Section 12
ILRS Station Reports

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Arequipa, Peru

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Figure 12-1. TLRS-3 NASA Station in Arequipa, volcano Misti in the background.

The TLRS-3 NASA station located in Arequipa Peru continued operations during 2009 and 2010.

Station Upgrades and Problems/Repairs

In January 2009, a telescope mount vibration in elevation continued due to tachometer problems affecting/restricting the SLR tracking. This problem became significantly worse by the end of April. At the end of July, Dennis McCollums (HTSI) changed the elevation tachometer. A problem with the delay originated by the bad signal of 10 MHz that coming from Distribution Amplifier HP-5087 was fixed. Due to PMT failure there was no tracking from October to December. Changed the control unit card in CU-401 and replaced 5A fuses in the PU-420. The T/R Switch failed intermittently.

In January 8-22, 2010 Dennis McCollums again visited the station performing the following engineering activities:

- Investigated and minimized reflection in the receiver optics
- Installed new Photek PMT318 and NSR PS350 high voltage power supply
- Realigned laser in lower table and verified position of rod in the oscillator, replaced oscillator lamps, wave plate, 69.910Mhz AML, pockels cell, and SHG.
- Fixed T/R switch position, balanced arm by making holes, replaced the complement of the sensor hall in the arm with one having a magnetic feature.
- Assembled one T/R switch motor using spare parts and achieved stable T/R switch function.
- Performed and verified complete Ceolostat alignment.
- Completed boresite and verified the reflections on the receiver optics under different tracking conditions; results were nominal

- Initially set PMT at 3200 volts, but had much noise and finally we tracked at 2900 volts.
- Completed TIU optimization, stability and Minico test; twice blew 5A fuse in the PU-420.
- A connection in the discriminator TC-494 was bad, awaited a new one with cables.
- Installed the calibrated MET-3.
- Replaced STBY switch in the switch chassis.

In February 2010, the track ball failure in elevation was cleaned. The mount occasionally is oscillating in azimuth during nighttime operations. We installed a new processor computer (Dell Precision 380). In March 2010, the track ball failure in azimuth was cleaned. The mount continues nighttime oscillation in azimuth on occasion. The laser was realigned laser and we performed a boresite. Blown 5A fuses in the PU-420 forced us to adjust the T/R switch and change the motor. The system obtained a low quantity of returns from January to March due the cloudy weather. A small telescope mount vibration in azimuth was due to tachometer problems during May to August. By September the tracking improved due to clear skies. We also replaced the azimuth tachometer.

Dennis McCollums returned to the station in October 2010, performing the following work with station staff:

- Started tracking with 3000V PMT.
- Started tracking LAGEOS satellites in high priority. Although the station had more returns from these satellites, clouds inhibited the tracking. Passes in clockwis direction had more returns than those in counterclockwise direction.
- Replaced T/R switch motor with one we received, but it was bad.
- Replaced 5A fuse twice in PU-420.
- Replaced amp lamps and put new separators in the amp head.
- Transmit filter failure, adjusted the screws.
- OAM had error in the sattrk program, and gave error 41, checked the 24V power supply - changed 2A fuse and the problem fixed.
- Trackball cleaned and replaced.
- Fuse in the card E-120 trackball modified.
- Put cover for protection on corner cube B, was painted black.
- The rms was variable due unstable cable or startdiode.
- Replaced AML, amplifier rod, SHG and T/R switch motor.
- The dome failed due to insufficient tire pressure.
- The rms was variable due unstable cable or photodiode.

Station Operations

In 2009, Arequipa operated using two shifts (16 hours) per day, five days a week. Three shift operations (24 hour coverage) for five days a week began in March 2010.

TLRS-3 tracks low orbit satellite during the day and night with good results. Mid-altitude orbiting satellites such as LAGEOS-1/-2 have better results during nighttime operations. TLRS-3 does not track high orbit satellites.

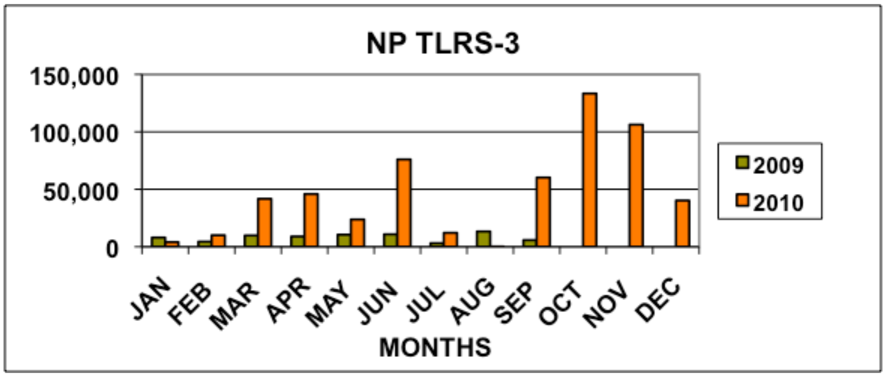

Figure 12-2. TLRS-3 normal point statistics for 2009 and 2010.

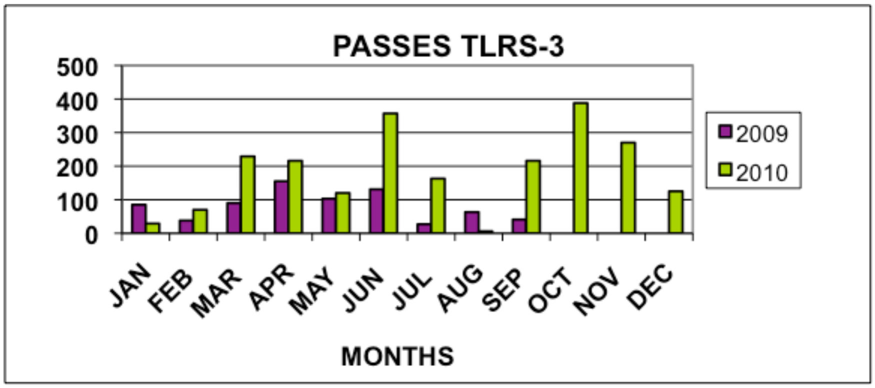

Figure 12-3. TLRS-3 pass statistics for 2009 and 2010.

Significant Events

In June 2009 David Carter, the NASA SLR Manager, Curtis Emerson, and Claudia Carabajal from GSFC visited Arequipa for discussions on the agreement between NASA and the National University of San Agustin. NASA personnel met with the Rector Dr. Valdemar Medina and Vice Rector Dr. Elisa Casta eda and visited the station for meetings with the station manager and supporting personnel.

Figure 12-4. David Carter, Curtis Emerson, Claudia Carabajal and TLRS-3 station crew during site visit in 2009.

July 1, 2009 commemorated the 50-year anniversary of the Arequipa SLR station. Initial tracking began using the Baker-Nunn Camera from 1950 until 1975 and continued with the Spacerays red laser until 1990. The current NASA TLRS-3 station has occupied the site since 1990. An anniversary ceremony was held to commemorate the event; attendees included the UNSA Vice rector Dr. Elisa Casta eda, current and former station personnel, and directors from the Institute Geophysical at UNSA. On July 13, a plaque was dedicated in memoriam to Dave

Hallenbeck who worked at the station since 1971, retired as station manager in 1998, and died of lung cancer in 1999.

In August 2009, Julio Marius from GSFC and his wife visited the station; he gave a presentation with Arequipa station manager at the IEEE Congress of Engineering Electronics INTERCON 2009 which was co-organized by UNSA. He was recognized by UNSA in a special ceremony and received a diploma and medal from UNSA's Rector. Marius also participated in interviews with local TV, radio, and newspapers. Staff from DLR and the Director of Geophysics Institute of Peru also visited the station. Many visitors from local schools and universities toured the TLRS-3, with presentations by station personnel.

Figure 12-5. UNSA Vice Rector Victor Linares, Rector Valdemar Medina, Vice Rector Elisa Castañeda and Julio Marius in ceremony of distinction.

Other Systems

UNAVCO sent a new computer (Acrosser) and Javad GPS receiver to Arequipa in June 2009; the receiver was sent back to UNAVCO in 2010 for repair. The CCD camera in the FPI Clemson experiment was replaced.

Personnel Changes

The crew at TLRS-3 consists of station manager Dr. Raul Yanyachi, senior operators Jorge Valverde and Manuel Yanyachi, and operator Mariano Gomez. Dante Corrales, Marco Higueras, and Kevynn Rodriguez continued training as operators. Janet Caceres is our administrative assistant and Wilberto Cañari serves as our maintenance assistant.

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KHz Ranging System Built, Tested and Observing

Work on the kHz ranging system built at the Beijing station began in January of 2010 and was completed in September of the same year. The system consists of two separate computers for tracking and data acquisition. A Latvia event timer A032-ET was used for the kHz measurements; it is connected to the data acquisition computer through a parallel port line. The two computers are linked by a serial port line; the main computer performs the satellite tracking and ranging control functions. Operators interface with the main computer and perform a majority of the ranging activities, such as tracking satellites, firing the laser, opening the range gate for the C-SPAD, making the computer clock synchronization to GPS time receiver, and aiming the laser beam at the satellites. The temperature control of the narrow band filter and the pin hole size control of the changeable diaphragm are also performed by the main computer. The diagram shown in Figure 12-6 shows the profile of the system.

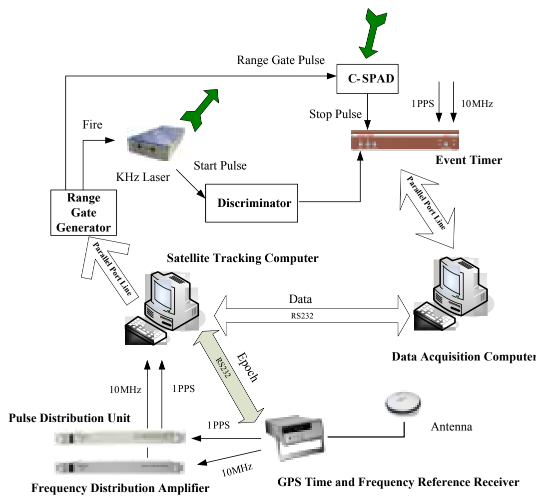

Figure 12-6. The Beijing station's kHz SLR system.

Daytime Tracking Tests

Daytime tracking tests were carried out in November and December of 2010; by the end of February of 2011 more than 100 daytime passes were obtained by the station. There was a lack of high satellite passes during these tests. Figures 12-7 and 12-8 show the daytime tracking results for the LAGEOS-2 satellite:

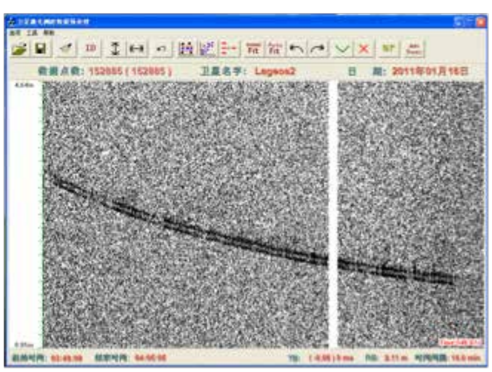

Figure 12-7. LAGEOS-2 daytime data pre-processing

Figure 12-8. LAGEOS-2 daytime tracking (11:49am-12:06am)

HQ Laser Operations

Equipment for upgrading the kHz laser ranging to an HQ kHz laser was ordered in 2008. The laser was delivered to the station on October 29, 2009 and after four days for installation and adjustments the system worked well. We used the laser for 1 kHz ranging and found it can produce a single pulse energy of 1.2 mj. The laser has high power stability (less than 1% RMS), a high pulse-to-pulse stability (not more than 1% RMS), and good beam quality (M2 < 1.5). Figure 12-9 shows the HQ laser system in the Beijing station, which has been operational since November 27, 2009.

Figure 12-9. The HQ laser installed at the Beijing SLR station.

Upgrading the Encoders and the Servos

The Renishaw angle encoders, imported from Britain, were installed in the SLR telescope mount both in azimuth and elevation, replacing the Round Inductosyn encoders. The azimuth encoder (model RESM20USA300) has a diameter of 300 mm and after 400 times subdivision the resolution ratio is 0.69 seconds of arc. The elevation encoder (model RESM20USA250) has a diameter of 250 mm and after 400 times subdivision the resolution ratio is 0.81 seconds of arc. A reading head (model SR050A) was installed for both angle encoders in azimuth and elevation. A subdivision box (model Si-NN-0400) was also installed and has a resolution of 50 nanometers.

For the servo systems we chose the DC Brush Servo Amplifier from Copley Controls Corporation of America as the drivers (type MOD 412); two separate systems were installed for the azimuth and elevation components. After the upgrading the tracking accuracy for both azimuth and elevation, we attained an RMS of 1 second of arc, an improvement from the 10 seconds of arc achieved with the original configuration. The new servo and encoder configuration is shown in Figure 12-10.

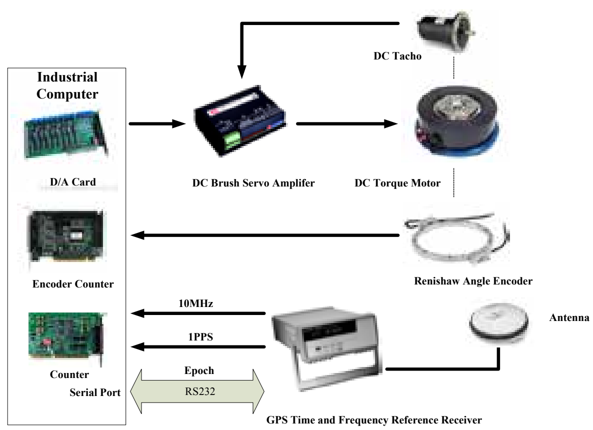

Figure 12-10. Schematic diagram of the servos and encoders.

The Range Gate Generator for kHz Measurement

The range gate generator was created on the base of FPGA (field programmable gate array) of the Xilinx Spartan3 series. The minimum control precision of the range gate is 5 nanoseconds and can be suitable for the kHz and daytime measurements. The elementary diagram for the range gate generator is shown in Figure 12-11.

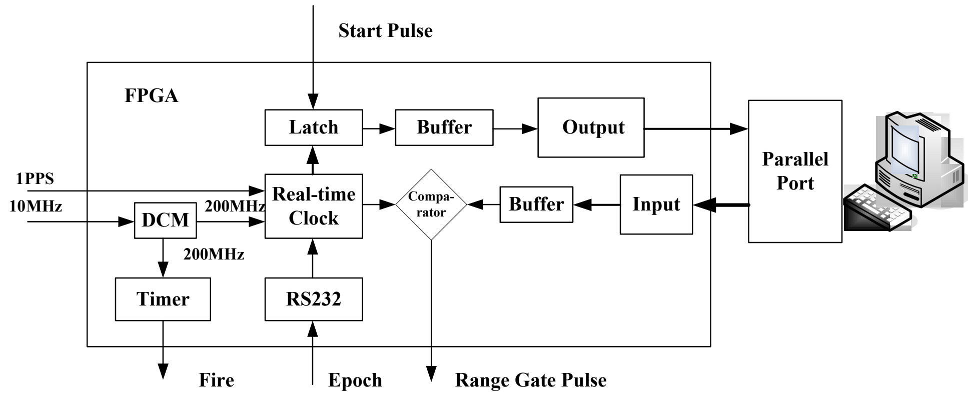

Figure 12-11. Elementary diagram for the range gate generator.

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Introduction

The Borowiec SLR station activity in 2009-2010 was limited only to 2009 and the first quarter of 2009. The station is offline since 25 March 2010 because of damage of the laser heads due to near 20 years of the laser operation. An exchange of the heads is not possible due to lack of these spare parts. The upgrading of the laser to a new model is possible but up to now we have not sufficient funds for this operation.

Figure 12-12. The Borowiec SLR staff (left to right): Stanislaw Zapasnik, Stanislaw Schillak, Danuta Schillak, Piotr Michalek, Pawel Lejba (and dog "Niunius" – important at night-time).

Changes in the System During 2009

Several changes in the SLR system were introduced in 2009: installation of the A032-ET event timer (replacing the Stanford Time Interval Counter and shown in Figure 12-13), implementation of new software for the event timer operation, and application of the new SLR data format (Consolidated Laser Ranging Data Format). These changes enabled the participation of the Borowiec SLR station in the first campaign for the time scale comparison by laser technique (Oct. 05-25, 2009) – Time Transfer by Laser Link (T2L2). All time delays between the Borowiec master clock (Hydrogen Maser) and the SLR reference point were determined to an accuracy level of 100 ps. Unfortunately the laser pulse energy was too low due to laser head problems for detection of the signals on the Jason-2 satellite.

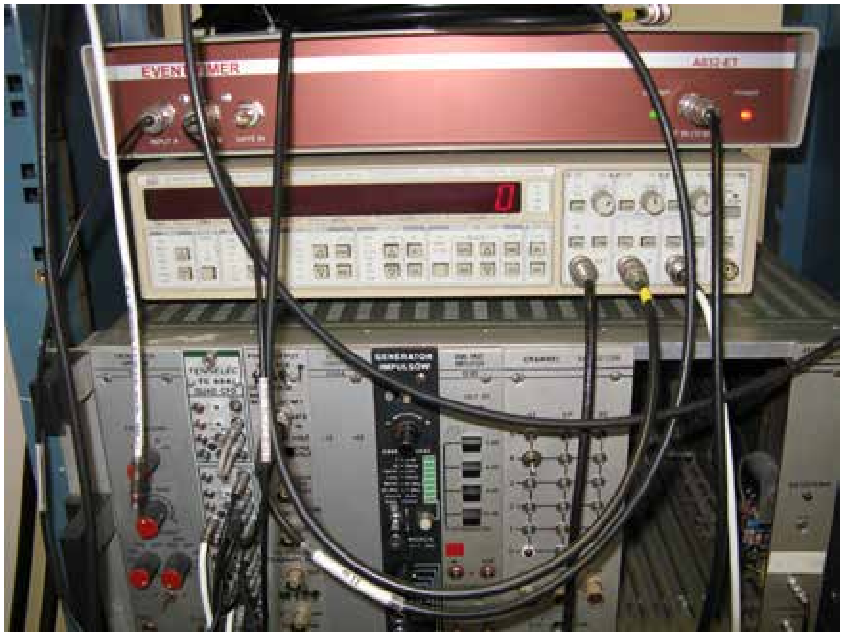

Figure 12-13. Riga Event Timer, below Time Interval Counter “Stanford”.

Operations

During 2009 and 2010 the Borowiec SLR station produced, collected, and delivered 10,248 normal points to the scientific user community, tracking 803 passes on 18 satellites. The problems with the energy and stability of the laser pulses limited the number of satellite passes.

Future Plans

First of all, we need to upgrade of the laser to the new Continuum model as soon as possible. Further efforts will concentrate on the modernization of the second Borowiec telescope including the exchange of the driving system, engines, and angle encoders, which is expected to permit the realization of daylight tracking and more accurate tracking than can be performed with the present telescope.

Other Tasks

The Borowiec SLR Analysis Group continued orbital analysis of the SLR data, determining the positions and velocities of all co-located GPS and SLR stations during the period 1993.0-2009.0 (25 stations). The determination of the SLR station positions and velocities from the low Earth orbiting satellites, Starlette, Stella, and Ajisai, were continued with a new version of GEODYN-II (0909), new models, and parameters. The terrestrial reference frames ITRF2000, ITRF2005 and ITRF2008 for SLR stations were compared using five years of LAGEOS data (1999-2003).

