2021 CleanSpace Industry Days

Preliminary Design of On-Orbit Manufacturing of Large Antenna Reflectors

23/09/2021 Airbus Defense & Space

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Introduction

OMAR Step 2

- Mission architecture
- On orbit Servicing Station design
- On orbit Manufactured Spacecraft
- **On orbit Manufactured large reflector antenna**

Study main objectives

Identification of processes and material usable for On Orbit Manufacturing and Assembly

↓

Identification the criteria needed in order to compare the processes and materials identified

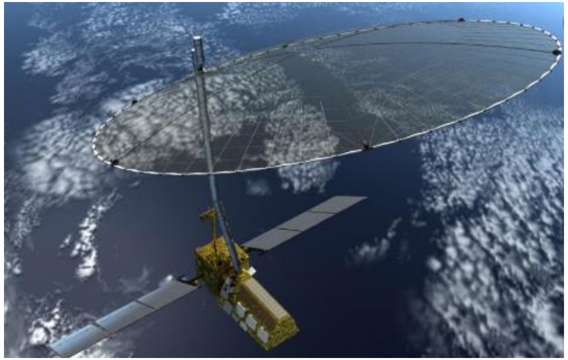
↓

Study the feasibility of the selected solution

Antenna reflectors

The range of use cases for reflector antennas is extremely wide but the critical driving requirements for the reflectors within many of these applications are similar.

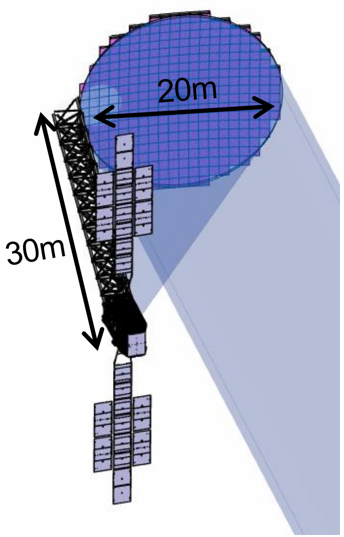
Many of the **design and technology** choices for current reflector products are heavily influenced by requirements which **are not applicable to on-orbit manufacture** (Deployment, launch loads …) which make it a good candidate for this study.



Use Cases Selection

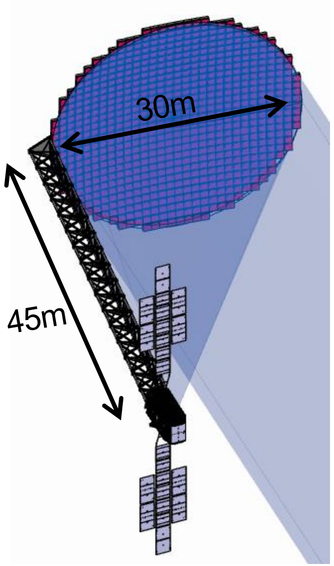
Use Case 1:

- GEO orbit
- High frequency (Ka Band)
- Large antenna reflector (20m)



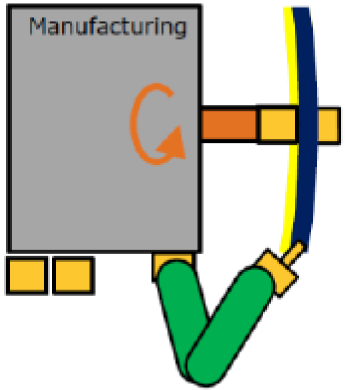
Use Case 2:

- LEO orbit
- Low frequency (S band)
- large antenna reflector (30m)

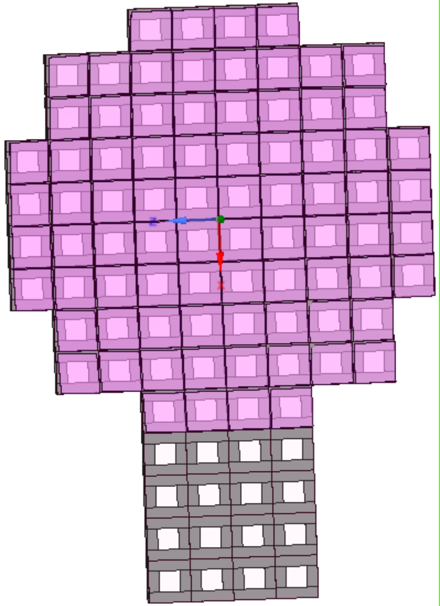


Preliminary Conceptual Designs for Study Case 1 & 2

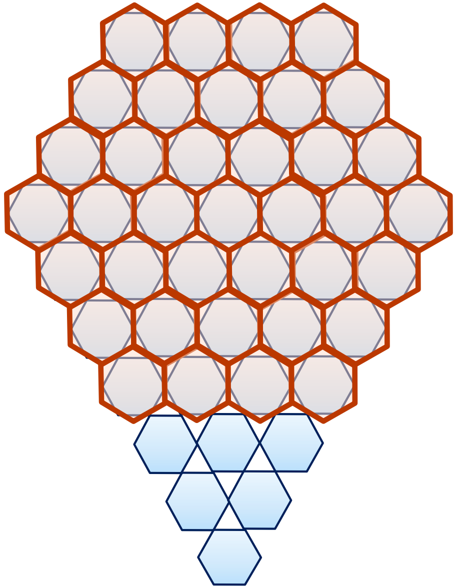
Full ALM Reflector



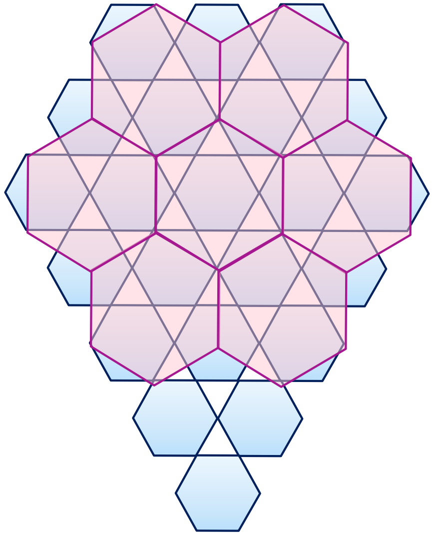
Brick Reflector



Hexagonal Reflectors & Truss



Unfurlable Reflectors & Truss



Conceptual Design: Choice criteria

Criteria

- Maturity/Risks
- Robotical Needs
- Performance (Mechanical & RF)
- Versatility
- Pollution
- Lead Time
- Stowability

Most constraining limitation

Conceptual designs

- **Full ALM reflector**
- **Brick reflector**
- **Unfurlable reflector & truss**
- **Hexagonal reflectors & truss**

