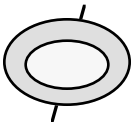

IGS SAMPLE DOCUMENT FOR AUTHORS

April 21, 1998

The following paper is a sample document for the preparation of papers within the International GPS Service for Geodynamics (IGS) internal proceedings. It is formatted in Microsoft Word, and follows very closely the instructions for International Association of Geodesy (IAG) manuscripts that are to be published by Springer-Verlag. Listed below are minor differences in format and some additional clarification.

Do not apply page numbers to individual papers, this will be done for the complete document. Page numbers in non-reproducible blue are requested.

Differences:

ï a single blank space between paragraphs permitting more white space and easier reading

ï headings for the tables and figures are in bold,

ï standard text is differentiated from computer output, using Courier 10 pt., indented 1/8" or 0.3175 cm,

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lynx http://igscb.jpl.nasa.gov/
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The attached sample document does not include the following case which may apply to your paper:

ï no equations are included, for equations, indent 1/8î or 0.3175 cm, include 1/2 blank line before and after, and the equation number is flushed right, as in the following example:

$$x_p \tilde{n} \beta_2 \tilde{n} \alpha_1 \sin\theta + \alpha_2 \cos\theta = x_p + v_{x_p} \qquad (3)$$

If you have any questions, please contact the IGS Central Bureau at igscb@igscb.jpl.nasa.gov

OR

If you would like a FAX annotated copy of the instructions, request either by e-mail or FAX: 818-393-6686, attention IGS Central Bureau.

THE INTERNATIONAL GPS SERVICE FOR GEODYNAMICS – BENEFITS TO USERS

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ABSTRACT

The International GPS Service for Geodynamics is an international scientific service which began formal operation at the beginning of 1994, following several years of planning (Mueller and Beutler, 1992) and a $1^1/_2$-year pilot service. The IGS collects, archives, and distributes GPS observation data sets, and uses these to generate high accuracy GPS satellite ephemerides, earth rotation parameters, coordinates and velocities of the IGS tracking stations, GPS satellite and tracking station clock information, and ionospheric information.

To accomplish its mission, the IGS consists of a network of GPS tracking stations, Data Centers, Analysis Centers, an Analysis Coordinator, a Central Bureau, and a Governing Board. The accuracies of IGS products are sufficient to support current scientific objectives, including the realization of the International Terrestrial Reference Frame (ITRF), monitoring of the earth's rotation and deformation of its liquid and solid components, ionsopheric monitoring, and scientific satellite orbit determination. A Central Bureau Information System (CBIS) allows public access to IGS products, which include precise GPS ephemerides within 2-3 weeks of real time. IGS contributors and customers communicate through electronic mail, and exchanges are archived for future reference.

INTRODUCTION

The primary objective of the International GPS Service for Geodynamics 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 it's conventions.

A proof of concept for the International GPS Service for Geodynamics was conducted with a three-month campaign during June–September 1992 (Beutler, 1993), and was

continued through a pilot service until the formal establishment of the IGS in 1993 by the International Association of Geodesy (IAG). The routine IGS started on January 1, 1994. IGS operates in close cooperation with the International Earth Rotation Service (IERS). The IGS *Terms of Reference* (Mueller, 1993) describes in broad terms the goals and organization of the IGS.

The 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 data products, including high accuracy GPS satellite ephemerides, earth rotation parameters, coordinates and velocities of the IGS tracking stations, GPS satellite and tracking station clock information, and ionospheric information.

In particular the accuracies of these products are sufficient for the improvement and extension of the International Terrestrial Reference Frame (ITRF), the monitoring of solid earth deformations, the monitoring of earth rotation and variations in the liquid earth (sea level, ice-sheets, etc.), for scientific satellite orbit determinations, and ionosphere monitoring.

To accomplish its mission, the IGS consists of a network of GPS tracking stations, several Data Centers, Analysis Centers, an Analysis Coordinator, a Central Bureau, and a Governing Board.

OPERATION OF THE IGS

Shown in Figure 1 is the distribution of sites that comprise the IGS global network of GPS tracking receivers. Within the next few years, expansion of the global network will address the paucity of sites near longitude 90°E, with planned coverage in Central Asia and islands in the Indian Ocean.

