





# **Objectives, Design and Initial Test Results of the Upcoming GAMA-Beta Solar Sail In-Orbit Demonstration**

ISSS NY 2023  
June 5th 2023



Institut für  
Systemleichtbau



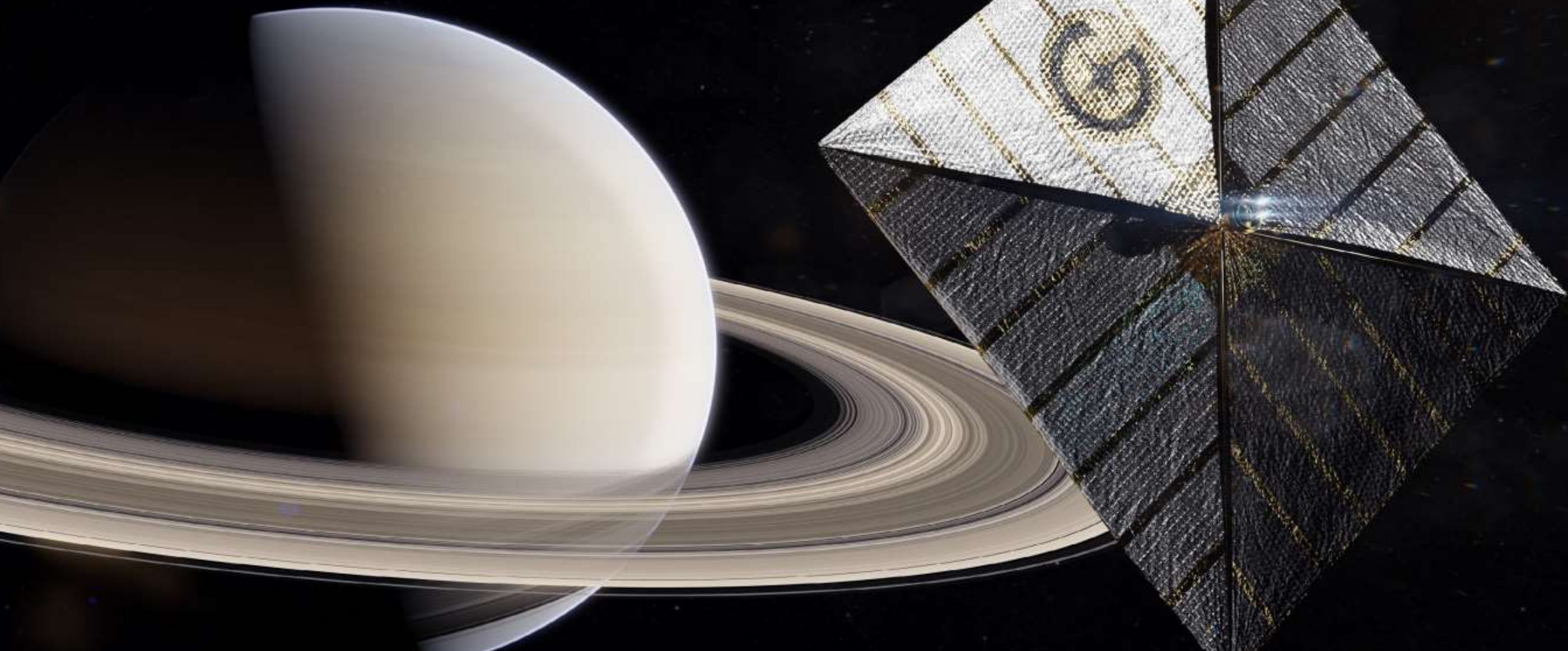


# GAMA INTRODUCTION

Reduce the cost of access to deep space by  
10x

What will it take to develop a vibrant  
commercial deep space economy?

**GAMA** : ALLOWING FREE  
& INFINITE PROPULSION



# Gama

- Private company (founded Oct 2020) just outside of Paris
- **Vision** : massively reduce the cost of deep space exploration
- **Gama Alpha** - 73m<sup>2</sup> sail launched Jan 2023 to LEO to demonstrate spin deployment from 6U cubesat.
- Developing expertise in large scale structure assembly, deployment, materials, GNC, and planning to scale team.
- Partnership with the CNES (facilities, expertise, funding) and a number of research institutions
- Collaboration with the DLR for **Gama Beta**





