



The International GNSS Service (IGS):  
"Perspectives and Visions for 2010 and Beyond"

IGS Workshop 2006



*International GNSS Service  
Formerly the International  
GPS Service*

*Association Internationale de  
Géodésie  
Union Géodésique et  
Géophysique Internationale*



*International Association of  
Geodesy  
International Union of  
Geodesy and Geophysics*



*Federation of  
Astronomical and  
Geophysical  
Data Analysis Services*

Proceedings

Darmstadt, Germany

8-12 May 2006

Edited by  
T. Springer  
G. Gendt  
J. M. Dow



## Preface

The title chosen by the Scientific Organising Committee for the 2006 IGS Workshop was:

### **“The International GNSS Service (IGS): Perspectives and Visions for 2010 and beyond”**

This reflects the main objective of the workshop, which was to contribute to charting the course of the IGS for the next years, and in particular: to prepare for the role of the IGS in the Global Geodetic Observing System (GGOS); to gather inputs for an update of the IGS Strategic Plan; to ensure that the real-time project is on the right track; and to consolidate the IGS approach to the new GNSS developments which are taking place (Galileo, GPS modernisation, Glonass revitalisation, various regional augmentation systems).

Some recent developments in the context in which we work and in the IGS itself underlined the need for such discussions. These are reflected for example in

- The adoption of new Terms of Reference of the IGS in March 2005 (involving a change of name, changes to the Board and its way of working and updated policies for the modes of operation of a number of the key IGS elements).
- The formal launch of the GGOS by the International Association of Geodesy in August 2005.
- A number of interactions and interfaces between the IGS and the Galileo project.
- Membership of IGS and IAG in the International Committee on GNSS (ICG), newly established under the auspices of the UN Office for Outer Space Affairs in December 2005.
- Expanding links with countries and regions previously less involved in the activities of the IGS (AFREF project, Korea, China).

Some 140 experts from about 26 countries participated in the workshop. The topics selected for the workshop sessions and documented in these Proceedings provide an excellent overview of a wide range of matters of concern to the IGS. I would like to thank the Scientific Organising Committee (G. Gendt - Chair, G. Blewitt, M. Caissy, T. Herring, M. Rothacher, T. Springer, R. Weber), as well as my colleagues in the Local Organising Committee (A. Kerruish, T. Springer, R. Zandbergen) and the ESA Conference Bureau (CONGREX) for contributing to what turned out to be a very productive and enjoyable week in May 2006 in Darmstadt.

John M. Dow

Chair of the IGS Governing Board and of the Workshop Local Organising Committee

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*Chairs: U. Hugentobler;H. van der Marel & T. Springer*

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*Chairs: M. Hernandez; Y. Bar-Sever & K. Senior*

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*Chairs: M. Hernandez; Y. Bar-Sever & K. Senior*

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R. Neilan and H.-P. Plag**
- 10:00 H.P. Plag GEO, GEOSS and IGOS-P: The framework of global Earth observations  
10:20 M. Rothacher GGOS: the IAG contribution to Earth observation  
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11:50 Discussion
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P. Steigenberger, I. Romero, P. Fang**
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14:30 J. Ray IERS Conventions and the IGS Reprocessing Campaign  
14:45 M. Fritsche Reprocessing of a global GPS network - Experiences and results from a  
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15:00 M. Ge Fast integrated estimation of huge GNSS global networks  
15:45 R. Orus Current status and expected improvements of ionospheric reprocessing  
16:00 I. Romero Review of the processing strategies of the ACs, stations and open  
discussion points  
16:15 Discussion
- 16:45 Other IGS product related topics: troposphere and multipath (OTHE1)  
M. Hernandez, Y. Bar-Sever, K. Senior**
- 16:45 S. Byun IGS Tropospheric Delay Combination Activities at JPL  
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- 09:00 J. M. Dow et al Position Paper: Preparing the strategic Plan 2008-2012  
09:20 G. Blewitt Rapid Determination of Earthquake Magnitude for Tsunami Warning  
Systems using GPS: An Opportunity for IGS to Make a Difference.  
09:40 J. Wang A global, 2-hourly atmospheric precipitable water dataset from IGS  
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14:15	S. Owen	Web-Based Services: Combined and Validated GPS Data Products and Data Browsing tools
14:30	R. Twilley	IGS Network Issues - Update since Berne Workshop 2004
14:45	R. Wonnacott	The AFREF Project
15:00	W. Gan	Crustal Movement Observation Network of China and its Phase II Project
15:15	C. Garcia	ESA/ESOC IGS network operations. Present and Future
15:30	G. Sella	NOAA-NGS CORS Network Guidelines for New and Existing Sites and its relation to IGS
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17:10	G. Weber	Streaming Real-Time IGS Products and Data Using NTRIP
17:30	Discussion	

