Space Debris Research in Switzerland

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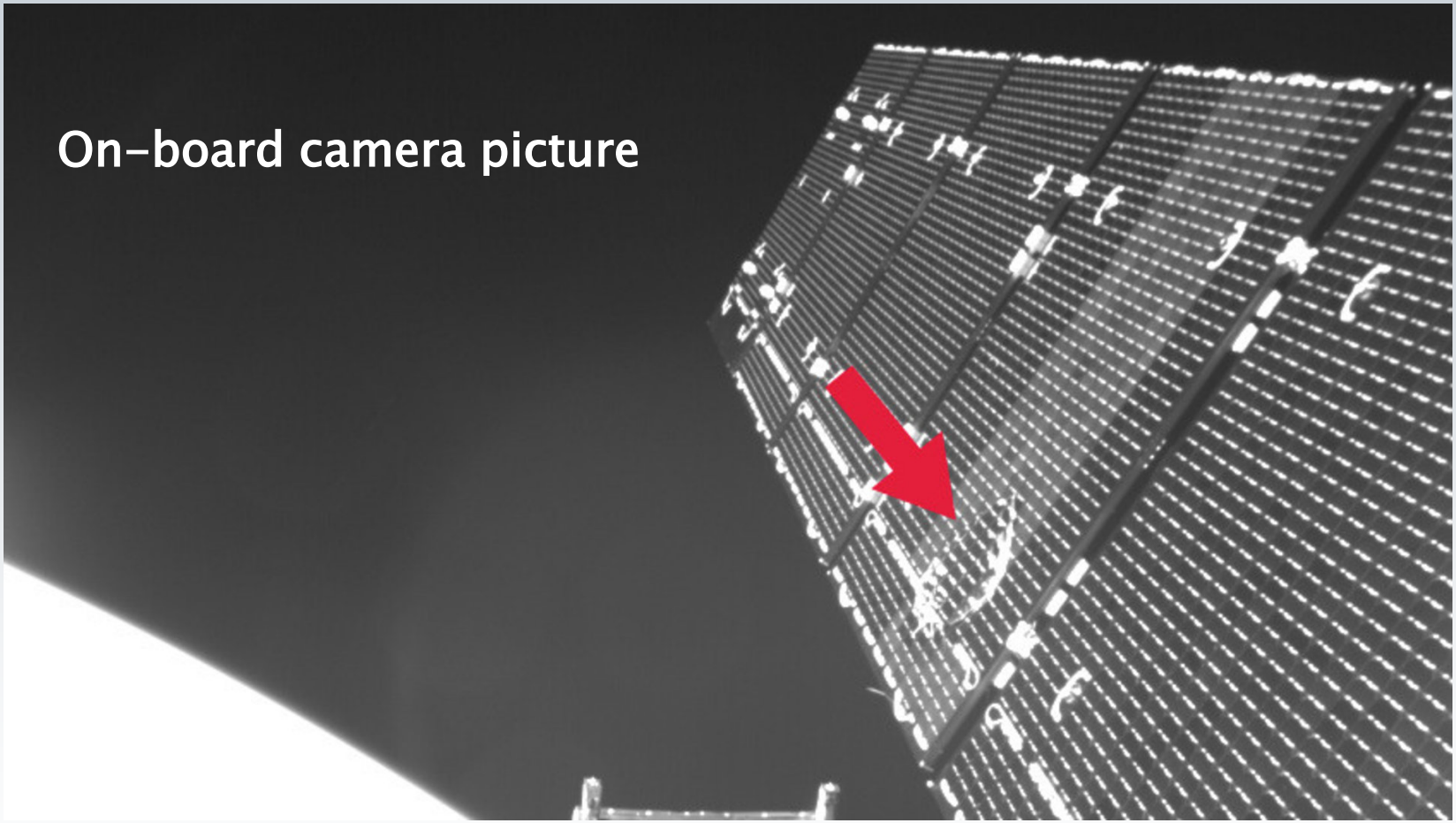
Why should we Care

- S/C Owners/Operators
  - Safety of flight
  - Prevent collisions (traffic management, collision avoidance maneuvers)
  - Contingency: cause?
- S/C designers
  - Risk analysis
  - Shielding (shields, passive shielding)
- Mission analysts, launch campaigns
  - Risk analysis, trajectory optimization
  - Launch conjunction analysis
- Governments, Space Agencies, Scientists
  - Protecting vital space services
  - Long term sustainable use of space
  - Evolution

