Design for Removal Mission Study

Cleanspace Days

18/05/2016

Ref.:TAS-D4R-Workshop

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Why D4R Design for Removal ?

- ESA Clean Space Initiative
  - Clean Space Branch : Key technologies for Space Debris Remediation

Sustainability of space exploitation

  - Demising objectives have large impact on satellite design up to feasibility status & do not cover failure case

  - **D4R = assessment of potential added value to implement tools for future ADR**

- D4R study : Interdisciplinary team
  - SSA
  - Relative navigation
  - GNC/ Stabilization & RdV
  - Vision Techniques
  - Capture mecanism

Recent evolution: constellations Compliant to LOS, BUT…

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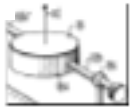
ESA Phase 0 Study - Industrial Consortium

THALES ALENIA SPACE – France (Prime)

- Study management
- Situational Awareness
- Rendez vous – Inspection
- Stabilization
- System trade-off

Retro-reflector for SSA & RdV

Patterns for RdV



Damping system for stabilization

THALES ALENIA SPACE – Italy

- Capture
- Technologies Roadmap
- Vision techniques
- Stabilization for capture phase

Gripping point for capture

Dedicated external Docking system for capture

AVIO– Italy

- Application to launcher upper stage
- Evaluation of proposed concepts

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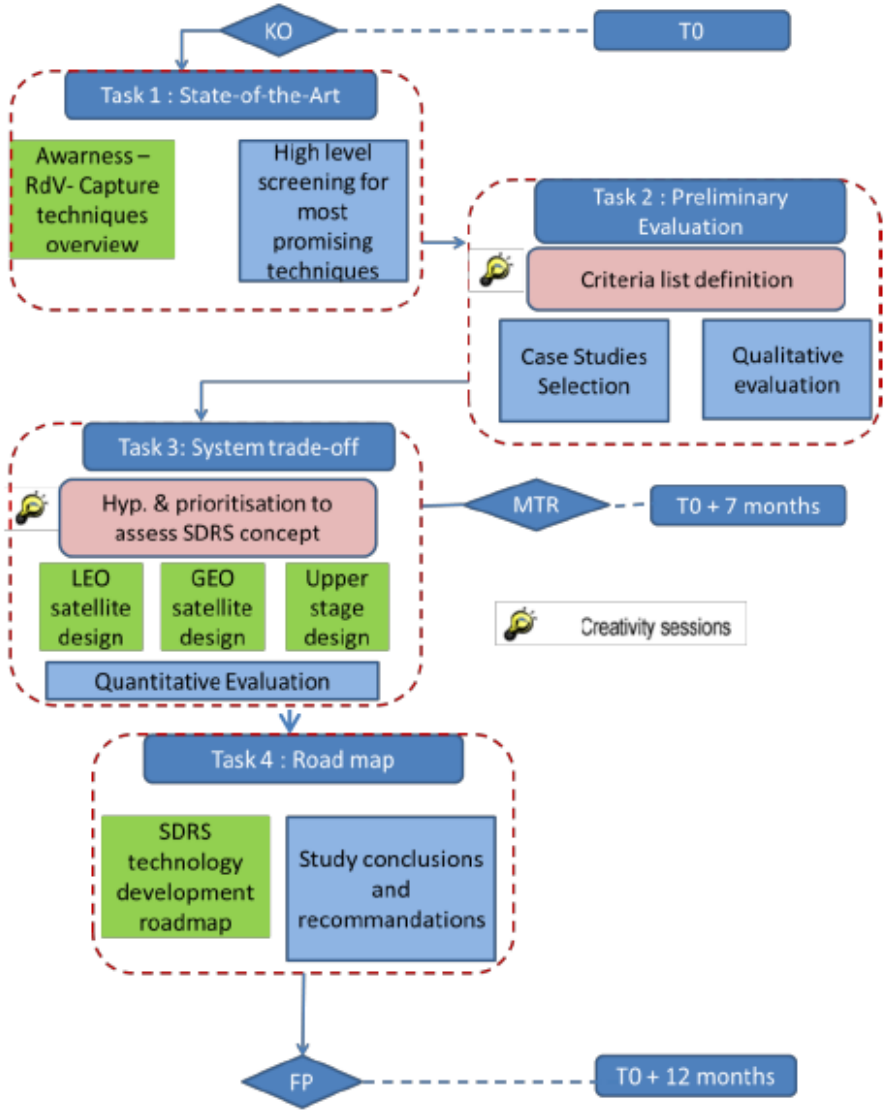
D4R Study Logic