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09:00	R. Zandbergen	GRAS GSN near-realtime data processing
09:15	C. Rocken	Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) - Mission status and real-time data processing
09:35	M. Opitz	Real Time Monitoring of IGS Products within the RTIGS Network
09:55	J. Perez	ESA/ESOC real time data processing
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11:00	Poster Viewing	
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12:00	L. Hothem	GPS Modernization Program - Current Status and Plans
12:15	C. Rizos	New GNSS Developments and the Impact on Providers and Users of Spatial Data Infrastructure
12:30	D. Navarro-Reyes	Galileo Status: GIOVE and ongoing Preparations for Experimentation
12:45	M.M. Romay-Merino	Galileo operational algorithms development: integrity, orbit determination and time synchronisation
<b>14:00</b>		<b>GGNSS Modernization and GNSS/LEO Synergies (GNSS/LEO Part 2)</b> <b>R. Weber and H. Boomkamp</b>
14:00	B. Schutz	LEO POD Requirements: Now and the Future
14:15	D. Svehla	Impact of a LEO Formation and a LEO/GPS Dual Constellation on the IGS Products

14:30 W. Soehne GGSP: Geodetic Contribution to the Galileo System  
14:45 S. Schaer GNSS analysis at CODE  
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**16:00 Switch to the absolute antenna phase center model (ABSA)**

**R. Schmid and G. Gendt**

16:00 G. Wübbena Absolute GNSS Antenna Calibration with a Robot: Repeatability of Phase Variations, Calibration of GLONASS and Determination of Carrier-to-Noise Pattern  
16:15 R. Schmid Generation of igs05.atx - status quo  
16:30 G. Gendt Validation of new IGS products generated with absolute antenna models  
16:45 R. Ferland From Relative to Absolute Antenna Phase Center Calibration: The effect on the SINEX products  
17:00 Y. Bar-Sever Space-based calibration of GPS antenna phase center offsets and its impact on precise geophysical applications  
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**09:00 Identification and Mitigation of GNSS Errors (ERRO)**

**U. Hugentobler, H. van der Marel, T. Springer**

09:00 U. Hugentobler Position Paper: Identification and mitigation of GNSS errors  
09:15 G. Gendt Quality and consistency of the IGS combined products  
09:30 V. Slabinksi IGS Rapid Orbits: Systematic Error at Day Boundaries  
09:45 C. Urschl Validation of GNSS orbits using SLR observations  
10:00 J.M. Sleewaegen Performance and Interoperability of GPS/Galileo Receivers and Observables  
10:15 J. Ray Systematic errors in GPS position estimates  
11:00 K. Larson Reducing the effects of multipath in high-rate GPS analysis: evaluation and implementation of modified sidereal filtering  
11:15 J. Boehm Mapping functions for atmospheric delay modelling in GNSS analysis  
11:30 Discussion

