Absolute Antenna Calibration

(Characteristics of Antenna Type)

Method

Geo++®-GNPCV Real-Time Calibration

Antenna Data

Manufacturer	:	CHC Shanghai HuaCe Navigation Technology Ltd.
Antenna Type	:	i80 GNSS
GNSS	:	GPS, GLO, GAL, BDS, SBAS
Product Number	:	1180020032221
IGS-Naming*	:	CHCI80 NONE

Radome Data

Manufacturer	:	
Radome Type	:	
Product Number	:	
IGS-Naming	:	NONE

Antenna Reference Point (ARP)

Horizontal Position	:	rotation axis, center of 5/8” thread
Vertical Position	:	(BAM) bottom of antenna mount
IGS-ARP	:	(BAM) bottom of antenna mount

North Mark

Description	:	Man-Machine Interface (MMI) points north, antenna connector points east, lemo connectors point west
IGS-NRP	:	(MMI) Man-Machine Interface

Remarks

* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab for acceptance.

Absolute Antenna Calibration

(Individual Characteristics of Antenna)

Antenna Data		
Manufacturer	:	CHC Shanghai HuaCe Navigation Technology Ltd.
Antenna Type	:	i80 GNSS
GNSS	:	GPS, GLO, GAL, BDS, SBAS
Product Number	:	1180020032221
Serial number	:	1001632
IGS Naming*	:	CHCI80 NONE

Radome Data		
Manufacturer	:	
Radome Type	:	
Product Number	:	
Serial Number	:	
IGS-Naming	:	NONE

Calibration Characteristics		
GNSS System	:	GPS+GLONASS*
Date	:	2016-02-29
Number of Calibrations	:	4
Setup-ID	:	0
Number of Frequencies	:	2
Customer	:	CHC - Shanghai HuaCe Navigation Technology Ltd. CN-201702 Shanghai
Elevation Increment	:	5°
Azimuth Increment	:	5°

PCV Characteristics

absolute 3D offsets
absolute PCV
PCV from 0° to 90° elevation
elevation and azimuth dependent PCV
free of any multipath influence

Remarks

* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab for acceptance.
* Individual GLONASS PCV were estimated using frequency independent L1, L2 GLO calibrations

Absolute Antenna Calibration
(Individual Characteristics of Antenna)

Antenna Data

Manufacturer	:	CHC Shanghai HuaCe Navigation Technology Ltd.
Antenna Type	:	i80 GNSS
GNSS	:	GPS, GLO, GAL, BDS, SBAS
Product Number	:	1180020032221
Serial number	:	1001633
IGS Naming*	:	CHCI80 NONE

Radome Data

Manufacturer	:	
Radome Type	:	
Product Number	:	
Serial Number	:	
IGS-Naming	:	NONE

Calibration Characteristics

GNSS System	:	GPS+GLONASS*
Date	:	2016-02-29
Number of Calibrations	:	4
Setup-ID	:	0
Number of Frequencies	:	2
Customer	:	CHC - Shanghai HuaCe Navigation Technology Ltd. CN-201702 Shanghai
Elevation Increment	:	5°
Azimuth Increment	:	5°

PCV Characteristics

absolute 3D offsets
absolute PCV
PCV from 0° to 90° elevation
elevation and azimuth dependent PCV
free of any multipath influence

Remarks

* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab for acceptance.
* Individual GLONASS PCV were estimated using frequency independent L1, L2 GLO calibrations

Absolute Antenna Calibration

(Individual Characteristics of Antenna)

Antenna Data

Manufacturer	:	CHC Shanghai HuaCe Navigation Technology Ltd.
Antenna Type	:	i80 GNSS
GNSS	:	GPS, GLO, GAL, BDS, SBAS
Product Number	:	1180020032221
Serial number	:	1001638
IGS Naming*	:	CHCI80 NONE

Radome Data

Manufacturer	:	
Radome Type	:	
Product Number	:	
Serial Number	:	
IGS-Naming	:	NONE

Calibration Characteristics

GNSS System	:	GPS+GLONASS*
Date	:	2016-03-02
Number of Calibrations	:	4
Setup-ID	:	0
Number of Frequencies	:	2
Customer	:	CHC - Shanghai HuaCe Navigation Technology Ltd. CN-201702 Shanghai
Elevation Increment	:	5°
Azimuth Increment	:	5°

