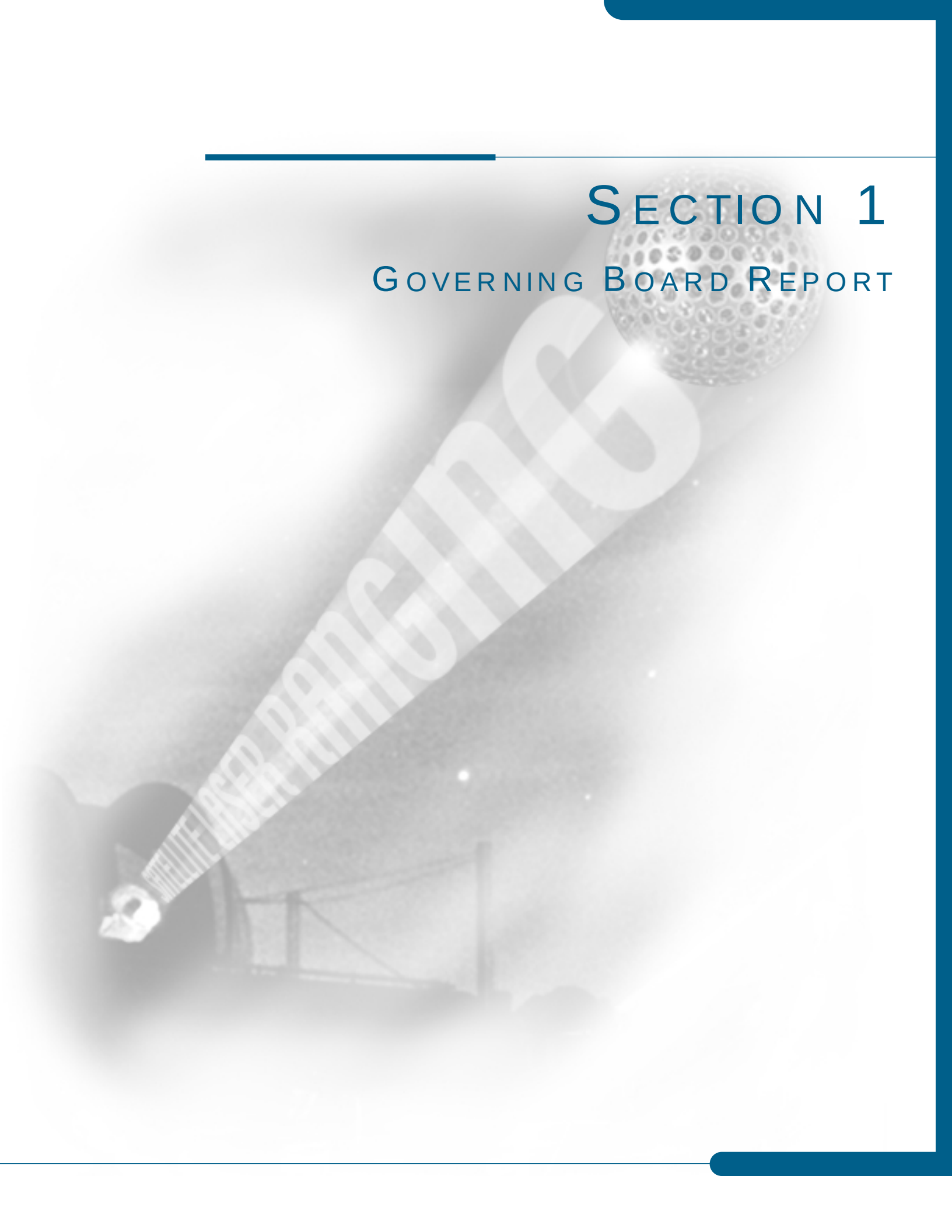
SECTION 1

GOVERNING BOARD REPORT



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SECTION 1. GOVERNING BOARD REPORT

