Splinter Meeting of the IGS Antenna Working Group

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1. Satellite antenna issues

1.1 MGEX extension for igs08.atx (1)

- since July 2015, igs08.atx contains phase center offset (PCO) information for **Galileo**, **BeiDou**, **QZSS**, and **IRNSS**
- submission of parallel files (igs08_wwww_woMGEX.atx) will probably be stopped after the Workshop
- phase center variations (PCVs) set to zero for all new GNSS
- Multi-GNSS Working Group will decide on the acceptance of phase center corrections estimated from terrestrial data (already available, e.g., for Galileo and BeiDou)

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ADVANCES IN SPACE RESEARCH
(a COSPAR publication)

www.elsevier.com/locate/asr

GNSS satellite geometry and attitude models

O. Montenbruck [a,*], R. Schmid [b], F. Mercier [c], P. Steigenberger [a], C. Noll [d], R. Fatkulin [e], S. Kogure [f], A.S. Ganeshan [g]

1. Satellite antenna issues

1.1 MGEX extension for igs08.atx (2) - open issues

- **GPS L5** (transmitted by SVN49 and all Block IIF satellites):
  - ➢ Provide zero values or copy LC estimates?
- **GLONASS G3** (transmitted by certain GLONASS-M and all GLONASS-K satellites)
  - some satellites have distinct L3 antenna, others have not
  - manufacturer values would be available
  - ➢ How to combine manufacturer information with estimated LC values?
- **QZSS SAIF** signal (transmitted by the auxiliary LS-ANT antenna)
  - L1 signals transmitted by two separate antennas
  - manufacturer values would be available
  - RINEX 3.03 carrier phase code: L1Z
  - ➢ ANTEX format update will be necessary

1. Satellite antenna issues

1.2 Unique SVN for GLONASS?

- Russian authorities started to **re**use GLONASS numbers "7nn" (numbers are no longer unique)
- first ambiguous numbers (701, 754); further ambiguities with every future launch
- unique SVN currently requested by the SINEX format, but also facilitates day-to-day operations

➢ Two possible solutions:

1. Move to **COSPAR number** as key satellite identifier (requires format and software changes; only "machine-readable")
2. Convert GLONASS numbers from **"7nn" to "8nn"** (at least necessary as a temporary solution)

1. Satellite antenna issues

1.3 Combined processing of terrestrial and LEO data

- goals: IGS to provide **independent** terrestrial **scale**; consideration of azimuth-dependent PCVs
- requirements: reanalyzing the full history of IGS/LEO data to derive new satellite antenna PCVs by **at least two ACs** considering:
  - igs14.atx receiver antenna calibrations
  - multiple GNSS (at least GPS and GLONASS)
  - nadir angles up to 17 deg
  - azimuth-dependence
- date: new set of satellite antenna corrections should be available before the start of **repro3**

➢ strategy? volunteers?

1. Satellite antenna issues

1.4 Updates for igs14.atx

- 7 ACs provided PCO estimates in their repro2 SINEX files: CODE, ESA, GFZ, JPL, MIT, NRCan, ULR
- new individual *z*-offset estimates for **13 latest** satellites: G064–G069, G071–G073, R743, R747, R754–R755
- reestimate *z*-offsets of **all** GPS and GLONASS satellites to compensate for AC orbit modeling changes (albedo, antenna thrust) affecting the orbit and terrestrial scale (Pasadena recommendation)
- switch to satellite-specific ***x*- and *y*-offsets**?
  - agreement between ACs would have to be checked
  - at least 5 ACs provided *x*- and *y*-components (GLO: only ESA)
  - beneficial for future estimation of azimuthal PCVs

