# Strategy for GEO survey and results from NEEMO-T03 telescope in Romania

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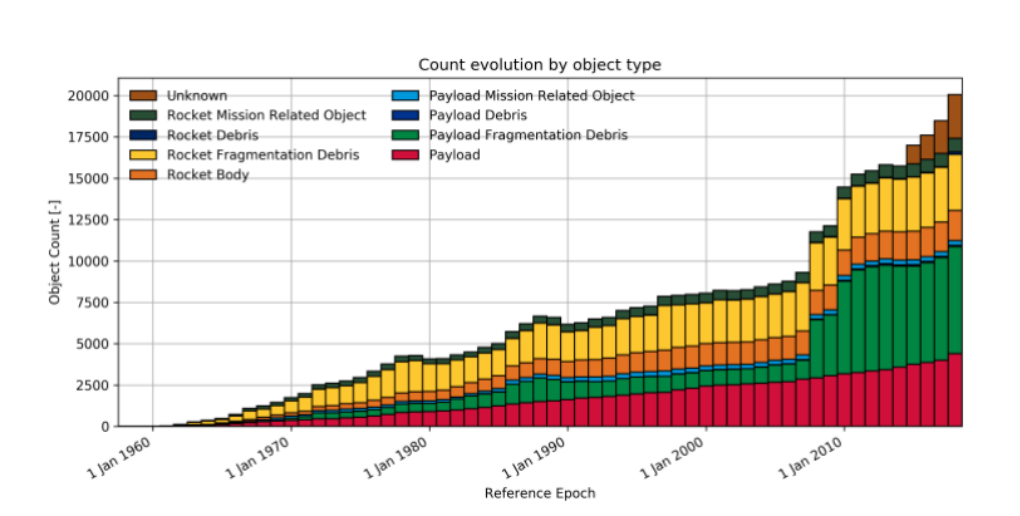
# Context




*Source: ESA'S ANNUAL SPACE ENVIRONMENT REPORT (2021)*

Space Scoreboard

| OBJECT TYPE | APPROX OBJECTS |
|---|---|
| Active Payloads | 5600 |
| Analyst Objects | 18800 |
| Debris | 20100 |
| Total | 44500 |

*Source: www.space-track.org*

**Currently (as of March 2022)*

High number of artificial space objects→ constant monitoring → SST activities

- Since 2018 Romania is a member in EU SST* Consortium
- National Centre for Space Surveillance and Tracking (COSST)
  - developing and improving the national sensor network
  - planning and coordination of sensors
  - processing and analysing the astronomical data

**European Union Space Surveillance and Tracking (www.eusst.eu)*

# Equipment

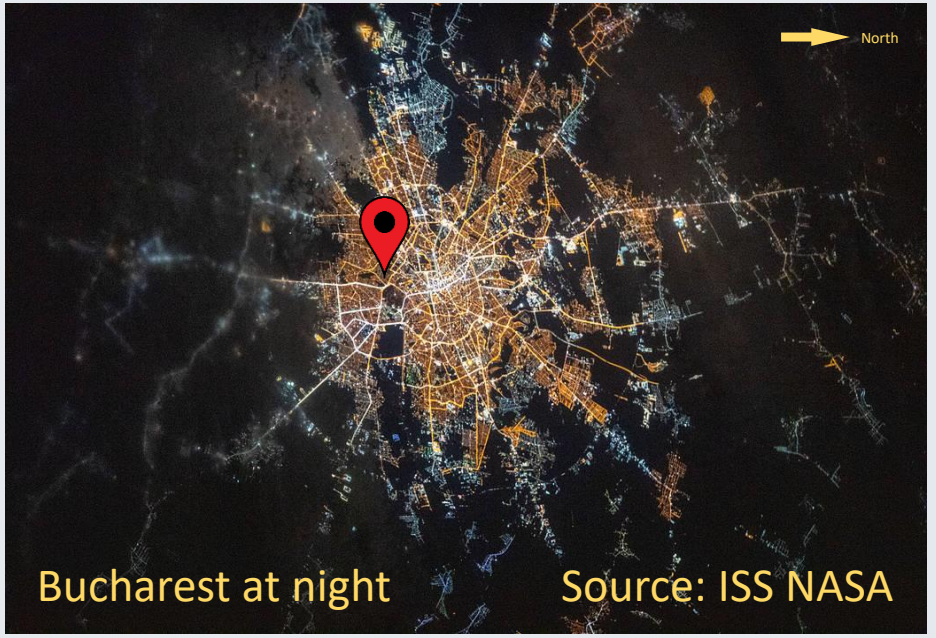
- Mobile platform (IAU code 073)

