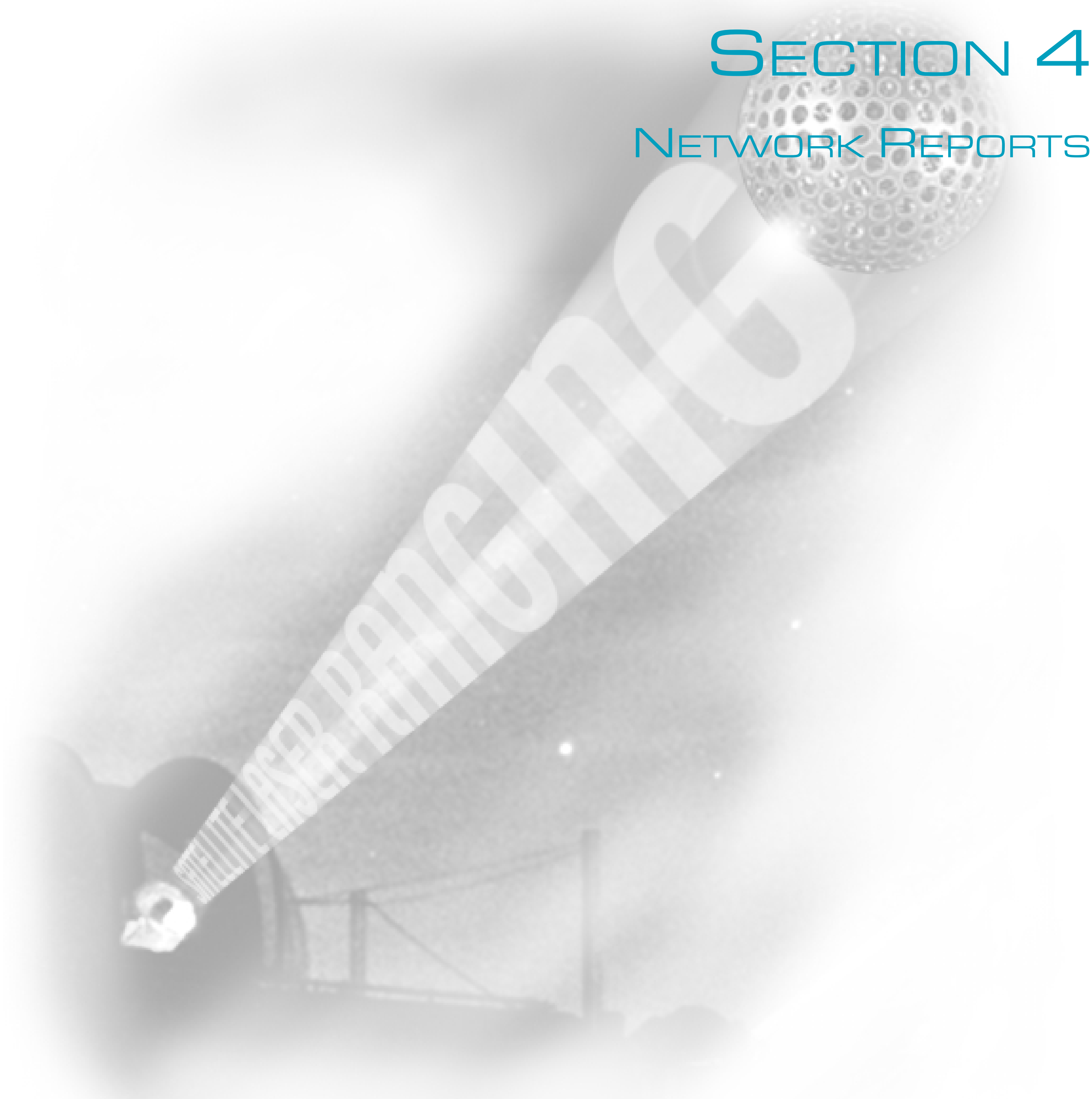
Section 4

Network Reports



SECTION 4 – NETWORK REPORTS

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

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

4.1 EUROLAS NETWORK/STATION REPORTS

Georg Kirchner, *Austrian Academy of Sciences*

BOROWIEC

Stanislaw Schillak

The SLR Borowiec station operated continuously during the year 2000 without major failures. It achieved returns during nighttime from 15 satellites in the frame of the ILRS tracking program. SLR Borowiec tracked 820 passes during the year, giving about 13000 normal points; the number of passes is strongly limited by weather conditions (70% clouds) and nighttime operations only. The accuracy of the system remains on the same level as before, with a normal points precision of 6 mm and a long term stability of 11 mm (ILRS Performance Card). The main improvement of the system was the change of the laser pulse width from 100 ps to 40 ps (using an etalon) on 28 February 2000. 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.

CAGLIARI

Aldo Banni, *Astronomical Observatory of Cagliari*

Cagliari Laser Station activity during the year 2000:

- 01.01. – 15.05: Repairs of the laser emitter and the event timer
- 15.05. – 15.07: Tracking of following passes: 29 Ajisai; 4 BE-C; 11 ERS-2; 2 GFO;
  18 LAGEOS-2; 4 Starlette; 5 Stella; 8 TOPEX/Poseidon
- 15.07. - Present: Repairs and updates on telescope electromechanics and electronics.

GRASSE

Permanent and Ultra Mobile Stations

Francis Pierron, *Observatoire de la Cote d'Azur*

During the year 2000 we continued with the permanent system to observe all LEO and LAGEOS satellites with an amount of 3800 passes and a very good stability. The LLR system ranged to LAGEOS, GLONASS and GPS passes simultaneously with lunar ranging.