Materials Criteria of interest

Criteria

Thermo Elastic/Mechanical performance

Compatibility with ISMA processes

Resistance to space environment

- **Radiation/ATOX/UV**
- **Magnetic interference**

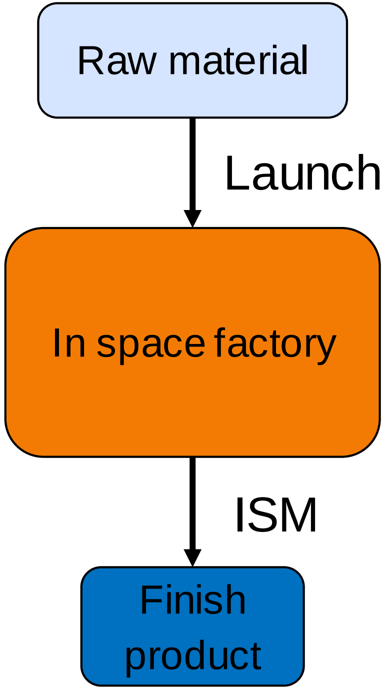
Most constraining limitation

Materials

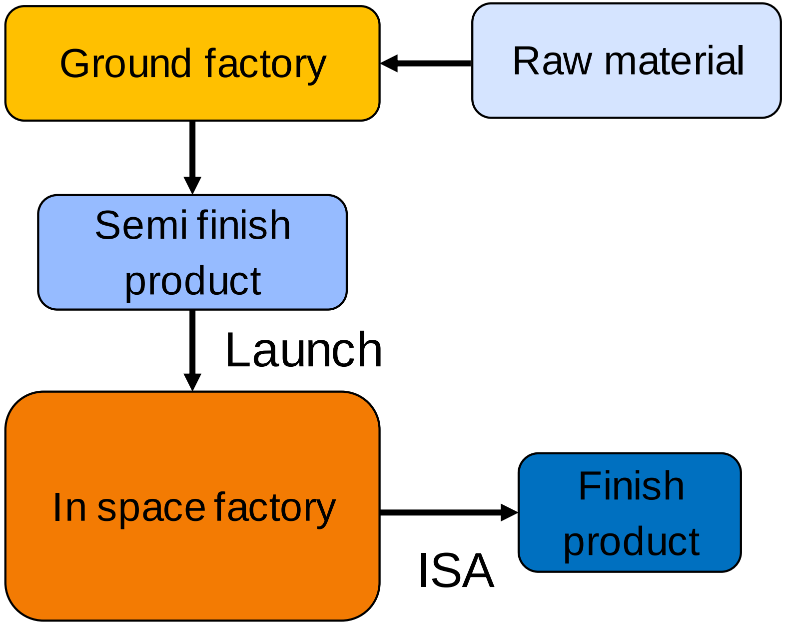
- **PEEK**
- **AlSi10Mg**
- **Ti-6Al-4V**
- **SiC**
- **PEEK with long carbon fibers**
- **Invar**

Manufacturing/Assembly Processes Identification

In space manufacturing (ISM)



In space assembly (ISA)



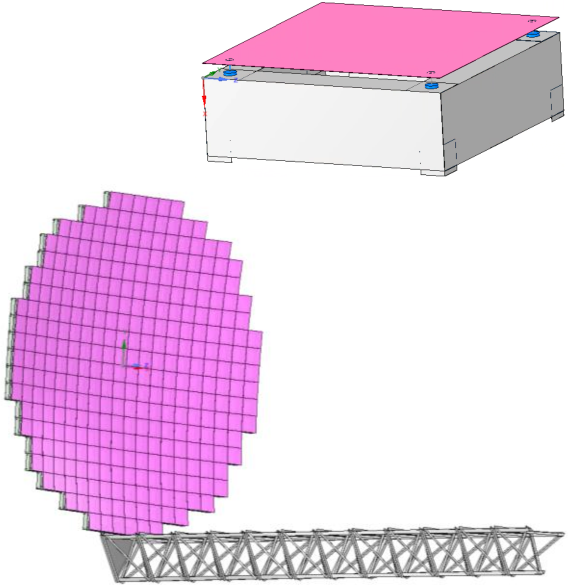
Manufacturing/Assembly Processes Identification

Process	Description
Laser Welding	Technique used to join pieces of metal or thermoplastics through the use of a laser
Bonding process	Bounding process adapted to thermoplastic matrix
Bolting	Screw and nut to assemble two parts

