

# ILRS Terms of Reference

*Last Revised: June 28, 2016*

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## 1.0 Introduction

### 1.1 Charter and Affiliations

The International Laser Ranging Service (ILRS) is an established Service of the International Association of Geodesy (IAG) and a key contributor to the Global Geodetic Observing System (GGOS). The primary objective of the ILRS is to support – through Satellite and Lunar Laser Ranging data and related products – geodetic, geophysical and other scientific research activities, as well as product development for the International Earth Rotation and Reference Systems Service (IERS), important for the maintenance of an accurate and stable International Terrestrial Reference Frame (ITRF). The service also develops and maintains the necessary standards/specifications and encourages international adherence to its conventions.

## 1.2 Objectives

The ILRS collects, merges, archives, and distributes Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observation datasets of sufficient accuracy to satisfy the objectives of a wide-range of scientific, engineering, and operational applications and experimentation. These data are used by the ILRS to generate a number of scientific and operational 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 gravitational field
- Fundamental physical constants
- Lunar ephemerides and librations
- Lunar orientation parameters

The accuracy of SLR/LLR data products is sufficient to support a variety of scientific and operational applications including:

- Realization and maintenance of the ITRF
- Access to Earth's center of mass relative to the global network and its time variations
- Monitoring three dimensional deformations of the solid Earth
- Monitoring Earth rotation and polar motion
- Monitoring the long-wavelength static and dynamic components of Earth's gravitational field
- Supporting, via precise ranging to altimeter satellites, the monitoring of variations in the topography of the liquid and solid Earth (ocean circulation, mean sea level, ice sheet thickness, wave heights, vegetation canopies, etc.)
- Calibration and validation of microwave tracking techniques (e.g., GPS, GLONASS, Galileo, BeiDou, and DORIS)
- Picosecond global time transfer experiments
- Determination of non-conservative forces acting on satellites
- Astrometric observations including determination of the dynamic equinox, obliquity of the ecliptic, and the precession constant
- Gravitational and general relativistic studies including Einstein's Equivalence Principle, gravitomagnetic frame-dragging, the Robertson-Walker beta ( $\beta$ ) parameter, and temporal variations of the gravitational constant,  $G$
- Lunar physics, including the dissipation of rotational energy, shape of the core-mantle boundary (Love number  $k_2$ ), and free librations and stimulating mechanisms
- Solar System ties to the International Celestial Reference Frame (ICRF)

## 1.3 Amendments to the ILRS Terms of Reference

A proposal to amend the ILRS Terms of Reference can be made in writing to the Chairperson of the Governing Board (see Section 3.0) by any ILRS Associate (see Section 5.1). Proposed amendments will be forwarded by email to the ILRS Governing Board for comment and amended as necessary by the Chairperson. Final approval of any amendment requires a 2/3 affirmative vote of the Governing Board. The modified Terms of Reference will then be

presented to the IAG for its concurrence. The Secretary of the ILRS Central Bureau will distribute adopted amendments to the Terms and subsequent Board actions to the Associates.

## **2.0 Permanent Components of the ILRS**

The ILRS accomplishes its mission through the following permanent components:

- Tracking Stations and Sub-networks
- Operations Centers
- Global and Regional Data Centers
- Analysis and Associate Analysis Centers
- Central Bureau

The characteristics and responsibilities of these entities are described in the following subsections.

### **2.1 Tracking Stations and Sub-networks**

ILRS 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 (preferably hourly, but at least daily) data transmission to one or more Operations and/or Data Centers (see below). Stations will be categorized as “Primary” if they meet data accuracy, data quantity, data delivery and GNSS co-location requirements as specified. Stations not yet meeting these requirements will be categorized as “Associate” status. The tracking data produced by the ILRS network stations are regularly and continuously analyzed by at least one ILRS Analysis Center or one mission-specific Associate Analysis Center. Tracking Stations may be organized into regional or institutional sub-networks.

### **2.2 Operations Centers**

The Operations Centers are in direct contact with tracking sites organized in a sub-network. Their tasks typically include the collection and merging of data from the sub-network, 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. Operations Centers may also provide the tracking sites with sustaining engineering, communications links, and other technical support. In addition, Operations Centers may perform limited services for the entire network. Individual tracking stations may also perform part or all of the tasks of an Operations Center themselves.

### **2.3 Data Centers**

#### **2.3.1 Regional Data Centers**

The Regional Data Centers help reduce and consolidate data traffic on electronic networks. They collect reformatted tracking data from Operations 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 Operations 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.

