INTERNATIONAL LASER RANGING SERVICE

2000

ANNUAL REPORT

September 2001

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NASA/TP—2001-209987

Available From:

NASA Center for Aerospace Information
7121 Standard Drive
Hanover, MD 21076-1320
Price Code: A17

National Technical Information Service
5285 Port Royal Road
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Price Code: A10

PREFACE

The 1999 Annual Report for the International Laser Ranging Service (ILRS), the first since the inception of the service in late 1998, was published as a reference to its organization and its components within the International Geodetic Community. This second Annual Report, for the year 2000, is provided as an annual update of the activities and plans for the service and its entities.

The content of this Annual Report also appears on the ILRS website at:

http://ilrs.gsfc.nasa.goc/ar2000_contents.html

This book and the website are organized as follows:

The first section of the Annual Report contains general information about the ILRS, it's mission, structure and Governing Board. Dr. Hermann Drewes' introductory remarks and the ILRS Chairman's report give a brief background and history of the ILRS and an overview of its organization.

- Section 1, the Governing Board Report, provides an overview of the ILRS, a brief history of its origin and establishment, the contributions that it provides to the scientific community, its interface with other organizations and a view on future prospects.
- Section 2, the Central Bureau Report, provides reports in the current status of Central Bureau activities, mission priorities, network campaigns, upcoming missions, the ILRS website, Network performance evaluations, and a report from the ILRS Science Coordinator.
- Section 3 includes the Working Group Reports, including accomplishments during the last year, and activities underway, as well as those planned for next year. The Working Groups have originated and developed many standards and procedures that have been implemented by the service.
- Sections 4, 5 and 6 include the Network, Operation Center and Data Center Reports. These sections provide the status of the data chain from the point of acquisition through archiving.
- Section 7 includes the Reports for the SLR Analysis and Associate Analysis Centers, as well as the LLR Analysis Centers. These reports include information on the data products generated by each, their computational capabilities and facilities, their personnel and their future plans.

The last section provides ILRS reference material: the Terms of Reference, the website Reference Card and Site Map,the Station Performance Report Card for 2000, a list of institutions contributing to this Annual Report, the list of ILRS Associate Members, a complete list of the ILRS components and a list of Acronyms.

The ILRS 2000 Annual Report will be a valuable reference to measure the progress of the ILRS and its components during the year, and a means to spell out some of the key items that need to be addressed in the future to make the ILRS a more effective service for the user community.

Acknowledgements

The editor would like to acknowledge the essential contributions of the following people to the preparation of the ILRS 2000 Annual Report:

- Carey Noll and Van Husson assembled many of the charts and figures for the report.
- Mark Torrence helped to edit the text and formatted and assembled the document.
- John Hazen designed the cover art and the layout for the color pages of the report.

Finally I would like to thank all of the ILRS colleagues who provided their contributions to the Annual Report.

Mike Pearlman
Secretary, ILRS Central Bureau

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The ILRS:

THE ILRS –AN IMPORTANT SERVICE FOR GEODETIC RESEARCH AND THE TERRESTRIAL REFERENCE FRAME

The International Laser Ranging Service (ILRS), in operation since autumn 1998, is one of the younger services of the International Association of Geodesy (IAG). This might be astonishing because Satellite Laser Ranging (SLR) is employed in geodesy for more than 30 years. The first great success of SLR had already evolved in the 1970's, when global tectonic plate motions were measured for the first time by geodetic methods with the necessary accuracy using LAGEOS Laser ranging. In the 1980's, Lunar Laser Ranging (LLR) provided the basis for a more precise determination of the motion of the moon, and in the early 1990's a considerable improvement of Earth gravity field models was achieved with SLR tracking of a large number of high and low orbiting satellites carrying Laser reflectors. So, what was the reason to wait until 1998 to install the ILRS in the IAG, and what is the outcome of the new service?

At the beginning of the geodetic SLR observations, the coordination of the measurements needed for satellite orbit determination and point positioning at the Earth's surface was mainly done within international projects, the most important being NASA's Crustal Dynamics Project (CDP). The CDP not only provided the global distribution of SLR observatories, it also stimulated various analysis groups to derive benefit from the challenges offered by the new technique. Many software packages for SLR data processing were developed during this time.