A lot of data acquired simultaneously on the two LAGEOS with the LLR system located nearby the SLR station gave us the opportunity to achieve very interesting work on relative station stability which appears today very good.

Beside these very fruitful operations we put our effort to complete major technical upgrades of our Ultra Mobile Station in order to calibrate very accurately the JASON satellite which should be launched in autumn 2001. The technical points of this French Transportable Laser Ranging System (FTLRS) upgrade are the following:

- New design of the receiving optics with an iris to adjust the field of view;
- Installation of compensated SPAD and replacement of the slip ring transmission for the return signal by a direct coaxial cable;
- Synchronised electro-optical shutter in the receiving path to isolate the SPAD at firing time;
- Doubled wavelength for the laser with shorter pulses (35 ps);
- New cooling system for the laser;
- New calibration system (motorized corner cube on telescope); and
- Start detection system with permanent monitoring of the signal level.

This work must be completed in summer 2001 to operate FTLRS in colocation with the permanent stations before moving to Corsica for the calibration campaign.

LLR Station

Jean-Francois Mangin, *Observatoire de la Cote d'Azur, CERGA*

In 2000 the Grasse LLR station got returns from the distant satellites: 82 passages on Etalon 1, 87 on Etalon 2, 69 on GLONASS 72, 47 on GLONASS 78, 85 on GLONASS 79, 109 on GLONASS 80, 98 on GPS 35, 78 on GPS 36, 152 on LAGEOS1, 121 on LAGEOS2.

During this same year, from the Moon, it got 95 normal points on Apollo XI, 66 on Apollo XIV, 670 on Apollo XV and only 1 on L21.

On February 13, 2000, the station was modified to range with only one 300-ps-pulse on the moon due to efficiency reasons and laser security. Its energy is only 150mJ in the green. The team has worked to add a 20ps laser for satellite ranging. It has worked also on setting up a velocity aberration corrective blade for the distant satellites, which will permit us to work with a low beam divergent (2 or 3 arc seconds) and with a small receiver diameter (5 arc second) in order to eliminate the center-side bias on the diode and especially to reduce the daylight noise.

GRAZ

Georg Kirchner, *Austrian Academy of Sciences*

Besides the routine tracking of more than 4000 passes, we finished our Graz Event Timer ("Graz E.T.“) using the Dassault modules, and integrated it into the ranging system. It is running since autumn 2000 without any problems, and it has helped to reduce our system jitter significantly; at present, our routine calibrations deliver about 3.2 mm RMS; the results from ERS-2, WESTPAC etc. are very similar.

Since spring 2000, we have been using the fully compensated Start Pulse Detection System (see the Matera Proceedings), which eliminates amplitude dependence and temperature drifts; the system helps to efficiently keep the calibration values constant.

To improve daylight tracking, we have installed a CCD and a frame grabber to view the backscatter of the outgoing laser beam; this allows quick and easy fine-adjustments of Coudé path offsets; with the beam being stable in the center, the field-of-view can be minimized, resulting in lower noise and higher data yield (see also the Matera Proceedings).

Graz has also joined now the EUROLAS Time Bias Exchange in near-real-time, providing very helpful information for the tracking of low satellites; in addition, we have installed fully automatic software routines which perform downloads of IRVs from various sources, do all prediction calculations, and manage the routine data flow between the station PCs.

HERSTMONCEUX

Philip Gibbs, *Natural Environment Research Council*

The Herstmonceux SLR station observed all satellites on the ILRS list during 2001.

A frame grabbing CCD + steerable final mirror in the Coude chain has enabled us to see and control the beam during daylight. This, plus the ability to do star pointing on bright stars during the day, has improved our daytime tracking for LAGEOS and above.

We have tried to improve the stability of our laser by:

- keeping the firing rate the same for all satellites;
- increasing laser firing rate to 13Hz for low satellites and very close to 13Hz for LAGEOS and above;
- collecting data on alternate shots for GLONASS et. al.;
- monitoring the strength of the dye and keeping within it very tight tolerances.

One interesting side effect of changing to 13Hz is that it seems to have changed the relative characteristic behaviour of our SR620 timers. We are currently investigating this.

The EUROLAS short-arc analysis package was upgraded to include all stations and most satellites.

Matera

Guiseppe Bianco, *Agenzia Spaziale Italiana*

The old SAO-1 SLR system, located at the Space Geodesy Center of the Italian Space Agency, Matera, Italy, underwent a series of failures due to the age of the equipment, which led the team to gradually limit the observations to low altitude satellites. Spare part availability became critical during the year 2000, and, since the SLR operational team was already being trained on the MLRO system, we decided to gradually decrease the operational load on the system. Operations finally ceased the end of the year.

The new Matera Laser Ranging Observatory (MLRO) was shipped from the USA at the end of 1999 and its installation in the new facility, at the ASI Space Geodesy Center, began in January 2000. In the spring the system was able to routinely observe all SLR satellites in single color mode. The major activities carried out in 2000 have been:

- installation of the equipment (telescope, optical tables, cabling, etc.) in the new facility;
- interfacing of the dome to the MLRO control system;
- preliminary hardware and software testing;
- hardware and software training of the Italian operational team; and
- documentation drafting.

A report on the MLRO was presented to the international SLR community during the 12th International Workshop on Laser Ranging, held in Matera, Italy, in November 2000. The SLR data acquired on LAGEOS-2 in 2000 led to a further refinement of the rate at which the satellite's spin is decreasing, as published by Bianco *et al* in *Geophysical Research Letters*.

