed in paragraph 8-11a. Climb gradients above 600 ft/NM require Flight Standards approval.

Note: See formula 5-3 to determine CG_{MA} increase method.

c. End of Section 1 Values. Calculate the assumed aircraft MSL altitude at the end of section 1b ($acft_{1b\_alt}$), the OCS MSL elevation at the end of section 1b (OCS_{1b_elev}), and the ROC at section 1b end (ROC_{end_1b}) using Formula 8-18.

Formula 8-18. Section 1b End Values

(1) $input\ DA,\ OCS\_1a_{elev},\ Length_{sec1b},\ CG_{MA}$

(2) $$MA_{slope} = \frac{fpnm}{CG_{MA} - 96}$$

(3) $$acft_{1b\_alt} = DA + \left(CG_{MA} \cdot \frac{Length_{sec1b}}{fpnm}\right)$$

(4) $$OCS_{1b\_elev} = OCS\_1a_{elev} + \frac{Length_{sec1b}}{MA_{slope}}$$

(5) $$ROC_{end\_1b} = acft_{1b\_alt} - OCS_{1b\_elev}$$

fpnm/(CG_{MA}-96) DA+(CG_{MA}*$Length_{sec1b}$/fpnm) OCS_1a_{elev}+ $Length_{sec1b}$/MA_{slope} $acft_{1b\_alt}$-OCS_{1b_elev}		
Calculator		
DA		Click Here to Calculate
OCS_1a_{elev}		
$Length_{sec1b}$		
CG_{MA}		
$acft_{1b\_alt}$		
OCS_{1b_elev}		
ROC_{end_1b}		

8-11. Final Approach Segment (FAS) Data Requirements. Values are as indicated unless otherwise specified.

a. Operation type: 0

b. Service Provider Identifier: 0

c. Airport Identifier: Use the heliport identifier. If the heliport does not have an identifier one must be obtained. For procedures serving multiple heliports, the identifier for the primary heliport should be used.

d. Runway Number: Final approach track rounded to nearest 10 degrees and enter as a two digit number.

e. Runway Letter: Leave blank.

f. Approach Performance Designator: 0

g. Route Indicator: Leave blank.

h. Reference Path Data Selector (RPDS): 0

i. Reference Path Identifier: [W] [Final approach track rounded to nearest 10 degrees (2 digits)] ["A" first procedure, "B" second procedure, etc.] EXAMPLE: W23A.

j. LTP/RDP Latitude: WGS-84 Latitude of RDP entered to five ten-thousandths of an arc second. The last digit must be rounded down to either a 0 or 5. EXAMPLE: 225436.2128N (*11 characters*) is entered for 22°54'36.2125"N.

k. LTP/RDP Longitude: WGS-84 Longitude of RDP entered to five ten-thousandths of an arc second. The last digit must be rounded to either a 0 or 5. EXAMPLE: 1093247.8783E (12 characters) is entered for 109°32'47.8780"E.

l. LTP/RDP height above ellipsoid (HAE): HAE value for RDP. The value is entered in meters using 5 characters. The first character is a + or – and the resolution value is in tenths of a meter. EXAMPLE: +00356 (+35.6 m), -00022 (-2.2 m).

m. Flight Path Alignment Point (FPAP) Latitude: WGS-84 Latitude of FPAP using the same requirements as paragraph 8-11j.

n. Flight Path Alignment Point (FPAP) Longitude: WGS-84 Longitude of FPAP using the same requirements as paragraph 8-11k.

o. TCH: 0000.0

p. TCH Units Selector: F (feet) or M (Meters)

q. Glidepath Angle: Specify in degrees, resolution of hundredths of a degree using 4 characters. EXAMPLE: 04.50

r. Course Width at Threshold: 106.75

s. ∆Offset: 0

t. Horizontal Alert Limit (HAL): 40

u. Vertical Alert Limit (VAL): 50

v. Final Approach Segment CRC Remainder: 32 bit cyclic redundancy check (CRC) appended to the end of each FAS Data Block in order to ensure approach data integrity. The CRC word is calculated on the entire data block.

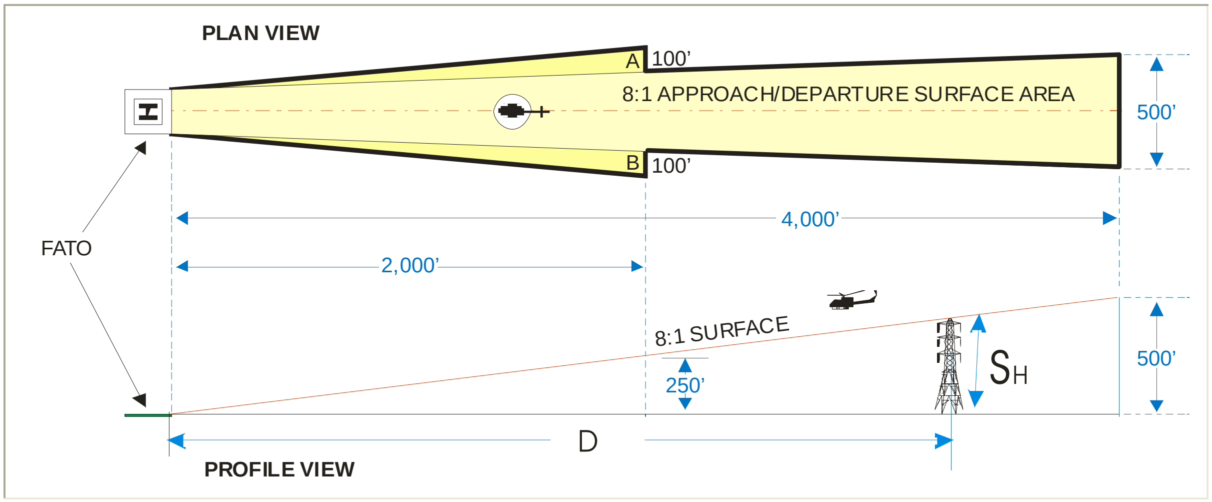
Appendix A. Conditions and Assumptions for IFR to VFR Heliport (IVH) (Proceed Visually) Approach Procedures

Before designing a special RNAV (GPS) IFR to a VFR heliport (IVH) approach procedure, ensure the heliport meets the following criteria:

1. FAA Form 7480-1, Notice of Landing Area Proposal, has been filed under Part 157.

2. No penetration of the 8:1 surface in AC 150/5390-2 is permitted (see figure A-1). Penetrations of either A or B areas but not penetrations of both areas are allowed if the obstructions are charted, and marked or lighted and if not considered a hazard. Use formula A-1 to determine height of the 8:1 surface.

Figure A-1. 8:1 Surface in AC 150/5390-2.



Formula A-1. 8:1 OCS height (S_H).

$$S_H = (r + HE) \cdot e^{\frac{D}{8r}} - r$$

Where:

D = C/L distance FATO edge to Obstacle

HE = Heliport Elevation

(r+HE)*e^(D/(8*r))-r

Calculator		
D (ft)		Click here to calculate
HE		
S_H		

3. An acceptable onsite evaluation of the heliport for VFR use is required. Order 8700.1, General Aviation Inspector's Guide, chapter 61 is to be used for evaluation of the heliport. Based on the FAA determination, a procedure can be developed under the following conditions:

a. No objection.

b. Conditional. Conditions have been resolved by the proponent, e.g., obstacle penetrations of the 8:1 approach area, transitional and lateral extension areas, or pertain to the minimum size of the FATO, TLOF, and Safety Area.

c. Objection. If an objection determination is issued, an IVH approach procedure is not authorized to be developed. A Point-in-Space (PinS) (Proceed VFR) approach procedure may be developed in accordance with chapter 5, paragraph 7.

4. An acceptable evaluation of the visual segment for flyability, obstacles, and visual references must be completed in both day and night flight conditions. The heliport or heliport visual references must be in clear view at the MAP, e.g., it cannot be completely obscured behind a building. A heliport is the area of land, water or a structure used or intended to be used for the landing and takeoff of helicopters, together with appurtenant buildings and facilities. Buildings and facilities associated with the heliport such as hangers, administration buildings, AWOS equipment, windsock, beacon, etc. located within 500 ft are acceptable visual references. Surrounding buildings and land marks are not allowable visual references, unless approved by Flight Standards. At least one of the following visual references must be visible or identifiable before the pilot may proceed visually:

a. FATO or FATO lights.

b. TLOF or TLOF lights.

c. Heliport Instrument Lighting System (HILS).

d. Heliport Approach Lighting System (HALS) or lead-in lights.

e. Visual Glideslope Indicator (VGSI).

f. Windsock or windsock light(s).*****

g. Heliport beacon.*

h. Other facilities or systems approved by Flight Standards (AFS-400).

***Note:** Windsock lights and heliport beacons should be located within 500 ft of the TLOF.

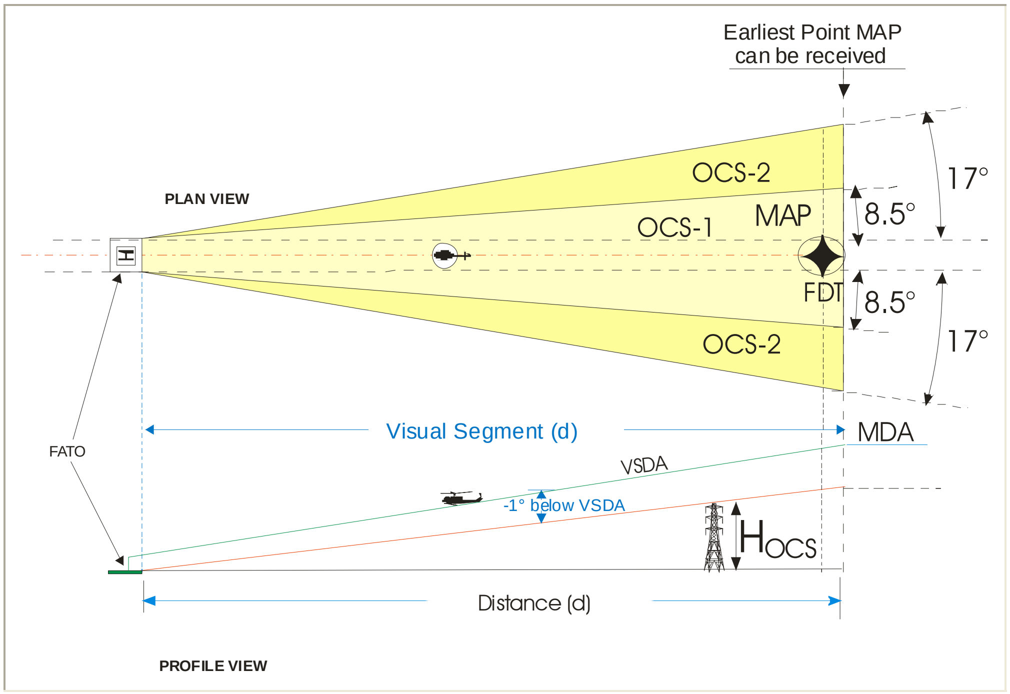
5. IFR Approach to a VFR Heliport (IVH) Analysis. The following analysis must be performed for authorizing an IVH procedure. Obstacle clearance surface (OCS) areas are applied using concepts from Order 8260.3, Volume 1, chapter 2, paragraph 251a (1) with the following exceptions:

a. **Alignment is always** centered on the visual segment centerline.

b. Length OCS-1 and OCS-2. The length of OCS-1 and OCS-2 begin from the edge of the FATO and extend to abeam the earliest point the MAP can be received (see figure A-2).

c. Area Width OCS-1 and OCS-2. OCS-1 splays outward 8.5 degrees from the outer edges of the FATO. OCS-2 splays outward 17 degrees from the outer edges of the FATO (see figure A-2).

Figure A-2. OCS for IVH Procedures.



Step 1: Calculate OCS-1 width ($W_{OCS\text{-}1}$) at distance (d) from the FATO edge using the formula A-2.

Formula A-2. OCS-1 Width (W_{OCS-1})		
$$W_{OCS\text{-}1} = \left[\tan\left(8.5^\circ \bullet \frac{\pi}{180}\right) \bullet d\right] + .5 \bullet F_W$$ Where: W_{OCS-1} = Perpendicular distance from the flight path to the edge of the OCS-1; d = Distance (ft) from the FATO edge measured along the flight path; F_W = FATO width		
[(tan(8.5*π/180)*d]+0.5*F_W		
Calculator		
d		Click here to calculate
F_W		
W_{OCS-1}		

Step 2: Calculate the OCS-2 width (W_{OCS-2}) at distance (d) from the FATO edge using the formula A-3.

Formula A-3. OCS-2 Width (W_{OCS-2})		
$$W_{OCS\text{-}2} = \left[\tan\left(17^\circ \bullet \frac{\pi}{180}\right) \bullet d\right] + .5 \bullet F_W$$ Where: W_{OCS-2} = Perpendicular distance from the flight path to the edge of the OCS-2; d = Distance (ft) from the FATO edge measured along the flight path; F_W = FATO width		
[(tan(17*π/180)*d]+0.5*F_W		
Calculator		
d		Click here to calculate
F_W		
W_{OCS-2}		

The slope of OCS-1 and OCS-2 is equal to the visual segment descent angle (VSDA) minus 1 degree measured from the FATO edge MSL elevation. Use formula A-4 to determine the MSL height of OCS-1 and OCS-2 at distance (D) from the FATO edge:

Formula A-4. OCS-1 and OCS-2 Slope (H_{OCS})

$$H_{OCS} = (r + HE) \bullet e^{\frac{D[\tan((VSDA-1)\cdot\frac{\pi}{180})]}{r}} - r$$

Where:

VSDA - 1= (VSDA minus 1 degree)
H_{ocs}= OCS-1 and OCS-2 MSL height
D = Distance (ft), FATO edge to obstacle
HE = Heliport/FATO edge elevation (MSL)

(r+HE)*e^(D*[tan((VSDA-1)*π/180)]/r)-r

Calculator

D		Click here to calculate
VSDA	°	
HE		
H_{OCS}		

d. If an unlighted obstacle penetrates OCS-1, a VGSI is required to be installed at the heliport.

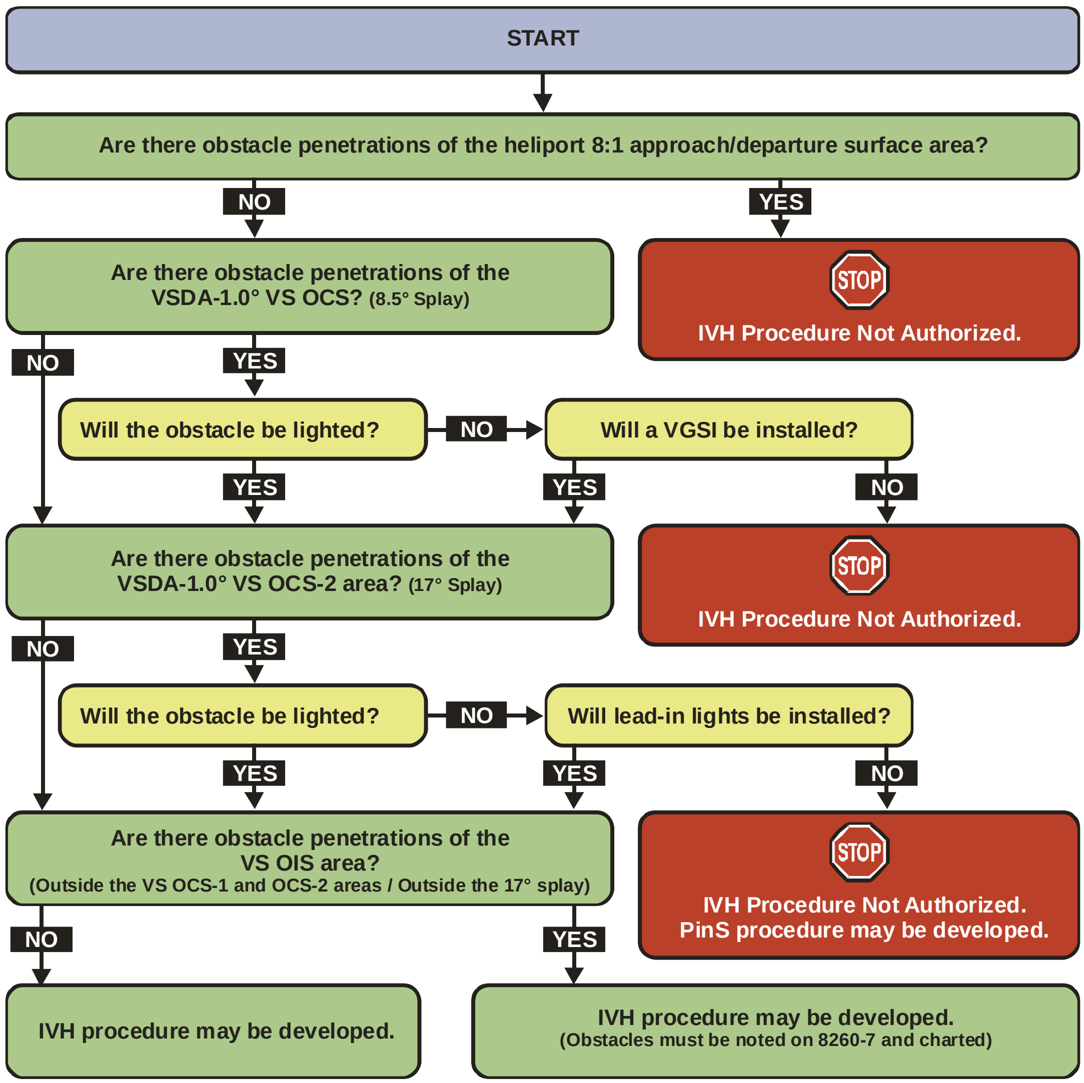
e. If an unlighted obstacle penetration is outside of OCS-1 but within OCS-2, the heliport must have lead-in lights to provide the pilot the visual cues to remain within the IVH OCS area.

f. The operational suitability of the lead in lights must be evaluated in accordance with appendix A, paragraph 4, during the night evaluation.

g If there are obstacle penetrations outside of the OCS-1 and OCS-2 areas but within the OIS area (see chapter 5, paragraph 5**,** these obstacle penetrations must be noted on 8260-7 and charted.

6. If any of these conditions are not met, a PinS (Proceed VFR) procedure may be developed in accordance with chapter 5, paragraph 7 (see figure A-3).

Figure A-3. IVH (Proceed Visually) versus PinS (Proceed VFR).



Appendix 2. TERPS Standard Formulas for Geodetic Calculations

1.0 Purpose.

The ellipsoidal formulas contained in this document must be used in determining RNAV flight path (GPS, RNP, WAAS, LAAS) fixes, courses, and distance between fixes.

Notes:

Algorithms and methods are described for calculating geodetic locations (latitudes and longitudes) on the World Geodetic System of 1984 (WGS-84) ellipsoid, resulting from intersections of geodesic and non-geodesic paths. These algorithms utilize existing distance and azimuth calculation methods to compute intersections and tangent points needed for area navigation procedure construction. The methods apply corrections to an initial spherical approximation until the error is less than the maximum allowable error, as specified by the user.

Several constants are required for ellipsoidal calculations. First, the ellipsoidal parameters must be specified. For the WGS-84 ellipsoid, these are:

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

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

$$SPHERE\_RADIUS\ (r) = \sqrt{ab} = 6{,}367{,}435.679716 \text{ m}.$$

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 calculation process some of which are illustrated in figure B-1:

Process 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).

Process 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).

Process 3: Given a point on a geodesic, find a second geodesic that is perpendicular to the given geodesic at that point.

Process 4: Given two geodesics, find their intersection point. (Labeled "4")

Process 5: Given two constant-radius arcs, find their intersection point(s). (Labeled "5")

Process 6: Given a geodesic and a separate point, find the point on the geodesic nearest the given point. (Labeled "6")

Process 7: Given a geodesic and an arc, find their intersection point(s). (Labeled "7")

Process 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")

Process 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")

Process 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")

Process 11: Compute the length of an arc.

Process 12: Determine whether a given point lies on a particular geodesic.

Process 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:

Process 14: Given a geodesic and a locus, find their intersection point.

