SECTION 4 - NETWORK REPORTS

4.0 INTRODUCTION

The ILRS Global Laser Ranging Network is made up of three regional networks:

- European Laser Network (EUROLAS) encompassing the European stations;
- NASA Network encompassing North America, and some stations in South America, South Africa and the Pacific
- Western Pacific Laser Tracking Network (WPLTN) encompassing Japan, China, Eastern Russia and Australia

and the Lunar Laser Ranging Network.

4.1 EUROLAS REPORT

Werner Gurtner, *EUROLAS*

Most of the organizational activities for the EUROLAS Network have now been subsumed under the ILRS Central Bureau and the various ILRS working groups. The routine long- and short-arc evaluations of passes performed by the NERC group have been extended to some non-EUROLAS stations. The near-realtime status exchange between now involving six of the EUROLAS stations continues to be useful for the operators, especially during the tracking of low satellites.

BOROWEIC

Stanislaw Schillak, *Space Research Centre, Polish Academy of Sciences*

The SLR Borowiec station operated continuously during the year 2001 without major failures. The station achieved returns during nighttime from 16 satellites under the framework of ILRS tracking program. SLR Borowiec tracked 709 passes during the year, producing about 11,000 normal points; the number of passes was strongly limited by weather conditions (75% clouds) and nighttime operations only. The accuracy of the system remains on a level similar to 2000, with a normal point precision of 8 mm and a long-term stability of 13 mm (according to the ILRS Performance Card). The main improvement in the system was the installation of a new cesium frequency standard HP-5071A as main station clock in December 2001. On-site orbital analysis of SLR data using the NASA GEODYN-II program was performed throughout the year. In addition to the SLR system operation, the Borowiec site is a permanent IGS station (BOR1), operating a Turbo ROGUE SNR 8000 receiver and IGLOS station (BORG) using a continuously operating 3S Navigation GPS/GLONASS receiver. Twice a year absolute gravimetric measurements are made at the site.

Figure 4.1-1. Borowiec SLR System, and the Boroweic staff (left to right): Jacek Bartoszak, Tomasz Celka, Danuta Schillak, Stanislaw Schillak, Stanislaw Zapasnik

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CAGLIARI

Aldo Banni, *Astronomical Observatory of Cagliari*

Laser station upgrades were underway through June 2001: the telescope (optics, motors, encoders, electronics, control/management hardware and software); the operations console (migration to Linux OS); devices (echo timing, signal processing). The station upgrade process continues.

Satellite observations were made from June 30 through the end of 2001. The observations began as soon as the equipment was available. Unfortunately there were several interruptions in the tracking, and a low level of operations.

Figure 4.1-2. Ranging from the Cagliari SLR site.

Table 4.1-1. Cagliari operations.

Total number of observation nights	70
Successful nights	36
Failed for meteorological problems	18
Failed for technical reasons	16
Low Earth Orbit Satellite observations	98
LAGEOS1-2 observations	8
RMS L.E.O. (cm)	5.8
RMS H.E.O. (cm)	3.9
L.E.O. Single shot precision (cm)	5.5
H.E.O. Single shot precision (cm)	3.8

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GRASSE PERMANENT AND ULTRA MOBILE STATION (FTLRS)

Francis Pierron, *CERGA*

During 2001 we continued to observe all LEO's and LAGEOS satellites with the permanent SLR system acquiring about 4400 passes with very good stability. The LLR system tracked LAGEOS, GLONASS and GPS passes simultaneously with lunar ranging.

We also completed a major technical upgrade of our Ultra Mobile Station in order to be able to very accurately calibrate the Jason satellite which was launched in December 2001 and tracked by FTLRS some days later.

Many technical points have been addressed in order to have both better accuracy and higher sensitivity to track LAGEOS. The FTLRS engineering work was completed at the end of summer 2001 and a qualification collocation campaign was conducted on different satellites including LAGEOS from September to December 2001 with the mobile system and the two others fixed stations (7835 and 7845) at the Grasse Observatory.

FTLRS collocation results

- 186 passes in three months on LAGEOS and all LEO satellites
- 52 LAGEOS passes including 41 simultaneous with the three systems
- 120 LEOS passes simultaneous with the fixed SLR station
- Validation of FTLRS performances at the level of few mm
- Bias SLR (7835) — FTLRS(7846) : 5 – 1 mm
- Comparison with European stations on common passes

  FTLRS - Graz : 3 – 1 mm

  FTLRS - Herstmonceux : -3 – 1 mm

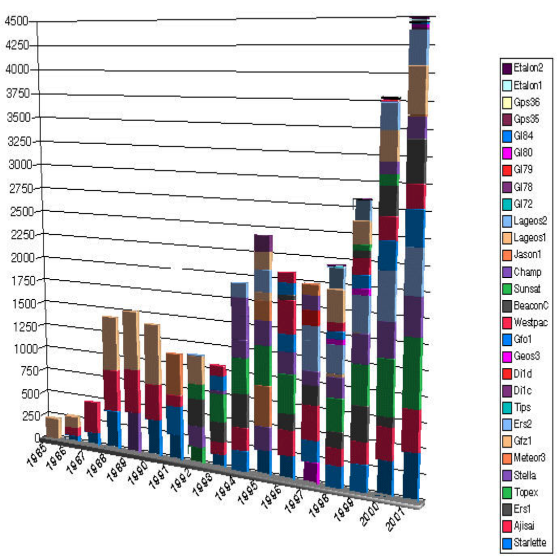

Figure 4.1-3. Passes acquired by the fixed SLR Systems, and the FTLRS System at Grasse.

The FTLRS system was packed for shipping at the end of December 2001 and moved it to Corsica Island (250 km south of Grasse in Mediterranean) on January 9, 2002. We deployed FTLRS at this site and acquired the first pass three days later and began the Jason1/TOPEX calibration campaign.

Figure 4.1-4. The Grasse Site.

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GRAZ

Georg Kirchner, Franz Koidl, *Austrian Academy of Sciences*

Range Gate Generator

In the summer of 2001, we began the design of a new range gate generator. The design was implemented in late autumn and winter by Martin Steindl, a diploma student from Deggendorf, Germany. Almost all of the hardware development was completed for the FPGA (Field Programmable Gate Arrays), resulting in the following specifications:

- requires external 1 pps, and 10 MHz frequency source;
- epoch based Range Gate pulses with < 500 ps resolution, and < 1 ns accuracy;
- laser repetition rates of up to some kHz;
- fully programmable via any standard 16-bit interface;
- complete epoch timing operation to ANY satellite, using the 10-Hz laser, or any future kHz laser system.

The hardware is finished, software implementation into our standard ranging programs is nearly completed.

Third Module for our Event Timer

For tests, for MultiColor measurements, and also for use as a spare part, we implemented a third Event Timer module (in addition to one start and one stop module) at the end of last year. One of the tests scheduled is to use the new module to measure the delay between compensated and uncompensated C-SPAD output, giving a measure of the return signal strength.

Ranging Software

The mount control has been changed completely in order to optimize pass switching between satellites, as we use that quite extensively. The mount now always takes the shortest path directly to the azimuth of next satellite. The mount also optimizes slewing between tandem satellites, like TOPEX — Jason1 and GRACE-A — GRACE-B, resulting in very short pass switching times, usually taking about ten seconds. That scenario allows more frequent pass switching, and gives more uniform distribution of normal points.

In the spring 2001 we finally joined the Real Time Time Bias Exchange Club, which is not only a very efficient tool for successful hunting of difficult LEO«s like Champ, but also proved to be an excellent motivation item for our observers — to get the highest score.

Operation

The year 2001 was the most successful year up to now for SLR Graz; for the first time, we acquired more than 5000 passes. To our surprise, this resulted in the highest number of NPs of all SLR stations, according to the ILRS Performance Report Card (slightly more than 100,000 NPs). The main disadvantage: We had to spend a lot of our capacity to keep the station running: more or less frequent repairs of dome mechanics, laser heads, laser power electronics, etc. Visit the Graz Web site at: http://www.iwf.oeaw.ac.at

Figure 4.1-5. The Graz SLR Site and staff: Georg Kirchner and Franz Koidl

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HELWAN

Magdy El-Saftawy, *National Research Institute of Astronomy and Geophysics (NRIAG)*

The observations from the Helwan SLR station are one of the most important in the SLR network because Helwan is one of two stations in Africa. The station was operated only by the Czech group (Czech Technical University of Prague) three months per year until 1997. During that period the Czech group was responsible for supplying the station by the spare parts and technical supports. During the 11$^{th.}$ International Workshop on laser Ranging (Deggendorf, Germany-1998) Prof. Dr. M. Tawadros announced that the Egyptian group is able to operate the station 12 months per year. During 1998 the station was operated by the Egyptian team with technical help from the Czech team. In 1999, 1391 observed passes were observed.

Figure 4.1-6. At the Helwan Station: the laser, mount, meterological sensors, a data analysis screen shot.

Figure 4.1-7. The Staff of the Helwan SLR station. From right to left: Sami Fath-allah., Dr. Magdy El-Saftawy, Dr. Eng. Makram Ibrahim, Dr. Yousry Hanna,Mohamed Yehya, Dr. Khalil Ibrahim and Eng. Abd El-Rahman Ahmed. .

In 2000, Helwan observed only 426 passes and in 2001 there were approximately 140 passes observed because there was very little support for the station and the staff, as well as a shortage in spare parts.