*Birlan, M., et all (2019); Trelia, M., et all (2020 )*

- Alt-az direct drive L-600 Planewave mount capable of tracking objects from LEO to HEO

- Two telescopes supported by the same mount:
  - NEEMO-T05 – 0.5 m f/7 Riccardi Dall-Kirkhamn
  - NEEMO-T03 – 0.35 m f/2.8 Riccardi-Honders astrograph

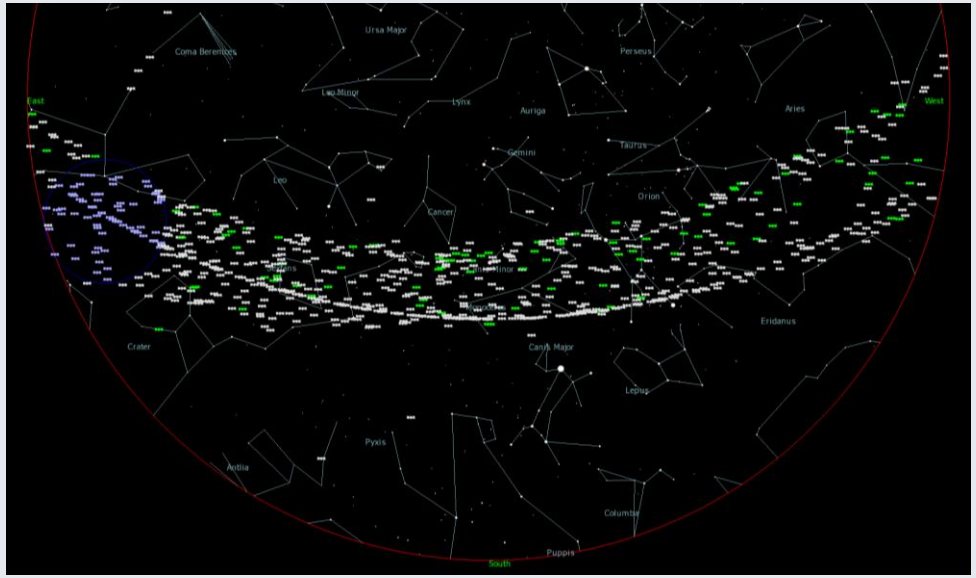
- FLI Kepler4040 sCMOS camera with
  - 4096 X 4096 pixels array
  - FOV of 2.1°X 2.1°
  - resolution of 1.85”/px (T03)



