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Kunming, 20-26 October 2024

The Newly Refurbished San Fernando Laser Station

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ESTACIÓN DE SEGUIMIENTO LÁSER
REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA

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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

MISSION

*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.*

International Laser Ranging Service

EUSST

esa

deimos

gmv

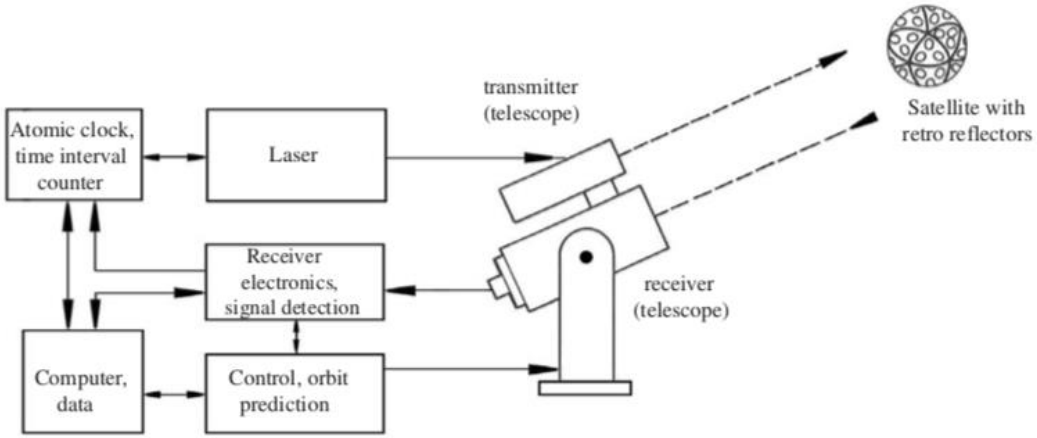
***ILRS** tracking tasks.*

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

***Space debris** tracking*

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

Prior Status

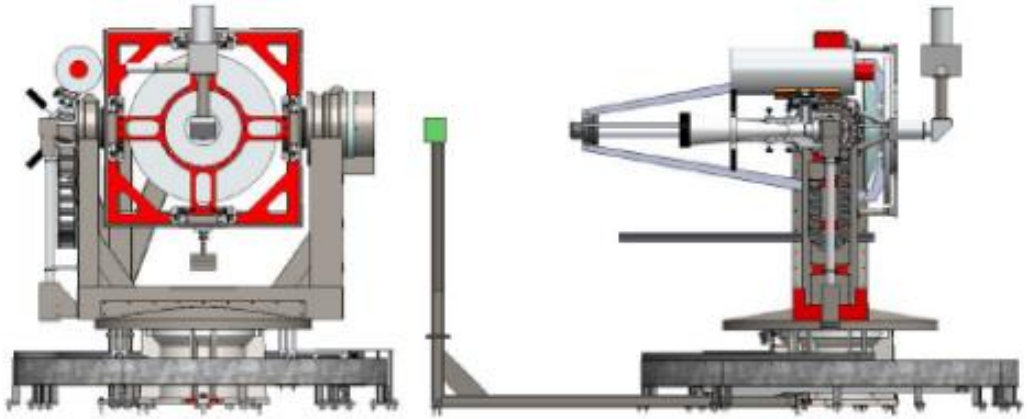


- *Control subsystem: **FPGA-RGG** developed by SFEL*
- *ToF measurement subsystem: **Event Timer** A032*
- *Time&Freq subsystem: ROA-PPS Synchro, Rubidium and White Rabbit*

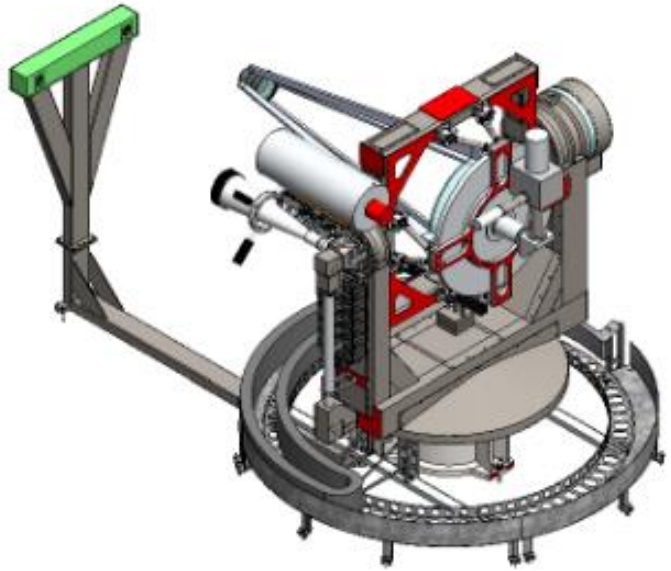
Altazimuth Mount (weakness):

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

ν Mount



- *Ready for 80 cm mirror & modular additions*
- *Incorporates coudé path*
- *Invariant point error <0.5mm*

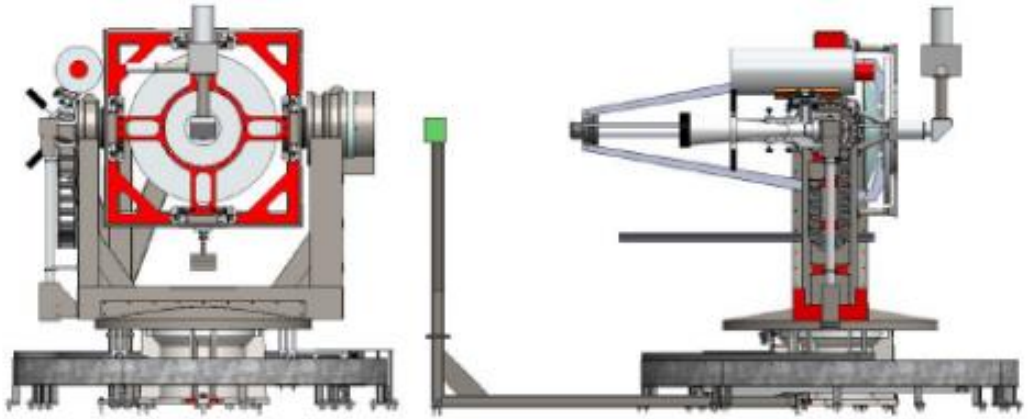


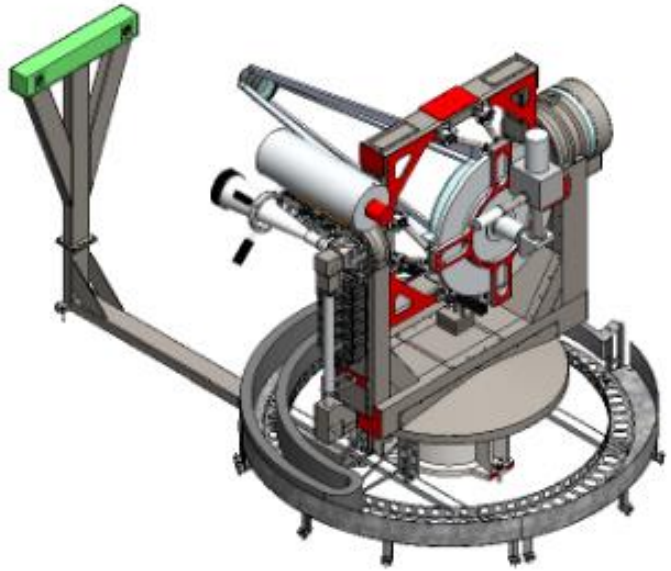
Key Aspects of the New Mount (AMELAS)