Above all, however, operational data handling systems were implemented for the CDP at the Crustal Dynamics Data and Information System (CDDIS) at NASA and the European Laser Consortium's Data Center (EDC) at DGFI. There was no urgent need for a detailed management of tracking activities such as priority lists and observation splitting, because there were only a few satellites available for SLR at the time. The observations were performed at an R&D level with emphasis on instrumental development and basic research on precise orbit determination and three-dimensional positioning. The results were exchanged within the projects and at international symposia. These results, however, improved so dramatically that SLR played a dominant role in geodesy during the 1980's and 1990's. It was the great success of the SLR scientific community in using the data that led to the necessity of a service.

Based on this success, many satellites with laser reflectors were launched for a broad spectrum of scientific purposes increased more and more. Today there are nearly 50 of those targets on artificial satellites and on the moon, and more than 20 of them are routinely tracked. Due to these expanding activities, the need became urgent for operational management of the observation activities, the data handling, and the data processing. Up to this point there was no formal mechanism for the scientists to come up with an operational structure for the coordination of activities required for routine use of laser ranging. It was mandatory to select a reasonable subset of targets among the large number of available satellites and lunar reflectors, to give priorities in the tracking, and to organize the necessary data handling and processing in order to guarantee the required product generation at a high level of accuracy.

The ILRS faced these requirements when setting up its organization. The first two years of the new service have been characterized by purposeful work toward a sophisticated structure and an effective operation. When we look today to the individual components of the Service, we find professional management at all levels from the Governing Board, the Central Bureau, the Observatories, the Data and the Analysis Centers, and the various Working Groups.

The satellite mission control is working routinely and effectively. It is accepted by all international institutions (scientific institutes and agencies) that the ILRS manages all the international SLR activities. The ILRS Governing Board decides

which satellites are added or deleted from the tracking list. The data flow between the observatories, the Data Centers and the Analysis Centers is very well established, and it is working well even in critical periods. The data analysis is on the way toward a routine product generation (Earth Orientation Parameters, EOP, Station Coordinates, SC, and Station Velocities, SV) at regular time intervals. The SLR products are required and used in more applications than ever before. They form the basis within the International Terrestrial Reference Frame (ITRF), for geophysical research in geodynamics, for the determination of the Earth's gravity field and Earth rotation.

SLR and the ILRS have a unique position in space geodesy and in the realization of the terrestrial reference frame. It is the only technique that provides directly the precise geocentric coordinates for points at the Earth's surface and for the Earth's center of mass. It has a long history and provides therewith a long time series of observations and derived parameters (EOP, SC, SV). It contributes significantly to the determination of the Earth's gravity field and to the establishment of a unique global height reference system, because it allows a more precise height determination than all the other geodetic space techniques. The scale of geodetic reference frames is derived in large part from SLR.

The present Annual Report is a document of the great success of the ILRS. It includes the most valuable information for all geodesists and geoscientists involved in space research. The international community is very much obliged to all the persons active within the ILRS. They did an extremely good job and I hope and I wish that this excellent work may be continued at the same level of quality in the future.

Hermann Drewes

President of the Commission on International Coordination of Space Techniques for Geodesy and Geodynamics (CSTG)