John Degnan, *National Aeronautics and Space Administration*

1.1 OVERVIEW OF SLR DURING 1999

Through international partnerships, the global distribution of SLR stations is slowly improving, especially in the Southern Hemisphere. NASA, working in cooperation with CNES and the University of French Polynesia, has moved MOBLAS-8 to the island of Tahiti and established SLR operations there. In late spring of 2000, MOBLAS-6 will move to Hartebeesthoek in South Africa (which already has VLBI, GPS, and DORIS facilities) to create the first Fundamental Station on the African continent. NASA and the South African Foundation for Research Development (FRD) will jointly sponsor operations in Hartebeesthoek. Recently, the Australian Survey and Land Information Group (AUSLIG), in partnership with NASA, took over the operations of the Yarragadee SLR system MOBLAS-5. Negotiations between NASA and the University of La Plata are ongoing to establish a new co-sponsored site in Argentina using the TLRS-4 system. An SLR system for a Chinese-Argentinean SLR station at the San Juan Observatory in western Argentina is being prepared by the Beijing Astronomical Observatory. The BKG in Germany has announced that another South American site in Concepcion, Chile, has been selected for their multi-technique Totally Integrated Geodetic Observatory (TIGO). This installation, scheduled for Spring 2001, will be the first Fundamental Station in South America following the termination of SLR and VLBI operations in Santiago, Chile. Thus, within a period of only one year, the number of SLR stations in South America may grow from one (Arequipa, Peru) to four. Operations at the new Australian station on Mt. Stromlo, which replaced the older Orroral site near Canberra, are going extremely well in terms of both data quantity and quality. Thus, we anticipate as many as eight SLR stations operating in the Southern Hemisphere by late 2001 compared to four today.

The Peoples' Republic of China has made a substantial investment in SLR stations and technology over the past two years. The SLR station in Kunming was recently re-established, bringing the total number of Chinese permanent sites to five (Shanghai, Changchun, Wuhan, Beijing, and Kunming). Under the technical leadership of Dr. Yang FuMin and with international cooperation, the data quality and quantity from the Chinese stations continue to improve, most notably at Changchun. In addition, the Wuhan SLR station has been recently moved to a site outside the city where there is significantly better atmospheric seeing, and construction is nearing completion on two mobile Chinese SLR stations which will occupy additional sites within China to support regional measurement programs. A modern Russian SLR station near Moscow started operation in 1999, and permission is being requested from the Russian government to integrate it into SLR operations. A second new Russian SLR station is under construction in the Altay region (see the Russian Network report, Section 4.3.1).

Elsewhere in Asia, the news is not so good. The Communications Research Laboratory (CRL) in Tokyo appears to be in the process of shutting down routine operations at its four Keystone sites by September 2000. Fortunately, the Simosato site, operated by the Japanese Hydrographic Institute, will continue to provide data in this important region.

The Japanese Space Agency (NASDA) is also planning to develop an SLR system for deployment on Tanga Shima Island in support of the ADEOS-III satellite. Scheduled for completion in early 2003, the system will undergo colocation test at GSFC prior to deployment.

Sites in the United States and Europe have been relatively stable over the past year with efforts continuing to improve overall performance or reducing the cost of SLR operations (e.g., NASA's SLR2000 system). One notable event is the recent installation of a new state-of-the-art system with lunar capability in Matera, Italy. For more detail on the global network status, the reader is referred to the individual subnetwork reports. A map of current and future permanent SLR sites is given in Figure 1.1-1.

