SOLITEC

Software Solutions GesmbH

Geodetic Calculation Services (GCS)

User Guide

GCS Version 2.0

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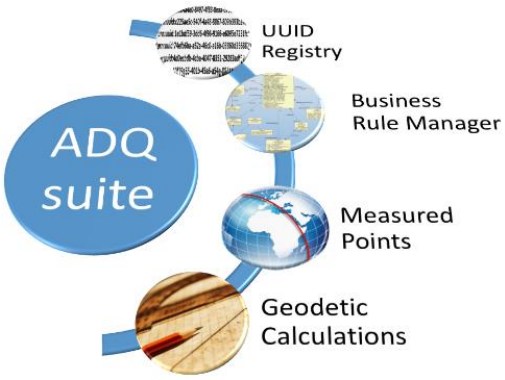
TABLE OF CONTENT

1 INTRODUCTION

The Geodetic Calculation Services (GCS) is one out of four modules, which SOLITEC offers in the scope of its product and service portfolio named "ADQsuite". For further information on the whole ADQsuite check out adq-suite.aero.



GCS provides several calculation routines documented in the FAA "Standard for Performance Based Navigation (PBN) Instrument Procedure Design" (Order 8260.58)" such as Direct, Inverse and Intersection. As a result of the calculations, GCS offers a range of processes for retrieving and validating geographical aeronautical data. The calculations take into account magnetic variation based on the World Magnetic Model (WMM).

2 GEODETIC CALCULATION ROUTINES

GCS provides geodetic computation routines based on the "Direct and Inverse Solutions of Geodesics on the Ellipsoid with Application of Nested Equations", published by Thaddeus Vincenty in the Survey Review Journal, in April 1975.

The FAA "United States Standard for Performance Based Navigation (PBN) Instrument Procedure Design" document (Order 8260.58) uses these calculations as the baseline for the algorithms defined and required for performing navigation and procedure design computations.

GCS Version 1.3.1 contains the following calculation routines based on the algorithms described in FAA Order 8260.58:

- Basic Calculations
  - Direct
  - Inverse
- Intersections
  - Bearing-Bearing
  - Segment-Segment
  - Segment-Bearing
  - Segment-Distance
  - Bearing-Distance
  - Distance-Distance
  - Abeamfix on segment
- Other Calculations
  - Point on segment
  - Arc length
  - Fixed Radius Arc Tangents

For a detailed description of each calculation type see **Annex I**.

3 LOG IN

If not already registered, you need to register first in order to get your log in details (i.e. email address and password) for accessing GCS. You can sign up for GCS via the corresponding website http://adq-suite.aero/ or opening the sign up page directly via https://gcs.solitec.com/users/sign_up.

Note: After singing up you have to be activated by the GCS administrator. Once this is done, you will receive a corresponding email with your login instructions and details.

Once you have received your log in details, you can use them to access GCS.

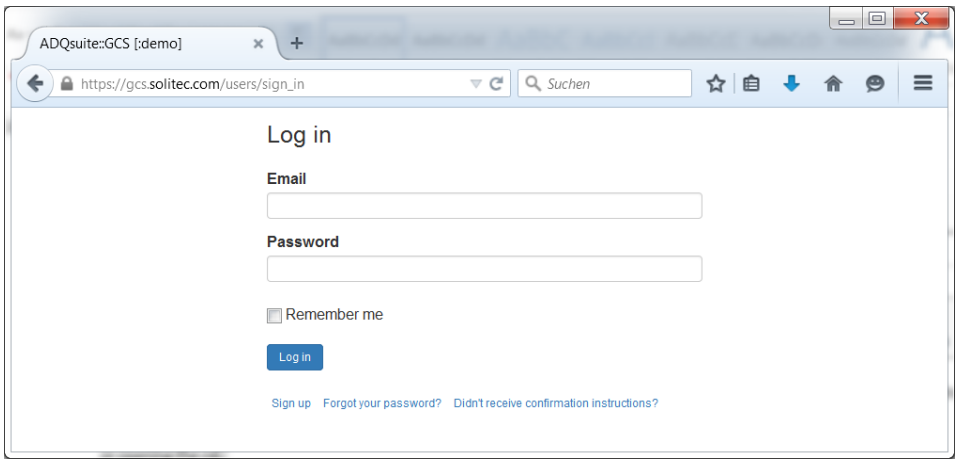


Figure 1. GCS – Log in

4 GRAPHICAL USER INTERFACE

The graphical user interface of all calculation types of GCS are structured into 4 sections:

- Header section (containing the menu items),
- Data input section
- Calculation result section
- Map

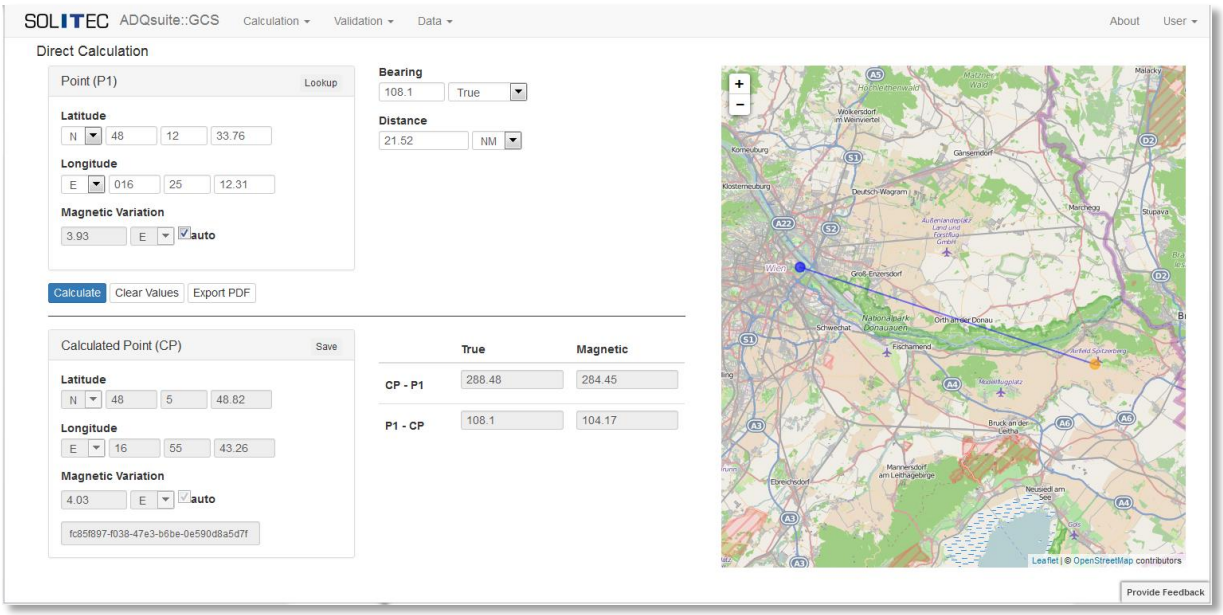


Figure 2. GCS - Graphical User Interface

4.1 Header Section

The header section contains the following main menu items:

- Calculation
- Validation

- Data
- About
- User

4.1.1 Calculation Menu

The calculation menu can be used to select and access the corresponding calculation type screen.

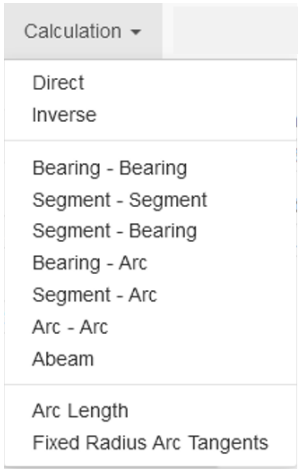


Figure 3. Calculation Menu

4.1.2 Validation Menu

The validation menu can be used to select and access the corresponding data validation service screen.

Note: As the services are customised for particular use cases applying specific calculation routines, not all services may be available for all users.

In the current version GCS provides the “Route Validation” service for all users.

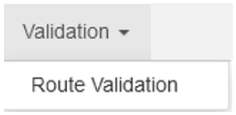


Figure 4. Validation Menu

4.1.3 Data Menu

The Data menu can be used to select the data management functionalities of GCS.

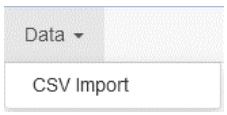


Figure 5. Data Menu

Currently a CSV import function is provided. In future versions of GCS also other data management functions such as AIXM import and CSV & AIXM export, will be provided.

For details about the CSV import function see chapter 6.

4.1.4 Help Menu

The Help menu contains an entry that to access the Online Help and another one to open the About screen.

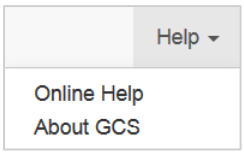


Figure 6. Help Menu

The about screen contains detailed information about the GCS version and a link to the ADQsuite website.

4.1.5 User Menu

The user menu can be used to logout of GCS.

4.2 Data Input Section

Depending on the selected calculation type or validation service, this section will give the user the possibility to enter the data that are used to perform the requested calculation or data validation, e.g. source point coordinates, bearing, distance, radius, arc direction.

For details about the input data see Annex I listing all the calculation types.

In order to initiate a calculation, the corresponding input fields have to be populated. After using the "Calculate" button, the output result fields are automatically filled with the corresponding values.

If Magnetic Variation is not filled, it will be calculated by the system (see also chapter 5).

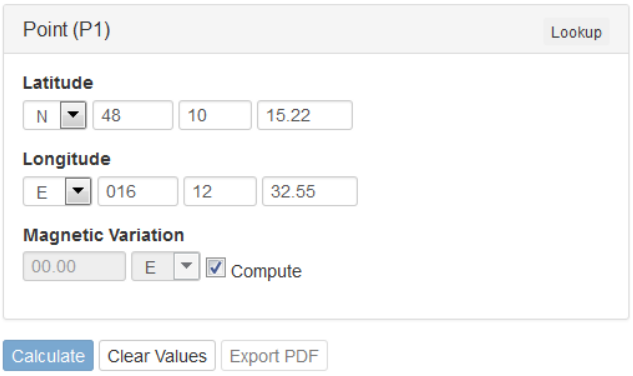


Figure 7. Data Input Section

The "Clear Values" button can be used to clear all input and subsequently also all output data fields.

4.3 Calculation Result Section

Depending on the selected calculation type or validation service this section will provide the calculated results, e.g. calculated point coordinates, bearing, distance and arc length.

For details about the input data, see Annex I listing all the calculation types.

4.4 Map

The input parameters and the results of the calculation and data validation respectively, are displayed on a map integrated into the GCS web application. Currently, leaflet based on the OpenStreetMap tile layer is used for that purpose.

To be able to distinguish the input and output data on the map, the elements are represented in different colours. Input data are **blue** and the calculation results are shown in **orange**.

In order to identify the points on the map, they can be clicked and will then show a corresponding label.

The example below shows a segment defined by two points and a distance (arc) from another point (the input data in blue), which results in an intersection with two resulting calculated points (presented in orange).