# Gama - Progress



# FAST ITERATION

Gama Alpha in <2 yrs - 73 m2 sail from 6U



FM Integration CNES

04/2022

Gama Alpha

08/2022



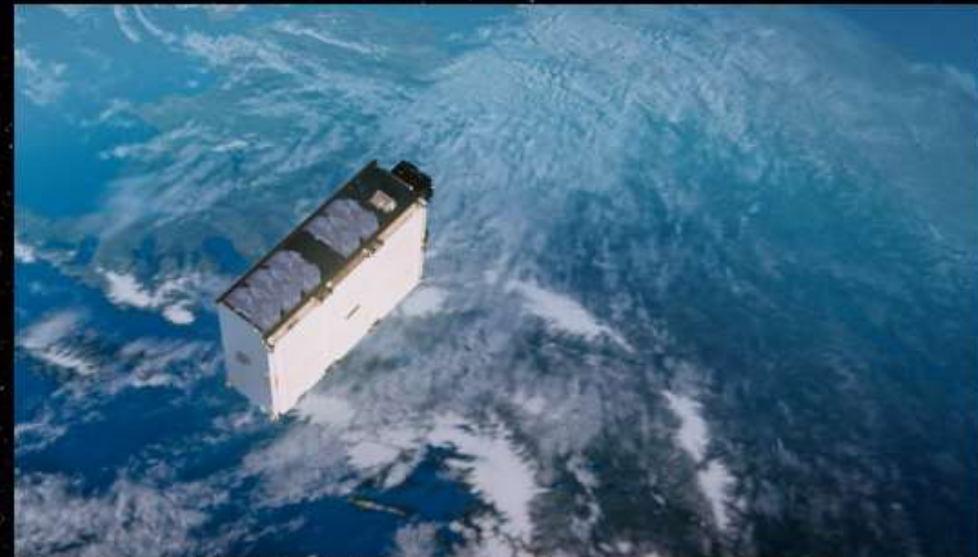
# 2023 = SPACE HERITAGE

Gama Alpha is in orbit - 3rd Jan 2023



SpaceX launch

01/2023



Gama Alpha commissioned

01/2023



## TIMELINE

# FIRST LAUNCH IN 2023



### GAMA ALPHA

2023 - Gama sail deployment in Low Earth Orbit (LEO).

### GAMA BETA

2025 - Demonstrating propulsion and deep space capabilities in high LEO

### GAMA GAMMA

2026+ First mission to Deep Space.

### GAMA DELTA

2027 - Flotillas of sails exploring deep space.

### GAMA EPSILON

2035 - First mission to the Oort cloud.





GAMA BETA  
**MISSION OBJECTIVES**



# Mission Objectives

OBJ-1	Demonstrate the proper deployment of a solar sail in Low Earth Orbit using deployable booms.
OBJ-2	Demonstrate the functioning of the control law implemented by Gama to generate enough thrust to meet predefined requirements (e.g., raising the semi-major axis).
