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

Madalina Trelia\(^{(1),(4)}\), Adrian Sonka\(^{(2),(7)}\), Mirel Birlan\(^{(2),(3)}\), Dan Alin Nedelcu\(^{(2),(3)}\), Violeta Poenaru\(^{(4)}\), Mugurel Balan\(^{(5)}\), Maria Alexandra Nita\(^{(6)}\)

\(^{(1)}\) Romanian Space Agency, Str. Mendeleev 21-25, 010362 Bucharest, Romania, madalina.trelia@rosa.ro

\(^{(2)}\) Astronomical Institute of the Romanian Academy, Str. Cutitul de Argint 5, 040557 Bucharest, Romania

\(^{(3)}\) IMCCE, Observatoire de Paris, 77 av Denfert Rochereau, 75014 Paris cedex, France

\(^{(4)}\) University of Bucharest, Faculty of Physics, Doctoral School of Physics, Str. Atomistilor 405, Magurele, Ilfov, Romania

\(^{(5)}\) Institute of Space Science, Str. Atomistilor 409, 077125 Magurele, Ilfov, Romania

\(^{(6)}\) GMV, Romania, 246C Calea Floreasca, SkyTower 32nd Floor, 014476 Bucharest, Romania

\(^{(7)}\) Amiral Vasile Urseanu Astronomical Observatory, Bb. Lascar Catargiu, no 21, Bucharest, Romania

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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

- 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

Several runs each night

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

GEO objects (DEC=-6.5 deg within the limits of the FOV)
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
Results (2020-2021)

- 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

![Graph 1: Semi-major axis vs. inclination of all observed objects]

![Graph 2: Active, Defunct, and Debris Satellites vs. Eccentricity and Semi-major Axis]

![Graph 3: Semi-major axis vs. inclination of all observed objects with GEO protected zone highlighted]
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 cm² 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!

Madalina Trelia
Romanian Space Agency/University of Bucharest
madalina.trelia@rosa.ro