IGS

IGS NETWORK

SYSTEMS WORKSHOP

PROCEEDINGS

NOVEMBER 2-5, 1998

Edited by
C. E. Noll
K. T. Gowey
R. E. Neilan

Abstract

The International GPS Service, the IGS, has been an operational service for nearly five years, providing GPS data and products from a globally distributed network of over 200 high precision GPS receivers. IGS data and products are freely available to all, thanks to the cooperation and participation of all the IGS members. In November 1998, the IGS convened a workshop in Annapolis, Maryland, USA, focusing on the network and infrastructure issues and how future plans for the IGS affect these components. The workshop provided a venue for the various network components of the IGS to meet and discuss our current configurations, problems and their resolutions, how to incorporate the many future requirements into the existing infrastructure, and what new technologies are available that could be incorporated into various levels of the service.

Acknowledgement

Forward

Carey E. Noll
NASA GSFC

NASA Goddard Space Flight Center, through the Crustal Dynamics Data Information (CDDIS), an IGS Global Data Center, in conjunction with the IGS Central Bureau, hosted the IGS Network Systems Workshop for three and one half days on November 2 through 5, 1998 in Annapolis, Maryland. The workshop was held at the Historic Inns of Annapolis; the Inns actually consists of three charming individual inns, with guest rooms all restored and furnished in original and reproduction antiques. Then venue provided workshop attendees with a view of early American surroundings and was convenient to the town's quaint shops, historic attractions, and colorful waterfront.

The goals of this workshop included:

- developing a closer community within the IGS infrastructure
- strengthening communications within this community
- improving the performance of the network
- developing a shared vision of the future network
- preparing a proceedings targeted along the lines of an "IGS Network Operations Plan" that would document the network operations of the IGS and future plans

The IGS has been an operational service for nearly five years, providing GPS data and products from a globally distributed network of high precision GPS receivers. Since its inception, the IGS had not sponsored a workshop of this type, focusing on the network and infrastructure issues and how future plans for the IGS affect these components. This workshop provided a venue for the various network components of the IGS to meet and discuss our current configurations, problems and their resolutions, how to incorporate the many future requirements into our existing infrastructure, and how to identify and take advantage of emerging technologies.

These proceedings document the position papers and presentations made during the workshop. Numerous discussions led to many specific recommendations and actions that are also documented in these proceedings.

Much of the planning for the workshop was conducted with the help of a web site; this site has been enhanced to provide summary information and photos from the workshop.   I
encourage readers of these proceedings to revisit the web site (http://cddisa.gsfc.nasa.gov/igs_netws/netws_home.html) to view some of the candid shots captured during the workshop.

I would first like to thank the organizing committee as well as all the session chairpersons and panel members for their active participation and efforts in coordinating their sessions,

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Executive Summary

Ruth Neilan, Angelyn Moore, IGS
Jan Kouba, NRCan
Carey Noll, NASA GSFC

Nearly 100 IGS colleagues gathered November 2 through 5, 1998 to attend a workshop dedicated to the infrastructure of our collaborative international organization. The IGS has been an operational service for nearly five years, providing GPS data and products from a globally distributed network of high precision GPS receivers to our internal users, especially the Analysis Centers, as well as to numerous external users. Since the inception of the IGS, we have not sponsored a workshop of this type, focusing on the network issues and how future planning of the IGS affect and are critically dependent on the foundation of the network. This workshop provided a great opportunity for people working within the various components of the IGS to meet and discuss current configurations, problems and resolutions. A good deal of time was devoted to understanding the many future requirements and how to begin incorporating these into our existing infrastructure. One of the key shifts in the IGS network is the realization of emerging application networks. For example, a subset of the IGS network is used for ITRF, a different subset has the characteristics to support precise time transfer, and yet another subset may meet the requirements defined for support to the low Earth orbiting (LEO) missions. This is a theme that was raised in nearly each position paper.

The final day of the workshop, November 6, was devoted to a summary session for the program committee to pull together the recommendations of the workshop. These recommendations were reviewed by the IGS Governing Board at its December meeting and approval was sought for the appropriate recommendations. The proceedings of the workshop are presented in this document and are also available on the CBIS web site. The final result of the workshop is intended to become a "Network Operations Plan" for the IGS Network System.

