Active Debris Recovery System for LEO Communications

Clean Space Industry Days 2021

ADR LEOCOM

Valdani Vicari & Associati
ECONOMICS & POLICY

QINETIQ

gmv INNOVATING SOLUTIONS

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Introduction

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Objectives of the Activity

Nowadays, almost **12000 objects** have been launched to space (**586** in 2019, **1273** in 2020… and **1389** in 2021 up to now). ~6500 are still in orbit, although ~4000 are operational. Besides, several thousands of debris pieces.

Studies indicate that to keep the debris population under control, the success ratio for disposal should be of 90% or 99% (higher than the current ratios).

There has been previous activities studying the removal of large objects. However, these are single missions, with high costs. Future missions will have cost as a driving factor, as well as possibility to service more than one mission.

The objective of the project was:

- **Understand the market** for debris removal
- to identify different **business models** for debris removal systems
- if a valid business model is identified, **initial design of the debris removal satellite**

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Team Organization

GMV Aerospace and Defence S.A.U. (GMV), Spain, acting as prime contractor.

QinetiQ Space NV (QinetiQ), Belgium, acting as subcontractor.

VVA Brussels SPRL (VVA), Belgium, acting as subcontractor

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Addressable Market

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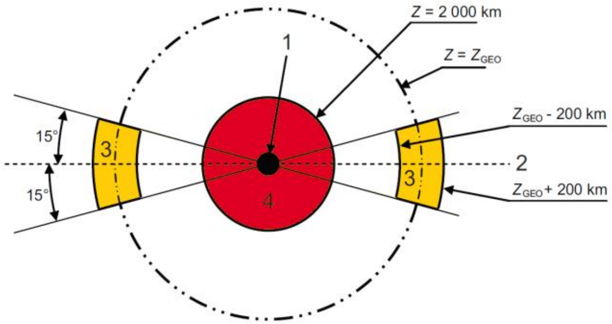
Addressable Market

Assumptions on Potential Market

The following assumptions will be considered in this section:

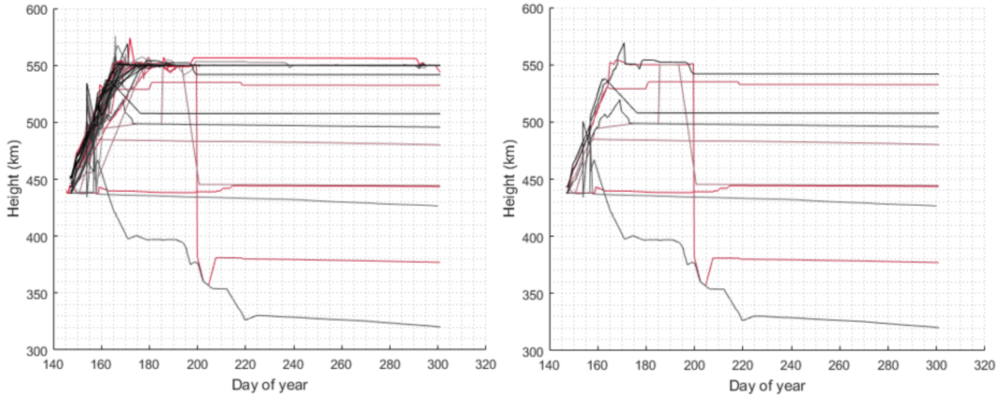
- Impact of Altitude
- Impact of the Kind of Mission
- Market Trends



Definition of the protected regions. LEO region is the area marked with 4 and painted in red (from ISO 24113:2011)

The following technical considerations were considered:

- Failure rate
- Satellite Physical Characteristics
- Removal as an EOL service
- Design for Removal



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Serviceable Market Legal Considerations

Main Topics

Lack of a specific international and national regulatory framework suitable to tackle with the multiple legal challenges the debris management conveys.

Current scenario does not provide enough legal certainty to encourage the development of ADR activities.

However, there is an ever-growing awareness regarding the urgent necessity of dealing with the space debris problem, in order to ensure the present and future sustainability of the space industry.