2. Receiver antenna issues

2.1 Updates for igs14.atx (1) - new robot calibrations

Antenna	Radome	IGS sites
AERAT2775_43	SPKE	ABMF LMMF
AOAD/M_T	DUTD	KIR0 MAR6 VIS0 **WSRT**
ASH700936D_M	SCIS	**LBCH** **PALM** **PALV** SCIP TIXI
ASH700936E	SCIS	**KSMV**
ASH701073.1	NONE	**METZ** REYK STR1
ASH701073.1	SCIS	**THU2** **THU3** TRO1
ASH701073.1	SNOW	**MTKA** **NYA1** REYK TRO1 WTZZ
ASH701945E_M	SCIS	**EPRT** MAJU MARS **QAQ1** SASK **SOLA**
ASH701946.3	NONE	KOUR MAL2
TRM29659.00	UNAV	BARH BRMU EPRT GUAT **MANA** **SSIA** **TUBI**
TRM57971.00	TZGD	**KOUC** **NRMD**

affects 18 **operational** /11 **IGS08** sites and 22 former installations

2. Receiver antenna issues

2.1 Updates for igs14.atx (2) - updated type mean calibrations

Some examples:

Antenna	Radome	# igs08	# ind. cal.	# IGS sites
AOAD/M_T	NONE	2	(14)	29
JAVRINGANT_DM	NONE	5	14	9
LEIAR25.R3	LEIT	5	111	27
LEIAR25.R4	LEIT	5	221	17
TPSCR.G5	TPSH	1	84	22
TRM57971.00	NONE	8	42	25
TRM59800.00	NONE	25	70	38

- precision and accuracy should benefit
- only significant changes in the number of individual calibrations will be considered (< 20 antenna types)
- generation of updated type mean values is time-consuming

2. Receiver antenna issues

2.2 Status of new calibration institutions

National Geodetic Survey (NGS):

- robot operational again?
- status of the GLONASS calibration?

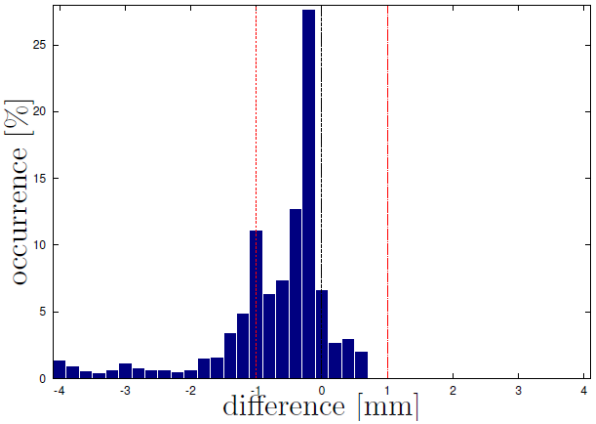
Geoscience Australia (GA):

- extensive comparisons have demonstrated satisfying agreement with igs08.atx values
- recommendation to accept GA as an IGS calibration facility
- any experience with calibrations for the BeiDou frequencies?

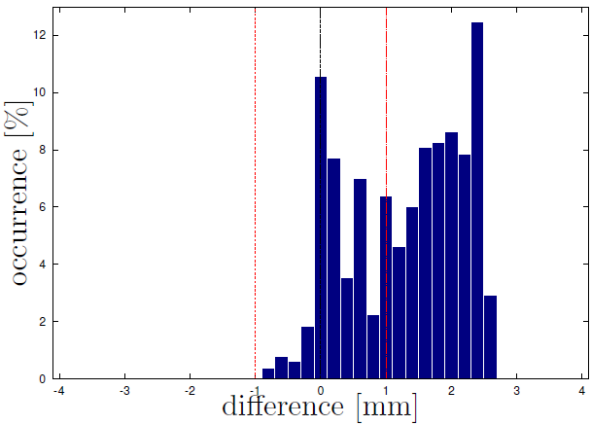
2. Receiver antenna issues

2.3 Chamber calibrations from Bonn for MGEX purposes (1)

- University of Bonn provided chamber calibration sets for 15 different antenna/radome combinations including 18 frequencies
- W. Aerts and M. Moore provided comparison with igs08.atx for GPS and GLONASS frequencies of 13 antenna types
- **Pasadena recommendation** to merge chamber with robot calibrations **was not implemented**, as the agreement between chamber results and igs08.atx values was not satisfying