- 12 months Phase 0 study
- SDRS segments
  - Situational awareness
  - Rendezvous
  - Inspection
  - Stabilization
  - Capture
  - Further stabilization
  - In-orbit servicing support
- Study cases
  - Failure mode
  - Propellant exhausted
  - No controllability



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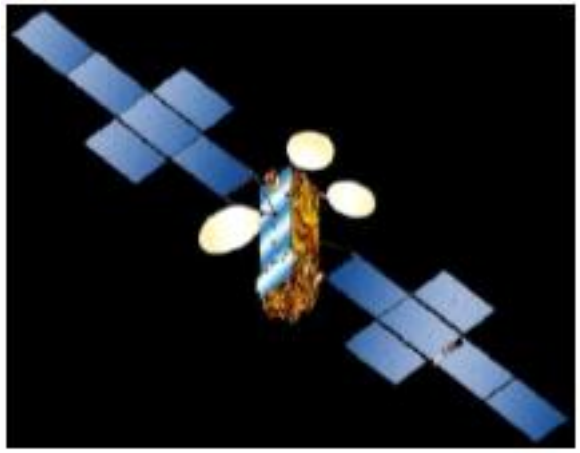
Target assumptions for GEO, LEO and constellations

- GEO
  - Genericity for representativity
  - Wide variety of versions for Spacebus NEO

