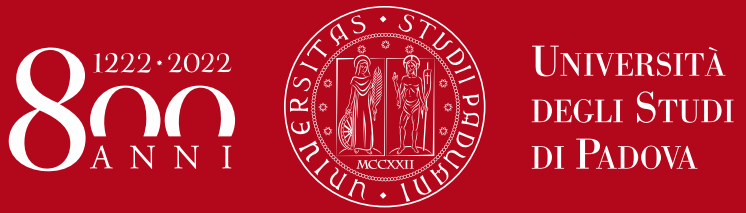


Development of a standard modular docking interface for On Orbit assembly and servicing

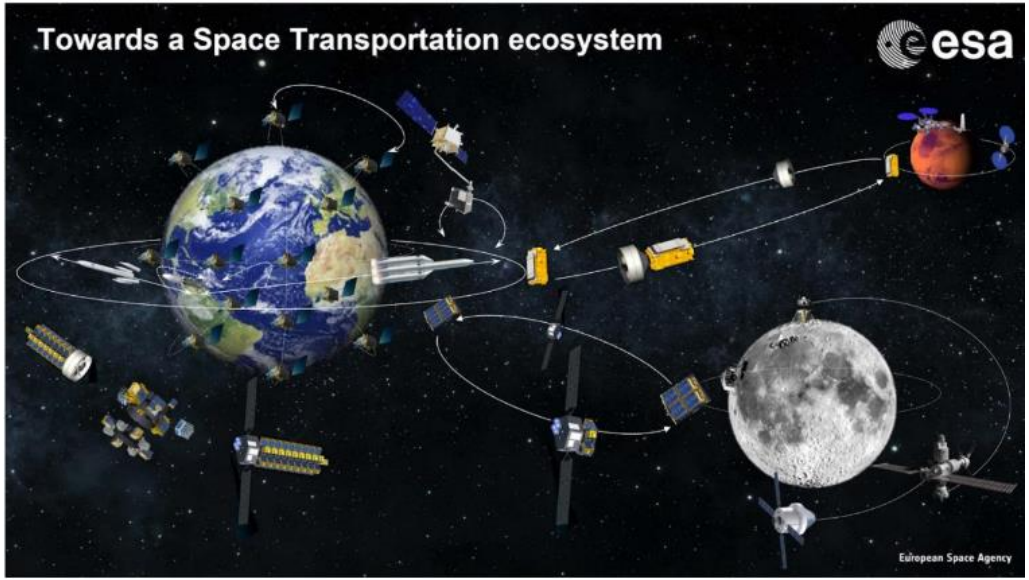
Giuseppe Ventura - 38th Cycle

Supervisor: Prof. Alessandro Francesconi

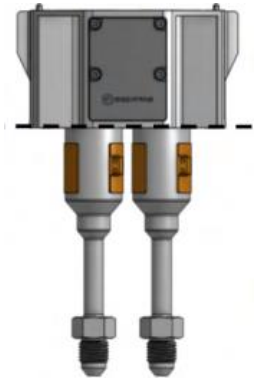
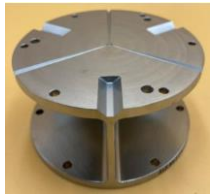
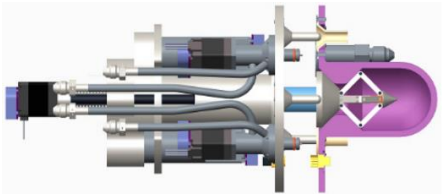
Admission to the third year - 16/09/2024

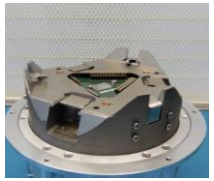
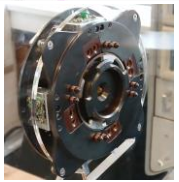
Space Logistic Ecosystem

- In orbit servicing
- In space assembly and manufacturing
- End of life managment and active debris removal
- Return to Earth