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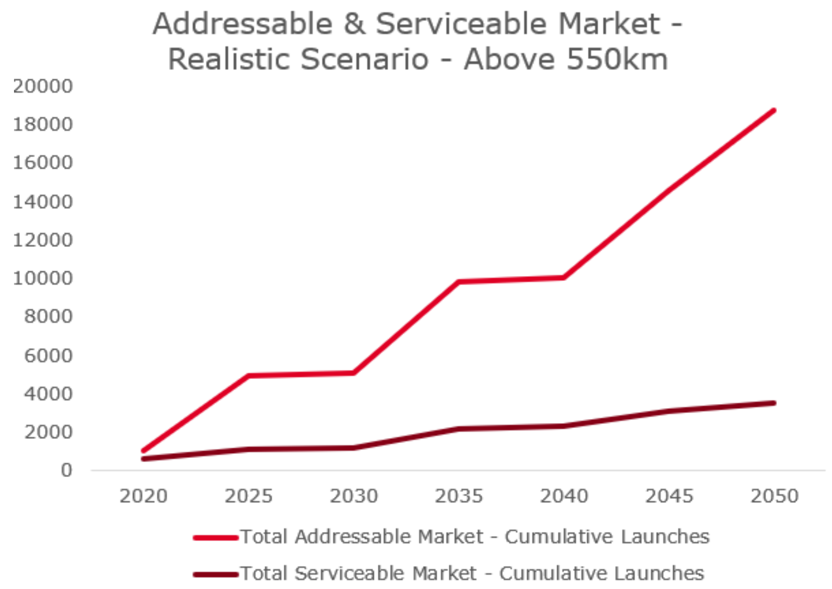
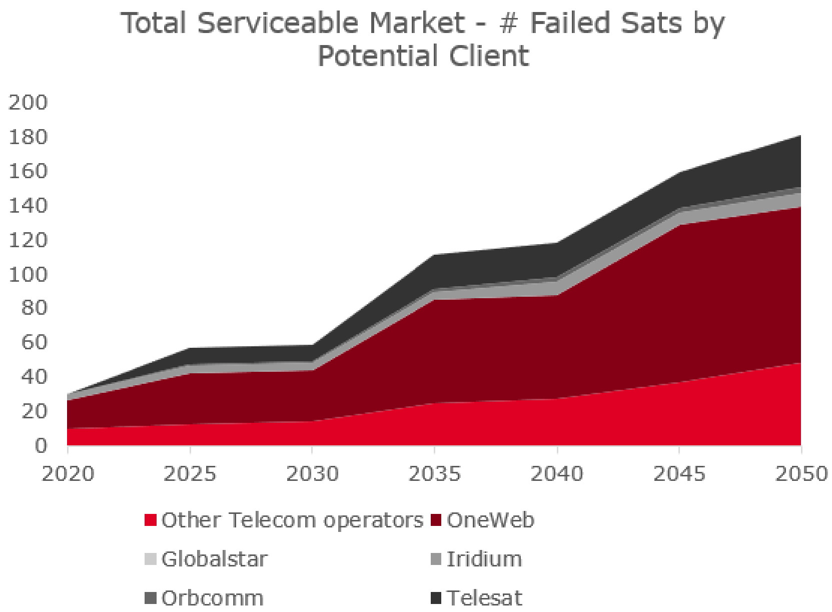
Market Analysis





Of the serviceable satellites, about **200** are expected to fail.

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Business Analysis

Mission concepts considered

1. Only small satellites captured
2. Small satellites and 1 large satellite at end of mission
3. Only one large EO satellite
4. Small satellites captured with chemical propulsion*
5. Only one large EO satellite with chemical propulsion
6. Servicing different constellations (Starlink, Oneweb, Telesat)

I. No plane change

OR

II. 5° RAAN Shift

OR

III. 15° RAAN Shift

a. Satellites captured 1 by 1

OR

b. Satellites captured 2 by 2

*Due to fuel consumption, no RAAN change considered for this case

Pricing strategies considered

Pay per debris
ADR-LEOCOM service activated based on request **once a satellite fails**.

Insurance model
A **fee paid per year** to ensure that in case of failure of their satellites, ADR-LEOCOM would deorbit their satellites with no, or limited, additional cost.