Payload Power from 3KW to 20 kW

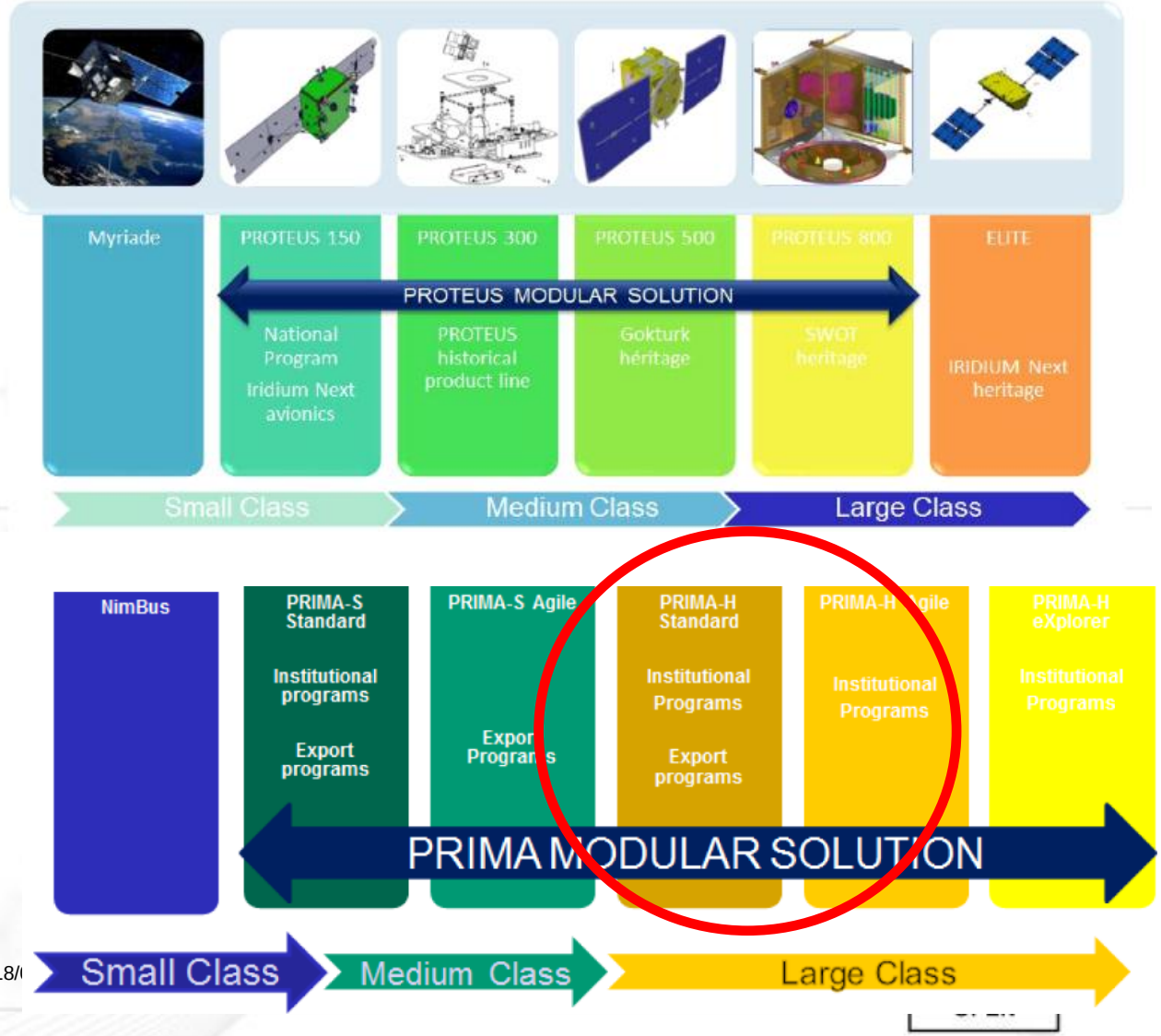
Payload Mass from 200 to 2000 kg

- Next GEO TAS dream product
- Full Electric propulsion
- Possible reconfiguration in orbit



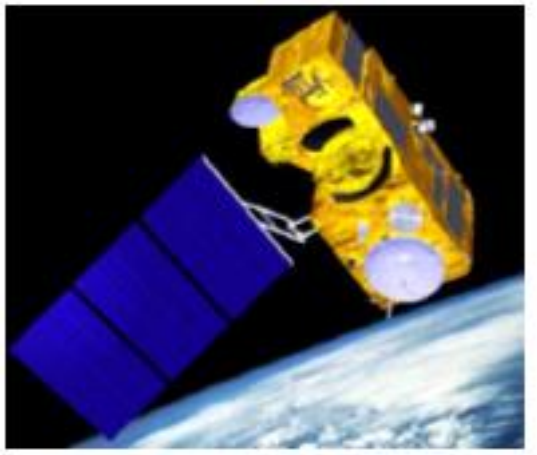
Target assumptions for GEO, LEO and constellations

