INTERNATIONAL LASER RANGING SERVICE

2001

ANNUAL REPORT

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PREFACE

This document is the 2001 Annual Report for the International Laser Ranging Service (ILRS). The individual groups that constitute the entities of the ILRS have provided updates on their activities and have given some insight into their plans for the future. Special attention has been given to the activities of the Working Groups where the users and practitioners work together to help develop the working level plans for implementation.

The contents of this Annual Report also appear on the ILRS website at:

http://ilrs.gsfc.nasa.gov/reports/ilrs_reports/ilrsar_2001.html

The 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. Introductory remarks by CSTG President Dr. Hermann Drewes and the ILRS Chairman's report give a very brief view of the organization and its recent activities.

- Section 1, the Governing Board Report, provides an overview of the ILRS, a history of its origin and establishment, the contribution 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 on the current status of the 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, the Working Group Reports, includes accomplishments during the past year, activities underway, as well as those planned for the next year. The Working Groups have originated and developed many of the standards and procedures that have been implemented by the service.
- Sections 4,5, and 6 include the Network, Operations Center and Data Center Reports. These sections provide the status of the data chain from the point of data acquisition through archiving.
- Section 7 includes reports for the SLR Analysis and Associate Analysis Centers, as well as the LLR Analysis Centers. These reports provide 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 2001, a list of institutions contributing to the Annual Report, the list of ILRS Associate Members, a complete list of the ILRS components and a list of acronyms.

In conjunction with the two previous Annual Reports, ILRS 2001Annual Report continues to provide a means of measuring the progress of the ILRS and its components, and to highlight the key items that need to be addressed in the future to make the ILRS a more effective organization.

ACKNOWLEDGEMENTS

The editors would like to acknowledge the following people for their essential contributions to the preparation of the ILRS 2001 Annual Report:

- Van Husson assembled charts and figures for the report.
- John Hazen designed the cover art and the layout for the color pages of the report.

Finally, we would like to thank all of our ILRS colleagues who provided their contributions to this Annual Report.

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THE ILRS:

WITHIN THE NEW STRUCTURE OF IAG AND THE INTEGRATED GLOBAL GEODETIC OBSERVING SYSTEM

The International Association of Geodesy (IAG) decided during its Scientific Assembly, Budapest 2001, to install a new structure starting with the next legislature period 2003–2007. The basic scientific components of this structure are the Commissions, the Services, the IAG Project(s), the Inter-Commission Committee(s) and the Communication and Outreach Branch.

The *Commissions* shall promote the advancement of science, technology and international cooperation in their fields. It was decided to establish the following four Commissions:

- Reference Frames,
- Gravity Field,
- Earth Rotation and Geodynamics,
- Positioning and Applications.

The Services are part of IAG's work and generate products relevant for geodesy and for other sciences and applications. At present the services of IAG are:

- International GPS Service,
- International VLBI Service,
- International Laser Ranging Service,
- International Earth Rotation Service,
- International Gravimetric Bureau,
- International Geoid Service,
- International Center for Earth Tides,
- Permanent Service for Mean Sea Level,
- International Bureau of Weights and Measures (Time Section).

Inter-Commission Committees shall handle well defined, important and permanent tasks involving all commissions. An example is a committee for geodetic theory and methodology.

The *Communication and Outreach Branch* provides the Association with communication, educational/public information and outreach links to the membership, to other scientific associations and to the world as a whole.

IAG Projects serve as the flagships of the Association for a long time period (decade or longer). They are of a broad scope and of highest importance for geodesy. Each IAG Project shall have a Steering Committee consisting of the Project Chair, one member from each Commission, two members-at-large, and the chairs of the Project sub-groups (if any).

A candidate IAG Project "Integrated Global Geodetic Observing System (IGGOS)" was proposed by Reiner Rummel et al. during the IAG Scientific Assembly 2001. It was discussed and approved by the "IAG Committee for the Realization of the New IAG Structure". A planning committee for the project consisting of about twenty persons was installed. This committee will take into account all the work performed by IAG in this area in order to design the objectives, the charter, and the structure of the project. It has to include a close cooperation with the IAG Services, relevant Commissions and Sub-Commissions.

The IGGOS should be seen as geodesy's contribution to the study of the System Earth composed by the solid geosphere, the hydrosphere and the atmosphere. It will provide its findings to interdisciplinary research, governmental agencies and private sectors. In this context one has to consider the existing initiatives in this field, such as the *United Nations (UN)* Integrated Global Observing Strategy (IGOS). The development and implementation of the IGOS is supported by a partnership of several groups of agencies, international research programs and other sponsors. It comprises three Global Observing Systems (G3OS):

- The *Global Terrestrial Observing System (GTOS)* established in 1996 by the Food and Agriculture Organization (FAO) of the UN, the International Council for Science (ICSU), the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO) and UNESCO.
- The *Global Climate Observing System (GCOS)* installed in 1998 by ICSU, UNEP, WMO, and the Intergovernmental Oceanographic Commission (IOC) of UNESCO;

- The *Global Ocean Observing System (GOOS)* agreed upon by a new Memorandum of Understanding between IOC, WMO, UNEP and ICSU end of 1998.