Proposed combination of materials and process

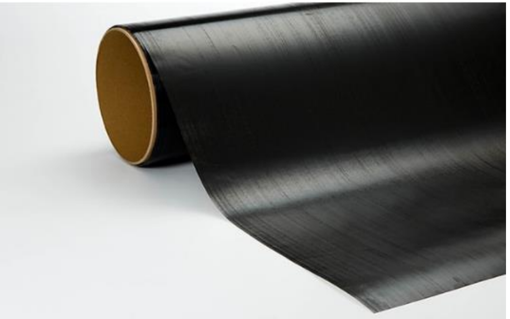
Conceptual Design

Brick Reflector



Materials

PEEK with long carbon fibers

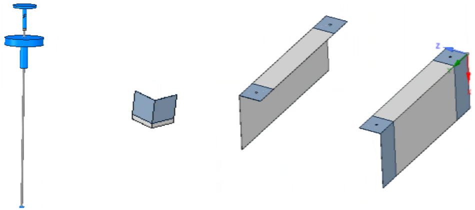


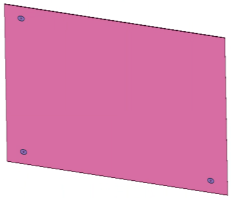
Processes

Unitary parts manufactured on-ground

+

Bonding Process





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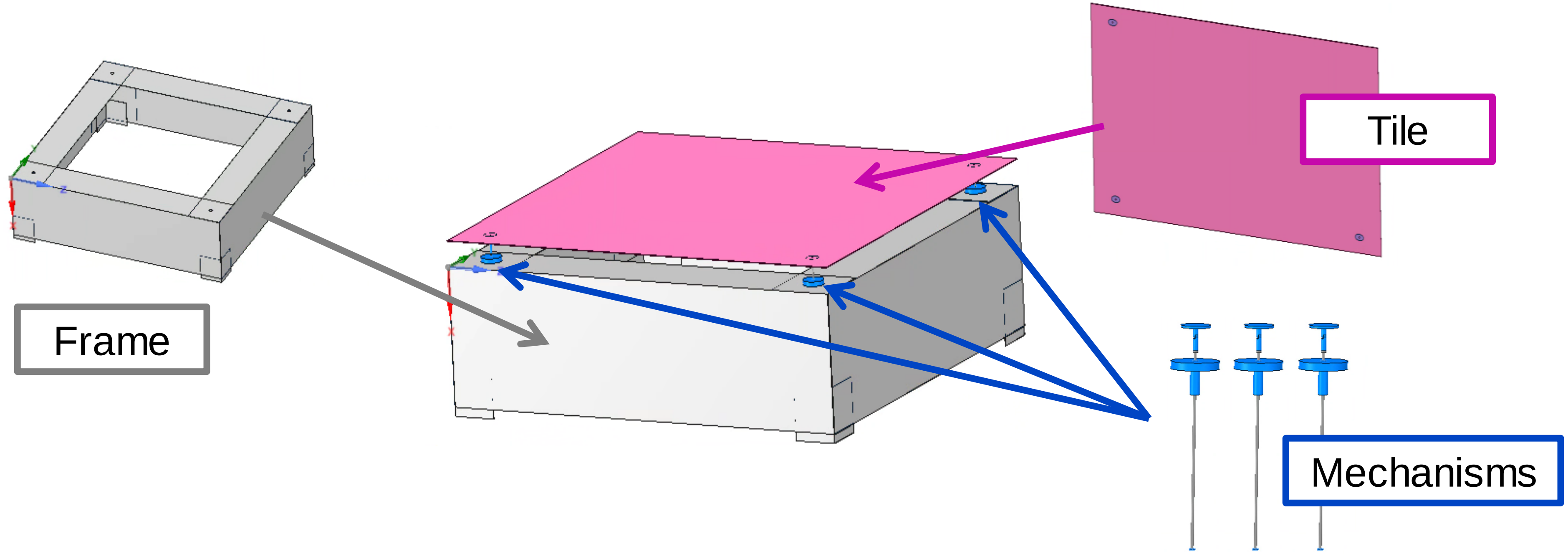
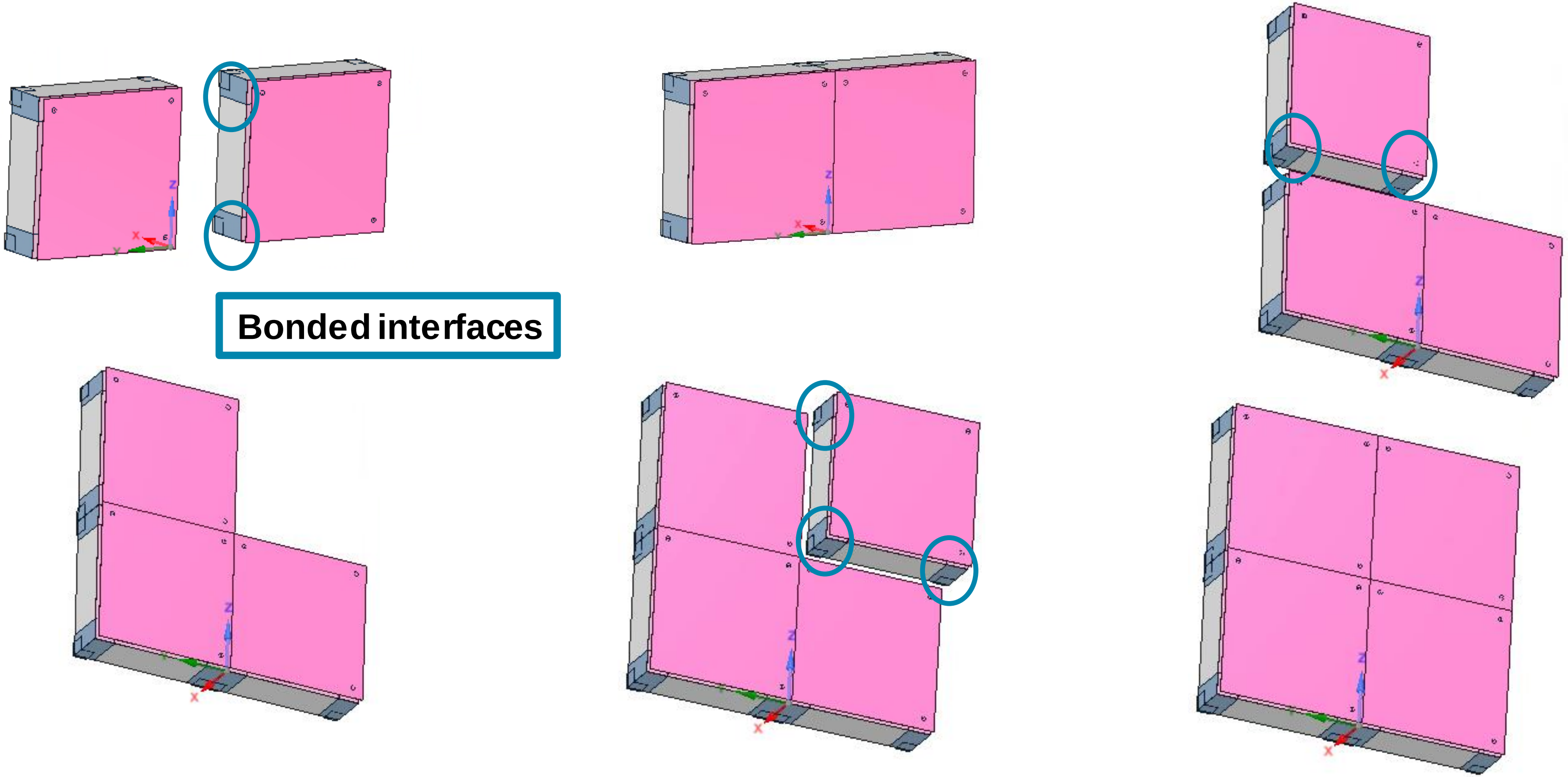
Brick Composition

