

QVS



23RD INTERNATIONAL WORKSHOP ON LASER RANGING (IWLR) Oct.20~26, 2024 Kunming, China



23rd International Workshop on Laser Ranging Kunming, 20-26 October 2024

The Newly Refurbished San Fernando Laser Station

LT CDR Manuel Ángel Sánchez Piedra Sergio Salata López



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- Prior status
- AMELAS project
- Other modifications in other subsystems
- Tentative schedule
- Upcoming projects
- Conclusions





Space Geodesy at ROA

ROA has been a pioneer in Spain in the tracking of artificial satellites.

Photographic Techniques

- 1958. Baker-Nunn camera
- 2010. TFRM Robotic Telescope Modernization

Satellite Laser Ranging (SLR)

- 1968. French Geodesic Campaign (CNES-GRGS)
- 1979. Transfer agreement to Spain
- 1999. Entry into ILRS
- 2017. Space debris project
- 2019. End of last quarantine







Space Geodesy at ROA

Both collaborative objects and space debris tracking.

SFEL has contributed with national and international networks in **geodetic** and **SST** purposes, also with companies in the space sector.

eesa



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ILRS tracking tasks.

- LEO-MEO
- EKSPLA PL2251 (500mW @532 30ps 10Hz)

Space debris tracking

- LEO
- EKSPLA NL317 (25W @532 8ns 10 Hz)













Prior Status









- Control subsystem: FPGA-RGG developed by SFEL
- ToF measurement subsystem: **Event Timer** A032
- Time&Freq subsystem: ROA-PPS Synchro, Rubidium and White Rabbit

Altazimuth Mount (weakness):

- 600 mm Cassegrain Telescope
- Launcher Telescope micrometric mechanical pointing
- Finder Telescope Analogic camera





v Mount





- Ready for 80 cm mirror & modular additions
- Incorporates coudé path

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• Invariant point error <0.5mm





Key Aspects of the New Mount (AMELAS)

Delivered by AVS (18th July 2024)

Main characteristics

OVS

- Supports arcsec pointing
- Direct drive & top components
- Ready for 80 cm mirror & modular additions
- Incorporates coudé path
- Invariant point error <0.5mm







AMELAS Project











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AMELAS Project











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AMELAS Project

Azimuth



Elevation





Pointing model



Current task:

- Pointing offset of about 80 stars
- Coefficients not only contribute to correct the pointing but also provide info on those factors that need to be optimized
- Corrections are currently in a range (max-min) of 20 arcsec

TF	tube flexure – sin ζ law		
TX	tube flexure – tan ζ law	ZH	AAT HA Z-gear effect in HA
IE	index error in elevation	ZE	AAT HA Z-gear effect in polar axis elevation
IA	index error in azimuth	HF	AAT main east-west horseshoe flexure
CA	nonperpendicularity of elevation and pointing axes	HGES	36^m gear error in HA – sin
AN	NS misalignment of azimuth axis	HGEC	36^m gear error in HA – cos
AW	EW misalignment of azimuth axis	DGES	9° gear error in Dec – sin
NPAE	nonperpendicularity of azimuth and elevation axes	DGEC	9° gear error in Dec – cos
ACES	Az centring error (sin component)	TFP	AAT tube flexure – non-Hooke's-law term
ACEC	Az centring error (cos component)	HFX	AAT residual horseshoe east-west
ECES	El centring error (sin component)	HFD	AAT residual horseshoe north-south
NDV	El centring error (cos component)	CD4A	AAT coudé 4 collimation error A component
NRA	Horizontal displacement of Nasmyth rotator	CD4R	AAT coudé 4 collimation error R component
NRY	Vertical displacement of Nasmyth rotator	CD4D	AA1 coude 4 commation error b component
AUX1A	Az change supplied through auxiliary reading 1	CD5A	AAT coudé 5 collimation error A component
AUX1S	LR change supplied through auxiliary reading 1	CD5B	AAT coudé 5 collimation error B component
AUX1E	El change supplied through auxiliary reading 1		





Definition of the new invariant point and global TIE

Exterior topographic/geodetic (7 points) network, local network inside the dome and the link between both.

