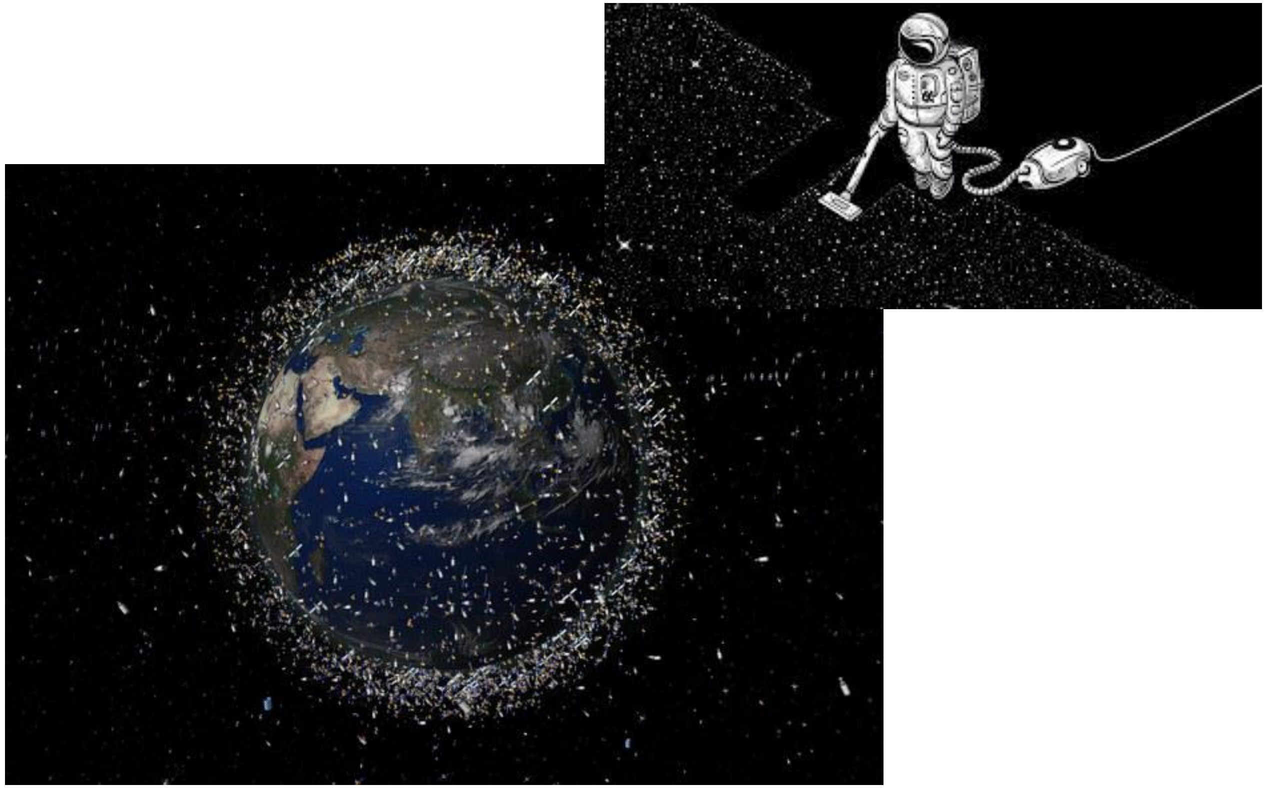
Clean Space Industrial Days 2018

Lessons learnt from the past three years of activities on Space Debris

October 25th, 2018 | Stefano Antonetti & Eleonora Luraschi

First Steps into Space Debris Mitigation



- Following a Life-Cycle approach
- Space as a Natural Resource
- Everything that goes up must go down…

  …. as soon as possible!