In addition to the SLR system operation, the Borowiec site is a permanent IGS station (BOR1) operating with a Trimble NetRS receiver and high-quality time service equipped with two hydrogen masers and two cesium frequency standards HP-5071A, a 500 ps Time Transfer System TTS-4 (produced in the Borowiec Observatory) and two-way system with accuracy 200 ps for time scales comparison. Gravity measurements are made by an absolute gravimeter two times per year.

Figure 12-14. After 20 years, these laser heads do not properly function; the reflective cover inside is destroyed and it is dangerous for other laser elements.

Figure 12-15. Operators room.

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The kHz SLR System in Changchun – Upgrades During 2009-2010

Changchun (station 7237) completed a kHz SLR system upgrade in July 2009 and achieved routine kHz SLR and daytime ranging.

kHz Ranging

We developed a new control system for our system and applied a kHz laser and an event timer.

1. kHz laser
   The RG30-L-532 series laser from Photonics Industries (USA) was installed in the ranging system. Obviously, the stability of laser has improved. The specification of the laser is as follows: 3mJ@532nm/1kHz/20ps, 0.4mrad divergence, pointing stability <10urad (typically 5urad). The typical lifetime of the pump diode exceeds 5000 hours. Since July 2009, Changchun has been using this laser at low power for more than 7140 hours, about 23 months, with an average use of 10 hours per day.

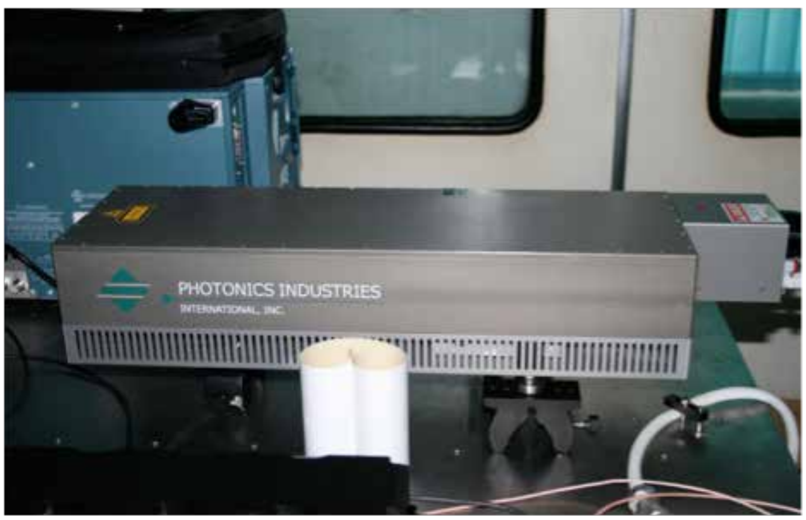

Figure 12-16. The photo of RG30-L-532 laser

2. Event timer
   The use of the A032-ET obtains epochs of laser firing with an accuracy to a few picoseconds.

3. Ranging control system
   For kHz ranging capability, we use a Windows PC to read the ET, drive telescope, control laser, indication data, display data, and archive data in kHz rates. We developed technology that consists of real-time data recognition, automatic gate, automatic range-gate and time-bias setting, a method for handling an enormous amount of data.

We developed a Range Gate Generator for our system, which generates range gate and laser fire, avoiding backscatter, with a precision of 10ns for kHz ranging.

Daylight Tracking

In order to reduce the background noise, an adjustable iris (0.5mm-7mm) is used in the receiving system. The smaller receiver field of view is 30 . The Narrow Band spectrum filter is also applied in the receiving system, and the center wavelength is 531.95nm, the bandwidth is 0.15nm, transmission>70%, work temperature is 23°C.

An experiment in the visibility of the kHz laser beam daylight has been accomplished. We tested a new sensitive camera, made in Germany and shown in Figure 12-17, for watching the laser beam. The camera uses technology that integrates backscatter to increase the signal/noise ratio, change exposure time, and image processing to obtain a clear and continuous image of the kHz laser beam.

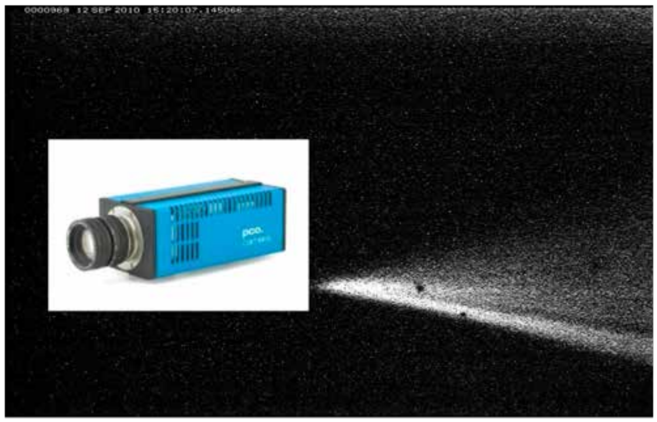

Figure 12-17. The PCO-1600 camera and laser beam imaging in daylight.

Routine Operations

In routine daylight tracking operations in Changchun, we need to scan for returns and save the previous bias for next pass.

From August 2009 through December 2010, during kHz ranging and daylight tracking, we have obtained about 12 thousand passes in total, including more than 33 hundred passes in daylight. Some days we are able to obtain 75 passes, including 34 pass in daylight.

Our data quality is good. Single shot precision is better than 13 mm for LAGEOS, and the normal point RMS is less than 1mm for LAGEOS. The Changchun SLR station is now one of the top three stations in the ILRS network.

Future Plans

In order to improve the capabilities of our SLR system, especially daylight ranging to HEOs, we plan to install a new near target for calibration, obtain kHz laser beam imaging in daylight, and research tracking stars in daylight to improve the telescope pointing accuracy.

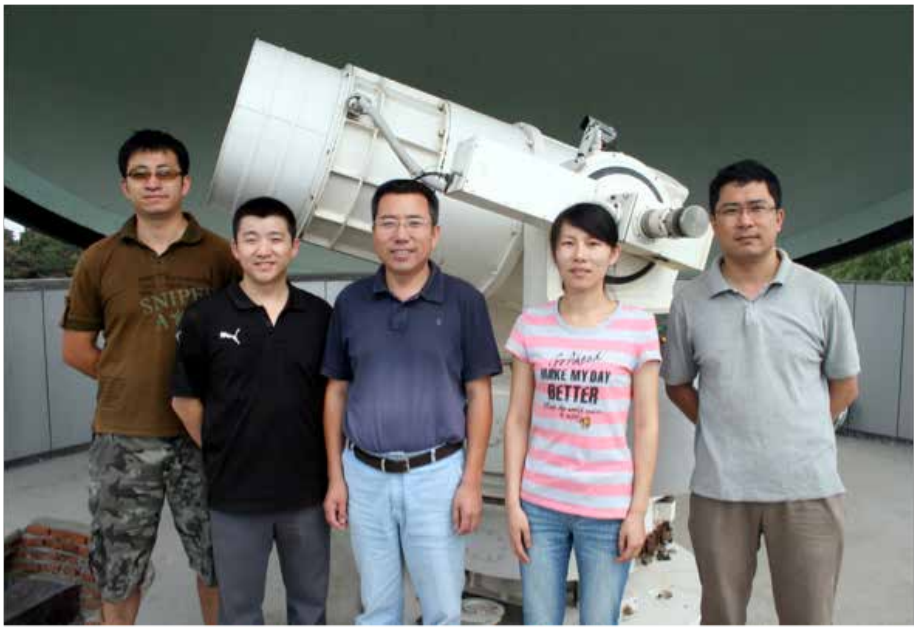

Figure 12-18. The Changchun SLR Station staff (left to right):
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During the report period of 2009-2010 the event that had by far the most serious impact on the operation of the SLR station of the Transportable Integrated Geodetic Observatory (TIGO) was the magnitude 8.8 earthquake on the night of February 27, 2010. It was the first time that a geodetic fundamental station was close to the epicenter of a major earthquake which was located off the coast of Maule, some 80 km distance NNW of the TIGO site. The entire observatory was displaced by roughly 3 meters in the WSW direction within only 30 seconds and the equipment was exposed to accelerations of up to 0.6 g. Although the containers in which TIGO-SLR equipment is housed were heavily shaken, only relatively little damage had to be repaired. Amongst the most serious problems were the overthrown optics table and dislocated telescope (see upper row of Figure 12-19). With collective effort of the TIGO-team and with the experience accumulated during previous maintenance work these damages could be rapidly resolved and preliminary operation could be resumed only six weeks after the earthquake. The SLR data obtained before and after the earthquake form an important contribution to the precise analysis of the post-seismic movement of the station (see Figure 12-19).

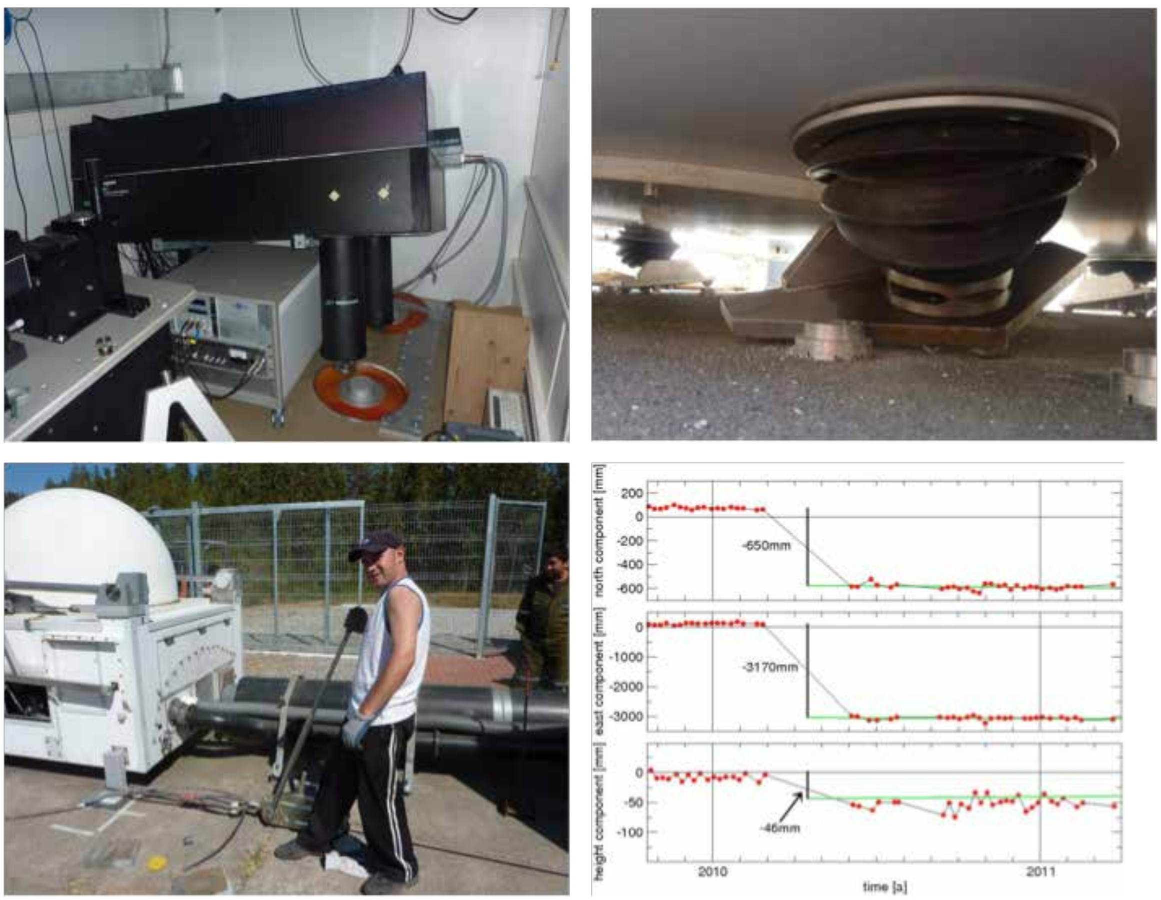

Figure 12-19: Photos taken after the earthquake of February 27, 2010. Upper left and right: Telescope and optics table overthrown by the shocks of the earthquake. Lower left: Coarse re-alignment of the telescope. Lower right: Displacement due to earthquake measured by TIGO-SLR.

Further important maintenance work that was carried out during the reporting period includes the on-site-repair of the pump laser's power supply after its deficiency in August 2010 and a thorough revision of the telescope's mechanics in February 2011. This fundamental maintenance was done with the outstanding expertise of former TIGO-SLR head of group Stefan Riepl and included the exchange of the azimuthal encoder

These events had an important impact on the measurement statistics of TIGO-SLR, which is also reflected in the monthly observation statistics plotted in Figure 12-20. After a new record year with roughly 5750 satellite passages measured in 2009 the first two months of 2010 continued in this direction with a new monthly record for the station of 828 satellite passages measured in January 2010. The challenges after the earthquake limited the productivity in 2010 and the number of measured satellite passages dropped to some 3150 in 2010. With the scheduled renewal of the pump laser in the second half of 2011 we expect to catch up to earlier performances in particular with respect to HEO satellites (GNSS and Etalon).

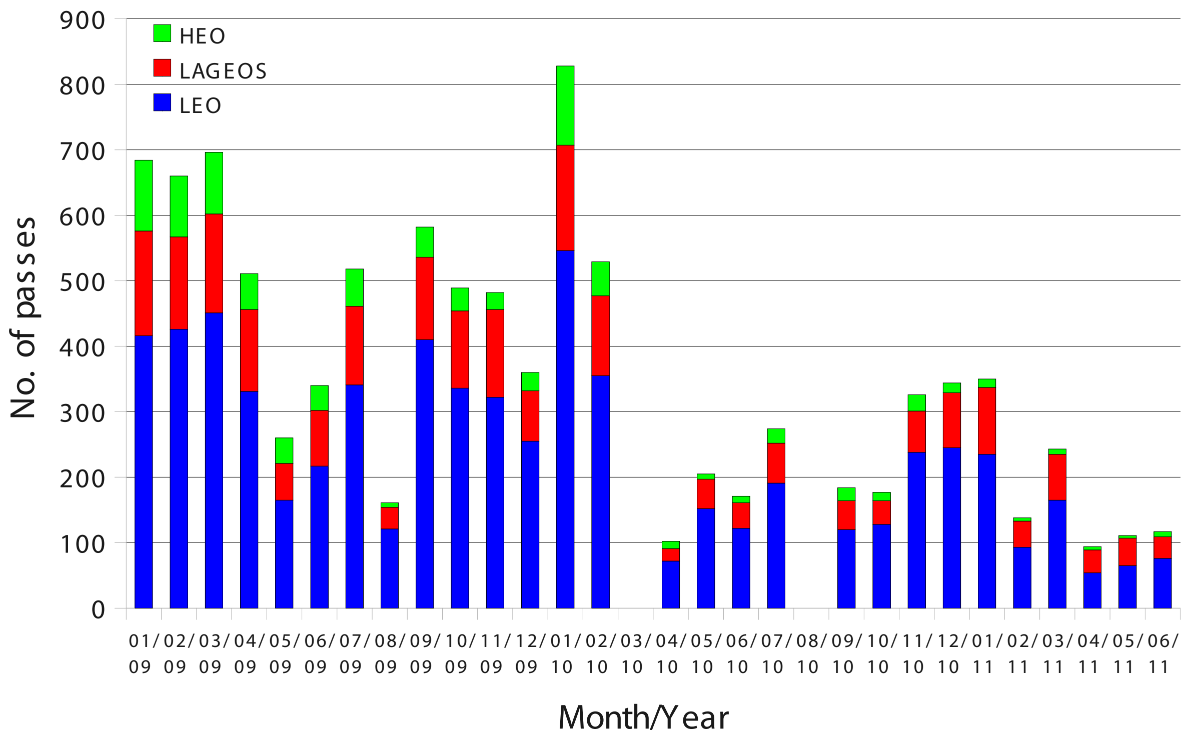

Figure 12-20: Number of passes per month from 2009 through June 2011. Note the effect of particular events on the overall statistics. Remaining deficiencies e.g., of the pump laser limit the measurements particularly of HEO satellites.

Regarding ongoing and future projects, most notably is the 2011 installation on the TIGO site of a three-wavelength tropospheric LIDAR system by the University of Concepción. This system initially aims at monitoring the aerosol concentration of the atmosphere at the TIGO site. Furthermore, automation of multi-color measurements of TIGO-SLR are planned and will be continuously integrated in the station's regular operation. Altogether a thorough analysis of atmospheric refraction effects is envisaged. With respect to the personnel structure the most significant change was the departure of the former head of the group Bernd Sierk in July 2010 and his replacement by Michael Häfner in November 2011.

Figure 12-21: The TIGO-SLR team (left to right, as of May 2011): Manuel Bravo, Maria-José Jerez, César Guaitiao, Víctor Mora, Ivo Fustos, Michael Häfner, Anatoli Poliak, and Marcos Avendaño (insets: Alejandro Fernández and former head of group Bernd Sierk).

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Paris Pre-Campaign for T2L2 Experiment (October/November 2009)

FTLRS was deployed for the first time in Paris for a two-month period in support of the time transfer project experiment with T2L2 on board equipment on Jason-2. This project is a collaboration between the Observatoire de la Côte d'Azur (France), CNES (French Space Agency) and the Observatoire de Paris. T2L2 is a two-way technique based on the timing of optical pulses emitted (and received) by a laser station and received by a space segment, as show in the formula below:

Figure 12-22. T2L2 reflector and receiver.

Ground: $\mathbf{T}_{\text{start}}$ $\mathbf{T}_{\text{return}}$.................Space: $\mathbf{T}_{\text{board}}$

From these three times the difference between the ground and space clock can be determined.

Second T2L2 International Campaign (June-August 2010)

Figure 12-23. FTLRS installed at the Paris Observatory.

Figure 12-24. Grasse MEO station.

Time transfer between Grasse/MEO system and Paris/FTLRS system

Figure 12-25. Transportable atomic fountain clock in Grasse developed and installed by the Observatoire de Paris group.

For the second time, FTLRS was installed on the roof of the Paris Observatory for a three-month period. The scientific purpose of this efficient campaign was to observe simultaneously as much as possible Jason-2 passes from Paris and Grasse in order to achieve very accurate time transfer. Both of these sites are equipped with atomic fountain clocks and hydrogen masers carefully calibrated for time comparisons.

