INTERNATIONAL GPS SERVICE

CALL FOR PARTICIPATION

In support of

LOW EARTH ORBITING MISSIONS

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International GPS Service

The Chairman of the Governing Board

Potsdam, January 11, 2000

Dear Colleague:

with the forthcoming Low Earth Orbiting Missions CHAMP, SAC-C, GRACE and others we will soon enter a new era of developments in the fields of solid Earth, oceanography and atmosphere sciences and applications. The IGS was extremely successful in organizing the resources of the international GPS community in the development of GPS science and applications. The pooling of resources led to a highly efficient and rapid development of the IGS global network, the development of support centers for analysis and data archiving, and the rapid advancement of GPS technique for science and applications. This was achieved because of the open nature of collaboration while maintaining friendly and supportive competition among the participants in the IGS.

The establishment of a space network of orbiting GPS receivers could be developed as an extension of the ground network while utilizing many of the resources which the IGS currently has in place. Therefore with a Call for Participation, detailed in the attachment to this letter, the IGS solicits support in the establishment of an enhanced subset of IGS infrastructure targeted at supporting Low Earth Orbiting missions.

It is clear that the IGS ground network will be a cost effective element to most applications of space-based GPS measurements. Recommendations to this effect were made by the IGS LEO Working Group, chaired by Mike Watkins in 1998. Furthermore, several participants in the IGS are also key players in the development of spacebased GPS applications. The IGS has a 'de facto' role in the development and applications for orbiting GPS receivers and the stage is set for the IGS to now play a significant role in the development of spacebased GPS receiver applications. With the development of a significant role in the arena of orbiting space receivers, the IGS will serve the broader geoscience community as well as potentially provide services for commercial interests.

The operation of a space network of GPS receivers in service to the broader geoscience community will place special requirements upon the acquisition and distribution of data from the ground network, new requirements on the analysis centers, expanded capacity for the archiving centers, or creation of new ones, and a broader representation of scientific disciplines and agencies on the IGS governing board. Therefore, the IGS will need to develop and extend its current organization in the next future.

It is for these purposes that the IGS is soliciting this Call for Participation.
Participation in this IGS activity is open to government agencies, educational institutions and other organizations whose financial resources allow a firm commitment to be made in support of these new and demanding activities. Proposals may be submitted at any time during the period ending April 3, 2000.

The enclosed document provides information on the participation solicited, where components will assume expanded roles and functions, and where new groups or components may be interested in contributing. Proposals may address any aspect or multiple aspects of the IGS LEO activity for which the proposing organization has the capability and capacity to support.

Those organizations interested in participating in the IGS LEO activity should submit a letter of intent by February 11, 2000, expressing their interest. IGS will offer full cooperation to groups involved in the development of support capabilities for LEO missions, and thus will enhance their effectiveness. For this reason, participants in current activities are also strongly encouraged to respond to this solicitation.

Your interest and cooperation in participating in this international effort are welcomed and appreciated. Please feel free to contact the IGS Central Bureau or myself with questions or comments regarding this call.

Sincerely yours,

Christoph Reigber
Chair, IGS Governing Board

INTERNATIONAL GPS SERVICE

CALL FOR PARTICIPATION

In support of

LOW EARTH ORBITING MISSIONS

EXECUTIVE SUMMARY

Soliciting proposals in support of enhancing a subset of the infrastructure of the International GPS Service (IGS) in support of Low Earth Orbiter (LEO) Missions. This support is for precise orbit determination (POD) of LEO satellites and high rate (~1Hz) GPS ground tracking data to support LEO space-based GPS applications. GPS data from these LEO platforms will be used for IGS POD solutions of the LEO and of the GPS constellation as well. Additional space applications plan to use onboard GPS receivers coupled with the high rate ground data to produce temperature and water vapor profiles in the neutral atmosphere and ionosphere imaging products. The POD will be assessed for potential improvement to overall IGS analyses.

PARTICIPATION IS REQUESTED IN THE FOLLOWING CATEGORIES

- GPS Stations
  - Globally distributed set of stations observing in the 'classic' (30 second) sampling and reporting data at the hourly and eventually rapid sub-hourly schedule for IGS ultra-rapid processing and product generation.
  - High rate tracking stations capable of sampling up to a 1 Hz rate with rapid (hourly to <15 minute, near real-time or data streaming) data delivery, operating according to standards established by the IGS (in concert with LEO mission requirements).

