RECOMMENDATIONS AND ACTION ITEMS
IGS Governing Board Retreat
Napa Valley, December 12-14, 1997

by
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One of the conclusions of the Retreat has been that the IGS Terms of Reference (January 1996 version), with some "fine tuning", still reflects the current needs. For this reason and also to provide a framework for the Retreat's Recommendations (Rs) and Action Items (**A**s) relevant portions of the terms are reproduced below, in **bold** letters between dotted lines, with the Rs and **A**s inserted at the appropriate locations.

In order to keep the Retreat as conducive for open discussion as possible formal Minutes were not kept. A "short hand"/informal record suitable to jag the memories of the participants is available from the Central Bureau.

The Recommendations/Action Items and the explanatory text as presented below are based on the final summary discussion of the Retreat Coordinators on December 14, 1998, on correspondence and conversations after the Retreat.

INTERNATIONAL GPS SERVICE FOR GEODYNAMICS
TERMS OF REFERENCE

The term "Geodynamics" in the name of IGS, at its inception, was meant to indicate that the primary users of the service are scientists involved in geodynamics, specifically using GPS for determining and/or monitoring positions on the surface of the Earth with the highest accuracy. Since other types of users (especially from the atmospheric and oceanic science communities) are appearing on the horizon the suggestion was made to eliminate the term "Geodynamics" from the title of IGS.

- R1: The name of the Service be the "International GPS Service".

- **A1**: Governing Board (GB) needs to consider R1 and vote.

The primary objective of the IGS is to provide a service to support, through GPS data products, geodetic and geophysical research

activities. Cognizant of the immense growth in GPS applications the secondary objective of the IGS is to support a broad spectrum of operational activities performed by governmental or selected commercial organizations. The Service also develops the necessary standards/specifications and encourages international adherence to its conventions.

IGS collects, archives and distributes GPS observation data sets of sufficient accuracy to satisfy the objectives of a wide range of applications and experimentation. These data sets are used by the IGS to generate the following data products:

- high accuracy GPS satellite ephemerides
- earth rotation parameters
- coordinates and velocities of the IGS tracking stations
- GPS satellite and tracking station clock information
- ionospheric information
- tropospheric information.

The accuracies of these products are sufficient to support current scientific objectives including:
- realization of global accessibility to and the improvement of the International Terrestrial Reference Frame (ITRF)
- monitoring deformations of the solid earth
- monitoring earth rotation
- monitoring variations in the liquid earth (sea level, ice-sheets, etc.)
- scientific satellite orbit determinations
- ionosphere monitoring
- climatological research, eventually weather prediction.

In the past the IGS combined products used primarily have been those related to the **IGS Reference Frames**, both terrestrial and inertial, recommended for GPS users. These are the station coordinates with their variations in time (defining the terrestrial frame) and the orbits of GPS satellites (defining the inertial frame), and the transformation parameters relating the two (the earth-rotation parameters). There have been some questions as to the internal consistencies of the above products.

Due to user requirements for using the GPS signals in various efficient modes and/or leading to more accurate results, it appears necessary for IGS to produce combined, timely and consistent additional

products, specifically GPS clock corrections, possibly an IGS time scale, tropospheric zenith biases and global and possibly regional ionosphere models.These, together with the reference frames (all based on the IERS Conventions, 1996), constitute the **IGS Reference System** assuring consistency for all GPS users of positioning in all modes.

Although non-positioning GPS user requirements are not clear at this time, it appears that there is (or will be in the near future) an increasing demand for rapid (real-time) and more accurate GPS orbits as well as the inclusion of other non-GPS satellites in the IGS framework (primarily the GLONASS and LEO satellites).

- R2: IGS is to produce combined, internally consistent, global products based on GPS observations as follows (several of these to a fair extent are already accomplished):
  a) station coordinates and velocities (incl.IGS SINEX products)
  b) orbital parameters
  c) earth rotation parameters
  d) GPS clock corrections
  e) IGS time scale
  f) tropospheric zenith delays
  g) ionosphere models

- **A2.1**: The Analysis Center Workshop in Darmstadt should address the issues a) - d) and f) and g) and make recommendations.
- **A2.2**: The recently established IGS-BIPM Pilot Project should address issue e) as already decided by the GB.

- R3: IGS should continue producing accurate orbits based on rapid and/or high rate data, investigate new requirements (e.g., for real time meteorology forecasting a twenty-station network providing 30s data down loaded every 6-12 hours is suggested. For LEO see A4.2 below) and suggest and implement improvements in availability (IGR) and precision (IGP).