Table 12-1. Preliminary Operational Results of the Campaign

Site	Passes with triplets	Passes with Triplets in Common View					
		Paris	Zimmerwald	Grasse	Matera	Wettzell	Simosato
Herstmonceux (GBR)	169	47	14	87	33	19	
Paris/FTLRS (FRA)	140		22	88	43	36	
Zimmerwald (CHE)	85			35	27	21	
Grasse (FRA)	350				77	58	
Matera (ITA)	190					38	
Wettzell (DEU)	167						
Koganei (JPN)	29						5
Simosato (JPN)	25						

Time Transfer Comparison: T2L2 and GPS and TW

- Atomic Fountain comparison
- T2L2-Microwave: inside 2 ns over 60 days
- Fountains give a frequency information; phase is integrated
- Global T2L2 performance: better than 100 ps over 1 minute of ranging

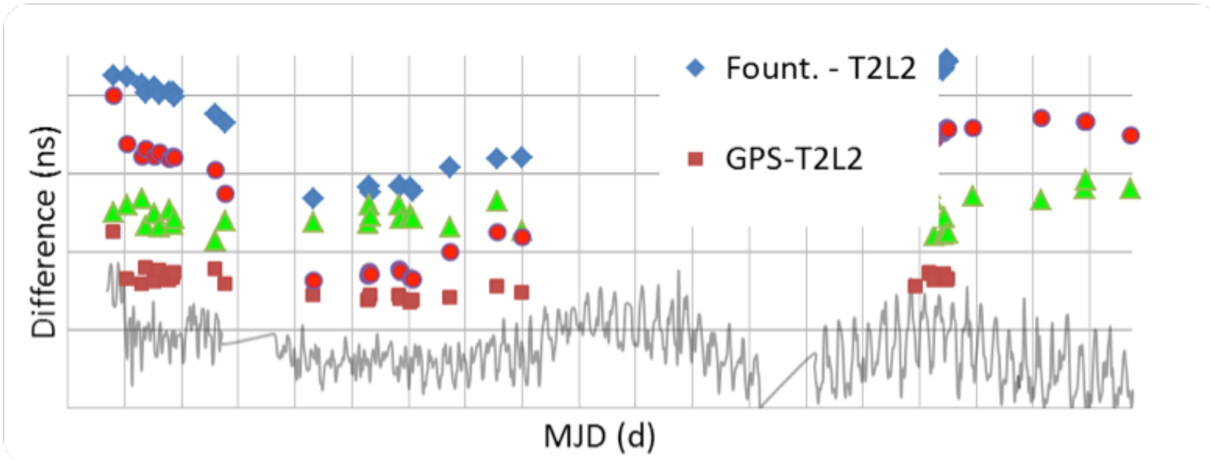

Figure 12-26. Global T2L2 performance.

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The kHz SLR System in Graz – Major Upgrades and Results during 2009 and 2010

During 2009 the implementation of our serial Bus was completed: Single BNC cables now connect major SLR station units with the PC, allowing software control of flip mirrors, filter settings, piezo drives in the mount, and also accepting observer command inputs. This configuration enables fast setting of multiple components via single key switches, or via software: A big benefit when tracking very low satellites like GOCE.

Mechanics, electronics and software now allow us to remove the wavelength filter for HEO satellites (LAGEOS and above) during nighttime operations. Because our narrow-bandwidth filter transmits only 35%, night ranging without this filter increases the return rate three times (Figure 12-27). For GLONASS satellites, this now results in passes with several 100.000 returns, with the potential capability for > 1 million returns per pass (forbearing pass switching). This capability might help for the planned Galileo satellites: All of them will be equipped with retro reflectors, and all of them will be at a distance of about 24,000 km, with corresponding low return rates.

The filter is also removed for the LAGEOS-1 and -2 satellites: besides getting more returns, here the fraction of multi-photon returns is also significantly increased, reducing satellite signature, and favoring our "leading edge post-processing method" developed last year.

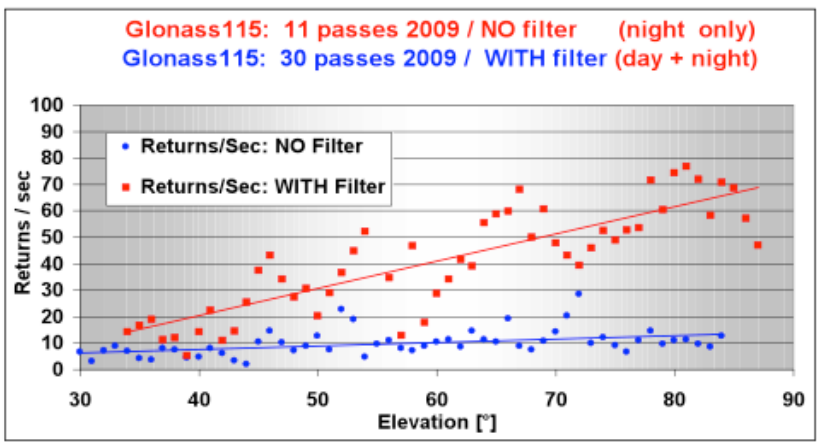


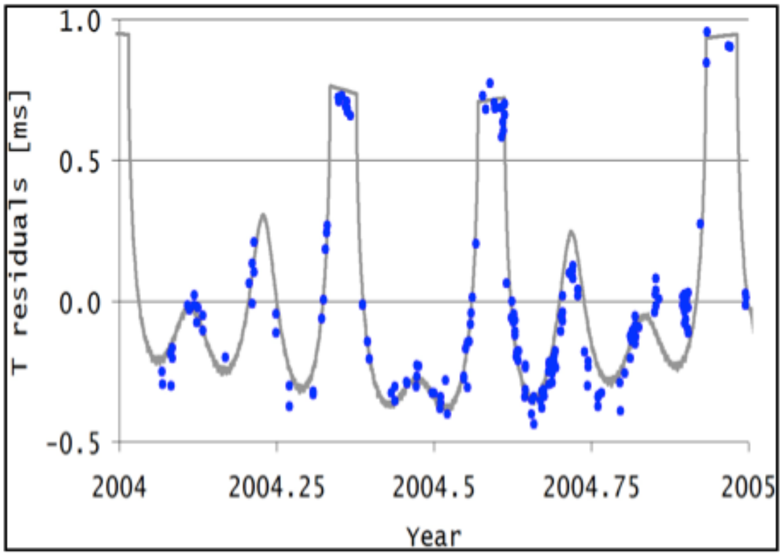
Figure 12-27: Increase of returns for distant satellites: 3 times more returns when filter is removed during night

For special satellites, like BLITS ("Ball Lens In The Space"), the filter is also removed: The relatively weak return signals (in spite of only about 830 km distance, due to its small retro cross section), can be increased, giving a rather constant RMS of 2.5 mm, allowing for significantly better spin parameter determinations (work was completed at the beginning of 2011).

Spin Parameter Determinations

The spin period of the Ajisai satellite for the last five years was determined with an accuracy of <0.005% (for the 2 s period, this is <100 µs), using the 2 kHz SLR data of Graz only. The spin period residuals calculated to an exponential trend function show a significant modulation (Figure 12-28/left: the blue dots); the grey line models a function which depends on the total solar irradiance (TSI) acting on Ajisai: The spin rate slow-down of Ajisai is slower if parts of the orbit are in Earth shadow and faster if in the sun (Yarkovsky-Schach effect).
Using Graz 2 kHz SLR data, we determined the spin axis precession of Ajisai (Figure 12-28/right). Ajisai's spin axis is almost parallel to Earth's spin axis, and it is synchronized with the right ascension of ascending node of the satellite orbit. The spin axis is precessing with a period of about 117 days, around a circle of 2.81 in

diameter.



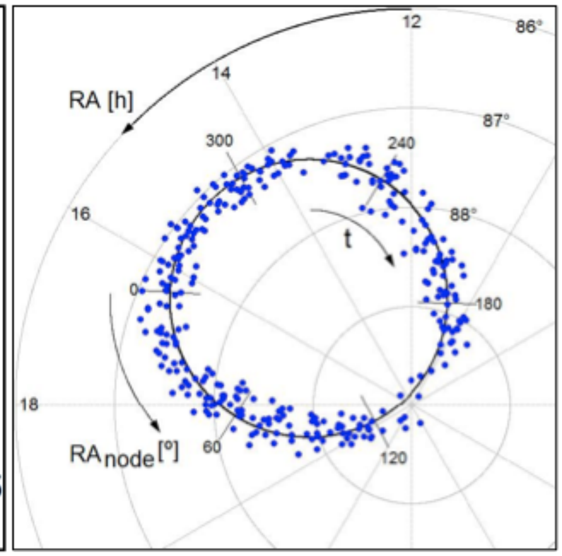


Figure 12-28/Left: Ajisai spin period residuals (blue dots) and the model function (grey line) which depends on TSI (Total Solar Irradiance) acting on Ajisai; plotted for the year 2004.

Figure 12-28/Right: Spin axis orientation (blue points) of Ajisai; determined from Graz 2 kHz SLR data, plotted in the inertial reference frame. The orientation of the spin axis follows t (time) direction, the right ascension of the ascending node (RAnode) is decreasing with time.

The Graz 2 kHz SLR system also measures the spin parameters of the nano-satellite BLITS (Ball Lens In The Space, launched September 2009). The objective of this pioneering mission is an experimental verification of the spherical glass retro-reflector concept. Analysis of the 2 kHz SLR measurements to BLITS shows that the spin period remains constant. However, the orientation of the spin axis is not constant in the inertial reference frame and follows the satellite's orbit.

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"There are 3 kinds of people: Those who can count, and those who can't ..."

Greenbelt MD (MOBLAS-7), USA

Dave McCormick, Curtis Emerson/NASA GSFC, Bob Stelmaszek/ITT, Thomas Varghese/Cybioms

Figure 12-29. MOBLAS-7 in Greenbelt, MD.

In 2009 and 2010, MOBLAS-7, located at the Goddard Geophysical and Astronomical Observatory (GGAO) in Greenbelt, Maryland, operations under the supervision of Maceo Blount. The station was able to track consistently in 2009 but was suspended for a significant portion of 2010 due to a radar error, violating FAA safety regulations.

In 2009, the station operations ran without many critical problems. Testing and simulation for Lunar Reconnaissance Orbiter (LRO) tracking began in April 2009. After successful testing, the station adjusted the operations schedule to 3 shifts/5 days per week and started LRO tracking at the end of June. MOBLAS-7 altered the laser repetition rate operate at 10 Hz for LRO tracking. A system delay drift was discovered on February 2010 in the ground test data and investigations lead to several changes in the wiring and the power supply of the laser. Cables that may have been causing delay issues were replaced and new connectors were purchased to further stabilize the system. In addition, the power supply was replaced to prevent it from causing power losses. After these changes the system delay drift over one hour period was less than 1mm.

Operator Robert Hicks retired in March 2010. The station, however, continued with a two-shift schedule with the help of William Weaver. Recently, two new staff members, Paul Beckwith and Tushar Ujla, have been added and are in training.

In March 2010, an error lead to a serious issue with the MOBLAS-7 radar and laser interlock system. All laser operations were temporarily halted for stations in the NASA network to ensure network safety. All stations except MOBLAS-7 were given permission to return to SLR operations on 05/07/2010. In order for MOBLAS-7 to perform tracking operations again it first had to undergo hazard analysis and receive NASA Safety and FAA concurrence for laser operations. Ranging operations resumed in November 2010 when the FAA was satisfied with the MOBLAS-7 safety systems and new procedures.

During the time that the laser was offline and non-operational, the station focused its efforts on ground ranging activities and attending to visitors. The station continued to perform ground testing on the universal counter units and the Laser Hazard Reduction System (LHRS). The LHRS upgrades included modifications made to the radar control card and the target determination logic. These modifications corrected a tuning error and an external triggering for multiple radar synchronization.

MOBLAS-7 hosted several tours in August 2010 for NASA management, NASA safety officials and FAA representatives, and NASA interns who were interested in learning more about the NASA SLR and LRO efforts. The staff also supported the GGAO public presentation during International Observe the Moon Day for the second year in a row. Over 100 visitors toured MOBLAS-7, with presentations given by Development Engineers and Station Operations personnel.

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Greenbelt MD (NGSLR), USA

Jan McGarry/NASA GSFC

Figure 12-30. NGSLR ranging to LRO orbiting the Moon.

NGSLR developers continued work on the system automation during the 2009-2010 time period while stabilizing the system performance and working toward a co-location with MOBLAS-7. The system continued to use the eyesafe Q-Peak laser with the 4-quadrant 12% QE detector until near the end of 2010, when the new 1 mJ in-house built laser and a single anode 40% QE Hammamatsu MCP-PMT detector were installed. The combination of the higher power laser and the higher QE detector are expected to permit daylight ranging to GNSS satellites. With the eyesafe laser and lower QE detector, the system had successfully tracked daylight LEO and LAGEOS satellites and nighttime GNSS.

NGSLR successfully performed 1-way ranging to LRO on its first attempt shortly after launch in June 2009 and has been successfully ranging to LRO ever since. Operational ranging to LRO coexists well with SLR R&D development since LRO-LR requires no receiver and each activity has its own separate laser. The lasers are easily swapped by insertion/removal of a mirror and a change of the start diode cable.

Figure 12-31. NGSLR staff (left to right): Howard Donovan, Tom Zadwodski, Scott Wetzel, Felipe Hall, Evan Hoffman, Tony Mann, Alice Nelson, Don Patterson, Jan McGarry, Tom Varghese, Bart Clarke, Julie Horvath, Randy Ricklefs, Jack Cheek, John Annen, John Degnan, Tony Mallama. Additional staff members: Peter Dunn, Mike Perry, Mark Torrence.

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Haleakala HI, USA

Daniel O'Gara/University of Hawai`i Institute for Astronomy

The TLRS-4 system has completed two more years of successful laser ranging operations at Haleakala. Since the installation of TLRS-4 at Haleakala Observatories in 2007, we have benefitted from several system upgrades that had been installed previously in other NASA SLR stations.

Figure 12-32. TLRS-4 at Haleakala, Hawai`i

In the first quarter of 2009, testing of the new system controller computer was completed. This computer is responsible for the control of the electronic systems during tracking operations. The new computer hardware and software system gave us increased speed and a large increase in storage capacity.

Later in 2009 the hardware and software system that performs the onsite data analysis was upgraded. As with the controller computer, this was an update from early 1990's technology and provided a large increase in speed and data storage capacity.

The most significant upgrade during this 2-year period was completed in late July 2010. HTSI installed at TLRS-4 a newly configured laser system that incorporated a solid-state replacement for the flowing dye cell system. This new laser configuration makes use of a saturable crystal (Cr+4:YAG) as a Q-switch. The laser is extremely stable and requires very little daily maintenance or adjustments. We are also no longer handling hazardous chemicals that were used to dissolve the dye used in the flowing dye cell system.

The ability of the TLRS-4 system (0.28 meter telescope) to see laser reflections from a GNSS target was proven again during tests in April and May 2010. GLONASS-120 and -102 were tracked over 12 separate attempts with returns seen on the tracking oscilloscope on about half of the attempts. However, a problem with recording the data at 4 Hz has not been resolved. We are currently restricting our tracking to all targets up to LAGEOS altitude.

Work has continued on the Laser Traffic Control System (LTCS). When completed, this web based system will monitor all of the participating telescopes at Haleakala Observatories and prevent the TLRS-4 laser from interfering with their operations.

TLRS-4 maintains a two-shift operation that provides 7 day a week, day and night coverage. Since we do not have a radar on site, each shift consists of a system operator and a mount observer. The two teams have been with TLRS-4 since 2008. Our two system operators are Mr. Craig Foreman (Laser Technician and Observatory Foreman) and Mr. Jake Kamibayashi (Laser Ranging Technician). Our two mount observers are Ms. Rikki Kaia and Ms. Vivian Kamibayashi; Haleakala staff are shown in Figures 12-34 and -35.

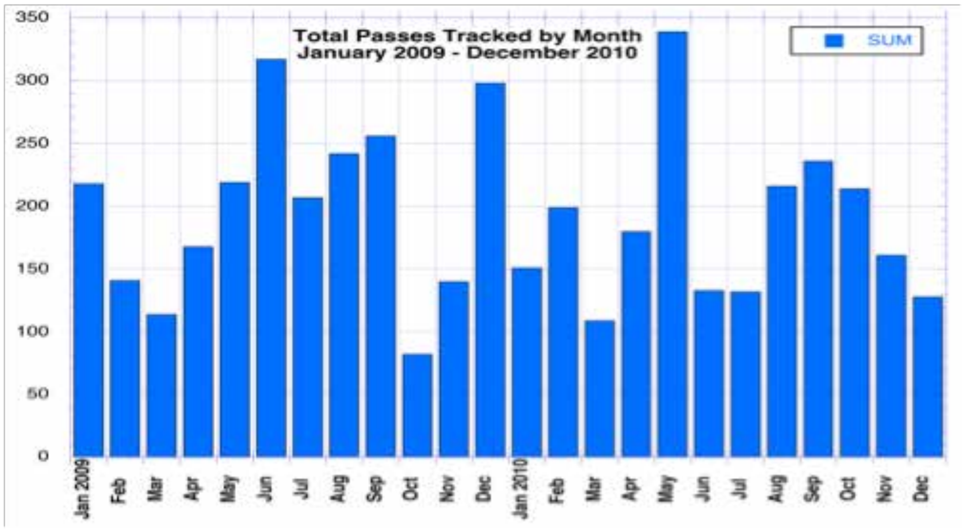

Figure 12-33. Total Passes/Pass Segments Tracked by Month (2009-2010)

Figure 12-34. Jake and Vivian Kamibayashi

Figure 12-35. Rikki Kaia, Dan O'Gara, Craig Foreman

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Hartebeesthoek, South Africa

Ludwig Combrinck/HartRAO

The MOBLAS-6 satellite laser ranging system (Figure 12-36) was installed at the Hartebeesthoek Radio Astronomy Observatory (HartRAO) during June 2000 in collaboration with NASA as part of the NASA SLR Network. Operations commenced in August 2000 and the site was inaugurated in November 2000.

Figure 12-36. MOBLAS-6, the telescope enclosure is in stow position.

Recent Activities

During the last 10 years, MOBLAS-6 and it's crew have supplied high quality satellite laser ranging data from Hartebeesthoek, South Africa. Several system failures and a spate of cloudy weather have reduced data volume during the last few years. Most of these issues have recently been addressed so that we expect a drastic improvement in data output. In addition, during the period of reporting, MOBLAS-6 was equipped to partake in ranging to the Lunar Reconnaissance Orbiter (LRO). First ranging results to LRO were achieved on December 6, 2009. To enable participation, HartRAO had to purchase a dedicated PC (Dell Precision Workstation T3400), a time interval card (Guidetech GT658), and serial card (Dual Serial Adapter, SIIG, Model #: JJ-P02012-S6). These were configured by NASA and shipped to HartRAO for installation. The configured equipment arrived in South Africa during the first week of September 2009.

System Upgrades

The processor computer was upgraded during early July 2009. New software was installed at the end of November 2009; the new version of the satellite tracking software has an Az-El Bias panel that uses the keyboard for biasing. Operators can use either the software for tracking via the keyboard or the digit switches for azimuth and elevation biasing. During October 2009 MOBLAS-6 suffered from a damaged oscillator head and this had to be replaced (inclusive of damaged associated parts, flashlamp ends, laser rod, etc.). All UPS batteries were replaced during mid-February 2010; these are typically replaced on a two-year cycle. At the end of November 2010, a rotary joint on the radar system failed, resulting in a short downtime, as safety could not be compromised. Don Patterson visited HartRAO from July 26 through August 11, 2010 to make repairs to MOBLAS-6's MPACS system. During August 2010, Tom Oldham revisited HartRAO to optimize the system (alignments and testing) for satellite tracking, to provide additional training, as required, to maintain optimal system performance and to verify ranging operations for the LRO satellite.

Figure 12-37. Willy Moralo and all other crew members received additional training during 2010. It is envisaged that at least two crew members will be sent to NASA for training during 2011 to enhance local maintenance and operating skills related to MOBLAS-6.

Recent upgrades (February 2011) also include a new laser table (Figures 12-38, -39), which was required due to movement of the optical components on the old table (which was delaminating), causing continual realignment and consequent down time. Thomas Oldham and the crew worked hard to get the new table installed, re-populated and also used the opportunity to do some training.

