The IGS Real-time Pilot Project

The Development of Real-time IGS Correction Products for Precise Point Positioning

Mark Caissy, Georg Weber, Loukis Agrotis, Gerhard Wübbena, and Manuel Hernández-Pajares
IGS RTWG Charter 2001
- Design and implement real-time infrastructure and processes → network → data → products (iono, clock and orbits) → users

IGS RTPP 2007 – 2010
- 2009 extended until end of 2011

2010 RTWG and RTPP charter combined
- 2011-2012 plan → projects IGS rt-services starting 2013 → data, clocks and orbits → real-time PPP

RT-Services are a part of the IGS strategic plan
- IGS → IAG Service → GGOS Natural Hazards theme
RTCM Multiple Signal Messages (RTCM-MSM)

- Multi-constellation observation data messages defined for GPS, Glonass and Galileo and others
  - Internet distribution via NTRIP Protocol
  - Messages capable of encoding 64 SV’s and 32 signals for each constellation
  - Generic GNSS observations supported (Code, Phase, Doppler, SNR and Loss of Lock Indicator)
  - Able to develop Rinex 2 and 3 compatible files
  - RTCM-MSM format and protocol nearing adoption by RTCM-SC104 members
Development of RTCM State Space Representation messages in 3 stages:

1) GPS and GLONASS: Satellite orbit corrections, satellite clock corrections, code biases and URA messages to allow dual frequency code based RT-PPP

2) Galileo support, ionosphere (VTEC) corrections and phase biases messages to allow single frequency RT-PPP and support of ambiguity resolution

3) Ionosphere (STEC) and troposphere corrections to allow RTK applications, i.e. cm accuracy in seconds.
Multi-constellation correction data messages defined to support GPS and Glonass.

- Internet distribution via NTRIP Protocol
- SV Clock correction message supports 1mm resolution
- SV Orbit correction message supports 1mm resolution
- GNSS Code Bias correction message supports 0.01m resolution
- RTCM-SSR format and protocol currently being voted on by RTCM-SC104
IGS ionospheric group has provided global VTEC maps since 1998 (12 day) and 2003 (2 day)
- optimal combination of 4 analysis centers

Availability of precise real-time ionospheric delay model
- Sub-meter single frequency navigation
- Space Weather effects monitoring.

RT global VTEC maps are being developed by UPC and DLR
- Target is a combined RT IGS ionospheric product
RT-IGS global VTEC: First results

- RT-IGS GNSS data-streams
- First UPC predicted global VTEC maps

- UPC 4D Iono model + Kriging interpolation (RT-TOMION)

- First real-time global VTEC maps

- RT-VTEC map (2D) in IONEX format, 15 minutes rate and latency (in future it could be provided as 3D grid and data stream).

- Main problem found so far: lack of worldwide distributed receivers

- In the meantime the availability of a good background model and the use of an efficient interpolation strategy are very important.
ACC Developments

- Assisted ACs to develop and improve their products:
  - 8 ACs in daily batch submissions for comparison and batch combination (see http://www.rtigs.net/pilot/products.php)
  - 6 AC RT streams used for RT combination and daily clock and orbit comparisons (RT comparisons used to isolate encoding and availability issues)
  - Emphasis on experimentation towards improved PPP solutions (see http://igs.bkg.bund.de/ntrip/ppp)

- Initiated WG on Ambiguity Fixing in PPP (led by M.Ge)
  - Performed a review of current techniques
  - Working on defining product set for potential IGS service
Generation/Evaluation of RT Combination Streams

- Improvements in clock outlier detection of IGS stream (disseminated as CLK30 in CoM and CLK31 in APC coordinates)
  - New scheme catches clock outliers but orbit problems (especially in the Ultras) are difficult to detect

- Reduction in the latency (thanks to BKG/TUP changes to BNC) from approx 25 sec to around 15 sec, which can now be easily reduced further if contributing ACs reduce their latency

- Evaluation of alternative combination technique developed by BKG
## AC Performance

<table>
<thead>
<tr>
<th>AC</th>
<th>Feb 6 2009</th>
<th>June 8 2010</th>
<th>March 9 2011</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Clock RMS (ns)</td>
<td>Clock Sigma (ns)</td>
<td>Clock RMS (ns)</td>
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<tr>
<td>Comb</td>
<td>0.29</td>
<td>0.22</td>
<td>0.16</td>
</tr>
<tr>
<td>RTComb</td>
<td>-</td>
<td>-</td>
<td>0.15</td>
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<tr>
<td>BKG</td>
<td>6.72</td>
<td>2.97</td>
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<tr>
<td>CNES</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>DLR</td>
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<td>0.10</td>
<td>0.20</td>
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<tr>
<td>ESOC</td>
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<tr>
<td>ESOC2</td>
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<tr>
<td>GFZ</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
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<td>0.67</td>
<td>0.62</td>
<td>0.24</td>
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<tr>
<td>GMV</td>
<td>1.67</td>
<td>1.66</td>
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<tr>
<td>TUW</td>
<td>0.70</td>
<td>0.53</td>
<td>0.71</td>
</tr>
<tr>
<td>Centre</td>
<td>Description</td>
<td>NTRIP Mountpoint</td>
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<td>------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<td></td>
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<tr>
<td>RTACC ESOC</td>
<td>RT combination from BKG, CNES, DLR, ESOC, ESOC2 and GFZ streams <em>(CoM /APC)</em></td>
<td>CLK30/31</td>
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<tr>
<td>CNES</td>
<td>RT clocks based on IGU orbits <em>(CoM/APC)</em></td>
<td>CLK90/91</td>
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<td>BKG with TU Prague</td>
<td><strong>GPS and GPS + GLONASS RT</strong> clocks using IGS ultra-rapid orbits <em>(CoM/APC)</em>.</td>
<td>CLK00/10, CLK01/11</td>
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<tr>
<td>DLR</td>
<td>RT clocks using IGS ultra-rapid orbits.</td>
<td>CLKC1/A1</td>
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<td>ESOC</td>
<td>RT clocks and TZD NRT batch orbits every 2 hours <em>(ESOC)</em> and using IGS ultras <em>(ESOC2)</em> <em>(CoM /APC)</em>.</td>
<td>CLK50/51, CLK52/53</td>
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<td>GFZ</td>
<td>RT clocks <em>(CoM/APC)</em></td>
<td>CLK70/71</td>
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<td>GMV</td>
<td>RT clocks <strong>based on GMV orbit solution</strong> <em>(CoM/APC)</em>.</td>
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<td>TUW</td>
<td>RT clocks based on IGU orbits <em>(CoM/APC)</em>.</td>
<td>CLK80/81</td>
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BNC rtppp results

-- kinematic solutions using globally distributed IGS sites.
NRCan – rtppp results

-- kinematic solutions using Canadian sites

Avg 2drms: .05 m

Avg 2drms: .07 m

Avg 2drms: .10 m
RTIGS is working within RTCM to further develop international standards for rt-data and rt-product formats – RTCM expected to adopt both in 2011.

Traditional IGS products are transitioning to real-time (data, iono, orbits, clocks).

The IGS will offer real-time clocks and orbits to serve rtppp users (decimetre level).

- Current target is 2011 IOC (within RTpilot) : 2013 FOC
- [http://www.rtigs.net](http://www.rtigs.net)