OBJ-3	Prove undeniably that the solar sail changes the orbital parameters over time due to the photonic force.
OBJ-4	Test new equipment suited for deep space in anticipation of the GAMMA mission.

*Table 1 Mission's objectives*

Main focus options:

- Sun-Synchronous Orbit preferable -> more launches, same angle throughout the year
- Preferably a polar orbit escape control law



## Notable Mission Requirements

### **Demonstrate and characterise solar sail propulsion unequivocally**

MIS-001 - The Spacecraft shall use a solar sail and be able to increase its semi-major axis at least equal to the sum of the trajectory recording error, the propagation error and a 20% safety margin

### **Prepare for deep space**

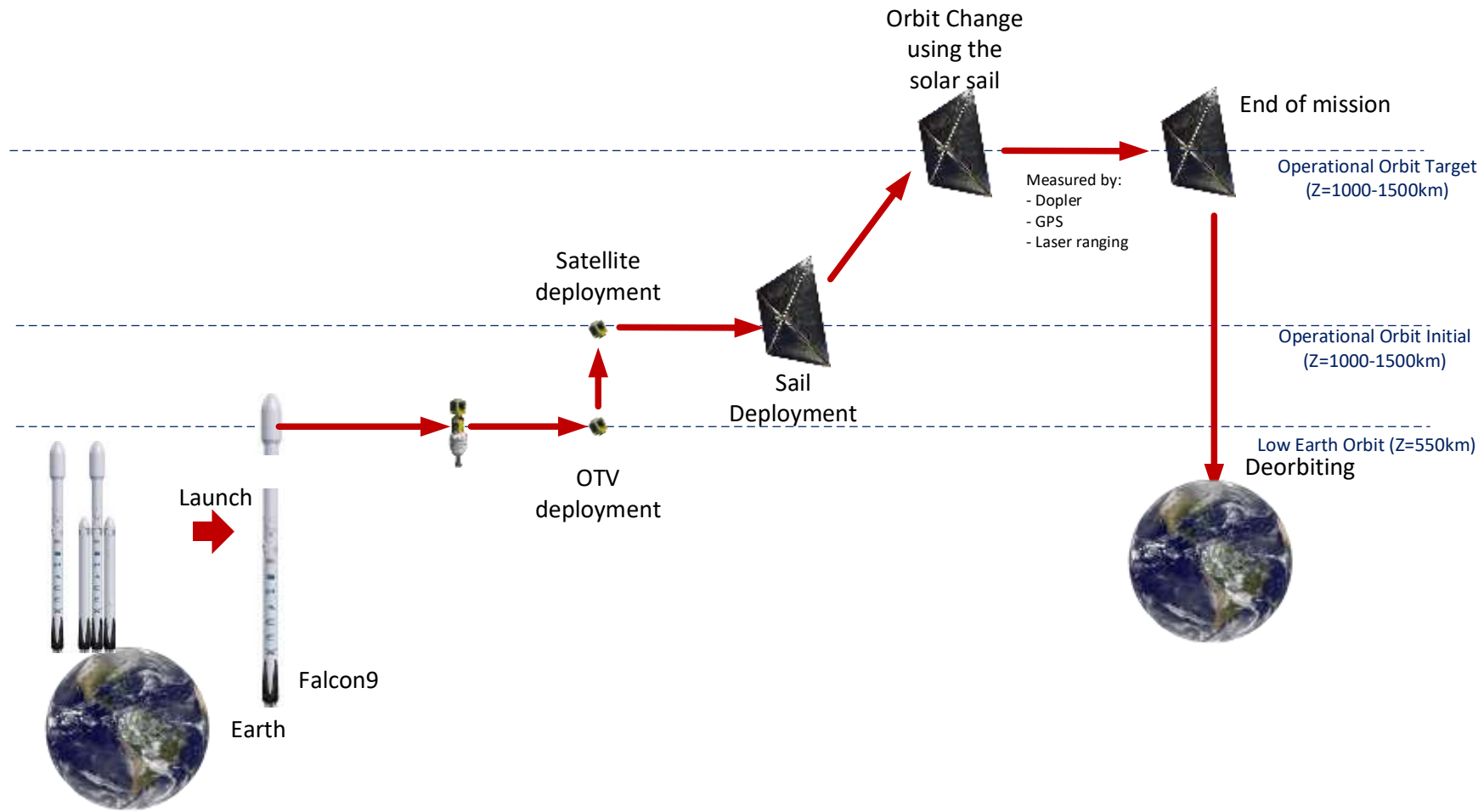
MIS-008 The Spacecraft shall qualify a system to desaturate the reaction wheels without using the magnetorquer for the mission duration at operational orbit

