Space Tug
Presentation for Clean Space Industrials days

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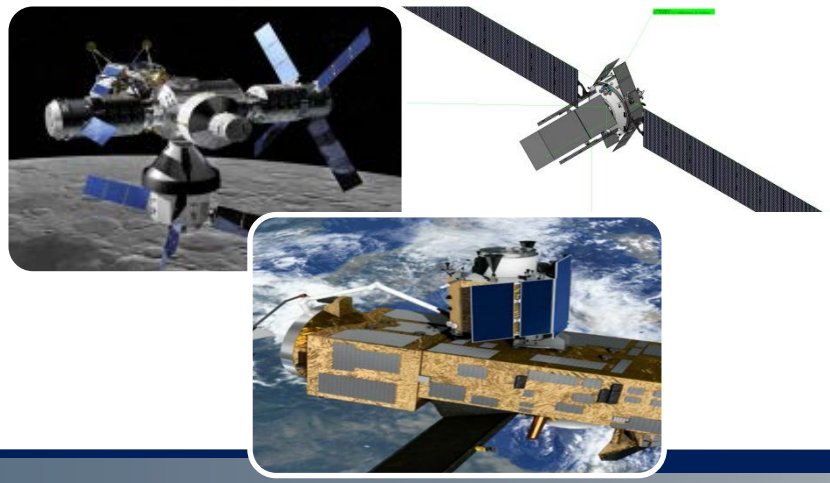
Space tug concept and time for opportunity

What ?
- Reusable in-orbit carrier to **ferry** and **service** satellites
- Paradigm change in access-to-space inspired from terrestrial logistics model

Why possible Now in Europe ?
- Rendez-vous experience
- Electric propulsion and Power upgrade
- Robotics progress

Why is it interesting ?
- Reusability: for launcher and orbital vehicle
- More payload or faster TTO
- Make new orbit access possible
- Tug = ProxOps & mating = On Orbit services easy



What for ?
- Human exploration
- Satcom, constellations delivery
- Satellite servicing,
- Active Debris Removal

Why Airbus D&S ?
- ATV and MPCV
- Telecom EOR
- E3000 and Astrobus
- Robotics Lab

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Our Vision

Life extension & PMD

Refuelling

Geo Hub

Surveillance

Debris removal

Delivery to Final Orbit

Intermediary Orbit

The 3 Loops concept: from Space Tug to SUV !

To deliver satellites with a resident orbital Tug, akin to goods distribution on Earth, and provide valuable On-Orbit Services.

