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STATION REPORT ON THE GODDARD SPACE FLIGHT CENTER (GSFC) 1.2 METER TELESCOPE FACILITY

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ABSTRACT

The 1.2 meter telescope system was built for the Goddard Space Flight Center (GSFC) in 1973-74 by the Kollmorgen Corporation as a highly accurate tracking telescope. The telescope is an azimuth-elevation mounted six mirror Coude system. The facility has been used for a wide range of experimentation including helioseismology, two color refractometry, lunar laser ranging, satellite laser ranging, visual tracking of rocket launches, and most recently satellite and aircraft streak camera work. The telescope is a multi-user facility housed in a two story dome with the telescope located on the second floor above the experimenter's area. Up to six experiments can be accommodated at a given time, with actual use of the telescope being determined by the location of the final Coude mirror. The telescope facility is currently one of the primary test sites for the Crustal Dynamics Network's new UNIX based telescope controller software, and is also the site of the joint Crustal Dynamics Project / Photonics Branch two color research into atmospheric refraction.

INTRODUCTION

The 1.2 meter telescope is located about 5 kilometers from the Goddard Space Flight Center in the middle of the Beltsville Agricultural Research Center (see Table 1). This telescope has been part of a wide variety of experiments since its development in

1973-74 by the Kollmorgen Corporation (now part of Contraves). It was originally built for Goddard as a highly accurate tracking telescope to use in the development and testing of satellite laser ranging (SLR) systems. Although there was preliminary work done in this area by both T.Johnson (GSFC) and C.O.Alley (University of Maryland), it was not until the mid 1980s that the telescope facility realized its full potential in this area with the development of the Experimental Satellite Laser Ranging System (ESLRS). The telescope's primary usefulness is in the areas of photon gathering and astronomical testing. As an astronomical observatory, it has drawbacks; these include the air bearings which distort the images, and the poor quality of seeing in the Baltimore-Washington region. The proximity to Goddard, however, makes the 1.2m telescope an excellent test facility for astronomical experiments, and the large aperture, highly accurate tracking capability, and excellent laboratory facilities make it an ideal system for developing and testing new ideas in satellite laser ranging.

TELESCOPE CHARACTERISTICS

The 1.2 meter telescope system is a multi-user azimuth-elevation mount housed in a two story dome (see Figure 1). The telescope is located on the second floor above the experimenters' area. The 15 ton assembly, as seen in Figure 2, consists of three sections: the yoke assembly, the trunnion with the primary mirror cell, and the forward tube truss (holding the secondary mirror). Air bearings, which raise the mount 0.005 millimeters above the support, are used for azimuth rotation to avoid the friction caused by roller bearings. The telescope is a six mirror Coude system with an effective system focal length of 33.13 meters (shown in Figure 3). The primary mirror is paraboloidal, 1.2 meters in diameter, with a focal distance of 3.2 meters. The secondary mirror is hyperboloidal, 0.4m in diameter, and is motor driven over a range of approximately 1.5 centimeters, giving the system the ability to focus from one kilometer to infinity. Three other flats direct the light from the telescope down into the experimenters' area below. Here a sixth mirror (the steering or pit mirror) can be rotated to direct the light to any of six experimenters' ports located at equidistant points around the circular pit area. All mirrors have been recently recoated with a broadband aluminum coating and SiOx overcoating. Peak reflectivity ranges from 88% to 92%.

The telescope was designed to meet a 20 arcsecond absolute positioning with a 5 arcsecond repeatability. In the current configuration the pointing is actually around 1 arcsecond due to the 28 term trigonometric error model used by the servo system computer. The servo system computer is a COMPAQ 386/20Mhz with 4Mbytes of memory. The tracking programs are written mainly in FORTRAN and run under the MS-DOS operating system. Timing for the software tasking is provided by 1Hz and 20Hz signals (accurate to 1 microsecond) and by the 36-bit NASA time code generator which consists of day of year and time of day. The computer closes the servo loop by reading the 22-bit encoders and performing software servo compensation; the telescope drive signals are output at 20Hz to provide a smooth track. The mount is able to track to the 1 arcsecond level at rates of up to 1 deg/sec in azimuth and up to 0.5 deg/sec in elevation. The actual speed of the mount is software limited to under 6 degrees per second in both axes.