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HERSTMONCEUX, THE NERC SPACE GEODESY FACILITY

Philip Gibbs, *NERC Space Geodesy Facility,* Graham Appleby, *ITE Monks Wood*

Shown in the photograph of the Herstmonceux station is the (7840) SLR tracking telescope, the dome housing the safety radar and the tower supporting the HERS IGS Z12 antenna and meteorological sensors. The antenna of the HERP Z18 IGLOS station is behind the radar dome and not visible in this picture. This photograph, containing hot links to several elements of the Facility, is at:

http://nercslr.nmt.ac.uk/sgf_site/site_map.htm

Figure 4.1-8. The Herstmonceux site.

Satellite Tracking

During 2001, Herstmonceux observed all the satellites on the ILRS list.

EUROLAS Workshop

We are in the early stages of planning a Workshop at Herstmonceux for the EUROLAS stations aimed at eliminating errors over the network. Stations will be invited to bring their SR timers to the workshop for intercomparisons.

Timer Calibration

In our continuing quest to understand and quantify the range-dependent errors in our SR timers, we purchased two HP5370b interval timers and repeated all the tests we had previously made with the PPET (those results were presented at the SPIE meeting in Florence in 1999). The results from the HP tests agreed with the previous PPET tests. As we now have the means to continually monitor the behaviour of our SR timers, and it appears from the results that the PPET and HP have no range dependant errors, we made the decision that from an early date in 2002 we would use the results to remove from all our observations this range-dependent error which can reach a magnitude of about 8mm at the distance of LAGEOS. Details, including a table for correcting historical Herstmonceux data, were subsequently given in SLRMail 0891. We have also made a moveable target and plan to investigate the detailed behaviour of our SR timers at calibration distances.

Radar Drive System

A complete, new servo control system and drive motors for the safety radar have been installed and is being commissioned. The new system will be directly controllable from software.

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MATERA

Giuseppe Bianco, *Agenzia Spaziale Italiana, Centro di Geodesia Spaziale "Giuseppe Colombo"*

During year 2001 the new MLRO (*Matera Laser Ranging Observatory*) has undergone extensive operational and debugging activities in preparation for the Acceptance Reviews foreseen for the first half of 2002. The system has performed quite satisfactorily and has been reported as the most precise SLR station in the ILRS network since when the first data were released, as illustrated in the following graph taken from the ILRS Web site:

http://ilrs.gsfc.nasa.gov/stations/performance_statistics/perf_2002q1.html

One of the most interesting activities has been the continuous monitoring of the LAGEOS-2 rotation rate by spectral analysis of full rate SLR orbital residuals observed by the MLRO.

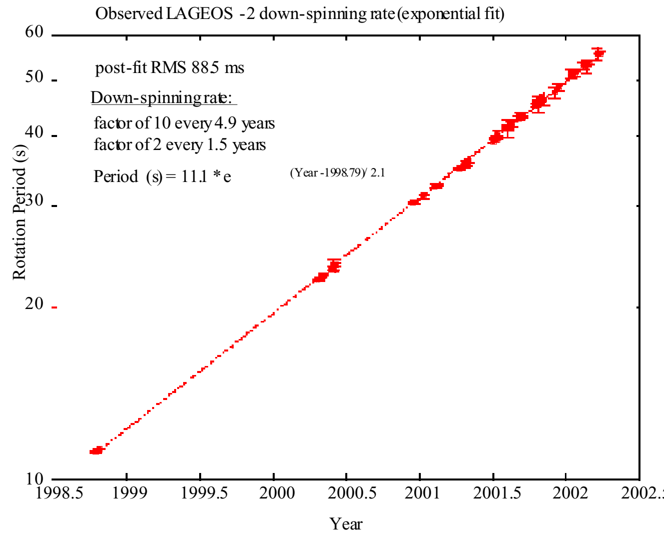

Figure 4.1-9. The MLRO Station, and LAGEOS-2 Spin Rate from MLRO Data.

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METSAHOVI

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Metsahovi (7806) was operational for the whole year. Some development work was devoted to comparisons of a new MOTIC multistop counter from Riga, HP 5370B and the old COMTIS currently in use. Comparisons of some AWG monthly coordinate solutions were continued, to improve the determination of the station position and possible range biases. Daylight capability was confirmed, but regular operation may need improvements in tracking and spectral filtering.

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POTDSAM

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In 2001, the currently operating Potsdam SLR station continued to support mainly LEO missions with special emphasis on CHAMP (the station tracked 135 passes of this satellite in 2001 under both day and nighttime conditions). Comparisons of the ranging electronics performance versus a Portable Pico Event Timer (P-PET) from Czech Technical University were done in September using three different SR620 time interval counters. Results of these comparisons with respect to counter linearity and stability were reported by Ivan Prochazka (CTU Prague) in the Toulouse Conference on Laser Radar Techniques in September.

Figure 4.1-10. Potsdam SLR Station: telescope mount, facility, operations room.

The new SLR system (consisting of separate transmit and receive telescopes) performed the first successful satellite ranging experiments in July/August 2001. The tests continued through the following months and demonstrated that the anticipated ranging performance will be met. Routine SLR operations of the new system are expected to begin in summer 2002 after a period of collocation measurements with the present operating station.

Figure 4.1-11. The new Potsdam SLR Station: facility, telescope mount operations room.

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SAN FERNANDO

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A complete review of the San Fernando SLR system was performed in the beginning of June with the invaluable collaboration and advise of Jean Gaignebet, Jean Louis Hatat and Jean F. Oneto from the Cote d Azur Observatory. Following this review, a C-SPAD was implemented as a new detector for satellite tracking during nightime, while the XP2233B PM is still used for daylight tracking. On June 25th the first successful observation using the C-SPAD was made. As a result, the observation rms for the LAGEOS satellites were dramatically reduced both in single shot (from 55 mm at the end of 2001 second quarter to 18 mm at the end of the year) and in normal point (from 12 mm at the end of 2001 second quarter to five mm at the end of the year).

Unfortunately, major damage to the HP5370A interval counter put the system out of operation from the end of July to the beginning of September. The Graz SLR station supported us by providing an SR620i counter which allowed resumption of operations in September, while we were awaiting the new SR620i. We received the new SR620i at the beginning of October and we kept both counters working together until the end of the year to validate operations.

Figure 4.1-12. San Fernando SLR System at night.

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TRANSPORTABLE INTEGRATED GEODETIC OBSERVATORY (TIGO)

Stefan Riepl, Hayo Hase, Armin Boer, *Bundesamt fur Kartographie und Geodoesie*

During the year 2001 the Transportable Integrated Geodetic Observatory (TIGO), including the SLR module, was in standby mode awaiting shipment to Concepcion, Chile. The negotiations over the previous years led finally to a diplomatic note exchange aiming at the joint operation of TIGO in Concepcion. Apart from the BKG the Chilean side formed a consortium to share expenses for infrastructure and man power, providing a means to host TIGO for at least three years. The Consortium consists of the following institutions:

- The Universidad de Concepcion,
- The Universidad Catolica de la Santisima Concepcion,
- The Universidad Bio Bio and
- The Instituto Geografico Militar.

As there were major upgrades affecting the control and timing system of the SLR module, TIGO was subject to a collocation with the WLRS. During this collocation the TIGO SLR module proved to be operational in two color mode and capable of ranging to GPS satellites at least with the infrared channel. Due to ongoing improvements of the infrared detector, only data from the blue channel (423.5nm) was taken to evaluate the measurement. The collocation results showed agreement of the satellite measurements with respect to the local survey at the millimeter level. Figure 4.1-13 shows a sample satellite pass measured by both systems simultaneously. Immediately following the collocation campaign in September, TIGO was prepared for shipment to Chile. Despite its transportable design, to ensure the integrity of the delicate instrumentation, all components were tightly packed individually and re-stowed in the containers. This two month effort payed off, as the shock recorders installed for transport monitoring indicated a peak acceleration of 13g during the loading procedure on the ocean vessel (Figure 4.1-14) and avoided any risk of damaging the equipment due to high humidity. In the meantime the construction of the platform was on its way completion as shown in figure 4.1-14. By the end of the year 2001 the foundations and electrical connections were ready to host the TIGO containers, which were scheduled to arrive in mid-January 2002.

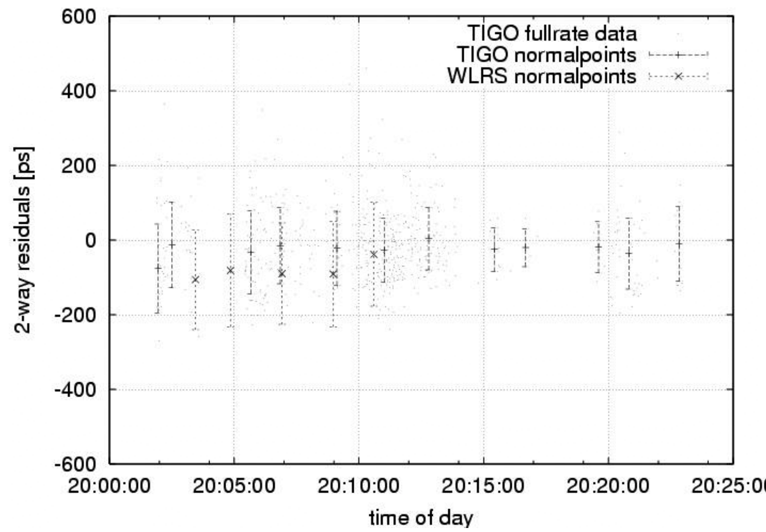

Figure 4.1-13: Sample satellite pass measured by the WLRS (532nm) and the TIGO SLR module (423.5nm). The points with error bars indicate the normal points, the dots represent the fullrate data of the TIGO SLR module.