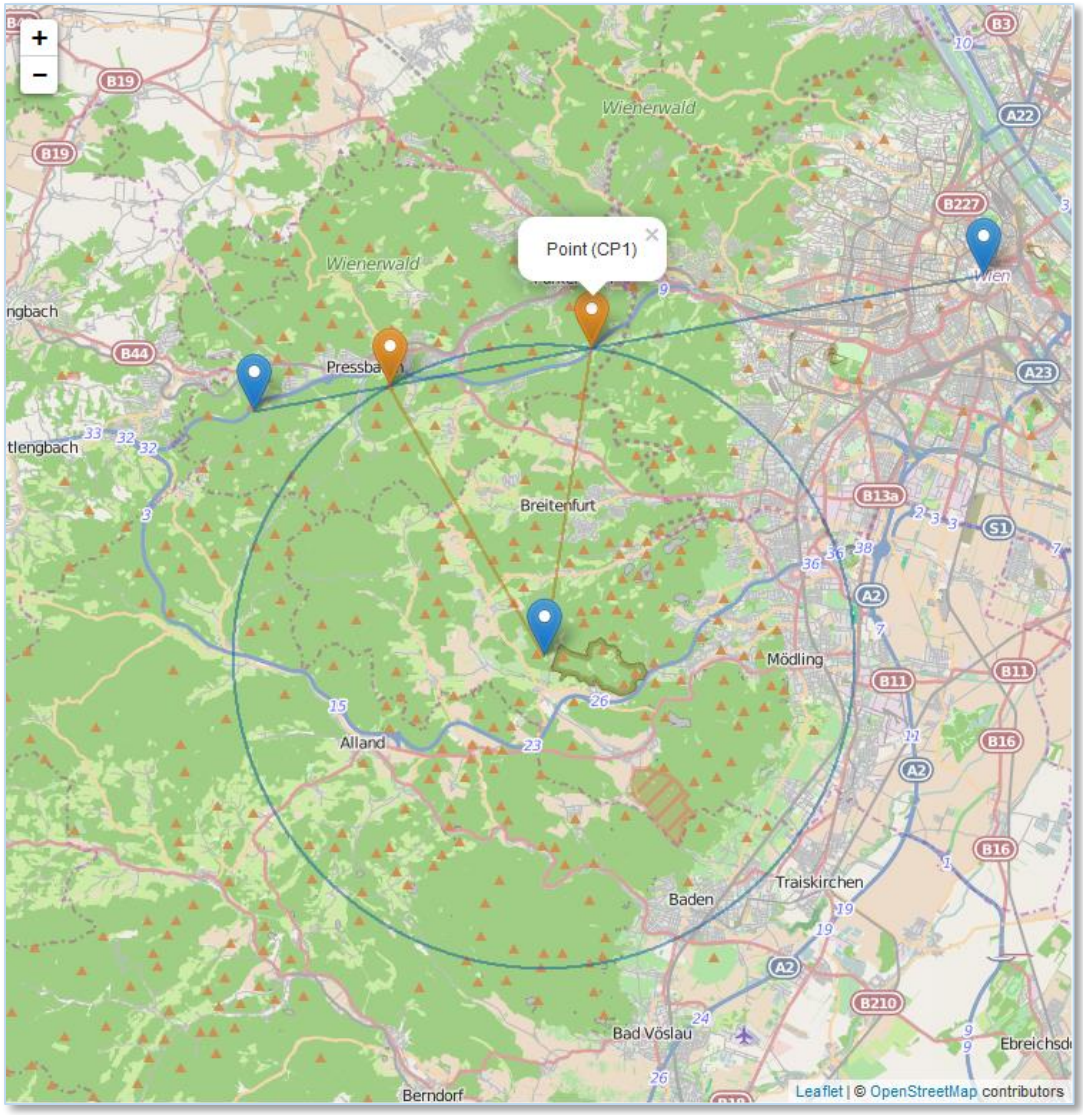


Figure 8.GCS – Map

4.5 Provide Feedback Function

In the right bottom corner on each you will find the “Provide Feedback button”. Using this button will open a corresponding dialog window, where the user can provide feedback, report bugs, etc.

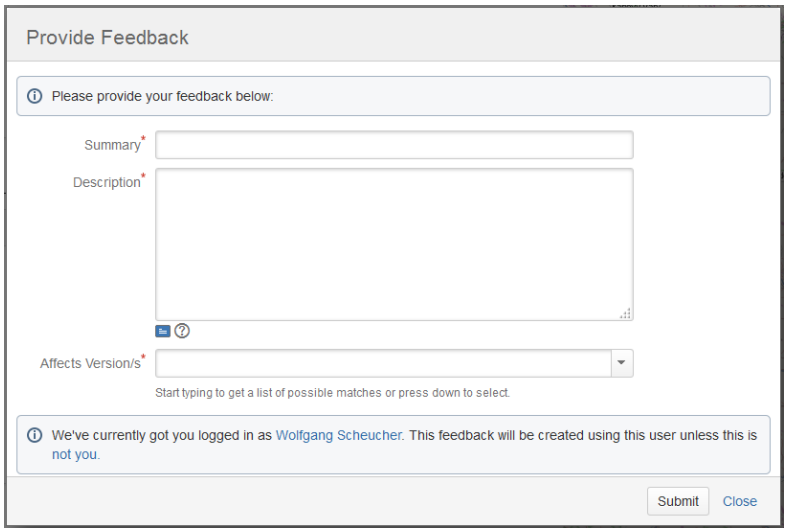


Figure 9. GCS Provide Feedback Window

5 MAGNETIC VARIATION SUPPORT

The support of the magnetic variation as a parameter, based on the latest version of the World Magnetic Model (WMM), is one of the features with the highest added value for the GCS users.

GCS applies the WMM for any calculation that involves magnetic variation. This includes the calculation of the magnetic variation:

- At the source point(s)
- At the calculated point(s)
- For Bearings

For more details about the WMM see http://www.ngdc.noaa.gov/geomag/WMM/DoDWMM.shtml.

5.1 Magnetic Variation Auto Function

This function applies the magnetic variation defined for the source point.

- In case the “auto” checkbox is selected (which is the default), GCS will calculate the magnetic variation for the source point automatically.
- In case the “auto” checkbox is de-selected, the user can manually enter the magnetic variation at the source point. The entered value will be kept for all subsequent calculations performed, as long as no other value is manually entered, or the auto checkbox is activated again.

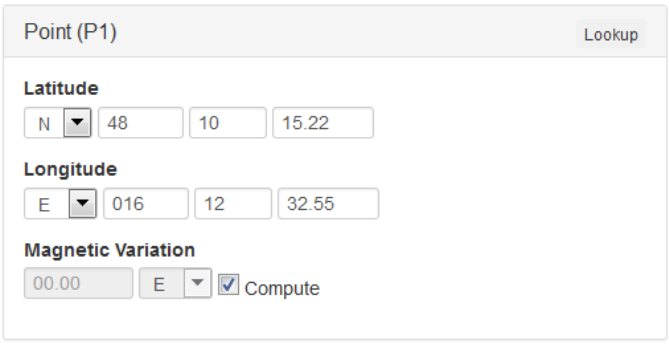


Figure 10. Magnetic Variation – auto function

Note: the magnetic variation at the source point is used for the further calculation and has an impact on the calculation result (e.g. bearings and calculated point position).

6 DATA MANAGEMENT

The GCS data management provides the possibility to upload points from a comma separated values (CSV) file, and allows to save calculated points in order to use them (via a data lookup function) as input for calculations.

6.1 Save Calculated Point

GCS provides the possibility to save points that are calculated. Therefore the user interface provides a corresponding “Save” button assigned to all point that are calculated.

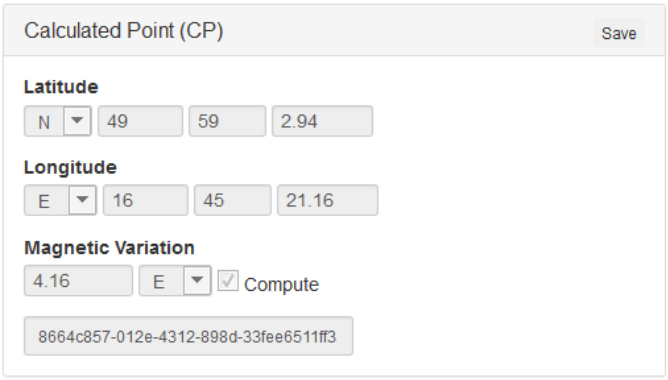


Figure 11. Save calculated point

When saving a calculated point, a “Designator” has to be given to that point. The Designator can be used later on to query the point for using it as source point for further calculations.

Figure 12. Save Point Window

The saved point(s) can be used as input data for further calculation by using the Point Lookup function.

6.2 Upload Points

This function can be accessed via the “Data” menu selecting the “CSV Import” entry.

This function can be used for the bulk upload of points, using as source a corresponding CSV file. The uploaded points can subsequently be used as data input for calculations via the Point Lookup function.

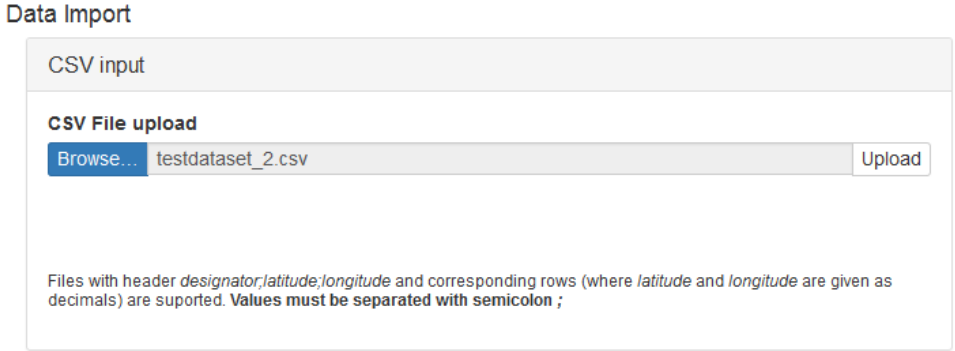


Figure 13. CSV Input

The structure of the CSV file has to be as described in the figure above.

In order to upload a csv file containing the point data the “Browse” button is used to locate and select the data file. Subsequently the upload button is used to upload the point data into GCS. A pop-up window shows the upload status information, i.e. how many records have been created (i.e. new points loaded into the system). In case the GCS data upload identifies that the designator of a point in the csv is already in the system, the corresponding point will be updated with the data (i.e. coordinates) provided in the csv.

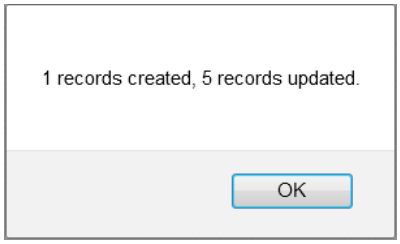


Figure 14. Data Upload Status Information

6.3 Point Lookup

Points that have been saved or uploaded into GCS, can be used as input for other calculations. Therefore the user interface provides a corresponding “Lookup” button in each Source Point section (e.g. P2).

