IGS

CELEBRATING A DECADE OF THE INTERNATIONAL GPS SERVICE

WORKSHOP & SYMPOSIUM 2004

Proceedings

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Contents

All available abstracts, presentation slides, posters, and papers are included on accompanying CD. A full color version of this publication is available on CD or at the IGS homepage (http://igscb.jpl.nasa.gov/).

Agenda xv

List of Participants xxi

Recommendations and Positions xxvii

Summary of IGS 10th Anniversary Symposium and Workshop xxxv

Opening Session

Welcome and Official Opening of the Workshop 3
J. Dow

Welcome from the University of Berne 5
U. Würgler

Welcome from the IAG 7
G. Beutler

Session 1: IGS Reference Frame Maintenance

Session Description 10

Session Summary 11
G. Gendt

IGS Reference Frame Maintenance (Position Paper) 13
R. Ferland, G. Gendt, T. Schöne

Oral Presentations

Environmental Issues and Monumentation ..... *CD*
Y. Bock

Current Challenges of Monitoring Station Height with GPS ..... *CD*
D. Dong, M. Heflin

IERS Rigorous Inter-Technique Combination Implications to IGS ..... *CD*
M. Rothacher, D. Thaller, R. Schmid, P. Steigenberger

Detection and Handling of EPN Station Irregularities ..... *CD*
C. Bruyninx, G. Carpentier, F. Roosbeek, A. Kenyeres

Poster Presentations

Contribution to EUREF of the ASI (Agenzia Spaziale Italiana) Matera Space Geodesy Centre "G.Colombo" (CGS) ..... *CD*
C. Ferraro, A. Nardi, G. Bianco, F. Vespe

Discontinuities in the IGS Tracking Stations Coordinate Time Series ..... *CD*
P. J. Mendes Cerveira, R. Weber

GPS Time Series and Sea Level ..... *CD*
M. Poutanen, H. Koivula, M. Tervo, K. Kahma, M. Ollikainen, H. Virtanen

Hafelekar GPS Permanent Station Seasonal Monitoring ..... *CD*
G. Stangl, C. Haslinger, E. Cristea

IGS Tide Gauge Benchmark Monitoring Pilot Project ..... *CD*
T. Schöne

Processing, Combination and Time Series Analysis of Continuous GPS Data: A Test Study ..... *CD*
M. E. Ayhan, C. Demir, A. Kilicoglu, A. Cingoz, B. Aktug, A. Kurt, H. Yildiz

Session 2: Other Reference Frame Issues

Session Description 36

IGS Reference Frames: Status and Future Improvements (Position Paper) 37
J. Ray, D. Dong, Z. Altamimi

Oral Presentations

Observations of Large-scale Frame Deformations and Related Effects ..... *CD*
T. Herring

Relationships Between Mass Redistribution, Station Position, Geocenter, and Earth Rotation: Results from IGS GNAAC Analysis ..... *CD*
G. Blewitt

Tests of IGS Reference Frame Stability ..... *CD*
Z. Altamimi, J. Ray

The Effect of the Second Order GPS Ionospheric Correction on Receiver Positions ..... *CD*
S. Kedar, G. Hajj, B. Wilson, M. Heflin

Improving IGS Timescale Stability and Tracking of UTC ..... *CD*
K. Senior, J. Ray

Poster Presentations

CERGOP-2/Environment ..... *CD*
P. Pesec

CODE High-rate GPS Satellite Clock Corrections ..... *CD*
H. Bock, R. Dach, U. Hugentobler, S. Schaer, G. Beutler

Continuously Operating GPS Receivers at Thule, Greenland ..... *CD*
S. A. Khan, F. B. Madsen, P. Knudsen

IENG: A New IGS Station in Italy ..... *CD*
V. Pettiti, D. Orgiazzi

Reprocessing of the Global GPS Network: First Results ..... *CD*
M. Rothacher, P. Steigenberger, R. Dietrich, M. Fritsche, A. Rülke

Rigorous Combination of GPS and VLBI to Study Reference Frame Related Issues ..... *CD*
M. Krügel, V. Tesmer, D. Angermann, D. Thaller, M. Rothacher, R. Schmid

Seasonal Height Errors and the TRF ..... *CD*
A. E. Niell

Swedish Activities During 10 Years as a Data Provider and Customer of the IGS: Geophysical and Geodedetic Applications ..... *CD*
J. Johansson, H.-G. Scherneck, M. Lidberg, R. Haas, S. Bergstrand, L. Jivall

The Impact of Auto- and Cross-correlations in Daily Solution Time Series of GPS Permanent Stations ..... *CD*
R. Barzaghi, A. Borghi, M. Crespi, F. Giannone, G. Pietrantonio, F. Riguzzi

Session 3: Real Time Aspects

Session Description 66

Session Summary 67
M. Caissy

Real-Time Data Flow and Product Generation for GNSS (Position Paper) 69
R. Muellerschoen, M. Caissy

Oral Presentations

IGS Real-time Network Prototype ..... *CD*
M. Caissy

Real Time Aspects, the JPL Perspective ..... *CD*
R. Muellerschoen

Global Products for GPS Point Positioning Approaching Real-Time ..... *CD*
Y. Gao, P. Heroux, M. Caissy

The EUREF-IP Ntrip Broadcaster: Real-time GNSS data for Europe ..... *CD*
D. Dettmering, G. Weber

ESA/ESOC Real Time Infrastructure ..... *CD*
C. Garcia, J. Dow, J. Perez, I. Romero

Poster Presentations

A HTTP Based Technique for Streaming GNSS Data over the Internet ..... *CD*
H. Gebhard

GFZ's Development of GPS Real-Time Network ..... *CD*
R. Galas, W. Köhler

Impact of Imperfect Orbit on Ground-based GPS Atmospheric Sounding Applications ..... *CD*
P. Fang, Y. Bock, S. Gutman

Real-Time IGS Protocol, Formats and Software Tools ..... *CD*
K. MacLeod, M. Caissy, R. Fong, B. Twilley, J. P. Bartolome, C. Garcia-Martinez, R. Galas, R. Muellerschoen

Real-Time Wide-Area Differential GPS Corrections from Natural Resources Canada ..... *CD*
P. Collins, F. Lahaye, K. MacLeod, Y. Mireault, P. Héroux

Swedish Activities During 10 Years as a Data Provider and Customer of the IGS: Realtime Applications ..... *CD*
C. Rieck, P. Jarlemark, R. Emardson, J. Johansson, B. Stoew, A. Frisk

Session 4: Network Issues

Session Description 78

Session Summary 79
A. Moore, C. Bruyninx, R. Twilley

Network Issues (Position Paper) 81
A. Moore, C. Bruyninx, R. Twilley

IGS Network Issues 2002-2004, Update Since Ottawa Workshop 89
M. Schmidt, A. Moore

Oral Presentations

Status of AFREF Project ..... *CD*
Z. Altamimi

North Eurasian GPS Deformation Array, History and Current State ..... *CD*
G. Steblov

Working with the IGS Network: The ESA/ESOC Experience ..... *CD*
I. Romero, C. Garcia, J. Dow

South Pacific Regional GPS Network ..... *CD*
B. Twilley

Poster Presentations

Activities of the Astrogeodetic Observatory in Jozefoslaw in the Last Decade ..... *CD*
J. B. Rogowski, J. Bogusz, M. Figurski, M. Kłęk, M. Kruczyk, L. Kujawa, W. Kurka, T. Liwosz

