Progress of iGMAS and IGMA Joint Trial Project

iGMAS TEAM

Kyoto Japan
2th Dec. 2017
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1. Introduction

In order to assist with public confidence in GNSS service and interoperability, IGMA Workgroup was set up in 2011, the Joint Trial Project (JTP) was recommended in 2015.

● In Feb. and Jun. 2016, the TOR was drafted and discussed during IGS workshop and ICG middle meeting. The JTP was launched in 2016 Nov., ICG-11.

● In May 2017, during IGMA workshop and IGMA Task Force Meeting in Shanghai, Methodology and Format was discussed. The JTP was launched inside IGS in Jul. 2017 during IGS workshop.

● In Oct. 2017, the format documents drafted by John and Shuli was distributed in IGMA Task Force. The preliminary assessments results from several MACs have been provided.
2. Progress of IGMA Joint Trial Project

- **Preliminary results from MACs**

Six MACs (DLR, GFZ, PECNY, CSR, GMV, XIAN) have provided initial GNSS assessment results.

<table>
<thead>
<tr>
<th>MAC</th>
<th>Sys</th>
<th>Num. of Par</th>
<th>Statistic Method</th>
<th>Parameters and Sampling Interval</th>
<th>Reference Files</th>
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<tbody>
<tr>
<td>GFZ</td>
<td>GPS, GLO, GAL, BDS</td>
<td>6</td>
<td>Daily SISRE RMS for each satellite</td>
<td>900s: R, T, N, C, SISRE 1day: SISRE RMS</td>
<td>GFZ MGEX product</td>
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<td>PECNY</td>
<td>GPS, GLO, GAL, BDS</td>
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<td>Daily SISRE RMS for each satellite</td>
<td>3hour: RMS/STD/MED (for CLK, POS, RAD, ALO, CRO) 900s: DIF (for POS, RAD, ALO, CLK, CRO), PDOP, UREEPO, SISRE, LATLON 1day: TOT_RMS/STD/MED, SISRMS</td>
<td>CODE MGEX product DLR navigation(brdm)</td>
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<tr>
<td>UTC5R</td>
<td>GPS, GLO, GAL</td>
<td>9</td>
<td>Daily and Weekly SISRE RMS for each satellite</td>
<td>600s: SISRE, (X, Y, Z, R, T, N, C)_diff 1day: SISRE RMS</td>
<td>GFZ MGEX product</td>
</tr>
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<td>XIAN</td>
<td>GPS, GLO, GAL, BDS</td>
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<td>Daily 95% SISRE statistics for each satellite</td>
<td>1day: 95% SISRE, (CLK, POS, R, T, N)_RMS 1hour: PDOP</td>
<td>iGMAS product</td>
</tr>
<tr>
<td>GMV</td>
<td>GPS</td>
<td>3</td>
<td>Daily SISRE RMS for each satellite</td>
<td>900s: PDOP, SISRE 1day: SISRE RMS</td>
<td>IGS product</td>
</tr>
<tr>
<td>DLR</td>
<td>GPS, GLO, GAL, BDS</td>
<td>11</td>
<td>Weekly 95% SISRE for each satellite Weekly SISRE RMS for each system</td>
<td>900s: R, T, N, C, dr_wul 1week: 95% SISRE, SISRE, (R, T, N, C)_RMS</td>
<td>CODE MGEX product</td>
</tr>
</tbody>
</table>
The Results from MACs are quite different at SISRE, especially for GLO, Gal and BDS.
2. Progress of IGMA Joint Trial Project

➢ Preliminary Analysis of MACs Results

Even for PDOP, CLK and Orbit Position, it’s also not consistent.
2. Progress of IGMA Joint Trial Project

- There’re so many differences at the number of parameters, assessment reference, calculation method, correction model, statistic method, sampling intervals. As well as the output filename, format, results intervals, time system of epoch mark, file output frequency, and the result itself.

- In order to make the results from MACs comparable, these issues should be discussed in detail and unified. (We have drafted the technical documents about the Standard for GNSS Monitoring and Assessment in including the definition, methodology and output format.)

