

# MoonLIGHT-2

INFN-CSN2 Experiment: Test of Gravity in the Solar System

CSN2-LNF, 26<sup>th</sup> June 2023

## Italian Participants:

INFN-LNF → ~ 9 FTE

INFN/University - Padova → ~ 2 FTE

INFN/University - Naples → ~ 6 FTE

ASI-Matera Laser Ranging Observatory → ~ 3 FTE

## USA Participants:

University of Maryland College Park (UMD), MD

Harvard-Smithsonian Center for Astrophysics (CfA), MA

University of California San Diego (UCSD), CA

NASA-SSSERVI

## Approved flights:

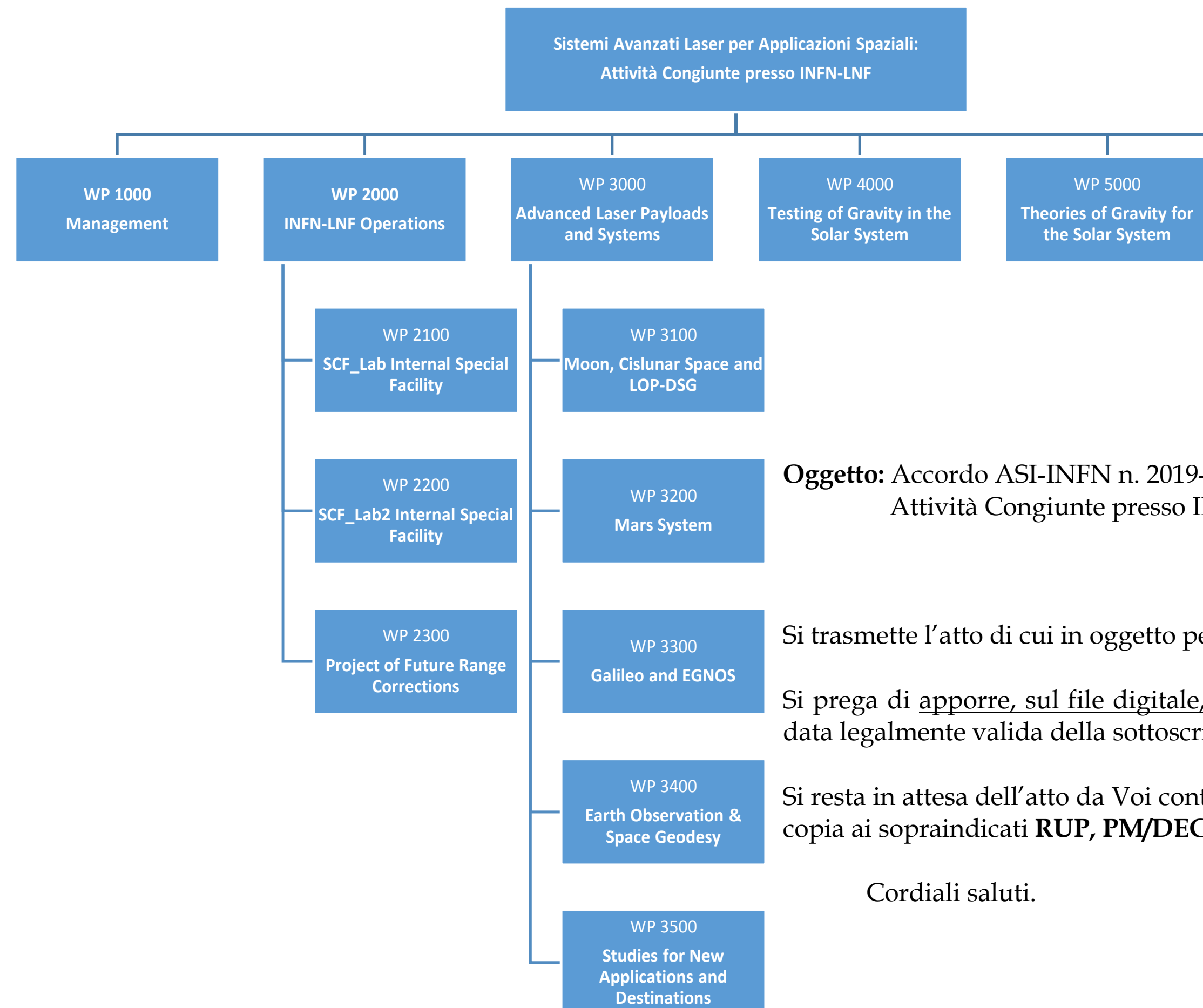
ESA (Prime = Intuitive Machines): mid 2024

