

## **International Laser Ranging Service (ILRS)**

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

*Chair of the Governing Board: Werner Gurtner (Switzerland)*

*Director of the Central Bureau: Michael Pearlman (USA)*

### **Contributions of the ILRS**

*The ILRS was organized as one of the IAG measurement services in 1998. The service collects, merges, analyzes, archives and distributes Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observation data sets to satisfy the objectives of scientific, engineering, and operational applications and programs. The basic observable is the precise time-of-flight of an ultra-short laser pulse to and from a retro-reflector array on a satellite. The Service also produces analogous lunar ranging observations. These data sets are 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 geocentre coordinates, static and time-varying coefficients of the Earth's gravity field, fundamental physical constants, lunar ephemerides and librations, and lunar orientation parameters. The ILRS generates a standard weekly product of station positions and Earth orientation for submission to the IERS, and produces LAGEOS combination solutions for maintenance of the International Terrestrial Reference Frame (ITRF). The ILRS participates in the Global Geodetic Observing System (GGOS) organized under the IAG.*

### **Organization and Role of the ILRS**

The ILRS accomplishes its mission through the following permanent components:

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

*The ILRS Tracking Stations range to a constellation of Earth satellites, the Moon, a lunar satellite, and eventually interplanetary spacecraft with state-of-the-art laser ranging systems and transmit their data on an hourly basis to an Operations or Data Centre. Stations are expected to meet ILRS data accuracy, quantity, and timeliness requirements, and their data must be regularly and continuously analyzed by at least one Analysis or mission-specific Associate Analysis Centre. Each Tracking Station is typically associated with one of the three regional sub-networks: National Aeronautics and Space Administration (NASA), EUROpean LASer Network (EUROLAS), or the Western Pacific Laser Tracking Network (WPLTN).*

Operations Centres collect and merge the data from the tracking sites, provide initial quality checks, reformat and compress the data if necessary, maintain a local archive of the tracking data, and relay the data to a Data Centre. Operational Centres may also provide the Tracking Stations with sustaining engineering, communications links, and other technical support. Tracking Stations may perform part or all of the tasks of an Operational Centre themselves.

*Global Data Centres are the primary interfaces between the Tracking Stations and the Analysis Centres and outside users. They receive and archive ranging data and supporting infor-*

*mation from the Operations and Regional Data Centres, and provide these data on-line to the Analysis Centres. They also receive and archive ILRS scientific data products from the Analysis Centres and provide these products on-line to users. Regional Data Centres reduce traffic on electronic networks and provide a local data archive.*

Analysis Centres retrieve data from the archives and process them to produce the official ILRS products. They are committed to follow designated standards and produce data products on a routine basis for delivery to the Global Data Centres and the IERS. Analysis Centres routinely process the global LAGEOS-1 and LAGEOS-2 data and compute weekly solutions of station positions and Earth orientation for combination and submission to the IERS. Analysis Centres also provide a second level of data quality assurance in the network. Analysis and Associate Analysis Centres produce station coordinates and velocities, geocentre coordinates, time-varying gravity field measurements, fundamental constants, satellite predictions, precision orbits for special-purpose satellites, regional geodetic measurements, and data products of a mission-specific nature. Associate Analysis Centres are also encouraged to perform quality control functions through the direct comparison of Analysis Centre products and the creation of “combined” solutions using data from other space geodetic techniques. Based on the longest observation time series of all space geodetic techniques, lunar laser ranging (LLR) analysis centres provide results for several dynamic parameters in the Earth-Moon system, e.g., orbital and libration parameters, reflector and station coordinates, and lunar physics quantities. Moreover, LLR is sensitive to nutation/precession, Earth rotation UT0, and polar motion. Also a variety of relativistic features are studied, like the strong equivalence principle, variation of the gravitational constant, metric or preferred-frame effects.

## **Central Bureau**

The ILRS Central Bureau (CB) is responsible for the daily coordination and management of ILRS activities. It facilitates communications and information transfer and promotes compliance with ILRS network standards. The CB monitors network operations and quality assurance of the data, maintains all ILRS documentation and databases, and organizes meetings and workshops. In order to strengthen the ILRS interface with the scientific community, a Science Coordinator and an Analysis Coordinator within the CB take a proactive role to enhance dialogue, to promote SLR goals and capabilities, and to educate and advise the ILRS entities on current and future science requirements related to SLR. The Science Coordinator leads efforts to ensure that ILRS data products meet the needs of the scientific community and that there is easy online access to published material relevant to SLR science and technology objectives.