In brief, the workshop was considered to be productive and engaging, both in the workshop meetings as well as during the discussions, breaks, social receptions, and dinners. Carey Noll put a tremendous amount of effort into the local organization of the workshop and it was a total success. We are all indebted to her for her dedication and positive attitude in everything she does. Thanks are also due to her staff for making the whole event possible.

A more detailed day by day summary follows.

Day 1 – Monday, November 2

The first day was devoted to bringing the attendees together to focus on the status of the IGS, current performance issues, and future requirements. The welcome was given by Dr. Clark Wilson from NASA headquarters, the funding sponsor of the workshop, and

followed by Dr. Vince Salmonson, Director of the Earth Sciences Directorate at GSFC, which includes the local organizing institution of the workshop, the CDDIS.

Prof. Gerhard Beutler provided an excellent keynote summary of the 'State of the IGS', stressing the important contribution of the improving and expanding IGS network, as well as the wealth of information in past IGS data. He pointed out that the IGS Network is the combining element of all space geodetic networks. He also showed the importance of complete and correct station information for daily analyses as well as for historical data in the very likely event of future reprocessing of the data sets.

The workshop was fortunate to have many representatives present from the Analysis Centers (ACs), and it was exceptional that the Analysis Center Coordinator, Jan Kouba could personally attend and participate in the whole workshop. The link between the network and the ACs must be strengthened and this workshop was a good attempt in promoting stronger connections. The second key talk, 'Current Network Performance,' given by Dr. James Zumberge, with co-authors Kouba, Tim Springer, and Werner Gurtner, was therefore extremely relevant. Some of the key points and recommendations that stem from this position paper were to highlight previous AC discussions and conclusions in regard to discrepancy resolution, improved and consistent naming conventions, and the need for clear guidelines at all levels of IGS operations. The need for instructions on how to make and document hardware changes to ensure the continuity of station solutions by the ACs was emphasized. The usefulness of network monitoring tools, e.g., the IGS network analysis routines, was acknowledged and more detailed metrics on data noise were suggested both here and again in subsequent discussions as a future improvement.

After a break, presentations on the future of GPS and as well future requirements of the IGS followed. We were fortunate to have David Minkel, Deputy Director of the NGS, to speak to us on 'GPS Modernization', the future GPS space systems. Minkel is very involved in civilian side of planning the dual-use enhancements to the future GPS space systems. He noted that the third frequency is converging on the region of 1181 MHz and that Block II satellites are lasting longer than expected, which in fact may delay the implementation of the new satellites with the third frequencies by a few years. He also stated that the U.S. military is now considering a new and improved signal structure and possibly leaving the original (less precise/robust P/Y code) to civilians.

The Future Requirements session was comprised of an excellent panel speaking for the future needs, requirements, and optimization of the IGS. Overviews were given by the IGS projects for tropospheric, ionospheric, timing, and Low Earth Orbiter (LEO) applications. Additional presentations included an overview of the IGEX (International GLONASS EXperiment) and its current status by Jim Slater. Seth Stein, the newly appointed Scientific Director of UNAVCO, gave an update on plate tectonics and noted that the IGS is responsible for providing the global framework that so much of the science depends on. A subsequent presentation by Frank Webb, Chair of the SCIGN GPS Board underscored the rapid densification of regional arrays and began to address how the IGS can develop an interface with these regional networks. Real-time

application perspectives and communication issues were pointed out by Mike Whitehead of Satloc Corporation.

Day 2 – Tuesday, November 3

On Tuesday morning, the Physical Site Specifications and Communication and Data Links sessions were scheduled. In the first session, chaired by Werner Gurtner, presentations were made on monumentation, site selection, multipath detection, status/updates of Hatanaka compression, and two antenna-related presentations. It was noted physical monumentation and its description in the site log could be improved. A number of global IGS stations are roof top installations, and even for properly (geodetically) monumented points, the monument-related site log entries are often rather sparse and inadequate. The site specification session ended with a consensus that a unique and consistent file naming convention must be developed and adhered to for site logs, station data files (RINEX), and station solutions files (SINEX). All of these conventions should be based on a unique (and officially adopted) four-character station name identifier. There was some discussion of the proposal forwarded by the ACs and it was recommended that the data centers and interested network people respond to this scheme to resolve any remaining issues, by proposing alternative approaches. Werner Gurtner agreed to handle the discussion on these issues by email and compile the suggestions with the goal to reach some resolution in the very near future.