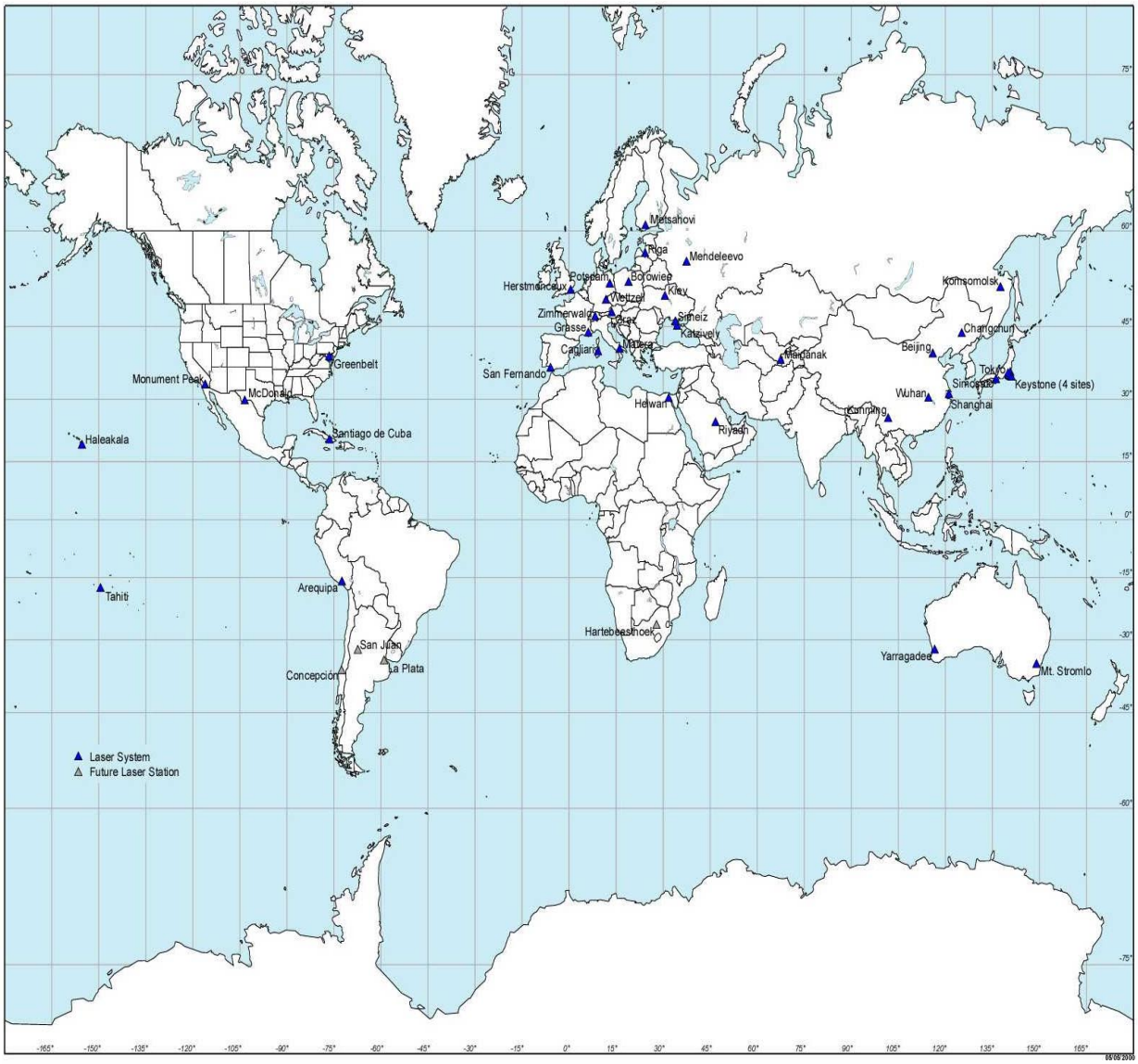

Figure 1.1-1 Current and future permanent SLR sites

The number of spacecraft tracked by SLR continues to grow at an accelerating rate. Within the next two year period, between 10 and 12 missions are likely to request SLR support (see Section 3.1). Interest in SLR has clearly been heightened by several recent failures of microwave navigation devices.

New applications of SLR data came to light during 1999. It was recently learned that all of the current constellation of approximately 20 SLR satellites are routinely tracked by ground-based radars assigned to keep track of space debris. The precise SLR orbital ephemerides are used operationally as "ground truth" to calibrate the ground radars, resulting in greatly improved trajectories for thousands of pieces of space debris, which could endanger the Space Shuttle, the International Space Station, as well as unmanned spacecraft. The SLR-calibrated data, with its tighter error bars, has helped to dramatically reduce the number of collision-avoidance maneuvers required by manned and unmanned spacecraft.