- **Direct and Controlled Re-entry after end-of-mission**
- **Dedicated and Independent satellite decommissioning system**
- **As modular and plug-and-play as possible.**

First Steps into Space Debris Mitigation

SOLID PROPULSION DE-ORBITING AND RE-ORBITING

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ABSTRACT

With many "innovative" de-orbit systems (e.g. tethers, aero breaking, etc.) and with natural de-orbit, the place of impact of unburned spacecraft debris on Earth can not be determined accurately. The idea that satellites burn up completely upon re-entry is a common misunderstanding. To the best of our knowledge only rocket motors are capable of delivering an impulse that is high enough, to conduct a de-orbit procedure swiftly, hence to de-orbit at a specific moment that allows to predict the impact point of unburned spacecraft debris accurately in remote areas. In addition, swift de-orbiting will reduce the on-orbit time of the 'dead' satellite, which reduces the chance of the dead satellite being hit by other dead or active satellites, while spiralling down to Earth during a slow, 25 year, or more, natural de-

2. Before this recent collision, the US military had catalogued some 19 000 pieces of space debris [2]. The collision added at least 194 pieces from the Iridium satellite and 505 from the Cosmos 2251 according to the US military [3].
3. As debris will have flown in more or less all directions, some spacecraft above the Iridium orbit, the Iridium spacecraft themselves, and as all debris at this altitude will eventually come down, all spacecraft below the Iridium orbit, are at risk.
4. The debris is expected to have a long life; estimates of thousands to ten thousand years were made by the Russian Chief of Mission Control, Vladimir Solovyov [4]

By the end of February 2009 it became clear that the

SOLID PROPELLANT DE-ORBITING FOR CONSTELLATION SATELLITES

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ABSTRACT

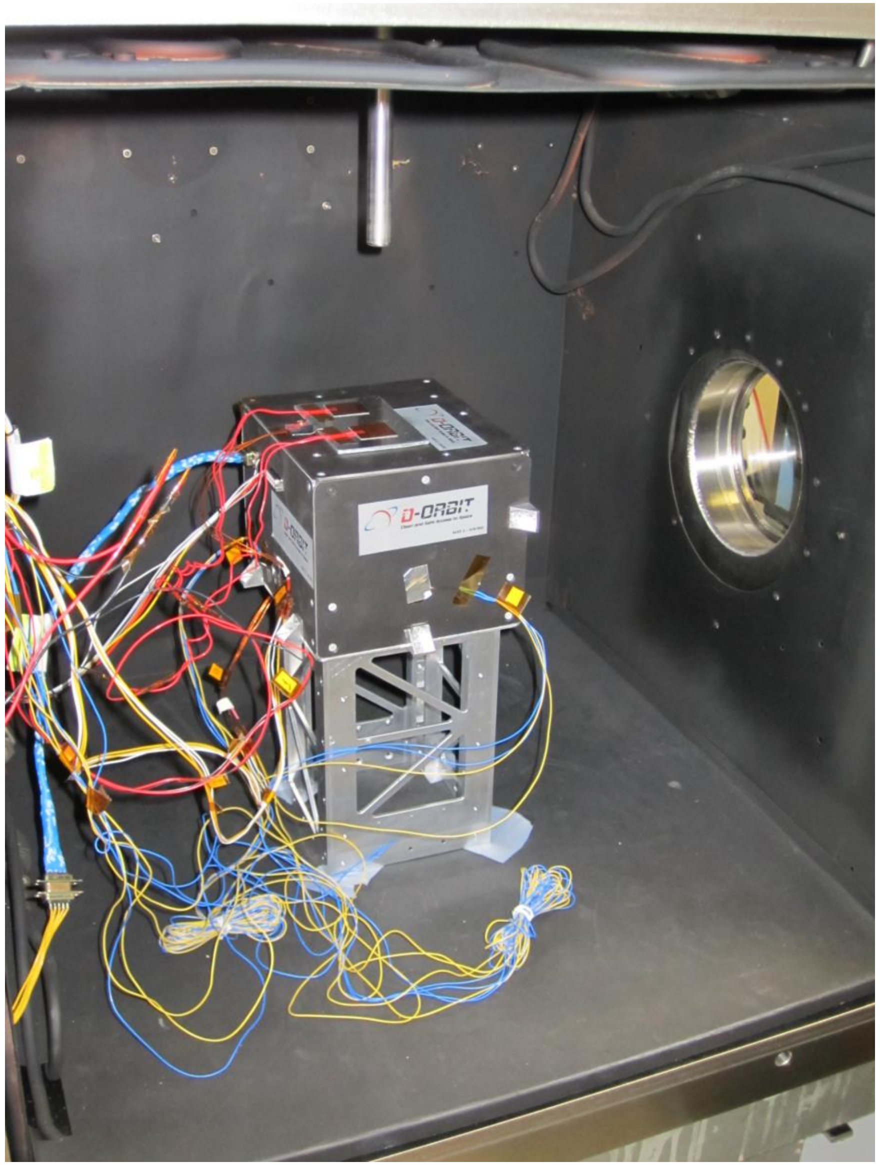
De-orbiting of spacecraft with a solid propellant is feasible. The main advantage is the fact that the system can be autonomous and very reliable, something that is especially required when one wants to de-orbit old or 'dead' satellites. The disadvantage of de-orbiting with a solid propellant is the implementation of the extra system and sometimes the, although small, mass penalty.
In this research, an existing Iridium satellite, that uses hydrazine de-orbiting, is adapted for de-orbiting with a solid propellant motor. This way the difference between the two systems can be compared.
It turned out that a cluster of motors would be lighter