EPN Network Coordination ..... *CD*
C. Bruyninx, G. Carpentier, F. Roosbeek

EUPOS - a new European Initiative of Establishment of the Multifunctional Reference Station System in Central and Eastern European Countries ..... *CD*
J. Sledzinski

Korean GPS Network (KGN) Activities ..... *CD*
P.-H. Park, K.-D. Park, J.-U. Park

On the use of Non-Permanent GPS Stations for Geokinematics ..... *CD*
J. Krynski, Y. M. Zanimonskiy

South Pacific Regional GPS Network ..... *CD*
B. Twilley, J. Manning, R. Govind

Sub-Daily Site Coordinates Variations in EUREF Permanent Network ..... *CD*
J. Hefty, M. Kovac, M. Igondova, M. Hrcka

UNAVCO Support to the GPS Global Network (GGN) and the International GPS Service ..... *CD*
O. Ruud, D. Stowers, S. Fisher, C. Meertens, V. Andreatta

Session 5: Data Transfer and Data Centers

Session Description 106

Session Summary 107
C. Noll, C. Meertens

Enhancing the IGS Data and Products Infrastructure – A Data Center Perspective (Position Paper) 109
M. Scharber, C. Noll

Oral Presentations

Addition of Real-Time Capability to the Japanese Dense GPS Network ..... *CD*
Y. Hatanaka, A. Yamagiwa, M. Iwata, S. Otaki

The Role of IGS Data Centers and Real-Time Data ..... *CD*
R. Muellerschoen, M. Caissy

New and Adapted Technologies for the Plate Boundary Observatory ..... *CD*
G. Anderson, K. Bohnenstiehl, D. Mencin, M. Jackson

New Server Concept at the BKG Data Centre ..... *CD*
H. Habrich

SOPAC IT Developments ..... *CD*
Y. Bock, P. Fang, B. Gilmore, P. Jamason, D. Malveaux, R. Nikolaidis, L. Prawirodirdjo, M. Scharber

Poster Presentations

Availability and Completeness of IGS/IGLOS Tracking Data ..... *CD*
S. Schaer, M. Meindl

ESA / ESOC IGS Activities ..... *CD*
J. Dow, C. Garcia, I. Romero, J. Feltens, R. Gautschi, J. Perez, E. Rojo, H. Boomkamp

Proposing to Host the Fourth Global Data Center at Korea Astronomy Observatory ..... *CD*
P.-H. Park, K.-D. Park, J.-U. Park, H.-C. Lim, J.-H. Joh

The CERGOP2 Database - Information for Geodynamic in Central Europe ..... *CD*
G. Stangl, P. Pesec, E. Cristea

The IGS Global Data Center at the CDDIS – An Update ..... *CD*
C. Noll, M. Dube

Session 6: Integrity Monitoring of IGS Products

Session Description 122

Session Summary 123
J. Zumberge

Integrity Monitoring of IGS Products (Position Paper) 125
J. F. Zumberge, H.-P. Plag

Oral Presentations

GNSS Integrity Concept ..... *CD*
B. Lobert

Products Produced Under the Direction of the AC Coordinator: Processes, Accuracies and Quality Control ..... *CD*
G. Gendt

The Use and Integrity Monitoring of IGS Products at Geoscience Australia ..... *CD*
R. Govind, J. Dawson, J. Manning

Poster Presentations

Modelling of GPS Satellite Clocks and Comparisons of IGU Clock Products ..... *CD*
V. Bröderbauer, R. Weber

Routine GPS Data Quality Check at GFZ Potsdam ..... *CD*
M. Ramatschi, R. Galas

Zero Difference Residuals for Multipath Maps and ZTD Quality Indication ..... *CD*
B. Gundlich, H. van der Marel

IGS 10th Anniversary Symposium

International GPS Service and International Association of Geodesy

The Accomplishments of the IGS and their Implications on the Future of Geodesy 135
G. Beutler

The IGS Strategic Plan and Future 149
J. Dow

Role of IGS - National Mapping Agency Perspective ..... *CD*
B. Engen, N. Beck

Scientific Research and Applications

Earth Science Research and Applications: Geodetic Infrastructure as Enabling Technology
A. Donnellan

Forecast Systems Laboratory: Transferring Science and Technology to Operational Weather Services ..... *CD*
B. Serafin

Gravity and Satellite Missions ..... *CD*
C. Reigber

Monitoring Crustal Deformations in an Island Arc ..... *CD*
K. Heki

GNSS Systems

GPS Policy, Management & Modernization ..... *CD*
D. Turner

Galileo and the European Developments ..... *CD*
J. Tjaden

The Galileo Programme Status ..... *CD*
S. Houg

Developments of the Glonass System and Glonass Service ..... *CD*
S. G. Revnivykh

International Cooperation, Education and Outreach

US – EU Cooperation ..... *CD*
K. Hodgkins

GNSS- The International Future: Building Upon the Synergy Between the Work of COPUOS and Capacity-building Activities of the UN Programme on Space Applications ..... *CD*
K. Hodgkins

Industry Perspectives on IGS Collaboration, Impact and Influence – Past, Present and Future 155
G. T. Johnston

The IGS and the Education of the Next Generation of Users 163
C. Rizos

Kinematics of Deformation in the Tibetan Plateau and its Margins Constrained by GPS Measurements 169
P.-Z. Zhang, Z. Niu

Improving the GPS L1 Signal ..... *CD*
T. Stansell

Panel – Visions for the Future

Summary of the IGS Symposium and Panel Discussion – "Visions for the Future" 177
R. Neilan

Session 7: Global Navigation Satellite Systems I

Session Description 184

Session Summary 185
J. Dow, R. Weber

Oral Presentations

GNSS Modernization ..... *CD*
D. Turner

Timing Applications for GNSS – IGS Partnership with the BIPM ..... *CD*
E. Felicitas Arias, G. Petit

Risk Mitigation in the Ground Mission Segment Using the Galileo System Test Bed ..... *CD*
M. Falcone, M. Lugert

GSTB-V1: The First Step Towards the Development of Galileo Navigation Algorithms ..... *CD*
Á. M. García, M. Romay Merino, C. H. Medel, A. Cezón Moro

The IGS GNSS Working Group – Charter and Plans ..... *CD*
R. Weber

Poster Presentations

A Software Tool to Evaluate Navigation Performances at Application Level ..... *CD*
A. Gavin

Session 8: Global Navigation Satellite Systems II

Session Description..... 188

Session Summary..... 189
J. Slater

Oral Presentations

The ITRF/Galileo Interface..... *CD*
C. Boucher

Time and Frequency Transfer Using GNSS ..... *CD*
P. Defraigne, C. Bruyninx, A. Moudrak, F. Roosbeek

GPS/GLONASS Antennas and Ground Planes: Size and Weight Reduction Perspectives..... *CD*
D. Tatarnikov, V. Filippov, I. Soutiaguine, A. Astahov, A. Stepanenko

The IGLOS Pilot Project – Transitioning an Experiment into an Operational Service ..... *CD*
J. Slater, R. Weber, E. Fragner

GNSS Analysis at CODE..... *CD*
S. Schaer, U. Hugentobler, R. Dach, M. Meindl, H. Bock, C. Urschl, G. Beutler