LEO Study case



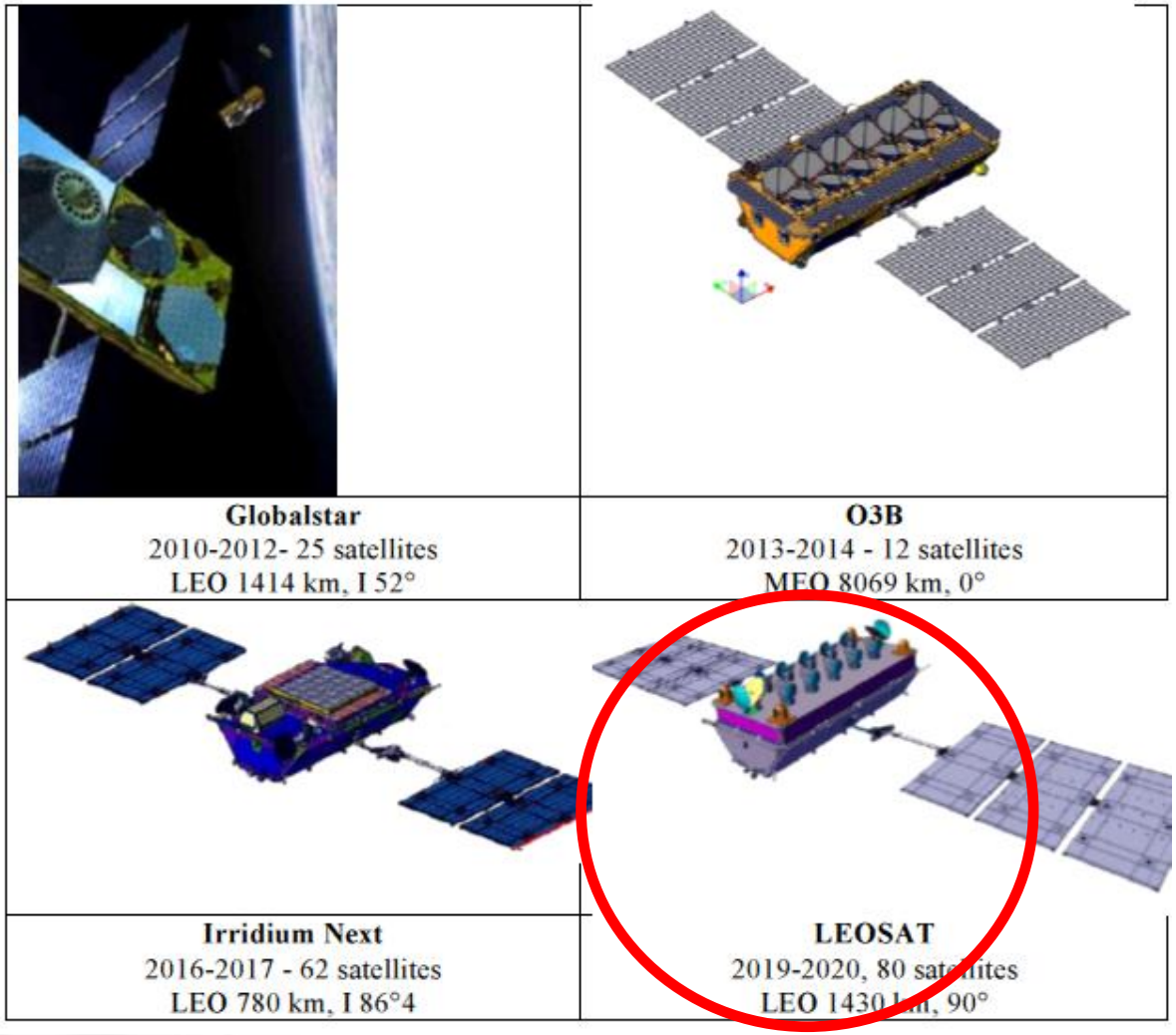
Small & Medium Classes range compliant to LOS

- Large class selected
- Typical LEO observation satellite ~2T
  - Dissymetric
  - Hydrazine



Target assumptions for GEO, LEO and constellations

Constellation study case



- Most of constellation satellites designed for
  - Natural re-entry
  - Or graveyard strategy
- Elite Platform is a good candidate
  - ELITE 2000 electric propulsion
  - DV performed at EOL to reach natural re-entry in 25-years

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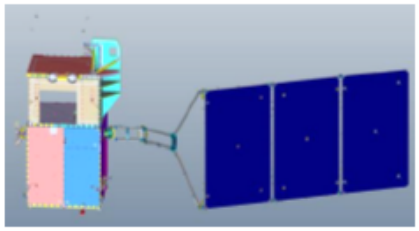
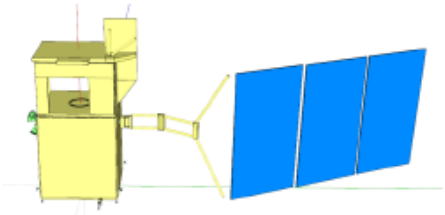
Methodology

