

National Geodetic Survey

GNSS Antenna Calibration Policy

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Outline:

1. Introduction
2. Terms of Reference
3. Calibration Eligibility
4. Rights and Responsibilities (R&R)
 - a. Provider R&R
 - b. NGS Calibration Team R&R
5. Calibration Process
6. Clone Calibrations

Introduction

The National Geodetic Survey (NGS) conducts antenna calibrations in order to provide more accurate access to the National Spatial Reference System (NSRS). A wide variety of Global Navigation Satellite System (GNSS) antennas are available and in use in nation-wide networks. In order to properly utilize the wide variety of antennas, the characteristics of these antennas must be accurately and consistently measured, so that the physical position of the points being positioned may be unambiguously determined. NGS conducts these calibrations as an essential service for the surveying, mapping, and engineering infrastructure of the U.S. These calibrations are an essential component of GNSS data processing and are used by vendor-supplied software as well as NGS' Online Positioning User Service (OPUS).

The NGS antenna calibration techniques have been developed by the Geosciences Research Division and are conducted by the Instrument and Methodologies Branch of the Geodetic Services Division at the calibration facility in Corbin, VA. Since 1994 NGS has computed relative antenna calibrations for more than 350 antennas. These calibrations have been publicly available at the web site www.ngs.noaa.gov/ANTCAL. Beginning in late 2011, NGS will conduct absolute antenna calibrations to accommodate the demand for greater accuracy and for 2-dimensional (elevation and azimuth) parameterization. These absolute calibrations will continue to be available at the NGS web site and will be published in the ANTEX format [<ftp://igscb.jpl.nasa.gov/igscb/station/general/antex14.txt>] as well as the legacy ANTINFO format. NGS operational absolute antenna calibration files incorporate as primary calibrations the IGS operational absolute antenna calibration type means valid for the particular global reference frame which NGS is using (which should include the NGS absolute antenna calibrations). See the FAQ on NGS ANTCAL website for additional information.

This document forms the NGS Antenna Calibration Policy, describing how antennas may be calibrated, under what conditions, and the respective roles of the person/company providing antennas for calibration and NGS. Adherence to this document will help the NGS Calibration Team meet a number of organizational goals:

- Set clear policies which will help NGS maintain the high standards of accuracy expected for NGS calibrations
- Maintain consistency of calibrations appearing in the NGS calibration database
- Serve the general public by emphasizing type mean calibrations of sales-ready antennas
- Provide calibration services and final published values to the public at no charge

Questions regarding this policy and antenna calibrations in general may be directed to NGS.AbsAntCal@noaa.gov. We welcome and appreciate feedback on this policy and NGS's antenna calibration services.

Terms of Reference

Provider	Company, university, or group submitting antennas for calibration
NGS Calibration Team	NGS staff conducting calibrations
PCO	Initial phase center offset, given in north-east-up components relative to the antenna reference point (ARP)
PCV	Phase center variations; may be provided as a function of elevation angle in the antenna frame (1D), or elevation and azimuth angle in antenna frame (2D)
ARP	Antenna reference point, a non-detachable physical reference point on the antenna to be defined by NGS. This is usually permanent point on the bottom surface of the antenna
Relative calibration	Phase center determinations from a stationary test pier referenced to a standard (Dorne Margolin choke ring antenna, type T: AOAD/M_T)
Absolute calibration	Robot calibration, where PCO/PCV are independent of the reference antenna
Type mean calibration	Calibration values for an antenna model, where several test samples are separately calibrated and averaged together
Clones	Identical antennas that are marked, labeled and sold as different models under different brand names
Antenna group	At least three identical antennas. (May include clones.)
Individual calibration	Calibration values are specific to antenna serial number; individual calibrations are conducted on a special case basis (see Calibration Eligibility)

ANTEX format	ANTenna EXchange Format, used to distribute antenna calibration values; see ftp://igscb.jpl.nasa.gov/igscb/station/general/antex14.txt for format description
ANTINFO format	Format historically used by NGS to distribute relative calibration values; see http://beta.ngs.noaa.gov/CORS-Proxy/ANTCAL2.0/documents/format.txt for format description [<i>*note: the location of this file will change when the database moves from the beta website</i>]
Antenna type	Abbreviated code used to uniquely identify an antenna. All Antenna Types are a 20-char string consisting of: <ul style="list-style-type: none"> • 3-char manufacturer • up to 13-char for antenna model • 4-char for radome type See the IGS format description at ftp://igscb.jpl.nasa.gov/pub/station/general/rcvr_ant.tab
Antenna name	A short description of the antenna. It should begin with the model/part number of the antenna as reflected in the label, and include the revision number, again as reflected in the label.
Radome	The removable device/cap that some users place over an antenna. Inclusion of a radome must be explicitly listed in the antenna type. If no radome is used then it must be listed explicitly as “NONE”.

