Flow, Archiving, and Distribution of Global GPS Data and Products for the IGS and the Role of the Crustal Dynamics Data Information System (CDDIS)

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INTRODUCTION

The International GPS Service for Geodynamics (IGS) was formed by the International Association of Geodesy (IAG) to provide GPS data and highly accurate ephemerides in a timely fashion to the global science community to aid in geophysical research. This service has been operational since January 1994. The GPS data flows from a global network of permanent GPS tracking sites through a hierarchy of data centers before they are available to the user at designated global and regional data centers. A majority of these data flow from the receiver to global data centers within 24 hours of the end of the observation day. Common data formats and compression software are utilized throughout the data flow to facilitate efficient data transfer. IGS analysis centers retrieve these data daily to produce IGS products (e.g., orbits, clock corrections, Earth rotation parameters, and station positions). These products are then forwarded to the global data centers by the analysts for access by the IGS Analysis Coordinator, for generation of the rapid and final IGS orbit product, and for access by the user community in general. To further aid users of IGS data and products, the IGS Central Bureau Information System (CBIS) was developed to provide information on IGS sites and participating data and analysis centers. The CBIS, accessible through ftp and the World Wide Web (WWW), provides up-to-date data holding summaries of the distributed data systems. The IGS, its data flow, and the archval and distribution at one of its data centers will be discussed.

THE INTERNATIONAL GPS SERVICE FOR GEODYNAMICS (IGS)

The purpose of this international service is to provide data from a global network of GPS tracking sites as well as derived products, such as highly accurate ephemerides, Earth rotation parameters, and a global reference frame, to the international science community to further understanding in geodetic and geophysical research. In 1991, a call for participation was issued, seeking participation from groups and agencies to install GPS sites and to serve as data centers and/or data analysis centers. The first IGS campaign was held mid-1992; a pilot service continued after this successful test period and the service became operational in January 1994. In general, the GPS tracking data are delivered, archived, and publicly available within 24 hours after the end of observation day. Derived products, including an official IGS orbit, are available within ten days.

During the IGS planning stages, it was realized that a distributed data management system was vital to the success of the service. A distributed system would provide for rapid turnaround of data from the global GPS network as well as ensure system backup and redundancy should a particular data center become unavailable for some period of time. Furthermore, establishment of standards in data formats and compression were necessary to ensure the efficient and timely flow of data and products. Lastly, a centralized information system was established to provide the user community with general information about the IGS and the current status of the receiver network, as well as the data holdings at the distributed data centers.

IGS DATA AND PRODUCTS

GPS Tracking Data

Raw receiver data are downloaded on a daily basis by operational data centers and converted into RINEX, Receiver INdependent EXchange format (Gurtner, 1994). GPS tracking data from the IGS network are recorded at a thirty second sampling rate. The GPS data unit typically consists of two daily files, starting at 00:00:00 UTC and ending at 23:59:30 UTC; one file contains the range observations, a second file contains the GPS broadcast ephemerides for all satellites tracked. These two RINEX data files form the smallest unit of GPS data for the IGS and after format conversion, are forwarded to a regional or global data center for archival and distribution. The format of the file names at the data centers is *ssssddd#.yyt*_Z, where *ssss* is the site name, *ddd* is the day of year, # is the file sequence number for the day (typically set to 0 to indicate a single file per site per day), *yy* is the year, and *t* is the file type (O for observation and N for navigation). The _Z designation denotes the file is in compressed format . Each site produces approximately 0.6 Mbytes of data per day in compressed RINEX format.

At the global data center, the ephemeris data files for a given day are merged into a single file, which contains the orbit information for all GPS satellites for that day. This daily ephemeris data file is also stored in compressed form and named BRDC*ddd*0.*yy*N_Z (where *ddd* is the day of year and *yy* is the year). Users can thus download this single file instead of all broadcast ephemeris files from the individual stations.

IGS Products

Seven IGS data analysis centers (ACs) retrieve the GPS tracking data daily from the global data centers to produce IGS data. These products consist of daily precise satellite ephemerides, clock corrections, Earth rotation parameters, and station positions. The files are sent to the IGS global data centers by these analysis centers in uncompressed ASCII (in general), using NGS SP3 format (Remondi, 1989) for the precise ephemerides and Software Independent Exchange Format, SINEX, (Blewitt et. al., 1995) for the station position solutions. The Analysis Coordinator for the IGS, located at NRCan, then accesses one of the global data centers on a regular basis to retrieve these products to derive the combined IGS orbits, clock corrections, and Earth rotation parameters as well as to generate reports on data quality and statistics on product comparisons (Beutler et. al., 1993). Furthermore, users interested in obtaining precision orbits for use in general surveys and regional experiments can also download these data from the global data centers. The time delay of the IGS rapid products is dependent upon the timeliness of the individual IGS analysis centers; on average, the combined orbit is generated within two to three days of receipt of data from all analysis centers (typically within ten days).

FLOW OF IGS DATA AND INFORMATION

The flow of IGS data (including both GPS data and derived products) as well as general information can be divided into several levels (Gurtner and Neilan, 1995) as shown in Figure 1:

- Tracking Stations
- Data Centers (operational, regional, and global)
- Analysis Centers
- Analysis Center Coordinator
- Central Bureau (including the Central Bureau Information System, CBIS)
- Governing Board

These components of the IGS will be discussed in more detail below.