Poster Presentations

C/A Code Biases in High-end Receivers ..... *CD*
A. Simsky, J.-M. Sleewaegen

GLONASS Data Analysis for IGS..... *CD*
H. Habrich, P. Neumaier, K. Fischer

Impact of Galileo on Geodetic Positioning Applications ..... *CD*
H. van der Marel, S. Verhagen, P. Joosten

Session 9: Precise Orbit Determination

Session Description..... 192

Session Summary..... 193
H. Boomkamp

Bigger, Better, Faster POD (Position Paper) 195
H. Boomkamp, R. König

Oral Presentations

High-performance Algorithms for Double Difference Data Processing..... *CD*
H. Boomkamp, J. Dow

Combined Solutions GPS+LEO ..... *CD*
R. König, C. Reigber, S. Zhu

Aspects of Large Station Networks for GPS Orbits and Clocks ..... *CD*
T. Herring

Routine Processing of Combined Solutions for GPS and GLONASS at CODE ..... *CD*
U. Hugentobler, S. Schaer, R. Dach, M. Meindl, C. Urschl

Ultra-rapids and Ultra-rapids Predictions for GPS..... *CD*
J. Douša, L. Mervart

Poster Presentations

GPS LEO POD Activity at CGS (Space Geodesy Centre "G. Colombo") ..... *CD*
A. Nardi, G. Bianco

Activities at the CODE Analysis Center ..... *CD*
S. Schaer, U. Hugentobler, R. Dach, M. Meindl, H. Bock, C. Urschl, A. Jaeggi,
P. Fridez, G. Beutler

A High Precision Analytical Surface Force Model For GPS Block IIR Satellites..... *CD*
M. Ziebart, S. Adhya, A. Sibthorpe, S. Edwards, P. Cross

High and Low POD Using GPS at CNES/GRGS ..... *CD*
S. Loyer, F. Perosanz, S. Bruinsma, F. Mercier

Orbit Determination of Low Earth Satellites at AIUB ..... *CD*
A. Jäggi, H. Bock, U. Hugentobler, G. Beutler

NRCan Analysis Centre Contributions to the IGS: 1994 – 2004 ..... *CD*
B. Donahue, Y. Mireault, C. Huot, P. Tétreault, J. Kouba

Kinematic Orbits for LEO Satellites - a New Product ..... *CD*
D. Svehla, M. Rothacher

USNO Analysis Strategy Summary ..... *CD*
V. J. Slabinski, J. R. Rohde, M. S. Carter, A. E. Myers, D. Pascu, W. H. Wooden

Large Scale GPS Processing at ESOC for LEO, GNSS and Real-Time Applications..... *CD*
H. Boomkamp, J. Dow

IGS LEO Pilot Project..... *CD*
H. Boomkamp

Kinematic LEO POD with Space- and Ground-Based Transceiver Constellation Tightly
Coupled with GPS: Simulation Study ..... *CD*
D. Grejner-Brzezinska, M. Bevis, C.-K. Hong, T.-S. Bae, J. LaMance, C. Rizos

IGS Analysis Center at GFZ Potsdam
M. Ge, F. Zhang, M. Ramatschi

Session 10: Antenna Effects

Session Description 206

Session Summary 207
R. Schmid, G. Mader, T. Herring

From Relative to Absolute Antenna Phase Center Corrections (Position Paper).....209
R. Schmid, G. Mader, T. Herring

Oral Presentations

New Anechoic Chamber Results and Comparison with Field and Robot Techniques ..... *CD*
B. Görres, J. Campbell, M. Siemes, M. Becker

Estimation and Validation of the IGS Absolute Antenna Phase Center Variations..... *CD*
M. Ge, G. Gendt

Impact of Absolute Antenna Phase Center Corrections on Global GPS Solutions ..... *CD*
R. Schmid, D. Thaller, P. Steigenberger, M. Rothacher, M. Krügel

The Effect of SCIGN Domes on the Vertical Phase Centre Position in Routine Processing of GPS Data ..... *CD*
H. Dragert, M. Schmidt

Local Monitoring of a Fundamental GPS Site..... *CD*
M. Rothacher, V. Lechner, W. Schlüter

Poster Presentations

Absolute Field Calibration of Carrier Phase Multipath ..... *CD*
F. Dilßner, G. Seeber, U. Feldmann, G. Wübbena, M. Schmitz, M. Bachmann

The Effect of SCIGN Domes on the Vertical Phase Centre Position in Routine Processing of GPS Data ..... *CD*
H. Dragert, M. Schmidt

The Impact of the PCV Parameters in the Coordinates Estimate ..... *CD*
R. Barzaghi, A. Borghi

Session 11: Ground-Based Neutral Atmosphere and Ionosphere Sounding

Session Description..... 222

Session Summary (Ionosphere Part)..... 223
H. Hernández-Pajares

IGS Ionosphere WG Status Report: Performance of IGS Ionosphere TEC Maps (Position Paper)..... 225
M. Hernández-Pajares

IGS Tropospheric Products and Services at a Crossroad (Position Paper)..... 251
Y. Bar-Sever

Oral Presentations

GNSS Ionosphere Analysis at CODE..... *CD*
S. Schaer

Usage of IGS TEC Maps to Explain RF Link Degradations by Spread-F, Observed on Cluster and Other ESA Spacecraft ..... *CD*
J. Feltens, J. Dow, G. Billig, D. Fornarelli, S. Pallaschke, B. Smeds, H.-J. Volpp, P. Escoubet, H. Laakso

Global Ionospheric Data Assimilation & IGS Collaboration with Space Weather Programs ..... *CD*
B. Wilson, C. Wang, G. Hajj, X. Pi, L. Mandrake, A. Komjathy, A. Mannucci

gAGE/UPC GNSS Ionosphere Activities: Real-time, Galileo, EGNOS and Tomography ..... *CD*
M. Hernández-Pajares, J. M. Juan, J. Sanz, A. Aragon, M. Garcia, R. Orus, P. Roldan

Poster Presentations

Activities of Swisstopo in GPS Meteorology ..... *CD*
E. Brockmann, D. Ineichen, G. Guerova, J.-M. Bettems, A. Somieski, M. Troller, M. Becker, P. Haefele

Determination of Ionospheric Delays of GPS Signals on the Basis of Measuring Results Obtained by a Single-Frequency Receiver ..... *CD*
M. Kaufman, S. Pasynok, D. Filonov

GIM Models for Single Frequency Radar Altimetry ..... *CD*
T. Schöne, S. Esselborn

GPS Ionosphere Rapid Service for Europe – Suggestions and First Experiences ..... *CD*
M. Figurski, J. B. Rogowski

GPS Tomography and Remote Sensing Techniques for Water Vapor Determination in the ESCOMPTE Campaign ..... *CD*
S. Lutz, M. Troller, A. Somieski, A. Walpersdorf, E. Doerflinger, A. Geiger, B. Bürki, O. Bock, H.-G. Kahle

Mapping Function Parameters Derived from Numerical Weather Model Data in Global GPS Network Analyses – A Comparative Study ..... *CD*
S. Vey, A. Rülke, R. Dietrich, M. Rothacher

MATRAG – Measurement of Alpine Tropospheric Delay by Radiometer and GPS ..... *CD*
P. Häfele, M. Becker, E. Brockmann, L. Martin, M. Kirchner

Modeling and Forecasting of TEC Obtained with IGS Network over Europe ..... *CD*
A. Krankowski, L.W. Baran, I.I. Shagimuratov