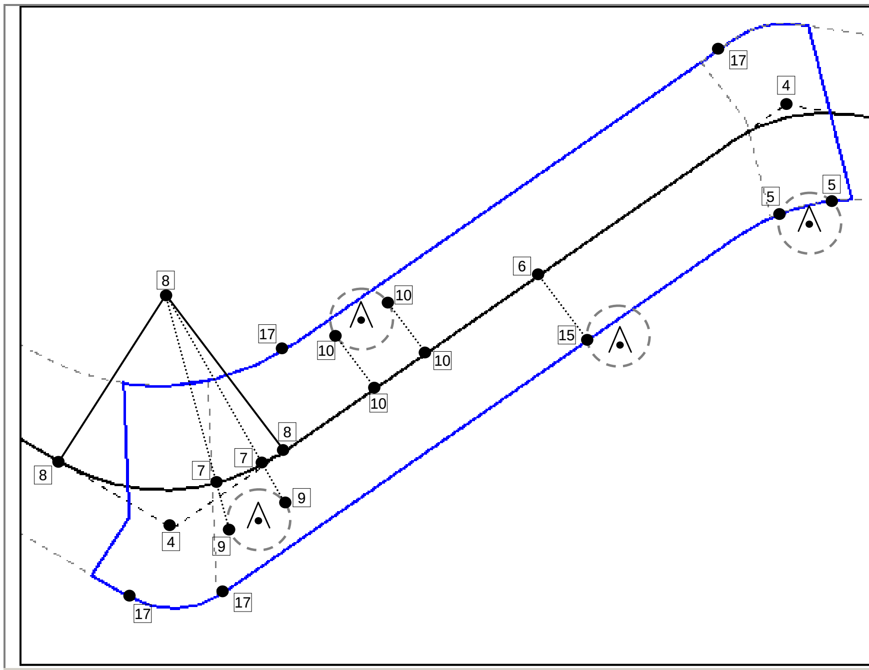
Process 15: Given a fixed-radius arc and a locus, find their intersection point(s). (Labeled "15")

Process 16: Given two loci, find their intersection.

Process 17: Given two loci and a radius, find the center of the arc tangent to both loci and the points of tangency. (Labeled "17")

The algorithm prototypes and parameter descriptions are given below using a C-like syntax. However, the algorithm steps are described in pseudo-code to maintain clarity and readability.

Figure B-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:

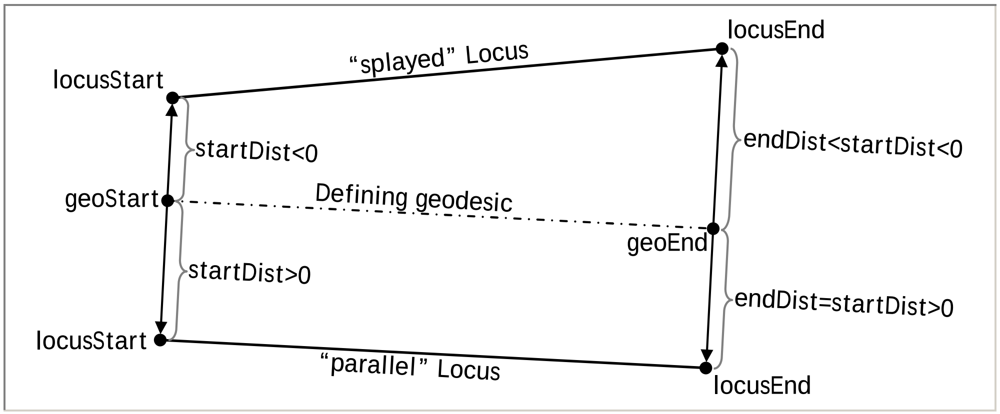
```
typedef struct {
   LLPoint geoStart;   /* start point of geodesic */
   LLPoint geoEnd;     /* end point of geodesic   */
   LLPoint locusStart; /* start point of locus    */
   LLPoint locusEnd;   /* end point of locus      */
   double startDist;   /* distance from geodesic  *
               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

```
    static double findLinearRoot(double* x, double* y,
                    long* err) {
  if (x[0] == x[1]) {
    /* function has duplicate x values, no root */
    return x[0];
  }
  else if (y[0] == y[1]) {
    if (y[0]*y[1] == 0.0) {
      return x[0];
    }
    /* duplicate y values in root function */
    return 0.5*(x[0]+x[1]);
  }
    return -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.

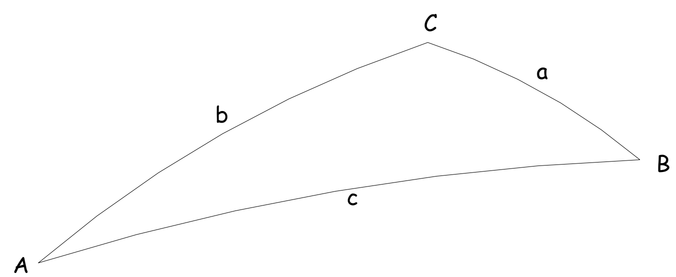
This iteration scheme works well for the algorithms described in this paper. Convergence is achieved very quickly because each starting solution is very close to the final solution, where the error is well approximated by a linear function.

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:

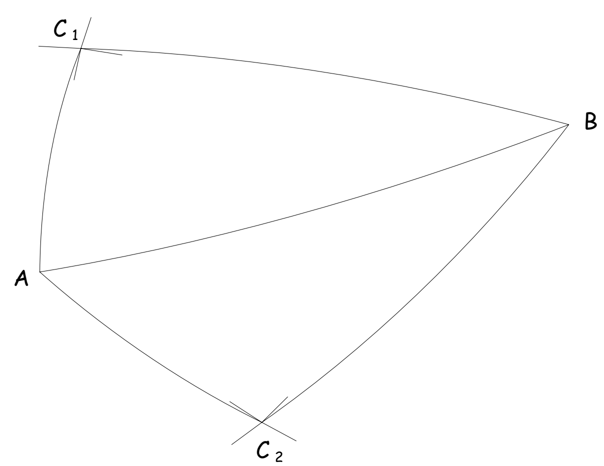
$$C = \cos^{-1}\left(-\cos(A)\cdot\cos(B)+\sin(A)\cdot\sin(B)\cos\left(\frac{c}{R}\right)\right),$$

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

Note: If distances a or b result from a reciprocal bearing, assign appropriate negative sign(s).

Run Direct from A to find C. Use given bearing and computed length b.

3.2.2 Spherical Distance Intersection.



Given A, B and distances AC and BC, find C_1 and C_2.

Run Inverse to find length and bearings between A and B.

Use spherical triangles to find angles A =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.

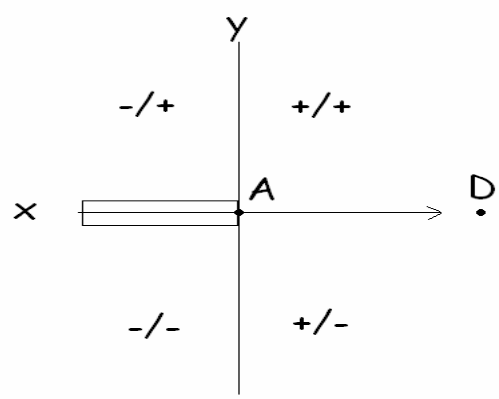
To compute the bearing from A to $C_{1,}$ start with the bearing from A to B and subtract angle A.

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.

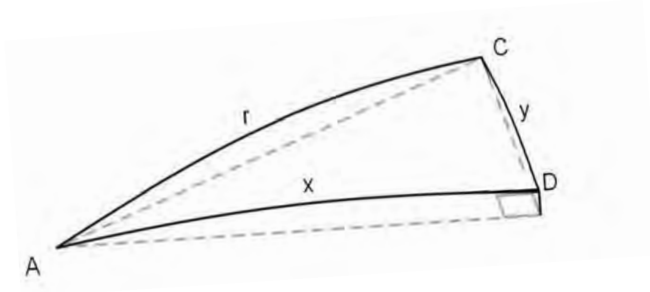
3.2.3 Spherical Tangent Point.

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.

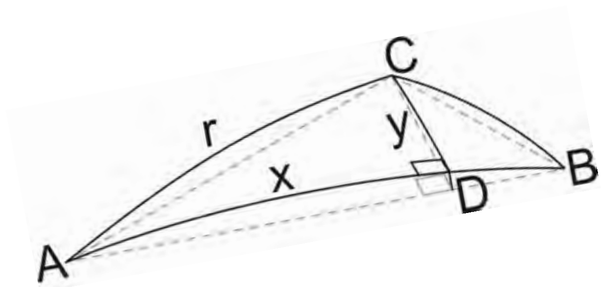
Find difference in bearings to compute angle A.

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.

<u>Vincenty's notation is annotated below</u>:

$a, b,$ major and minor semi axes of the ellipsoid.

$f,$ flattening $= \frac{a-b}{a}$.

$\phi,$ 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.

$$\tan \sigma_1 = \frac{\tan U_1}{\cos \alpha_1} \tag{1}$$

$$\sin \alpha = \cos U_1 \sin \alpha_1 . \tag{2}$$

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

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

$$2\sigma_m = 2\sigma_1 + \sigma \tag{5}$$

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

$$\sigma = \frac{s}{bA} + \Delta\sigma \tag{7}$$

Equations (5), (6), and (7) are iterated until there is a negligible change in σ. The first approximation of σ is the first term of (7).

Note 1: For 1 cm accuracy, σ can change no more than 1.57e-009.

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

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

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

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

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

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.

$\lambda = L$ (first approximation) (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).

The remainder of this appendix will assume the direct and inverse use the following named functions:

`Long WGS84Dest (LLPoint, origin, double course, double distance, LLPoint* dest, double eps)` returns an `LLPoint` representing the destination point, where the inputs are:

`LLPoint origin`	=	Starting `LLPoint` with lat/lon in radian
`Double course`	=	Azimuth of geodesic at origin in radians
`Double distance`	=	Distance to desired point (in NM)
`LLPoint* dest`	=	Reference to `LLPoint` that will be updated with lat/lon of destination
`Double eps`	=	Maximum error allowed in computation

`Long WGS84Inverse (LLPoint origin, LLPoint dest, double* crs, double* bcrs, double* dist, double eps)` returns course and distance where the inputs are:

`LLPoint origin`	=	Coordinates of starting point
`LLPoint dest`	=	Coordinates of destination point
`Double* crs`	=	Reference to double that will be updated with course at origin in radians
`Double* bcrs`	=	Reference to double that will be updated with reciprocal course at destination in radians
`Double* dist`	=	Reference to return value that will contain the distance between `origin` and `dest`
`Double eps`	=	Maximum error allowed in computation

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. The following pseudo-code represents an algorithm that will calculate the correct azimuth at any point on a geodesic described by its start and end points. This azimuth can easily be extended to find the azimuth of an intersecting geodesic at the point if the angle of intersection is known.

3.5.1 Input/Output.

`double WGS84GeodesicCrsAtPoint(LLPoint startPt, LLPoint endPt, LLPoint testPt, int length, double* startCrs, double* revCrs, double* distToPt, long* err, double tol, 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 endPt`	=	Coordinates of end point of geodesic
`LLPoint testPt`	=	Point at which course of geodesic is to be determined
`double* startCrs`	=	Azimuth of geodesic at `startPt` in radians
`double* revCrs`	=	Reciprocal azimuth of geodesic at `endPt` in radians
`double* distToPt`	=	Distance from `startPt` to `testPt` in NM
`double tol`	=	Accuracy tolerance for intersection calculation
`double eps`	=	Convergence parameter for forward/inverse algorithms

3.5.2 Algorithm Steps.

STEP 1: Use the WGS84PtIsOnLine algorithm to check that `testPt` actually lies on geodesic defined by `startPt` and `endPt`.

STEP 2: Use Inverse algorithm to determine course and distance from `testPt` to `startPt`. Denote course as `crsToStart`.

STEP 3: Use Inverse algorithm to determine course and distance from `testPt` to `endPt`. Denote course as `crsToEnd`.

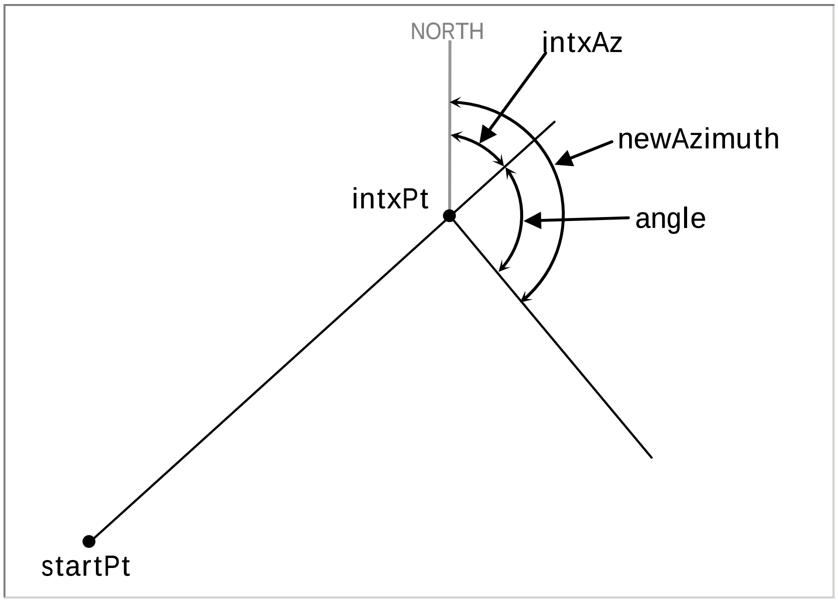
STEP 4: If `testPt` lies on geodesic between `startPt` and `endPt`, then the correct azimuth is `crsToEnd`.

STEP 5: If `testPt` lies on the geodesic beyond `endPt`, then the correct azimuth is `crsStart +` π.

STEP 6: 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 B-3. Projecting A Geodesic Through A Point Along The Specified Azimuth.



3.6 Determine If Point Lies on Geodesic.

This algorithm returns a 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 beyond both the start and end points.

Note that this algorithm relies on the concept of equality for two `LLPoint` structures. This will be defined to mean that the distance between the two `LLPoints`, as calculated using the inverse algorithm, is less than `tol`.

3.6.1 Input/Output.

`int WGS84PtIsOnLine(LLPoint startPt, LLPoint endPt, LLPoint testPt, LineType lengthCode, double tol, double eps)` 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

`LineType lengthCode`	=	Integer that specifies extent of line.
		`0`: geodesic exists only between `startPt` and `endPt.`
		`1`: geodesic extends beyond `endPt.`
		`2:` geodesic extends behind `startPt.`

`double tol`	=	Maximum difference allowed in distance
`double eps`	=	Convergence parameter for forward/inverse algorithms

3.6.2 Algorithm Steps.

See figure B-4 for an illustration of the variables.

STEP 1: Use inverse algorithm to calculate the azimuth and distance from `startPt` to `endPt`. Denote these values by `crs12` and `dist12`, respectively.

STEP 2: Use `WGS84PtIsOnCrs` algorithm to determine if `testPt` lies on geodesic given by `startPt` and `endPt`.

1. Use inverse algorithm to calculate the distance from `startPt` to `testPt`. Denote this value by `tmpDist1Test`.

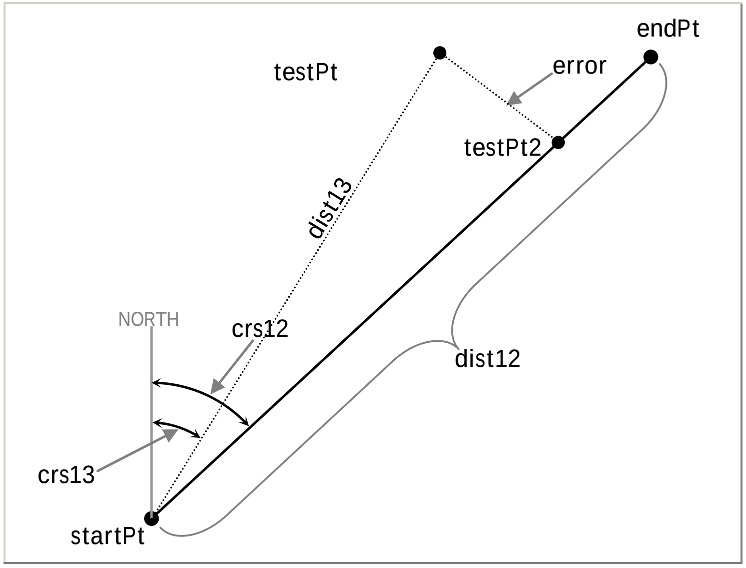
2. Use direct algorithm to project a point from `startPt`, along `crs12`, a distance equal to `tmpDist1Test`. Denote this point by `comparePt.`

3. Use `WGS84PointsAreSame` algorithm to determine if `testPt` is equal to `comparePt`.

STEP 3: Examine `error` to determine whether `testPt` lies on the geodesic within `tol` as follows:

1. If (`error` $\leq$ `tol`) then
   a. If (`lengthCode` > 0) or (`dist13-dist12` $\leq$ `tol`) then
      (1) `onLine` = `true`
   b. else
      (1) `onLine` = `false`
2. end if
3. Else if (`lengthCode = 2`)
   a. Use the direct algorithm to project point from `startPt`, along `crs12+`π a distance `dist13`. Again, denote this point again by `testPt2`
   b. Use the inverse algorithm to recalculate `error`, which is the distance from `testPt` to `testPt2.`
   c. If (`error` $\leq$ `tol`) then `onLine` = `true`
      (1) Else `onLine` = `false`
4. End if
5. Else
   a. `onLine` = `false`
6. End if

Figure B-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, ArcDirection orientation, 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
`ArcDirection orientation`	=	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 B-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 6.0 - Calculate Angular Arc Extent to calculate the angle subtended by the full arc. Denote this value by `arcExtent`.

b. If (`arcExtent` = 360°) then

(1) `onArc = true.`

c. else.

(1) Use the inverse algorithm to calculate the azimuth from center to `testPt`. Denote this value by `testCrs`.

(2) Use Algorithm 6.0 - Calculate Angular Arc Extent to calculate the angle subtended by and arc starting at `startCrs`, but ending at `testCrs`, with the same `orientation`. Denote this value by `subExtent`.

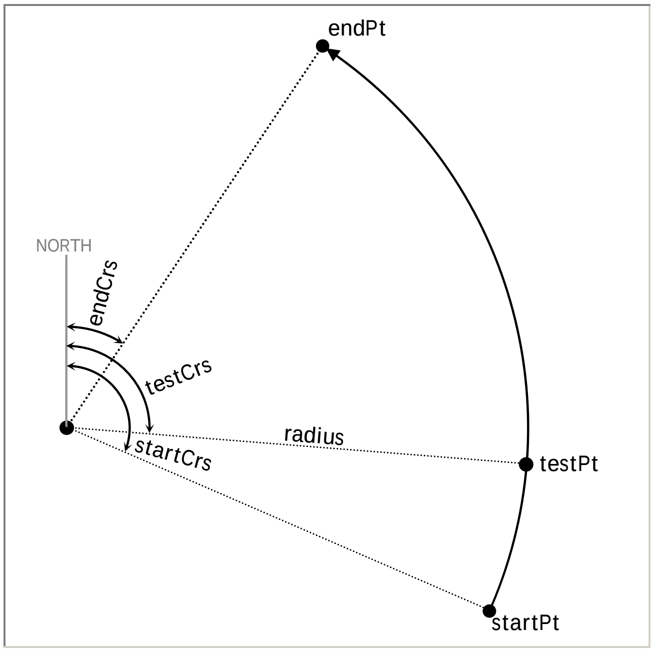
(3) If `(-.002 ≤ subExtent ≤ arcExtent +.002)` then traversing arc from `startCrs` to `endCrs`, one would encounter `testPt`, so it must lie on arc.

(a) `onArc = true`.

d. end if.

STEP 4: end if.

Figure B-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 B-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 6.0.

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, `dtheta = 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`.

(1) Compute azimuth from arc center to end point of sub-arc number `i`: `theta = startCrs + i*dtheta.`

(2) 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`.

(3) Convert `p2` to ECEF coordinate `v2`.

(4) Use direct algorithm from `center`, using azimuth `theta+dtheta` and distance `radius`, to project endpoint of sub-arc. Denote this point by `p3`.

(5) Convert `p3` to ECEF coordinate `v3`.

(6) Subtract `v2` from `v1` to find chord vector between `p1` and `p2`. Denote this vector by `chord1`. Compute `x1 = |chord1|`.

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

(8) Compute dot product of `chord1` and `chord2`. Denote this value as `d`.

(9) Use the following calculation to compute the length `L` of the sub-arc: (see figure B-7)

(a) `xi = d/(x1*x2)`

(b) `sigma = sqrt(1-xi^2)`

(c) `R = (x2*sqrt((x1/x2 - xi)^2 + sigma^2))/(2*sigma)`

(d) `A = 2(π - arccos(xi))`

(e) `L = R*A`

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

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

(10) Add `L` to cumulative `length` to get total length of sub-arcs through sub-arc number `i`: `length = length + L`.

f. end for loop.

g, Compute error, which is the change in length calculation between this iteration and the last: `error = abs(length – 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 = length`.

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

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

Figure B-6. Calculating Arc Length.