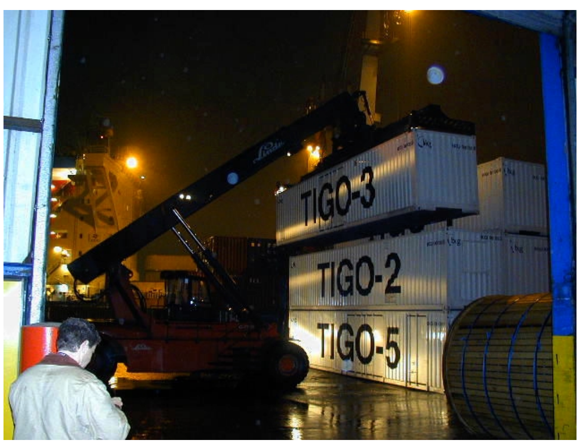

Figure 4.1-14 (left): The TIGO six pack (six containers) during loading onto the ocean vessel; (right): The platform for hosting the TIGO containers in Concepcion under construction.

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WLRS

Anja Schlicht, *Fundamentalstation, Wettzell*

In 2001, the WLRS telescope control unit was upgraded and re-integrated into the overall control software. The new control system was completed in April 2001, and again ready for laser ranging. Several more months are needed to debug the software and to adjust and improve the hardware (electronics and optics) in order to make use of the new picosecond event timer using 4 Dassault modules. During 2001, WLRS was in engineering status only.

The WLRS with its monoaxial telescope and the rotating miror as transmit-receive-switch could not measure very low-orbiting satellites, such as Champ. In 2001, a second small telescope with a Hamamatsu H 7422p-40 photomultiplier as a new detector was added to the primary telescope. The second receive path is coupled to the real time calibration facility via a set of mirrors reflecting a small part of the laser pulse into the second aperture. Figure 4.1-15 shows the small second telescope mounted on the primary 75cm telescope.

Figure 4.1-15. Second aperture at the WLRS to measure very low orbiting satellites.

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ZIMMERWALD

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Dielectric Coating

Early 2001 the three smaller mirrors of our telescope (i.e., M2 and M2 and the deflection mirror DM used by the tracking and CCD cameras) were recoated with broad-band dielectric coating. The previous protected silver coatings did not age favorably under the rather harsh atmospheric conditions. The new coatings show a very good reflectivity for the laser wavelengths as well as in the full band used for the optical astronomy activities.

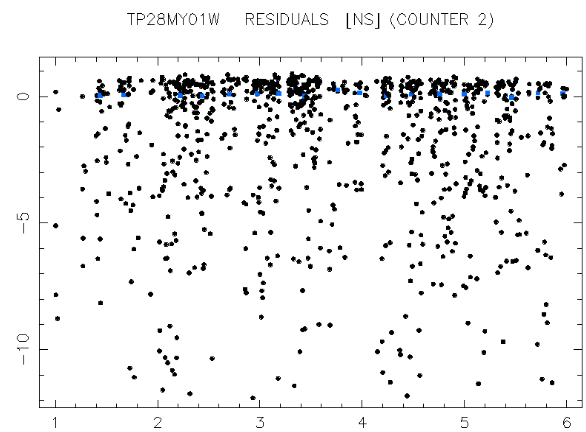
Ranging in the Infrared

Range tests with a SPAD in the primary wavelength of our Titanium-Sapphire laser (846 nm) showed an unacceptable high scatter of the ranges (Figure 4.1-16):

We will purchase one of the new infrared Hamamatsu photo multipliers and start doing tests in 2002.

Laser Pulse Width

The single-shot RMS of flat-target calibrations continued to be larger than expected. Stereak camera pulse-width observations performed by J. Gaignebet of the Grasse Observatory and his group revealed that the pulse width was much larger than the expected 100 ps FWHM. An change of the etalon in the laser restored the pulse width to the nominal value.



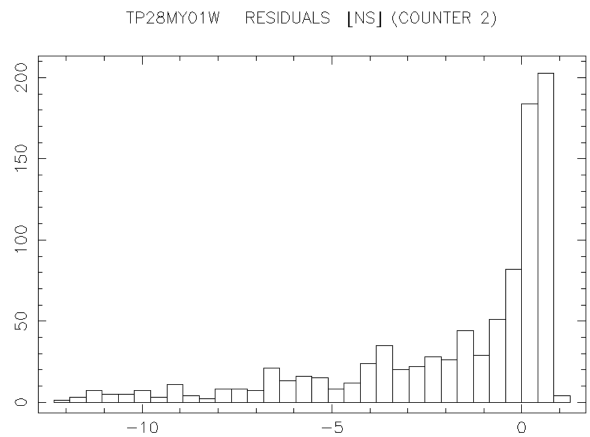


Figure 4.1-16. A. Residuals of a TOPEX Pass in Infrared. B.Histogram of the Residuals of a TOPEX Pass in Infrared

Station Computer

The two clustered VAX computers were replaced by one DEC Alpha system. The source code of the user programs only needed marginal modifications; however, all programs had to be recompiled.

Fully-Automated Operation

The tracking program was modified to allow it to run in batch (i.e., background) mode, too. A very few input variables only (power-up time, start time, stop time, observer) have to be specified when the program is launched. All the rest, i.e., laser power up, initialization of the telescope, opening of the dome, definition of the observation scenario within the specified observation window, tracking and data collection, standby mode at the end, is performed automatically by the software. An observer can connect a special client program through TCP/IP with the tracking program for remote control of the batch process, if necessary. The automated operation is mainly used to bridge gaps between subsequent shifts or to extend shifts beyond the standard 8 to 9 hours.

Satellite Tracking

The year 2001 was the most productive year since the installation of the new system in 1995/1996, with more than 3,000 passes, 45,000 normal points and 40,000 minutes of successful tracking.

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Figure 4.1-17. The Zimmerwald Station.

4.2 NASA NETWORK

David Carter, *NASA Goddard Space Flight Center,* Jack Stevens*, HTSI*

The NASA SLR Network during 2001 consisted of eight solely operated or partnered stations. Stations were located within North America, the West Coast of South America, the Pacific, Western Australia, and South Africa. NASA SLR operations are supported by Honeywell Technical Solutions, Inc. (HTSI), University of Hawaii, University of Texas, Universidad Nacional de San Agustin, Australian Surveying & Land Information Group, the National Research Foundation of South Africa and the University of French Polynesia/CNES.

MOBLAS-4

Jack Stevens*, HTSI*

MOBLAS-4 provided satellite laser ranging capability on a 24 hour, 7-day per week basis at the Monument Peak, California location. The MOBLAS-4 occupation at Monument Peak during 2001 represents its 18^{th} year at this site.

The MOBLAS-4 system ranked among global leaders in all significant data quantity and quality performance categories in 2001. MOBLAS-4 was first among all global SLR systems in total LEO pass segments tracked, which totaled 4,586. MOBLAS-4 also ranked second among global systems in total number of pass segments tracked with 5,997.

The system and crew achieved 97% efficiency in the capture and production of high quality LAGEOS passes with an average single shot RMS of less than 9mm.

System upgrades to MOBLAS-4 during 2001 included the installation of the Laser Data Processing System containing the new Generic Normal Point Processing package v2.0.

Figure 4.2-1. MOBLAS-4 Station, Monument Peak, California.

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MOBLAS-5

Jack Stevens*, HTSI*

MOBLAS-5 provided satellite laser ranging capability on a 12 hour, 6 1/2-day per week basis at the Yarragadee, Australia location. The MOBLAS-5 occupation at Yarragadee during 2001 was it s 22^{nd} year at this location.

MOBLAS-5 productivity and data quality was among SLR global leaders in all statistically relevant categories in 2001. The system and crew provided more satellite tracking coverage (over 100,000 ranging minutes) than any other SLR system in the world. MOBLAS-5 also ranked first among all global SLR system in total satellite pass segments tracked (over 6,300). SLR data yields included over 89,000 total NP captured while maintaining outstanding data quality standards.

The MOBLAS-5 system produced over a 98% high quality LAGEOS NP capture rate with an average single shot RMS of 9.8mm.

No major system configuration changes to MOBLAS-5 occurred during 2001.

Additional information for MOBLAS-5, a joint NASA/GSFC and the National Mapping Division of Australian, can be found in the following section.

Figure 4.2-2. MOBLAS-5 Station, Yarragadee, Australia.

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MOBLAS-6 AT HARTRAO

Ludwig Combrinck and Wilhelm Haupt, *Space Geodesy Programme, HartRAO*

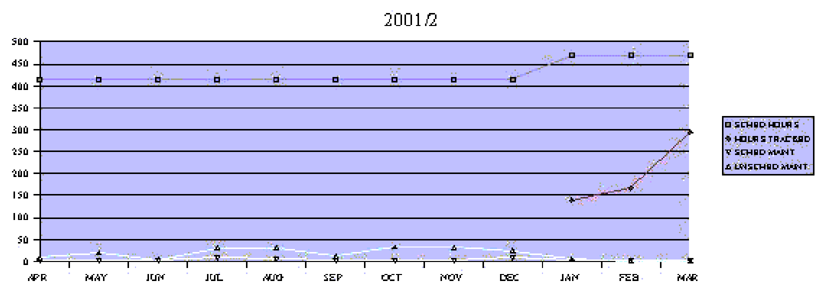
Figure 4.2-3. MOBLAS-6 at HartRAO.

During 2001 MOBLAS-6 continued to operate as part of the Hartebeesthoek Radio Astronomy Observatory (HartRAO) Space Geodesy Program in collaboration with NASA. High quality data are delivered consistently, MOBLAS-6 ranked first in the ILRS community for best LAGEOS NP RMS during 2001. The station proved to be reliable as no major repairs to instrumentation had to be carried out, although some older supporting peripherals (e.g. air conditioner) failed, adversely affecting tracking operations. Spares and other inventory items were captured into a database system to simplify maintenance.