$LEIAR25.R4\_\_\_\_LEIT$ on G02



$TRM59800.00\_\_\_\_NONE$ on G02

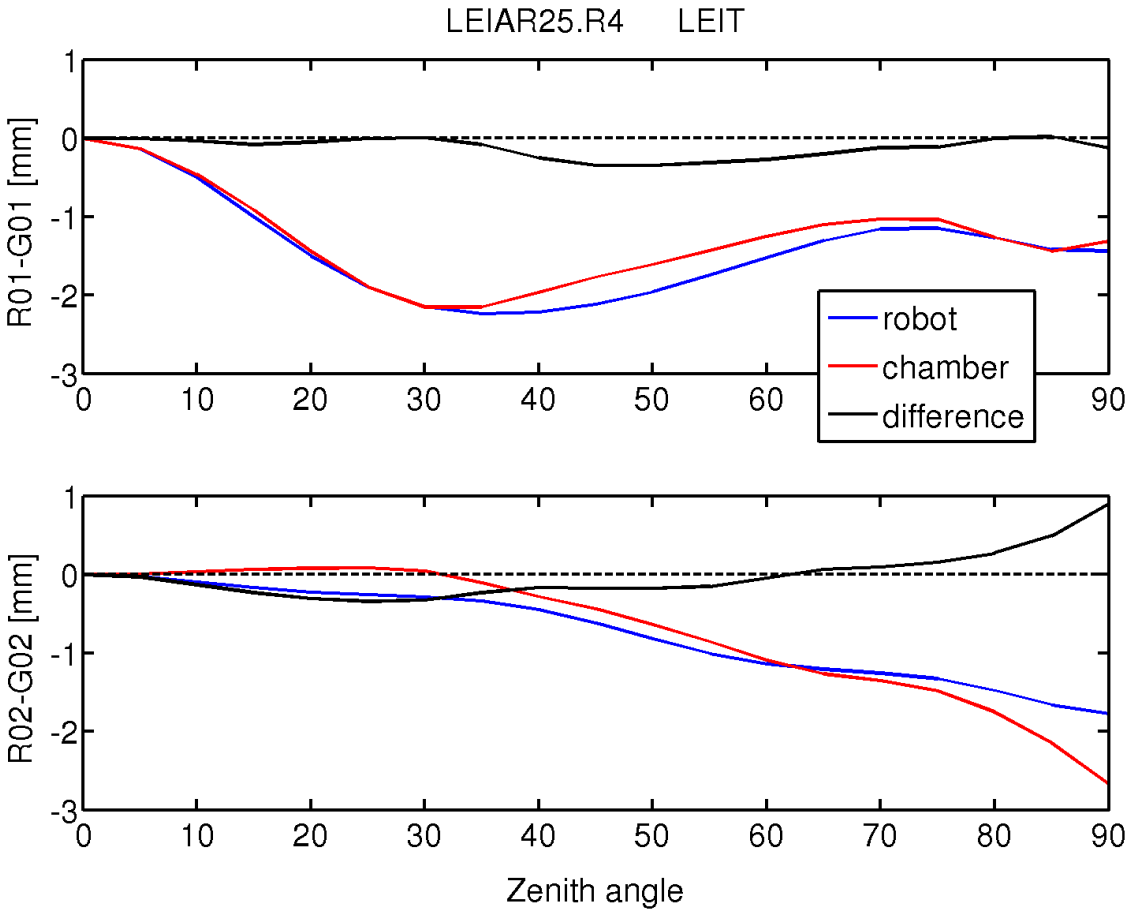
2. Receiver antenna issues

2.3 Chamber calibrations from Bonn for MGEX purposes (2)

Antenna	Radome	# MGEX sites	Agreement with igs08.atx
TRM59800.00	NONE	32	fair?
JAV_RINGANT_G3T	NONE	19	fair?
LEIAR25.R3	LEIT	18	good
LEIAR25.R4	LEIT	14	excellent
TRM57971.00	NONE	14	excellent
TRM59800.00	SCIS	10	fair?
LEIAR25.R4	NONE	8	n.a.
SEPCHOKE_MC	NONE	5	n.a.
JAVRINGANT_DM	NONE	4	n.a.
TRM55971.00	NONE	4	excellent
JAVRINGANT_DM	SCIS	2	n.a.
TPSCR.G5	TPSH	2	n.a.