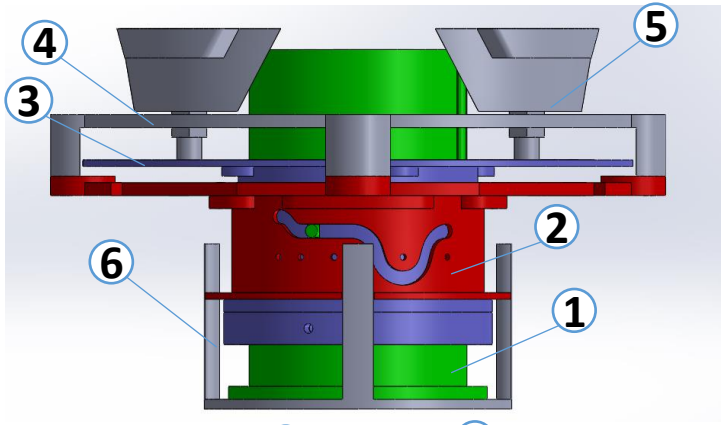


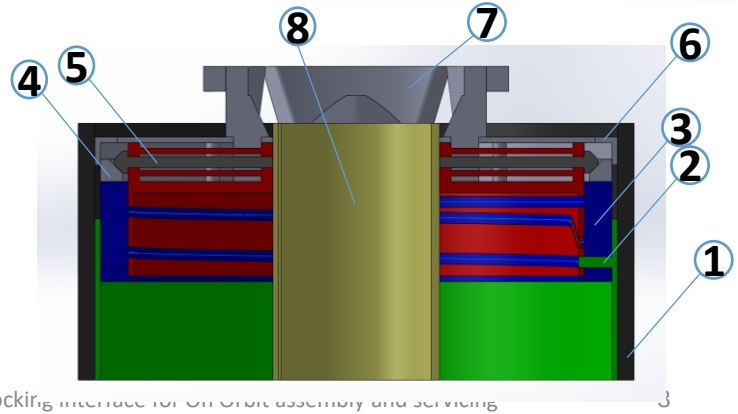
Docking interfaces analysis

Interfaces design and prototyping



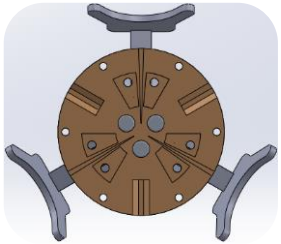


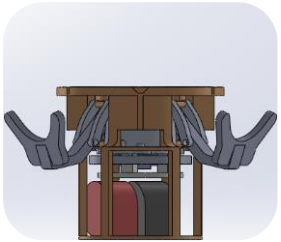
Functional requirements definition

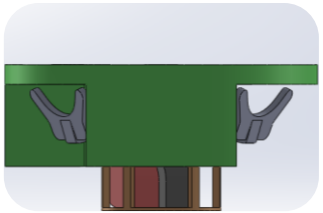
WEIGHT [kg]	DIMENSION [mm]	MAX POWER [W]	ADD-ON	DOCKING TIME [sec]	GEOMETRIC FEATURES	TARGET ORBIT	TEMPERATURE RANGE [°C]
MECHANICAL AXIAL-LATERAL [N]	MECHANICAL BENDING - TORQUE [Nm]	ELECTRIC POWER EXCHANGE	DATA TYPE EXCHANGE	THERMAL POWER EXCHANGE	FUEL TYPE	LEAKAGE [scc/s]	MISALIGNMENT [mm]	MISALIGNMENT [deg]