Swedish Activities During 10 Years as a Data Provider and Customer of the IGS: Atmospheric Monitoring ..... *CD*
B. Stoew, G. Elgered, R. Emardson, L. Gradinarsky, R. Haas, P. Jarlemark, J. Johansson

VMF and IMF Mapping Functions Based on Data from the ECMWF ..... *CD*
H. Schuh, J. Boehm

Agenda

Sunday, February 29th, PM	
12:00 – 17:30	Governing Board Meeting

Monday, March 1st, AM	
9:00 – 13:00	Onsite Registration

Monday, March 1st, PM		
Opening Session (Chairs: W. Gurtner)		
13:30	J. Dow	Welcome and Official Opening of the Workshop
13:35	U. Würgler	Welcome from the University of Berne
13:45	G. Beutler	Welcome from the IAG
13:50	W. Gurtner	Administrative communications
Session 1: IGS Reference Frame Maintenance (Chairs: R. Ferland, G. Gendt, T. Schöne)		
14:00	R. Ferland	IGS Reference Frame Maintenance
14:25	Y. Bock	Environmental Issues and Monumentation
14:40	D. Dong	Current challenges of monitoring station height with GPS
14:55	M. Rothacher	IERS Rigorous Inter-Technique Combination Implications to IGS
15:10	C. Bruyninx	Detection and Handling of EPN Station Irregularities
15:25		Open Discussion
15:45		*Coffee Break*
Session 2: Other Reference Frame Issues (Chairs: J. Ray, D. Dong, Z. Altamimi)		
16:15	J. Ray	IGS Reference Frames: Status and Future Improvements
16:35	T. Herring	Observations of large-scale frame deformations and related effects
16:50	G. Blewitt	Relationships between mass redistribution, station position, geocenter, and Earth rotation: Results from IGS GNAAC analysis
17:05	Z. Altamimi	Tests of IGS Reference Frame Stability
17:20	S. Kedar	The effect of the second order GPS ionospheric correction on receiver positions
17:35	K. Senior	Improving IGS Timescale
17:50		Open Discussion
18:30		*Ice Breaker*

Tuesday, March 2nd, AM

Session 3: Real Time Aspects (Chairs: M. Caissy, R. Muellerschoen)

8:30	R. Muellerschoen, M. Caissy	Real-Time Data Flow and Product Generation for GNSS
8:45	M. Caissy	IGS Real-time Network Prototype
9:00	R. Muellerschoen	Real Time Aspects, the JPL Perspective
9:15	M. Caissy	Global Products for GPS Point Positioning Approaching Real-Time
9:30	D. Dettmering	The EUREF-IP Ntrip Broadcaster: Real-time GNSS data for Europe
9:45	C. Garcia	ESA/ESOC Real Time Infrastructure
10:00		Open Discussion
10:15		*Coffee Break*

Session 4: Network Issues (Chairs: A. Moore, C. Bruyninx, B. Twilley)

10:45	M. Schmidt	IGS Network Issues 2002-2004, Update Since Ottawa Workshop
11:00	Z. Altamimi	Status of AFREF Project
11:10	G. Steblov	North Eurasian GPS Deformation Array, History and Current State
11:25	I. Romero	Working with the IGS network: The ESA/ESOC experience
11:40	B. Twilley	South Pacific Regional GPS Network
11:55	A. Moore	Network Issues
12:10		Open Discussion

Tuesday, March 2nd, PM

12:30		*Lunch Break*

Session 5: Data Transfer and Data Centers (Chairs: C. Noll, M. Scharber, C. Meertens)

14:00	C. Noll	Enhancing the IGS Data and Products Infrastructure – A Data Center Perspective
14:15	Y. Hatanaka	Addition of real-time capability to the Japanese dense GPS Network
14:30	R. Muellerschoen	The Role of IGS Data Centers and Real-Time Data
14:45	G. Anderson	New and adapted technologies for the Plate Boundary Observatory
15:00	H. Habrich	New Server Concept at the BKG Data Center
15:15	Y. Bock	SOPAC IT Developments
15:30		Discussion, Wrap-up
15:45		*Coffee Break*

Session 6: Integrity Monitoring of IGS Products (Chairs: J. Zumberge, H.-P. Plag)

16:15	J. F. Zumberge	Integrity Monitoring of IGS Products
16:35	B. Lobert	GNSS Integrity Concept
16:55	G. Gendt	Products produced under the direction of the AC Coordinator: Processes, accuracies and quality control
17:15	R. Govind	The Use and Integrity Monitoring of IGS Products at Geoscience Australia (GA)
17:35		Open Discussion

Splinter Meetings

18:00 – 19:30	Data Center Working Group Meeting
18:00 – 19:30	GNSS Working Group Meeting
18:00 – 19:30	Troposphere Working Group Meeting

Wednesday, March 3rd, AM

IGS 10th Anniversary Symposium (Chairs: J. Dow, R. Neilan)

8:00 – 8:30		Symposium Registration

International GPS Service and International Association of Geodesy

8:30	J. Dow, W. Gurtner	Introductions and Welcome, Announcements
8:40	G. Beutler	The Accomplishments of the IGS and their Implications on the Future of Geodesy
9:10	J. Dow	The IGS Strategic Plan and Future
9:25	B. Engen	Role of IGS – National Mapping Perspectives

Scientific Research and Applications

9:45	A. Donnellan	Earth Science Research and Applications, Geodetic Infrastructure as Enabling Technology
10:15		*Coffee Break*
10:45	B. Serafin	Atmospheric Research and Applications
11:15	C. Reigber	Gravity and Satellite Missions
11:45	K. Heki	Monitoring Crustal Deformation in an Island Arc

Wednesday, March 3rd, PM

IGS 10th Anniversary Symposium (Chairs: J. Dow, R. Neilan)

12:15		*Photo Session*
12:30		*Lunch*
GNSS Systems		
13:30	D. Turner	GPS Policy, Management & Modernization
13:55	J. Tjaden	Galileo and the European Developments
14:15	R. Oosterlinck	The Galileo Programme Status
14:35	S. Revnivykh	Developments of the Glonass system and Glonass Service
International Cooperation, Education and Outreach		
14:50	K. Hodgkins	US-EU Cooperation
15:05	K. Hodgkins	GNSS- The International Future
15:25	G. Johnston	Industry Perspectives on IGS Collaboration, Impact and Influence – Past, Present and Future
15:45		*Coffee Break*
16:15	C. Rizos	IGS and the Education of the Next Generation of Users
16:30	P. Zhang	GPS Developments in China and Its Applications in Geodynamic Studies of Continental Asia
16:45	T. Stansell	Improving the GPS L1 Signal
Panel - Visions for the Future		
17:00	B. Serafin	Visions for the Future
19:30		*Official Dinner*
	R. Neilan	*The Spirit of the IGS - A Decade of Images*

Thursday, March 4th, AM

Session 7: Global Navigation Satellite Systems I (Chairs: J. Dow, R. Weber)

8:50	D. Turner	GNSS Modernization
9:10	E. Felicitas Arias	Timing applications for GNSS – IGS partnership with the BIPM
9:30	M. Falcone	Risk Mitigation in the Ground Mission Segment using the Galileo System Test Bed
9:50	M. Romay Merino	GSTB-V1: The First Step Towards the Development of Galileo Navigation Algorithms
10:10	R. Weber	The IGS GNSS Working Group – Charter and Plans
10:20		*Coffee Break*

Session 8: Global Navigation Satellite Systems II (Chairs: J. Slater, R. Langley)

