Space debris problem and the potential Slovak contribution to related development, research, and industrial services

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Space Safety

Space Debris



Planetary Defense





Clean Space

Space Weather



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Human space activities

Satellite infrastructure

Manned flights





Space debris overview

Fragments

• Everything created by human and its activities in space but no longer suit any purpose

Defunct spacecraft



Fig. – Astra GEO satellite Astra 1E/1F Source: SES Astra



Fig. – ENVISAT, picture taken by Pleiades S/C **Source:** ESA/CNES

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Fig. – Al2O3 slag, MLI foil, solar panel Source: NASA

Rocket upper stages



Fig. – Upper stage Agena D Source: NASA





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European services and R&D activities

Collision Avoidance



Re-entry Analysis



Fragmentation Analysis



Active Debris Removal



In-Orbit Servicing



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Space Debris service – Collision Avoidance example





70-cm mirror



Fig. – AGO70 research telescope

Slovak contribution – ground-based infrastructure 20-cm mirror



Fig. – Astros-2 experimental survey telescope at Astronomical and Geophysical Observatory, Modra (SK)



Fig. – ESA LEO satellite SENTINEL 3A Satellite captured with Astros sensor. Astros Solutions s.r.o.

at Astronomical and Geophysical Observatory, Modra (SK). Photo credit: Stanislav Griguš

Fig. – Astra constellation captured with AGO70 sensor using BVR filters. Zigo et al. (2021)



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Slovak contribution – rotation dynamics modeling



Fig.– Photometric measurements acquired by AGO 70cm telescope during night 20181016 (left) and the constructed light curve (middle) and its phase diagram (right) for the object Titan 3C Transtage R/B (74039C). Hrobár et al. (2022), Kyselica et al. (2022)



Fig.— Animation depicting ClearSpace-1 captures Vespa. Credit: ESA

Light curve for object 13021D (AVUM DEB - ADAPTOR), 80 points with total length of 230 s



Fig.– Photometric light curve acquired by AGO 70cm telescope during night 20200812 (left) for the object Avum Deb Adaptor (13021D). Šilha et al. (2021)

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Slovak contribution – re-entry events modelling







Fig. – AMOS recording of CZ-3B R/B acquired by **AMOS-HK**, duration 51.65 s, 1033 frames

Video credit: Comenius University

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Slovak contribution – re-entry events modelling

AMOS-MK

AMOS-HK

Fig. – Time vs heigh for four selected fragments for which the tarjectories were estimated using new proposed method of LOS intersections. Pure geometry is considered at this stage. Bartková et al. (2023)



Slovak contribution – object characterization





Fig. Reflectance spectra of LEO satellites acquired by AMOS-Spec cameras. Žilková et al. (2022)



ESA SK-S2P study





- ESA Contract No. 4000136251/21/D/AP Slovak Space Safety Programme (SK-S2P) study
- Potential of Slovak academia and industry in Period 2





Space Debris Core



DRACO



ADRIOS



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Way forward and conclusions

- Space safety and space debris related services crucial for sustainability of space missions
- Large step for Slovakia becoming Associated MS of ESA
- Slovak academia and industry able to join ESA S2P activities and be part of international consortia
- Slovak strong potential contributions to ground-based observations, re-entry analysis, ADR and IOS support



Fig. – Map of ESA MS Zdroj: ESA



Thank you for attention !