2. Receiver antenna issues

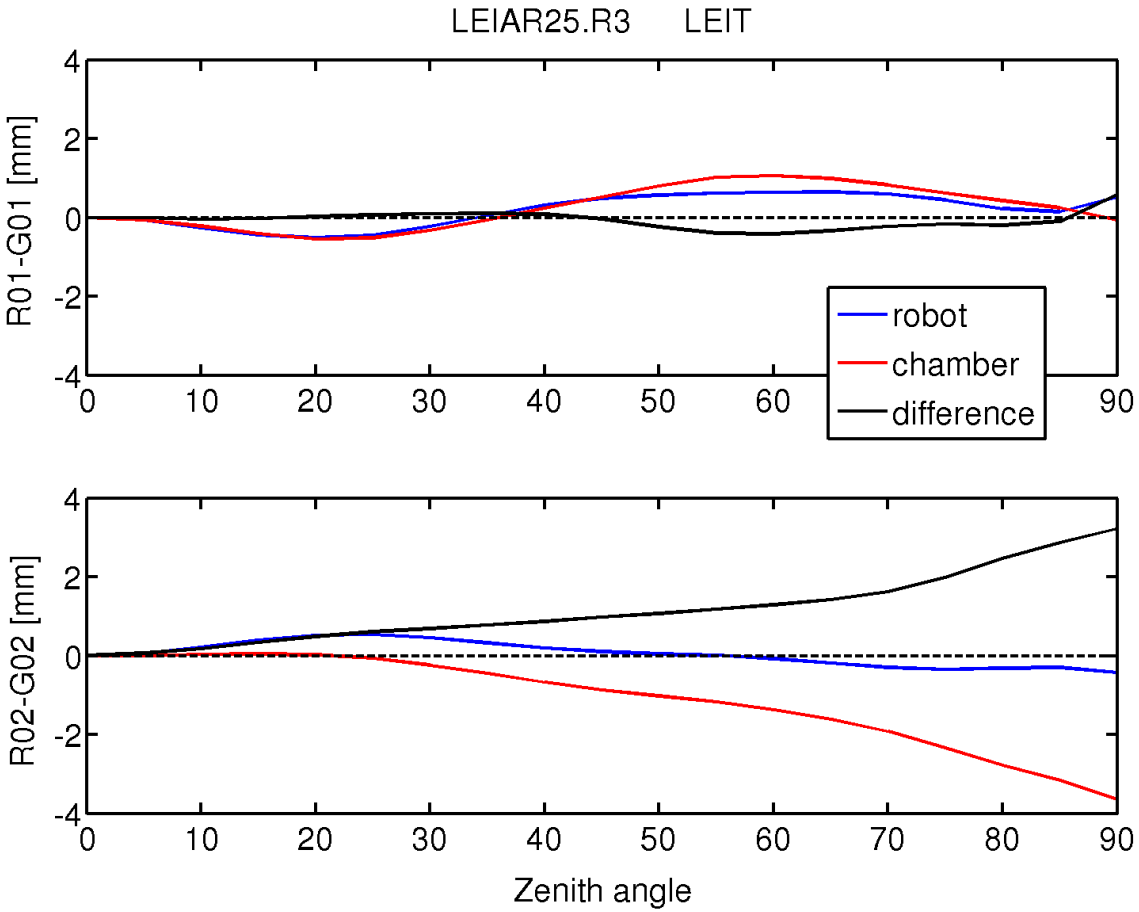
2.3 Chamber calibrations from Bonn for MGEX purposes (3)



- **Delta PCVs** (GLONASS w.r.t. GPS) show good agreement for some antenna types,...