Personnel

MOBLAS-6 lost its manager to KACST at the end of January 2010. Johan Bernhard was one of the initial members of staff appointed during the installation and commissioning of MOBLAS-6 at HartRAO. The accumulated experience and know-how lost as a result of his departure adversely influenced operations. Appointment of a suitable replacement proved to be problematic and time consuming as major organizational restructuring was also in place. Willy Moralo was promoted to Operations Supervisor and Lusanda Ntsele was appointed as Technical Manager in October 2010. Current personnel complement is therefore:

- Ludwig Combrinck (Associate Director: Space Geodesy)
- Willy Moralo (Operations Supervisor)
- Lusanda Ntsele (Technical Manager)
- Klaas Ramaoka (SLR Operator)
- Tshepo Makate (SLR Operator)
- Sammy Tshefu (SLR Operator)

Figures 12-38 and -39. Lusanda Ntsele and Willy Moralo (left) assisted by Klaas Ramaoka and Sammy Tshefu (right) during the installation of the new laser table in MOBLAS-6.

New Developments

A new system (Figure 12-40) is being developed next door to MOBLAS-6 in collaboration with the Observatoire de la Côte d'Azur (OCA) and NASA. This equipment will be developed as a dual SLR and LLR capable system. The telescope (ex-OCA) has a one-meter mirror and will be refurbished at HartRAO. A new laser system with an expected output of 200 mJ, 200 ps pulse length at 532 nm will be constructed in collaboration with NASA.

Figure 12-40. The SLR/LLR telescope located in its newly built enclosure. This enclosure runs on three tracks. Adjacent to the enclosure is a modified 12-meter long shipping container which will house the control room, laser system and power supplies. It is planned to move the new SLR/LLR system to the semi-arid Karoo region, to a site close to Matjiesfontein where we are developing a new space geodesy and geophysics observatory.

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Helwan, Egypt

Makram Ibrahim/NRIAG

The Helwan satellite laser ranging station belongs to the space research laboratory of the National Research Institute of Astronomy and Geophysics (NRIAG). The station is operated under the cooperation between the NRIAG and the Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering (CTU - FNSPE).

Although the precision of the measurements of the Helwan SLR station is good, there is bad performance of the Helwan SLR station during the previous years, as the total number of passes observed during 2007, 2008, 2009 and 2010 are, 54, 21, 6 and 0 respectively. This level of performance is due to several reasons, one being the old Laser Radar Electronic unit (LRE), which was installed at the station 20 years ago. New equipment, such as the Laser Radar Control System (LRC), redesigned completely by Dr. Miroslav Cech, will be installed in the station during July or August 2011. It is expected to improve the performance of the Helwan SLR station in the near future.

Helwan SLR-Station Staff

- Associate Prof. Dr. Makram Ibrahim, the head of space science laboratory and the principal chief of the Helwans SLR station
- Dr. Khalil Ibrahim, head of solar and space science department.
- Mr. Hany Mahmoud, assistant researcher.
- Mr. Mahmoud Mostafa, assistant researcher engineer.
- Mr. Mohamed Yehya , specialist scientific
- Mr. Sami Fath-allah, technician


Figure 12-41. The Egyptian and Czech chiefs (from left to right) Dr. Makram Ibrahim and Dr. Josef Blazej

Recent Equipment and Upgrades to the Helwan-SLR Station

A satellite laser radar system with full computer control based on minicomputer system HP 2100 has been operating in Helwan since 1981. From 1987 to 1989, an IBM-PC computer and special control electronics based on Z80 microprocessors were implemented in the laser radar system. The control system covers all important functions for satellite ranging and calibration: two axes mount control with stepper motors, range and epoch counter, laser trigger, HP-IB interface for HP5270 or Stanford SR620 counters, arming and gate control. A new servo motor control system was developed in 1994. In 2009, the laser radar control system was completely redesigned by Dr. Miroslav Cech. The new system is based on a powerful 80C188EB microprocessor operating with 1MB memory. Special circuits for range and epoch reading are included. The control system connected to the main station computer via fast RS232C interface based on 16550 chips. A second serial port is used for high accurate meteorological station MET-3. Two DC servomotors (for azimuth and elevation) are controlled in closed loop feedback. Special microchips HP HCTL-1100 are used. HCTL-1100 is a high performance, general purpose motion control IC. A very precise time interval counter (resolution 20 ps) HP5370B or Stanford SR620 is connected via HP-IB interface based on second generation of HP-IB micro controller Ines i7210. Firmware is written in C language and assembler and is very flexible. Furthermore, the firmware is compatible with the old LRCS system at the command level. The new control system will increase the reliability of the laser station.

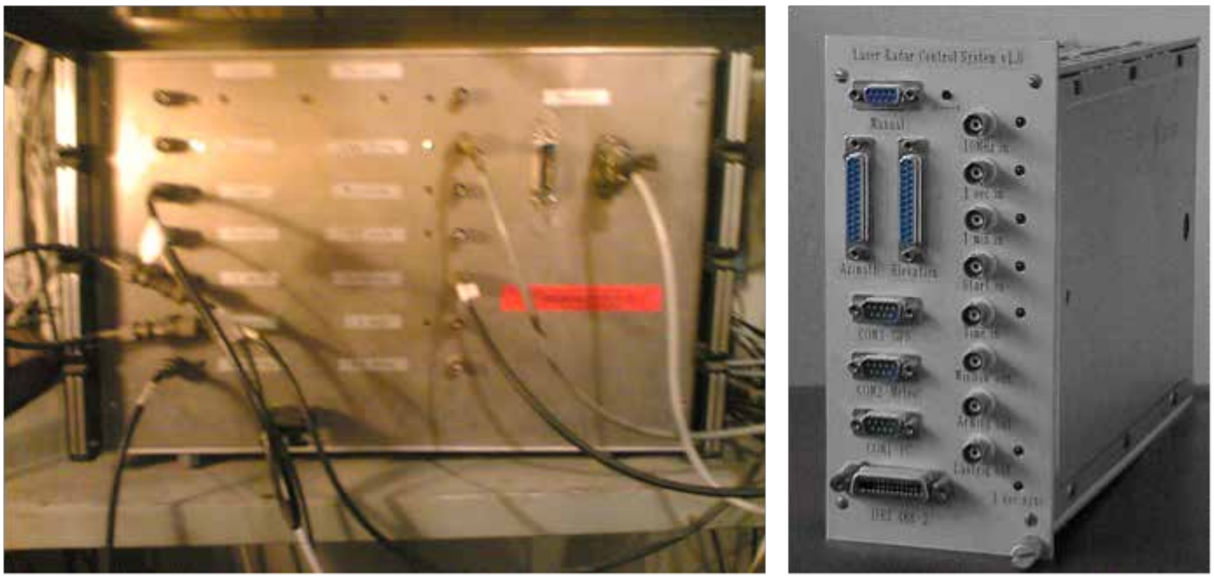

Figure 12-42. The old LRE (left) and the new LRC (right).

Future Plans

A Hamamatsu H6533 box with PMT tube 4998 has been used since 1998. The quantum efficiency of this PMT is 10 % at 532 nm and of normal gain equal 5.6 10^6. The mode of the PMT is single photoelectron detection. It consists of a PMT tube and high voltage (HV) with precise divider. The Tennelec TC 952A high voltage power supply with stable 2500 volts is used as a source for the PMT to obtain standard parameters. It is expected the change of that PMT in the near future, due to the long operating time of that PMT which in fact affect its sensitivity.

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Introduction

The SGF operates a dual laser SLR system comprised of a 12Hz, Nd:YAG, 20mJ, 100ps laser and a 2kHz, Nd:VAN, 0.4mJ, 10ps laser purchased from High Q Laser. Switching between the systems is achieved in less than 30 seconds and this requires separate calibrations. The SGF observer selects the laser best suited for each satellite, usually 12Hz for daytime GNSS and in poor sky conditions and kHz for greater precision and night tracking. The 12Hz system is run at 14Hz for synchronous detection at the LRO satellite orbiting the Moon. The kHz system has not performed as well as expected and it has thus proved to be of great benefit to have retained a dual-laser system. Investigations into the under-performance of the kHz system lead to a discovery that the dichroic mirror, internal to the telescope, was highly sensitive to polarization and it has been replaced. A study into the impact of the atmosphere on the SLR return signal strength was initiated with a system upgrade to LiDAR capability. In addition to the ILRS-supported subset of the GLONASS constellation, all GLONASS satellites are routinely tracked, with the extra ones being given a lower priority. This experiment appears to have had little negative impact on the overall productivity of the station.

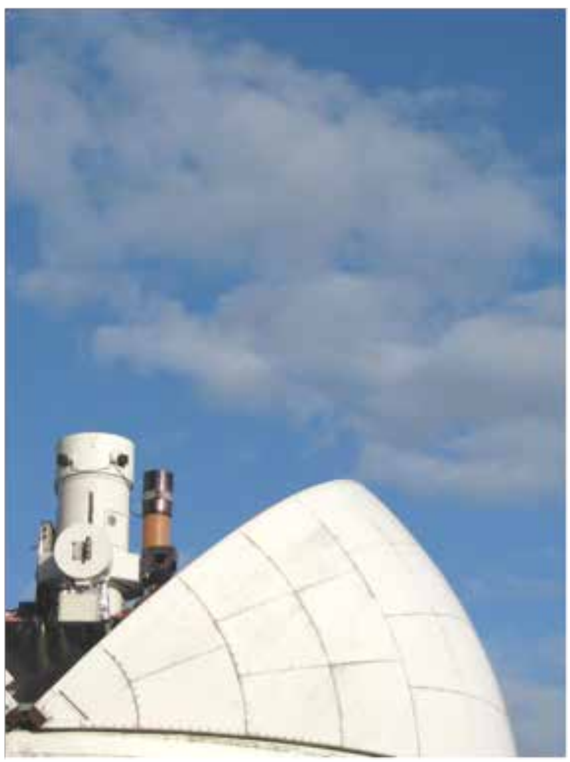
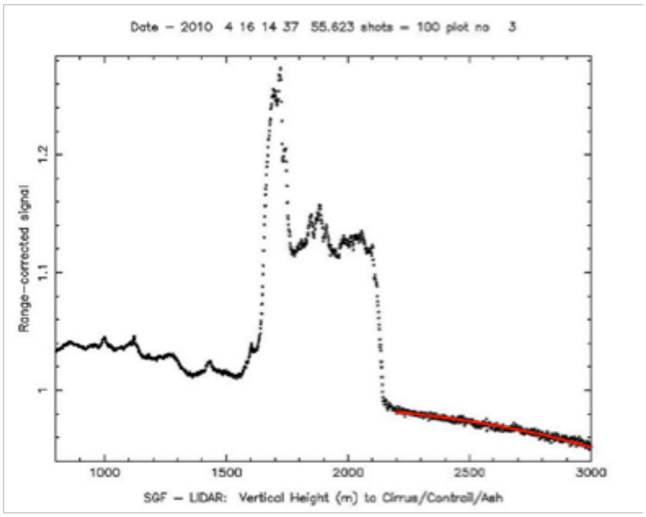


Figure 12-43. The SGF telescope and dome.

The SGF continued to operate a FG-5 absolute gravimeter on a weekly basis to measure local gravity and height change. In support of this, a lot of work in this period was focused on the stability of the SGF site, which is located on a bed of clay. This included short-baseline GPS analysis and the commencement of regular digital leveling to survey relative height changes between monuments around the site. Significant investment was made in the SGF with the acquisition and installation of an active Hydrogen Maser. This now provides epoch and frequency for the SLR system and drives the HERS GNSS receiver.

LiDAR

An elastic LiDAR observational capability was developed at the site to study different aspects of the atmosphere. This includes aircraft contrails, atmospheric transparency, particularly during ranging support of LRO and also included the tracking of the ash plume following the eruption of the Icelandic volcano Eyjafjallajökull in April 2010. The volcano sent a plume of dust and ash up into the atmosphere over most of the European continent. The SGF began LiDAR observations a day before the ash cloud was expected to arrive over the South East of England and continued them routinely as requested by the UK Met Office. Some observations showed increased backscatter due to the ash and dust particles at variable heights and thickness. The plot, above right, shows reflective layers of material, most likely ash particles from the volcano, at heights of from 1.1 to 1.6 km.



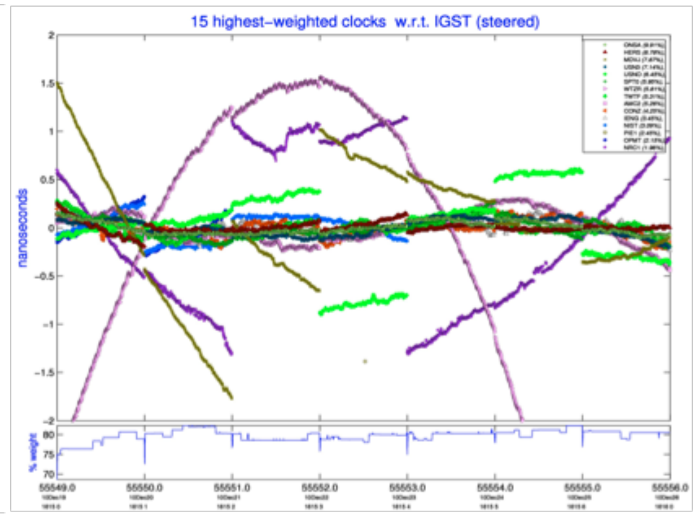


Figure 12-44. (left) A LiDAR backscatter profile through the atmosphere containing some volcanic ash.

Figure 12-45. (right) A weekly IGS clock comparison showing the new H-maser to be performing well.

Active Hydrogen Maser

An active hydrogen maser frequency source, an 'i-Maser', was installed at the beginning of 2010 in a dedicated air conditioned lab. The maser's performance and the environmental stability are continually monitored remotely. The frequency source from the i-Maser is now used to drive the HERS GNSS site, which was upgraded with a Septentrio receiver. This enables this site to contribute to the IGS timescale at relatively high weight, see plot right. The maser is performing very well and to specification.

Since May 2010 the maser one-second tick and 10MHz frequency have been used as the source for driving the SLR event timer. All measurements are therefore benefiting from the more stable frequency source, and time-tag epochs are no longer being steered to UTC(GPS). This provides maser-driven epochs for SGF ranging data, which is of particular interest to the LRO mission and to the T2L2 experiment on Jason-2.

Optical Studies, Dichroic Losses

A new dichroic mirror was installed and has properties ideal for the SLR system. The previous dichroic mirror had not been replaced for many years and was found to be degraded and highly polarization-sensitive. Below are the results of laser-bed tests for polarization-dependence for the old (left) and new (right) dichroic mirrors. Installation of the new dichroic led to an improvement in signal-return of more than 100%.

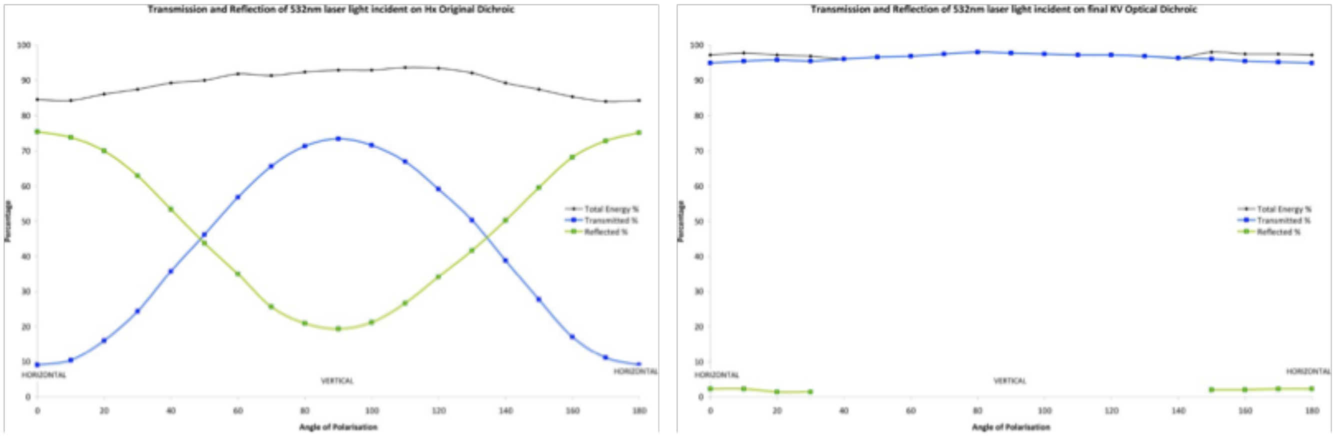


Figure 12-46. The old (left) and new (right) dichroic mirror tests for reflectance dependence on polarisation .

Monitoring Site Stability by GPS Baseline Analysis

To study the horizontal stability of the local site around the SGF, short GPS baselines were calculated using the GAMIT GPS analysis software. The HERS-HERT baseline, plotted right, can be determined to mm-level precision on a daily basis. The near-annual variation present in the baseline suggests a movement in one of the GNSS site monuments or an artifact inherent in the GPS analysis technique and this discovery is leading to further investigation into the local stability of the SGF site and monuments.

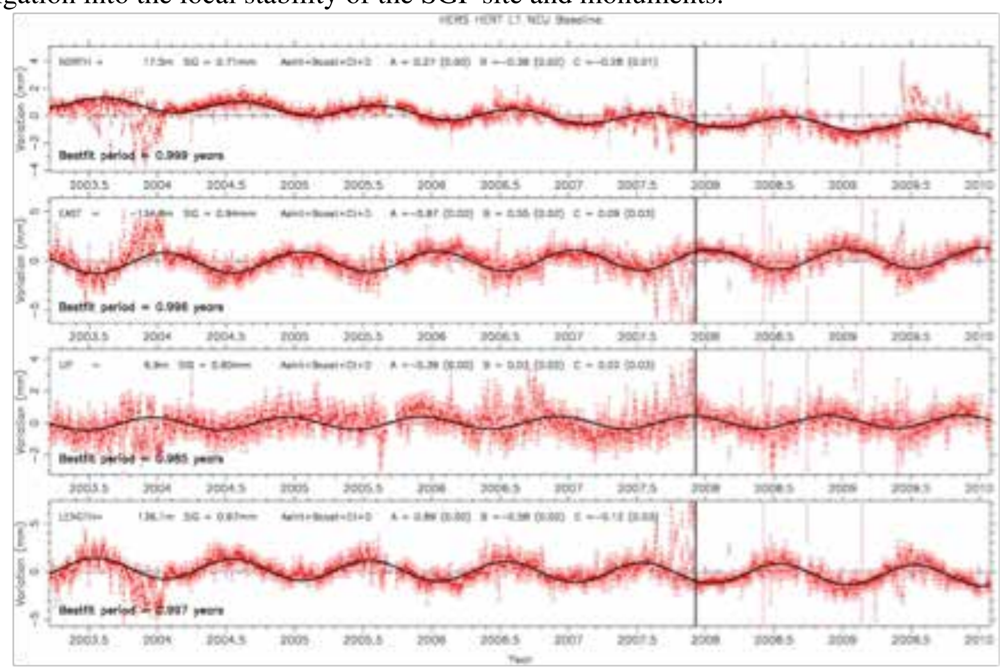


Figure 12-47. The components of the short baseline between HERS and HERT as determined using GAMIT.

Monitoring Site Stability by Digital Leveling

A campaign to monitor potential small differential height variations around the SGF site, particularly between the different technique monuments, began in 2010 using a Leica DNA03 digital level. The leveling run includes a gravimetry pier, three GNSS monuments, a UK Ordnance Survey pillar and an invar barcode strip permanently mounted on the SLR telescope pillar. The digital level can determine height changes to a precision of 0.3mm.

Figure 12-48. SGF team members performing a digital leveling run.