The MOBLAS-6 system exceeded the global network standard of 1500 high quality satellite tracks, by tracking over 2,700 total satellite segments, and delivered over 27,000 normal points. Noteworthy accomplishments included above standard tracking of LEO satellites. Current tracking is maintained at 116 hours per week. This comprises two 8-hour shifts per day for three weeks and three 8-hour shifts per day for one week. Depending on future funding, it is envisaged that 24 hour per day tracking could be done on a routine basis.

Future activities will include a complete site survey to determine eccentricities between the SLR, VLBI, GPS and DORIS reference points in order to quantify discrepancies detected by previous site surveys.

Operational Hours vs Maintenance Hours



2001/2	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
SCHED HOURS	415	415	415	415	415	415	415	415	415	470	470	470	5145
HOURS TRACKED										139	167	295	601
SCHED MAINT	2	2	2	8	5	2	2	2	8	3	2	2	40
UNSCHED MAINT	8	20	4	30	30	12	33	32	24	6	1	0	200

Comments: **Unscheduled Maint: Breakdowns, power failures etc.**
Scheduled maintenance: preventative, routine checks, repairs during tracking or unsuitable weather conditions.

Figure 4.2-4. MOBLAS-6 Operational versus Maintenance Hours.

The plot of operational versus maintenance hours (Fig.4.2-4) indicates a reasonably high ratio of scheduled hours to unscheduled maintenance. Actual hours tracked has only been recorded after 2001.

Our winter months are more conducive to tracking and subsequent data output as summer months tend to have cloudy spells for several days or typically thunderstorms in the late afternoon. The MOBLAS-6 crew are integrated with the other space geodetic activities to allow a wider base of training and skills development.

Geodetic crew at HartRAO: Ludwig Combrinck (Programme Leader), Wilhelm Haupt (Station Manager), Louis Barendse, Johan Bernhardt, Marisa Nickola, Lesiba Ledwaba, William Moralo, Pieter Stronkhorst, Piet Mohlabeng, Conrad Mahlase.

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MOBLAS-7

Jack Stevens, *HTSI*

MOBLAS-7 provided satellite laser ranging capability on a 24 hour, 7-day per week basis at the Greenbelt, Maryland location. The year 2001 in Greenbelt was the 20th year MOBLAS-7 has been at this location.

In 2001, the MOBLAS-7 system was again among the global SLR system leaders in both SLR data productivity and data quality. Data volume increased from 2000 in all relevant statistical categories. MOBLAS-7 ranked 2nd among all global SLR systems in total satellite segments tracked with 6,242. In addition, 95,622 Normal Points were delivered to the scientific user community, representing the 2nd highest total data volume among all global SLR systems. MOBLAS-7 also produced 4,988,826 fullrate observations which was 3rd highest globally.

The system and crew achieved 98% efficiency in the capture and production of high quality LAGEOS with an average single shot RMS of 1cm.

Configuration changes at MOBLAS-7 during 2001 included the installation of the Generic Normal Point Processing System in February. In addition, the MOBLAS-7 Laser Cavity (Pulse Slicer) was upgraded in September 2001.

Figure 4.2-5. MOBLAS-7 at GGAO, Greenbelt, Maryland.

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MOBLAS-8

Keitapu Maamaatuaiahuta, *Tahiti Geodetic Observatory, maamaatu@upf.pf*

Due to many system breakdowns and important crew training sessions, tracking in 2001 was primarly done during the months of April and May.

Figure 4.2-6. MOBLAS-8 in Tahiti.

Major technical problems encountered at MOBLAS-8 were:

- MPACS failure in February 2001
- Burning of the slip rings around March 2001.
- MPACS failure in July 2002. Because some crewmembers were leaving, the MPACS was not fixed until new crewmembers joined in September 2001.
- Major changes in crewmembers at MOBLAS-8:

During the first half of the year, the crew was composed of Nicolas Blanchard (station Manager), Karl Daues (technician operator), Sebastien Deroussi (operator), and Katia Garceran(operator). Sebastien Deroussi left the team at the end of May. Karl Daues resigned by the end of June. Nicolas Blanchard left at the end of September.

Two new crewmembers, David Gavin and Yannick Vota, started in September.
The station manager has been Keitapu Maamaatuaiahutapu since July 2002.

By November 2001, tracking re-started at MOBLAS-8 with HTSI engineers as well as training of new crewmembers. The crewmembers are now: Keitapu Maamaatuaiahutapu (station manager), David Gavin (technician operator), Yannick Vota (technician operator), Katia Garceran (logistics). The Web site url is:

http://www.upf.pf/geos/laser.html

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HOLLAS

Dan O'Gara, *LURE Project, University of Hawaii*

The Mount Haleakala Laser Station (HOLLAS) tracking operations were hindered in 2001 due to the failure of a sub-contractor to deliver an acceptable telescope controller. The telescope controller was the final piece of the system upgrade at HOLLAS, but the delivered device never met specifications. And, after months of negotiations, the sub-contractor went out of business. A replacement telescope controller was designed and constructed in 2001 using University of Hawaii engineers and technicians. This in-house developed controller was being installed at the observatory for testing at years end.

In June the Air Force Research Laboratory s prime contractor, Boeing Rocketdyne, installed at HOLLAS a real time connection to the FAA radar in Honolulu. However, the system does not have the capability to safely control the laser autonomously. It is being used at HOLLAS as a display only. A real time display is available both to the operator inside, and to the Laser Safety Officer (LSO) outside. Modifications to make the system safe for use as a replacement for the LSO have been discussed with the Boeing developers.

Figure 4.2-7. The HOLLAS Station Mount Haleakala, Hawaii .

Because of the development of the in-house telescope controller, HOLLAS was able to field only a single full time, 2 person satellite tracking shift during the year, using a telescope controller that has very poor tracking characteristics. Despite the technical problems, HOLLAS was able to contribute 16,525 Normal Points to the ILRS during 2001. Further, HOLLAS was ranked in the top third in three of the ranking categories used in the ILRS Global Performance report. (LAGEOS Single Shot RMS, LAGEOS Short Term Bias, and Data Delivery Latency).

HOLLAS Team Members: Dan O Gara (Project Manager), Craig Foreman, William Lindsey, Jr., Timothy Georges, and Jacob Kamibayashi.

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McDonald Laser Ranging Station (MLRS)

Peter Shelus, *University of Texas*

The McDonald Observatory laser ranging station, MLRS, is located in the Davis Mountains of west Texas, near Fort Davis, Texas (USA). It continued its SLR/LLR activities as a part of the NASA laser ranging network during 2001. The principal source of funding is a contract from NASA Goddard Space Flight Center, Code Y. However, vital additional funding is provided by several grants from NASA Code S and the National Science Foundation. SLR data volume continued to be excellent during this report period and LLR data volume was somewhat improved over that obtained during 2000. Total data yield for the MLRS, including the Moon, were 3,534 passes (up from 3,174 passes), 37,498 normal points (up a bit from 37,057 normal points), and 34,384 minutes (up from 31,687 minutes) of tracking data.

All MLRS SLR/LLR data are available through the several data centers of the ILRS. These data are transmitted to the data centers in near-real-time, using standard SLR/LLR formats. Because of a continuing very tight financial situation, there have only been minimal upgrades and improvements at the MLRS. Activity continues to be directed toward keeping the station operational and in a data gathering mode.

Peter J. Shelus, Project Manager, continued his efforts on behalf of the ILRS, serving as associate director of the ILRS/AWG, member of the ILRS Directing Board, and lunar representative to the IERS. Mr. Randall L. Ricklefs, Software Manager, continued his efforts on behalf of the ILRS, serving as a member of the Data Formats Working Group and spear-heading the project for a more comprehensive data format to be used for SLR, LLR, and laser transponder data. Mr. Jerry R. Wiant continued as Project Engineer. Observers at the MLRS were Windell L. Williams, Kenny T. Harned, Martin L. Villarreal, and Anthony R. Garcia. Rachel M. Green served in the role as part-time Technical Assistant.

Figure 4.2-8. The MLRS Station at McDonald Observatory, Texas. Staff members(left to right): Martin Villarreal, the mouser , and Jerry R. Wiant

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TLRS-3, AREQUIPA

Jack Stevens*, HTSI*

TLRS-3 supplied SLR tracking from Arequipa, Peru for the 11th year at this location.

The TLRS-3 SLR tracking coverage increased slightly in 2001 logging 13,608 minutes (10,520 in 2000). TLRS-3 contributed over 27,000 NP to the scientific user community. Once again TLRS-3 provided outstanding tracking coverage of LEO satellites, collecting over 24,000 NP for these satellites during 2001. The system and crew achieved 99 % efficiency in the capture and production of high quality LAGEOS with an average single shot RMS of less than 8mm.

Figure 4.2-9. TLRS-3 at Arequipa, Peru.

Configuration changes at TLRS-3 during 2001 included the installation of the Generic Normal Point Processing System in May. In addition, the TLRS-3 received a True Time GPS steered rubidium and CNS clock.

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TLRS-4

Jack Stevens*, HTSI*

TLRS-4 functioned as an engineering test bed in Greenbelt, Maryland in 2001

4.3 WESTERN PACIFIC LASER TRACKING NETWORK (WPLTN)

AUSTRALIAN STATIONS

Jim Steed, *Geodesy Section/Division of National Mapping, jimsteed@auslig.gov.au*

The Australian Surveying and Land Information Group (AUSLIG) was renamed National Mapping Division (NMD) after merger in October with the former Australian Geological Survey Organization (AGSO) to become the new entity Geoscience Australia. Throughout the year AUSLIG/NMD funded and oversaw the operation of both the MOBLAS 5 (Yarragadee) and the Mount Stromlo SLR stations, through contracts with BAE Systems and Electro Optic Systems respectively.