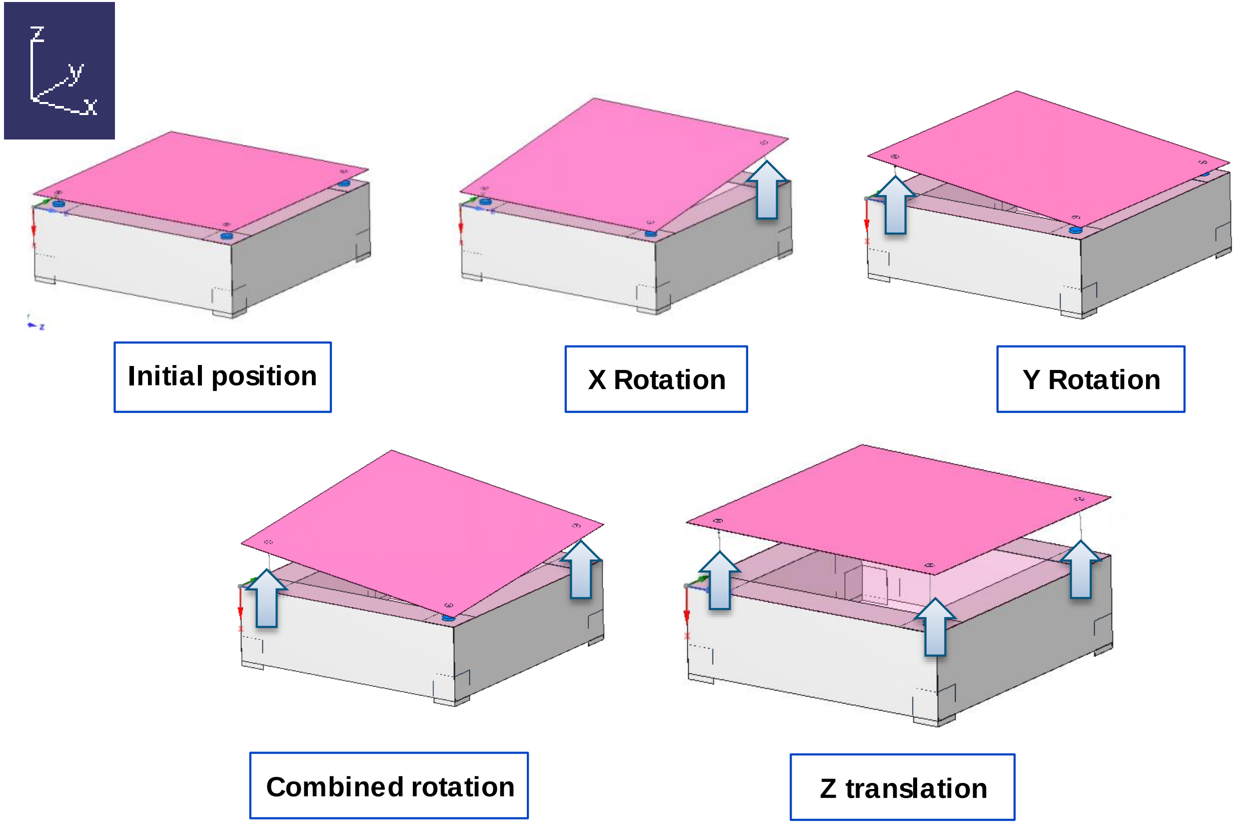


Each Brick is composed of:
- A frame made of the assembly of 8 L-shaped blades
- A Tile (RF reflective surface)
- 3 mechanisms that allow the tuning of the position/orientation of the reflective surface isostatically

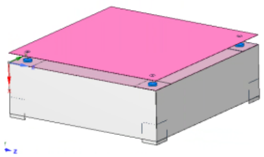
4 Bricks flat assembly sequence



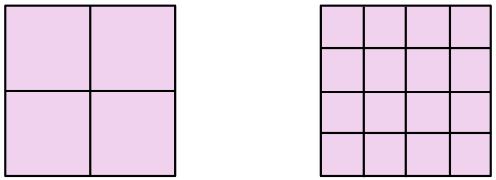
Brick’s component: the Mechanisms



Scale and impacts

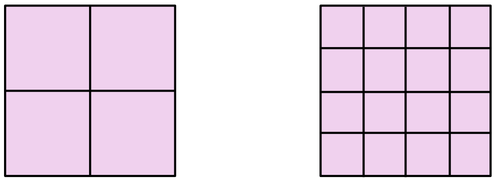


The size of the generic element need to be adapted to the need of the mission. A big element will lead to a light reflector but also to bad surface approximation



Mass 1 < Mass 2

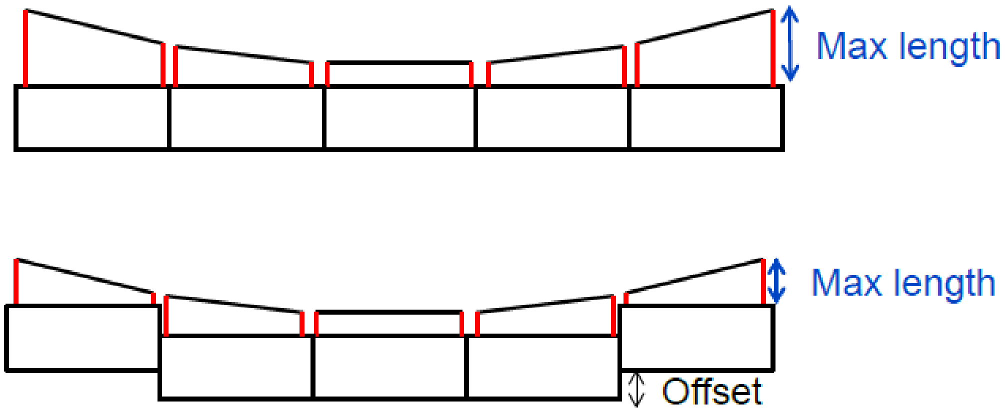
Mass
vs
RF performance



Surface accuracy 1 > Surface accuracy 2

Mechanism tuning range

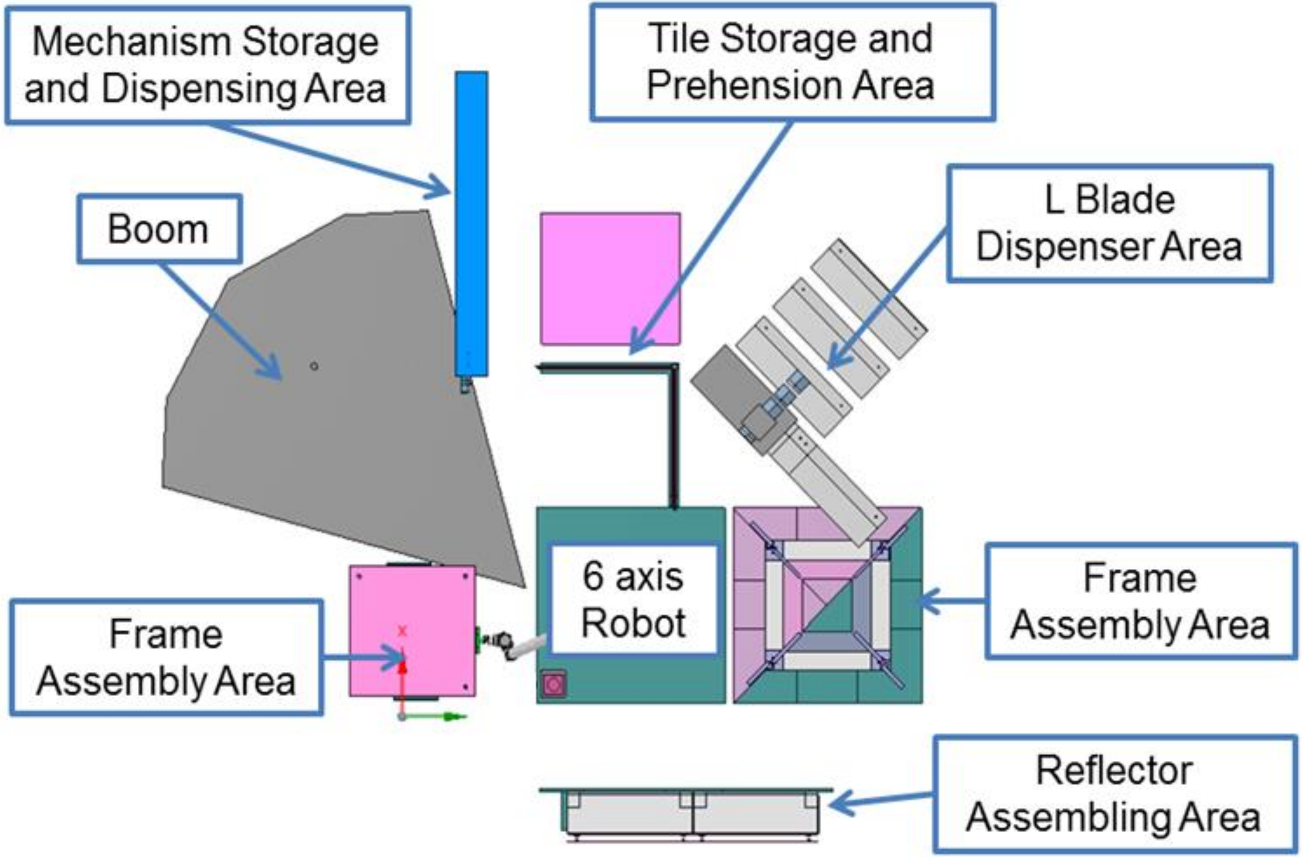
Tuning range of the mechanisms depends on the back structure ability to “fit” the parabola.