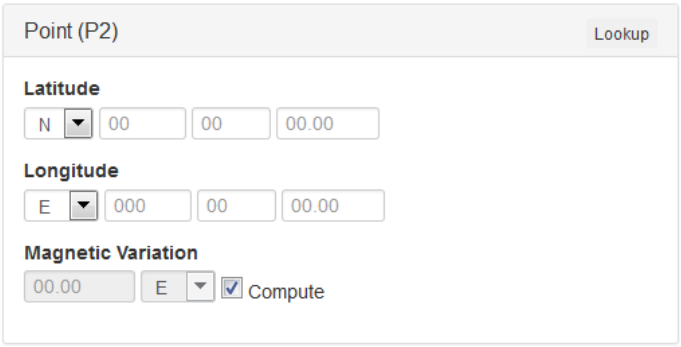


Figure 15. Source Point Section

The stored points can be searched by using their “Designator”.

Figure 16. Lookup Point Window

7 REPORTING

For each calculation type and data validation a corresponding PDF report can be created.

To generate such a report, the “Export PDF” button is used.

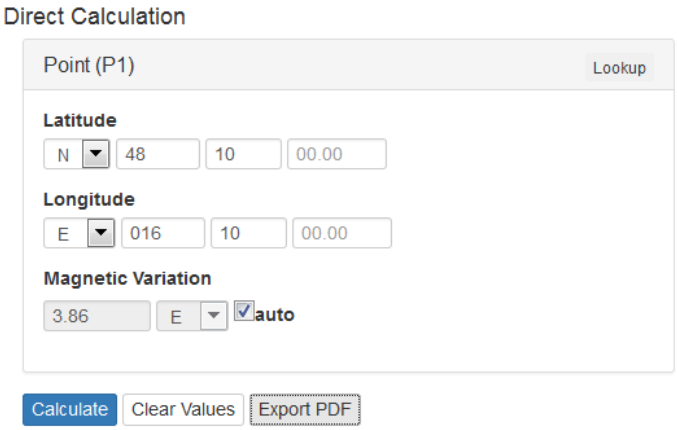
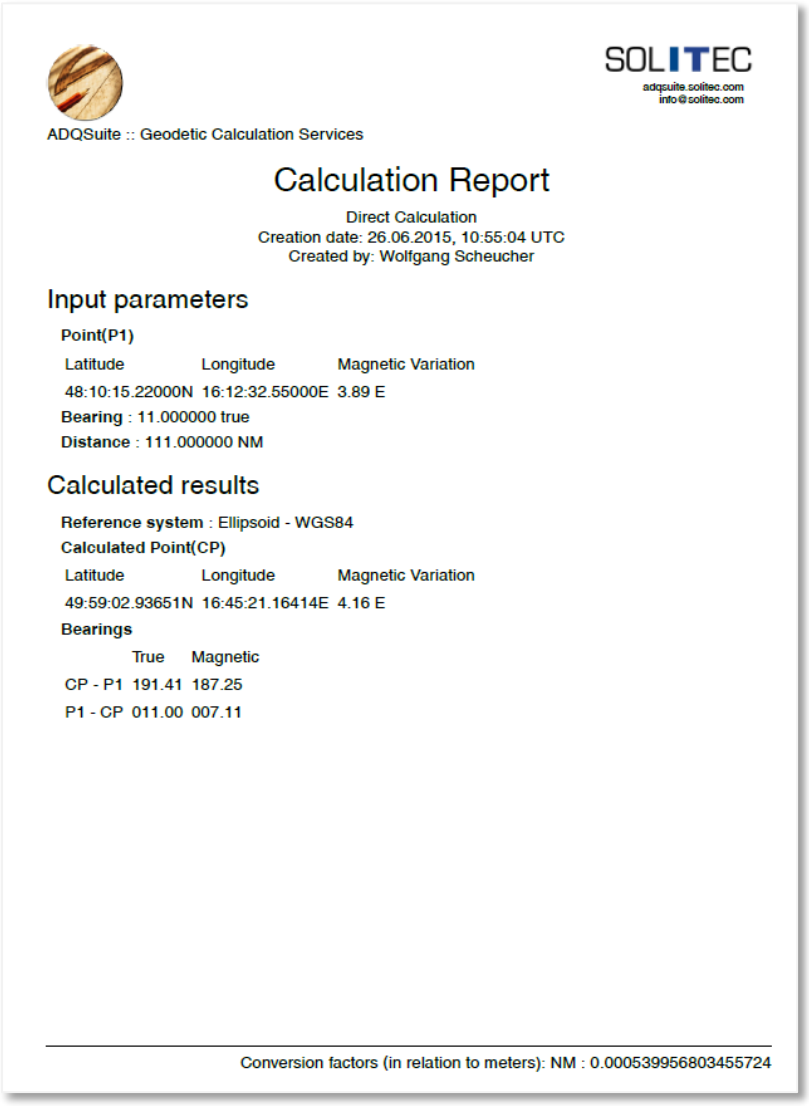


Figure 17. Export PDF

The corresponding report contains all the input data and the output results. Additionally the report provides

- Creation date: date/time when the report was generated (UTC!)
- Created by: user name

See an example below for the Direct calculation:



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Calculation Report

Direct Calculation
Creation date: 26.06.2015, 10:55:04 UTC
Created by: Wolfgang Scheucher

Input parameters

Point(P1)

Latitude	Longitude	Magnetic Variation
48:10:15.22000N	16:12:32.55000E	3.89 E

Bearing : 11.000000 true
Distance : 111.000000 NM

Calculated results

Reference system : Ellipsoid - WGS84
Calculated Point(CP)

Latitude	Longitude	Magnetic Variation
49:59:02.93651N	16:45:21.16414E	4.16 E

Bearings

	True	Magnetic
CP - P1	191.41	187.25
P1 - CP	011.00	007.11

Conversion factors (in relation to meters): NM : 0.000539956803455724

Figure 18. GCS - Report

8 UUID GENERATION

Some of the GCS calculations, e.g. the “Direct calculation” support the generation of Universally Unique identifiers (UUID). UUIDs are used in AIXM 5.1 as artificial identifier for feature instances. See below the example of an UUID for a Designed Point with designator “LUGAX” coded in AIXM 5.1 format:

```
<hasMember xlink:type="simple">
   <aixm:DesignatedPoint gml:id="uuid.de6c1417-85e2-4a4c-ba3d-b96f1489ae7c">
      <gml:identifier codeSpace="urn:uuid:">de6c1417-85e2-4a4c-ba3d-b96f1489ae7c</gml:identifier>
      <gml:boundedBy xsi:nil="true"/>
      <aixm:timeSlice>
         <aixm:DesignatedPointTimeSlice gml:id="uuid.f0381684-be97-4c8b-a025-6323fa2e106c">
            <gml:validTime xlink:type="simple">
            <aixm:interpretation>BASELINE</aixm:interpretation>
            <aixm:sequenceNumber>1</aixm:sequenceNumber>
            <aixm:correctionNumber>0</aixm:correctionNumber>
            <aixm:featureLifetime xlink:type="simple">
            <aixm:designator>LUGAX</aixm:designator>
```

Figure 19. AIXM 5.1. Example for UUID

Using the e.g. the Direct Calculation for the resulting calculated point a UUID will be generated.

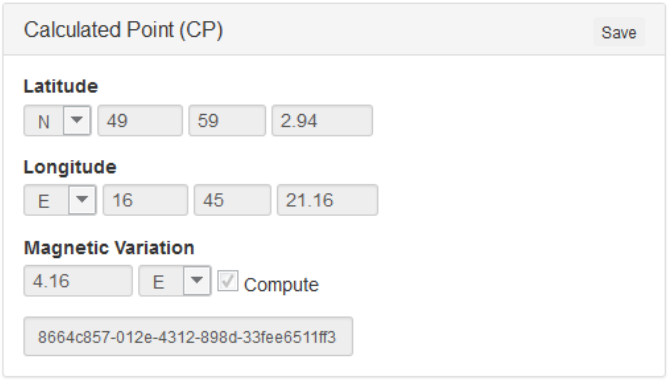


Figure 20. UUID Generation

Note: The UUID generation function is currently implemented just for test purposes. It is not further used or saved.

9 DATA VALIDATION

In addition to the standard set of calculation routines, GCS can provide customised data validation services, based on customers business processes. In GCS version 1.3.1, we have made the award winning “Route Validation” service available[1].

9.1 Route Validation

One of the most common validations needed to be performed on aeronautical data is for the En-route structure, composed of airways and route segments. Each route segment is defined by a pair of significant points (start and end), by a length and by one or two (magnetic) bearings, if the route segment is unidirectional or bidirectional. This information is provided usually in the AIP, in ENR 3 section:

[1] SESAR SWIM Master Class 2014 Best-in-Class Award

Route Designator {RNP Type}	[Route Usage Notes]								
Significant Point Name	Significant Point Coordinates								Remarks
{RNP Type}	Track MAG ↓ ↑	Dist NM	(COP)	Upper limit / Lower limit	Minimum flight altitude	Lateral limits (KM)	FL series ↓	FL series ↑	Controlling unit {Airspace class} Remarks
1	2	3	4	5	6	7	8	9	10
G783 (RNAV 5)	Route availability: (1) H24								
▲ TANSU FIR BDRY	224136N 0542828E								(2) (3) (4) (8)
	064° / 244°	47.0		FL 330 / FL 265			Odd(1)	Even(1)	[Class A]
▵ RIGIL	230146N 0551430E								
	014° / 194°	51.0		UNL / FL 195			Odd(1)	Even(1)	[Class A]
▵ ELUDA	235107N 0552905E								(5)
	014° / 194°	25.3		UNL / FL 145			Odd(1)	Even(1)	[Class A]
▵ **AL AIN** DVOR/DME (ALN)	241535.1N 0553622.9E								(6)
	040° / 220°	27.1		UNL / FL 145			Odd(1)	Even(1)	[Class A]
▵ GIDIS	243600N 0555600E								(7)
	023° / 203°	23.7		UNL / FL 145			Odd(1)		[Class A]
▵ BUBIN	245742N 0560642E								

Point/Segment Remarks:
(2) Eastbound traffic contact EMIRATES ACC 5 minutes before TANSU
(3) Transfer point between BAHRAIN ACC and EMIRATES ACC
(4) EMIRATES ACC FREQ: 125.725 MHZ (North of ALN), 128.250 MHZ (South of ALN)
(5) Cross N563
(6) Cross P899
(7) Cross R401
(8) Southbound traffic Level restrictions at TANSU: Only FL300 and FL320 available if routing via PURDA. FL300 and FL320 not available if routing via KIPOM

Figure 21. AIP ENR 3 Route Description

A routine route segment validation process is straight forward: it takes into account the geographical position of the start and end significant points, attempts to calculate the distance between them (usually a geodetic line on WGS84 ellipsoid) and the forward / reverse tracks between these two points. The challenge a data specialist faces when presented with such a scenario is given by the fact that the tracks are magnetic. In order to perform geodetic calculations, the specialist has to:

1. Identify / calculate the magnetic variation at each significant point of the route,
2. Calculate the true tracks from the given magnetic tracks.

9.1.1 Business Process

GCS comes forward and supports such a scenario by automating the two steps presented above. Using the World Magnetic Model (WMM) parameters and algorithms, it determines automatically the magnetic variation at each and every SignificantPoint of the route, and then it applies the magnetic variation value to each and every true bearing resulting from the Inverse solution used for this service.

The results (segment length and tracks) are compared with the values of the attributes in the received data and any difference that exceeds the accuracy at the required resolution is identified and reported.