IDM-CIC modelling

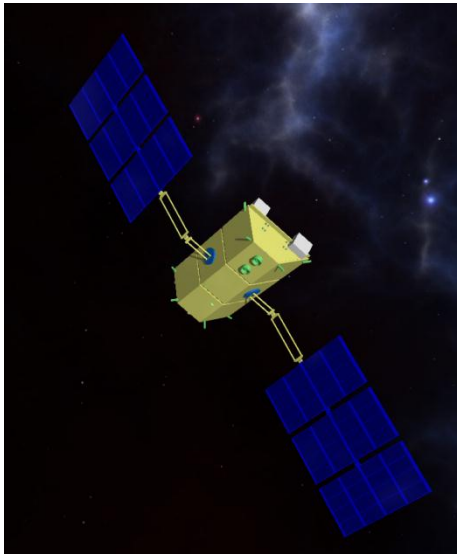


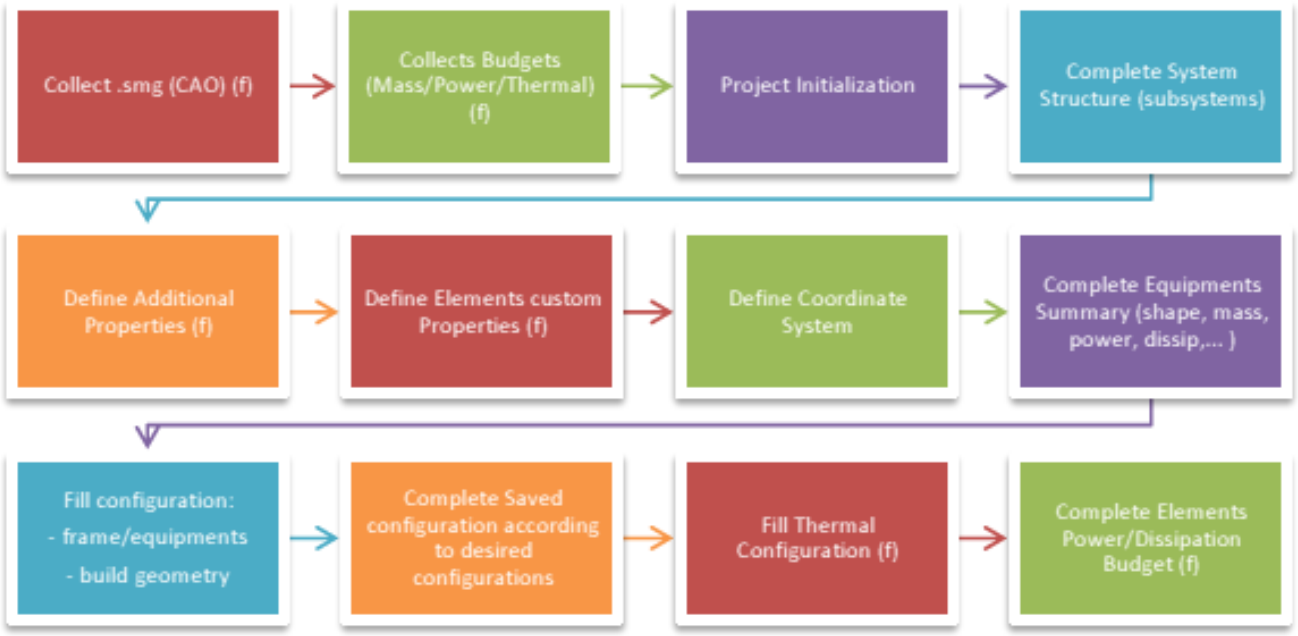
Sentinel 3 seen in Catia

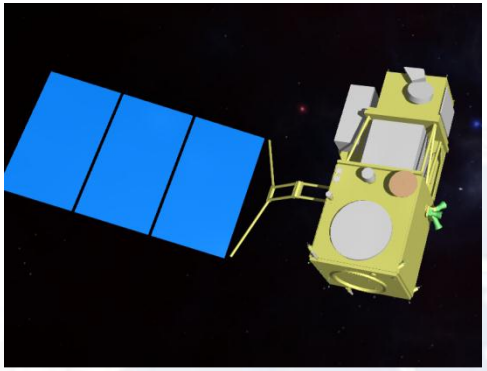
IDM optimization



Sentinel 3 seen in IDM







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Qualitative approach based on programmatic & performance criteria

- Programmatic
  - Development cost
  - Recurrent cost (manufacturing & AIT/V)
  - Schedule impact
  - Chaser cost
- Technical
  - Mass/ Power/ Inertia / Dimensions
  - Performance
  - TRL
  - Risk
  - LOS
  - Synergy with in-orbit servicing
- Chaser
  - Cost
  - Risk