Sentinel-1A

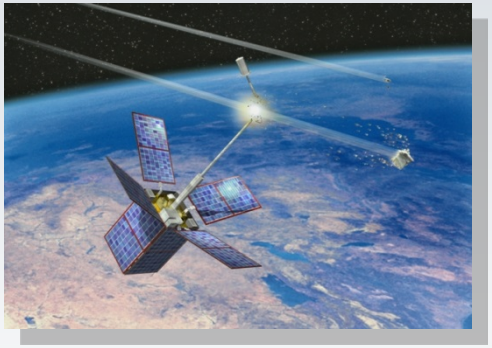


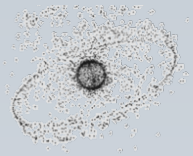
Impact on August 23, 2016

Small power loss (5%) → analysis revealed attitude & orbit changes → mm-size impactor (SSN found 5 obj. in vicinity)

Space Debris Research

- Open Questions
  - Population
    - how many?
    - size distribution?
    - orbit regions?
    - nature of objects?
    - sources, sinks?
  - Physics/Mechanisms
    - creation
    - evolution of orbits
    - long-term evolution: → models
- Approach
  - Search for debris (surveillance)
  - Determine orbits
  - Characterize





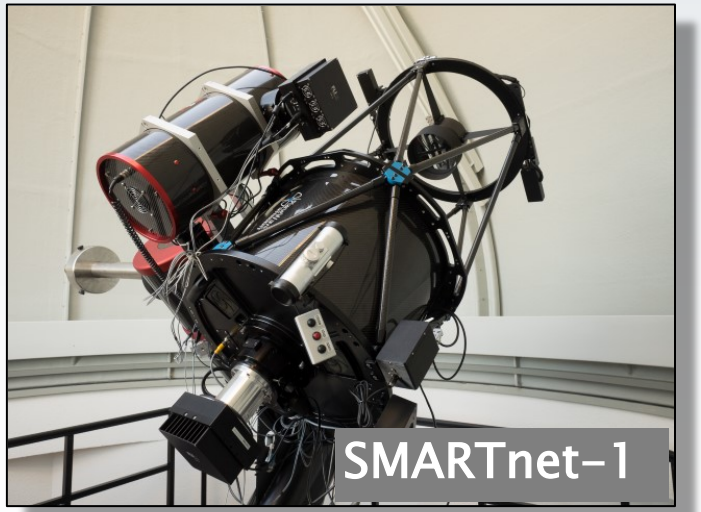
Space Debris Research

Space debris research provides information on environment through

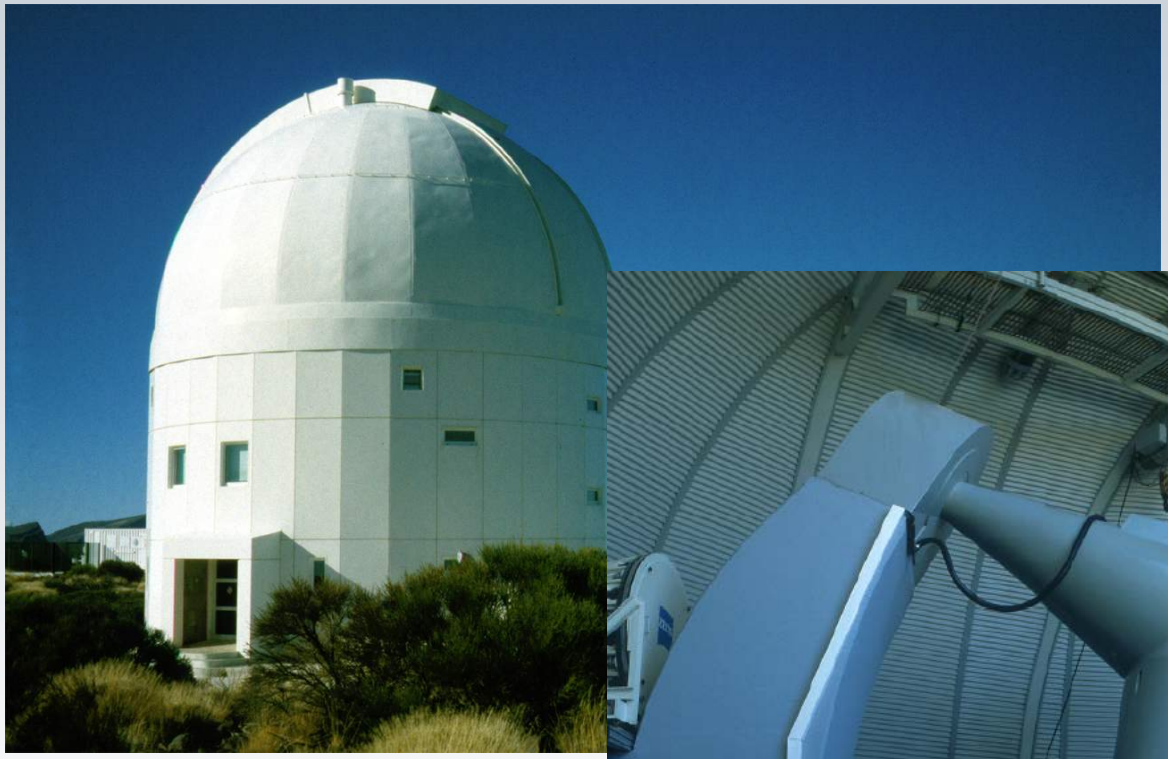
- Extending the catalogues of "known" space objects towards smaller sizes (deterministic population)
  → enable active collision avoidance (safety of operations)
- Acquiring statistical orbit information on small-size objects in support of statistical environment models
  → statistical risk analysis (e.g. mission analysis, shielding, etc.)
  → input data for long-term evolution models
  → identification of debris sources
    - progenitors of debris clouds (breakup events)
    - disintegrations of spacecraft due to aging processes
- Long-term monitoring of environment
  → identification of new sources
  → verification of evolution models
- Characterizing objects
  → nature of objects; support ADR