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Concepts & Mission Strategy

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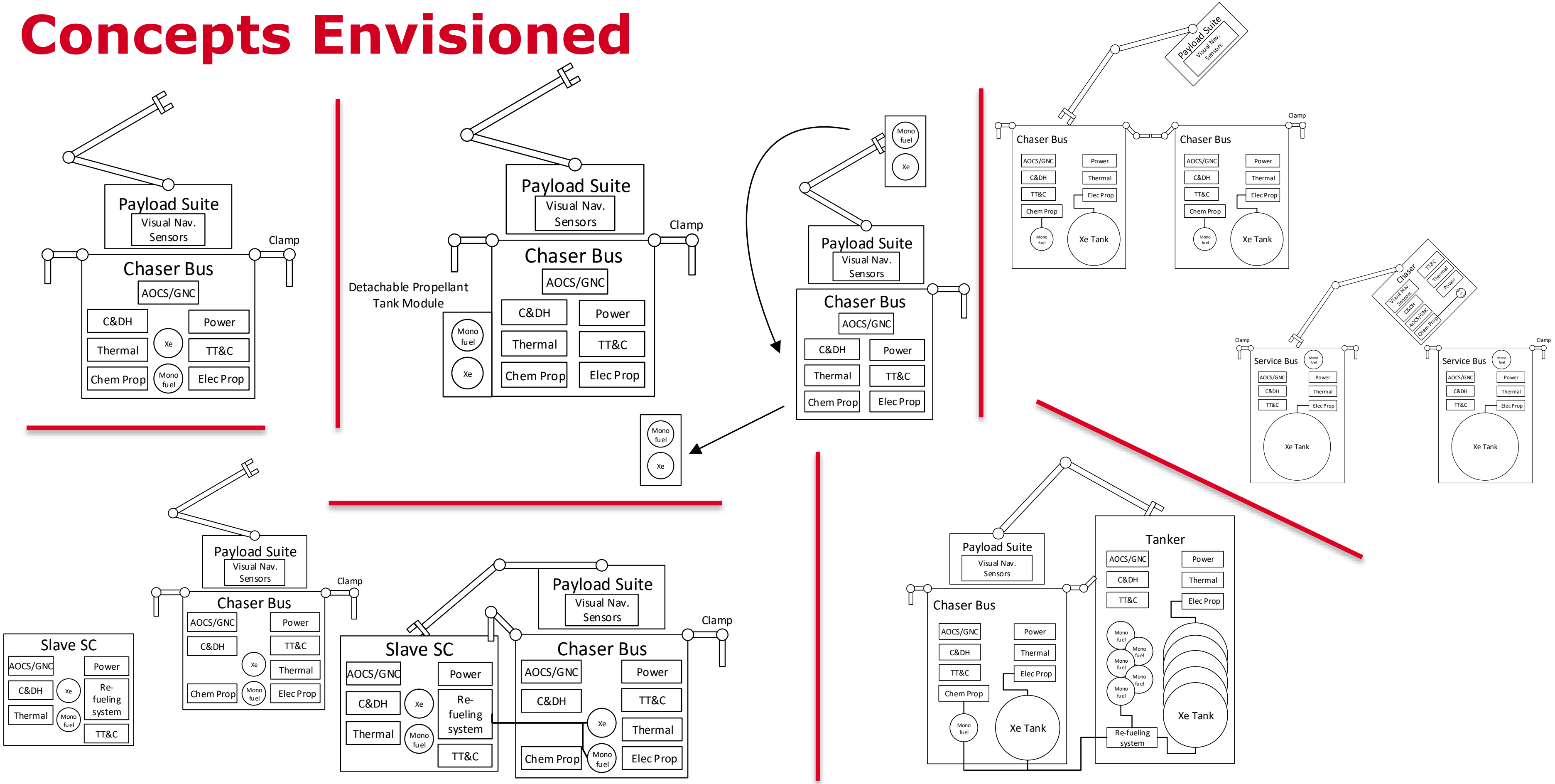
Concepts Envisioned