The CB has been actively providing new facilities to expedite communication and performance review, and adding to the technical and scientific database. The information available via the ILRS Web Site has grown enormously since its inception, and many new links to related organizations and sites have been established. The site provides details on the ILRS, the satellites and campaigns, individual SLR station characteristics, a scientific and technical bibliography on SLR and its applications, current activities of the Governing Board, Working Groups, and Central Bureau, meeting minutes and reports (including annual reports), tracking plans, and much more.

The Central Bureau maintains the ILRS Web site, <http://ilrs.gsfc.nasa.gov>, as the primary vehicle for the distribution of information within the ILRS community. Enhancements to the ILRS Web site continue. The ILRS station information pages were expanded to include various reports and plots to monitor network performance. Station operators, analysts, and other ILRS groups can view these reports and plots to quickly ascertain how individual stations are performing as well as how the overall network is supporting the various missions.

Detailed information on satellites supported by the ILRS is also available on the ILRS Web site, organized by mission.

### ***Governing Board***

*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. There are sixteen members of the Governing Board (GB) - three are ex-officio, seven are appointed, and six are elected by their peer groups (see Table 1). A new Board was installed in October 2008 at the 16<sup>th</sup> International Workshop on Laser Ranging in Poznan Poland.*

### ***Working Groups***

*Within the GB, permanent (Standing) or temporary (Ad-Hoc) Working Groups (WG) carry out policy formulation for the ILRS. At its creation, the ILRS established four standing WGs: (1) Missions, (2) Data Formats and Procedures, (3) Networks and Engineering, (4) Analysis, and (5) Transponders for lunar and planetary ranging. 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 Coordinator and Deputy Coordinator (see Table 1). The WGs continue to attract talented people from the general ILRS membership who contributed greatly to the success of these efforts.*

The Missions WG, with a set of evolving formal and standardized documentation, has been working with new satellite missions to seek ILRS approval for SLR observing support, if such support is deemed necessary for the success of the mission, and is within the operational capabilities of the network. The WG works with the new mission personnel and campaign sponsors to develop and finalize tracking plans and to establish recommended tracking priorities.

The Data Formats and Procedures WG completed the implementation of the Consolidated Prediction Format (CPF) for a much wider variety of laser ranging targets including (1) Earth-orbiting retro-reflector satellites, (2) Lunar reflectors, (3) asynchronous and synchronous transponders. The new expanded format capability, with more complete modeling representation, has improved tracking on lower satellites and has removed the need for drag and special manoeuvre files as well as virtually all satellite time-bias corrections. The working group also designed and began implementing the Consolidated Laser Ranging Data format (CRD), which accommodates full rate, sampled engineering, and normal point data types for artificial satellite, lunar, and now transponder ranging data. The format change was required to incorporate higher precision fire times for transponder ranging and to more efficiently represent full rate data from kHz laser-repetition-rate stations. The format was designed to be flexible and expandable and to incorporate additional statistical and configuration data unavailable in the earlier formats. Implementation and initial validation of the CRD format is being monitored by the WG through a cooperative effort with the OCs, DCs, and AGs (organized through the Analysis WG). The Working Group has also coordinated the implementation of new features to support mission support restrictions due to satellite vulnerability.

Table 1. ILRS Governing Board (as of June 2009)

Zuheir Altamimi	Ex-Officio, President of IAG Commission	France
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
Werner Gurtner	Appointed, EUROLAS, Governing Board Chair	Switzerland
Giuseppe Bianco	Appointed, EUROLAS	Italy
David Carter	Appointed, NASA	USA
Jan McGarry	Appointed, NASA	USA
Yang Fumin	Appointed, WPLTN	China
Ramesh Govind	Appointed, WPLTN	Australia
Vincenza Luceri	Elected, Analysis Representative, Analysis Working Group Deputy Coordinator	Italy
Erricos C. Pavlis	Elected, Analysis Representative, Analysis Working Group Coordinator	USA
Wolfgang Seemüller	Elected, Data Centres Rep., Data Formats and Procedures WG Coordinator	Germany
Jürgen Mueller	Elected, Lunar Representative	Germany
Graham Appleby	Elected, At-Large, Missions Working Group Coordinator	UK
Georg Kirchner	Elected, At-Large, Networks and Engineering Working Group Coordinator	Austria

The Networks and Engineering WG is assisting stations to upgrade to high repetition rate lasers and to implement some adaptations to the existing normal point format to accommodate this high rate data. Software has been made available to the stations for on-site normal point data quality verification. Work continued on the bias problems with the Stanford SR620 counters, but laboratory calibrations did not prove to be sufficiently stable to reduce biases below the several cm level. The Signal Processing Study Group completed its modeling of the LAGEOS retro-reflector arrays and is now working on Etalon.

