International Laser Ranging Service (ILRS)

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http://ilrs.gsfc.nasa.gov/

In this document we have incorporated the IAG standards for the use of “Committee” to replace “Working Group” for those entities that lie within the Services.

Development

Satellite Laser Ranging (SLR) was established in the mid-1960s, with early ground system developments by NASA, SAO, and CNES. Early US and French satellites provided laser targets that were used mainly for inter-comparison with other tracking systems, refinement of orbit determination techniques, and as input to the development of ground station fiducial networks and global gravity field models. Early SLR brought the results of orbit determination and station positions to the meter level of accuracy. The SLR network was expanded in the 1970s and 1980s as other groups built and deployed systems, and technological improvements began the evolution toward the decimeter and centimeter accuracy. Since 1976, the main geodetic target has been LAGEOS (subsequently joined by LAGEOS-2 in 1992), providing the backbone of the SLR technique’s contribution to the realization of the International Terrestrial Reference Frame (ITRF). Lunar tracking activity began in 1969 after the deployment of the first retro-reflector array on the surface of the Moon by the Apollo 11 astronauts.

Tracking campaigns were initially organized through COSPAR and through the Satellite and Lunar Laser Ranging (SLR/LLR) Sub-commission on the Coordination of Space Techniques for Geodesy and Geodynamics (CSTG). With strong encouragement from the President of the CSTG, the Sub-commission Steering Committee undertook the formation of the International Laser Ranging Service, ILRS in April 1998, following a similar initiative that had brought the GPS community together under the International GPS (now GNSS) Service, IGS, in 1993. The ILRS is one of the space geodetic services of the International Association of Geodesy (IAG) and is a member of the IAG’s Global Geodetic Observing System (GGOS).

The ILRS is a major component of GGOS, providing observations that contribute to the determination of the three fundamental geodetic observables and their variations, that is, Earth's shape, Earth's gravity field and Earth's rotational motion. The ILRS continues as one of the fundamental inputs to the ITRF. Currently, 35 stations in the ILRS network track 60 – 70 satellites in LEO, MEO, GNSS, and synchronous orbits. Some stations in the ILRS network support lunar ranging and ranging to the Lunar Orbiter, with plans to extend ranging to interplanetary missions with optical transponders.

On the current path toward mm accuracy SLR and LLR practitioners are now building new systems and upgrading old ones to improve ground system performance using higher pulse repetition rates (0.1 – 2 KHz) for faster data acquisition; smaller, faster slewing telescopes for more rapid target acquisition and pass interleaving; capabilities to ranging from Low Earth Orbiting (LEO) satellites to the Earth navigation satellites; more accurate pointing for greater link efficiency; narrower laser pulse widths for greater precision; new detection systems for greater ranging accuracy; greater temporal, spatial, and spectral filtering for improved signal to noise conditions; more automation for operational economy (24/7) and greater temporal coverage; and modular construction and more off-the-shelf components for lower fabrication/operations/maintenance cost.

Mission

The ILRS collects, merges, analyzes, archives and distributes Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observation data sets of sufficient accuracy to satisfy the GGOS objectives of a wide range of scientific, engineering, and operational applications and experimentation. The basic observable is the precise time-of-flight of an ultra-short laser pulse to and from a retroreflector-equipped satellite. These data sets are used by the ILRS to generate a number of fundamental added value products, including but not limited to:

- 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 Earth's gravity field;
- Fundamental physical constants;
- Lunar ephemerides and librations;
- Lunar orientation parameters.

Structure

The ILRS structure includes the following permanent components:

- Tracking Station Networks and Sub-networks;
- Operations Centers;
- Global and Regional Data Centers;
- Analysis, Lunar Analysis, and Associate Analysis Centers;
- Central Bureau;
- Governing Board and specialized Committees (Analysis; Missions; Networks and Engineering; Data Formats and Procedures; and Transponders).

Information on these permanent components can be found in the ILRS website (http://ilrs.gsfc.nasa.gov/). From time to time, the ILRS also establishes temporary Study Groups to address timely topics.

Governing Board (2015)

- Michael Pearlman, Ex-officio, Director Central Bureau
- Carey Noll, Ex-officio, Secretary Central Bureau
- Geoff Blewitt, Ex-officio, President IAG Commission 1
- Daniela Thaller, Appointed, IERS representative to ILRS
- Giuseppe Bianco, Appointed, EUROLAS Network Rep.
- Georg Kirchner, Appointed, EUROLAS Network Rep.
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- Erricos C. Pavlis, Elected, Analysis Center Rep.
- Horst Müller, Elected, Data Center Representative
- Jürgen Müller, Elected, LLR Representative
- Matt Wilkinson, Elected, At Large Representative
- Ulrich Schreiber, Elected, At Large Representative, Chair of the Governing Board

Past Governing Board Chairs

- John Degnan
- Werner Gurtner (deceased)
- Graham Appleby

Products

The most important aspects of the SLR and LLR observations are absolute accuracy and long, stable time histories at a number of sites. Accuracy approaches the level of a few mm for modern stations; time histories can be 30 years or more on some satellites, and more than 45 years on the Moon. Since the inception of the service, the ILRS has put the generation of official analysis products high on its agenda. Official submissions to the IERS include weekly solutions for station coordinates and Earth Orientation Parameters (EOPs) submitted on a daily frequency. Additionally, some of the ILRS Analysis Centers (ACs) submit estimates of GM and time-varying geocenter motion to the IERS Global Geophysical Fluids Center. Other user products include static and time-varying coefficients of Earth's gravity field, accurate satellite ephemerides for POD and validation of altimetry, relativity, and satellite dynamics, backup POD for other missions, and Lunar ephemeris for relativity studies and lunar libration for lunar interior studies.

The products of the Analysis, Lunar Analysis, and Associate Analysis Centers are made available to the scientific community through the two Global Data Centers:

- Crustal Dynamics Data Information System (CDDIS) at NASA’s Goddard Space Flight Center, Greenbelt, MD, USA,
- European Data Center (EDC), at DGFI - TUM, Munich, Germany

The high accuracy of SLR/LLR data products support many scientific, engineering, and operational applications including:

- Realization and maintenance of the International Terrestrial Reference Frame (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 variations and polar motion
- Monitoring the long wavelength static and dynamic components of Earth's gravity 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
- Astrodynamical observations including determination of the dynamic equinox, obliquity of the ecliptic, and the precession constant
- Gravitational and general relativistic tests, including Einstein's Frame-dragging, Equivalence Principle, the Robertson-Walker b parameter, and time rate of change of the gravitational constant, G
- Lunar physics including the dissipation of rotational energy, shape of the core-mantle boundary (Love Number k2), and free librations and stimulating mechanisms
- Solar System ties to the International Celestial Reference Frame (ICRF)

Contacts

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Publications

The ILRS Central Bureau maintains a comprehensive website as the primary vehicle for the distribution of information within the ILRS community. This site can be accessed at http://ilrs.gsfc.nasa.gov. Many ILRS and related publications and reports can now be accessed online through the ILRS website including:

- ILRS Terms of Reference and Working Group Charters
- ILRS Network Description and Status
- ILRS Satellite Descriptions and Tracking Information
- ILRS Service Reports (first volume published covers year 1999)
- ILRS Meeting Reports and Presentations (Governing Board, General Assembly, Working Group)
- ILRS Associates Directory
- ILRS Organizations and Technical Contacts
- Science and Engineering References and Reports