System Upgrades of the NASA SLR Network

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Abstract

The NASA Satellite Laser Ranging Network has been fully operational in the field for over twenty years. During this time the Network has seen many modifications and upgrades to maintain system operations and more importantly, to increase data quality and quantity. Through a declining budget, NASA continues to ensure system operations and performance are maintained at the highest level. During the last two years, the MOBLAS, TLRS, MLRS, and HOLLAS have received both hardware and software changes to maintai n and enhance system operations. This poster will detail the upgrades to the receiver subsystem, the laser subsystem, the mount subsystem, the processing software, and the communications subsystem of the NASA SLR Network.

Receiver Subsystem

Photek PMT 318

The Network's current Micro Channel Plate / Photo Multiplier Tubes (ITT F4129F), have reached the end of their operational lifespan. A new assembly from Photek has been chosen as a replacement. Four of these new tubes have been procured, and lab testing of the first article has been completed. This new PMT is currently installed at the MOBLAS-7 station. All indications are that this Photek PMT offers a large improvement in data quality and quantity.

Tracking at MOBLAS-7 has produced calibrations across the board that have been improved by 1mm. The daytime/nighttime calibration numbers are between 3.8 mm and 5.0 mm RMS, with the average being 4.4 mm. Satellite RMS's for LAGEOS passes have yielded excellent sub centimeter RMS results. Cal RMS's have also improved in the HSLR mode the. The background noise levels with this tube are less than 10 milli-volts.

The new tube has been mechanically engineered to have identical form and fit with the Network's existing tube assembly. Additionally, the ITT MCP/PMT utilizes a separate "gating module" requiring 120 volts AC at the telescope mount. This arrangement has been improved with the integration of the gating module into the MCP/PMT tube assembly. The voltage required for operating the gating module reduced to 5 volts DC.

Meteorological Measurement System (MET3)

The MET3 sensor package has been installed on all of the MOBLAS and TLRS systems, as well as the McDonald Observatory, and HOLLAS. This fully automated, highly accurate sensor measures barometric pressure, temperature, and relative humidity. It is calibrated and traceable to the National Institute of Standards and Technology.

Laser Subsystem

Pulse Slicer Upgrade

The new cavity dump system uses a 15-stage solid state avalanche board (Marx Bank Board) triggered by a new fast photo diode (PF Delay Adjust Board).

The Marx Bank Board charges a series of capacitors in parallel. The rejected train exiting the oscillator cavity triggers the fast photo diode on the PF Delay Adjust Board. The output of the PF Delay Adjust Board triggers the 15 stage avalanche transistors on the Marx Bank Board. Then through these fast-switching transistors it aligns the capacitors in series in a plus to minus configuration, which sums the voltages on each capacitor. This fast switching and summing generates a short 4.0KV pulse with a rise time of 1 nanosecond and a fall time of less than 1 microsecond.

The stepper power supply boards, 150 volts and 300 volts, are driven from the existing 24 volt power supply from the oscillator Power Unit (PU420). The 300 volt power supply powers the Marx Bank Board. The 150 volt power supply board powers the PF Delay Adjust Board.

Just as with the old technique, the sliced pulse's polarization is rotated 90 degrees using a Pockels Cell operating at or near 4.0KV. The new arrangement, placing the Pockels Cell in the oscillator cavity, generates a total energy exiting the oscillator equivalent to that of the single pulse, which was produced via the old pulse selector.

Series 800 Oscillator Head Replacement

The current Series 400 and 600 Oscillator Heads are no longer manufactured. It has been replaced with the Series 800 head. This new head offers a quick change mounting plate. The cooling water is routed through the units base plate.

Mount Subsystem

Second Generation Radar - Laser Hazard Reduction System (LHRS)

Improvements were made to the RF Transmit Power Monitoring Circuit. These changes produced more accurate readings of the magnetron output power, and significantly improved the system immunity to external noise sources. The LHRS Receiver Tuning software was improved to enhance the tuning of LHRS RF Receiver. This also increased the LHRS RF Receivers immunity to external noise sources.

A Radial Pointing Error Conversion routine has been instituted. This transforms Azimuth/Elevation pointing angles to a Radial pointing angle between the radar command pointing position and the radar actual pointing position. This routine takes into account the large Azimuth cosine pointing error at Point of Closest Approach (PCA), and computes "True" angular error between radar actual and command pointing angles, thus greatly reducing false laser disable signals.

The LHRS Servo Control Software was improved. A three term Proportional Integral Derivative with feed forward software has been installed. This improvement reduces pointing errors from +/- 0.50 degrees to +/- 0.09 degrees.