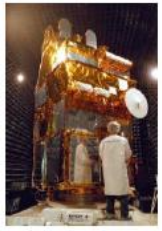
▼ this figure of merit compared to ► this figure of merit	Weighting factor
Programmatic	
development cost	7,1
recurrent cost	8,6
Technical	
Mass	8,4
Power	7,9
Dimensions	7,7
Inertia	7,3
TRL	7,6
Risk	8,5
Synergy with in-orbit servicing	7,1
LOS impact	7,9
Performance	8,6
Chaser	
Chaser risk	6,8
Chaser cost	6,5
	100,0

Various solutions to improve SSA & vision

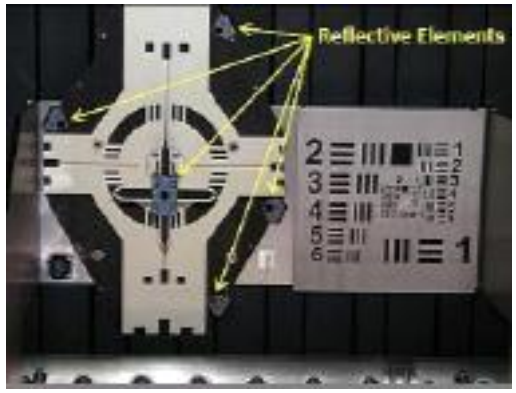
ISS retroreflectors

Retroreflector array of Envisat. Courtesy of ESA

#1 : laser retro-reflectors

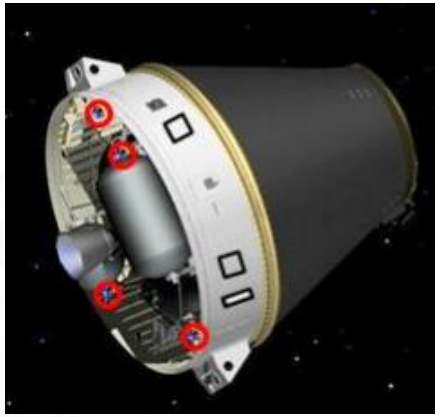


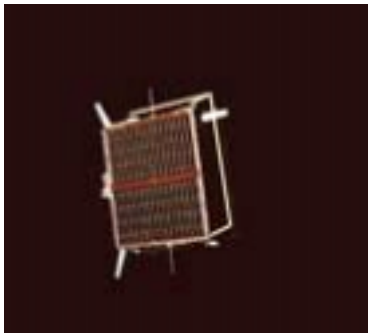
Golden MLI on Spot 4. Courtesy of CNES



STORRM system

#2 : reflective elements





Mango reflective tapes on contour

#3 : Patterns for pose estimation

#4 : LED illuminator

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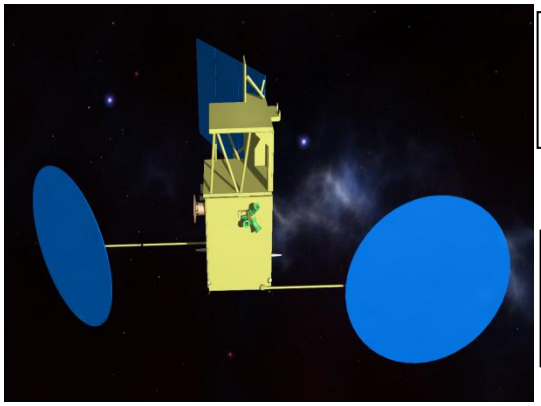
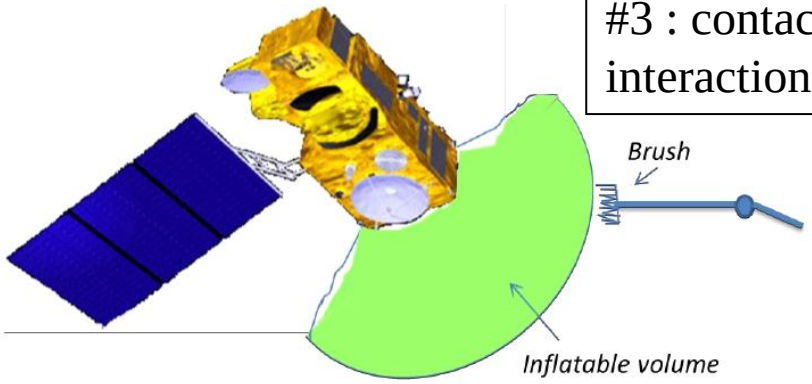
Various solutions to consider for stabilization



