Status of Active Debris Removal (ADR) developments at the Swiss Space Center

Muriel Richard, Benoit Chamot, Volker Gass, Claude Nicollier
muriel.richard@epfl.ch

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ADR mission architecture studies

• Questions:
  - What is the best architecture (= cheapest?) to remove 5-10 large debris per year?
  - What is the best way to get organised internationally? (not yet answered)

• Considering population of “500 most wanted debris” [R1]:
  - Mostly large rocket bodies
  - 1000 – 8000 kg
  - Mostly 71°, 81°, 83° and SSO inclinations

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Mass Power Cost

Spread in RAAN at launch minimized
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- Provides a parametric mission and debris removal campaign cost

First results to be published during 6th European Conference on Space Debris, 22-25 April 2013, Darmstadt, Germany
ADR demonstration opportunity

- Participated in EC FP7 Call SPA.2013.2.3-02: “Security of space assets from in-orbit collisions”

- This call asks for a demonstration mission, which purpose is to perform an in-orbit removal of debris in a low-cost manner

- **Consortium coordinator: GMV (Spain)**
  - Partners: Univ. Bologna, ALMASpace, Thales Alenia Space, EPFL, TSD, Univ. Roma La Sapienza, Poli Milano, ONERA, D-Orbit, DTM

- **Will test and validate:**
  - Guidance, Navigation & Control, before and after capture
  - Vision based approach system
  - Multi-capture demos, inc. Robotic and/or Net capture
  - Mission operations concept, autonomy level
Optical detection of debris

- In collaboration with Uni-Bern Astronomical Institute (Prof. T. Schildkecht), preparing an optical characterisation of SwissCube CubeSat

- AIUB has a long experience in the field of debris observation (mainly in high-altitude orbits, GEO/GTO/MEO)
  - Based on optical observations with the telescopes at the Zimmerwald observatory and in Teneriffe, AIUB developed high precision propagators to predict the position of debris objects, including high area-to-mass ratio objects
  - Has a permanently updated debris catalogue and algorithms to identify and extract debris objects from telescope images
  - AIUB is also trying to identify shape, size and rotation states using light curve analysis.
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- Future developments:
  - More advanced propagators, identification of debris shapes, rotation rates and spin axis orientation using light curve analysis and direct imaging
  - Improved and automated observation technologies
  - Debris detection and tracking using the Zimmerwald Satellite Laser Ranging (SLR) station

- Interests of AIUB:
  - Verify AIUB’s orbital determination/observations with on board-measurements
  - Verify light curve spectra
  - Verify on-board observation/tracking techniques (algorithms)
  - Have onboard telescope images on ground for comparison.
CleanSpace One Project

• After the launch of SwissCube CubeSat (Sept. 2009), started ADR technology program called “Clean-mE”

• Research and development most efficient when targeted to a concrete application
  => Start of CleanSpace One project

• The objectives of the CleanSpace One project are to:
  - Increase awareness, responsibility in regard to orbital debris and educate aerospace students
  - Demonstrate technologies related to Orbital Debris Removal
  - De-orbit SwissCube.
**CleanSpace One NanoSat**

- **CleanSpace One nanosat:**
  - Based on a CubeSat platform as preliminary assumption
  - Preliminary (Phase 0) design done using CDF
  - Launch ~ 2017

- Critical technologies provided by partner institutions (open to international cooperation). Satellite platform designed by students.

- Operations performed by students in partnership with professional institutions

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**CleanSpace One conceptual design**
Vision based systems – current work

• With EPFL Prof. J-P. Thiran’s laboratory, research developments for one 2-D camera and optical flow
  - Motion reconstruction algorithms
  - Algorithms developed, first iteration
  - Current process: creation of representative images, characterisation of algorithm performances

• Hardware implementation
  - Cameras: have discussions with Space-X and with PhotonFocus
  - Evaluation of various CubeSat based computers
Capture mechanisms – current work

• Three designs in parallel:

1. Underactuated mechanisms
   - Work under/in cooperation with Prof. Lauria, HES-Geneva

2. Dielectric polymer actuators
   - Work under/in cooperation with Prof. H. Shea

3. Compliant mechanisms
   - Work in cooperation with F. Campanile, EMPA
Conclusions

• The Swiss Space Center is pursuing mission architecture studies and development of technologies needed for Orbital Debris Removal

• Participation in mission oriented proposals
  - CleanSpace One project in fund raising phase, student team started in September 2012
  - EC FP7 ADR
  - Nanosat demonstrators have three major advantages:
    ▪ Tests and demonstrates key elements for orbital debris removal, focuses the development on something real
    ▪ Relatively cheap demonstration mission, proposes low-cost mission options
    ▪ Continues education in a very motivating field

• Our goal is to help community, fill in technology gaps, and propose low-cost solutions that integrates within international developments