The year 1999 also marks the first full operating year for the new International Laser Ranging Service (ILRS). From my perspective as the first Governing Board Chairman, the establishment of the ILRS appears to have re-energized the satellite and lunar laser ranging communities with a heightened spirit of international cooperation and has provided a true focal point for a user community seeking SLR services.

1.2 ORIGIN AND ESTABLISHMENT OF THE ILRS

For many years, international SLR activities had been organized under the Satellite and Lunar Laser Ranging (SLR/LLR) Subcommission of the CSTG. The Subcommission provided a venue for organizing tracking campaigns, adopting data formats, reporting on network status, and sharing technology. However, membership and commitment to the Subcommission were informal, and the main focus was on systems and data acquisition rather than on the production of consistent and high quality data products for end users.

With strong encouragement from Gerhard Beutler, then President of the CSTG, the CSTG SLR/LLR Subcommission Steering Committee undertook the formation of the ILRS. A draft Terms of Reference, detailing the mission and the organization of the new service was written and accepted by the CSTG Executive Board in May 1997. A joint CSTG/IERS Call for Participation in the new ILRS was drafted by the SLR/LLR Subcommission Chairman, John Degnan, and the SLR Representative on the IERS Directing Board, Bob Schutz, and issued on 24 January 1998. Institution proposals in response to the Call were evaluated at a special meeting of the CSTG SLR/LLR Subcommission Steering Committee and subsequently approved by both the CSTG Executive Board and the IERS Directing Board on 18 April 1998. ILRS approval was granted to 46 tracking stations, 4 Operations Centers, 3 Analysis Centers, 4 Lunar Analysis Centers, 18 Associate Analysis Centers, 2 Global Data Centers and 1 Regional Data Center. The Central Bureau was established at the NASA Goddard Space Flight Center with John Bosworth as Director and Michael Pearlman of the Harvard-Smithsonian Center for Astrophysics as Secretary.

Appointments and elections of Governing Board members were carried out during the summer of 1998. On 22 September 1998, the CSTG SLR/LLR Subcommission was officially disbanded, and replaced by the First ILRS General Assembly, held in conjunction with the 11th International Workshop on Laser Ranging in Deggendorf, Germany. The first ILRS Governing Board meeting was held on 25 September 1998; John Degnan was elected by the Board as Chairperson, and the Coordinators and Deputy Coordinators for the various Working Groups were also selected.

In July 1999, the Directing Board of the International Association of Geodesy (IAG), meeting at the IUGG Conference in Birmingham, UK, established the ILRS as an official Service of the IAG, on an equal par with the other three IAG Services - the International Earth Rotation Service (IERS), the International GPS Service (IGS), and the newly established International VLBI Service (IVS).

1.3 ORGANIZATION OF THE ILRS

The ILRS accomplishes its mission through the following permanent components:

- Tracking Stations and Subnetworks
- Operations Centers
- Global and Regional Data Centers
- Analysis, Lunar Analysis, and Associate Analysis Centers
- Central Bureau (Director, J. M. Bosworth; Secretary, M. Pearlman)
- Governing Board and Working Groups (Chairperson, J. J. Degnan)

Tracking Stations range to a constellation of approved satellites (including the Moon), contained in a list of satellites compiled and approved by the ILRS Governing Board, through the use of state of the art laser tracking equipment and data transmission facilities which allow for a rapid (at least daily) data transmission to one or more Operations and/or Data Centers (see below). Tracking Stations may be organized into regional or institutional **subnetworks**.

Operational Centers are in direct contact with tracking sites organized in a subnetwork. Their tasks include the collection and merging of data from the subnetwork, initial data quality checks, data reformatting into a uniform format, compression of data files if requested, maintenance of a local archive of the tracking data, and the electronic transmission of data to a designated ILRS Data Center. Operational Centers also provide the tracking sites with sustaining engineering, communications links, and other technical support. In addition, Operational Centers can perform limited services for the entire network. Individual tracking stations can also perform part or all of the tasks of an Operational Center themselves.