Tracking Stations

The global network of GPS tracking stations are equipped with precision, dual-frequency, P-code receivers operating at a thirty-second sampling rate. The IGS currently supports over 100 globally distributed stations. These stations are continuously tracking and are accessible through phone lines, network, or satellite connections thus permitting rapid, automated download of data on a daily basis. Any station wishing to participate in the IGS must submit a completed station log to the IGS Central Bureau, detailing the receiver, site location, responsible agencies, and other general information. These station logs are accessible through the CBIS. The IGS has established a hierarchy of these 100 sites since not all sites are utilized by every analysis center (Gurtner and Neilan, 1995). A core set of approximately forty or fifty sites are analyzed on a daily basis by most centers; these sites are called global sites. Sites used by one or two analysis centers for densification on a regional basis are termed regional sites. Finally, sites part of highly dense networks, such as one established in southern California to monitor earthquake deformation, are termed local sites. This classification of IGS sites determines how far in the data center hierarchy the data are archived. For example, only global sites should flow to the global data center level, where regional sites would be archived at a regional data center only.

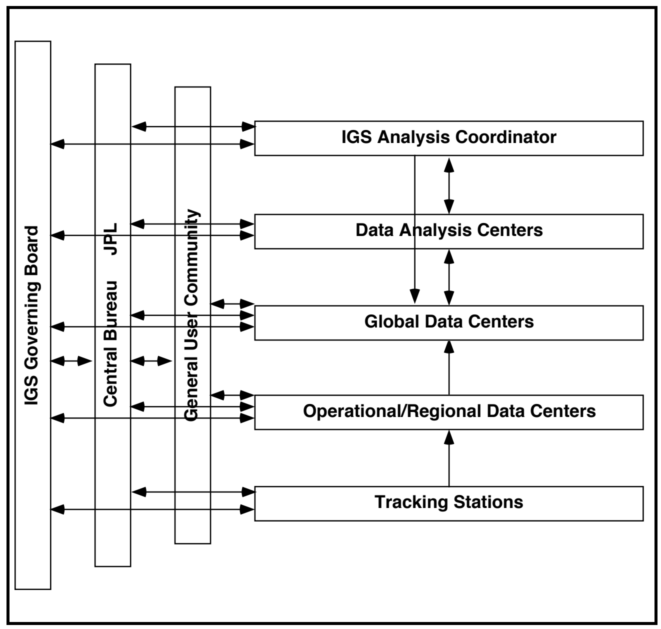

Figure 1. Flow of IGS Data

Data Centers

The IGS has also established a hierarchy of data centers to distribute data from the network of tracking stations: operational, regional, and global data centers. Operational data centers are responsible for the direct interface to the GPS receiver, connecting to the remote site daily and downloading and archiving the raw receiver data. The quality of these data are validated by checking the number of observations, number of observed satellites, date and time of the first and last record in the file. The data are then translated from raw receiver format to a common format and compressed. Both the observation and navigation files are then transmitted to a regional or global data center within a few hours following the end of the observation day.

Regional data centers gather data from various operational data centers and maintain an archive for users interested in stations of a particular region. These data centers forward data from designated global sites to the global data centers within at most 24 hours of receipt. IGS regional data centers have been established in several areas, including Europe and Australia.

The IGS global data centers are ideally the principle GPS data source for the IGS analysis centers and the general user community. Global data centers are tasked to provide an on-line archive of at least 150 days of GPS data in the common data format, including, at a minimum, the data from all global IGS sites. The global data centers are also required to provide an on-line archive of derived products, generated by the seven IGS analysis centers. There are currently three IGS global data centers:

- Crustal Dynamics Data Information System (CDDIS), at NASA's Goddard Space Flight Center in Greenbelt Maryland
- Institut Geographique National (IGN) in Paris, France
- Scripps Institution of Oceanography (SIO) in La Jolla California

These data centers equalize holdings of global sites and derived products on a daily basis. The three global data centers provide the IGS with a level of redundancy, thus preventing a single point of failure should a data center become unavailable. Users can continue to reliably access data on a daily basis from one of the other two data centers. Furthermore, three centers reduce the network traffic that could occur to a single geographical location.

Analysis Centers

Seven IGS data analysis centers (ACs) retrieve the GPS tracking data daily from the global data centers to produce daily orbit products and weekly Earth rotation parameters and station position solutions; the IGS ACs are:

- Center for Orbit Determination (CODE) at the Astronomical Institute of Berne (AIUB) Switzerland
- European Space Agency (ESA) in Darmstadt Germany
- Geodatisches ForschungsZentrum (GFZ) in Potsdam Germany
- National Resources of Canada (NRCan) (formerly Energy, Mines, and Resources, EMR) in Ottawa Canada
- Jet Propulsion Laboratory (JPL) in Pasadena California
- National Geodetic Survey (NGS) in Rockville Maryland
- Scripps Institution of Oceanography (SIO) in La Jolla California

These solutions, along with summary files detailing data processing techniques, station and satellite statistics, etc., are then submitted to the global data centers within one week of the end of the observation week.