Delivered by AVS (18th July 2024)

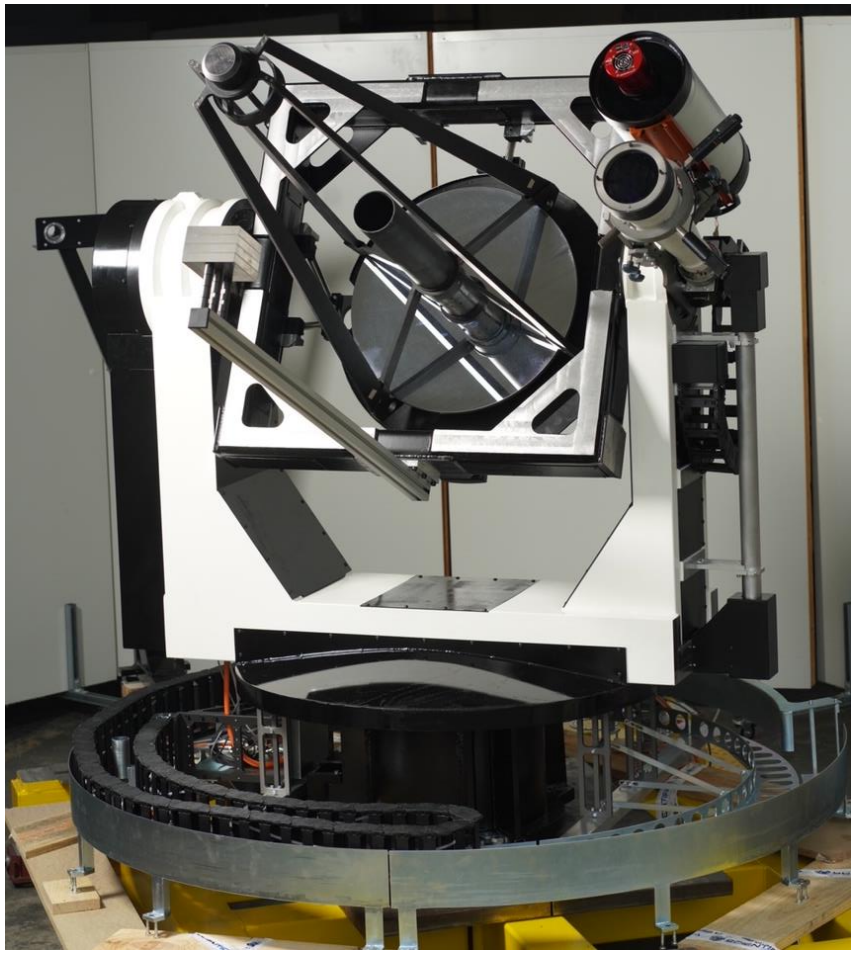
Main characteristics

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

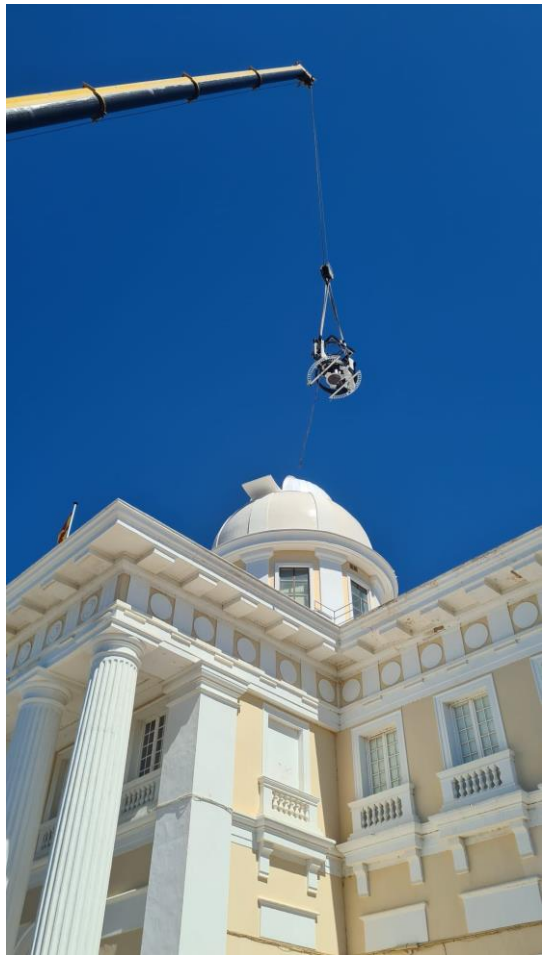


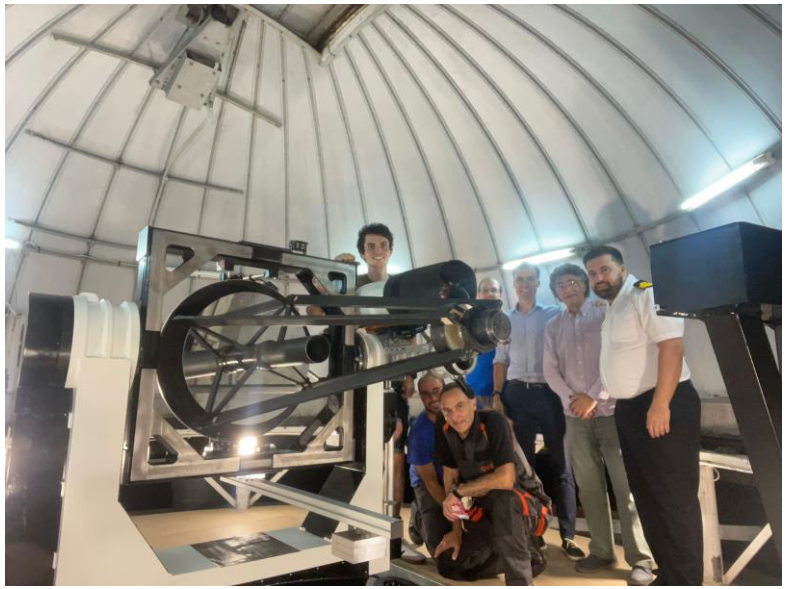


AMELAS Project



AMELAS Project

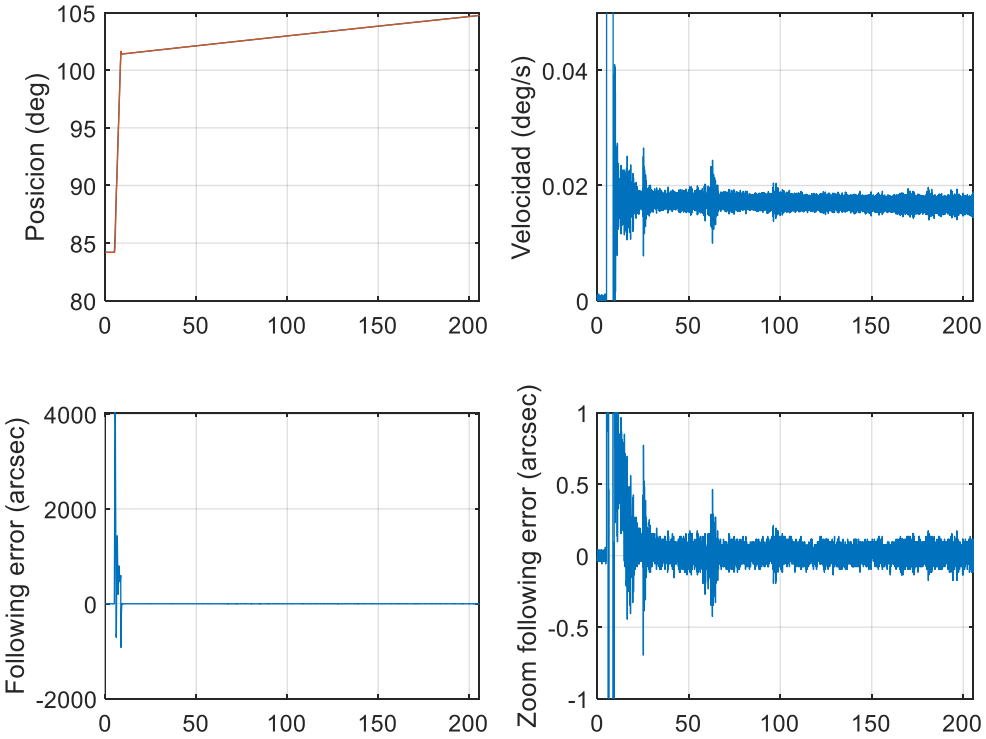




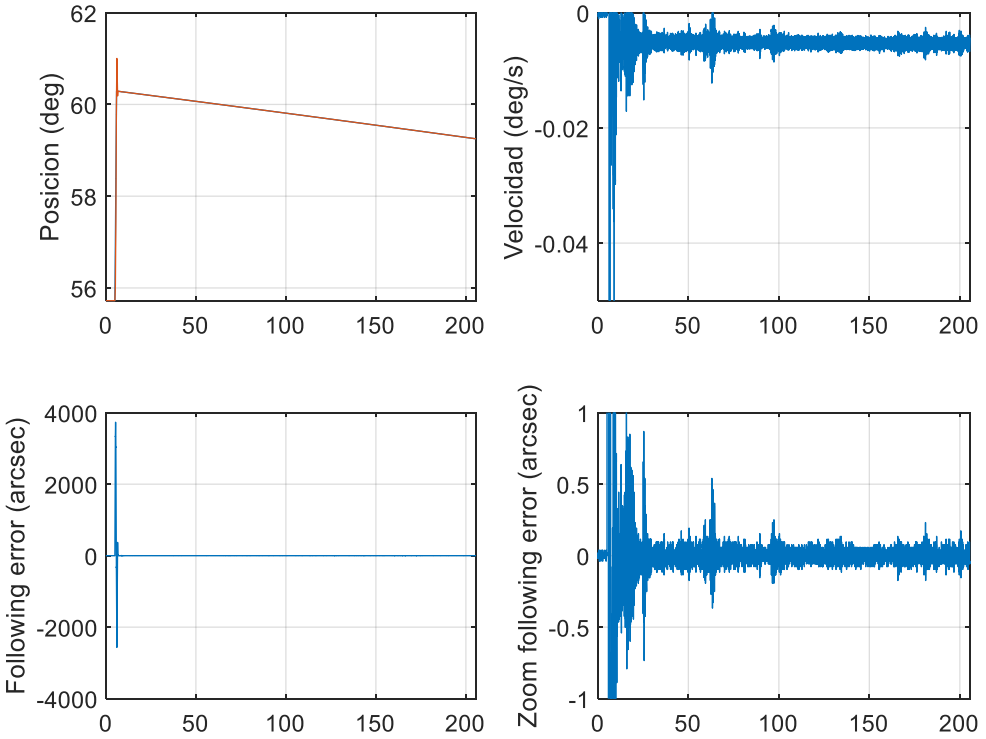



AMELAS Project

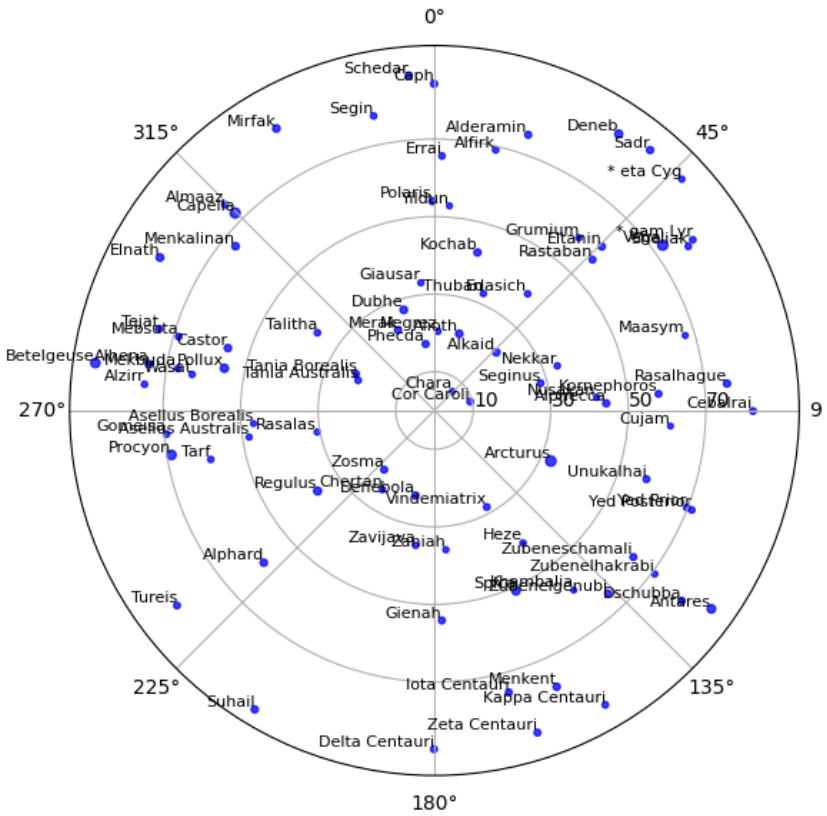
Azimuth



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
IE	index error in elevation
IA	index error in azimuth
CA	nonperpendicularity of elevation and pointing axes
AN	NS misalignment of azimuth axis
AW	EW misalignment of azimuth axis
NPAE	nonperpendicularity of azimuth and elevation axes
ACES	Az centring error (sin component)
ACEC	Az centring error (cos component)
ECES	El centring error (sin component)
ECEC	El centring error (cos component)
NRX	Horizontal displacement of Nasmyth rotator
NRY	Vertical displacement of Nasmyth rotator
AUX1A	Az change supplied through auxiliary reading 1
AUX1S	LR change supplied through auxiliary reading 1
AUX1E	El change supplied through auxiliary reading 1