The Analysis WG completed its pilot projects to assess, document and resolve differences among analysis products from the Analysis and Associate Analysis Centres. Eight centres have qualified as Analysis Centres; four additional centres have expressed interest in becoming Analysis Centres, two of them already in the qualifying process. A Combination Centre and a Backup Combination Centre have been in operation since 2004. The WG has developed and implemented the process to deliver LAGEOS derived site positions and EOP to the IERS as required on a weekly basis. A 1983-2008 reanalysis of the LAGEOS and LAGEOS 2 data was provided to the IERS in support of the development of ITRF2008. Work is underway to add additional official ILRS products including precision orbits and certified data corrections.

The Transponder Working Group has been involved in a number of activities in transponder and one-way ranging. Ground based hardware simulations for laser transponder operations at interplanetary distances have been successfully carried out within the frame of the Transponder Working Group. Results are promising and currently under review at "Planetary and Space Science". The first time transfer experiment T2L2 is under way on the satellite Jason 2. A second time transfer proposal (ELT) utilizing a laser link for the atomic clock ensemble in space (ACES) mission on the ISS has progressed to the point that it is ready to be accepted for

the baseline design of ACES. The transponder working group also actively supports LRO, where one-way laser ranging will improve the orbit calculations for the laser altimeter.

## **ILRS Network**

### *Satellite Laser Ranging (SLR) Network*

The present ILRS network includes forty stations in 23 countries (see Figure 1.) Stations designated as operational have met the minimum ILRS qualification for data quantity and quality. A dozen stations dominated the network with the Yarragadee, Mt Stromlo, Zimmerwald, and San Juan stations being the strongest performers. From start-up in 2005, the San Juan Station performance has been dramatic; in 2008 station performance has risen to second only to Yarragadee. There has also been noticeable improvement at Greenbelt, San Fernando, Concepcion, Mount Haleakala, Arequipa and Katzively. The improved orbital coverage over the Pacific region should have a very fundamental impact on our ILRS data products. The Arequipa stations and Mt Haleakala Stations were both rededicated in early 2007 with the NASA TLRS-3 and 4 SLR systems respectively; both are back in operation. In addition to San Juan, the rest of the Chinese SLR network continues its very strong support for the ILRS network. The Changchun station maintained its very strong performance, and data yield continues to improve at the new Shanghai station. The Chinese Mobile TROS system had its first session at the Korea Astronomy and Space Science Institute (KASI), Daejeon, Korea in mid-2008; the next session is scheduled for mid-2009. The Riyadh station continues to do well playing a vital role in the network as the only SLR station on the Arabian Peninsula. Data started flowing again from the Russian Stations, including the new station at Altay. The TIGO system in Concepción, Chile underwent substantial repairs in the 2005-6 time frame and is now performing very well, having reached full operational status in the network. SLR data are again flowing from the new MEO station at Grasse, France; the French Transportable Laser System (FTLRS) conducted a campaign in Burnie, Tasmania in 2008 to support altimeter calibration and validation for Jason. While there it supported the general ILRS requirements.

Several stations have moved to higher repetition rate lasers. In the spring of 2008, the Zimmerwald Station introduced its new 100 Hz system and rapidly became one of the major data producers in the network. The Graz system continues its impressive performance with 2 kHz operations, a technology that will most likely become more prevalent in the network as time goes on. A 2 kHz laser has been added to the Herstmonceux station; several other stations have this upgrade underway.

A number of stations using the Stanford Counter have experienced timing (range) errors in some cases as large as a centimetre. Calibration procedures have not been successful in addressing the problem and several of these stations have now gone to new epoch timing units – in particular the units now made by the University of Latvia. Additional stations have also moved the SPAD detectors.

