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OHB's vision for On-Orbit Servicing

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A major responsibility to take on

A clean space is **not a pre-condition** for space operations. It is our role, as space industry, to make it sustainable for current and future activities.

As Large System Integrator, OHB has the responsibility to make space **safer and more sustainable**.

- ✓ End-of-life strategies
- ✓ Demisability
- ✓ On-orbit-servicing / ADR

Our vision: offering sustainable services for spacecraft in GEO and LEO

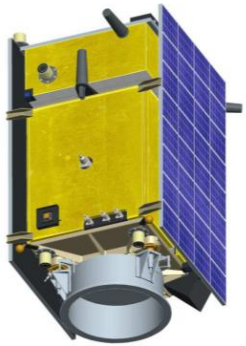
More than a decade of space heritage

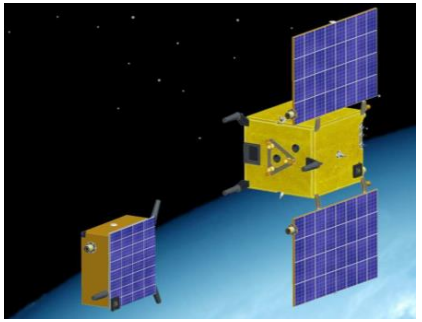
The Prisma mission
Ten years ago, on June 15th, 2010, the Swedish satellite mission Prisma was launched into orbit. OHB Sweden, a subsidiary of the space and technology group OHB SE, was the prime contractor for the project. The mission consisted of two satellites, Mango and Tango, designed, built, tested and operated to demonstrate formation flying and rendezvous manoeuvres, whilst also providing first flight opportunities for a number of new sensor and actuator technologies.

Photo of Tango by Mango in space. © OHB Sweden

The technologies successfully demonstrated

- Autonomous Formation Flying based on a GPS system and a Formation Flying RF sensor system;
- Homing and Rendezvous based on VBS only;
- Proximity Operations, based on GPS and VBS;
- Final Approach and Recede Operations, based on VBS only.



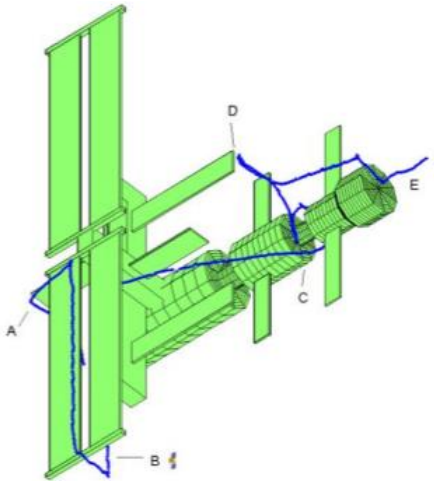


PRISMA Combine (Main and Target together) in launch configuration (left) and deployed (right) © OHB Sweden

More than a decade of space heritage

The PROX GPS experiments have shown the feasibility and practical application of a GPS navigation system in closed loop with an autonomous forced motion control system in extreme proximity of another spacecraft.
More than 100 successful PROX experiments have been executed. Out of these, 14 were performed maneuvering around a large virtual structure.

Tango observed with the DVS on-board Mango © OHB Sweden



Tango PROX GPS track around a large virtual orbiting structure © OHB Sweden

The mission model

- On-Orbit Inspection
- On-Orbit Servicing (e.g. docking, maintenance using manipulators, refueling etc)
- On-Orbit Assembly