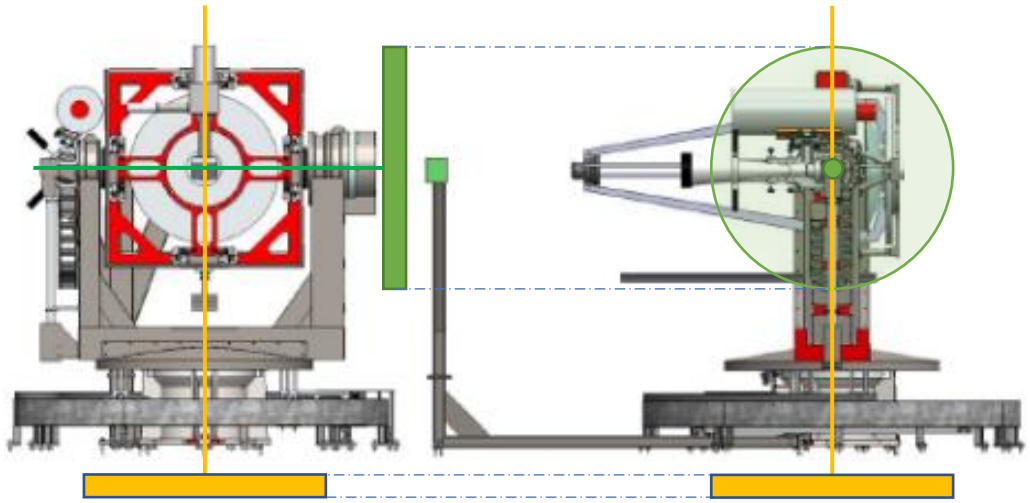
ZH	AAT HA Z-gear effect in HA
ZE	AAT HA Z-gear effect in polar axis elevation
HF	AAT main east-west horseshoe flexure
HGES	36^m gear error in HA – sin
HGEC	36^m gear error in HA – cos
DGES	9° gear error in Dec – sin
DGEC	9° gear error in Dec – cos
TFP	AAT tube flexure – non-Hooke's-law term
HFX	AAT residual horseshoe east-west
HFD	AAT residual horseshoe north-south
CD4A	AAT coudé 4 collimation error A component
CD4B	AAT coudé 4 collimation error B component
CD5A	AAT coudé 5 collimation error A component
CD5B	AAT coudé 5 collimation error B component

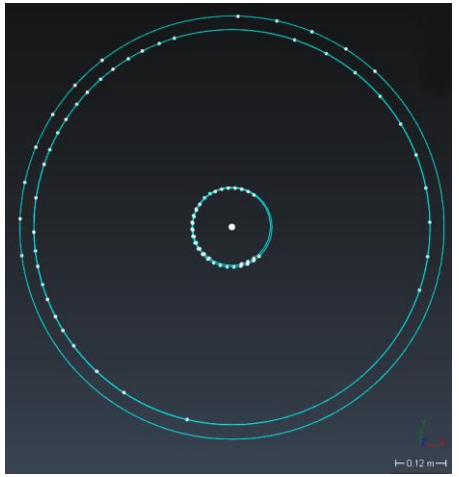
Definition of the new invariant point and global TIE

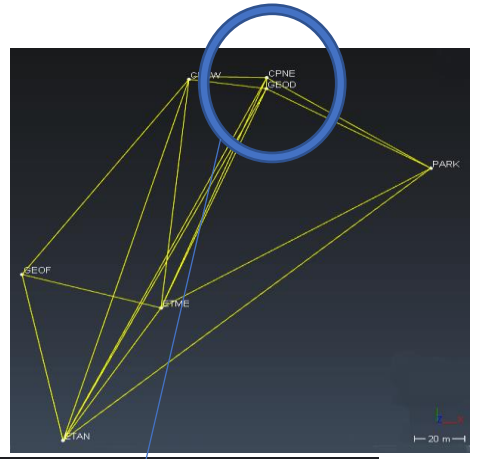
Exterior topographic/geodetic (7 points) network, local network inside the dome and the link between both.

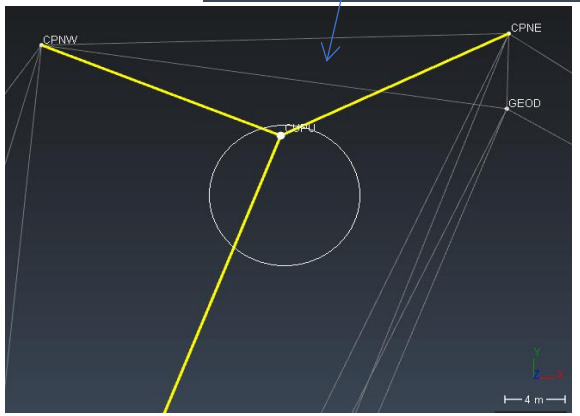
Combine classical topography and geodesy methodologies and dimensional control and mesaurement of structures.

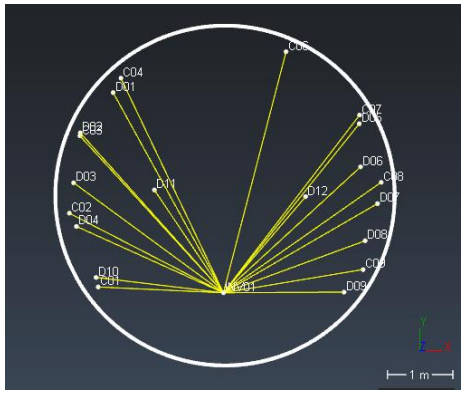
Report will be submitted to ILRS.











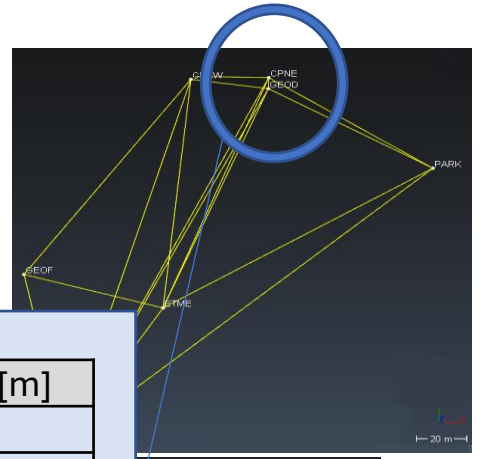
Definition of the new invariant point and global TIE