John Luck retired from active duty on 19 December 2001 after nearly 36 years monitoring Earth rotation by one means or another and keeping track of the country s time if not his own.

The activities of Geoscience Australia's Space Geodesy Analysis Center (SGAC) are described separately. Geodesy personnel played key roles in organizing SLR activities, and other space geodesy activities, for the Permanent Committee on GIS Infrastructure in the Asia-Pacific region (PCGIAP), especially through the latest of its series of annual campaigns Asia-Pacific Regional Geodetic Project 2001 (APRGP 01) which have been conducted since 1997. Similarly, substantial contributions were made to the Asia-Pacific Space Geodynamics project (APSG).

YARRAGADEE

The station operated virtually unimpeded during 2001. It acquired 3850 LEO, 1172 LAGEOS-1 and -2, and 1380 high satellite passes, for a total of 6402 passes for the calendar year (the same as Mt. Stromlo last year!), comfortably ahead of second best for productivity. In fact, it ranked 1st of all stations in 6 of the 14 categories reported in the 4th Quarter 2001 ILRS Performance Report, and 2nd in another 3 categories. This was accomplished in spite of unusually heavy rainfall during much of the year.

MOBLAS-5 contributed notably in the post-launch intensive tracking campaigns on the new missions STARSHINE 3, LRE and Reflector; and was able to range to the magnetically-stabilized northern-hemisphere-preferring satellite Beacon Explorer C far more often than expected. For these superior performances it won the AUSLIG Excellence Award in October.

Figure 4.3-1. MOBLAS-5 Station, Yarragadee, Australia. Staff members (left to right): Peter Bargewell, Vince Noyes, Randall Carman, Brian Rubery, Jack Paf

The full local tie survey was repeated in April 2001. It connected the intersection of axes to ground marks, calibration targets, GPS, GLONASS, DORIS and timing antennae. A new feature was connection to a leveling mark for absolute gravity meters, for which a brick building was constructed in April on the concrete slab on which a 30-foot communications tower once rested. The report is available at:

http://www.auslig.gov.au/geodesy/techrpts/pdf/techrep4.pdf

The new absolute gravity site was occupied in June 2001 by an FG-5 absolute gravity meter. All the other space geodesy instruments operated nominally.

A kangaroo hopped around inside the compound in December causing minimal damage to itself, and the cleaner s car caught fire. It was not recorded whether the two incidents were related.

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MOUNT STROMLO

This station underwent several planned interruptions during 2001, nevertheless its performance was highly respectable, acquiring 3148 LEO, 870 LAGEOS-1 and -2, and 397 high satellite passes for a total of 4415 passes for the calendar year. A small deterioration in the station s ranging precision was noticed in this period, possibly due to a subtle problem with the laser.

Overall, weather was worse than usual, with much high cloud limiting high-satellite opportunities. The whole observatory was closed by bushfires on Christmas Eve and Day, but fortunately sustained no damage. Ladybird swarms affected the system in March, which triggered extensive repairs to the dome (which automatically follows the telescope). The elevation axis was completely rebuilt to improve tracking stability over a month in October/November, and plans were finalized to rebuild the azimuth axis and re-survey the local ties early in 2002.

The operating contractor, Electro Optic Systems, by agreement, uses Mt. Stromlo station for testing its space debris tracking development programs. Electro Optic Systems received a new R&D grant during the year. The resulting increase in such activity had a small effect on SLR productivity, but successfully ranged to quite small particles with the High Energy Laser, as predicted in several papers presented at the Matera ILRS Workshop.

Figure 4.3-2. The Mount Stromlo Station, Australia station and staff (left to right): Dr. Chris Moore, Mark Elphick, Bill Bane.

Key Point of Contact

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NSW 2620		
AUSTRALIA		

PORTABLE SATELLITE LASER RANGER (PSLR)

The PSLR has been restored to an operational state in the Department of Applied Physics at Curtin University, Perth. Replacement of key components has been completed, and a re-write of the control software is underway to integrate the upgraded components and to allow porting to other operating systems, specifically Linux. The PSLR should have full tracking capability in 2003, and it is hoped to tested at Yarragadee.

CHINESE STATIONS

BEIJING

Wang Tanqiang,, *Research Institute of Surveying and Mapping*

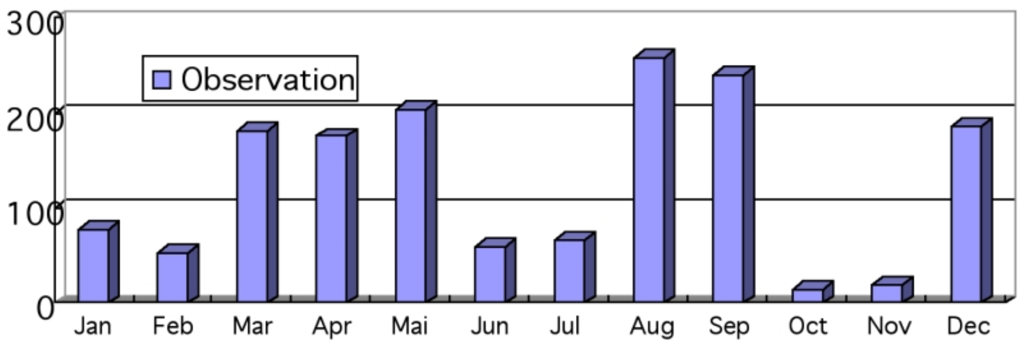

Figure 4.3-3. Observations from the Beijing SLR site in 2001.

Figure 4.3-4. The whole Staff in Beijing SLR Station

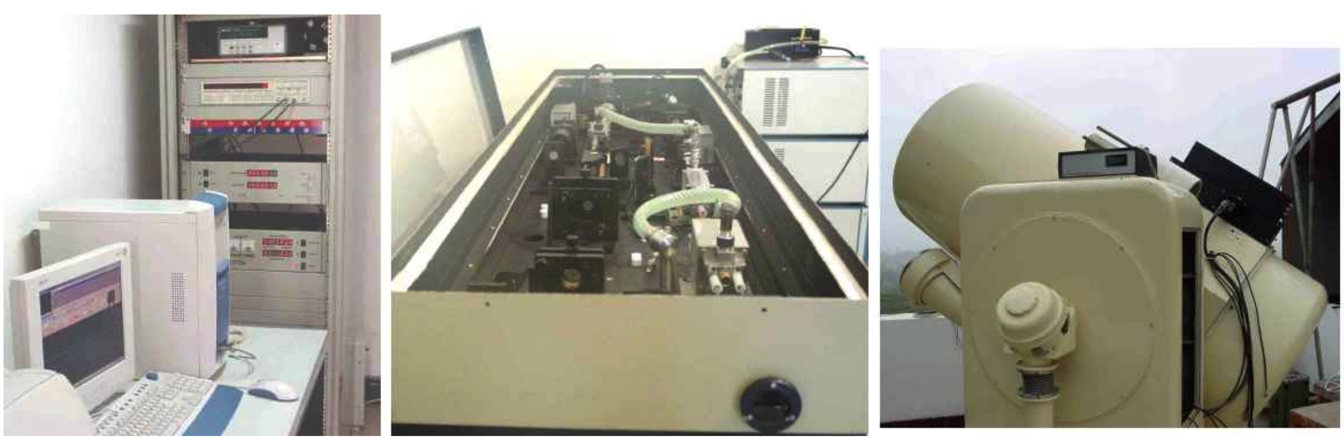

Figure 4.3-5. The new SLR system to be installed in San Juan, Argentina, will be ready before the end of 2002

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CHANGCHUN

You Zhao, Cunbo Fan, Chengzhi Liu, *Changchun Observatory*

Changchun Observatory has updated its satellite laser ranging (SLR) system since 1997, including satellite orbit prediction, tracking, data collection, data preprocessing and data delivery. After the system update, the single-shot precision improved from 5-7 cm to 1-2 cm for satellites and from less than 1 cm for ground targets. The normal point precision reached 4-7 mm. In recent years, the amount of observation data has increased dramatically. Each year, more than 2000 passes data were obtained, and, in 2001, 3438 passes data were obtained, a record for the Changchun SLR station.

In addition, the system stability has been greatly improved. According the to report issued by International Laser Ranging Service (ILRS), the long-term and shot-term stability of the SLR system has become better and better. The long-term stability improved to 1 cm or better from 4 cm and the short-term stability improved to 2 cm from 6 cm.

The Changchun station has become a very important participant in the international SLR Network.

- Receiving System: The C-SPAD with time walk compensation circuit and the temperature control shell was adopted as photo-electronic detector instead of the old PMT. The features of C-SPAD are high quantum efficiency, low time walk, automatic compensation and low working voltage. The C-SPAC decreased the system ranging bias caused by the variation of return signal amplitude and has larger dynamic range.
- Timing System: HP58503A GPS time frequency receiver supplies the primary 10 MHz signal and the second pulse that synchronizes the control system and receiving system to GPS time. The tracking software was improved to synchronize time automatically for each pass to reduce time walk and enhance the stability of timing system.
- Servo System and Encoder Electronics: A new servo system for the mount was built. As some microprocessors were substituted for the old relays, the stability improved. The new servo system adopted IGBT improving the tracking capability for low orbit satellites, and the tracking error for high orbit satellite apparently was diminished. The new encoder electronics uses a circuit with 23 bit (0.155) resolution, improving the output signal. Also, the output signal of the encoder is less affected by the intensity variation of encoder light. So the encoder is more stable.
- Laser system: A Nd:YAG laser was adopted for satellite laser ranging. Some procedures were adopted for system safety so that the laser could work continuously and automatically.
- Meteorological Sensor: The barometric has a resolution of 0.01mbar and, an accuracy 0.1mbar/year. The meteorological data is read automatically for each pass.
- Satellite Prediction and Pre-processing Software: A new prediction software for satellites was introduced improving prediction accuracy. The prediction accuracy of range for low orbit satellite approached 20 m and was better for LAGEOS. Accurate position prediction has helped to increase the return rate from satellite. The accurate ranging predictions allowed the narrowing of the range gate and reduced the interference from background noise. The data pre-processing screens the raw data and generates normal points for precise orbit determination and other applications. Occasionally the laser produces double pulses, which might introduce a rang biases. We developed special software for detecting and repairing double pulses.