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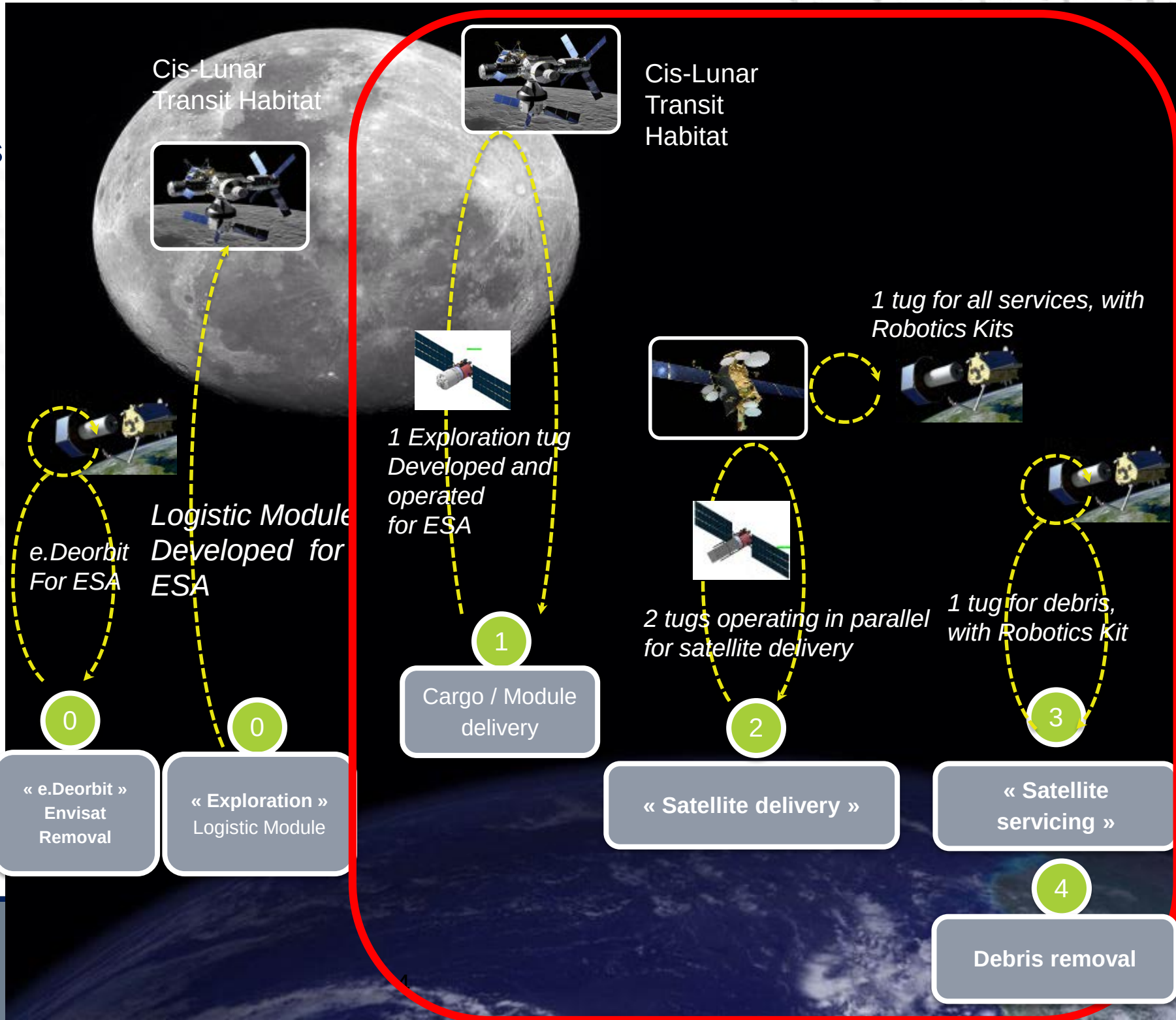
The Space Tug: market segments and operational scenario