The operational benefit and the added value proposed by GCS consists in the following:

- It provides an accurate (to the level of millimetre) calculation of the aeronautical data,
- It automates a process, which for an entire route network published in a State AIP may otherwise take days to perform.

Version 1.3.1 of the GCS comprises the Route Segment Validation process. It validates route segment data provided in AIXM 5.1 format.

The Route Segment validation process of the GCS calculates tracks and length of the route segments of a route and validates it against provided values. It returns the given (provided) value, the calculated value and the difference between the two values. The calculations are done using the xlink:href referenced EnRouteSegmentPoint start and end of RouteSegment. Position data in the Curve element are checked by comparison to the EnRouteSegmentPoint.

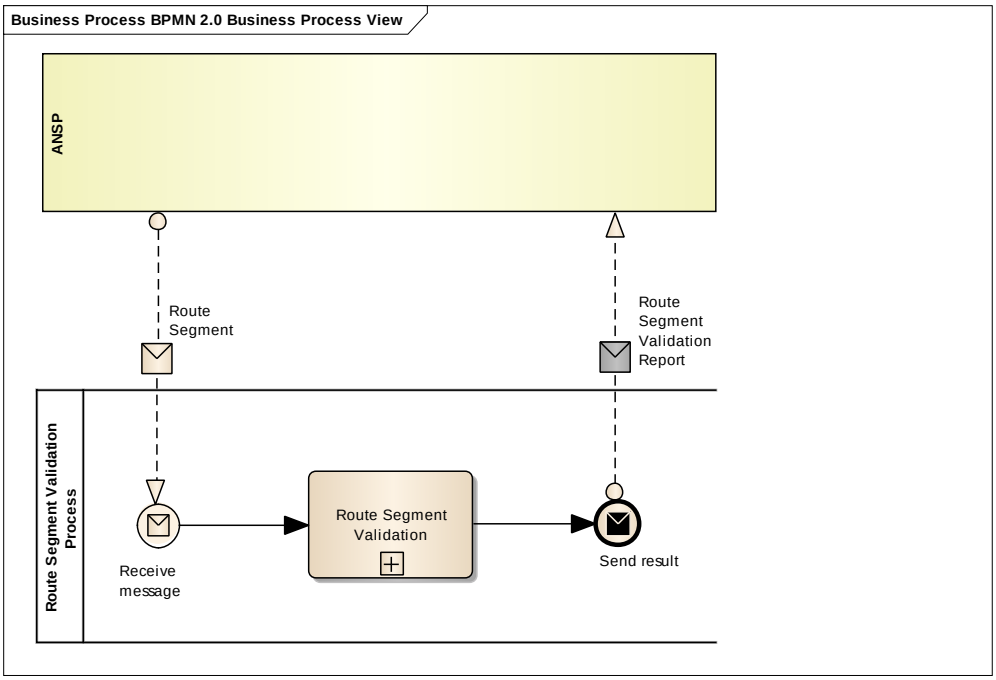


Figure 22. Business Process Overview

9.1.2 Route Validation Provision

The route validation service is provided as

1. **Web Processing Service** (system to system connection) and
2. **Web Application** integrated in the GCS GUI.

Ad 1) GCS is developed as an OGC compliant Web Processing Service (WPS) Version 1.0. For the technical details how to retrieve and use that service see Annex II.

Ad2) Part of GCS is also a web application with a corresponding Graphical User Interface (GUI) and map visualisation.

9.1.3 Data Input

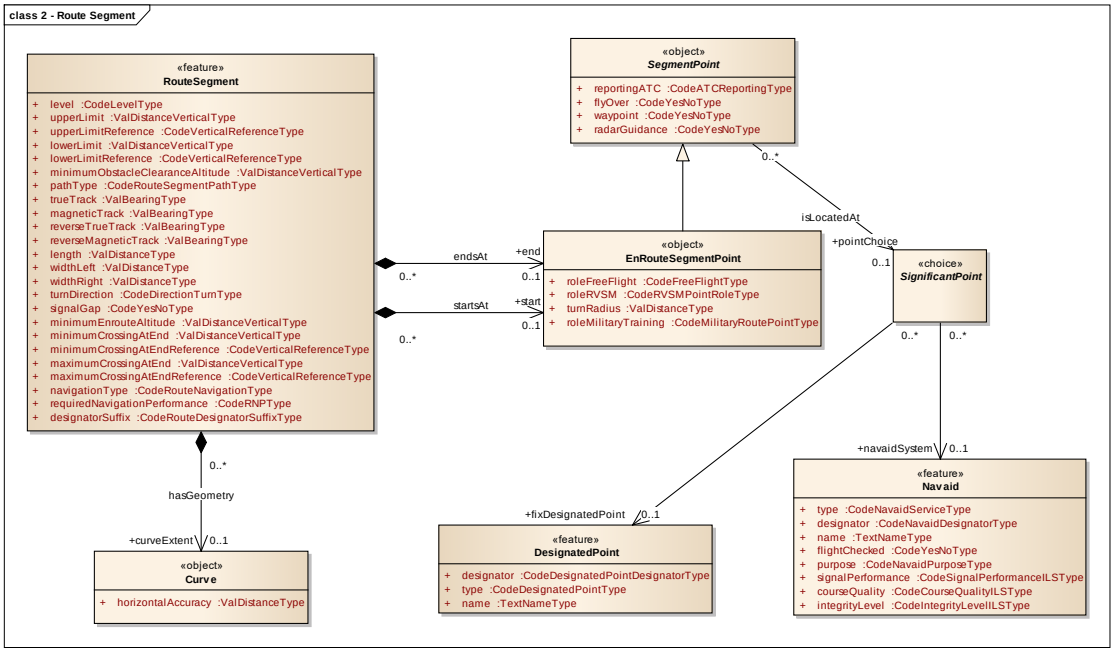


Figure 23. AIXM 5.1 Route Segment UML

AIXM_BasicMessage is the default input source expected by GCS (other AIXM 5.1 application schemas may also be supported).

In AIXM 5.1 all properties within a timeslice feature are optional. In order to perform the required calculations the input data file as minimum must contain values other than Null for the following properties:

- RouteSegment.start,
- RouteSegment.end,
- EnRouteSegmentPoint.pointChoice, (Note: fixDesignatedPoint and navaidSystem is supported by GCS)
    - DesignatedPoint.designator, and
    - DesignatedPoint.location, or
    - Navaid.designator and
    - Navaid.location.

Note: AIXM feature instances used as start and end of the RouteSegment (i.e. DesignatedPoint and/or Navaid) have to be included in the AIXMBasicMessage and have to be local referenced. In case one of these input data elements is missing, the calculation cannot be performed and an error will be returned.

Optional input data:

- RouteSegment.trueTrack,
- RouteSegment.magneticTrack,
- RouteSegment.reverseTrueTrack,
- RouteSegment.reverseMagneticTrack,
- RouteSegment.length.

Optional input data for validation of the gml geometry:

- RouteSegment.curveExtent.

Note: gml:GeodesicString with gml.posList or gml.pos is supported.

9.1.4 Validation Process

The Route Segment Validation service calculates the following data of route segments (Note: all calculations are done based on the WGS84 ellipsoid, using the Vincenty Inverse method):

- length,
- true track,
- reverse true track,
- magnetic track,
- reverse magnetic track.

The calculation is done using the location of the start point and the end point of the route segment provided as EnRouteSegmentPoint in the AIXM 5.1 data file. These points are referenced using the xlink:href attribute.

Thus, it is important that these start and end points (which in AIXM 5.1 are SignificantPoint of choice either DesignatedPoint or Navaid – see Figure 24 and Figure 25) are contained in the same AIXM 5.1 data file.

```
<aixm:start>
   <aixm:EnRouteSegmentPoint gml:id="uuid.6321b378-ded8-4001-bfce-6fbb98ba938c">
      <aixm:pointChoice_fixDesignatedPoint xlink:type="simple"
         xlink:href="#uuid.de6c1417-85e2-4a4c-ba3d-b96f1489ae7c"/>
   </aixm:EnRouteSegmentPoint>
</aixm:start>
```

Figure 24. AIXM 5.1 pointChoice


```
<hasMember xlink:type="simple">
   <aixm:DesignatedPoint gml:id="uuid.de6c1417-85e2-4a4c-ba3d-b96f1489ae7c">
      <gml:identifier codeSpace="urn:uuid:">de6c1417-85e2-4a4c-ba3d-b96f1489ae7c</gml:identifier>
      <gml:boundedBy xsi:nil="true"/>
      <aixm:timeSlice>
         <aixm:DesignatedPointTimeSlice gml:id="uuid.f0381684-be97-4c8b-a025-6323fa2e106c">
            <gml:validTime xlink:type="simple">
            <aixm:interpretation>BASELINE</aixm:interpretation>
            <aixm:sequenceNumber>1</aixm:sequenceNumber>
            <aixm:correctionNumber>0</aixm:correctionNumber>
            <aixm:featureLifetime xlink:type="simple">
            <aixm:designator>LUGAX</aixm:designator>
```

Figure 25. AIXM 5.1 DesignatedPoint

Subsequently, the result of the calculations is compared to the corresponding property values of the data provided in the AIXMBasicMessage, and the differences between the calculated and given values are computed.

Note: The corresponding AIXM 5.1 property values may be Null or missing. In this case, only the calculated value(s) will be returned in the output process.

The calculations are done for all Route segments contained in the input file.

In addition, a compliancy check for position data contained in the Curve element of the AIXM 5.1 message is made. The position of the EnRouteSegmentPoint is compared with the one provided in the curveExtent of the RouteSegment element. The result is reported.

```
<aixm:curveExtent>
  <aixm:Curve gml:id="gmlID163620" srsDimension="2" srsName="urn:ogc:def:crs:OGC:1.3:CRS84">
    <gml:segments>
      <gml:LineStringSegment>
        <gml:posList>53.46416666666667 25.599166666666665 53.015277777777776 25.705</gml:posList>
      </gml:LineStringSegment>
    </gml:segments>
  </aixm:Curve>
```

Figure 26 AIXM 5.1 curveExtent

9.1.5 Process Output

As output the given value (provided in the AIXM 5.1 message), the calculated value and the difference between the two values are returned. In addition, the result of the curve check is provided.

9.1.5.1 GCS as Web Processing Service

The output of the validation process is the “Route Segment Validation Report”. As validation result the output contains the following data for each Route Segment provided in the AIXMBasicMessage:

- designator of start EnRouteSegmentPoint,
- designator of end EnRouteSegmentPoint,
- length (given, calculated and difference),
- trueTrack (given, calculated and difference),
- magneticTrack (given, calculated and difference),
- reverseTrueTrack (given, calculated and difference),
- reverseMagneticTrack (given, calculated and difference).

The report also contains the result of the Curve check, i.e. it will be either “Ok” or “Error”

This validation report is provided in XML format and can also be retrieved in human readable PDF.

The XML output also contains Metadata information.

The structure of the Route Segment Validation Report is described in the corresponding XML schema “gcs_route_report.xsd”.

9.1.5.2 Graphical User Interface

The same calculation as provided by the WPS of GCS can also be performed using the GCS web application (see Figure 27).

