3.4 Technique Centres
3.4.1 International GNSS Service (IGS)

International Global Navigation Satellite Service 2012

The International Global Navigation Satellite System Service (IGS) was established in 1994 with a mission to provide the highest quality Global Navigation Satellite System (GNSS) data and products for scientific use. The IGS products, including Earth rotation parameters and global tracking station coordinates and velocities, are provided to IERS as the GNSS technique contribution to the realization of the International Terrestrial Reference Frame (ITRF). IGS activities and developments in 2012 that are of interest to IERS are summarized within this report. The information herein was compiled from the 2012 IGS Technical Report, which includes detailed report sections by the heads of all of the IGS Components and Working Groups. The Technical Report should be consulted for more detailed information regarding the IGS activities in 2012. It is available for download from the publications section of the IGS website <www.IGS.org>.

Summary of Routine Operational Activities

IGS network stations are maintained and operated globally by many institutions, making tracking data available at different latencies from daily RINEX files to real-time streams for free public use. IGS tracking data held by each of the four global Data Centers on permanently accessible servers increased in volume over last year by over 1 Tb (15 million files). Many of these data are redundantly provided through the IGS regional Data Centers. The IGS Analysis Centers and Associate Analysis Centers utilize tracking data from 70 up to more than 350 stations to generate and control the quality of highest-precision products up to four times per day. Product Coordinators combine these products on an operational basis and assure their quality. Nearly 700 IGS final, rapid, ultra-rapid and GLONASS-only product files as well as 140 ionosphere files are made available per week as well as daily troposphere files for more than 300 stations. The interest of users in IGS products is documented by the download statistics that records typically over 150 000 file (25 Gb) downloads per day (CDDIS statistics). The Central Bureau assumes responsibility for day-to-day management of the service, interaction with station operators, and answering to a typical number of 150–200 questions and requests from users per month. All these activities are performed all year and day-by-day, with high redundancy and reliability based on the pooled resources of more than 200 institutions worldwide.

Network Status

The Central Bureau monitors a globally distributed network of 440 select GNSS tracking stations that operate according to the IGS guidelines. In addition to GPS, 196 provide tracking data

from the Russian GLONASS satellites. Approximately 107 IGS stations provide real-time data streams so support the IGS Real Time Pilot Project activities.

Three new stations have been added to the IGS network in 2012, all providing real-time and multi-GNSS observation data:

- BRUX Brussels, Belgium
- KAT1 Katherine, North Territory, Australia
- MGUE Malargue, Argentina

Integration into IGS of the 18 NGA monitoring stations that was initiated last year is still being worked on. Two issues must still be addressed before these stations are useful to the IGS Analysis Centers, requiring this activity to be continued in 2013:

1. Antennas must be calibrated by an IGS certified calibration lab.
2. A firmware induced quarter cycle phase ambiguity must be removed from the previous data sets and fixed in the receiver firmware going forward.

Due to number of reference frame stations retiring from service and position discontinuities, IGb08 was adopted on GPS week 1709 (07 Oct 2012). IGb08 includes 33 stations affected by position discontinuities from IGS08 and 3 new stations co-located with decommissioned IGS08 stations. This update increases the number of usable reference frame stations by about 36 and the number of usable core stations by about 15.

Analysis and Core Product Generation

The IGS core products have continued to be routinely combined and delivered to users in a timely manner through 2012. To ensure continued production of high-quality IGS products, the Analysis Center Coordinator (ACC) performed high-level oversight and quality control of Analysis Center (AC) products, combination performance, and maintenance of the ACC website with updated plots. Also performed was coordination among ACs to assimilate changes made by them and to ensure that the best analysis models and procedures are used, along with coordination among the other relevant IGS components, preparation of component reports, and coordination of the IGS 2nd reprocessing campaign.

Despite a few minor delivery delays caused by power or network outages of the combination server, all of the IGS core products met availability targets (Table 1). The addition of new ACs to the IGS Ultra-rapid and Rapid products has improved product reliability. However, the overall high quality of those two products was unchanged from 2011. Product quality was effected by a number of factors, including 1) introduction of Ultra-rapid products by two

3.4.1 International GNSS Service (IGS)

Table 1: IGS core products and availability targets. Availability is defined as the percentage of time that accuracy, latency and continuity of service meet target specification.

