Activities in Active Debris Removal (ADR)

CleanSpace One Project

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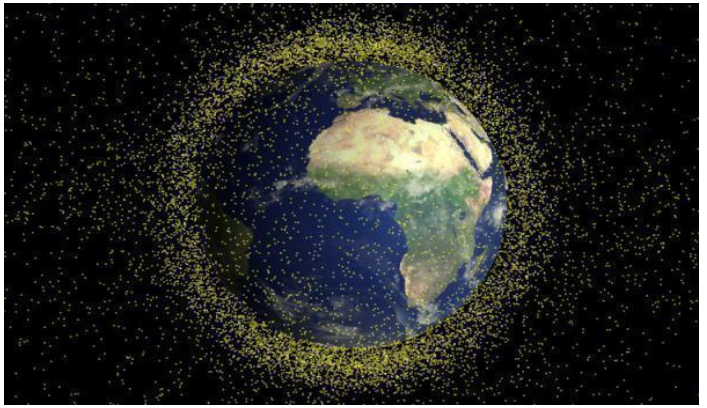
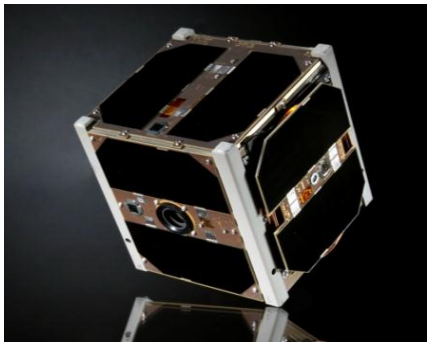
October 2012



Context

- **Swiss Space Center launched SwissCube, the first Swiss student satellite, in September 2009**
  - **CubeSat family (10 x 10 x 10 cm3, 1 kg)**
  - **SwissCube is on 720-km SSO orbit, still operational**



- **After the launch, started research to develop technologies for Orbital Debris Removal of Non-Cooperative Debris (under a program called "*Clean-mE* ")**
  - **Low level funding**

- **CONCLUSION: research and development most efficient when targeted to a concrete application**

  => Start of *CleanSpace One* project

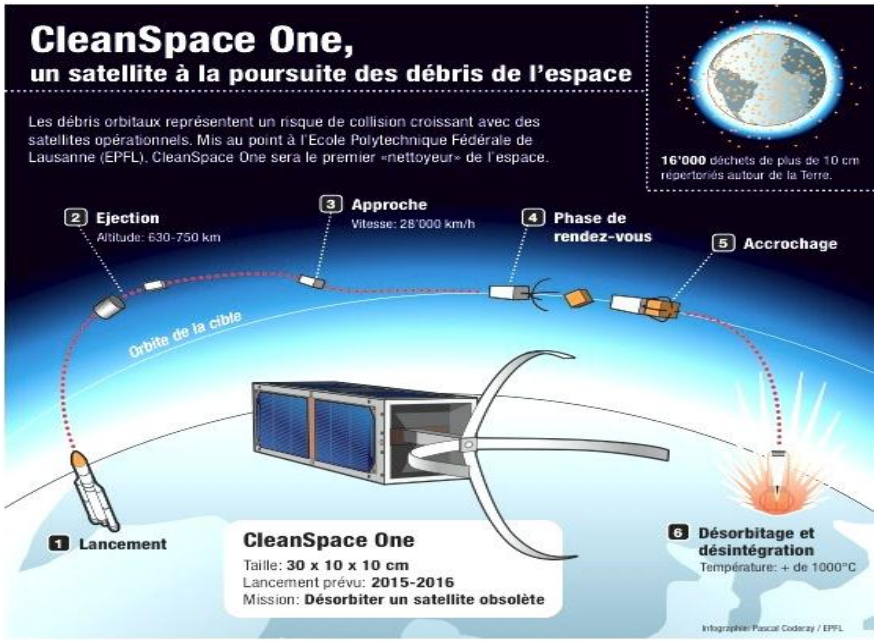
Project Objectives

- **The objectives of the *CleanSpace One* project are to:**

1. **Increase awareness, responsibility in regard to orbital debris and educate young people;**