The Changchun Observatory is developing daylight tracking capability, and performing research in data analysis and applications. A new control system is being adopted to further improve data quality and quantity.

The following are photos of Changchun SLR site and staff:

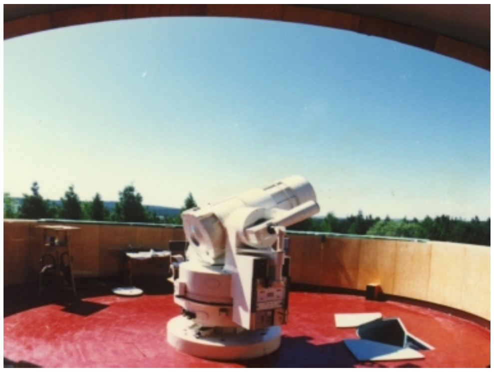

Figure 4.3-6. The Changchun SLR telescope; The staff group, from left to right: Cunbo Fan, Yong Cheng, Xingwei Han, Xinhua Zhang, Haitao Zhang, Jiangyong Shi, You Zhao, Chengzhi Liu. The backgroud of the photo is the SLR building after new decoration.

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KUNMING

Wu Wang, *Yunnan Observatory*

The Kunming SLR station acquired about 1100 passes in 2001. Most were collected in Jan-May. From June through October the weather was almost always cloudy or rainy. In spite of the down time, station data yield continues to improve. We overcame some difficulties in 2001, a thunderstorm caused major system damage.

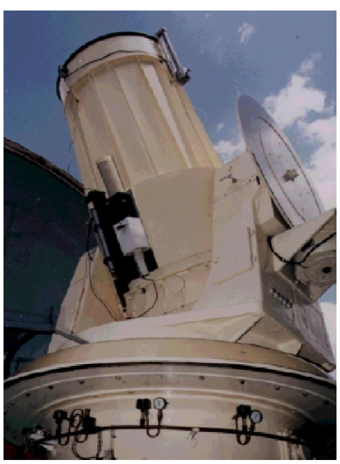

Figure 4.3-7. The Kunming SLR station and staff.

In the future, the system will be configured for tracking low satellites, and for daylight tracking.

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SHANGHAI

Yang Fumin, *Shanghai Observatory*

The most important event for the Shanghai SLR Station in 2001 was acquiring a piece of land to build the new observatory (Figure 4-3.9). Construction on the present observatory began in 1982, and it was put into operation in November 1983 in time for the MERIT Campaign. The observatory was a temporary and simple one. It has taken more than ten years to get permission from the local government for a plot of land that is located on the top of the Sheshan hill beside the 1.56 meter optical telescope. The distance between the new site and old one is about 400 meters. The construction has begun and will be completed the end of 2002. The present SLR instrument will be moved into the new observatory by the spring of 2003.

Figure 4.3-8. Drawing of the new Shanghai SLR Station

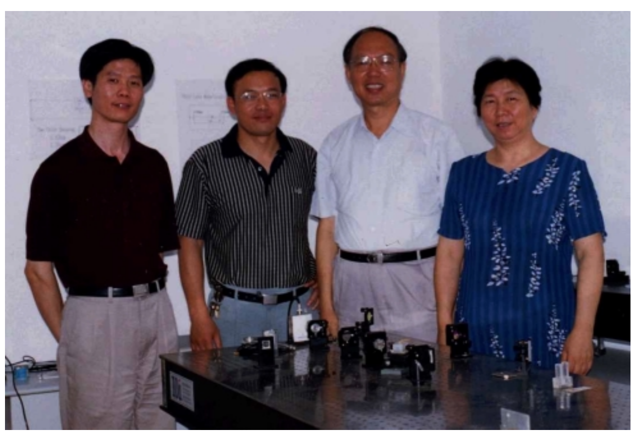

Figure 4.3-9. Photo of part of the staff of the Shanghai SLR station. From left to right: Chen Juping (electronics), Zhang Zhongping (software and data management), Yang Fumin (head of the group) and Chen Wanzhen (laser and mechanics). Two observers are not shown in the photo.

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TROS

Guo Tangyong, *State Seismological Bureau*

In 2000, the construction began on TROS by Institute of Seismology, China Seismological Bureau. A series of test were done at the Wuhan site. The results of tests showed that the system performance met the design specifications:

Table 4.3-1. TROS System performance.

Parameter	Value
The max range	20000 km
Single shot precision	20mm
Laser energy	15mj
Wavelength of laser	5320A
Max Slew Rate Az & El	5deg/s
Max. Repetition Rate	10[Hz]
Receiving Aperture	375mm

The TROS began tracking in August 2000 and stopped in October 2001 at the Beijing SLR Station. TROS moved to the Urumqi site where it began tracking in April 2001. Then TROS moved to the Lhasa site where it began tracking in august 2001. The passes are summarized in Table 4.3-2.

Table 4.3-2. Passes tracked by the TROS System beginning in October 2001.

Site	Beijing 7343	Urumqi 7355	Lhasa 7356
L1 & L2	42	44	120
Total passes	344	87	241

Figure 4.3-10. TROS at the Lhasa SLR site, and at the Urumqi site from April 15-June 12, 2001.

Figure 4.3-11. The performance evaluation meeting for TROS in Sep. 2001 at the Lhasa site.

Figure 4.3-12. The TROS is prepared to track satellites at the Lhasa site.

Figure 4.3-13. Operator checking equipment before beginning tracking; laser s wave form on the oscilloscope; tracking informations.

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WUHAN

Guo Tangyong, *State Seismological Bureau*

In 2001, the Wuhan SLR station stopped tracking for upgrades of the tracking door and the dome. For subsequent tracking work, the entire system will be checked or updated. Daily tracking work will be begin towards the end of 2002.

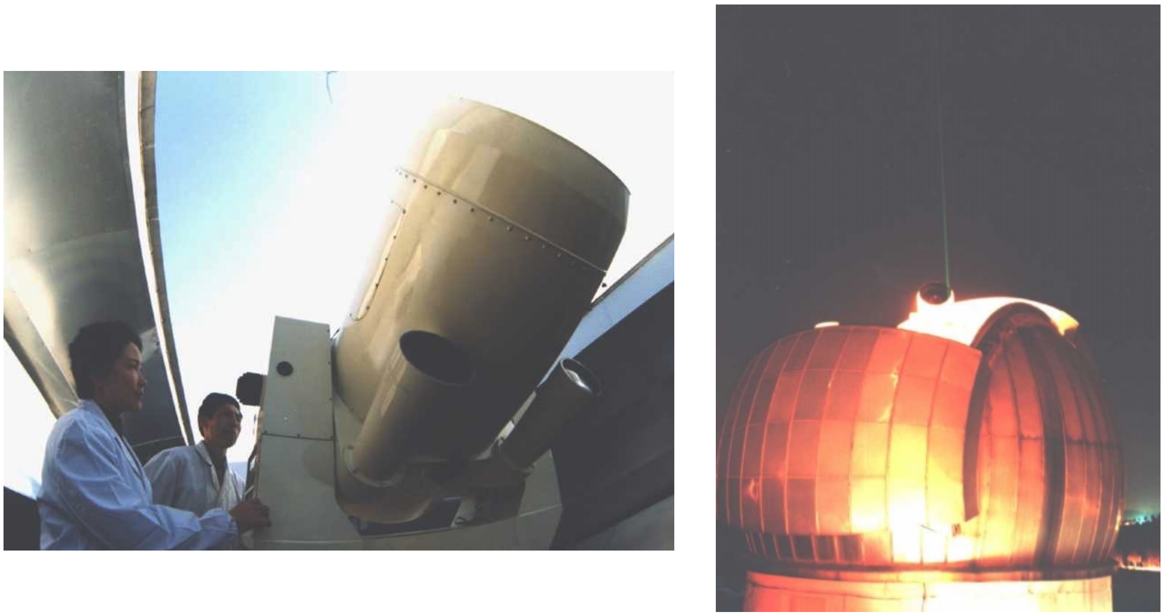

Figure 4.3-14. Operator adjusts the SLR receive equipment; Wuhan night ranging.

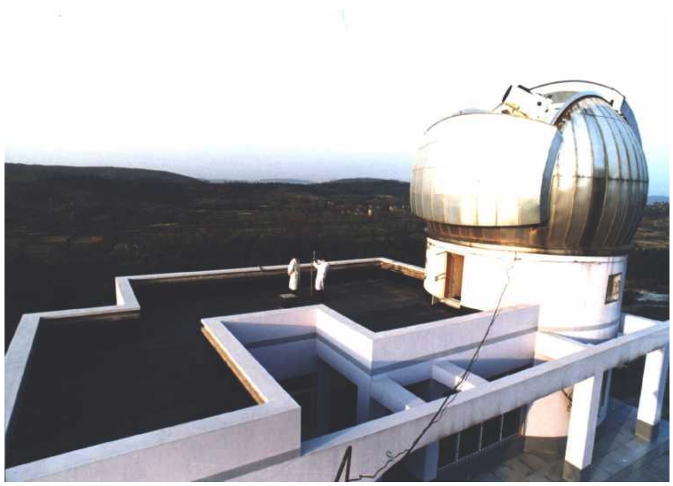

Figure4.3-15. The Wuhan SLR station after upgrading.

