

# NGS Antenna Calibration Procedures

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## Introduction

NOAA's National Geodetic Survey (NGS) conducts antenna calibrations in order to provide more accurate access to the National Spatial Reference System (NSRS), as an essential service for the surveying, mapping, and engineering infrastructure of the U.S. Antenna 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).

This document describes the antenna calibration process at NGS. After defining salient terms (see [glossary](#)), we outline which antennas are eligible for calibration at NGS. We also describe the roles and responsibilities of the NGS calibration personnel and those providing antennas for calibration.

A companion document, the [NGS Antenna Calibration Policy](#), describes the policy and purpose of the antenna calibration program at NOAA's National Geodetic Survey (NGS).

For additional information on antenna calibrations and how calibrations are used in GNSS software and data processing, see the [ANTCAL FAQ](#).

Adherence to both the Policies and Procedures will help the NGS calibration program 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
- Eliminate inherent barriers between these high-precision products of various manufacture and design that would otherwise prevent them from working together to their full potential
- Encourage a healthy, competitive atmosphere among manufacturers that results in a much greater freedom of choice for the positioning community
- Increase accessibility of services rendered by the positioning community to the general public

## Background

NOAA's National Geodetic Survey (NGS) conducts antenna calibrations in order to provide more accurate access to the National Spatial Reference System (NSRS). The NSRS is tied to the wide variety of Global Navigation Satellite System (GNSS) antennas that are available and in use in nation-wide networks. To properly use these antennas and define the NSRS, antenna characteristics 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](http://www.ngs.noaa.gov/ANTCAL). Beginning in 2013, 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 as well as the legacy ANTINFO format.

## Terms of Reference

Terms are defined in the Antenna Calibration Glossary available on the NGS website at <http://www.ngs.noaa.gov/ANTCAL/>.

# Absolute and Relative Calibrations

For the foreseeable future, NGS will continue to operate both absolute and relative calibration facilities. Absolute calibrations will be the primary form of antenna calibration; relative calibrations will be conducted under special circumstances where absolute calibration is not feasible. 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.

Circumstances where absolute calibration is not possible and relative calibration will be required include, but are not limited to:

- Antennas weighing more than 30 lbs (13.6 kg). This weight restriction applies to the total configured weight, including required antenna mounts, groundplanes, radomes, etc.
- Integrated antenna-receiver units which cannot be modified to use an external receiver.

These conditions may change with future revisions of this document.

## 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), 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 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 NGS at [NGS.AntCal@noaa.gov](mailto:NGS.AntCal@noaa.gov) to inquire about individual calibration.
- 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 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.
- 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 document.
- 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 (13.6 kg). This includes the antenna plus any additional equipment such as a radome or removable ground plane. Weight limitations may change with future revisions to this document.
- The NGS will no longer copy calibration data from an existing Antenna Code to create a calibration for a different Antenna Code. Claims by an Antenna Provider 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.

## Clone Calibrations

Clones are identical antennas which are marked, labeled and sold as different models under different brand names. Manufacturers may request that a Clone calibration be included in

the NGS calibration database under a separate Antenna Code, but the identical nature of the originally calibrated antenna and the Clone must first be definitively determined. This section outlines how NGS will test and potentially publish Clone calibrations.

- 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 is considered a true clone. NGS will average the new sample with values from the the original Antenna Type and publish this new type mean under the new Antenna Code. 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 sample is not a valid clone. 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 Code. Poor comparisons (RMS > about 1mm) may require additional samples be submitted.

## **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 run.
- Antenna Provider will only submit antennas in good health. Calibrations will not be conducted for antennas that NGS 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). Providers outside of the U.S. must provide all international return shipping paperwork for all packages. See Shipping for additional detail.
- 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 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.
- Calibration values and a detailed calibration report (absolute only) are emailed to Provider after the calibration is completed.
- Provider may suggest an Antenna Code. Antenna Codes must 1) comply with 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 Code is similar or identical to the Antenna Name, however, many cases exist where the manufacturer chose a different Antenna Code 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'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 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 will consider suggestions for Antenna Codes for the submitted antennas, but will make the final decision on the codes upon coordination with the IGS Antenna Working Group. The final Antenna 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

1. Fill out the request form at <http://www.ngs.noaa.gov/AntCalRequest/>. First-time visitors to this website will have to register as an Antenna Provider. You will be asked for contact information, shipping address, and detailed information on the antennas being submitted (for example, brand, model number, number of antennas being sent).
2. After review and approval of the initial request, NGS will contact the Provider with a tentative calibration date. Scheduled dates are approximate.
3. 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.
4. After completing calibration, NGS
  - a. sends results (and report, for absolute calibrations) via email to Provider point of contact
  - b. publishes calibration values to the NGS Calibrations website, and
  - c. ships antennas back to Provider at Provider's expense, using Provider's original packaging.

## Shipping

Shipping charges, all shipping-related fees, and customs paperwork, both to and from the NGS facility, are separate from the calibration service and are the responsibility of the Antenna Provider. Providers must understand that we are an antenna calibration service, not a professional shipping service. To ensure antennas are returned, Providers must properly complete and include with the shipment a Commercial Invoice (three copies) and any other required Customs forms. It is not possible for the NGS to know what it will take to get antennas back into a particular country.

In addition to handling Customs issues, Providers are also expected to do one of the following:

1. Include prepaid return airbill (s) with shipment. The carrier must be able to pick up packages at our facility.
2. Attach prepaid airbill(s) in PDF format to an email. Again, the carrier must provide pickup service.
3. Provide a valid UPS or FedEx account number. We cannot use account numbers from any other carrier. If the number will not work in the carrier's online shipping service, we will notify the Antenna Provider to make other arrangements.

## Contact

Questions regarding these procedures and antenna calibrations in general may be directed to [NGS.antcal@noaa.gov](mailto:NGS.antcal@noaa.gov). We welcome and appreciate feedback on these procedures and NGS's antenna calibration services.