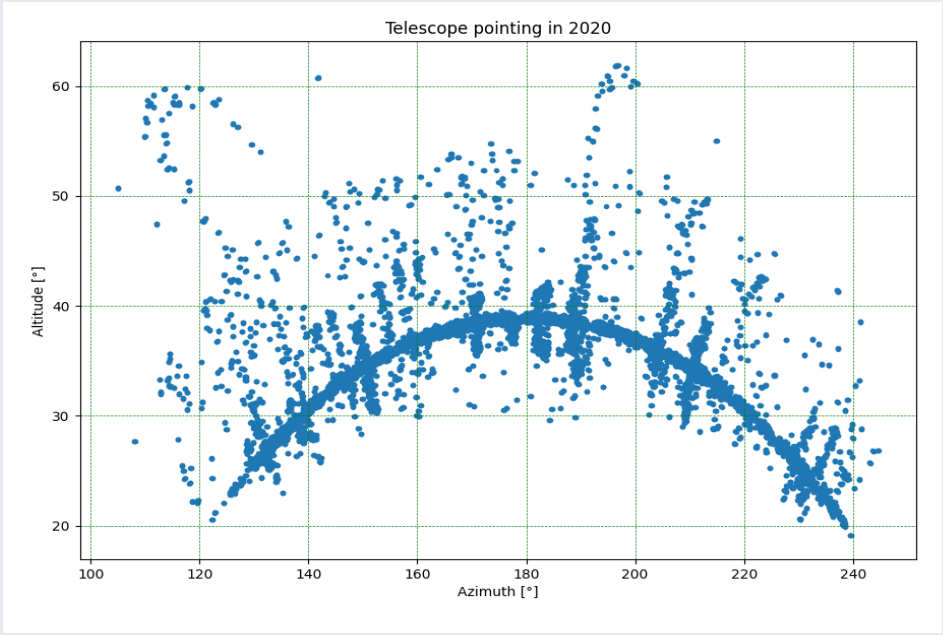

# Observation strategy

Several runs each night

trade-off no. of objects vs. no. of individual images acquired → GEO objects (DEC=-6,5 deg within the limits of the FOV) → Eastern horizon → 3 consecutive images/field 2.5 seconds exposure time → telescope moves to the West → new set of 3 images are acquired → Repeat



