

Clean Space

**Guaranteeing the future of space activities
by protecting the environment - a new
cross-cutting initiative of ESA**

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Environmental concerns are at the forefront of public attention:

- new legislative demands such as REACH, RoHS but also LOS
- green technologies provide competitive advantage

Space Industry is also under pressure:

- risk of supply chain disruptions (direct or indirect),
- interest and request from their customers, operator clients, employees and stakeholders (e.g. Arianespace, comparisons ground/space solutions).

Concerns regarding the sustainability of the exploitation of space:

- Recently space debris related events have made news headlines worldwide (ROSAT, Ariane 4 tank, ISS evacuations ...)

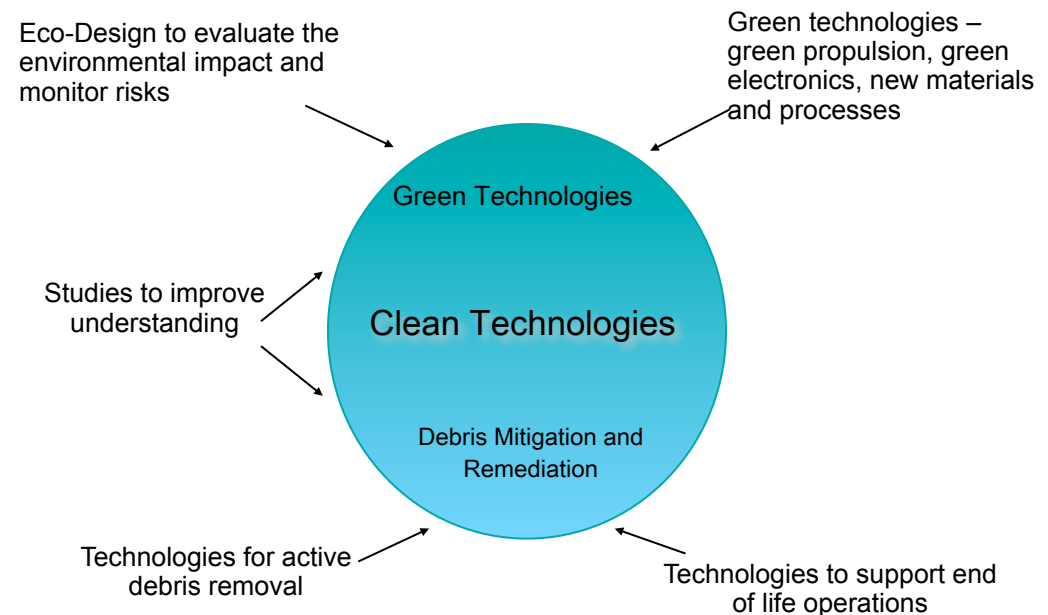
With the proposed Clean Space initiative, ESA gives a pro-active answer to these environmental challenges both on Earth and in space, including its own operations as well as those performed by European space industry.

-> turning a threat into an opportunity

Clean Technologies for space are defined by ESA as those which contribute to the reduction of the environmental impact of space programmes, taking into consideration the overall life-cycle and the management of residual waste and pollution resulting from space activities, both in the Earth eco-sphere and in space.

Four Branches:

- 1 – Eco-Design
- 2 - Green Technologies
- 3 – Space Debris Mitigation
- 4 – Space Debris Remediation



Sustainability of space exploitation

- Simulations by NASA and ESA show that the number of debris keeps growing even if no further objects are launched
- The current environment is already impacting the operations in SSO (e.g. substantial increase of the number of Collision Avoidance Manoeuvres carried out per year).

In-orbit collisions

- Risk of in-orbit collisions is increasing with time. Operational satellite (Iridium) was destroyed by collision with debris (Cosmos).
- Risk of an ESA satellites encountering a catastrophic collision in the next 50 years between $\sim 7.5\%$ and $\sim 11\%$.

International awareness

- World-wide actions to limit the proliferation of space debris by active debris removal (~ 5 objects per year)

Clean Space / 4-Space Debris Remediation Objectives



Develop technologies for space debris rendezvous, capture and re-entry.

Adopting a system approach, technology developments are planned to be focused on a mission for the controlled de-orbit of heavy objects.

Place European industry at a forefront position on anticipated future markets.

Space Debris Remediation

Recent and Ongoing ESA Activities



Several technology and system studies have been carried out in the past years. Most notably:

Technologies:

- RObotic GEostationary orbit Restorer (ROGER), 2010
- Three Ariadna research studies on novel space debris removal concepts (foams, ion beam shepherd, hybridsail), 2010-11
- SysNova, June-December 2012

Concurrent Design Facilities studies:

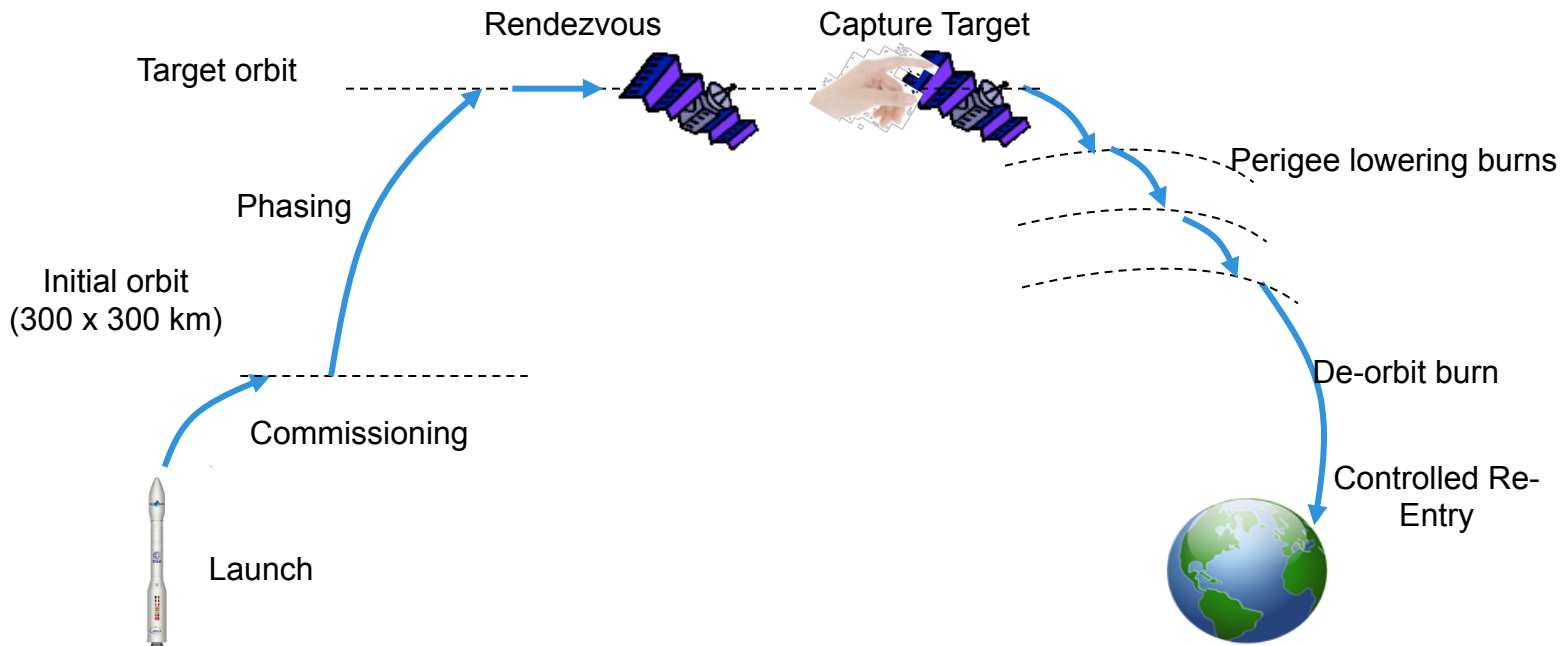
- De-orbit, July 2009
- Envisat De-Orbit, March 2011
- e.Deorbit, September 2012

Space Debris Remediation

Recent and Ongoing ESA Activities

e.Deorbit

- Preliminary system design for most promising options, identify the required technology roadmap, and investigate its (their) applicability to other ESA missions
- Assessment of feasibility, programmatic, risk and cost aspects of a mission for the controlled de-orbiting and re-entry of a large, massive, un-cooperative target in SSO, using technologies analysed in previous CDF studies (e.g. tentacles, robotic arm, net)



Space Debris Remediation

Recent and Ongoing ESA Activities

e.Deorbit - system options

Orbit

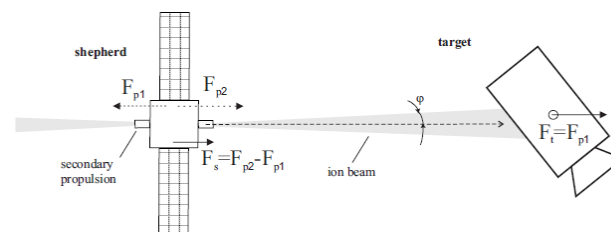
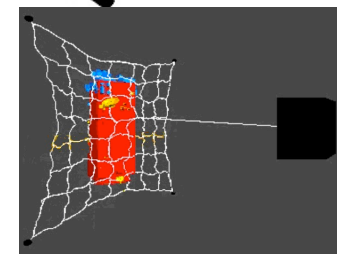
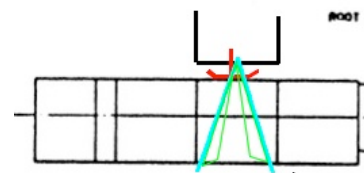
- Re-orbit to >2000 km
- De-orbit to <600 km
- Controlled re-entry

Propulsion

- Chemical (CP)
- Electrical (EP)

Capture techniques

- Robotic arm
- Tentacles
- Net
- Ion-beam shepherd



Focus on tentacles and nets with identification of key open points requiring further analysis

Clean Space / 4-Space Debris Remediation Overview



ESA carried out several system studies for the de-orbiting of a heavy object to:

- Evaluate costs
- Assess risks
- Identify technology gaps

Involvement of European stakeholders (industries and space agencies)

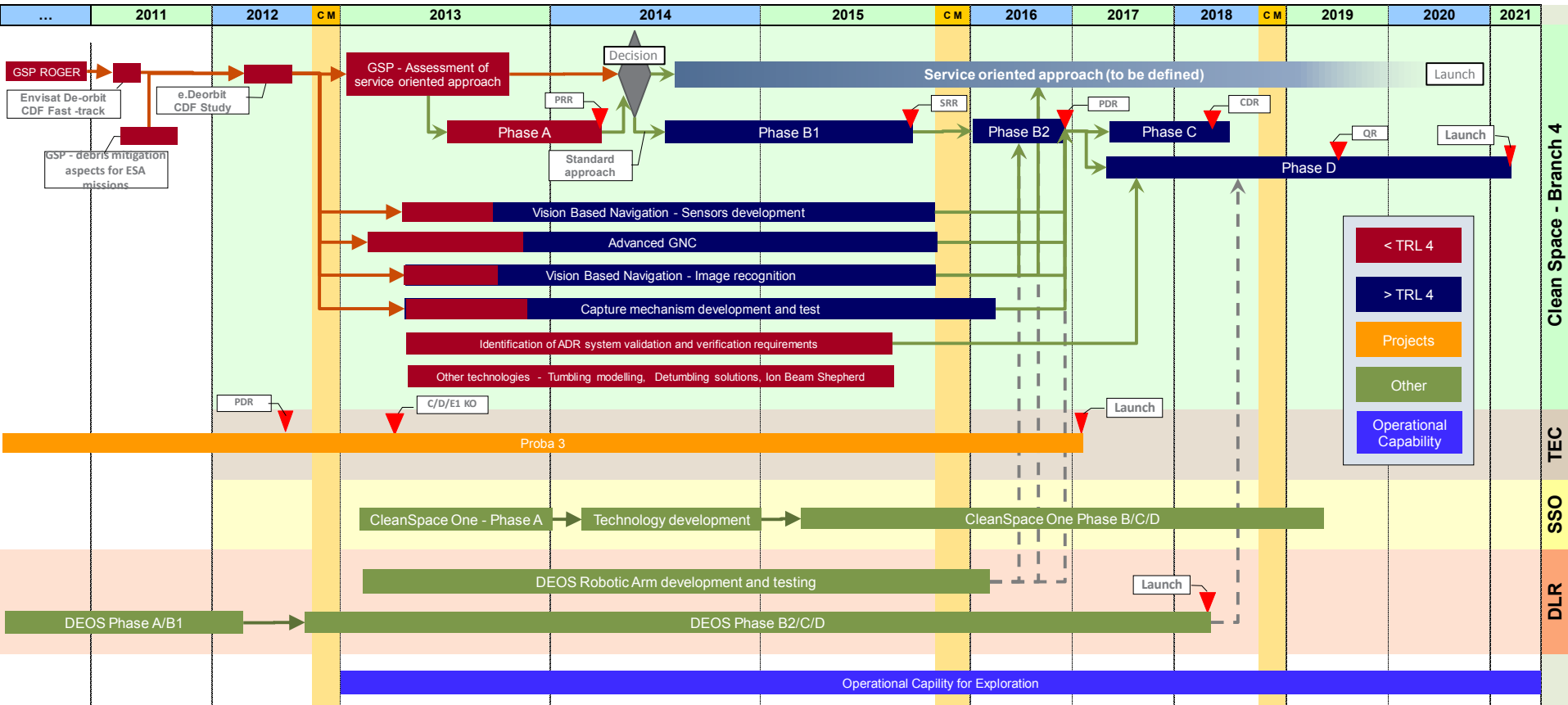
Very preliminary initial technical discussions with international partners

Industrial workshop was organised at ESOC in Sep 2012



Roadmap

Clean Space / 4-Space Debris Remediation Roadmap



Mature ADR technologies

- Adapt and upgrade existing sensor suit to perform rendezvous with un-cooperative targets
- Promote technology maturation of capture mechanisms: net, harpoon, clamping
- Study and develop control of stack after capture, push or pulling approaches

System approach targeting a heavy object controlled re-entry

- Phase A and B1 mission design
- Service-oriented approach to ADR

Study alternative approaches for other targets

- Stabilisation of tumbling targets
- Ion Beam Shepherd

The Clean Space initiative is a cross-cutting theme within ESA's Technology programmes, making ESA an exemplary space agency in terms of terrestrial and space environmental protection.

Active Debris Removal activities form an essential part of the overall Clean Space Initiative.

Following internal preparatory activities and intensive consultations with stakeholders in 2012, ESA plans to implement in the next 2 years a dedicated set of technical and system activities within its existing R&D programmes.

These aim at helping European space industry to

- use resources more effectively
- implement regulations
- mitigate risks

and by fostering innovation, the Clean Space initiative will help European industry turn an apparent threat into an opportunity.