Chairman's Remarks

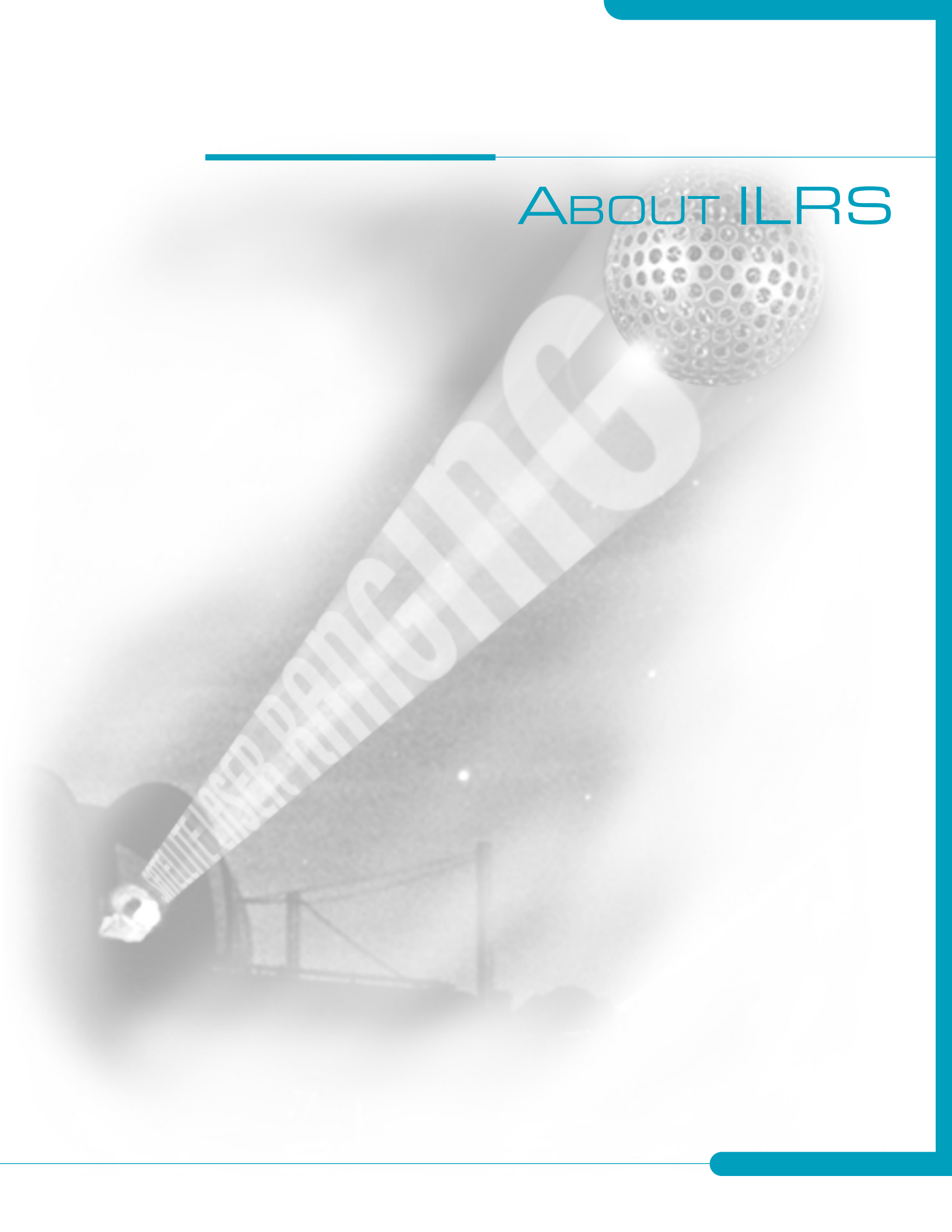
I am pleased to present to our ILRS Associates our second Annual Report covering ILRS activities in the millennium year 2000. The 1999 ILRS Annual Report is also available as hard copy from the Central Bureau or online at the ILRS Web Site. Our Secretary, Mike Pearlman, is to be especially commended for his doggedness and determination in bringing these reports together.

The International Laser Ranging Service (ILRS) was created on 22 September 1998 at the 11th International Workshop on Laser Ranging in Deggendorf, Germany. The Central Bureau (CB) was established at the NASA Goddard Space Flight Center with John Bosworth and Mike Pearlman respectively serving as Director and Secretary. In July 1999, the ILRS was elevated to the rank of an IAG Service by the IAG Directing Board, on an equal footing with the established International GPS Service (IGS) and the newly created International VLBI Service (IVS), with close ties and representation on the International Earth Rotation Service (IERS) Directing Board. New Governing Board elections were held last summer and the new Board was installed in November 2000 at the 12th International Workshop on Laser Ranging in Matera, Italy. Due to recent changes in the makeup of the IERS, the ILRS representation on the IERS Directing Board was increased from one to two voting members. The ILRS Governing Board has designated our Analysis Coordinator, Ron Noomen, and our Lunar Laser Ranging Representative, Peter Shelus, as the official ILRS delegates to the IERS Directing Board.