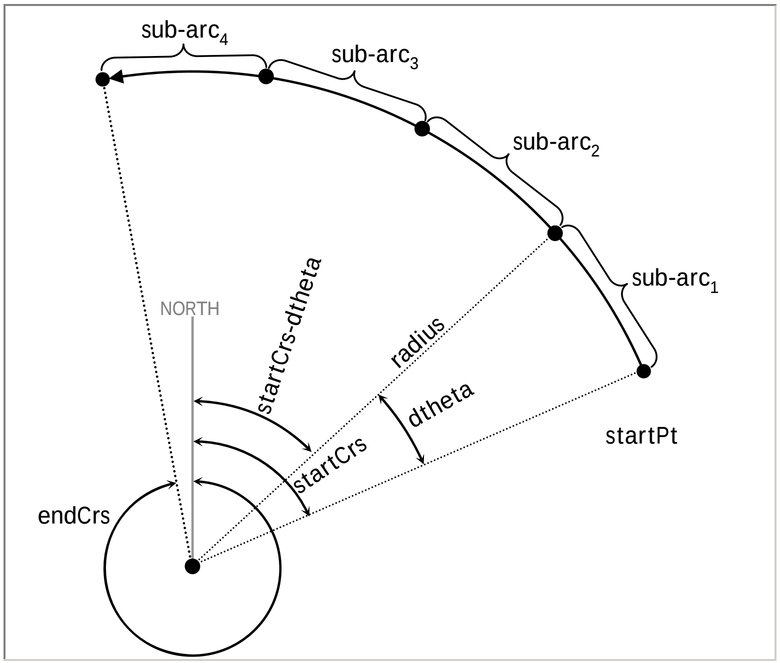
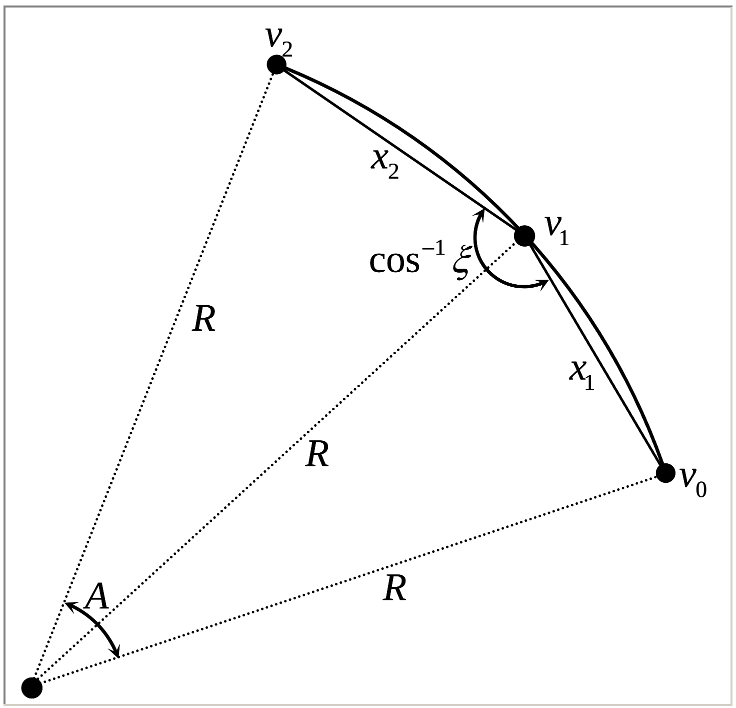


Figure B-7. Calculating the Sub-Arc Length.



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)` 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 WGS84DistToLocusP (Locus loc, LLPoint geoPt, double *faz, 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 *faz`	=	Pointer used to return forward azimuth of geodesic at `geopt`. This is needed if `geopt` is not between `geoStart` and `geoEnd`.
`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:

$$\mathtt{distToLoc} = \mathtt{loc.startDist} + \frac{\mathtt{distance}}{\mathtt{geoLen}} * (\mathtt{loc.endDist} - \mathtt{loc.startDist})$$

STEP 4: End if

STEP 5: Return `distToLoc`

3.10 Project Point on Locus from Point on Defining Geodesic.

Given a point on the defining geodesic, this algorithm computes the corresponding point on the locus.

3.10.1 Input/Output.

```
LLPoint WGS84PtOnLocusP (Locus loc, LLPoint geoPt,
LLPoint* ptonloc, double* perpCrs, 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
`LLPoint* ptonloc`	=	Pointer to LLPoint, updated with coordinates of point on locus abeam given point.
`double* perpCrs`	=	Pointer to double, updated with azimuth from point on geodesic to point on locus.
`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 `*perpCrs = fcrs + π/2`

STEP 5: Else, the locus lies to the left of the geodesic. Let

`*perpCrs = fcrs - π/2`

STEP 6: End if

STEP 7: Use the direct algorithm to project a point along `*perpCrs`, 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.

`int WGS84PtIsOnLocus (Locus loc, LLPoint testPt, LLPoint* ptOnGeo, double tol, double eps)` 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
`LLPoint* ptOnGeo`	=	Pointer to `LLPoint`, updated with point on defining geodesic abeam the given point on the locus.
`double tol`	=	Maximum allowable error
`double eps`	=	Convergence parameter for forward/inverse algorithms

3.11.2 Algorithm Steps.

See figure B-8 for an illustration of the variables.

STEP 1: If `testPt` is the same as `loc.geoStart` or `loc.geoEnd` then return a reference to `ptOnGeo` containing the appropriate point.

STEP 2: Use Algorithm 5.1 to project `testPt` onto the locus's defining geodesic. Denote the projected point as `ptOnGeo`.

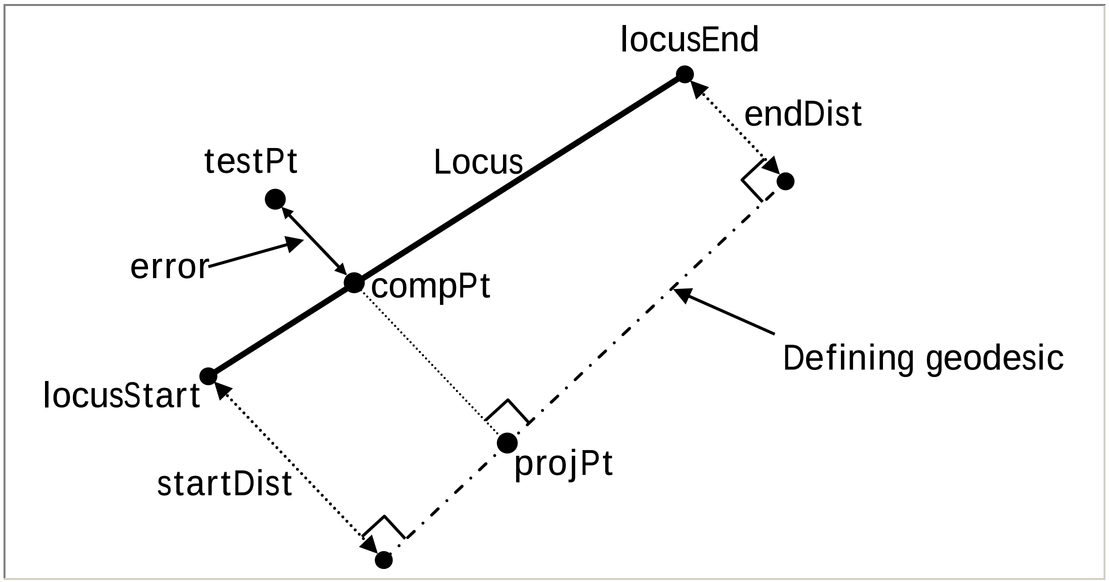
STEP 3: Use Algorithm 3.6 to determine whether `ptOnGeo` lies on the locus's defining geodesic. This will account for an infinite or semi-infinite locus. If it does not, then return `0` (false).

STEP 4: Use the Inverse Algorithm to find the course between `loc.geoStart` and `testPt`. Use this course to determine which side of the locus `testPt` falls. Apply the appropriate sign to this distance, `distFromPoint`.

STEP 5: Use Algorithm 3.9 to calculate the correct expected locus distance, `locDist`.

STEP 6: If `abs`(`distFromPoint - locDist`) <= tol, then the point is on the locus. Return a reference to the projection on the defining geodesic.

Figure B-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 B-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:

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

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

$$\text{slope} = \text{atan}(\text{slope})$$

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

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

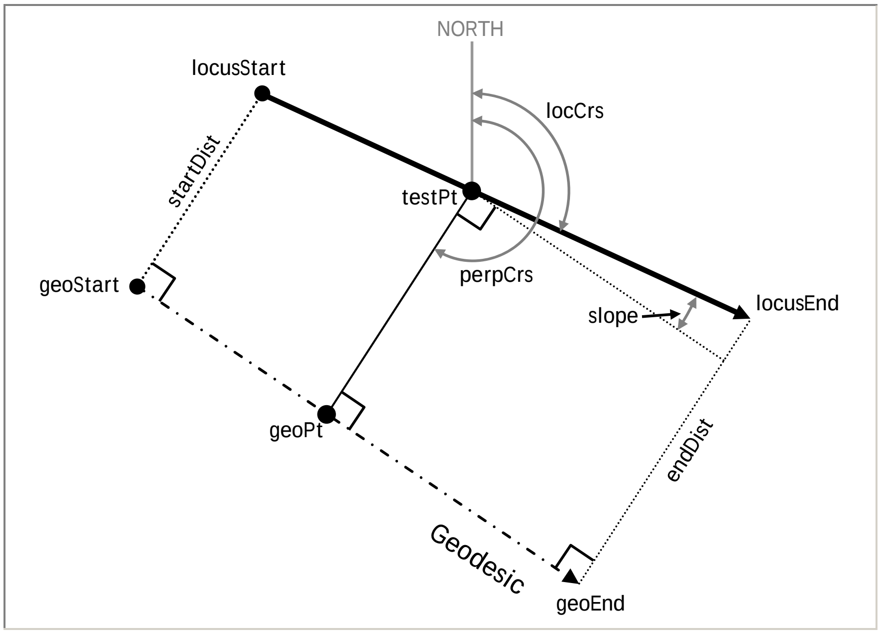
STEP 8: If (`distToLoc < 0`), then `testPt` lies to the left of the geodesic, so `perpCrs` points to the right of the locus's course:

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

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

STEP 10: Return `locCrs`

Figure B-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.

`long WGS84CrsIntersect(LLPoint pt1, double crs13, double* crs31, double* dist13, LLPoint pt2, double crs23, double* crs32, double* dist23, LLPoint* intx, double tol)` returns a reference to an `LLPoint` structure that contains the intersection coordinates, where the inputs are:

`LLPoint pt1`	=	Start point of first geodesic
`double crs13`	=	Azimuth from `pt1` to intersection point
`double* crs31`	=	Reference to azimuth from intersection point to `pt1`
`double* dist13`	=	Reference to distance from `pt1` to intersection
`LLPoint pt2`	=	Start point of second geodesic

`double crs23`	=	Azimuth from `pt2` to intersection point
`double* crs32`	=	Reference to azimuth from intersection to `pt2`
`double* dist23`	=	Reference to distance between `pt2` and intersection point
`LLPoint* intx`	=	Reference to intersection point
`double tol`	=	Maximum error allowed in solution
`double eps`	=	Convergence parameter for forward/inverse algorithms

4.1.2 Algorithm Steps.

See figure B-10 for an illustration of the variables.

STEP 1: Use inverse algorithm to calculate distance, azimuth and reverse azimuth from `pt1` to `pt2`. Denote these values by `dist12`, `crs21` and `crs12`, respectively. Run a check to see if `pt1` lies on the geodesic defined by `pt2` and `crs23` and if `pt2` lies on the geodesic defined by `pt1` and `crs13`.

a. If `pt1` falls on geodesic 2 and `pt2` falls on geodesic `1`.

(1) Return an error. Courses are collinear. There are infinite intersections.

b. If `pt1` falls on geodesic `2`.

(1) Return intersection = `pt1`.

c. If `pt2` falls on geodesic `1`.

(1) Return intersection = `pt2`.

STEP 2: Calculate the signed azimuth difference in angle between `crs12` and `crs13`, denoted by `angle1`.

STEP 3: Calculate the signed azimuth 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 `pt1-pt2` line and cannot intersect in this hemisphere. Use reciprocal course so that the nearest intersection may be found.

a. If `abs(angle1) > abs(angle2)`

(1) `angle1 = (crs13+π) - crs12`

b. Else

(1) `angle2 = crs21 - (crs23+π)`

STEP 5: End if.

STEP 6: Locate the approximate intersection point, `intx`, using a spherical earth model. See the documents referenced in section 2.2 methods to accomplish this.

STEP 7: The following steps describe the function `iterateLineIntersection` which is called once the initial approximation, `intx`, of the line intersection is found. The purpose of the `iterateLineIntersection` function is to further refine the solution.

STEP 8: Use the inverse algorithm to calculate `dist13`, the distance from `pt1` to `intx`.

STEP 9: Use the inverse algorithm to calculate `dist23`, the distance from `pt2` to `intx`.

STEP 10: If `dist13 < tol`, then the intersection point is very close to `pt1`. Calculation errors may lead to treating the point as if it were beyond the end of the geodesic. Therefore, it is helpful to move `pt1` a small distance along the geodesic.

1. Use the direct algorithm to move `pt1` from its original coordinates 1 nm along azimuth `crs13 + π`.

2. Use the inverse algorithm to calculate the azimuth `acrs13` for the geodesic from the new `pt1`.

STEP 11: Repeat steps 10, 10(1), and 10(1) for `pt2` and `crs23`.

STEP 12: If (`dist23` < `dist13`) then the intersection point is closer to `pt2` than `pt1`. In this case, the iterative scheme will be more accurate if we swap `pt1` and `pt2`. This is because we iterate by projecting the approximate point onto the geodesic from `pt1` and then calculating the error in azimuth from `pt2`. If the distance from `pt2` 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` = `pt1`

b. `pt1` = `pt2`

c. `pt2` = `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 `pt2` will be measured as a function of distance from `pt1`. The two most recent distances from `pt1` are stored in a two element array. This array is initialized with the distance from `pt1` to `intx`:

STEP 15: Use the direct algorithm to project `intx` onto the geodesic from `pt1`. Use `pt1` 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 `pt2` to `intx`.

STEP 17: Initialize the error array:
`errarray[0] = signedAzimuthDifference`(`acrs23`, `crs23`).

`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 `intx` onto the geodesic from `pt1`. Use `pt1` 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 `pt2` to `intx`.

STEP 21: Initialize the error array:
`errarray[1] = signedAzimuthDifference(acrs23, crs23)`.

STEP 22: Initialize `k = 0`

STEP 23: Do while (`k=0`) or ((`error` > `tol`) and (`k` ≤ `MAX_ITERATIONS`))

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 `pt1`. Use `pt1` 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 `pt2` to `intx`.

d. Use the inverse algorithm to compute the distance from `newPt` to `intx` (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)
```

f. Increment `k`: `k` = `k` + 1

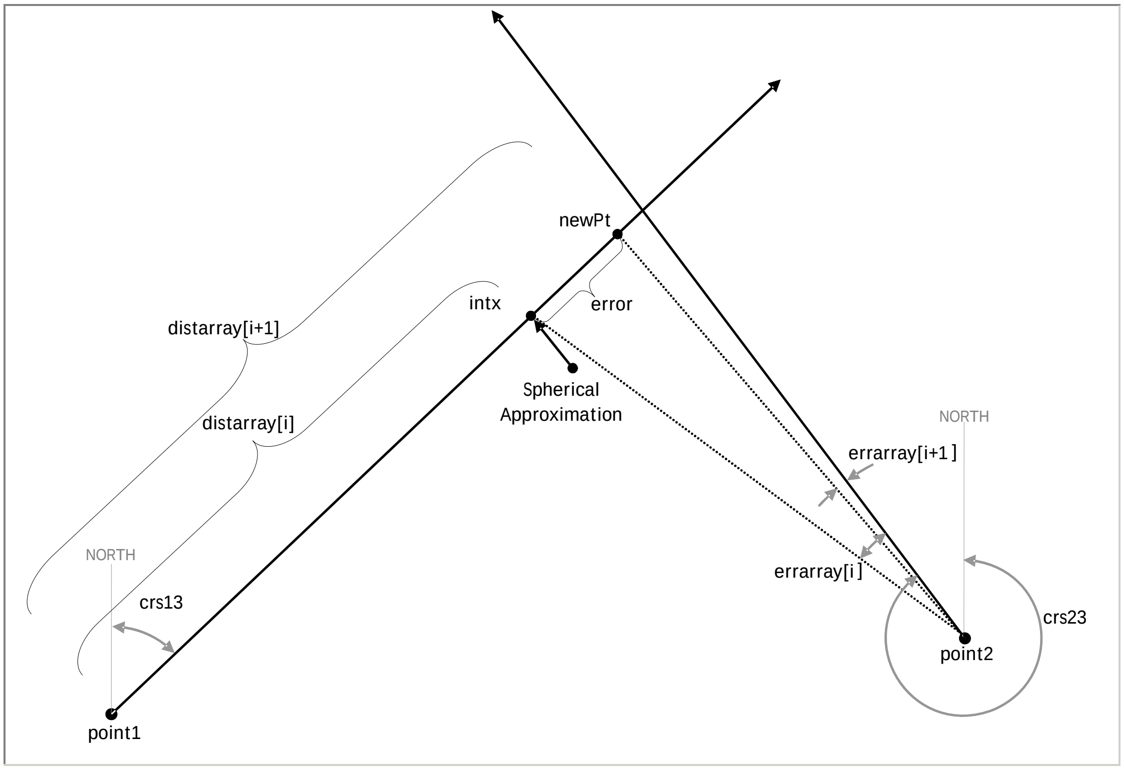
STEP 24: End while loop

STEP 25: Check if `k` reached `MAX_ITERATIONS`. If so, then the algorithm may not have converged, so an error message should be displayed.

STEP 26: The distances and azimuths from `pt1` and `pt2` to `intx` are available at the end of this function, since they were calculated throughout the iteration. It may be beneficial to return them with the `intx` coordinates, since they may be needed by the calling function. If this is done, and if `swapped = 1`, then the original identities of `pt1` and `pt2` were exchanged and the azimuths and distances must be swapped again before they are returned.

STEP 27: Return `intx`.

Figure B-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.

`long WGS84ArcIntersect(LLPoint center1, double radius1, LLPoint center2, double radius2, LLPointPair intx, 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

`LLPointPair intx`	=	Two-element array of `LLPoint` objects that will be updated with intersections' coordinates
`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 B-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.

STEP 4: End if

STEP 5: Calculate approximate intersection points, `intx[0]` and `intx[1]`, according to section 3.2.

STEP 6: Iterate to improve approximation to `pt`:
a. `k` = 0

b. Use inverse algorithm to find azimuth from `center2` to `pt`, denote this value as `crs2x`.

c. Use direct algorithm to move `pt` 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 `pt`. 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(errarray[1]) > tol`), improve approximation

(1) Use direct function to move `pt` 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.

(2) Use inverse function to find azimuth from `center2` to `pt`, `crs2x`.

(3) Use direct function to move `pt` along `crs2x` to circumference of circle2. Use `center2` as starting point, `crs2x` as azimuth, and `radius2` as distance.

(4) Use inverse algorithm to compute distance and azimuth from `center1` to `pt`. Denote these values as `dist1x` and `crs1x`, respectively.

(5) Update function arrays:

```
crsarray[0] = crsarray[1]
crsarray[1] = crs1x
errarray[0] = errarray[1]
errarray[1] = error
```

(6) Use linear root finder to find the azimuth value that corresponds to zero error. Update the variable `crs1x` with this root value.

(7) Increment `k`: `k = k` + 1

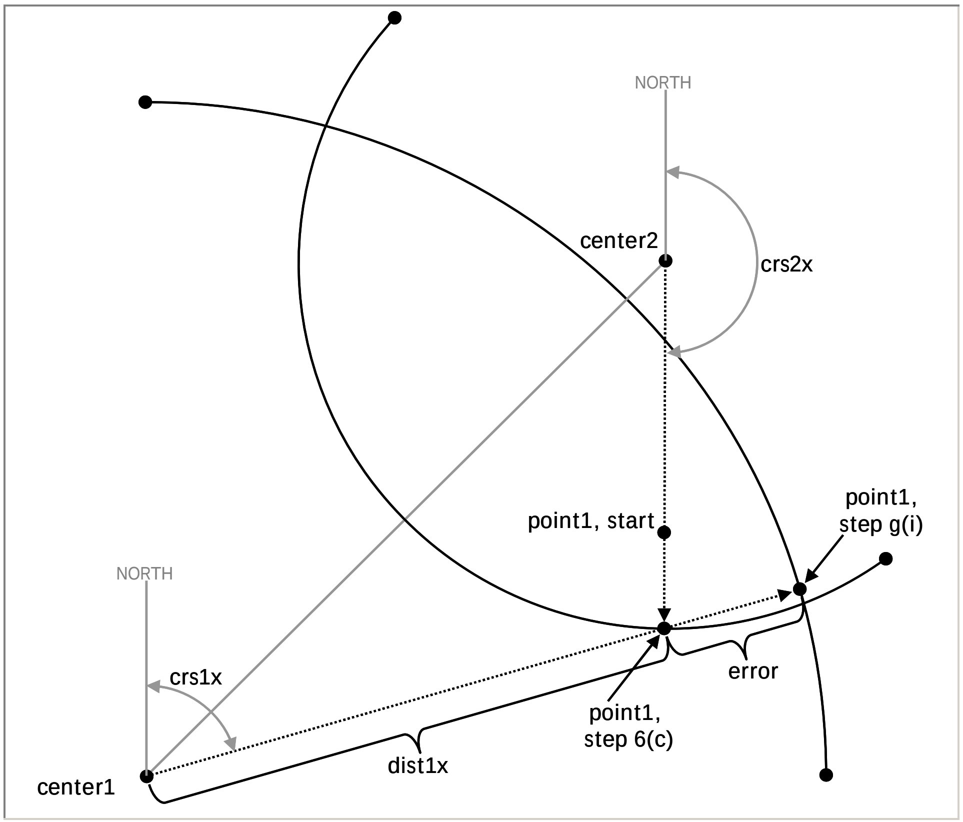
h. End while loop.