The telescope facility has the ability to track satellites, aircraft, planets, the moon, the sun, and the stars. Predictions for satellites can either be in the form of Inter-Range-Vectors or NORADs. Aircraft acquisition uses onboard GPS data relayed to the ground in real-time or just visual observation; tracking is accomplished by using the digitized camera image of an onboard light source (such as running lights or laser diode beacon). The right ascension and declination of stars comes from the FK4 (soon to be FK5) catalog or from operator type-in of apparent position. Planetary prediction data, as well as the moon and the sun, comes yearly from the Flight Dynamics Support Branch at Goddard in the form of Chebyshev polynomials.

Acquisition aids are also available with the telescope. Operators in the dome can view through a 0.3 meter finder telescope boresighted with the main telescope. Also boresighted on the 1.2m telescope are an RCA Silicon Intensified Tube (SIT) camera and a CCD camera. An RCA SIT camera is also located in the pit area below the telescope in the focal plane. This camera was used during the RME experiment (see experiments listed below) and is also used for star calibrations. The video image from all three cameras can be viewed in the telescope control room and can be sent through the Colorado Video X-Y Digitizer for closed loop tracking by the servo computer. Table 2 lists the pertinent information on the finder scope and cameras.

PAST TELESCOPE EXPERIMENTS

PLANETARY OBSERVATION

The telescope served as a field test facility for bread board optical heterodyne spectrometers in the near and thermal infrared. This work was in support of earth and planetary atmospheric observations and was performed in the 1970s and early 1980s by M. Mumma and colleagues at NASA/GSFC.

A Laser Heterodyne Spectrometer for Helioseismology was an experiment performed at the telescope facility in the early 1980s to measure solar oscillations by mixing solar radiation with the output of a frequency stabilized CO_2 laser. D. Glenar of Colgate University was the principal investigator in support of ongoing work at GSFC.

ATMOSPHERIC LIDAR

A laser induced resonant fluorescence experiment took place in the early 1980s. This experiment, conducted by C.Gardner of the University of Illinois Department of Electrical Engineering, measured the density of atomic sodium at altitudes up to 100km using a dye laser mounted to the telescope trunnion.

LUNAR LASER RANGING

The design and testing of a high average power laser and special electronics for lunar ranging was overseen by C.O.Alley of the University of Maryland Department of Physics. Limited lunar ranging from the telescope was also accomplished during the early 1980s.

TIME COMPARISONS

C.O.Alley and colleagues at the University of Maryland set up and operated a laser link to the United States Naval Observatory (USNO) from the 1.2m telescope facility for time comparisons in support of the LASSO experiment. This link provided the highest precision time comparison (30 psec) as of that date (1983).

A comparison of East-West versus West-East one way propagation times of laser light pulses was also performed by C.O.Alley and R.A.Nelson. This was the first experiment to make such a direct measurement and provided the highest precision ever achieved in a time comparison with a transported atomic clock (40 picoseconds to USNO and back).

AUTOMATED GUIDING AND TWO-COLOR REFRACTOMETRY

D.Currie and D.Wellnitz of the University of Maryland Department of Physics developed the Automatic Guider System (AGS) during the period from 1975 to 1978 for automated tracking of continuous light sources. The AGS was used to perform automated star calibrations at the 1.2m telescope during the late 1970s.

D.Currie and D.Wellnitz also developed and tested at the 1.2m telescope a Two Color Refractometer, based on the AGS design, to measure atmospheric refraction. The final experiment performed at the USNO measured atmospheric refraction in a single night to a precision previously requiring one month's observations.

SINGLE COLOR SATELLITE LASER RANGING

The Experimental Satellite Laser Ranging System (ESLRS) operated as an R&D facility from 1982 to 1986. It was one of the first centimeter level, high return to transmit ratio satellite laser ranging systems. This system was developed by T.Zagwodzki, J.McGarry and J.Degnan of NASA/GSFC.

