



## 13 –Po05: **Satellite Photometry** and **Laser Ranging (SPR)**

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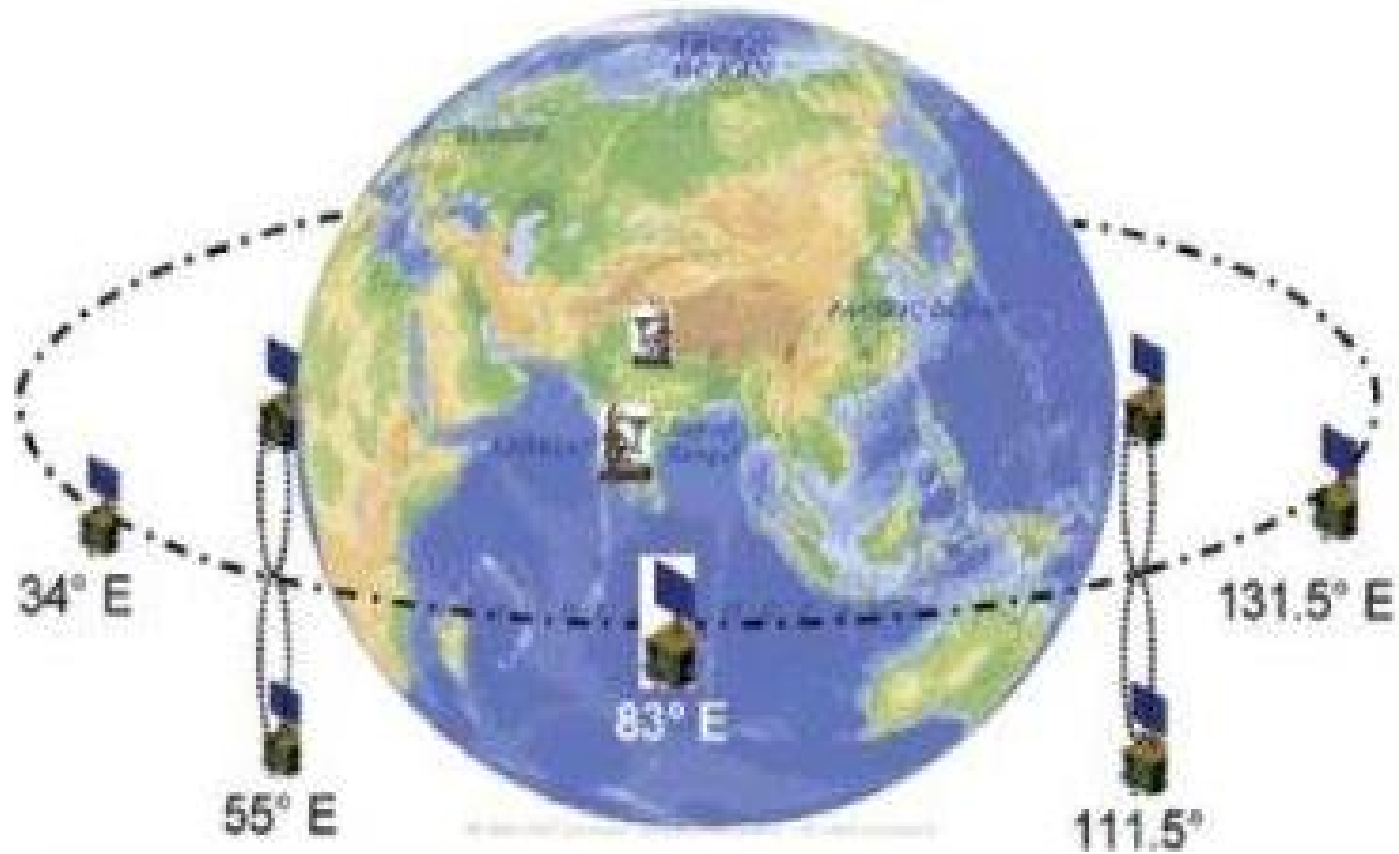
**Acknowledgement:** Cybioms Corporation gratefully acknowledges the vision of ISRO Management and Technical leadership for SPR in particular Messrs.: Kamalakar (ISRO LEOS Director) and Bhaskar (SPR Project Director)

# Satellite Photometry and Laser Ranging (SPR)

## Abstract:

ISRO has started the deployment of its regional navigational GEO/ GSO satellites. The radar tracking data for orbit determination (POD) will be significantly enhanced by the high ranging accuracies provided by SLR. In this regard, the process of establishing two remotely controlled Satellite Photometry and Ranging (SPR) facilities separated by nearly 2000 km has begun with a master control facility at a third location. The near term plan is to deploy 2 SLR systems in the next 2 years to create the required local observation geometry. The planned SLR systems have state of the art (1) telescopes with adaptive optics, (2) high resolution imaging capability to support photometry and debris tracking, (3) SLR hardware and software to support GEO ranging, and (4) capability to add a Ground Terminal in the future for laser communications. An overview of the systems is presented.