STEP 7: Store `point` in array to be returned: `intx[0] = point`.

STEP 8: Repeat step 6 for approximation `intx[1]`.

STEP 9: Return array `intx`.

Figure B-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.

`long WGS84LineArcIntersect(LLPoint pt1, double crs1, LLPoint center, double radius, LLPointPair intx, 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
`double crs1`	=	Initial azimuth of geodesic at start point
`LLPoint center`	=	Geodetic coordinates of arc center point
`double radius`	=	Arc radius in nautical miles
`LLPointPair intx`	=	Two-element array of `LLPoint` objects that will be updated with intersections' coordinates
`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 B-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`. Denote the distance as `perpDist`.

STEP 2: Use inverse Algorithm to calculate the azimuth of the geodesic at `perpPt`. Denote the azimuth from `perpPt` to `pt1` as `crs`.

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 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 7: 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 8: Initialize iteration count `k = 0`.

STEP 9: 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 10: Calculate error for this iteration: `error = radius – radDist`

STEP 11: 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 12: Do one iterative step using spherical approximation near intersection point (see figure B-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 figure B-13:

```
B=abs(signedAzimuthDifference(bcrs, rcrs)
```

c. Calculate the angle opposite the radial error:
`A=acos[sin(B)*cos(abs(error)/sphereRad)]`

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

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

f. Else, use a spherical triangle approximation for `c`:
`c=sphereRad*asin[sin(error/sphereRad)/sin(A)]`

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 as `radDist`.

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

<u>STEP 13</u>: 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]  = error
```

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

<u>STEP 14</u>: End while loop

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

<u>STEP 16</u>: Repeat steps 13 - 14 to improve solution for `intx[1]`

<u>STEP 17</u>: Return `intx[0]` and `intx[1]`

Figure B-12. Locating First Intersection of Geodesic and Arc.

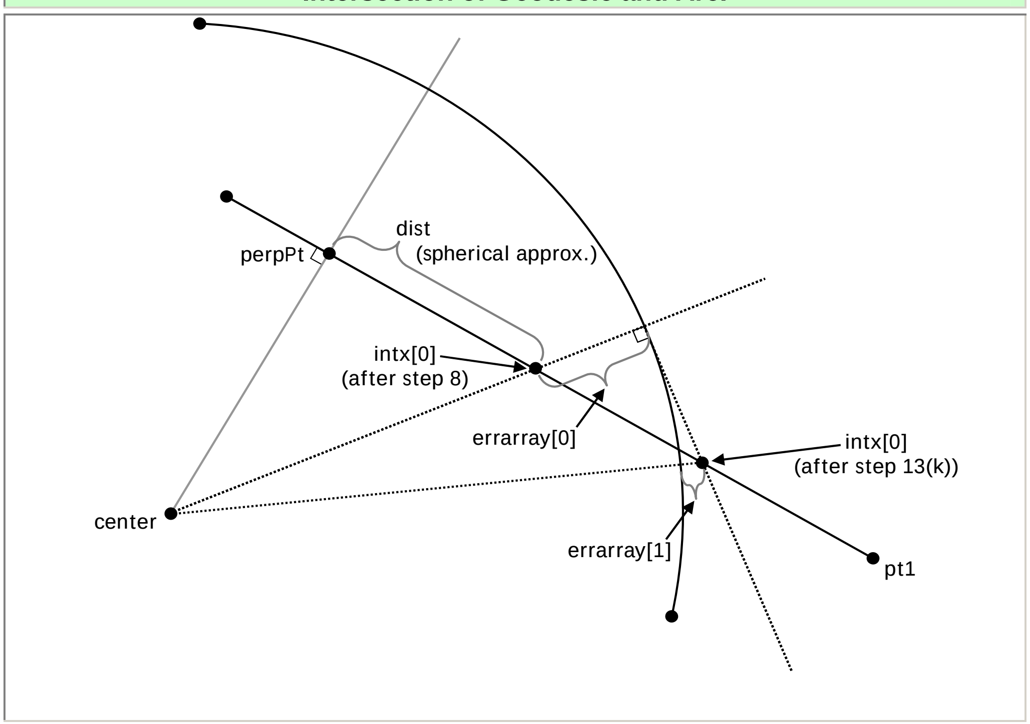
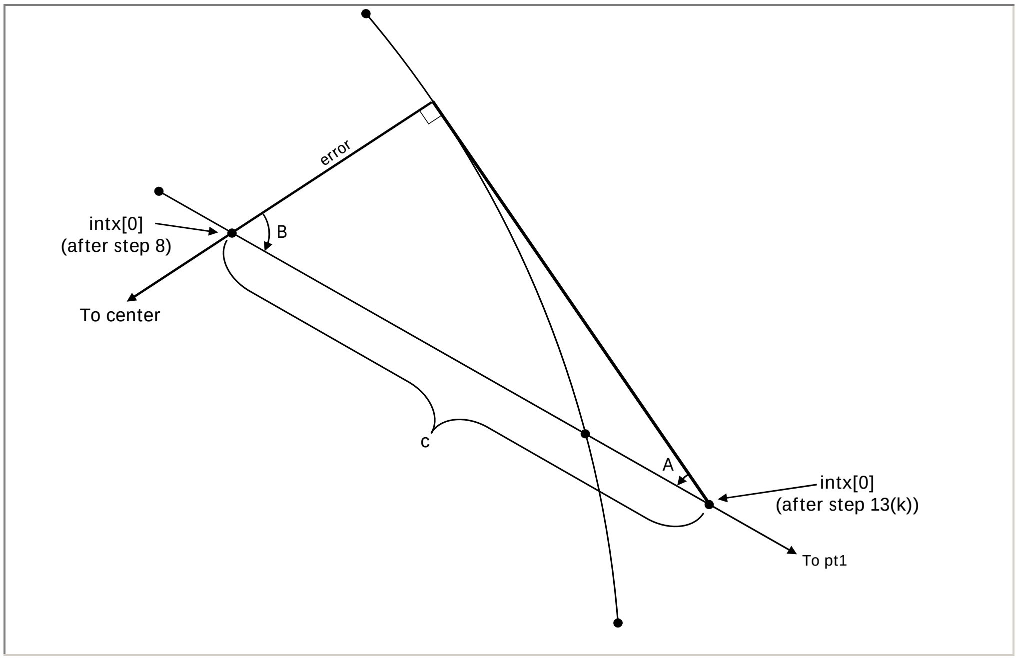


Figure B-13. Area Near the Appropriate Geodesic-Arc Intersection Point With Spherical Triangle Components That Are Used to Improve the Solution.



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 outgoing geodesics, the two tangent points must be different distances from the geodesics' intersection point.

4.4.1 Input/Output.

`long WGS84TangentFixedRadiusArc(LLPoint pt1, double crs12, LLPoint pt3, double crs3, double radius, ArcDirection* 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

`ArcDirection* 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 B-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 6.2). Denote this value by `vertexAngle`:
`vertexAngle=signedAzimuthDifference(crs21,crs23)`

STEP 7: If `abs(sin(vertexAngle)) < tol`, then either there is no turn or the turn is `180` degrees. In either case, no tangent arc can be found.

a. Return empty array.

STEP 8: Else if `vertexAngle > 0` then course changes direction to the right: `dir = -1`

STEP 9: Else, the course changes direction to the left: `dir = 1`

STEP 10: End if

STEP 11: Use spherical triangle calculations to compute the approximate distance from `pt2` to the points where the arc is tangent to either geodesic. Denote this distance by `distToStart`:

a. `B=vertexAngle/2`

b. If (`radius > sphereRad*B`) then no arc of the required radius will fit between the given geodesics

(1) Return empty array

c. End if

d. Calculate `distToStart` using the approximate formula from Napier's Rule of Circular Parts.

```
distToStart=sphereRad*asin(tan(radius/sphereRad)/tan(B))
```

STEP 12: Initialize the iteration count: `k = 0`

STEP 13: Initialize the error measure: `error = 0.0`

STEP 14: 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):`

```
distToStart=distToStart+(error/sin(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 π`/2` to `perpCrs` to get the azimuth from `startPt` to center of arc:

```
perpCrs=perpCrs+π/2
```

e. Else, the tangent arc must curve to the left. Subtract `π/2` from `perpCrs` to get the azimuth from `startPt` to center of arc:

```
perpCrs=perpCrs-π/2
```

f. End if.

g. Use the direct algorithm to locate the arc center point, `centerPoint`. Use `startPt` as the starting point, `perpCrs` for the azimuth, and radius for the distance.

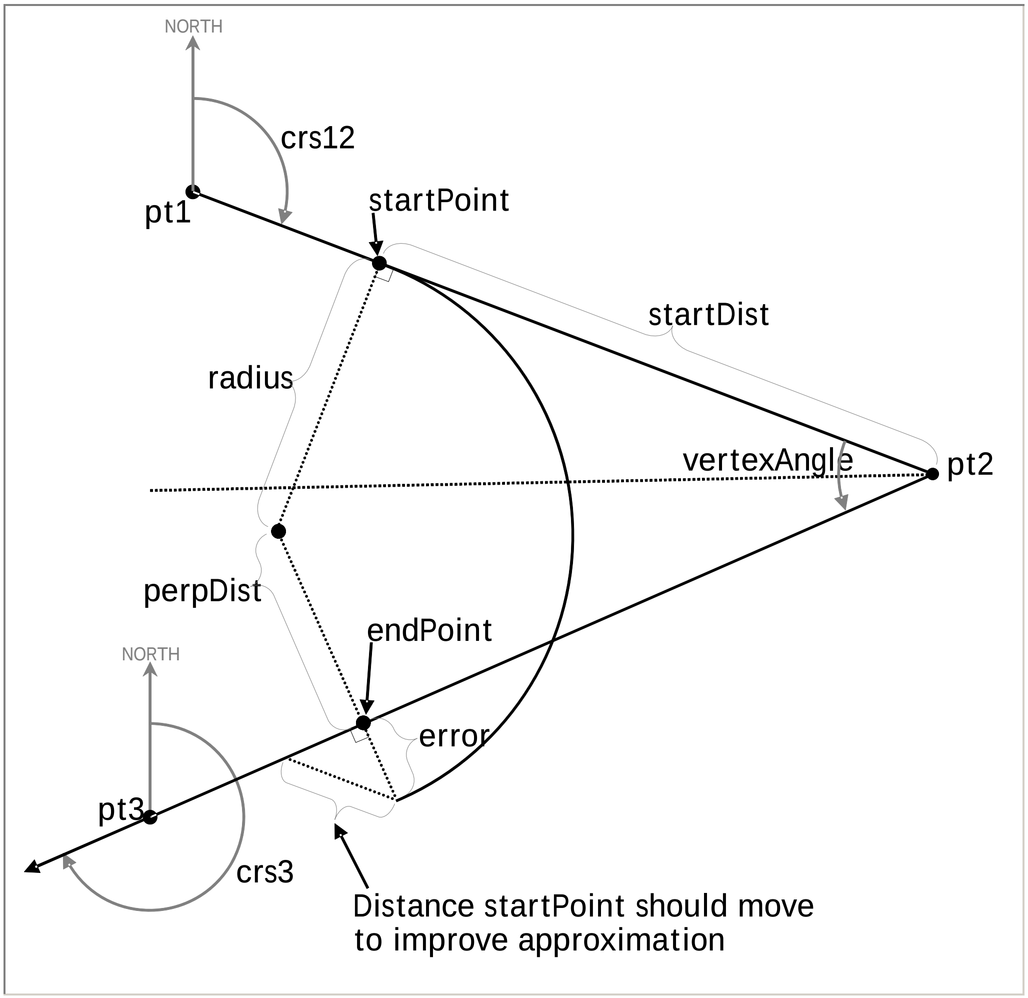
h. Use Algorithm 5.1 to project `centerPoint` to the second geodesic. Denote the projected point by `endPt`. This is approximately where the arc will be tangent to the second geodesic. Denote the distance from `centerPoint` to `endPoint` as `perpDist`.

i. 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 `startPoint` until both `startPoint` and `endPoint` are the correct distance from `centerPoint`.

STEP 15: End while.

STEP 16: Return the values for `centerPoint`, the center of the arc, `startPoint`, the tangent point on the first geodesic, and `endPoint`, the tangent point of second geodesic.

Figure B-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 sub-segment's OEA, where a parallel (represented as a locus of points) intersects the geodesic end line.

4.5.1 Input/Output.

`long WGS84GeoLocusIntersect(LLPoint geoSt, LLPoint geoEnd, LLPoint* pint, 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 geoSt`	=	Geodetic coordinates of start point of geodesic
`LLPoint geoEnd`	=	Geodetic coordinates of end point of geodesic

`Locus loc`	=	Structure defining locus of points
`LLPoint* pint`	=	Reference to `LLPoint` that will be updated with intersection coordinates.
`double tol`	=	Maximum error allowed in solution
`double eps`	=	Convergence parameter for forward/inverse algorithms

4.5.2 Algorithm Steps.

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

STEP 1: Use the geodesic intersection algorithm (Algorithm 4.1) to find a first approximation to the point where the given geodesic and locus intersect. Use the start and end coordinates of the locus along with the start and end coordinates of given geodesic as inputs to the geodesic intersection algorithm. This will erroneously treat the locus as a geodesic; however, the calculated intersection will be close to the desired intersection. The geodesic intersection algorithm will return the approximate intersection point, `pt1`, along with the courses and distances from the `pt1` to the start points of the locus and given geodesic. Denote these courses and distances as `crs31, dist13, crs32, dist23,` respectively.

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

a. Return empty point.

STEP 3: End if

STEP 4: Use the inverse algorithm to calculate the course from `geoSt` to `geoEnd`. 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 `geoSt`. Denote these values as `distBase` and `crsBase`, respectively.

STEP 6: Obtain the forward course of the locus's defining geodesic. This course is stored `as loc.geoAz`. Denote this course 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`.

<u>STEP 8</u>: 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 lays.

<u>STEP 9</u>: Calculate the distance from `pt1` to the locus. This is the initial error: `errarray[1] = distFromPt – abs(distLoc)`.

<u>STEP 10</u>: Save the initial distance from `geoSt` to the approximate point: `geodarray[1] = distBase`. We will iterate to improve the approximation by finding a new value for `distBase` that makes `errarray` zero.

<u>STEP 11</u>: 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 B-16).

a. Calculate the angle between the geodesic from `pt1` to `pInt` and the geodesic from `pt1` to `geoSt`:

```
theta=abs(signedAzimuthDifference(crsFrompt,crsBase))
```

b. Calculate a new value for `distBase`:
```
newdistbase=distbase-errarray[1]/cos(theta)
```

<u>STEP 12</u>: Initialize the iteration count: `k = 0`.

<u>STEP 13</u>: Do while (abs(`errarray[1] > tol`) and (`k < maxIterationCount) )`

a. Use `geoSt, fcrs`, and `newDistBase` in the direct algorithm to update the value of `pt1`.

b. Save the current values of `errarray` and `geodarray`:
```
errarray[0] = errarray[1]
geodarray[0] = geodarray[1]
```

c. Set `geodarray[1] = newDistBase`.

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 `geodarray` and `errarray` to find the distance value that makes the error zero. Update new`DistBase` with this root value.

STEP 14: End while

STEP 15: Return `pint=pt1`.

Figure B-15. Intersection of Geodesic with Locus of Points.

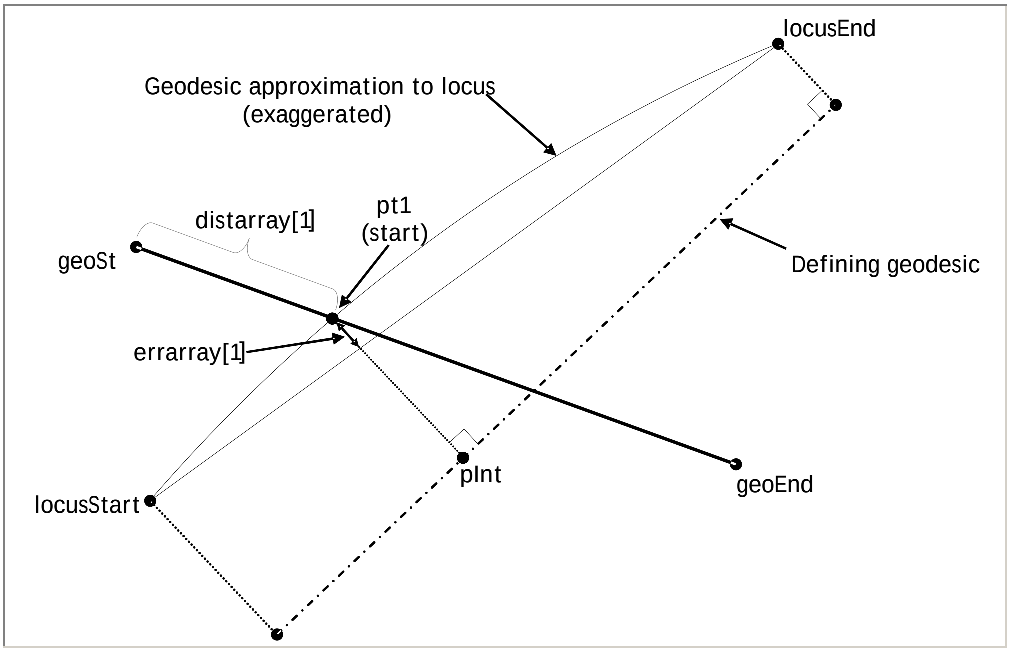
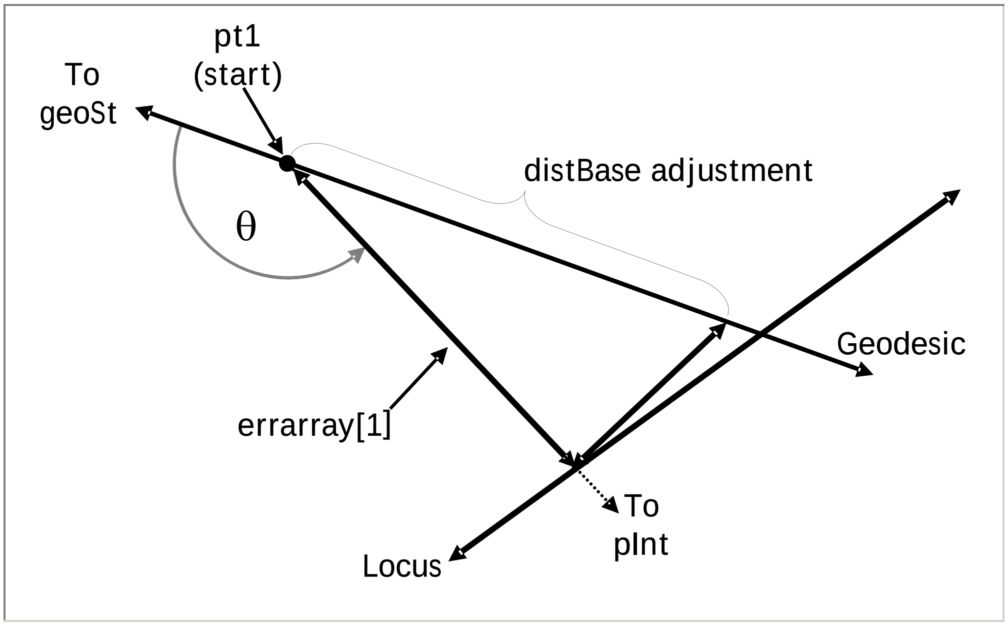


Figure B-16. Computing First Update to Locus-Geodesic Intersection.



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.

`long WGS84LocusArcIntersect(Locus loc, LLPoint center, double radius, LLPointPair intx, 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

`LLPointPair intx`	=	Two-element array of `LLPoint` that will be updated with intersection coordinates.
`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 B-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 5.2 to project the center of the arc to the locus. Denote the projected point as `locpt`. Denote the distance and course from `center` to `locpt` as `distFromPoint` and `crsFromPoint`, respectively. If `locpt` is on or within the radius of the arc, then it will be used to find the intersection(s) of the locus and the arc, `intx`.

STEP 4: If (`distFromPoint > radius`), then no approximate intersections were found. Return `NULL`.