The LHRS Diagnostic Software has been enhanced to translate the hex data stream and the hex values in LHRS Local Control chassis microprocessor memory locations into text. This permits easier real-time system status checks, and reduces time required for troubleshooting.This capability also eliminates any manual hex conversion calculation errors.

An error detected with any of the following conditions will cause the LHRS to issue a transmit laser energy disable signal:

Error checking of the LHRS Command Angle Data and the LHRS Encoder Angle Data was improved to increase LHRS fault protection. This insures that the radar correctly follows host command angles.

Mechanical Connection Verification between LHRS Local Control Chassis and the Host System Encoder has been instituted providing increased fault protection of LHRS. It insures that the LHRS is properly connected to the Host System.

Data integrity verification between the LHRS Local Control Chassis and the LHRS Remote Control Chassis has been increased. This ensures that data transfer between these chassis's is accurate.

If the Host System encoder synchronization signal is not present the LHRS will issue a transmit laser energy disable signal.

A Radar Microprocessor Watchdog Timer was installed. This circuit ensures that the microprocessor is operational.

Finally, the use of Current Off The Shelf (COTS) "Short Haul" Modems in place of the FSK Modems improves serial data communication reliability between the LHRS Local Control Chassis and the LHRS Remote Chassis.

HOLLAS Encoder Upgrade

The original mount controller at LURE (HOLLAS) had been replaced in March 2000 as part of the complete system upgrade initiated in September 1999. This replacement system had been designed and constructed by a sub-contractor from the mainland. During acceptance testing, it was apparent that this system did not meet specifications. Unfortunately, the sub-contractor went out of business before the controller could be fixed.

A few weeks of research convinced the University that a mount controller could be designed and constructed using only commercial off-the-shelf components. Further, it could be completed in less time and for less money by using University technicians and engineers rather than going out for bid and engaging another sub-contractor.

The University designed system was operational by February 2002, and met or exceeded all original technical specifications. The final product could be used as designed by any positioning system that uses Inductosyn® transducers, or position sensors that output A quad B signals, and is driven by DC torque motors.

Processing Software

Red Hat Linux v5.2

The new operating system is Red Hat Linux 5.2, which has improved security features over the previous version of Red Hat Linux 5.0.

GNP v2.5.3F

The previous version of Generic Normal Point (GNP v1.93), had data fitting problems which caused the generation of invalid normal points, loss of normal points, and inconsistent satellite RMS's that did not reflect 'true' system performance. GNP v1.93 always produced a bad normal point when the first or last observation was an outlier (e.g. background noise, multipulse, etc.). Instead of rejecting this outlier in the 3 sigma editing, it is accepted and formed into a single observation normal poi nt. 'Valid' satellite returns near this outlier were rejected which sometimes results in the loss of other 'valid' normal points. In addition, there were occasional fit failures on robust passes, which is evidenced by unusually high data rejection and/o r satellite RMS's. All attempts at patching the software failed to eliminate these issues. These fitting techniques required a major revision.

In 1999, Honeywell Technology Solution Inc. added additional modern data fitting technology in the GNP software package. This enhanced GNP software was developed on an Open VMS computer at HTSI Headquarters and was named GNP v2.0. After many enhancements to GNP v2.0, a software conversion to the field computer platform, an exhaustive benchmark, and NASA CCB approval, the new software was finally available. This final version was GNP v2.5.3F (the F stands for Field Software).

The changes to the new GNP software are largely transparent to the user on station, although there are several differences that will be noticeable. These differences reside primarily in the data analysis capability and the data management process, but will also influence a significant change in tracking philosophies.

They include:

The current input and output files remain the same for the processor software. Two new files are created for every pass and they are included in the .ZIP output file. These files are the .RES and .ANL files. The .RES file is a listing of the final fit residuals (full-rate and normal point), and the .ANL file is an analysis file. These additional data files will enable better monitoring of system performance.

During the early stages of the software rewrite, it was determined that the largest source of fitting problems were large gaps in the data. These gaps are due to the loss of satellite returns for various reasons (eg. multi-satellite tracking, cloud cover, loss of signal). Gaps larger than 10 minutes did induce fit failures. Therefore, GNP v2.5.3F will not accept gaps that are longer than 10 minutes. It was for this reason that CONPRO was modified to keep pass segments as separate files.

GNP V2.5.3F is more conservative in identifying real data; therefore passes with a high percentage of noise may be rejected (i.e. no normal points are formed). This does not mean that a station will generate less normal points over the long term. Benchmark tests revealed that the GNP V2.5.3F generated up to 10% more normal points than GNP V1.93. In this case, higher quality leads to higher quantity. Satellite RMS's will be more consistent from pass to pass and day to day, and offer a truer reflection of system performance. Also, the new GNP will not produce normal points if there are less than 5 returns in the pass.

