



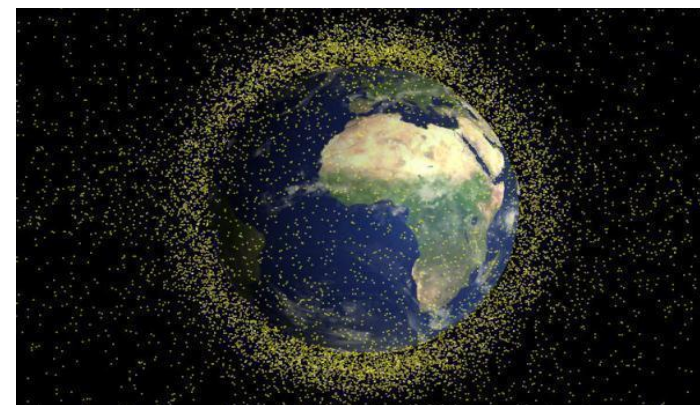
# Activities in Active Debris Removal (ADR)

## *CleanSpace One* Project

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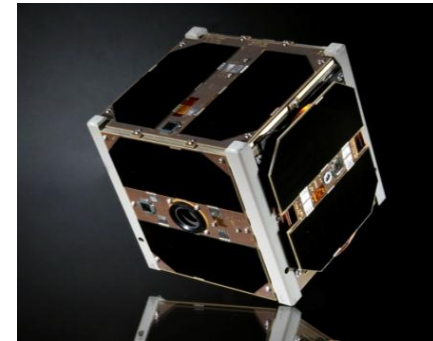
October 2012



# Context

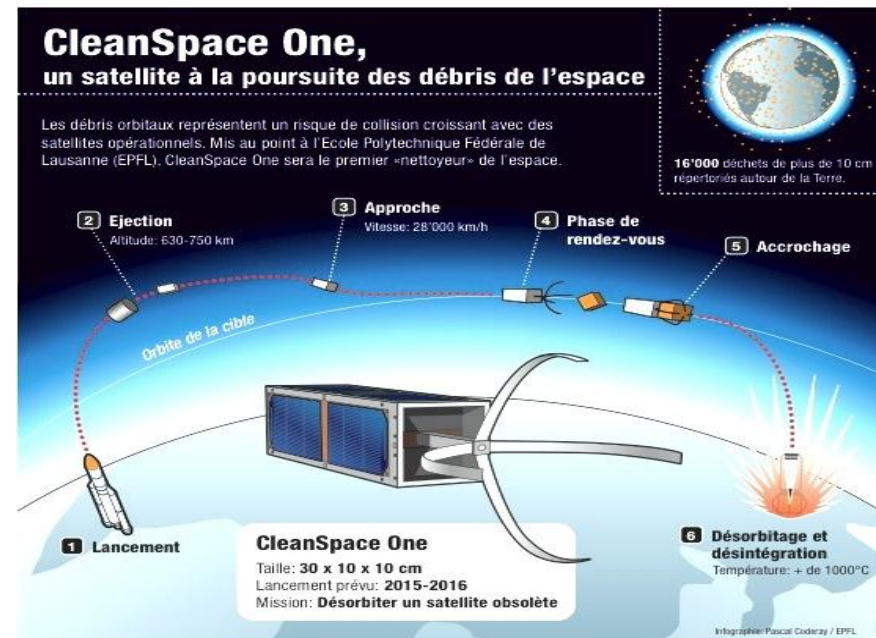
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- Swiss Space Center launched SwissCube, the first Swiss student satellite, in September 2009
  - CubeSat family (10 x 10 x 10 cm<sup>3</sup>, 1 kg)
  - SwissCube is on 720-km SSO orbit, still operational
- After the launch, started research to develop 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



