International Laser Ranging Service (ILRS)

http://ilrs.gsfc.nasa.gov

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Overview

The ILRS is the international source that provides Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observation data and data products for scientific and engineering programs with the main focus on Earth and Lunar applications. The basic observables are the precise two-way time-of-flight of ultra short laser pulses from ground stations to retroreflector arrays on satellites and the Moon and the one-way time-of-flight measurements to spaceborne receivers (transponders). These data sets are made available to the community through the CDDIS and the EDC archives, and are also used by the ILRS to generate fundamental data products, including: accurate satellite ephemerides, Earth orientation parameters, 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 ephemerides and librations, and lunar orientation parameters.

SLR is one of the four space geodetic techniques (along with VLBI, GNSS, and DORIS) whose observations are the basis for the development of the International Terrestrial Reference Frame (ITRF), which is maintained by the IERS. SLR defines the origin of the reference frame, the Earth center-of-mass and, along with VLBI, its scale. The ILRS generates daily a standard product of station positions and Earth orientation based on the analysis of the data collected over the previous seven days, for submission to the IERS, and produces LAGEOS/Etalon combination solutions for maintenance and improvement of the International Terrestrial Reference Frame. The latest requirement is to improve the reference frame to an accuracy of 1 mm accuracy and 0.1 mm/year stability, a factor of 10–20 improvement over the current product. To address this requirement, the SLR community will need to significantly improve the quantity and quality of ranging to the geodetic constellation (LAGEOS-1, LAGEOS-2, and LARES) to support the definition of the reference frame, and to the GNSS constellations to support the global distribution of the reference frame.

The ILRS participates in the Global Geodetic Observing System (GGOS) organized under the IAG to integrate and help coordinate the Service activities and plans.

ILRS Structure

The ILRS Organization (see Figure 1) includes the following permanent components:

- Tracking Stations organized into Sub-networks
- Operations Centers

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- Global and Regional Data Centers
- Analysis and Associate Analysis Centers
- Central Bureau
- Working Groups

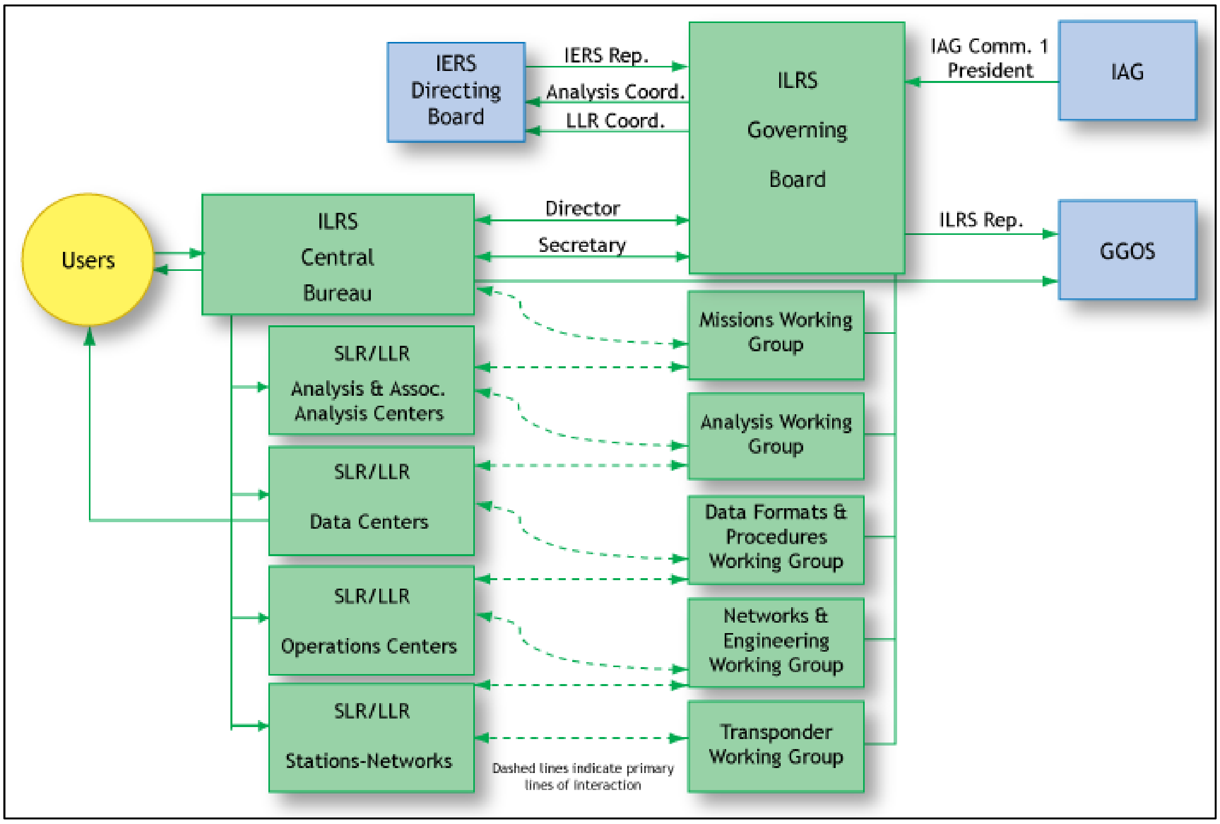

Figure 1. The organization of the International Laser Ranging Service (ILRS).

The role of these components and their inter-relationship is presented on the ILRS website (*http://ilrs.gsfc.nasa.gov/about/organization/index.html*).

The Governing Board (GB) is responsible for the general direction of the service. It defines official ILRS policy and products, determines satellite-tracking priorities, develops standards and procedures, and interacts with other services and organizations. The members of the current Governing Board, selected and elected for a two-year term, are listed in Table 1.