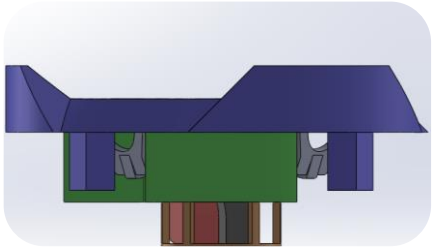
End of the first year: MASI v1.0

MASI : Modular Androgynous Standard Interface









Docking interface

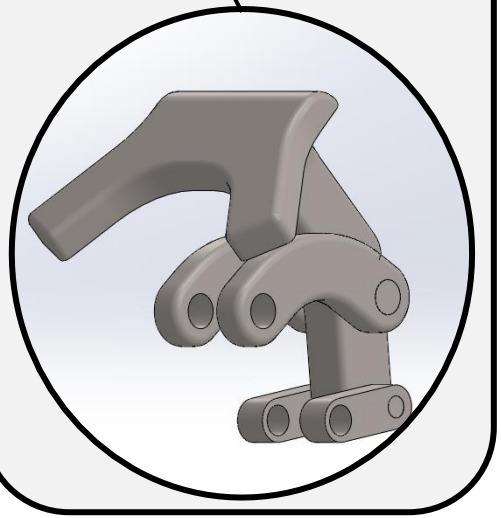
+ Refuelling module

+ Alignment module

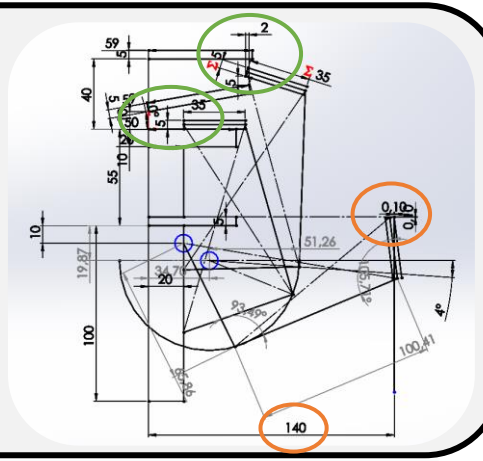
Mechanism optimization

Concept mechanism

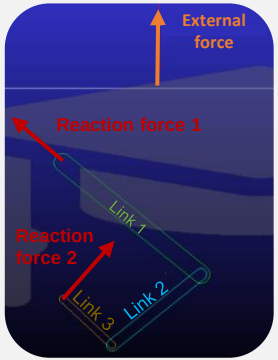
4-bar mechanism



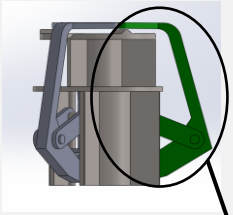
Trajectory constraints and Dimension constraints