PCV Characteristics

absolute 3D offsets
absolute PCV
PCV from 0° to 90° elevation
elevation and azimuth dependent PCV
free of any multipath influence

Remarks

* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab for acceptance.
* Individual GLONASS PCV were estimated using frequency independent L1, L2 GLO calibrations

Absolute Antenna Calibration
(Individual Characteristics of Antenna)

Geo++®

Antenna Data

Manufacturer	:	CHC Shanghai HuaCe Navigation Technology Ltd.
Antenna Type	:	i80 GNSS
GNSS	:	GPS, GLO, GAL, BDS, SBAS
Product Number	:	1180020032221
Serial number	:	1001642
IGS Naming*	:	CHCI80 NONE

Radome Data

Manufacturer	:	
Radome Type	:	
Product Number	:	
Serial Number	:	
IGS-Naming	:	NONE

Calibration Characteristics

GNSS System	:	GPS+GLONASS*
Date	:	2016-02-26
Number of Calibrations	:	2
Setup-ID	:	0
Number of Frequencies	:	2
Customer	:	CHC - Shanghai HuaCe Navigation Technology Ltd. CN-201702 Shanghai
Elevation Increment	:	5°
Azimuth Increment	:	5°

PCV Characteristics

absolute 3D offsets
absolute PCV
PCV from 0° to 90° elevation
elevation and azimuth dependent PCV
free of any multipath influence

Remarks

* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab for acceptance.

* Individual GLONASS PCV were estimated using frequency independent L1, L2 GLO calibrations

Absolute Antenna Calibration

(Individual Characteristics of Antenna)

Geo++®

Antenna Data

Manufacturer	:	CHC Shanghai HuaCe Navigation Technology Ltd.
Antenna Type	:	i80 GNSS
GNSS	:	GPS, GLO, GAL, BDS, SBAS
Product Number	:	1180020032221
Serial number	:	5555555
IGS Naming*	:	CHCI80 NONE

Radome Data

Manufacturer	:	
Radome Type	:	
Product Number	:	
Serial Number	:	
IGS-Naming	:	NONE

Calibration Characteristics

GNSS System	:	GPS+GLONASS*
Date	:	2016-02-24
Number of Calibrations	:	2
Setup-ID	:	0
Number of Frequencies	:	2
Customer	:	CHC - Shanghai HuaCe Navigation Technology Ltd. CN-201702 Shanghai
Elevation Increment	:	5°
Azimuth Increment	:	5°

PCV Characteristics

absolute 3D offsets
absolute PCV
PCV from 0° to 90° elevation
elevation and azimuth dependent PCV
free of any multipath influence

Remarks

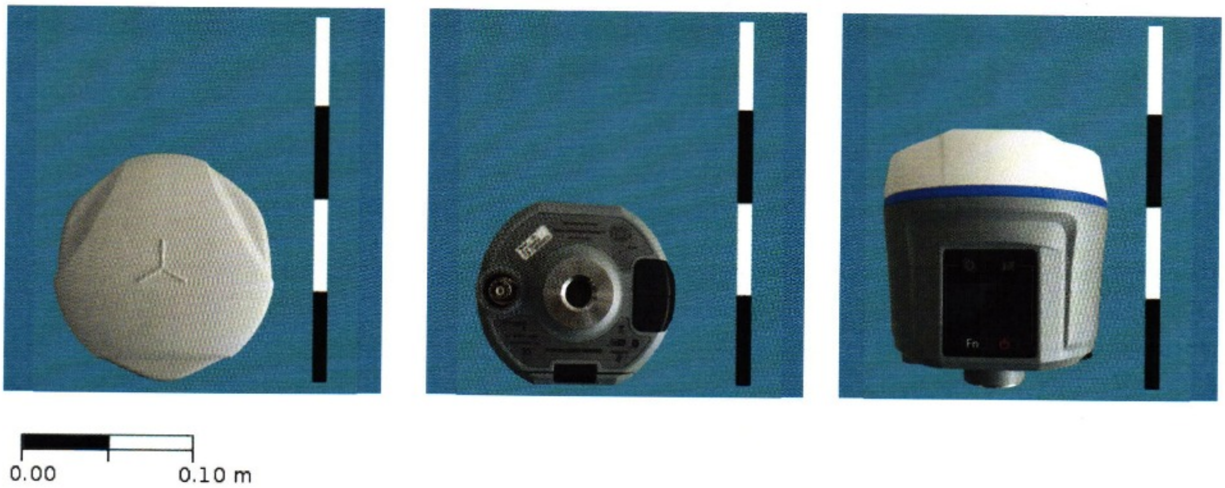
* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab for acceptance.