### **2.3.2 Global Data Centers**

The 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 online access to tracking data received from the Operations Centers/Regional Data Centers
- Provide online access to ancillary information, such as site information, occupation histories, meteorological data, site specific engineering data, satellite orbit information, satellite predictions, center of mass values, and other related information
- Receive/retrieve, archive and provide online access to ILRS scientific data products received from the Analysis Centers
- Backup and ensure the integrity of ILRS data and products

## **2.4 Analysis Centers**

The analysis centers fall into three categories: Analysis Centers, Lunar Analysis Centers, and Associate Analysis Centers.

### **2.4.1 Analysis Centers**

The Analysis Centers (ACs) access and process tracking data from one or more data centers for the purpose of quality control purposes or for the generation of ILRS products. The ACs are committed to deliver the products routinely, without interruption, at an adopted frequency and with a time lag approved by the Governing Board to meet ILRS requirements. The products are generated using designated standards and delivered to the Global Data Centers, to the IERS (as per bilateral agreements), and to other interested bodies. At a minimum, the Analysis Centers must process the global LAGEOS-1 and LAGEOS-2 data sets and are encouraged to include other geodetic satellites in their solutions. It is anticipated that list of satellites to be included in routine analysis by the ACs can be extended if requested by the Analysis Standing Committee and/or the ILRS Central Bureau.

The ACs provide, at a minimum, daily-resolution Earth orientation parameters, weekly-averaged station coordinates and satellite orbits, on a daily basis, as well as other products, required by the IERS. The ACs also provide a second level of quality assurance on the global data set by monitoring individual station range and timing systematic errors via the fitted orbits (primarily based on the LAGEOS-1 and LAGEOS-2 satellites).

### **2.4.2 Associate Analysis Centers**

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 of 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, Galileo, Compass/BeiDou, DORIS, etc.), in support of the ITRF or precise orbit determination. Organizations that desire to eventually become Analysis Centers may also be designated as Associate Analysis Centers by the Governing Board until they are fully accredited Analysis Centers.

### **2.4.3 Lunar Analysis Centers**

Lunar Analysis Centers process normal point data from the LLR stations and generate a variety of scientific products including precise lunar ephemerides, librations, and orientation parameters that provide insights into the composition and internal makeup of the Moon, its interaction with Earth, tests of General Relativity, and solar system ties to the ICRF.

## **2.5 Central Bureau**

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 (GB). 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, website and databases, produce reports as required, and organize meetings and workshops.

Although the Chairperson of the Governing Board is the official representative of the ILRS to external organizations, the CB, in agreement with the directives established by the GB is responsible for the day-to-day liaison with such organizations.

The CB coordinates and publishes all documents required for the satisfactory planning and operation of the Service, such as standards/specifications regarding the performance, functionality and configuration requirements of all elements of the Service including user interface functions.

The CB operates the communication center for the ILRS. It produces and/or maintains a hierarchy of documents and reports, in both hard copy and electronic form, including network information, standards, newsletters, electronic bulletin board, directories, summaries of ILRS performance and products, and biannual reports summarizing the status of the Service.

The Central Bureau may propose to the GB names of individuals to be considered by the ILRS Associates for election as At-Large members on the GB to help ensure the proper representation of important contributing organizations.

The responsibilities and activities of the CB may be distributed between different groups and organizations according to written agreements and charters.

In summary, the CB performs a long-term coordination and communication role to ensure that ILRS participants contribute to the Service in a consistent and continuous manner and that they adhere to ILRS standards.

The CB is headed by a CB Director, who is an ex-officio member of the ILRS Governing Board. The Secretary of the CB is also an ex-officio member of the ILRS GB.

## 3.0 Governing Board

### 3.1 Roles and Responsibilities

The ILRS Governing Board is responsible for the general directions in which the ILRS is providing its services. It defines the official ILRS products, decides upon the satellites to be included in the ILRS tracking list, accepts standards and procedures prepared and proposed by the individual bodies of the ILRS, and ensures, through its chairperson, contact with other services and organizations.

The GB exercises general control over the activities of the ILRS including modifications to the organization that would be appropriate to maintain efficiency and reliability, while taking full advantage of the advances in technology and theory.

Most GB decisions are to be made by consensus or by a simple majority vote of the members, provided that there is a quorum consisting of at least ten members of the GB. In case of a lack of a quorum, the voting is conducted by teleconference, email, or mail. Changes in the ILRS Terms of References and the Chairperson of the GB can be made by a 2/3 majority of the members of the GB, i.e., by twelve or more votes.

### 3.2 Membership

The GB consists of ex-officio members, members chosen by the regional networks, members appointed by the Board, and members elected by their peers within the ILRS.