Within the GB, permanent (standing) or temporary (ad-hoc) Working Groups (WGs) carry out policy formulation for the ILRS. The WGs are intended to provide the expertise necessary to make technical decisions, to plan programmatic courses of action, and are responsible for reviewing and approving the content of technical and scientific databases maintained by the Central Bureau. All GB members serve on at least one of the five WGs, led by a Chair and Co-Chair (see Table 1). The WGs continue to attract talented people from the general ILRS membership who contributed greatly to the success of these efforts.

Table 1. ILRS Governing Board (as of May 2015)

Tonie van Dam	Ex-Officio, President of IAG Commission 1	Luxembourg
Michael Pearlman	Ex-Officio, Director, ILRS Central Bureau	USA
Carey Noll	Ex-Officio, Secretary, ILRS Central Bureau	USA
Bob Schutz	Appointed, IERS Representative to ILRS	USA
Giuseppe Bianco	Appointed, EUROLAS, Governing Board Chair	Italy
Georg Kirchner	Appointed, EUROLAS, Networks and Engineering Working Group Co-Chair	Austria
David McCormick	Appointed, NASA	USA
Jan McGarry	Appointed, NASA, Transponder Working Group Co-Chair	USA
Wu Bin	Appointed, WPLTN	China
Toshimichi Otsubo	Appointed, WPLTN, Missions Working Group Chair	Japan
Vincenza Luceri	Elected, Analysis Representative, Analysis Working Group Deputy Chair	Italy
Erricos C. Pavlis	Elected, Analysis Representative, Analysis Working Group Chair	USA
Horst Mueller	Elected, Data Centers Representative, Data Formats and Procedures Working Group Chair	Germany
Jürgen Müller	Elected, Lunar Representative	Germany
Ulrich Schreiber	Elected, At-Large, Transponder Working Group Chair	Germany
Matt Wilkinson	Elected, At-Large, Networks and Engineering Working Group Chair	UK
Former Governing Board Members during 2011-2015		
Graham Appleby	Elected, At-Large, Former Governing Board Chair	UK
David Carter	Appointed, NASA	USA
Ramesh Govind	Appointed, WPLTN	Australia
Hiroo Kunimori	Appointed, WPLTN	Japan
Francis Pierron	Appointed, EUROLAS	France

Data Products

The main ILRS analysis products consist of SINEX files of weekly-averaged station coordinates and daily Earth Orientation Parameters (x-pole, y-pole and excess length-of-day, LOD) estimated from 7-day arcs of SLR tracking of the two LAGEOS and two Etalon satellites. As of May 1, 2012, the weekly analysis product is no longer the official ILRS Analysis product (thence reserved for Pilot Project use only), replaced by the same type of analysis performed on a DAILY basis by sliding the 7-day period covered by the arc by one day forward every day. This allows the ILRS to respond to two main users of its products: the ITRS Combination Centers and the IERS EOP Prediction Service at USNO. The former requires a single analysis per week, the latter however requires as “fresh” EOP estimates as possible, that the “sliding” daily analysis readily provides. Two types of products are distributed for each 7-day period: a loosely constrained estimation of coordinates and EOP and an EOP solution, derived from the previous one and constrained to an ITRF, currently ITRF2008. Official ILRS Analysis Centers (ACs) and Combination Centers (CCs) generate these products with individual and combined solutions respectively. Both the individual and combined solutions follow strict standards agreed upon within the ILRS Analysis Working Group (AWG) to provide high quality products consistent with the IERS Conventions. This description refers to the status as of May 2015. Each official ILRS solution is obtained through the combination of solutions submitted by the official ILRS Analysis Centers:

- ASI, Agenzia Spaziale Italiana
- BKG, Bundesamt für Kartographie und Geodäsie
- DGFI, Deutsches Geodätisches ForschungsInstitut
- ESA, European Space Agency
- *GA, Geosciences Australia (up until the end of 2012)*
- GFZ, GeoForschungsZentrum Potsdam
- GRGS, Observatoire de Cote d'Azur
- JCET, Joint Center for Earth Systems Technology and Goddard Space Flight Center
- NSGF, NERC Space Geodesy Facility

These ACs have been certified through a benchmark process developed and adopted by the AWG. The official Primary Combination Center (ASI) and the official Backup Combination Center (JCET) follow strict timelines for these routinely provided products.

In addition to operational products, solutions obtained from re-analysis have been provided covering the period back to 1983 in support of ITRF development. The ILRS products are available, via ftp from the official ILRS Data Centers CDDIS/NASA Goddard Space Flight Center (*ftp://cddis.gsfc.nasa.gov/*) and EDC/DGFI (*ftp://ftp.dgfi.badw-muenchen.de*).

The individual ILRS AC and CC contributions as well as the combinations are monitored on a daily basis in graphical and statistical presentation of these time series through a dedicated website hosted by the JCET AC at: *http://geodesy.jcet.umbc.edu/ILRS_AWG_MONITORING/*

The main focus of the Analysis WG activities over the past two years was the improvement of modeling used in the reduction of the SLR data and generation of the official products in preparation for the development of the next ITRF model, ITRF2014, Luceri et al., 2014). In particular, all ACs made major efforts to comply with the adopted analysis standards and the IERS Conventions 2010, the consistent modeling of low degree time-varying gravitation and the realistic modeling of the mean pole in computing the pole tide effects (Pavlis et al., 2014). Since the delivery of the ILRS contribution to ITRF2014, the AWG has focused on a set of Pilot Projects to test, evaluate and adopt new models and practices that will limit or mitigate the effect of systematic errors in the ILRS data, improve the final products through realistic description of geophysical processes, and strengthen the quality of the products by including an additional accurate target: LARES (Pavlis et al., 2015). As far as the LLR analysis activities, a new service has been instituted via a web application, where one can obtain predictions for LLR observations at a specific site and they can also have their LLR data checked for validity, prior to submitting them to the Data Centers for archival. Currently, the LLR group is in the process of developing a unique data set of all available LLR data in the newly adopted CRD format, in order to better serve the community and to conform with the ILRS standards.