Analysis Center Coordinator

The Analysis Center Coordinator, located at NRCan, retrieves the derived products and produces a combined IGS orbit product based on a weighted average of the seven individual analysis center results. The combined orbit is then made available to the global data centers and the IGS CBIS within ten days following the end of the observation week.

Central Bureau

The Central Bureau, located at JPL, sees to the day-to-day operations and management of the IGS. The Central Bureau facilitates communication within the IGS community through several electronic mail services. The Central Bureau also has created, operates, and maintains the Central Bureau Information System (CBIS) (Liu, et. al., 1995), designed to disseminate information about the IGS and its participants within the community as well as to other interested parties. The CBIS was developed to provide a central source for general information on the IGS as well as pointers to the distributed data centers, guiding users to the most efficient access to data and product holdings. In addition, the CBIS contains general information about the current status of the GPS constellation, the IGS global network, and the various data and analysis centers associated with the IGS. The CBIS contains information about:

- IGS organization and operation
- global network of GPS tracking sites
- general descriptions of GPS receivers and antennas
- access information and data holdings summaries for the IGS data centers
- descriptions of GPS data flow
- up-to-date data and product availability charts
- GPS system status
- IGS electronic mail archives
- software for general use (e.g., UNIX-compatible compress/decompress routines for various platforms)
- IGS combined orbit product archive

The CBIS server is accessible over the Internet, via anonymous ftp, and the WWW.

Governing Board

The IGS Governing Board, consisting of fifteen elected members from the IGS participants, is responsible for the overall management of the IGS and recommending modifications to the organization of the service in order to improve its efficiency, reliability, etc.

OPTIMIZATION OF THE FLOW OF DATA AND INFORMATION

During the IGS design phases, it was realized that a distributed data flow and archive scheme would be required. The network of fixed GPS receivers could easily grow to over 200. Therefore, the volume of data transmitted must be optimized in order to make efficient use of electronic networks in place around the world. Furthermore, a centralized data information system would be required to monitor the flow of data and provide general information on data holdings and status of the IGS in general.

The network of IGS sites is composed of GPS receivers from a variety of manufacturers. To facilitate the analysis of these data, raw receiver data are downloaded on a daily basis by operational data centers and converted into the standard format (RINEX). Data products generated by IGS analysis centers are also available in standard formats, developed by the GPS user community.

A second area of standards employed by the IGS is in data compression. The daily GPS data in RINEX format from a single site are approximately 2.0 Mbytes in size; with a network of nearly 100 sites, this totals 200 Mbytes per day. Thus, to lessen electronic network traffic as well as storage at the various data centers, a data compression scheme was promoted from the start of the IGS test campaign. It was realized that the chosen software must be executable on a variety of platforms (e.g., UNIX, VAX/VMS, and PC) and must be in the public domain. After testing several packages, UNIX compression was the software of choice and executables for VAX/VMS and PC platforms were obtained and distributed to data and analysis centers. This data compression algorithm reduces the size of the distributed files by approximately a factor of three; thus daily GPS files average 0.6 Mbytes per site, or a total of 60 Mbytes per day.

The Central Bureau Information System (CBIS), discussed earlier, is an electronic service accessible via Internet and WWW for distributing information to the IGS user community. Although the CBIS is a central data information system, the underlying data are updated via automated queries to the distributed data centers. These queries update the CBIS data holdings information as well as GPS status reports and IGS electronic mail archives several times per day. Other data, such as station configuration logs and the official IGS product archives, are deposited when new or updated information is generated.

DATA ARCHVING AND DISTRIBUTION AT THE CDDIS

The Crustal Dynamics Data Information System (CDDIS) (Noll, 1993) has been operational since September 1982, serving the international space geodesy and geodynamics community. This data archive was initially conceived to support NASA's Crustal Dynamics Project (Smith and Baltuck, 1993); since the end of this successful program in 1991, the CDDIS has continued to support the science community through NASA's Space Geodesy Program (SGP). The main objectives of the CDDIS are to store all geodetic data products acquired by NASA programs in a central data bank, to maintain information about the archival of these data, and to disseminate these data and information in a timely manner to authorized investigators and cooperating institutions. Furthermore, science support groups analyzing these data submit their resulting data sets to the CDDIS on a regular basis. Thus, the CDDIS is a central facility providing users access to raw and analyzed data to facilitate scientific investigation. A portion of the CDDIS data holdings is stored on-line for remote access. Information about the system is also available via remote download or via the WWW at the Uniform Resource Locator (URL) address *http://cddis.gsfc.nasa.gov/cddis.html*.

The CDDIS began archiving GPS tracking data in early 1992 in support of NASA programs and expanded this user community to include the IGS at the start of the test campaign in mid-1992. As stated previously, the role of the CDDIS in the IGS is to serve as one of three global data centers. In this capacity, the CDDIS is responsible for archiving and providing access to both GPS data from the global IGS network as well as the products derived from the analysis of these data.