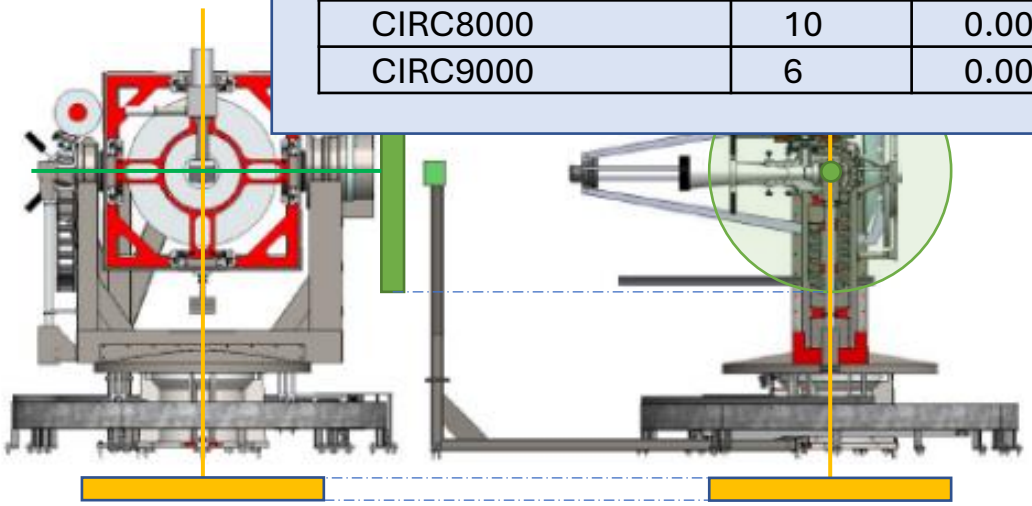
Exterior topographic/geodetic (7 points) network, local network inside the d

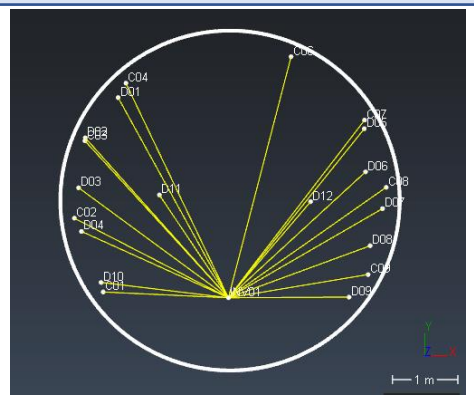
Com
dime

Repo

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



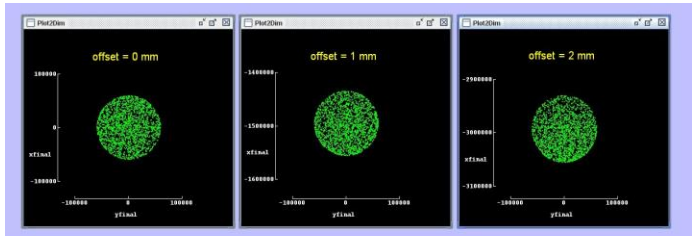


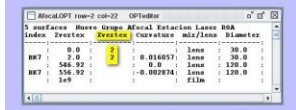


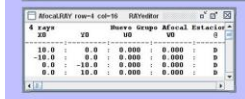
Improvement in other subsystems

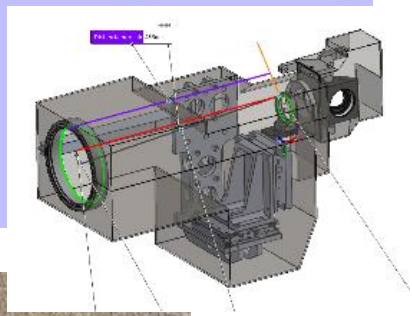
New ToF Measurement System

- *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

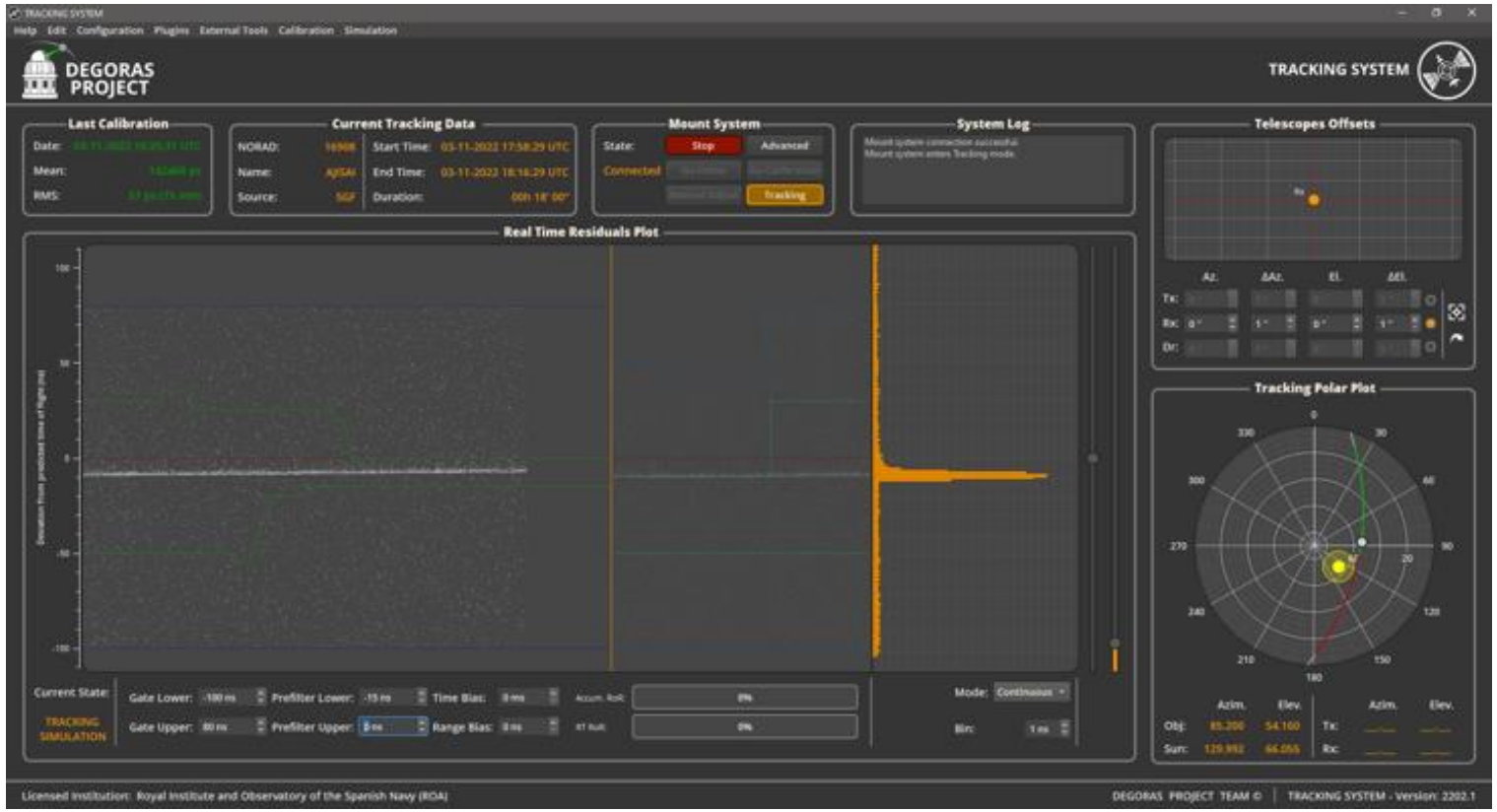
- *Celestron RASA 8 + CMOS ZWO ASI 2600*
- *Useful for space debris*