- As the reference of the monitoring and assessment, the status of GNSS orbits with high accuracy from different ACs are analyzed first here.
### 3. Reference for Monitoring and Assessment

#### IGS MGEX multi-GNSS orbit/clk

<table>
<thead>
<tr>
<th>No.</th>
<th>AC</th>
<th>Orbit</th>
<th>CLK</th>
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<td></td>
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<tr>
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<td>gps glo</td>
<td>Gps glo</td>
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<td>2</td>
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<td>gps glo gal bds qzs</td>
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<tr>
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<td>JAXA</td>
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<td>5</td>
<td>TUM</td>
<td>gal qzs</td>
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<tr>
<td>6</td>
<td>Wuhan</td>
<td>gps glo gal bds qzs</td>
<td>gps glo gal bds</td>
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<table>
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<th>gps</th>
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#### iGMAS multi-GNSS orbit/clk

<table>
<thead>
<tr>
<th>No.</th>
<th>AC</th>
<th>Orbit</th>
<th>CLK</th>
</tr>
</thead>
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<tr>
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<td></td>
<td>Final</td>
<td>Rapid</td>
</tr>
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<td>4(gps glo gal bds)</td>
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<tr>
<td>2</td>
<td>CGS</td>
<td>4</td>
<td>gps gal bds</td>
</tr>
<tr>
<td>3</td>
<td>CHD</td>
<td>4</td>
<td>glo gal bds</td>
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<tr>
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<td>CUM</td>
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<td>4</td>
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<table>
<thead>
<tr>
<th>AC</th>
<th>IGMAS(BDT)</th>
<th>gps</th>
<th>glo</th>
<th>gal</th>
<th>bds</th>
</tr>
</thead>
</table>

3. Reference for Monitoring and Assessment

SLR Validation of BDS/GLONASS orbit from ACs

The BDS, Galileo, Glonass orbit from IGS(CODE,GFZ) and iGMAS(9 ACs+iSC) are validated by SLR observations during 1-30th Sept. 2017.

● For BDS and GLONASS, the accuracy of most iGMAS ACs are consistent with IGS(CODE,GFZ).
3. Reference for Monitoring and Assessment

SLR Validation of **Galileo** orbit from ACs

- For **Galileo**, there’re some differences between iGMAS ACs and IGS ACs. Some model corrections should be consistent.
3. Reference for Monitoring and Assessment

Combination products are necessary

- Difficult to keep the series continuous and stable absolutely for one AC. The combination is necessary.
- For GPS, the IGS final combination products are very continuous and stable. It’s also necessary to make combination products for other GNSS systems.
- iGMAS is improving its multi-GNSS combination products gradually which can be a choice for the reference.

Gaps in orbit series from each Analysis Center
4. Capability of iGMAS

- In Jul. 2016, iGMAS started open routine service. 7+ ACs for GNSS reference solution, 1 MAC for M&A, Tracking network, 3 Data Centers, et al.

- iGMAS can M&A constellation status, quality of navigation signals, accuracy of navigation information and service performance.

- iGMAS can provide basic BDS/GPS/Glonass/Galileo products with high accuracy as reference for M&A.
Monitoring and Assessment Elements of iGMAS

4. Capability of iGMAS

4 types M&A elements and 32 parameters
The basic products can provide the reference for Monitoring and Assessment, also for research and system technology test.
The timeliness of 5+ AC’s productions is more than 90% in 2016. It will be much better in 2017.
4. Capability of iGMAS

iGMAS Combination Products (iCS)

The availability in 2017 is more stable than 2016 and 2015.
4. Capability of iGMAS

iCS BDS/Galileo Orbit Products

**BeiDou GEO Orbit Accuracy**
- BDS GEO Orbit Accuracy (unit/mm)

**BeiDou IGSO/MEO Orbit Accuracy**
- BDS IGSO/MEO Orbit Accuracy (unit/mm)

**Galileo Orbit Accuracy**

**Compared to GFZ products:**
- The accuracy of BDS final product in GEO is better than 200cm, as for IGSO/MEO is better than 8.0cm.
- The accuracy of Galileo final product is better than 9.0cm.
4. Capability of iGMAS

Comparison of iCS Orbit with IGS

Compared to IGS products:
- the accuracy of GPS final orbit is better than 1.2cm.
- the accuracy of GLONASS orbit is better than 2.5cm.
4. Capability of iGMAS