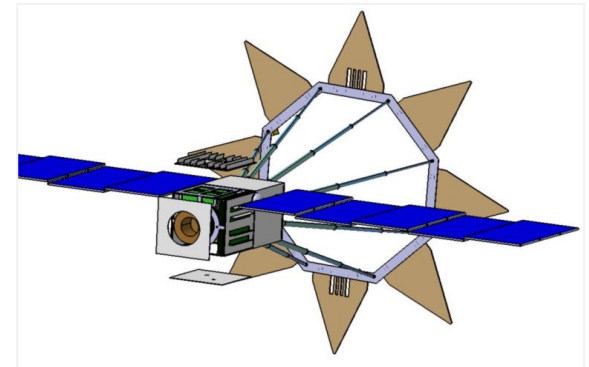
# Project Objectives

- 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*

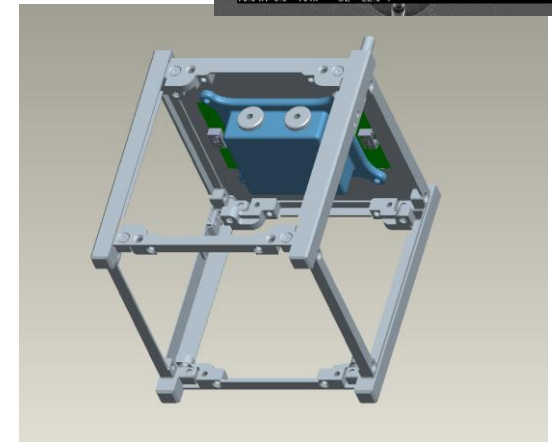
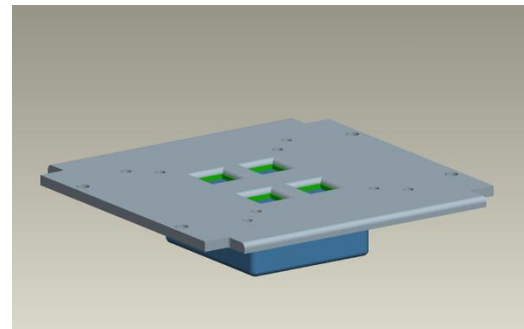
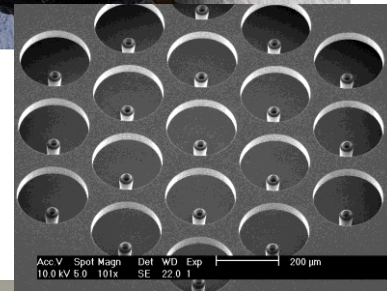
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- ***In orbit maneuvering and Rendezvous***
  - Development of highly efficient propulsion system and attitude control system for a nano-satellite to minimize amount of fuel that need to be carried. Key factor is how close can a launch vehicle deliver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



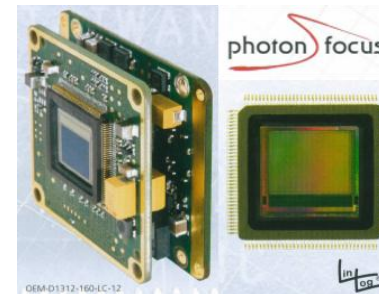
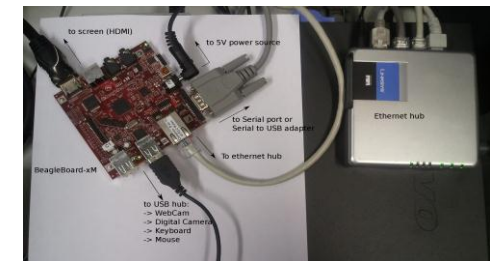
# Micro-propulsion system

- **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](http://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



# Capture mechanisms – current work

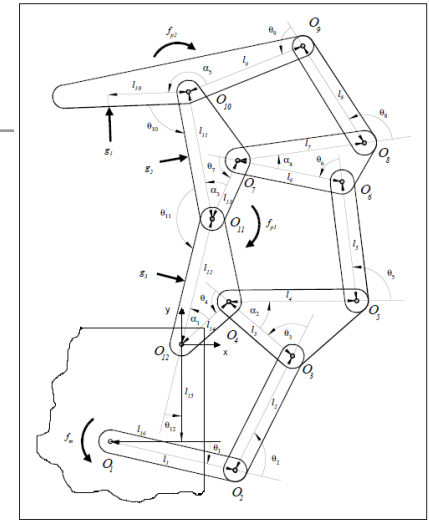
- Three designs in parallel:

1. Underactuated mechanisms

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

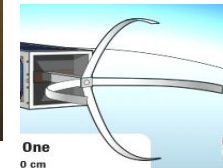
**Hes·SO**

University of Laval  
concept



2. Dielectric polymer actuators

- Work under/in cooperation with Prof. H. Shea, EPFL



**EPFL**  
ÉCOLE POLYTECHNIQUE  
FÉDÉRALE DE LAUSANNE

3. Compliant mechanisms

- Work in cooperation with F. Campanile, EMPA



**EMPA**  
Materials Science & Technology



# Other related activities

- **Mission architecture studies**

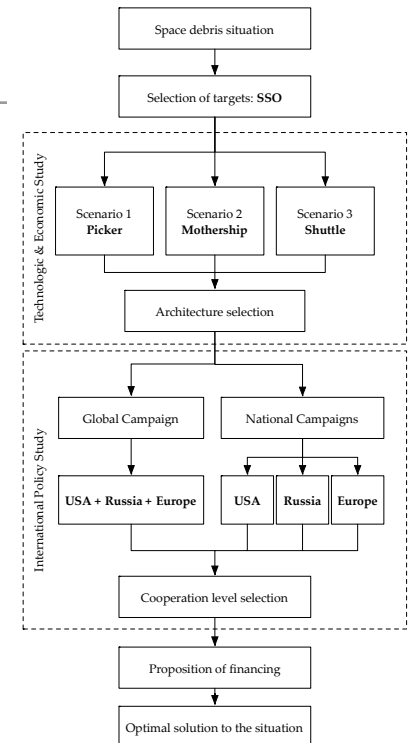
- High level mission architecture tool elaborated within a joint EPFL / MIT master thesis
- Purpose is to evaluate technology options and mission cost versus mission architecture