		Sample Interval	Accuracy	Latency	Continuity	Target Availability
GPS Satellite Ephemerides / Satellite and Station Clocks						
Broadcast (for comparison)	Orbits	1s	~100 cm	real time	Continuous	99.99%
	Sat. Clocks		~5 ns RMS; ~2.5 ns Sdev			
Ultra-Rapid (predicted half)	Orbits	15 min	~5 cm	predicted	4x daily, at 03, 09, 15, 21 UTC	95%
	Sat. Clocks		~3 ns RMS; ~1.5 Sdev			
Ultra-Rapid (observed half)	Orbits	15 min	~3 cm	3-9 hours	4x daily, at 03, 09, 15, 21 UTC	95%
	Sat. Clocks		~150 ps RMS; ~50 ps Sdev			
Rapid	Orbits	15 min	~2.5 cm	17-41 hours	daily, at 17 UTC	95%
	Sat. & Stn. Clocks	5 min	~75 ps RMS; ~25 ps Sdev			
Final	Orbits	15 min	~2 cm	12-18 days	weekly, every Thursday	99%
	Sat. & Stn. Clocks	Sat: 30 s; Stn.: 5 min	75 ps RMS; 20 ps Sdev			
Real-time	Orbits	5-60 s	~5 cm	25 seconds	Continuous	95%
	Sat. Clocks	5 s	300 ps RMS; 120 ps Sdev			
GLONASS Satellite Ephemerides						
Final		15 min	~3 cm	12-18 days	weekly, every Thursday	99%
Geocentric Coordinates of IGS Tracking Stations (over 250 Sites)						
Positions of Real-time Stations	Horizontal	daily	3 mm	1-2 hours	daily	99%
	Vertical		6 mm			
Final Positions	Horizontal	weekly	3 mm	11-17 days	weekly, every Wednesday	99%
	Vertical		6 mm			
Final Velocities	Horizontal	weekly	2 mm/yr	11-17 days	weekly, every Wednesday	99%
	Vertical		3 mm/yr			
Earth Rotation Parameters						
Ultra-Rapid (predicted half)	Polar Motion	daily integrations at 00, 06 12, 18 UTC	~200 µas	real time	4x daily, at 03, 09, 15, 21 UTC	99%
	Polar Motion Rate		~300 µas/day			
	Length-of-day		~50 µs			
Ultra-Rapid (observed half)	Polar Motion	daily integrations at 00, 06, 12, 18 UTC	~50 µas	3-9 hours	4x daily, at 03, 09, 15, 21 UTC	99%
	Polar Motion Rate		~250 µas/day			
	Length-of-day		~10 µs			
Rapid	Polar Motion	daily integrations at 12 UTC	~40 µas	17-41 hours	daily at 17 UTC	99%
	Polar Motion Rate		~200 µas/day			
	Length-of-day		~10 µs			
Final	Polar Motion	daily integrations at 12 UTC	0.03 mas	~11-17 days	weekly, every Wednesday	99%
	Polar Motion Rate		~150 µas/day			
	Length-of-day		0.01 ms			
Atmospheric Parameters						
IGS Final Tropospheric Delay: *zenith path delay (ZPD) plus north, east gradients*		5 min	~4 mm for ZPD	~ 3 weeks	daily	99%
Ionosphere TEC Grid		2 hours; 5 deg (Lon.) x 2.5 deg (Lat.)	2-8 TECU	~11 days	weekly	99%
Rapid ionosphere TEC Grid		2 hours; 5 deg (Lon.) x 2.5 deg (Lat.)	2-9 TECU	<24 hours	daily	95%

Analysis Centers, 2) a switch to daily SINEX combinations, 3) Adoption of IGb08, and 4) Studies of the Rotational Offset between IGU and IGR and of the Final Orbit Misalignment. Details regarding the effects of these factors on the IGS products are described within the Analysis Coordinator Section of the IGS Technical Report.