CONPRO v5.0

As a result of the GNP upgrade segments of passes, within an hour of each other, are no longer combined into a single file (i.e. a single pass). For example, if the operator tracks a multi-satellite scenario, consisting of LAGEOS, AJISAI, and TOPEX satellites, and then returns to the LAGEOS pass, there will be 4 separate files. Because the new CONPRO software no longer combines pass segments, the number of files that are produced during processing has significantly increased.

Communications Subsystem

Automated Data Delivery Facilitated

TLRS-3 has made infrastructure improvements that enabled an "always on" condition of the station's Internet connection. This improvement eliminated the problems commonly associated with "dial-up" Internet providers. Most importantly, this new communications link enabled the automation of data delivery to the network of TLRS-3's tracking data, as well as the automated daily delivery of TIV's to the station. Improved line quality, connection speeds, and overall dependability has been improved.

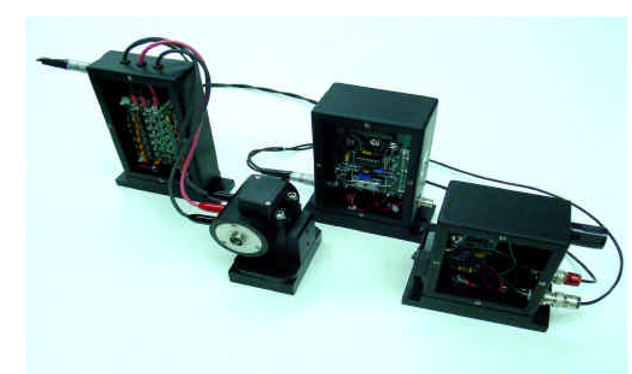
Photek PMT 318

Receiver Subsystem

Photek PMT 318 –

- 3 Stages
- Active Diameter: 18 mn
- QE at 532 nm; better th 13%
- Jitter at Single PE Leve <100 pS

Pulse Slicer



Laser Subsystem

Pulse Slicer –

- Eliminates Krytrons (longer produced)
- Reduces Maintenanc

Series 800 Oscillator Head

Laser Subsystem

Series 800 Oscillator Head –

- Eliminates the Series 400 Brews Angle
- Replaces the Series 600 Oscillat Head
- Easier to Perform Maintenance

HOLLAS Mount and Controller Upgrade

Mount Subsystem

Mount and Controller Upgrade

- Utilized COTS Components
- University designed and Implemented
- Will Work with a Variety of Positioning Systems

Second Generation Radar (LHRS)

Mount Subsystem

Second Generation Radar (LHRS) –

- Replaced FSK Modems with COTS units
- Added Watchdog Circuitry to Microprocessor
- Power Supply Upgrades
- Laptop PC Maintenance and Operati Mode

MET3 Meteorological Measurement System

Receiver Subsystem

MET3 –

- Calibrated and Certified Accuracy (traceable to National Institute of Standards and Technology)
- Automated logging of barometric pressure, temperature and humidity
- Pressure Accuracy; ± 0.7 mBar (600 1100 mB)
- Temperature Accuracy; ± 1 degree C
- Humidity Accuracy; ± 10%

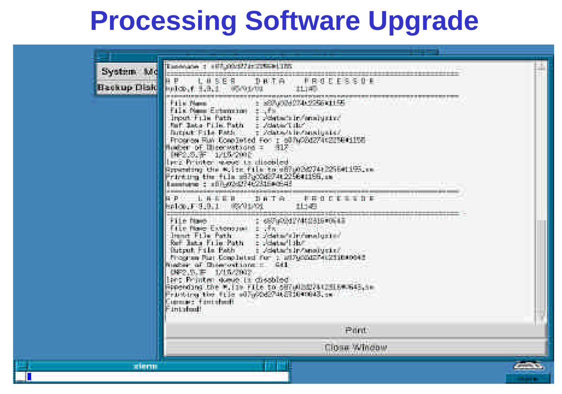
Elimination of "Dial-up" Internet Connections

Communications Subsystem

Data Delivery –

- Automated Hourly Data Delivery
- Daily Automated TIV Delivery

Processing Software Upgrade



Processing Software

Generic Normal Point (GNP) v2.5.3F, Red Hat Linux 5.2, CONPRO v5.0, HPLDP v9.9.1, Laser Processing System v1.3 –

- GNP v2.5.3F replaces GNP v1.93
- CONPRO v5.0 replaces CONPRO
- HPLDP v9.9.1 replaces HPLDP v9.9
- Red Hat Linux v5.2 replaces v5.0
- Laser Processing System v1.3 replaces the original LPS