* Individual GLONASS PCV were estimated using frequency independent L1, L2 GLO calibrations

Geo++® GmbH
Steinriede 8, 30827 Garbsen, Germany
Tel. 05131-4689-0, Fax 05131-4689-99
www.geopp.com

Calibration of GPS/GLONASS Antenna CHC i80 GNSS
Deriving a GNPCV Type Mean from Absolute Calibrations with a Robot

(IGS Name*: CHCI80 NONE)



Calibration Method

The applied Geo++® calibration method of GNSS antennas with a robot determines the absolute antenna offset in horizontal and vertical position as well as the absolute elevation and azimuth dependent phase center variations (PCV) for both frequencies. The resulting PCV are completely independent from the used reference antenna (absolute calibration) and allow the complete modeling of the receiving characteristic of the antenna.

Scope of the applied absolute GPS antenna calibration is:

- absolute offsets and absolute PCV
- special approach with inclined and rotated antenna (robot)
- elimination of multipath
- coverage of the complete elevation range from 0° to 90°
- coverage of complete antenna hemisphere
- precise determination of PCV using a large number of different antenna orientations
- simultaneous estimation of L1 and L2 PCV for GNSS
- weather independent measurements
- at least two redundant calibrations per individual antenna

Basic concept of the calibration method is the separation between multipath and phase center variation. A special observation procedure with different antenna orientations is used for the determination of absolute PCV and for multipath elimination.

The processing is done in real-time. Primary result is a spherical harmonic expansion of the PCV as function of zenith distance and azimuth with complete variance-covariance data directly after the calibration. Finally absolute horizontal and vertical mean offsets as well as absolute elevation and azimuth dependent phase observation corrections for the calibrated antenna can be derived.

* It is not officially included in the IGS naming convention at writing of this protocol. Check rcvr_ant.tab or gpp_rcvr_ant.tab.

Geo++® GmbH
Steinriede 8, 30827 Garbsen, Germany
Tel. 05131-4689-0, Fax 05131-4689-99
www.geopp.com

Calibration Procedure

A sample of individual CHCI80 NONE calibrations conducted with the Geo++® calibration method with a robot is the basis for the calculation of the type mean. The individual calibrations are rigorously adjusted considering the full variance-covariance information.

Scope of the GNPCV type calibration:

- individual calibrations at least of five antennas of same manufacturing series
- adjustment of a type mean using entire variance–covariance data

The type mean of the CHCI80 NONE antenna is derived from five individual antennas with serial numbers 1001632, 1001633, 1001638, 1001642 and 5555555. Each antenna was calibrated at least twice, which gives 16 individual GPS and 16 individual GLONASS calibrations.

Calibration Result

The GNPCV Type Mean is the adjusted mean of the five individual CHCI80 NONE GNSS antennas. The Antenna Reference Point (ARP) is the reference point used in the calibration. The reference direction to north is defined by the Man-Machine Interface (MMI). The antenna height has to be measured to the ARP, which is vertically defined to the bottom of antenna mount (BAM) and horizontally to the rotation axis defined by the center of 5/8" thread.

Geo++® GmbH
Steinriede 8, 30827 Garbsen, Germany
Tel. 05131-4689-0, Fax 05131-4689-99
www.geopp.com

Calibration Result GPS

The absolute GPS PCV excluding the mean phase center offsets for the L1 and L2 frequency are depicted below:

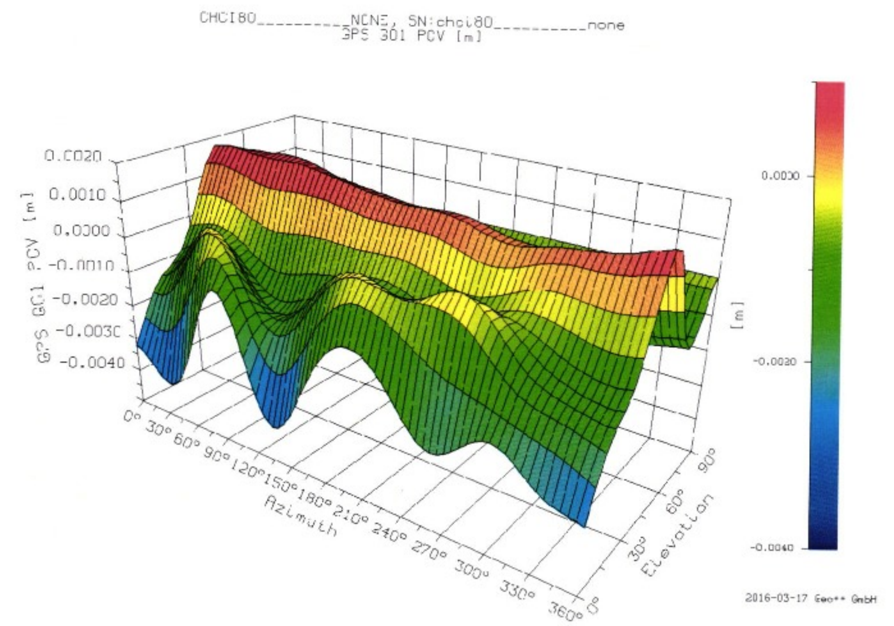


Figure 1: GPS L1 PCV

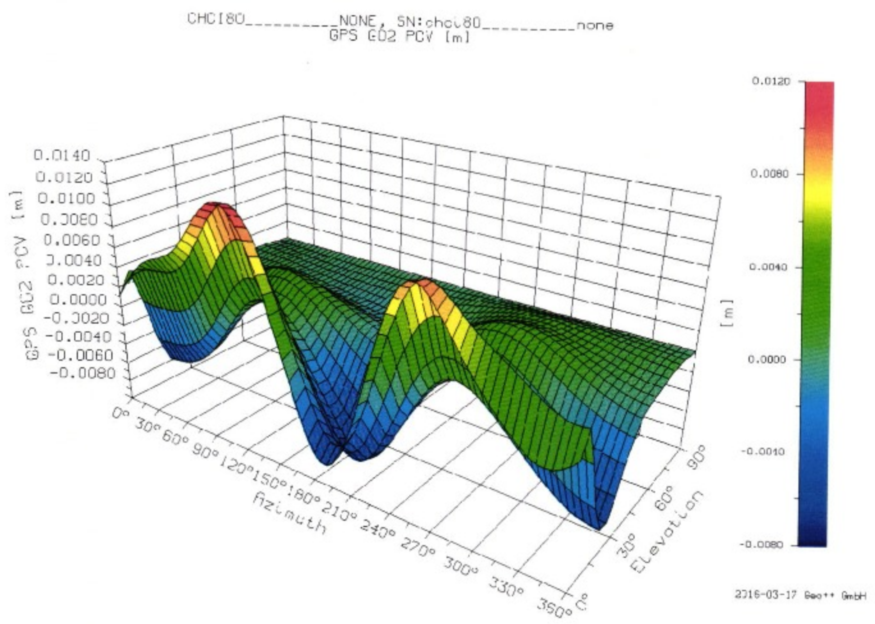


Figure 2: GPS L2 PCV

Geo++® GmbH
Steinriede 8, 30827 Garbsen, Germany
Tel. 05131-4689-0, Fax 05131-4689-99
www.geopp.com

Calibration Result GLONASS

The absolute GLONASS PCV calibration considers the individual frequencies of the GLONASS satellites and estimates a so-called Delta PCV. The Delta PCV is a PCV change with frequency. With the Delta PCV from this adjustment the actual GLONASS PCV can be computed for any GLONASS frequency channel number using the simultaneously estimated GPS PCV. The GLONASS PCV can be used in combination with the GPS PCV to interpolate for any other frequency channel number of GLONASS. The given GLONASS PCV are computed for frequency channel number k=0. The absolute GLONASS PCV excluding the mean phase center offsets for the L1 and L2 frequency are depicted below:

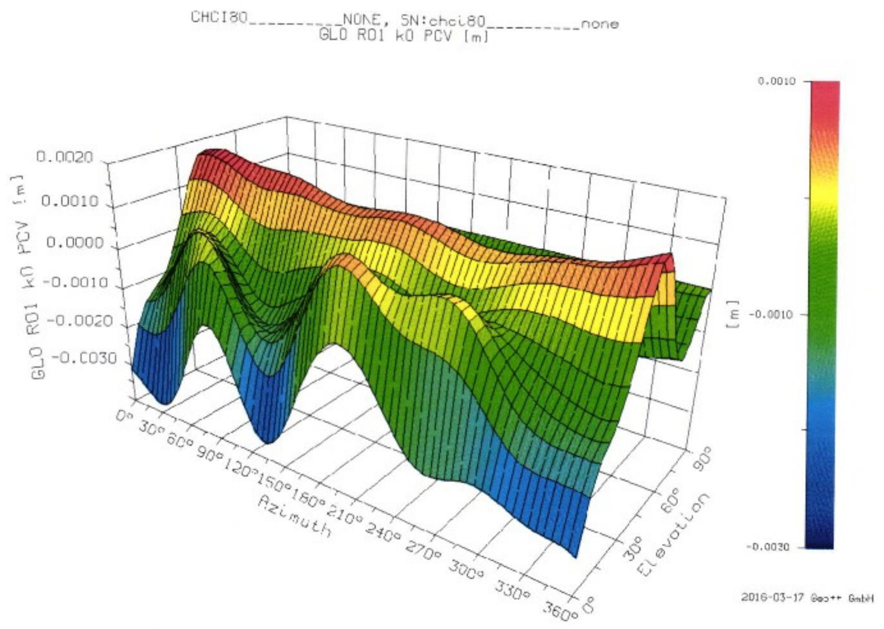


Figure 3: GLONASS L1 PCV

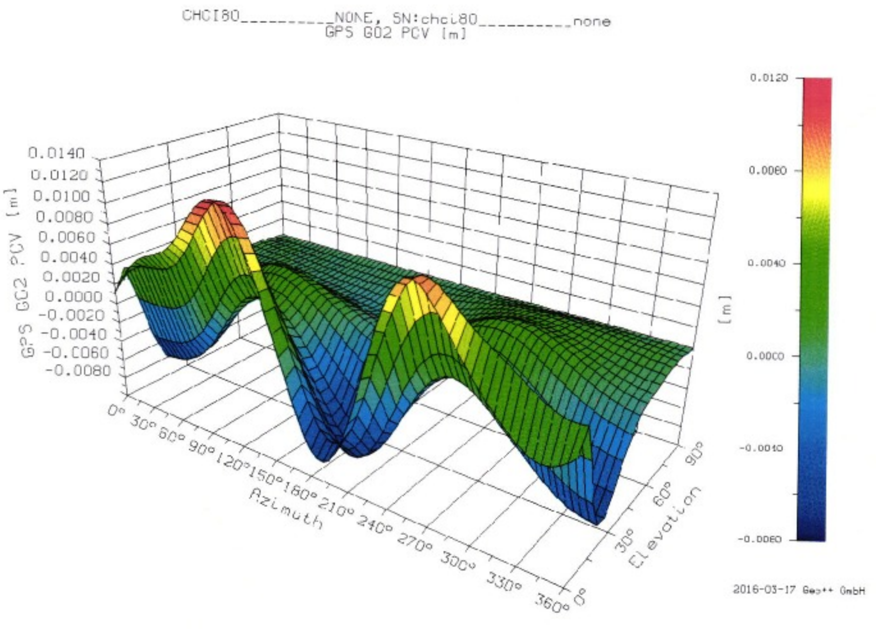


Figure 4: GLONASS L2 PCV

Geo++® GmbH
Steinriede 8, 30827 Garbsen, Germany
Tel. 05131-4689-0, Fax 05131-4689-99
www.geopp.com