Metsahovi

Matti Paunonen, *Finnish Geodetic Institute*

Metsahovi (7806) operated the whole year, weather, light conditions and manpower permitting. The technical status is principally that described again in the Deggendorf Proceedings. Some development work was completed or was continued:

- An accurate time interval calibrator for testing linearity of the time interval counters is in use. It is used as a status monitor in ranging operations. A verbal description was given in the Matera conference.
- The PMT and the filter have been installed in the instrument room
- The passage of the start and return laser pulses to the common PMT detector has been verified.
- Preparations are being made to use a MCP photomultiplier, on loan from Graz, and a new sensitive timing discriminator (gating electronics, installation place)
- Design studies are underway for daylight ranging capability (narrow band filters, multistop counter, background noise level)
- Actions are in process to commence geodetic VLBI operations at Metsahovi within two years

POTSDAM

Reinhart Neubert, *GeoForschungsZentrum*

The hardware for the new SLR station Potsdam was completed at the end of 2000 (except the focal units). Acceptance tests of the laser and the telescope drive systems were performed in December 2000 at the site. Preliminary star tracking demonstrated the overall pointing accuracy of both telescopes to be about 5” or better. First ranging tests shall be performed in 2001. A description of the system can be found in the proceedings of the Matera Workshop.

PRAGUE SLR GROUP

Ivan Prochazka, *Technical University of Prague*

Progress continues in two areas:

- Picosecond event timing techniques and applications in a Portable Calibration Standard for SLR
- Development of the solid state photon counting technology. New modifications of SPADs on Silicon have been tested with the goal of timing resolution and dynamical range improvement. The active quenching and gating electronics for non gated operation of the SPAD detector package has been developed and tested. The modification of the SPAD detector package tailored for the Mars optical transponder is under development.

RIGA

Kasimirs Lapushka, *Astronomical Institute, University of Latvia*

With the support of Deggendorf Technical High School and our own efforts, the following new implementations have been made:

- The custom made Selective Time-Interval Counter (SETIC), 10 ps level, has been installed together with fast returned signal amplitude measuring unit (AMU);
- Hamamatsu metal package PMT type R7400 U-02, 12mm seated length, rise time 0.78 ns, QE at 532 nm 15%, together with C5594 series high speed preamplifier and C3830 HV multioutput DC power supply have been installed;
- GPS Time and Frequency Reference Receiver series 58540A Symmetricom, for Epoch synchronizing has been installed.

SAN FERNANDO

Jorge Garate, *Real Instituto y Observatorio Armada*

In 2000 the San Fernando SLR station acquired almost 3000 LEO passes, with more than 50000 normal points and more than 400 LAGEOS passes with almost 4000 Normal Points during 2000. The most of the trackings was done during nighttime, but some daylight data was taken on low satellites.

The calibration target was replaced with a new one installed inside the telescope dome. So, the accuracy was improved. At the end of 2000, range precision and stability had improved withthe LAGEOS normal point rms was 10 mm, and the long term stability was 30 mm, compared to 12 mm and 50 mm respectively at the end of 1999. Some improvement remains as the long-term stability does not quite meet the ILRS standards of 20 mm. In order to reach further improvement, we have designed and built an interface device to attach a CSPAD to the telescope. We expect to replace the photomultiplier with the CSPAD during 2001.

WLRS

Anja Schlicht, *Fundamentalstation, Wettzell*

The year 2000 stood against the background of the new control system for the Wettzell Laser Ranging System (WLRS). Figure 4.1-1 shows the modular structure of the new control unit and the communication paths between the modules. The telescope control unit and the scheduler server are python programs based on a C-library whereas the measuring unit is a LabVIEW program. The communication is mainly based on TCP-IP connections between the computers and RS-232 interfaces between the measuring computer and the event timer and the radar, respectively.

In the first part of the year the testing of the control system was the primary goal. This phase ended in October when the new control system took over the routine tracking. Some improvements were recognized with the new event timer. First of all the rms of the calibrations got smaller. For the avalanche photodiode it decreased from approximately 2.5 cm to 1.5 cm and for the MCP detector from about 1.5 cm to 1 cm. This is due to the better resolution of the PET4 in contrast to the old MRCS timer.

The new event timer has not only a better resolution, but also a better stability The scatter in the range bias on LAGEOS has deceased from about 6 cm to about 3 cm.

The change of the control system also required a general redesign of the telescope control. This was mostly done in the year 2000 with the final implementation starting in January 2001.