Computer Architecture

The CDDIS is operational on a dedicated Digital Equipment Corporation (DEC) VAX 4000 Model 200 running the VMS operating system. This facility currently has nearly thirty Gbytes of on-line magnetic disk storage and 650 Mbytes of on-line rewriteable optical disk storage. The CDDIS is located at NASA's Goddard Space Flight Center and is accessible to users 24 hours per day, seven days per week. The CDDIS is available to users globally through electronic networks using TCP/IP (Transmission Control Protocol/Internet Protocol) and DECnet (VAX/VMS networking protocol), through dial-in service (300-, 1200-, 2400- and 9600-baud) and through the GTE SprintNet system.

Currently, two magnetic disk drives, totaling nearly eight Gbytes in volume, are devoted to the storage of the daily GPS tracking data; a third drive is used for storing GPS products, special requests, and supporting information. A dual-drive, rewriteable optical disk system provides additional on-line disk storage for GPS data. This unit contains two 5.25 inch optical disk drives with a capacity of 325 Mbytes per platter. These disks also serve as the long-term archive medium for GPS data on the CDDIS. Approximately one week of GPS tracking data (with a network of eighty sites) can be stored on a single side of one of these platters. The older data continues to be stored on these optical disks and can easily be requested for mounting and downloading remotely by the user. Alternatively, if the request is relatively small, data are downloaded to magnetic disk, providing temporary on-line access.

CDDIS GPS Archive

The IGS data are retrieved and/or transmitted daily by operational and regional data centers to the global data centers. For the CDDIS, the Australian Survey and Land Information Group (AUSLIG) in Belconnen Australia, NOAA's Cooperative International GPS Network (CIGNET) Information Center (CIC) in Rockville Maryland, ESA, GFZ, the Geographical Survey Institute (GSI) in Tsukuba Japan, JPL, and NRCan make data available to the CDDIS from selected receivers on a daily basis. In addition, the CDDIS accesses the remaining two global data centers, SIO and IGN, to retrieve (or receive) data holdings not routinely transmitted to the CDDIS by a regional data center. Table 1 lists the data sources and their respective sites that are currently transferred daily to the CDDIS. These data are summarized and archived to public disk areas in daily subdirectories; the summary and inventory information are also loaded into an on-line data base. Status files are also updated reflecting the current data holdings and time delays in data delivery; these files are automatically uploaded to the IGS CBIS.

TABLE 1. Sources of GPS Data Transferred to the CDDIS

Source	Sites						No. Sites
AUSLIG	CAS1	DAV1	HOB2	MAC1			4
CIGNET	BRMU	FORT	HNPT	KELY	RCM5	SOL1	9
	USNA	WES2	WUHN				
NRCan	ALBH	ALGO	DRA0	STJO	YELL		5
ESA	KIRU	KOUR	MALI	MAS1	PERT	VILL	6
GFZ	KIT3	LPGS	POTS	ZWEN			4
GSI	TAIW	TSKB					2
IGN	ANKR	BOR1	BRUS	EBRE[1]	GRAS	GRAZ	24
	HART	HERS	IRKT	JOZE	KERG	KOSG	
	MATE	MDVO	METS	NYAL	OHIG	ONSA	
	PAMA	REYK	TROM	WETT	WTZR	ZIMM	
JPL	AOA1	AREQ	AUCK	BOGT	CARR	CASA	42
	CAT1	CHAT	CICE	CIT1	CRO1	EISL	
	FAIR	GODE	GOLD	GUAM	HARV	IISC	
	JPLM	KOKB	LBCH	MADR	MCM4	MDO1	
	NLIB	OAT2	PIE1	QUIN	SANT	SEY1	
	SHAO	SNI1	SPK1	THU1	TIDB	UCLP	
	USC1	USUD	WHC1	WHI1	WLSN	YAR1	
KOREA	TAEJ						1
SIO	MONP	PIN1	PVEP	SIO3	VNDP		5
UNAVCO	POL2						1
Totals:	**103 sites from 11 data centers**						

Notes: [1]EBRE data currently delivered by ICC but will be delivered by IGN upon resolution of communication issues.

The IGS data archive of the CDDIS consists of the GPS observation and navigation files in compressed RINEX format as well as summaries of the observation files used for data inventory and reporting purposes. These data are organized on disk by GPS day and by file type (observation, navigation, summary). Under the current ninety to one hundred station network configuration, approximately 150 days worth of GPS data are available on-line to users at one time. During 1994, the CDDIS archived data on a daily basis from an average of sixty stations; during 1995, this number increased to over ninety stations by the end of the year. Each site produces approximately 0.6 Mbytes of data per day; thus, one day's worth of GPS tracking data, including the CDDIS inventory information, totals nearly 60 Mbytes. For 1995, the CDDIS GPS data archive totaled over eighteen Gbytes in volume; this represents data from over 30K observation days. Of the ninety or more sites archived each day at the CDDIS, not all are of "global" interest; some, such as those in Southern California, are regionally oriented. The CDDIS receives data from these sites as part of its NASA archiving responsibilities.