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Concept Selected

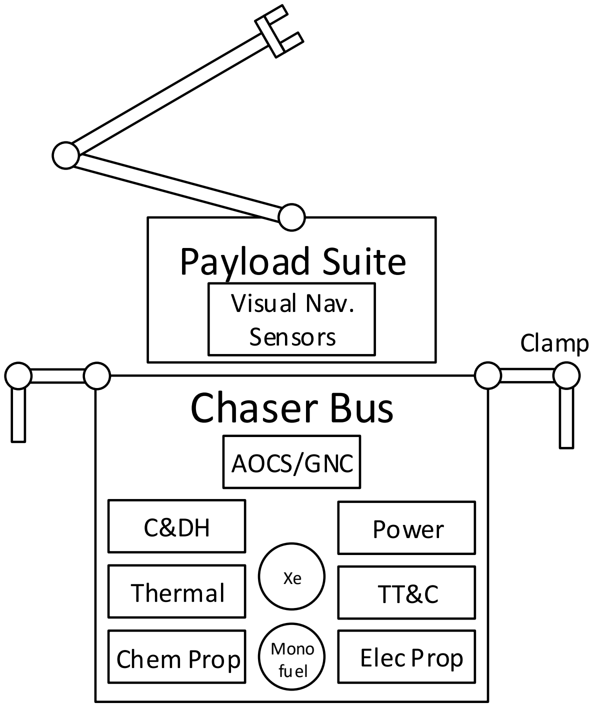
Chaser SC consists of bus + capture system

The Chaser bus contains all the vital subsystems

2 propellant tanks in the centre for dual-propulsion

When fuel is depleted, the Chaser SC itself is deorbited, together with the capture system

The tank sizes are made as large as possible to maximize the number of de-orbit manoeuvres and service lifetime to ensure adequate profitability



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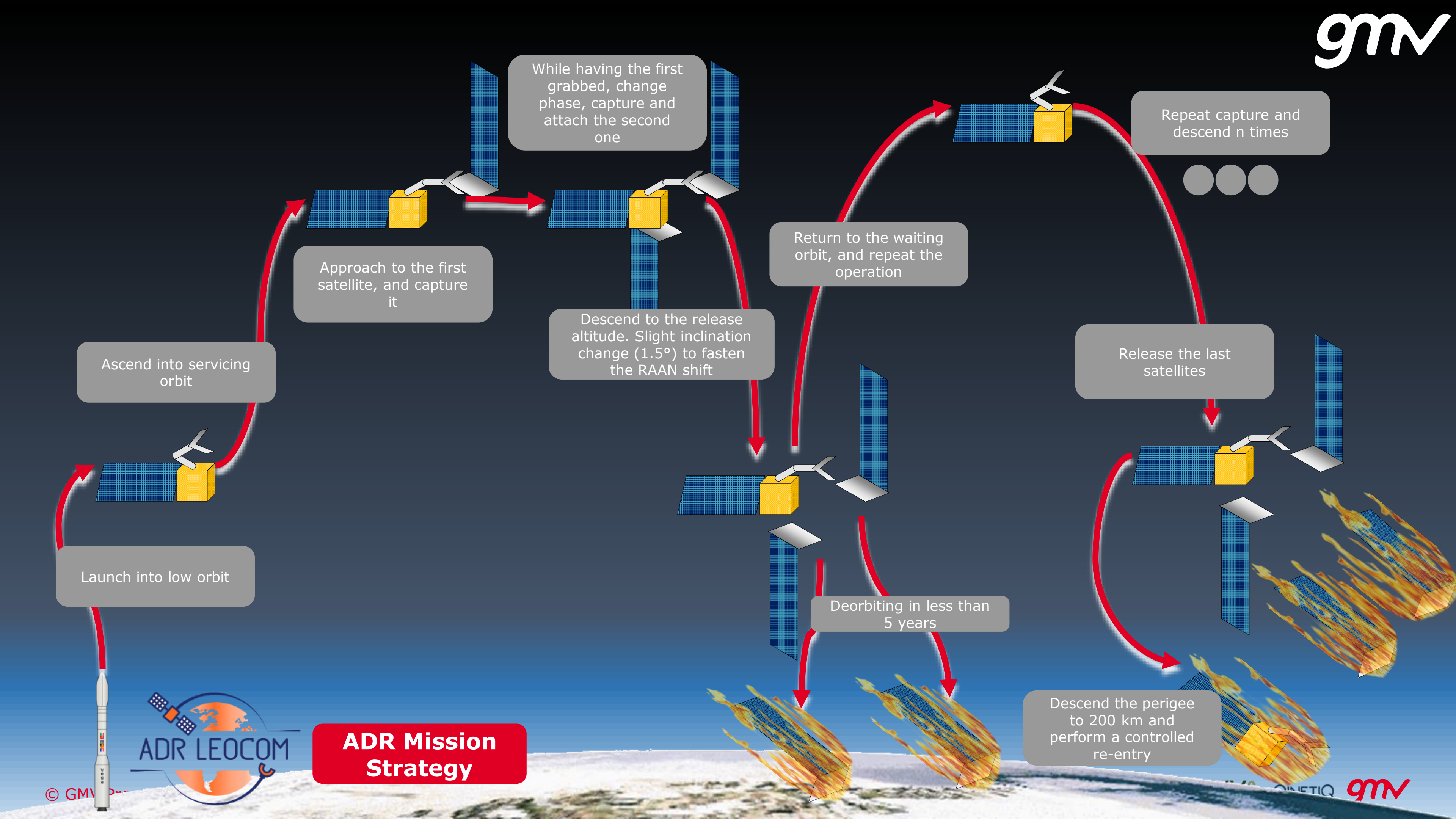