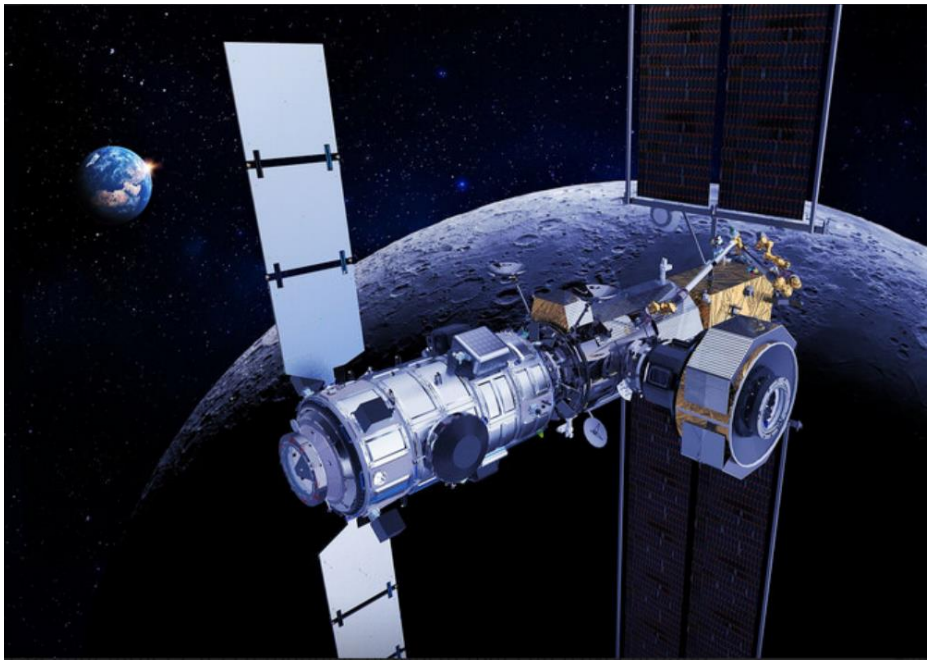
The PROX VBN was able to position the Mango satellite at points expressed in a reference frame fixed to Tango. Any rotation of Tango will in this way cause Mango to follow along. In the practice, this would enable the chaser satellite to perform operations on the target satellite.

More to come, with the Lunar Gateway...

OHB System AG will take part in the realisation of the ESPRIT module (*European System Providing Refuelling, Infrastructure and Telecommunications*) for the new **Lunar Orbital Platform Gateway**.

As an international first, OHB will be developing a system for **refuelling** the electrical propulsion system of the Lunar Gateway with **Xenon**. OHB has the full responsibility for the Xenon refuelling assembly.

OHB also developed a Xenon refuelling system **breadboard** as part of ESPRIT phase A/B1.

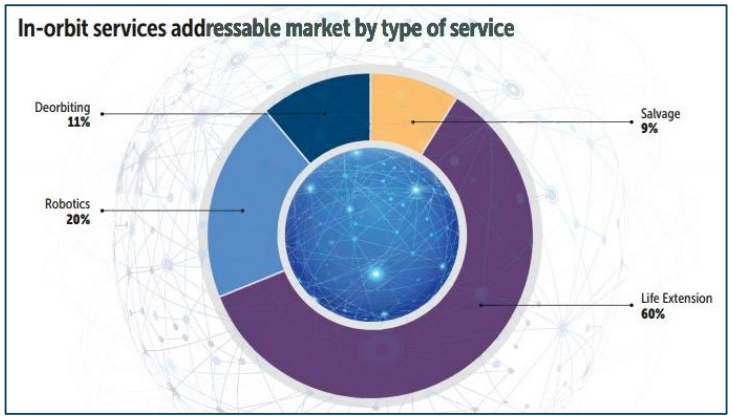


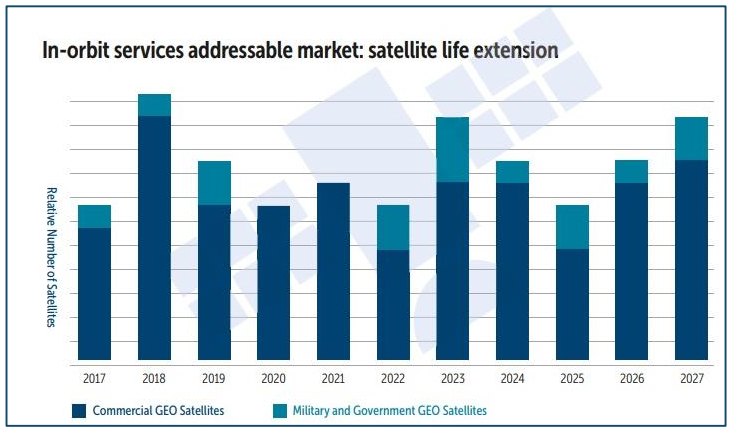
Artistic representation of the Lunar Gateway © TAS