10:45	C. Boucher	The ITRF/Galileo interface
11:05	P. Defraigne	Time and Frequency Transfer Using GNSS
11:25	D. Tatarnikov	GPS/GLONASS Antennas and Ground Planes: Size and Weight Reduction Perspectives
11:45	J. Slater	The IGLOS Pilot Project – Transitioning an Experiment into an Operational Service
12:05	S. Schaer	GNSS Analysis at CODE

Thursday, March 4th, PM

12:25		*Lunch Break*

Session 9: Precise Orbit Determination (Chairs: H. Boomkamp, R. König)

14:00	H. Boomkamp	Bigger, better, faster POD
14:15	H. Boomkamp	High-performance algorithms for double difference data processing
14:30	R. König	Combined Solutions GPS+LEO
14:45	T. Herring	Aspects of Large Station Networks for GPS Orbits and Clocks
15:00	U. Hugentobler	Routine Processing of Combined Solutions for GPS and GLONASS at CODE
15:15	J. Douša	Ultra-rapids and ultra-rapids predictions for GPS
15:30		Open Discussion
15:45		*Coffee Break*

Session 10: Antenna Effects (Chairs: R. Schmid, G. Mader, T. Herring)

16:15	G. Mader	From Relative to Absolute Antenna Phase Center Corrections
16:30	B. Görres	New anechoic chamber results and comparison with field and robot techniques
16:45	M. Ge	Estimation and validation of the IGS absolute antenna phase center variations
17:00	R. Schmid	Impact of Absolute Antenna Phase Center Corrections on Global GPS Solutions
17:15	M. Schmidt	The Effect of SCIGN Domes on the Vertical Phase Centre Position in Routine Processing of GPS Data
17:25	M. Rothacher	Local Monitoring of a Fundamental GPS Site
17:35		Open Discussion

Splinter Meetings

18:00 – 19:30	Ionosphere Working Group Meeting
18:00 – 19:30	Real Time Working Group Meeting

Friday, March 5th, AM

Session 11: Ground-Based Neutral Atmosphere and Ionosphere Sounding
(Chairs: Y. Bar-Sever, M. Hernández)

8:30	M. Hernández	IGS Ionosphere WG Status Report: Performance of IGS Ionosphere TEC Maps
8:45	S. Schaer	GNSS Ionosphere Analysis at CODE
8:55	J. Feltens	Usage of IGS TEC Maps to explain RF Link Degradations by Spread-F, observed on Cluster and other ESA Spacecraft
9:05	B. Wilson	Global Ionospheric Data Assimilation & IGS Collaboration with Space Weather Programs
9:15	M. Hernández	gAGE/UPC GNSS Ionosphere Activities: Real-time, Galileo, EGNOS and Tomography
9:25	Y. Bar-Sever	Discussion of Operational Issues with Derivation of IGS Tropospheric Products for Climatology and Weather Forecasting
10:15		*Coffee Break*

Session Summaries and Closing Session (Chairs: A. Moore, J. Dow, G. Gendt)

14:00 – 15:00	Governing Board Wrap-up Meeting

List of Participants

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IGS 10th Anniversary Symposium and Workshop
1-5 March 2004, Bern, Switzerland
Recommendations and Positions

		Page
1.0	Symposium Recommendation	xxvii
2.0	IGS Reference Frame Maintenance	xxvii
3.0	Other Reference Issues	xxviii
4.0	Real Time Aspects	xxx
5.0	Network Issues	xxx
6.0	Data Transfer and Data Centers	xxx
7.0	Integrity Monitoring of IGS Products	xxxi
8.0	GNSS Sessions	xxxi
9.0	Precise Orbit Determination	xxxii
10.0	Antenna Effects	xxxii
11.0	IGS Troposphere Combination Products	xxxiii
12.0	IGS Ionosphere WG	xxxiv

1.0 Symposium Recommendation

1.1 "The International GPS Service (IGS) endorses the final report of the United Nations Action Team on Global Navigation Satellite Systems (GNSS) (A/AC.105/C.1/L.274). The proposed establishment of an International GNSS Committee as a mechanism to further cooperation among system providers, international GNSS organizations, and users is strongly encouraged. The IGS and the International Association of Geodesy (IAG) will support and contribute to the successful realization of this effort."

2.0 IGS Reference Frame Maintenance

2.1 To resolve potential constraints issues, it is proposed that for GPS weeks 1268 to 1270 (April 25 – May 15, 2004), the ACs contribute SINEX solutions obtained without constraints on any parameters along with their usual SINEX solution. If for any reason, any apriori constraints (orbit, troposphere … etc) are used on any parameters, they must be reported along with their expected influence on SINEX parameters.

2.2 Check/compare the effect of the weighting strategy on the estimated transformation parameters with the current IGS SINEX combination strategy by selecting a few GPS weeks.

2.3 Estimate and report a scale factor between IGS weekly combined solution and the IGS realization of ITRF.

2.4 Review the combination procedures with the GNAACs, to better explain and possibly reduce the observed differences. Ideally, in this type of analysis, the processing noise should be kept well below (one order of magnitude) the signal.

2.5 The modeling differences between ACs need to be compared to understand the observed small systematic differences between the AC station coordinates, orbits and clocks. As a starting point, a summary of all the AC processing/modeling is being compiled. The information avail-

able from the *.acn files is used for this compilation. The ACs should update the file every time any significant analysis change is made.

2.6 Generate two lists of station position discontinuities: one with "known/certain" station position discontinuities and another one with "suspected/probable" discontinuities. Some ACs have already identified a number of discontinuities; their contribution is certainly welcomed. A related activity is to recombine the weekly/cumulative solutions to include the discontinuities.

2.7 Provide updates to the reprocessed weekly SINEX solutions. It is suggested to keep those solutions separate from the official ones (CDDIS), and with a distinct, but similar naming convention. Updates should be provided when significant improvements have been made.

2.8 The ACs need to verify the stability of the RF stations before constraining them during the generation of the (ultra) rapid orbit/clock products. Additionally, a PPP will be applied after the combination to check the RF station positions.

2.9 The ACs should be prepared to reprocess the IGS data. The detailed procedure should be discussed after the absolute antenna phase center variation models are decided (see Antenna session).

2.10 All IGS satellite clocks should be in ITRF center of network. This is the case for the (Ultra) Rapid products and should be realized for the Final product too. ACs should fix their shifted station coordinates while back substituting for final clocks (use of AC station solutions transformed into RF by Helmert transformation) (short term)

2.11 The quality of the PPP realization of ITRF using IGS products (Rapid and Final) will be monitored; changes in the combination have to be prepared. For the most demanding users, the 7-parameter transformations will be made available.

3.0 Other Reference Issues

3.1 *Develop reinforced IGS reference frame strategy*: The IGS should officially designate reference frame stations according to a set of operating standards mutually accepted by all components of the organization. The station operators must be actively involved and committed to this process. The IGS needs to develop a long-range, proactive strategy to reinforce and secure the long-term stability of a sustainable and robust reference frame incorporating appropriate quality assessment systems and much improved user interfaces.

3.2 *Verification of IGS PPP consistency:* The IGS should commission a thorough study of the consistency of its Final orbits and clocks for global precise point positioning relative to the associated weekly sets of station coordinates. In particular, the effects of possible geocenter and scale differences should be well studied and remedies for any defects should be developed. Ideally an ongoing quality-checking process should be implemented to continuously monitor the consistency and precision of IGS products.