Launch into low orbit
Ascend into servicing orbit
Approach to the first satellite, and capture it
While having the first grabbed, change phase, capture and attach the second one
Descend to the release altitude. Slight inclination change (1.5°) to fasten the RAAN shift
Return to the waiting orbit, and repeat the operation
Repeat capture and descend n times
Release the last satellites
Deorbiting in less than 5 years
Descend the perigee to 200 km and perform a controlled re-entry
ADR LEOCOM
ADR Mission Strategy

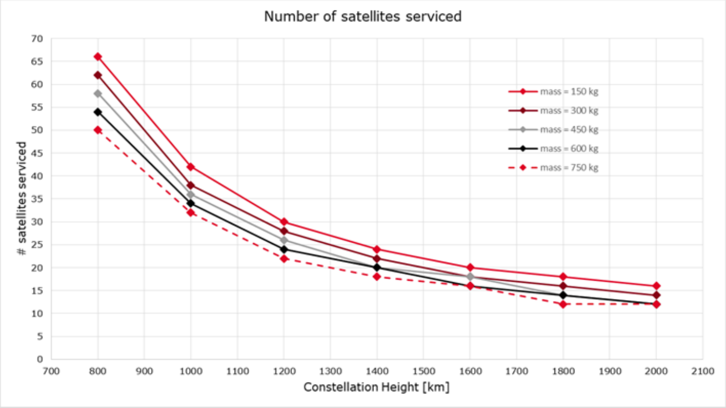
Mission Strategies

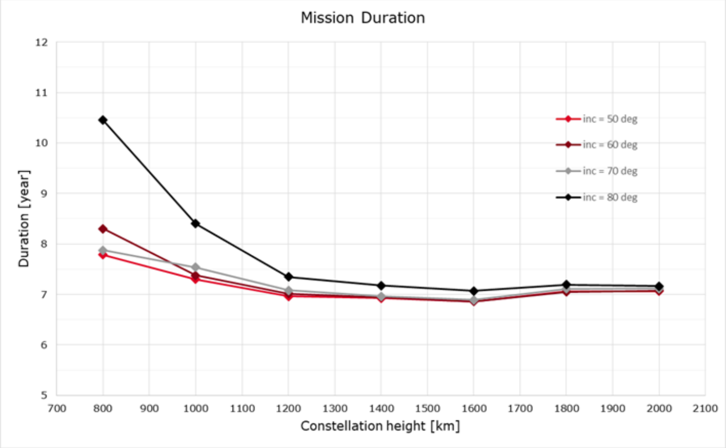
It has been analysed the effect of the **satellite mass** and **constellation inclination** for a wide range of **constellation heights** in LEO over the **number of satellites serviceable** and the **mission duration**