Calibration Eligibility

Antenna Provider eligibility:

- Antenna Providers are typically vendors or manufacturers serving the precise positioning communities, which include but are not limited to: surveyors, GIS users, university researchers, federal and state agencies, and civil engineering firms. In short, almost anyone who can provide a qualifying antenna group (see Terms of Reference above and Antenna eligibility below) for a period of time, and is willing to fully cover shipping to and from the NGS facility, is welcome to participate.
- Antenna calibrations are subject to export controls determined by the U.S. State Department in effect at the time of the request.

Antenna eligibility:

- Acceptable antennas are sales-ready models where each sample provided for calibration possesses labels and markings as described below. In general, NGS will not accept pre-production models for calibration services.
- Sample antennas used to determine calibration values for an Antenna Type must be marked and labeled the same way production models will be marked and labeled for sale to end users. These markings and labels serve as antenna identifiers, and include brand

name and one or more of the following: a model name, a model number, any revision number, and/or a part number.

- Limited individual calibrations will be conducted by special request only. Acceptable individual calibration reasons include university research and antennas believed to deviate from the type mean value. Individual calibrations will be scheduled as allowed by the type mean calibration schedule. Contact the Calibration Team at NGS.AbsAntCal@noaa.gov to inquire about individual calibration.
- For absolute calibrations, all antennas *must* have a standard radio frequency (RF) connector for use with an external receiver. “Smart” antennas or antennas that are integrated with receivers may need to be modified by the Antenna Provider prior to submission in order to comply. This requirement may change with future revisions of this policy.
- For relative calibrations, all antennas *should* have a standard RF connector for use with an external receiver. While non-compliance will not prevent relative calibration of these units, it will significantly retard their progress. The NGS may assign these antennas a lower priority.
- At this time, absolute calibrations can only be conducted on antenna units with a total configured weight of less than 30 lbs. This includes the antenna plus any optional equipment such as a radome or removable ground plane. Weight limitations may change with future revisions to this policy.
- Antennas must be easily mounted onto a standard 5/8-11 threaded mount. If an unmodified antenna cannot be mounted onto a 5/8-11 stud, the Provider should provide a mounting adapter which will interface with the standard 5/8-11 thread. If the antenna cannot be readily mounted to a 5/8-11 stud and is submitted without an adapter, the antenna will receive a lower priority at NGS Calibration Team discretion.
- Provider-supplied mounting adapters must possess a name and a number for positive identification, and a 5/8-11 threaded hole for mounting to the test stand. When the adapter is properly set up and mounted in a normal upright position, the vertical axis of the center of the 5/8-11 threaded hole must precisely intercept a clearly identifiable, nondetachable, permanent point on the bottom surface of the antenna, which will serve as the ARP. Acceptable examples are an etched X or small dimple, the center of a screw hole, or the head of a Philips screw; decals are not acceptable.
- If a mount adapter supplied by a Provider is deemed unnecessary to conduct calibrations, NGS staff may elect not to use this item in the calibration process.
- The NGS will no longer copy calibration data from an existing Antenna Type to create a new type. Antenna Provider claims that a new model number is identical to a previously calibrated model (i.e. clones or revisions) will be taken under advisement, but no longer be assumed and must be demonstrated. See Clones Calibration section for more information.

Rights and Responsibilities (R&R)