- **A3**: The Analysis Center Workshop in Darmstadt should address this issue and make recommendations.

- R4: IGS should support the tracking of GLONASS and LEO satellites.

- **A4.1**: The GB should support tracking of GLONASS satellites by actively promoting within IGS the International GLONASS Experiment (IGEX), currently scheduled Sep.-Dec.,1998, pending on the discussion on GLONASS at the GB business meeting in Darmstadt.

- **A4.2**: The LEO Working Group should continue its work (in collaboration with various groups involved in the use of LEOs for atmospheric science). Specific recommendations are to be made on the appropriate number of tracking stations and sampling rate (1-5s?) and on the feasibility of IGS processing of occultation and/or other flight data.

The IGS accomplishes its mission through the following components:
- networks of tracking stations
- data centers
- Analysis and Associate Analysis Centers
- Analysis Coordinator
- Central Bureau
- Governing Board.

NETWORKS OF TRACKING STATIONS

IGS Stations provide continuous tracking using high accuracy receivers and have data transmission facilities allowing for a rapid (at least daily) data transmission to the data centers (see below). The stations have to meet requirements which are specified in a separate document. The tracking data of IGS stations are regularly and continuously analyzed by at least one IGS Analysis Center or IGS Associate Analysis Center....

IGS Stations which are analyzed by at least three IGS Analysis Centers for the purpose of orbit generation, where at least one of the Analysis Centers lies on a different continent than the station considered, are in addition called IGS Global Stations.

All IGS stations are qualified as reference stations for regional GPS analyses. The ensemble of the IGS stations forms the IGS network (polyhedron).

The IGS global network needs an overall enhancement. The IGS Infrastructure Committee is involved considering issues related to the existing network e.g., instrumentation, monumentation, reporting, performance, data communication and flow, quality control, archiving, site and RINEX standards. Plans for a coordinated systematic effort to expand/densify the network to the proposed (about 200 stations)

Polyhedron is still lacking. On the other hand, the regional densification efforts are progressing, and limits are to be set up as to the inclusion of the regional stations into the IGS Polyhedron (being pro-active at the same time). Use of the network for climatology would also require the installation of high stability accurate barometers.

- R5: The global IGS Network should be enhanced in the overall sense.

- **A5.1**: The IGS Infrastructure Committee is to continue its work and report to the GB at its next regular meeting in Boston.
- **A5.2**: The GB should consider appointing a Network Manager/ Coordinator, within or outside the CB, to coordinate a systematic effort to complete the IGS Polyhedron. The responsibility would include the formulation of network standards and checking performance.
- **A5.3**: The CB/GB should make a systematic and concerted effort to request stations to install high stability/accuracy barometers (the alternative of using routinely produced atmospheric pressure grids should be explored, although their availability in near real time might be a challenge).
- **A5.4**: The GB should consider organizing an IGS Network Workshop to have an open discussion on network/station issues and to develop a direct interaction between the GB and the stations, upon which rest all IGS activities.

DATA CENTERS

The data centers required fall into three categories: Operational, Regional, and Global Data Centers....

The Global Data Centers are the main interfaces to the Analysis Centers and the outside user community. Their primary tasks include the following:

- receive/retrieve, archive and provide on line access to tracking data received from the Operational/Regional Data Centers

- provide on-line access to ancillary information, such as site information, occupation histories, etc.,

- receive/retrieve, archive and provide on-line access to IGS products received from the Analysis Centers

- backup and secure IGS data and products.

It was noted that, with the exception of CDDIS (which is doing an admirable job), not all Global Data Centers are producing regularly their Access Reports. In view of the importance of keeping track of the users of IGS products it is recommended that such reports be published on a regular basis.

- R6: It is recommended that all Global Data Centers publish Access Reports on a monthly basis.

- **A6**: The CB is to contact the relevant Global Data Centers and encourage them to comply with R6.

ANALYSIS CENTERS

The analysis centers fall into two categories: Analysis Centers and Associate Analysis Centers.

The Analysis Centers receive and process tracking data from one or more data centers for the purpose of producing IGS products. The Analysis Centers are committed to produce daily products, without interruption, and at a specified time lag to meet IGS requirements. The products are delivered to the Global Data Centers and to the IERS (as per bilateral agreements), and to other bodies, using designated standards.