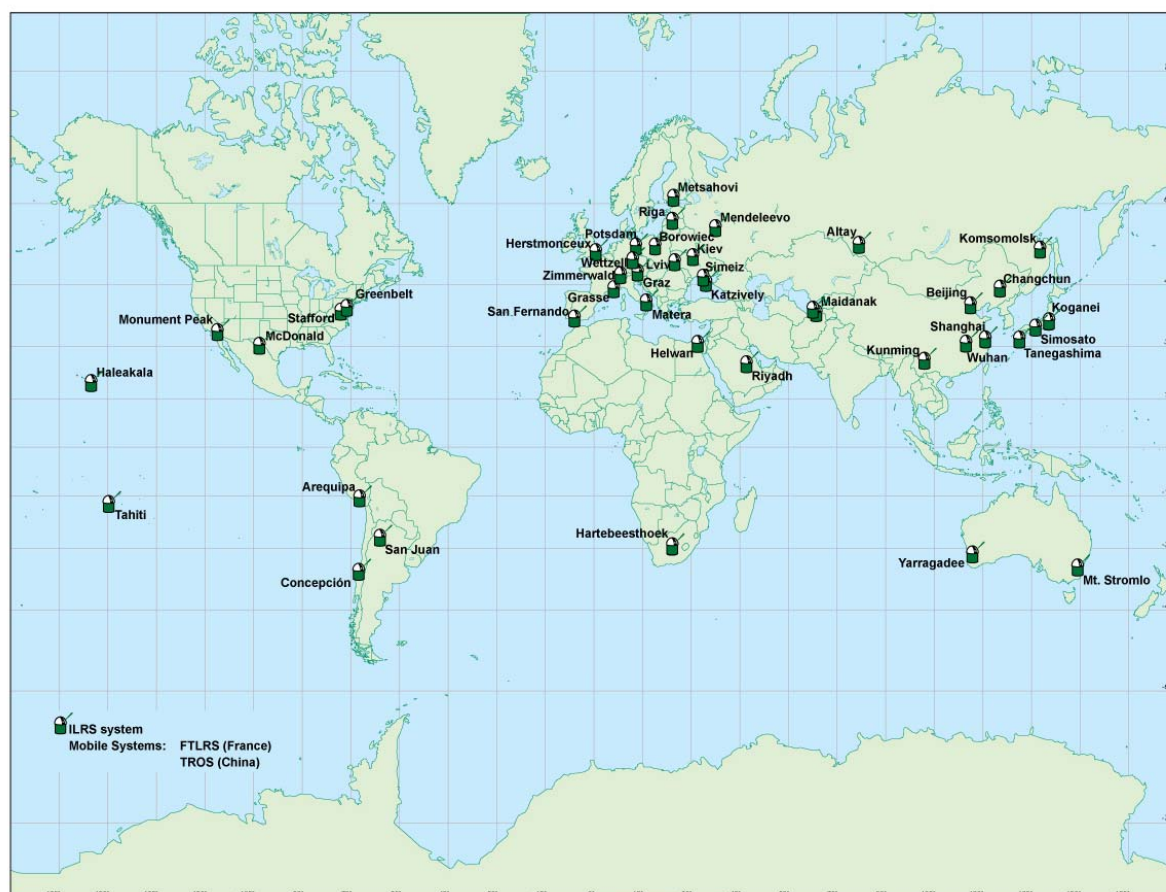


Figure 1. ILRS network (as of June 2009).

### *Lunar Laser Ranging (LLR) Network*

During three U.S. American Apollo missions (11, 14, and 15) and two un-manned Soviet missions (Luna 17 and Luna 21), retro-reflectors were deployed near the landing sites between 1969 and 1973 (Figure 2). The LLR experiment has continuously provided range data for about 40 years, generating about 16300 normal points. The main benefit of this space geodetic technique is the determination of a host of parameters describing lunar ephemeris, lunar physics, the Moon's interior, various reference frames, Earth orientation parameters and the Earth-Moon dynamics. LLR has also become the strongest tool for testing Einstein's theory of general relativity in the solar system; no violations of general relativity have been found so far. However, the basis for all scientific analyses is more high quality data from a well distributed global LLR network.

From all of the ILRS observatories (nearly 40), there are only a few sites that are technically equipped to carry out Lunar Laser Ranging (LLR) to retro-reflector arrays on the surface of the Moon (Figure 3). The McDonald Observatory in Texas, USA and Observatoire de la Côte d'Azur, France are the only currently operational LLR sites. The latter has undergone renovation since late 2004, and it is expected to imminently return to action in 2009. The McDonald observatory has major problems to get further LLR tracking funded. Thus no system upgrade could be made in the past years and at the end of 2009, even any financial support for lunar tracking will be cut down, so that lunar laser ranging is not possible anymore. A new site with lunar capability has been built at the Apache Point Observatory, New Mexico, USA, equipped with a 3.5 m telescope. This station, called APOLLO, is designed for mm accuracy ranging. A new set of data from APOLLO was released in 2008 with an addi-

tional ~200 normal points, and a promise to soon make the data available in the newly adopted ILRS data format.

The Australian station at Mt. Stromlo is expected to join this group in the future, and there are plans for establishing lunar capability at the South African site of Hartebeesthoek, and at Wettzell observatory, Germany, once there are new telescopes installed. Also other modern stations have demonstrated lunar capability, e.g., the Matera Laser Ranging Station, Italy in 2005, but all of them suffer from funding restrictions or technical problems when upgrading their systems. Hopefully, further sites may provide lunar data on a routine basis in the near future.

Current LLR data are collected, archived and distributed under the auspices of ILRS. All former and current LLR data are electronically accessible through the EDC in Munich, Germany and the CDDIS in Greenbelt, Maryland.