The next session was devoted to 'Benchmarking' the IGS Network. It has been noted that the IGS communication paths are not as efficient as they could be. It was pointed out that ACs must shop frequently at many data centers (DCs) to retrieve data fast enough for generation of the rapid products. To this end the Central Bureau and the Infrastructure Committee, with technical assistance by UNAVCO, have been working on a questionnaire to map the communications and data flow of the IGS network. By understanding the characteristics of the current network configuration, we can work to develop more efficient paths and methods to support the ACs. The consensus seems to be developing that data 'pushes', from the lowest levels all the way up to DCs and ACs may be a more efficient approach to data distribution.

In the afternoon the newly designed and expanded IGS CBIS web site was demonstrated. It was agreed that this site is a very useful improvement over the original site. A few minor improvements were suggested and everyone is encouraged to explore the site and provide comments and suggestions.

A long poster session was held in the afternoon with a large block of time set aside for people to discuss posters on an individual basis. A reception with great food and drink was hosted by the people at Ashtech; many thanks to Robert Snow.

Day 3 – Wednesday, November 4

Data center issues began the day and a number of issues were raised, such as SIO's concentrated effort to clean up past records, site information, etc. and the Seamless Archive approach. However, there was considerable discussion on the list of recommendations from the ACs on how to deal with inconsistent, non-compliant, or 'bad', poor quality data. The ACs want to exclude such data from their analyses, as it corrupts the solution and is difficult for them to deal with. The DCs, with Carey Noll and Jeff Dean in the lead, agreed to investigate the situation and develop an approach that would help to ease the ACs' processing. The ACs have proposed separate data directories; however, the DCs did not agree with this concept and would like to devise a different solution.

The Network Monitoring session was chaired by Ruth Neilan and Angie Moore; most of the time was devoted to discussion. The CB is committed to resolving the data discrepancies and consistency problems and plans to improve quality monitoring in conjunction with regional network managers. It was noted that each IGS agency must be responsible for the validity of their information, and that the CB could monitor and respond, but that each agency has the ultimate control. Updating of site logs and where the logs should reside in order to minimize future problems was also discussed. Consensus was that appropriate software tools (such as an automatic site log generation and editing program) should be developed and used at the lowest level possible, closely monitored and assisted by the Network Coordinator at the CB. The challenge to eliminate the data discrepancies and incomplete information by the end of 1998 was issued by Ruth Neilan. (Errors and inconsistencies files were posted at the workshop and individual stations were challenged to come forward with corrections as soon as possible).

In the late afternoon, the Network Upgrade Panel addressed network enhancement issues and GPS instrumentation. Yehuda Bock presented a compelling case demonstrating that even mundane changes, such as antenna reinstallation/antenna replacements (of the same type) can create significant (mm) changes. It was argued that a significant subset of the IGS stations (e.g., the 47 ITRF stations) should receive special care. It was emphasized repeatedly that the IGS needs clear guidelines on how to manage past, present, and future hardware changes so that solution step functions are mitigated.

The last session was devoted to the GLONASS and GPS manufacturers (3S Navigation, Trimble, Allen Osborne, Javad, Ashtech, and Leica). All representatives assured the audience that Y2K and Wk 1024 problems will be tested and by early next year firmware upgrades (if necessary) will be distributed to users (free of charge). The newest receiver and antenna demonstrated to the IGS was from Javad; this antenna seems to include a few innovations, such as a new choke ring design with separately tuned for L1 and L2 frequencies (somehow electronically), a newly design, forty channel GPS/GLONASS

receiver with tracking aiding (a high elevation SV aids the low elevation SV tracking, purportedly increasing the low elevation SNR by 10 Db!).