The Analysis Centers provide as a minimum, ephemeris information and earth rotation parameters on a weekly basis, as well as other products, such as coordinates, on a quarterly basis. The Analysis Centers forward their products to the Global Data Centers.

Associate Analysis Centers are organizations that produce unique products, e.g., ionospheric information or Fiducial Station coordinates and velocities within a certain geographic region. Organizations with the desire of becoming Analysis Centers may also be designated as Associate Analysis Centers by the Governing Board until they are ready for full scale operation.

- R7: Depending on the outcome of the Analysis Center Workshop in Darmstadt the above descriptions of the Analysis and Associate Analysis Centers should be reviewed. The GB decisions in San Francisco/Napa Valley re. the GNAACs/RNAACs, may also have an effect.

- **A7**: The AC Coordinator together with the Chair of the Densification Project recommend the necessary changes to the Terms of Reference as per R7, if necessary.

ANALYSIS COORDINATOR

The Analysis Centers are assisted by the Analysis Coordinator.

The responsibility of the Analysis Coordinator is to monitor the Analysis Centers activities to ensure that the IGS objectives are carried out. Specific expectations include quality control, performance evaluation, and continued development of appropriate analysis standards. The Analysis Coordinator is also responsible for the appropriate combination of the Analysis Centers products into a single set of products. As a minimum a single IGS ephemeris for each GPS satellite is to be produced. In addition, IERS will produce ITRF station coordinates/velocities and earth rotation parameters to be used with the IGS orbits.

The Analysis Coordinator is to fully interact with the Central Bureau and the IERS. Generally the responsibilities for the Analysis Coordinator shall rotate between the Analysis Centers with appointments and terms specified by the Governing Board.

In view of R2 above, the present Analysis Coordinator's role will be significantly expanded and it is unlikely that a single person (or organization) will be able to handle the responsibilities related to all the different combined global products now contemplated. There is also a question of coordinating the regional densification projects (connected to the Polyhedron) in some central way.One of the responsibilities here would also be the education of users on how to use IGS products.

- R8: It is recommended that Working Groups be appointed for **Tropospheric Products**, for **Ionospheric Products**, for ITRF

Densification and possibly others (pending on the recommendations of the Analysis Center Workshop in Darmstadt). The Analysis Center Coordinator should be an ex-officio member of all Working Groups. The alternative of appointing individual "Coordinators" for each application (instead of the Working Groups) may also be considered.

- **A8.1**: Based on the recommendations of the Darmstadt Analysis Workshop, the GB should appoint new Working Groups or Coordinators as per R8 and clarify their relationship/interaction (reporting requirements, etc.) with the CB and the GB.
- **A8.2:** The concept of Working Groups or additional Coordinators, together with their responsibilities and reporting/interaction requirements should be incorporated in the Terms of Reference.

CENTRAL BUREAU

The Central Bureau (CB) is responsible for the general management of the IGS consistent with the directives and policies set by the Governing Board. The primary functions of the CB are to facilitate communications, coordinate IGS activities, establish and promote compliance to IGS network standards, monitor network operations and quality assurance of data, maintain documentation, and organize reports, meetings and workshops, and insure the compatibility of IGS and IERS by continuous interfacing with the IERS. To accomplish these tasks the CB fully interacts with the independent Analysis Coordinator described above.

Although the Chairperson of the Governing Board is the official representative of the IGS at external organizations, the CB, consonant with the directives established by the Governing Board, is responsible for the day-to-day liaison with such organizations....

The CB coordinates and publishes all documents required for the satisfactory planning and operation of the Service, including standards/specifications regarding the performance, functionality and configuration requirements of all elements of the Service including user interface functions.

The CB operates the communication center for the IGS. It maintains a hierarchy of documents and reports, both hard copy and electronic, including network information, standards,

newsletters, electronic bulletin board, directories, summaries of IGS performance and products, and an Annual Report.

In summary, the Central Bureau performs primarily a long term coordination and communication role to ensure that IGS participants contribute to the Service in a consistent and continuous manner and adhere to IGS standards.

The Central Bureau has performed well, especially in the areas of coordinating the network and communication. However, partly due to the rapid expansion of IGS over the past several years, other CB tasks described in the Terms of Reference either had to be farmed out to persons (usually volunteers) outside the CB, contracted to other organizations (e.g., UNAVCO) or neglected.