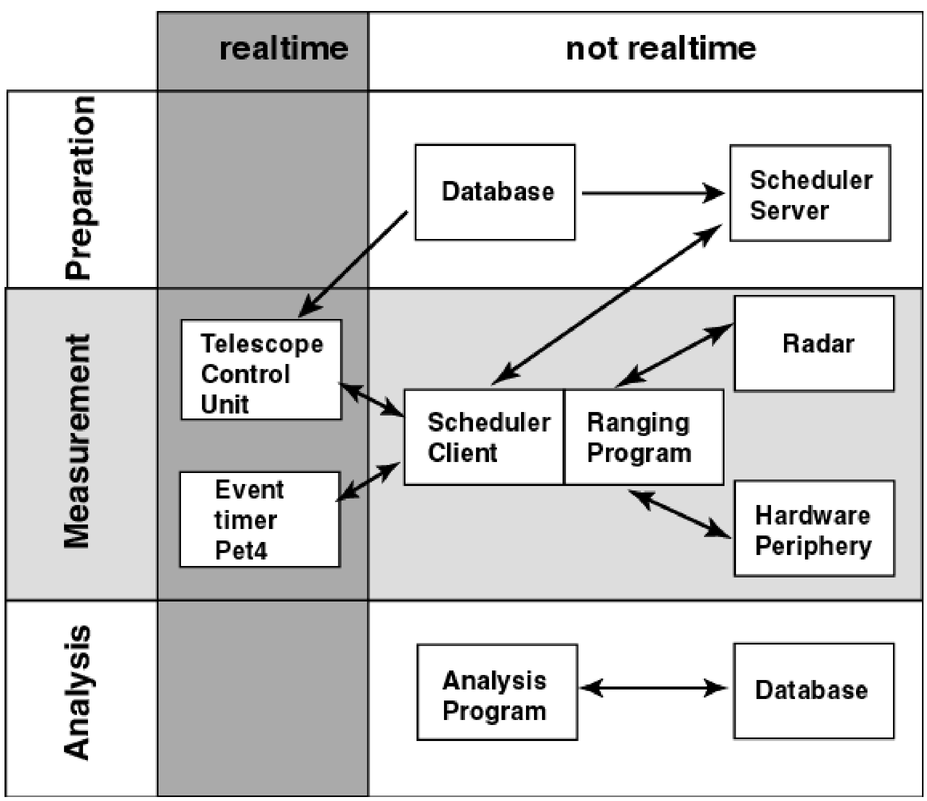


Figure 4.1-1: Scheme of the construction of the new control system. It has a modular structure which separates units needing realtime from the one which don't depend on an exact timing. The arrows indicate the communication paths between the units.

ZIMMERWALD

Werner Gurtner, *Astronomical Institute of Berne*

The year 2000 showed the best six months ever with respect to the number of observed satellite passes: After the re-coating of the telescope mirrors (M2 and M3) in April 2000 with a protected silver coating the station collected from May through October data from more than 2000 passes. Unfortunately the reflectivity of the mirrors soon started to deteriorate again. In early January 2001 the mirrors were removed from the telescope and sent for re-coating, this time to another company which offered a long-duration, broadband dielectric coating.

The larger-than-expected single-shot rms for both the photomultiplier and the SPAD detectors could finally traced to the pulse width of the laser, which exceeded the requirements of 100 ps by a factor of about three. A replacement of the oscillator etalon reduced the pulse width to 100 ps and the single-shot calibration rms decreased to about 70 ps for the SPAD and 100 ps for the photomultiplier.

In order to improve the tracking performance during the day, when a very narrow field of view is used, a motorized and computer-controlled mirror was introduced to correct the aberration by steering the transmitting beam accordingly.

A web server on the station computer and some modifications in the control software allows access to system status information, observation and auxiliary data on the web.

The control software was upgraded to allow for an automated operation at least for a limited period of time (up to about three hours).

4.2 NASA NETWORK

David Carter, *NASA Goddard Space Flight Center*
Paul Stevens, *Honeywell Technology Solutions Inc.*

The NASA SLR Network during 2000 consisted of nine 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 Technology Solutions, Inc. (HTSI), University of Texas, University of Hawaii, Universidad Nacional de San Agustin, Australian Surveying & Land Information Group (AUSLIG), University of French Polynesia/CNES and the National Research Foundation of South Africa. These stations and their operating agencies are shown in the table 4.2-1 below.

Location	SLR System Name	Operating Agency
Monument Peak, California, USA	MOBLAS-4	HTSI
Greenbelt, Maryland, USA	MOBLAS-7	HTSI
Greenbelt, Maryland USA * (*Operational test bed)	TLRS-4	HTSI
Mt. Haleakala, Maui, Hawaii USA	HOLLAS	University of Hawaii
Fort Davis, Texas, USA	MLRS	University of Texas at Austin
Arequipa, Peru	TLRS-3	Universidad Nacional de San Agustin
Yarragadee, Western Australia	HOLLAS	University of Hawaii
Yarragadee, Western Australia	TLRS-3	Universidad Nacional de San Agustin
Hartebeesthoek, South Africa	MOBLAS-5	Australian Surveying & Land Information Group
Tahiti, French Polynesia	MOBLAS-8	University of French Polynesia/CNES

Table 4.2-1. The NASA Satellite Laser Ranging Network of Stations

CONTRACTOR OPERATED STATIONS

MOBLAS-4 – Monument Peak, California USA

MOBLAS-4 provided satellite laser ranging capability on a 24 hour, 7-days per week basis at the Monument Peak, California location. The MOBLAS-4 occupation at Monument Peak during 2000 represents its 17th year at this site.

MOBLAS-4 remained one of the most productive SLR systems in the world, delivering over 83,000 Normal Points to the global scientific community. MOBLAS-4 was the 2000 global leader in total LEO NP produced and delivered to the SLR community (69,578). Data quality was also excellent, producing over a 98% high quality LAGEOS NP capture rate. Single shot LAGEOS RMS was also excellent, averaging below 9mm for the year.

System upgrades to MOBLAS-4 during 2000 was limited to a newly calibrated MET3 weather sensor package that was installed in April 2000.

Crew at MOBLAS-4: Gary Gebet (station manager), Ted Doroski, Ron Sebeny, and Roy Swickard.

MOBLAS-7 – Greenbelt, Maryland USA

MOBLAS-7 provided satellite laser ranging capability on a 24 hour, 7-days per week basis at the Greenbelt, Maryland location. The MOBLAS-7 occupation at Greenbelt during 2000, was its 19th year at this location.

In 2000, the MOBLAS-7 system was again among the global SLR system leaders in both productivity and data quality. The system and crew achieved 98 % efficiency in the capture and production of high quality LAGEOS NP while delivering over 68,000 NP (all satellites) to the scientific user community.