### **Qualify as a drag sail**

MIS-009 The solar sail shall be qualified as a deorbiting device at operational orbit



# Concept of Operations



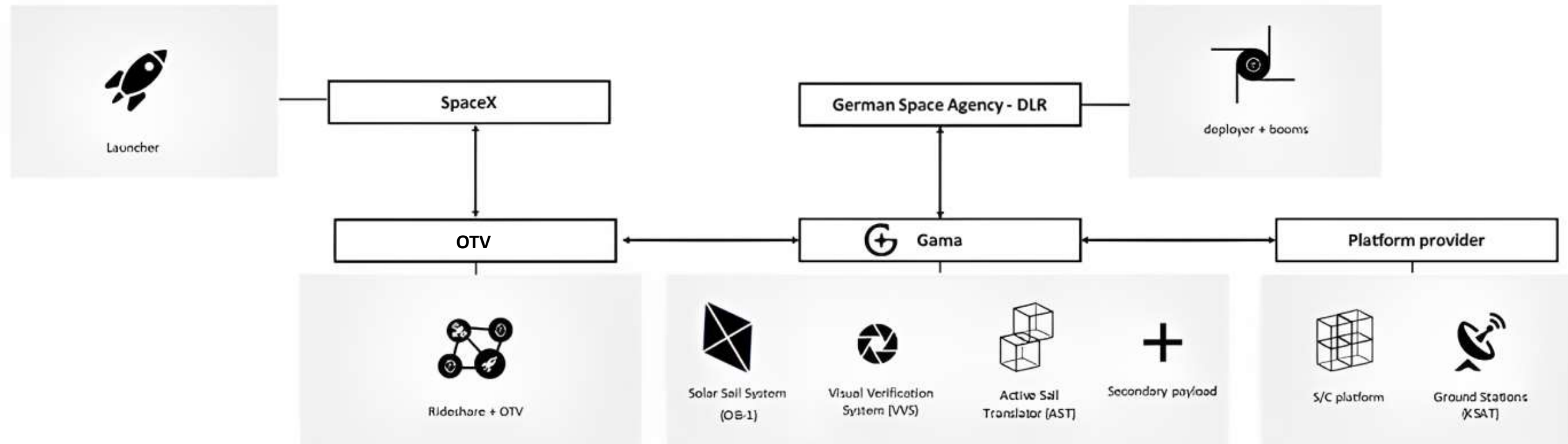




GAMA  
**DESIGN**



# System Architecture

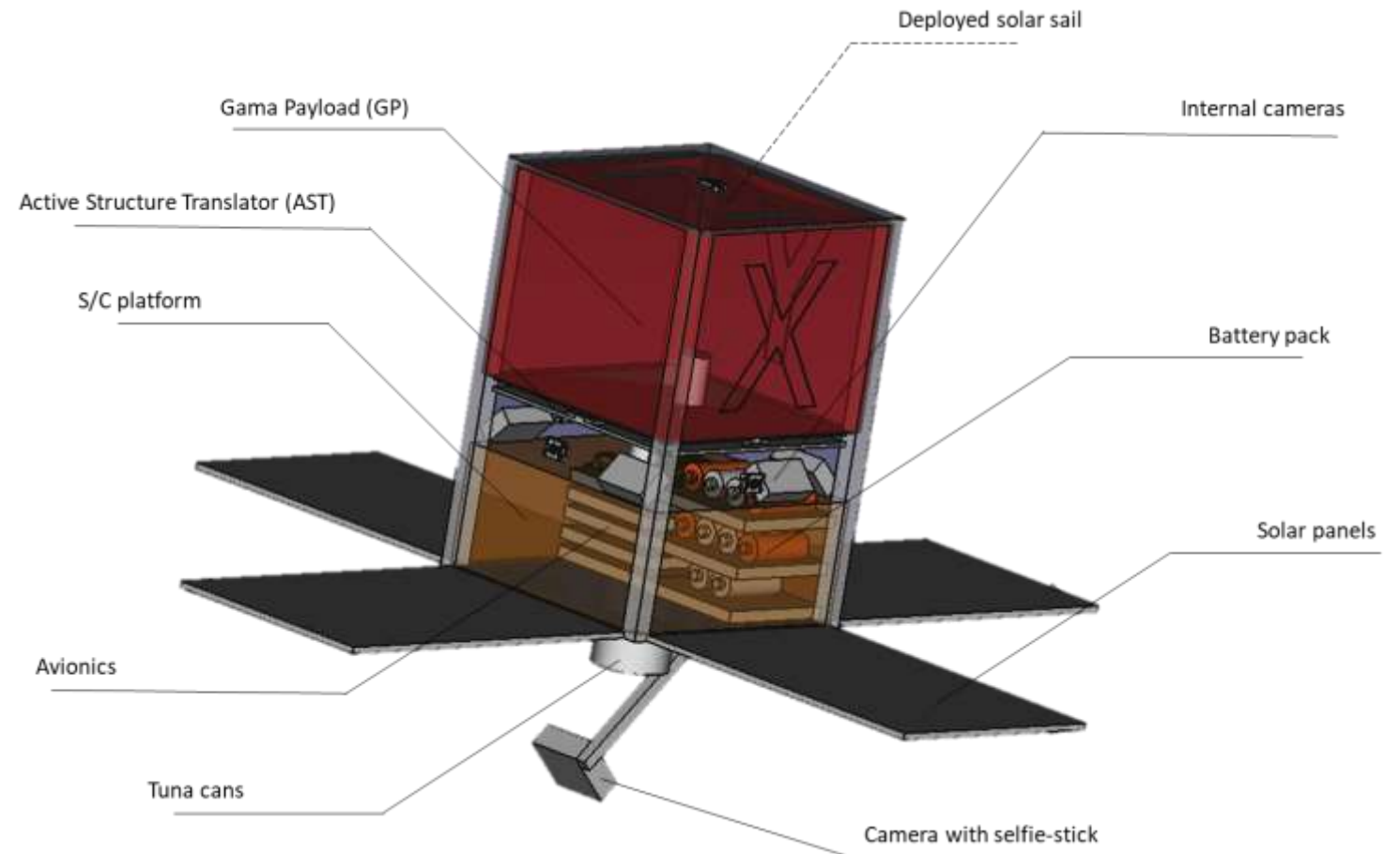




# Satellite overview

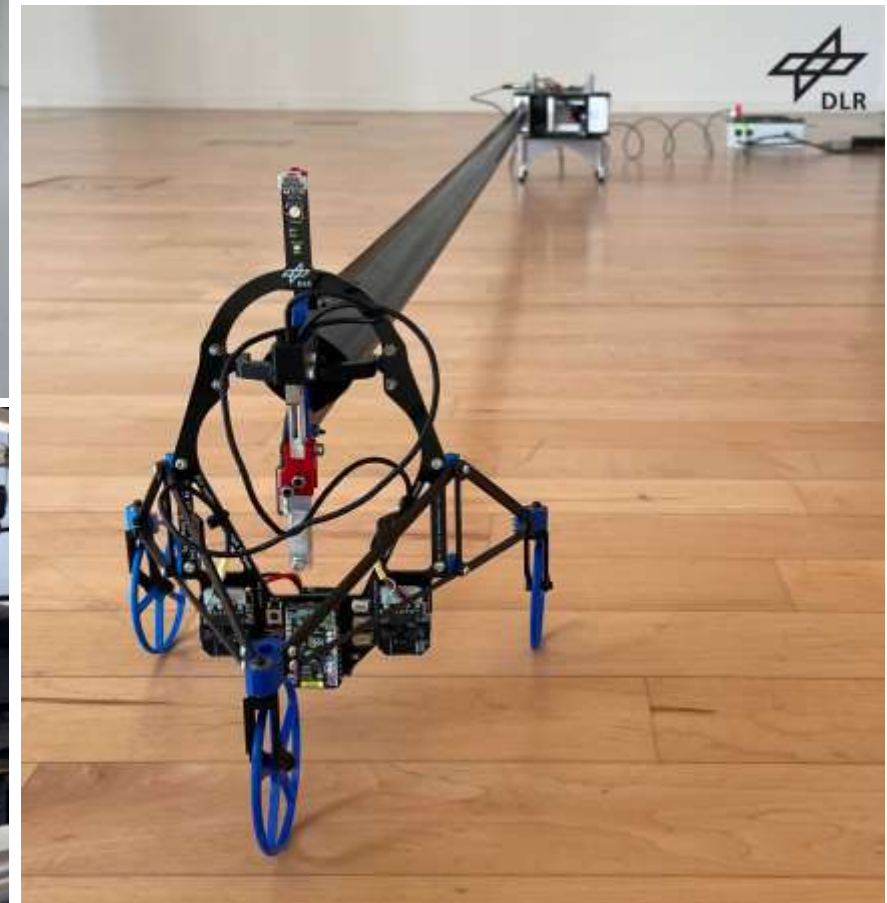
## Early design

- 25-30kg, including backup propulsion for deorbiting
- 50-90m<sup>2</sup> monolithic sail