The ex-officio members:

Director of the Central Bureau	1
Secretary of the Central Bureau	1
President of IAG Commission I (Reference Systems) (or his/her delegate)	1
IERS Representative	1

Appointed positions:

NASA SLR Network Representatives	2
EUROLAS Network Representatives	2
WPLTN Network Representatives	2
At-Large Members Appointed by the GB	2

Members elected by their peers within the ILRS Associates include:

Analysis and Associate Analysis Center Representatives	2
Data Centers Representative	1
LLR Representative	1
<u>At-Large Representatives</u>	<u>2</u>

Total: 18

Past GB Chairs are invited to participate in all GB meetings as non-voting members.

### **3.3 Nominations and Election of Members**

Candidates for the elected board positions, including two At-Large positions, are nominated and elected for a two-year term by members of the ILRS components that they represent. At-Large members are elected from the full ILRS membership. The GB appoints two additional At-Large Members, also for a two-year term, once the first 16 members are seated and the chair of the Board has been elected. The At-Large members (both elected and appointed) are intended to help compensate for under-representation among the various components of the ILRS or to provide additional skills, organizational representation, geographic representation, or knowledge of use to the Board in carrying out its duties.

ILRS Associates (see Section 5.1), together with the GB, may nominate and vote for the elected members of the GB as prescribed above. The Call for Nominations and GB Elections will be conducted bi-annually by the Central Bureau using the official email lists. Board members will serve two-years terms starting on January 1; this calendar timeframe was implemented in January 2016. The nomination and election process will be completed prior to that date.

With the exception of At-Large members, GB nominees must be associated with the relevant ILRS component (e.g., Analysis, Data Centers, Lunar, etc.), and only ILRS Associates officially associated with that component, as determined by the official email lists maintained by the CB, may participate in the election of their representative(s). The full ILRS membership can nominate and vote for the elected At-Large candidates. The GB will be final arbiter on an individual's qualifications for a particular elected post on the Board. Election is by a simple majority of votes received. In the unlikely event of a tie vote, the GB will make the final selection in Executive Session.

In the event that a GB position is vacated during a term, a replacement will be appointed by the represented entity or chosen through a special election, whichever is appropriate.

### **3.4 Election and Role of Chairperson**

The Board elects the GB Chairperson from among its members for a term of two years, renewable for one additional term (a total of 4 years). Nomination and selection of the Chairperson is carried out in GB Executive Session if scheduling permits, or by teleconference meeting or email. The Chairperson does not vote, except in case of a tie.

### **3.5 Frequency of Governing Board Meetings and ILRS General Assemblies**

The Board shall endeavor to meet annually and at such other times as shall be considered appropriate or opportune by the Chairperson or at the request of at least eight GB members.

### **3.6 Rights and Privileges of GB Members**

Members of the GB may be eligible to become IAG Fellows, with the appropriate rights and privileges, following two years of recognized service.

### **3.7 ILRS Representation on External Entities**

The Chair of the GB is the official representative of the ILRS to external organizations, but may delegate that as described below.

The chair of the Analysis Standing Committee (ASC) serves as one of the ILRS voting members on the IERS Directing Board. The Lunar Representative acts as the second voting representative

of the ILRS on the IERS Directing Board. The IERS in turn designates a representative to serve as an ex-officio voting member of the ILRS GB.

The ILRS GB also appoints a representative to the Steering Committee of IAG Commission 1: Reference Frames.

## **4.0 ILRS Committees, Study Groups, and Boards**

The ILRS now uses the IAG standard term “Committee” to replace the former title “Working Group” for those entities that focus on particular areas within the Service.

The GB, at its discretion, can create or disband Committees. A Committee may be either permanent (Standing Committee) or temporary (Ad-Hoc Committee) in nature. Standing Committees are created by the GB to carry out business of the ILRS for indefinite periods (more than 4 years). Occasionally, Ad-Hoc Committees are generally appointed to carry out special investigations or tasks of a temporary or interdisciplinary nature. Currently, the ILRS Standing Committees are:

- Missions Standing Committee (MSC)
- Data Formats and Procedures Standing Committee (DFPSC)
- Networks and Engineering Standing Committee (NESC)
- Analysis Standing Committee (ASC)
- Transponders (and Precision Time Transfer) Standing Committee (TSC)

The valid activities for Standing or Ad-Hoc Committees are defined by their Charters. Modifications to the charters of existing Committees must be submitted by the corresponding Chair for approval by the GB. In order to create a new Committee, the sponsor must submit a proposed charter, which clearly states the goals and responsibilities of the new group, for approval by the GB.