1. INTRODUCTION

Currently thousands of 'dead' satellites are orbiting the Earth, thereby creating a risk of collision with other satellites and even manned spacecraft. Therefore these satellites need to de-orbited. In order top determine the feasibility of de-orbiting research was conducted to de-orbit constellation satellites.
Constellations are divided in orbital slots that should hold one active satellite each. When a failing satellite becomes inactive and is replaced by a new one, the inactive satellite might collide with the new one because it remains uncontrolled in the same slot in the constellation. Therefore it is of the immediate interest of the owner of the constellation to have failing

-- 2012 SRM Fire Test

-- 2013 – Alice 2 Launch



European Programmes

Our experience

TVC System for SRM

Investigation, selection and design of a TVC mechanism for de-orbiting of spacecraft by means of SRMs

SDM Market Assessment

Estimation of the global and European market for SDM solutions for LEO satellites

CleanSat

to mature the specifications for the selected Building Blocks for future LEO spacecraft

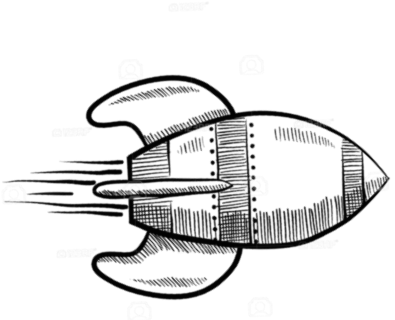
TeSeR (Technologies for Self-Removal)

Development of a cost-efficient, but highly reliable Post-Mission Disposal module.