- Carbon fibre booms (DLR)
- Secondary scientific payload





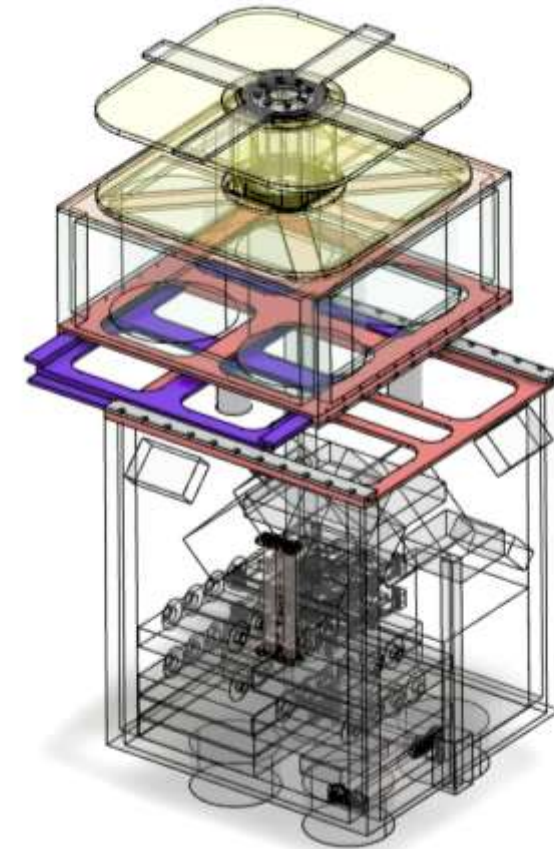
## DLR Deployer and carbon fibre booms





## Attitude control

- Need to
  - Balance centre of mass (CM) and solar sail centre of pressure (CP)
  - Counter disturbance torque from sail asymmetries
  - Desaturate reaction wheels
- Multiple options being evaluated, including a two-axis translation table shown here