- **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



B. Chamot, Master thesis MIT August 2012



# Summary *CleanSpace One*

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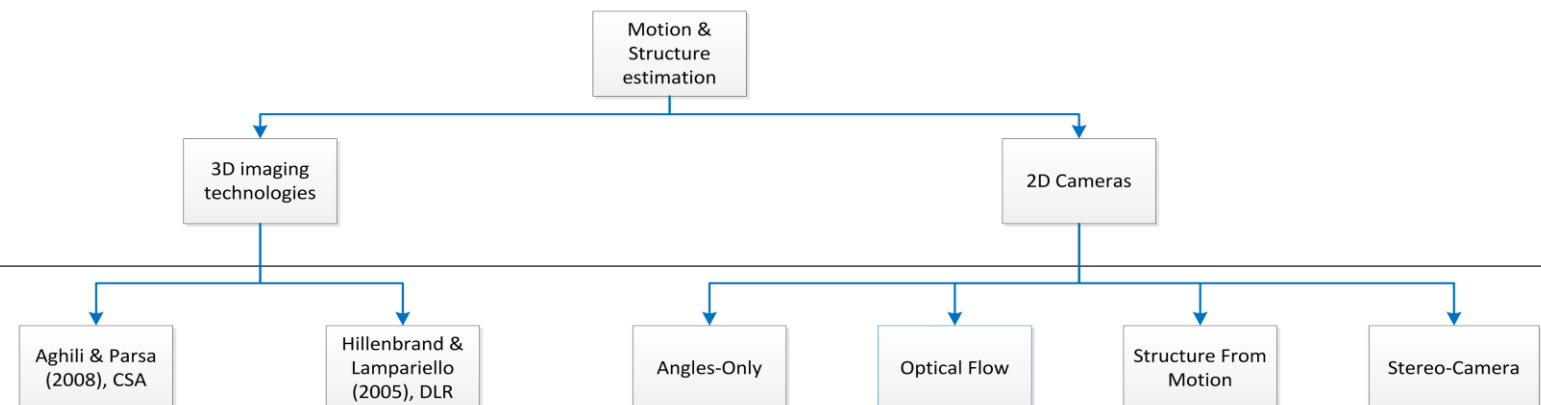
- The Swiss Space Center has started the development of critical and innovative technologies needed for Orbital Debris Removal
- The Swiss Space Center provides an efficient frame for supervising research and tailoring it to space applicable demonstrators
- Swiss Space Center's plans are meant to be 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

Motion estimation techniques evaluation		Close Range Operations					
Fonction	<div style="text-align: center;">  <pre> graph TD     A[Motion &amp; Structure estimation] --&gt; B[3D imaging technologies]     A --&gt; C[2D Cameras]     B --&gt; D[Aghili &amp; Parsa (2008), CSA]     B --&gt; E[Hillenbrand &amp; Lampariello (2005), DLR]     C --&gt; F[Angles-Only]     C --&gt; G[Optical Flow]     C --&gt; H[Structure From Motion]     C --&gt; I[Stereo-Camera]                     </pre> </div>						
Algorithmics							
Evaluation	<ul style="list-style-type: none"> <li>Assumes known orientation of the target</li> <li>Models dynamics of target and predicts pose and orientation accurately up to 20 s. ahead</li> <li>Reasonable performances with measurements at 2Hz: &lt;10% on position, &lt;15° on orientation</li> <li>Requires consequent processing capabilities</li> </ul>	<ul style="list-style-type: none"> <li>Assumes depth and space correspondence between sensed points</li> <li>Models motion and dynamics</li> <li>Reasonably good prediction accuracy (100 s) : 52% of measurements below 10 cm position / 20° orientation error</li> <li>Extensions with stabilisation of target have been developed</li> <li>High processing power required for decent performances (40Hz @~4500MIPS, with 100 points)</li> </ul>	<ul style="list-style-type: none"> <li>Provides only position and distance of the target</li> <li>Possible method for MRO (navigation to the target)</li> <li>Lowest processing requirements</li> </ul>	<ul style="list-style-type: none"> <li>Long heritage</li> <li>Motion estimation only</li> <li>Low power requirements</li> <li>Implementation available</li> <li>Minimal development required</li> <li>Can reconstruct depth</li> </ul>	<ul style="list-style-type: none"> <li>Similar to SLAM (Simultaneous Localisation And Mapping)</li> <li>Motion estimation only</li> <li>Notable heritage from DARPA challenge</li> <li>High computing power required</li> <li>Some developments required</li> </ul>	<ul style="list-style-type: none"> <li>Noise &amp; error propagation issues</li> <li>Calibration required</li> <li>Requires consequent processing capabilities (optimisation methods)</li> </ul>	