Antenna Provider R&R

- For type mean calibrations, Antenna Providers will submit an antenna group with a minimum of 3 and a maximum of 5 antenna samples. Multiple antennas are required to estimate variability within a manufacturer's model.
- Antenna Provider will only submit antennas in good health. Calibrations will not be conducted for antennas that the NGS Calibration Team determines to be in poor condition.
- Antenna Provider pays for shipping to and from the NGS facility in Corbin, Virginia. Shipping must be done via Federal Express (FedEx) or United Parcel Service (UPS). Note the following options for domestic shipping.
 1. Include a return airbill with each shipment
 2. Send a return airbill (PDF) via email
 3. Supply a third-party account number
- Providers outside of the U.S. must provide all international return shipping paperwork for all packages, or make arrangements with a U.S.-based freight forwarder. The accuracy of the return airbill is the responsibility of the Provider and will not be verified by NGS.
- Provider is responsible for proper packaging for roundtrip shipping of the antennas. NGS is not responsible for damage during shipping.
- Provider must submit a high quality (engineering) drawing of the Antenna Type being calibrated. The drawing will include top, bottom and side views which will be used to unambiguously identify the Antenna Reference Point (ARP) and antenna orientation feature. Dimensions are optional, but are helpful to antenna calibration users for identifying an Antenna Type.
- Calibration values and a detailed calibration report are emailed to Provider after the calibration is completed.
- Provider may suggest an Antenna Type. Antenna Types must 1) comply with NGS and/or IGS naming conventions (see Terms of Reference), and 2) be directly traceable to the markings or labeling found on the submitted antennas.
- Provider may suggest an Antenna Name. The Antenna Name should begin with the model/part number of the antenna and include the revision number, as reflected in the label. This may mean that the Antenna Type is similar or identical to the Antenna Name, however, many cases exist where the manufacturer chose a different Antenna Type so for identification purposes the Antenna Name must explicitly include the model and revision number.
- All calibration values are publicly available via the Internet at <http://www.ngs.noaa.gov/ANTCAL>. Requests for calibration values to remain private to the Provider will not be honored.

NGS Calibration Team's R&R

- NGS conducts calibration free of charge; calibration does not include antenna shipping costs (see Provider R&R)
- NGS schedules calibrations on a first-come, first-served basis determined by the date and time of Antenna Calibration Request web form submissions. Antennas present at the Corbin facility will be calibrated ahead of late-arriving antennas.
- NGS Calibration Team will communicate with the Provider about schedule delays or changes.
- Calibrated antennas are returned with a calibration report (absolute only) and calibration values. Calibration values are expressed as PCO and PCV components, and will be distributed in multiple formats (absolute = ANTINFO and ANTEX formats; relative = ANTINFO format only)
- NGS Calibration Team will consider suggestions for Antenna Type codes for the submitted antennas, but will make the final decision on the codes. The final Antenna Type code will be based upon a combination of physical information (markings and labeling) from the antennas submitted and information submitted in the Calibration Request form.
- This is strictly a voluntary program. The NGS will not solicit antennas for calibration, except when such calibration would benefit the NGS in its stated mission and goals.

Calibration Process

- The Provider emails NGS.AbsAntCal@noaa.gov with contact information, shipping address, and information about antennas and requested calibration type. Upon email verification by the NGS Calibration Team, the antenna or antenna group enters the calibration queue.
- After review and approval, NGS Calibration Team will provide the Provider with a tentative calibration date. Scheduled dates are approximate.
- Provider ships antennas to the NGS Corbin, VA facility to arrive before the scheduled calibration date. If antennas are not received in time, the next group in the queue will be calibrated.
- After completing calibration, NGS (1) sends results and report via email to Provider point of contact, (2) publishes calibration values to the NGS Calibrations website, and (3) ships antennas back to Provider (at Provider's expense).

Clone Calibrations

A complete antenna group submission and full type mean calibration may not be necessary for clone antenna models that meet the following criteria.

- Case 1: For a clone whose counterpart has been previously calibrated by the NGS, the Antenna Provider may submit a single clone antenna. The Antenna Provider must confirm that the clone is identical in every way (except markings and labels).

The submitted antenna is then calibrated.

- If the sample antenna's results compare favorably to the previously calibrated antenna group (within the RMS of the type mean or measurement error), the new sample will be averaged with the previously calibrated antenna group and the resulting type mean will be published under the new Antenna Type. The original Antenna Type and published values will not be modified.
- If the sample antenna's results are outside the RMS of the type mean or measurement precision of the previous model, the Provider will be notified and asked to submit at least two more samples for a new type mean calibration. Without additional samples, the calibration will be canceled.
- Case 2: If a manufacturer confirms that two or more antenna models are identical in every way (except markings and labels), a mix of these antenna models may be submitted as the group of 3-5 antennas normally submitted. The antennas will be treated as a single antenna group. If individual results compare favorably (RMS of type mean < about 1mm), the data will be averaged and published under each new Antenna Type. Poor comparisons (RMS > about 1mm) may require additional samples be submitted.