The user has to manually load the AIXM file that contains the Route data by using the corresponding “AIXM 5.1 upload” button. Once loaded, the GCS will start with the calculations. When finished, the “Select Route Segment” dropdown list will be populated with all route segments.

The list can then be used to display the given and calculated data of each route segment that was within the uploaded AIXM file.

In addition, the selected route segment is displayed on the map. In order to obtain a PDF report of the Route validation the “Export PDF“ button has to be used. For more details about the PDF report see chapter 9.1.5.3.

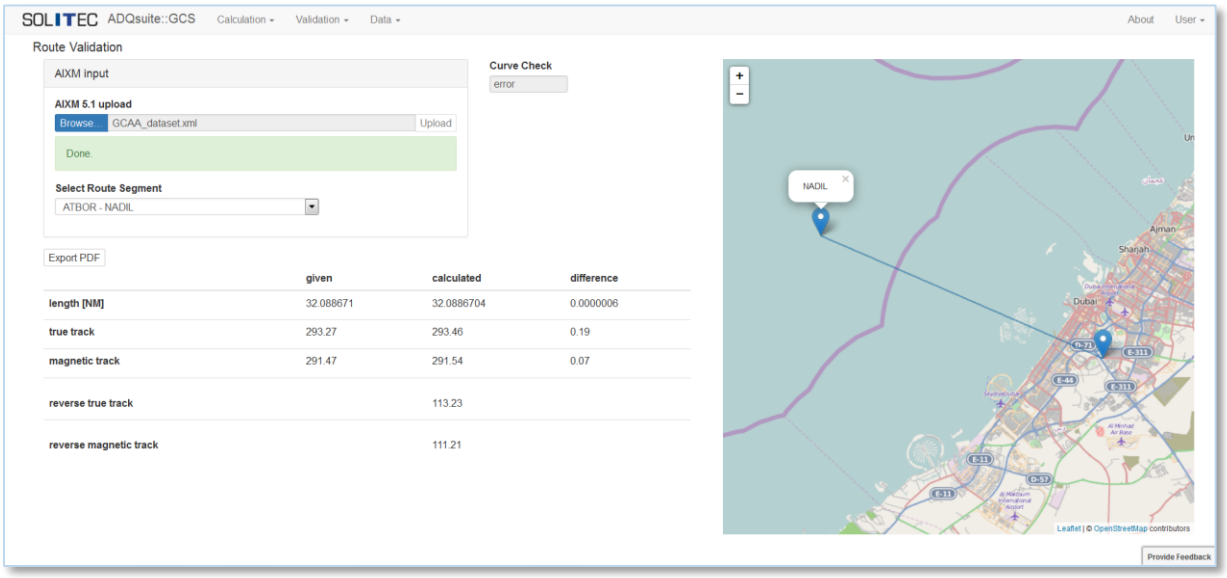


Figure 27. GCS Route Validation - Web Application

In case the Start or End point cannot be loaded into GCS (because it is missing, or not according to the AIXM 5.1 schema) the GUI will show a corresponding error in the dropdown and as reference the UUID of the route segment concerned, see the figure below:

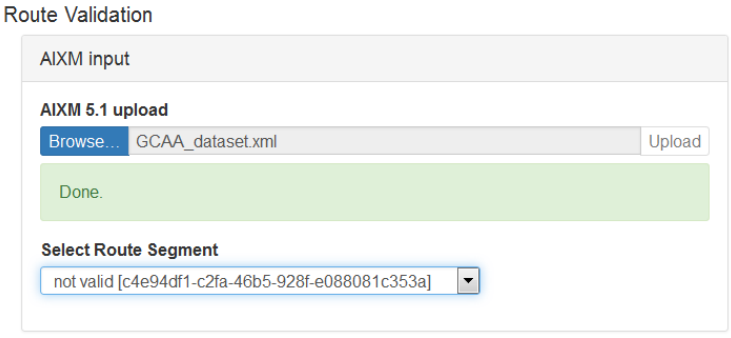
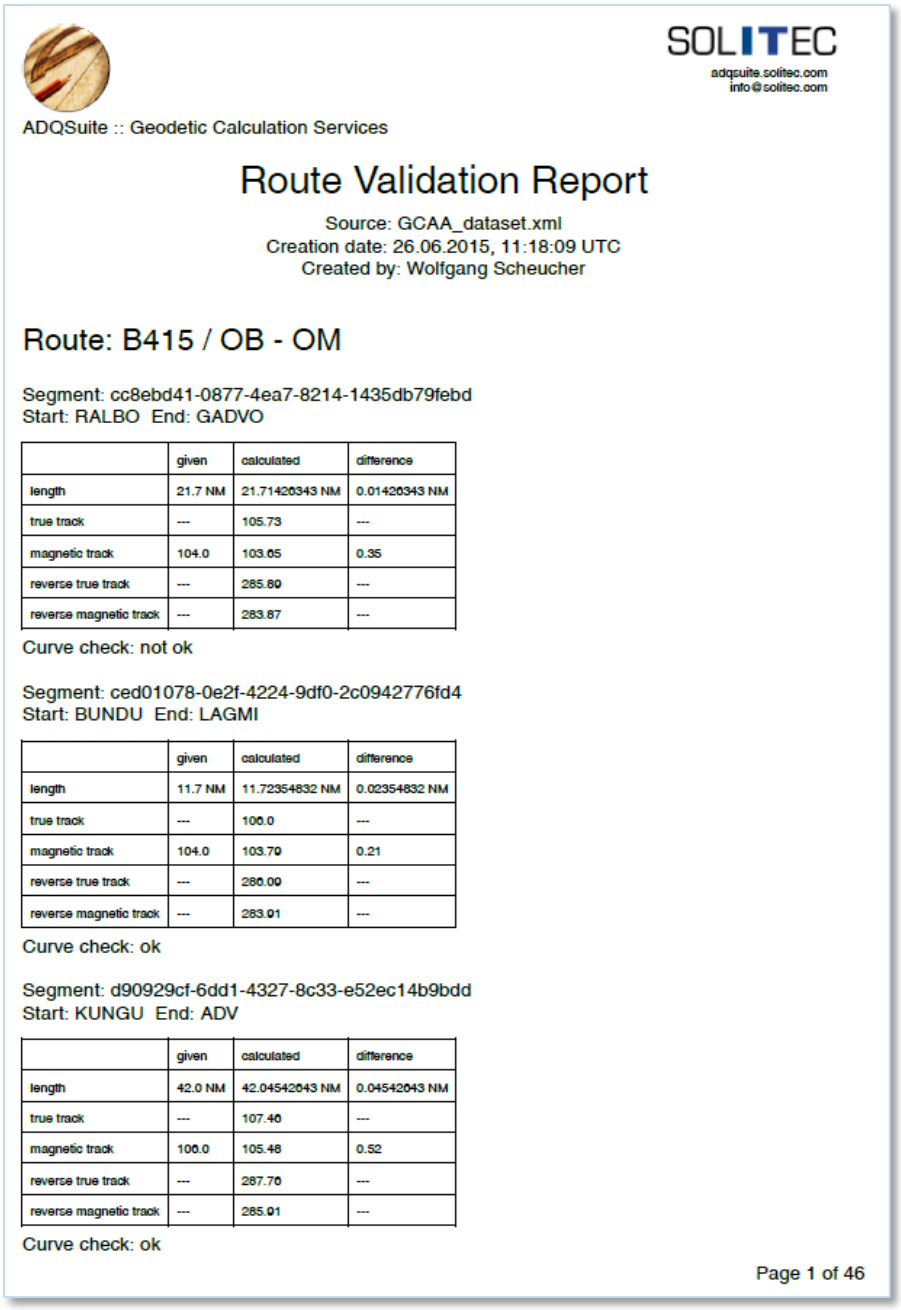


Figure 28. GCS Web Application – Route Segment Error

9.1.5.3 PDF Report

For both the Web service and the Web application of the route validation a PDF report can be obtained. On the pdf report the route segments are grouped by the Route designator as provided in the AIXM 5.1 source file. All route segments that could not be calculated are listed at the end of the report. See below a sample PDF report of the Route validation:



SOLITEC
adqsuite.solitec.com
info@solitec.com

ADQSuite :: Geodetic Calculation Services

Route Validation Report

Source: GCAA_dataset.xml
Creation date: 26.06.2015, 11:18:09 UTC
Created by: Wolfgang Scheucher

Route: B415 / OB - OM

Segment: cc8ebd41-0877-4ea7-8214-1435db79febd
Start: RALBO End: GADVO

	given	calculated	difference
length	21.7 NM	21.71426343 NM	0.01426343 NM
true track	---	105.73	---
magnetic track	104.0	103.65	0.35
reverse true track	---	285.80	---
reverse magnetic track	---	283.87	---

Curve check: not ok

Segment: ced01078-0e2f-4224-9df0-2c0942776fd4
Start: BUNDU End: LAGMI

	given	calculated	difference
length	11.7 NM	11.72354832 NM	0.02354832 NM
true track	---	106.0	---
magnetic track	104.0	103.79	0.21
reverse true track	---	286.09	---
reverse magnetic track	---	283.91	---

Curve check: ok

Segment: d90929cf-6dd1-4327-8c33-e52ec14b9bdd
Start: KUNGU End: ADV

	given	calculated	difference
length	42.0 NM	42.04542643 NM	0.04542643 NM
true track	---	107.46	---
magnetic track	106.0	105.48	0.52
reverse true track	---	287.76	---
reverse magnetic track	---	285.91	---

Curve check: ok

Page 1 of 46

WARNING: UNRESOLVED ROUTE SEGMENTS

Segment: 2841d2df-1242-48d2-a7a8-be30b9d354fa
Missing or invalid reference to route.
Start point is missing
End point is missing

Segment: 345a6adb-90ab-4de1-859a-908a1c96af70
Missing or invalid reference to route.
End point is missing

Segment: 49472bcb-ca20-465d-8438-62dcdb25ce70
Missing or invalid reference to route.

Segment: 4b9a1d74-4833-4a39-850e-3fa98ae8c33a
Missing or invalid reference to route.

Figure 29. Route Validation PDF Report

10 ANNEX I: GCS SUPPORTED CALCULATION ROUTINES

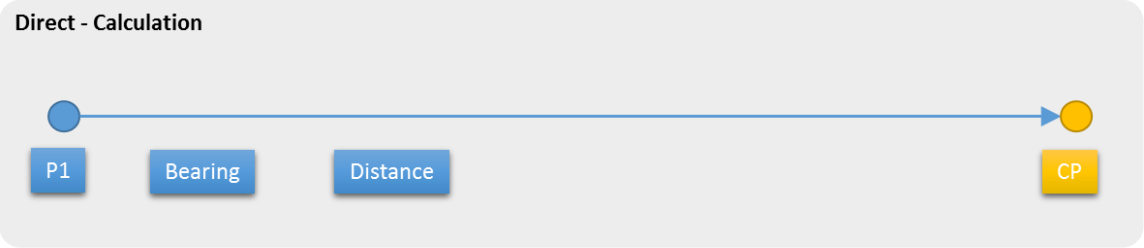
This annex contains all calculation types currently provided by GCS.