IGS Data and Product Archive Procedures

Software was written at the CDDIS to automatically process the incoming IGS data on a daily basis. The programs are queued to run automatically at certain times of the day to check the receiving areas, i.e., the operational data center accounts on the CDDIS, for new IGS data. The new GPS data files are then processed: the data are transferred to the correct daily subdirectories on the public disk areas, the observation data are then decompressed and summarized, and finally the summary information is loaded into the CDDIS data base. The summary process performs elementary data checking and extracts information that can be used to inventory the data in the CDDIS. Figure 2 illustrates the data flow, from station to public archive on the CDDIS. Typically, the archiving routines on the CDDIS are executed several times a day for each source in order to coincide with their automated delivery processes. In general, the procedures for archiving the GPS tracking data are fully automated, requiring occasional monitoring only, for replacement data sets or re-execution because of system or network problems.

The CDDIS generates weekly reports utilizing the summary information available in the on-line data base. Additional reports summarize the GPS data on a yearly basis. The CDDIS also maintains an archive of and indices to IGS Mail and Report messages. These reports are distributed via the IGS reporting mechanisms and stored on-line for ftp download or browsing through the WWW.

The derived products from the IGS Analysis Centers are also delivered to the CDDIS, usually within seven days of the end of the observation week; the combined products produced by the IGS Analysis

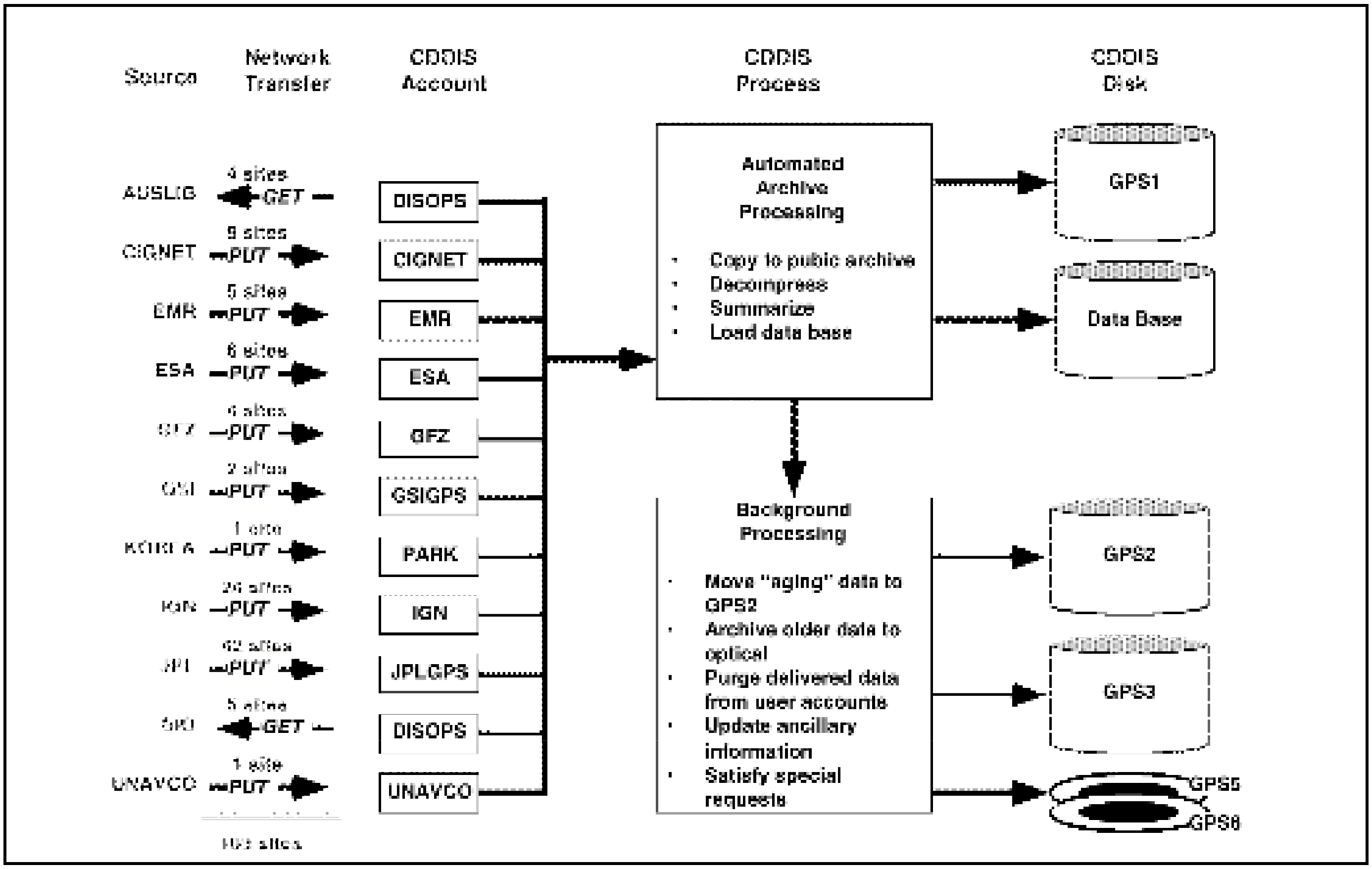

Figure 2. Flow of GPS Data from IGS Site to the CDDIS

Coordinator are available a few days following the arrival of all product files from the individual ACs, typically within ten days. Automated routines to copy the IGS products to the public archives are also executed on the CDDIS several times per day. The files from all analysiscenters as well as the combined orbit are stored on disk by GPS week. All IGS products generated since the start of the IGS test campaign in June 1992 are available on-line on the CDDIS.