The NASA/RME experiment in 1991 used the U.S.Air Force low orbiting, high lidar cross-section Relay Mirror Experiment satellite to investigate streak camera returns from satellites, and to develop and test a system design for later two color work. Streak camera waveforms from RME showed clearly resolved responses from the individual cubes on the satellite. This experiment was conducted by T.Zagwodzki and J.McGarry.

TWO-COLOR STREAK CAMERA AIRCRAFT LASER RANGING

The goal of this experiment was to determine the azimuthal variations in the atmospheric induced range delay using doubled (532nm) and tripled (355nm) frequencies from the facility's Nd:YAG laser to a corner cube mounted on the NASA T-39 aircraft. Waveforms were recorded with a Hamamatsu C1370 2-psec resolution streak camera. The aircraft was acquired by using a GPS receiver onboard the aircraft whose output was transmitted to the ground computer via a radio link. Once the aircraft was visually acquired, the ground computer was able to lock onto and track the aircraft's laser diode beacon by digitizing the image seen in a camera mounted on the telescope. This experiment was successfully completed in early August 1992. The principal experimenters were P.Millar, J.Abshire, J.McGarry, and T.Zagwodzki, all of NASA/GSFC.

CURRENT TELESCOPE PROJECTS

TWO-COLOR STREAK CAMERA SATELLITE LASER RANGING

Recent upgrades to the ESLRS at the 1.2m telescope facility have been made to allow measurements of two color differential delay to the ERS-1, STARLETTE and AJISAI satellites using a single-photoelectron sensitive Hamamatsu Streak Camera. Differential two color measurements will be used to analyze the accuracy of existing satellite ranging atmospheric refractivity models. This work is being performed by T.Zagwodzki, J.McGarry, J.Degnan, all of GSFC, T.Varghese of Bendix, and colleagues from GSFC, Bendix and Hughes-STX.

SATELLITE LAUNCH TRAJECTORY TRACKING

In support of the Office of Naval Research and later the Air Force SDIO work, the University of Maryland has been observing the Firefly and Firebird series of launches from Wallops and Cape Canaveral using a wide field camera installed on the 1.2m telescope and the University of Maryland Optical Metric Mapper at the Coude focus. Acquisition is provided by realtime Launch Trajectory Acquisition System (LTAS) data via a high speed direct link. This work is being performed by D.Currie and D.Wellnitz of the University of Maryland.

SUPPORT OF LASSO EXPERIMENT

Attempts at visual acquisition of the Meteosat satellite (MP2), in order to range to the LASSO experiment, have been attempted using both the RCA Silicon Intensified Target camera on the mount and at the Coude focus, and using the University of Maryland Zibion camera installed on an auxiliary 12-inch telescope mounted to the 1.2m telescope. Due to the low magnitude of the visual MP2 and the poor seeing in the Baltimore-Washington area, all attempts at seeing MP2 to date have been unsuccessful. This work has been a joint effort between the Crustal Dynamics Project at GSFC, the Photonics Branch at GSFC, and the University of Maryland Physics Department.

MONITORING LAGEOS SATELLITE'S SPIN

Evaluation is in progress to determine the feasibility of monitoring the spin vector of the LAGEOS satellite (and later LAGEOS II) to support the prospective experiment to measure the Lense-Thirring Effect predicted by General Relativity. This is a joint experiment involving NASA, the Italian Space Agency, and the U.S.Air Force. The University of Maryland effort is being conducted by D.Currie, D.Wellnitz and P.Avizonis.

SOFTWARE DEVELOPMENT AND CHECKOUT

New CDP Network Telescope Controller Software is being designed to replace all of the telescope computers in the NASA Network with 486 compatible computers. The 1.2m telescope is the primary test system for the new software which will operate in the UNIX environment and will provide a user friendly, menu driven, graphical interface for the crews. The software team consists of J.McGarry (GSFC), J.Cheek (Hughes-STX), R.Ricklefs (University of Texas), P. Seery (Bendix), and K.Emenheiser (Bendix).

ACKNOWLEDGEMENTS

The authors would like to thank Jack Bufton (GSFC), Carol Alley (University of Maryland), and Dennis Wellnitz (University of Maryland) for detailed information on past projects at the telescope. A special thanks goes to the CDP SLR Manager, Larry Jessie, for photographing the telescope.