In creating the structure for the new ILRS, the Working Groups (WG's) were intended to be the focal points for most Governing Board activities. The WG's recommend policy or actions in their areas of responsibility which are then voted on by the full Governing Board. They are also responsible for recommending and/or providing additional material to the Central Bureau for inclusion in the knowledge databases. I am pleased to report that the WG's continue to attract talented people from the general ILRS membership who have contributed greatly to the success of these efforts. The Missions WG has formalized and standardized the mission documentation required to obtain ILRS approval for new missions and campaigns. They continue to work with new missions and campaign sponsors to develop and finalize tracking plans and to establish recommended tracking priorities. The Data Formats and Procedures WG has been tightening up existing formats and procedures, rectifying anomalies, providing standardized documentation through the web site, and setting up study subgroups and teams to deal with more complicated or interdisciplinary issues. The Networks and Engineering WG has (1) developed the new ILRS Site and System Information Form which is being distributed to the stations to keep the engineering database current, (2) provided a new online satellite-link analysis capability for system design and performance evaluation, and (3) initiated the development of the ILRS technology database. The Analysis WG has been working with the ILRS Analysis Centers to develop a unified set of analysis products presented in the internationally accepted SINEX format. Three associated pilot programs are underway to assess differences among analysis products from the different centers. The Signal Processing Ad-Hoc WG is working on improved center-of-mass corrections and signal processing techniques for SLR satellites. More detailed information on the activities of the Working Groups and the Central Bureau can be found elsewhere in this volume. ILRS Associates who wish to volunteer their time or ideas in support of any of these organizations are encouraged to contact the Central Bureau or the appropriate WG Coordinator.

John J. Degnan
ILRS Governing Board Chairperson
Code 920.3, Geoscience Technology Office
NASA Goddard Space Flight Center
Greenbelt, MD 20771 USA

About ILRS



ILRS Organization

Mission:

The International Laser Ranging Service (ILRS) organizes and coordinates Satellite Laser Ranging (SLR) to support programs in geodetic, geophysical and lunar research activities and provides the International Earth Rotation Service (IERS) with products important to the maintenance of an accurate International Terrestrial Reference Frame (ITRF).

Role:

The ILRS was established as a service of the International Association of Geodesy (IAG) in 1998. Prior to the formation of the ILRS, international SLR activities where coordinated under IAG Commission VIII—the International Coordiantion of Space Techniques for Geodesy and Geodynamics (CSTG). The ILRS is one of three services, with the IGS (International GPS Service) and the IVS (International VLBI Service for Geodesy and Astrometry), in the IAG that support scientific measurements.

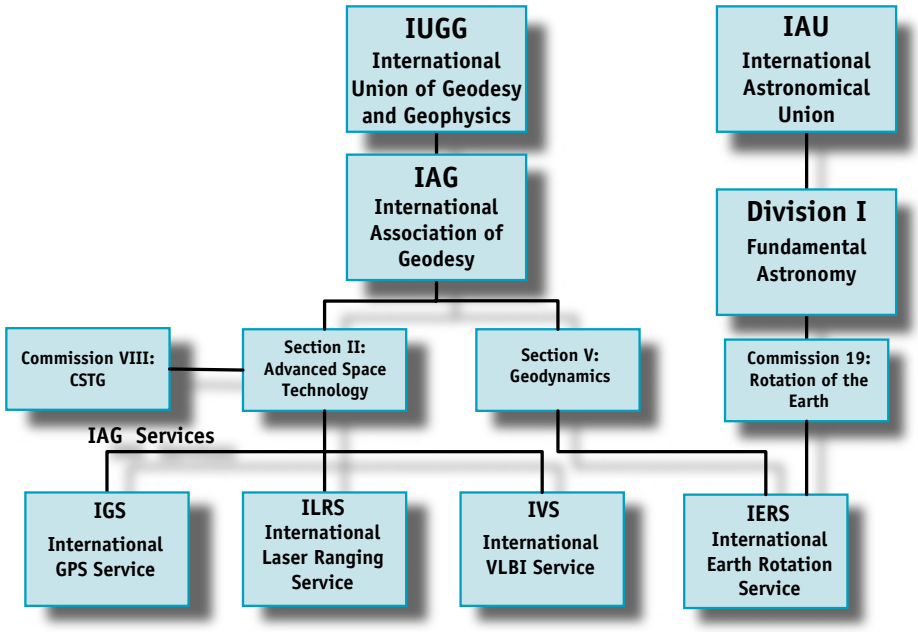
The ILRS develops (1) the standards and specifications necessary for product consistency and (2) the priorities and tracking strategies required to maximize network efficiency. The service collects, merges, analyzes, archives and distributes satellite and lunar ranging data to satisfy a variety of scientific engineering and operational needs and encourages the application of new technologies to enhance the quality, quantity and cost effectiveness of its data products. The ILRS works with (1) new satellite missions in the design and building of retroreflector targets to maximize data quality and quantity and (2) science programs to optimize scientific data yield.