3.3 *IGS Precise Point Positioning (PPP) service:* The IGS should institute procedures to maintain the documentation of all necessary analysis methods, conventions, and constants so that non-specialized users can use IGS products with maximum accuracy and minimum effort. Ideally, a freely available, open software package and other automated electronic tools should be provided as a service for precise point positioning by general and expert users. The IGS should consider inviting agencies to provide such services operationally, where the quality and integrity would be continuously monitored by the IGS.

3.4 *Absolute antenna patterns and the IGS scale:* When the IGS implements absolute antenna phase patterns for the satellites and tracking network, the effect on the average scale of the combined products should be carefully evaluated to verify that it closely matches ITRF2000/IGS00.

3.5 *Handling geocenter motions:* The IERS is encouraged to adopt an elaborated celestial-terrestrial transformation of the form:

$$ICRF = P * N * R * W * [TRF + O(t)]$$

to explicitly account for geocenter motion. The sense of the geocenter offset vector is from the center of the "instantaneous" TRF(t) frame to the ITRF origin such that [TRF + O(t)] is aligned to ITRF. This should be the understanding of the geocenter parameters in the SINEX format. Realization of geocenter offsets using a Helmert transformation approach, as already implemented by the IGS, is also recommended.

3.6 *Conventional contributions to station displacements:* Following traditional practice in treating Earth orientation variations, the IERS Conventions should be interpreted such that the summation of various model effects for a priori, non-linear station displacements includes only those which: 1) have known closed-form expressions with high a priori accuracy; and 2) have periods of variation near 1 d or shorter (with some exceptions). Currently, these criteria include diurnal and semidiurnal tidal displacements for the solid Earth, ocean loading, and atmospheric loading, as well as the longer-period Earth and ocean tides and the mostly longer-period pole tide. The ocean tidal loading should account for the whole-body translation of the solid Earth that counterbalances the motion of the ocean mass, in contradiction to Chapter 7 of the IERS Conventions 2003. The "permanent" component of the solid Earth deformation is also included in the tidal model in keeping with long-standing geodetic practice. Currently, the IERS does not provide models for the diurnal/semidiurnal displacements due to atmospheric loading or geocenter motion.

3.7 *Tropospheric path delay products:* The IGS Troposphere Working Group should consider measures to ensure the highest possible accuracy, precision, and consistency of its zenith path delay products with the IGS00 reference frame. In particular, the station coordinates used for troposphere products should match those of the IGS weekly terrestrial reference, and methods to account for the current differences in scale should be developed and applied.

3.8 *Handling subdaily variations:* Analysis Centers should ensure that they are using the newest IERS models for subdaily EOP and solid Earth tidal variations. The Analysis Coordinator is asked to work with the IERS to develop suitable models for the effects of high-frequency nutation in polar motion, subdaily geocenter variations, and subdaily atmospheric loading. Centers should prepare to implement these models as soon as they become available.

3.9 *Handling pole tide deformations:* Analysis Centers should ensure that they remove the mean pole position from the instantaneous polar motion before computing the pole tide effect. The linear trend provided in IERS Conventions 2003, Chapter 7, eqn (23a) and (23b) is recommended for this purpose.

3.10 *Nutation models:* Analysis Centers should not rely on the IAU1980 nutation model alone. To do so will cause longer period polar motion errors. If the IAU1980 model is used, corrections from the published IERS nutation offsets should also be applied. Alternatively, a more accurate nutation model (with or without observed offsets) can be considered.

3.11 Neglected ionospheric corrections: The IGS and Analysis Centers should consider methods to attenuate the present level of error caused by the neglect of higher-order ionospheric delay corrections. See recommendation 12.4.

4.0 Real Time Aspects

4.1 The UDP transport protocol is preferred for real-time data and product distribution.

4.2 Organizations operating real-time data networks are encouraged to reformat a subset of their data into the format proposed by the RTWG and permit easy access to these real-time data streams. RTWG will provide information to make the mechanism for access clear.

4.3 Together with the DCWG, the RTWG will assess long-term archival and provision of the data in the RT streams.

4.4 The RTWG and DCWG will together map a strategy to provide assessments of the RT data streams.

4.5 Quality monitoring of the predicted portion of the IGS Ultra Rapid orbits is an initial RT product goal (joint with Integrity Monitoring session).

4.6 More frequent, exploratory communication among RTWG members is needed.

5.0 Network Issues

5.1 New stations proposed to the IGS should be described on a web page and announced to the community, but added to the IGS network only on the request of an AC or Coordinator.

5.2 The "Global" station designation should be discontinued. The 99 IGb00 Reference Frame stations will be promoted on station lists and a letter will be written to agencies operating IGb00 stations, noting the significant effort and responsibility and requesting a reaction to the Reference Frame station guidelines.

5.3 The analysis community should develop a plan to handle North and East eccentricities.

5.4 The IGSMail list will be split into IGSMail (for messages such as IGS Workshops, new IGS stations, product-related announcements, major DC announcements, sessions at conferences, enhancements to web pages or services, etc.) and IGSStation (for station configuration notices, outage or repair notifications, and RINEX data replacement notification).

5.5 Monitoring and encouraging compliance to the data recording and transmission guidelines is encouraged.

6.0 Data Transfer and Data Centers

6.1 Clarify the roles of IGS DCs with respect to real-time data and data products
- Near term: Archive metadata and monitor quality of transmitted data streams.
- Long term: Offer end users a publicly-available mechanism for data consumption/retrieval/ subscription.

6.2 IGS operational data centers should archive raw receiver data indefinitely and provide access to these data upon request for data revision or scientific study on a limited basis.

6.3 Establish guidelines for GPS data file revision and define a methodology for notification, archival, and permanent catalog of revised data.

6.4 Work with the IGS Network Coordinator to improve timeliness of IGS data and data products.

7.0 Integrity Monitoring of IGS Products

7.1 IGS should use its RT data streams to

- Monitor the Ultra-Rapid predicted orbits to detect and flag outlier satellites and
- Estimate improved satellite clocks based on the RT data.

7.2 The goal is to have a near real-time (<10 minutes) product with quality similar to the Rapid product.

8.0 GNSS Sessions

8.1 Revise all format standards used by IGS entities (to transfer tracking data, orbit & clock information, and derived products) to properly exploit all opportunities offered by Next Generation Satellite System signals**.**

8.2 The IGS asks for a proper calibration of GALILEO, GLONASS and modernized GPS satellite antennas (before launch) and for providing that data to the scientific community.

8.3 It is encouraged to put laser retro-reflectors on all GNSS satellites

8.4 In order to collocate the GALILEO Reference Frame (GRF) to ITRF the IGS asks for a proper calibration of GRF Reference Station antennas and for providing that data to the scientific community.

8.5 The IGS should start as soon as possible the discussion with receiver manufacturers to explore an optimal set of signals (from GPS, Galileo, Glonass) to be tracked by future GNSS receivers.

8.6 The IGS GNSS WG should be recognized as an interface for information exchange and for stimulating cooperation between IGS and entities involved in the technical set up of GALILEO, modernized GPS and GLONASS.

- The IGS GNSS WG should develop a test plan during the next 12-18 months for collecting and evaluating test data from the first two trial GALILEO satellites, using data from the prototype GALILEO sensor stations that apparently will be co-located at IGS stations.
- In coordination with the Galileo Program, IGS should consider how best to realize the Galileo terrestrial reference frame.
- The IGS GNSS WG should develop a test plan to collect and evaluate the new GPS civil signals as soon as possible (L2C in 2004). GPS modernized signals should be integrated into the current IGS processes in a continuing evaluation phase as the new constellation of satellites is populated and capable receivers are produced and implemented.