Table 1: 1.2 meter telescope location

1.2m TELESCOPE LOCATION	North American Datum 1927 CLARK 1866 ellipsoid
LATITUDE (geodetic)	39.02136044 degrees
LONGITUDE (east)	283.31712961 degrees
HEIGHT (above ellipsoid)	0.053198 km

Table 2: Acquisition and Tracking Aids

	Field of View	Dimmest object that can be seen
SIT camera in pier	70 mdeg diameter	8th magnitude
Finder scope	250 mdeg diameter	9th magnitude
CCD camera	200 by 300 mdeg	3rd magnitude
SIT camera on mount	2 by 3 degrees	8th magnitude

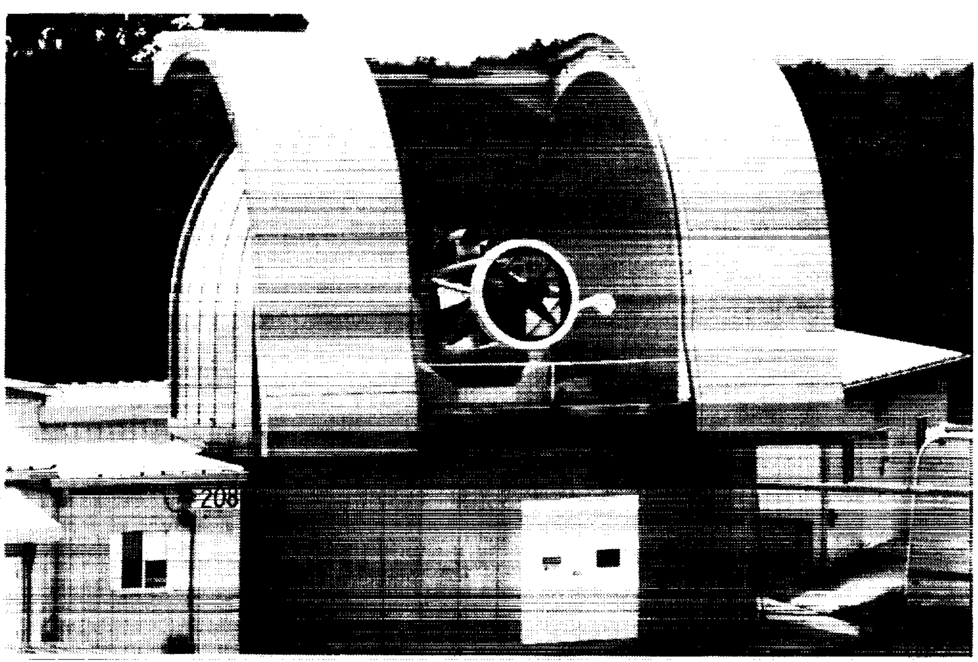

Figure 1: 1.2 meter telescope facility

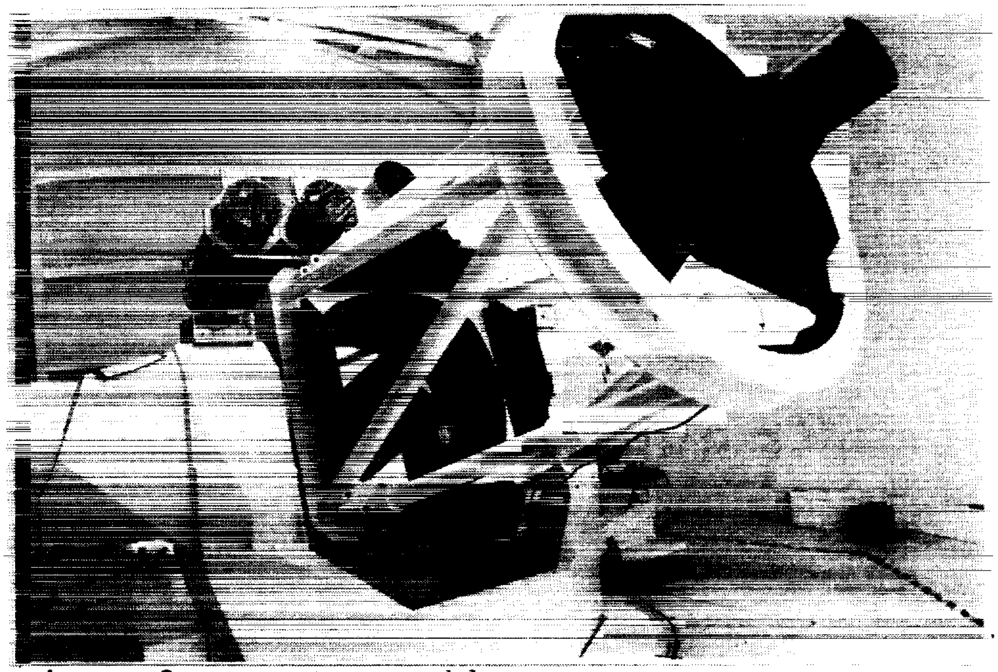

Figure 2: Mount assembly

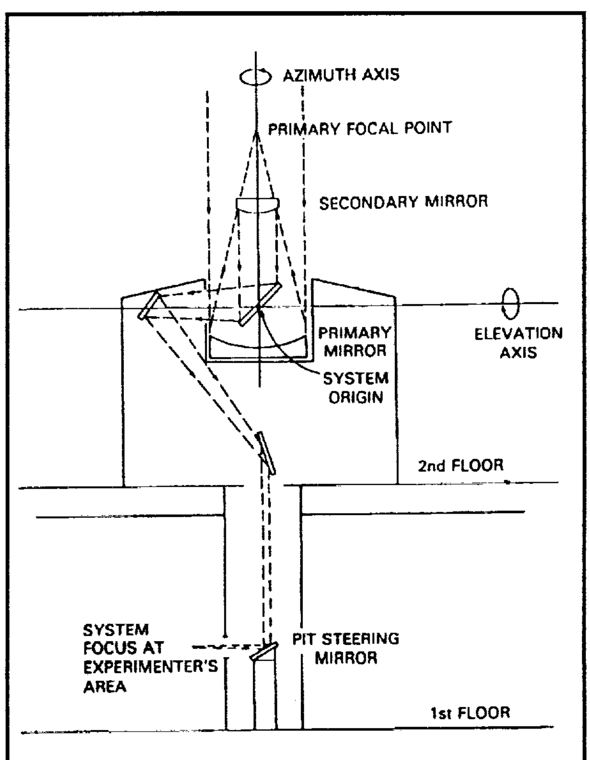

Figure 3: Coude system

Session Summaries

SESSION SUMMARIES

On the last day of the conference, each of the session chairman were asked to summarize, in vu-graph form, major conclusions or observations distilled from the individual talks within their sessions. These vu-graphs are reproduced in the following pages (with some minor editing on my part to improve clarity and eliminate duplication) along with comments made by workshop participants following the formal presentation by the session chairman. I have made no attempt in this record to identify the source of individual comments.

John Degnan

SCIENTIFIC APPLICATIONS AND MEASUREMENTS REQUIREMENTS
Bob Schutz/Richard Eanes

The science applications of SLR were summarized as follows:

Mean Gravity Field

Gravity field improvements - GEM-T3, TIG2, GRIM

Gravity Field Fluctuations/Variability

Longterm J_2
18.6 year tide
seasonal correlation with atmosphere

Terrestrial Reference Frame/Earth Orientation

Polar Motion
0.5 milliarcsecond routine accuracy on X and Y for 3 day values
1 day series available
Rapid Service UT1
Possible use of ETALON to extend to higher frequencies
Motion of network relative to center of mass of Earth/oceans/atmosphere
RMS 1 cm in X,Y; 3 cm in Z
Relative Station Positions
Best: 0.5 cm
Typical: 1-2 cm
Relative Motion
Horizontal velocities: 1 to 10 mm/yr for 40 or 50 sites
Vertical motions: Available for the "best-behaved sites"