Jan Kouba has pointed out that while he was listening to the representatives from the receiver manufacturers, showing how every one is nowadays supplying six pairs of observables (code and phase on C/A, P1 and P2) it occurred to him that the IGS currently has a problem. Namely that the TurboRogues (the vast majority of receivers in the IGS network) under AS give C/A and (C/A + P2-P1) instead of P2, and that we cannot match this pair with any of the above three pairs. The implications of this fact are inconsistencies/incompatibility (at 1-2 ns level) in the satellite clock solutions and L1/L2 satellite calibration biases. Clearly this needs to be thought through and the IGS should make some decision for current and future hardware updates. This concern was discussed with some of the hardware representatives and clarification/confirmation on what specific receivers exactly output should be forthcoming, and hopefully soon.

On Wednesday night the group was graciously hosted by Leica for a guided, one-hour historical candlelight tour of Annapolis, led by several local women in authentic 17th century dresses, and with the full moon rising. This activity was followed by a banquet dinner at the historic Brice House of Annapolis. Many thanks are due to the folks at Leica, Tom Stansell and James Stowell, for sponsoring such an enjoyable social event.

Day 4 – Thursday, November 5

On Thursday, the New Communication Technology session included discussions of the next generation Internet and the STARTAP network and were presented by Steve Goldstein, Director at the National Science Foundation of the Networking and Communications Division. Currently some fast connections devoted to research and education are already globally available. It was suggested to talk to your local Internet service provider to explore the possibility of getting connected. Steve's slides are included in the proceedings. In the second presentation, a private communication consultant, Greg Piesinger, concentrated mainly on getting data from stations via various communication techniques, as well as the real time applications.

The workshop ended by asking attendees to join in working group discussions: Physical Sites, Data Centers, Network Upgrades (including communications and future requirements), and Network Monitoring. After the lunch break, the leaders of each of the above four groups presented summary recommendations and conclusions for the forum discussion.

The Physical Site groups recommendations included the outstanding issue of the unique four-character ID, and as noted above, it was taken upon by the group leader, Werner Gurtner. Also recommended was rigorous standardization of site log formats and time stamping of site logs, with incorporation into the SINEX files.

The Data Center group presented a list which included the need for developing DC guidelines, immediate site log updates (hours not days), planning for handling and use of

hourly data, a commitment to look into the flagging of data considered non-compliant or 'bad' by ACs, and to work with the CB to develop the station functional characteristic matrix (identifying what IGS stations may meet requirements for various applications).

Network Monitoring also presented a set of recommendations, including team and community building, noting that most problems stem from lack of communication thus focusing on the need for improving communications amongst DC/AC and IGS station managers. 'Accreditation' or re-registering of IGS stations should be considered. The group also supported the 'challenge' by the CB to eliminate station discrepancies.

The Network Upgrade group suggested that a selected subset of important stations be systematically updated with 'homogenous' hardware and that these sites have two 'hot' installations which are established and analyzed. This created a great deal of discussion that was impossible to resolve in the short time remaining; it was recommended that the Infrastructure Committee should perhaps prepare a proposed plan on how to approach this issue.

Day 5 – Friday, November 6

Friday morning was a summary session for the program committee and the session chairs. Ruth Neilan encouraged Jan Kouba to begin by presenting the 'AC shopping list' (i.e., the recommendations of the Zumberge, et. al. position paper presented on Monday). This list was not completely included in the context of the established panels and discussion groups and it is important for the AC considerations and suggestions to be addressed.

Each panel moderator again presented the final recommendations of each group and these are included in this proceedings document.

At this time, it is most appropriate to thank the program committee, session chairs, and panel members for a job well done. Many thanks to all the contributors and participants. A very special and heartfelt thanks goes to Carey Noll and her staff for their outstanding local organization and attention to detail. The workshop was a wonderful experience for all who attended and has produced many sound recommendations for the inevitable improvement of the future IGS network.

Recommendations and Actions

Ruth Neilan
IGS

Below are the recommendations resulting from the IGS Network Workshop conducted in Annapolis Maryland in November 1998. Following these recommendations is a set of action items that were clearly defined by those participating at the workshop.

Recommendations are generally made to the IGS Governing Board, require a response in terms of acceptance or rejection of the recommendation, and if accepted, follow with defined actions from the relevant IGS component(s). Recommendations and actions are then reviewed by the GB until they are completed and closed. The following recommendations will be reviewed by the Governing Board at its next meeting.