Satellite Laser Ranging

ILRS Network

The present ILRS network includes over forty stations in 27 countries (see Figure 2); some of these stations are undergoing refurbishment and upgrade. During the last five years, new Russians stations joined the ILRS network in Arkhyz, Zelenchukskaya, Svetloe, Badary, Irkutsk, Baikonur (in Russia), and Brasilia (Brazil) filling-in very important geographic gaps. The Russians are planning new SLR systems in other sites including Havana (Cuba), Harteebesthoek (South Africa), and several other locations. SLR and LLR data are again flowing from the new MeO (Metrology and Optics) station at Grasse, France. A new SLR station is currently in Sejong, Korea and two new stations are under construction in India. The TIGO system, operational in Concepción Chile since 2002, has recently been closed and will be relocated to La Plata Argentina in 2015. New SLR stations are also being planned for Metsahovi (Finland) and Ny Ålesund (Norway). The NASA Space Geodesy Project (SGP) is planning for construction of up to ten new, next generation SLR systems as part of core sites; the first two systems are planned for deployment at McDonald, TX and Haleakala, HI in the 2017 time frame; several are planned to replace current legacy systems. Large gaps are still very prominent in Africa and South America and discussions are underway with several groups in the hope of addressing this shortcoming.

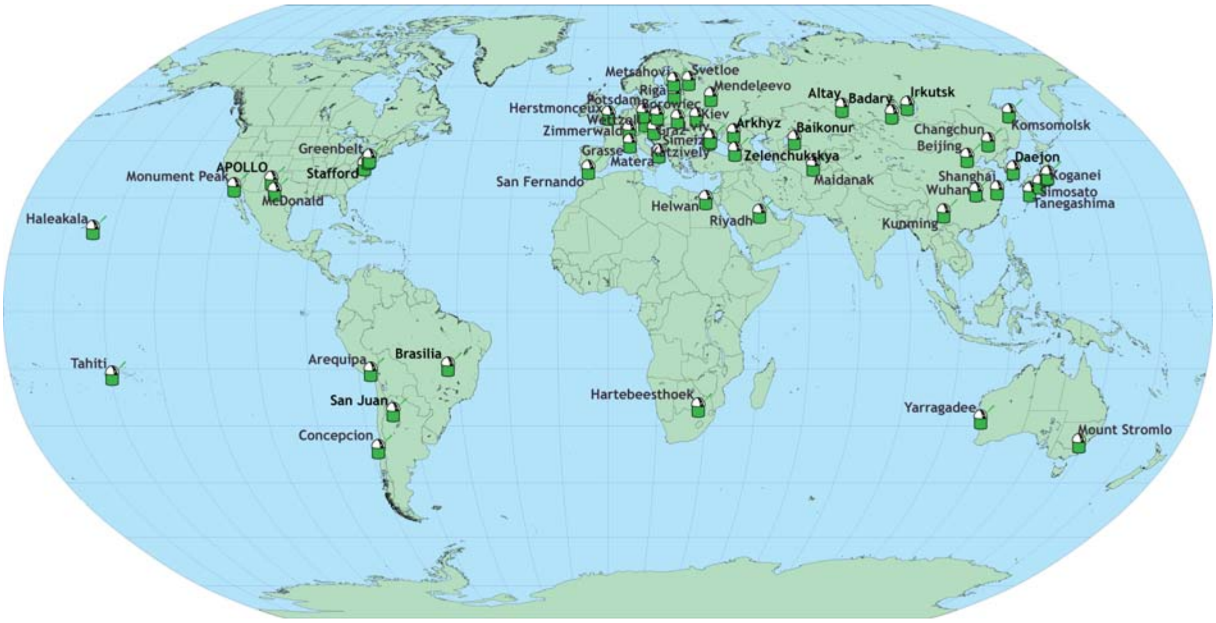

Figure 2. ILRS network (as of May 2015).

Stations designated as operational have met the minimum ILRS qualification for data quantity and quality. In general, stations continue to improve their performance. Several stations dominated the network with the Yarragadee, Changchun and Mt. Stromlo stations being the strongest performers. The next group of stations with impressive contributions included Greenbelt, Zimmerwald, Herstmonceux, Monument Peak, Graz, Matera, and Wettzell. During the twelve-month period from April 2014 to March 2015, 27 stations met the ILRS minimum requirement for total numbers of passes tracked (see Figure 3).

Several stations are now operating with kHz lasers and fast detectors, thereby increasing data yield and allowing them to be more productive with pass interleaving, a critical step as the number of satellites being tracked with SLR is increasing dramatically. Some stations have demonstrated mm precision normal points, a fundamental step toward addressing the new reference frame requirements.