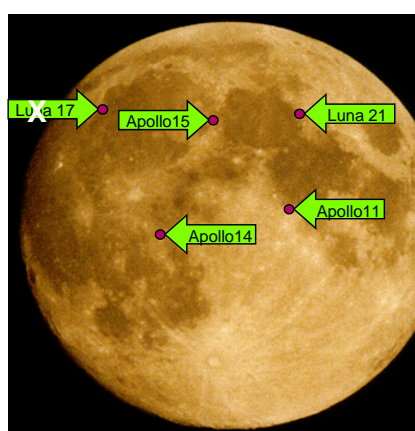


Figure 2. Retro-reflector sites on the Moon, Luna 17 has never been successfully tracked.



Figure 3. ILRS sites with potential lunar capability demonstrated in the past or planned for the near future.

### ILRS Tracking Priorities and Mission Support

*The ILRS is currently tracking 28 artificial satellites including passive geodetic (geodynamics) satellites, Earth remote sensing satellites, navigation satellites, and engineering missions (see Table 2). The stations with lunar capability are also tracking the lunar reflectors. In response to tandem missions (e.g., GRACE-A/-B) and general overlapping schedules, stations have begun 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.*

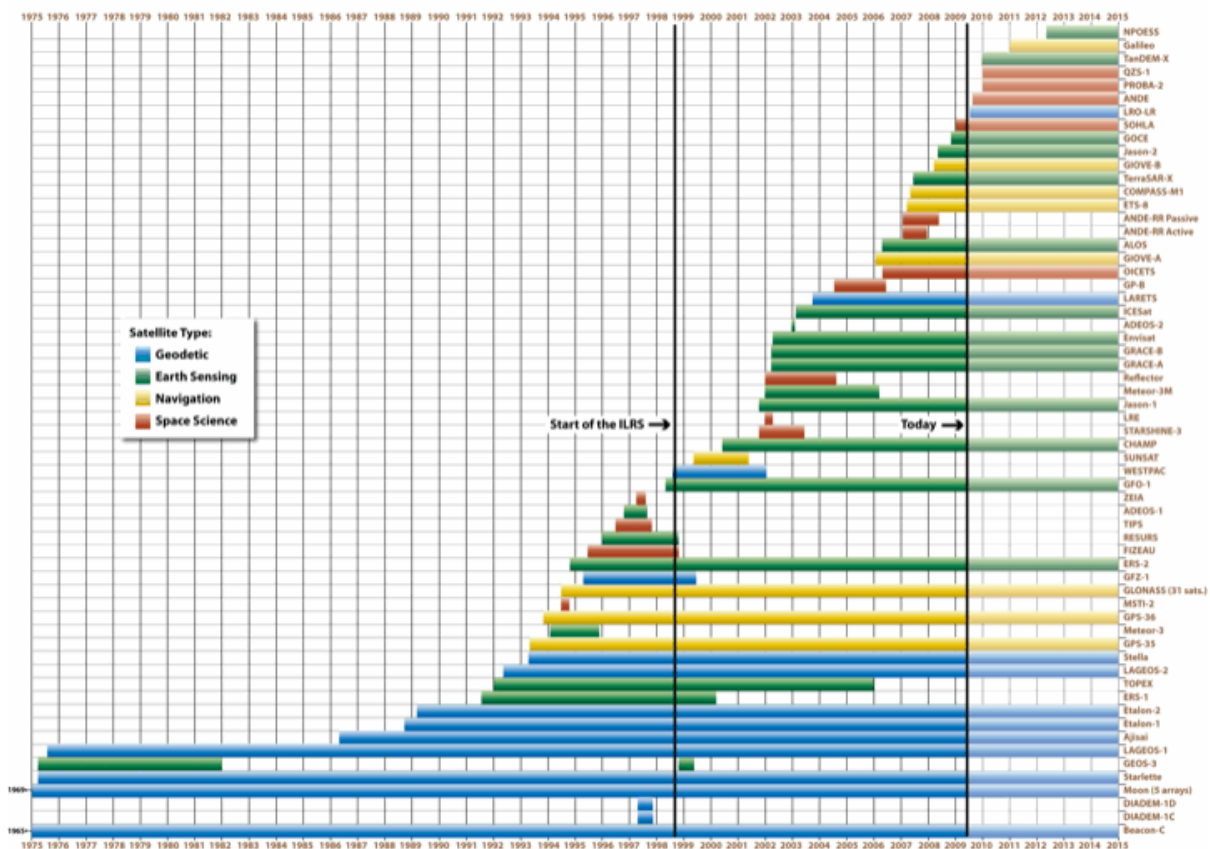
Table 2. ILRS Tracking Priorities (as of June 2009)