Ocean Surface Study with SLR tracked altimetric satellites

ERS-1 orbits controlled by laser tracking

Time Transfer

Preliminary LASSO results from Grasse and MLRS $<$ 100 ps

SCIENCE GOALS AND REQUIREMENTS

GOALS	REQUIREMENTS
Mean Gravity Field 2 cm LAGEOS <10 cm TOPEX, AJISAI, STARLETTE	Better control of systematic error Better global coverage Satellite campaigns Altimetric satellite tracking
Gravity Field Variations	Continued operations by stable network Multiple targets
Earth Orientation	Continued operations by core network Better coverage of sidereal day Multiple targets
Terrestrial Reference Frame	Continued operations by core network Subcentimeter control of systematics Better Southern Hemisphere coverage
Ocean Topography	More ERS-1 coverage Good TOPEX support
Time Transfer	More attempts with Meteor-P2 Wider participation CRL, OGO

COMMENTS

(1) The breadth of SLR applications is not adequately known in the scientific community.

(2) It is essential that instrumental errors in SLR be minimized at a small level because the scientific analyses based on SLR could be either misled or limited by such systematics.

(3) The global SLR community needs to assist all participants to reach a uniform level of performance and a common operational view.

(4) Developments in two color techniques are important, but the competitiveness, and perhaps survival, of SLR will not be accomplished solely on those efforts. We, as a community, must find the right balance between new developments and conducting operations, i.e. regular and high quality tracking.

(5) SLR should play to its strengths, e.g. gravity and vertical positioning.

(6) The community should establish ties to Global Change.

(7) Carroll Alley reminded the group that lunar ranging was developed to support relativistic and fundamental physics studies whereas the present program appears to be tightly tied to Earth science.

TIMELY ISSUES
Andrew Sinclair

SATELLITE SIGNATURE

Issue has been raised previously
Subject is controversial
Effects of signature have been clearly established by two papers
Signature primarily affects single photon systems
Has consequences for data screening and center-of-mass computations

DATA SCREENING

Simple 3 sigma screening not adequate for skew data
Two methods
- adaptive median filtering
- determine bias of mean from peak

Tasks
- write up details
- develop subroutine for assessment
- CSTG Working Group to consider extra information in data format

MISSION PLANNING

Interleaving of passes

LASER TECHNOLOGY
Helena Jelinkova

LASER TRANSMITTER SUMMARY

Wavelength	0.53 μm (1.06 μm) Nd:YAG
Length of pulses	30 psec to 400 psec
Energy	20 mJ to 300 mJ
Repetition Rate	2 to 10 Hz
Maintenance	1 alignment/pass to 1 alignment/0.5 year (Improving)

GOALS AND ISSUES

Multipulse Transmitter (to maximize energy usage)

- Semitrain
- Full train

Multiwavelength Transmitters

- Doubled and third harmonic
- Stokes and Anti-stokes
- New Active Materials

10 picosecond pulses compression by

- Brillouin + Raman
- Raman
- Negative Feedback
- Colliding Pulse Method

Space use of Diode-pumped lasers

- High efficiency
- Long life

COMMENTS

Billion shot flashlamps have been demonstrated but lamp failure is catastrophic whereas diode arrays degrade.

EPOCH AND EVENT TIMING
Ben Greene

SUMMARY

Streak cameras presently at 2 psec; future resolution and accuracy = 0.5 psec

Electronic timing systems presently at 3 psec; future 1 psec resolution and accuracy

Both technologies are approximating useful levels for 5 mm two color ranging

COMMENTS

General agreement on first bullet

Disagreement on second bullet although new technologies (e.g. GaAs) are becoming available

There has been insufficient vision on the part of the funding agencies in developing this technology

DETECTOR TECHNOLOGY
Thomas Varghese

SUMMARY

High speed single photoelectron detectors (SPADS)

High speed, low jitter microchannel plate photomultipliers (230 psec) benefit from effects

Streak cameras represent the leading edge of high accuracy

COMMENTS

SPADs are useful for lunar ranging

Subcentimeter level ranging has been established on a global level and we are approaching millimeter accuracies

CALIBRATION TECHNIQUES/TARGETS
Jean Gaignebet

SUMMARY

Recommended formation of a study group for the design of improved laser retroreflector arrays. G. Lund offered to chair.