2. **Demonstrate technologies related to Orbital Debris Removal;**

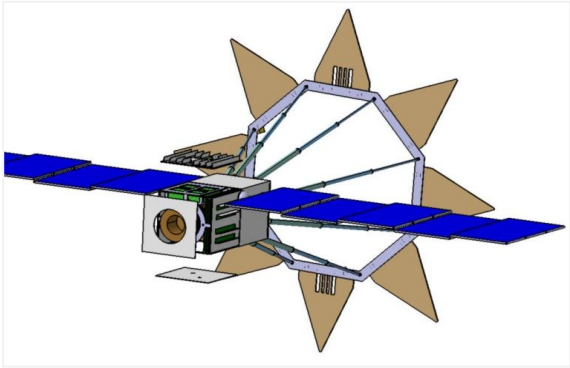
3. **De-orbit a known and politically acceptable debris.**



CleanSpace One NanoSat

- *CleanSpace One* **NanoSat**
  - **Remove 1 debris (> 10 cm, < 1m)**
  - **Based on a CubeSat 3U-6U platform as preliminary assumption**
  - **Preliminary (Phase 0) design done using CDF**
  - **VEGA or PSLV, launch ~ 2016-17**

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



- **Operations performed by students in partnership with larger and professional institutions**

Technical Challenges for *CleanSpace One*

- ***In orbit maneuvering and Rendezvous***
  - **Development of highly efficient propulsion system and attitude control system for a nano-satellite to minimize amount of fuel that need to be carried. Key factor is how close can a launch vehicle deliver our flight system to the target.**

- ***Target identification & tracking***
  - **Employ passive (Vision Based System) instruments to identify object and characterize its state (position and rotations)**
  - **Perform in phase manoeuvring, with high level of autonomy**

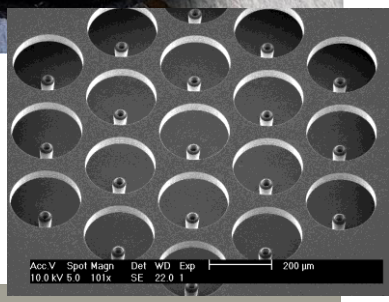
- ***Grappling, safe, versatile, adaptative and reliable***

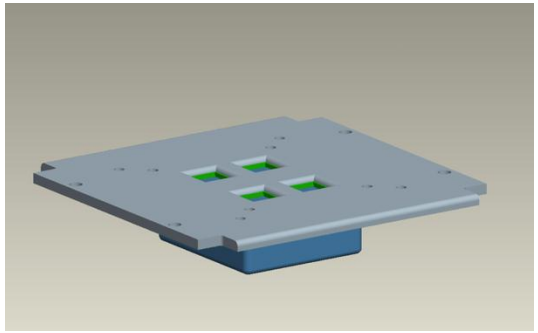
- ***Controlled de-orbiting maneuver***

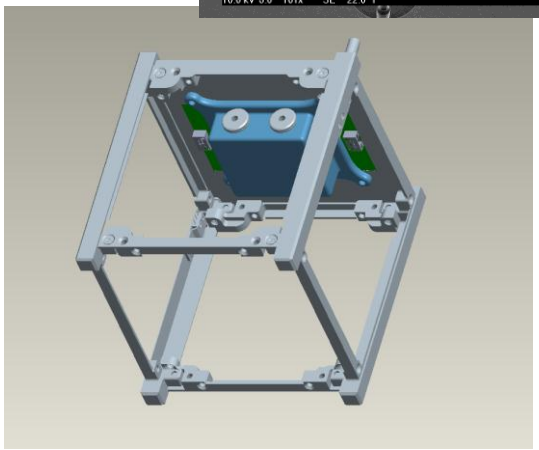
Micro-propulsion system

- **Propulsion needs to remove SwissCube:**
  - Orbit altitude matching ~ 120 m/s (from 500 km)
  - RAAN changes ~ 50 m/s
  - Inclination change ~ 100 m/s
  - De-orbit DV ~ 230 m/s (to get to 3-yr deorbiting orbit)

- **Current work: MicroThrust (www.microthrust.eu)**
  - FP7 activity with TNO, NAnoSpace, QMUL, SystematIC and EPFL
  - Development of a breadboard in 2012, tests in 2013
  - Expected performances > 500 m/s at Isp 3000 s