Second Reprocessing Campaign (IG2)

Preparations for the second reprocessing campaign (IG2) are underway. The past year was spent establishing a set of minimum analysis standards (see items delineated in black on the IG2 web page at <http://acc.igs.org/ reprocess2.html>), which was finalized at the 2012 Workshop. Since then, the ACs have worked to implement nearly all of these minimum standards. A few Analysis Centers still need to adopt models for 2nd-order ionosphere effects, Earth radiation (visible and infrared) and satellite thrusting due to signal transmission along the antenna bore site. In addition to the minimum analysis standards, other models are proposed and can be adopted as each AC chooses. These are shown in red at the IG2 website.

Multi-GNSS Experiment

The Multi-GNSS Experiment (MGEX), considered a key project that will enhance IGS capabilities to support the emerging satellite navigation systems, has proceeded with high priority since its launch in February 2012. The focus of this cornerstone experiment is the data flow, the understanding of observables, the characterization of the tracking equipment, and the generation of products. The very successful Workshop on GNSS Biases held in Bern from January 18–19 addressed very significant issues related to the implementation of multi-GNSS within IGS. The launch of a Multi-GNSS Pilot Project is targeted in 2015.

Real-time Service

The real-time Working Group is proceeding toward launch of an Initial Operating Capability (IOC) Real-Time Service (RTS) in the first half 2013. The initial service will provide real-time GPS orbit and clock corrections, as well as experimental GLONASS corrections. Other satellite systems will be included within the service as they become available. The service is focused on supporting geophysical applications, e.g., natural hazards monitoring in the framework of GGOS, but it will support a large variety of applications in positioning, navigation, time transfer, system monitoring and others. More information and an updated status of the service can be found on the RTS website at <rts.igs.org>.

Formats and Standards

The joint IGS/RTCM RINEX Working Group is preparing a plan for the transition from RINEX 2.11 to RINEX 3.0x over the next few years. While tracking data from GNSS-capable equipment shall

be solely available in RINEX 3 after a target date to be specified, tracking data from legacy receivers will continue to be available in RINEX 2 for the foreseeable future. The IGS GB affirmed the transition to RINEX 3 and the further elaboration of the transition plan.

The Infrastructure Committee has completed a thorough review and revision of the IGS Site Guidelines. The guidelines were publicly reviewed and were approved at the July Governing Board meeting subject to final comments being integrated. In particular, a real-time section is to be added prior to the Guidelines being fully adopted.

Governance

The IGS Governing Board met a total of four times in 2012: April 25 business meeting during the EGU General Assembly in Vienna; July 22 regular meeting and July 22 post workshop meetings associated with the IGS Workshop in Poland; and December 2 regular end-of-year meeting prior to the AGU Fall Meeting in San Francisco. The IGS Executive Committee – consisting of Urs Hugentobler, Chuck Meertens, Ruth Neilan, Chris Rizos, Tim Springer and with regular participation of John Dow and Steve Fisher and of WG Chairs as required – has met ten times in 2012 by teleconference.

None of the current Governing Board member's terms expired in 2012, thus no election took place. The GB membership of Steve Fisher as IGS CB Secretariat was approved by the Board. Given the successful review of the work of the IGS Working Groups and Pilot Projects documented with the very successful IGS Workshop in Olsztyn, the GB extended the terms of those WG and PP Chairs whose terms terminated end of 2012 by another two years. The current Governing Board Members are listed in the organization section of the IGS website.

Strategic Planning

The new IGS Strategic Plan 2013–2016 was developed in 2012 by the IGS CB and EC as an updated version of the current Strategic Plan 2008–2012, defining IGS goals and objectives and including elements that allow for a better monitoring and reporting of progress. At the same time the CB prepared a Progress Report for the period 2008–2012 that records and quantifies, based on the annual implementation plans, the progress made by the IGS in the different fields addressed by the Strategic Plan. The final version of the two documents are available for download from the publications section of the IGS website.