Offset between the bricks to roughly fit the parabolic shape to minimize the tuning range needed.

In that case, 180mm tuning range is sufficient for Use Case 1 & 2

Space Factory Overview



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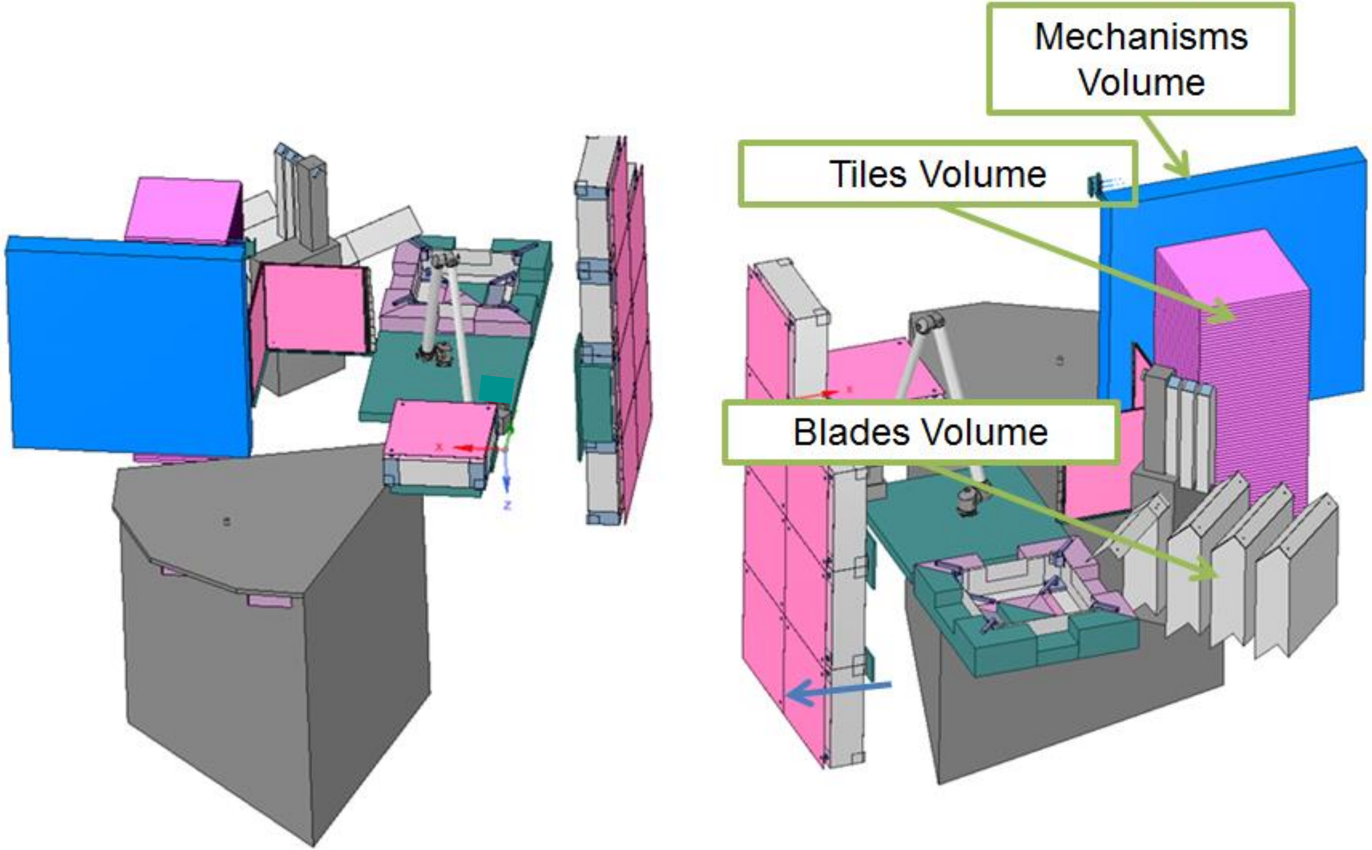
Space Factory Overview



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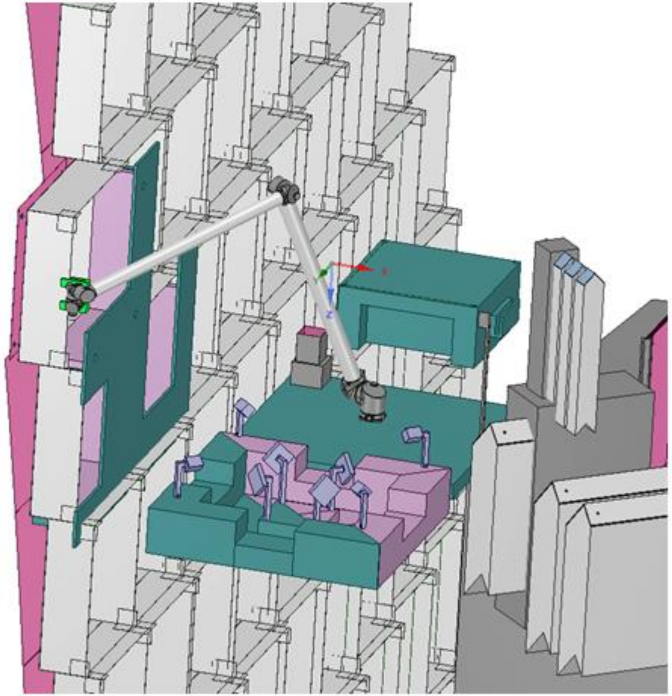
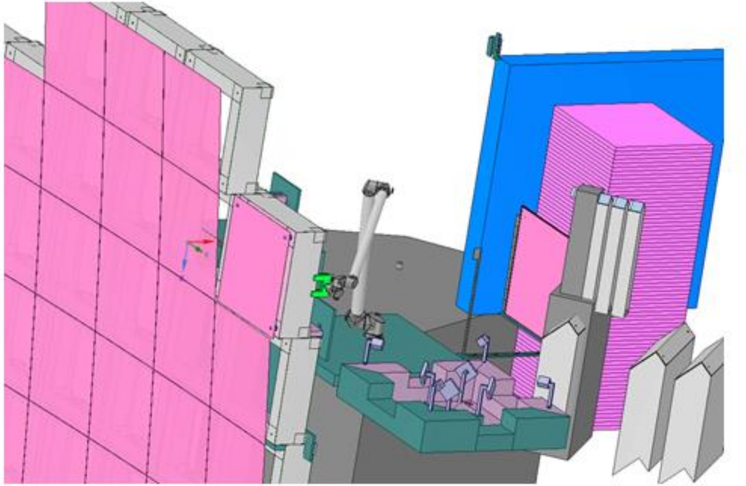
AIT/AIV Sequence: Reflector Growth

