GNSS Absolute Antenna Calibration at the National Geodetic Survey

Background

What is GNSS Antenna Calibration?

Antenna calibration is a measurement of the antenna phase center (the apparent point of phase signal reception for a GNSS antenna).

Antenna phase center:
- Differs between antenna models and manufacturers
- Is affected by antenna radome and antenna mount

A full calibration is the sum of two different components:
- PCO (phase center offset)
- PCV (phase center variations)

Advantages of absolute calibrations:
- Better fuller description of phase behavior
  - Depends only on calibrated antenna (reference-free)
  - Includes 5-10 elevation coverage
  - Captures azimuthal variations
  - Multipath removed/regulated
  - The way of the future
- International GNSS Service (IGS) standard
- Used in OPUS
- Used in CORUS multiyear (IGS08 epoch 2008.0 and NAD83(2011)) epoch 2010.0
- Compatible with absolute calibrations from any IGS-sanctioned facility

Why Do I Need Antenna Calibration?

To account for range errors introduced by the antenna element and hardware

Calibrations are a required input for many GNSS data processing software

Omitting calibrations leads to estimation errors:
- Long baselines
- Combining multiple antenna models
- Height errors

Calibration values are dependent on software implementation

Calibration values are defined by antenna calculators

Calibration values are reference antenna values

Calibration values are defined by calibration facility

Calibration values are publically distributed via

Relative vs. Absolute Calibration?

Calibration values are referenced to a reference antenna (L5, tracking, D or M, T)

Independent of reference antenna

Method

Calibration Setup

- Antenna ARP = 50 cm above concrete pad (zero tilt)
- 10 cm Sokkia extension used to separate test antenna from robot

- Flat field & concrete pad
- Well-behaved multipath environment
- 5 meter baseline (N-S orientation)
- Precise baseline from accuracy
- Baseline orientation used to fix robot reference frame

Calibration values are reference antenna values

Calibration values are independent of reference antenna

Calibration values are defined by calibration facility

PCO: Position Correction Offset

PCV: Position Correction Variations

PCO solution uses the antenna's full PCV pattern

PCV solution uses a small portion of the full PCV pattern

Solution method:
1. Solve for PCO
2. Remove PCO from data, solve for PCV using spherical harmonics
3. NOAAS PCV + degree 8, order 8
4. Full PCV + degree 8, order 8

The robot moves the test antenna between two closely spaced times. During that time internal the satellite used moved a negligible amount. Therefore, multipath and PCV/PCO at the reference antenna are unchanged, and drop out when observations at the two times are differenced.

Data Collection and Reduction

Data Collection (all 4 directions)

Geometric range

Satellite XYZ/Velocity values (for graphics)

Sampled values were collected from antennas in 4 different orientations on the robot over time.

Solution method:
1. Solve for PCO
2. Remove PCO from data, solve for PCV using spherical harmonics
3. NOAAS PCV + degree 8, order 8
4. Full PCV + degree 8, order 8

Results

IGS08

E

U [mm]

PCO

PCV

Topcon CR-G3

IGS08

E

U [mm]

NGS

0.26 -0.03 119.38

M08

0.26 0.83 119.20

Javad RingAnt-DM

Javad RTX200

0.28 -0.07 119.04

NGS

0.39 0.12 120.60

Trimbles Zephyr 2

TRIM5971

IGS08

E

U [mm]

NGS

0.28 -0.07 119.04

M08

0.26 0.83 119.20

NGS

0.39 0.12 120.60

Conclusions

- Solid methodology and testing facility are in place
- Able to compute type means from 3-5 samples (not shown)
- Favorable individual comparison to IGS published values: close PCO match; good statistics to residuals
- Small systematic discrepancies remain for all antenna models: residuals skew to negative; bias ~10 cm elevation on L2

- Individual NGS calibrations versus the IGS08 published type mean for the antenna model

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Please see our website at http://ift2010.ifp.be for more information