The colour code used is as follows:

Bearing Blue = Input value

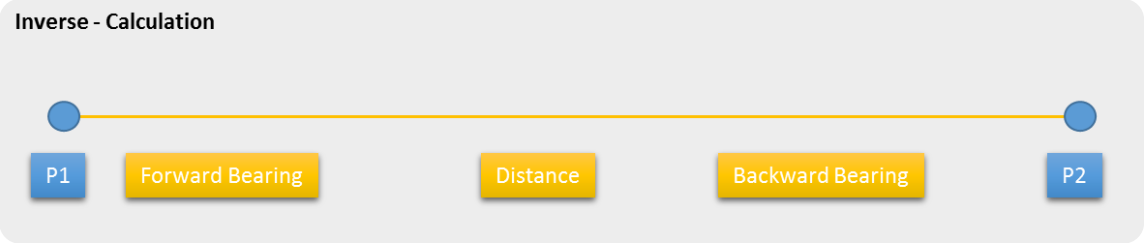
Distance Orange = Output value

10.1 Direct Calculation



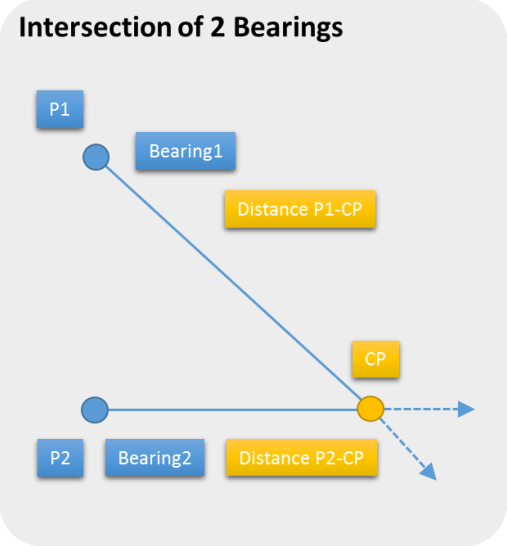
Calculates a point (CP) based on a given point (P1) a bearing and distance.

10.2 Inverse Calculation



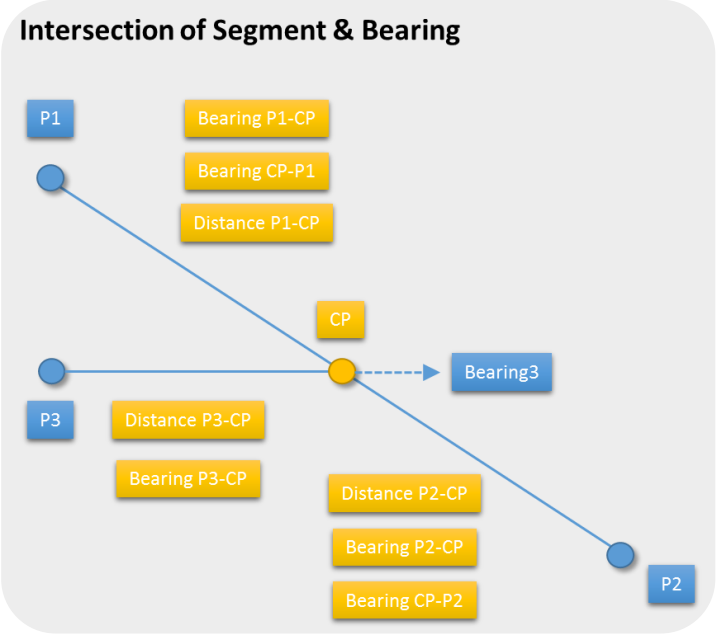
Calculates the distances and the bearings between 2 given points (P1 & P3).

10.3 Intersection of 2 Bearings



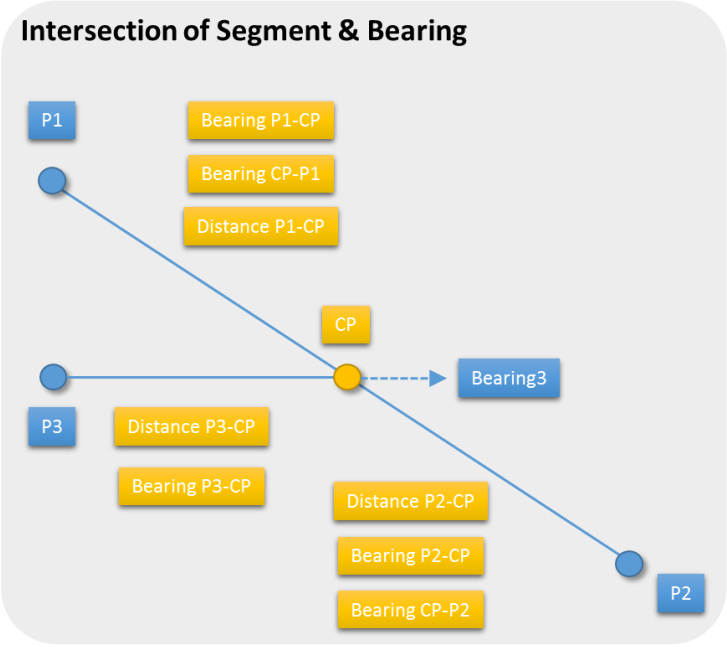
Calculates the position (CP) of the intersection of 2 bearings from two given points (P1 & P2).

10.4 Intersection of 2 Segments



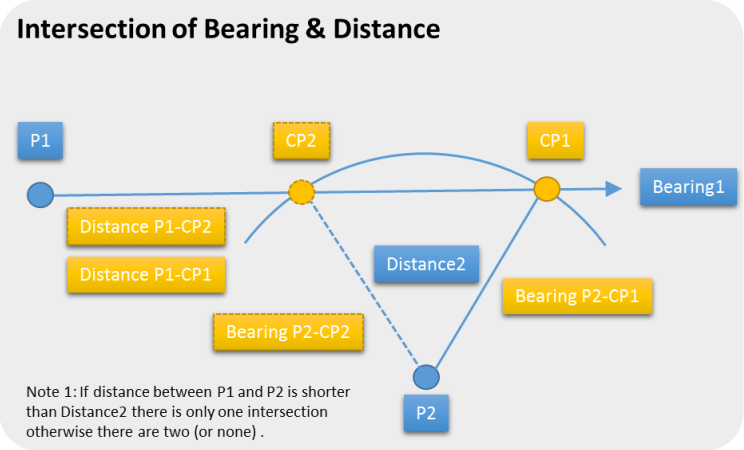
Calculates the position (CP) of the intersection 2 segments defined by given points (P1 & P2) and (P3 &P4).

10.5 Intersection of Segment & Bearing



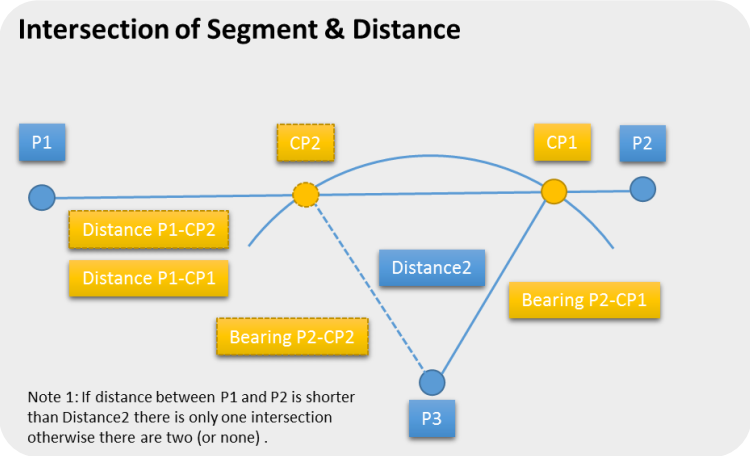
Calculates the position (CP) of the intersection of a segment defined by given points (P1 & P2) and a bearing from a given point (P3).

10.6 Intersection of Bearing & Distance



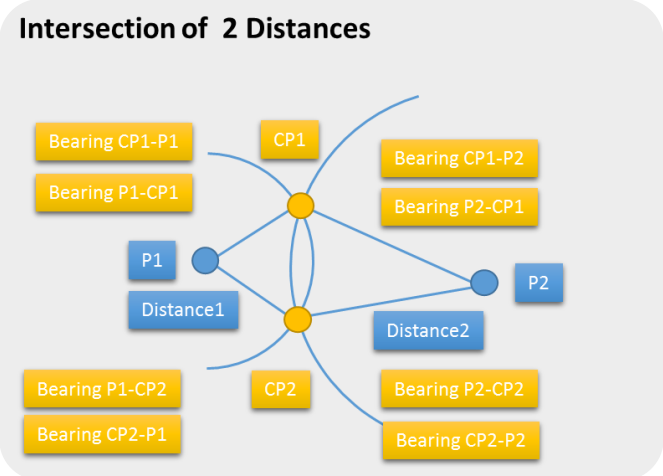
Calculates the position(s) (CP1 & eventually CP2) of the intersection of a bearing from a given point (P1) and the distance from another given point (P2).

10.7 Intersection of Segment & Distance



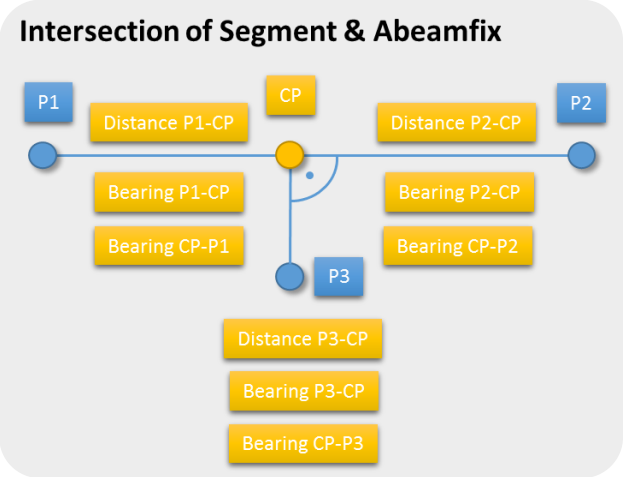
Calculates the position(s) (CP1 & eventually CP2) of the intersection of a segment defined by given points (P1 & P2) and a distance from a given point (P3).

10.8 Intersection of 2 Distances



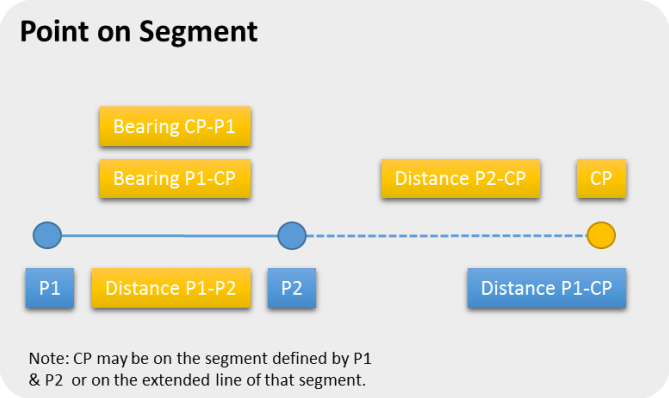
Calculates the positions (CP1 &CP2) of the intersection of a distance from a given point (P1) and the distance form another given point (P2).