Global Data Centers are the primary 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, meteorological data, site specific engineering data, etc.
- Receive/retrieve, archive and provide on-line access to ILRS scientific data products received from the Analysis Centers
- Backup and secure ILRS data and products

Regional Data Centers reduce traffic on electronic networks. They collect reformatted tracking data from Operational Data Centers and/or individual tracking stations, maintain a local archive of the data received and, in some cases, transmit these data to the Global Data Centers. Regional Data Centers may also meet the requirements for Operational Centers and Global Data Centers (as defined in the previous and following paragraphs) of strictly regional network operations and

duplicate activities of Global Data Centers to facilitate easy access to the information and products.

Analysis Centers receive and process tracking data from one or more data centers for the purpose of generating ILRS products. The Analysis Centers are committed to produce the products, without interruption, at an interval and with a time lag specified by the Governing Board to meet ILRS requirements. The products are delivered to the Global Data Centers, to the IERS (as per bilateral agreements), and to other bodies, using designated standards. At a minimum, Analysis Centers must process the global LAGEOS-1 and LAGEOS-2 data sets and are encouraged to include other geodetic satellites in their solutions. The Analysis Centers provide, as a minimum, Earth orientation parameters on a weekly or sub-weekly basis, as well as other products, such as station coordinates, on a monthly or quarterly basis or as otherwise required by the IERS. Analysis Centers also provide a second level of quality assurance on the global data set by monitoring individual station range and time biases via the fitted orbits (primarily the LAGEOS 1 and 2 satellites) used in generating the quick-look analysis results.

Associate Analysis Centers are organizations that produce special products, such as satellite predictions, time bias information, precise orbits for special-purpose satellites, station coordinates and velocities within a certain geographic region, or scientific data products of a mission-specific nature. Associate Analysis Centers are encouraged to perform additional quality control functions through the direct comparison on individual Analysis Center products and/or the creation of "combined" solutions, perhaps in combination with data from other space geodetic techniques (e.g. VLBI, GPS, GLONASS, DORIS, PRARE, etc.), in support of the IERS International Terrestrial Reference Frame (ITRF) or precise orbit determination. Organizations with the desire of eventually becoming Analysis Centers may also be designated as Associate Analysis Centers by the Governing Board until they are ready for full scale operation.

Lunar Analysis Centers process normal point data from the Lunar Laser Ranging (LLR) stations and generate a variety of scientific products including precise lunar ephemerides, librations, and orientation parameters which provide insights into the composition and internal makeup of the Moon, its interaction with the Earth, tests of General Relativity, and Solar System ties to the International Celestial Reference Frame.

The **Central Bureau** (CB) is responsible for the daily coordination and management of the ILRS in a manner consistent with the directives and policies established by the Governing Board. The primary functions of the CB are to facilitate communications and information transfer within the ILRS and between the ILRS and the external scientific community, coordinate ILRS activities, maintain a list of satellites approved for tracking support and their priorities, promote compliance to ILRS network standards, monitor network operations and quality assurance of data, maintain ILRS documentation and databases, produce reports as required, and organize meetings and workshops.

The **Governing Board** (GB) consists of 16 members - 3 are ex-officio, 7 are appointed (2 from each major network - NASA, EUROLAS, and WPLTN - and one IERS appointee), and 6 members are elected by their peer groups (2 Analysis, 1 Data Center, 1 Lunar, and 2 At-Large Representatives). All GB members serve on at least one of four Standing **Working Groups** (WG), led by a Coordinator and Deputy Coordinator. The four Standing Working Groups are: **(1) Missions, (2) Networks and Engineering, (3) Analysis, and (4) Data Formats and Procedures.** The GB may also create Temporary or Ad-Hoc Working Groups when the need

arises. In 1999, an **Ad-Hoc Signal Processing Working Group** was assembled, under the leadership of Graham Appleby, to provide improved satellite range correction models to the analysts. Table 1.4-1 lists the current GB membership, their nationality, and special function (if any) on the Governing Board.