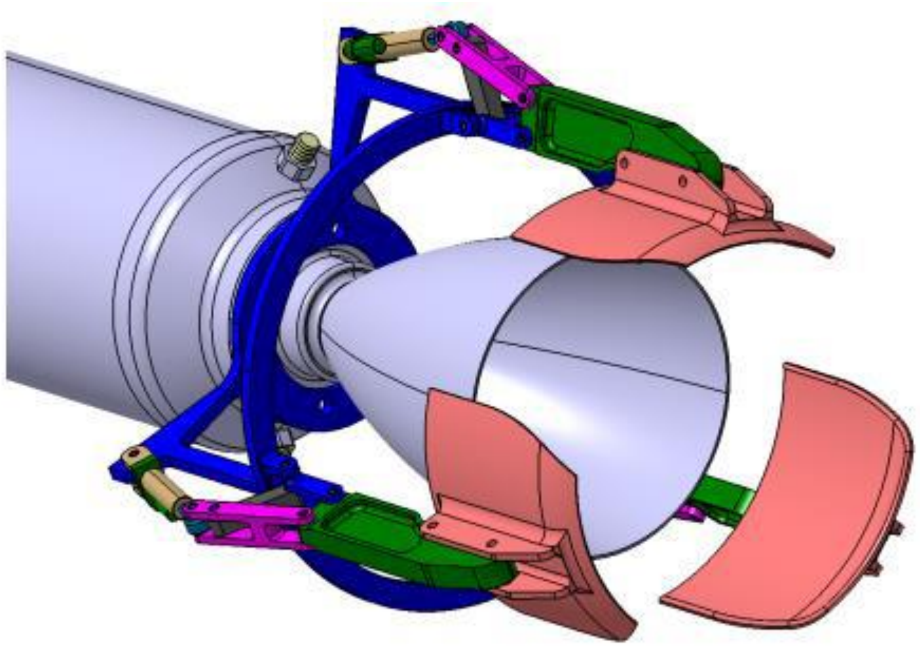
D3

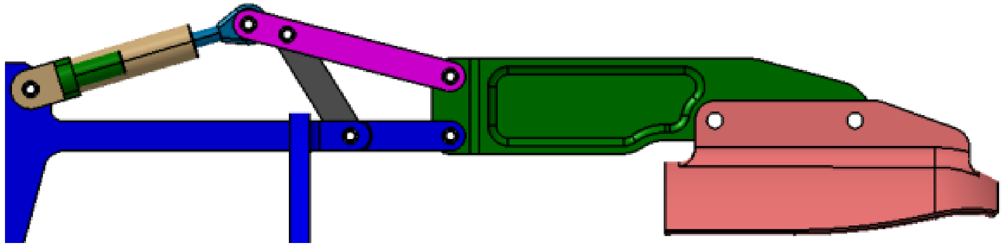
Development of an autonomous Decommissioning Device for Satellites and Launcher stages including demonstration throught the D-SAT mission