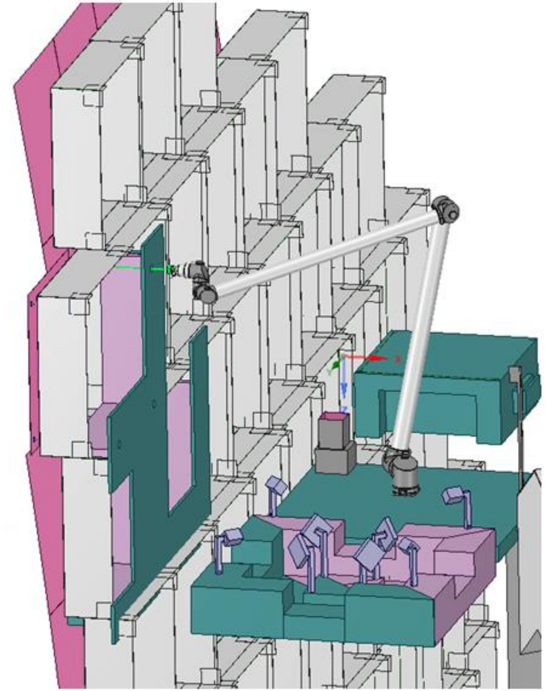
Brick assembled to the other bricks from 2 different views

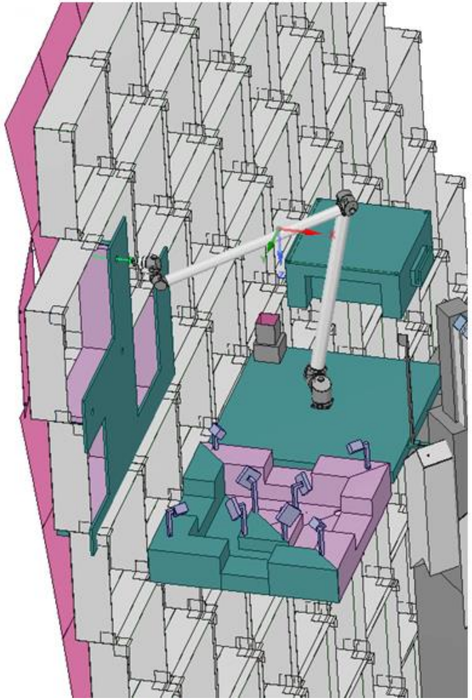




AIT/AIV Sequence: Reflector Growth

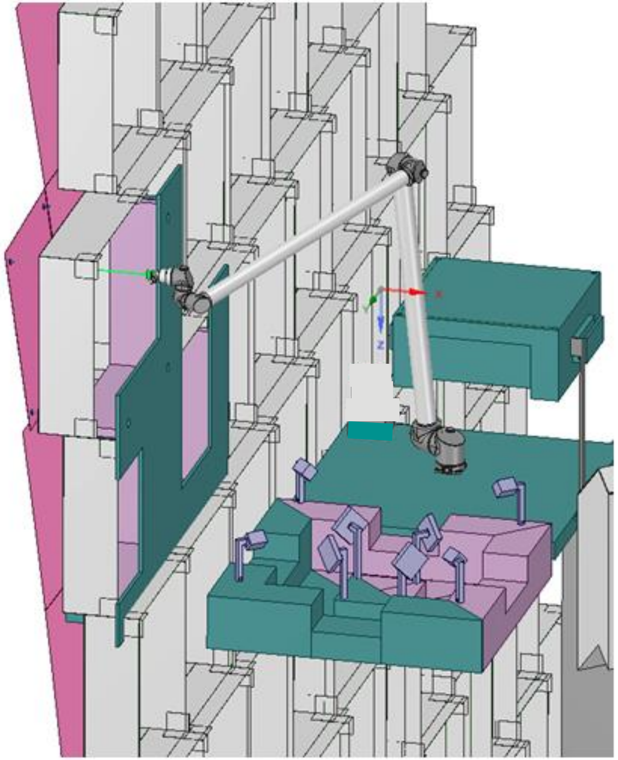
Tuning of the 1st mechanism height:

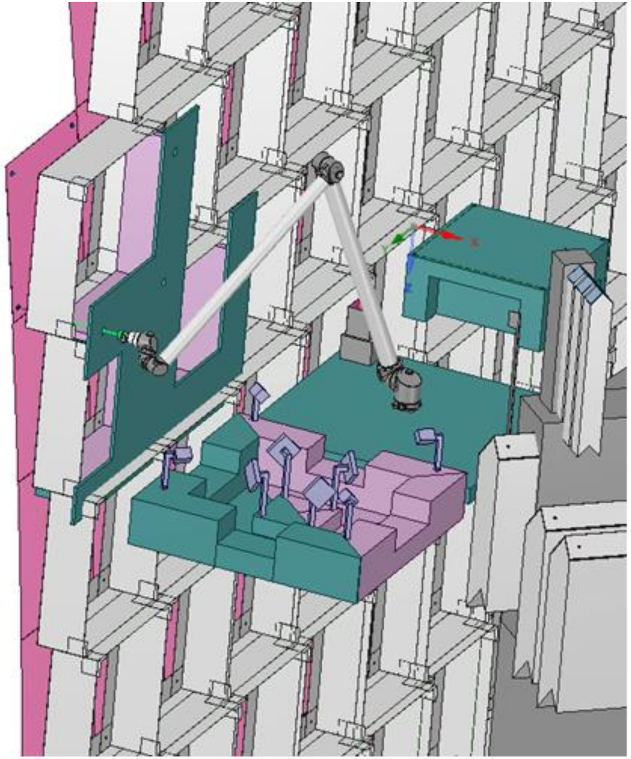




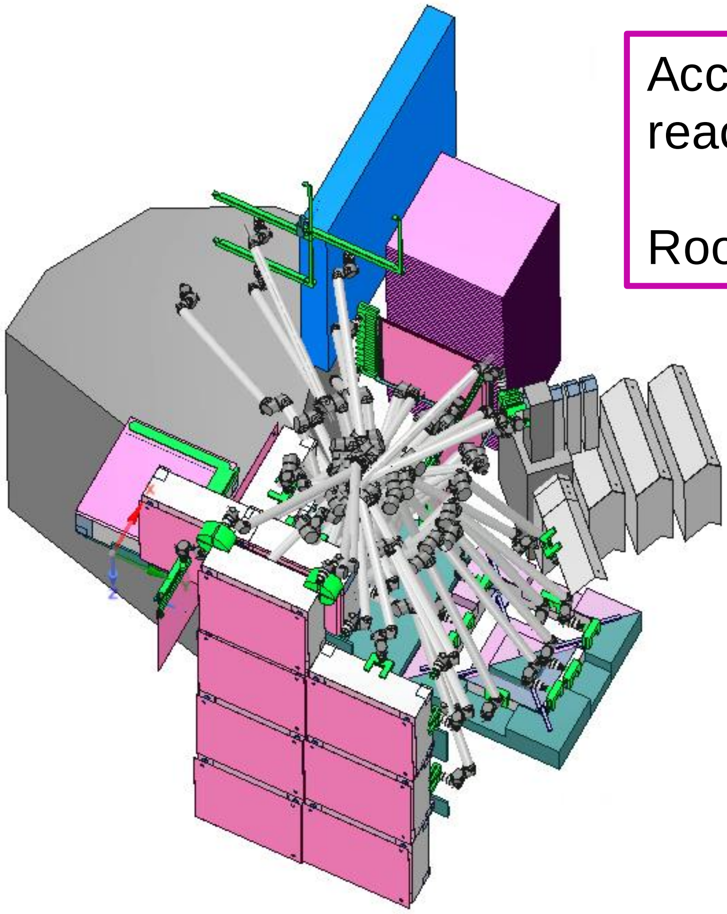
AIT/AIV Sequence: Reflector Growth

Tuning of the 2nd and 3rd mechanisms height:





Accessibility Simulation



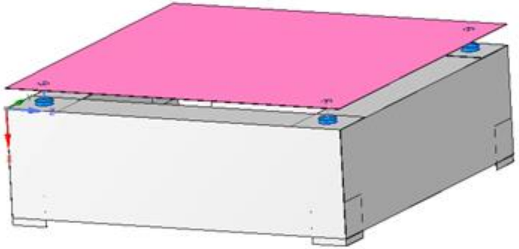
Accessibility checked with one robot: All poses can be reached with the proposed robot configuration.

Room available: final trajectories expected feasible

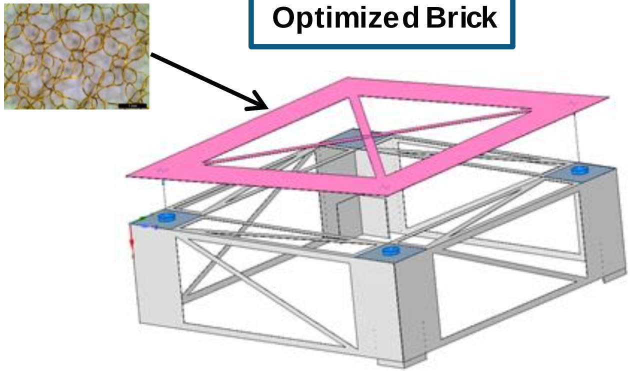
Brick Mass Budget

As the generic elements are duplicated as many time as needed to form the reflector, a dedicated mechanical optimization need to be done top reduce the mass of this elements to the minimum

Full Brick



Optimized Brick



Assembly Time

Frame Assembly 45min → Mechanism Installation 45min → Tile Assembly 45min → Reflector Growth 30min → **Total Time for 1 Brick: 3hrs***

	Reflector Use Case 1	Reflector Use Case 2
Manufacturing Time *[hours]	948	2148
Manufacturing Time* [days]	40	90

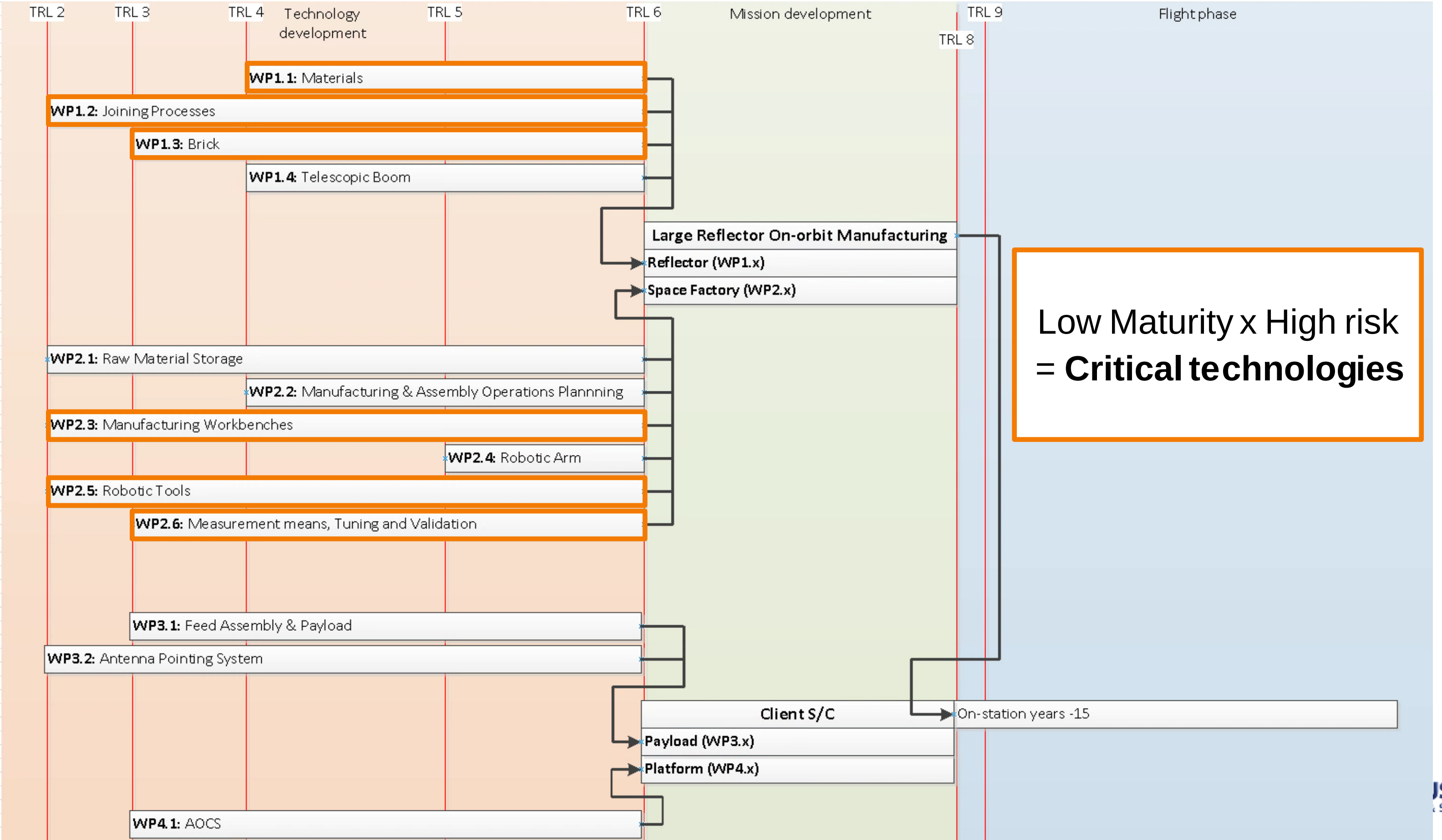
* Including 10% margin

This table needs for an additional 50% margins in order to take into account the following points :

- Go no go in case of problem ? (Clash ? Positioning error ? Unpredicted behavior ?)
- Factory visibility from ground ?
- Factory power availability ?