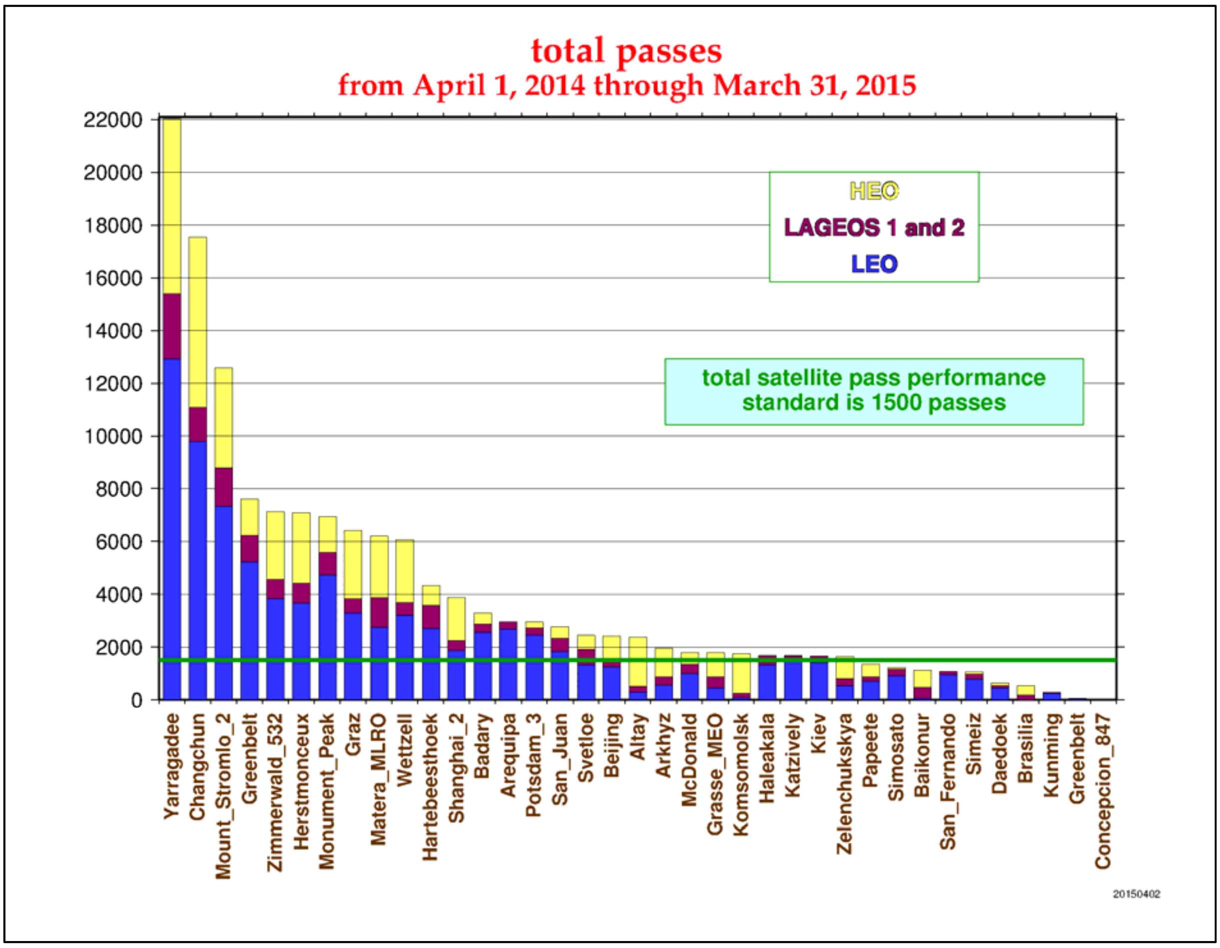

Figure 3. ILRS network performance (total passes).

Satellite Missions

The ILRS is currently tracking nearly eighty artificial satellites including passive geodetic (geodynamics) satellites, Earth remote sensing satellites, navigation satellites, and engineering missions (see Figure 4). The stations with lunar capability are also tracking the lunar reflectors. In response to tandem missions (e.g., GRACE-A/-B, TanDEM-X/TerraSAR-X) and general overlapping schedules, many stations are tracking satellites with interleaving procedures.

The ILRS assigns satellite priorities in an attempt to maximize data yield on the full satellite complex while at the same time placing greatest emphasis on the most immediate data needs. Priorities provide guidelines for the network stations, but stations may occasionally deviate from the priorities to support regional activities or national initiatives and to expand tracking coverage in regions with multiple stations. Tracking priorities are set by the Governing Board, based on application to the Central Bureau and recommendation of the Missions Working Group (see *http://ilrs.gsfc.nasa.gov/missions/mission_operations/priorities/index.html*).