Access Procedures

The CDDIS is an open archive which serves a wide user community interested in space geodesy and geodynamics data. Therefore, any interested users are permitted access to the archive of GPS data and products.

As stated previously, the data archives on the CDDIS are accessible remotely through Internet, DECnet, and dial-up phone lines. Potential users of the CDDIS are asked to request the user account name and password information since the GPS archives are not accessible through an open or "anonymous" account. The CDDIS permits both remote file transfer and direct connections through Internet (i.e., ftp or telnet) and DECnet (i.e., COPY over the network or SET HOST). Dial-up users can run KERMIT or XMODEM software on the CDDIS to upload GPS data and products to their remote hosts. General information about the CDDIS and the GPS data availability, as well as a link to the IGS CBIS and other related resources, are accessible through the CDDIS home page on the WWW.

Users interested in data from time periods currently not on-line can submit a special request to the CDDIS. The staff will then attempt to satisfy this request in the most efficient method possible. A significant amount of staff time is expended on fielding inquiries about the IGS and the CDDIS data archives as well as identifying and making data available from the off-line archives. To satisfy requests for off-line data, the CDDIS copies data from optical disk archive to an on-line magnetic disk area, or for larger requests, mount the optical disks in a scheduled fashion, coordinating with the user as data are downloaded.

Statistics On Data Flow

An important goal of the IGS is to provide analysis centers timely access to the GPS tracking data. The initial requirements stated that data from global sites was to be available for analysis through the global data centers within 72 hours of the end of the observation day. The IGS Pilot Service tightened this requirement and had requested that data be made available within 48 hours. To meet this objective it is imperative that regional data collection centers retrieve data from the receivers as regularly and in as automated a fashion as possible. Data retrieval and transmission must be routine and programmed to allow for consistent flow of data on a daily basis. Upon arrival at the CDDIS, these data must be processed quickly and made available to the user community. The CDDIS typically processes data within hours of receipt via automated procedures.

A majority of the data delivered to and archived on the CDDIS since the start of the IGS operational service in 1995 were available to the user community within 24 hours after the observation day. Figure 3 shows that seventy-five percent of the data from all sites delivered to the CDDIS were available within one day of the end of the observation day; nearly ninety percent were available within two days. Figure 4 shows these statistics in hours for the current set of “global stations”, those stations processed by three or more IGS Analysis Centers on a daily basis. As can be seen, approximately eighty percent of the data are available to users within 36 hours. These statistics were derived from the results of the daily archive report utilities (Gurtner and Neilan, 1995) developed by the IGS Central Bureau and executed several times each day on the CDDIS. The IGS tracking stations and data centers hope to further improve these statistics by testing new procedures to push data to the global data centers even faster. This already remarkable statistic would not have been possible, however, without the adoption of standards in data formatting and compression.

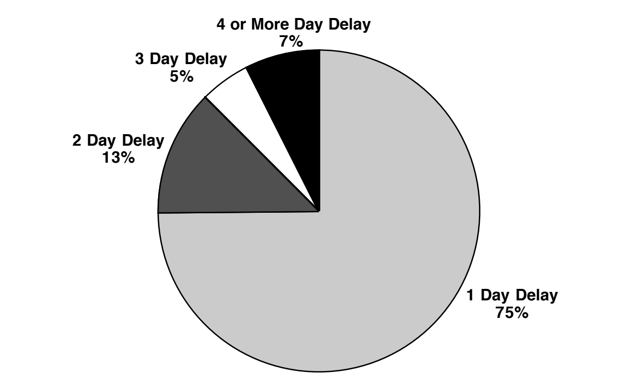

Figure 3. CDDIS GPS Data Availability Statistics (All Stations)

The chart shown in Figure 5 summarizes the monthly usage of the CDDIS for retrieval of GPS data during 1994 and 1995. The data reflected in this figure was produced daily by automated routines that peruse the log files created by each network access of the CDDIS. In total, nearly 640K files where transferred, amounting to approximately 160 Gbytes in volume for 1994. Averaging these figures for that year, users transferred 53K files per month, totaling 13 Gbytes in size. In 1995, nearly 1.25 million files were transferred totaling 320 Gbytes in volume. Users transferred on average 104K files, 27 Gbytes in volume, per month in 1995. The chart in Figure 6 details the total number of host accesses per month with the number of distinct (i.e., unique) hosts (i.e., users) per month shown as an overlay. Here, a host access is defined as an initiation of an ftp or remote DECnet copy session; this session may list directory contents only, or may transfer a single file or many files. Figure 7 illustrates the profile of users accessing the CDDIS during 1995; these figures represent the number of distinct hosts in a particular country or organization. Nearly half of the users of GPS data available from the CDDIS come from U.S. government agencies, universities, or corporations. As can be seen, the system usage continues to grow as GPS technology is utilized by an increasingly diverse user community.