Recommendations are also to alert the GB of critical issues, such as R3 below.

Network Workshop Recommendations

R1. IGS sites should be reviewed and classified according to their functional characteristics to support various IGS applications (e.g., POD, LEO, time transfer, etc.). Compliance with published (or developing) documentation on station requirements, standards and guidelines should be reviewed for each site.

R2. Implementation of additional stations in Africa, Asia, and oceanic regions should be actively pursued to improve the robustness and geographic distribution of the IGS network.

R3. All IGS components should be aware of the Y2K and GPS week 1024 rollover issues, and carefully plan operations during these events to ensure that IGS systems will experience minimal impact. The IGS Network Coordinator will have the CBIS act as a clearinghouse for information on these issues and any plans that may develop. Test data sets and software should be made available through the CBIS to the data and analysis centers.

R4. The IGS should develop a long-term strategy for sustainable growth and development to guarantee the standardization, data quality, and longevity of the IGS infrastructure.

R5. A plan should be developed to coordinate the upgrade and standardization of a uniform, global network of IGS stations (50-100 sites) to support mm-accuracy applications (ITRF, LEO, ionosphere, troposphere, etc.), to the extent possible.

R6. A global communications solution for the IGS network data paths should be investigated, planned, and implemented.

Network Workshop Action Items

Actions are followed by a * indicate a short note of the responsible component/person or status. Schedule for completion of all items have not yet been detailed.

Stations and Sites

Station Naming
A1. The 'Four Character' station naming conventions must be resolved and procedures developed for adherence to this convention. The proposal forwarded by the ACs should be reviewed by all IGS components, especially the Data Centers, and a final solution must be achieved.
* CB moderate discussion and resolution.

Station changes
A2. Changes affecting the IGS stations must be carefully documented and advertised. The process for notification of station changes and historical logging of changes must be improved and defined.
* IC and CB.

A3. Guidelines for implementing and documenting hardware and/or station changes should be developed and incorporated into station guidelines documentation. The acceptance criteria for IGS stations should include physical site characteristics
* IC and NC, similar to above.

A4. An IGS working group should be formed to focus on issues of antenna calibration and radome effects.
* Question as to if this should fall within the IC and report as a subcommittee to the IC?

Future Applications
A5. Network requirements for emerging IGS projects and applications should be developed. The document 'Procedures for Becoming an IGS Station' should be reviewed and amended to include additional station requirements unique to IGS projects and applications.
* IC, WG chairs and CB.

A6. Compliance with published (or developing) documentation on station requirements, standards and guidelines should be reviewed for each site (follows with station classification).
* CB and IC.

IGS Station Accreditation

A7. It is recommended that periodic "accreditation" of IGS sites be performed. An IGS site certification plaque should be presented to each station, noting period of accreditation.
* The process of accreditation should be developed after the standards and guidelines for the stations have been reviewed and accepted, including the requirements for the 'application networks'. The CB and relevant components will provide input and review, especially ACC, AAC, DCs.

ITRF

A8. The 47 sites used for the IGS ITRF realization should take special care in terms of heightened awareness and advisories to users, particularly (ACs). These sites should maximize uptime, minimize changes, and notify when anomalies occur.
* Notify the relevant stations of importance. Heightened monitoring and advisories by the CB and stations managers.

Documentation Related

A9. Rigorous standardization of site logs should be implemented, with all necessary information included. Automatic site log generating and editing programs should be developed.
- Add monument and marker information (keywords)
- Add timing-related information (e.g., cable lengths, include modification date)
- Review section on auxiliary information
- Include URL of auxiliary information (CB or station/operational center)
- Strongly remind sites to provide auxiliary information
- Antenna part/serial number should be included in the RINEX header

* CB and IC to take action.

A10. Analysis center processing should be consistent with the current <igs.snx> file available through the CBIS for the SINEX file information blocks.
* ACC and CB and IRFC. CB works to create consistency in the fundamental information supplied to SINEX template, ACC ensure ACs use, and IRFC provides the feedback to CB and ACC.