The purpose of these observing systems is mainly policy oriented rather than dealing with scientific objectives. Their mission is to provide policy-makers with interdisciplinary data they need to detect, locate, understand and warn of changes in the terrestrial ecosystems.

Geodesy (IAG), is very active in some of ICSU's interdisciplinary committees, namely

- Scientific Committee on Antarctic Research (SCAR),
- Committee on Space Research (COSPAR),
- Scientific Committee on the Lithosphere (SCL) with the International Lithosphere Programme (ILP), where IAG has its representatives and common projects, commissions and other activities.

We may thus regard the IAG Project IGGOS as an interface between IAG Commissions and Services on one side, and the ICSU, WMO and UN initiatives on the other side. Within the geodetic community, in particular within IAG, IGGOS shall provide a consistent reference system for all groups of fundamental geodetic parameters:

- Earth rotation parameters (precession, nutation, rotational velocity, pole position),
- Terrestrial position parameters (point coordinates and velocities, surface models - DTM's - and deformations),
- Gravity field parameters (gravity anomalies, height anomalies, geoid, deflections of the vertical, "mean" sea level).

It is understood that reference systems include the definition of a set of geometric and physical parameters necessary for the measurement and the description of the geometry and physical processes within the Earth's system. It shall hereby use consistent standards in geometry (origins, orientations, scales, ...), in physics (speed of light in the media, geocentric gravitational constant, ...), and in dynamics (geopotential and other forces). It shall employ consistent, coordinated observation techniques (e.g., within an Integrated Space Geodetic Network, ISGN) and unique data exchange formats (e.g., SINEX).

These requirements have to be accomplished primarily by the IAG Services. The interaction and coordination of the services' activities is the basic concept of IGGOS. The three pillars of geodesy – geometry and kinematics, Earth orientation and rotation, gravity field and dynamics – shall be combined to a consistent, unified observing system. From this combination a series of new products for Earth sciences shall emerge, such as the feasibility of establishing a global mass balance and the provision of fundamental observables for modeling the system Earth.

The scientific foundations will mainly come from the relevant IAG Commissions. The products to be given to the interdisciplinary community, however, will be provided by the Services. IGGOS is not seen as a new "Super-Service" that generates the products or the scientific results, but it is to coordinate the scientific work and to serve as an interface to the non-geodetic scientific community and to society. It shall strive for the fulfillment of the requirements mentioned above. IGGOS will not be able to operate without the IAG Services.

In this sense, the ILRS plays an important role within the IGGOS concept. Satellite Laser ranging provides unique information for the study of the Earth's system. It gives the best information on the geocentric origin and the scale of the terrestrial reference frame, and it is capable to precisely monitor recent crustal deformations (plate tectonics, isostatic movements, etc.). It is the best technique to connect geometric (station coordinates) and gravity field parameters. It is an important tracking and calibration tool for many Earth observing satellites.

As a conclusion it has to be stated that IGGOS is not thinkable and would not be successful without the intensive engagement of the ILRS. With its decision to join the IGGOS activities, the ILRS supported essentially the new IAG structure and project.

Hermann Drewes

President of the Commission on International

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
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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 were 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.

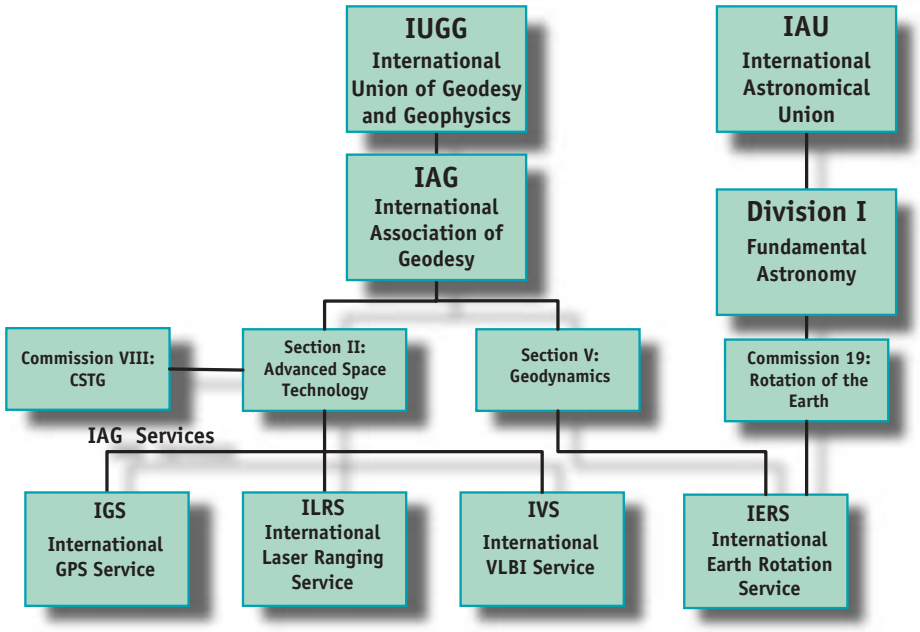
The ILRS develops (1) the standards and specifications necessary for product consistency and (2) the priorities and tracking strategies required to maximize network efficiency. The service collects, merges, analyzes, archives and distributes satellite and lunar ranging data to satisfy a variety of scientific 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 publicaly available.

