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
On-board camera picture

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: \( \rightarrow \) models

• Approach
  ▪ Search for debris (surveillance)
  ▪ Determine orbits
  ▪ Characterize
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

1-m ZIMLAT
Switzerland

SMARTnet-1
Surveys at the ESA 1–m Telescope, Tenerife

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

**N2010067, ~ 16 mag**
AMR = 2.9 m²/kg

**S95300, ~ 16 mag**
AMR = 29.3 m²/kg
Characterization – Light Curves

rotation period
spin axis, shape

- ZIMLAT
Remediation

EPFL CleanSpace One
09051B Swisscube
Attitude Motion of Topex

SLR Residuals

Optical Light Curve
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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