## IRNSS Constellation: Regional Coverage



## IRNSS Constellation - Ground Track





## Satellite Photometry and Ranging (SPR): Background

- Indian Space Research Organization (ISRO) intends to establish 2 identical facilities for
  - <1> Satellite Photometry (and Debris Tracking)
  - <2> Satellite Laser Ranging (SLR)
  - <3> Laser Communications (future...)
- SLR to be performed for POD of India's Navigational GEO satellites.
- ISRO invited Global Tenders; Cybioms was selected for the implementation of the project;
- Cybioms will build 2 advanced SPR systems to deploy at Mount Abu and Ponmudi
- Operationally automated SPR systems will be remotely controlled from Bangalore, India, 1000km away
- Multiple deliveries and Multi-phased Deployment planned (2014-15)

## SPR: Geographical Locations

SPR Site, Mount Abu,  
<between Jodhpur  
(Rajasthan)  
& Ahmedabad (Gujarat)>

Mission Control  
Facility, Hassan,  
Bangalore

SPR Site, Ponmudi,  
<near Trivandrum,  
Kerala>



## SPR Designated Site #1: Mount Abu

- Mount Abu is located at **24° 36' Latitude, 72° 42' Longitude**);
- This is a site ~ **1200 meters** above MSL;
- ISRO already has made astronomical and lidar observations from this site.
- SPR facility will be located in the proximity of the existing facilities.
- **Deployment Address:** PRL Campus, Gurushikar, Mount Abu, Rajasthan-30750, INDIA



## SPR Designated Site #2: Ponmudi, South India

- Ponmudi is located at  $8^{\circ} 45'$  Latitude,  $77^{\circ} 6'$  Longitude.
- This is a site at ~600 meters above MSL;
- SPR facility will be located in the proximity of the **Indian Institute of Space Technology** (IIST) and ISRO's Vikram Sarabhai Space Center (VSSC)
- IIST Campus, Ponmudi Hills, Trivandrum, Kerala-695551, INDIA





## Primary Mission: Laser Ranging to IRNSS Satellites

- Laser Ranging to 7 IRNSS Satellites with retro-reflectors for POD
  - 3 Spacecraft in Geostationary Orbit (33.5E, 83E, 131.5E)
  - 2 Spacecraft in Geosynchronous Orbit (inclination 29°, 55 E)
  - 2 Spacecraft in Geosynchronous Orbit (inclination 29°, 111.5 E)
- Ranging to Geodetic satellites for tectonic plate motion, ocean height variation studies, etc.

## Part 1: Satellite Photometry - Major Modules

1. 1 meter Ritchey Chretien Telescope with (1) Coude, (2) Cassegrain, and (3) Nasmyth Foci
2. 6 meter dome to protect the Telescope /instrumentation from the elements
3. 4kx4k CCD camera for very high sensitivity faint object imaging
4. Tip-Tilt -Refocus Hardware + Piezo control Software for Active/ Adaptive Optics
5. High frame rate CCD camera for active/ adaptive optics for fast imaging and atmospheric compensation

## Part 1: Satellite Photometry - Major Modules

1. Multi-sensor (pressure, temp, humidity, wind, precipitation, visibility, cloud cover, lightning) weather station
2. High resolution, high accuracy, state of the art Servo-system for ATP and Telescope, dome, Tertiary mirror control;
3. Computer HW for device control, data acquisition, and data processing
4. SW to support device control, data acquisition, and data processing

## Part 1: Satellite Photometry - Performance

Advanced Telescope supporting:

1. Pointing Accuracy:  $\sim 1$  arcsec
2. Resolution:  $< 0.01$  arcsec;
3. Jitter :  $< 0.01$  arcsec RMS
4. Detection Capability:  $\sim$  Magnitude 21
5. Operations: Automated for Operations and Remote Control



## Part 2: Satellite Laser Ranging - Major Modules

1. DPSS Laser Oscillator + FL pumped amp: (20mJ, 30 ps, 50Hz) OR (12mJ, 30ps, 100pps)
2. Time and Frequency electronics
3. TX-RX Electronics: MCP- PMT, Photodiodes, Gating devices, amplifiers, multiplexers, CFDs
4. Picosecond Electronics: Signal Processing & Event Timer
5. Control Electronics (10-5000 Hz) capable of laser firing, gating devices, collision avoidance,
6. CCD Camera: Target (stars, satellite, etc.) acquisition, and fine telescope pointing
7. Servo-control: (1) Telescope, (2) Dome, (3) Tertiary Mirror, (4) Point-ahead, (5) Beam Attenuation, (6) Adaptive Optics, (7)
8. Computing HW for (1) Device control, (2) data acquisition, and (3) data processing
9. SW for (1) Device Control, (2) Data acquisition, (3) Data processing, (4) Automation

## Part 2: Satellite Laser Ranging - Performance

### 1. Full Rate (FRD) Single Shot Precision:

- LEO satellites: < 5mm
- Lageos: < 6mm
- HEO: <12 mm
- GEO: TBD

### 2. Normal Point (NPT) Precision:

- LEO satellites: <1mm
- Lageos: <1mm
- HEO: <5 mm
- GEO: TBD



### 3. Automated scheduling and Tracking based on set priorities

### 4. Automated Data Processing and Data Transmission

## Part 3: Laser Transmission Safety

### 1. Tiered Safety Architecture:

- Cameras
- Radar

### 2. Radar Safety

- X-band Radar for inner layer protection
- Range and Pointing angle overlay with sky coverage