The basic observable is the precise time-of-flight of an ultrashort laser pulse to and from a satellite, corrected for atmospheric delays. These data sets are used by the ILRS to generate a number of fundamental data products, including:

- Centimeter accuracy satellite ephemerides
- Earth orientation parameters (polar motion and length of day)
- Three-dimensional coordinates and velocities of the ILRS tracking stations
- Time-varying geocenter coordinates
- Static and time-varying coefficients of the Earth's gravity field
- Fundamental physical constants
- Lunar ephemeredes and librations
- Lunar orientation parameters

All ILRS data and products are archived and are publically available.

The organizations listed in Section 8.7 contribute to the ILRS by supporting one or more ILRS components.

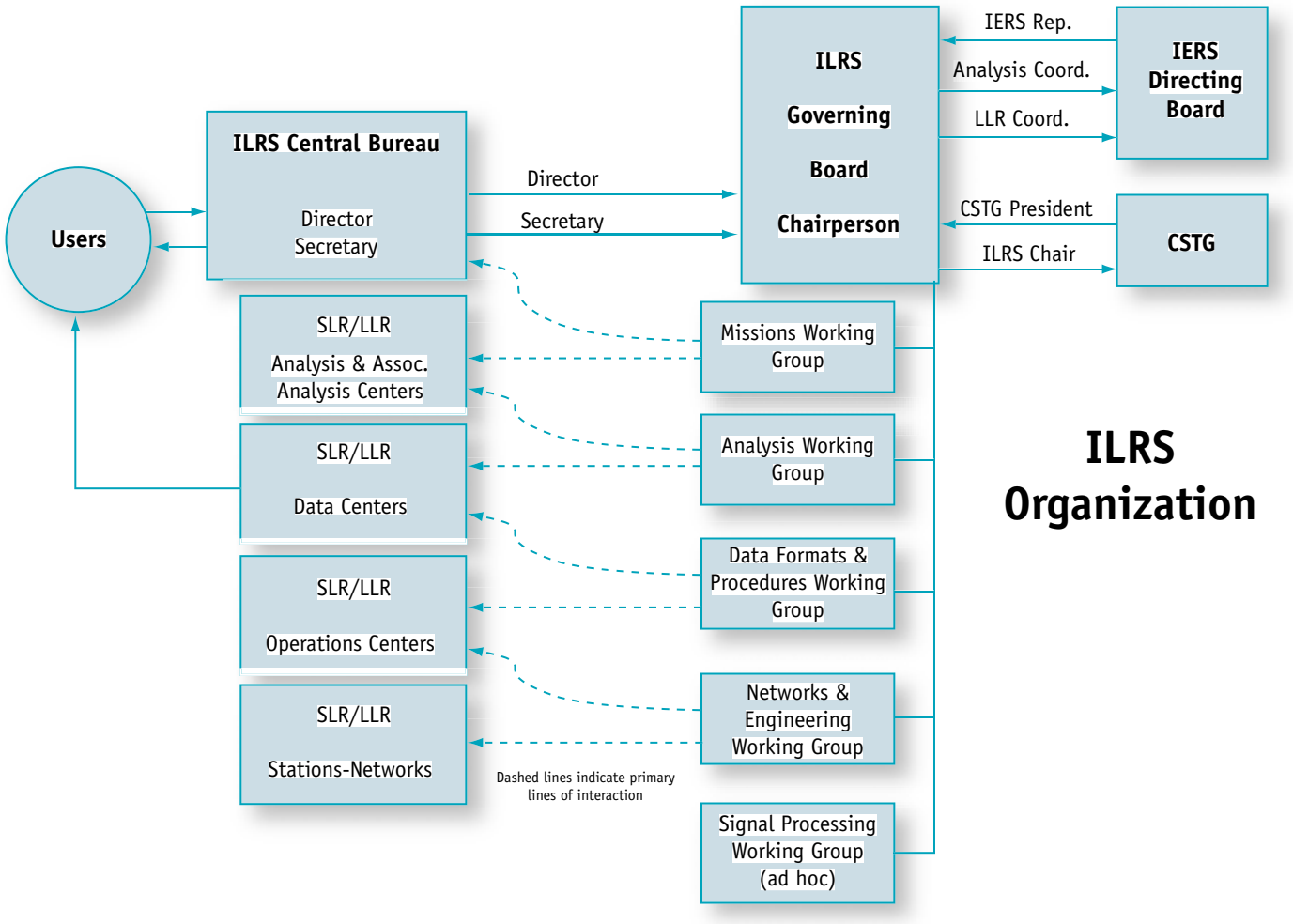


Structure:

The ILRS is organized into permanent components:

- a Governing Board,
- a Central Bureau,
- Tracking Stations and Subnetworks,
- Operations Centers,
- Global and Regional Data Centers and
- Analysis, Lunar Analysis and Associate Analysis Centers.