<b>Satellite Priorities</b>					
<b>Priority</b>	<b>Mission</b>	<b>Sponsor</b>	<b>Altitude (km)</b>	<b>Inclination (degrees)</b>	<b>Comments</b>
1	GOCE	ESA	295	96.7	
2	GRACE-A, -B	GFZ/JPL	485-500	89	Tandem mission
3	CHAMP	GFZ	429-474	87.3	
4	TerraSAR-X	Infoterra/DLR/ GFZ/CSR	514	97.44	First priority for acquisition phase only
5	Envisat	ESA	796	98.6	Tandem with ERS-2
6	ERS-2	ESA	800	98.6	Tandem with Envisat
7	Jason-1	NASA/CNES	1,350	66.0	
9	Jason-2	NASA, CNES, Eumetsat, NOAA	1,336	66.0	Tandem with Jason-1
9	Larets	IPIE	691	98.2	
10	Starlette	CNES	815-1,100	49.8	
11	Stella	CNES	815	98.6	
12	Ajisai	NASDA	1,485	50	
13	LAGEOS-2	ASI/NASA	5625	52.6	
14	LAGEOS-1	NASA	5850	109.8	
15	Beacon-C	NASA	950-1,300	41	
16	GIOVE-B	ESA	23,916	56	
17	Etalon-1	Russian Federation	19,100	65.3	
18	Etalon-2	Russian Federation	19,100	65.2	
19	COMPASS-M1	China	21,500	55.5	
20	GLONASS-115	Russian Federation	19,100	65	Replaced GLONASS-99 on 03/31/2009
21	GLONASS-109	Russian Federation	19,100	65	Replaced GLONASS-95 on 05/28/2008
22	GLONASS-102	Russian Federation	19,100	65	Replaced GLONASS-89 on 05/04/2007
23	GPS-36	US DoD	20,100	55.0	
24	GIOVE-A	ESA	29,601	56	
<b>Lunar Priorities</b>					
<b>Priority</b>	<b>Retro-reflector Array</b>	<b>Sponsor</b>	<b>Altitude (km)</b>		
1	Apollo 15	NASA	356,400		
2	Apollo 11	NASA	356,400		
3	Apollo 14	NASA	356,400		
4	Luna 21	Russian Federation	356,400		



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 (see Figure 4). New missions added during this reporting period included: ETS-8, GIOVE-B, Jason -2 (with T2L2); COMPASS-M1, SOHLA-1, TerraSAR-X and GOCE. The network continued to support the GLONASS program: GLONASS 102 replaced GLONASS 89 in May 2007. GLONASS 109 replaced GLONASS 95 in March 2008, and GLONASS 115 replaced GLONASS 99 in April 2009. ETS-8 was the first ILRS target in synchronous orbit. In April the GPS receiver on Jason-1 failed and SLR became the primary means of POD. The ANDE satellites reentered in late 2007 and early 2008. The network was successful tracking down to 300 km and in some cases even below. The GFO-1 Mission ceased operating in November 2008. The radio systems aboard had failed several years prior and the SLR was the only means of POD for the altimeter. The SOHLA-1 and OICETS missions are tracked for short campaigns as requested.

*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 retro-reflectors as a fail-safe backup tracking system, to improve or strengthen overall orbit precision, and to provide important inter-comparison and calibration data with onboard microwave navigation systems.*



Support Request Form, which is accessible through the ILRS Web site. 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 retro-reflector 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 3 along with their sponsors, intended application, and projected launch dates.

Once tracking support is approved by the Governing Board, the Central Bureau works with the new missions to develop a Mission Support Plan detailing the level of tracking, the schedule, the points of contact, and the channels of communication. New missions normally receive very high priority during the acquisition and checkout phases and are then placed at a routine priority based on the satellite category and orbital parameters. After launch, reports with network tracking statistics and operational comments are issued weekly. The Central Bureau monitors progress to determine if adequate support is being provided. New mission sponsors (users) are requested to report at the ILRS meetings on the status of ongoing campaigns, including the responsiveness of the ILRS to their needs and on progress towards achieving the desired science or engineering results.

One interesting application for SLR is the tracking support of the Lunar Reconnaissance Orbiter (LRO), launched June 17, 2009. The LRO mission objective is to conduct investigations that will be specifically targeted to prepare for and support future human exploration of the Moon. The LRO Laser Ranging (LR) system will use one-way range measurements from laser ranging stations on the Earth to LRO to determine LRO position at sub-meter level with respect to Earth and the center of the Moon (on the lunar near-side or whenever possible). The LR aspect of the mission will allow for the determination of a more precise orbit than possible with S-band tracking data alone. The flight system consists of a receiver telescope, which captures the uplinked laser signal and a fiber optic cable, which routes it to the LOLA instrument. The LOLA instrument captures the arrival time of the laser signal, records that information and provides it to the onboard LRO data system for storage and/or transmittal to the ground through the RF link.

