Multi-GNSS WG Splinter Meeting

Agenda

Part 1 (16:00-16:45; MGWG)

- Welcome
- Multi-GNSS modeling issues
  - SP3 extension
  - SINEX station coordinates
  - Clock reference, biases
  - Attitude laws and axis conventions for GAL,BDS,QZSS
  - SRP modeling
  - PCOs and PCVs

Part 2 (16:45-17:30; with Infrastructure WG)

- MGEX quality control (tools, results)
  - Anubis
  - BQC
- RINEX3
  - MGEX needs and experience
  - RINEX3 transition plan

Recommendations

Multi-GNSS Working Group

Rolf Dach	AIUB	Orbit and clock products
Jan Dousa	Geod. Obs. Pecny	Data quality control
Ahmed El-Mowafy	CUT	System characterization, data QC
Heinz Habrich	BKG	Data Holdings
Satoshi Kogure	JAXA	QZSS
Richard Langley	UNB	Constellation status monitor
Yolanda LIU	BACC	Data quality control
Hans van der Marel	TU Delft	System characterization
Oliver Montenbruck	DLR/GSOC	Chair, Multi-GNSS Working Group
Felix Perosanz	CNES	System characterization, products
Chris Rizos	UNSW	External representation
Axel Rülke	BKG	Data center and quality control
Tim Springer	ESA/ESOC	Selected data analyses
Peter Steigenberger	DLR and TUM	Orbit and clock products
Maik Uhlemann	GFZ	Orbit and clock products
Rene Warnant	ULG	Ionosphere
Qile Zhao	Wuhan University	BeiDou

SP3 Format Extension

- New SP3d format proposal (Draft Sept. 2013)
- Coordination: Rolf Dach, Steve Hilla
- Key features:
  - more than 85 satellites; if # of sats exceeds 85, the required numer of header additional lines is added (minimum 5 sat-specific header lines as before)
  - Free number of comment line (minimum 5 as before) and extension
  - Comments extended to 80 columns

SINEX Station Coordinates

- Users need station positions
- Currently only one SINEX file for all (?) MGEX stations from latest ESOC 14d processing campaign

- What about new stations?
- How to proceed?

Clock Reference, Biases

- No established convention for clock reference of
  - Galileo (defacto E1/E5a)
  - BeiDou (defacto B1I/B2I)
  - QZSS (L1CA/L2C vs L1CA/L5)
- Different receivers track different signal flavors (X vs Q)
  - Can we lump those into a common clock or do we need to estimate distinct clocks?
  - How can we establish DCBs between X and Q or S, L, and X tracking?

Attitude Laws and S/C Reference Systems (1)

- Yaw steering (YS) employed by Galileo, BeiDou, QZSS
  - But different axis conventions (+x vs –x to deep space)
- Orbit normal (ON) mode
  - QZSS at |β|<~20°, BDS(MEO,IGSO) at |β|<~4°
  - BDS(GEO)
- Exact transitions unknown

- AC OD S/W needs to handle these modes (antenna offset, PWU) consistently
- Need to agree on common naming of s/c axis

Attitude Laws and S/C Reference Systems (2)

- Option A: manufacturer coordinate system
  - Consistency with literature and ILRS
- Option B: „IGS convention“
  - Common attitude law in yaw steering for all constellation
  - Different (potentially confusing) yaw angles in orbit normal modes

SRP

- Ovious indications for SRP mismodeling in QZSS, GAL
- BeiDou „ROCK“ model (CSNC 2014); no experience yet
- QZSS box-wing-cone model under development for QZSS (Madoca)