During the Gateway activities, OHB focused on the objective to design an effective Xenon refuelling system for ESPRIT, but also to ensure that the design is well suited to be used in **future servicing missions**.

A large market in both GEO and LEO…

$3 billion overall market estimation





(source: Northern Sky Research)

There's Now a Gas Station... In Space!

On-orbit assembly will deliver major benefits in coming decade

Orbit Fab raises $3M to make orbital refueling easier, cheaper and more accessible

Blue Canyon Technologies chosen by Made In Space for orbital manufacturing demo mission

Maxar Wins $142 Million NASA Contract to Demonstrate In-Orbit Assembly

Report: Space tugs will develop rapidly

Here's how robots could repair or dispose of broken satellites in orbit

The Pentagon wants a roadside assistance service in space

Space Robotics Market To See Strong Growth and Business Scope During 2020 to 2027 | Key Players: Altius Space Machines, Astrobotic Technology, Effective Space

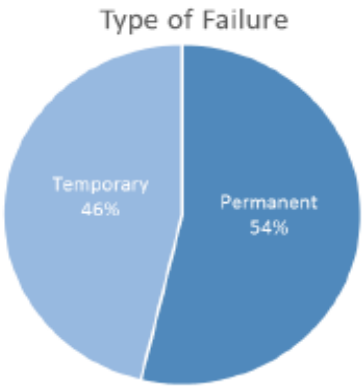
Maxar and NASA will demonstrate orbital spacecraft assembly with a new robotic arm

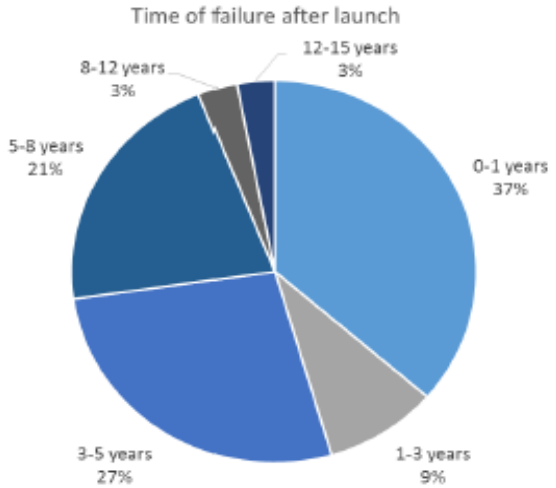
Space Force Calls For 'Trash Trucks' For All The Orbiting Junk

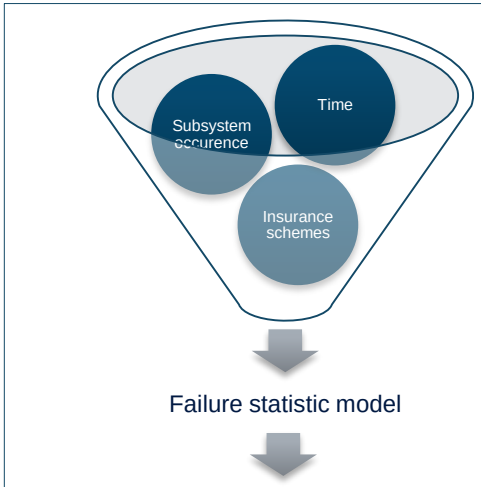
Astroscale successfully demos in-space capture-and-release system to clear orbital debris

What do we need to implement the business, tap the market?