Table 3. Upcoming Missions (as of June 2009)

<b>Mission</b>	<b>Sponsor</b>	<b>Planned Launch Date</b>	<b>Mission Duration (years)</b>	<b>Altitude (km)</b>	<b>Inclination (degrees)</b>	<b>Application</b>
ANDE	NRL	Jul-2009	1-3	350	51.6°	Atmospheric modeling
BLITS	IPIE	Aug-2009	5	832	98.77°	Test of retro-reflector technology
PROBA-2	ESA	Dec-2009	2	721	98°	Technology validation
QZS-1	JAXA	2010	12	32K-40K	45°	
STSAT-1	KAIST	Mid-2009		390-1500	80°	Technology development and Earth brightness
TanDEM-X	DLR, GFZ, EADS, Astrium, InfoTerra	Mid-2009	5	514	97.44°	Digital elevation models
NPOESS	NOAA, NASA, DoD	2013	7	833	98.7°	Sea surface height

## Official Analysis Products

The ILRS products consist of SINEX files of weekly station coordinates and daily Earth Orientation Parameters (x-pole, y-pole and excess length-of-day, LOD) estimated from 7-day arcs. Two types of products are distributed each week: a loosely constrained estimation of coordinates and EOP and an EOP solution, derived from the previous one and constrained to an ITRF, currently ITRF2000. Official ILRS Analysis Centres (AC) and Combination Centres (CC) 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 2003. This description refers to the status as of January 2009. Each official weekly ILRS solution is obtained through the combination of weekly solutions submitted by the official ILRS Analysis Centres:

- ASI, Agenzia Spaziale Italiana
- BKG, Bundesamt für Kartographie und Geodäsie
- DGFI, Deutsches Geodätisches Forschungsinstitut
- GA, Geosciences Australia
- GFZ, GeoForschungsZentrum Potsdam
- GRGS, Observatoire de Côte d'Azur
- JCET, Joint Center for Earth Systems Technology
- NSGF, NERC Space Geodesy Facility

These ACs have been certified through benchmark tests developed by the AWG. The official Primary Combination Centre (ASI) and the official Backup Combination Centre (DGFI) follow strict timelines for these routinely provided products.

In addition to operational products, solutions have been provided covering the period back to 1983. A current effort is underway to provide similar solutions on a daily basis, with a minimal 2-day delay, primarily to provide IERS' NEOS centre with robust EOP observations for their weekly forecasting. The ILRS products are available, via ftp from the official ILRS Data Centres CDDIS/NASA Goddard (<ftp://cddis.gsfc.nasa.gov/>) and EDC/DGFI (<ftp://ftp.dgfi.badw-muenchen.de>).

### *ILRS Contribution to ITRF2008*

The time series of weekly solutions from 1983 to the end of 2008, produced by the Primary Combination Centre, was delivered to IERS/ITRS as an official ILRS contributed data set for ITRF2008. Several months of joint work within the ILRS AWG were devoted to the quality assessment of the contributing solutions from the ILRS ACs as well as the final combined solutions from the ILRS CCs. The preliminary version of the combined ILRS time series was submitted in April 2009. Figures 5 and 6 show the origin and scale differences with respect to the old ITRF realization, ITRF2005 (actually the SLRF2005 frame, a derivative of ITRF2005, scaled for compliance to the SLR scale and merged with the ITRF2000 normal equations to cover all sites tracking between early 80's to present,



with engineering tests and logs. After these extensive investigations it became apparent that even for the best sites some of the biases are best determined by analysis rather than engineering tests, and that was the route adopted for the establishment of a database with definite biases for all sites with known bias problems during specified periods. The entire bias database will be made public on the ILRS web pages and it will be maintained in the future for the benefit of all SLR data users. The description of the official contribution to ITRF2008 will be made available on the ILRS pages once the new model is finalized and adopted by ITRS.

*The official ILRS Combination (ILRS-A)*

ASI produces the official ILRSA combination solution and it is routinely compared with the backup combined solution ILRSB produced by DGFI following a fundamentally different approach. Comparisons show a good agreement between the two solutions and absence of any systematic differences.

1. mean 3D wrms of the site coordinates residuals with respect to SLRF2005 (Table 4 and Figure 7);
2. mean differences of the translation and scale parameters with respect to SLRF2005 (Table 5);
3. EOP residuals with respect to EOP 05 C04 (Table 6) for the year 2008.