There is a need to monitor and keep records on individual SLR stations and configurations.

An interesting corner cube design based on the Fizeau effect was presented by V. Shargorodsky of Russia.

MULTIWAVELENGTH RANGING/STREAK CAMERAS
Karel Hamal

EXPECTED GOALS	ACHIEVED
Optimum wavelength pair	Preliminary
Two Color Ranging MCP	Not yet
MCP	Some progress
SPAD	single color
Streak Camera	
Optimum Satellite & Fizeau Cubes	Promising
Figure of Merit	Controversial
Laser	Stokes/Antistokes Cr:LiSAF

COMMENTS

Raman systems will never have high figure of merit; frequency shift is relatively small.

A Fizeau target is already in a 620 Km orbit. V. Shargorodsky will send the satellite orbit parameters by telex to the Smithsonian Astrophysical Observatory.

Russians will fly a new target at 1000 Km altitude by the end of the year. Only one cube (Fizeau) is visible at a time.

SLR DATA ANALYSIS/MODEL ERRORS

Ron Kolenkiewicz, Richard Eanes

Dynamic, Semi-dynamic, and Geometric Analyses
Orbital models and nonconservative forces

With increased data precision, the effect of time-varying gravity on the satellites is important, and the tracking site motions due to ocean and atmospheric loading needs to be considered.

Geopotential at the one to two level still exist for LAGEOS. More high quality data should improve this below one cm - especially at new sites or recently improved sites.

Systematic errors in the data due to satellite signature and calibration errors must be reduced to less than one cm.

A large non-gravitational signal affecting the LAGEOS eccentricity and perigee at the few meter level has been detected by the analysis groups at GSFC and UT/CSR. The effect was especially large in 1989 and 1991. The current models that explain the along -track or "drag" acceleration on LAGEOS do not explain the eccentricity anomaly. We need a physical explanation for the once per revolution accelerations on LAGEOS.

An attempt should be made to improve the atmospheric correction for single wavelength SLR by means of acoustic and/or lidar sounding of the atmospheric temperature profile.

There is a need for improved second generation SLR satellites with much more stable and deterministic center-of-mass corrections.

With the increased altitude and number of geodetic satellites (e.g., ETALONS and LAGEOS II), the use of geometric analysis to obtain geophysical parameters should be utilized.

Partly random seasonal fluctuations in the mass distribution of the atmosphere limit our ability to ever completely eliminate gravitational model error. Rather we must consider the error as an opportunity and track the fluctuations over time.

Obtaining successful results for the variations of the vertical component of station positions requires that biases in the SLR data be controlled much better than they have in the recent past. Solutions for range bias show some interesting regionally correlated signals that are evidence of either height variations or of some other model defect that is unknown. However, there are also large sudden changes in the biases that are certainly due to problems at the stations.

OPERATIONAL SOFTWARE DEVELOPMENTS

Georg Kirchner

Software developments are freely exchanged between groups.

Community relies on exchanges, standardized formats, etc.

Conclusions from the Splinter Meeting:

> Transputer-based SLR control system has no disadvantages (according to the engineer who built it)
>
> Stations should transmit full rate data by E-mail in compressed form
>
> The community should investigate possible standardization of SLR operating and control systems.

LUNAR LASER RANGING
Christian Veillet

The loss of Haleakala to the LLR community is "very unfortunate".

There are presently only two regularly working lunar stations (CERGA and MLRS).

LLR needs lots of observations in order to adequately support the science.

LLR is important to lunar studies and fundamental physics.

LLR pushes individual station performance to the limit.

LLR stations could range to cubes in lunar orbit.

FIXED STATION UPGRADES/DEVELOPMENTS
John Degnan

There appear to be at least two hardware configurations capable of subcentimeter range accuracy:

150 psec pulse, MCP/PMT, and constant fraction discriminator

35 psec pulse, SPAD

There is a continued international interest in SLR as evidenced by the development of new stations and continued upgrades of established stations

There is a new emphasis on higher degree of automation to drive down operational costs.