2. Receiver antenna issues

2.3 Chamber calibrations from Bonn for MGEX purposes (4)



- ... but sometimes the difference between robot and chamber is bigger than the Delta PCV signal itself.

2. Receiver antenna issues

2.3 Chamber calibrations from Bonn for MGEX purposes (5)

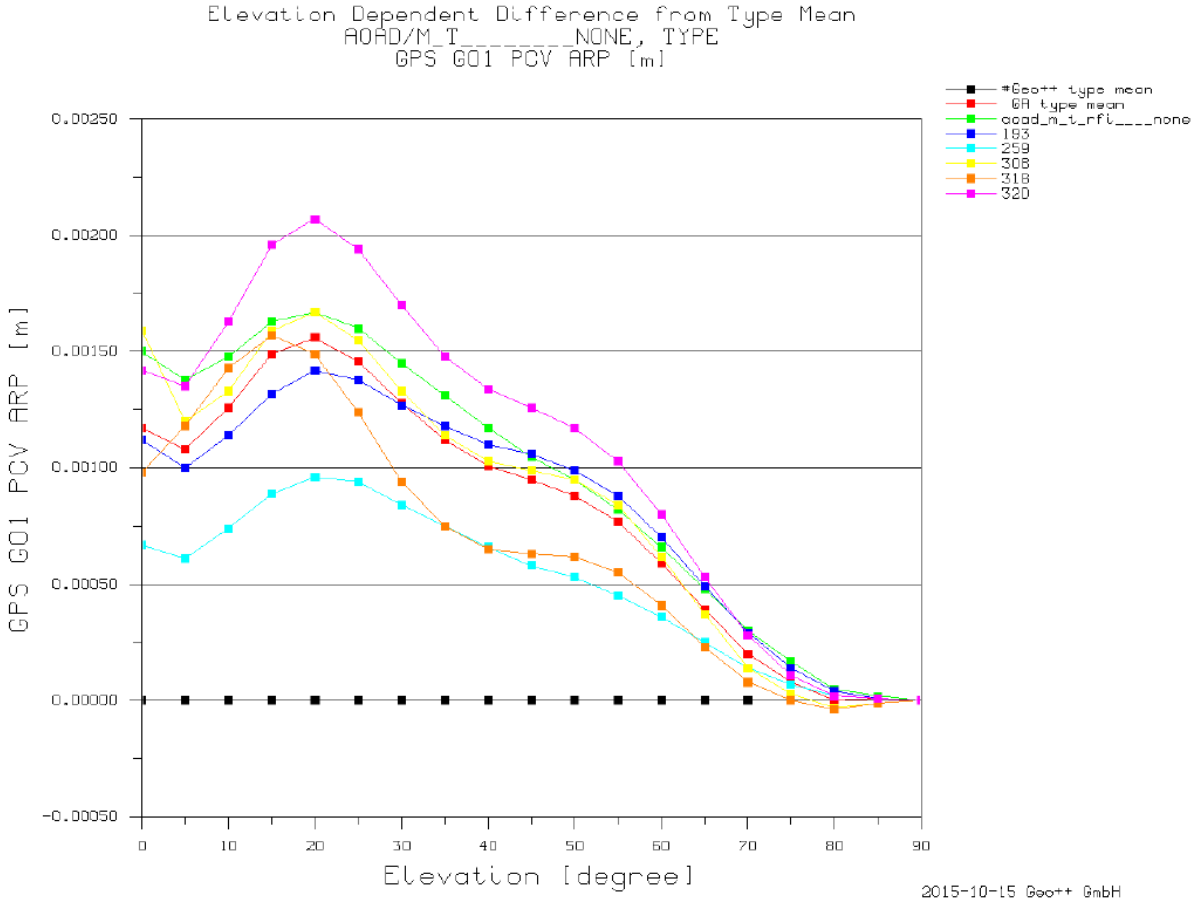
How to proceed?