A11. IGS analysis centers should report solutions only for the sites that have proper documentation available through the IGS Central Bureau, e.g., DOMES number, site log file, as well as data from a least one global or regional data center.
* AC, ACs, AACs, CB and GDC, RDC. The CB will generate the list of stations with compliant documentation on the CBIS. Methods for determining cross reference of this list with data holdings and analysis reporting must be developed. CB, IC, AAC, DCs will lead.

A12. An official IGS document derived from the "Physical Site Specifications" document presented at the workshop should be generated and made available at the CBIS.
* IC and CB.

A13. File formats should be maintained across files, tables, and lists to ensure automated comparison software functions correctly.
* How to approach this -- which files? Clarify this issue, identify and prioritize specific files. IC.

Data Center Issues

Data Quality
A14. Data Centers should implement strategies for handling low quality data, problematic data, or non-compliant station data so that these data are excluded from the analysis center submissions and IGS combination.
* It is not clear that this is a data center issue or even one that should be handled solely by the Data Centers. Refer this action to the Network Coordinator, GDC, ACC, and IC for problem resolution.

A15. A standards and guidelines document should be developed for data centers in consort with the CB. An evaluation process should be conducted for all data centers.
* GDC and CB, for standards and guidelines. The GB for the evaluation and review. Note that the new Terms of Reference incorporate the periodic review of all IGS components.

Data Flow
A16. Existing data flow paths initiated in the 'IGS Network Benchmarking' should be evaluated and optimized to improve timeliness of data delivery. This includes optimizing data transfers with 'data-push' philosophy techniques. Backup and redundant data flow paths should be identified and tested.
* CB and UNAVCO to complete the benchmarking. Work with DCs to review data flow between operational centers and GDCs, evaluate and document how ACs are accessing data. IC and NC to develop redundant plans for network operations.

A17. Hourly data should be incorporated into the IGS data flow at the Global Data Center level and plans developed to handle the high rate LEO data.
* GDC plans and LEO WG, CB.

Data Archiving
A18. A review of the results from SIO quality-checking program should be initiated, and issues such as plans for re-RINEXing of older data addressed. Such data operations should be performed by the data source where possible. Plans need to be developed

for correcting problems found in historic data archives and for synchronizing the data center archives.
SIO to take the lead, discussions with DCs, GDCs, ACC, and IC.

A19. IGS Data Centers should be involved with the development of the seamless archive in order to evaluate this development and assess IGS contributions and benefits.
SIO, CDDIS, and JPL involved. Will report on progress and findings at next IGS meeting.

Network Coordination and Monitoring

Monitoring and Communication
A20. To improve the sense of community among the responsible IGS network people, the Network Coordinator will coordinate the development guidelines, goals, and objectives for a station managers reference manual, and develop tools and recommended usage where appropriate.
Implicit, will obtain support from other members of the IC (and UNAVCO).

A21. With assistance from regional network managers, the Network Coordinator will develop tools and compile recommendations for improved monitoring of the IGS network. Targeted communications will be used to take action on events as needed.
ibid.

A22. Using existing metrics, the Central Bureau should be responsible for communicating with station operators regarding poor performance and/or problems in documentation of site configuration.
Implicit, NC with support of ACC, GDC, IC where needed.

A23. The CBIS should enable communication vehicles (e.g., newsgroups, mail lists, etc.) of varying scopes for the IGS components and projects (e.g. site operations issues, data center issues, general issues, etc.) .
CB is in process of installing a new CBIS platform with the capabilities for enabling these communications.

AGENDA

Convened by

Ruth Neilan   Carey Noll
International GPS Service   Crustal Dynamics Data Information System

Hosted by
National Aeronautics and Space Administration

02-05 November, 1998
Annapolis, MD USA

Monday, November 02, 1998

1:00 p.m.	R. Neilan C. Noll	Welcome and Announcements
	C. Wilson	Welcome from NASA HQ, Program Scientist for Geodynamics and Geopotential Fields
	V. Salmonson	Welcome from NASA GSFC, Director of Earth Sciences

Session 1: Overview of the IGS

1:20 p.m.	G. Beutler	State of the IGS
	J. Zumberge, J. Kouba, T. Springer	Current Network Performance
2:20 p.m.		Break