PCOs and PCVs

- RX antenna PCOs/PCVs for new signals will be incorporated into next ANTEX file

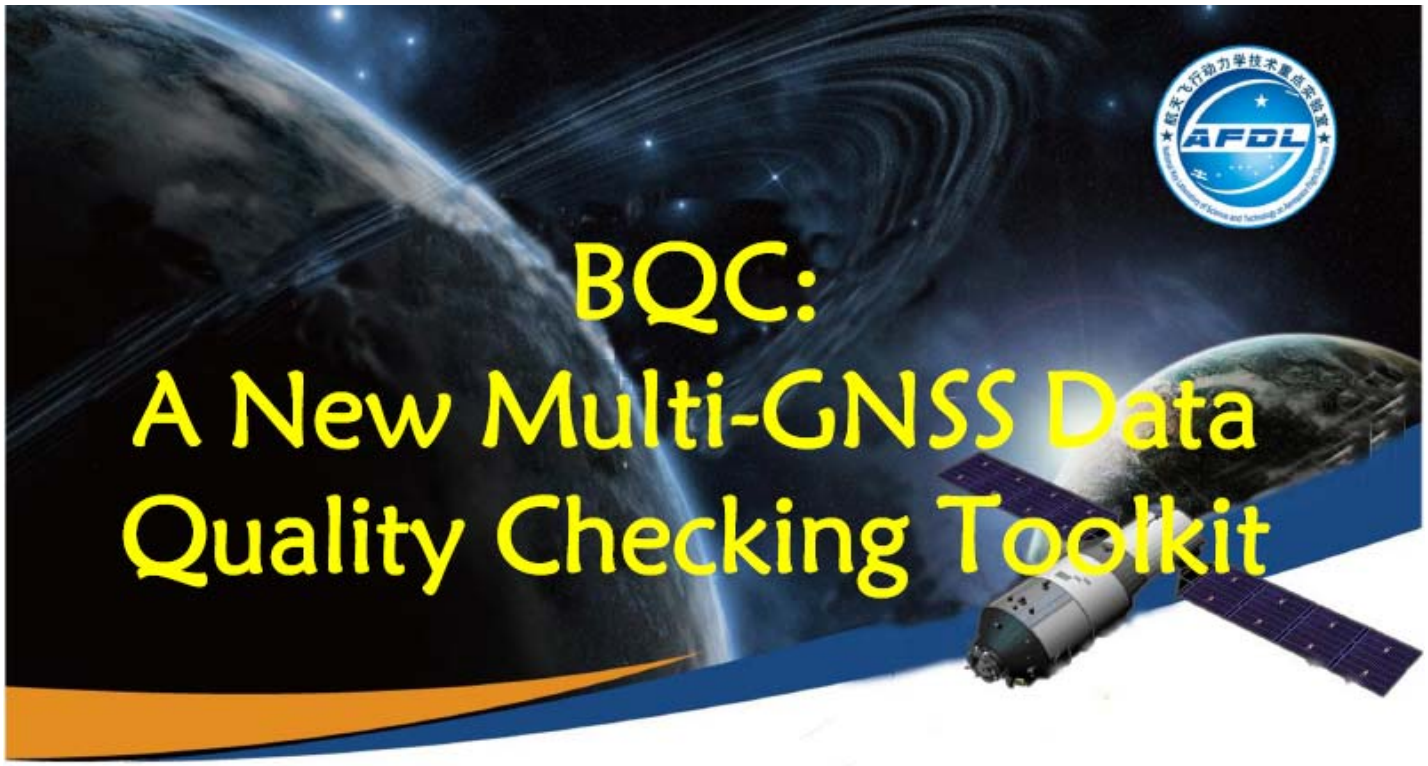
- Conventional TX antenna PCOs for GAL and BDS based on images/models/ruler (apparently not bad)
- Manufacturer values for QZSS (frequency-wise)

Quality Control

- Presentation Jan Dousa & Pavel Vaclavovic

BQC

- Quality Control Software developed at Bejing Aerospace Center
- Consistent Multi-GNSS / RINEX3 support
- Highly inspired by teqc
- Key parameters
  - SNR
  - Code Multipath
  - Cycle slip detection and repair



Dr. Huicui LIU
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Beijing Aerospace Control Center
03/2014

BQC

A profile of BQC

BQC: BACC multi-GNSS data QC toolkit

(1) Compatible signals

*All frequencies and all signal types defined in RINEX 3 of **GPS** / **GLONASS** / **Beidou** / **Galileo** / **SBAS** / **QZSS***