Improvement in other subsystems

Software Development

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

Improvement in other subsystems



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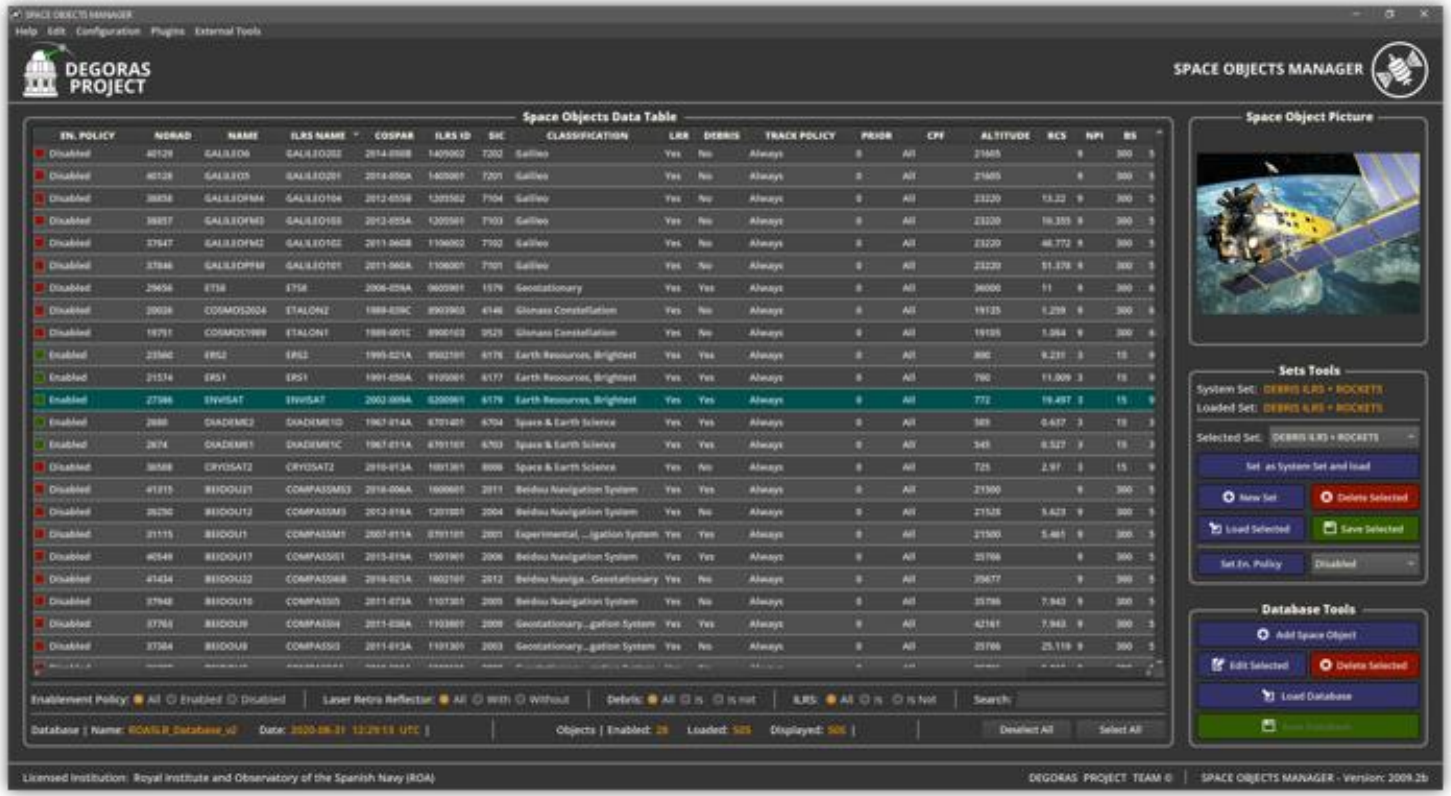

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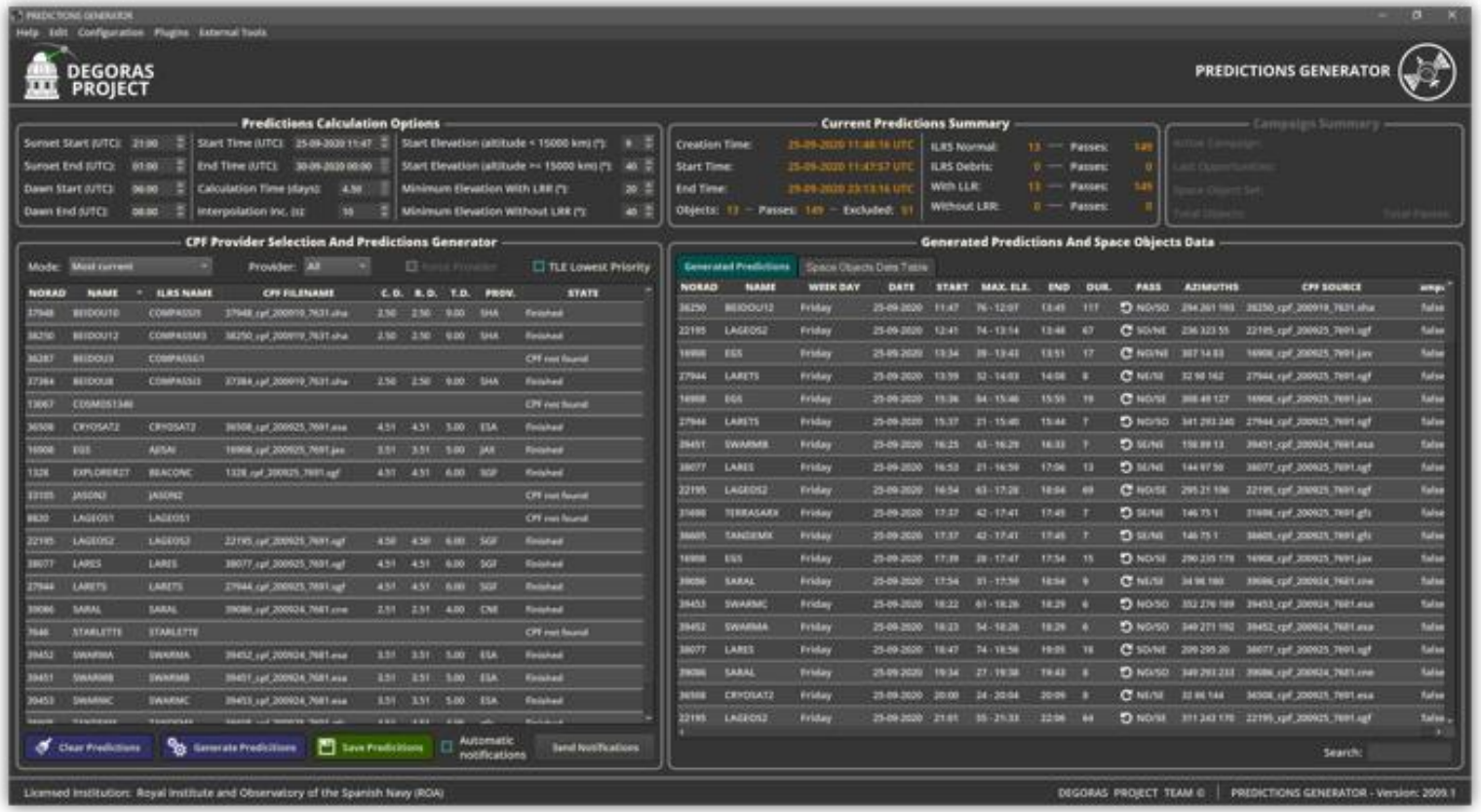