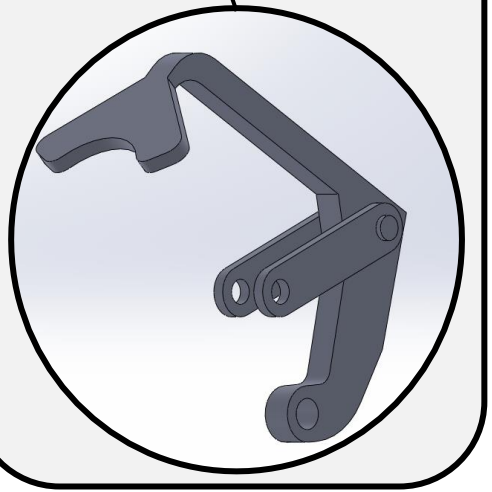
Reaction loads minimization



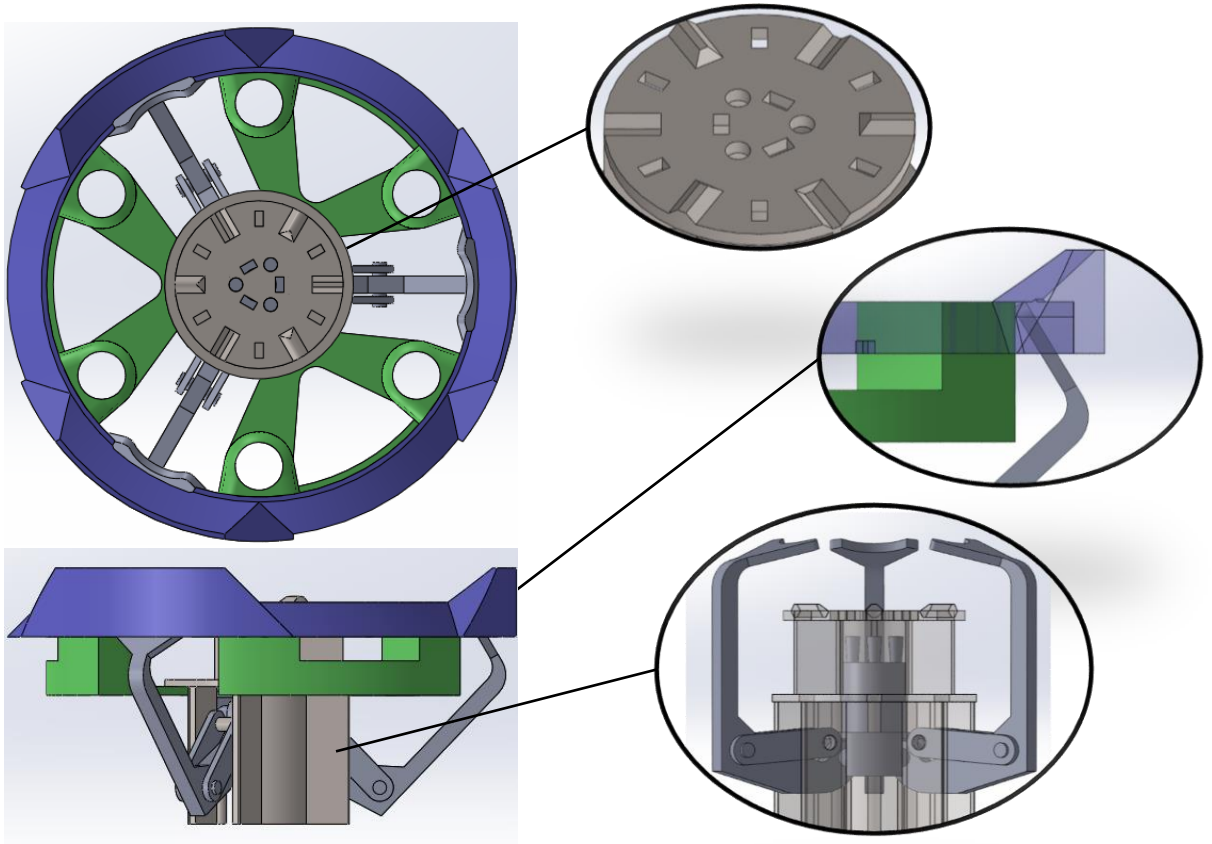
New mechanism



3-bar mechanism

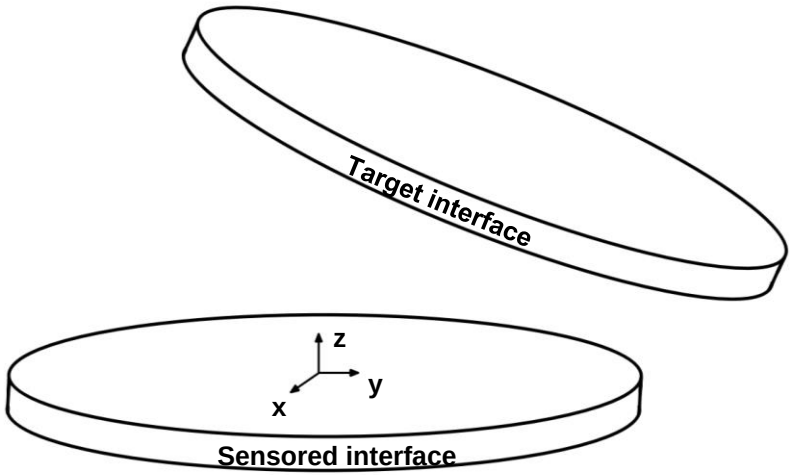


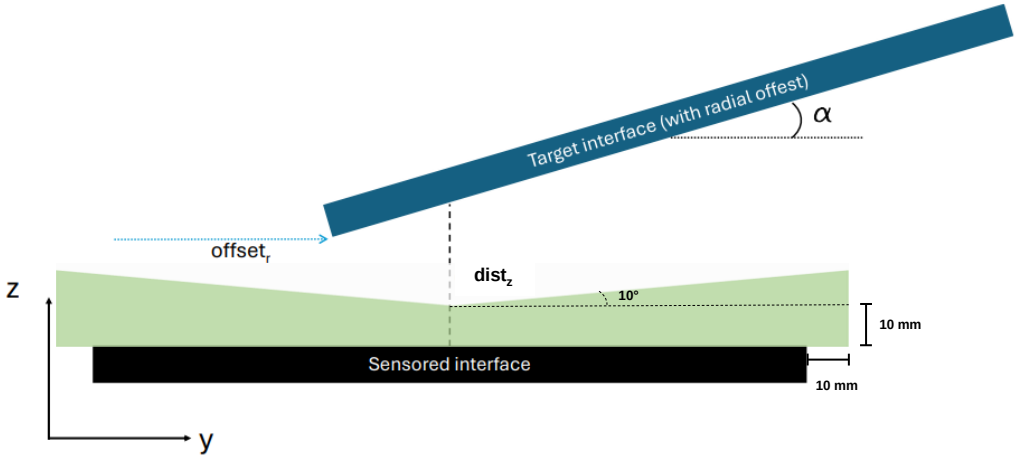
- **Reduction of components number**
- **More compact design and easier storage for launch phase**
- **Transfer of higher mechanical loads**
- **Higher reliabilty**

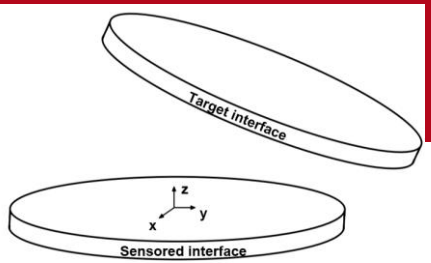


Attitude estimation subsystem design

Specification: Ensure feedback on the target interface's position and orientation, triggering the closing mechanism only within the acceptable volume