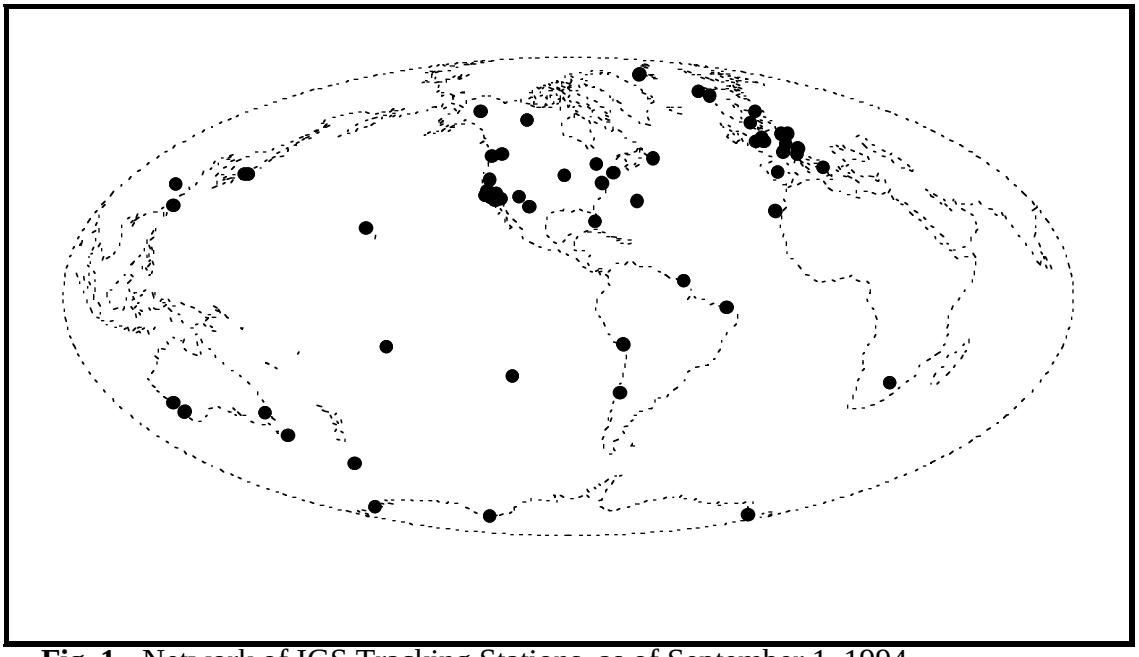

Fig. 1. Network of IGS Tracking Stations, as of September 1, 1994.

Table 1. IGS Data Centers.

Operational & Regional	
National Oceanic and Atmospheric Administration	US
Institut für Angewadte Geodäsie	Germany
Natural Resources, Canada	Canada
Norwegian Mapping Authority	Norway
Jet Propulsion Laboratory	US
Global	
NASA/Goddard Space Flight Center	US
Institut Géographique National	France
Scripps Institution of Oceanography	US

Each site has a high-precision dual-frequency P-code receiver which records measurements at 30-sec intervals. IGS Operational Data Centers (Table 1) are in direct contact with the tracking sites, and are responsible for fetching raw receiver data, formatting it in a common standard (Gurtner, 1994), and forwarding the data to Regional or Global Data Centers.

Reformatted tracking data from several Operational Data Centers are collected at Regional Data Centers. A local archive of the data received is maintained, and the data are transmitted to the Global Data Centers. Regional Data Centers thus serve to reduce traffic on electronic networks.

The Global Data Centers serve as interfaces to the Analysis Centers and the external user community. Their purpose is to receive/retrieve, archive, and provide on-line access to tracking data. In addition, Global Data Centers provide access to Analysis Center products.

There are currently seven IGS Analysis Centers (AC's) (Table 2) – three in the US, one in Canada, three in Europe – that routinely analyze some subset of the data from the IGS global network. AC's compute precise GPS ephemerides and earth orientation parameters. Daily results are posted periodically, typically once each week.

Table 2. IGS Analysis Centers.

Astronomical Institute–University of Berne	Switzerland
European Space Agency	Germany
GeoForschungsZentrum	Germany
Jet Propulsion Laboratory	US
National Oceanic and Atmospheric Administration	US
Natural Resources, Canada	Canada
Scripps Institution of Oceanography	US

Table 3. Approximate accuracies of IGS products.

