Recent Developments in the International GNSS Service (IGS)

John M. Dow\textsuperscript{1} and Ruth E. Neilan\textsuperscript{2}

\textsuperscript{1}Chair, IGS Governing Board; ESA/ESOC, Darmstadt, Germany
\textsuperscript{2}Director, IGS Central Bureau; JPL, Pasadena, USA
IGS Products

- Data from a global network of tracking stations
- Precise orbits (few cm), predictions (<10 cm)
- Clock corrections (satellite, ground: <1 ns)
- Ground positioning (<1 cm)
  - Consolidated input of GNSS to the International Terrestrial Reference Frame (ITRF)
- Ionosphere maps
- Troposphere corrections
- Differential code biases
- Antenna phase centre models

IGS products in constant development, quality control as key driver
IGS Components

- Tracking network
- Network Coordinator
- Data Centres
- Analysis Centres and Associate Analysis Centres
- Analysis Centre Coordinator
- Reference Frame Coordinator
- Timing Products Coordinator
- Infrastructure Committee (2009-)
- Working Groups and Pilot Projects
- Central Bureau
- Governing Board
# IGS Core Product Lines (2010)

<table>
<thead>
<tr>
<th>Series</th>
<th>ID code</th>
<th>Latency</th>
<th>Issue times (UTC)</th>
<th>Data spans (UTC)</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| **Ultra-Rapid**  | IGU     | real-time | 03:00, 09:00, 15:00, 21:00 | +24 hr @ 00:00, 06:00, 12:00, 18:00 | • for real-time apps  
• GPS only  
• issued with prior IGA |
| (predicted half) |         |         |                   |                  |                                              |
| **Ultra-Rapid**  | IGA     | 3 - 9 hr | 03:00, 09:00, 15:00, 21:00 | -24 hr @ 00:00, 06:00, 12:00, 18:00 | • for near-real-time apps  
• GPS only  
• issued with following IGU |
| (observed half)  |         |         |                   |                  |                                              |
| **Rapid**        | IGR     | 17 - 41 hr | 17:00 daily       | ±12 hr @ 12:00 | • for near-definitive, rapid apps  
• GPS only |
| **Final**        | IGS     | 11 - 17 d | weekly each Thursday | ±12 hr @ 12:00 for 7 d | • for definitive apps  
• GPS & GLONASS |

J. Ray, IGS ACC
<table>
<thead>
<tr>
<th>Series</th>
<th>Product types</th>
<th># of contributing ACs</th>
<th>Output sample interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ultra-Rapid</strong> (IGA + IGU)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPS orbits</td>
<td>7 / 6 / 2 / 3 / 4 / 3</td>
<td>15 min</td>
<td></td>
</tr>
<tr>
<td>GPS SV clocks</td>
<td>4 / 1 / 3</td>
<td>15 min</td>
<td></td>
</tr>
<tr>
<td>ERPs: PM / LOD</td>
<td>6 / 6</td>
<td>6 hr</td>
<td></td>
</tr>
<tr>
<td><strong>Rapid</strong> (IGR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPS orbits</td>
<td>8 / 6 / 2 / 1 / 6 / 7</td>
<td>15 min</td>
<td></td>
</tr>
<tr>
<td>GPS SV clocks</td>
<td>6 / 1 / 5</td>
<td>5 min</td>
<td></td>
</tr>
<tr>
<td>station clocks</td>
<td>6 / 1 / 5</td>
<td>5 min</td>
<td></td>
</tr>
<tr>
<td>ERPs: PM / LOD</td>
<td>8 / 8</td>
<td>daily</td>
<td></td>
</tr>
<tr>
<td><strong>Final</strong> (IGS)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GPS orbits</td>
<td>9 / 7 / ~1 / ~8</td>
<td>15 min</td>
<td></td>
</tr>
<tr>
<td>GPS SV clocks</td>
<td>5 / 1 / 6</td>
<td>5 min</td>
<td></td>
</tr>
<tr>
<td>station clocks</td>
<td>7 / 1 / 6</td>
<td>30 s</td>
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<tr>
<td>GLO orbits</td>
<td>6 / 1 / 5</td>
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<td></td>
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<tr>
<td>GLO SV clocks</td>
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<td></td>
</tr>
<tr>
<td>ERPs: PM / LOD</td>
<td>9 / 9 / ~2 / ~3 / 7 / 6</td>
<td>daily</td>
<td></td>
</tr>
<tr>
<td>Terrestrial frame</td>
<td>9 / ~1 / ~8</td>
<td>weekly</td>
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</table>
IGS Working Groups and Pilot Projects

- Antenna Working Group
- Bias and Calibration Working Group
- Clock Products Working Group
- Data Centre Working Group
- GNSS Working Group
- Ionosphere Working Group
- Low Earth Orbiters (LEO) Working Group
- Tropospheric Working Group
- Real-Time Working Group
- Reference Frame Working Group
- Tide Gauge Benchmark Monitoring Pilot Project
- Orbit Modelling Working Group (2010-)