STEP 5: End if.

STEP 6: Else if `distFromPoint` is equal to `radius` within tolerance level, then:

a. Locus is tangent to arc. One intersection exists.

b. `intx[0]=locpt`

STEP 7: End if.

STEP 8: Otherwise, `distFromPoint` must be less than `radius`, meaning there are two possible intersections. These two approximate intersections are found using spherical trigonometry and the direct algorithm. Denote the approximate intersections as `intx[0]` and `intx[1]`.

STEP 9: Use the inverse algorithm to compute the forward and reverse course from `loc.geoStart` to `loc.geoEnd`. Store these values as `fcrs1` and `bcrs`, respectively.

<u>STEP 10:</u> 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 `perpPint` to `loc.geoStart`.

c. Use Algorithm 3.10 to project `locPt` onto the locus from `perpPint`.

d. Use the inverse algorithm to calculate `distCent`, the distance from `locPt` to `center`.

e. Calculate the error and store it in an array:
`errarray[1] = distCent – 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 m below.

g. Save the current value of distbase to an array: `geodarray[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)`

k. Project `Pt1` on the defining geodesic a distance `newDistbase` along course `fcrs1` from `loc.geoStart`.

   (1) Use Algorithm 3.10 to project `locPt` onto the locus from `Pt1`.

   (2) Use the inverse algorithm to calculate `dist1`, the distance from `locPt` to `center`.

   (3) Calculate the error: `error = dist1 – radius`

   (4) Update the distance and error arrays:
```
geodarray[0] = geodarray[1]
geodarray[1] = newDistbase
errarray[0] = errarray[1]
errarray[1] = error
```

(5) Use a linear root finder with `geodarray` and `errarray` to find the distance value that makes the error zero. Update `newDistbase` with this root value.

l. End while.

m. If `locPt` is on the locus according to Algorithm 3.11, then

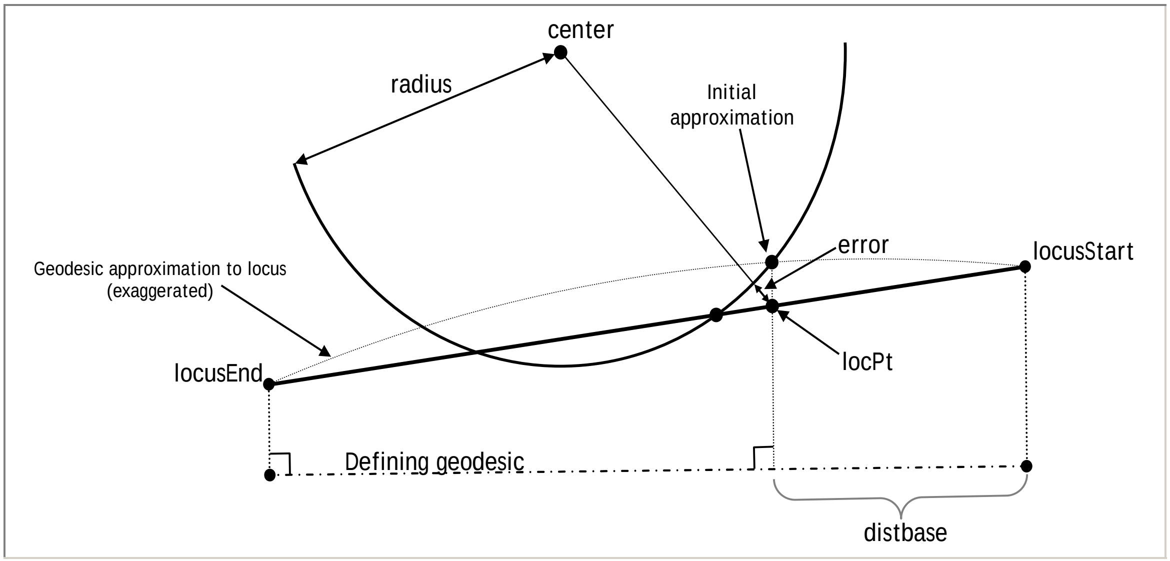
(1) Copy `locPt` to the output array: `intx[n] = locPt`.

(2) Update the count of intersection points found: `n = n + 1`.

<u>STEP 11</u>: End for loop

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

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



4.7 Intersections of Two Loci.

4.7.1 Input/Output.

`long WGS84LocusIntersect(Locus loc1, Locus loc2, LLPoint* intx, 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

`LLPoint* intx` = Reference to `LLPoint` that will be updated with intersection coordinates.

`Double tol` = Maximum error allowed in solution

`Double eps` = Convergence parameter for forward/inverse algorithms

4.7.2 Algorithm Steps.

See figure B-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 (abs`(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`:

(1) 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`.

(2) Use the inverse algorithm to calculate `distbase`, the distance from `loc1.geoStart` to `pint1`.

h. Else

(1) 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

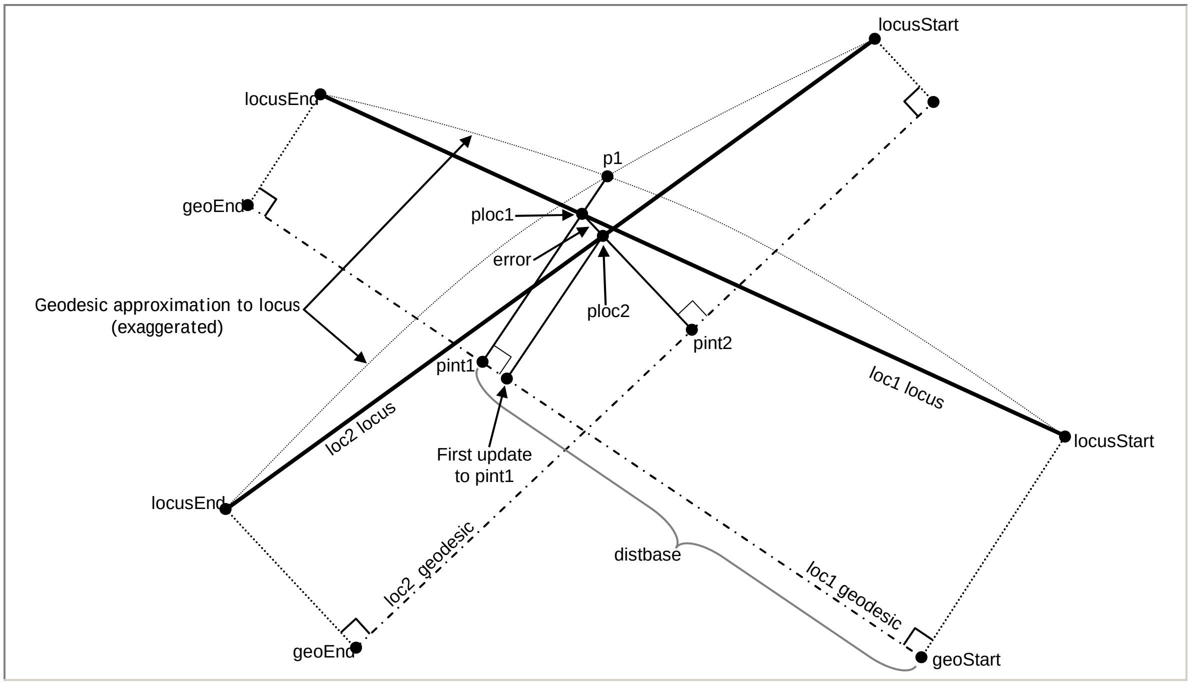
j. Increment iteration count: `k = k + 1`

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

STEP 12: Use Algorithm 3.11 with inputs of `loc1` and `ploc1` to determine if `ploc1` lies on the `loc1`. Then use Algorithm 3.11 with inputs of `loc2` and `ploc1` to determine if `ploc1` lies on the `loc2`. If `ploc1` does not lie on both `loci`, return `NULL`.

STEP 13: Return `ploc1`.

Figure B-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.

`long WGS84LocusTanFixedRadiusArc(Locus loc1, Locus loc2, double radius, LLPoint* centerPoint, LLPoint* startPoint, LLPoint* endPoint, ArcDirection* 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

`LLPoint* centerpoint`	=	Reference to `LLPoint` that will contain arc's center coordinates.
`LLPoint* startPoint`	=	Reference to `LLPoint` that will contain arc's start point coordinates.
`LLPoint* endpoint`	=	Reference to `LLPoint` that will contain arc's endpoint coordinates.
`ArcDirection* 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 B-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: $\mathtt{crs32} = \mathtt{crs32} + \pi$.

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`.

<u>STEP 6</u>: 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 B-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`:
$$\mathtt{angle} = \mathrm{abs}\left(\mathrm{signedAzimuthDifference}\left(\mathtt{rcrs1},\mathtt{rcrs2}\right)\right)$$

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

<u>STEP 7</u>: Calculate the inclination angle of loc1 relative to its geodesic:
$$\mathtt{locAngle} = \mathtt{atan}\left[\left(\mathtt{loc1.endDist} - \mathtt{loc1.startDist}\right) / \mathtt{geoLen1}\right]$$

<u>STEP 8</u>: Initialize `distbase` = `0.1`

<u>STEP 9</u>: Initialize the iteration count: `k = 0`

<u>STEP 10</u>: Do while (`k = 0`) or ((`k < maxIterationCount`) and `abs(error) > tol) )`

a. Use direct algorithm with starting point `loc1.geoStart`, course `gcrs1`, and distance `distbase` to project point `geoPt.`

b. 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):

$$\mathtt{lcrs1} = \mathtt{lcrs1} - \mathtt{dir} * \frac{\pi}{2}$$

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

STEP 12: End while

STEP 13: Return `intx`.

Figure B-19. Arc Tangent to Two Loci.

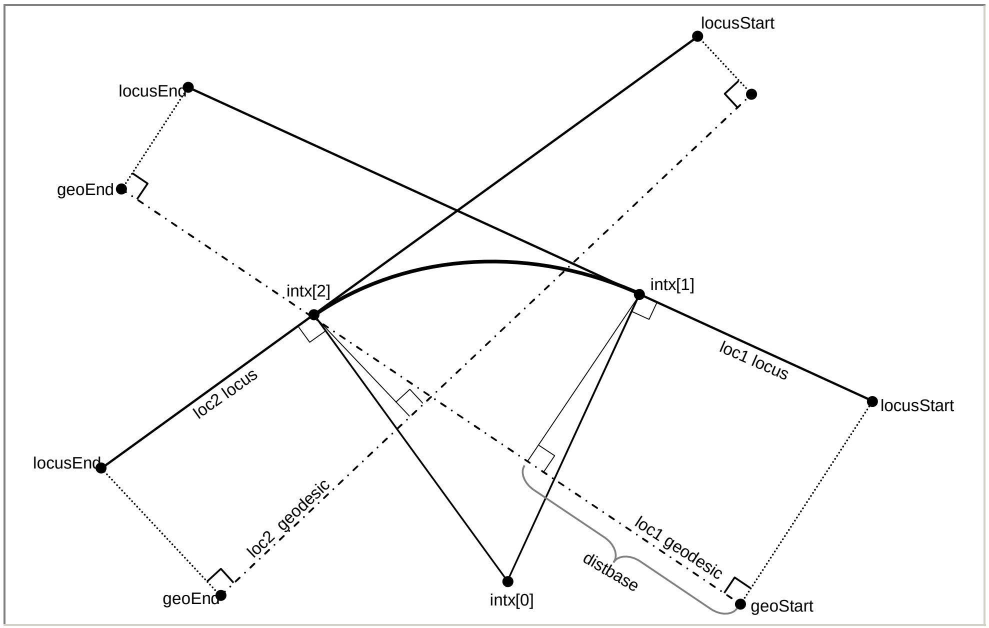
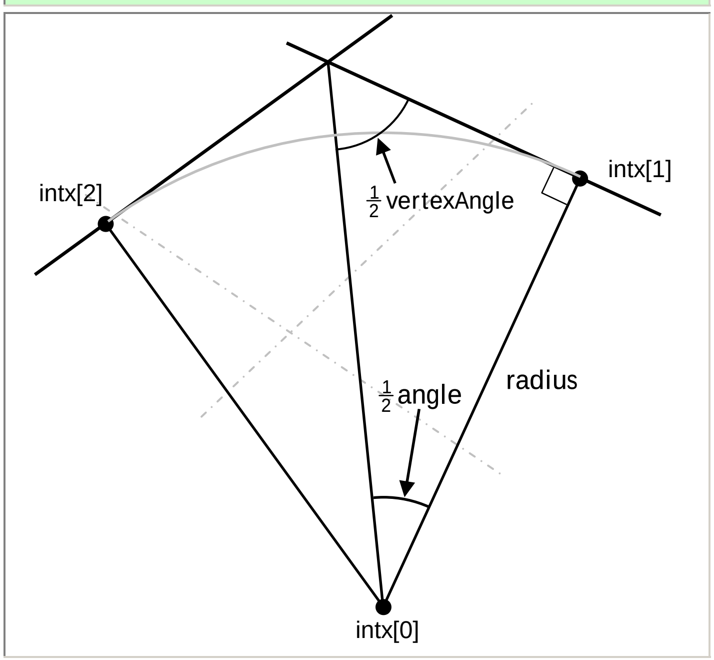


Figure B-20. Spherical Triangle Construction Used for Calculating the Approximate Vertex Angle at the Intersection of Two Loci.



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.

`long WGS84PerpIntercept(LLPoint pt1, double crs12, LLPoint* pt2, LLPoint pt3, 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 pt3`	=	Coordinates of point to be projected to geodesic
`LLPoint* pt2`	=	Reference to `LLPoint` that will be updated with coordinates of projected point.
`double* crsFromPoint`	=	Reference to azimuth of geodesic from `pt3` to projected point, in radians.
`double* distFromPoint`	=	Reference to distance from `pt3` to projected point, in radians.
`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 4g may be modified to return a `NULL` solution (see figure B-21).

STEP 1: Use the inverse algorithm to calculate the distance, azimuth, and reverse azimuth from `pt1` to `pt3`. Denote these values as `crs13`, `crs31`, and `dist13`, respectively.

STEP 2: Calculate the angle between the given geodesic and the geodesic between `pt1` and `pt3`. This is accomplished using `signedAzimuthDifference` function (see Algorithm 6.2)

```
angle=abs(signedAzimuthDifference(crs13, crs12))
```

STEP 3: If (`dist13 <= tol`), then `pt2` is the same point as `pt1`.

STEP 4: If π`/2-angle` < `tol`, then the projected point `pt2` is very close to or behind `pt1` (the start of the geodesic), so extend the geodesic backward far enough to catch the projection. Use a spherical triangle approximation to calculate the needed extension distance.

a. `B=angle`

b. `a=dist13/sphereRad`

c. `b=asin(sin(B)sin(a))`

d. `dist12=2*sphereRad*atan(tan(0.5*(a-b))*sin(0.5*(A-B)))`

e. If `abs(dist12) < tol`, then the projected point is identical to `pt1` to within the required accuracy.

(1) `crsFromPoint = crs31`;

(2) `distFromPoint = dist13`;

(3) Return `pt2 = pt1`

f. End if.

g. Use the direct algorithm to move `pt1` along reverse geodesic course. Use `1.1*dist12` for the distance, `crs12+`π for the azimuth, and then store the new location in the temporary variable `newPt1`. A distance greater than `dist12` is used to compensate for possible errors in the spherical approximation.

h. Use the inverse algorithm to calculate the azimuth from `newPt` to `pt1`. This value replaces the original azimuth value `crs12`.

(1) Rename `newPt1` as `pt1: pt1 = newPt1`.

STEP 5: Calculate the approximate distance from `pt1` to the projected point using the spherical triangle formula from steps 4(a) through 4(d). Denote the approximate distance found as `dist13`.

STEP 6: Use the direct algorithm to project a point on the given geodesic distance `dist13` from `pt1`. Use `pt1` for the starting point, `dist12` for distance, and `crs12` for azimuth. Denote the computed point by `pt2`.

STEP 7: Use the inverse algorithm to calculate the azimuth `crs21` from `pt2` to `pt1`.

STEP 8: Use the inverse algorithm to calculate the azimuth `crs23` and distance `dist23` from `pt3` to `pt2`

STEP 9: Calculate the angle between the geodesics that intersect at `pt3`, and cast that angle into the range `[0, π]` using the following formula (see Algorithm 5.1):

```
angle=abs(signedAzimuthDifference(crs21, crs23))
```

STEP 10: Calculate the error and store it as the first element in the error function array: `errarray[0] = angle - π/2`

STEP 11: Store the current distance from `pt1` to `pt2` in the distance function array: `distarray[0] = dist12`

STEP 12: A second distance/error value must be calculated before linear interpolation may be used to improve the solution. The following formula may be used:

```
distarray[1]=distarray[0]+errarray[0]*dist23
```

STEP 13: Use the 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 `crs12` for azimuth. Denote the computed point by `pt2`.

STEP 14: Use the inverse algorithm to calculate the azimuth `crs21` from `pt2` to `pt1`.

STEP 15: Use the inverse algorithm to calculate the azimuth `crs23` from `pt2` to `pt3`.

STEP 16: Calculate the error in angle (see Algorithm 5.1):

```
errarray[1]=abs(signedAzimuthDifference(crs21, crs23))-π/2
```

STEP 17: Initialize the iteration count: `k = 0`

STEP 18: 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 `dist12`.

b. Use the direct algorithm to project point on the given geodesic distance `dist12` from `pt1`. Use `pt1` for the starting point, `dist12` for distance, and `crs12` for azimuth. Denote the computed point by `pt2`.

c. Use the inverse algorithm to calculate the azimuth `crs21` from `pt2` 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
errarray[1]=abs(signedAzimuthDifference(crs21,
crs23))-π/2
```

f. Calculate the difference between the two latest distance values. This serves as the error function for measuring convergence:

```
error=abs(distarray[1]-distarray[0])
```

STEP 19: End while

STEP 20: Set `crsToPoint = crs32`

STEP 21: Set `distToPoint = dist23`

STEP 22: Return `pt2`

Figure B-21. Projecting a Point to a Geodesic.

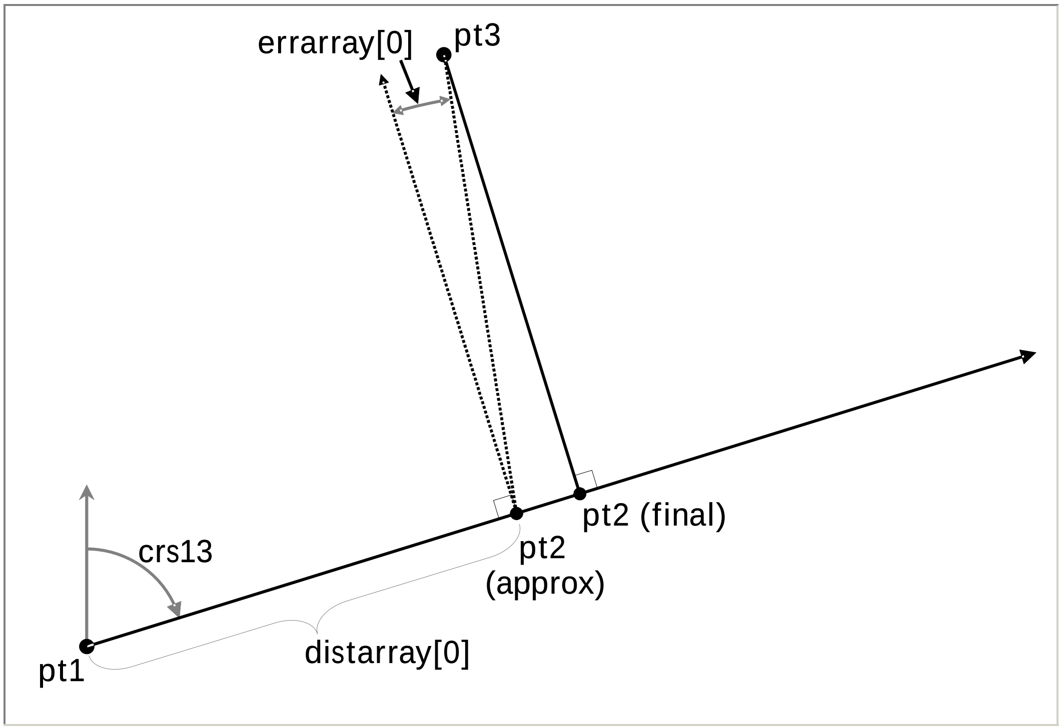
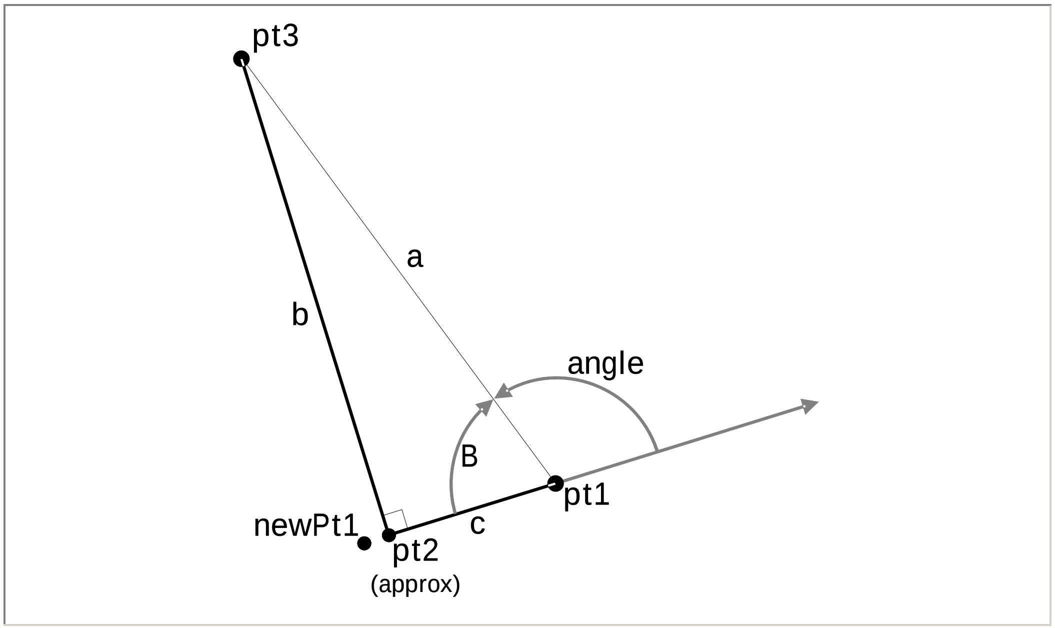


Figure B-22. Elements of Spherical Triangle Used to Determine New Geodesic Starting Point When Projected Point Lies Behind Given Starting Point.



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 B-23 for an illustration of the variables.

STEP 1: Define the course and distance from `loc.geoStart` to `loc.geoEnd` as `gcrs` and `gdist`, respectively. This course and distance is a part of the locus structure.

a. `gcrs=loc.geoAz`

b. `gdist=loc.geoLength`

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, `perpPt`, will be returned along with the course and distance from `pt2` to `perpPt`. 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`.

<u>STEP 3</u>: End If.

<u>STEP 4</u>: Use the inverse algorithm to compute `lcrs`, the course from `loc.locusStart` to `loc.locusEnd`.

<u>STEP 5</u>: 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.)

<u>STEP 6</u>: Calculate the locus inclination angle, relative to its geodesic:

```
locAngle=atan((loc.startDist-loc.endDist)/gdist)
```

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

<u>STEP 8</u>: Use the inverse function to calculate the distance from `loc.geoStart` to `geoPt`. Store this value as `distarray[1]`.

<u>STEP 9</u>: Initialize the iteration count: `k = 0`

<u>STEP 10</u>: 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`:

```
angle=signedAzimuthDifference(lcrs, crsToPoint)
```

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 (`k = 0`) then a direct calculation is used to improve the approximation:

```
newDist=distarray[1]+errarray[1]*cos(locAngle)
```

g. 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`.

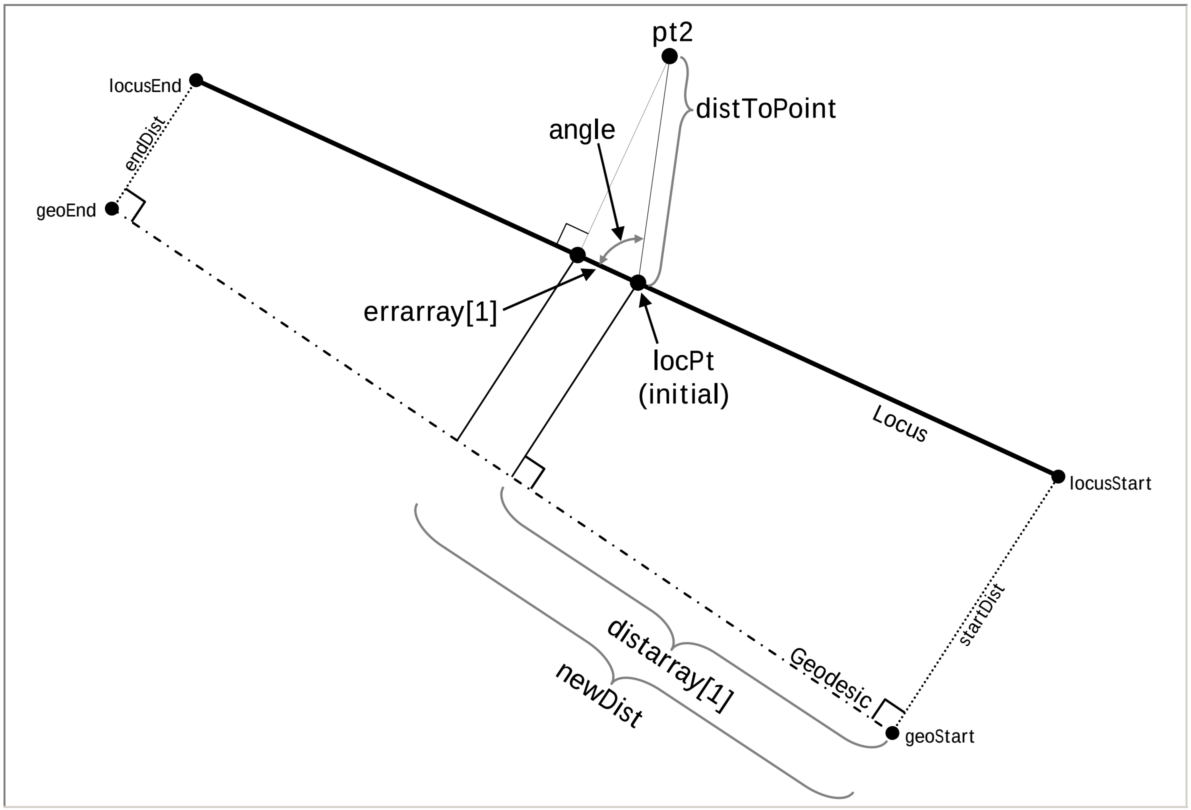
h. End If

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

STEP 11: End while

STEP 12: Return `locPt`

Figure B-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.

`long WGS84PointToArcTangents(LLPoint point, LLPoint center, double radius, LLPointPair tanPt, 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
`LLPointPair tanPt`	=	Two-element array of `LLPoint` objects that will be updated with tangent points' coordinates

`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 B-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. $C = a\cos\left(\tan(b)/\tan(a)\right)$.

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 6.2 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`

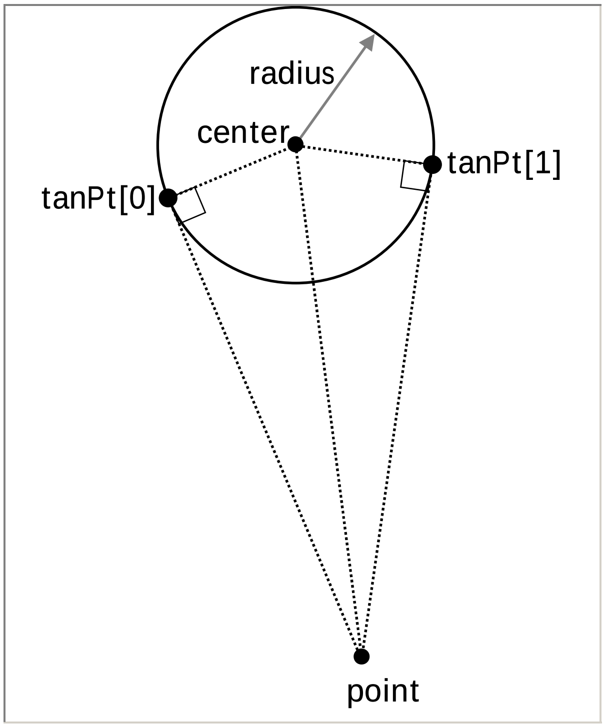
g. Increment the iteration count: `k = k + 1`

STEP 9: End while loop.

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

STEP 11: Return `tanPt[0]`and `tanPt[1]`

Figure B-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.

`long WGS84PerpTangentPoints(LLPoint lineStart, double crs, LLPoint center, double radius, LLPointPair linePts, LLPointPair tanPts, double tol)` updates geodesic intercepts, but 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 center
`double radius`	=	Arc radius
`LLPointPair linePts`	=	Two-element array of projected points on Geodesic

`LLPointPair tanPts` = Two-element 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 B-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 6.2):
$\texttt{angle1} = \text{signedAzimuthDifference}(\texttt{crs}, \texttt{crsStartToCenter})$

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`:

(1) If the circle lies to the right of the line:
`perpCrs = strCrs + π/2`

(2) If the circle lies to the left of the line:
`perpCrs = strCrs - 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`

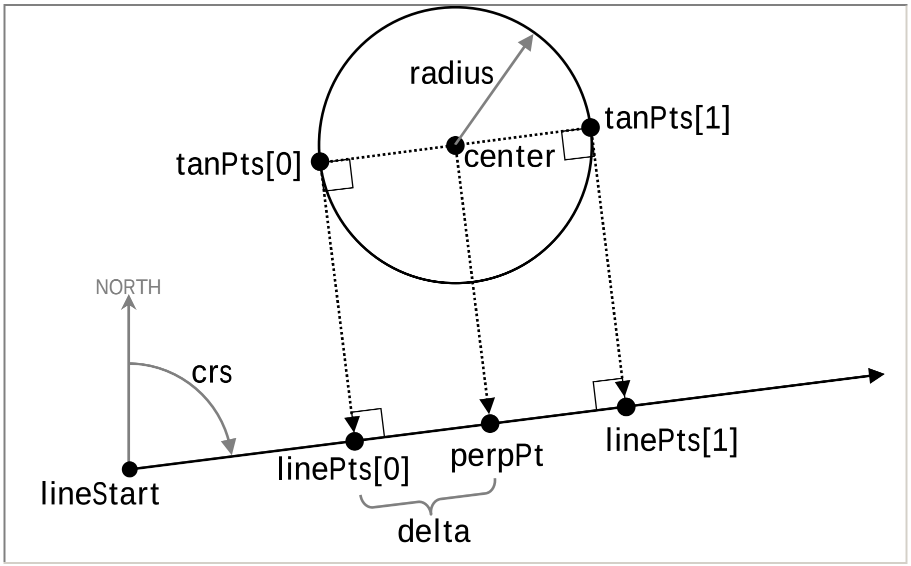
g. Increment the iteration count: `k = k + 1`

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 B-25. Projecting an Arc to a Geodesic.



Attachment A - Useful Functions.

6.0 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.

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

6.01 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 (counter-clockwise) 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

6.1 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

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

6.2 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 $[-\pi,\pi)$:

$$\texttt{signedAzimuthDifference}(a_1,a_2) = \mathrm{mod}(a_1 - a_2 + \pi, 2\pi) - \pi$$

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 $\mathrm{signedAzimuthDifference}(a_1,a_2) > 0$ 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;  }
```

[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

6.3 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 computed as the geometric mean of the meridional and prime-vertical curvatures at the arc's center.

Given the arc center's latitude θ, the ellipsoidal semi-major axis a and flattening f, compute the local radius of curvature R as follows:

$$e^2 = f(2-f)$$
$$M = \frac{a(1-e^2)}{(1-e^2\sin^2\theta)^{\frac{3}{2}}}$$
$$N = \frac{a}{\sqrt{1-e^2\sin^2\theta}}$$
$$R = \sqrt{MN}$$

If the radius and subtended angle of the of the constant radius arc are r and A, respectively, then the length of the arc is given by:

$$L = AR\sin\left(\frac{r}{R}\right).$$

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

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	Inpu	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 (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	40:10:24.50000S	70:12:45.60000W	38:04:35.80000S	68:12:40.70000W	180.0	0.00000	1101.09725	183.0	4.51831	1229.27714	58:30:33.90883S	70:12:45.60000W
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	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	30.0	211.06373	143.91656	300.0	119.74208	19.77535	42:14:26.98106N	69:49:37.30186E
test71	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	30.0	211.32322	176.85994	0.0	180.00000	38.02981	42:42:38.39108N	70:12:40.70000E
test72	40:10:24.50000N	68:12:45.60000E	42:04:35.80000N	70:12:40.70000E	20.0	202.00309	360.70415	10.0	190.64949	226.37015	45:47:19.54035N	71:08:48.89165E

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	40:10:24.50000S	70:12:45.60000W	40.0	38:04:35.80000S	68:12:34.70000W	20.0	10.0	1	38:21:17.65803S	68:33:50.38808W	38:27:34.84485S	68:23:56.35353W	38:24:44.64049S	68:21:54.05514W
test24	40:10:24.50000S	70:12:45.60000W	40.0	38:04:35.80000S	68:12:34.70000W	350.0	5.0	1	38:12:57.08171S	68:17:09.17935W	38:16:05.07958S	68:12:12.22289W	38:12:05.00846S	68:10:54.32298W
test25	40:10:24.50000S	70:12:45.60000W	190.0	38:04:35.80000S	68:12:34.70000W	20.0	15.0	1	41:21:05.57583S	70:09:04.40926W	41:18:28.19792S	70:28:40.65479W	41:26:30.42675S	69:50:29.08027W
test26	40:10:24.50000S	70:12:45.60000W	300.0	38:04:35.80000S	68:12:34.70000W	90.0	15.0	-1	38:11:39.46782S	73:47:56.44226W	38:24:20.78704S	73:58:07.81572W	37:56:40.09827S	73:46:48.10003W
test27	40:10:24.50000S	70:12:45.60000W	320.0	38:04:35.80000S	68:12:34.70000W	120.0	50.0	-1	37:18:22.45450S	71:50:53.37418W	37:49:40.64492S	72:39:57.99848W	36:35:56.07395S	71:17:47.86633W
test28	40:10:24.50000S	70:12:45.60000W	30.0	38:04:35.80000S	68:12:34.70000W	120.0	15.0	-1	38:15:18.86600S	68:27:05.40167W	38:08:02.37874S	68:43:44.12803W	38:02:19.38377S	68:17:33.22322W
test29	40:10:24.50000S	70:12:45.60000W	30.0	38:04:35.80000S	68:12:34.70000W	180.0	10.0	-1	38:02:17.85831S	68:25:14.17729W	37:57:27.29149S	68:36:18.51623W	38:02:18.53972S	68:12:34.70000W
test30	40:10:24.50000S	70:12:45.60000W	20.0	38:04:35.80000S	68:12:34.70000W	190.0	20.0	-1	37:17:13.88439S	68:27:34.64341W	37:10:42.09265S	68:51:15.15355W	37:20:43.05501S	68:02:53.31084W
test31	40:10:24.50000S	68:12:45.60000E	90.0	38:04:35.80000S	70:12:34.70000E	7.0	75.0	1	38:55:19.71316S	68:27:39.15441E	40:10:23.50671S	68:27:55.56302E	39:05:15.43802S	70:03:01.29112E
test32	40:10:24.50000S	68:12:45.60000E	90.0	38:04:35.80000S	70:12:34.70000E	307.0	25.0	1	39:41:25.57535S	72:06:36.70261E	40:06:25.30217S	72:08:02.42702E	39:21:06.63156S	72:25:28.25205E
test33	40:10:24.50000S	68:12:45.60000E	180.0	38:04:35.80000S	70:12:34.70000E	10.0	25.0	1	41:46:59.98555S	68:46:10.63681E	41:47:04.84568S	68:12:45.60000E	41:51:40.05992S	69:19:01.62673E
test34	40:10:24.50000S	68:12:45.60000E	175.0	38:04:35.80000S	70:12:34.70000E	10.0	20.0	1	41:52:26.37245S	68:51:35.20384E	41:54:16.88004S	68:24:55.35570E	41:56:09.94304S	69:17:54.15406E
test35	40:10:24.50000S	68:12:45.60000E	140.0	38:04:35.80000S	70:12:34.70000E	355.0	30.0	1	40:53:00.52340S	69:52:16.78699E	41:12:40.22975S	69:22:19.13720E	40:50:23.93467S	70:31:40.17600E
test36	40:10:24.50000S	68:12:45.60000E	35.0	38:04:35.80000S	70:12:34.70000E	20.0	50.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
test37	40:10:24.50000S	68:12:45.60000E	35.0	38:04:35.80000S	70:12:34.70000E	45.0	50.0	-1	38:58:15.99199S	70:34:27.34186E	38:30:25.98705S	69:41:20.68237E	38:22:52.33996S	69:49:18.75679E
test38	40:10:24.50000S	68:12:45.60000E	40.0	38:04:35.80000S	70:12:34.70000E	20.0	10.0	1	38:21:56.65274S	69:51:00.76931E	38:28:13.89538S	70:00:54.83463E	38:25:23.66587S	70:02:57.19466E
test39	40:10:24.50000S	68:12:45.60000E	40.0	38:04:35.80000S	70:12:34.70000E	350.0	5.0	1	38:13:14.64955S	70:08:04.12833E	38:16:22.65986S	70:13:01.09183E	38:12:22.57289S	70:14:19.00895E
test40	40:10:24.50000S	68:12:45.60000E	190.0	38:04:35.80000S	70:12:34.70000E	20.0	15.0	1	41:19:48.53358S	68:16:44.73461E	41:17:11.20581S	67:57:08.86172E	41:25:13.27841S	68:35:19.75280E
test41	40:10:24.50000S	68:12:45.60000E	300.0	38:04:35.80000S	70:12:34.70000E	90.0	15.0	-1	38:11:40.61138S	64:37:37.05220E	38:24:21.93390S	64:27:25.68277E	37:56:41.23801S	64:38:45.31315E
test42	40:10:24.50000S	68:12:45.60000E	320.0	38:04:35.80000S	70:12:34.70000E	120.0	50.0	-1	37:18:44.79574S	66:35:00.43984E	37:50:03.14293S	65:45:55.73018E	36:36:18.21450S	67:08:05.70311E
test43	40:10:24.50000S	68:12:45.60000E	30.0	38:04:35.80000S	70:12:34.70000E	120.0	15.0	-1	38:15:26.42644S	69:58:20.50710E	38:08:09.92689S	69:41:41.76083E	38:02:26.92225S	70:07:52.65334E
test44	40:10:24.50000S	68:12:45.60000E	30.0	38:04:35.80000S	70:12:34.70000E	180.0	10.0	-1	38:02:49.25073S	69:59:55.13263E	37:57:58.65008S	69:48:50.73899E	38:02:49.93235S	70:12:34.70000E
test45	40:10:24.50000S	68:12:45.60000E	20.0	38:04:35.80000S	70:12:34.70000E	190.0	20.0	-1	37:19:00.32748S	69:57:10.89521E	37:12:28.38650S	69:33:29.89561E	37:22:29.58087S	70:21:52.79009E
test46	40:10:24.50000N	68:12:45.60000E	90.0	42:04:35.80000N	70:12:34.70000E	7.0	75.0	1	41:25:26.60664N	68:25:52.36461E	40:10:23.78448N	68:25:37.91699E	41:17:07.07993N	70:04:51.00769E

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	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

	Input										
	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	39:47:56.96798N	68:58:57.69087E								
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	40:12:17.80000S	68:11:50.60000E	39:55:35.80000S	70:12:34.70000E						