10.9 Intersection of Segment & Abeamfix



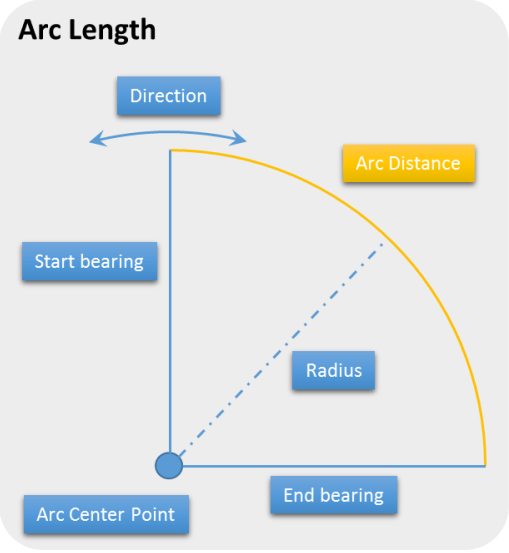
Calculates the perpendicular position (CP) (i.e. shortest distance) on a segment defined by given points (P1 & P2) form a given point (P3).

10.10 Point on Segment



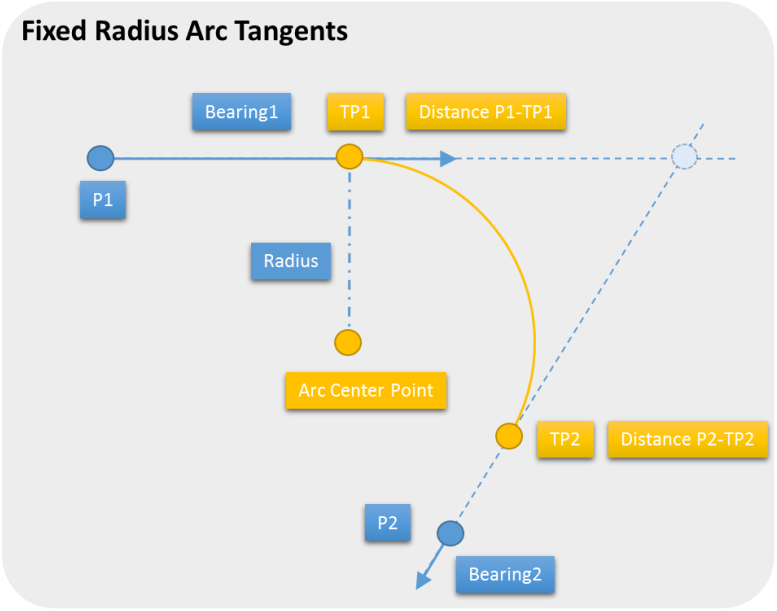
Calculates the position (CP) on a segment or extension of a segment defined by given points (P1 & P2) based on a distance given form P1.

10.11 Arc Length



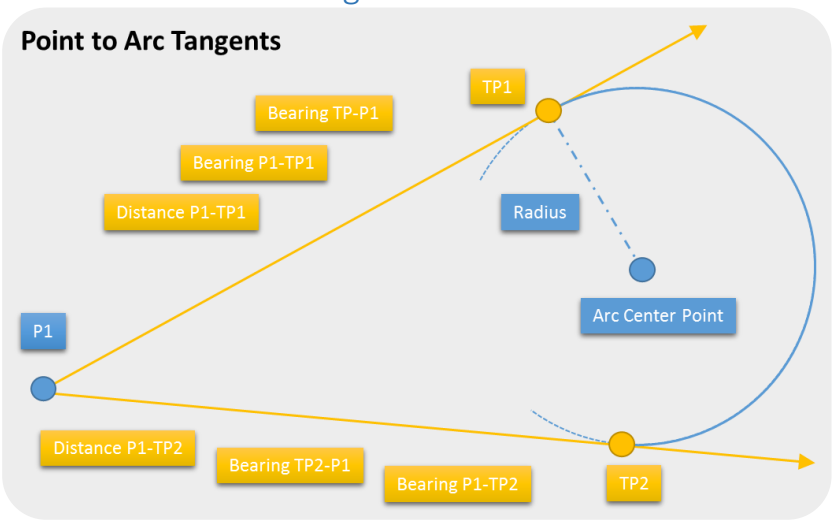
Calculates the length of an arc defined by a starting bearing and end bearing a radius and an arc direction.

10.12 Fixed Radius Arc Tangent



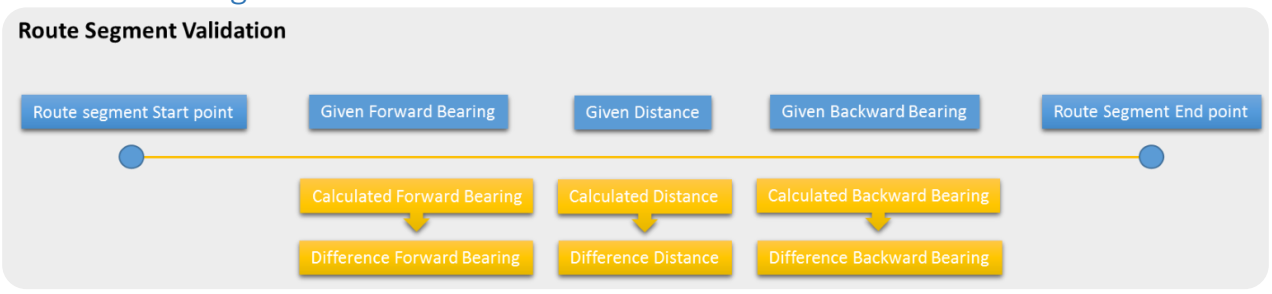
Calculates the 2 tangent points (TP1 & TP2) on an arc and the arc center point based on the bearing from 2 given points (P1 & P2).

10.13 Point To Arc Tangent



Calculates the 2 tangent points (TP1 & TP2) on an arc based on a given arc center point, a radius and a given point (P1).

10.14 Route Segment Validation



Calculates the true and magnetic forward & backward bearing and distance between the start and end point of a route segment.

Subsequently compares the calculated values with the one given in the uploaded AIXM file and returns also the differences identified.

The validation also includes a “curve check”, this is a check if the start and end point position of the route segment matches with the corresponding positions defined in the curve element (in case this element is provided in the AIXM file).

11 ANNEX II: Route Validation WPS

The following physical interfaces are provided as appendix to this document:

- wpsGetCapabilities.xml
- wpsDescribeProcess_Route_Segment_Validation.xml
- gcs_route_report.xsd

11.1 WPS GetCapabilities

```
<?xml version="1.0" encoding="UTF-8"?>
<wps:Capabilities service="WPS" version="1.0.0"
xmlns:wps="http://www.opengis.net/wps/1.0.0"
xmlns:ows="http://www.opengis.net/ows/1.1"
xmlns:xlink="http://www.w3.org/1999/xlink">
  <ows:ServiceIdentification>
    <ows:Title>GCS WPS Server</ows:Title>
    <ows:Abstract>The Geodetic Calculation Service (GCS) provides several
calculation routines based on FAA "United States Standard for Performance Based
Navigation (PBN) Instrument Procedure Design" (Order 8260.58) such as Direct,
Inverse and Intersection. As a result of the calculations it offers a range of
processes for retrieving and validating geographical aeronautical data. The
calculations take into account magnetic variation based on the World Magnetic Model
(WMM) of the date of the transaction. GCS supports data processing in AIXM 5.1
format. It provides metadata on the basis of Commission Regulation (EU) 73/2010
(ADQ).</ows:Abstract>
    <ows:Keywords>
      <ows:Keyword>ADQ</ows:Keyword>
      <ows:Keyword>WPS</ows:Keyword>
      <ows:Keyword>AIXM</ows:Keyword>
      <ows:Keyword>geospatial</ows:Keyword>
      <ows:Keyword>geoprocessing</ows:Keyword>
    </ows:Keywords>
    <ows:ServiceType>WPS</ows:ServiceType>
    <ows:ServiceTypeVersion>1.0.0</ows:ServiceTypeVersion>
    <ows:Fees>NONE</ows:Fees>
    <ows:AccessConstraints>NONE</ows:AccessConstraints>
  </ows:ServiceIdentification>
  <ows:ServiceProvider>
    <ows:ProviderName>SOLITEC Software Solutions GesmbH</ows:ProviderName>
    <ows:ProviderSite xlink:href="http://adq-suite.aero"/>
    <ows:ServiceContact>
      <ows:IndividualName>Wolfgang Scheucher</ows:IndividualName>
      <ows:PositionName>Business Development</ows:PositionName>
      <ows:ContactInfo>
        <ows:Address>
          <ows:DeliveryPoint>Dresdner Strasse 43</ows:DeliveryPoint>
          <ows:City>Vienna</ows:City>
          <ows:PostalCode>1200</ows:PostalCode>
          <ows:Country>Austria</ows:Country>

<ows:ElectronicMailAddress>wscheucher@solitec.com</ows:ElectronicMailAddress>
        </ows:Address>
      </ows:ContactInfo>
    </ows:ServiceContact>
  </ows:ServiceProvider>
  <ows:OperationsMetadata>
    <ows:Operation name="GetCapabilities">
      <ows:DCP>
        <ows:HTTP>
          <ows:Get xlink:href="https://gcs-wps.solitec.com/ows"/>
        </ows:HTTP>
      </ows:DCP>
    </ows:Operation>
    <ows:Operation name="DescribeProcess">
      <ows:DCP>
        <ows:HTTP>
```

```
          <ows:Get xlink:href="https://gcs-wps.solitec.com/ows"/>
        </ows:HTTP>
      </ows:DCP>
    </ows:Operation>
    <ows:Operation name="Execute">
      <ows:DCP>
        <ows:HTTP>
          <ows:Post xlink:href="https://gcs-wps.solitec.com/ows"/>
        </ows:HTTP>
      </ows:DCP>
    </ows:Operation>
  </ows:OperationsMetadata>
  <wps:ProcessOfferings>
    <wps:Process wps:processVersion="1">
      <wps:Identifier>DirectCalculation</wps:Identifier>
      <wps:Title>Direct Calculation</wps:Title>
      <wps:Abstract>Executes direct calculation based on input data</wps:Abstract>
    </wps:Process>
    <wps:Process wps:processVersion="1">
      <wps:Identifier>InverseCalculation</wps:Identifier>
      <wps:Title>Inverse Calculation</wps:Title>
      <wps:Abstract>Executes inverse calculation based on input data</wps:Abstract>
    </wps:Process>
    <wps:Process wps:processVersion="1">
      <wps:Identifier>RouteSegmentValidation</wps:Identifier>
      <wps:Title>Route Segment Validation</wps:Title>
      <wps:Abstract>Calculates the true track, magnetic track and length of the
route segments of a route and validates it against input data provided in an
AIXMBasicMessage.</wps:Abstract>
    </wps:Process>
  </wps:ProcessOfferings>
  <wps:Languages>
    <wps:Default>
      <ows:Language>en-US</ows:Language>
    </wps:Default>
    <wps:Supported>
      <ows:Language>en-US</ows:Language>
    </wps:Supported>
  </wps:Languages>
</wps:Capabilities>
```