- Data Centers
  - Organize and provide access to classic hourly and eventually rapid subhourly data for Precise Orbit Determination (POD)
  - Organize and provide access to high rate ground station data for science applications
  - Organize and provide access to GPS flight receiver data for POD and science applications

- Associate Analysis Centers (AACs) for LEO Project
  Analysis centers that propose to incorporate the GPS flight receiver data into their processing stream for:
  - Generating scientific POD for the LEO satellites within a one-year phased pilot demonstration project:

        - Phase I - utilizing data from the currently operational GEOSAT Follow On satellite (GFO).
        - Phase II – utilizing data from the CHAMP and SAC-C satellites scheduled for launch in April 2000.
    - AACs will demonstrate POD for these satellites as data is made available by mission responsible entities.
    - AACs will investigate and assess potential improvement of the suite of IGS classic products (orbits, EOPs, etc.)

- Coordinator(s)
    - Coordination of the AACs for development, comparison and quality control of the new products.
    - Assess the overall impact of meeting LEO requirements and incorporating LEO GPS into the IGS processes. Assess impact on IGS products.

- IGS Analysis Centers (ACs)
    - A general call to IGS ACs to develop the capabilities for hourly processing. It is expected that the established ACs will follow the agreed upon recommendations of the La Jolla AC Workshop, June 1999, by developing and demonstrating sub-daily processing. (See IGS Mail Message # 2359 from IGS AC Coordinator, Tim Springer).

INTERNATIONAL GPS SERVICE

DETAILS ON LEO CALL FOR PARTICIPATION

The Mission of the International GPS Service

The IGS clearly has the interest, experience and infrastructure to become involved in LEO mission support activities. The following extract from the IGS Terms of Reference (located at http://igscb.jpl.nasa.gov) reveals that these activities are certainly within the stated mission of the IGS.

> *The primary objective of the IGS is to provide a service to support, through GPS data and 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 and 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 hydrosphere (sea level, ice-sheets, etc.)*
> - *Scientific satellite orbit determinations*
> - *Ionosphere monitoring*
> - *Climatological research, eventually weather prediction.*

One can further see that specific to the IGS mission are the scientific objectives of a support capability for ‘‘scientific satellite orbit determination and climatological research, eventually weather prediction.’’ These objectives clearly drive this Call for Participation in support of LEO missions.

LEO Recommendations

In March, 1999 an IGS/GFZ/JPL workshop was conducted in Potsdam, Germany to explore the relationship between the IGS and an array of LEO missions planned for the next decade. A summary session of the workshop resulted in the proposal of four recommendations made by the LEO Working Group. These recommendations are:

R1: The standards for ground stations in the LEO subnetwork be codified and distributed.

R2: The IGS Analysis Centers should develop a new rapid analysis product (orbit, clock, EOP, and predictions) with a latency of less than 3 hours. This would be demonstrated through voluntary participation in a pilot project initiated in late 1999.

R3: A new efficient format should be developed for the 1 Hz ground data.

R4: A Pilot Project for the use of flight data for POD purposes (including effect on the GPS AC products) should begin as soon as possible. The WG further recommends that for the duration of the Pilot Project, the 1 Hz ground data be handled by the network operators and data centers in the new format (as yet not defined) described in R3. The Call for Participation will also request additional LEO ground sites following the standards of R1.

These recommendations were accepted by the IGS Governing Board at its 11th meeting in La Jolla, in June 1999.

Call for GPS Network Stations

A globally distributed set of stations observing in the 'classic' (30 second) sampling and reporting data at the hourly and eventually sub-hourly schedule for IGS rapid processing and product generation is required. The IGS has made great progress in this area in terms of hourly network operations and data collection. One can see from the attached map of current hourly stations that there are many stations operating in this mode. This Call specifically targets those areas where there are gaps in the hourly network, most notably due to the lack of communications or stations in areas of Africa, Asia, China, India, Russia and Southeast Asia.