GPS ephemerides	10 – 30 cm
GPS clocks	0.5 – 5 nsec
earth orientation – pole	0.2 – 0.7 mas
earth orientation – length of day	0.1 – 0.5 ms/day
station coordinates (annual solutions)	3 mm – 3 cm

The IGS Analysis Coordinator – Jan Kouba at Natural Resources, Canada – is responsible for producing a single IGS orbit, based on the combination of orbits from the separate AC's (Beutler, et al., 1993). Because of consistency checks, the combined orbit is largely free of some systematic errors that occasionally remain in results from individual AC's. Agreement among AC's in GPS satellite ephemerides is generally at the level of 10 to 30 cm. It is estimated that the absolute accuracy of the IGS orbits is at least one order of magnitude better than the broadcast ephemeris, even when anti-spoofing is in effect.

IGS contribution to the IERS

Estimates of earth orientation and station coordinates from the AC's are coordinated with the IERS (Feissel and Essaïfi, 1994). Through the IGS, GPS-derived station locations are contributing more and more to the ITRF. Over the next few years, a major goal of the IGS will be to include in the ITRF the coordinates of a number of sites that comprise dense regional GPS networks.

Table 3 summarizes the approximate accuracies of IGS orbits, clocks, earth orientation, and station locations (Feissel and Essaïfi, 1994, Kouba, 1993, and Blewitt, 1992).

CENTRAL BUREAU INFORMATION SYSTEM

The Central Bureau Information System (CBIS) provides public access to products of the IGS, and also provides a means of electronic messaging among IGS participants. The system, developed in late 1993 by Werner Gurtner, runs automatically.

The CBIS is a client on the Internet's World Wide Web, allowing access with user-friendly Mosaic and Lynx interfaces. For example, on most Unix systems, the command

```
lynx http://igscb.jpl.nasa.gov/
```

will connect the user to the CBIS. For those with X-window terminals, xmosaic for Unix systems, or the equivalent Macintosh or Windows application, allows a graphical interface to the CBIS.

At the top level of the CBIS one views the following:

```
The Central Bureau, funded by NASA at Caltech's Jet Propulsion
Laboratory, supports an Information Service:

*  IGS Mail: An archive of exchanges among IGS participants.

*  IGS Reports: An archive of reports from IGS Data and Analysis
   Centers.
```

Table 4. Top-level of CBIS anonymous ftp area.

files:	IGSCB.DIR NEWS.TXT README.TXT TREE.TXT
center	contains information on the various IGS Centers (Analysis, Data, etc.)
data	indicates where – at which Data Centers – Rinex data reside
general	miscellaneous information on GPS, IAG, and IGS, including the IGS Terms of Reference
mail	contains indices of mail messages, and the messages themselves
product	contains Analysis Center products: precise ephemerides, earth orientation,weekly summaries
software	contains source code for CBIS-exploring utilities
station	contains information on IGS stations

```
*  Regional Mail: An archive of exchanges among those interested in
   specific regional GPS networks.

These collections, with other data, are also available through
anonymous FTP.
```

Categories in bold can be selected for further exploration. By sending a message to igscb@igscb.jpl.nasa.gov, you can request that your Internet e-mail address be added to one or more of the mail and report distribution lists. The anonymous FTP category is explained in more detail in Table 4, where top-level files and directories are given.

BENEFITS TO USERS

The IGS has been in formal operation for less than a year, and detailed analysis strategies that exploit the qualities of its data and products are still being developed.

High quality Rinex tracking data from the global tracking network, GPS ephemerides that are more accurate than the broadcast orbits by at least an order of magnitude, and precisely-determined locations of dozens (and eventually hundreds or more) of sites distributed over the entire globe, all provide benefits to users.

Geodynamics investigators who use GPS in local regions can include data from one or more nearby IGS stations, fix the site coordinates from such stations to their ITRF values, and fix GPS satellite positions to their IGS-determined values. By doing so the investigator can reduce data from his own network with maximum accuracy and minimum computational burden. Furthermore, the results will be in a well-defined global reference frame.

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