NASA (Prime = Firefly): mid 2024

## Partner Space Agencies:



# JointLab INFN-Frascati with ASI-Matera: 1 July 21 - 30 June 25: 1.5M€ (delay/suspension due to COVID-19)



Spett.le  
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Nucleare - INFN  
Via Enrico Fermi, 40  
00044 - Frascati

Att.ne  
Prof. Fernando Ferroni  
Presidente

PEC: [presidenza@pec.infn.it](mailto:presidenza@pec.infn.it)

c.c.: RUP: Giuseppe Bianco  
DEC /PM: Catia Benedetto  
Unità Contratti: Francesca Paccagnini  
Unità contratti – Segreteria Flora Leucci

**Oggetto:** Accordo ASI-INFN n. 2019-15-HH.0 per "Sistemi Avanzati Laser per Applicazioni Spaziali:  
Attività Congiunte presso INFN-LNF".

Si trasmette l'atto di cui in oggetto per la Vostra sottoscrizione.

Si prega di apporre, sul file digitale, la firma digitale, unitamente alla marca temporale, che attesta la data legalmente valida della sottoscrizione.

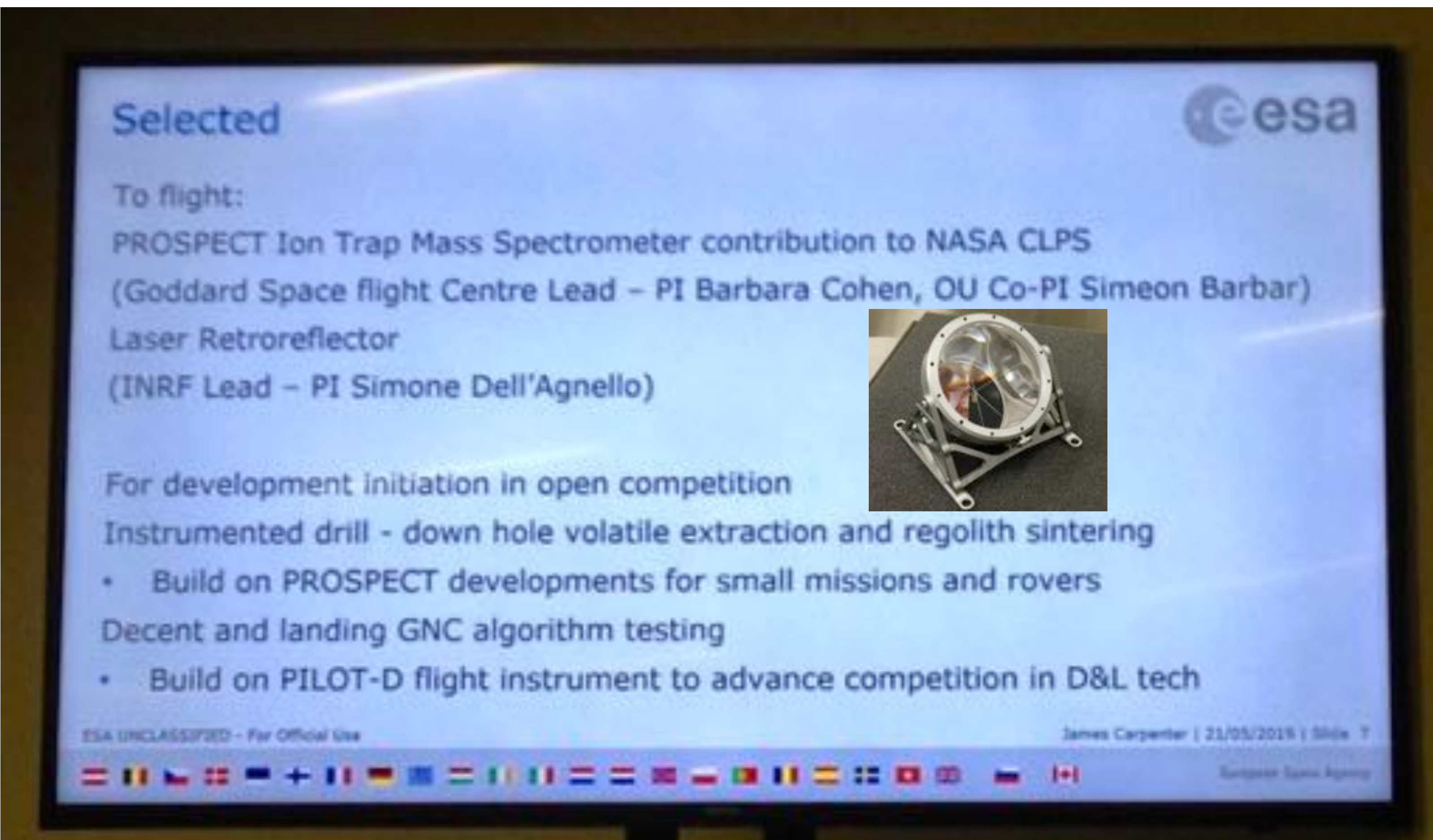
Si resta in attesa dell'atto da Voi controfirmato, da inviare ad [asi@asi.postacert.it](mailto:asi@asi.postacert.it), con comunicazione in copia ai sopraindicati **RUP, PM/DEC, Responsabile Contrattuale ed Unità Contratti-Segreteria**.