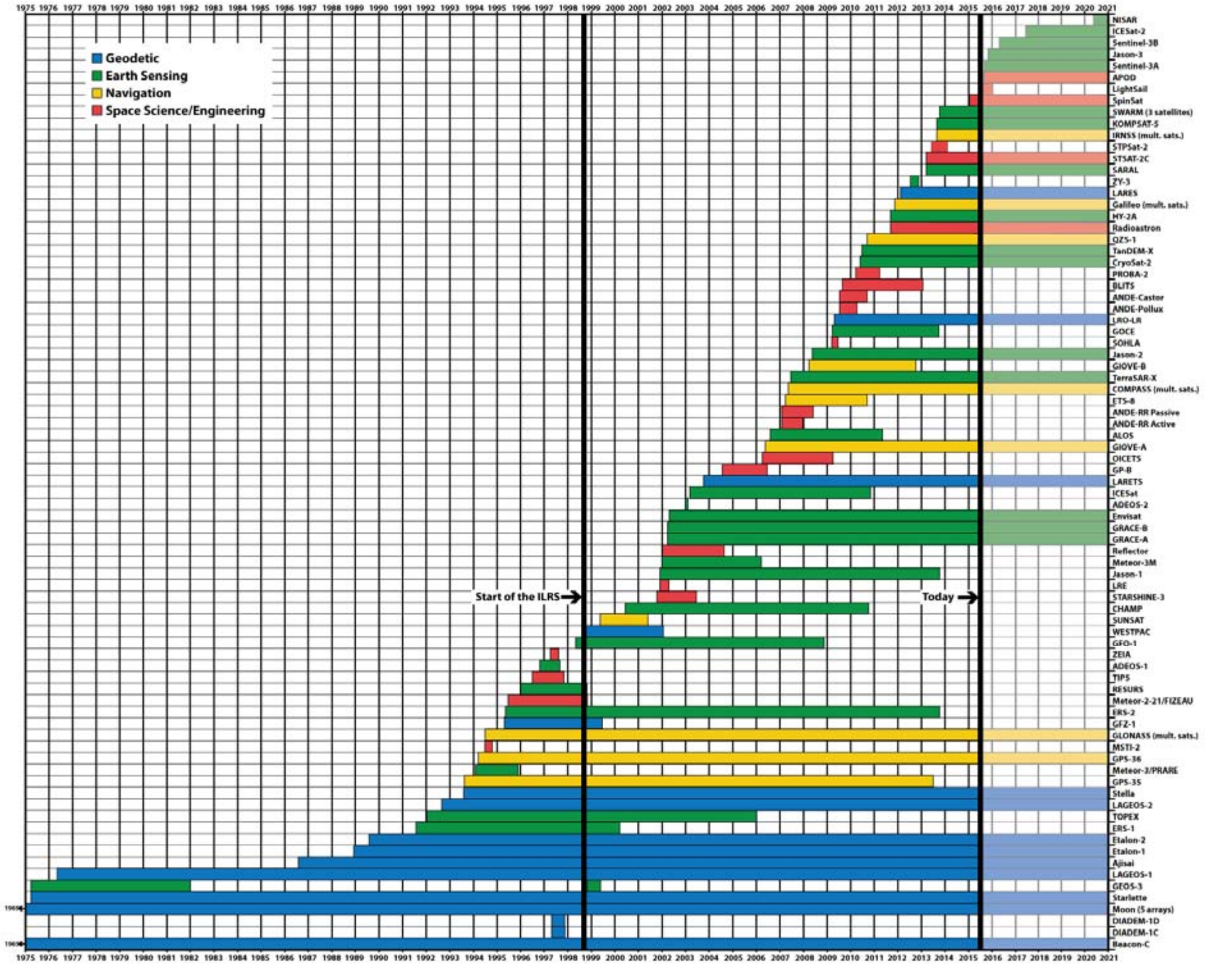

Figure 4. The past, current and future tracking roster for the ILRS network (as of May 2015).

Missions are added to the ILRS tracking roster as new satellites are launched and as new requirements are adopted. Missions for completed programs are deleted from the ILRS priority list (see Figure 4). Notable recent losses include the altimeter missions Envisat (ESA) and Jason-1 (NASA/CNES), after over ten years of ILRS support for each fully operational mission, as well as GOCE and BLITS. The ILRS continues to track Envisat to provide ephemerides and orientation data to help with trajectory/safety planning.

During this reporting period, LARES was added to the geodetic satellite constellation to support the reference frame and relativity studies. Several new satellites were added in geosynchronous and MEO orbits. The ILRS tracking roster presently includes six GLONASS satellites, four Compass, and eight Galileo satellites. Following discussions at the ILRS Technical Workshop, “Satellite, Lunar and Planetary Laser Ranging: Characterizing the Space Segment,” in Frascati, Italy in November 2012, and agreements that were approved by the ILRS and GGOS after deliberations within the “LAser Ranging to GNSS s/c Experiment (LARGE)” Study Group meeting in April 2014, several stations routinely track segments of passes of all 24 active GLONASS satellites and beyond. The newer “high” satellites are using retroreflector arrays that satisfy the ILRS standard. As a result, stations are having greater success with daylight ranging.

The tracking approval process begins with the submission of a Missions Support Request Form, which is accessible through the ILRS website (*http://ilrs.gsfc.nasa.gov/docs/2009/ilrsmsr_0901.pdf*).

The form provides the ILRS with the following information: a description of the mission objectives, mission requirements, responsible individuals and contact information, timeline, satellite subsystems, and details of the retroreflector array and its placement on the satellite. This form also outlines the early stages of intensive support that may be required during the initial orbital acquisition and stabilization and spacecraft checkout phases. A list of upcoming space missions that have requested ILRS tracking support is summarized in Table 2 along with their sponsors, intended application, and projected launch dates.

Table 2. Recently Launched and Upcoming Missions (as of May 2015)

Satellite Name	Sponsor	Purpose	Launch Date
Recently Launched			
Compass (6 satellites)	Chinese Defence Ministry	Positioning, navigation, timing	2007-2012
Galileo (8 satellites)	ESA	Positioning, navigation, timing	2011-2015
IRNSS (4 satellites)	ISRO	Positioning, navigation, timing	2013-2015
KOMPSAT-5	KARI,	Earth observation	Aug-2013
LARES	ASI/ESA	Geodesy, relativity	Feb-2012
RadioAstron	Lavochkin Association	Space science	Jul-2011
SARAL	CNES/ISRO	Earth observation	Feb-2013
SpinSat	NRL	Atmospheric density determination	Sep-2014
STPSat-2	AFRL	Spacecraft development	Nov-2010
STSAT-2C	MEST/KAIST	Spacecraft development	Jan-2013
SWARM	ESA	Earth observation	Dec-2013
Approved by ILRS for Future SLR Tracking			
APOD/PN-1A, -1B, -1C, -1D	Beijing Aerospace Control Center	Engineering	Aug-2015
LightSail-A	Planetary Society	Engineering	May-2015
NISAR	NASA	Earth sensing	2020
Future Satellites with Retroreflectors			
GPS-III	U.S. DoD, DoT	Positioning, navigation, timing	TBD
HY-2B	CNES, CNSA	Earth observation	2012
HY-2C	CNES, CNSA	Earth observation	2015
HY-2D	CNES, CNSA	Earth observation	2019
ICESat-2	NASA	Ice sheet mass balance, sea level	2016
Jason-3	NASA, CNES, Eumetsat, NOAA	Oceanography, climate change	2015
Sentinel-3A and -3B	ESA (GMES)	Oceanography	2014
SWOT	NASA, CNES	SAR altimeter	2016