In addition to the rapid expansion of IGS, the other major difficulty the CB is facing when trying to fulfill its responsibilities is primarily structural/ organizational in nature. Although it is difficult to assess the situation from the outside, it seems evident that partly due to the fact that probably no single person has full time responsibility within the CB, every one is "spread to thin" and fragmented. The Director of the CB has at least three jobs and it appears that only one person reports to her (the liaison to UNAVCO). The UNAVCO contract to help with the network involves one staff position spread out over six persons. Others working for the CB, instead of reporting to the Director, in fact report to one of JPL's Group Supervisors, who in turn reports to certain Section/ Division heads, not directly in charge of the Director of the CB. It appears that such a structure (although maybe efficient for other purposes), combined with the fragmentation of individual responsibilities, lead to difficulties in meeting JPL's original commitment to IGS and in some cases even to conflicts of interests within JPL.

- R9: It is recommended that the tasks of the CB as described in the Terms of Reference be reviewed and the future tasks of the CB clearly defined, with the "left-over" responsibilities appropriately assigned to organizations or individuals outside the CB, which will closely interact with the CB.

- R10: It is recommended that the host organization of the CB review and streamline the CB organization, with fragmentation reduced to a minimum and lines of reporting and responsibilities clearly defined.

- R11: It is also recommended that at least two persons should be given full time responsibility within the CB. One of these should be

the Director, the other may be the Network Coordinator (see A5.2 above).

- R12: It is recommended that, provided that the recommendation for the additional Coordinators are adopted (see R8 above), their interaction with the CB be clearly defined.

- **A**9: The Director of the CB should discuss R9-11 with the appropriate officials of the host organization and present a plan to eliminate the above difficulties to the GB and the progress at its next regular meeting in Boston.

- **A**10: **A**10: The GB should appoint a sub-committee to work with the Infrastructure Committee and the Director of the CB to accomplish R9 and R12.

- **A**11: The Central Bureau section of the Terms of Reference will have to be modified after the fact.

GOVERNING BOARD

The Governing Board (GB) consists of fifteen members. They are distributed as follows:

Elected by IGS Associates (see below):		
Analysis Centers' representatives	**3**	
Data centers' representative		**1**
Networks' representatives	**2**	
Elected by the Governing Board upon recommendations from the Central Bureau, for the next term:		
Representatives of Analysis,		
Data Centers or Networks		**2**
Members at large		**2**
Appointed members:		
Director of the Central Bureau		**1**
Representative of the IERS	**1**	
IGS representative to the IERS	**1**	
IAG/FAGS representative	**1**	
President of IAG Sect. II		
or Com.VIII (CSTG	**1**	
Total		**15**

The appointed members are considered ex officio and are not subject to institutional restrictions. The other ten persons must be members of different organizations and are nominated for each position by the IGS components they represent as listed above (six persons) , or by the Central Bureau (four persons) for a staggered four year term renewable once. The GB membership should be properly balanced with regard to supporting organizations as well as to geography.

The election for each position is by the number of nominations received from the relevant IGS component, i.e., from the networks (for this purpose organizations operating two or more Global Stations are considered a network), from the Analysis Centers and from the Data Centers. In case of a tie, the election is by the members of the Governing Board and the IGS Associate Members (see below) by a simple majority of votes received. The election will be conducted by a nominating committee of three members, the chair of which will be appointed by the Chair of the IGS Governing Board...

The IAG / FAGS representative is appointed by the IAG Bureau (or by FAGS) for a maximum of two four-year terms...

The secretariat of the GB is provided by the Central Bureau...

The experience of the past several years indicate that the nomination procedure for both groups of elected GB members, i.e., those nominated by the IGS Associates and those by the CB may be improved to assure wider participation in the nomination process. In addition, it has been suggested to include all (or most) Coordinators in the deliberations of the GB. The appointed representation of IAG and FAGS on the GB needs clarification as well.

- **A**12: The GB should appoint a sub-committee to review the current nomination/appointment procedures for GB membership and to recommend improvements by the end of 1998.

Additional Recommendations/Action Items:

- **A**13: Periodic performance review requirement for each IGS component be incorporated in the Terms of Reference. The GB is to set up procedures for such regular reviews (how often and how?) and for the follow up of the recommendations (whether positive or negative).

- R13: The GB should consider forming an Advisory Committee for Commercialization of IGS products. The Committee should include representatives of organizations experienced in such ventures, e.g., WMO, UCAR/NCAR, IRIS, ESA (its business arm).

- R14: The GB should consider forming a committee, with external participation, with the task to prepare the IGS Long Range and Strategic Plan. Reporting should be at the IAG General Assembly in 1999.

(January 31, 1998)