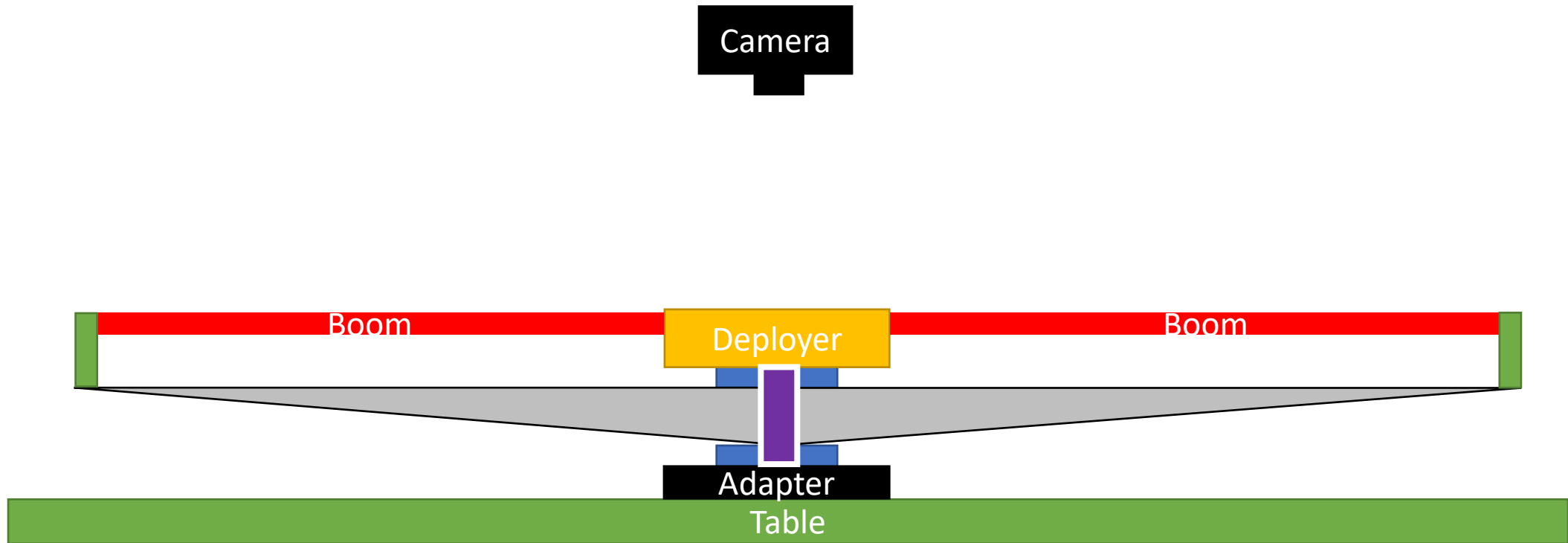




GAMA BETA  
**Initial Test Results**



# 1G sail deployment tests





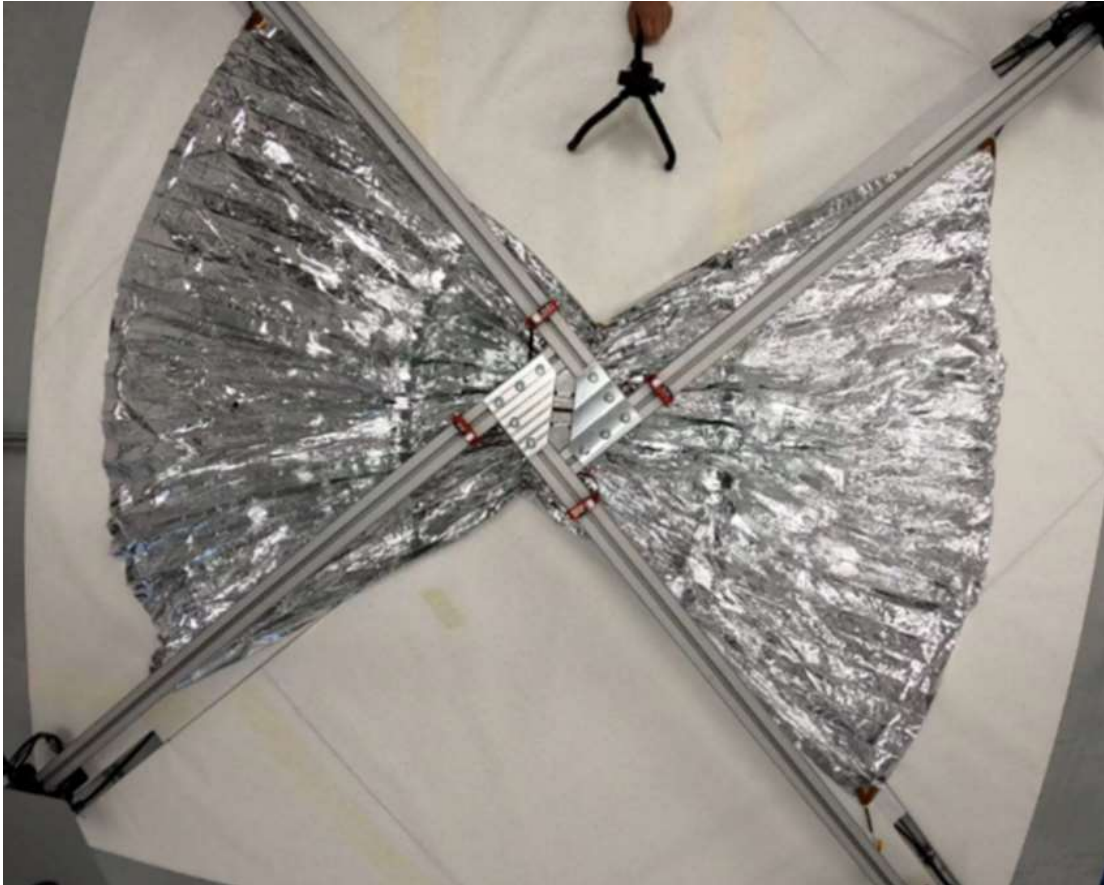
## 1G sail deployment tests

- No human intervention
- Test sail assembly, folding, packaging and sail hub design
- Measure tip loads over repeated deployments to establish force profile relationship to sail size
- Initial small-scale tests of a 2x2m sail on a mechanised test bench (no deployer / boom)
- Subsequently larger sizes with deployer and booms, in nominal and non-nominal cases