- Higher satellite masses reduces the number of satellites that can be serviced

- Close-to-polar constellations extend the mission duration, being less affected by the mentioned effect

- Higher constellation altitudes reduce the number of satellites that can be serviced, whereas it has not a clear effect on the mission duration if inclination is not close to be polar and above 1000 km altitude





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Design

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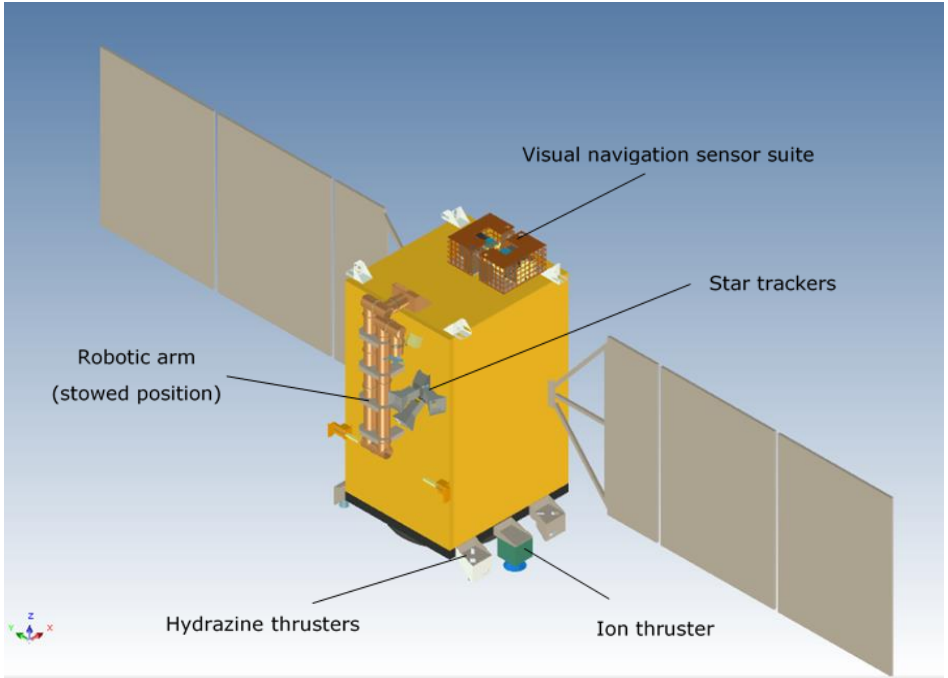
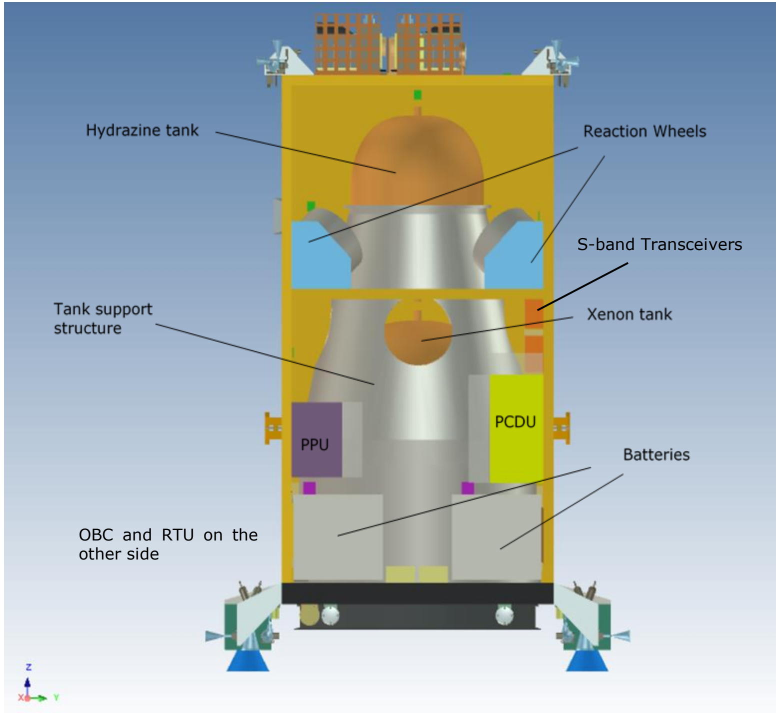
Configuration Design





