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MATERA LASER RANGING OBSERVATORY (MLRO); AN OVERVIEW

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Abstract:

The Agenzia Spaziale Italiana (ASI) is currently under negotiation with the Bendix Field Engineering Corporation (BFEC) of the Allied Signal Aerospace Company (ASAC) to build a state-of-the-art laser ranging observatory for the Centro di Geodesia Spaziale, in Matera, Italy. The contract calls for the delivery of a system based on a 1.5 meter afocal Cassegrain astronomical quality telescope with multiple ports to support a variety of experiments for the future, with primary emphasis on laser ranging. Three focal planes, viz. Cassegrain, Coude, and Nasmyth will be available for these experiments. The open telescope system will be protected from dust and turbulence using a specialized dome which will be part of the building facilities to be provided by ASI. The fixed observatory facility will be partitioned into four areas for locating the following: laser, transmit/receive optics, telescope/dome enclosure, and the operations console. The optical tables and mount rest on a common concrete pad for added mechanical stability. Provisions will be in place for minimizing the effects of EMI, for obtaining maximum cleanliness for high power laser and transmit optics, and for providing an ergonomic environment fitting to a state-of-the-art multipurpose laboratory.

The system is currently designed to be highly modular and adaptable for scaling or changes in technology. It is conceived to be a highly automated system with superior performance specifications to any currently operational system. Provisions are also made to adapt and accommodate changes that are of significance during the course of design and integration.

MLRO : An Overview

Objective: Build a state-of-the-art, multi-purpose, laser ranging observatory in Matera, Italy

General Features

- Day and night automated ranging capability on all CCR-equipped satellites (> 400 km) and the moon
- Application of state-of-the-art technology in all sub-systems
- Real time calibration and interleaved multi-satellite tracking
- Multicolor ranging capability
- Advanced computing environment and data analysis tools
- Computerized documentation, with features such as relational database, expert system and hypermedia text

System Specifications

- LAGEOS ranging :
  - Single shot precision : ~5 mm
  - Normal point precision : <1 mm
- Low orbit satellite (ERS-1, Starlette, etc.) :
  - Single shot precision : 3 - 5 mm
- Lunar ranging :
  - Single shot precision : ~1 cm
- Real time calibration/ground ranging :
  - Single shot precision : <=2 mm
- Range accuracy: Better than 2mm

MLRO : An Overview

Telescope

- Near diffraction limited afocal Cassegrain telescope with a 1.5 meter primary and a 10 centimeter secondary; combination of a tertiary mirror and coude optics for transmission/reception

- Broadband coating for maximum spectral response from UV to near-IR

- Maximum slew rate :
  Azimuth axis : 20 degrees/second
  Elevation axis : 5 degrees/second

- Multiport system for other experiments

Laser

- Diode pumped laser for injection seeding

- Regenerative amplification followed by power amplifiers

- Pulse duration : <125 psec

- Pulse energy (532 nm) : >200 mJ

- Repetition rate : >=10 Hz

- Computer controlled beam divergence

- Modularity for energy scaling / multi-wavelength generation

- Laser firing stability : better than 20 nsec

MLRO : An Overview

Control System

- Software in high level languages
- Automatic recording of all operational parameters
- Automated star calibration, mount modelling
- Computer-assisted optical alignment and verification
- Distributed data acquisition, processing, and control
- Advanced computing/control environment
- Automated system/sub-system simulation and debugging

Transmit/Receive Electronics

- Detection : High Q.E, high speed MCP-PMT/APD
- Signal processing :
  - Speed : 1 - 5 GHz
  - Dynamic range : 20
  - Jitter : <10 psec
- Event timer :
  - Clock frequency : 200 - 1000 MHz
  - Verniers : 4 - 8
  - Time resolution : 1 - 2 psec
  - Accuracy : 5 - 10 psec
  - Jitter : 10 - 20 psec
- Clock : Cesium with disciplined oscillator
- Gating : Range gate adjustable from 10 nsec to 10 μsec

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MLRO : An Overview

Current Status (Sept 1992)

- ASI and Bendix proceeding with negotiation/finalization of contract
- Estimated contract start in December 1992
- MLRO delivery in 42 months

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PERFORMANCE OF THE UPGRADED ORRORAL LASER RANGING SYSTEM

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1. Upgrade Arrangements

An Agreement 'being in respect of a project to develop Laser and Control Systems Upgrade to Orroral Laser Ranging System' between Electro Optic Systems Pty.Ltd. (EOS) and The Industry Research and Development Board (IRDB) of the Commonwealth Department of Industry, Technology and Commerce was signed on 23 March 1990. On the same day, a corresponding 'Agreement for Collaborative Research and Development of Laser and Control Systems Upgrade to Orroral Laser Ranging System' between the Australian Surveying and Land Information Group (AUSLIG) of the Commonwealth Department of Administrative Services and EOS, was signed. Under these Agreements, the research and development costs were shared between the three parties according to a standard IRDB formula, with AUSLIG having the option to purchase the prototype for its residual value upon successful demonstration. IRDB involvement was directed towards fostering export-oriented Australian high-technology industry.

The old system was de-commissioned on 6 March 1991, although preparatory work such as moving the laser and installing the heads and capacitor banks necessary for conversion to Active-Active mode was completed prior to that date. LAGEOS I was acquired a month later, on 10 April, and AJISAI on 12 April 1991 in Orroral's first-ever attempt at a 'low' target. The following eight months were spent in debugging and refining the new system and preparing for the ill-fated attempt to measure the geodetic baseline between the Orroral Laser Ranging System (OLRS) and the Saudi Arabian Laser Ranging Observatory (SALRO) set up at the Camberra Deep Space Communications Complex, Tidbinbilla to complement terrestrial and GPS surveys and to link SLR at Orroral with VLBI at Tidbinbilla.

The upgraded OLRS was deemed by AUSLIG to be operational from 1 January 1992, and final payment to EOS for purchase of the residual prototype was made in June 1992. A contract for software maintenance and further development was awarded to EOS in November 1992.

2. System Prior to 1991

The original system was the Orroral Lunar Laser Ranger (LLR), lent to the Division of National Mapping (Natmap) in 1973 under a Memorandum of Understanding involving NASA, Smithsonian Astrophysical Observatory and US Air Force Geophysical Laboratory. It was upgraded to include ranging to artificial