Since several remote sensing missions have suffered failures in their active tracking systems or have required in-flight recalibration, the ILRS has encouraged new missions with high precision orbit requirements to include retroreflectors as a fail-safe backup tracking system, to improve or strengthen overall orbit precision, and to provide important intercomparison and calibration data with onboard microwave navigation systems.

The ILRS network has been involved in one-way ranging and time transfer programs. The first time transfer experiment T2L2 (Time Transfer by Laser Link) continues to demonstrate improved time transfer capabilities with the Jason-2 satellite; to date, time transfer to an accuracy of 100 ps has been demonstrated with potential of greater accuracy as the data analysis continues. A second time transfer proposal (European Laser Timing, ELT) utilizing a laser link for the atomic clock ensemble in space (Atomic Clock Ensemble in Space, ACES) mission on the International Space Station (ISS) has progressed to the point that it is ready to be accepted for the baseline design of ACES. The ILRS supported the Lunar Reconnaissance Orbiter (LRO), where one-way laser ranging from a subset of the ILRS network was used to improve the orbit determination for the laser altimeter and surface positioning. Approximately a dozen ground stations supported one-way ranging to LRO. The ILRS network provided nearly 4,200 hours of tracking over the five years the LRO-LR activity was funded. Ground-based hardware simulations for planning and designs for laser transponders have also been carried out by several groups looking forward to interplanetary ranging.

Lunar Laser Ranging (LLR) Network

The LLR results are considered among the most important science return of the Apollo era. Of all the active ILRS observatories very few are technically equipped to track retro-reflector arrays on the surface of the Moon or spacecraft orbiting around the Moon. In 2014, only three Lunar Laser Ranging (LLR) sites collected ranging data to the Moon: the Observatoire de la Côte d’ Azur, France (430 NPs), the APOLLO site in New Mexico, USA (212 NPs) and the Matera Laser Ranging station in Italy (6 NPs). Unfortunately, no NPs have been obtained from the McDonald Observatory in Texas, USA. This means, a time series of LLR tracking at McDonald, which has run for four decades, has been interrupted.

The LLR measurement statistics for 2014 (Figure 5) shows that about two thirds of the data have been collected at the French MeO site near Grasse and about one third of the data at APOLLO. Figure 6 illustrates the statistics for the observed retro-reflector arrays, where much better coverage of all reflectors was achieved than in previous years. Nevertheless, most of the data was obtained on the big Apollo 15 reflector array (56%). Figure 7 presents the entire LLR data set from 1970 to 2014 showing the amount of data collected by each of the active LLR sites in each year. The total data yield over this period is about 21,000 NPs, recently averaging about 600 NPs per year. At the Observatoire de Paris, an “assisting tool” has been developed to support lunar tracking by providing predictions of future LLR observations as well as a validation of past LLR normal points. This tool and further information can be accessed via the ILRS website (*http://ilrs.gsfc.nasa.gov/science/scienceContributions/lunar.html*).

LLR data analysis is carried out by a few major LLR analysis centers: Jet Propulsion Laboratory (JPL), Pasadena, USA; Center for Astrophysics (CfA), Cambridge, USA; Paris Observatory Lunar Analysis Center (POLAC), Paris, France; Institute of Geodesy (IfE), University of Hannover, Germany. In the last few years, the National Institute for Nuclear Physics (INFN), Frascati, Italy, and the Graduate University for Advanced Studies (SOKENDAI), Tokyo, Japan, have also increased their analysis activities. The six LLR analysis centers focus on different research topics (such as relativity, lunar interior, etc.). In addition, various research projects have been successfully run combining LLR, GRAIL, and LRO data.

One general objective of LLR analysis is to improve accuracy from the current cm to the mm level. The various analysis centers continue their comparison initiative to mutually improve the various reduction codes. Recent activities also include comprehensive simulations to show the potential benefit of improved tracking with additional observatories and/or to new reflectors.

Above all, LLR remains one of the best tools to support lunar science, to study the Earth-Moon dynamics and to test General Relativity in the solar system (Müller et al. 2014). LLR analysis steadily reduces the margins for a possible violation of Einstein's theory of relativity and impressively underpins its validity – now in the 100th year of its existence.

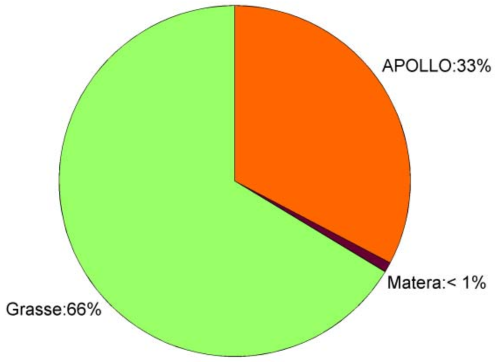

Figure 5. Observatory statistics in 2014.