Session 2: Future Directions

2:45 p.m.	D. Minkel	What's on the Horizon for the GPS Satellite System
	C. Wilson, Moderator	Future Requirements Panel • Troposphere Applications for short and long period monitoring, including sea level applications – Mike Bevis, IGS Governing Board Member, IGS Troposphere Project, [Gerd Gendt, Chair] • Ionosphere Applications – Carlos Garcia, IGS Ionosphere Project [Joachim Feltens, Chair] • Network Implications for Global Change Monitoring – Hans-Peter Plag, Norwegian Mapping Authority, Head Geodetic Division 1, Global Geophysics • Precise Time Transfer – Jim Ray, Co-Chair IGS/BIPM Pilot Project on Precise Time Transfer • GLONASS and IGEX Update – Jim Slater, IGEX Steering Committee, Office of the Secretary of Defense • Scientific User Perspective – Seth Stein, UNAVCO Scientific Director • LEO Network, IGS role (including GLONASS for occultations) – Mike Watkins, Chair IGS LEO Working Group, Deputy Manager, JPL Tracking Systems and Applications Section • Regional Networks and the IGS Global Network, Specialized Applications, and the International Infrastructure – Frank Webb, Chair SCIGN Executive Committee • Real Time Applications – Mike Whitehead, SATLOC Corporation
5:30 p.m.		Reception, Governor Calvert House

Tuesday, November 03, 1998

Session 3: Physical Site Specifications

9:00 a.m.	W. Gurtner	Physical Site Specifications
9:30 a.m.	W. Gurtner, Moderator	Panel Discussion • Ludwig Combrinck, South Africa • Martin Hendy, Australia • Yuki Hatanaka, Japan • [Jan Johansson, Sweden] • Gerry Mader, USA • Mike Schmidt, Canada
11:00 a.m.		Break and Group Photo
11:30 a.m.	[S. Fisher], A. Moore, [L. Estey], D. Stowers, F. Boler	Communication and Data Links
12:30 p.m.		Lunch

Session 4: Demonstrations and Poster Session

2:00 p.m.	R. Liu, [K. Gowey], R. Neilan	IGS Information System Demonstration
3:00 p.m.	R. Neilan	Poster Overview and Viewing
4:00 p.m.	W. Gurtner	RINEX Splinter Meeting
5:30 p.m.	Ashtech	Reception, Governor Calvert House

Wednesday, November 04, 1998

Session 5: Data Center Issues

9:00 a.m.	C. Noll	Data Center Issues
9:30 a.m.	C. Noll, Moderator	Panel Discussion • Mark Caissey, Canada • Loic Daniel, France • Jeff Dean, USA • Heinz Habrich, Germany • Yuki Hatanaka, Japan • Myron, McCallum, USA • Dave Stowers, USA
10:30 a.m.		Break

Session 6: Network Monitoring

11:00 a.m.	A. Moore	IGS Network Monitoring
11:30 a.m.	A. Moore, Moderator	Panel Discussion • Carine Bruyninx, Belgium • Herb Dragert, Canada • Werner Gurtner, Switzerland • Rune Hanssen, Norway • Jan Kouba, Canada/Switzerland • Barb Perin, USA • Dave Stowers,
12:30 p.m.		Lunch

[ ] denotes a contributing author unable to attend the workshop.

Session 7: Network Upgrade Issues

2:00 p.m.	Y. Bock	Strengthening the IGS Infrastructure
2:30 p.m.	Y. Bock, Moderator	Panel Discussion • Jim Davis, USA • Simon McClusky, USA • Chuck Meertens, USA • Angelyn Moore, USA • Hans van der Marel, Netherlands
3:30 p.m.		Break
3:45 p.m.	R. Neilan, C. Noll	GPS Instrumentation Overview – Future of High Precision GPS Tools Invited Speakers (15 minutes each): • Jacques Beser, 3S Navigation • Javad Ashjaee, Javad • Michael Jackson, Trimble • Hans Kunze, AOA • Robert Snow, Ashtech • Tom Stansell, James Stowell , Leica
5:15 p.m.	R. Neilan, Moderator	Questions and Discussion
6:00 p.m.	Leica GPS	Candlelight Tour of Annapolis and Banquet at the Brice House