	Input										
	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	Geodesic Input	38:01:17.80000S	68:11:50.60000E	40:12:17.80000S	69:56:34.70000E						
	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	39:44:32.88343S	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	41:49:41.8125 3N	69:56:23.6694 5W	38:30:50.3527 2N	69:59:38.8532 8W						
test8	LocusInp uts	42:54:35.8000 0N	70:11:34.7000 0W	38:36:54.7497 0N	66:48:53.1121 0W	42:45:33.4587 9N	70:31:08.9200 1W	38:25:55.700 18N	67:13:10.9719 1W	17.0	22.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	41:48:11.2142 8N	69:44:43.2787 9W	39:41:58.4778 9N	68:08:06.4480 2W						
test9	LocusInp uts	42:54:35.8000 0N	70:11:34.7000 0W	38:34:20.9298 5N	73:28:27.3739 7W	42:47:21.8889 5N	69:55:16.8235 1W	38:30:28.695 75N	73:19:31.7971 7W	-14.0	-8.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	41:47:15.3317 5N	70:45:57.1355 6W	39:49:26.3001 6N	72:19:59.9361 4W						
test10	LocusInp uts	40:24:35.8000 0N	75:11:34.7000 0W	40:13:30.1326 0N	68:39:33.2928 9W	40:09:35.1524 9N	75:11:34.7000 0W	39:53:32.477 81N	68:41:28.2940 0W	15.0	20.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	40:05:22.1852 8N	72:22:58.4868 8W	N/A	N/A						
test11	LocusInp uts	40:24:35.8000 0N	75:11:34.7000 0W	41:52:02.6308 8N	68:51:37.8257 1W	40:17:01.5793 1N	75:08:10.5002 1W	41:46:14.448 89N	68:49:34.6745 8W	8.0	
	ArcInputs	6.0	40:10:24.5000 0N								
	Outputs	70:12:45.6000 0W	100.0	41:03:30.8815 9N	72:04:03.6671 7W	41:40:47.0691 6N	69:16:07.9330 3W				
test12	LocusInp uts	40:24:35.8000 0N	75:11:34.7000 0W	37:59:52.6040 3N	69:33:17.7337 1W	40:34:24.0808 0N	75:05:01.4892 4W	38:11:04.655 06N	69:24:54.6459 8W	-11.0	-13.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	39:22:31.1091 7N	72:06:39.1575 8W	38:30:24.5213 7N	70:07:20.1753 1W						
test13	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0W	42:09:50.6694 2N	70:21:34.7000 0W	37:09:34.1097 3N	70:01:33.7441 6W	42:09:49.715 95N	70:06:47.2225 4W	16.0	11.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	38:30:36.7511 3N	70:02:54.7744 7W	41:50:21.1627 0N	70:06:25.6778 3W						
test14	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0W	41:15:08.9818 0N	66:39:17.4351 8W	37:14:37.7729 8N	70:30:55.3685 5W	41:19:17.778 92N	66:46:46.4276 2W	-9.0	-7.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	100.0							
	Outputs	38:40:34.8682 1N	69:15:50.3909 0W	39:59:51.9250 0N	68:03:11.5422 7W						
test15	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0W	41:29:39.4876 1N	73:34:58.7850 0W	37:15:24.5696 0N	70:08:25.9039 6W	41:34:48.499 58N	73:23:33.8085 4W	12.0	10.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0W	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	LocusInp uts	42:54:35.8000 0N	70:11:34.7000 0E	38:34:20.9298 5N	66:54:42.0260 3E	42:46:50.8063 2N	70:29:02.2793 8E	38:26:06.617 68N	67:13:38.9838 6E	-15.0	-17.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	41:47:43.4019 6N	69:42:02.5004 1E	39:42:31.1481 6N	68:07:53.5097 7E						
test25	LocusInp uts	40:24:35.8000 0N	65:11:34.7000 0E	40:13:30.1326 0N	71:43:36.1071 1E	39:57:34.6063 8N	65:11:34.7000 0E	39:41:33.836 75N	71:40:32.6380 2E	27.0	32.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	39:53:11.0887 5N	68:04:30.9394 0E	N/A	N/A						
test26	LocusInp uts	40:24:35.8000 0N	65:11:34.7000 0E	41:52:02.6308 8N	71:31:31.5742 9E	40:13:14.4277 8N	65:16:40.7150 7E	41:41:24.264 79N	71:35:17.0690 7E	12.0	11.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	40:58:28.4060 6N	68:17:39.1668 3E	41:37:44.2769 8N	71:17:08.4632 2E						
test27	LocusInp uts	40:24:35.8000 0N	65:11:34.7000 0E	37:59:52.6040 3N	70:49:51.6662 9E	40:38:51.3523 9N	65:21:07.2755 6E	38:11:56.325 57N	70:58:53.5592 9E	-16.0	-14.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	39:25:51.8708 6N	68:16:33.7600 2E	38:30:27.4268 2N	70:19:30.2173 2E						
test28	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0E	42:09:50.6694 2N	70:21:34.7000 0E	37:09:12.0321 4N	71:36:38.0418 9E	42:09:20.381 91N	71:44:56.4178 6E	60.0	62.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:56:06.4922 9N	71:39:23.3095 9E	41:22:52.7168 1N	71:43:31.9281 9E						
test29	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0E	41:24:05.8131 5N	73:46:45.5983 0E	37:14:44.7226 5N	70:10:50.5808 7E	41:28:28.203 39N	73:37:51.0786 4E	-10.0	-8.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:45:47.1679 3N	71:21:43.1653 7E	40:00:12.6274 2N	72:22:22.7926 6E						
test30	LocusInp uts	37:09:35.8000 0N	70:21:34.7000 0E	41:29:39.4876 1N	67:08:10.6150 0E	37:17:49.4571 8N	70:40:12.7566 2E	41:37:22.578 04N	67:25:18.7593 8E	17.0	15.0
	ArcInputs	40:10:24.5000 0N	70:12:45.6000 0E	100.0							
	Outputs	38:32:19.4432 9N	69:47:05.3648 1E	40:42:42.1017 9N	68:08:47.2353 3E						
test31	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	35:08:30.4250 8S	72:09:14.0235 6E	40:07:30.9990 7S	72:50:51.1749 2E	35:11:43.385 67S	71:45:09.3074 1E	-17.0	-20.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	N/A	N/A	N/A	N/A						
test32	LocusInp	40:04:35.8000	73:12:40.7000	44:45:10.4951	70:48:49.9031	39:47:12.8682	72:11:43.6127	44:24:55.275	69:38:47.3187	50.0	54.0

	uts	0S	0E	9S	2E	3S	1E	06S	9E		
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	41:39:29.0062 7S	71:12:51.3478 2E	N/A	N/A						
test33	LocusInp uts	40:04:35.8000 0S	72:12:40.7000 0E	36:27:08.3818 2S	67:49:48.4732 3E	40:05:18.2547 6S	72:11:45.4206 7E	36:28:29.216 23S	67:47:58.3980 9E	-1.0	-2.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:30:19.5107 2S	70:11:27.2805 5E	N/A	N/A						
test34	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	39:53:37.8685 2S	66:42:33.3856 0E	39:09:33.0448 3S	73:12:40.7000 0E	39:08:42.682 17S	66:46:46.3932 7E	55.0	45.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	39:11:05.7225 7S	71:57:05.4938 2E	39:11:02.2519 3S	68:28:29.0564 6E						
test35	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	37:26:38.4937 4S	67:46:21.3580 3E	40:15:51.4884 9S	73:04:11.2378 5E	37:36:39.957 75S	67:38:02.4512 4E	-13.0	-12.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	39:56:39.8330 7S	72:21:46.0648 1E	38:35:25.4801 4S	69:32:05.8006 5E						
test36	LocusInp uts	40:04:35.8000 0S	73:12:40.7000 0E	42:25:59.2966 6S	67:21:39.9786 0E	39:48:07.1044 4S	73:00:21.1133 6E	42:10:42.839 13S	67:11:35.5881 6E	19.0	17.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	40:04:47.0450 2S	72:22:55.4861 7E	41:31:16.7205 9S	68:55:09.2053 0E						
test37	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0E	43:04:47.8144 1S	70:11:34.7000 0E	38:04:34.4626 3S	70:29:18.5182 4E	43:04:45.463 40S	70:34:46.5016 0E	-14.0	-17.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:31:11.6240 1S	70:29:45.3465 2E	41:49:14.9963 0S	70:33:18.3380 7E						
test38	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0E	42:16:02.9504 1S	73:45:33.8554 4E	38:24:06.7176 1S	69:31:39.7345 5E	42:32:52.832 50S	73:12:02.2158 0E	37.0	30.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:33:41.5692 4S	69:39:34.0270 9E	41:11:49.9870 5S	71:56:32.1518 8E						
test39	LocusInp uts	38:04:35.8000 0S	70:11:34.7000 0E	42:18:57.4280 8S	66:43:26.9596 8E	38:15:23.2324 3S	70:34:25.8761 4E	42:27:09.694 05S	67:00:23.7756 2E	-21.0	-15.0
	ArcInputs	40:10:24.5000 0S	70:12:45.6000 0E	100.0							
	Outputs	38:30:35.9106 6S	70:22:22.1225 5E	40:59:38.8952 1S	68:18:29.6020 1E						
test40	LocusInp uts	40:24:35.8000 0S	65:51:34.7000 0E	40:13:30.1326 0S	72:23:36.1071 1E	41:39:38.4501 7S	65:51:34.7000 0E	41:23:21.122 81S	72:30:27.6781 5E	75.0	70.0

	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	70:12:45.60000W	100.0	39:59:27.59845S	72:22:15.85364W	38:53:50.98943S	68:49:29.99867W				
test57	LocusInputs	40:24:35.80000S	74:11:34.70000W	42:31:36.14552S	68:09:51.81717W	40:18:21.23809S	74:07:25.46446W	42:26:04.62097S	68:06:41.82104W	-7.0	-6.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	41:05:49.43225S	72:02:08.19523W	41:49:47.02230S	69:57:20.41362W						
test58	LocusInputs	43:09:35.80000S	70:21:34.70000W	38:09:24.03567S	70:21:34.70000W	43:09:34.62530S	70:05:10.96760W	38:09:23.35138S	70:08:53.99850W	12.0	10.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	41:50:20.72573S	70:06:13.83966W	38:30:22.24016S	70:08:39.65340W						
test59	LocusInputs	43:09:35.80000S	70:21:34.70000W	38:57:14.60461S	66:46:39.46882W	43:06:47.86496S	70:27:14.25600W	38:55:40.03026S	66:49:55.83317W	-5.0	-3.0
	ArcInputs	40:10:24.50000S	70:12:45.60000W	100.0							
	Outputs	41:36:12.38507S	69:04:54.50326W	40:25:02.16784S	68:03:28.13705W						
test60	LocusInputs	43:09:35.80000S	70:21:34.70000W	38:44:26.17734S	73:27:19.42040W	43:06:11.82930S	70:13:13.26597W	38:42:09.85051S	73:21:37.86961W	7.0	
	ArcInputs	5.0	40:10:24.50000S								
	Outputs	70:12:45.60000W	100.0	41:36:07.22647S	71:20:47.96044W	40:08:27.78107S	72:23:09.88582W				
test61	LocusInputs	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	70:24:20.88368W	-0.5	-0.5
	ArcInputs	42:54:35.00000N	70:51:34.00000W								
	Outputs	1.0	42:55:05.00175N	70:50:23.28330W	N/A	N/A					
test62	LocusInputs	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	70:24:20.88368W	-0.5	-0.5
	ArcInputs	42:54:35.00000N	70:50:14.00000W								
	Outputs	1.0	42:55:05.00771N	70:51:24.71201W	42:55:04.98026N	70:49:03.26644W					
test63	LocusInputs	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	70:24:20.66356W	-1.0	-1.0
	ArcInputs	42:55:35.00000N	70:48:52.00000W								
	Outputs	1.0	42:55:35.00776N	70:50:13.66761W	42:55:34.94358N	70:47:30.33244W					
test64	LocusInputs	42:54:35.00000N	70:51:34.00000W	42:54:31.76521N	70:24:21.10373W	42:52:34.96830N	70:51:34.00000W	42:52:31.73523N	70:24:21.98336W	2.0	
	ArcInputs	2.0	42:53:05.00000N								
	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	LocusInp uts	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:57:35.0462 4N	70:51:34.0000 0W	42:57:31.808 85N	70:24:19.7825 1W	-3.0	-3.0
	ArcInputs	42:56:35.0000 0N	70:46:12.0000 0W								
	Outputs	1.0	42:57:34.9240 4N	70:46:16.5022 7W	42:57:34.9168 7N	70:46:07.3243 2W					
test66	LocusInp uts	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:50:34.9359 0N	70:51:34.0000 0W	42:50:31.704 55N	70:24:22.8620 5W	4.0	
	ArcInputs	4.0	42:51:35.0000 0N								
	Outputs	70:44:52.0000 0W	1.5	42:50:34.8184 3N	70:46:22.9951 5W	42:50:34.6409 8N	70:43:21.2222 5W				
test67	LocusInp uts	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:59:35.0761 8N	70:51:34.0000 0W	42:59:31.837 07N	70:24:18.9005 0W	-5.0	-5.0
	ArcInputs	42:58:35.0000 0N	70:43:32.0000 0W								
	Outputs	2.0	42:59:34.9358 4N	70:45:53.6482 1W	42:59:34.6045 8N	70:41:10.0928 1W					
test68	LocusInp uts	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:48:34.9027 9N	70:51:34.0000 0W	42:48:31.673 17N	70:24:23.7397 8W	6.0	
	ArcInputs	6.0	42:49:35.0000 0N								
	Outputs	70:42:12.0000 0W	1.5	42:48:34.6329 0N	70:43:42.7194 9W	42:48:34.3855 6N	70:40:41.5853 8W				
test69	LocusInp uts	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	43:01:35.1054 3N	70:51:34.0000 0W	43:01:31.864 59N	70:24:18.0175 4W	-7.0	-7.0
	ArcInputs	43:00:05.0000 0N	70:43:32.0000 0W								
	Outputs	2.0	43:01:34.9363 5N	70:45:20.3213 4W	43:01:34.6829 1N	70:41:43.2892 1W					
test70	LocusInp uts	42:54:35.0000 0N	70:51:34.0000 0W	42:54:31.7652 1N	70:24:21.1037 3W	42:46:34.8689 9N	70:51:34.0000 0W	42:46:31.641 08N	70:24:24.6165 8W	8.0	
	ArcInputs	8.0	42:47:35.0000 0N								
	Outputs	70:42:12.0000 0W	1.5	42:46:34.5988 4N	70:43:42.6294 2W	42:46:34.3516 2N	70:40:41.6754 5W				

WGS84LocusIntersect Test Results

Test Identifier											
	Locus 1 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	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

	2 Inputs										
	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	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

	Inputs										
	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	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 1 Inputs										
	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	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

	Inputs										
	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	38:45:52.61565N	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	2.0
	Outputs	1	40:12:40.65368N	68:31:48.78239W	40:10:40.58699N	68:31:51.74766W	40:12:26.42800N	68:29:13.25421W				
test6	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	39:01:03.20612N	64:47:37.88516W	41:04:35.80000N	68:12:34.70000W	38:59:30.11207N	64:49:15.15895W	41:03:47.85119N	68:13:22.43586W	-2.0	-1.0	2.0
	Outputs	1	40:11:11.47812N	66:48:27.88628W	40:09:11.45603N	66:48:33.10050W	40:12:45.83878N	66:46:51.01920W				
test7	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	36:50:12.19034N	70:12:45.60000W	40:10:24.47060N	70:10:09.05140W	36:50:12.18382N	70:11:30.85698W	-2.0	-1.0	
	Locus 2 Inputs	38:10:03.48978N	71:19:20.31330W	41:04:35.80000N	69:12:34.70000W	38:10:32.28515N	71:20:27.08581W	41:05:35.81205N	69:14:52.14842W	-1.0	-2.0	3.0
	Outputs	1	40:02:07.33483N	70:06:18.24880W	40:02:08.38728N	70:10:12.59388W	40:00:39.58907N	70:02:53.61827W				
test8	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	36:50:55.82985N	69:51:03.26240W	40:10:14.00441N	70:15:21.54623W	36:50:50.82261N	69:52:17.75645W	2.0	1.0	
	Locus 2 Inputs	38:02:20.08909N	70:59:31.55324W	41:04:35.80000N	69:12:34.70000W	38:01:55.78214N	70:58:22.10446W	41:03:45.03132N	69:10:10.92536W	1.0	2.0	2.0
	Outputs	1	39:33:03.94733N	70:08:17.79894W	39:32:52.95267N	70:10:52.28475W	39:32:13.76421N	70:05:56.86447W				
test9	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	37:35:08.04987N	67:31:03.26743W	40:11:41.67410N	70:10:45.63905W	37:35:45.28280N	67:30:04.02642W	-2.0	-1.0	
	Locus 2 Inputs	37:45:08.92078N	67:50:36.68693W	41:04:35.80000N	68:12:34.70000W	37:45:03.92163N	67:51:52.07835W	41:04:25.30511N	68:15:12.76089W	-1.0	-2.0	3.0
	Outputs	1	38:09:11.85636N	67:58:23.76723W	38:07:20.13532N	68:01:22.77621W	38:09:27.92001N	67:54:36.46855W				
test10	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:52:36.59194N	67:36:46.62423W	40:09:15.60015N	70:10:37.39889W	42:52:00.69938N	67:35:41.22861W	2.0	1.0	
	Locus 2 Inputs	39:55:58.22492N	69:41:27.77537W	43:04:35.80000N	68:12:34.70000W	39:56:37.33295N	69:43:55.28280W	43:04:56.31878N	68:13:51.63678W	-2.0	-1.0	2.0
	Outputs	1	41:21:07.17487N	69:07:28.71056W	41:19:57.56277N	69:05:18.90622W	41:20:26.72878N	69:04:58.69814W				
test11	Locus 1 Inputs	40:10:24.50000N	70:12:45.60000W	42:41:33.37650N	67:18:27.47257W	40:11:41.67410N	70:14:45.56095W	42:42:13.47196N	67:19:28.01914W	-2.0	-1.0	
	Locus	38:47:21.082	67:28:11.049	42:04:35.800	68:12:34.700	38:47:40.921	67:25:39.675	42:04:46.215	68:11:15.351	2.0	1.0	2.0

	2 Inputs	27N	43W	00N	00W	31N	82W	51N	30W			
	Outputs	1	42:00:55.564 89N	68:13:02.909 37W	41:59:35.847 42N	68:11:02.562 25W	42:01:16.982 68N	68:10:24.500 96W				
test12	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	36:53:06.456 88N	70:56:01.642 36W	40:10:34.919 46N	70:14:02.688 42W	36:53:26.367 62N	70:58:29.160 09W	1.0	2.0	
	Locus 2 Inputs	37:29:19.581 28N	71:54:04.490 05W	40:04:35.800 00N	69:12:34.700 00W	37:28:05.079 86N	71:52:06.219 43W	40:03:57.199 27N	69:11:34.832 83W	2.0	1.0	2.0
	Outputs	1	38:53:33.203 66N	70:29:18.124 52W	38:53:54.263 04N	70:31:49.447 79W	38:52:17.757 84N	70:27:18.546 19W				
test13	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	41:46:39.602 65N	74:04:18.294 68W	40:08:40.492 57N	70:14:03.841 14W	41:45:46.340 67N	74:04:55.276 67W	-2.0	-1.0	
	Locus 2 Inputs	40:59:32.625 80N	72:36:48.383 18W	41:04:35.800 00N	68:12:34.700 00W	41:00:32.585 02N	72:36:52.381 81W	41:06:35.869 47N	68:12:34.700 00W	-1.0	-2.0	2.0
	Outputs	-1	40:59:45.331 28N	72:06:21.690 23W	40:58:00.362 64N	72:07:38.620 39W	41:01:45.254 31N	72:06:29.561 62W				
test14	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	43:02:23.578 55N	67:56:26.256 58W	40:09:24.433 55N	70:10:30.058 11W	43:01:52.206 97N	67:55:16.512 06W	2.0	1.0	
	Locus 2 Inputs	43:40:32.943 22N	72:11:18.241 39W	42:04:35.800 00N	68:12:34.700 00W	43:42:19.591 29N	72:10:02.385 29W	42:05:27.780 65N	68:11:54.406 31W	-2.0	-1.0	2.0
	Outputs	-1	42:12:06.973 04N	68:32:37.780 57W	42:13:08.443 40N	68:34:56.482 41W	42:13:50.862 69N	68:31:16.863 80W				
test15	Locus 1 Inputs	40:10:24.500 00N	70:12:45.600 00W	39:30:57.684 85N	65:58:09.515 26W	40:11:23.631 81N	70:12:32.004 53W	39:32:54.838 06N	65:57:35.357 82W	-1.0	-2.0	
	Locus 2 Inputs	41:23:57.635 85N	67:49:25.737 53W	38:04:35.800 00N	68:12:34.700 00W	41:24:03.117 84N	67:50:45.132 38W	38:04:46.243 10N	68:15:06.102 22W	1.0	2.0	2.0
	Outputs	-1	39:51:21.557 10N	68:04:58.824 54W	39:53:19.411 10N	68:04:28.855 74W	39:51:10.298 89N	68:02:23.689 37W				
test16	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	40:05:30.770 99S	65:52:03.221 58W	40:11:24.544 24S	70:12:45.600 00W	40:07:30.717 40S	65:51:55.575 62W	1.0	2.0	
	Locus 2 Inputs	41:23:11.704 67S	68:44:56.512 07W	38:04:35.800 00S	68:12:34.700 00W	41:23:27.023 65S	68:42:18.386 98W	38:04:43.113 48S	68:11:19.277 04W	2.0	1.0	2.0
	Outputs	1	40:09:04.418 61S	68:32:58.982 77W	40:11:04.496 07S	68:32:56.834 33W	40:09:18.875 49S	68:30:23.618 82W				
test17	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	40:05:30.770 99S	65:52:03.221 58W	40:09:24.455 59S	70:12:45.600 00W	40:03:30.823 74S	65:52:10.860 08W	-1.0	-2.0	
	Locus 2	40:51:02.568 24S	65:49:04.579 09W	38:04:35.800 00S	68:12:34.700 00W	40:52:10.594 42S	65:51:14.904 08W	38:05:08.509 46S	68:13:38.436 18W	-2.0	-1.0	2.0