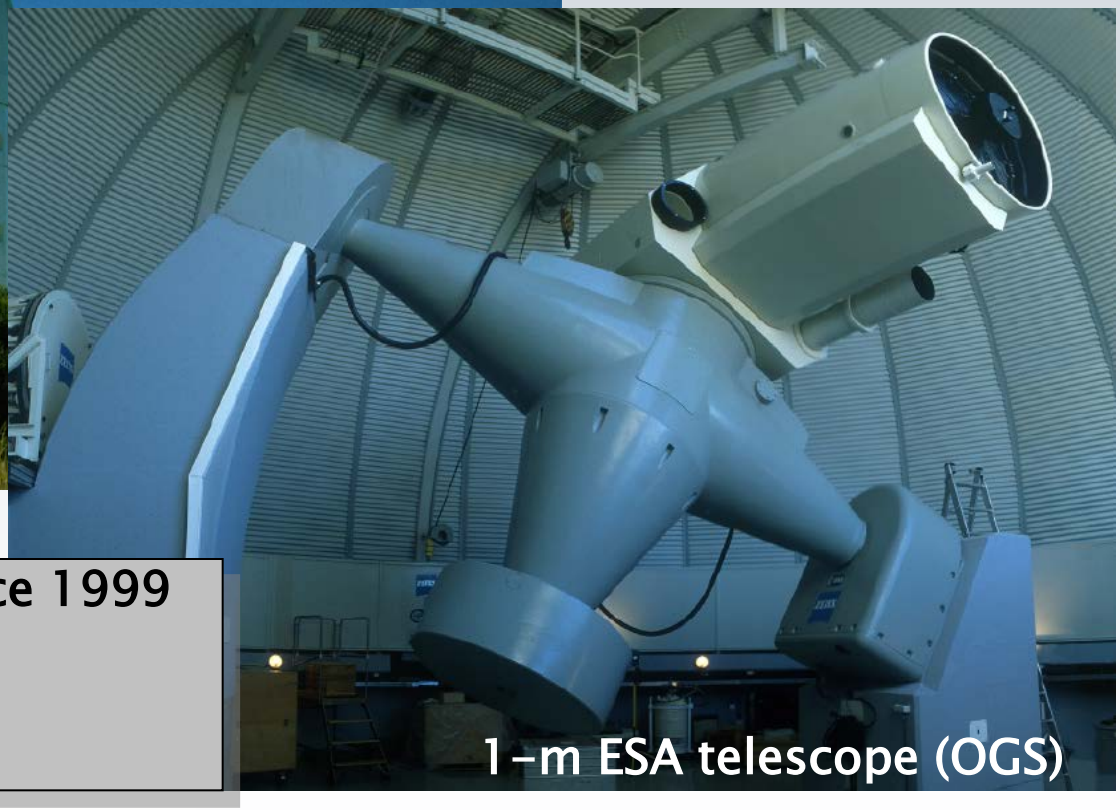
Swiss Optical Ground Station Zimmerwald

Contributing Swiss Sensors



Surveys at the ESA 1-m Telescope, Tenerife