ICG-5, Torino, Italy, 18-22 October 2010
IGS as a multi-GNSS Service

- Galileo: IGS/IAG centres are involved in
  - 13 station global Galileo Experimental Sensor Station network, now tracking GIOVE-A & -B
  - Galileo Geodetic Reference Provider Prototype
  - Giove tracking data evaluation in coordination with Galileo Project Office
- Continuing independent monitoring of operational GNSS’s (currently GPS, GLONASS) and their spatial and time references
  - Glonass orbit solutions from 5 IGS centres consistent to 3-4 cm
- Multi-system GNSS solutions
  - Four AC’s are providing fully compatible ultra-rapid GNSS solutions: GPS + GLONASS > experimental combination under evaluation
  - Routine multi-system IGS GNSS product is feasible, but GLONASS tracking network still lacks optimal global distribution
  - Focus on inter-system biases
- A Multi-GNSS Campaign is in the early planning stage
IGS Tracking Networks

IGS Station Network

421 stations
38 receiver types
97 antenna+radome types
100+ organizations

GPS

GNSS (GPS, GLONASS, Galileo) at Malindi, Kenya

Glonass/GPS

ICG-5, Torino, Italy, 18-22 October 2010
Reprocessing: 1st Campaign (IG1)

- To obtain a full history of IGS Final products in a fully consistent framework (IGS05)
- Absolute antenna model (igs05.atx)
- P1-C1 satellite code biases updated
- IERS 2003 Conventions generally implemented
- Participation of 11 Analysis Centres
- Time series for ~900 stations, 643 with > 2 years data
- Provided IGS contribution with homogeneous products to ITRF2008
Reprocessing: clock combination
Checking the solution series with PPP

- PPP with IG1 orbits & clocks, 4 weeks/year
- Network of ~80 stations (~25 in 1994)
- Plot shows weekly mean rms difference between PPP and weekly SINEX
IGS Real-time Pilot Project

• Maintain a global IGS RT receiver network, generate RT products (orbits, clocks), and investigate standards for RT data and products
• Currently ca. 120 RT stations, >35 participating organisations, 6 active Analysis Centres (NRCan, ESA, BKG, DLR, GMV, TUW)
• ESA/ESOC provides Analysis Centre Coordinator and Combination Centre
• Target real-time clock rms: 0.3 ns (vs 4ns for Broadcast); 5-6 cm for orbits; 10 sec latency
Real Time Combination Solution

Accuracy (compared to IGS Rapids)
- Orbit: 4-6 cm 1-D RMS
- Clock RMS: 0.2 ns
- Clock Sigma: 0.1 ns
- Latency of Individual Solutions: 7-15 s
- Latency of Combination: 20 – 30 s

ICG-5, Torino, Italy, 18-22 October 2010
Standards and Formats for Real-Time

- Promotion of new formats and protocols through IGS participation in the Radio Technical Commission for Maritime Services (RTCM), Special Committee 104 (SC-104) on DGNSS
  - Supporting the introduction of State Space Representation formats, allowing dissemination of global orbit and clock corrections via IP using NTRIP
  - Proposing and participating in the development of High Precision multi-constellation observation messages
  - Working with RTCM facilitates acceptance and introduction of these formats directly into GNSS receiver firmware
Global Geodetic Observing System

- IGS is one of the building blocks of IAG’s Global Geodetic Observing System (GGOS), the contribution of geodesy to the Global Earth Observing System of Systems (GEOSS)

- Bringing strengths of GNSS to observing system of all geodetic techniques

- Integrated Standards and Conventions (IERS Conventions 2010)

- Unified Analysis Workshop 2009, GGOS Retreat 2010
IGS Workshop 2010

• IGS Workshop was held at Newcastle, U.K. from 27 June to 2 July 2010

• Topics included:
  – Combining GNSS signals
  – Network infrastructure (antenna monuments, receivers for new signals, phase centre calibrations, data flow and standards, …)
  – Real-time products
  – Re-processing data 1994-2010
  – Orbit modelling (new WG set up)
  – Loading and tides
  – Ionosphere, troposphere

• See http://igs.org for program, presentations and (soon) consolidated recommendations

• A meeting of ICG WG-D took place, minutes via ICG Secretariat
Conclusions

• IGS continues its long history of successful, leading-edge projects and products – supported by long- and medium-term strategic planning
• The IGS provides the reference for many GNSS applications
  – Reliable, rapidly available, highest accuracy products for a wide community of users
• Quality control is a key driver for the IGS: systematic comparisons and feedback motivate improvements
• Innovation and new developments, e.g.,
  • Multi-system GNSS infrastructure and analysis products
  • Real Time Pilot Project
  • Re-processing
  • Infrastructure Committee
  • GGOS
• More information at http://igs.org