# Recent and future operation of Helwan-SLR station

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## Abstract

We concerned on the recent Satellite Laser Ranging (SLR) from the Helwan station. The recent equipments used for the operation of the Helwan SLR-station are described. A new Laser Radar Control (LRC) system had been tested theoretically and will apply during august, 2011 to the Helwan station. The results and the analysis of the data obtained recently using the cpf-formats are given. The future operation of the Helwan-SLR station which is expected to improve after the upgrading with the LRC, is also discussed.

# 1. The description of the present Helwan SLR-station

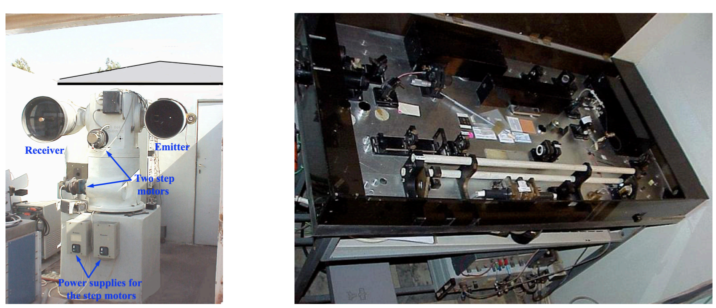
The tracking of the artificial earth satellites from the Helwan has started in the year 1974. A lot of modifications and upgrading have been applied to the Helwan-SLR station in order to improve its accuracy and performance (Hamal, K. , 1978, Jelinkova, H., 1984, Prochazka, I. , 1989, Tawadros, M. et. al, 2000, Ibrahim, M. ,2005). For this end, a brief description of the H-SLR station is given.

The mount configuration is Azimuth/Elevation with a coude system of mirrors for the transmitted beams as shown in fig. 1(a). The movement drive is consisting of 2 step drive motors, and the maximum tracking rate is 2 deg./sec. The guiding of the mount is a computer controlled. The receiving system of the mount is a spherical mirror lens of diameter 40 cm, and optical filter of 6 nm with 80 % transmission. The type of the detector is a Photomultiplier (PMT) manufactured by Hamamatsu model H6533. The quantum efficiency of this PMT is 10 % at 532 nm and of normal gain equal 5.6 million. The mode of the PMT is single photoelectron detection (Cech, M., et.al, 1998).

The laser transmitter (as shown in fig.1b ) is composed of Nd: YAG oscillator, Pulse selector, three amplifiers system and a Second Harmonic Generator (SHG); it produces a semi train of pulses. The wavelength of the laser is 0.53µm with output energy of 80 millijoule, the pulse width is 20 psec and its repetition rate is nearly 5 Hz. The divergence of the laser beam is adjustable and can reach to 0.1 mill radians. The laser transmitter is placed outside the mount and then the laser beam is directed to the satellite through the mount via a four coude of mirrors.

The ranging electronics of the system consists of a time interval counter of type a Stanford SR620 of resolution equal 4 ps. The time and frequency system, is GPS Time/Frequency standard, manufactured by Helwlett-Packard of model 58503B, and it measures the time with accuracy below than 110 nsec.

The meteorological station (MET-3) is installed to improve temperature, humidity and atmospheric pressure s' measurements. The pressure sensor model is a Digiquartz MET3 and it measures with accuracy of 0.1 mbar. The temperature sensor model is Platinum resistance temperature probe and it measures with accuracy ~ 0.5 deg C. As for the model of the humidity sensor, it is a capacitance probe and its accuracy is 2 % at 25 deg C. The Laser Radar Control (LRC) unit used at the Helwan station is used since 20 years and will replace by a new one as explained in section3.




**(a)** **(b)**

**Fig1. The mount of the H-SLR Station in (a) and the used Nd:YAG laser transmitter in (b)**

# 2. Recent satellites tracking

The data obtained from satellite tracking is the distance between the satellite under observation and the station. The most recent data of the satellites tracked from Helwan SLR station has been obtained during the years 2008 and 2009. The observations are carried out for low orbit satellite only; by the way during 2007 we started observation of the satellites using the CPF-formats as a prediction of their positions (Blazej, J. et al, 2008).

The analysis of the data is based on calculating the difference between the observed and the predicted ranges of the satellites. To analyze and remove the noise of the Helwan satellite laser ranging data, a procedure has been used. The principal phases of the analysis as explained (Tawadros, M. et al, 2000 , Ibrahim, M., 2005).