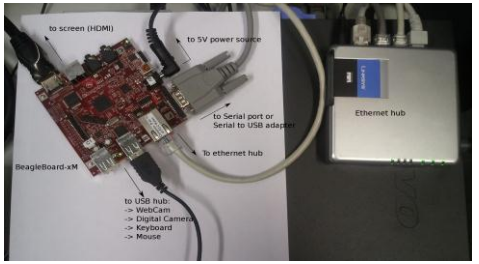


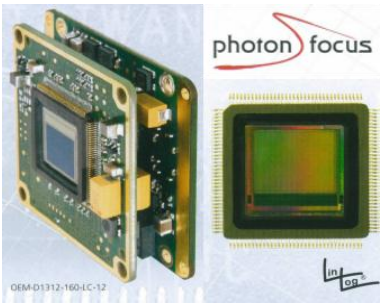
Vision based systems – current work

- **Evaluating motion estimation algorithms**
  - 3D: Aghili & Parsa (2008, CSA), Hillenbrand & Lampariello (2005, DLR)
  - 2D: Angles only, optical flow, structure from motion, etc.

- **With EPFL Prof. J-P. Thiran's laboratory, research developments for one 2-D camera and optical flow**
  - 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





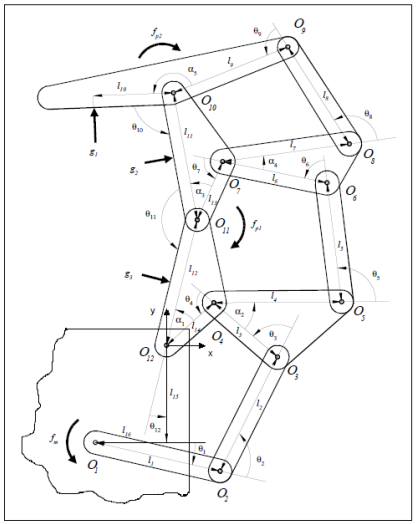
C. Paccolat, Master thesis EPFL July 2012

Capture mechanisms – current work

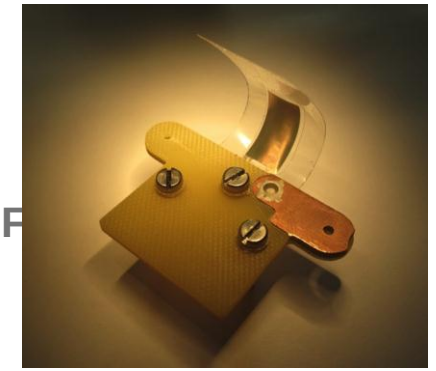
- **Three designs in parallel:**

Hes·so

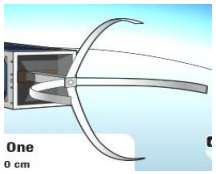
University of Laval concept



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



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



EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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

EMPA
Materials Science & Technology

CleanSpace One
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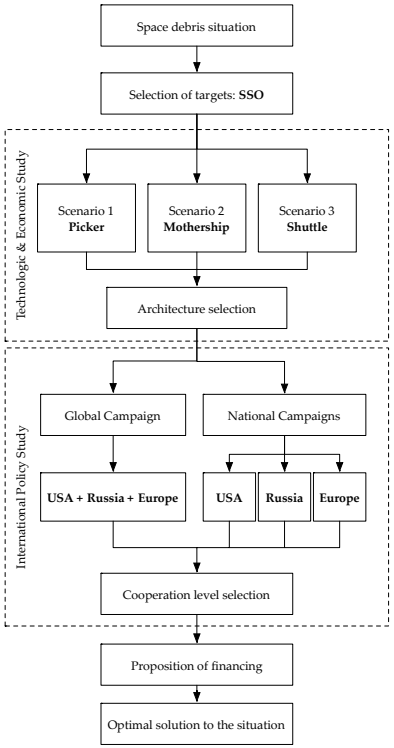
Other related activities

- **Mission architecture studies**
  - High level mission architecture tool elaborated within a joint EPFL / MIT master thesis
  - Purpose is to evaluate technology options and mission cost versus mission architecture



B. Chamot, Master thesis MIT August 2012

- **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
  - SSC proposes (low-cost) platform design

- **Approach and capture test**
  - Student project: 5 Master, 6 semester projects
  - Prototype demonstration of rendezvous maneuvers
  - Test in a swimming pool

Summary *CleanSpace One*

- **The Swiss Space Center has started the development of critical and innovative technologies needed for Orbital Debris Removal**
- **The Swiss Space Center provides an efficient frame for supervising research and tailoring it to space applicable demonstrators**
- **Swiss Space Center's plans are meant to be in line with European space agencies and industries**
- **CleanSpace One project in fund raising phase, student team started in September 2012**

Thank you

Vision based systems – current work