Cordiali saluti.

U.O. Contratti  
Il Responsabile  
Dott.ssa Luciana Gentile



# MoonLIGHT-2 **selected by ESA** for a lunar mission (490kE for dual Earth pointing actuators)



ESA Contract No. 4000129000/19/NL/TFD

with

INFN - Laboratori Nazionali di Frascati

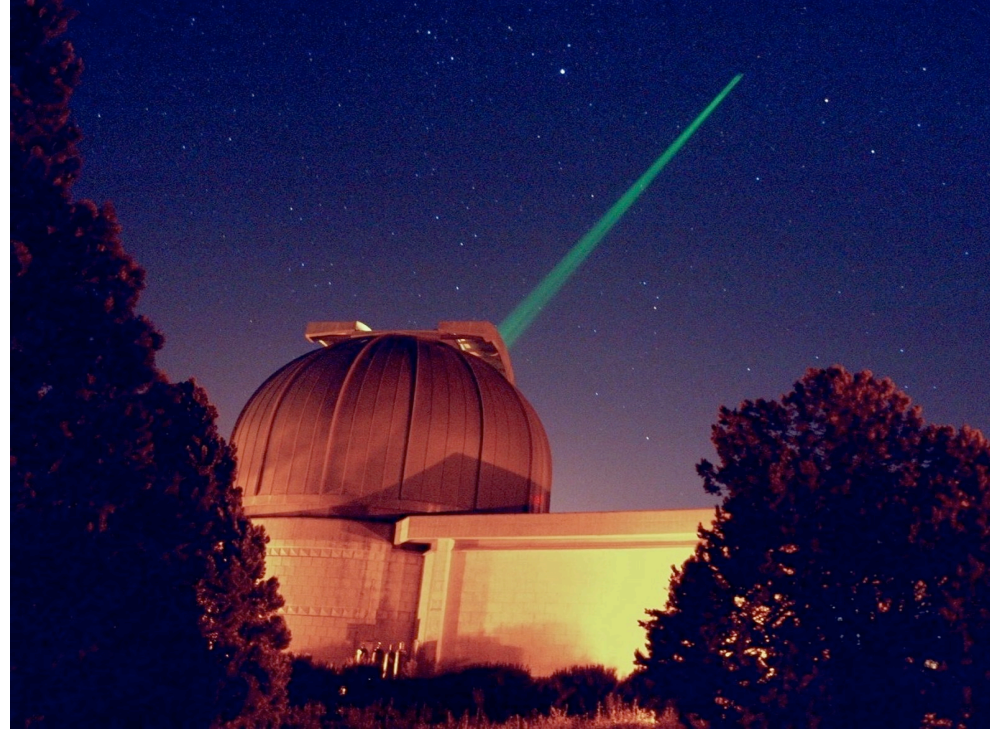
LUNAR LASER RETROREFLECTOR POINTING ACTUATOR

Contract for development of MPAc (MoonLIGHT Pointing Actuator)