Fast Satellite Switching with kHz

The high repetition-rate laser allows 1mm normal point precision to be reached in a short time period, often less than the ILRS-recommended duration of a normal point. The SGF displays in real time the normal point precision and once a value of 1mm is reached the observer is free to consider other satellites in the schedule and switch, with the option of returning to the previous satellite later in its pass. This lead to a novel, experimental approach to SLR observing where only minimal time was spent on one satellite before switching to the next. The plot to the right shows an attempt to track a high number of coinciding satellite passes and to minimize the time spent on one satellite with efficient satellite switching. Working in this manner requires the observer to be closely aware of which satellites have recently been tracked and which satellites should be the next priority for SLR. It may be possible to automate some of this decision-making process.

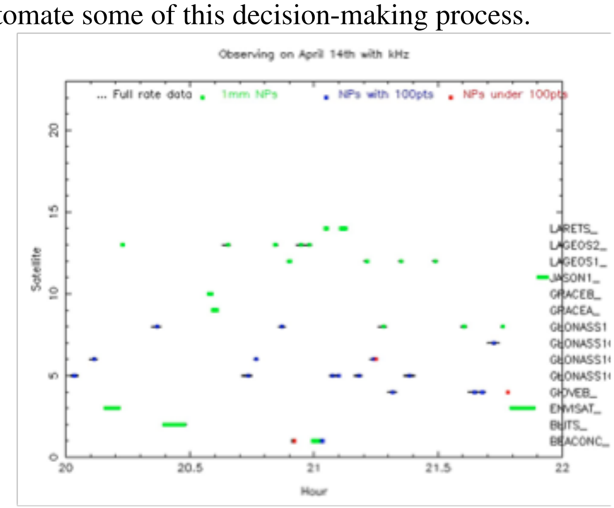


Figure 12-49. Fast switching between many satellites over 2 hours of SLR observing.

TerraSAR-X and TanDEM-X Simultaneous SLR Measurements

When TanDEM-X was positioned in close orbit to its partner mission TerraSAR-X, a technique was developed at the SGF to switch automatically between the two satellites at 10 second intervals. This is achieved through a combined single prediction and a shared data file. The observations from each satellite are then separated during data reduction, which is carried out on the individual satellites.

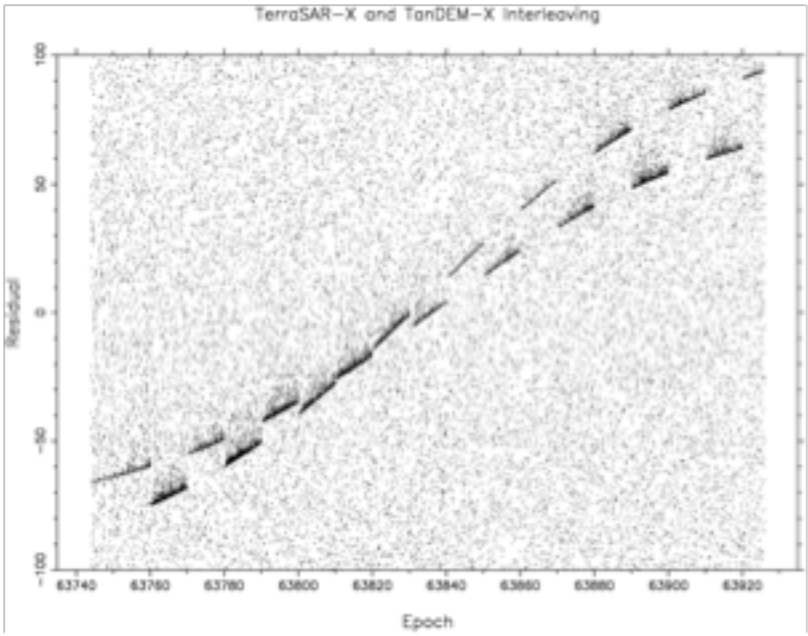


Figure 12-50. SLR returns from TerraSAR-X and TanDEM-X using the interleaving technique.

Acknowledgements

The continuing support for the work of SGF Herstmonceux by the Services and Facilities management team of the UK Natural Environment Research Council and by its Space Geodesy Facilities Steering Committee are gratefully acknowledged.

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Kiev, Ukraine

Mikhail Medvedsky, Viktor Pap/Agency Main Astronomical Observatory of NAS of Ukraine

Introduction

The Main Astronomical Observatory of Ukraine built the Kiev SLR station in 1985. Since April 1996, the station has performed routine satellite laser ranging operations and on January 22, 1999, the station began permanent laser tracking operations as part of the ILRS network. Today, most low-orbiting satellites as well as LAGEOS are tracked on routine basis. High-orbiting satellites, such as GPS, Etalon, and GIOVE, are not tracked due to the lack of required technical resources. However, since 2010, after improvements to the signal detection system and software, high-orbiting satellites have been tracked. Today, the station is ranging to all available satellites: both low- and high-orbiting targets. Four people work at the Kiev station; the system is operational 6 to 7 days per week, weather permitting. The station performs ranging activities at night in semiautomatic mode with only one operator.

Figure 12-51. Kiev telescope and station staff (left to right): Vitaliy Kostogryz, Michael Medvedsky, and Viktor Pap; the staff also includes chief engineer Juriy Glushchenko.

Figure 12-52. Station operations at night

Figure 12-53. The system's calibration target, placed in the observatory's main building.

Figure 12-54. The new laser system of our station, installed in 2008.
The laser unit (left) and power supply, control unit, laser cooling unit (right).

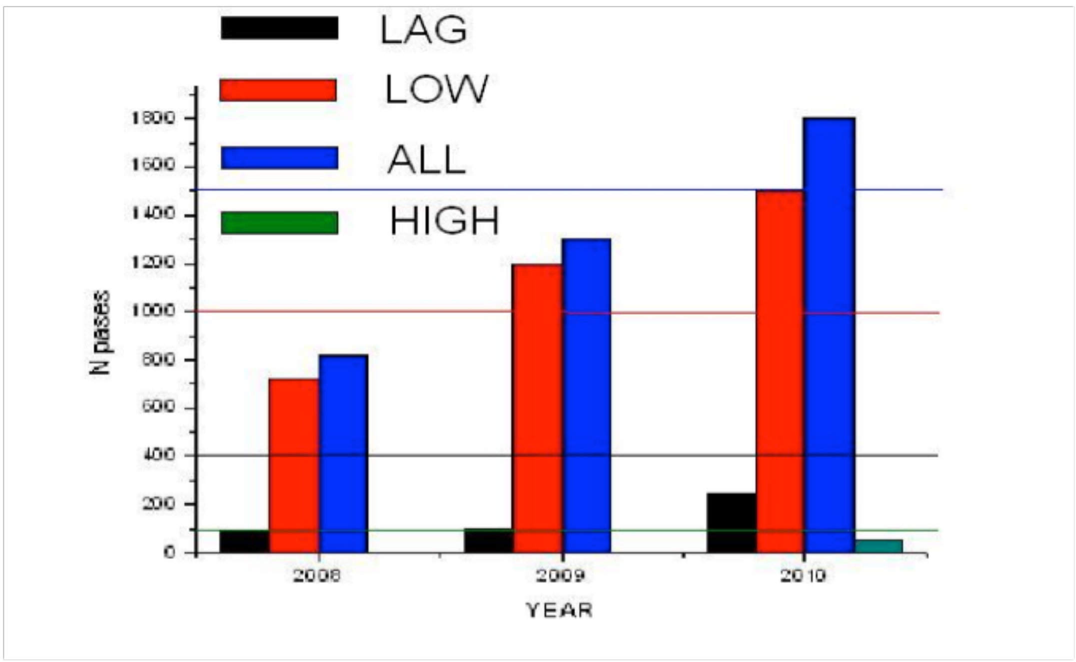

Figure 12-55. The number of passes satellite laser ranging in Kiev SLR station

System Upgrades

The station's hardware and software were upgraded at the end of 2010. A new PMT was installed; a new PMT pre-amplifier was also constructed and installed. The time-gate system has been adjusted for ranging to high-orbiting satellite. The dome of station was adjusted; the dome is now lighter and we have not experienced any problems during hard frost conditions. A CFD discriminator was adjusted and the single-shot RMS has improved to 2 cm at calibration and 2.5 cm during satellite ranging.

Future Plans

In the near future, the staff plans to develop a daylight ranging unit and plans to obtain a new time interval counter and PMT.

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Kunming, China

Xiong Yaoheng, Zheng Xiangming, Fu Honglin, Li Yuqiang/National Astronomical Observatories, Yunnan Observatory, CAS

Introduction

Figure 12-56 shows the Kunming station's SLR system. The system was built to perform Satellite Laser Ranging (SLR) work in 1998, and has produced a series of valuable data for users who utilize these data for scientific research. The telescope was upgraded from 2003 to 2006, and resumed operations in 2007 with improved tracking capabilities. Before 2009, this system had a 1-10Hz ranging frequency.

Figure 12-56. Kunming SLR system

System Upgrades

Now the Kunming station has been upgraded to kHz frequencies, using a kHz laser (Figure 12-57) and a A033-ET (Figure 12-58), as well as other equipment. The Kunming SLR system has successfully obtained daylight ranging data in late October 2010.

Figure 12-57. Kunming's kHz laser

Figure 12-58. A033-ET with <5ps precision

Future Plans

It has not been easy to carry out high repeat frequency co-optical path SLR, and our experiment of realizing kHz co-optical path SLR at the Kunming station has completely proved this. However, at the same time, our experiment indicated that the co-optical path kHz satellite laser ranging technique could be fulfilled. Therefore, we will continue to carry out LLR experiments in this system in the upcoming months.

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Observation results

The Lviv SLR station acquired 457 passes (7,628 normal points) from 12 satellites during 2009-2010 (434 LEO satellites passes with a total of 7,444 normal points and 23 ≈ passes with a total of 184 normal points). The mean error of measurement data consist: the calibration on the ground-based target - 12.7 mm, the ranging on LEO satellite Starlette – 45.7mm, the ranging on geodetic satellite ç – 56.5mm.

Recent Developments

A small amount of SLR observations within the period 2009-2010 was due to several station systems failures: in the early 2009 the HDD of the main server (with the software for initial data for satellite tracking and SLR results pre-processing) failed; later the frequency standard failed and was subsequently repaired. In the end of 2009, the failure of the laser water-cooling system resulted in the destruction of the optical parts of the laser oscillator and intensifier. We are trying to repair and purchase the necessary parts for the laser, and hope to complete its repair by the end of 2011.

Nevertheless, we worked on SLR system improvements to satisfy ILRS requirements. The software for preliminary processing of observational results in full-rate and normal point format was modernized to support the new CRD data format. Our system is currently in the "OC Validated" stage.

For the purpose of improving the protection system of receiving channel of the telescope TPL-1M, a new shutter was developed and placed into the receiving path of telescope.

For preparation of SLR observations in late of 2010, the reserve set of main and secondary mirrors of the telescope were recovered through government financial support for the national property object. We also purchased an Agilent DSO6104L 1GHz oscilloscope through financial support of the rector of our University. This equipment allows us to test the Hamamatsu PMT and at last put it into operation.

Future Plans for System Improvements

By the end of 2011, we plan to finish the system repairs and obtain SLR results at first at the previous accuracy level, and next after changing the mirrors set and putting the Hamamatsu PMT into operation with improved accuracy. We also plan to continue updating the station software for restricted SLR tracking operations.

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Matera, Italy

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During years 2009-2010 the MLRO (Matera Laser Ranging Observatory) has mostly been in routine, full time (24/7) operations. However, in 2009 MLRO experienced a significant 7-months down time due to severe problems to the telescope mount and controller which have been solved in September. In 2010 operations went much more smoothly, with twice as much data produced.
The tables and figures below summarize the weekly number of passes observed by MLRO in each year.

Table 12-2. 2009 pass summary: acquired/scheduled

Sat	acqu / sched [%]	acqu / sched [#]	sat NP [#]
HIGH	6.9	193/2794	2269
LOW	15.0	1951/12995	29109
LAGEOS	19.8	588/2977	7056

Table 12-3. 2010 pass summary: acquired/scheduled

Sat	acqu / sched [%]	acqu / sched [#]	sat NP [#]
HIGH	19.4	770/3976	8172
LOW	31.4	4226/13455	59373
LAGEOS	39.9	1228/3077	14123

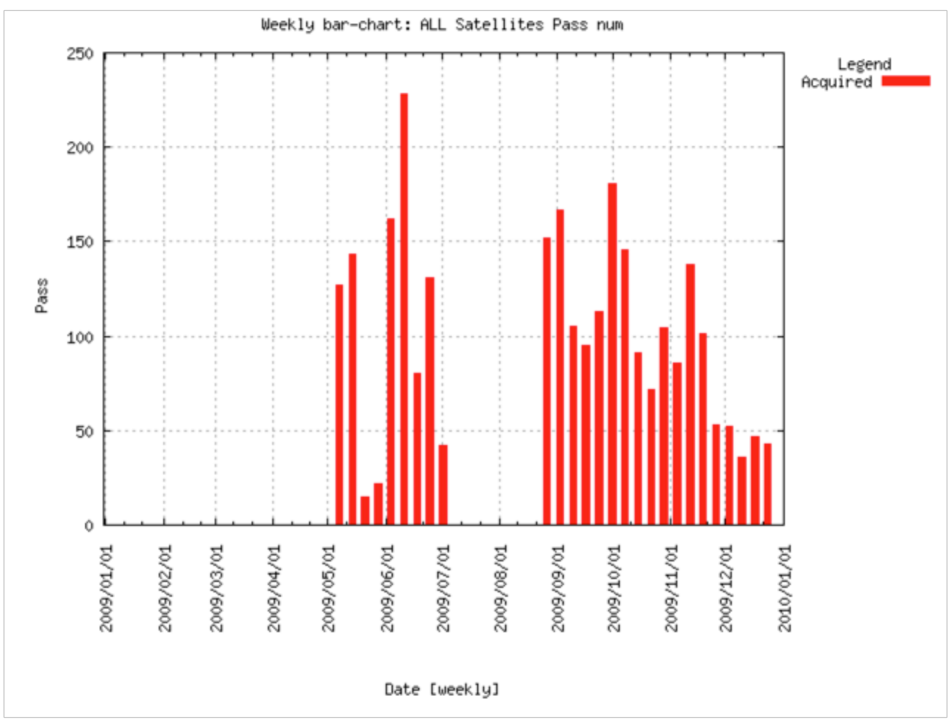

Figure 12-59. MLRO pass totals for 2009.

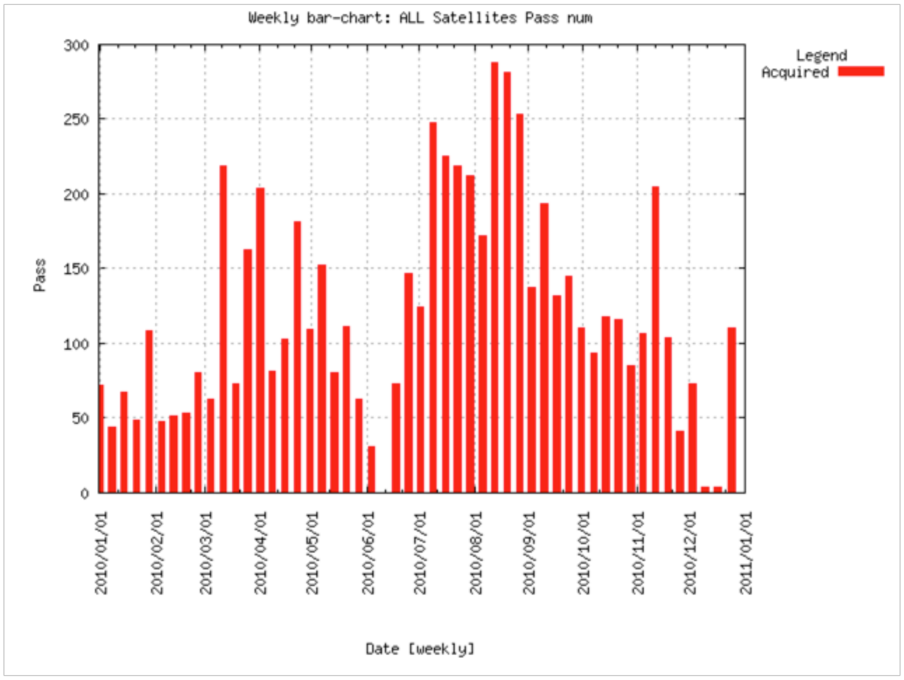

Figure 12-60. MLRO pass totals for 2010.

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McDonald TX, USA

Peter J. Shelus, Jerry R. Wiant, Randall L Ricklefs, John C. Ries, Judit G. Ries/Center for Space Research and McDonald Observatory, University of Texas at Austin

The McDonald Laser Ranging Station (MLRS)

The McDonald Laser Ranging Station (MLRS) is located at McDonald Observatory in the Davis Mountains of west Texas, near the town of Fort Davis, TX (USA). In addition to ranging to artificial satellites (SLR), it is one of the very few stations that also performs laser ranging to the Moon (LLR). For the past several years, we have also been involved in the Lunar Reconnaissance Orbiter (LRO) program.

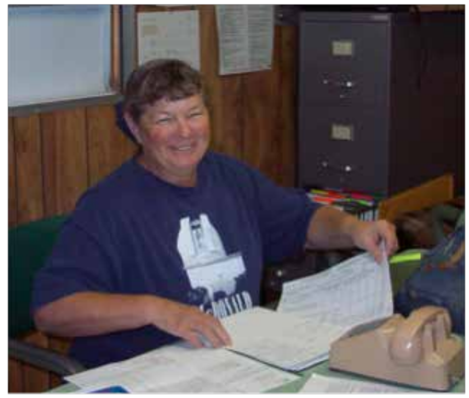
Figure 12-61. MLRS

Our support comes from an operations contract from the National Aeronautics and Space Administration (NASA). In the recent past, LLR support came from a research grant from the National Science Foundation (NSF).

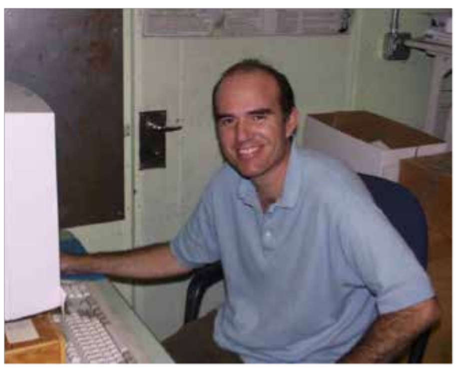
Dr. Peter J. Shelus is Project Manager. Mr. Jerry R. Wiant is Project Engineer and Mr. Randall L. Ricklefs is Software Manager. Dr. John Ries provides quality control for our SLR data. Dr. Judit Ries provides part-time logistical support for our LLR data product. Mr. Ken T. Harned and Mr. Anthony R. Garcia are observers. Ms. Rachel M. Green serves as a part-time Technical Assistant.