	Inputs											
	Outputs	1	40:03:14.47849S	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	41:09:00.289 76S	70:25:29.091 05W	41:08:38.535 06S	70:28:05.303 41W	41:10:18.257 57S	70:23:28.270 22W				
test24	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	38:26:46.467 74S	73:53:15.484 61W	40:12:08.492 21S	70:14:03.907 52W	38:27:37.217 79S	73:53:56.335 33W	-2.0	-1.0	
	Locus 2 Inputs	38:59:53.214 74S	73:29:12.959 94W	39:04:35.800 00S	69:12:34.700 00W	38:58:53.224 54S	73:29:09.342 42W	39:02:35.688 26S	69:12:34.700 00W	-1.0	-2.0	2.0
	Outputs	-1	39:02:21.677 93S	72:38:46.919 55W	39:04:03.709 82S	72:40:08.199 04W	39:00:21.629 99S	72:38:41.871 65W				
test25	Locus 1 Inputs	40:10:24.500 00S	70:12:45.600 00W	37:15:52.751 97S	68:07:31.780 07W	40:11:24.522 18S	70:10:29.991 73W	37:16:21.590 37S	68:06:25.839 60W	2.0	1.0	
	Locus 2 Inputs	36:21:10.677 74S	71:47:01.134 06W	38:04:35.800 00S	68:12:34.700 00W	36:19:28.943 58S	71:45:42.083 55W	38:03:43.779 56S	68:11:56.713 84W	-2.0	-1.0	2.0
	Outputs	-1	37:57:02.695 88S	68:31:21.637 89W	37:56:05.076 32S	68:33:34.749 30W	37:55:19.155 11S	68:30:04.714 14W				
test26	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	40:05:30.770 99S	72:33:27.978 42E	40:11:24.544 24S	68:12:45.600 00E	40:07:30.717 40S	72:33:35.624 38E	1.0	2.0	
	Locus 2 Inputs	41:23:11.704 67S	69:40:12.887 93E	38:04:35.800 00S	70:12:34.700 00E	41:23:27.023 65S	69:42:51.013 02E	38:04:43.113 48S	70:13:50.122 96E	2.0	1.0	2.0
	Outputs	1	40:09:04.647 98S	69:52:10.380 91E	40:11:04.725 55S	69:52:12.518 66E	40:09:19.104 87S	69:54:45.745 00E				
test27	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	40:05:30.770 99S	72:33:27.978 42E	40:09:24.455 59S	68:12:45.600 00E	40:03:30.823 74S	72:33:20.339 92E	-1.0	-2.0	
	Locus 2 Inputs	40:51:02.568 24S	72:36:04.820 91E	38:04:35.800 00S	70:12:34.700 00E	40:52:10.594 42S	72:33:54.495 92E	38:05:08.509 46S	70:11:30.963 82E	-2.0	-1.0	2.0
	Outputs	1	40:03:15.216 15S	71:47:36.655 50E	40:05:15.183 67S	71:47:43.736 13E	40:02:08.545 36S	71:49:46.618 23E				
test28	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	43:30:29.876 90S	68:12:45.600 00E	40:10:24.470 60S	68:15:22.148 60E	43:30:29.868 64S	68:14:08.047 91E	-2.0	-1.0	
	Locus 2 Inputs	40:56:44.386 23S	68:00:39.317 49E	38:04:35.800 00S	70:12:34.700 00E	40:56:13.101 74S	67:59:31.742 72E	38:03:35.713 46S	70:10:23.116 08E	-1.0	-2.0	3.0
	Outputs	1	40:25:28.598 97S	68:19:12.510 23E	40:25:27.850 71S	68:15:16.818 63E	40:27:01.081 04S	68:22:34.804 66E				
test29	Locus 1 Inputs	40:10:24.500 00S	68:12:45.600 00E	43:29:41.803 26S	68:36:41.648 63E	40:10:34.937 24S	68:10:09.640 46E	43:29:47.302 91S	68:35:19.564 75E	2.0	1.0	
	Locus 2 Inputs	40:46:58.965 10S	67:41:36.038 96E	38:04:35.800 00S	70:12:34.700 00E	40:47:34.755 34S	67:42:39.460 34E	38:05:44.686 44S	70:14:39.222 71E	1.0	2.0	2.0
	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
	Outputs	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
	Outputs	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
	Outputs	-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
	Outputs	-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	40:04:35.80000N	68:12:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	N/A	N/A	N/A	N/A
test2	40:04:35.80000N	67:12:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	38:58:50.99979N	68:42:19.92957W	41:17:02.57149N	68:34:37.49185W
test3	40:04:35.80000N	60:42:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	38:33:51.49399N	69:38:46.59230W	41:48:38.13537N	69:47:36.01065W
test4	40:04:35.80000N	47:18:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	38:32:36.38289N	69:45:21.56093W	41:50:24.89752N	70:17:02.95660W
test5	42:54:35.80000N	70:11:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	41:10:08.36776N	68:27:18.83665W	41:10:59.53083N	71:57:22.47464W
test6	64:54:35.80000N	70:11:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	40:15:27.76756N	68:02:23.12392W	40:15:31.95981N	72:23:07.86461W
test7	52:54:35.80000N	70:11:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	40:21:58.95584N	68:02:59.46118W	40:22:10.22316N	72:22:30.19164W
test8	40:24:35.80000N	75:11:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	41:43:51.26621N	70:59:57.14126W	38:44:18.56935N	71:18:35.69631W
test9	40:24:35.80000N	85:11:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	41:50:23.42412N	70:17:57.13255W	38:33:20.77969N	70:44:13.68450W
test10	40:24:35.80000N	80:11:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	41:49:34.92720N	70:30:17.76805W	38:34:51.79348N	70:51:10.47505W
test11	37:09:35.80000N	70:21:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	39:17:29.76121N	72:02:47.41811W	39:11:04.58987N	68:28:26.79906W
test12	30:09:35.80000N	70:21:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	39:53:58.01340N	72:21:11.40785W	39:51:26.97905N	68:04:57.44757W
test13	25:09:35.80000N	70:21:34.70000W	40:10:24.50000N	70:12:45.60000W	100.0	39:59:12.99136N	72:22:13.50689W	39:57:25.86494N	68:03:36.34196W
test14	40:04:35.80000N	72:12:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	N/A	N/A	N/A	N/A
test15	40:04:35.80000N	73:12:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	38:58:59.31128N	71:43:22.32134E	41:16:52.48137N	71:51:05.39764E
test16	40:04:35.80000N	80:12:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	38:33:38.85748N	70:45:44.00068E	41:48:54.91998N	70:35:56.19986E
test17	40:04:35.80000N	85:12:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	38:32:40.44989N	70:40:33.55927E	41:50:14.09817N	70:21:45.92010E
test18	42:54:35.80000N	70:11:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	41:10:59.53083N	71:57:22.47464E	41:10:08.36776N	68:27:18.83666E
test19	52:54:35.80000N	70:11:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	40:22:10.22315N	72:22:30.19164E	40:21:58.95586N	68:02:59.46118E
test20	57:54:35.80000N	70:11:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	40:18:20.82175N	72:22:56.15166E	40:18:13.61636N	68:02:34.42092E
test21	40:24:35.80000N	65:11:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	41:43:58.89962N	69:26:00.45951E	38:44:06.31619N	69:07:22.38700E
test22	40:24:35.80000N	55:11:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	41:50:23.55695N	70:07:38.55861E	38:33:20.46158N	69:41:19.14594E
test23	40:24:35.80000N	60:11:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	41:49:35.71820N	69:55:21.25651E	38:34:50.41383N	69:34:26.43627E
test24	37:09:35.80000N	70:21:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	39:11:04.58989N	68:28:26.79904E	39:17:29.76123N	72:02:47.41812E
test25	32:09:35.80000N	70:21:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	39:47:00.76207N	68:06:16.51285E	39:50:03.52790N	72:20:10.72389E
test26	27:09:35.80000N	70:21:34.70000E	40:10:24.50000N	70:12:45.60000E	100.0	39:55:34.77439N	68:03:58.36606E	39:57:35.60852N	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	68:12:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	N/A	N/A	N/A	N/A
test41	40:04:35.80000S	66:47:25.30000W	40:10:24.50000S	70:12:45.60000W	100.0	41:26:06.94082S	68:46:38.84215W	38:51:27.83161S	68:53:19.53080W
test42	40:04:35.80000S	56:47:25.30000W	40:10:24.50000S	70:12:45.60000W	100.0	41:50:00.49059S	70:00:06.82169W	38:32:50.15608S	69:44:01.95578W
test43	40:04:35.80000S	59:47:25.30000W	40:10:24.50000S	70:12:45.60000W	100.0	41:49:07.32741S	69:51:10.22069W	38:33:29.54331S	69:40:33.17198W
test44	38:04:35.80000S	70:11:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	38:50:48.30732S	68:54:26.10830W	38:49:55.28969S	71:29:33.42171W

test45	28:04:35.80000S	70:11:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	39:55:44.66533S	68:03:56.29379W	39:55:27.43828S	72:21:31.28285W
test46	33:04:35.80000S	70:11:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	39:46:03.95424S	68:06:35.51577W	39:45:36.78730S	72:18:46.32802W
test47	40:24:35.80000S	74:11:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	38:51:54.10807S	71:32:55.13292W	41:39:02.49151S	71:13:58.65781W
test48	40:24:35.80000S	84:11:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	38:33:30.19485S	70:45:01.28168W	41:50:19.19941S	70:19:56.15761W
test49	40:24:35.80000S	80:11:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	38:34:51.79347S	70:51:10.47504W	41:49:34.92720S	70:30:17.76806W
test50	43:09:35.80000S	70:21:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	41:02:16.59197S	72:05:02.69299W	41:08:20.56609S	68:25:37.35380W
test51	48:09:35.80000S	70:21:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	40:28:45.82853S	72:21:17.78853W	40:31:11.70040S	68:04:49.12313W
test52	53:09:35.80000S	70:21:34.70000W	40:10:24.50000S	70:12:45.60000W	100.0	40:21:08.09707S	72:22:38.37153W	40:22:30.13116S	68:03:03.81110W

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

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Appendix C. Administrative Information

1. Distribution. 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.

2. Background. The analysis of Global Positioning System/Wide Area Augmentation System (GPS/WAAS) navigation flight test data provides the basis for these criteria. A significant difference exists between approach procedures to runways and approach procedures to heliports. Approaches to runways terminate in relatively obstacle-free environments. Approaches to heliports commonly terminate in areas of dense population and large buildings. Speed limitations incorporated in these criteria provide the smallest obstacle clearance areas, the shortest segment lengths, and the lowest ceiling and visibility minimums. The graphic illustrations in this order are not to scale. The guidance published in this directive supersedes previous guidance concerning helicopters published in Terminal Instrument Procedures (TERPS) Instruction Letters (TILs) and other correspondence.

3. Definitions.

a. Approach Procedure Types using RNAV (GPS).

(1) IFR to an IFR Heliport (Public and Special). An IFR approach to a heliport that meets Advisory Circular (AC) 150/5390-2, Heliport Design, standards for an IFR heliport.

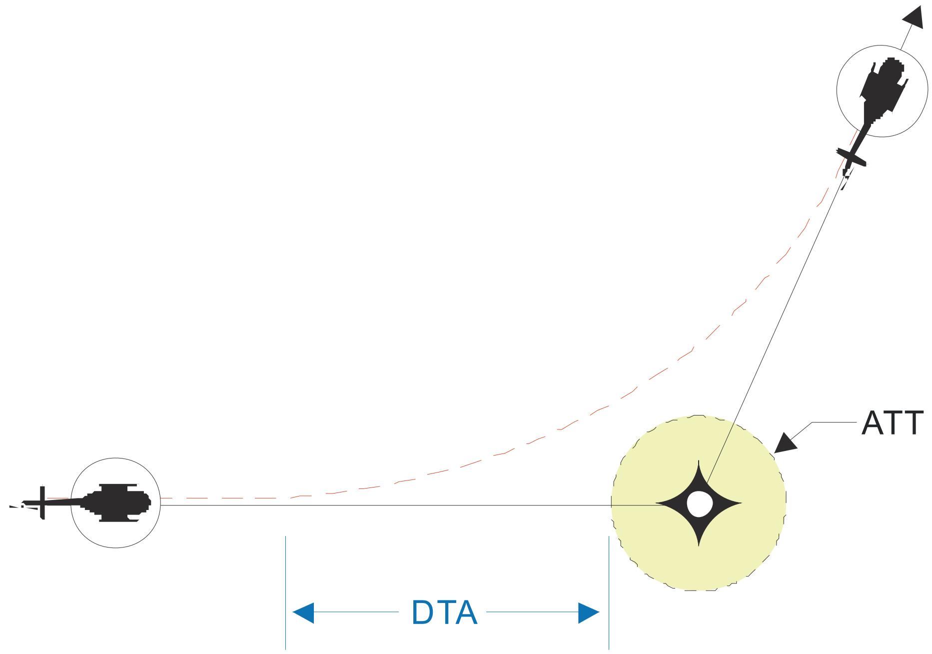
(2) IVH (Proceed Visually) (Special). An IFR approach to a VFR heliport that meets AC 150/5390-2 standards. This procedure requires flight standards approval. The phrase “Proceed Visually” is charted on the procedure for the visual segment from the MAP to the heliport. IVR applies IVH criteria to an approach to a VFR runway.

(3) Point-in-Space (PinS) Approach (Proceed VFR) (Public and Special). An IFR PinS approach to one or more VFR heliports. The phrase “Proceed VFR” is charted on the procedure for the VFR segment following the MAP.

(4) IFR to a Runway (Public and Special). An IFR helicopter approach procedure to a runway.

b. Distance of Turn Anticipation (DTA). DTA represents the maximum distance prior to a fly-by-fix that a helicopter is expected to start a turn to intercept the course of the next segment. The along-track tolerance (ATT) value, associated with a fix, is added to the DTA value when DTA is applied (see figure C-1 and formula 2-6).

Figure C-1. Distance of Turn Anticipation (DTA)



DTA = Radius x tan (degrees of turn ÷ 2)

c. Fly-By Fix. A fly-by fix is a waypoint where a turn is initiated prior to reaching it.

d. Fly-Over Waypoint (WP). A fly-over WP is a waypoint over which an aircraft is expected to fly before one turn is initiated.

e. Final Approach and Takeoff Area (FATO). A defined area over which the final phase of the approach to a hover, or a landing, is completed and from which the takeoff is initiated. The guidance for a FATO is published in AC 150/5390-2.

f. Fictitious Helipoint (FHP). The FHP is located 2,600 ft beyond the MAP and 9,023 ft in front of the flight path alignment point (FPAP). It is used to establish the approach course width for the WAAS.

g. 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, mean sea level (MSL) elevation, and WGS-84 Geoid height. The FPAP is used in conjunction with the FHP and the geometric center of the WGS-84 ellipsoid to define the final approach azimuth [localizer performance with vertical guidance (LPV) glidepath's vertical plane, where used) associated with a localizer performance (LP) or LPV final course.

h. Flight Technical Error (FTE). FTE is the measure of the pilot or autopilot's ability to control an aircraft so that its indicated position matches the desired position.

i. Global Navigation Satellite System (GNSS) Azimuth Reference Point (GARP). A calculated point 1,000 ft beyond the FPAP lying on an extension of a geodesic line from the landing threshold point/fictitious threshold point (LTP/FTP) through the FPAP. This point is used by the airborne system as the origin of the lateral guidance sector. It may be considered as the origin of an imaginary localizer antenna.

j. 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 a mean sea level (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 MSL in the oceans. It is the reference surface for MSL heights.

k. Heliport Approach Lighting System (HALS). The HALS is a distinctive approach lighting configuration designed to prevent it from being mistaken for an airport runway approach lighting system. HALS consists of ten bars of lights at 100-ft increments and has a length of 1,000 ft (305 m). HALS provides a visibility credit of 1/4 statute mile (SM) for nonprecision approaches.

l. Height Above Landing Area Elevation (HAL). The HAL is the height of the minimum descent altitude (MDA) above helipoint elevation.

m. Height Above Surface (HAS). HAS is the height of the MDA above the highest terrain/surface within a 5,200-ft radius of the MAP in the PinS procedure.

n. Helipoint Crossing Height (HCH). The HCH is the height of the vertical guidance path above the heliport elevation at the helipoint.

o. Helipoint. The helipoint is the aiming point for the visual segment and is normally centered in the touchdown and lift-off area (TLOF). The TLOF is normally centered in the FATO.

p. Heliport. An area of land, water, or structure used or intended to be used for helicopter landings and takeoffs and includes associated buildings and facilities. IFR and VFR heliports are described in AC 150/5390-2.

q. Heliport Elevation (HE). For heliports without a precision approach, the heliport elevation is the highest point of the FATO expressed as the distance above mean sea level (MSL).

r. Heliport Reference Point (HRP). The geographic position of the helipoint, measured at the center of the FATO or the central point of multiple FATOs, expressed as (WGS-84/NAD-83) latitude and longitude to the nearest hundredth of a second. The HRP elevation is equal to the heliport elevation.

s. Initial Departure Fix (IDF). The first fix on a PinS departure procedure where application of IFR obstruction protection and air traffic separation standards are provided.

t. IFR Heliports. Facility specifications for IFR Heliports are described in chapters 6 or 7 as appropriate of Advisory Circular 150/5390-2, Heliport Design. Chapter 6 of AC 150/5390-2 relates to paragraph 5.3 of this order for nonprecision IFR approach procedures to IFR heliports.

u. Landing and Takeoff Site. The area of intended landing and takeoff. It can be a heliport, helistop, vertiport, or other point of landing designated for a PinS approach.

v. Landing Threshold Point. 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.

w. Proceed Visually. This phrase requires the pilot to acquire and maintain visual contact with the FATO or elements associated with the FATO such as heliport lighting, precision approach path indicator (PAPI), etc. at or prior to the MAP. Obstacle and terrain avoidance from the MAP to the FATO is the responsibility of the pilot. A missed approach procedure is not provided between the MAP and the landing FATO.

x. Proceed VFR. For PinS procedures, this phrase requires the pilot to proceed from the MAP to the selected landing area on the approach chart with no less than the visibility and ceiling required on the approach chart. For flights that do not terminate at the selected landing area on the approach chart, the pilot is required to proceed from the MAP under the applicable VFR for ceiling and visibility required by the applicable Title 14 Code of Federal Regulations (14 CFR) but no less than the visibility required on the approach chart, operations specifications (OpsSpec), or letter of agreement (LOA). The pilot is responsible for obstacle and terrain avoidance from the MAP to the landing site. A missed approach procedure is not provided between the MAP and the landing site. The landing site is not required to be in sight from the MAP.

y. 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.

z. Touchdown and Lift-Off Area (TLOF). A TLOF is a load bearing, generally paved area, normally centered in the FATO, on which the helicopter lands or takes off (see AC 150/5390-2).

aa. United States Air Force (USAF).

bb. United States Army (USA).

cc. United States Coast Guard (USCG).

dd. United States Navy (USN).

ee. VFR Heliports. Standards and recommendations for VFR and IFR heliports are described in chapters 2 through 5 and chapter 8 of AC 150/5390-2. Paragraph 5.4 of this order relates to VFR heliports.

ff. Minimum instrument meteorological condition airspeed (V_{mini}). V_{mini} means instrument flight minimum speed, utilized in complying with minimum limit speed requirements for instrument flight. This is the certified minimum airspeed that a specific helicopter is approved to enter instrument meteorological flight conditions.

gg. Visual Segment Descent Angle (VSDA). The angle of descent in the visual segment.

hh. Visual Segment Descent Point (VSDP). The descent point within the visual segment of a helicopter instrument approach to an IFR heliport or runway.

ii. Visual Segment Reference Line (VSRL). A line perpendicular to the final course at a distance of 75 ft (22.9 m) from the helipoint for public use heliports and 50 ft (15.27 m) from the helipoint for heliports with special instrument procedures. It extends 75 ft (22.9 m) on each side of the final course centerline for public use heliports and 50 ft (15.27 m) on each side of the final course centerline for heliports with special instrument procedures. For IFR procedures the line is 75 ft (22.9 m) from the helipoint and it extends 75 ft (22.9 m) on each side of the final approach course.

jj. Wide Area Augmentation System (WAAS) Localizer Performance (LP). The LP approach applies lateral-only WAAS guidance (and reduced OEA) within the FAS to a PinS.

4. Data Resolution. See chapter 2, paragraph 2.

5. Related Publications. All directives in this order refer to the latest editions:

a. Advisory Circular 150/5390-2, Heliport Design.

b. Order 7130.3, Holding Pattern Criteria.

c. Order 8260.3, United States Standard for Terminal Instrument Procedure (TERPS).

d. Order 8260.19, Flight Procedures and Airspace.

e. Order 8260.40, Flight Management System Instrument Procedures Development.

f. Order 8260.45, Terminal Arrival Area (TAA) Design Criteria.

g. Order 8260.54, United States Standards for Area Navigation (RNAV).

6. 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.

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Directive Feedback Information

Please submit any written comments or recommendation for improving this directive, or suggest new items or subjects to be added to it. Also, if you find an error, please tell us about it.

Subject: Order 8260.42B, United States Standard for Helicopter Area Navigation

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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