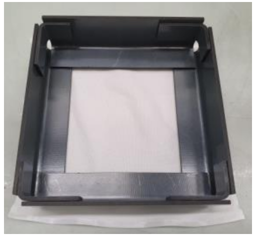
Moreover, the manufacturing time presented here does not consider the resupply of the factory and the attach of the reflector to the client satellite

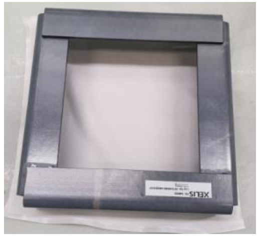
Roadmap

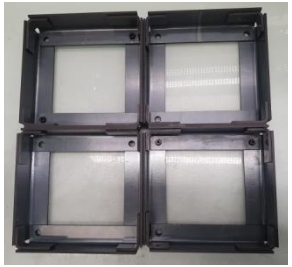


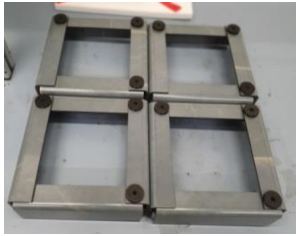
Low Maturity x High risk
= **Critical technologies**

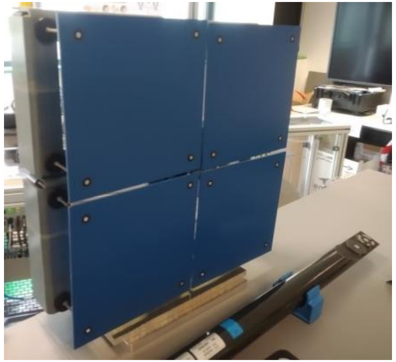
Mock-up: Frame Assembly

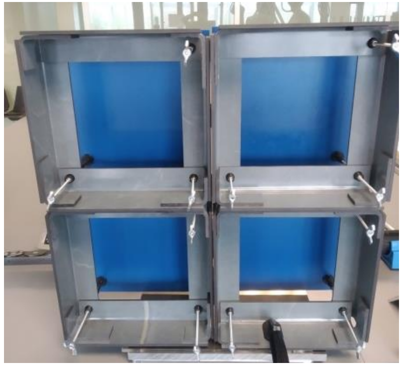




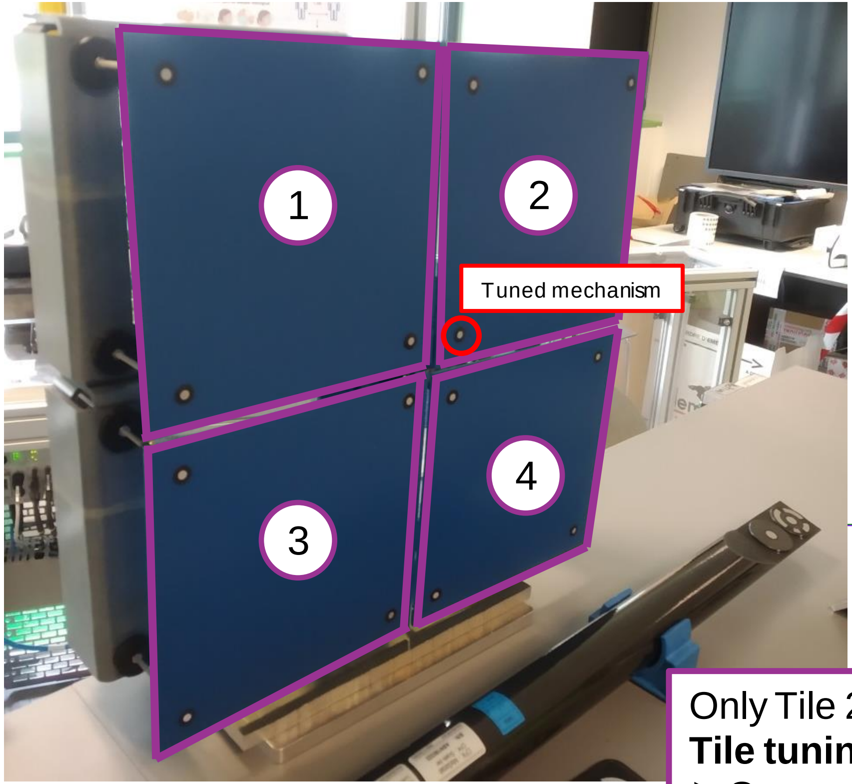


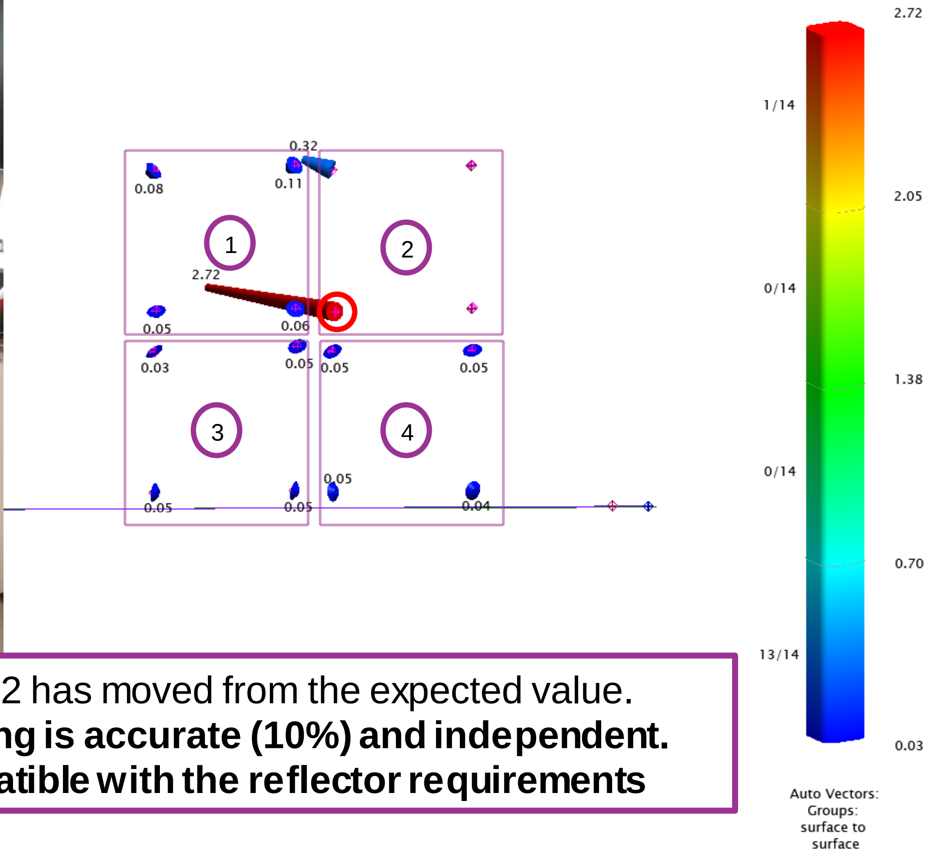






Mock-up: Robotic Tuning & Measure





Only Tile 2 has moved from the expected value.
Tile tuning is accurate (10%) and independent.
►Compatible with the reflector requirements

Conclusion

This study laid down the foundations for the on-orbit manufacturing & assembly of a large antenna reflectors

- Identification of criteria for material and process adapted to OOMA activities
- Identification of a combination of design/material and process
- Identification of roadmap in order to mature the technologies

The main outcome is the importance of the DESIGN-TO-ISMA approach
➔ The design and the processes have to be developed and think together


Thank you