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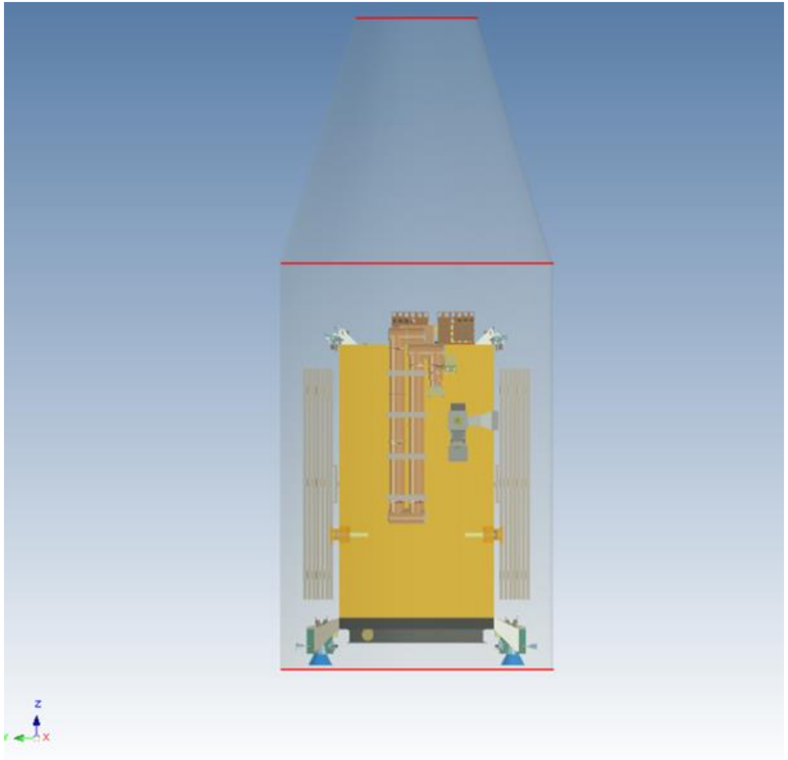
VEGA-C Accommodation