The Chair of each Standing Committee is selected by the GB from amongst its members for a period of two years to ensure close coupling of the Committee with the GB and its goals. The Chair and Co-chairs of the Analysis Standing Committee (ASC) are customarily selected from the two elected analysis representatives. The Committee Chairs may serve additional terms at the discretion of the GB. The Committee Chairs can independently appoint additional Committee members from among the other GB members, ILRS Associates or ILRS Correspondents (see below). The Committee Chairs may also designate a Deputy or Co-Chair to act on his/her behalf in his/her absence. All GB members, with the exception of the ex-officio members and the Chairperson, are required to serve on at least one of the Standing Committees.

The Chairs for Ad-Hoc Committees are chosen by the GB, from inside or outside the GB membership in order to best fulfill the goals of that Committee.

The GB may also create Study Groups to address focused issues. Study Groups typically focus on topics requiring a briefer analysis or system study leading to a final determination. Ad-Hoc Committees would address issues/activities on a longer-term basis that may lead to a policy decision by the GB.

### **4.1 Analysis Standing Committee**

The ASC includes, at a minimum, one representative from each of the ILRS Analysis Centers, the Lunar Representative, and may include representatives of Associate Analysis Centers as well.

The ASC chair and co-chair, in coordination with the other Committee members, are responsible for monitoring ASC activities to ensure that the ILRS objectives are being addressed. Specific expectations include global data quality control, station performance evaluation and reporting, and continued development of appropriate analysis standards and formats for the final science products. The ASC chair is also responsible for the appropriate combination of designated Analysis Center products into a single and coherent set of products.

The Analysis Standing Committee chair and co-chair ensure that the ILRS products produced by the ILRS Analysis and Associate Analysis Centers conform to IERS requirements and standards. The Analysis and Lunar Representatives on the GB must work within their own disciplines to maintain observational data and product integrity. They must also work together in an effort to unify analysis approaches in the two areas, bringing together the best of both, and, when possible, learning from the other.

## **4.2 Quality Control Board**

The ILRS GB has created a Quality Control Board (QCB) to establish and monitor procedures to provide diagnostic and remedial tools for use by the stations and other users in the community. The QCB will work within the ASC, the NESC, and the CB, and colleagues who can help the board to pursue these issues and guide remedial procedures. The QCB will select a chair to lead the effort.

## **5.0 Definitions**

### **5.1 ILRS Associates**

Persons affiliated with recognized ILRS institutions and who routinely participate in any of the ILRS activities (management, missions, tracking, engineering, operations, data analysis, archiving, etc.) are eligible to be ILRS Associates. To gain official membership in the ILRS, an approved ILRS institution must submit the person's name, email, and primary ILRS function in the organization to the CB. ILRS Associates do not have to be employed by their institution sponsor; they merely need to provide a recognized ILRS-related service to the sponsoring institution under a contractual or cooperative arrangement. The Associate's stated function shall determine his/her eligibility to nominate and/or vote for specific GB representatives as described in Section 3.3.

Associates may attend open (non-executive) ILRS meetings, which are announced to the general community by the CB, place nominations for elected GB posts, vote in ILRS elections, and serve on the Governing Board if appointed or elected. The CB maintains a directory (electronic and/or hard copy) of ILRS Associates, and their approved association with a particular component of the ILRS.

ILRS Associates are considered IAG Affiliates with the corresponding rights and privileges.

### **5.2 ILRS Correspondents**

ILRS Correspondents are persons on a mailing list maintained by the Central Bureau, who do not actively participate in the ILRS, but who either express interest in receiving ILRS publications, wish to participate in workshops or scientific meetings organized by the ILRS, or generally are interested in ILRS activities. Ex-officio ILRS Correspondents are the following persons:

- IAG President and Vice-President

- IAG Secretary General
- Presidents of IAG Commissions:
  - IAG Commission 1: Reference Frames
  - IAG Commission 2: Gravity Field
  - IAG Commission 3: Earth Rotation and Geodynamics
  - IAG Commission 4: Positioning and Applications
- IAG Inter-commission on Theory (ICCT)
- IAG Communication and Outreach Branch (COB)
- Chairs and Directors of affiliated IAG Services:
  - International GNSS Service (IGS)
  - International VLBI Service for Geodesy and Astrometry (IVS)
  - International DORIS Service (IDS)
  - International Gravity Field Service (IGFS)
  - International Earth Rotation and Reference Systems Service (IERS)
  - Other IAG Services.
- Chair of the Global Geodetic Observing System (GGOS)
- IUGG Secretary General
- Former Governing Board members