Configuration changes at MOBLAS-7 during 2000 were limited to the MET3 weather sensor upgrade in March. A new ground target (pier B) was installed during 2000 at the Greenbelt site and utilized by the MOBLAS-7 system for routine ground tests. This target replaced the former pier B that had shifted during a bad drought period in the area.

Crew at MOBLAS-7: Maceo Blount (Station Manager), Diglio Simoni, Jay Steigelman, and Ken Tribble.

TLRS-4 – Greenbelt, Maryland USA

TLRS-4 continued to function as an Engineering Test facility in Greenbelt, Maryland in 2000. TLRS-4 served as host for the successful deployment and testing of the advanced Generic Normal Point processing (GNP) software package. As a result of successful GNP testing at TLRS-4, all NASA SLR network systems will receive operational versions of this critical software package in 2001. TLRS-4 was also used to test repair and replacement parts prior to field deployment allowing MOBLAS 7 to operate without interruption.

UNIVERSITY OPERATED STATIONS

Mt. Haleakala, Maui, Hawaii USA

The Mount Haleakala Laser System (HOLLAS) completed an extensive upgrade of all control hardware and software systems during the year 2000. The first satellite returns with the upgraded system were recorded in August 2000. The telescope control system built by a sub-contractor never operated to specifications, and has negatively affected tracking efficiency. Plans to either repair or replace this system are being considered. By the end of 2000, HOLLAS was operating a single 2 person tracking shift, with the 3 other members of the HOLLAS team working on completion of the upgrades.

A real time connection to the local FAA Airport Radar system is to be completed by 2001. The system is being designed and constructed for use at HOLLAS during laser operations. This system will be integrated into the HOLLAS satellite tracking system, and will enable single person tracking operations at HOLLAS.

Crew at HOLLAS: Dan O'Gara (station manager), Craig Foreman, Bill Lindsey, Jake Kamibayashi, and Timothy Georges.

McDonald Laser Ranging Station – Ft. Davis, Texas USA

The McDonald Observatory Laser Ranging Station (MLRS) located in the mountains of west Texas, continued its SLR/LLR activities during 2000, under contract to NASA/GSFC. Although SLR data volume was very good at the MLRS, LLR data volume worsened somewhat during 2000. Some responsibility can be claimed by several equipment problems throughout the year, however, the poor weather was mainly responsible for the less than desired LLR data yield. Total data yield for the MLRS, including the Moon, were 3,174 total passes, 37,057 normal points, and 31,687 minutes of tracking data.

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

Peter 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. Ricklefs, Software Manager, continued his efforts on behalf of the ILRS, serving as a member of the Data Formats Working Group and spear-heading a project for a more comprehensive data format that will be used for SLR, LLR, and laser transponder data.

Crew at MLRS: Jerry Wiant (Project Engineer), Windell L. Williams, Kenny T. Harned, Martin L. Villarreal, Anthony R. Garcia, and Rachel M. Green.

PARTNER OPERATED STATIONS

TLRS-3 – Arequipa, Peru

TLRS-3 continued to supply SLR data from Arequipa, Peru for the 10th year with the TLRS-3 system. This system had replaced the SAO-2 ruby system in 1990. As a result of system issues at TLRS-3, SLR tracking coverage was limited to only 10,520 minutes during 2000. Though system operations were not maximized, TLRS-3 contributed over 21,000 NP to the scientific user community. TLRS-3 also provided outstanding tracking coverage of LEO satellites, collecting over 20,000 NP for these satellites during 2000.

No significant configuration changes were implemented in the TLRS-3 during 2000.

Crew at TLRS-3: Victor Lucano (station manager), Janet Caceres, Modesto Canari, Marino Gomez, Jorge Valverde, Manuel Yanyachi, and Raul Yanyachi.

MOBLAS-5 – Yarragadee, Western Australia

MOBLAS-5 provided satellite laser ranging capability on a 16 hour, 7-day per week basis at the Yarragadee, Australia location. The MOBLAS-5 occupation at Yarragadee during 2000 was its 21st year at this location.

MOBLAS-5 productivity was among SLR global leaders in all statistically relevant areas in 2000. The system and crew provided more satellite tracking coverage (over 93,000 ranging minutes) than any other SLR system in the world. SLR data yields included over 79,000 total NP captured while maintaining outstanding data quality standards. The MOBLAS-5 system produced over a 98% high quality LAGEOS NP capture rate.

Configuration changes at MOBLAS-5 during 2000 included the replacement of the GPS Steered Rubidium unit with an improved SRS oscillator equipped unit in June 2000. This will increase the reliability of the unit. Also, a newly calibrated MET3 weather sensor package was also installed in March 2000.

Crew at MOBLAS-5: Vince Noyes (station manager), Randall Carman, Peter Bargewell, Jack Paff, and Brian Rubery.

MOBLAS-6 – Hartebeesthoek, South Africa

The MOBLAS-6 system began 1st year of operations by a South African Research Foundation crew in their new home. MOBLAS-6 was transferred to its Hartebeesthoek Radio Astronomy Observatory (HARTRAO) facility located in) in Krugersdorp, South Africa in June 2000 and commenced SLR operations in July 2000. The successful transfer of MOBLAS-6 was coordinated through a collaborative effort of NASA and the South African National Research Foundation. The system was formally dedicated at the HARTRAO on November 20, 2000.