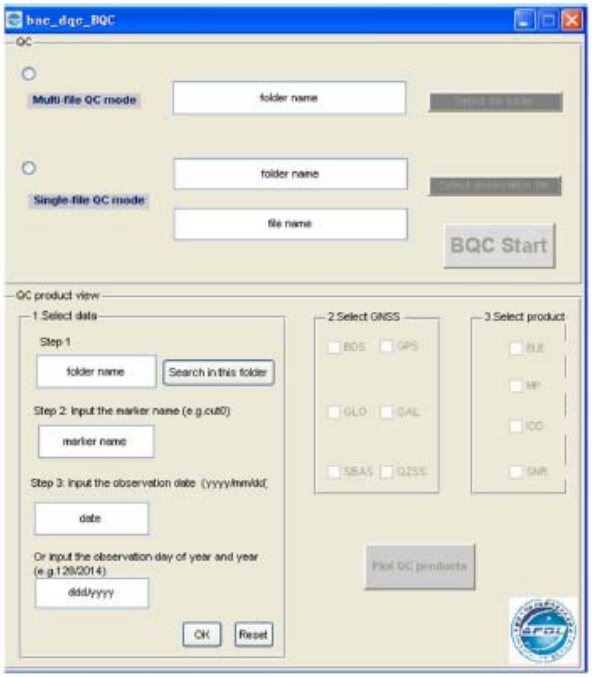
(2) Analysing modes

- *Single file QC mode*
- *multi-file QC mode*

(3) viewing products

- *Elevation (ELE)*
- *Code multipath (MP)*
- *Time-rate of ionospheric delay (IOD)*
- *Signal-to-noise ratio (SNR)*

in TXT reports and graphs



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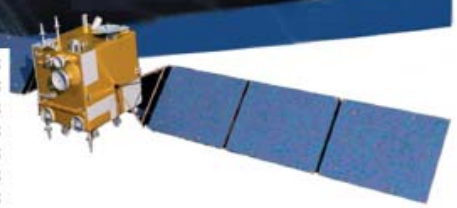
BQC

IGS

All the observation types recorded in o file

```
G   12 C1C L1C S1C C2W L2W S2W C2X L2X S2X C5X L5X S5X      SYS / # / OBS TYPES
S    3 C1C L1C S1C                                         SYS / # / OBS TYPES
R   12 C1C L1C S1C C1P L1P S1P C2C L2C S2C C2P L2P S2P     SYS / # / OBS TYPES
E   12 C1X L1X S1X C5X L5X S5X C7X L7X S7X C8X L8X S8X     SYS / # / OBS TYPES
J   15 C1C L1C S1C C1X L1X S1X C2X L2X S2X C5X L5X S5X C6X SYS / # / OBS TYPES
       L6X S6X                                            SYS / # / OBS TYPES
C    9 C2I L2I S2I C7I L7I S7I C6I L6I S6I                 SYS / # / OBS TYPES
```