SLR

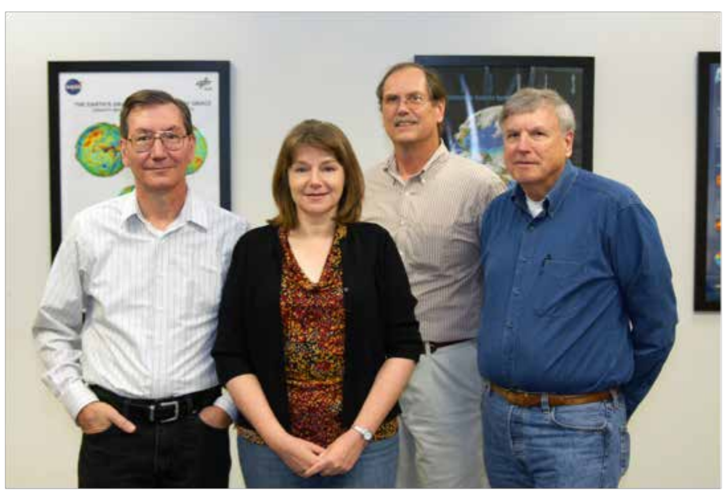
SLR data volume from the MLRS continues to be less than optimal, due to the reduction in manpower that has been forced by a sequence of funding cuts over the past several years.
In addition, the station is showing its age. The MLRS can do with upgrade and refurbishment. Day-to-day activity is directed toward keeping the station operational and in a data-gathering mode.

Jerry Wiant and Rachel Green




MLRS observers Anthony Garcia and Ken Harned



John Ries, Judit Ries, Randall Ricklefs and Peter Shelus

Figure 12-62. MLRS Staff

ICESat

Ranging to the ICESat target continued to the end of that very successful experiment. The MLRS was one of a handful of ILRS SLR stations that had been specially configured to range safely to ICESat. That satellite had a downward looking telescope that would have been irreparably damaged by inadvertent laser pulses from the ground.

LLR

Ranging to the Moon continues. The MLRS is one of only three laser stations that have been ranging to the moon during this report period. The LLR station at Apache Point, New Mexico is still not an official member of the ILRS, and its data are not yet in the CDDIS data archives. The French LLR station has just recently begun LLR operations after being down for several years for refurbishment and upgrade.

MLRS LLR data are available through the several data centers of the ILRS. The data are transmitted to the centers in near real-time, using standard ILRS formats. A Hamamatsu MCP has been made available by GSFC to the MLRS to replace the two Varian photomultiplier tubes that had been used over the past 25 years for LLR operations. Although not as sensitive as the Varian tubes and a bit noisier, it has allowed the continuation of LLR observations.

LRO-LR

The MLRS was designated as a ground station to participate in the LRO-LR project. Extensive work had been performed to get the station ready. LRO was launched in June 2009. We have been continuously working on the LRO target from October 2009 down to the current date. We are happy to say that the MLRS has been involved in a very good number of 2, 3 and 4 station simultaneous observing operations.

Data Quality Control

Regular SLR data processing and quality control is performed in Austin by John Ries. The analogous LLR tasks are performed by Judit Ries.

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Metsähovi, Finland

K. Arsov, A. Raja-Halli, J. Näränen, M. Poutanen/Finnish Geodetic Institute, Finland

The Metsähovi research station was founded in the mid-1970s, and over the years it has become an essential part of the activities of the Finnish Geodetic Institute. The instrumentation of the station serves both the Institute's own research and the international scientific community. The following instruments are currently installed at the Metsähovi research station: satellite laser ranging (SLR), geodetic Very Long Baseline Interferometry (VLBI) in a co-operation with the Aalto University, GPS and GLONASS receivers, a DORIS beacon and a superconducting gravimeter. Absolute gravity is regularly measured in the gravimetric laboratory where the National reference point of gravity exists. There is also a seismometer of the University of Helsinki. Metsähovi is one of the few fundamental stations in the world where all major geodetic observing instruments are installed in the same site.

In 2006 a decision was made to purchase a modern kHz laser and a contract was made with the High Q Laser Production GmbH of Austria. The laser ordered is a diode-pumped Nd:VAN solid state laser with the pulse rate up to 2 kHz and the pulse energy > 0.5 mJ. The laser is of the same type what Graz and Herstmonceux are currently using.

At the same time, a major renovation of the 1 m Cassegrain-Mangin telescope was needed. It includes the replacement of the drive and control system as well as separation of outgoing and incoming signals. New encoder has been installed to the azimuth ring and, together with new motors, testing will start in summer 2011. The new optical solution for separating outgoing and incoming beam has been developed together with the University of Latvia in Riga and installing of the new system will start in summer 2011. With the new optics, the focal length of the telescope is reduced from the Coudé focus to the Cassegrain focus inside the telescope. Due to the reduced focal length we will lose some effective aperture, however considering the large aperture of the telescope this is acceptable. As the telescope has been disassembled, the primary mirror was recoated, the telescope mount has been leveled and a preliminary study has been made on how to best tie the telescope to the local reference frame. The aim is to install the new systems to the telescope during the year 2011 and to start testing the telescope in fall/winter 2011.

Parallel to that, work on new 2 kHz operational software is ongoing. It is tailored to our new equipment and is currently capable of dealing with 2 kHz observations frequency. Improvement in the filtering of residuals, automation in the range gate setting, time bias estimation and management as well as smart session planning is implemented. Laser control as well as telescope communication and steering are under development. Furthermore, a new FPGA based SLR controller is designed and programmed. It is implemented into our new SLR software and many time-critical tasks are incorporated into this controller. It is fully controlled by the SLR operational software. For the future a new post-processing software development is foreseen and is under planning currently.

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Monument Peak CA, USA

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Figure 12-63. MOBLAS-4 site at Monument Peak, CA

MOBLAS-4, located at Monument Peak in Mt. Laguna, California, has consistently provided SLR tracking for 27 years. During 2009 and 2010, the NASA-contractor operated station faced critical challenges and achieved great accomplishments. In February of 2010, MOBLAS-4 was able to track the Lunar Reconnaissance Orbiter (LRO) successfully and has since tracked it regularly. The tracking schedule was adjusted due to conducting three-way ranging efforts of LRO with NGSLR and McDonald Observatory (MLRS). In the fall of 2010, MOBLAS-4 completed the first simultaneous three-way ranging effort with NGSLR and MLRS and they proceeded to achieve further two-way and three-way ranging LRO missions.

In May 2009, the processor computer was upgraded, increasing the prediction and data processing times significantly. On February 4, 2010, the on-site DORIS activity was terminated due to an electromagnetic interference with a television tower adjacent to the site. MOBLAS-4 laser operations were temporarily suspended in April 2010 due to a laser safety infringement at NASA partner station MOBLAS-7 in Greenbelt, MD. After a thorough investigation and instated resolutions, laser operations resumed on May 7, 2010.

The most significant challenge overcome by MOBLAS-4 was due to the radar failure that occurred during the summer of 2007. The station operation schedule was reduced to one shift/five days a week and the usage of a mount observer was implemented. In June 2010, the failed radar unit was replaced with a unit that had previously been located at MOBLAS-7 in Greenbelt. The radar was leveled, boresighted, and successfully tested for aircraft detection. After extensive tests and verification, laser tracking operations utilizing the radar resumed on June 22, 2010, allowing the station to operate on a two shift schedule.

MOBLAS-4 is operated by Ronald Sebeny, station manager, and Theodore Doroski (shown in Figure 12-64 below). The station had the pleasure of hosting a tour for Dr. Tom Murphy and the AstroPhysics club from the University of San Diego in January 2009. The station was also able to assist Glen Sasagawa from University of California San Diego in a GPS-related project requiring GPS survey measurements. MOBLAS-4 continues to consistently track the priority satellites and remains a core ILRS station.

Figure 12-64. MOBLAS-4 staff (left to right): Ronald Sebeny and Theodore Doroski.

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Mount Stromlo, Australia

Chris Moore/EOS Space Systems Pty Limited, Gary Johnston/Geoscience Australia

The Mt. Stromlo Space Research Centre is a fundamental space geodesy site that currently consists of a high precision satellite laser ranging (SLR) station based on a 1m aperture telescope, and an experimental facility based on a 1.8m aperture telescope. The site is also supported by IGS GPS and IGLOS GLONASS receivers, IDS DORIS beacon, and a comprehensive local tie network.

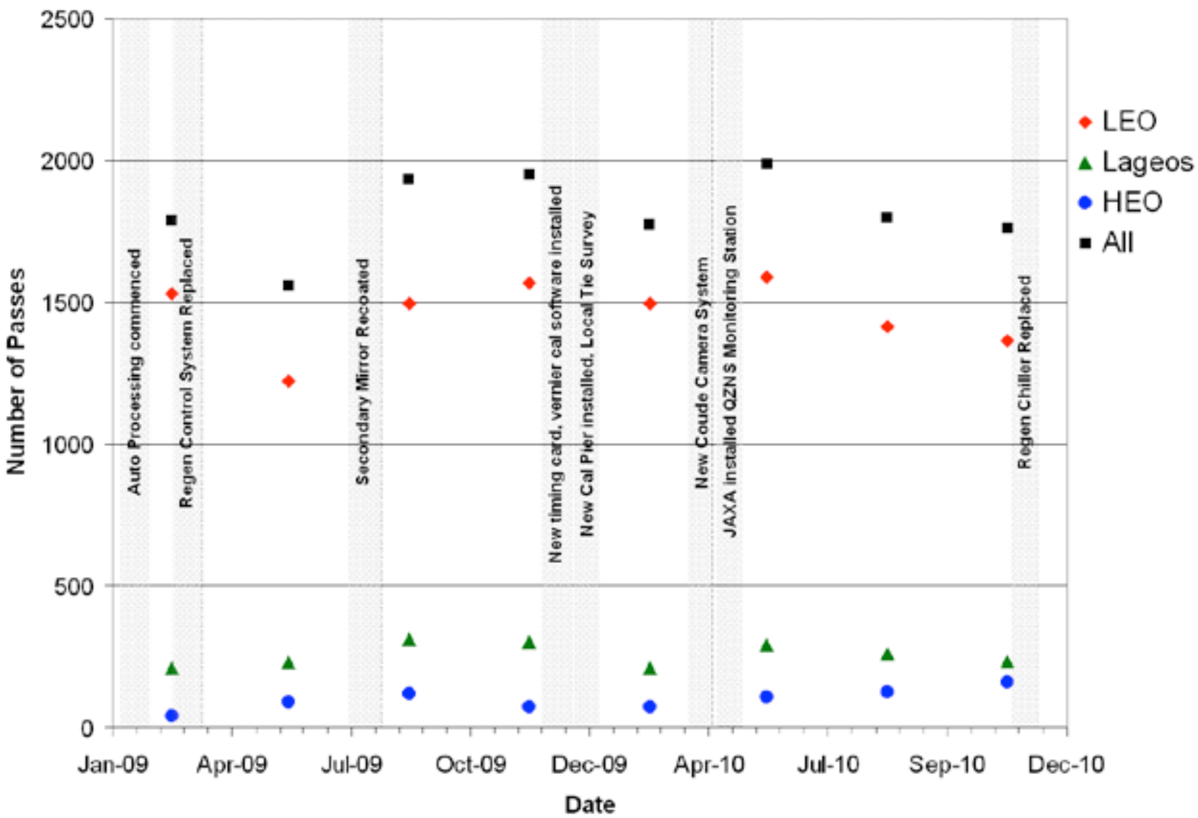

Figure 12-65. Productivity at Mt Stromlo during 2009-2010 with major events identified.

Mt. Stromlo SLR Station (STL3, 7825)

The Mt. Stromlo SLR station has now been operating continuously since December 2004 and continues to be one of the most productive SLR stations. Figure 12-65 shows the productivity that has been obtained over the period 2009 to 2010 in terms of low earth orbit (LEO), high earth orbit (HEO), and LAGEOS passes tracked.
This figure also shows a number of the major events that occurred at the station during this period. A major milestone was the transition to automated post processing early in 2009 that allowed more rapid publication of data products. The station is now routinely operated in an 'unmanned' mode without any significant loss of productivity. One operator provides supervisory and maintenance roles during normal business hours.
Since Q2 2010, Mt Stromlo station incorporates a new monitoring station to support tracking of the satellite constellation that will be part of the Japanese Space Agency's Quasi Zenith Satellite System (QZSS).
Mt Stromlo Experimental Ranging Station (STRK, 7826)

The experimental facility continues to provide a research and development facility for visually tracking and ranging to space debris, the development of guide star and ablation lasers and other projects (see www.eos-aus.com for more information).

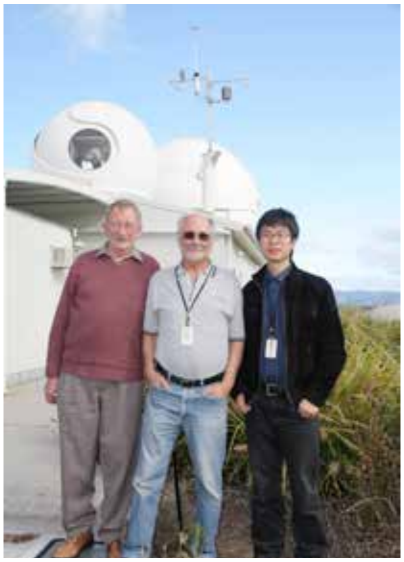

Figure 12-66. Mt. Stromlo SLR Station Manager Dr Chris Moore (C), consultant Dr John Luck (L) and operator Sihang Li (R).

GNSS

The two IGS sites at Mt Stromlo (STR1 and STR2) continue to provide a variety of GNSS data products, including a 1 Hz real-time data stream. A third GNSS antenna/receiver has been installed at the observatory on the northwest pillar. This new site STR3 is capable of tracking the Galileo satellites along with GPS and GLONASS, and is providing a 1 Hz real-time stream to the Cooperative Network for GIOVE Observation (CONGO) project Local Tie Survey

A full local tie survey was completed in 2009 including the connection to the 1.8m telescope and the new GPS mount. A report detailing the survey is in preparation.

Gravimetry

As part of the AuScope gravity program the Reynolds dome at Mt Stromlo has been refurbished into a dedicated absolute gravity comparison facility for four instruments. Commissioning of this facility has already begun. The super-conducting gravimeter continues to operate, with frequent calibration from AuScope's FG5 237 gravimeter. Continuing observations from this gravimeter extend the vertical gravity monitoring series at Mt Stromlo.

References

Woods, A. and R.E. Ruddick (2009): "The 2009 Mount Stromlo Local Tie Survey", Geoscience Australia (In preparation).

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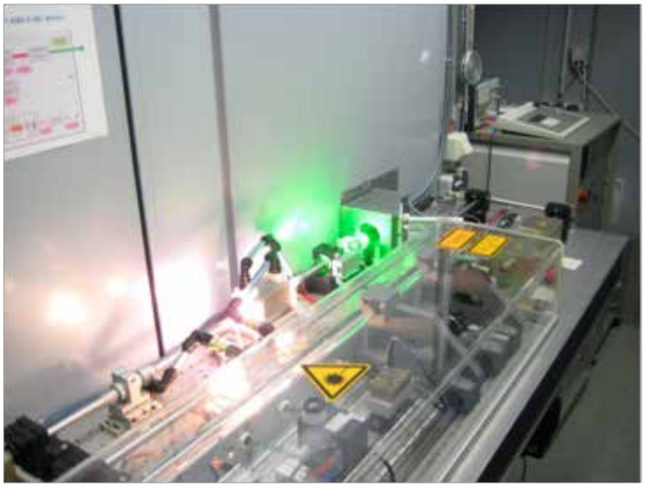

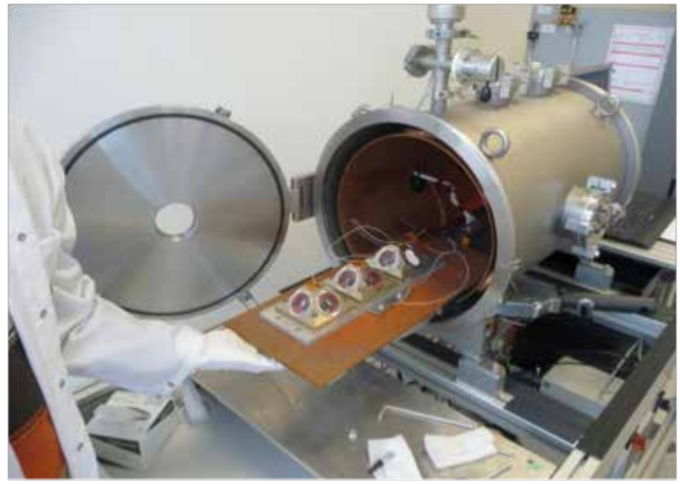

Figure 12-67: (left) Laser Transmitter of 7841
Figure 12-68: (right) LRR Arrays for Swarm Potsdam(Vacuum Test)

The system 7841 was maintained in standard operational conditions (with day- and nighttime tracking capabilities for LEOs and LAGEOS) during 2009 and 2010 and tracked a total of 3167 and 2780 passes, respectively. The higher number of passes in 2009 is mainly result of the unusually good sky conditions in spring of this year. While no substantial changes in hardware were performed, the tracking software was modified in a way to perform a fast switchover between TerraSAR-X and TanDEM-X during the close formation flight of both spacecraft. This is based on an idea by Philip Gibbs (NERC Herstmonceux).

Preparatory work for the system upgrade to kHz tracking capability was started in 2009 with the purchase and test of a Nd:YVO laser system. First indoor ranging tests demonstrated the readiness of the self-made range gate generator, which is based on the ARM-7 micro-controller.

Three low-signature laser retro reflector arrays of the CHAMP type were manufactured, tested and delivered for the ESA magnetometry mission Swarm and another one for the Spanish radar satellite PAZ. A feasibility study for a single large hollow laser retro reflector to be flown on GNSS satellites was performed and the encouraging results were reported during the ILRS workshop “SLR Tracking of GNSS Constellations” (Metsovo/Greece, September 2009. The main advantage of such a LRR is the absence of any target signature (pulse spreading) within the return signal as compared to extended multi-prism arrays, which are currently in use. This would allow for millimeter accuracy in laser ranging to satellites in the GNSS orbit by advanced SLR ground systems.

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Riga, Latvia

Kazimirs Lapushka, Kalvis Salminsh/Astronomical Institute of University of Latvia, Yuri Artyukh/Institute of Electronics and Computer Science

Main Activities (2009-2010)

Routine tracking efforts in Riga include:

- During 2009 and 2010 a slight improvement in weather conditions was observed. In the year 2009 a total of 126 clear weather opportunities allowed the Riga SLR station to obtain 804 passes from 20 satellites, yielding a total of 954,093 data points and forming 19,378 normal points. See Table 12-5 for details.
- In the year 2010, 136 clear weather opportunities allowed the station to obtain 1,333 passes from 19 satellites, yielding a total of 949,744 data points and forming 25,062 normal points. See Table 12-5 for details.
- Main attention was concentrated on LAGEOS and LEO laser ranging. Sky conditions during the year and high signal energy losses in the telescope receiving channel seriously hampered a systematic laser ranging of the high-orbiting satellites.
- According to the satellite range bias analysis reports from Dr. Toshimichi Otsubo, Riga's calculated average per year range bias (ARB) for satellites LAGEOS-1 and -2 are as shown in Table 12-4.

Table 12-4. Average Range Bias for LAGEOS-1 and -2.

2009	LAGEOS-1	43 passes	ARB = -0.6 mm
	LAGEOS-2	49 passes	ARB = -26,7 mm
2010	LAGEOS-1	75 passes	ARB = -14.4 mm
	LAGEOS-2	57 passes	ARB = -10.2 mm

Telescope optical systems upgrade

During 2009, intensive efforts were undertaken to find an acceptable solution for a telescope transmit-receive channels separation. As mentioned in the station's ILRS report for 2007-2008, a "small blood" solution was only partially successful. Therefore significant changes in the construction of the receiver's channel optical system were designed during 2009 (see Figure 12-69. Manufacturing of new optical components and mechanical systems was made during year 2010. We are planning to test a new system in the summer of 2011.