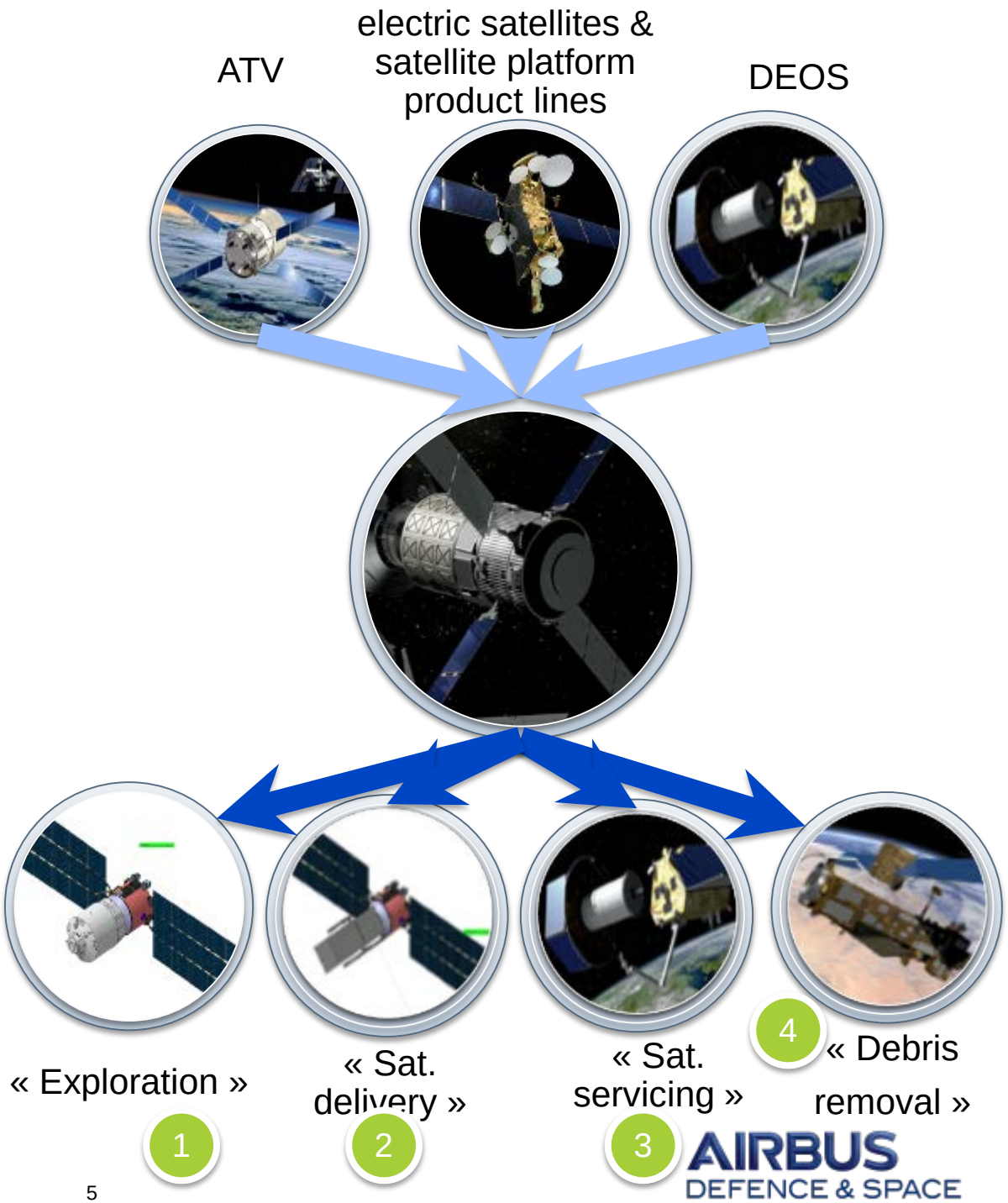


Product Line approach

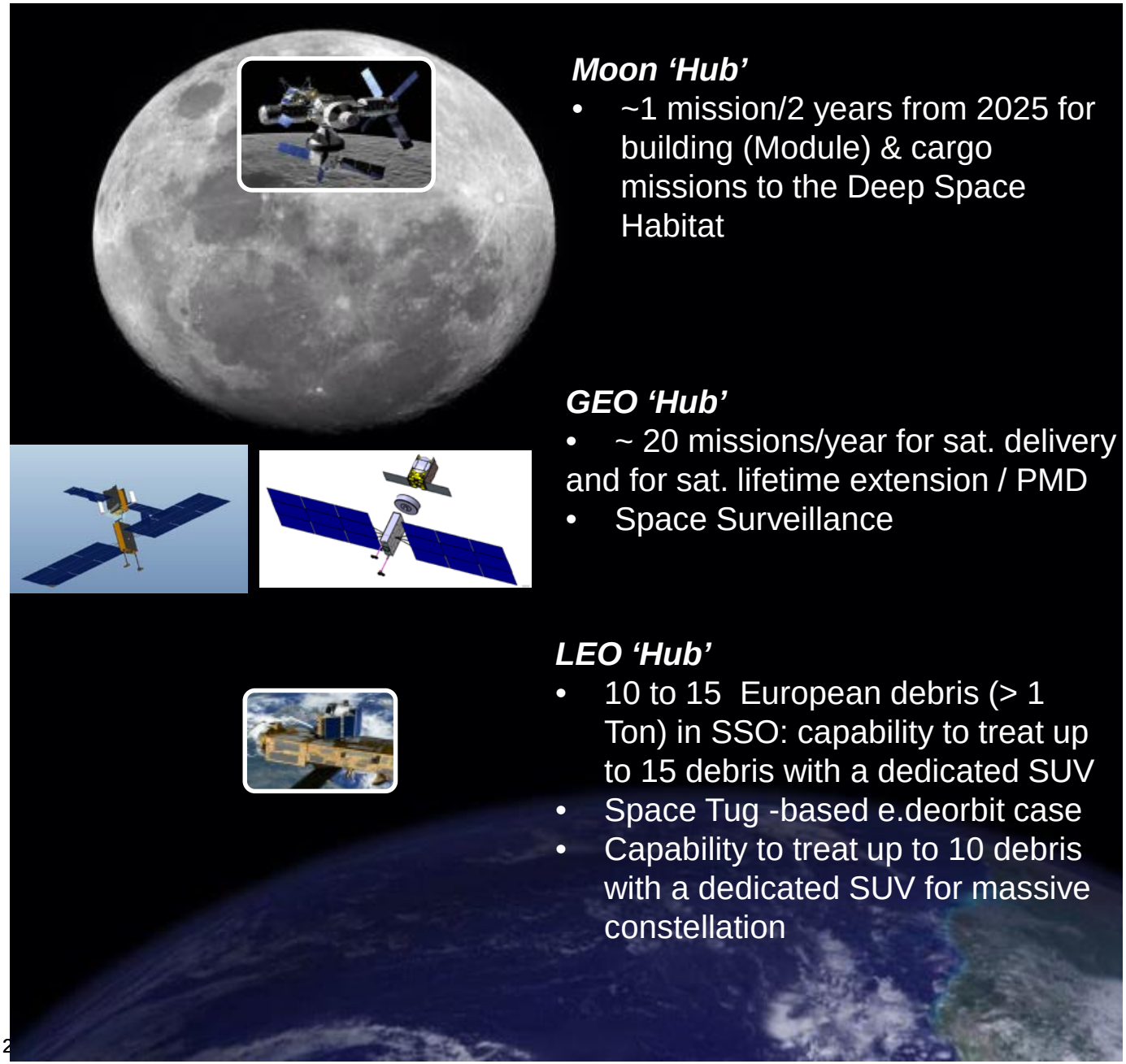
Heritage

Generic platform and common technologies (e.g. high thrust electric propulsion, Power management, solar arrays, radiation, Rendez-vous, robotics)

Product Line with Customised vehicle by application



Short-term addressable market



Moon 'Hub'

- ~1 mission/2 years from 2025 for building (Module) & cargo missions to the Deep Space Habitat

GEO 'Hub'

- ~ 20 missions/year for sat. delivery and for sat. lifetime extension / PMD
- Space Surveillance

LEO 'Hub'

- 10 to 15 European debris (> 1 Ton) in SSO: capability to treat up to 15 debris with a dedicated SUV
- Space Tug -based e.deorbit case
- Capability to treat up to 10 debris with a dedicated SUV for massive constellation

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Zoom on Active Debris Removal

- Rendez-vous approach common : compatible with product line, including e.deorbit

  ❑ cooperative (or designed for) / uncooperative
    - o Quiet debris with on-purpose handling system
    - o Quiet debris with accessible launcher interface
    - o Quiet debris with no accessible handling
    - o Tumbling debris: fly-around, capture (i.e. specific propulsion and capture kit)

  ❑ Capture with arm or with alternative methods (net, harpoon,…) & « tethered » motion

  ❑Natural demise or controlled re-entry
    - o Transfert and leave at 400 km / 500 km tbc
    - o Transfert and boost with the debris or leave with deorbit kit