Countries continue to sponsor stations outside their national borders (e.g., Poland in Tunisia) which will help to provide better global coverage.

MOBILE SYSTEM UPGRADES/DEVELOPMENTS
Erik Vermaat

Highly transportable systems are now demonstrating the same state-of-the-art quality as larger stations (< 10 mm)

Mobile stations typically operate in the single or few photoelectron regime

Mobile stations are becoming more miniaturized as evidenced by the latest system, the French Transportable Laser System (FTLRS).

Automation is a major driver in reducing costs.

Levels of standardization is a key issue.

Conference

Summary/Resolutions

CONFERENCE SUMMARY/RESOLUTIONS
Michael Pearlman

RESOLUTION

We wish to acknowledge and thank all of the representatives from NASA Headquarters, Goddard Space Flight Center, and Bendix Field Engineering Corporation for their untiring efforts in support of the 8th International Workshop on Laser Ranging Instrumentation. Without the hard work, dedicated backing, and personal interest of each of these individuals, this workshop would not have enjoyed the tremendous successes that it did. The help and support of John Degnan is especially recognized.

RESOLUTION

As satellite ranging develops towards millimeter accuracy and the use of multiple wavelengths, one of the most important contributions to the energy link budget and satellite signature to ranging accuracy is the design of the laser retro array.

The SLR community appreciates the idea and proposal of the Russian Space Device Engineering Institute to compensate for angular velocity aberrations via the Fizean effect.

We strongly recommend the continuation of space experimentation in this field.

The SLR community proposes that SLR stations and experts in this field should participate in the construction and subsequent tracking of a satellite designed for this purpose.

RESOLUTION

Whereas the Workshop participants recognize the importance of improving the global distribution of SLR sites and applauds the efforts of various member nations to extend coverage outside their national borders through:

1. The establishment of fixed station (e.g., USA in South America, Czechoslovakia in Egypt, Poland in Tunisia, and Germany in Cuba).

and,

2. The use of mobile systems (USA, Germany, the Netherlands, and France).

We resolve to encourage all member nations in the SLR community to assist, to the best of their ability, in the development and/or operation of stations outside their national borders and particularly in the Southern Hemisphere.

RESOLUTION

We would like to recommend the creation of a special study group to investigate all possible new generation laser ranging retroreflector concepts for optical signature and (null) center of mass correction.

RESOLUTION

Whereas, future analysis of our laser data products would benefit by a knowledge of the configuration of the hardware and software by which it was obtained, we resolve to document our operational configurations and changes there to and record these at a centralized facility in a manner as to be defined by the CSTG.

RESOLUTION

We resolve to initiate experiments designed to improve the atmospheric correction through the use of real-time temperature profiles based upon acoustic wave tracking (SODAR).

Business Meeting/

Next Workshop

BUSINESS MEETING/NEXT WORKSHOP
Carroll Alley

It was decided by the participants that the next workshop should be held within two years. Three participants offered to host the next workshop. The proposers were John Luck of Australia, Yang Fu Min of the Peoples' Republic of China, and Erik Vermaat of the Netherlands. Sentiment was strong among many of the delegates that the ninth workshop should be held in either Asia or Australia since previous workshops had all been located in Europe or the United States. The delegates decided (in a very close vote) to hold the next meeting in the September to November 1994 time frame in Canberra, Australia. The meeting will be hosted by the Australian Survey and Land Information Group (AUSLIG).

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The Eighth International Workshop for Laser Ranging Instrumentation was held in Annapolis, Maryland in May 1992, and was sponsored by the NASA Goddard Space Flight Center in Greenbelt, Maryland. The workshop is held once every 2 to 3 years under differing institutional sponsorship and provides a forum for participants to exchange information on the latest developments in satellite and lunar laser ranging hardware, software, science applications, and data analysis techniques. The satellite laser ranging (SLR) technique provides sub–centimeter precision range measurements to artificial satellites and the Moon. The data has application to a wide range of Earth and lunar science issues including precise orbit determination, terrestrial reference frames, geodesy, geodynamics, oceanography, time transfer, lunar dynamics, gravity and relativity. This Proceedings is a compendium of full papers based on material presented at the Annapolis workshop.

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