IGS Workshop

The 2012 biennial IGS Workshop was hosted by the University of Warmia and Mazury in Olsztyn, Poland, and was attended by about 230 participants. The scientific program included sessions where a wide range of activities associated with the IGS were

presented and discussed. Session topics included the status and achievements of the IGS Multi-GNSS Experiment; the IGS network infrastructure and real-time activities; modeling of observations and station motions; modeling of atmosphere delays and applications; space vehicle dynamics and attitude; clock modeling and time scale realization; antenna calibration; geodetic applications of IGS products; the relevance of the IGS for the geodetic and wider community. Jointly with the IGS Workshop a meeting of the "Compatibility and Interoperability Working Group" of the United Nations International Committee on GNSS (ICG) took place, which provided an opportunity for interaction and exchange between IGS and representatives from the different GNSS operators (GPS, GLONASS, Galileo and Biedou). A short workshop summary may be found in IGSMAIL #6635. The workshop presentations, posters and recommendations can be found on the IGS website at <http://www. igs.org/presents/poland2012/>.

Outreach

The IGS is well represented on the GGOS Coordinating Board. It plays a leadership role in the International Committee on GNSS (ICG), in particular by co-chairing Working Group D on Reference Frames, Timing and Applications, and by participating in the planning for the international GNSS Monitoring and Assessment System (iGMAS). The IGS is also well represented in the International Earth Rotation and Reference Systems Service (IERS) and in IAG Sub-Commission 1.2 on Global Reference Frames, in the RTCM SC104, and others.

IGS has been involved with many outreach activities in 2012. The following list provides a selection of presentations at international meetings and articles in geospatial magazines. In addition the IGS CB together with the RT WG prepared a statement citing the reasons for the IGS involvement in real–time activities. The IGS was also given visibility as session organizers of, or presenters in, IGS–related sessions at conferences such as those of the EGU in Vienna and AGU in San Francisco. Additional IGS related publications, citations and presentations are listed within the IGS bibliography in the publications section of the IGS website.

Presentations at International Meetings

- PPP-RTK Symposium, March 12–13, Frankfurt/Main, U. Hugentobler: "From GPS to GNSS – Challenges and Prospects".
- FIG Working Week, May 6–10, Rome, R. Neilan: "The IGS in Support of Science and Society – new Roles, New Challenges, New Products".
- 3rd China Satellite Navigation Conference, May 15–19, Guangzhou, C. Rizos: "The IGS in the Multi-GNSS Era: New Roles, New Products, New Challenges".

- Asia Oceania Geoscience Society, August 13–17, C. Rizos and R. Neilan: “New Roles, New Challenges and New Products for the International GNSS Service (IGS)”.
- 3rd Colloquium Galileo Science, August 31–September 2, Copenhagen, R. Weber: “The IGS Multi-GNSS Global Experiment”.
- INTERGEO, October 9–11, Hannover, C. Rizos: “The International GNSS Service (IGS): Supporting the Geospatial Industry”.
- ICG-7, November 5–9, Beijing, C. Rizos: “The IGS: A Multi-GNSS Service”.

Articles

- Caissy, M., L. Agrotis, G. Weber, M. Hernandez-Pajares, U. Hugentobler: “Coming Soon: The IGS Real-Time Service”, GPS World, June 2012.
- Rebischung, P., J. Griffiths, J. Ray, R. Schmid, X. Collilieux, B. Garayt: “IGS08: the IGS realization of ITRF2008”, GPS Solutions, 16(4):483–494.
- Rizos, C.: “GNSS Service Analysis Workshop Held in Poland”, GIM International Magazine, November 2012.
- Weber, R., U. Hugentobler, R. Neilan: “IGS M-GEX – The IGS Multi-GNSS Global Experiment”, Proceedings of the 3rd International Colloquium on Scientific and Fundamental Aspects of the Galileo Program.
- J. Griffiths, J. and J. Ray: Sub-daily Alias and Draconitic Errors in IGS Orbits, GPS Solutions, doi: 10.1007/s10291-012-0289-1, (2012).

Position Statement

- “Why Is IGS Involved in Real-Time GNSS?” <ftp://igs.org/pub/resource/pubs/ IGS_why_in_RT.pdf>

Steven Fisher