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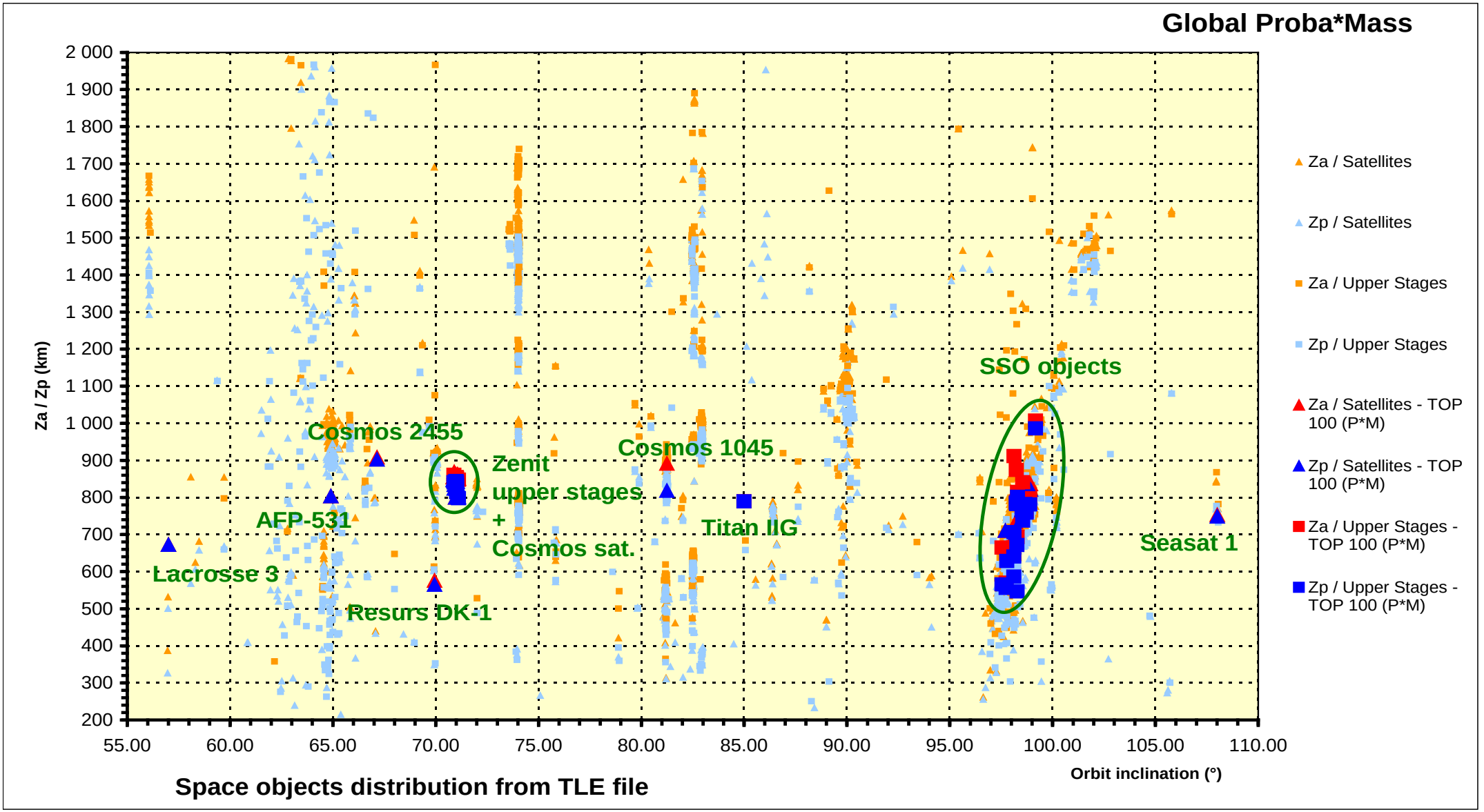
TOP 30 satellites on 2012 TU-Braunswick list