Name	Position	Place of Residence
Bob Schutz	Appointed, IERS Representative to ILRS	USA
David Carter	Appointed, NASA	USA
Francois Barlier	Elected, At-Large, Missions WG Deputy Coordinator	France
Hermann Drewes	Ex-Officio, CSTG President	Germany
Hiroo Kunimori	Appointed, WPLTN, Missions WG Coordinator	Japan
John Bosworth	Ex-Officio, Director ILRS Central Bureau	USA
John Degnan	Appointed, NASA, Governing Board Chairperson	USA
John Luck	Elected, At-Large, Data Formats & Procedures WG Coordinator	Australia
Michael Pearlman	Ex-Officio, Secretary, ILRS Central Bureau	USA
Peter Shelus	Elected, Lunar Rep., Analysis WG Deputy Coordinator	USA
Richard Eanes	Elected, Analysis Rep.	USA
Ron Noomen	Elected, Analysis Rep., Analysis WG Coordinator	Netherlands
Werner Gurtner	Appointed, EUROLAS, Networks & Eng. WG Coordinator	Switzerland
Wolfgang Schlueter	Appointed, EUROLAS, Networks & Eng. WG Deputy Coord.	Germany
Wolfgang Seemueller	Elected, Data Centers Rep., Data Formats & Procedures WG Deputy Coordinator	Germany
Yang FuMin	Appointed, WPLTN	PRC

Table 1.3-1: Current ILRS Governing Board

1.4 INTERFACE WITH OTHER ORGANIZATIONS

Although the ILRS is no longer a sub-Commission of the CSTG, the ILRS continues to maintain close ties with its former parent organization. Hermann Drewes has recently replaced Gerhard Beutler as CSTG President following Gerhard's elevation to IAG Vice-President. The chairpersons of the three IAG space geodetic services - IGS, ILRS, and IVS - all serve on the CSTG Executive Board. This enhances the coordination and cooperation between the various space geodetic communities.

During the past year, the IGS solicited and received support from the ILRS in two IGEX campaigns designed to evaluate the quality of GLONASS orbits as determined by microwave and optical techniques. As many as nine GLONASS satellites (3 in each of 3 planes) were tracked during the first campaign; by mutual agreement, this was later reduced to 3 satellites during the extended campaign which continues today. Similarly, in January 2000, a Joint IVS/IGS/ILRS Working Group was formed, under the leadership of the IVS, to study anomalies in GPS orbits using a combination of GPS, VLBI, and SLR tracking. Richard Biancale and Graham Appleby were recommended by the ILRS Analysis WG to serve as ILRS representatives to the Joint Working Group and approved by the full Board.

The ILRS also maintains close ties with the International Earth Rotation Service (IERS), which is a prime user of laser ranging data in maintaining the Terrestrial Reference Frame. The Analysis Coordinator (Ron Noomen) on the ILRS Governing Board is a voting member of the IERS Directing Board, and an SLR Representative (Bob Schutz) is appointed by the IERS to serve as a voting member of the ILRS Governing Board. The Lunar Representative (Peter Shelus), who also serves as the Deputy Coordinator of the Analysis WG, is an invited attendee at IERS Directing Board meetings and can vote in the Analysis Coordinator's absence.

A diagram showing the internal structure of the ILRS and its interfaces with key organizations is shown in Table 1.3-1.

1.5 CURRENT STATUS AND FUTURE PROSPECTS

The first operating year of the International Laser Ranging Service (ILRS) has been an active one. While all of the ILRS institutions have worked hard to meet the demanding new requirements, we would like to highlight two areas that we believe will have a major impact on SLR operations, i.e. the Working Groups and the Central Bureau. These groups have submitted more detailed individual reports elsewhere in this volume so only brief will be given.

WORKING GROUPS

Working Groups (WG's) were originally created to serve as the primary foci for Governing Board activities. Coordinators and Deputy Coordinators for the four Standing Working Groups were chosen from among the Governing Board members at their first meeting in Deggendorf. At our Second General Assembly in den Haag, Netherlands, our first Ad-Hoc (temporary) Working Group on Signal Processing was created and placed under the direction of Graham Appleby. We are very pleased to report that all of these WG's have attracted talented people from the general ILRS membership who have contributed greatly to the success of these efforts.