About 3.4 M€ and 65.000 man-hours



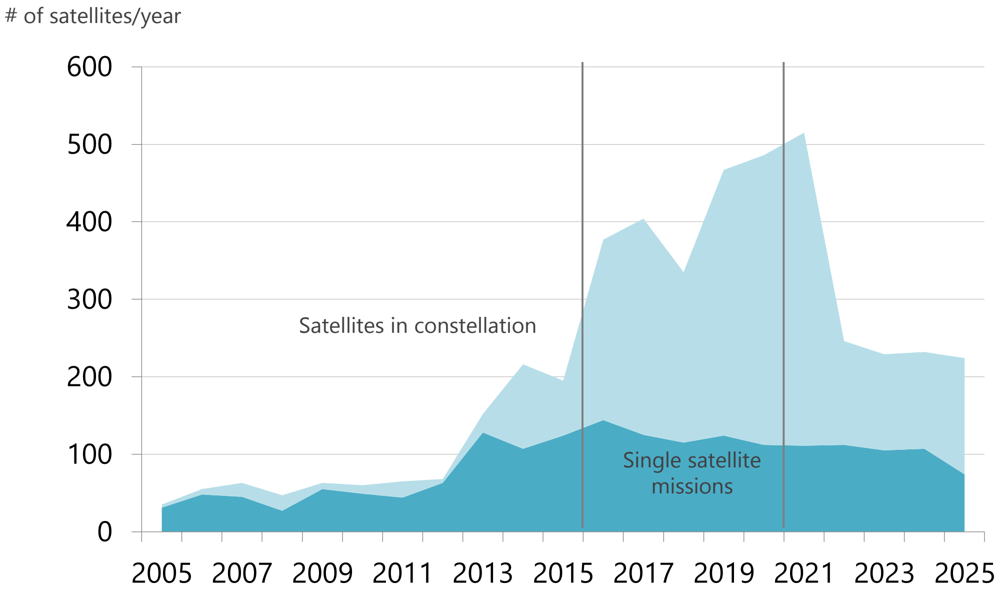
ESA – Thrust Vector Control Systems

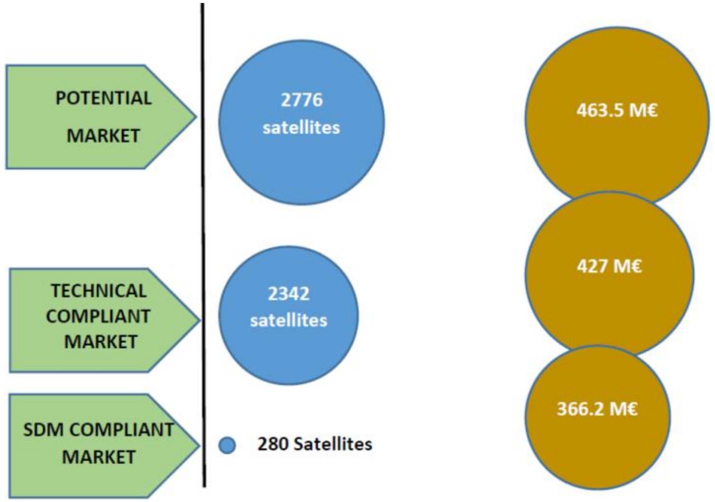




- ESA GSP Activity (In team with Almatech and Sitael)
- Active thrust vectoring of SRMs in Space have never been implemented
- Considerable thermal issues due to the length of the burn (up to a couple of minutes)
- It needs to operate even after 15 years of inactivity
- Required for most of the EOL decommissioning manoeuvres (see D-SAT mission)

ESA – SDM Market Assessment



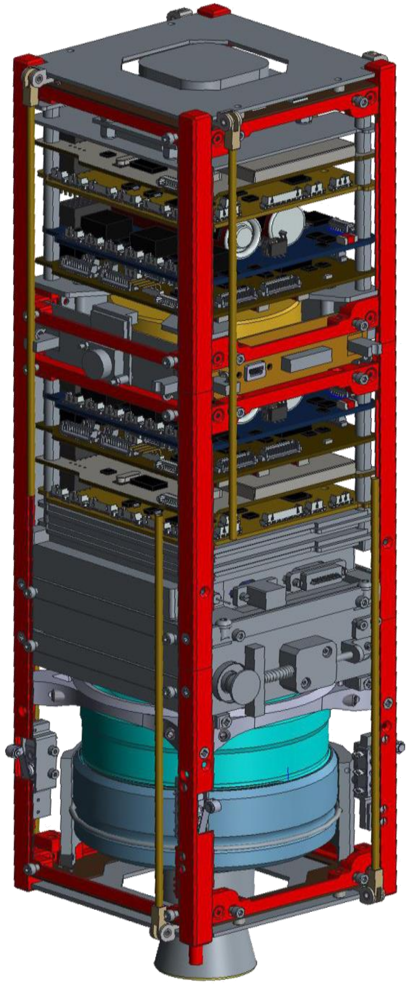


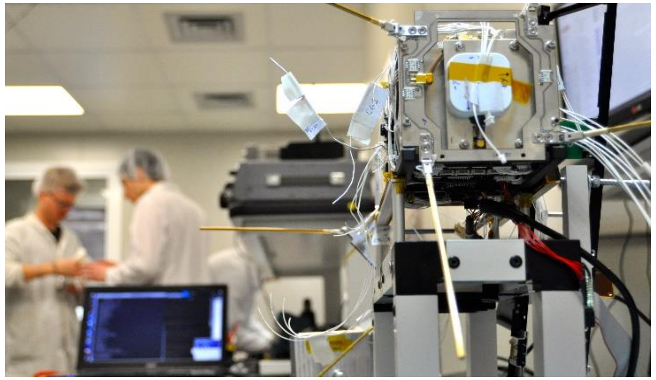
- Assessment SDM-related market in 2020-2025 time-frame (in team with Euroconsult)
- About half a billion Euro potential market for Space Debris Mitigation Solutions
- The market size is very sensitive to the price of the SDM solutions (the willingness to pay is still quite low, especially for constellation operators)
- Uniformity of adoption of the SDM regulations throughout the world will contribute increasing the market size

ESA – Clean Sat #BB14

- TVC system and propellant behavior to long-time exposure to radiations are the most urgent issues to be addressed.
- For the full-autonomous, space-class components the system has cost and mass that are considerable (about 10 to 15% of the total mass of the satellite).
- Current design of spacecraft usually does not allow large accelerations and this limits the performance of the system.
- Autonomy is a high desirable feature
- SRM is the best option for most the applications but it is not the only option