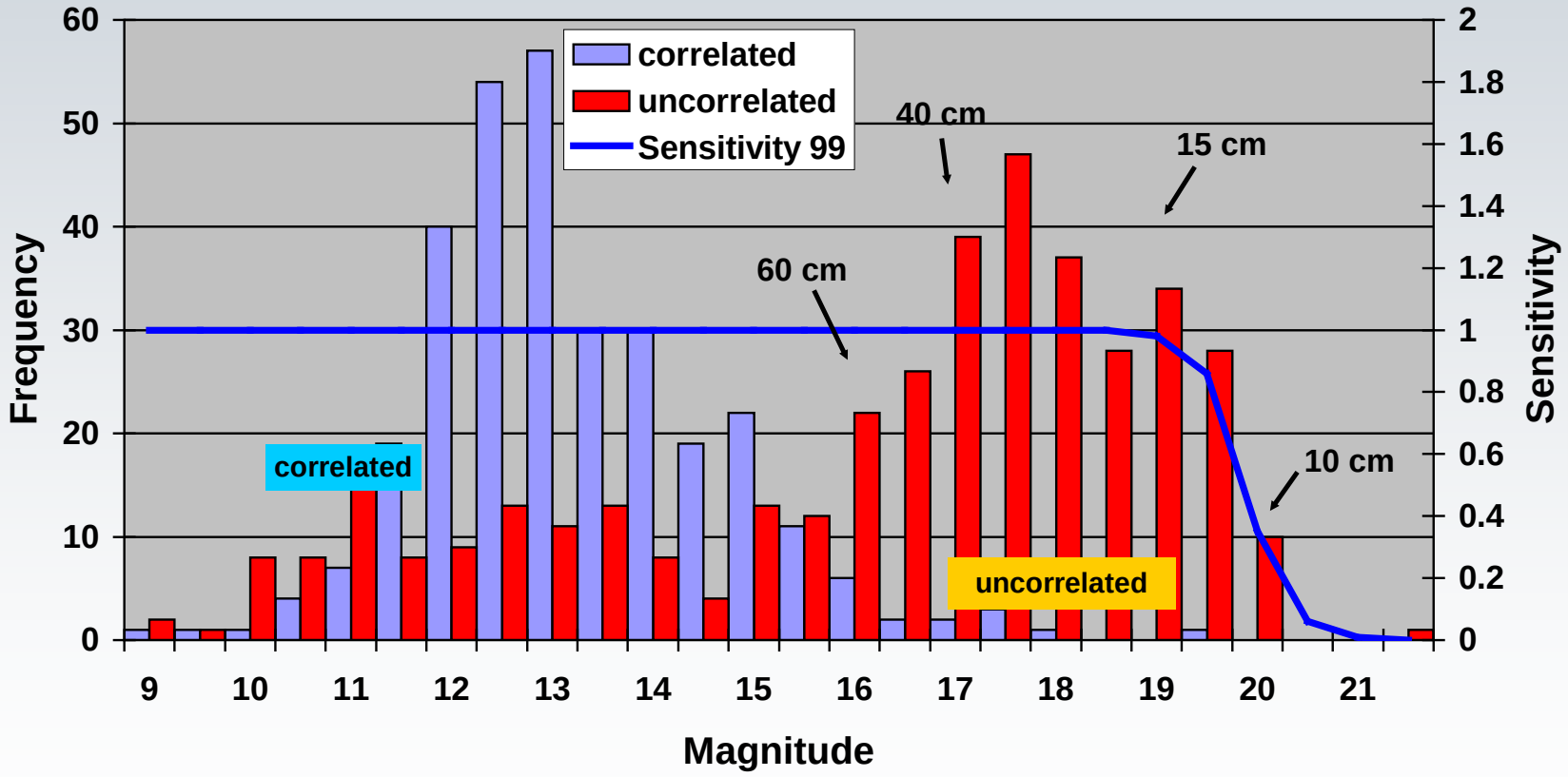
1-m ESA telescope (OGS)

Continuous program since 1999
10-12 nights/month
operated by AIUB

Key Scientific Results (several “firsts”)