Due to the upgrading of the station, the precision of it measurements had been improved. In this part, an example has been given for the satellite Champ tracked during the year 2008. The observed range of the satellite as well as the range residuals after the polynomial fitting is plotted versus the number of laser shots and the results are shown in Fig.2. The histograms of the range residuals of the polynomials are computed and plotted in Fig.3. (after removing the points with weight 0), for the same satellite represented in Fig.2. Using the results of the 2.5 Sigma, which is the general standard in SLR on-site data processing, gives nearly the accuracy of the measurements of this satellite is 0.084 nsec.

The primary output of the satellite laser ranging stations is the normal point's data. The method used for the generation of the normal points as well as the selection of the value of the bin size are given in details (Ibrahim et al., 2001, Sinclair, 1997). The normal points are computed for each observed satellite. As an example Tab.1 represents the normal points as computed for the same satellite Champ. It gives average precession of 88 ps.

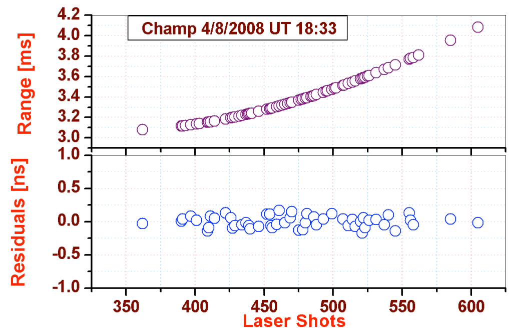



**Fig 2. The number of laser shots are plotted vs. the observed range in ms in the upper part and vs. the residuals in nsec in the lower part for the satellite Champ.**

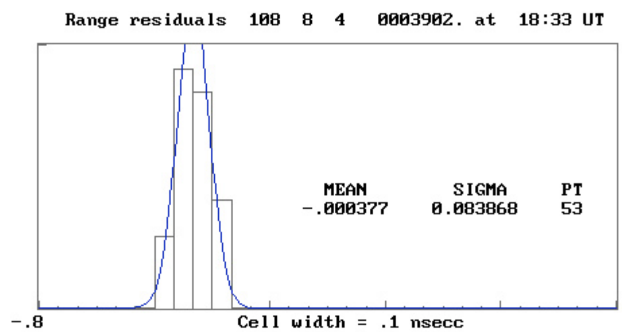



**Fig.3. Histogram of the range residuals as computed for Satellite Champ observed at 4/8/2008.**

**Tab.1. The number of normal points as computed for the satellite Champ Observed at 4/8/2008.**

| Ser. | H | M | S | Range(ms) | Psec | PT/PNT |
|---|---|---|---|---|---|---|
| 1 | 18 | 33 | 56.8003 | 3.0783 | 88 | 1 |
| 2 | 18 | 34 | 3.80031 | 3.12706 | 31 | 4 |
| 3 | 18 | 34 | 8.8003 | 3.18521 | 105.7 | 7 |
| 4 | 18 | 34 | 12.4003 | 3.23847 | 70.2 | 7 |
| 5 | 18 | 34 | 17.4003 | 3.32732 | 109.1 | 9 |
| 6 | 18 | 34 | 22.0003 | 3.42327 | 90.3 | 7 |
| 7 | 18 | 34 | 28.4003 | 3.57729 | 75.5 | 9 |
| 8 | 18 | 34 | 32.4003 | 3.68449 | 103.4 | 4 |
| 9 | 18 | 34 | 36.0003 | 3.78745 | 90.7 | 3 |
| 10 | 18 | 34 | 41.4003 | 3.95233 | 88 | 1 |
| 11 | 18 | 34 | 45.4003 | 4.08175 | 88 | 1 |

By the way, Fig.4 shows the range in ms as measured for the satellite Envisat observed from H-SLR station during 2009. What we want to show here is the few number of the observed points. That is due to the LRE errors message which we receive usually during the recent observations. So, our hope is, by the change to a new LRC, we get rid of the majority of problems produced by the LRE.