Combine classical topography and geodesy methodologies and dimensional control and mesaurement of structures.

Report will be submitted to ILRS.

















Definition of the new invariant point and global TIE

Exterior topographic/geodetic (7 points) network, local network inside

Circunference name	Points	Average CQ 3D [m]	Average 2D CQ [m]	Average CQ [m]
CIRC1000	21	0.0003	0.0003	0.0000
CIRC2000	12	0.0005	0.0005	0.0001
CIRC3000	13	0.0003	0.0003	0.0000
CIRC4000	19	0.0003	0.0003	0.0000
CIRC5000	13	0.0001	0.0001	0.0000
CIRC6000	20	0.0001	0.0001	0.0000
CIRC7000	10	0.0005	0.0005	0.0001
CIRC8000	10	0.0005	0.0005	0.0001
CIRC9000	6	0.0005	0.0005	0.0001
	Circunference name CIRC1000 CIRC2000 CIRC3000 CIRC4000 CIRC5000 CIRC5000 CIRC6000 CIRC7000 CIRC8000 CIRC9000	Circunference namePointsCIRC100021CIRC200012CIRC300013CIRC400019CIRC500013CIRC600020CIRC700010CIRC800010CIRC90006	Circunference namePointsAverage CQ 3D [m]CIRC1000210.0003CIRC2000120.0005CIRC3000130.0003CIRC4000190.0003CIRC5000130.0001CIRC6000200.0001CIRC7000100.0005CIRC8000100.0005CIRC900060.0005	Circunference namePointsAverage CQ 3D [m]Average 2D CQ [m]CIRC1000210.00030.0003CIRC2000120.00050.0005CIRC3000130.00030.0003CIRC4000190.00030.0003CIRC5000130.00010.0001CIRC6000200.00010.0001CIRC7000100.00050.0005CIRC8000100.00050.0005CIRC900060.00050.0005















New ToF Measurement System

- Eventech ESST 7 Series
- Extremely precise & reliable time tagging device
- 1.5 ps RMS time-tag precision

New launcher telescope

- Optomechnic based on COTS
- Beam pointing and divergence control (5''-120'')

New finder telescope

- Celestron RASA 8 + CMOS ZWO ASI 2600
- Useful for space debris









- Station Control
- Tracking Programme
- Space Objects Database
- Prediction Generator
 - Safety System
- Mount Control







Software Development

• Station Control

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- Safety System

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Mount Control



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Software Development

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TERELAS

New Cassegrain Telescope (800 mm)

1 arcsec star image

Lighter and greater reflectivity

Space debris

$$n_{pe} = \eta_q \left(E_T \frac{\lambda}{hc} \right) \eta_t G_t \sigma \left(\frac{1}{4\pi R^2} \right)^2 A_r \eta_r T_a^2 T_c^2$$

KIROA

New KHz laser

Combine in the same device ILRS and SST tasks 532 nm, 1-5 KHz, 20 W, < 75 ps



CUPROA

Speed >15°/s (re-entries) Slit dome according to TERELAS aperture Integrated in station control SW

ESTACIÓN DE SEGUIMIENTO LÁSER REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA



Operation Center to Control simultaneously

ROA sensors







Staff is the most valuable resource

- Cohesive group that works with enthusiasm to carry out all the projects we face.
- 2 observers
- 4 engineers (multi-discipline)
- 1 Navy officer (PhD student)





Tentative schedule



- Finish current GMV campaign (12/24)
- Finish current improvement tasks (12/24)
- Evaluation period ILRS Quarentine (TBC with ILRS)
- Possible participation in DLR EU SST Call (01/25)



Conclusions



- ROA is making efforts to achieve the state-of-the-art IOT be a **reliable member of ILRS**
- Several improvements have been developed (i.e. new mount) in a very short period of time
- Ready to face new challenges: multiestatic observations, blind and daylight tracking,...





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