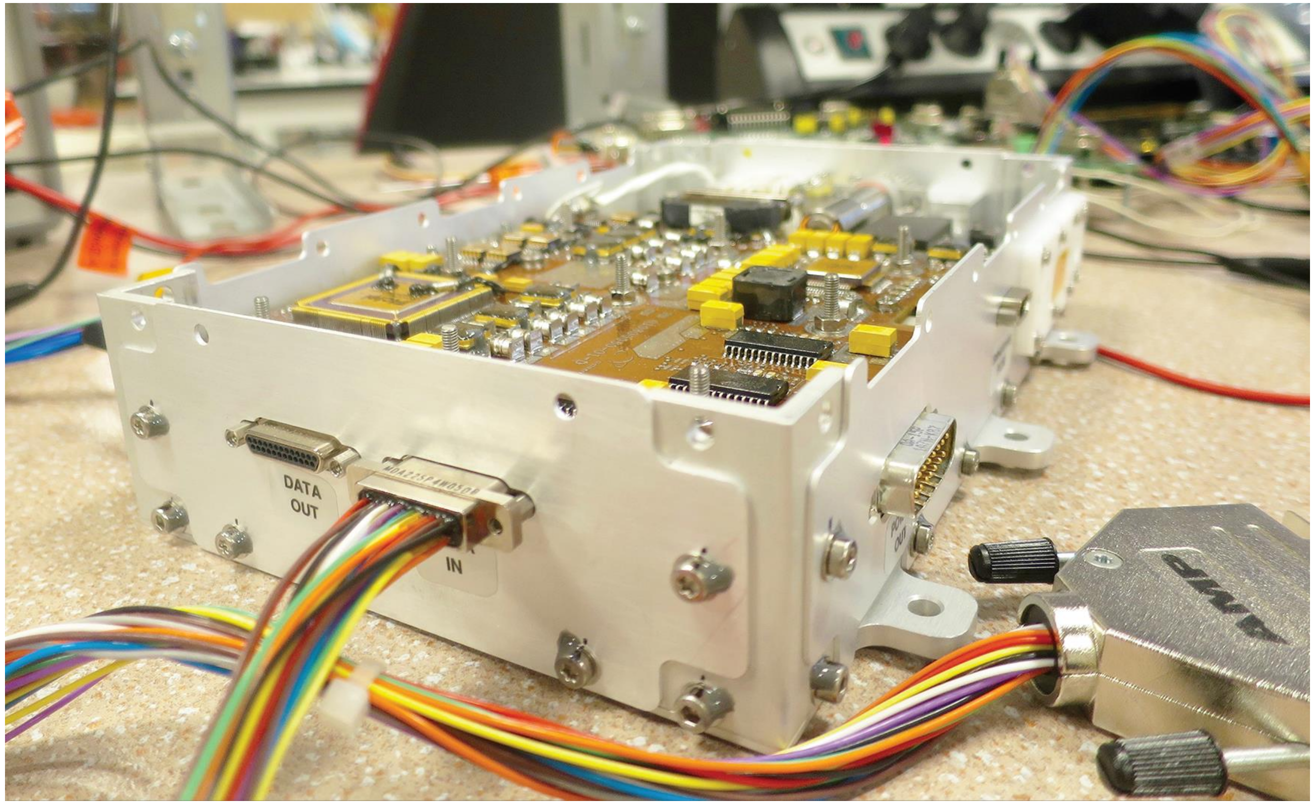
EC H2020 – D3





- Customers (i.e. satellites manufacturers) are generally not ready to adopt SDM solutions, unless being imposed
- A TVC system is highly recommended for this kind of decommissioning manoeuvre
- Autonomy and reliability are key aspects of a decommissioning system

EC H2020 – TeSeR



- Standardization is considered as a fundamental asset by satellite manufacturers
- Target of SDM technologies will initially be large constellation operators, due to the scarcity of efficacy of the regulations
- Institutional funding entities should be also first customers in order to support adoption of SDM solutions.

Lessons Learnt - Summary

SPACE is a **Common** natural resource.

The Tragedy of Commons is usually solved either regulating (e.g. taxing) or privitizing the common good.

Large constellations of satellites are de facto privitizing certain orbits: these will be very likely the first to adopt space debris mitigation and remediation solutions

This opes a bunch of new opportunities related to Active Debris Removal and In-Orbit Services

The focus of future systems shall be Autonomy and high-reliability

D-ORBIT
NEW SPACE SOLUTIONS