8.7 Access to cross-link measurements between the GNSS satellites should be provided, this is a very important measurement type with inestimable impact on all derived products. A white paper on this topic will be prepared in an attempt to influence the GPS III development.

8.8 Transition combination of GLONASS orbits to IGS AC Coordinator.

9.0 Precise Orbit Determination

9.1 The position paper concludes that the processing of more GNSS satellites (GLONASS, in the future Galileo and modernized GPS) will probably not lead to substantial capacity problems. It is therefore recommended that the IGS Analysis Centres consider the future inclusion of GLONASS data processing in their POD systems, following the example set by the CODE Analysis Centre.

9.2 The inclusion of LEO data (typically requiring high-rate data processing) is currently posing capacity problems for most centres that study this possibility, but these problems will be compensated at least in the long term by increasing computer power. It is recommended that centres that work on LEO GPS data continue their efforts to find alternative methods of exploiting this data as long as switching to high-rate data would remain prohibitive.

9.3 Within IGS, the available information on process sizes and processing cost is rather rudimentary, so that the Position Paper analysis necessarily introduced certain assumption on trends and future growth rates. It is recommended that the Analysis Centres start collecting processing metrics in a systematic way, in particular for the most fundamental POD process size parameters:

- Process execution times
- Memory used by each process
- Number of estimated parameters
- Number of included tracking observations

9.4 Time series of these fundamental quantities can greatly enhance insight in the projected increase of IGS capabilities and processing needs with time.

10.0 Antenna Effects

10.1 Antenna/Radome Combinations:

- The use of radomes should be avoided at sites to be used for inter-technique comparison unless needed for antenna protection.
- Only radomes that have repeatable calibrations and mountable with reproducible physical relation to the antenna (centered position, azimuthal orientation) should be introduced into the IGS network.
- Combinations of antennas and radomes that are already calibrated by Geo++ and/or NGS should be introduced into *igs_01.pcv* (possibly at the time of the adoption of absolute antenna phase center corrections).
- If new radome calibrations become available, the impact on the RF realization will have to be checked before introduction.
- If an existing non-calibrated pair is removed from a station, it should be calibrated for any future re-analysis.

10.2 If available, physically distinct subgroups of antennas should be introduced into the files *rcvr_ant.tab* and *igs_01.pcv*.

10.3 RF sites should install local antenna arrays in order to guarantee the stability of the global terrestrial reference frame on the (sub-)mm-level.

10.4 The ANTEX format (relative or absolute offsets and patterns) should become the official IGS format.

10.5 Timescale for decision on absolute phase center models:

- Adopting absolute receiver and satellite antenna calibrations should be considered according to the following plan:

  By June 2004: Reconciliation of the satellite antenna phase center offsets and patterns and offsets between the groups generating these results.

  Sep-Dec 2004: IGS AC submission of final products with both relative and absolute phase center models used.

  Jan 2005: Evaluation of the effects of relative and absolute phase center models.

  March 2005: Decision on the adoption of absolute phase center models.

- Actions:

  Values for old PRNs and GPS Block SVs (particularly Block I) are needed.

  Possible time dependence of values as fuel expended on satellites should be explored.

  Elevation angle cut off tests with relative and absolute phase center models (orbits free!) should be performed and evaluated.

11.0 IGS Troposphere Combination Products

11.1 The Troposphere WG will consider alternate approaches including the following proposal for IGS Trop product generation:

- Discontinue the current IGS Ultra Rapid trop product for lack of use (leave operational weather forecasting applications to regional networks)
- Replace the current IGS Final trop product with a higher quality, higher efficiency Final product based on the IGS Combined orbit and clock solutions
- Carry out regular comparison with AC Final trop solutions
- Carry out periodic comparison campaigns with independent techniques (WVRs, VLBI, radiosondes), and other GPS solutions
- Immediately reprocess 10-12 years of data from all IGS sites to establish long-term consistent climatology

11.2 Met sensors:

- Short term: Request input from the community about interest in the calibration problem, preference of solutions

- Long term: Work with the World Meteorological Organization on the transfer of ownership of met packages to weather bureaus (with help from NOAA/FSL)

12.0 IGS Ionosphere WG

12.1 The use of the final IGS product is quite large (154,000 IONEX files downloads in 2003, 68% from Non-IAAC users). However for the rapid product, started in Dec 2003, very few downloads are registered from its temporarily server at UPC. In this context to promote its use, the next actions items have been adopted:

- To send a new e-mail to the IGS e-mail list.
- Moving the igs-iono e-mailing list to igscb.
- Moving rapid product server from UPC to CDDISA.

12.2 After receiving inputs from VLBI, Altimeter and Timing users, it has been decided to:

- Maintain the present generation of both final and rapid IGS TEC maps.
- Include the list of GPS receivers used for timing in the list of IAAC used stations to compute the ionospheric product, in order to ensure IGS DCB estimations for such receivers.

12.3 There has not been consensus between the IAACs on increasing the temporal and spatial resolution of the present ionex files, including densification.

12.4 The Ionosphere WG should suggest a suitable method to remove or mitigate the 2nd order ionospheric error for the ACs to apply in their data reduction. This activity might be performed in collaboration with the IAG ionospheric sub-commission.

Summary of IGS 10th Anniversary Symposium and Workshop

Bern, Switzerland, 1-5 March 2004

In March 2004, nearly 300 people gathered to celebrate the 10th Anniversary of the International GPS Service at a symposium and workshop hosted by the University of Bern in Switzerland. Ten years ago, on 1 January 1994 the IGS began official operations as a recognized and approved service of the International Association of Geodesy. In Bern, we recalled many of its accomplishments since the initial planning of the activity in 1989 and the proof of concept Test Campaign from June through September of 1992, and noted the incredible progress to date. Step by step, the incremental advances seem small until one looks back and realizes just how far the IGS has come. Today the IGS counts more than 200 contributing organizations in over 80 countries and a tracking network of 350+ stations, with many supporting regional networks consisting of stations too numerous to count, all this providing a fundamental framework for supporting a myriad of activities and applications.

Symposium March 3

The Symposium sessions on Wednesday, March 3 were aimed at:

- celebrating the history, development and accomplishments of the IGS over the last decade and how this has benefited multi-disciplinary applications
- providing a view of the evolution and future of Global Navigation Satellite Systems over the next 10-20 years, and
- exploring the future of international cooperation, use of GNSS, and the evolving role of IGS.

Our invited speakers in the four sessions of the day covered a variety of key topics:

- From IAG and IGS, an overview of IGS history, development and IGS responsibilities and strategic directions
- A fascinating session on Scientific Research and Applications – applications to Earth science, atmospheric research, gravity and space missions and earthquake/deformation science
- A topic on everyone's mind: the new and evolving GNSS systems. The symposium was honoured with the active participation of representatives from GPS, GLONASS, and Galileo systems and program offices
- The final session targeted International Cooperation, Education and Outreach, which are key elements of the IGS strategic objectives. This session included a view of the future of international GNSS within the framework of the UN GNSS Action Team, an industry perspective of IGS impact and influence, the critical need for educating the next generation, advancements in earthquake research China, and the importance of incorporating modernised GPS signals as soon as possible.