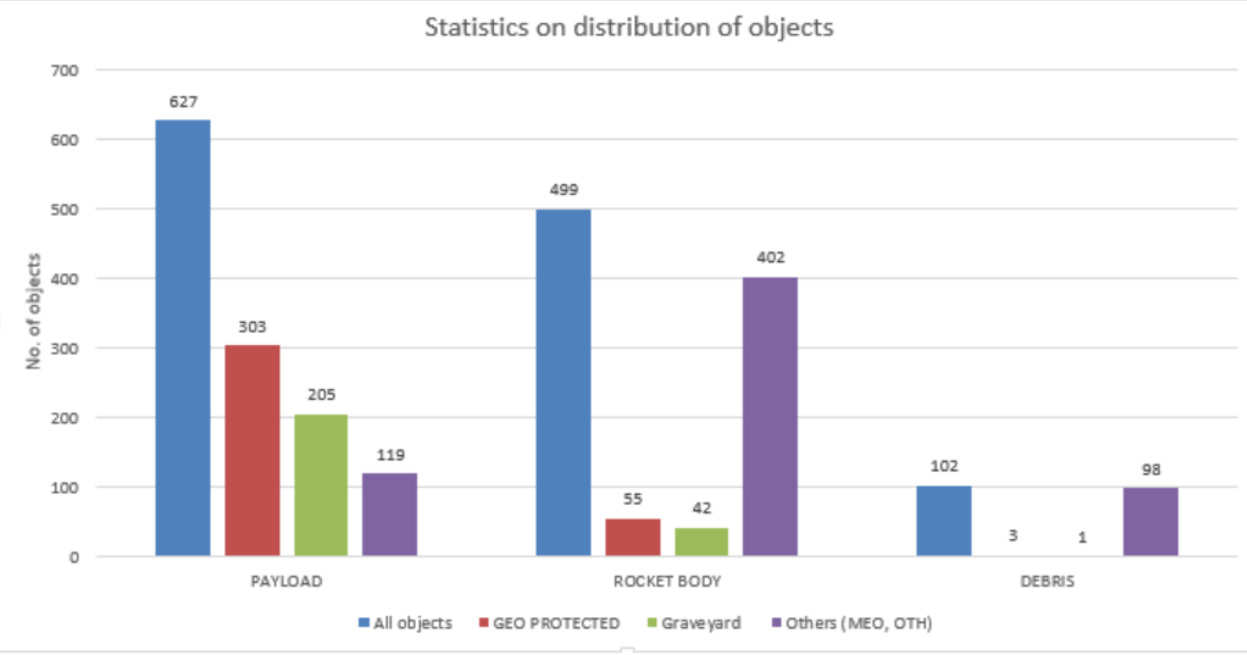

Sky from Bucharest on 21 March 2022, 21:00 UTC

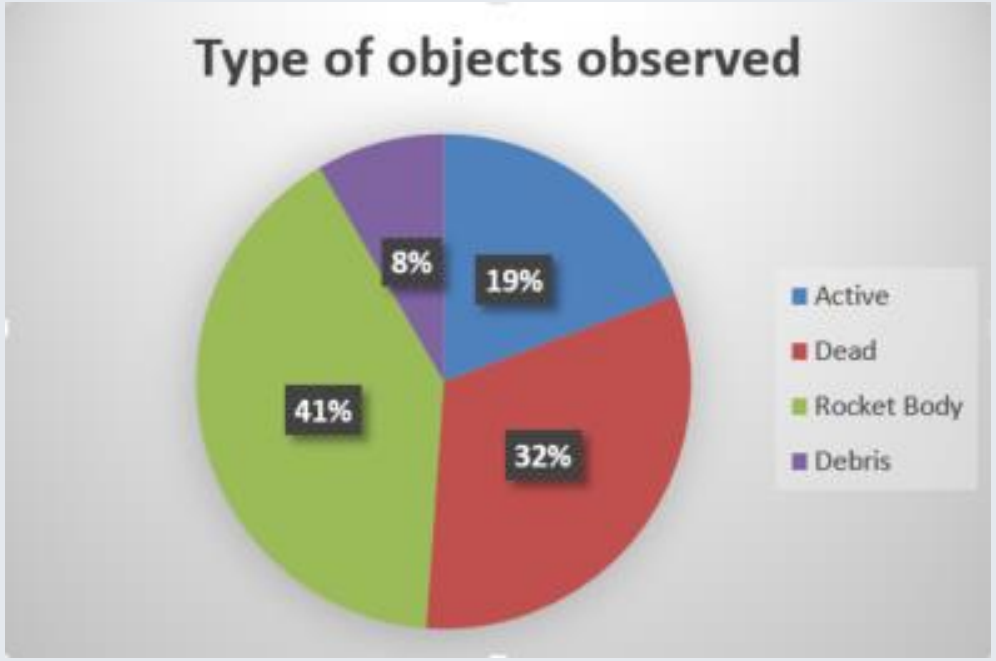


# Results (2020-2021)

- ✓ 32 535 tracks for **1 230** unique objects
- ✓ **1/3** of total no. of objects from GEO Protected Zone and Graveyard orbits respectively
- ✓ smallest objects observed have RCS = 30 $cm^2$ at furthest distance of 45 000 km