As a numerical reference, the pure elevation dependent PCV are listed below in the international ANTEX format (see ANTEX format description for details). However, the complete model of the antenna consists of elevation and azimuth dependent PCV values.

```
     1.4            M                                       ANTEX VERSION / SYST
A                                                           PCV TYPE / REFANT
                                                            END OF HEADER
                                                            START OF ANTENNA
CHCI80          NONE                                        TYPE / SERIAL NO
ROBOT               Geo++ GmbH            5    2016-03-04METH / BY / # / DATE
     5.0                                                    DAZI
     0.0  90.0   5.0                                        ZEN1 / ZEN2 / DZEN
     4                                                      # OF FREQUENCIES
   G01                                                      START OF FREQUENCY
     -0.13      -0.49   +131.04                             NORTH / EAST / UP
   NOAZI   +0.00   +0.24   +0.83   +1.39   +1.56   +1.15   +0.27   -0.72   -1.40   -1.49   -1.01   -0.24   +0.41   +0.68   +0.60
+0.47   +0.69   +1.47   +2.60
   G01                                                      END OF FREQUENCY
   G02                                                      START OF FREQUENCY
     -1.47      -1.16   +107.77                             NORTH / EAST / UP
   NOAZI   +0.00   -0.07   -0.22   -0.32   -0.29   -0.20   -0.21   -0.46   -0.84   -1.02   -0.56   +0.75   +2.57   +4.01   +3.99
+1.90   -1.62   -4.47   -3.64
   G02                                                      END OF FREQUENCY
   R01                                                      START OF FREQUENCY
     -0.13      -0.49   +131.04                             NORTH / EAST / UP
   NOAZI   +0.00   +0.19   +0.67   +1.18   +1.42   +1.21   +0.59   -0.25   -1.00   -1.35   -1.22   -0.71   -0.10   +0.32   +0.40
+0.27   +0.30   +0.93   +2.48
   R01                                                      END OF FREQUENCY
   R02                                                      START OF FREQUENCY
     -1.47      -1.16   +107.77                             NORTH / EAST / UP
   NOAZI   +0.00   -0.09   -0.28   -0.36   -0.23   +0.06   +0.26   +0.14   -0.26   -0.60   -0.32   +0.95   +3.00   +4.94   +5.57
+4.05   +0.83   -2.00   -1.20
   R02                                                      END OF FREQUENCY
   G01                                                      START OF FREQ RMS
   NOAZI    0.00    0.01    0.03    0.06    0.08    0.09    0.09    0.08    0.08    0.08    0.09    0.09    0.10    0.10    0.10
0.10    0.10    0.11    0.12
   G01                                                      END OF FREQ RMS
   G02                                                      START OF FREQ RMS
   NOAZI    0.00    0.01    0.04    0.07    0.09    0.10    0.10    0.10    0.09    0.09    0.10    0.10    0.11    0.11    0.11
0.11    0.12    0.13    0.14
   G02                                                      END OF FREQ RMS
                                                            END OF ANTENNA
```

Garbsen, March 18, 2016

Dr.-Ing. G. Wübbena

Literature

Wübbena, G., M. Schmitz, F. Menge, G. Seeber, C. Völksen (1997). A New Approach for Field Calibration of Absolute Antenna Phase Center Variations. *Navigation*, Journal of The Institute of Navigation, Vol. 44, No. 2, 247-256.

Menge, F., G. Seeber, C. Völksen, G. Wübbena, M. Schmitz (1998). Results of Absolute Field Calibration of GPS Antenna PCV. Proceedings of International Technical Meeting, *ION GPS-98*, Nashville, Tennessee.

Wübbena, G., M. Schmitz, F. Menge, V. Böder, G. Seeber (2000). Automated Absolute Field Calibration of GPS Antennas in Real-Time. Proceedings of International Technical Meeting, *ION GPS-00*, Salt Lake City, Utah.

Schmitz, M., G. Wübbena, G. Boettcher (2002). Tests of phase center variations of various GPS antennas, and some results. *GPS Solutions*, Volume 6, Number 1-2, Springer, 18-27.

Geo++® GmbH
GeoService® GmbH

Conditions for Antenna Calibration

The Geo++®-Method for Absolute Antenna Calibration operates the GNSS antenna to be calibrated on a robot and a second near-by reference station. The second GNSS system consisting of an antenna (normally geodetic chokering antenna with radome) and a standard GNSS receiver is provided by Geo++® GmbH / GeoService® for the period of calibration and is included in the price.

Generally, standard cables, mount and GNSS receiver available at Geo++® GmbH / GeoService® GmbH are used with the antenna to be calibrated. The default interfacing at the GNSS antenna is a 5/8" thread.

A GNSS receiver must be made available by the customer, if the antenna cannot be operated with a standard GNSS receiver or if a particular GNSS receiver shall be used. Any special cables, cable connectors and/or mounts to be considered in the calibration must be provided by the customer. The robot used for the automated field calibration is limited with respect of antenna weight and dimensions. In case of having any doubts on the required equipment, this has to be clarified with technical staff beforehand.