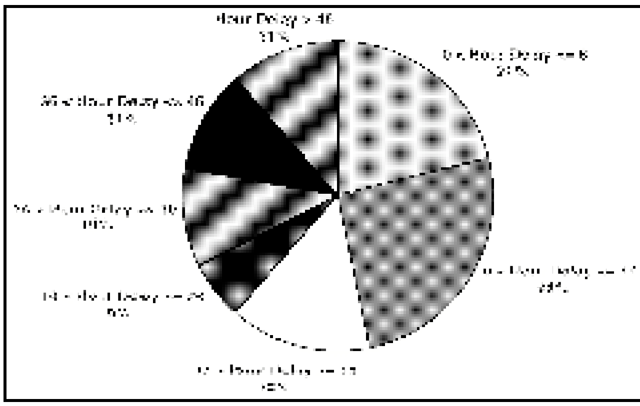

Figure 4. CDDIS GPS Data Availability Statistics (Global Stations Only)

CONCLUSIONS

The IGS has shown that near real-time availability of GPS data is a reality. The hierarchy that was established in both tracking stations and data centers has streamlined data flow, with the global data center serving as the main interface between the data and the user. Standards in data formats and compression software are essential to the successful operation of the IGS. Furthermore, automation in data archiving and retrieval is a necessity in order to provide near real-time access to data over an extended period of time. The IGS has found, however, that some data flow paths require optimization in order to prevent the flow of redundant data to data centers, as well as scheduling of data deliveries to avoid congestion over electronic networks. The IGS would also like to encourage the stations and operational data centers to upload the data to regional and global data centers even faster than the current 36 hour average. This schedule would permit the analysis centers to produce more rapid orbit products.

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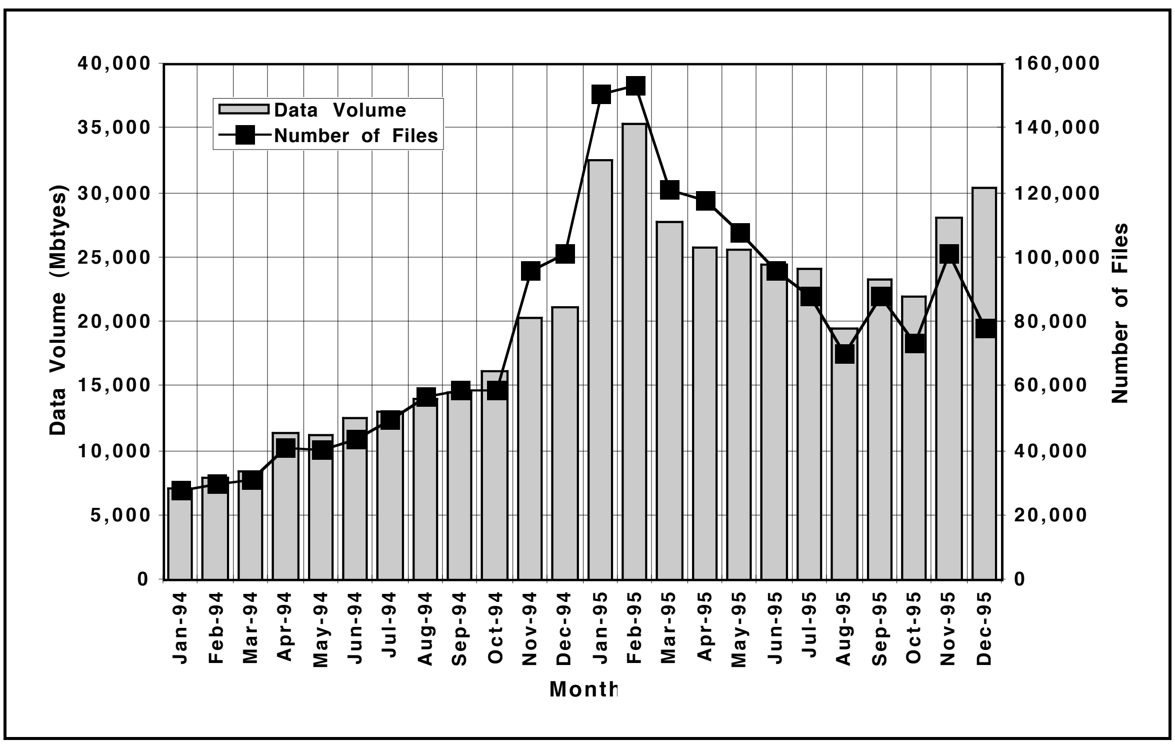

Figure 5. Data Volume Number and of Files Transferred to/from the CDDIS during 1994 and 1995 in Support of the IGS