INFN Resp.: M. Muccino



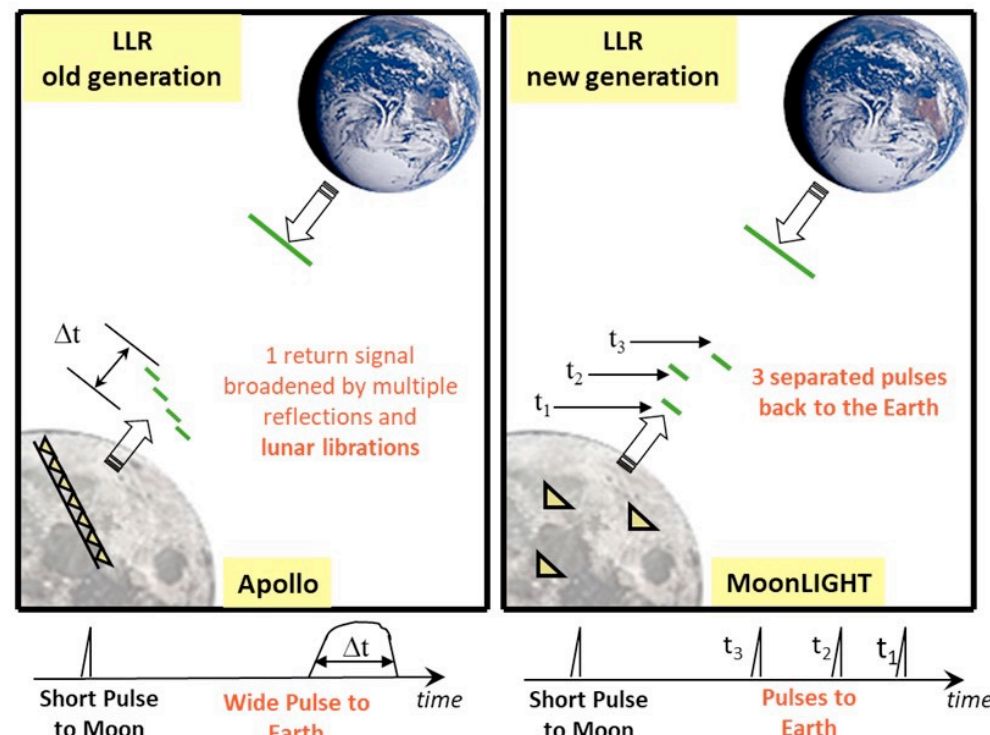
# The MoonLIGHT Experiment



Apollo and Luna missions placed five arrays of CCRs on the surface of the Moon. These reflectors reflect light parallel to the incident beam. Through a technique known as LLR, it has been possible to perform high accuracy/precision measurements of the Earth-Moon distance by firing short-pulse laser from ground stations to these LRAs on the Moon and measuring two-way time of flight.

The precision of the LLR is limited because Apollo and Lunokhod arrays are affected by the lunar librations in longitude, caused by the eccentricity of the Moon's orbit around the Earth. This tilt increases the dimension of the return pulse and therefore the uncertainty.

The aim of MoonLIGHT is to reduce the error contribution of LLR measurements by more than two orders of magnitude, taking LLR back to the situation where the error was dominated by the laser pulse.



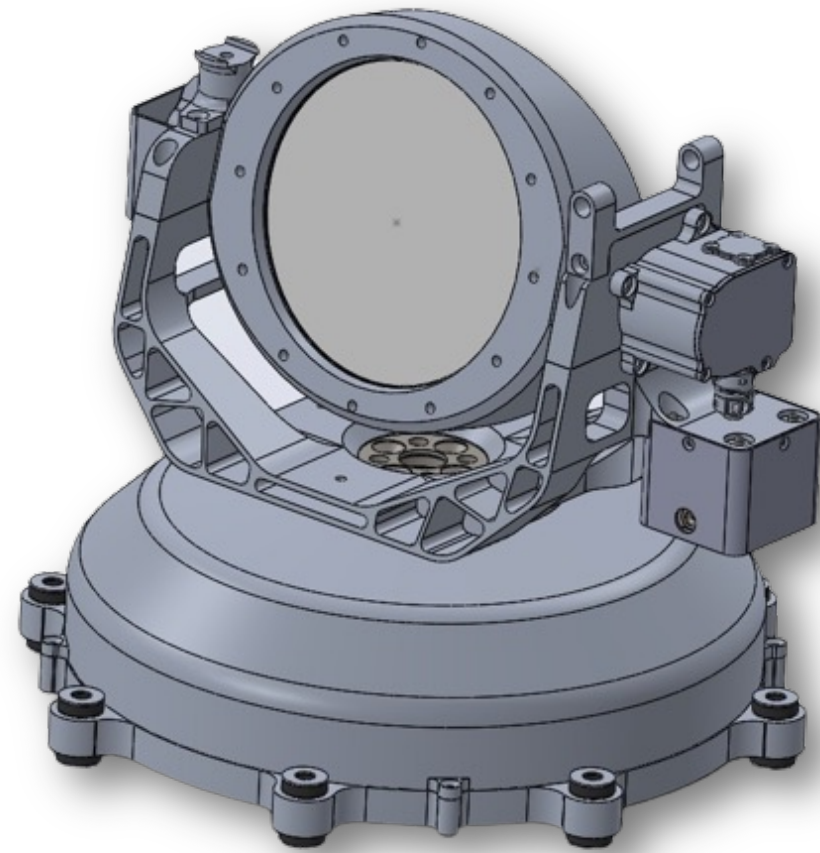
The idea is to move from a multi-CCR array to a series of single, larger CCRs, whose performance is unaffected by lunar librations. Reaching the ranging precision of 1mm or even less would considerably improve the measurement of different gravitational parameters and consequently, the results of the different scientific studies.