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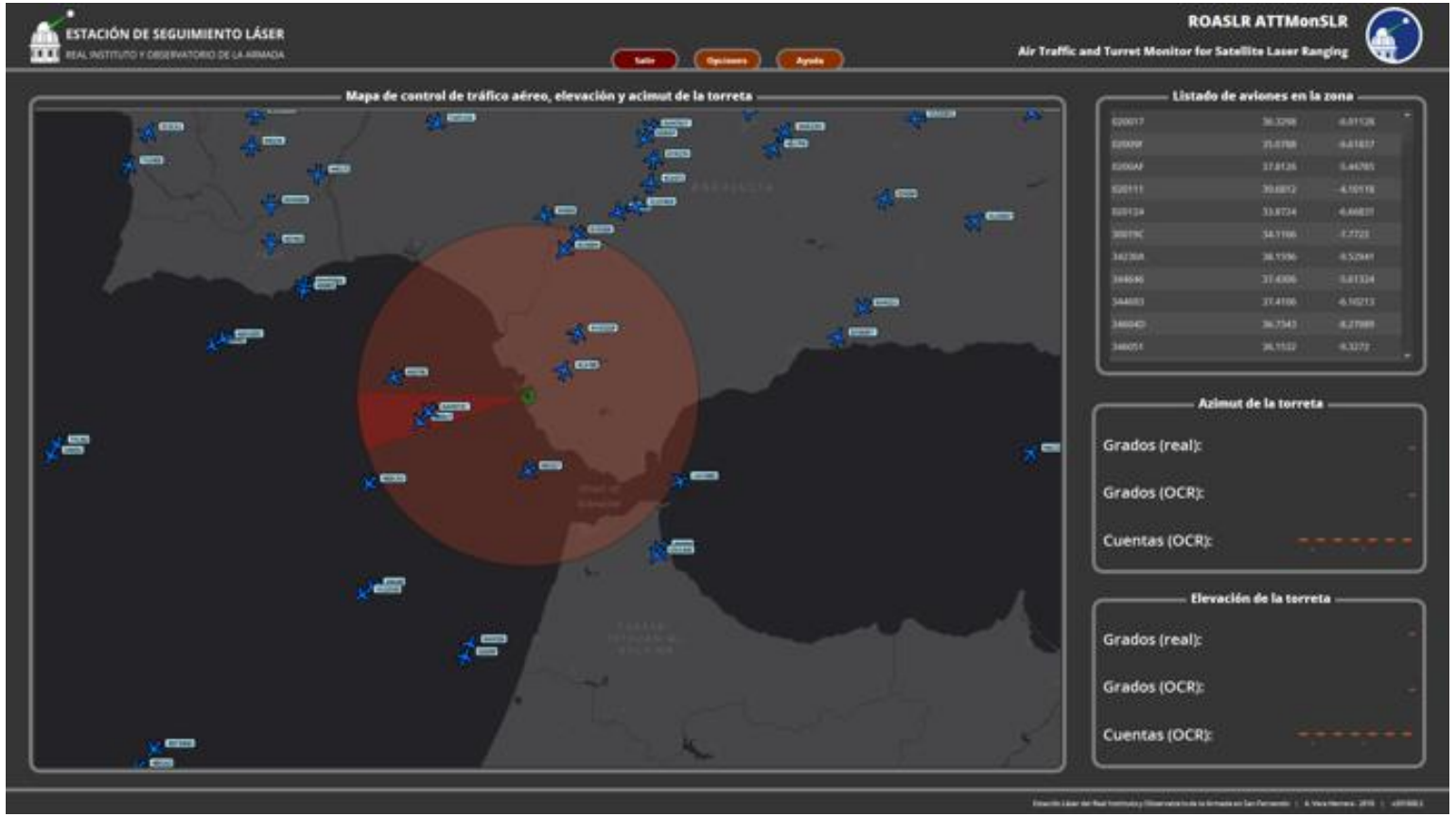

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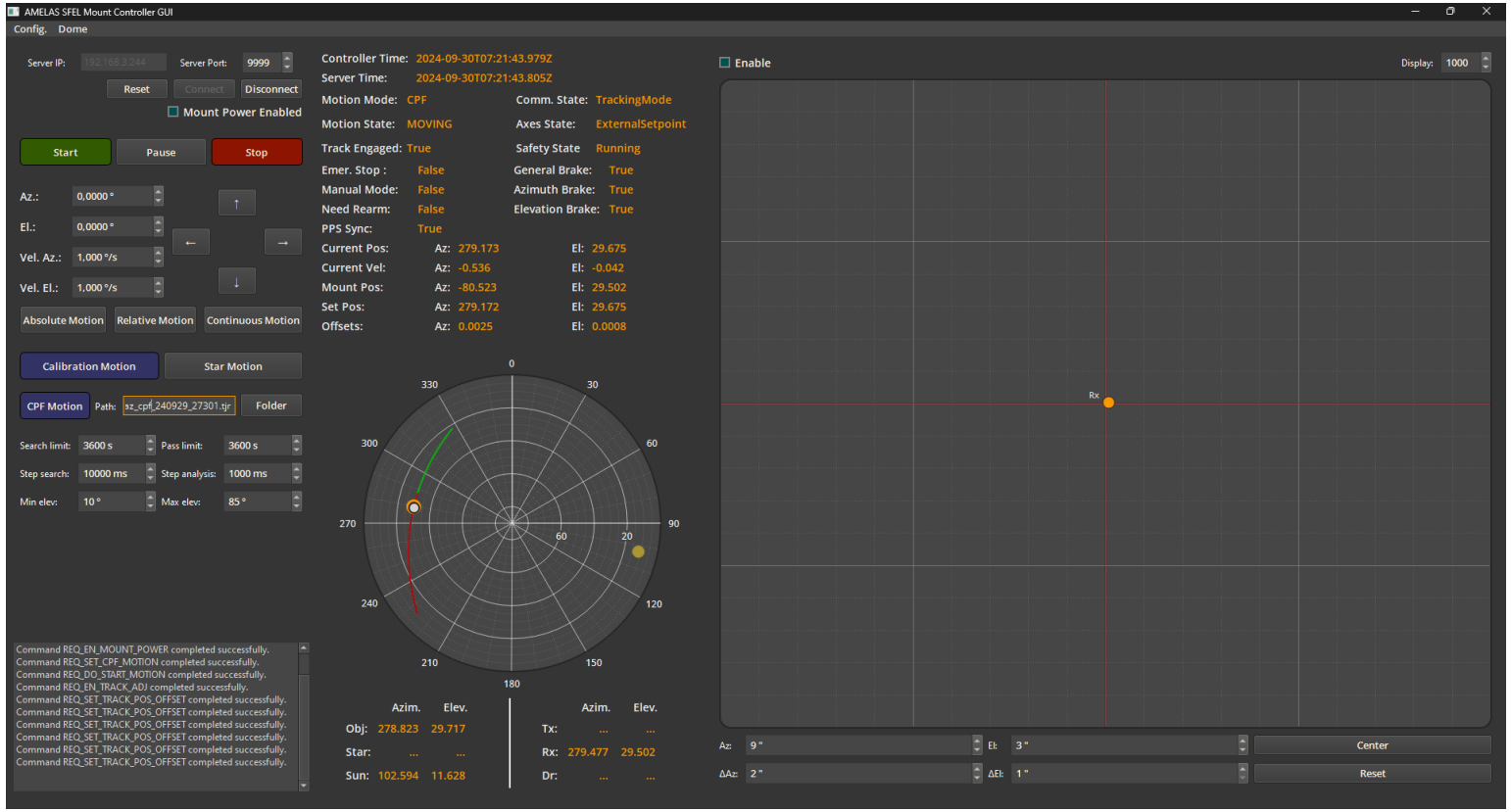