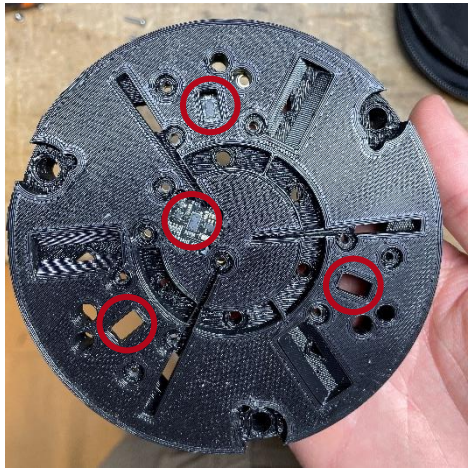






Attitude estimation subsystem design

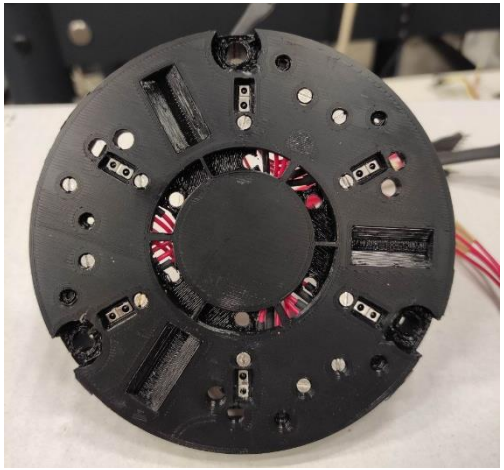
First iteration



✗ **No lateral offset evaluation**

✗ **Low sensor precision and slow acquisition**

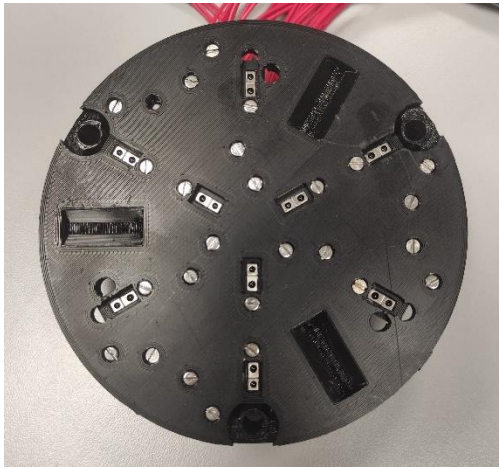
Second iteration



✗ **No lateral offset evaluation**

✓ **High sensor precision and fast acquisition**

Third iteration

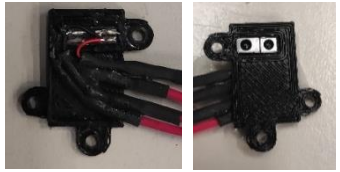


✓ **Lateral offset evaluation**

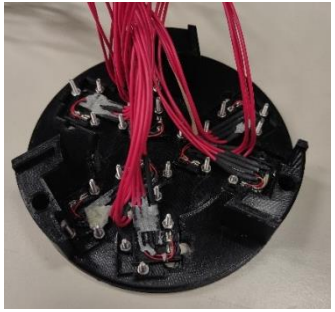
✓ **High sensor precision and fast acquisition**