Absolute Antenna Calibrations require the **provision** of the following equipment **by the customer**:

1.) completely functioning GNSS antenna (to be calibrated)

2.) any documentation on GNSS antenna
(geometry, definition of geometric Antenna Reference Point ARP)

3.) if applicable, antenna cable (10 meter) and/or connector to N adapter

4.) if applicable, DIN adapter or 5/8" screw/interface for mounting antenna

The antenna calibration is no verification of antenna functioning or positioning performance, because only high elevation satellites are used and the antenna is tilted and rotated. Calibrations performed with no completely functioning antennas will be charged.

An appointment for the actual time period of calibrations is required and must be agreed upon with the technical staff. The period of time required for a single antenna calibration including handling and evaluation takes approximately 1 to 2 weeks. In case of several antennas within one order, handling is reduced and every additional calibration requires roughly one day. Nevertheless, due to the complexity of the system, fixed deadlines cannot be guaranteed. Please consider this for your disposition. It is absolutely necessary to contact Geo++® GmbH / GeoService® GmbH before sending any antenna.

The results will be delivered approx. 1 to 2 weeks after final measurements. The result of the antenna calibration is a type description, for each antenna a calibration protocol and absolute offsets as well as absolute elevation and azimuth dependent PCV in the international Antenna Exchange format ANTEX. On the antenna housing, a label will be attached showing the calibration date and, if necessary, the orientation direction used in the calibration.

The **calibration result** has to be used for the processing of data that is observed with the calibrated antenna. It is allowed to publish the results. It is, however, proposed to advise on the loss of quality while applying the corrections for other antennas and to apply rigorous computed type means using below given guideline.

The calibration data is used for the analysis of antenna model series and where appropriate used in the computation of type means of the Geo++® GNPCVDB database.

A **Description of the Antenna Calibration** with explanations about the calibration procedure can be made available on request.

The methods for antenna calibration are continuously advanced and optimised. The conditions shown above represent the state-of-the-art at the time this text was written.

Guideline text for providing the individual result of a GNSS antenna calibration:

The results of the calibration are only valid for the individual antenna. The high accuracy of the absolute field calibration with a robot revealed significant individual differences in model series. Therefore, the high quality is lost while using the individual calibration for other antennas. An analysis of the antenna model series and the rigorous computation of a type mean from extensive calibration data for use with a not individually calibrated antenna is only recommended using the complete variance-covariance matrix. Type means from such a computation are provided under http://www.gnpcvdb.geopp.de/.

Geo++® GmbH
GeoService® GmbH

Description of Antenna Calibration

Geodetic and precise GNSS measurements make the exact knowledge of the reception characteristics of the used GNSS antennas and therefore a calibration necessary.

Generally, it is differentiated between the antenna offset and the phase center variations (PCV), while the antenna offset represents a kind of mean influence of the phase center variations.

The applied Geo++® calibration method determines the absolute antenna offset in horizontal and vertical position as well as absolute elevation and azimuth dependent PCV for both frequencies. The resulting PCV are completely independent from the used reference antenna and allow the complete modeling of the receiving characteristic of the antenna. This is required for a combined use of different GNSS antenna types or for differently orientated antennas. In addition, an analysis of the phase center variations and judgment of the general quality and receiving characteristics of the antenna are possible (azimuth dependency).

Basic aspects of the applied absolute field calibration in real-time are:

- absolute offsets and absolute PCV through observation configuration
- special approach with inclined and rotated antenna (robot)
- elimination of multipath
- coverage of the complete elevation range from 0° to 90°
- coverage of complete antenna hemisphere
- significant determination of PCV using a large number of different antenna orientations
- weather independent measurements
- simultaneous estimation of L1 and L2 PCV for GNSS
- at least two redundant calibrations for individual antenna

Basic concept of the calibration method is a separation between multipath and phase center variation. A special observation procedure with different antenna orientations is used for the determination of absolute PCV and for multipath elimination.

The processing is done in real-time. Therefore the complete results are directly available after the calibration. The calibration covers the complete receiving area of the antenna down to elevation angles of 0 degree. Hence, antenna calibrated with this method are suited for *All-In-View* applications (e.g. use on reference stations).

The result is stored in an absolute antenna calibration file, which contains absolute horizontal and vertical offset as well as absolute elevation and azimuth dependent corrections for the calibrated antenna. It can be arranged, that instead of elevation and azimuth dependent corrections only elevation dependent without azimuth dependency are derived. The antenna height must be measured up to the antenna reference point (ARP) of the calibration.