**13:00 Other IGS product related topics: ionosphere (OTHE2)**

**M. Hernandez, Y. Bar-Sever, K. Senior**

13:00 A. Komjathy Daily JPL Processing of 1200+ Ground-Based GPS Receivers to Estimate Interfrequency Biases and Other Practical Applications  
13:15 J. Feltens Realized and planned improvements in ESA/ESOC ionosphere modelling  
13:30 R. Orus Improving Ionospheric determinations at UPC: Kriging and Wide Area RTK techniques  
13:45 M. Hernandez-Pajares Summary and current status of IGS Ionosphere WG activities  
14:00 Discussion

**14:15 Other IGS product related topics: time transfer (OTHE3)**

**M. Hernandez, Y. Bar-Sever, K. Senior**

14:15 Ch. Salomon ACES Mission - an overview  
15:00 O. Montenbruck Dual-frequency GNSS receivers for Space Applications

**15:45 Summary Session**

**(Recommendations and Actions, Presented by Session Organisers)**

**17:00 End of Workshop**

## List of Participants

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## Summary of Recommendations

### "The International GNSS Service (IGS): Perspectives and Visions for 2010 and beyond"

#### Session : Reprocessing Issues, Standardization, New models (REPR)

- REPR1:** Station selection will be a list of recommendations after analysing “missing stations”
- REPR2:** NGA stations: Ask for full data set (past and current), otherwise no commitment. ACs should include them on a best effort basis.
- REPR3:** Processing summary: ACs need to provide information on their processing in the new summary before the reprocessing kick-off.
- REPR4:** Recommendations for common standards documented in the position paper.
- REPR5:** Troposphere: GMF recommended; troposphere combination still open
- REPR6:** P1-C1 DCBs to be used back to 1994 except for periods with AS off. As monthly averages or constant?
- REPR7:** Clock Files: Nominal 300 sec, 30 sec on a best effort basis (coordinated with LEO).
- REPR8:** For the current reprocessing effort weekly SINEX files shall be provided.
- REPR9:** Discontinuities: Should be indicated in SINEX files with validity intervals. Has to be clarified with combination centres.
- REPR10:** Reprocessed orbits should be validated with SLR.

#### Session: Ionosphere Products

- IONO1:** For analysis centers: To test the reprocessing performance and required resources in the IGS pilot reprocessing campaign (January-March 2000).
- IONO2:** For analysis centers: To consider the temporal resolution increasing of the maps to 15 min (during pilot reprocessing campaign?).
- IONO3:** For analysis centers: To consider the possibility of estimating maps of ionospheric effective heights (during pilot reprocessing campaign?)
- IONO4:** For users, second order ionospheric correction: Importance of using a more realistic geomagnetic model, such as the International Geomagnetic Reference Model (IGRM, Geopack subroutines, Tsyganenko, 2001), with a reduction of up to ~60% of correction error in certain regions

**Session: Preparing the Strategic Plan 2008-2012: Solicitation of Ideas on the Future Needs of Scientific and other Users (VISI)**

- VISI1:** The need for an IGS Strategic Planning (SP) retreat this year is confirmed.
- VISI2:** IGS infrastructure is to be considered in the SP (HW, SW, monumentation) – a WG is needed.
- VISI3:** IGS must identify and clarify the needs of its stakeholders (users, IGS centres, supporting organisations, IAG,...)
- VISI4:** There is a need to establish and maintain a list of users (and their applications). Registration for product access may be considered (again).
- VISI5:** An IGS WG should take care of interfaces with receiver manufacturers . In particular inputs concerning next generation receiver requirements should be gathered by the WG
- VISI6:** GGOS becomes a central objective, with IGS playing a leading role, intensifying interactions with other IAG services and commissions.
- VISI7:** (Efficient) reprocessing must become a permanent feature of the IGS .
- VISI8:** IGS has to play a more prominent role in the international context. More publications.