Attitude estimation subsystem testing

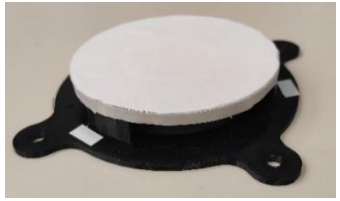
Sensor and cover



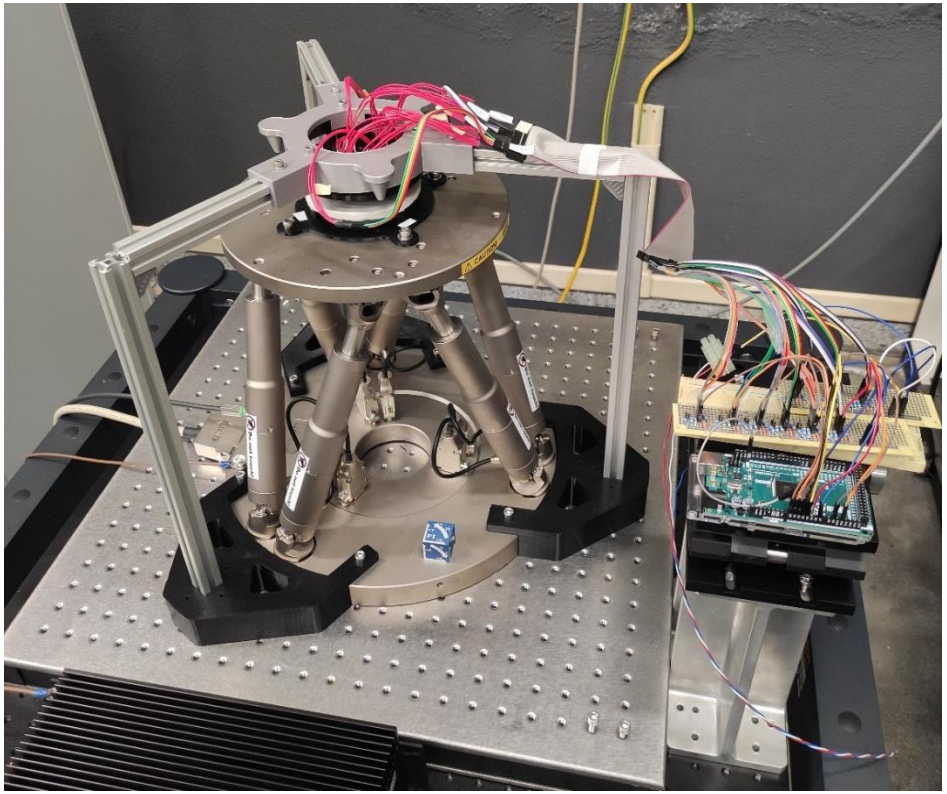
Sensors assembly



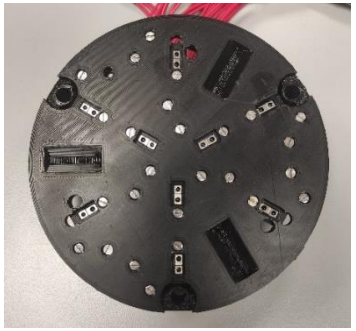
Target interface



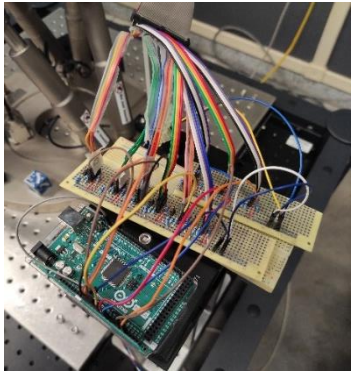
Test facility



Sensored interface

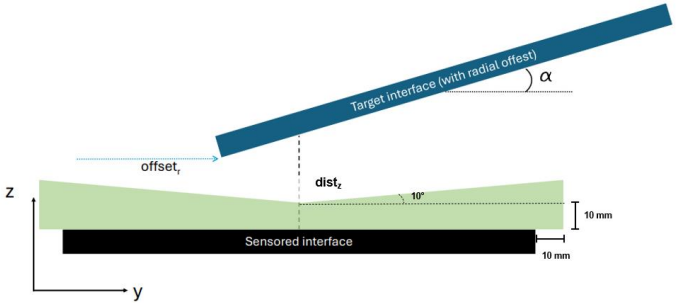


Arduino and power circuit



Attitude estimation subsystem performance

	z [mm]	r [mm]	r [deg]	x [deg]	y [deg]
Range	[0, 12]	[-11, 11]	[0, 360]	[-12, 12]	[-12, 12]
Error	$\sigma = 0.5$	± 1.5	± 15.0	± 1.0	± 1.0



Advantages

1) No contact required
2) No markers required
3) It works with both MASI and MICE

Performance to improve

1) Increase the operating range
2) Increase the precision of the lateral offset estimation

Next test steps

1) Introduce MASI features on target interface
2) Material of more realistic reflectivity for target interface

Next steps

Mechanism detailed design

FEM and multibody analysis

Actuators and power trasmission parts sizing

Refuelling system design

Actuators and valves sizing

Fluidic system design

Experimental campaign

Validation of virtual simulations

Test on fluid exchange subsystem and mechanism operations

Timing

WBS NUMBER	TASK TITLE	% OF TASK COMPLETE	FIRST YEAR												SECOND YEAR												THIRD YEAR											
			T1			T2			T3			T4			T1			T2			T3			T4			T1			T2			T3			T4		
			O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
1	State of art definition																																					
1.1	Systems type analyses	100%																																				
1.2	Environmental scenarios and constraints definition	100%																																				
1.3	Mechanisms and interfaces analysis	100%																																				
2	Conceptual design																																					
2.1	Functional requirements definition	100%																																				
2.2	Mechanisms and interfaces design	70%																																				
2.3	Virtual prototyping and simulations	40%																																				
3	Physical design																																					
3.1	Detailed design, manufacturing and assembly	20%																																				
3.2	Experimental campaign	30%																																				
4	Writing PhD thesis and reports																																					
4.1	Writing reports	50%																																				
4.2	Article redaction	30%																																				
4.3	Writing PhD thesis	30%																																				
Site scheduling			University of Padova												Thales Alenia Space												Aborad period											

PNRR

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a Thales / Leonardo company

Thanks for the attention