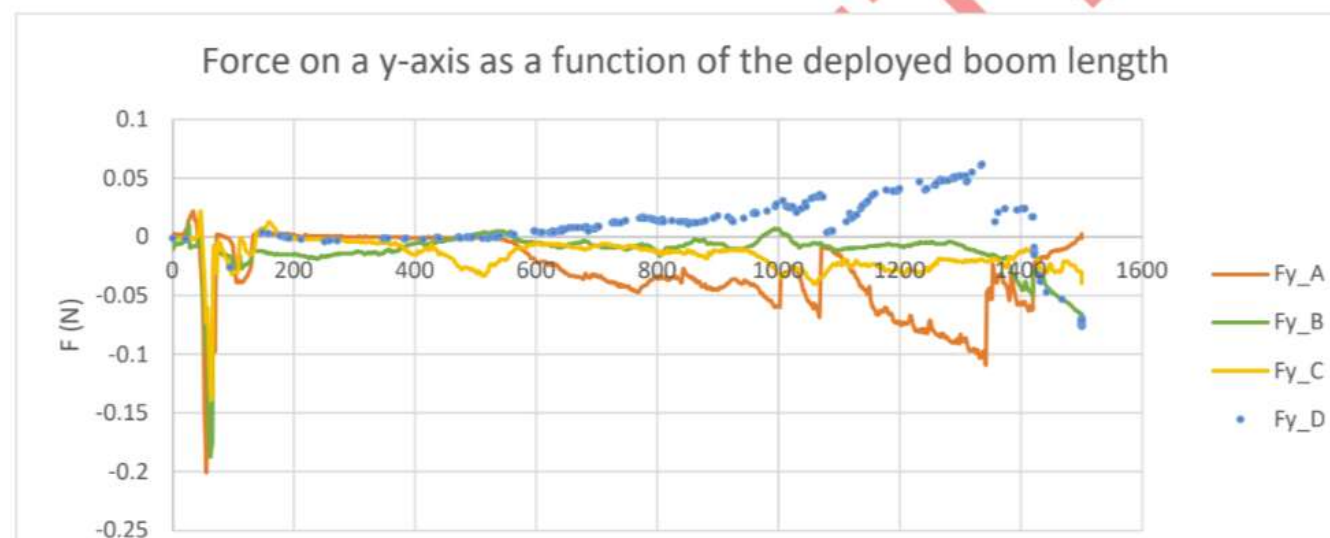
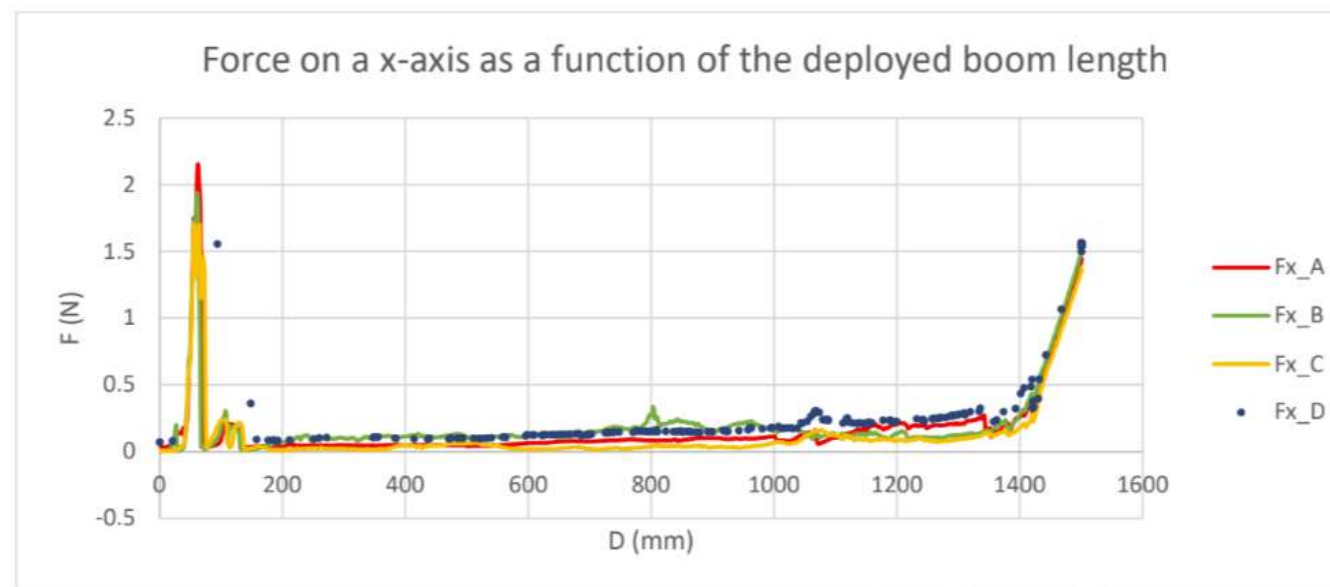
## 1G sail deployment tests





## 1G sail deployment tests

- Consistent and acceptable force profile over repeated deployments
- Phase 1 – sail release
- Phase 2 - unrolling
- Phase 3 – unfolding
- Phase 4 – tensioning





## Test plan

- Current 2x2m sail deployments
- August 2023 - 4x4m sail deployment (using DLR booms and deployer)
- 64m<sup>2</sup> by end of year
- Important focus on machines that will build the machines