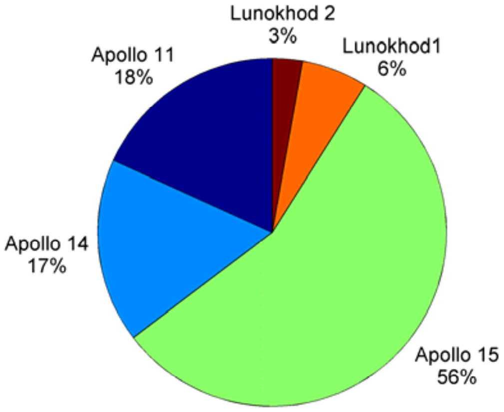

Figure 6. Reflector statistics in 2014.

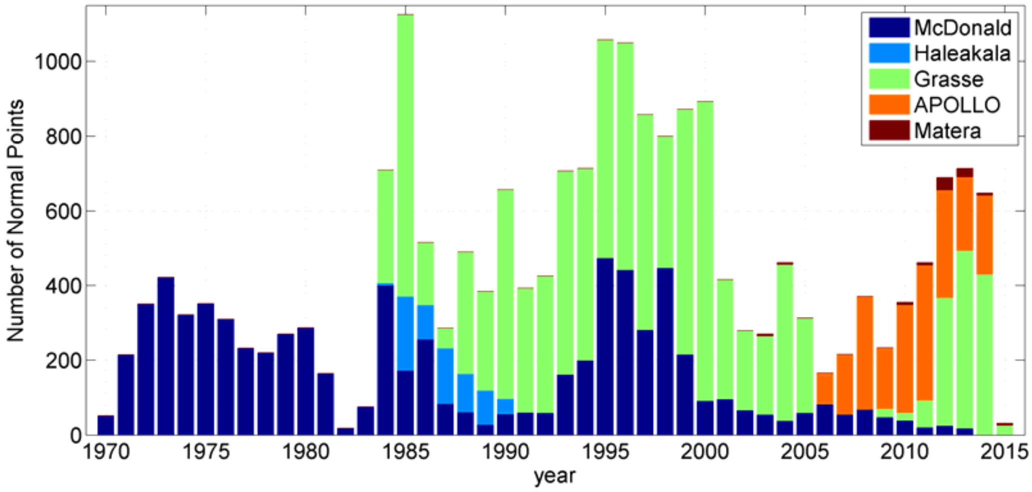

Figure 7. Data yield of the global LLR network of stations (through the end of 2014).

Recent Activities

Mission Campaigns

During the 18th International Workshop on Laser Ranging in Japan in November 2013, the ILRS agreed to expand the ILRS network support of the various GNSS constellations. To that end, the ILRS and GGOS jointly formed a study group, the LAser Ranging to GNSS s/c Experiment (LARGE). The objectives of this study group are to define an operational GNSS tracking strategy for the ILRS that addresses all proposed requirements and to clarify outstanding ILRS and IGS issues with the GNSS satellites and ground stations. The satellite constellations of interest with retroreflector arrays include GLONASS, BeiDou (Compass), Galileo, and GPS. The GLONASS constellation is fully populated. BeiDou and Galileo (including GIOVE) constellations are in process. GPS satellites with laser retroreflector arrays will begin launching in the 2018 timeframe. When completed, the full GNSS complex should reach about 80 satellites.

Two GNSS tracking campaigns have been held thus far to determine strategies for the ILRS network to support tracking of this future large number of GNSS satellites. The first session was held in August and September 2014. Stations were asked to track as many GNSS targets as possible (24 GLONASS, 4 Beidou, and 5 Galileo satellites). Although several stations were able to accomplish this goal, few stations obtained more than one segment per pass and very few daylight passes were tracked. A second GNSS campaign was held from November 2014 through January 2015 with a reduced number of satellites (6 GLONASS, 4 Beidou, and 4 Galileo). Stations were asked to track three segments per pass and include daylight tracking.

In addition to the LARGE effort, the ILRS has supported several other tracking campaigns, including the IRNSS constellation at geosynchronous orbits.

ILRS Meetings

The ILRS organizes regular meetings of the Governing Board and working groups. These meetings are typically held in conjunction with ILRS workshops, such as the ILRS Technical Workshops (oriented toward SLR practitioners) or the biannual International Workshop on Laser Ranging. A summary of recent and planned ILRS meetings is shown in Table 3. Minutes and presentations from these meetings are available from the ILRS website (*http://ilrs.gsfc.nasa.gov/about/reports/meeting_reports.html*).

The ILRS also conducts meetings of the Central Bureau on a monthly basis. These meetings review network station operation and performance, as well as coordinate support of upcoming missions, monitoring and managing the ILRS infrastructure, and future directions and activities, such as the implementation of the new ILRS website.

In May 2011, the Bundesamt fuer Kartographie und Geodaesie/BKG (Geodetic Observatory Wettzell and TIGO), the Research Group Satellite Geodesy of the Technische Universitaet Muenchen and the ILRS sponsored the 17th International Workshop on Laser Ranging in Bad Kötzting, Germany. Over 140 attendees participated in the workshop. Various ILRS-related meetings were held in conjunction with the workshop, including the 23rd General Assembly of the ILRS, and Governing Board and working group meetings. A trip to the Geodetic Observatory Wettzell and an introduction to the TWIN VLBI project was arranged.