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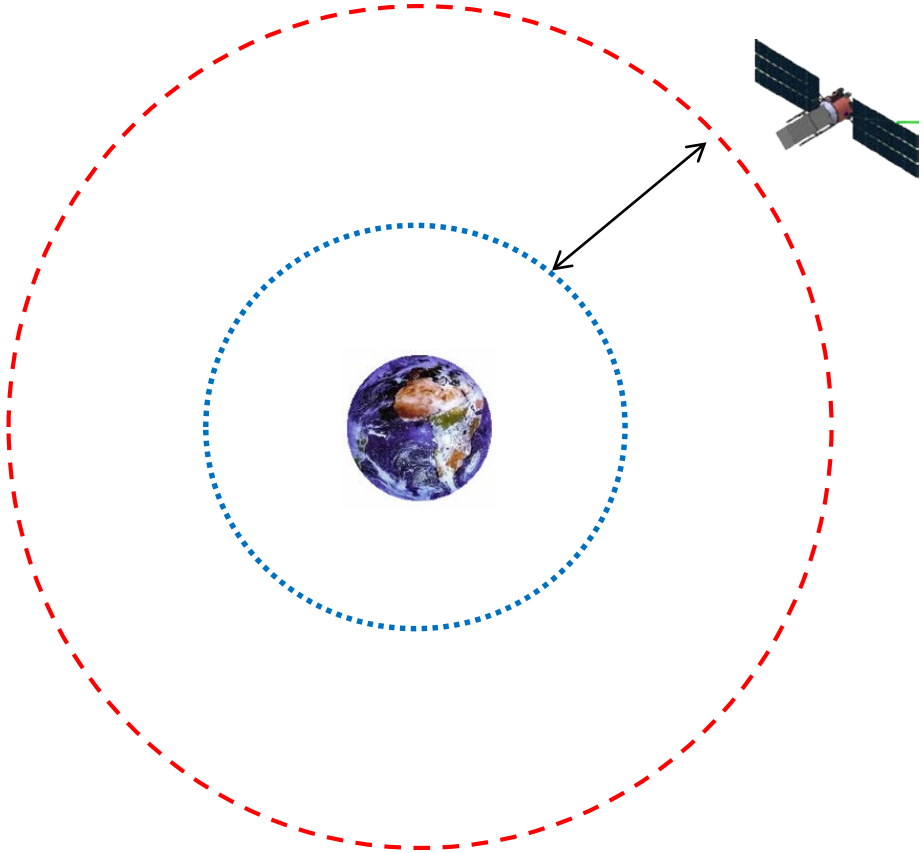
Reaching SSO Debris challenge: tackling Orbit Plan change

Different altitude **loitering** orbit on given **duration** for **RAAN natural drift adaptation (J2 effect)**



Assumptions :

- Stand-alone Tug
- Change plan with natural RAAN drift when different circular altitude
- S/C deorbitation assumption: Tugging to 400 km / 500 km orbit for natural erosion (natural demise)
- Alternative: deorbit kit when necessary

SSO Debris Removal mission with a Space Tug
Delta-V analysis preliminary conclusions

- European '1st/2nd Priority' debris from Proba-Mass figure of merit are not randomly distributed in terms of RAAN
- Addressing '1st/2nd Priority' debris in a same mission is very interesting in terms of delta-V
- In those conditions, stand-alone SUV typical debris removal capability is as follows:
  - **Up to 15 Major European debris capturable for one Tug**
  - **One Debris transported to 400 km / 500 km (for natural reentry) every 3 months**
  - **Interesting cost rough order of magnitude per debris**

Massive constellation : the heterogeneous case with the SUV

Using a (several) resident multi-mission "Space Tug" chaser(s)

- Target S/C spin assumed controlled
- Dead S/C capture is performed with Space Tug robotic Arm (on serviced S/C launch interface or specific grappling feature)
- S/C tugged to a ~400 km / 500 km orbit destination. Uncontrolled de-orbitation with full natural demise
- Homogeneous constellation orbital planes & homogeneous failed target distribution is assumed
- Orbital plane transfer capability with altitude

Typical sizing and performances

- 30 kW prop power with 4,5t propellant
- Scenario 1 with one Space Tug
  - o On-demand service from a waiting orbital plane
  - o Can change 180° RAAN within 12 to 16 months
  - o 8 up to 20 missions
- Scenario 2 with 4 Space Tugs
  - Systematic visit of each plane once a year
  - 1 Tug can visit 1 plane every ~2-3 months
  - All planes can be serviced at 12 months period with a fleet of 4 Space Tugs

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