Prior to deployment to South Africa, key members of the South African crew spent several months training with HTSI personnel at the Greenbelt SLR facility. The South African crew played an important role in the setup of the system at the HARTRAO and provided training to the remaining crewmembers with the assistance of HTSI engineers.

Upon satisfying all engineering issues associated with the transition of the system, MOBLAS-6 delivered excellent SLR data quality and volume. The MOBLAS-6 system returned over a 91% high quality LAGEOS NP capture rate, with single shot LAGEOS RMS averages below 9.5mm. In addition, the system in the last 5 months of 2000 produced over 3,800 NP (all satellites).

No major configuration changes were introduced to MOBLAS-6 during 2000. However, extensive optical alignments to the system were performed to optimize SLR tracking when the system was relocated to the HARTRAO.

Crew at HARTRAO: Ludwig Combrinck (Programme Leader),Wilhelm Haupt (station manager), Louis Barendse, Johan Bernhardt, Marisa Nickola, Lesiba Ledwaba, William Moralo, Pieter Stronkhorst, Piet Mohlaabeng.

MOBLAS-8 – Tahiti, French Polynesia

The MOBLAS-8 SLR system located at Tahiti, French Polynesia operated for the 3rd year at this location. A variety of maintenance and weather issues significantly impacted SLR activities during 2000 at MOBLAS-8. The system was limited to 10,697 minutes of laser ranging operations, which negatively affected total data yields. The system did capture over 15,000 total NP, which included 3,085 LAGEOS NP. Despite operational difficulties, MOBLAS-8 achieved a 93% efficiency rate in the capture and production of high quality LAGEOS NP.

Configuration changes in MOBLAS-8 included the MET3 weather sensor upgrade in April.

Crew at Tahiti: Nicolas Blanchard (station manager), Karl Daues, and Sebastien Deroussi.

4.3 WESTERN PACIFIC LASER TRACKING NETWORK (WPLTN)

Hiro Kunimori, *Communications Research Laboratories*
John Luck, *Australian Surveying and Land Information Group*

The WPLTN was established on 11 November 1994 during the Ninth International Workshop on Laser Ranging Instrumentation inf Canberra (WPLS, 1994). Its Executive Committee initially consisted of two representatives each from Russia, China, Japan, and Australia, to which have been added one each from Saudi Arabia and India. Separate reports for the Australian, Chinese, Russian, and Japanese sub-networks are given below.

AUSTRALIAN STATIONS

John Luck, *Australian Surveying and Land Information Group (AUSLIG)*

Yarragadee (7090)

The Yarragadee SLR station is operated by AUSLIG in partnership with NASA. The station operated virtually unimpeded throughout 2000. It acquired 3502 LEO, 1124 LAGEOS and 1438 high satellite passes, for a total of 6064 passes to be the second most productive of all stations. It ranked first in 4 of the categories of the ILRS Global Performance Report Card for 4th Quarter 2000, and second in 5 categories.

Day-to-day operations continue to be funded by AUSLIG, with sustaining engineering provided by NASA-HTSI which included a new laser oscillator (installed August), a XL-DC steered rubidium (June) to replace the cesium ensemble, and upgraded radar (Nov). The installation of a UPS Solid State Converter to the mains supply resulted in a 50% drop in power consumption.

Discussions continued between NASA and AUSLIG on funding arrangements after 30 June 2002, without finalisation. The adjacent radio tracking station for Universal Space Network, which shares infrastructure with the SLR station, was completed in December.

Mt. Stromlo (7849)

The station acquired 3937 LEO, 1460 LAGEOS and 1005 high satellite passes for a total of 6402 passes, the most pass-productive of all stations. It ranked first in 3 of the categories of the ILRS Global Performance Report Card for 4th Quarter 2000, and second in 4 categories.

The introduction of fully autonomous tracking for 80 hours per week from March, and automatic post-processing, had a significant impact on productivity and on station costs. Automatic FTP transmission of normal point files to EDC every 3 hours commenced in July. See *J.Luck, C.Moore & B.Greene: "Autonomous Laser Ranging Results from Mount Stromlo" in Proc. 12th International Workshop on Laser Ranging, Matera, Nov 2000*. R&D concentrated on a high energy laser, and a new transmit/receive system catering for very high powers at several different wavelengths including eyesafe. A unique system to inhibit laser firing when the beam would interfere with astronomical observations by the co-located Mount Stromlo Observatory was completed. It involves real-time communications with the domes and a neat algorithm.

The station operator, Electro Optic Systems Pty.Ltd., was awarded a substantial R&D grant from the Department of Industry, Science and Resources to develop a project of advanced applications of laser tracking with high commercial potential. Much of the testing will be done at Stromlo using the high energy laser and related equipment.

CHINESE SLR NETWORK IN 2000

Yang Fu Min, *Shanghai Observatory*

During the year 2000 the Chinese SLR network of five fixed stations and two mobile systems, tracked 7086 passes from 28 satellites. The tracking capability of Kunming station was upgraded, particularly for LAGEOS and high orbit satellites including GPS-35, -36. But the servo system still needs to be upgraded for low orbit satellite tracking. The problem with the frequency standard for the SR620 counter was corrected on October 23, 2000. The Wuhan station was moved from the old site to the new observatory in the southeast suburbs about 15 km away away from the city. Wuhan began operations April 2000, and the station ID was changed from 7236 to 7231. The mobile system TROS, built and operated by the Institute of Seismology in Wuhan, obtained 42 passes from LAGEOS-1, LAGEOS-2 and 289 passes from other satellites during collocation with Beijing station from August to October 2000. The TROS system was moved to Urumqi, the biggest city on the northwest border. In April 2001, the mount and the SFUR laser, moved 3800 km from Beijing to Urumqi. In Urumqi, the SFUR laser which was made by the Shanghai Institute of Optics and Fine Mechanics performed very well and the TROS system tracked 43 passes of LAGEOS from April 23 to June 5. In August 2001, the TROS system moved to Lhasa, Tibet.