- merge chamber with robot results for **limited number** of antenna types (excellent or good agreement between chamber and igs08.atx)?
- put all chamber results to a **test file** that MGEX ACs can analyze?
- replace certain robot calibrations by chamber results with the switch to igs14.atx??

2. Receiver antenna issues

2.4 AOAD/M_T subtypes?

- Geo++ and GA see systematic differences between subgroups
- serial number probably not sufficient for classification
- cannot be considered for igs14.atx



2. Receiver antenna issues

2.5 Individual calibrations

- differences between individual and type mean calibrations demonstrated by several authors (e.g., Baire et al. 2014)
- differences in the position domain can reach the cm level
- individual calibrations have been applied for certain stations of the EUREF Permanent Network (EPN) for nearly 10 years

➢ What can the IGS learn from the EPN?

3. IGS antenna files and formats

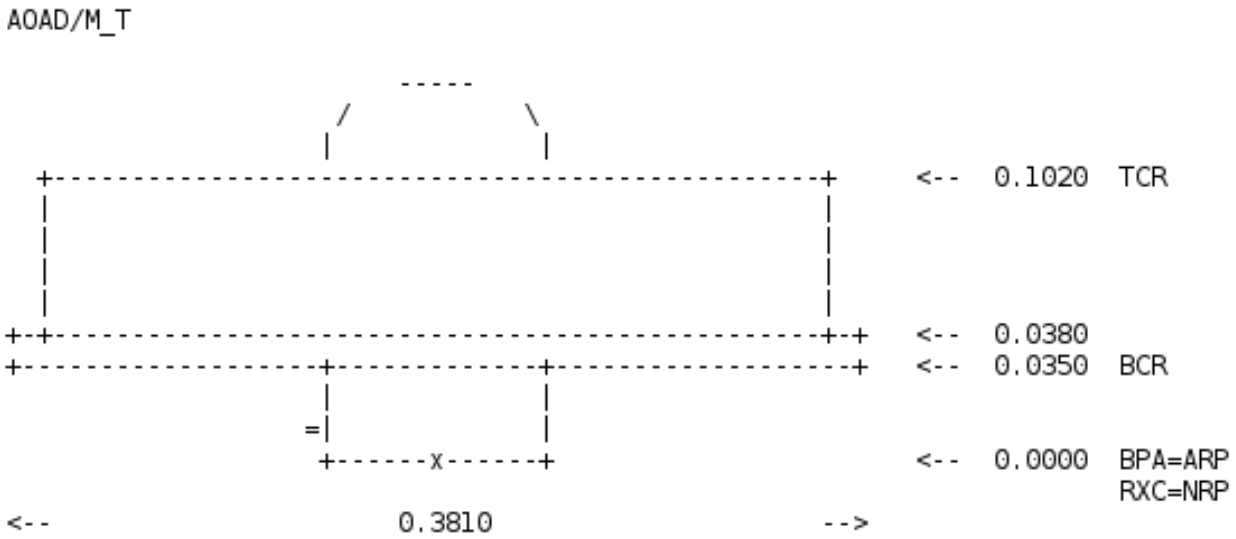
3.1 ANTEX 2.0

- effort needed as soon as igs14.atx is ready
- long list of open issues:
  - identical frequencies for different GNSS (avoid duplication of correction values)
  - code calibrations for satellite and receiver antennas (e.g., BeiDou measurements are affected by significant elevation-dependent code variations)
  - QZSS SAIF signal
  - RMS values
  - carrier-to-noise patterns
  - etc.

3. IGS antenna files and formats

3.2 antenna.gra

- so far, machine-readable section only contains antenna types for which a sketch is available
- reasonable to make an exception for old antenna types?

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Machine-readable quick reference section begins here.
3S-02-TSADM TOP UNK
3S-02-TSATE BPA UNK
AERAT1675_120 BAM NOM
AERAT2775_43 TOP NOM
AOAD/M_B BCR UNK
AOAD/M_T BPA RXC
```

4. Any other business

Further questions or comments?