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

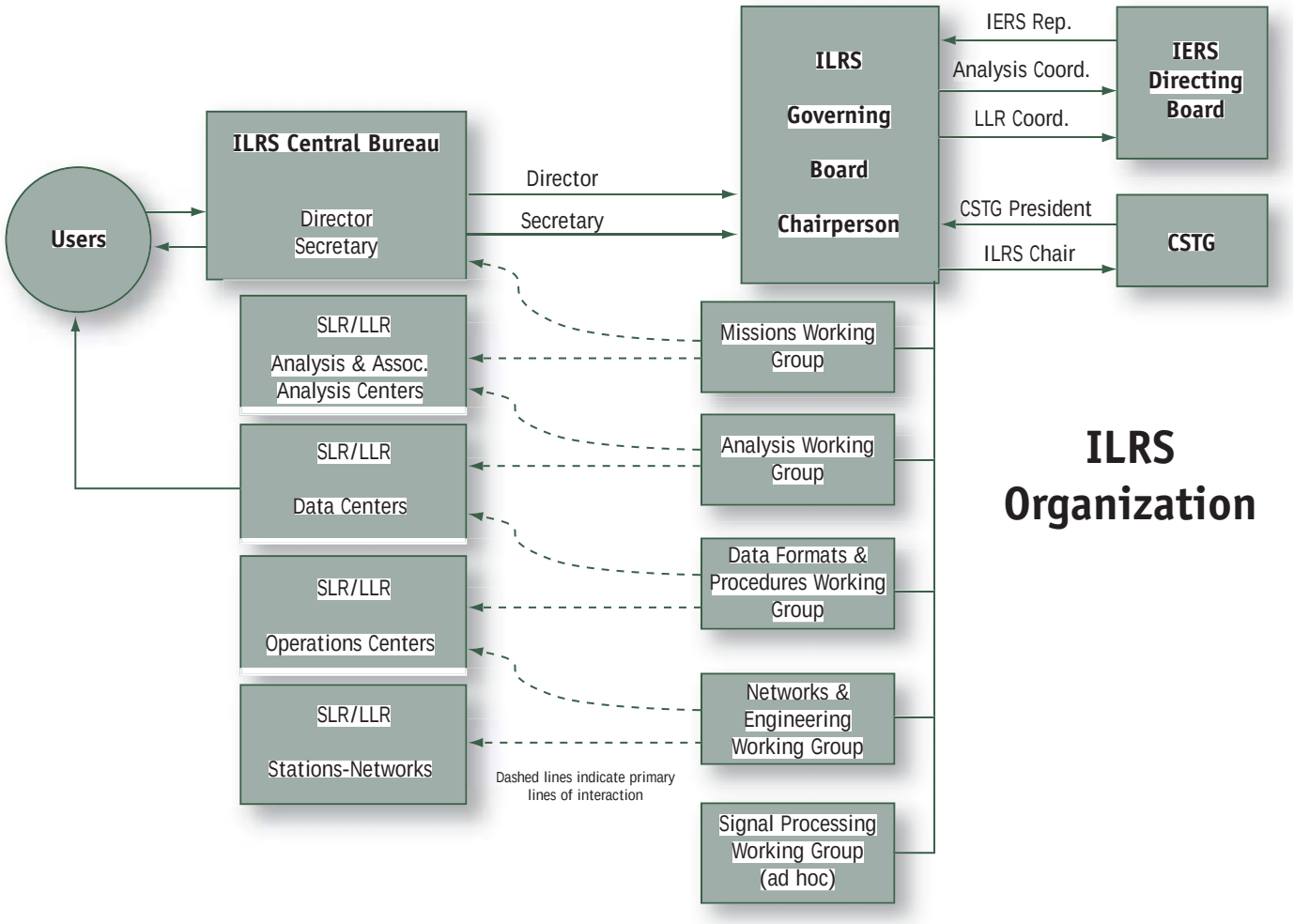


Structure:

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/IFE
Riga
MCC
BKG
Mendeleevo
GFZ/Potsdam
Borowiec
RC/Herstmonceux
GAOUA/Kiev
Komsomolsk
Wettzell
DGFI
Graz
Simeiz
Paris
Katzively
CERGA/Grasse
Changchun
Cagliari
CLG/BAS
Beijing
CRL
Maidanak
NASDA
San Fernando
ASI/Mate
Simosato
Keystone (4 sites)
AIUB/Zimmerwald
Wuhan
Helwan
Shanghai
Kunming
Riyadh
Hartebeesthoek
Yarragadee
Mt. Stromlo
GA/NMD
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: Carey Noll

Position: Ex-Officio, Secretary ILRS Central Bureau

Affiliation: NASA Goddard Space Flight Center, USA

Name: Michael Pearlman

Position: Ex-Officio, Director, 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