Call for High Performance IGS Subnetwork

A subset of uniformly distributed stations within the IGS ground network capable of high data rate (up to 1 Hz sampling) operations and near real-time data availability is required. These stations are expected to operate according to standards and interfaces established by the IGS in concert with LEO mission operation requirements. These stations should also be referenced to hydrogen maser clocks wherever feasible. The data from this subnet needs to be made available to the data centers and hence analysis centers on a sub-daily schedule. This places requirements of very high reliability upon the operation of the subnet, which probably is best achieved through redundancy either at the subnet sites themselves or through a doubling of the size of the subnetwork. The ground communication links to support these data acquisition requirements will need to be evaluated and upgraded in certain locations.

Currently, there are two groups within the IGS who are closely linked to upcoming missions CHAMP, SAC-C, GRACE, the GeoForschungsZentrum Potsdam and Jet Propulsion Laboratory. With respect to ground support, a set of stations has been jointly identified (and in parts newly established) for CHAMP mission support, as shown in the attached map. It is expected that these stations and augmentations by other agencies would constitute the initial high-rate IGS ground subnetwork.

It is important to note that the IGS must be prudent in the operation of high-rate stations. The proposed data rate of 1 Hz is a factor of 30 over current station data files; however, special formats and compression should reduce this to a factor of ~17. This is still a significant amount of data for transfer and for data centers and analysis centers to manage.

In this regard, proposed high rate stations will be evaluated based mostly on location, performance and redundancy.

Note that the 1 Hz rate requirement is to be evaluated by the LEO Working Group. Also, the eventual elimination of Selective Availability (SA) on the GPS satellites should greatly relax the requirements for the high-rate ground network.

Data Formats

The standards and data formats for the high rate ground data are yet to be explicitly defined within the IGS. The CHAMP mission team is currently implementing a form of compressed Turbo-binary developed by GFZ. This takes advantage of the data stream from the Allen Osborne TurboRogue or ACT receivers and compresses the large data quantities for more efficient data transfer. JPL has developed a method of emulating the Turbo-binary compressed formats for the Ashtechs in the CHAMP mission network. The IGS Network Coordinator and Central Bureau will be involved in reviewing various high rate data formats employed in both global and regional arrays with the help of a subcommittee. A resulting recommendation for the adoption of a format extensible to all receivers and hopefully all missions will be forthcoming at the IGS Network Workshop in Norway, July 2000, or shortly thereafter. A preliminary standard or tools will be available by March for those organizations interested in contributing ground data to the CHAMP and SAC-C missions.

The format for the GPS space receiver data will be documented and made available to the IGS through the CHAMP and SAC-C mission representatives in the LEO Working Group.

Call for Data Centers

Data Centers are solicited to fulfil three functions:

1) Organize and provide access to the hourly classic data.
2) Organize and provide access to high-rate ground station data.
3) Organize and provide access or links to the sets of GPS flight receiver data.

Currently a number of IGS data centers are developing or operating to provide access to hourly 30-second data. A goal over the next year and a focus of the planned IGS Network Workshop, July 2000, in Oslo, Norway, is the standardization of data center structures to facilitate common access processes by users.

Data centers interested in handling high rate ground data and/or the flight receiver data will have to operate according to agreed upon standards to initiate these common access procedures, file and directory naming conventions, etc.

Access to mission data will be coordinated between the mission network managers and the IGS Central Bureau Network Coordinator with assistance of the IGS LEO Working Group.

Call for Associate Analysis Centers (AACs)

- Associate Analysis Centers (AACs) for LEO Project
  Analysis centers that propose to incorporate the GPS flight receiver data into their processing stream for:

  - Generating scientific POD for the LEO satellites within a one-year phased pilot demonstration project:
    - Phase I - utilizing data from the currently operational GEOSAT Follow On satellite (GFO).
    - Phase II – utilizing data from the CHAMP and SAC-C satellites scheduled for launch in April 2000.
  - AACs will demonstrate POD for these satellites as data is made available.
  - AACs will investigate and assess potential improvement of the suite of IGS classic products (orbits, EOPs, etc.)

Phase I of the pilot project will concentrate on GFO. The LEO WG has identified a test data set that uses the GPS data collected onboard GFO that can be used to investigate POD of GFO and provide an initial assessment of LEO data inclusion into the IGS OD processes.

Call for Coordinator(s)

- Coordinate the AACs for development, comparison and quality control of the new products
- Assess the overall impact of meeting LEO requirements and incorporating LEO GPS into the IGS processes. Particularly assess impact on IGS products.