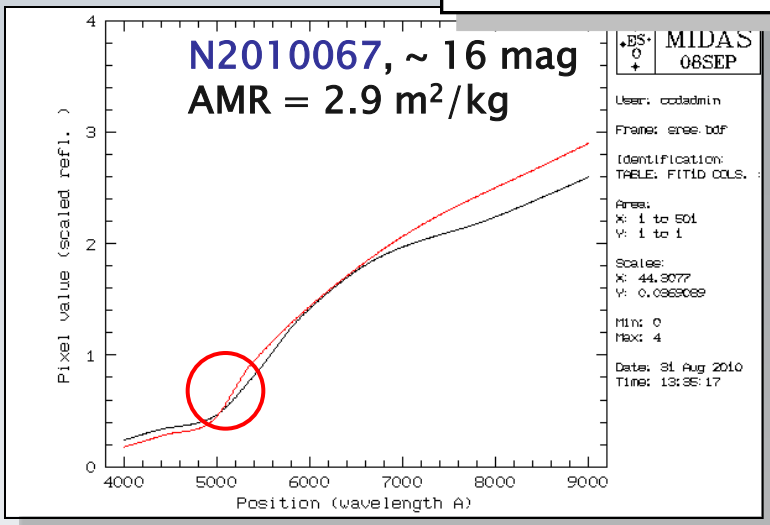
- Longest and most sensitive observations of the GEO/GTO /MEO regime
  - Discovery of small-sized (dm) debris in GEO
  - >18 years of continuous monitoring
    ➔ clusters of debris in orbital element space discovered, evolution studied
  - Essential input data for ESA MASTER environment model
- Discovery of "new" (i.e. previously unknown) population of high area-to-mass (AMR) ratio objects
- First spectra of high area-to-mass (AMR) ratio objects
- Attitude Motion of small and large size debris

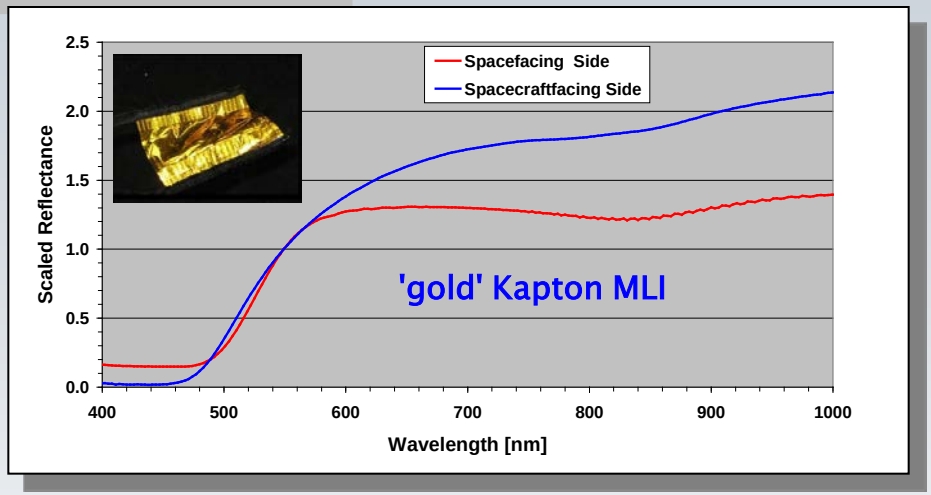
Small-Sized Fragments in GEO (example)