The view of main peripheral hardware to laser telescope used during reported years is shown in Figure 12-70.

Software upgrade

The Riga SLR station is currently being upgraded with a new Windows-based data management, prediction, and on-site data processing software. The new software is designed as a client-server application for use at the station and as a 3-tier application to access part of the system functionality via WWW. Compared to the previous version, the prediction generation and on-site data processing workflow has been improved.

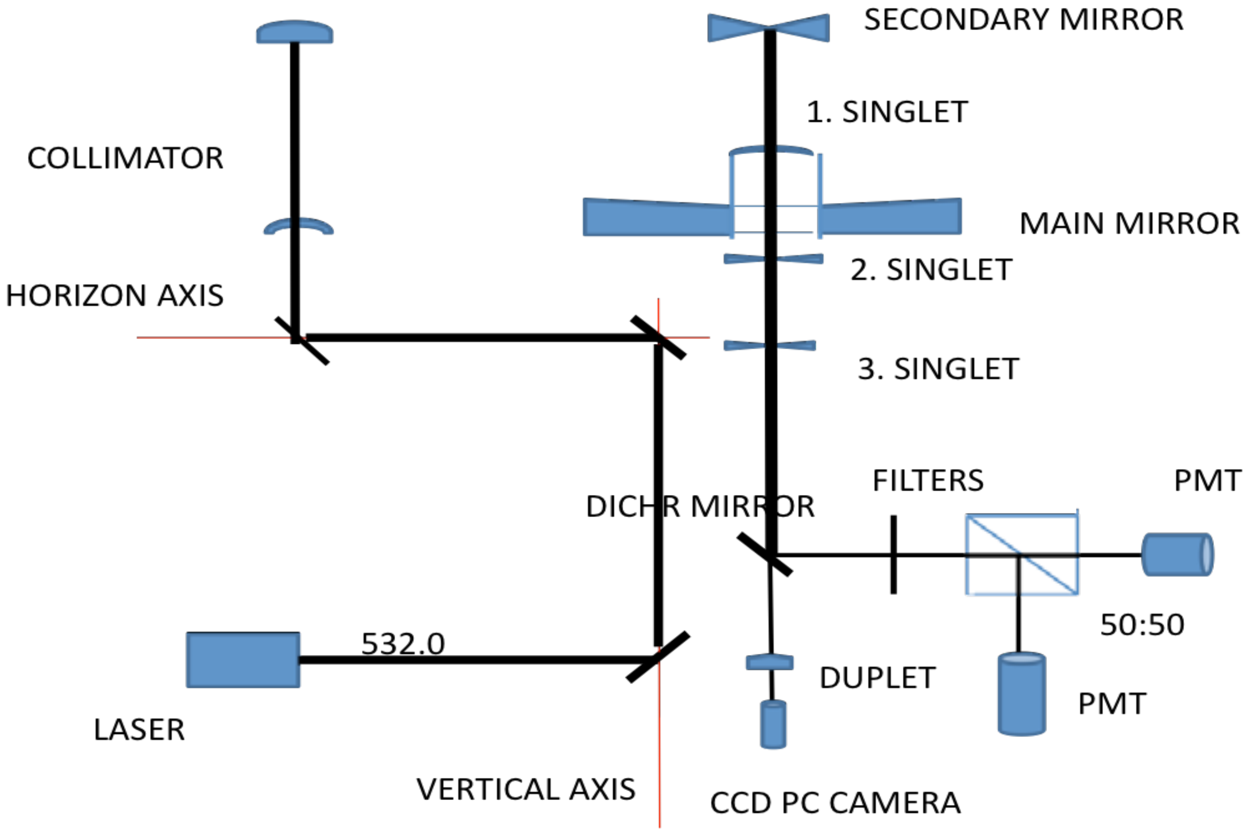

Figure 12-69. Laser telescope channels separation principle (not in scale)


Figure 12-70. Electronics for telescope drive and data registration left; "EKSPLA" Electro-optically Q-switched SBS-compressed Nd:YAG laser SL312 with pulse energy 120 mJ at 532 nm, pulse duration 150 ps (FWHM), pulse duration stability 10%, repetition rate 10 Hz, beam profile Hat Top, diameter 9 mm and divergence <0.5 mrad right.

Figure 12-71. Riga-1884 Station staff. From left: A.Meijers, K. Dzenis, K. Pujats, J. Sharkovskis, K. Salminsh, K. Lapushka

Event Timers group activities

The research group from IECS continued its activities in the area of Event Timer development. In particular, the Event Timer A033-ET has been developed as an advanced version of the previous model A032-ET, well known in SLR community. In terms of functionality and operation speed, the A033-ET and A032-ET are closely related instruments, but the new model differs by considerably improved precision of time measurement (~2 ps RMS). Since 2010 the A033-ET is commercially available.

Figure 12-72. Event Timer A033-ET

Generally the A033-ET performance meets the basic requirements of most SLR applications, potentially supporting millimeter ranging precision at a repetition rate of up to 3-5 kHz. Nevertheless, R&D activity directed to the further improvement of Riga Event Timers (such as their reliability, friendliness and hardware simplicity) continued.

Table 12-5. RIGA-1884, Years 2009-2010 Data Production

SATELLITE	2009		2010	
	#passes	#NPts	#passes	#NPts
AJISAI	57	1,138	107	1,911
ANDE-C	2	24	-	-
ANDE-P	1	11	-	-
BLITS	12	87	39	242
CHAMP	32	509	11	167
COMPASS-1M	1	12	-	-
CRYOSAT-2	-	-	95	1,660
ENVISAT	139	3,627	140	2,630
ERS-2	155	3,885	153	2,895
ETALON-1	2	19	4	36
GOCE	7	89	26	392
GRACE-A	18	559	68	1,483
GRACE-B	23	655	70	1,277
JASON-1	86	2853	153	4,057
JASON-2	94	2975	169	4,604
LAGEOS-1	43	610	75	744
LAGEOS-2	49	610	57	678
LARETS	-	-	38	254
STARLETTE	41	577	41	443
STELLA	15	162	41	406
SOHLA	4	43	-	-
TANDEM-X	-	-	19	468
TERRASARX	23	933	27	715
TOTAL:	804	19,378	1,333	25,062

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San Fernando, Spain

Jorge Gárate, José Martín Dávila, Manuel Quijan, Luis M. Cortina/Real Instituto y Observatorio Armada

About 6,500 successful satellite passes were tracked by the Spanish San Fernando Naval Observatory Satellite Laser Ranging station (SFEL: 7824), from the beginning of 2009 to the end of 2010. About 78,000 normal points, corresponding to more than 5,000 LEO's, about 600 LAGEOS, and 150 high satellites passes, were delivered to the ILRS Data Centers. Data quality remained stable, about 15 millimeters for single shot rms, and 3 to 4 millimeters for the normal points rms over LAGEOS passes, in accordance with the SLR Global Performance Report Cards.

This observational effort is possible by the work of five permanent system operators who cover mainly the night tracking spans. We must also acknowledge the invaluable support of the San Fernando Naval Observatory technical staff, represented by other five civil technicians plus five Spanish Navy petty officers, who filled the observation time gaps. It should be also remarked that the technical team was completed in 2010, since a new engineer, Luis M. Cortina, joined us.

An important milestone was reached in July 2009. Since July 6th to 18th local ties between the SLR and the IGS permanent GPS antenna receiver reference marks were surveyed. Classical geodetic observations were made by a Spanish National Geographic Institute (Instituto Geografico Nacional de Espa a: IGNE) working team. Some other geodetic references located in the Observatory, as the second IGS Antenna Reference mark (ROAP) which was included in the IGS Time Transfer Experiment, were also integrated in the investigation.

The objective of the survey was to verify old values, modifying them as needed, and to complete the information linking not only these three reference points together but also linking them with other points to allow further reviewing: there are a number of survey monuments and pillars within the observatory to be used as reference marks for the local ties determination through terrestrial connections.

Local ties determination at ROA is actually complicated due to the situation of the main points. The SLR station is located inside the closed dome at the top of the Observatory main building while the intermediate reference marks are placed on the terrace. This configuration means that there are large height gradients, and it is also difficult to get a direct line of sight from the reference points located on the terrace to the SLR telescope reference point. Furthermore, to look for the telescope axis cross point is not an easy task due to the reduced dimensions of the SLR telescope dome. Lastly, a background of scattered buildings of very different heights and large trees that hinder the visual intermediate between them seem to be not the best scenario to ensure uncertainty improvements.

Regardless, surveying results were delivered as a contribution to the International Reference Frame Research Working Groups.

On January 1 2010, a new Research Action funded by the Spanish Government began. It is entitled "Satellite Laser Ranging Automation and accuracy improvement" ("Automatización y mejora de la precisión de las observaciones láser de satélites"). The objective of this action is to improve the satellite tracking accuracy, in particular laser observations on highest satellites. This objection should be obtained by improving the pointing ability when acting on the telescope mount movement controls. Furthermore, an automation increase has also been proposed.

Improvements in the telescope movement control should produce a better tracking stability. In such a way, tracking losses would be minimized. On the other hand, an increase of the system processes automation should produce a decreasing dead time span since the satellite is rising over the horizon, until the effective tracking begins. As a consequence, SLR station performance must be enhanced because it will obtain a larger number of returns, and a better accuracy in the tracking results.

A remarkable additional benefit from automation is to invest the ROA SLR station with tracking swap ability: GNSS and other HEO tracking lasts some hours, because the long time the satellite is over the station horizon. Usually some lower satellite flies over there as well. The HEO tracking might be interrupted to track a lower satellite. Once this tracking is over, the system should recover the higher satellite. In practice this means beginning a new acquisition procedure. Telescope pointing improvement, as well as increased automation, would make this swap procedure feasible.

The research action is on its way. The different options for the movement control system have been studied, and after a careful comparison process, new tools have been purchased. The implementation on the system is scheduled for the period 2011-12.

At the beginning of 2010, systematic errors in the pressure measurements associated with the satellite ranging were uncovered after the comparison of some different pressure time series obtained from different barometers installed at the observatory. Once the error law was calculated, it was delivered to the ILRS Analysis Centers. The problem was reported in the Data Formats and Procedures Working Group meeting in Vienna, on May 6, 2010.

In order to promote the San Fernando SLR activities, presentations were given at different Spanish Universities. For example, on March 24, 2009, the conference titled Satellite Laser Ranging was given at the Technical University of Madrid, and on June 22, 2009, a new presentation entitled San Fernando Naval contribution to Satellite Geodesy: SLR & CGPS was shown at the University of Zaragoza.

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Introduction

The San Juan SLR station, which is working under the cooperation in astronomy between NAOC and UNSJ, has operated five years since the end of February 2006. The observations of the SLR station have made excellent contributions to the ILRS. These results are mainly from the efforts of the station staffs of NAOC and OAFA and the good weather of San Juan. In the end of 2009, the San Juan SLR station began to upgrade the SLR system for daylight and kHz tracking through the support of the project "Cooperation observation and research of SLR between China and Argentina", and the SLR system upgrades will be completed in 2012. In July of 2009, the dean and vice-dean of the FCEFN and the director of OAFA of UNSJ visited NAOC at the invitation of the director of NAOC. Both sides reviewed the developments and achievements of the collaborations in astronomy in the past years, believe that the development of the cooperation will make more significant contributions to the development of astronomy in the world, and signed the cooperation agreement on SLR during 2010 to 2020 and the memorandum of understanding for cooperation on astronomical observation and research in the future.

Figure 12-73. Ceremony for signing agreements of cooperation on astronomy between NAOC and UNSJ.

Operations

The San Juan SLR system (station 7406) was maintained in good working condition and acquired 6,818 passes and 88,848 normal points on all SLR satellites during 2009. However, the station experienced some problems in 2010; examination and maintenance of the power supply of the observatory led to a halt in observations for over a month. A variety of equipment failures began to appear, the supply of dichloromethane encountered a serious problem, and bad weather conditions hampered laser ranging activities. These events caused a significant reduction in the observation days. The SLR equipment failures were solved in 2011 and the system is now experiencing normal operations. The observational results of the station during 2009 and 2010 are shown in Figures 12-74 and -75.

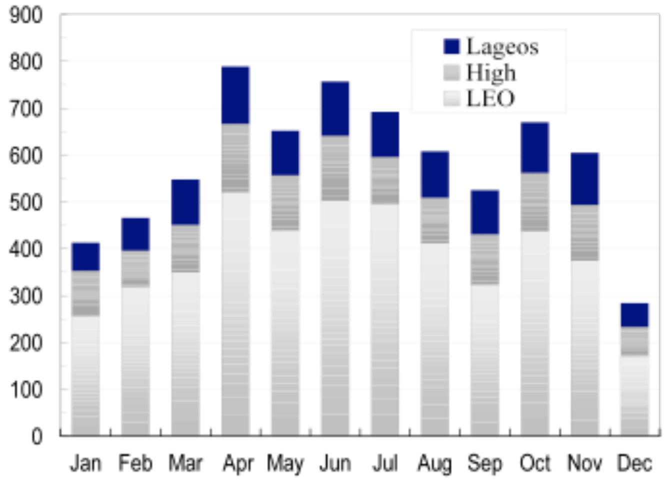

Figure 12-74. Number of passes per month in 2009

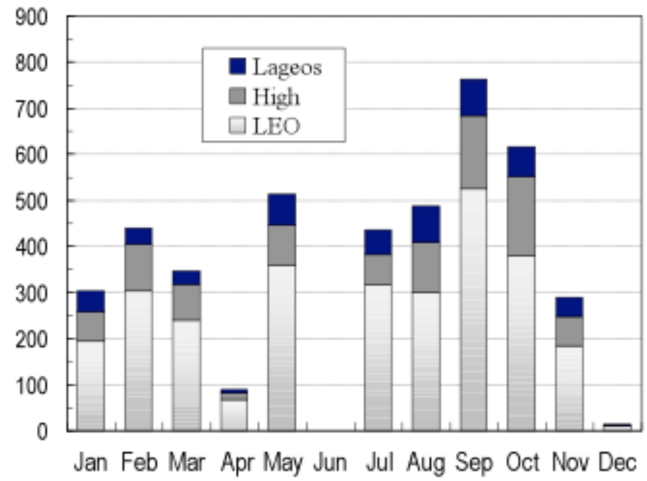

Figure 12-75. Number of passes per month in 2010

System Upgrades

In 2010, a company in China started to make a new kHz laser for the SLR system, and the laser should be completed in 2011. The laser will then be used for three-month trial observation at the Changchun station. Control and operating system upgrades are under development through cooperation between NAOC and the Changchun station. These upgrades include: an A033-ET event timer for kHz operations, a set of pulse distribution module (designed by the Graz station staff) for the start and C-SPAD stop pulse and their output represented by NIM logic Pulse for A033-ET, and a set of steel grating encoders to be used in place of the old AZ-EL inductosyns. The system integration and tests are being done through cooperation with the Changchun and Beijing stations. After completion of the system preparation, the equipment will be delivered to the San Juan station and the upgrades will be completed in 2012.

Future Developments at the San Juan Station

We plan to realize routine observation of kHz and daylight tracking in 2012. In the end of 2010, NAOC and UNSJ approved a 40-meter radio telescope cooperative project (VLBI). We hope the San Juan station will become an integrated observational station with SLR, GPS, and VLBI in the coming years.

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During 2009-2010, the Shanghai SLR station has continued to update the system for routine satellite tracking kHz repetition rate laser at nighttime and in daylight. Since October 2009 the station has been routinely performing with a kHz repetition rate at nighttime. In August 2010, daylight tracking with the kHz laser was successfully implemented to LEO satellites. Meanwhile, several laser ranging measuring experiments were also done, such as Pico-Event Timer measurements, uncooperative targets laser ranging, and dual SLR system ranging to satellites.

KHz SLR Measurement

The Shanghai SLR station obtained 1,526 and 2,658 passes in 2009 and 2010 respectively. The ability and stability of laser ranging observations were obviously improved after adopting the kHz SLR system. On August 14, 2010, the Shanghai SLR station firstly ranged to the Compass GEO/IGSO satellites with kHz repetition rate, 1W output power laser at the slope range of 3,8800 km and 3,6000 km respectively.

After realizing routine kHz SLR measurements at nighttime, the Shanghai station concentrated on kHz daylight laser tracking and in August 2010 obtained kHz laser returns from the LEO satellites in daylight. We have been updating the receiving system in order to range to LAGEOS and HEO satellites.

Pico-Event Timer

The Shanghai SLR station imported a new Pico-Event Timer from Czech Technical University in Prague with a resolution of less than 1 ps. Firstly we used the high precision event timer to measure the calibration and the precision (about 2 ps). In order to take full advantage of the high measuring precision, we are developing functions of the event timer to measure satellites in the kHz SLR system for millimeter precision laser ranging.

Uncooperative Targets Laser Ranging

In 2010, the Shanghai SLR station upgraded the experimental measuring system of uncooperative targets laser ranging by using the stable high power laser with the output power of 10W, improving the capability of servo-tracking, adopting Two Line Elements (TLE) prediction. Through the above upgrades, the measurement efficiency of the laser ranging system is obviously increased and the measuring maximum distance of targets is about 1,200km. We have gained support for further studies of un-cooperative space target ranging technology.

Dual SLR System Ranging to Satellites

Using two SLR systems with an aperture of 60 cm and 35 cm at the Shanghai SLR station simulates the ground terminal and the spacecraft terminal respectively to investigate one-way interplanetary laser ranging technology; the distance between the two measuring systems is about 70 m. The aperture of the 60 cm SLR system emits the laser pulse and the aperture of 35 cm telescope receives returns from satellites. The laser transmitting path to satellites is defined by the 60 cm aperture; the 35cm aperture defines the laser transmitted path to deep space terminals. The measurements for satellites with retro-reflector arrays were performed in December 2010 and received returns from Ajisai, LAGEOS, and Compass-M1; the simulated equivalent interplanetary distance reaches to Jupiter.

Onboard Laser Time Transfer Experiment

Shanghai Observatory has preformed the LTT (Laser Time Transfer) experiment between the Compass-M1 satellite and the ground station in 2007. In July 2010, another improved LTT payload onboard the Compass IGSO1 satellite was launched with an orbital altitude of 36,000 km. Based on the aforetime experiment, some improved technologies have been applied in the new LTT payloads, such as one gate mode adopted, two different FOV used, narrower filter etc. At the end of August 2010, the first measurement experiment was implemented successfully by using a one-meter laser ranging system; the clock difference between satellite and ground was obtained. Compared to the LTT experiment of the Compass-M1 satellite, the performances of the new LTT payload on Compass IGSO1 and the laser ranging system on the ground are more advanced. The LTT measurement was also performed much easier. Additional LTT experiments between satellite and ground, and time synchronization for different stations on the ground in the Chinese regions or beyond China will be carried out in future.

Figure 12-76. The members of Shanghai SLR station from left to right: Meng Wendong, Li Pu, Chen Juping, Zhang Haifeng, Qin Si, Shi Hailong, Cao Guangzhong, Wu Zhibo, Zhang Zhongping.

Figure 12-77. High power laser beams

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Abstract

Unfortunately, we were unable to replace the old laser with a new unit as planned. However, the station continues to work in a stable fashion and the quantity of satellite's passes did not fall below 1000. Software upgrades for new formats (CPF and CRD) have been completed.

Figure 12-78. SLR-1873. General view.

Current Status

As we informed earlier, the basic our problem with the Simeiz laser ranging system is the old laser. The laser is constructed on an old element base with which we continue to have repair problems. Unfortunately, we could not replace the old laser with a new unit as previously planned. These problems were why we were unable to reach the ILRS required level of ranging of 1500 passes.