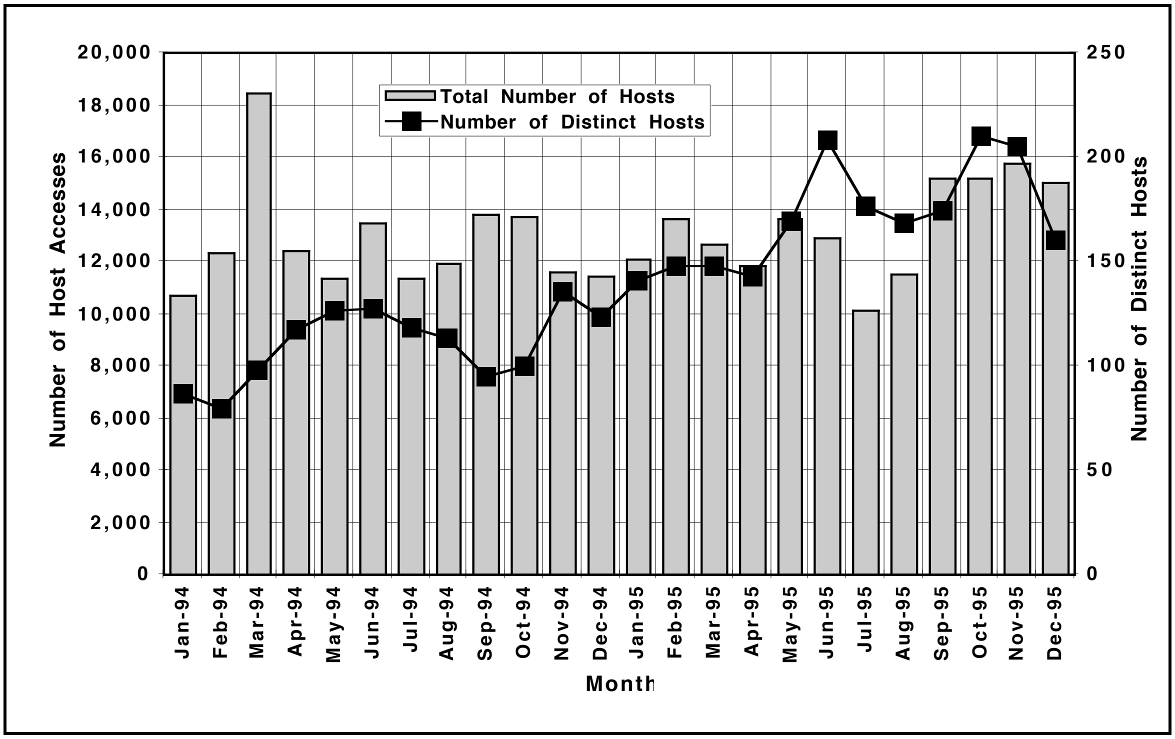

Figure 6. Number of Host Access to the CDDIS during 1994 and 1995 in Support of the IGS

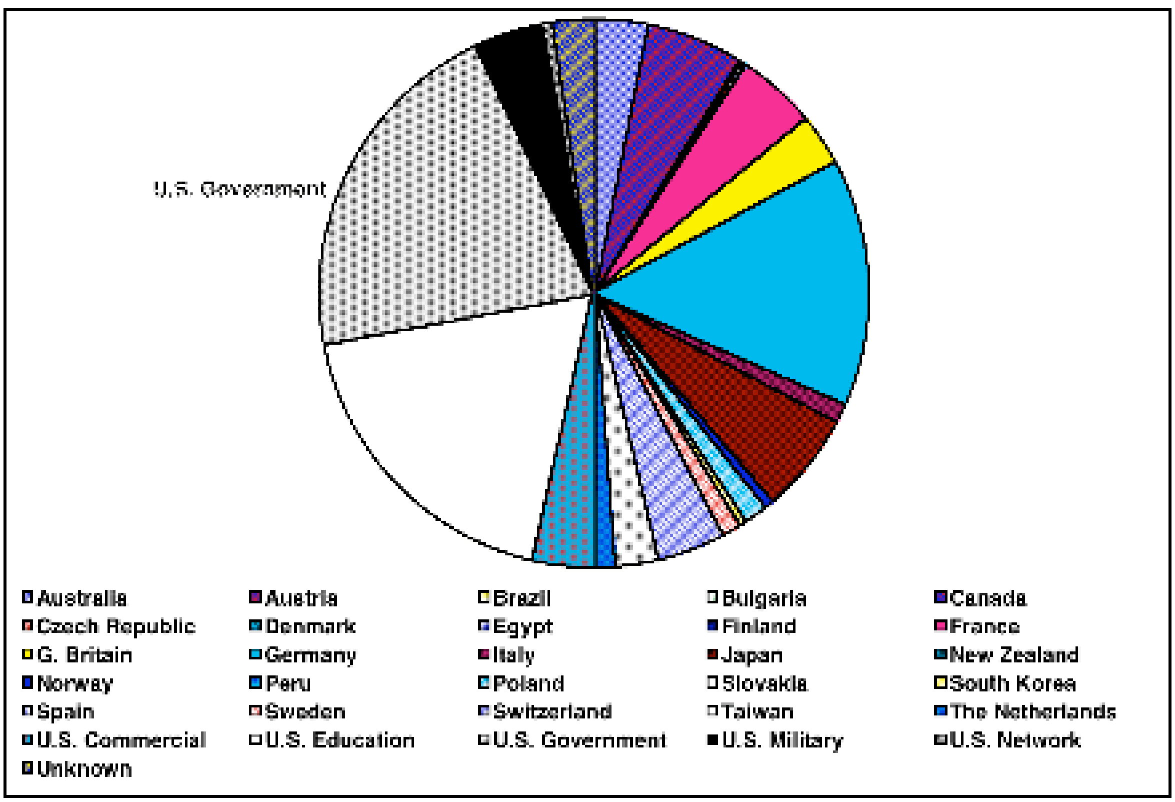

Figure 7. Distribution of IGS Users of the CDDIS