- **Missions (Coordinator: Hiroo Kunimori, Japan)**
  - This group has formalized and standardized the required mission documentation needed to obtain ILRS approval for new missions and campaigns.
  - These new procedures have been applied to several ongoing campaigns and upcoming missions such as CHAMP.
  - The group continues to work with new missions and campaign sponsors to develop and finalize tracking plans and to establish recommended tracking priorities.
- **Data Formats and Procedures (Coordinator: John Luck, Australia)**
  - This very active group has been tightening up existing formats and procedures, rectifying anomalies, providing standardized documentation via the Web site, and setting up study subgroups and teams to deal with more complicated issues.
  - This group also recommended the establishment of the Ad-Hoc Signal Analysis WG.
- **Networks and Engineering (Coordinator: Werner Gurtner, Switzerland)**
  - This group has developed a new ILRS Site and System Information Form which is being distributed to the stations in an effort to update the engineering database.
  - The group has provided a new online link analysis capability for computing mean signal strengths expected from individual stations on different satellites.

  - The group continues to add to the CB technology database and, with the help of Ulrich Schreiber (Germany), organized a successful ILRS Calibration Workshop in Florence last September.

- **Analysis (Coordinator: Ron Noomen, The Netherlands)**
  - This group has been working with 13 different ILRS analysis centers to achieve a unified set of analysis products presented in the internationally accepted SINEX format. Three associated pilot programs are underway.
  - To plan and implement these programs, the Analysis WG conducted a 3 day workshop in Frankfurt, Germany, in January 2000 and will conduct another in Delft, The Netherlands, in May. They also recommended the ILRS representatives to the Joint IVS/IGS/ILRS Working Group on GPS Anomalies.
- **Signal Processing (Coordinator: Graham Appleby, United Kingdom)**
  - This Ad-Hoc group is computing Center-of-Mass distributions for a number of satellites and developing recommendations for computing satellite corrections for different ranging hardware configurations.

CENTRAL BUREAU

The Central Bureau (CB) has also been extremely active. In addition to providing effective communications to, and coordinating the various activities of, the various elements of the ILRS, the CB has been actively providing new conveniences (such as targeted email exploders) and adding to the technical and scientific database. The information available via the ILRS Web Site has grown enormously during the past year, and many new links to related organizations and sites have been established. The site provides details and photographic material on the ILRS, the satellites and campaigns we support, individual SLR station characteristics, a scientific and technical bibliography on SLR and its applications, current activities of the Governing Board Working Groups and Central Bureau, meeting minutes and reports (including annual reports), tracking plans, etc. A new ILRS Reference Card was recently distributed to all ILRS Associates and Correspondents of record to provide easy online access to much of this material and to targeted email exploders. In coming months and years, we expect much more technical material and reports to be made available online with an enhanced search capability to quickly isolate more specific material of interest.

FIFTH ILRS GENERAL ASSEMBLY IN MATERA

The Fifth ILRS General Assembly will be held in conjunction with the 12th International Workshop on Laser Ranging to be held in Matera, Italy, during the week of November 13-17, 2000. The 12th SLR Workshop is sponsored by the Centro Geodesia Spaziale of the Agenzia Spaziale Italiana. The Program Chair, Dr. Giuseppe Bianco, will proudly treat attendees to a tour of the new lunar-capable Matera Laser Ranging Observatory (MLRO) and its state-of-the-art equipment. The precise date, time, and location of the General Assembly and the program agenda will be posted on the ILRS Web Site and distributed to all ILRS Associates and Correspondents via SLRmail when the information becomes available.

A new Governing Board will be installed at the Matera workshop. Elections will be held during the Summer of 2000 via E-mail as in the past election. At-Large members will again be elected last. Prior to the elections, the subnetworks and the IERS will be given the opportunity to reconfirm their current representatives or appoint new ones.

Prior General Assemblies were held in:

- Deggendorf, Germany, September 1998 (11th Workshop on Laser Ranging)
- Den Haag, Netherlands, April 1999 (EGS Symposium)
- Florence, Italy, September 1999 (Europto Laser Radar Conference)

Reports on ILRS meetings are routinely available online at the ILRS Web Site.

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