Coordinator(s) will be intimately involved in the activities of the new Associate Analysis Centers for the LEO Project. This role assumes responsibility for the coordination of technical developments necessary for inclusion of the LEO data into the POD estimation processes. Through comparison and communication with the participating centers the analysis systems will be improved and measures of quality control will be defined.

The experience gained during the one-year pilot project phase will enable an assessment of the impact on IGS meeting LEO requirements. Close cooperation with the IGS Analysis Center Coordinator is expected.

Call for IGS Analysis Centers (ACs)

- IGS Analysis Centers (ACs)
  - A general call to IGS ACs to develop the capabilities for hourly processing. It is expected that the established ACs will follow the agreed upon recommendations of the La Jolla AC Workshop, June 1999, by developing and demonstrating sub-daily processing. (See IGS Mail Message # 2359 from IGS AC Coordinator, Tim Springer).

Any AC which does not plan to follow these recommendations should send a message to the IGS AC Coordinator with copies to the IGS Governing Board Chair and the Central Bureau.

LETTER OF INTENT

Those organizations interested in submitting a proposal in response to this Call for Participation should send a one-page non-binding Letter of Intent, due by February 11, 2000. The Letter of Intent should state that you intend to submit a proposal. This letter should be sent to the IGS Central Bureau:

Ruth Neilan, Director
IGS Central Bureau
Jet Propulsion Laboratory
M/S 238-540
4800 Oak Grove Drive
Pasadena, CA 91109 USA
Telephone Number: (818) 354-8330
Fax Number: (818) 393-6686
Email: igscb@igscb.jpl.nasa.gov

This letter should include the following information:

- Organization name and address
- Name, address, and telephone and fax numbers of the principal point of contact
- Specific areas of support which will be addressed in the proposal.

Letters of intent must be received on or before February 11, 2000. Material in these letters is for information purposes only and is not binding on the signatories. Those organizations responding will receive additional documentation and information in the future.

GENERAL PROPOSAL INFORMATION

Proposals submitted in response to the Call for Participation must include specific details on the technical support that will be offered by the organization and a management plan. These two main proposal sections will be used for proposal evaluation and to facilitate comparative analysis. Proposal must be signed by an official authorized to certify institutional support, sponsorship and management of the proposed activities.

Proposals are due on or before April 3, 2000, at the address provided above. The IGS Governing Board reserves the right to consider proposals received after this deadline if such action is judged to be in the interest of the IGS; however, there is no guarantee that such late proposals can be considered.

PROPOSAL EVALUATION AND SELECTION

The principal elements considered in evaluating any proposal are its relevance to the IGS objectives, intrinsic merit, and its overall contribution to the service when compared to potential contributions available through other proposals. In addition to these criteria, management factors will be considered separately in the selection.

If the IGS Governing Board decides to accept only a portion of the proposal, the submitting organization will be given the opportunity to accept or decline such partial acceptance.

Organizations responding to this Call for Participation will be notified by the Chairman of the IGS Governing Board of the outcome of the proposal selection process in June 2000.

SCHEDULE OF IGS LEO ACTIVITY

February 11, 2000	Letters of intent due
February 18, 2000	LEO preliminary standards outline
April 3, 2000	Proposals due
April/May	Evaluation/Selection
Pilot Demonstration	LEO WG will propose dates for one year project
July 26, 2000	Meeting at the Network Workshop in Norway

PROPOSAL PREPARATION DETAILS

The Proposal should be structured as follows:

- Cover Page (details below)
- Proposal Summary
- Description of Proposed Activities
- Management Proposal
- Financial Arrangements

The Cover Page should contain the following information:

- IGS LEO component referred to
- parent/funding organization
- name and title of authorizing official
- name and title of primary point of contact
- mailing address
- phone/fax/email
- cooperating organizations/institutes
- signatures (the cover page should be signed both by the Authorizing Official committing the organization/institution to the IGS activity and the primary point of contact involved)

Please send your proposal via postal mail to the IGS Central Bureau at the above address. For easier distribution to the reviewers, an additional e-mail version should be made available (in ASCII or attached Word or WordPerfect file). Please send the email version to igscb@igscb.jpl.nasa.gov.

Proposals should not exceed 15 pages.

Append:

Maps: IGS hourly network, CHAMP mission H/R network