#1 : embedded actuators

#2 : actuactors transferred

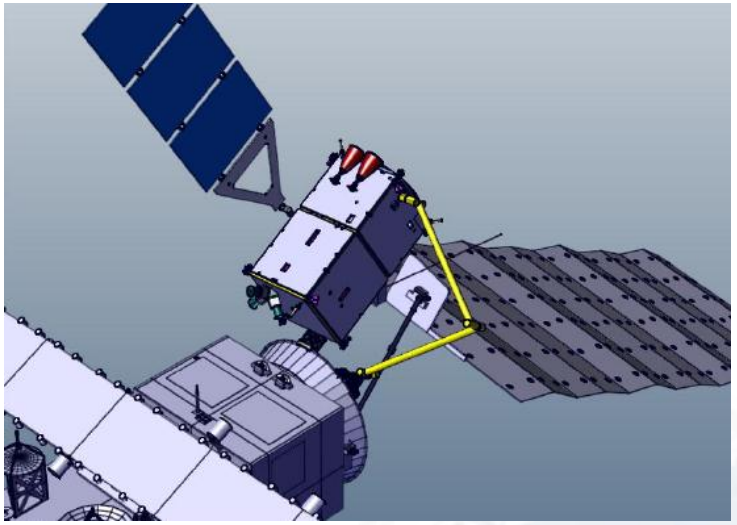
#3 : contact interaction



#4 : contactless solution

e.Deorbit Phase A study:

Tumbling value limits grapping capability



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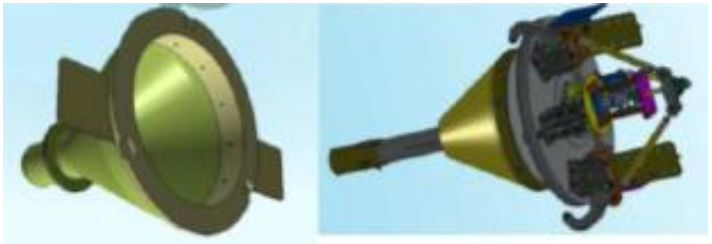
Large number of solutions for capture

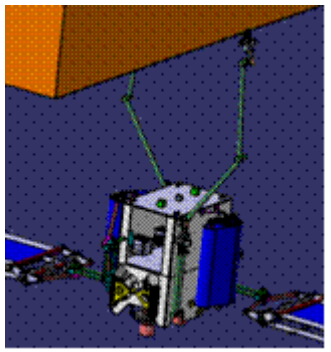
Handle of Docking Mechanism

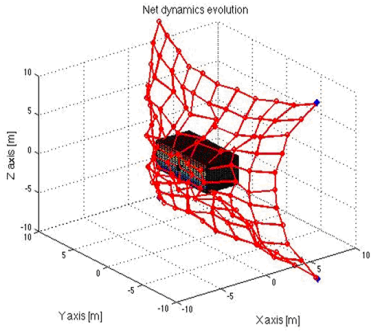


TASI Probe and Drogue concept

ASSIST docking
2D markers & reflectors for Lidar

#1 : Rigid link : tentacles, robotic, clamp, probe docking





#2 : Flexible link : net, hook, harpoon

#3 : reorbit & deorbit : inflatable systems

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Conclusion

- Debris management rules could not be sufficient in some case
- D4R can mitigate risk

- Economically viable solution to propose, Cheapest..
- Potential anticipation impact on
  - Next debris additional rules
  - Market analysis with lifetime potential increase versus reliability

Pave the way for a business plan for in-orbit servicing ?

Debris Management is a major objective for TAS

- Space System Awareness to prevent collision with Active S/C
  - SSA preparatory program since 2010
- ADR system concepts
  - Started in 2011 with OTV & EASE CNES activities, ESA e.Deorbit phase A-B1
  - Autonomous Rendez-vous activities
  - Docking & Robotic activities
- End to End Dynamics simulation Rendez-vous and modelling
- Transverse enhancing technology
  - Electrical thrust, PPU management and semi-controlled re-entry
  - Refolded solar array
  - Design for Demise
  - Additive manufacturing

Objective in line with TAS experience, know-how & investment in technologies