Software Development

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- ***Mount Control***

Upcoming projects

TERELAS

New Cassegrain Telescope (800 mm)

1 arcsec star image

Lighter and greater reflectivity

Space debris

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

CUPROA

Speed >15º/s (re-entries)

Slit dome according to TERELAS aperture

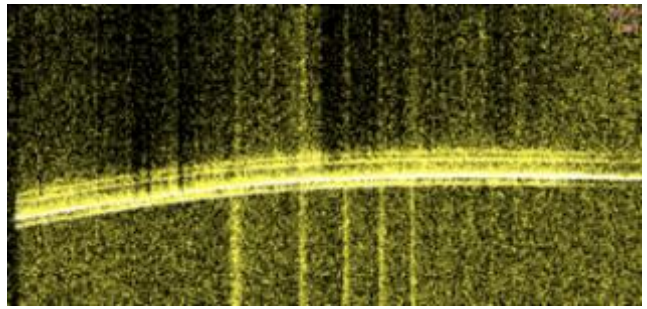
Integrated in station control SW

KIROA

New KHz laser

Combine in the same device ILRS and SST tasks

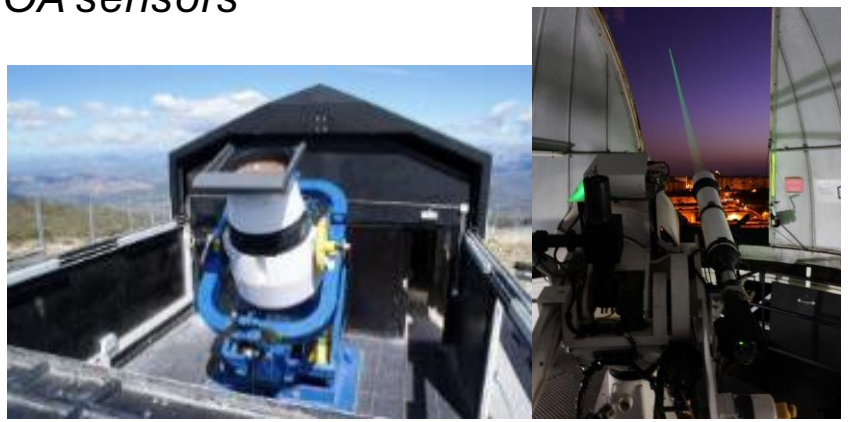
532 nm, 1-5 KHz, 20 W, < 75 ps

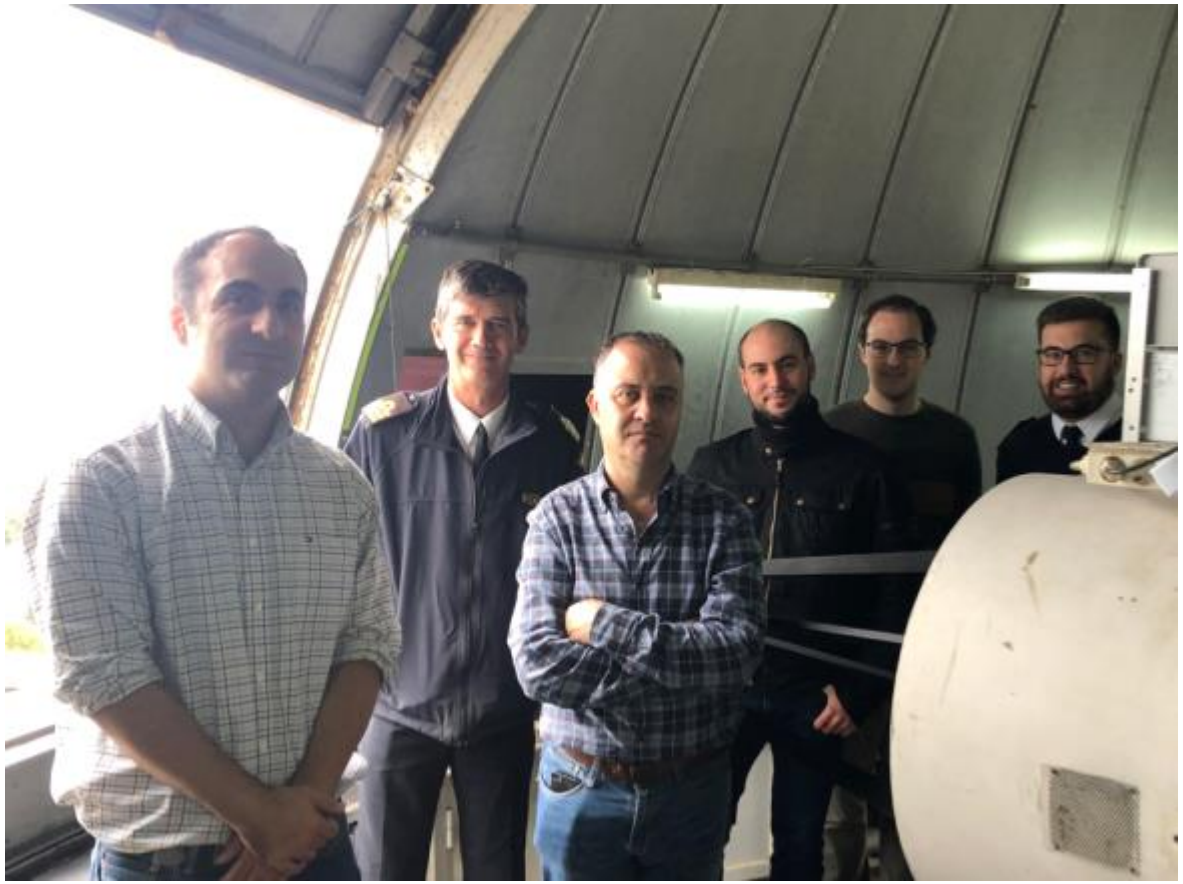


CORA

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,…*

¡Thanks for your attention!

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