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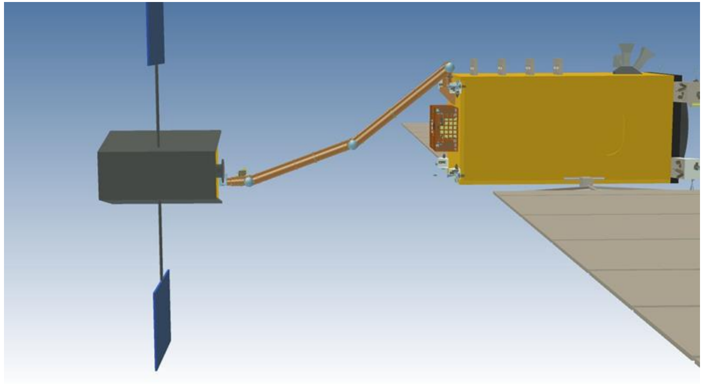
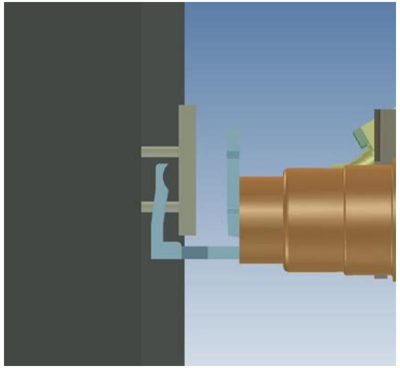
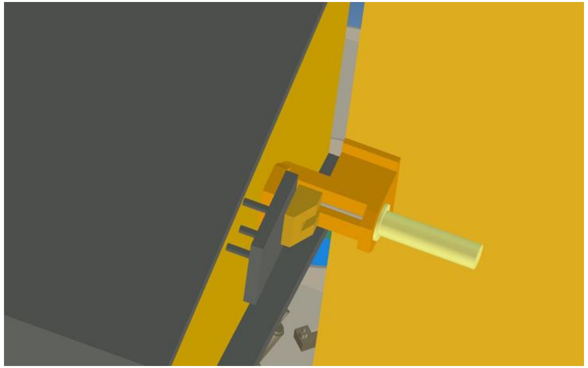
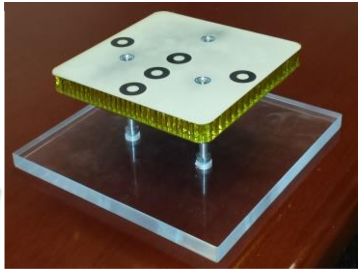
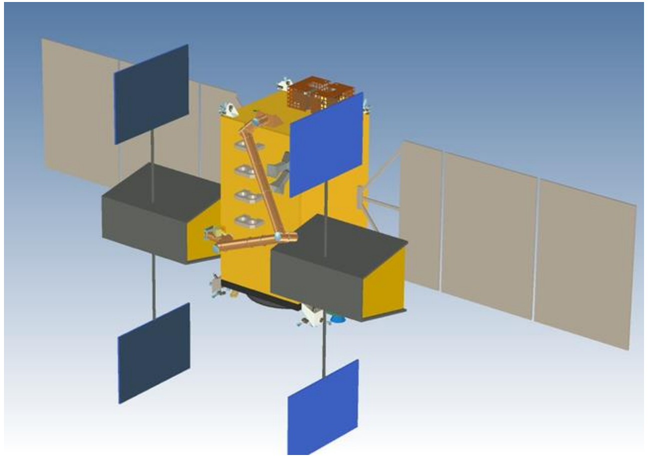
Robotic Capture Concept











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Business Plan

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Business Plan

- The ADR service can be profitable when offered to LEO operators with **over 300 satellites** in their constellation, with **satellite mass of around 150kg** and an **altitude above 700km**
- The **insurance model of payment is preferred** by satellite operators.
- Regulation compelling deorbit would decrease price sensitivity, and may therefore make smaller constellations serviceable.
- **Public funding will likely be needed** to cover the significant costs of the pilot satellite, and could be used to **reduce the price** of the service, making it more attractive to operators.

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Potential to service several clients

As mentioned above, the chaser is designed to service constellations with satellites of a mass around 150kg, with 300+ satellites and an altitude above 700km.

While only OneWeb falls into this range, two constellations will operate above 700km, with around 300 satellites, but a mass of around 700kg. These are Telesat and Viasat.

Servicing these larger satellites pose the following technical challenges:

- Attaching 2 satellites of significantly larger mass and dimensions to the chaser
- Significant shift in CoM to attach two 700kg satellites would impose a challenge for the AOCS
- Robotic arm joints would have to be strengthened

As a preliminary assessment, due to the substantial differences between OneWeb satellites and satellites with heavier masses (700kg+), **a re-design of the chaser spacecraft and robotic arm would be required**.

This would make the business case unviable unless a large public grant covered development costs, due to the lower profit margins for constellations of just 300 satellites.

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Next Steps

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Next Steps

This is a changing environment, and the next steps should certainly be affected by the evolution of the services and constellations.

However, space debris in general is a problem with no indication will be reduced in the future. So continuing development these missions is a must.

If a service like this should happen in the future, several steps must be considered:

- It would be of interest to develop and cheapen robotic technologies, in general, due to their importance on ADR and IOS activities.
- Further studies on the impact of operations for future satellites of the low orbit mega-constellations. Although space is big, having a shell of thousands of satellites at ~500-600 km may have impact in launches, raising orbits, and the natural decay of satellites and other objects.
- Legislation has to be further developed, covering and clarifying the different aspects of life and demise of a satellite, as well as insurances, liability and responsibility in ADR/IOS activities.

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Thank you

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