RCS = Radar Cross Section



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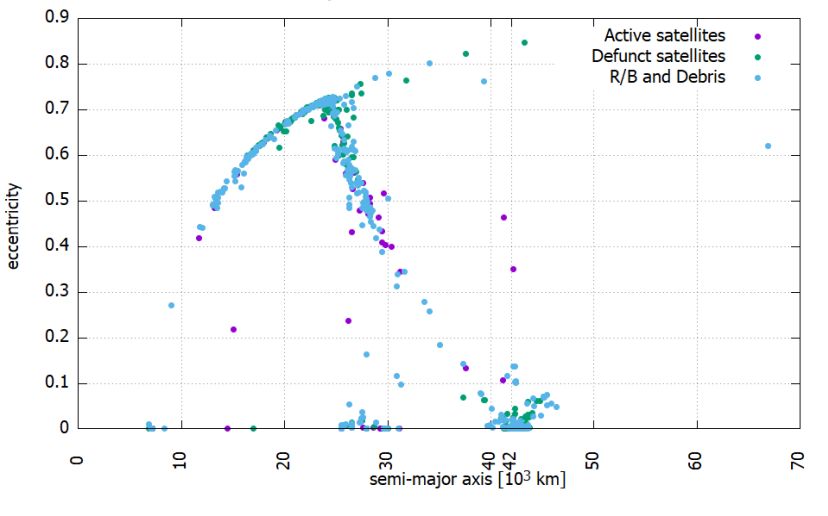
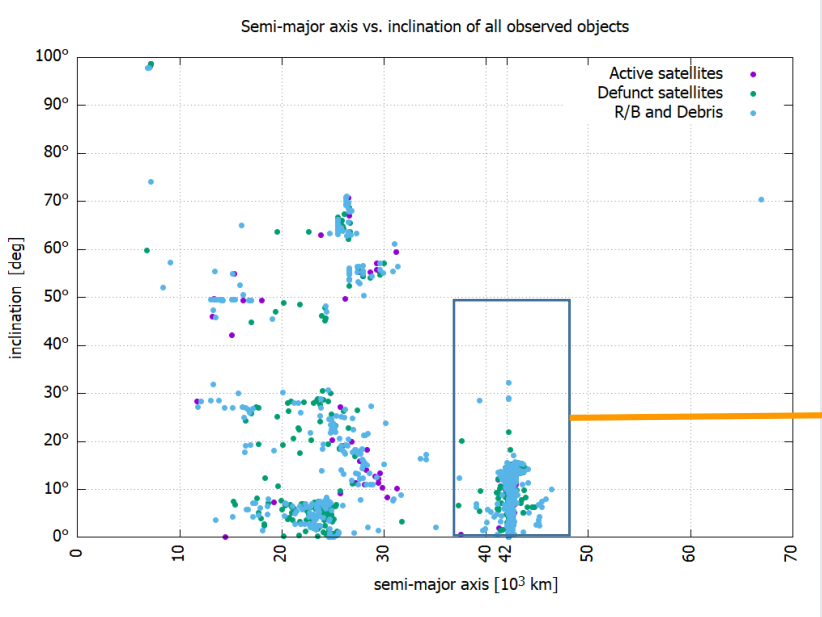
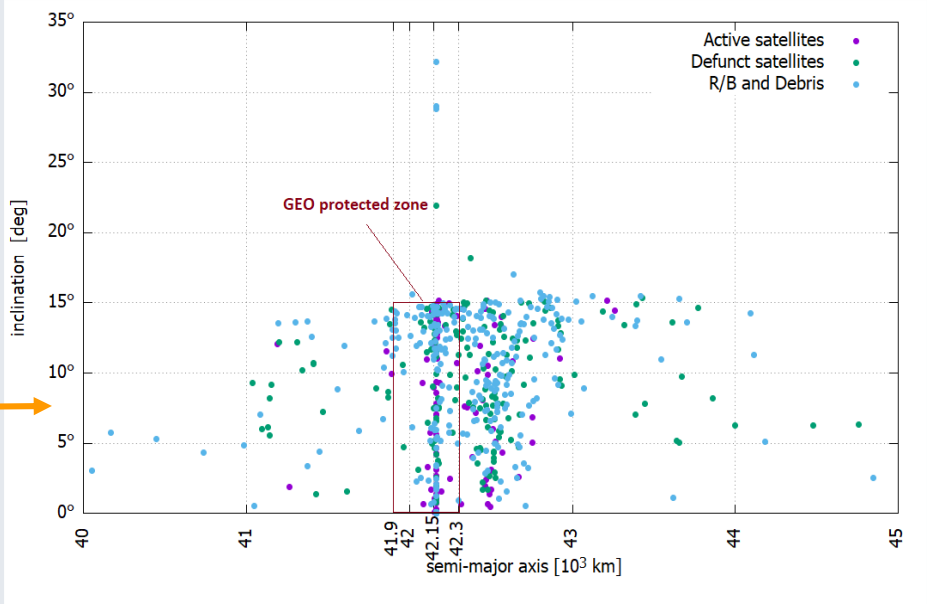


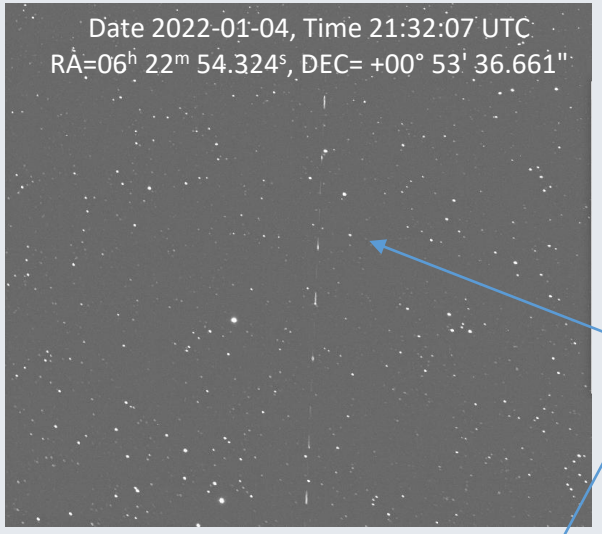

- ✓ 2 representative groups in MEO & GEO
  - Navigation Satellites: Galileo (calibration campaigns), Glonass, GPS
  - Upper stages in GTO (Geostationary Transfer Orbits)
  - Defunct satellites in graveyard orbits