- 50% of GEO satellites will experience operational impacts due to fuel depletion
- By 2029: demand of around 50 GEO life extension missions
- Half of GEO satellites are suffering from temporary/permanent damages
- 6% of GEO satellites launched achieve their 8th operation year without a failure







What do we need to implement the business, tap the market?

To enable the servicing market to grow, each entity has a role to follow

- The industry should work hand in hand with commercial customers and work together on sustainable concepts.
- The public sector will identify measures to grant sustainability in orbit, compliance, potentially applying incentives and penalties.

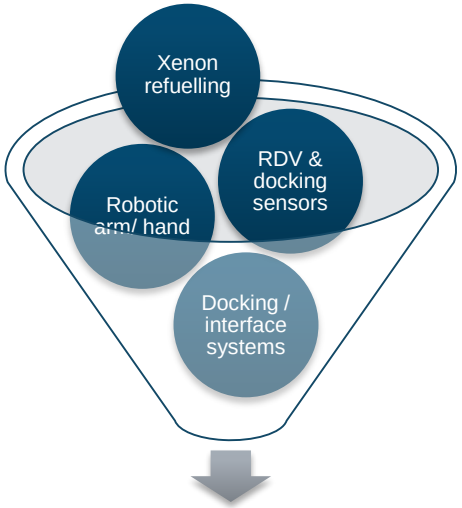
In our case, OHB is specialised in integrated systems which are already developed and available for servicing, enabling lower development costs and lower risks.

We believe that the sustainability and the profitability of the servicing business consists of offering multi-purpose mission based on all valuable servicing technologies already developed

Servicer conceptual design & drivers

Exemplary services of interest

- Cooperative AOCS takeover
- Assembly
- Refurbishment
- Refuelling
- In-orbit experimentation



Key operational capabilties for OOS operations

Payloads identified for services from non-invasive inspections up to active manipulation and refuelling operations

- Rendezvous and docking sensors
- Inspection sensors
- Robotic P/L
- Refuelling P/L
- Docking / interface systems

The OOS main high level drivers are also its added values…

- validate satellite manufacturing techniques able to sustain dropping costs of space assets and utilities
- offer an “option to act“
- perform space debris prevention & management
- enable the creation of infrastructure & capabilities to enable the space logistics

Conclusive remarks & main challenges to come

- **Standardization efforts** will enable companies to mitigate harmful interference with other space activities:
  - Identify risks
  - Ways to assess risks
  - Specific mitigation steps
  - Lexicon of related terms and process to handle new terms

    ✓ Technical Implementation Standards (Normative and Implementable)
    ✓ Technical Reference Standards (Normative but not Implementable)
    ✓ Best Practice Standards (Informative)
    - Design Practices
    - Operational Practices
    ✓ Informative Documents (Other Informative)
    ✓ Hybrid Documents which have multiple functions from the above list

- Alternatively private sectors set the standards

Conclusive remarks & main challenges to come

- Definition of a **roadmap** to integrate
  - First services based on available technologies
  - First revenues to fund first incremental technological improvements
  - Manage the new “designed-for-servicing” paradigm
  - Build up of Know-how and first response task force
- Earn trust of the commercial **operators**
  - Incentives for the operators that dispose satellites
  - Tighter regulations / penalties
- Earn trust of **investors**
  - Set up a commercial business with a commercial mind-set
  - No new developments, only solutions

1. The sustainability of the servicing business stands only in the case the servicer can reliably perform different services.

2. Support of public institutions to tackle the challenge of a commercial (competitive) low-risk mission.

3. Celestial mechanics have an impact on the servicer spacecraft design. The needed versatility of the servicer cannot withstand with frequent changes of the orbital planes; therefore, the servicer shall target a specific orbit.

Is OOS the new iPhone?

- Nobody needed an iPhone before it appeared on the market…
- Apple didn‘t just offer a product, but a brand new set of contents and services!
- Several other markets (directly or indirectly connected) have been enabled.

Thank you

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