Satellite	P-PET rms (mm)	SLR rms (mm)	Time bias (us)	Range bias (ns)
Starlette	7.5	12.7	0.1	0.02
Beacon-C	9.3	13.8	0.1	0.00
Ajisai	10.9	15.9	0.1	0.00
LAGEOS 2	10.5	17.3	0.1	-0.01
Starlette	9.0	15.1	0.1	0.03
LAGEOS 1	8.5	14.2	0.1	0.01
Beacon C	19.2	19.7	0.1	0.02
Topex	22.4	35	0.1	0.00
Topex	4.9	10.8	0.1	0.00
LAGEOS 1	7.0	13.5	0.1	0.00
Stella	6.1	12.4	0.1	0.00
Beacon C	10.0	16.1	0.1	0.00
Starlette	8.4	12.9	0.1	0.01
Westpac	--	16.6	0.1	0.03
LAGEOS 2	8.5	16.1	0.1	0.00
ERS-2	4.0	10.5	0.1	0.01
Mean			0.1	0.01

Table 4.3-1. Summary of the P-PET test at Shanghai (August 16-22, 2001).

The performance of the lasers at Shanghai, Changchun and Beijing was improved during the year 2000. The output energy and repetition were increased. The system stability (including short term and long term of range bias) for all stations received more attention. More calibrations during the routine observation were performed. But large range biases and some data editing from the Chinese stations appeared in the analysis reports published by the UTX/CSR. The Changchun system did achieve the ILRS standard for both short term and long term stability and without obvious bias. The Shanghai station has had a fixed bias -40 mm for several years and -80 mm since July 2001 as reported in the CSR report. In order to identify the biases, K. Hamal and I. Prochazka of the Czech Technical University brought a Portable Pico Event Timer (P-PET) and an independent data acquisition and processing software package to Shanghai to perform a comparative calibration experiment during August 16-22, 2001. The joint team measured three short distance targets and found the differences of the system delays from these targets to be only 2-3 mm. The P-PET calibration package, operating in parallel with the existing SLR system, tracked 16 passes satellites. The comparison of ranging accuracy, time bias and range bias for each pass are listed in the Table 4-3.1. The range biases were derived from the point to point comparison with the full-rate data obtained by two systems for each pass. The epoch differences were about 1 microsec. and range differences averaged a few mm. The range bias is still an issue and may be associated with the station coordinates used by CSR.

The SLR system for the San Juan Observatory in Argentina is under construction. The mount has been tested and the mirrors have been coated. The SFUR laser is ready. The system is scheduled for collocation tests with Beijing station in October 2001.

RUSSIAN LASER NETWORK

Natalia Parkhomenko, *Space Research Institute for Precision Engineering*

SLR Station Komsomolsk (1868)

The Komsomolsk station did not operate in late of 2000 because of ongoing repairs to the telescope pointing system.

SLR Maidanak 2 (1864)

An agreement between the Russian Government and the Government of the Uzbek Republic was made and funding was obtained to upgrade the Maidanak 2 SLR station (1864). We plan to replace the computers, pointing system, laser and to establish daytime laser ranging. The upgrad is scheduled to be completed in the second quarter 2002.

SLR Station Maidanak 1 (1863)

The Maidanak 1 SLR station (1863) is ready for operation after upgrading. The station will operate in engineering status up to end of September 2001.

New SLR Station in near Moscow

We have requested permission to include a new Shelkavo SLR station located near Moscow in the ILRS.

Japanese SLR Network

Hiroo Kunimori, *Communications Research Laboratory*

The KeyStone Project began satellite observations in 1998 by Communications Research Laboratory (CRL). The data quality was good, but the data yield averaged from 20 passes per month at best (from Tateyama) to 10 passes per month in the worst case (from Miura). All four systems, Koganei(7328), Miura(7337), Tateyama(7339), and Kashima(7335) ceased operations in May 2000. In the fall 2000, while Miura station was being prepared to be dismantled, the Tateyama and Kashima Stations resumed operations to monitor deformation caused by volcanic activity south of Tokyo during August 2000. When the Tateyama station resumed operation, a position change of several cm was measured, confirming VLBI results. The KeyStone SLR stations will be put into long term storage in 2001. Additional information can be found at:

http://www2.crl.go.jp/hk/slr/keystone/keystone.html

The Simosato SLR station (7838) operating under the Japanese Hydrographic Department of the Maritime Safety Agency, suffers from mount servo problem resulting from lightening damage in 1999. However, data production continues to increase (see Section 8.4). The HTLRS operated from June 2000 through September 2000 during its second occupation at the Northern Island.

The global and high accuracy trajectory system (GUTS) Project was initiated in 1999 by National Space Development Agency (NASDA) for precise orbit determination using GPS and SLR. In 2000, the orbit determination software for ADEOS-II was completed. A new SLR station planned to be located near the Tanegashima launch site on the Southern Island, was in its final design phase. Details can be found at:

http://god.tksc.nasda.go.jp/slrsub/index.html

4.4 LUNAR NETWORK

Peter Shelus, *University of Texas*
Francois Mignard, *Observatore del la Cote d'Azur*

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, now in the final testing stages after being installed in Matera, Italy. Routine operation of the MLRO should begin in 2001. LLR data was gathered in previous years by the Wettzell SLR station in Germany. However, equipment upgrades and other operational matters prevented LLR data from being obtained in 2000. LLR data may be obtained at Wettzell during 2001. Figure 4.4-1 illustrates annual data yields from the two routinely operating LLR stations over the past decade.