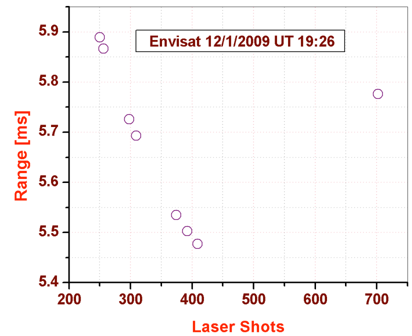



**Fig. 4. The laser shots as measured for the observed range in ms for the Envisat observed at at 12/1/2009**.

The precision of the measurements of the Helwan SLR station are compared with the precision of other SLR stations, and the results are given in Fig.5 as computed for the satellite Starlette in the period from October 1, 2007 till December 31, 2007 (http://ilrs.gsfc.nasa.gov/images/2007_12_str_rms.html). It shows that the root mean square value from H-SLR station is 8.4 mm.

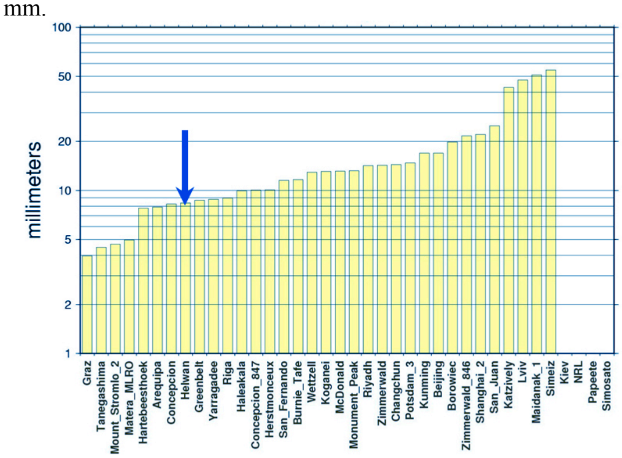



**Fig. 5 The deduced precession of the satellites passes tracked during 2000 for the satellites Lageos-1 and Lageos-2.**

# 3. New Laser Radar Control (LRC)

A satellite laser radar in Helwan has been operating since 1981 with full computer control based on minicomputer system HP 2100. In the period 1987-1989 IBM-PC computer and special control electronics based on Z80 microprocessors were implemented to the laser radar (Cech, M. & Novotny, A., 1989). 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 (Cech, M., 1994).

In the 2009 the laser radar control system was completely redesigned. The new system is based on powerful 80C188EB microprocessor operating with 1MB memory. Special circuits for range and epoch reading are included. The control system is 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 servo motors (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. The control system consists of two printed boards in Camac unit with a size 14x22x30 cm , as sown in Fig. 6 (a). A firmware is written in C language and Assembler and it is very flexible. Firmware is compatible with old LRCS system on command level (Dr. Mirosalv Cech, private information). A computational power of microprocessor is sufficient to implement simple real time operating system (in future).

The new system will increase the reliability of the laser station.

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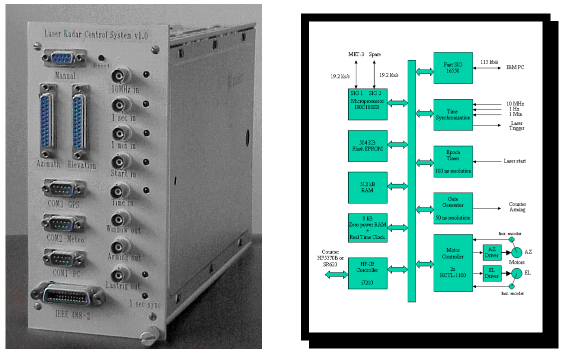


**(a)** **(b)**

**Fig.6 A new laser radar control in Camac unit in (a) and its Block diagram in (b)**

A block diagram of the LRC is shown in Fig. 6(b). The control system consists of two printed boards in Camac unit with a size 14x22x30 cm . A firmware is written in C language and Assembler and it is very flexible. Firmware is compatible with old LRCS system on command level. A computational power of microprocessor is sufficient to implement simple real time operating system (in future).

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## Conclusion

The results and the analysis of the data obtained recently using the cpf-formats are given and shows a high precision of the measurements. The total number of passes observed during 2007, 2008 and 2009 are, 54, 21 and 6. It shows that, although the precision of the measurements of the Helwan SLR-Station is good, its performance became bad especially during the previous years. That is the reason why the observations from H-SLR station are reduced. That performance is referred in fact to some reasons; one of them is the old LRE unit which installed at the station 20 years ago. There is upgrading of new equipment (LRC) of the satellite laser ranging station at Helwan-SLR station. It will be installed to the station during august 2011. It is expected to improve the performance of the Helwan SLR-Station in the near Future.

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