The procedures for the antenna calibration are under steady development and progress. The presented method represents the state-of-the-art technique at writing.

Format of
Geo++® PCV Antenna File

1. NAME

Geo++® antenna file

2. DESCRIPTION

The following text describes the format of the Geo++® antenna files.

Antenna files may contain information on the three dimensional antenna phase center offsets and antenna phase center variations (PCV). The PCV can be elevation dependent or both, elevation and azimuth dependent.

3. File Format

The format of the Geo++® antenna file uses keywords to indicate different information. Comment lines are allowed and do have a '#' as the first sign of the line. However, comment lines are not allowed within a data section (i.e. the data section, which are labeled with the keyword VARIATIONS L1= and/or VARIATIONS L2=).

The meaning of the keywords is described in the following. The '=' sign is part of the keyword and is not separated by a blank from the previous alphanumerical character.

TYPE=

is an alphanumerical description of the antenna type. The TYPE= entry generally contains the IGS naming convention consisting of Antenna code and IGS Antenna Dome code.

NO OF FREQUENCIES=

indicates the number of frequencies, which follow in the Geo++® antenna file. For dual frequency antenna the entry is "2", for single frequency antenna "1".

OFFSETS L1=

contains the L1 offsets of the phase center in north, east and height component for the L1 frequency. The unit of the values is in meter [m]. The three numbers are separated by a blank.

OFFSETS L2=

contains the L2 offsets of the phase center in north, east and height component for the L2 frequency. The unit of the values is in meter [m]. The three numbers are separated by a blank.

ELEVATION INCREMENT=

is the increment of elevation of the PCV. The unit of the increment is degree [deg]. The increment can be individually selected, however, a common value for the ELEVATION INCREMENT= is 5 deg.

AZIMUTH INCREMENT=

is the increment of azimuth of the PCV. The unit of the increment is degree [deg]. The increment can be individually selected, however, a common value for the AZIMUTH INCREMENT= is 5 deg. An increment of 0° specifies a file with only elevation dependent PCV.

Format of Geo++® PCV Antenna File

VARIATIONS L1=

is followed in the next line by the actual PCV values of L1. The lines contain PCV values sorted by increasing elevations from 0 to 90 deg. The number of PCV values within the line is determined by "columns: 90/(elevation increment)+1". For just an elevation dependent data set, only one line of PCV correction is given. Additional azimuth dependent PCV follow in a new line. The corresponding number of lines is determined by "rows: 360/(azimuth increment)+1" and starts from 0 deg and ends with 360 deg azimuth. The row for 0 deg has to be repeated for the 360 deg row. The PCV values are given in units of meter [m].

VARIATIONS L2=

is followed in the next line by the actual PCV values of L2. The lines contain PCV values sorted by increasing elevations from 0 to 90 deg. The number of PCV values within the line is determined by "columns: 90/(elevation increment)+1". For just an elevation dependent data set, only one line of PCV correction is given. Additional azimuth dependent PCV follow in a new line. The corresponding number of lines is determined by "rows: 360/(azimuth increment)+1" and starts from 0 deg and ends with 360 deg azimuth. The row for 0 deg has to be repeated for the 360 deg row. The PCV values are given in units of meter [m].

STANDARD DEVIATIONS L1=

is followed in the next line by the standard deviation (1 sigma) of PCV values from the complete spherical harmonic model for the L1 frequency. The same format as for PCV is used. Refer to „VARIATIONS L1=“. This entry is optional.

STANDARD DEVIATIONS L2=

is followed in the next line by the standard deviation (1 sigma) of PCV values from the complete spherical harmonic model for the L2 frequency. The same format as for PCV is used. Refer to „VARIATIONS L2=“. This entry is optional.

4. DIFFERENCES to IGS/NGS FORMAT

The Geo++® antenna files are different to PCV definition at IGS in the following aspects:

- all values given in meter (instead of mm in IGS)
- all parameters (offset and PCV) with the same sign convention (opposite to IGS)
- sign of PCV (opposite to IGS)
- PCV listed starting from 0 to 90 deg elevation (opposite to IGS)

The Geo++® sign of the PCV originates from the intention to have consistent corrections for offset and PCV. The offsets of the phase center (PC) are added. Therefore the PCV should be added to a range or phase range as well. This defines the sign of the PCV in the Geo++® antenna file, which is opposite to the IGS.