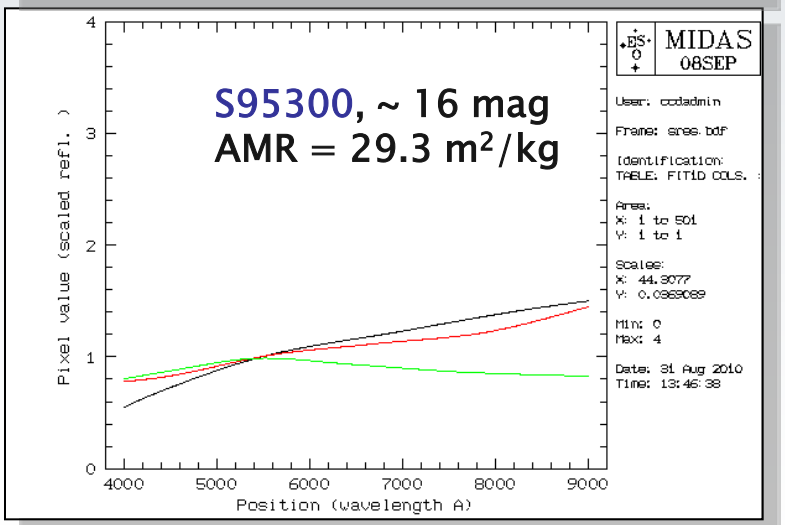


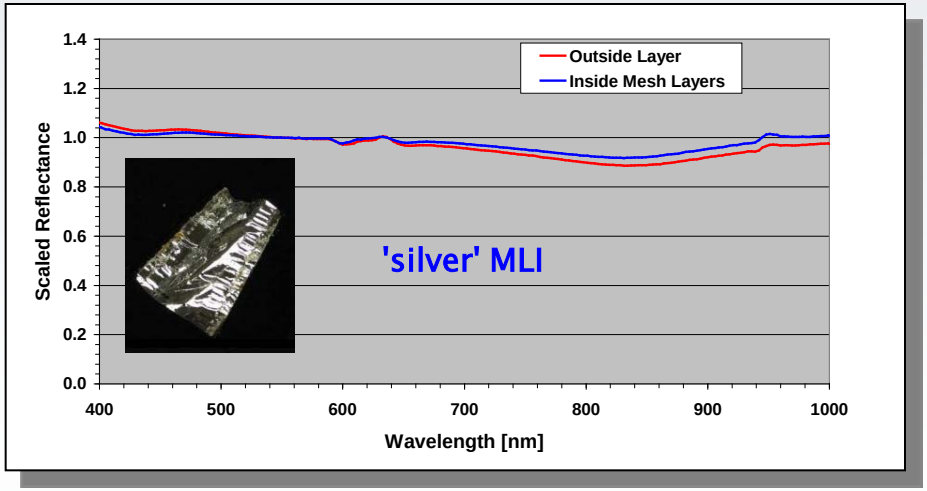
Characterization – Spektrophotometry

Comparison with Lab Spectra

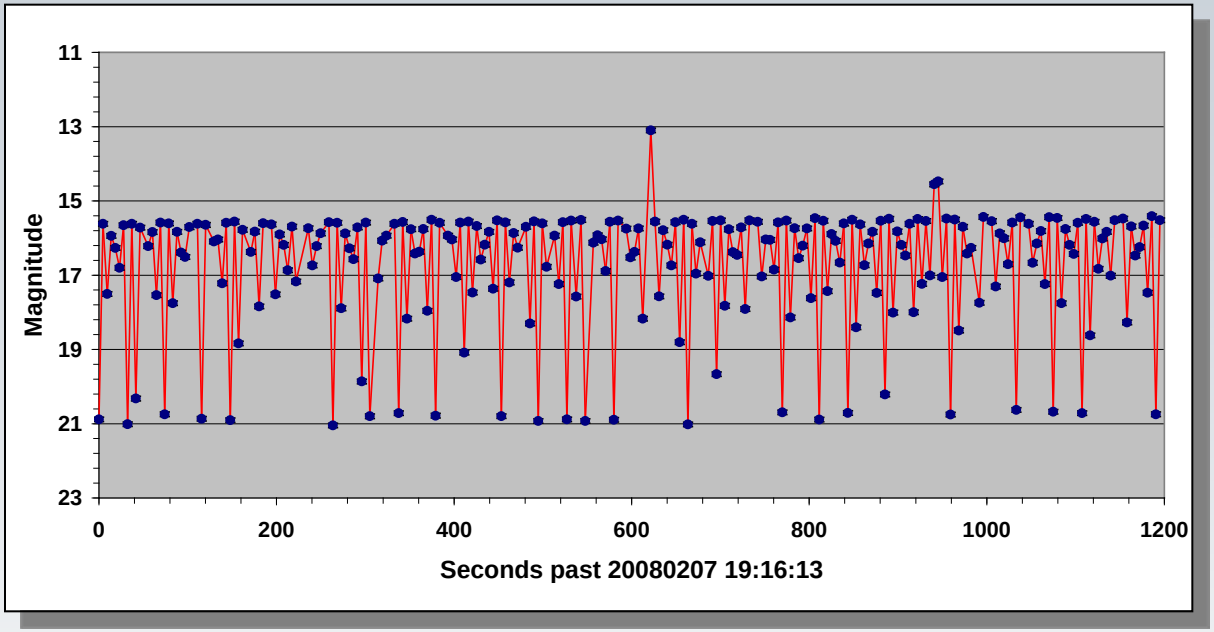


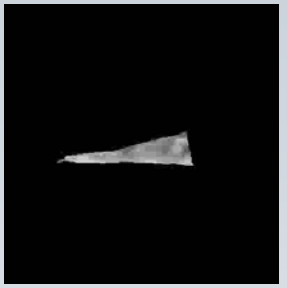


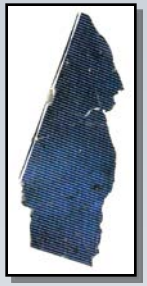


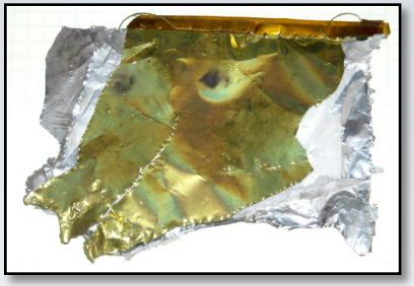


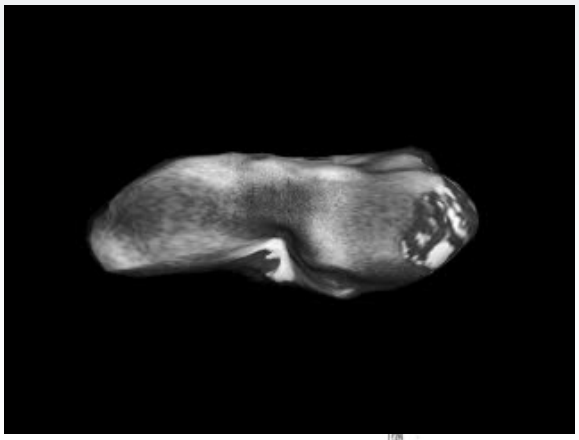
Characterization – Light Curves





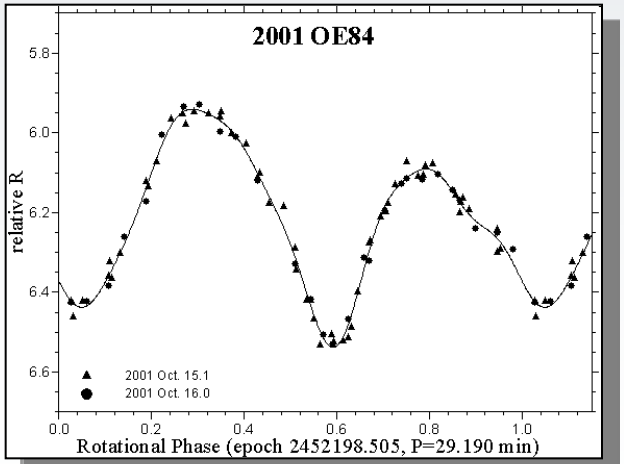




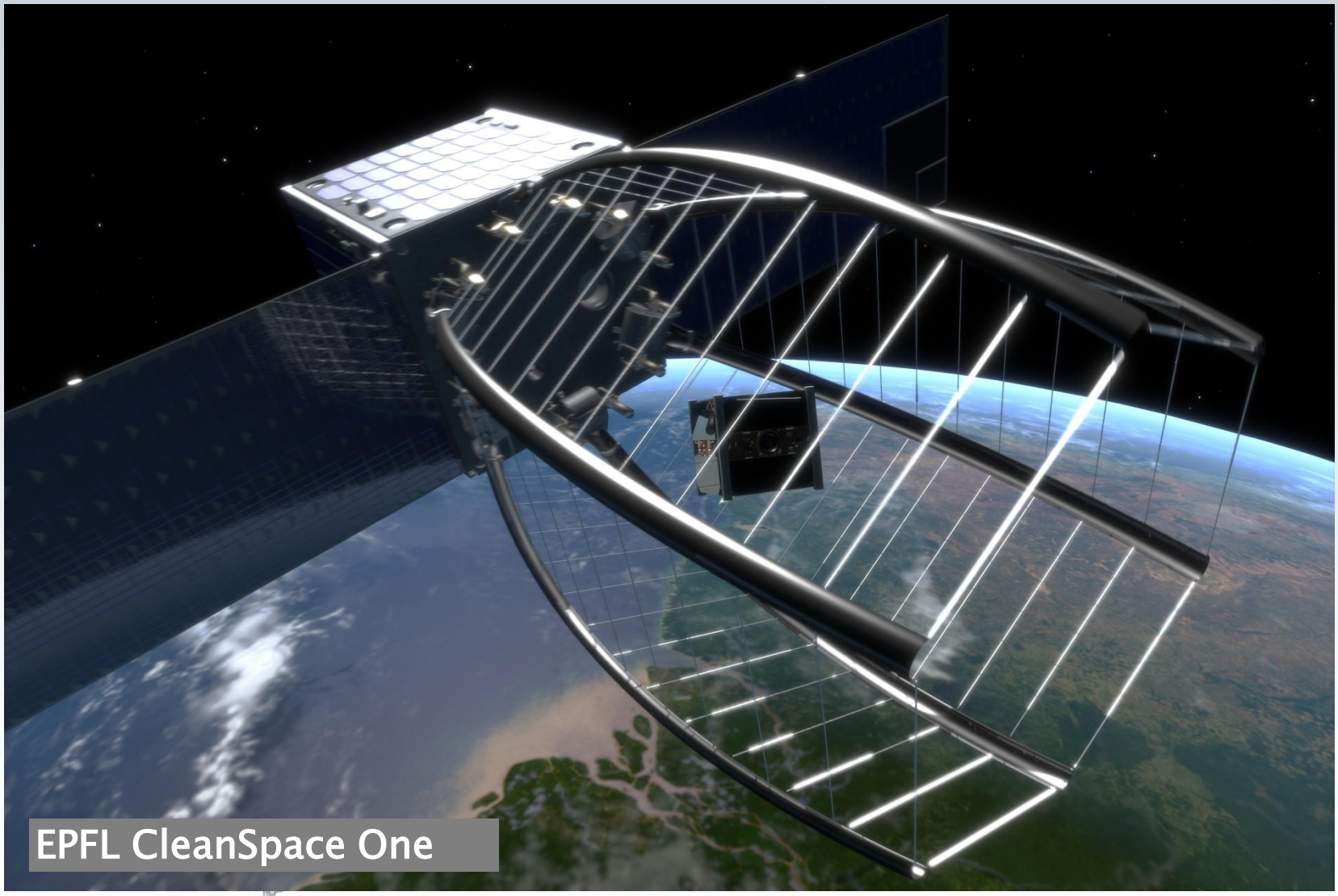


rotation period
spin axis, shape

- ZIMLAT



Remediation



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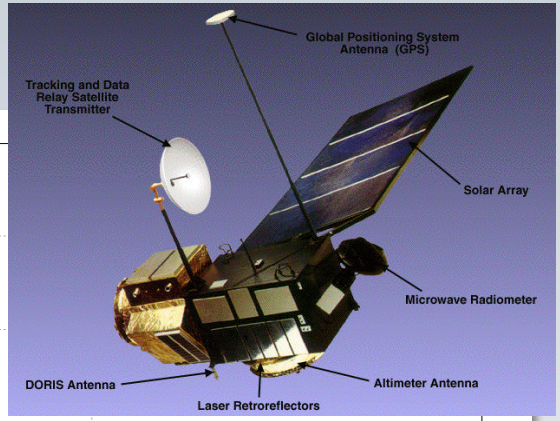
Attitude Motion of Topex



International Collaboration

- Active participation in the Inter-Agency Space Debris Coordination Committee (IADC)
- Fostering international collaboration trough bi- and multilateral scientific cooperation
  - partner of Int. Scientific Optical Network ISON
  - scientific collaboration with Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences (KIAM)
  - cooperative observations with ESA, NASA, JAXA and other space agencies
  - operational support for ESA
- Establishing AIUB/DLR SMARTnet telescope network
  - robotic telescopes in Switzerland, South Africa, Australia, …

Summary

>25 years of Space Debris Research in Switzerland

- **Optical survey techniques**
  - Algorithms (detection, survey scenarios)
- **Observations**
  - 18 years of space debris surveys at OGS for ESA
  - Operational, continuous, highly automated observation programs using the Zimmerwald sensors
- **Orbit Catalogues**
  - Orbit determination techniques/software
  - Build-up and maintenance of space debris catalogue (GEO/GTO)
  - International collaboration
- **Physical Characterization**
  - area-to-mass ratio from orbital evolution
  - sizes from photometry
  - attitude motion and shapes from light curves
  - materials from color photometry, spectra

→ **Scientific basis for sustainable use of outer space**

Thank you for your attention

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