OBSERVATOIRE DE LA COTE D'AZUR (OCA)

The OCA station, located in the south of France on the Calern Plateau near Grasse, performed well during 2000 with no major incidents. Weather conditions were good during the spring and summer, before the start of an exceptionally long spell of poor weather, not yet over by spring 2001. As mentioned last year, the OCA observing program is no longer a lunar only program. The program is divided among the four retroreflectors on the Moon, the two LAGEOS targets, and the several high altitude artificial satellites (GLONASS, Etalon, and GPS). Despite this large increase in the number of targets under observation, the 2000 data yield for the Moon remains excellent and the number of normal points has is now an all time high.

The OCA station netted 830 normal points in 2000 (up from 653 in 1999). However, due to a change in the optical configuration and the consequent need to fire the laser with less energy, the average number of returns per normal point has gone down from 93 to 45. For safety reasons, a single impulse of about 200 mJ is used instead of two impulses of 250 mJ. 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 funding of the OCA station had been questioned by national authorities and investigated by a dedicated committee in June 1999. Eventually, based upon the quality of the work carried out, the scientific value of the output and the moderate annual cost (not counting salaries) the committee recommended that the operation should continue for the next four years. This promised has been fulfilled for the second year in 2000. The Paris Observatory Lunar Analysis group has been very active to exploit this data for Earth rotation, the dynamics of the Moon and the links of reference frames.

MCDONALD LASER RANGING STATION (MLRS)

The McDonald Observatory station, MLRS, located in the mountains of west Texas, continued its LLR activities during 2000. LLR data volume worsened in 2000 and, unfortunately, has not returned to the levels that were experienced in earlier years. Although some responsibility can be claimed for several equipment problems throughout the year, the poor weather was 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 all ILRS artificial satellite targets. Total data yield for the MLRS, including the Moon, were 3,174 total passes, 37,057 normal points, and 31,687 minutes of tracking data.

The MLRS station netted only 89 lunar normal points in 2000 (down from 206 in 1999). 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 has been no upgrades or improvements at the MLRS. Activity is directed toward keeping the station operational and in a data gathering mode.

KEY POINTS OF CONTACT

OCA: Francois Mignard
OCA/CERGA
Av N. Copernic
06130 Grasse, FRANCE
francois.mignard@obs-azur.fr

MLRS: Peter J. Shelus
McDonald Observatory
University of Texas at Austin
Austin, TX 78712-1083, USA
pjs@astro.as.utexas.edu

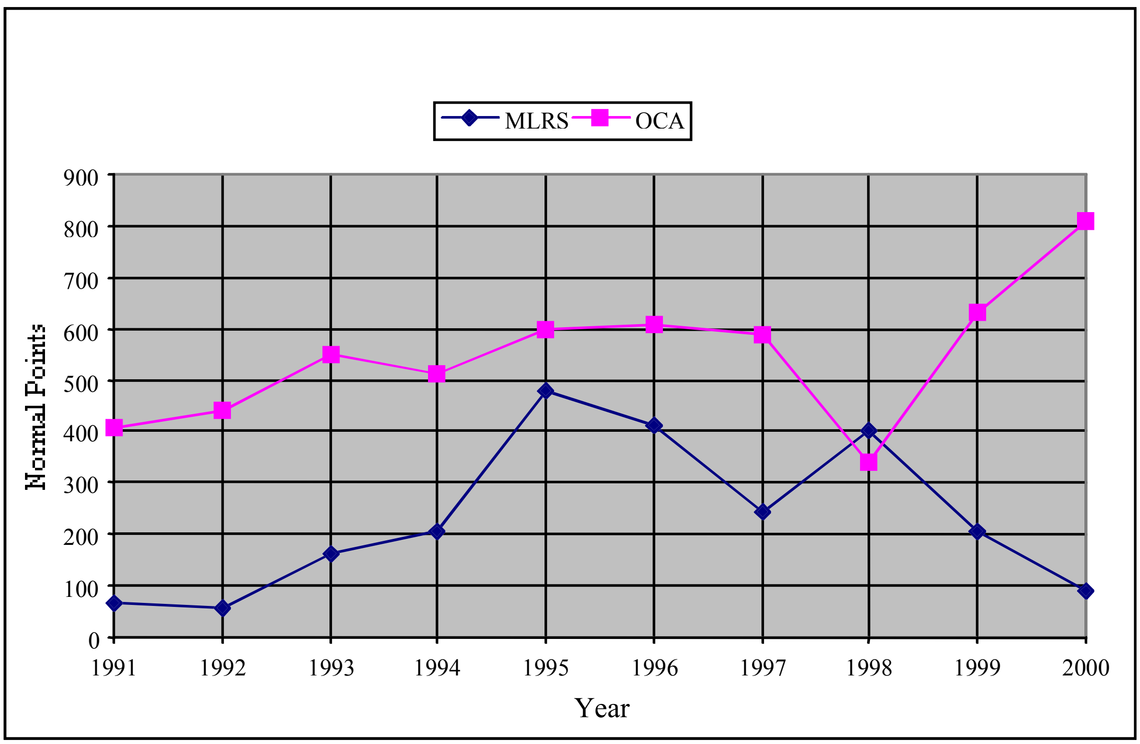


Figure 4.4-1: Summary of Annual LLR Normal Points

This page is intentionally blank