Thursday, November 05, 1998

Session 8: New Communications Technologies

9:00 a.m.	S. Goldstein	International High Performance Networking
9:45 a.m.	G. Piesinger	Real Time Global WADGPS Data Collection Network
10:30 a.m.		Break

Session 9: Working Group Discussions

11:00 a.m.		Working Groups • Physical Site Specifications, Werner Gurtner • Communications, Wayne Shiver • Data Centers, Jeff Dean/Loic Daniel • Network Monitoring, Angelyn Moore/Hans-Peter Plag • Upgrade Issues, Yehuda Bock • Future Applications Requirements for the IGS, Jim Ray
12:30 p.m.		Lunch

Session 9 (continued): Working Group Summaries

2:00 p.m..		Working Groups • Physical Site Specifications, Werner Gurtner • Communications, Wayne Shiver • Data Centers, Jeff Dean/Loic Daniel • Network Monitoring, Angelyn Moore/Hans-Peter Plag • Upgrade Issues, Yehuda Bock • Future Applications Requirements for the IGS, Jim Ray
4:00 p.m.	R. Neilan, C. Noll	Future Steps and Next Meeting
4:00 p.m.		Adjourn
7:00 p.m.		Tour of Goddard Geophysical and Astronomical Observatory (GGAO)

Friday, November 06, 1998

Summary Session for Program Committee

9:00 a.m.		Wrap up with session chairs

POSTER PRESENTATIONS

Author	Title
Current Network Performance	
Arthur Niell, Haystack, USA	Eccentricity at Westford and Implication for ITRF
Physical Site Specifications	
Tom Clark, GSFC and Bruce Schupler, ATSC, USA	High Accuracy GPS Antenna Measurements
Tom Clark, GSFC, USA	20-30 nsec Timing Accuracy for Less Than $1000
Ken Hudnut, Frank Wyatt, et. al., USGS,USA	SCIGN Radomes and Adapters
Tetsuro Imakiire, GSI, Japan	Daily Variation of Antenna Position Caused by Solar Radiation
Tetsuro Imakiire, GSI, Japan	Swelling Up of GPS Sites by Frozen Soil
Finn Bo Madsen, KMS, Denmark	IGS Stations at Thule, Greenland
Data Center Processes	
Jeff Behr, USGS, USA	SCIGN Operations Center at the USGS Pasadena
Yehuda Bock, SIO, USA	SOPAC
Loic Daniel, IGN, France	The IGN Global Data Center Activities and Plans
Heinz Habrich, BKG, Germany	BKG Regional IGS Data Center
Myron McCallum, UNAVCO, USA	Data Distribution via Seamless Archives
Meghan Miller, CWU/MIT, USA	Pacific Northwest Geodetic Array (PANGA) and Data Analysis Center
Carey Noll, CDDIS, USA	Recent Enhancements of the CDDIS
Peter Pesec, Graz, Austria	The Data/Analysis Center OLG, Austria
Joel Sachs, UMBC, USA	Can You Data Mine GPS Data?
Hans van der Marel, Delft, The Netherlands	WWW-Based Distribution of GPS Data
Network Monitoring	
Juergen Neumeyer, GFZ, Germany	Remote Controlled GPS Station Based on Ashtech GBS Software
Peter Pesec, Graz, Austria	Monitoring of the Austrian GPS Stations Array
Hans van der Marel, Delft, The Netherlands	Monitoring of the Dutch Active GPS Reference System
Network Upgrade Issues	
Hans van der Marel, Delft, The Netherlands	Distributing Tailored GPS Data by Means of Virtual GPS Reference Stations
Other	
Jeff Behr, USGS, USA	SCIGN
Nancy Doyle, NGS, USA	CORS on the Web
Carlos Garcia, ESA, Germany	The ESA/ESOC GPS Stations
Oivind Ruud, UNAVCO, USA	University NAVSTAR Consortium (UNAVCO) Facility Support to Permanent Global Positioning System (GPS) Network Installation and Operation
Jim Slater, NIMA, USA	Current State and Plans for the NIMA/DoD GPS Network
Grigory Steblov, RDAAC, Russia	Northern Eurasia Deformation Array

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