# Test Facilities



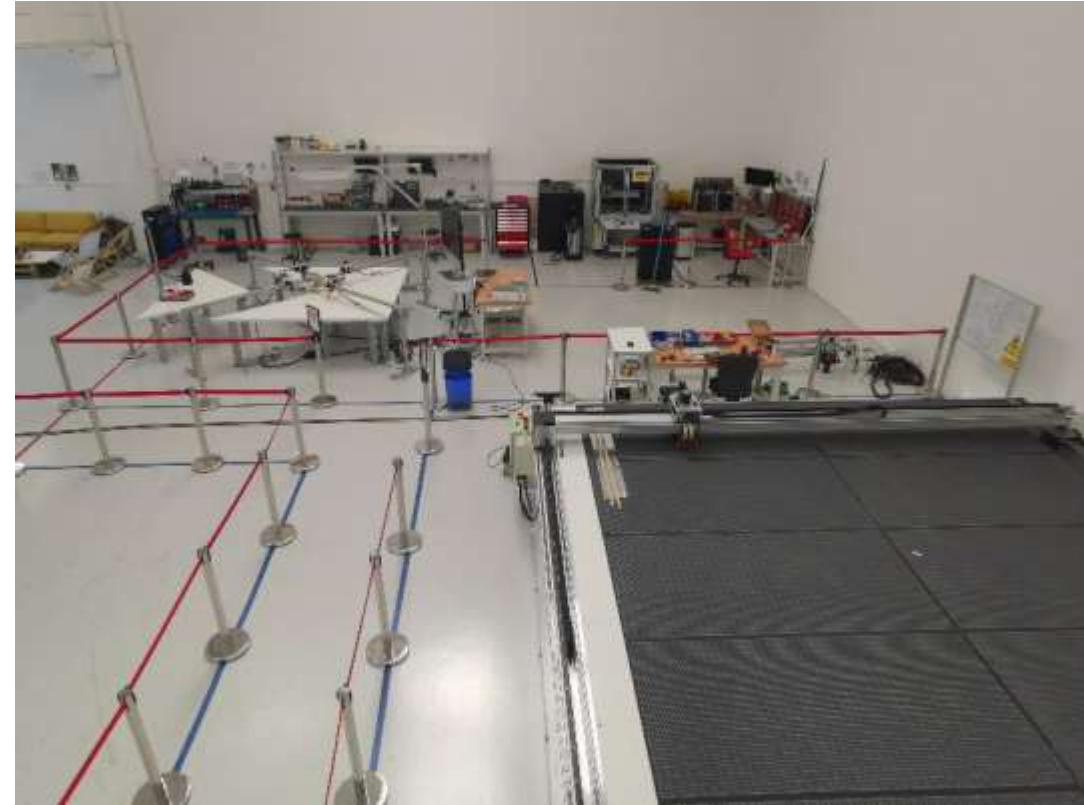
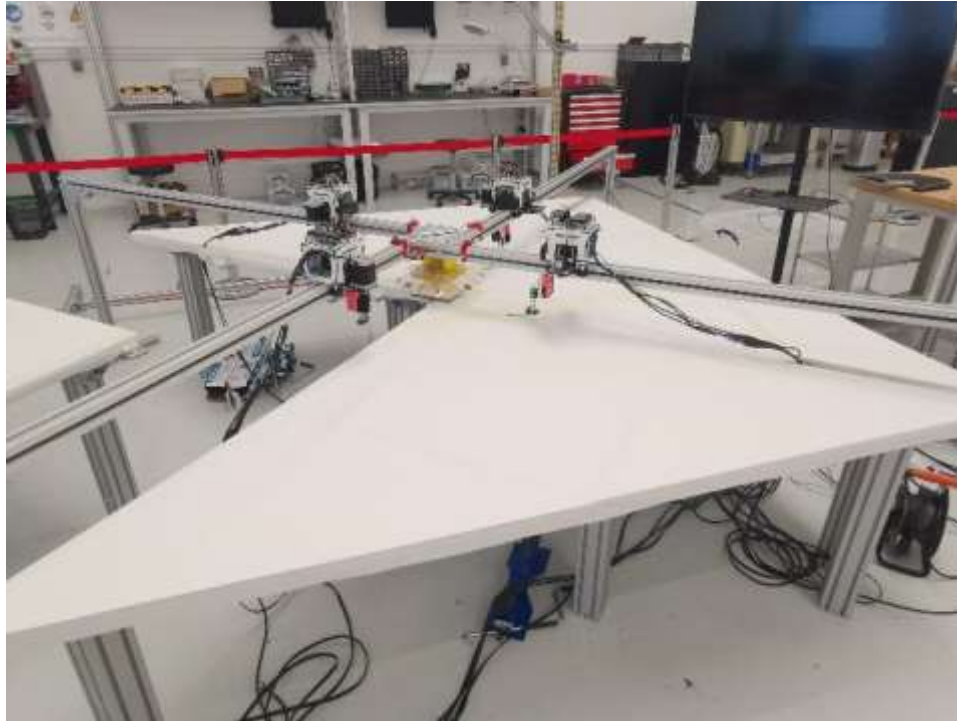
**250m<sup>2</sup> warehouse**  
130m<sup>2</sup> offices



# Test Facilities



GAMA BETA





THANK YOU!

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