Corresponding QC results

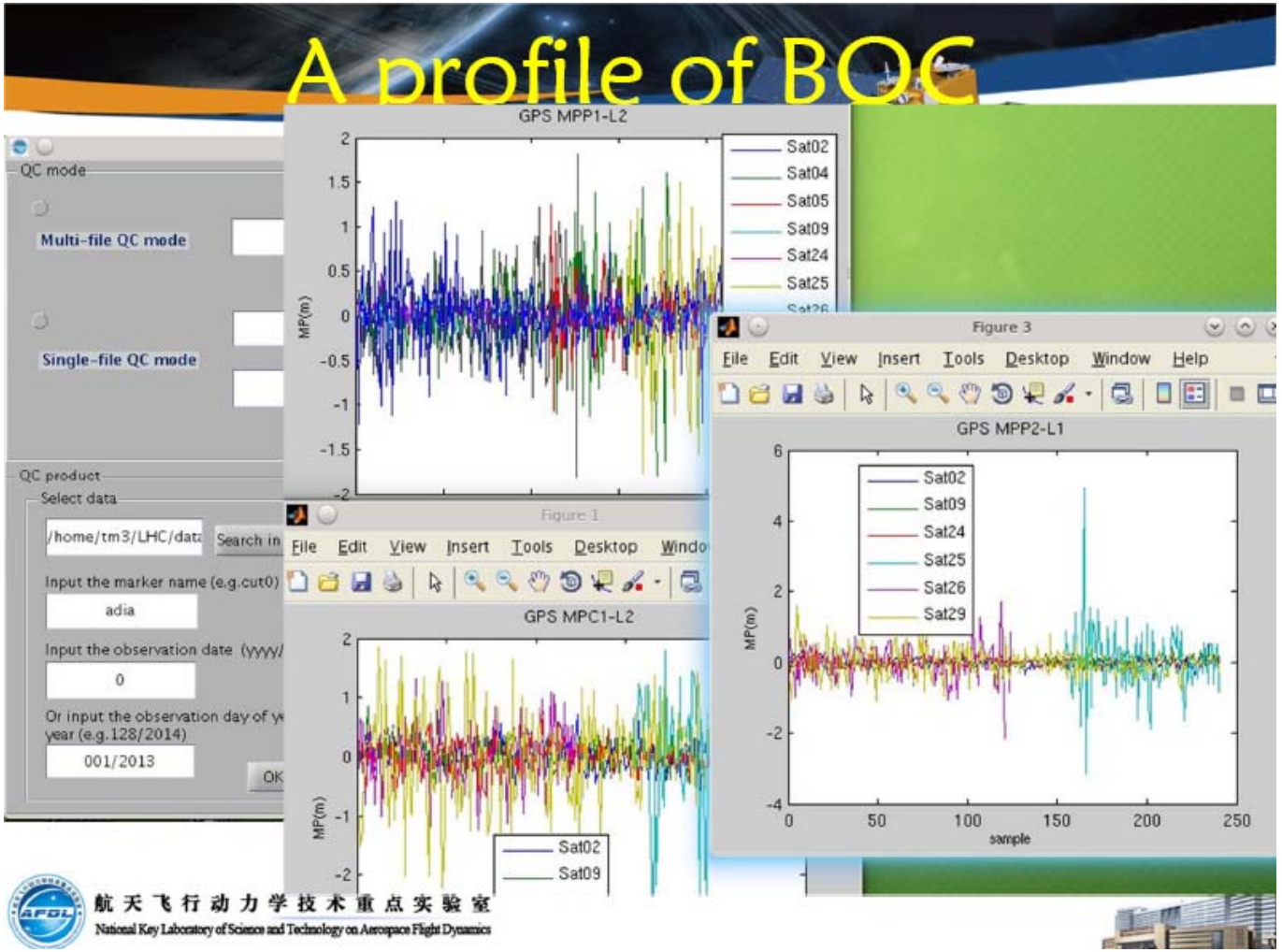
```
-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*GPS summary
Band choise : L1->1 L2->2 L5->5

##SNR summary
      G01   G02   G03   G04   G05   G06   G07   G08   G09   G10   G11   G12   G13   G14   G15   G16   G17   G18
S1C   -    43.2  38.7   -    41.7  41.4   -     -     -     -     -    46.5   -    35.1  38.0  44.3   -    46.1
S2W   -    27.3  20.3   -    26.0  25.3   -     -     -     -     -    33.8   -    16.9  20.3  29.4   -    31.9
S2X   -     -     -     -   39.7   -     -     -     -     -     -    43.5   -     -   37.3   -     -     -     -     -     -     -     -    40.
S5X   -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -    46.0   53.1

##Slip_detection summary
            total   G01   G02   G03   G04   G05   G06   G07   G08   G09   G10   G11   G12   G13   G14   G15   G1
1C2W          18    -     1     1     -     1     1     -     -     -     -     -     1     -     1     1     1     -     1     -
1C2X           8    -     -     -     -     1     -     -     -     -     -     -     1     -     -     1     -     -     -     -     -     -     -
1C5X           4    -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -
IOD1C-2W      47     0     0     0     0     0     2     0     0     0     0     0     0     0     0     0     0     5
IOD2X-1C      28     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
IOD5X-1C       1     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
MP1C-2W        6    -     0     0     -     0     0     -     -     -     -     -     0     -     0     0     2     -     1     -
MP2W-1C        0    -     0     0     -     0     0     -     -     -     -     -     0     -     0     0     0     -     0     -
MP2X-1C        1    -     -     -     -     0     -     -     -     -     -     0     -     -     0     -     -     -     -     -
MP5X-1C        0    -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -

##Multipath summary
            total   G01   G02   G03   G04   G05   G06   G07   G08   G09   G10   G11   G12   G13   G14   G15   G1
MP1C-2W     0.62    -    0.82   0.72    -    0.83   0.66    -     -     -     -    0.54    -    0.84  1.03  0.77
MP2W-1C     0.41    -    0.45   0.54    -    0.50   0.38    -     -     -     -    0.38    -    0.60  0.70  0.44
MP2X-1C     0.44    -     -     -     -    0.59    -     -     -     -     -     -    0.45    -     -    0.70    -     -     -     -     -     -
MP5X-1C     0.38    -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -     -
```

BQC


A profile of BQC
QC mode
Multi-file QC mode
Single-file QC mode
QC product
Select data
/home/tm3/LHC/data
Search in
Input the marker name (e.g.cut0)
adia
Input the observation date (yyyy/
0
Or input the observation day of y
year (e.g.128/2014)
001/2013
OK
GPS MPP1-L2
MP(m)
Sat02
Sat04
Sat05
Sat09
Sat24
Sat25
Figure 1
File Edit View Insert Tools Desktop Windo
GPS MPC1-L2
MP(m)
Sat02
Sat09
Figure 3
File Edit View Insert Tools Desktop Window Help
GPS MPP2-L1
MP(m)
sample
Sat02
Sat09
Sat24
Sat25
Sat26
Sat29
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RINEX3 – MGEX Experience (1)