Table 3. Recent ILRS Meetings (as of May 2015)

Timeframe	Location	Meeting
May 2011	Bad Kötzting, Germany	17th International Workshop on Laser Ranging ILRS Governing Board meeting ILRS Working Group meetings ILRS General Assembly
September 2011	Zurich, Switzerland	ILRS Analysis Working Group meeting
December 2011	San Francisco CA, USA	ILRS Governing Board meeting
April 2012	Vienna, Austria	ILRS Governing Board meeting ILRS Working Group meetings
November 2012	Frascati, Italy	ILRS Technical Workshop "Satellite, Lunar, and Planetary Laser Ranging: Characterizing the Space Segment" ILRS Governing Board meeting ILRS Working Group meetings
April 2013	Vienna, Austria	ILRS Analysis Working Group meeting
September 2013	Potsdam, Germany	ILRS Analysis Working Group meeting
November 2013	Fujiyoshida, Japan	18th International Workshop on Laser Ranging ILRS Governing Board meeting ILRS Working Group meetings ILRS General Assembly
April 2014	Vienna, Austria	ILRS Analysis Working Group meeting
October 2014	Annapolis MD, USA	19th International Workshop on Laser Ranging ILRS Governing Board meeting ILRS Working Group meetings
April 2015	Vienna, Austria	ILRS Analysis Working Group meeting
October 2015	Matera, Italy	ILRS Technical Workshop
2016	Potsdam, Germany	20th International Workshop on Laser Ranging

The ILRS Technical Workshop 2012: "Satellite, Lunar and Planetary Laser Ranging: characterizing the space segment" was held at the Frascati National Laboratories of the INFN-LNF, Frascati, Italy on November 5-9, 2012, in conjunction with a one-day Workshop on "ASI-INFN ETRUSCO-2 Project of Technological Development and Test of SLR Payloads for GNSS Satellites." The meeting focused on the laser ranging space segment including retroreflector arrays for Earth orbiting satellites and the Moon, with special attention to the expanding role of ranging to GNSS and geosynchronous satellites. Topics also included receivers in space for time transfer experiments (T2L2), one-way ranging to lunar orbiters (LRO) and interplanetary spacecraft (MLA, MOLA), and data relay systems.

The 18th International Laser Ranging Workshop was held in Fujiyoshida Japan, November 11-15, 2013. The theme of the 18th workshop was "Pursuing Ultimate Accuracy and Creating New Synergies." An important topic for this workshop was maximizing accuracy in the network with the intent of enhancing the potential for laser ranging by including activities in relevant fields. The workshop was funded by the National Institute of Information and Communications Technology (NICT) International Exchange Program, the Support Center for Advanced Telecommunications Technology Research (SCAT), the Geodetic Society of Japan, and the Society for Promotion of Space Science, and is academically supported by the Science Council of Japan, the Geodetic Society of Japan and also by the Japan Society for Aeronautical and Space Sciences. Over 150 attendees participated in the workshop. As with most workshops, ILRS-related meetings were held in conjunction with the workshop. Attendees were also able to make a trip to the Koganei Geodetic Observatory during the week.

The 19th International Workshop on Laser Ranging was held in Annapolis, MD October 27-31, 2015. NASA, along with the Smithsonian Astrophysical Observatory (SAO) and the International Laser Ranging Service (ILRS), sponsored the workshop, with help from several corporate supporters. Over 180 attendees participated in the workshop from 23 countries. NASA Goddard Space Flight Center (GSFC) had the unique opportunity to host this event at the birthplace of SLR: October 31, 2014 marked the 50th anniversary of the first successful SLR measurement, conducted at what is now the Goddard Geophysical and Astronomical Observatory (GGAO). The theme for this workshop, “Celebrating 50 Years of SLR: Remembering the Past and Planning for the Future” allowed attendees to look back on the many accomplishments of the laser ranging community and present plans for future advances in SLR technology and science. The workshop featured sessions of invited talks by the pioneers in the field as well as science sessions highlighting SLR’s positive impact on various NASA and international missions. In addition to the events in Annapolis, the participants were given a daylong tour of GSFC and GGAO. A new format for a station operations session was introduced at this workshop where ILRS experts met in small groups with station engineers and operators to provide solutions to common station problems, information to maintain station stability, and guidelines for interacting with the analysts in determining station biases. These station clinics were well attended and well received by the workshop attendees.

Publications

Detailed reports from past meetings can be found on the ILRS website. ILRS Biannual Reports summarize activities within the service over the period since the previous release. They are available as hard copy from the CB or online at the ILRS website. The ILRS published the 2009-2010 ILRS Report in late 2012. This latest volume is the fifth published report for the ILRS and concentrated on achievements and work in progress rather than ILRS organizational elements.

In October 2012, the ILRS Central Bureau implemented a new design for the ILRS website, *http://ilrs.gsfc.nasa.gov*. The redesign process allowed for a review of the organization of the site and its contents, ensuring information was made current and remained useful to the laser ranging community.

ILRS Analysis Center reports and inputs are used by the Central Bureau for review of station performance and to provide feedback to the stations when necessary. Special weekly reports on on-going campaigns are issued by email. The CB also generates monthly and quarterly Performance Report Cards and posts them on the ILRS website (*http://ilrs.gsfc.nasa.gov/network/system_performance/index.html*). These Report Cards evaluate data quantity, data quality, and operational compliance for each tracking station relative to ILRS minimum performance standards. These results include independent assessments of station performance from several of the ILRS analysis/associate analysis centers. The statistics are presented in tabular form by station and sorted by total passes in descending order. Plots of data volume (passes, normal points, and minutes of data) and RMS (LAGEOS, Starlette, calibration) are created from this information and available on the ILRS website. Plots, updated frequently, of multiple satellite normal point RMS and number of full-rate points per normal point as a function of local time and range have been added to the ILRS website station pages.

Other Activities

In April 2013, the ILRS was accepted as a network member of the International Council for Science (ICSU) World Data System (WDS). The WDS strives to enable open and long-term access to multidisciplinary scientific data, data services, products and information. The WDS works to ensure long-term stewardship of data and data services to a global scientific user community. The ILRS is a network member of the WDS, representing its two data centers and coordinating their activities within the WDS.

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