The Governing Board, with broad representation from the international SLR and LLR community, provides overall guidance and defines service policies, while the Central Bureau oversees and coordinates the daily service activities, maintains scientific and technological databases and facilitates communications. Active Working Groups in (1) Missions, (2) Networks and Engineering, (3) Data Formats and Procedures, (4) Analysis and (5) Signal Processing provide key operational and technical expertise to better exploit current capability and to challenge the ILRS participants to keep pace with evolving user needs. The ILRS currently includes more than 40 SLR stations, routinely tracking about 20 retroreflector-equipped satellites and the Moon in support of user needs.



ILRS Organization

ILRS Component Map


FFI
Metsahovi
ESA/ESOC
IAA
IA/RAS
IMVP
Newcastle U
FESG
MCC
Riga
BKG
GFZ/Potsdam
Mendeleevo
Borowiec
RC/Herstmonceux
GAOUA/Kiev
Wettzell
DGFI
Simeiz
Paris
Graz
Katzively
CERGA/Grasse
AIUB/Zimmerwald
Cagliari
ASI/Matera
Maidanak
San Fernando
Helwan
Riyadh
Komsomolsk
Changchun
Beijing
Simosato
Keystone (4 sites)
Wuhan
Shanghai
Kunming
Hartebeesthoek
Yarragadee
Mt. Stromlo
AUSLIG
Mobile Systems: FTLRS-1 (France)
TIGO (Germany)
TROS (China)
75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
30°
-15°
0°
15°
30°
45°
60°
75°
90°
105°
120°
135°
150°
165°

Governing Board

Name: Herman Drewes

Position: Ex-Officio, CSTG President

Affiliation: Deutsches Geodätisches ForschungsInstitut, Germany

Name: John Bosworth

Position: Ex-Officio, Director ILRS Central Bureau

Affiliation: NASA Goddard Space Flight Center, USA

Name: Michael Pearlman

Position: Ex-Officio, Secretary, ILRS Central Bureau

Affiliation : Harvard-Smithsonian Center for Astrophysics, USA

Name: Werner Gurtner

Position: Appointed, EUROLAS, Networks & Engineering Working Group Coordinator

Affiliation: Astronomical Institute of Berne, Switzerland

Name: Wolfgang Schlüter

Position: Appointed, EUROLAS

Affiliation: Bundsamt für Kartographie und Geodäsie, Germany

Name: David Carter

Position: Appointed, NASA Missions Working Group Deputy Coordinator

Affiliation : NASA Goddard Space Flight Center, USA

Name: John Degnan

Position: Appointed, NASA, Governing Board Chairperson

Affiliation : NASA Goddard Space Flight Center, USA

Name: Yang Fumin

Position: Appointed, WPLTN

Affiliation : Shanghai Observatory, Peoples Republic of China

Name: Hiroo Kunimori

Position: Appointed, WPLTN, Missions Working Group Coordinator

Affiliation: Communications Research Laboratory, Japan

Name: Bob Shutz

Position: Appointed, IERS Representative to ILRS

Affiliation: Center for Space Research, University of Texas, USA

Name: Graham Appleby

Position: Analysis Center Representative, Signal Processing Working Group Coordinator

Affiliation: Natural Environment Research Council (NERC), UK

Name: Ron Noomen

Position: Elected, Analysis Rep., Analysis Working Group Coordinator

Affiliation: Delft University of Technology, The Netherlands

Name: Wolfgang Seemueller

Position: Elected, Data Centers Representative, Data Formats & Procedures Working Group Deputy Coordinator

Affiliation: Deutsches Geodätisches ForschungsInstitut, Germany

Name: Peter Shelus

Position: Elected, Lunar Rep., Analysis Working Group Deputy Coordinator

Affiliation: University of Texas at Austin, USA

Name: Georg Kirchner

Position: Elected, At Large Network and Engineering Working Group Deputy Coordinator

Affiliation: Austrian Academy of Sciences, Austria

Name: John Luck

Position: Elected, At-Large, Data Formats & Procedures Working Group Coordinator

Affiliation: Australian, Surveying and Land Information Group, Australia