In 2010, we worked on a new model of the master generator with a shorter impulse [1]. This system has had a small improvement in our results. The station also uses a new external target for system calibration.

Current Goals

Modernization of the Simeiz SLR station proceeds:

- Repair, restore or change old laser transmitter.
- Modernization of optical schemes.
- Start implementation of the new time registration and gate generator.
- Continue processing GPS data with GAMIT/GLOBK.

System Configuration

Element	Description
Mount	Alt-Az. 1m mirror
Angular encoders	FARRAND controls, 0.4”
Time interval counter	SR620
PMT	H6533
Time & Freq standard	TC-74, sec. from GPS.
Laser	350 ps, 5Hz. (18 years old)
Software	GUI in JAVA, server in C++, low-level modules in C, Linux OS.
Ephemerides	CPF, (in F77)

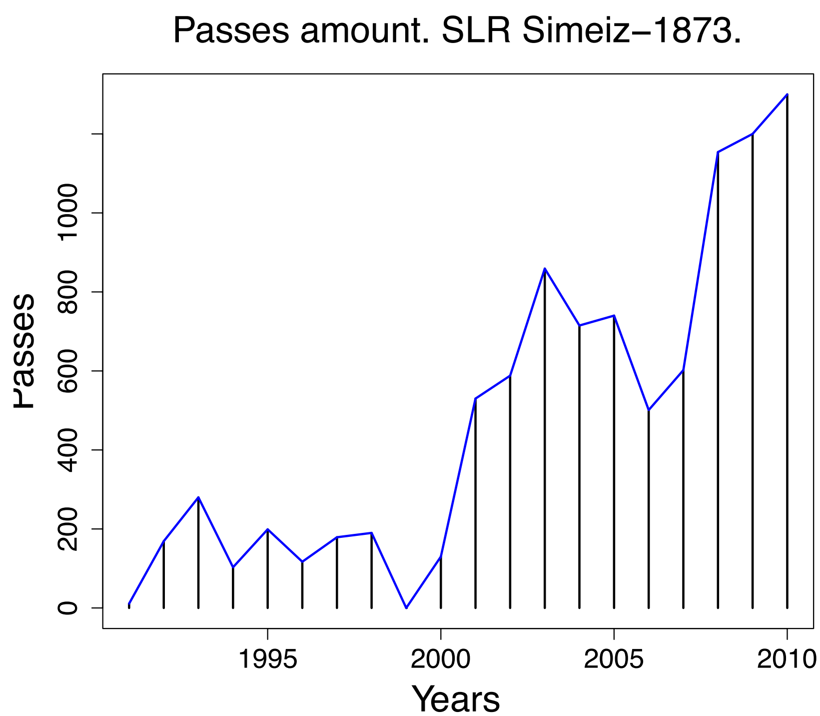

Figure 12-79. Amount of satellite laser ranging data from 1991 to 2010.

Historical dates

- Regular satellite laser ranging started in our observatory in 1976 as an INTERKOSMOS station with a laser system installed by K. Hamal on a KRIPTON telescope.
- In 1988 the Crimean Astrophysical Observatory installed a new station (near the old station).
- Co-locations with the IFAG (now BKG) MLTRS system were conducted in 1991.
- A modernization program was undertaken in 2000 under a CRDF grant.
- A permanent GPS receiver has been operating near "Simeiz-1873" since 2000.
- In 2004 the GPS receiver became an IGS site "GPS-CRAO".
- 2008 first year Simeiz obtained 1000 SLR passes per year.
- In 2009-2010 completed implement of new ILRS formats (CPF and CRD) in 2009-2010.
- In 2010, work on new master generator with shorter impulse.

References

И.В. Артемов , Д.И. Неяченко,, А.И. Дмитроца, С. Филиков, Ю. Мартышин Повышение эффективности сжатия импульса неодимового лазера.// Изв.Крымск.Астрофиз.Обсерв. - 2010 Рік.- Том.~106, No 1.-~С.~148-154.
(I.V. Artemov, D.I. Neyachenko, A.I. Dmytrotsa, S. Filikov, U. Martyshin Increase of efficiency of compression of an impulse of the laser.// Izv. Crimean Astrophys. Observ – 2010, Vol. 106, #1, P.148-154)

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Figure 12-80. MOBLAS-8 at the Outumaoro University Campus, near Papeete, Tahiti

MOBLAS-8, located at the Outumaoro University Campus, near Papeete, Tahiti, has consistently provided SLR tracking from 1997, despite its remote location causing high operating costs (custom fees, electricity bill), and insufficient staffing.

Crew:

- Jean-Pierre Barriot (Head),
- Yannick Vota (technician)
- Laurent Mercier (technician)
- Youri Verschelle (technician)

Principal events 2009-2010:

- 2009:

- MPACS instability: from 03/03 to 06/03 (1 week)
- MPACS power supply failure: 26/03 (1 day)
- Dual power amplifier failure: from 31/03 to 19/11 (about 8 months)
- Trip of Dennis McCollums in October 2009 to fix the problem
- New laser chiller installation

- 2010:

- 5370A HP counter failure: from 11/02 to 09/03 (1 month)
- Air conditioning failure (oscillator and amplifier laser heads were wet because of the condensation): 26/03 (one day)
- Elevation power amplifier failure: from 07/04 to 12/04 (one week)
- 5370A HP counter failure: from 27/04 to 25/06 (2 months)
- Power amplifier failure: from 16/07 to 29/09 (2 months)
- Elevation pointing unstable: 26/10 (one day)

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Introduction

Japan Aerospace Exploration Agency's (JAXA) Satellite Laser Ranging system called "GUTS-SLR" (GMSL, Tanegashima), was completed in the spring of 2004. The GUTS-SLR is located in Tanegashima Island, where the Japanese launch site is also located. The GUTS-SLR is operated by remote control from the Tsukuba Space Center (TKSC), approximately 1100 km away from SLR station. Routine SLR operations began on September 1st, 2004.

Facilities/Systems

GUTS-SLR is capable of ranging to various satellites, from low-earth-orbiting satellites to geostationary satellites. The ranging accuracy of the GUTS-SLR system evaluated by single-shot RMS is less than 10 mm for the LAGEOS satellite and less than 20 mm for ETS-8 (JAXA geostationary satellite). The GUTS-SLR station is operated almost automatically according to the predetermined sequence. An operator only needs to turn on/off the initial power supply, manually operate the initial acquisition when the orbit prediction has an error, and perform maintenance on the system regularly. An operational plan for the whole GUTS system is organized by the Master Control and Operation Planning Subsystem called COPs. COPs also monitors operational conditions of each subsystem. In 2010, as part of the large-scale maintenances, the mirrors except the primary one were recoated. After the maintenances, the position of GUTS-SLR was precisely re-measured for the first time since the completion.

Figure 12-81. Tanegashima station

Current Activities

GUTS-SLR has tracked various satellites, from low-earth-orbiting satellites to geostationary satellites. GUTS-SLR successfully performed the campaign for High Accuracy Clock (HAC) Experiment, one of the main experiments of ETS-8, which was the first time for JAXA to successfully track a geostationary satellite using SLR. HAC experiments were finished in 2010. GUTS-SLR is now conducting the campaign for the QZS-1 launched in Sep. 2010.

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From 2009 onwards a number time of transfer experiments were carried out repeatedly in Wettzell. Apart from observing the Jason-2 satellite including the T2L2 package, developed by CNES and the Observatoire de Cot Azur (Grasse, France) a feasibility study for the European laser time transfer experiment on behalf of EADS/ Astrium has been designed and built (Schreiber et al. 2010). Both concepts are based on a combination of two-way and one-way SLR. Standard SLR range measurements were taken at the Wettzell station and, using the satellite on-board clock, the epochs at the arrival of the laser pulses at the satellite were obtained. For this type of measurement, it was required that the new CRD format of the ILRS was implemented, because a resolution of the start epoch at the level of picoseconds is required. Using the combined SLR-data from both, the WLRS and the satellite signal arrival epoch measurements, clock offsets and drifts between the timescales can be calculated with high resolution. In order to perform a similar time transfer experiment on the International Space Station (ISS), a significant reduction of mass of the space segment was required. This was achieved by sharing the timer with the microwave time comparison link (TWSTFT) and by simplifying the detector concept. The engineering model of the space segment is currently under construction. Furthermore the WLRS contributed to the NASA Lunar Reconnaissance Orbiter (LRO) one-way ranging effort, following the formal acceptance as a ranging station by NASA.

In March 2009, a new detector (Photec PMT-MCP 210) was qualified for SLR operations and integrated into the WLRS. Its high quantum efficiency, at 532nm and increased bandwidth, promises improved ranging performance. Furthermore, together with the GM10-50B gating module, the installation could be simplified over the earlier setting. An Ortec 9327 discriminator performs the analog to digital conversion.

Improving the in-sky-safety of the WLRS was a major action item for 2009. The implementation of the Honeywell Laser Hazard Reduction System (LHRS) commenced in 2009 (Figure 12-82). Recently, we also integrated a secondary aircraft transponder receiver system as an additional safety system. Detected aircraft are plotted over a skyplot of satellite tracks in order to identify potential hazards. The top right corner of Figure 12-83 shows this feature.

Between November 2009 and July 2010 a major refurbishing of the WLRS telescope drives took place. Motors, encoders, hydraulics and control system software were replaced. The final tests showed encouraging operations of the WLRS. After resuming operations, developments for an improved T/R-switch started. WLRS currently cannot track very low altitude satellites because of limitations of the T/R system at repetition rates at or below 10Hz. By increasing the repetition rate to 20Hz this limitation can be overcome. The new T/R switch design is in an advanced state but still a work in progress. At the same time, a system to control the epoch of laser fire has been implemented.

Another ongoing project is the extension of the SLR control software towards an automatically tracking software package, which can handle both SLR systems in Wettzell. The advantages are easy portability to other SLR systems and the capability of handling up to 1kHz laser pulse repetition rates. A slightly adapted version that works on the WLRS (screenshot shown in Figure 12-83) is currently operational. The new system uses the CPF predictions, which already include the Earth orientation parameters (EOP). The new Consolidated Laser Ranging Data (CRD) format is now generated in both the old and new WLRS control system software.

Figure 12-82: Honeywell LHRS at WLRS

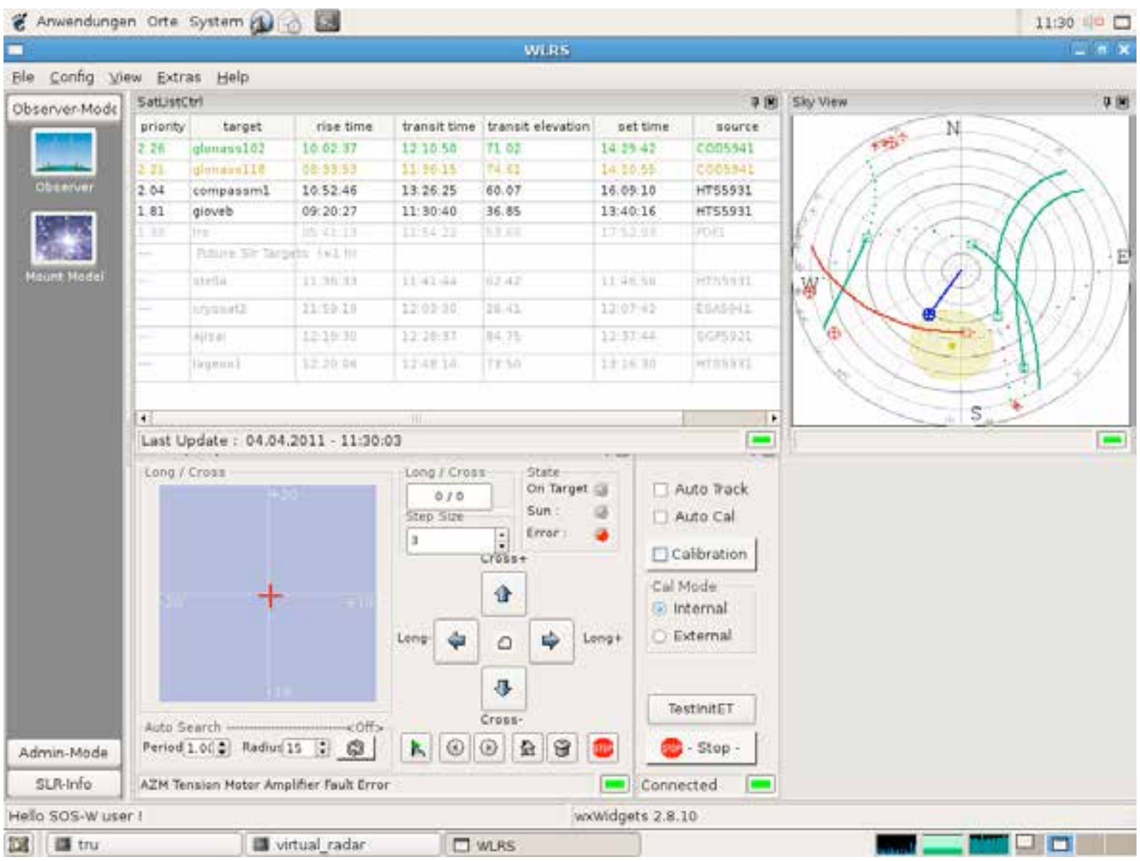

Figure 12-83. Screenshot of WLRS-software.

In the near future, the software upgrade will be used routinely. There are also efforts to resume the LLR measurements at a laser wavelength of 532 nm and the fundamental wavelength of 1064 nm.

References

Schreiber et al. 2010: K. U. Schreiber, I. Prochazka, P. Lauber, U. Hugentobler, W. Schäfer, L.Cacciapuoti, and R. Nasca, "Ground-Based Demonstration of the European Laser Timing (ELT) Experiment", IEEE TUFFC, 57, 3, 728 - 737, (2010)

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Yarragadee, Australia

Vince Noyes/EOS Space Systems Pty. Ltd.

General

A total of 13,957 passes were tracked during 2009 that produced 264,206 normal points and during 2010 this increased to 16,362 passes with 281,879 normal points. Yarragadee has continued to increase its data yield over the previous reporting period and maintain the top global position for total data collected.

New satellites successfully tracked during the report period included QZS-1, TanDEM-X, SOHLA-1, PROBA-2, ANDE Castor and Pollux, CryoSat-2, BLITS, GOCE, and LRO-LR.

Yarragadee staffing levels increased to eight when two new technicians joined us in May 2010 to support the growing aerospace precinct.

Figure 12-84. MOBLAS-5 SLR station staff: kneeling, left to right Peter, Bargewell and Vince Noyes; standing, left to right, Jack Paff, Brian Rubery, Randall Carmen, Dave Essers, John Colley; inset: Peter Thomas.

SLR System Upgrades

The laser and detection system was upgraded in June 2010. The upgrades included: a new laser table, a saturable absorber (to replace the dye cell system), a new laser chiller, and a new Photek MCP. The system was also upgraded in October 2009 to be capable of 10Hz ranging. The maser for VLBI came on-line in 2010 and became the prime 10 MHz reference for LRO-LR in May.

Geoscience Australia conducted a complete local tie survey mid July 2010.

Guest Equipment Upgrades

The 12m VLBI antenna was constructed in 2010 and most of the electronics installed.

Future Plans for the Site

The VLBI2010 installation nears completion and will be observing in the first half of 2011. The Midwest Space Communications Facility (of which the Yarragadee Geodetic Observatory is part) continues to grow and the newest ground station, which is owned and operated by the Swedish Space Corporation, will be operational in mid 2011.

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Zimmerwald, Switzerland

Adrian Jäggi, Martin Ploner, Johannes Utzinger, Marcel Prohaska, E. Pop, W. Gurtner/Astronomical Institute of Bern

In the 2009 and 2010 period the experiences with the 100 Hz Nd:YAG system installed in 2008 were consolidated for routine operations. The design of the system enables a high flexibility in the selection of the actual firing rate and epochs by adjusting the pulse rate between 90-110 Hz. An additional decimation may be achieved by means of a pockels cell. Together with pulse energies of about 8 mJ at 532 nm, synchronous operation in one-way laser ranging experiments to spaceborne optical transponders is possible. As the second non-US station, Zimmerwald successfully ranged to the Lunar Reconnaissance Orbiter (LRO) for the first time on 28 July 2009.

Figure 12-85 shows the number of observed satellite passes in the 2009 and 2010 period. Weeks with a top performance, e.g., between 6th and 12th September 2009 with a total of 396 observed satellite passes, demonstrate the outcome under optimal weather conditions. The gap from December 2009 to January 2010 was caused by a relatively long service intervention. Damaged optical parts of the laser system were replaced and parts of the control electronics had to be reconfigured.

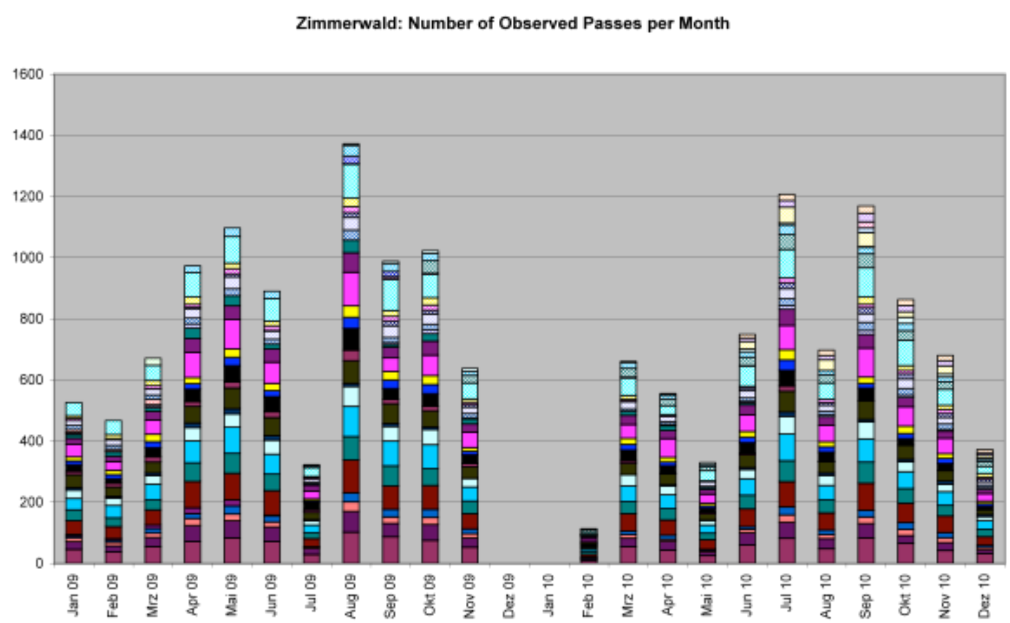

Figure 12-85: Number of observed passes per month in the 2009 and 2010 period.

Zimmerwald significantly contributed to new and advanced concepts and procedures within the ILRS, e.g.,

- one-way ranging to the LRO satellite in synchronous mode
- regular tracking of all satellites at high orbital altitudes, e.g., all GLONASS satellites according to the ILRS priority list
- regular tracking of satellites at very low orbital altitudes, e.g., the GOCE satellite, which was tracked by Zimmerwald as the first European station

The maintenance and operation of the satellite laser ranging facility are performed and supported by the Astronomical Institute of the University of Bern (AIUB), the Federal Office of Topography (swisstopo), the Swiss National Science Foundation (SNF), and the Swiss Academy of Sciences (sc|nat).

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