A new multi-purpose Mobile Satellite Laser Ranging (MSLR) system

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Features

- Multipurpose

  Usually Satellite laser Ranging Systems are made for specific aplications, and cannot be used for other purposes

- Mobile

  Moving of SLR from site to another location is very complicated task for SLR, our is a ready solution to be used as mobile

The objectives of development the new MSLR system

The objectives of the new MSLR system is to carry out:

- ***high precision night and day ranging*** measurements of distant space objects including special geodetic satellites, Medium Earth orbit - MEO as well as geostationary and above it High Earth orbit - HES with passive retro emitting elements
- ranging space objects with ***light dispersed surface*** including Low Earth orbit - LEO, mini and micro satellites, for example Cubsat, space debris, etc.
- ranging ***low flying platforms*** as airplanes, baloons, missiles and others with and without retro emitting elements
- point-to-point ***free space communication*** link as a ground station terminal or other optical long-haul communications

To achieve these objectives the following system's technical capabilities is required

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The MSLR technical performance objectives

The proposed development – the new MSLR system:

- Is fully equipped – ***switch on and work***
- MSLR system is made ***modular*** with the possibility of interchangeability of system nodes for each objective execution
- MSLR telescope is placed in a rotating ***astronomical pavilion*** mounted on the standard sea container roof
- MSLR system measuring system is placed in climate stabilized ***operator room*** in the container
- MSLR system equipment includes adjustment and alignment ***facilities*** for quick SLR measuring and other systems device testing, adjusting and aligning
- MSLR system is constructed to be reliable and simple, easy to dismantle and assemble, adjust and align, ***easy to move***
- Standard container is equipped with ***fixed transport boxes*** for packaging SLR telescope dismantled assemblies and measuring equipment and special sockets for dismantled astronomical pavilion components, assemblies and telescope support components in transport mode
- Container with a MSLR in transport mode secures system to be ***transported by sea, land and air*** vehicles

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MSLR system applications

MSLR system application field is:

- High precision (sub-centimeter) night and day ranging measurements of distant space objects as special geodetic, global positioning systems (GPS,Galileo, Glonas), as well as geostationary and above it satellites with passive retro emitting elements for appropriate monitoring networks, scientific and other organizations as well as appropriate universities
- High precision ranging measurments of distant LEO space objects with light dispersed surface including mini and micro satellites, space debris and other space objects for appropriate LEO and space debris monitoring networks, scientific and other organizations as well as appropriate universities
- High precision ranging of low flying platforms such as airplanes, baloons, missiles and other objects with and without retro emitting elements for scientific and other organizations as well as appropriate universities
- Point-to-point space communication link as a ground station terminal or other optical long-haul communications for scientific, communication and other organizations as well as appropriate universities

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MSLR system foreground

- For special geodetic satellites with passive retro emitting elements, high precision ranging, the highly mobile - portable SLR (PSLR) system was developed [1] in Riga (1994 – 1999) – see picture below
- The PSLR system working model has been sited on survey mark RM1 adjacent to MOBLAS 5 at Yarragadee in Western Australia and the first field tests results (sept.1995 – apr.1996) are shown in [2], [3]
- It was passed to Curtain University (Perth, West Australia) for exploration /use, which ended with master's research work [4]
- Studies have shown the expected results: PSLR is capable of ranging within sub-centimer RMS error to geodetic satellites with measuring equipment by that time (1995)
- The PSLR system ideology and experience is valuable and applicable in developing the new SLR

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Opportunities and benefits PSLR system modification to a new MSLR system

PSLR prototype operation in field conditions showed that:

- PSLR main telescope optical system, optical channels assemblies and mechanical assemblies have been successfully constructed
- The main optical system is stable, including the primary mirror's weight compensation mechanism and the secondary mirror distance temperature compensation mechanism
- SLR telescope can be constructed in parallel channels or coaxial design or replaceable (one to the other)
- MSLR system telescope (optical channels) assemblies and measuring equipment nodes is made modular with the possibility of interchangeability of system nodes
- MLRS system can be deployed in automated astronomical pavilion placed on a standard sea container roof and laser transmitter and measuring equipment must be placed inside the container

MSLR specification

Optical systems:

The main optical system - mirror system:

- Main mirror (aspherical, facilitated): D=620 mm, Thickness: 80 mm, Central hole diameter: 180 mm, Radius of the nearest radius: 1800 mm, Weight: less then 20 kg, Material: SITAL CO-115M, Number of active supports – 6
- Secondary mirror (aspherical): d=200 mm, Thickness 25 mm, Material - SITAL CO -115M, Weight: 0,6 kg
- Coude F-ratio: 1/6
- Focal length 3600 mm

The ***main optical system*** can be used in:

- 3 optical channel SLR configuration (coaxial optical system): for transmitting laser pulse (diameter of beam for *transmission channel*: >20 mm), *receiving photoelectrical channel* (angle of view: 0.25 – 4 arcmin), *visual control channel* (field of view: about 24 arcmin/25.4 mm)
- 2 optical channel configuration (parallel optical system): for *receiving photoelectrical channel* (angle of view: 0.25 – 4 arcmin), *visual control channel* (field of view: about 24 arcmin/25.4 mm) with separate Laser Collimator for transmitting laser pulse

Separate **Laser Collimator**: 3 lens system, output aperture 120 mm, diameter of beam for transmission channel: >20 mm

In addition the **telescope-guide** (aperture 40 mm, field of view: 4°) for visual control is installed

The optical channel opto-mechanical assemblies are made with modular capabilities to be quickly replaceable as optical channel configuration and as channel optical nodes

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Telescope mount

(Alt/Az configuration) axes actuators

- Azimuthal axis turning angle: +/- 270°, axis rotation speed range: from 0.1 arcsec/sec till 5°/sec
- Altitude axis turning angle: - 5°/+ 95°, axis rotation speed range: from 0.1 arcsec/sec till 3°/sec
- The servo systems data exchange rate: at least 1,000 times per second
- The telescope axes are coupled directly to their axes rotation angle, encoders coupled directly to the telescope's axes rotation angle measuring device

The telescope's axes servo system is equipped with (wireless) handpad for the telescope hand control

The separate control workstation (1) for the telescope control with the appropriate control and satellite ephemeris software

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Laser transmitter

SLR measurements quality crucially depends on the laser transmitter characteristics and the ability to maintain them in outdoor conditions. The laser/s must be placed in operator's room with climate control

The new generation laser for high precision (sub-centimeter) night and day ranging measurements has:

- up to 25 mJ per pulse at 1064 nm at least 50 Hz repetition rate
- thermo stabilized second harmonic generator options
- < 30 ps pulse duration
- beam pointing stability (better then 10 arcsec)
- pulse duration stability (better then 3%)
- pulse triggering stability (better then 15 ps jitter)
- diode pumped and air-cooled
- remote control via keypad
- laser head and electronics placed in climate controlled boxes, that provides optimum conditions for laser, in a temperature range outdoors from 15ºC to – 25ºC

The optical/mechanical assemblies of a laser transmitter input in the telescope has been met with modular capabilities to be quickly replaceable as laser input unit, laser transmitters and/or their harmonic generators

The main optical system/separate Laser Collimator (module) is designed to work up to 1600 nm wave length, allowing it to be used for free space optical communication purpose

SLR measurement system

SLR measurement system includes, for example, high precision (sub-centimeter) night and day ranging measurements :

- high-speed light photon receiver:
- new generation (fast) SPAD (Single Photon Avalanche Diode) detector
- new generation (ultra fast) PMT (PhotoMultiplier Tube)
- the High-speed Event Timer (HSET) - a PC-based instrument: single-shot RMS resolution - better then 5 ps, measurement rate - up to 20 MHz repeatability of precision in temperature range (0ºC – 40ºC) – better than 3 ps RMS

HSET in addition to other required data are processed in measurment workstation (2) with the appropriate SLR software and network connection

For other SRL objectives another HSET can be used, for example, for space debris ranging the custom HSET with group space objects ranging capabilities is welcome

SLR photon receiver sensor optical-mechanical assemblies in the telescope has met with modular capabilities to quickly replace/complement optical filters and diaphragms assemblies and sensors

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Additional equipment for SLR operations

Additional instruments and equipment to provide and ensure appropriate quality of SLR:

- Time base – GPS Disciplined Rb Reference: long term stability (Allan Deviation) - not less then 2x10E-13 per day; output: 1pps (UTC Offset - not more then 50ns RMS); 10 MHz Sine output - long term stability - not less then 2x10E-11 per month
- GPS receiver: typical specification for permanent GPS stations
- Climate station:
- Temperature: -50ºC till +60ºC
- Humidity: 0 till 100% RH
- Atmospheric pressure
- Wind speed and direction: equiped with 10 m pole mast for listed in instruments
- All workstations as well as base and additional apparatus are equipped with UPS

Additional test equipment for MSLR verifiy on-site are provided: test and adjustment instruments and tool kits for testing and adjusting MSLR mechanical, optical and electronic systems and spare parts as well as backup devices

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MSLR system location

MSLR is placed in a single unit to facilitate and simplify the operation, maintenance and transportation locating it in the rebuilt standard shipping container

MSLR system placement include:

- rebuilt standard 20' shipping container
- mounted on the container roof folded rotating astronomical pavilion with its control system
- telescope and laser head support systems, positioned on a separate fundations
- operator room with measuring equipment is separated from the telescope
- operator room is equipped with the climate system

MSLR container with build in telescope and laser head is placed on a pre-prepared concrete foundations on the observation site

Estimated MSLR system and shelter total weight: less then 3,500 kg

The container and its contents in transport performance allows it to transport with sea, land and air vehicles

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MSLR advantages

Excellent technical parameters

Multipurpose-

Mobile

Reasonable price

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