Table 4. 3D wrms of the site coordinates residuals w.r.t. SLRF2005

	ILRSA(mm)	
	1983-1993	1993-2008
All sites (mean)	52	10
Core sites (mean)	15	7

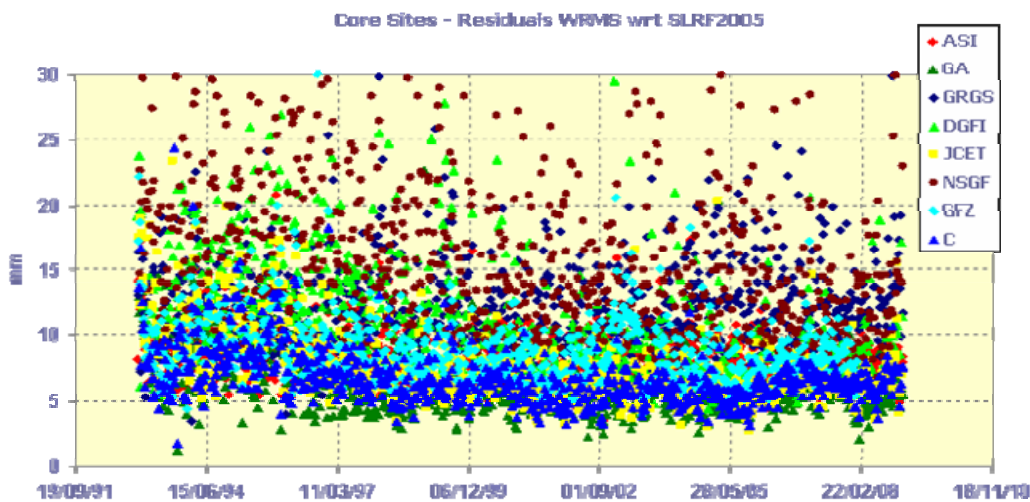


Figure 7. 3D wrms of the core site coordinates residuals with respect to SLRF2005.

Table 5. Translation and scale differences between ILRSA and SLRF2005

	<b>TX(mm)</b>	<b>TY(mm)</b>	<b>TZ(mm)</b>	<b>Scale(mm)</b>
Weighted Mean	-2 ± 4	0 ± 4	0 ± 9	6 ± 4
WRMS	3	3	6	2

Table 6. EOP daily residuals with respect to EOPC04 for ILRSA

<b>ILRSA</b>	1983-1993		1993-2008	
	<b>WMEAN</b>	<b>WRMS</b>	<b>WMEAN</b>	<b>WRMS</b>
EOP-X (mas)	-0.058	0.468	-0.024	0.156
EOP-Y (mas)	-0.092	0.434	0.030	0.131
LOD (ms)	-0.012	0.061	0.001	0.024

The individual as well as the combinations of the ILRS ACs and CCs are monitored on a weekly basis with a graphical and a statistical presentation of these time series through a dedicated web site hosted by the JCET AC at [http://geodesy.jcet.umbc.edu/ILRS\\_QCQA/ILRS\\_OPS/](http://geodesy.jcet.umbc.edu/ILRS_QCQA/ILRS_OPS/).

## Meetings and Reports

The ILRS organizes semi-annual meetings of the Governing Board and General Assembly; General Assemblies are open to all ILRS Associates and Correspondents. These meetings are typically held in conjunction with ILRS workshops, such as the fall 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 7. Detailed reports from past meetings can be found on the ILRS Web site.

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 Web site.

ILRS Analysis Centre 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 quarterly Performance Report Cards and posts them on the ILRS Web site. The 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 centres. The statistics are presented in tabular form by station and sorted by total passes in descending order. Plots of data volume (passes, normal points, minutes of data) and RMS (LAGEOS, Starlette, calibration) are created from this information and available on the ILRS Web site. 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 Web site station pages.

Table 7. Recent ILRS Meetings (as of June 2009)

Timeframe	Location	Meeting
April 2008	Vienna, Austria	ILRS Working Group Meetings Analysis Working Group Meeting
October 2008	Poznan, Poland	16 <sup>th</sup> International Workshop on Laser Ranging 14 <sup>th</sup> ILRS General Assembly and WG Meetings Analysis Working Group Meeting ILRS Working Group Meetings
April 2009	Vienna, Austria	ILRS Working Group Meetings Analysis Working Group Meeting
September 2009	Metsovo, Greece	ILRS Technical Workshop “SLR Tracking of GNSS Constellations” 15 <sup>th</sup> ILRS General Assembly and WG Meetings Analysis Working Group Meeting ILRS Working Group Meetings
January 2011	Concepcion, Chile	17 <sup>th</sup> International Workshop on Laser Ranging