11.2 WPS Process Description

```
<?xml version="1.0" encoding="UTF-8"?>
<wps:ProcessDescriptions service="WPS" version="1.0.0" xml:lang="en-US"
xmlns:wps="http://www.opengis.net/wps/1.0.0"
xmlns:ows="http://www.opengis.net/ows/1.1"
xmlns:xlink="http://www.w3.org/1999/xlink">
  <ProcessDescription wps:processVersion="1" storeSupported="false"
statusSupported="false">
    <ows:Identifier>DirectCalculation</ows:Identifier>
    <ows:Title>Direct Calculation</ows:Title>
    <ows:Abstract>Executes direct calculation based on input data</ows:Abstract>
    <DataInputs>
      <Input minOccurs="1" maxOccurs="1">
        <ows:Identifier>DirectInputData</ows:Identifier>
        <ows:Title>Direct Calculation Input Parameters</ows:Title>
        <ows:Abstract>Point P1, bearing and distance</ows:Abstract>
        <ComplexData>
          <Default>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#DirectInput</Schema>
            </Format>
          </Default>
          <Supported>
```

```
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#DirectInput</Schema>
            </Format>
          </Supported>
        </ComplexData>
      </Input>
    </DataInputs>
    <ProcessOutputs>
      <Output>
        <ows:Identifier>DirectResultData</ows:Identifier>
        <ows:Title>Direct Calculation Result Data</ows:Title>
        <ows:Abstract>Calculated Point, bearings.</ows:Abstract>
        <ComplexOutput>
          <Default>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#DirectOutput</Schema>
            </Format>
          </Default>
          <Supported>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#DirectOutput</Schema>
            </Format>
            <Format>
              <MimeType>application/pdf</MimeType>
            </Format>
          </Supported>
        </ComplexOutput>
      </Output>
    </ProcessOutputs>
  </ProcessDescription>
  <ProcessDescription wps:processVersion="1" storeSupported="false"
statusSupported="false">
    <ows:Identifier>InverseCalculation</ows:Identifier>
    <ows:Title>Inverse Calculation</ows:Title>
    <ows:Abstract>Executes inverse calculation based on input data</ows:Abstract>
    <DataInputs>
      <Input minOccurs="1" maxOccurs="1">
        <ows:Identifier>InverseInputData</ows:Identifier>
        <ows:Title>Inverse Calculation Input Parameters</ows:Title>
        <ows:Abstract>Point P1, Point P2</ows:Abstract>
        <ComplexData>
          <Default>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#InverseInput</Schema>
            </Format>
          </Default>
          <Supported>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#InverseInput</Schema>
            </Format>
          </Supported>
        </ComplexData>
      </Input>
    </DataInputs>
    <ProcessOutputs>
```



```
      <Output>
        <ows:Identifier>InverseResultData</ows:Identifier>
        <ows:Title>Inverse Calculation Result Data</ows:Title>
        <ows:Abstract>Calculated distance, bearings.</ows:Abstract>
        <ComplexOutput>
          <Default>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#InverseOutput</Schema>
            </Format>
          </Default>
          <Supported>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-
suite.aero/gcs/0.2/gcs_calculation.xsd#InverseOutput</Schema>
            </Format>
            <Format>
              <MimeType>application/pdf</MimeType>
            </Format>
          </Supported>
        </ComplexOutput>
      </Output>
    </ProcessOutputs>
  </ProcessDescription>
  <ProcessDescription wps:processVersion="1" storeSupported="false"
statusSupported="false">
    <ows:Identifier>RouteSegmentValidation</ows:Identifier>
    <ows:Title>Route Segment Validation</ows:Title>
    <ows:Abstract>Calculates the true track, magnetic track and length of the route
segments of a route and validates it against input data provided in an
AIXMBasicMessage.</ows:Abstract>
    <DataInputs>
      <Input minOccurs="1" maxOccurs="1">
        <ows:Identifier>RouteSegmentData</ows:Identifier>
        <ows:Title>Route Segment Data</ows:Title>
        <ows:Abstract>AIXM 5.1 data needed for the validation process.
                    A. Minimum input data:
                    RouteSegment.start, RouteSegment.end;
EnRouteSegmentPoint.pointChoice, Note: fixDesignatedPoint and navaidSystem is
supported; Note: AIXM feature instances used as start and end of the RouteSegment
have to be included in the AIXMBasicMessage and have to be local referenced;
DesignatedPoint.designator, DesignatedPoint.location, Navaid.designator,
Navaid.location
                    B. Optional input data:
                    RouteSegment.trueTrack, RouteSegment.magneticTrack,
RouteSegment.reverseTrueTrack, RouteSegment.reverseMagneticTrack,
RouteSegment.length
                    C. Optional input data for CurveCheck:
                    RouteSegment.curveExtend, Note: gml:GeodesicString with
gml.posList or gml.pos is supported.</ows:Abstract>
        <ComplexData maximumMegabytes="5">
          <Default>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>

<Schema>http://www.aixm.aero/schema/5.1/message/AIXM_BasicMessage.xsd</Schema>
            </Format>
          </Default>
          <Supported>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>

<Schema>http://www.aixm.aero/schema/5.1/message/AIXM_BasicMessage.xsd</Schema>
            </Format>
```



```
          </Supported>
        </ComplexData>
      </Input>
    </DataInputs>
    <ProcessOutputs>
      <Output>
        <ows:Identifier>RouteSegmentValidationReport</ows:Identifier>
        <ows:Title>Route Segment Validation Report</ows:Title>
        <ows:Abstract>As validation result the output contains the following data
for all Route Segments provided in the AIXMBasicMessage:
                    Start designator of EnRouteSegmentPoint, end designator of
EnRouteSegmentPoint, length (given, calculated and difference), trueTrack (given,
calculated and difference), magneticTrack (given, calculated and difference),
reverseTrueTrack (given, calculated and difference, reverseMagneticTrack (given,
calculated and difference), compliancy check for Curve position data. In case given
length or track values are Null or missing only the calculated values will be on
the report. Note: If a mandatory data input is missing a corresponding error
messages is returned.</ows:Abstract>
        <ComplexOutput>
          <Default>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-suite.aero/gcs/rsg-validation-
report/0.2/gcs_route_report.xsd</Schema>
            </Format>
          </Default>
          <Supported>
            <Format>
              <MimeType>text/xml</MimeType>
              <Encoding>UTF-8</Encoding>
              <Schema>http://schemas.adq-suite.aero/gcs/rsg-validation-
report/0.2/gcs_route_report.xsd</Schema>
            </Format>
            <Format>
              <MimeType>application/pdf</MimeType>
            </Format>
          </Supported>
        </ComplexOutput>
      </Output>
    </ProcessOutputs>
  </ProcessDescription>
</wps:ProcessDescriptions>
```


11.3 gcs_route_report.xsd

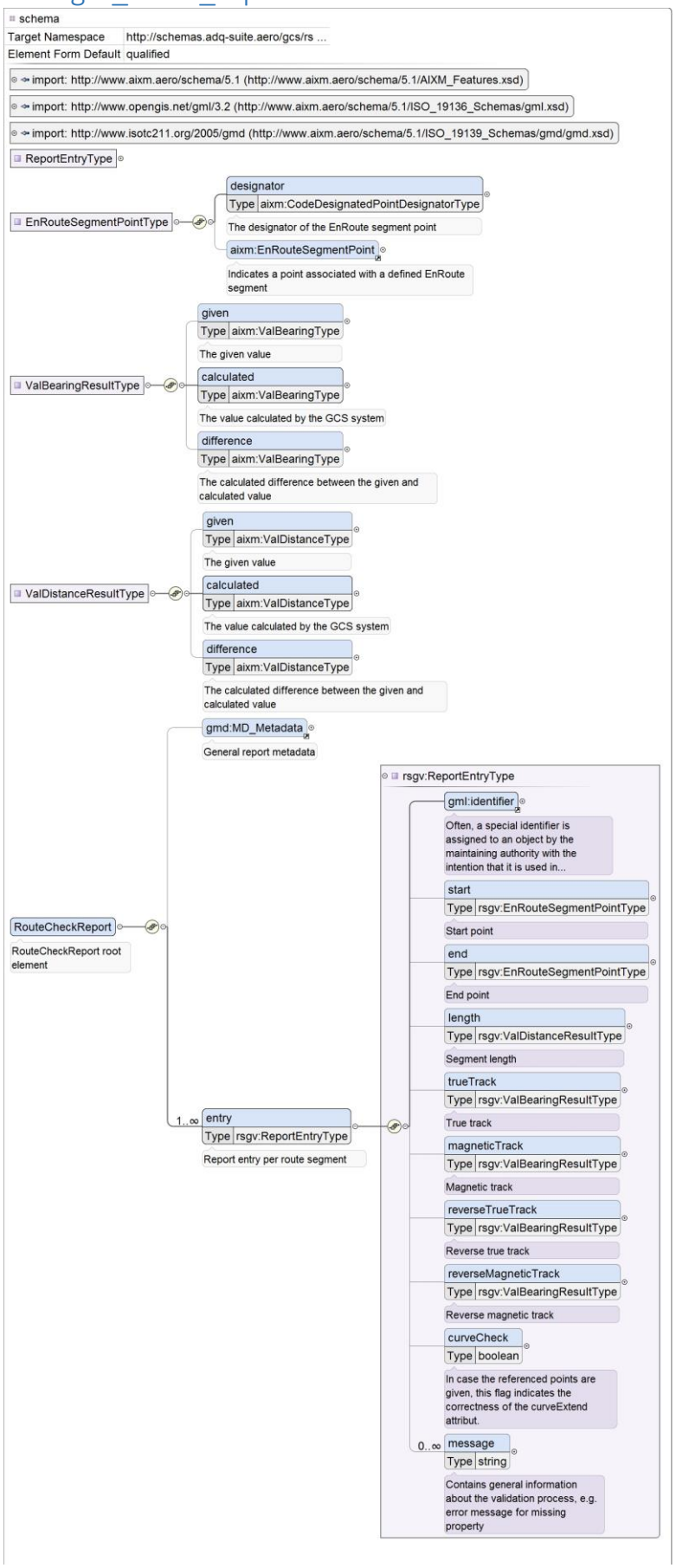


Figure 30. gcs_route_report.xsd – Diagram

12 ANNEX III: GCS 2.0 Release Notes

The SOLITEC GCS team announces the release of GCS 2.0. This release contains several updates and fixes. We have mainly focused on enhancing our system-to-system interface with a SWIM compliant authentication mechanism and by providing additional calculations as Web Services.

12.1 Updates and fixes in this release

GCS 2.0 includes the following updates and bug fixes:

T	Key	Summary	P	Status
	AGCS-236	Trigger calculation		Resolved
	AGCS-134	Service Desk Account Creation		Closed
	AGCS-539	Update server based framework to latest stable version		Resolved
	AGCS-533	Add menu to Release Notes & User Guide.		Resolved
	AGCS-480	Route Validation: File without routes		Resolved
	AGCS-615	GUI not responding		Resolved
	AGCS-595	Fatal Error in while searching in Registered User Form		Resolved
	AGCS-616	cn in LDAP shall contain the email address		Resolved
	AGCS-527	Redirect to login after deployment not working		Resolved
	AGCS-530	Upload CSV fails, wrong status message		Resolved