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JAPANESE STATIONS

SIMOSATO

Masayuki Fujita, *Hydrographic Department/Japan Coast Guard*

The Simosato Hydrographic Observatory (figure 4.3-16 below) is located in the bucolic area of central Japan; it is about four hours by the train from Osaka, the second largest city of Japan. Since it is close to the Pacific coast, the meteorological conditions do not always allow laser tracking.

The observatory has currently six staff members including the director. In April four members of the observatory staff were replaced. Every night, the satellite tracking observations were being carried out by two staff members.

The SLR tracking system undergoes regular maintenance by the professional staff six times a year. Comprehensive maintenance is performed twice a year. Very few components of the system were upgraded and/or repaired in 2001. In April, a small problem occurred in the transmitter, but it was repaired in May. In August, the servomotor and encoder controlling the azimuth and elevation axes of the telescope had to be replaced. In December, the start pulse detector was replaced with a photo detector with 50ps resolution. Nevertheless, some portions of the system, such as the telescope, parts of the controlling and signal receiving electric circuits, are still composed of the original parts introduced in 1982 and need to be replaced to attain higher quality observations.

Figure 4.3-16. Simosato Hydrographic Observatory.

Key Point of Contact

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Russian Stations

Natalia Parkhomenko, *SRI for Precision Instrument Engineering*

Komsomolsk

Station operations will discontinue from July, 2002 through the end of 2002 for modernization of the telescope, tracking system, laser, distance measurement systems.

Figure 4-3.17. Komsomolsk Site.

Maidanak, (1863 and 1864), and Mendeleevo

These systems were operational in 2001.

Figure 4-3.18. Maidanak SLR Stations; Mendeleevo Site

SLR station near the Moscow

The station makes regular ranging measurements, but we still do not have permission for the station to participate in the ILRS; we will continue our efforts to obtain the permission.

Figure 4-3.19. SLR station near the Moscow.

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The MCC-M is regularly making estimations of the station s ranging precision (Table 4.3-3). Besides this, IPIE is currently conducting several experiments in space to solve some SLR problems.

Table 4.3-3. Russian Mission Control Center Residual Analysis Report

Residuals are summarized for the following 3-day arcs: wtd rms(cm)

LAG-1 LAG-2	3-DAY ARC	02/06/30 12.00 - 02/07/03 12.00	1.6
LAG-1 LAG-2	3-DAY ARC	02/07/01 12.00 - 02/07/04 12.00	1.6
LAG-1 LAG-2	3-DAY ARC	02/07/02 12.00 - 02/07/05 12.00	1.8
LAG-1 LAG-2	3-DAY ARC	02/07/03 12.00 - 02/07/06 12.00	2.1
LAG-1 LAG-2	3-DAY ARC	02/07/04 12.00 - 02/07/07 12.00	1.9
LAG-1 LAG-2	3-DAY ARC	02/07/05 12.00 - 02/07/08 12.00	1.6
LAG-1 LAG-2	3-DAY ARC	02/07/06 12.00 - 02/07/09 12.00	1.9
LAG-1 LAG-2	3-DAY ARC	02/07/07 12.00 - 02/07/10 12.00	1.6
LAG-1 LAG-2	3-DAY ARC	02/07/08 12.00 - 02/07/11 12.00	1.8
LAG-1 LAG-2	3-DAY ARC	02/07/09 12.00 - 02/07/12 12.00	1.8
LAG-1 LAG-2	3-DAY ARC	02/07/10 12.00 - 02/07/13 12.00	1.7

Shelkovo (1111 NP)

	DATA	T ini	T fin	SC	TTL	INC	ME mm	RMS mm	ORMS mm	ELEV	T deg C	P mbar	H %	CALIB mm	TB us	RB mm	PRMS mm	SCI
1111	04.07.02	00:53	01:16	L1	10	07	-42	20	50	032-060	17	1003.9	61	27609	12	-33	4	0
1111	04.07.02	20:03	20:25	L1	06	05	-17	25	30	041-070	21	1001.9	52	27610	0	-17	25	0
1111	04.07.02	23:35	00:00	L1	08	08	-52	37	68	039-055	19	1001.9	59	27610	-17	-56	22	0
1111	08.07.02	21:37	22:02	L1	07	05	-6	10	12	034-067	19	996.9	86	27609	0	-6	10	0
1111	12.07.02	19:47	20:06	L1	07	05	-14	17	22	054-073	22	999.9	63	27611	-10	-17	3	0
1111	12.07.02	23:09	23:39	L1	10	06	-25	10	29	025-062	17	1000.3	83	27610	5	-21	7	0

Adopted abbreviations

Date - Day, Month, Year;
Tini,Tfin - Time Interval of Passes (hh:mm);
SC - Spacecraft Name;
TTL - Total Measurements Number in the Pass;
INC - Included Measurements Number in the Pass;
ME - Math.Expectation;
RMS - Root Mean Sguare for ME;
ORMS - Root MEAN Sguare for the Orbit;
ELEV - Elevation Angles (min-max)
T - Temperature, Celsium degrees;
P - Atmospheric Pressure, mbar;
H - Huminity, %;
CALIB - Calibration Delay Shift, mm;
TB - Time Bias, microsec (if TB = " * ", then no estimate for TB);
RB - Range Bias, mm (if RB = " * ", then no estimate for RB)
PRMS - Precise RMS for Approx. Polynomial, mm;
SCI - System Configuration Indicator;

Spherical retroreflector on board of the METEOR-3M(1) satellite

Most of the passive SLR satellites have been launched during the years when the SLR station equipment provided an accuracy of several centimeters. But now, with the new equipment providing an accuracy of several millimeters, the systematic target errors caused by the retroreflector design and their distribution over the satellite surface are limiting the distance measurement precision.

On board of the METEOR-3M(1) satellite, a novel-type retroreflector is installed, having an unique design based on the spherical Luneberg lens principle. It has a spherical symmetry, and a constant CoM correction value with an accuracy of about ±0.02 mm. In contrary to currently used cube corner prism retroreflectors, this retroreflector has a practically zero target error.

Starting from December, 2001, a joint experiment is conducted by GSFC and IPIE on laser ranging of the Optical Luneberg Lens on board of the METEOR-3M(1)spacecraft. Two American SLR stations (Greenbelt and Monument Peak) and one Russian station near Moscow are taking part in the experiment. The limited number of stations participating in the experiment was caused by fear that laser light may cause interference during operation of the SAGE instrument installed by NASA on board of the METEOR-3M(1) spacecraft. Currently all the limitations have been lifted, and we are asking the ILRS for support of the METEOR-3M(1) mission with the spherical retroreflector on board.

OTHER STATIONS

RIGA

Kazimirs Lapushka, *Astronomical Institute of the University of Latvia*

Besides performing routine ranging operations, characterization of the new event timer and a rapid signal amplitude measuring system continued. We also preformed a calibration system upgrade and stabilization.

Some mechanic, electronic and optical components were added to the system to maintain a low-noise system status as much as possible to prepare the system for daylight ranging in the 2002.

Some modifications to the system software were introduced to increase the drive precision of the laser telescope and data pre-processing quality.

The signal processing group from the Institute of Electronics and Computer Science of the University of Latvia has continued design and investigation of a new upgrade to the event Timer MOTIC (Modular Time-Interval Counter). One component of this program was a comparison of MOTIC, STANFORD and P-PET system timers which was carried out at the Potsdam and Wettzell SLR stations at the end of 2001. Results of that comparison showed that MOTIC and P-PET timers are really in the same class of precision instruments.

Figure 4.3-20. Riga station staff (*left to right*): K. Lapushka, I.Abakumovs, V.Laposhka.

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SIMEIZ

Shtirberg L.S., Tatevian S.K., Dmitrotsa A.I., Nejachenko D.I., Minin O.A., Filikov S.V. *Simez*, Michael˚R. ˚Pearlman, *SAO*, Daniel Nugent, *HTSI*

In 2001, upgrade of the Simiez SLR station continued under a grant from the US Civilian Research and Development Foundation (CRDF) in cooperation with the Smithsonian Astrophysical Observatory. Equipment was purchased under the grant and installed by station personnel. The station software was also substantially rewritten to connect all of the major subsystems. The upgrades included Farrand Controls angular encoders for the mount, a new Hamamatsu H6533 photomultiplier, an HP5370B time interval unit, a black and white CCD to aid acquisition, a new Pentium-2 computer and interface cards. During the year, with the system improvements, the station acquired 550 satellite passes, ninety-six of which were on LAGEOS. The main issue remaining is the laser, which has severe reliability problems and has a relatively wide pulse width of about .4 nsec.

Figure 4.3-21. The Simeiz SLR Station.

By agreement between NASA and the Crimean Astrophysical Observatory, a new IGS station (CRAO) was set up in Simiez. An SNR-8000 GPS was installed just in front of the SLR station. Aside from supporting the IGS network, the new GPS also provides timing for the SLR.

In 1999 the Simiez SLR stations was included in the list of national facilities in the Ukraine, qualifying it for some funding for further improvement.

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SALRO

Turki Al-Saud, Abdallah Azzeer and John Guilfoyle, *KACST/Institute of Space Research*

The SALRO site at the Solar Village, Saudi Arabia. The Solar Village is about 45 km north west of Riyadh.

Photograph was made July 9, 2002, while tracking the Etalon-2 satellite after dusk.

The site has many shrubs and hedges, giving it the feel of an oasis in the desert.

The site is operated primarily during daylight and early evening hours.