**Session: Network and Data Centre issues (NWDC)**

- NWDC1:** All IGS data flow is performed using “push” only and verified uncorrupted.
- NWDC2:** Stations/OCs, ODCs, and RDCs will define primary and secondary data centers to push their data to; IGS CB will create and maintain supplemental material summarizing this data flow
- NWDC3:** Stations/OCs should document replacement of data files and notify the IGS through automated procedures
- NWDC4:** IGS DCWG :  
a) Perform limited test during 2006  
d) Specify detailed implementation plan

**Session: Real Time Network and Products (REAL)**

- REAL1:** Call for participation in the pilot project shall be completed as soon as possible.
- REAL2:** The RTIGS working group shall complete the planned network in time for the start the pilot project.
- REAL3:** The pilot project shall involve the broadest participation as possible from both with and outside of the IGS community.

- REAL4:** RTCM 3.0 shall be investigated for the purpose of determining whether or not it is suitable format for adoption as the standard for use within the real-time IGS.
- REAL5:** During the pilot project, NTRIP shall be evaluated as a data and product delivery mechanism.
- REAL6:** The NTRIP community shall be encouraged to provide the UDP protocol as an option for the NTRIP server.

**Session: GNSS Modernization and GNSS/LEO Synergies (GNSS)**

- GNSS1:** IGS AC's are encouraged to upgrade their current software capabilities to enable processing of hybrid GNSS data in order to base their submissions to all IGS product lines (orbits, clocks and atmosphere monitoring) on a complete set of GPS+GLONASS data.
- GNSS2:** IGS AC's (in dialog with manufacturers) are asked to perform simulation studies to identify an adequate/preferred ensemble of GNSS signals (based on currently available and upcoming GNSS signals) to be delivered by new GNSS receiver types which allows to improve (at least ensures to keep) the current quality of IGS GNSS products.
- GNSS3:** IGS AC's are encouraged to further integrate their LEO processing facilities with their IGS routine analysis facilities, in order to improve the understanding of current results for CHAMP and GRACE, and to enable LEO data analysis in parallel to the IGS re-processing effort.

**Session: Switch to the absolute antenna phase center model (ABSA)**

- ABSA1:** Transition to absolute PCVs (igs05\_www.atx) is planned in parallel with the switch to the new ITRF2005 (~Sept 2006).
- ABSA2:** Existing calibrations in the ANTEX file (igs05\_www.atx) will not be changed after the transition. Until that converted field calibrations can only be replaced by robot calibrations if not affecting the RF stations.
- ABSA3:** Add the storage of GLONASS specific receiver antenna corrections and carrier-to-noise patterns (CN0) to the ANTEX format
- ABSA4:** SINEX files shall include SATA\_Z parameters (constrained).

**Session: Identification and Mitigation of GNSS Errors (ERRO)**

- ERRO1:** IGS should stimulate research leading to a better understanding of the different error sources and technique-related problems, in particular of not well understood effects such as near-field and internal multipath and their mitigation. Possibilities are the organization of dedicated workshops or sessions at assemblies such as AGU or EGU or the preparation of a Journal of Geodesy Special Issue, inviting a wider community for participation.

- ERRO2:** Improve consistency between AC products and of combined IGS products, in particular for precise point positioning. As a first step ACs shall fill an analysis questionnaire that gives a detailed description of the analysis. Consistency with respect to used IERS Conventions has to be verified. All ACs shall implement the recommendation of Bern concerning consistency of orbits and clocks with ITRF.
- ERRO3:** The ACs shall evaluate the effects of Earth albedo and MW power thrust, the GMF/VMF1 mapping function, an improved hydrostatic zenith path delay (i.e., mean sea surface air pressure), higher order ionosphere corrections.
- ERRO4:** The effect of monumentation on near field multipath shall be studied further to identify an optimum monumentation. IGS station operators shall be encouraged to use optimum monument designs.
- ERRO5:** Overlap position differences of consecutive orbits shall be added to the rapid and final combination protocols.
- ERRO6:** The interface to receiver manufacturers has to be intensified to possibly agree on a common minimal tracking mode for IGS like activities. Investigate the possibility to use the GSTB-V2 network for studying the optimum Galileo signal combination.