**SLR Validation of iCS Orbit**

The final product accuracy (radial) of **BDS GEO** satellite orbit is better than 50.0cm, **IGSO / MEO** is better than 10.0cm, **GLONASS** is better than 13.0cm, and **Galileo** is better than 8.0cm.
4. Capability of iGMAS

**iCS Clock Products**

- **BDS clock accuracy (unit/ns):**
  - GEO: better than 0.7ns
  - IGSO / MEO: better than 0.3ns

- **GPS clock accuracy (unit/ns):**
  - Better than 0.1ns

- **GLONASS clock accuracy (unit/ns):**
  - Better than 0.15ns

- **Galileo clock accuracy (unit/ns):**
  - Better than 0.3ns

Compared to GFZ products:
- BDS final CLK, GEO is better than 0.7ns,
- IGSO / MEO is better than 0.3ns;
- GPS final CLK is better than 0.1ns;
- GLONASS final CLK is better than 0.15ns;
- Galileo final CLK is better than 0.3ns;

iGMAS iCS products are prospective for reference too.
5. Scope of China Contributions to JTP

- Monitoring of all GNSS:
  - GPS, GLONASS, Galileo, BeiDou, later also QZSS, etc
- Contribute the basic set of parameters but not limited
- Initially offline, later near-realtime and realtime
- Station resources
- Monitoring and Assessment Center (MAC)
- GNSS Reference Solutions
- HUB for information exchange and share
From IGS stations in China, SHAO (Shanghai), CHAN (Changchun), LHAZ (Lhasa) and GUAO (Urumqi), some will be chosen to participate in the Joint Trial Project.

**Station Status at present**

<table>
<thead>
<tr>
<th>Site Name</th>
<th>City/Town</th>
<th>Receiver Type</th>
<th>Antenna Type</th>
<th>GPS</th>
<th>GLO</th>
<th>GAL</th>
<th>BDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHAO</td>
<td>Shanghai</td>
<td>ASHTECH UZ-12</td>
<td>AOAD/M_T</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHAN</td>
<td>Changchun</td>
<td>ASHTECH UZ-12</td>
<td>ASH701945E_M</td>
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<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>LHAZ</td>
<td>Lhasa</td>
<td>LEICA GR25</td>
<td>LEIAR25.R4</td>
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<tr>
<td>GUAO</td>
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<td>ASH701945B_M</td>
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<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

Receivers will be updated for tracking GPS, GLONASS, GALILEO and BDS signals.
5. Scope of China Contributions to JTP

- Monitoring and Assessment Center

- iGMAS Monitoring and Assessment Center is in Xi'an.
- Provide four types (32 parameters) M&A information with various update intervals.
- Routine running for more than two years.

iGMAS MAC is ready to provide a fully operational monitoring service. The results have accumulated more than two years.
5. Scope of China Contributions to JTP

- **HUB for information Exchange and Share**

The HUB is set for tracking data and M&A information collecting and sharing from/to all the participants of the JTP and other users. Now, the preliminary results from MACs and analysis report can be downloaded.
5. Scope of China Contributions to JTP

- HUB for information Exchange and Share

- All users can register on [http://112.65.161.230/Eng-register.html](http://112.65.161.230/Eng-register.html) to download the data and products with FTP, and accessible IGS real-time data.
6. Summary

- At present, so quite different at the methodology, output and the result itself from MACs.
- In order to make the results from MACs comparable, the definition, methodology and output format should be discussed in detail and unified. Standard for GNSS Monitoring and Assessment should be discussed together for all related activities, such as ICG IGMA, iGMAS, MGA.
- As the reference of the monitoring and assessment, for BDS and GLONASS, the accuracy of most iGMAS ACs are consistent with IGS (CODE, GFZ). For Galileo, model corrections should be consistent in iGMAS.
- For GPS, the IGS final combination products are very continuous and stable. It’s also necessary to make combination products for other GNSS systems. iGMAS is improving its multi-GNSS combination products gradually which can be a choice for the reference.
Thanks!

● iGMAS WEBSITE: [www.igmas.org](http://124.205.50.178:8011)

● Mobile APP