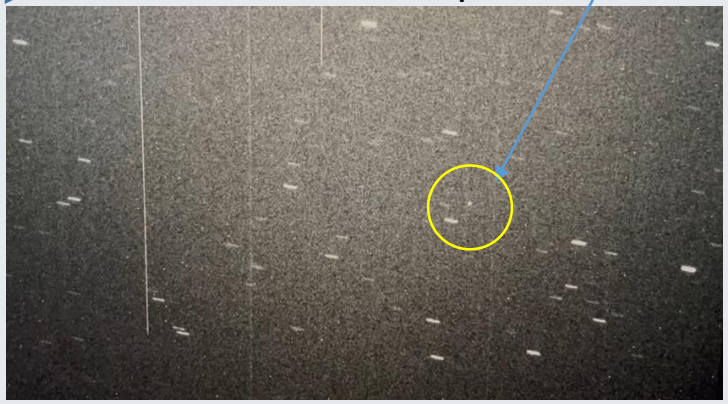
# Additional science

Asteroids observations



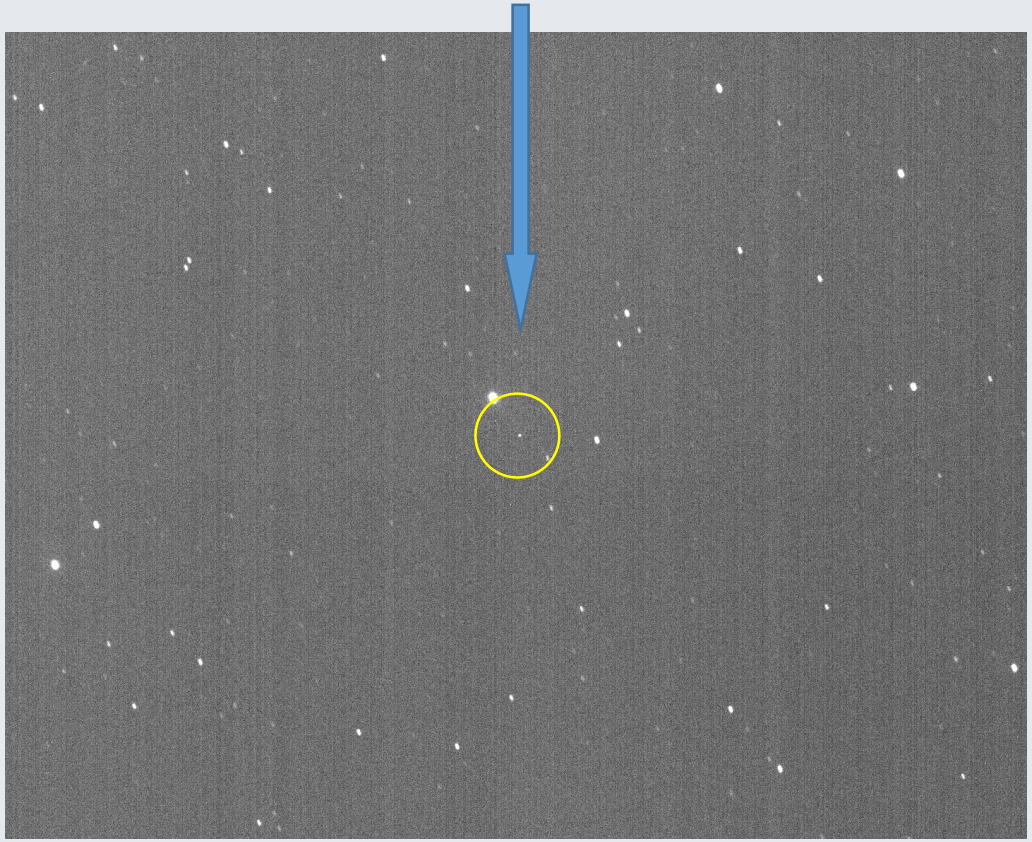

Satellites with brightness variations

Routine EU SST operations



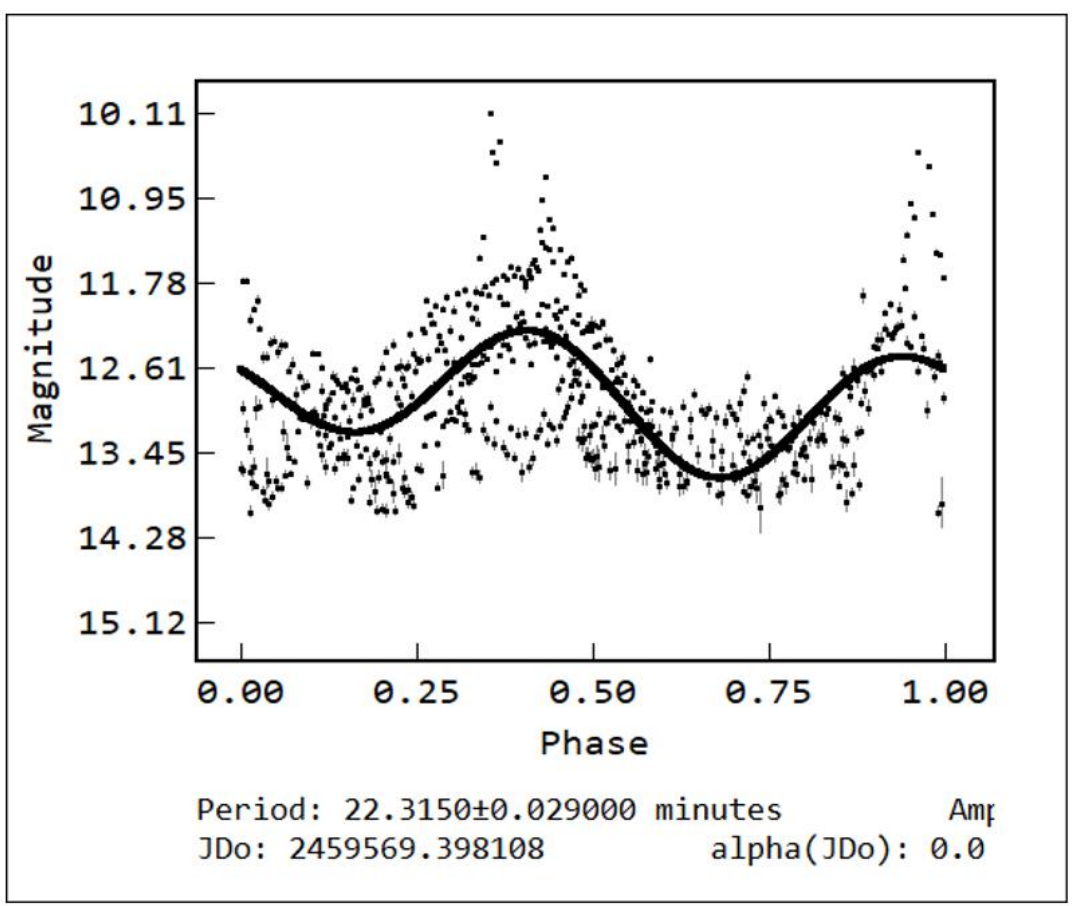
Different strategy

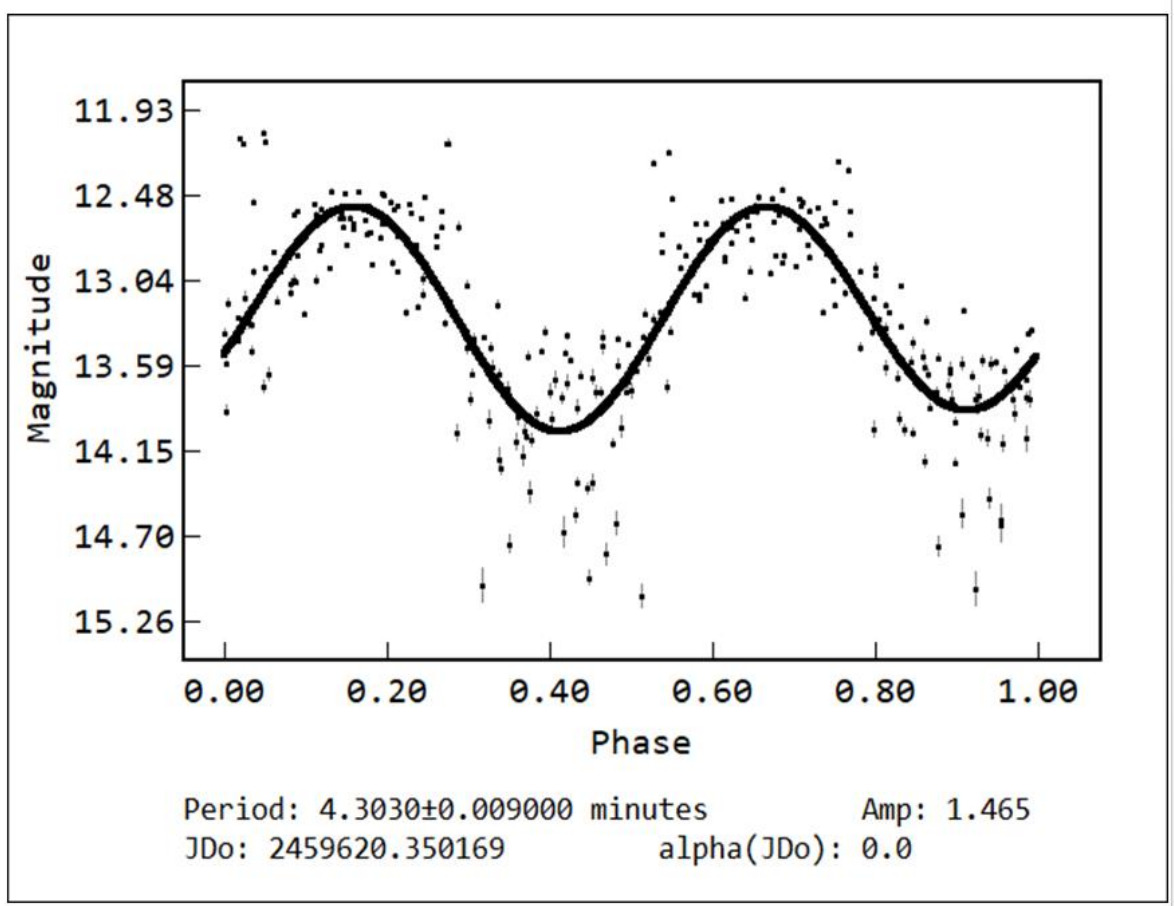
- NEEMO-T03 telescope in tracking mode
- 1 sec exposure time
- 1→2 h continuous observations



Satellite 1981-073A
Date 2022-02-15

# Lightcurves




**Phased plots for two defunct satellites, 1981-073A (left) and 1984-063A (right).**

# Conclusions

- Current strategy to survey  GEO satellites with  NEEMO-T03 telescope
- Analysed data from 2 years of operations in EU SST
- Evaluate the telescope  performance assessing
  - survey completeness of objects orbiting in the GEO protected region  and graveyard orbits at ≈ 1/3 of the total population due to visibility constraints (inner city observatory
  - minimum RCS = 30 $cm^2$ at 45 000 km
  - detected a significant population of objects with HEO
- Additional science
  - satellites with brightness variations
  - telescope in tracking mode
  - obtain their lightcurves
  - determined their rotational period
  - one object is a tumbler
  - second completes a rotation in ≈ 4 minutes
  - further systematic study to be made during my PhD thesis

THANK YOU FOR YOUR ATTENTION!

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