- RINEX3 is vital to transport observation and nav data of new constellations
- Distinction of observation type attributes propagates into data processing (clocks, biases)

- Phase alignment header issues of no relevance for MGEX
- Confusion among manufacturers about proper choice of signal identifiers (numerous errors in MGEX archives; X vs Q, 2D)
- Mixed use of *1I and *2I for BeiDou after redefinition in 3.02 (many stations continue to deliver „old“ identifier)

- Heterogenous tool chains for RINEX3 cause inconsistent and/or wrong data (daily vs high-rate; various problems related to R/T(raw)-to-MSM-to-RINEX chain at BKG) (NOT a format problem)

RINEX3 – MGEX Experience (2)

- Inconsistent/wrong population of RINEX nav data fields (flags, etc.)
- Lacking 8+3 file name „inhibits“ production of BeiDou-only nav files
- No CNAV/CNAV2 data format
  - Currently no clear majority for either comprehensive or minimalistic format extension
- Nav header does not support frequent iono parameters (BDS, GAL)

- All MGEX entities employ the old 8+3 file naming

- MGEX data problems reduce motivation of RINEX2 users to switch to RINEX3 (not a RINEX3 *format* problem)

Clean-up?

- NRCan offers to assist fix of Rinex header related to BeiDou signal issue (THANKS!)

- Which B1 signal identifier do we want in RINEX 3.03? NB: China will adopt L1/E1 for future signals; conflict with *1? is highly predictable!
- Need to consider other problems as well?
- Need to consistently update 3 archives!
- How to ensure consitency of new submissions?
- Document problems or fix problems? (only provider may update data)

Recommendation (TBC)

RINEX3 Transition Plan

Goal

- One network, one archive

RINEX3 Transition Plan - Thoughts

- Parallel (redundant, potentially inconsistent) versus unique data holding (straight)
- New file naming can facilitate mixed RINEX2/3 archive but adds a further „obstacle“
- Parallel RINEX2/3 data limit motivation of ACs and users to switch to RINEX3
- Users need evidence for proper contents of RINEX3 data
- Would a downconverter (RINEX3-to-RINEX2 and long-to-short-name for the legacy processing) help? If so, who could provide it?
- How to ensure „universal“acceptance of transition plan (governing board, users, providers)
- Current focus is on observation files; what problem will we face with RINEX3 nav files?

RINEX3 Transition Plan - Roadmap

- Preparation (6 months; completed end 2014)
  - Formulate transition plan (AI: NC, DC, MGEX, …;1 Oct. 2014)
  - Circulate, review, adopt (AI: GB, Dec 2014)
  - Provision of relevant RINEX3 tool(s) (QC, converters) (end 2014)
- Implementation phase (6 months; completed by mid 2015)
  - Revised structure of data archives; common sitelog holdigs
  - Station-wise review and transition
  - and AC-by-AC transition to RINEX3
  - Parallel RINEX2 submissions tolerated
- Finalization (until end 2015)
  - Fix remaining problems, assits backbenchers
  - Terminate RINEX2 generation by end 2015

Recommendations

- Adopt new SP3d format (for >85 satelites) within IGS
- Adopt GPS-style s/c axes conventions for GAL/BDS/QZSS to achieve consitent handling of yaw steering mode across all constellations and satellites; orbit normal mode needs to be „translated“ consistently. ACs shall implement constellation-specific nominal attitude modes (yaw steering *and* orbit normal mode)
- Populate IGS ANTEX file with transmit antenna PCOs for new constellations and anechoic chamber calibrations of receive antenna for new frequencies

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Action Items

- GFZ and AIUB will provide SINEX files on a routine basis as part of their MGEX processing (might not include all stations but most of them)
- All ACs shall document signals used to obtain clock estimates in both CLK and SP3 files,
- Felix Perosanz will write/coordinate whitepaper on IGS-style s/c axis conventions for new constellations
- Nacho Romero will discuss with data centers how to make use of available/envisaged QC tools for check data prior to archival
- BKG is requested to conduct proper checks before changing BNC versions used in RINX3 generation for MGEX
- RINEX WG shall add note on old 8+3 names to next RINEX ammendment