The symposium concluded with a Panel Discussion on "Visions for the Future". This forum provided an hour of lively discussion focusing on the following questions addressed to the panel:

- What is your vision for the future of GNSS and the breadth of its uses?

- How should IGS evolve in order to meet the operational and scientific challenges of the future?
- A summary of the day and the panel will be included in the proceedings.

Technical Workshop 1,2,4 & 5 March 2004

IGS workshops set the stage for the future directions and developments of the IGS. Sessions are proposed and the chairs and members draft an "IGS Position Paper" on a specific topic related to the IGS components: stations, networks, data centres, analyses, projects or working groups. These are the basis for recommendations that are brought forward for discussion, adoption, and subsequent implementation within the IGS. Colleagues come together at IGS workshops to discuss the position papers and proposed recommendations – they consider, debate, argue (sometimes heatedly) on the exact priorities and how to realise them. At this 10th IGS Workshop there were 10 of these papers to review (!). This workshop generated numerous recommendations in each session, as the IGS continues the trend of cooperative improvement. Included below and also in a separate e-mail are the final recommendations generated from these very productive session discussions. The final session of the workshop was a summary session where the session chairs provided final details to the entire group of attendees.

The sessions of this workshop were:

- IGS Reference Frame Maintenance
- Reference Frame Issues
- Real-time Aspects
- Network Issues
- Data Transfer and Data Centers
- Integrity Monitoring of IGS Products
- Global Navigation Satellite Systems
- Precise Orbit Determination
- Antenna Effects
- Ground Based Neutral Atmosphere and Ionosphere Sounding

The recommendations and the proceedings provide more detail. Some of the key issues generating much discussion (which continues) deal with the reference frame stabilization and improvement; how the IGS moves towards real-time processes; adoption of absolute antenna calibrations; an approach to generating a new IGS troposphere product; and positioning the IGS to influence and integrate future GNSS, as has been demonstrated with GLONASS.

Of Special Note…

On behalf of the attendees, I wish to extend sincere thanks to our sponsors who provided additional resources for a memorable event, by staffing their exhibits, sponsoring coffee breaks, supporting the ice breaker, appetizers and other enjoyable, even magical activities:

Leica Geosystems

Trimble

Thales Navigation

Septentrio Satellite Navigation

SwissTopo

Javad Navigation Systems

The official dinner on Wednesday evening was held at the Kursaal and was enjoyed by all participants. The food was excellent and the magic show by Siderato (also known as Prof. Dr. Peter Mürner, Academic Director at the University of Bern), tailored to the IGS gathering, was a real highlight of the evening.

IGS Governing Board Update

The Board met on Sunday 29 February, and met again for a summary session at the close of the workshop, on Friday 5 March. The GB welcomed Prof. Chris Rizos from the University of New South Wales as an appointed member. Prof. Markus Rothacher, Technical University of Munich and Dr. Jim Zumberge, NASA/JPL were both re-elected as AC representatives last December. Jim Ray of NOAA/NGS resigned his position as analysis representative effective at the end of 2003, and at the March GB meeting, the Board appointed Peng Fang of Scripps Institution of Oceanography to fill the vacated position. Prof. Geoff Blewitt, University of Nevada at Reno, was welcomed in 2003 as the IAG representative to the GB. All terms are for four years. The current listing of the IGS GB is included at the end of this message.

From the GB meetings in Bern, a few points can be highlighted. The IGS can expect a new Global Data Center to be established in Korea by the Korean Astronomic Observatory based on a proposal to the Board that was approved last year.

The IAG had recently gone through a significant restructuring placing services at the same level as the commissions. IGS fully supports this new organization. Further information on the IAG can be found at http://www.iag-aig.org/

IGS is engaged in the new IAG project chaired by the former chair of the IGS, Prof. Chris Reigber. This project is GGOS – Global Geodetic Observing System. The IAG and GGOS are focusing on greatly improving the visibility of the geodetic systems as a fundamental requirement for the Global Earth Observing System (GEO) objectives and attempting to formulate a theme within the IGOS partnership. GGOS is just forming and as plans become more concrete you will be informed.

The IGS relations with BIPM continue to strengthen. Ken Senior of the Naval Research Lab assumed in 2003 the role of IGS clock products coordinator for the joint IGS-BIPM time and frequency activity. Dr. Felicitas Arias will join the IGS GB as the BIPM-CCTF representative to the IGS, and Senior will reciprocate attending BIPM-CCTF meetings.

IGS Network Coordinator Dr. Angelyn Moore has done an excellent job in preparing the IGS Site Guidelines and Site Checklist – see http://igscb.jpl.nasa.gov/network/netindex.html. She has also coordinated the refocusing of IGSMail for major announcements relevant to the entire IGS community, including product and data center announcements, new or discontinued stations, as well as meeting and publication notices. IGSMail has been a key mechanism for communications within the IGS since 1993 and there was an interest in separating the many detailed technical and day-to-day operational notices into a separate mail list. These were split into a mail list called IGSStation as of April 2004.

The IGS GB has contributed to the UN Action Team on GNSS since 2002. IGS was fortunate to welcome Ken Hodgkins, Co-Chair of the UN GNSS Action Team, to the symposium. He provided a summary presentation of the team's activities and recommendations to COPUOS. The final report of the team is available through the UN Office of Outer Space Affairs (A/AC.105/C.1/L.274) or from the IGS Central Bureau, with a key recommendation (supported by the IGS GB) that an International Coordinating Committee on GNSS be established, bringing system providers and international user organizations together to facilitate communications and coordination. Another key recommendation of the report strongly endorses the establishment of AFREF – a continental reference system for Africa - long supported by the IGS and IAG, but to date moving slowly due to severe lack of resources and the difficulties faced by developing nations.

The GB is also in the process of revising the Terms of Reference (ToR) to better reflect the evolving organization and the breadth of activities. The revised ToR should be complete by the end of 2004. The Board continues to strive to implement the Strategic Plan, and will meet over the next year to review the plan and revise it accordingly. The Plan is available at the IGS Website maintained by the Central Bureau – all publications can be viewed at http://igscb.jpl.nasa.gov/overview/pubs.html.

This summarizes the recent activities of the IGS and the Governing Board. To quote Geoff Blewitt, "The success of the IGS is indicated by what it enables." The IGS could not do this without the efforts of each of you – many thanks for your continued contribution and commitment to the IGS. If you have any questions or comments, please feel free to contact me.

Yours sincerely,

John M. Dow

Acknowledgements and thanks to the following Committees

Scientific Program Committee, IGS Workshop:

Gerd Gendt, Chair, ACC

Angie Moore , Co-chair, Network Coord.

Robert Weber Co-chair, former ACC

Urs Hugentobler

Richard Langley

Jim Ray

Markus Rothacher

Jim Zumberge

Michael Meindl, Associate Member, Proceedings Editor

IGS Symposium Committee:

John Dow, Chair

Norm Beck

Gerhard Beutler

Ruth Neilan, Co-chair

Michael Meindl

Local Organizing Committee, AIUB, University of Bern:

Werner Gurtner, Chair,

Heike Bock

Pierre Fridez

Christine Gurtner

Michael Meindl

IGS Governing Board

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- Yoaz Bar-Sever/Jet Propulsion Laboratory, USA/Troposphere Working Group, Chair
- Norman Beck/Natural Resources Canada/Network Representative
- Gerhard Beutler/University of Bern, Switzerland/IAG Representative
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