Figure 4.3-22. SALRO tracking station.

Re-Commissioning in 2000

KACST issued an O&M contract in mid 2000 with the aim of making SALRO operational once again, after it sat unused for some time. Several months were spent in 2000 making all equipment operational.

Spares from the defunct Orroral Observatory and the CRL 1.5 m SLR system were used in this effort, and thanks go to those organizations for their assistance.

By the end of 2000, SALRO was capable of successful SLR to satellites in all orbit categories, except the very lowest — a limitation of the mechanical transmit/receive system which remains.

While the entire system received attention to varying degrees, it was the laser, receiver and pulse-handling electronics that required the most work. The acquisition software had previously been upgraded by EOS to deal with the Y2K problems.

The team consists of two KACST staff trainees and two expatriate engineers working under the O&M contract.

Operations Commence January 1, 2001

With all the gross problems cleared, use of the system commenced on a production basis. Operational procedures were developed in tandem with fine tuning of the system. Staff training assumed a higher priority. One observations shift operated all year.

2001 was a transitional year, commencing as engineering and ending by achieving compliance with all the ILRS guidelines.

Some periods of down-time exceeding one week were required to overcome random failures, and implement major improvements such as the installation of a new compensated SPAD detector. The incidence of failures and unscheduled down-time is now minimized with the implementation of a preventative-maintenance program.

Winter: mid December to mid March. Cold, with very clear skies quite often. Occasional rain, some cloud periods lasting several days. Generally good SLR conditions day and night, routine daylight GPS acquisitions possible.

Autumn: October to mid December. Cooler, generally clear. Good SLR conditions day and night.

Summer: mid June through September. Generally clear, with varying degrees of sky haze at all times.

Day: high temperatures and directed sunlight on the telescope make SLR operations difficult.

Night: no problems, including occasional GPS acquisitions.

Spring: mid March to mid June: Difficult SLR conditions, day and night. Increasing daytime temperatures, very hazy at times, occasional cloud periods lasting several days — generally unsettled.

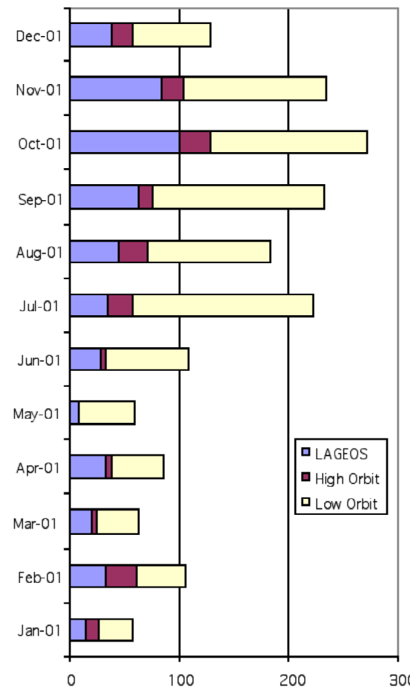

Figure 4.3-23. SALRO tracking station.

Plans

- boost productivity by expanding operations to cover 2 shifts 5 days per week.
- re-survey the site, work to remove any residual errors in adopted site coordinates.
- analyze and tune to eliminate systematic errors, range biases, etc.
- engineering improvements to the telescope (sun shields), AC/refrigeration systems, etc.
- site development to include analysis capability, GPS calibration etc.

Conclusions

- KACST have a firm commitment to continue and develop SALRO operations, raising the profile of this science and its derivatives within the organization.
- environmental conditions allow useful operations all year round, with peak performance occurring in autumn and winter. (see Figure 4.3-23)

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4.4 LUNAR NETWORK

Peter Shelus, *University of Texas*

INTRODUCTION

The Lunar Laser Ranging (LLR) network consists of the Observatoire de la Cote d Azure (OCA) station in France and the McDonald Laser Ranging Station (MLRS) in the USA. Both stations operate in a multiple target mode, observing SLR targets in addition to the lunar surface retroreflectors. The Matera Laser Ranging Observatory (MLRO) is also a joint SLR/LLR station, still in the testing and verification stages for LLR, after being installed in Matera, Italy. There were no LLR data reported by the Wettzell SLR station in Germany.

There is new LLR-related activity going in the United States at the Apache Point Observatory in New Mexico. Work is progressing on the implementation of a completely new LLR station. A laser has been ordered and other equipment is being put into place. Presently, they are concentrating most intently on detector and timing electronics. Their belief is that that a 3.5-m telescope and 1 arcsecond image quality at their site, will produce a high photon-rate regime, able to achieve millimeter precision in a matter of minutes. The University of Washington research group is optimistically looking forward to sending first photons skyward before the end of 2002.

OBSERVATOIRE DE LA COTE D AZUR (OCA)

Jean-Francois Mignard, *OCA, CERGA*

The OCA station, located in the south of France on the Calern Plateau near Grasse, performed well in 2001. On the technical side, there were no major incidents. However the data yield was a bit lower than desired due to exceptionally bad weather during the year. As mentioned in last year's report, the OCA observing program is no longer a lunar only one. It is divided among the four retroreflectors on the Moon, the two LAGEOS targets, and the several high altitude artificial satellites (GLONASS, Etalon, and GPS).

The OCA station netted 350 normal points on the Moon in 2001 (down from 830 in 2000), a 10-year low. The retirement (uncompensated) of one scientists and observers negatively impacted the observing program. For safety reasons, a single pulse of about 200 mJ is now used instead of a two-pulse-train of 250 mJ. This also contributed to the lower data yield. An ongoing study is aiming at using the two polarizations of the laser beam to double the energy per pulse fired to the Moon, without hazard to the laser. This improvement is now being implemented and should increase the data yield during poor weather times. A major refurbishing of the steering of the dome was undertaken early in 2002, leading to a break in OCA observations for several weeks.

Validated OCA LLR data are made available through the data centers of the ILRS and can also be retrieved from the OCA local web-site, with a monthly update, in both the old and new formats. Quick distribution (within 2 days) is also guaranteed to associated teams in Europe and in the US. The Paris Observatory Lunar Analysis group has been very active in exploiting the LLR data for Earth rotation, the dynamics of the Moon and the links of reference frames with significant publications in these areas.

The annual funding of the OCA station remains fragile and was, in fact, trimmed in early 2002. However, including other targets in the routine observing program allows the station to augment its main funding with additional support from the national space program, a much more secure solution for the future. A major review of OCA activity should occur either in 2003, or early 2004, which could lead to an important internal reshuffling of the activities between the artificial satellite and the lunar stations on the plateau.

Regarding the artificial satellite observations being made with the lunar station, the targets are limited to LAGEOS I and II as well as artificial satellites of higher altitude (GPS, GLONASS and Etalon). More than 6,500 normal points have been produced for the two LAGEOS targets and 3,000 for the others (1,200 for Etalon—1 and -2, 700 for the GLONASS satellites and 1,000 for GPS 35 and 36). A dedicated campaign involving the artificial satellite station, the lunar station and the mobile station was carried out in the fall of 2001 in order to assess the systematic differences among the three stations and determine the accuracy of the renovated mobile station before a 6-month calibration campaign on Jason-1. One should also note the successful OCA search for the Japanese satellite LRE as a result of a sustained campaign of several months due to lack of precision of the ephemeris. The station was officially acknowledged with a recognition award presented by the Japanese Space Agency.

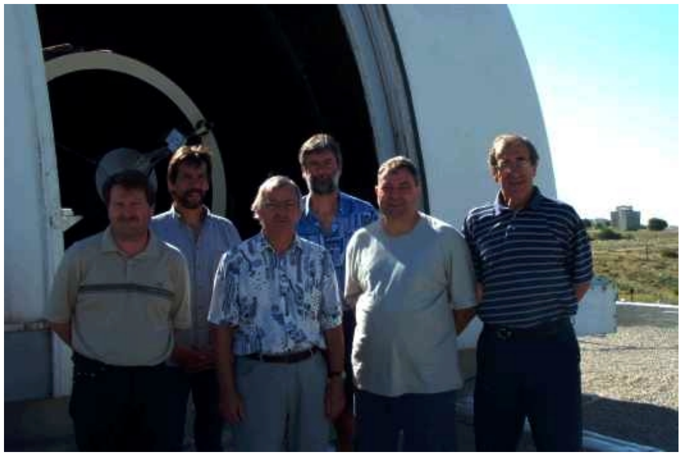

Figure 4.4-1. The team of the Grasse LLR (left to right)˚ in front: Maurice Furia, Jacques Depeyre, Jean-Fran ois Mangin, Jean-Marie Torre, Dominique F raudy, G rard Vigouroux˚.

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MCDONALD LASER RANGING STATION (MLRS)

Peter J. Shelus, University of Texas

McDonald Observatory laser ranging station, MLRS, is located in the mountains of west Texas, near Fort Davis, and continued its LLR activities during 2001. LLR data volume was approximately the same as it was during the previous year. Although some responsibility can be claimed for several equipment problems throughout the year, the poor weather continues to be mainly responsible for the less than desired LLR data yield. Similar to the OCA station, the MLRS observing program is not lunar only and the station ranges to most ILRS artificial satellite targets. Total data yield for the MLRS, including the Moon, were 3,534 total passes (up from 3,174 total passes), 37,498 normal points (up a bit from 37,057 normal points), and 34,384 minutes (up from 31,687 minutes) of tracking data.

The MLRS station netted 92 lunar normal points in 2001 (up slightly from 89 in 2000). MLRS LLR data are made available through the data centers of the ILRS. All data is transmitted to the data centers in near-real-time, using standard SLR formats.

Because of a very tight financial situation, there have been no upgrades or improvements at the MLRS. Activity is directed toward keeping the station operational and in a data gathering mode.

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