The reflector, designed for MoonLIGHT with a front face of 10 cm, is an uncoated CCR of Suprasil 311, a radiation-resistant grade of Fused Silica, characterized by a very low thermal expansion that minimizes thermal effects that could affect optical performances.



# MoonLIGHT Pointing Actuator (MPAc)



The CCR field of view, in far field conditions, is quite narrow (a cone with an opening angle of about  $34^\circ$ , whose apex is geometrically located in the vertex of the CCR), and it needs to be pointed precisely to the Earth. On account of the fact that the industry of landers could not guarantee such an accurate pointing of the device, INFN proposed the MoonLIGHT Pointing Actuator (MPAc) project to ESA in 2018. In 2019 ESA chose MPAc (and another instrument) among 135 eligible scientific project proposals.

The MPAc design aims to implement a modular configuration, being able to isolate the CCR from the electronics and moving elements. It must operate in Ultra High Vacuum space conditions, in a wide operating temperature range. The MPAc is divided into three main blocks with very different functions and characteristics.

1. The CCR Housing contains the MoonLIGHT retroreflector and its integration structure.
2. The elevation frame, is responsible of the generation of the “Elevation” rotation and contains some actuators and sensors.
3. The base frame represents the interface with the lander and contains most of the electronics and the motor responsible of generating the “Azimuth” rotation.

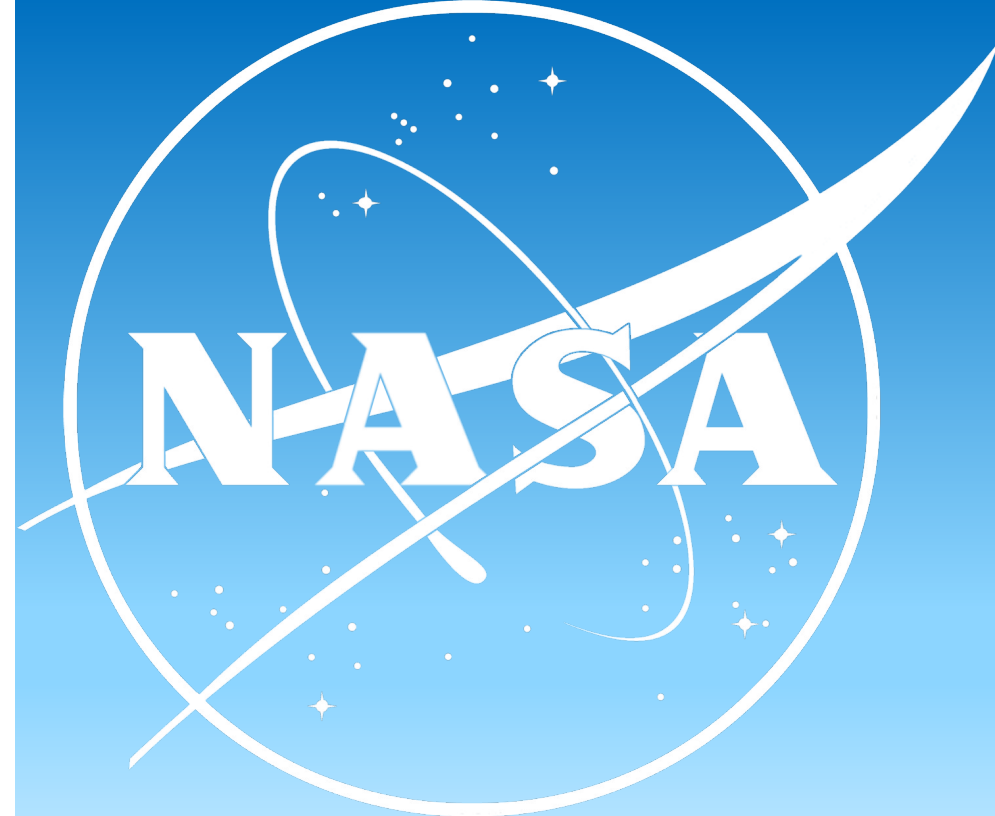
MPAc can be activated and commanded from Earth. Pointing is performed after knowing the actual attitude of the lander on the lunar surface, sending a command that the integrated microcontroller uses to move the two stepper motors to the desired position.

Mechanics, electronics and software have been tested with the 3 first prototypes, two in plastic and one in aluminum. The next step for the qualification is the design and manufacturing of the Engineering Model.



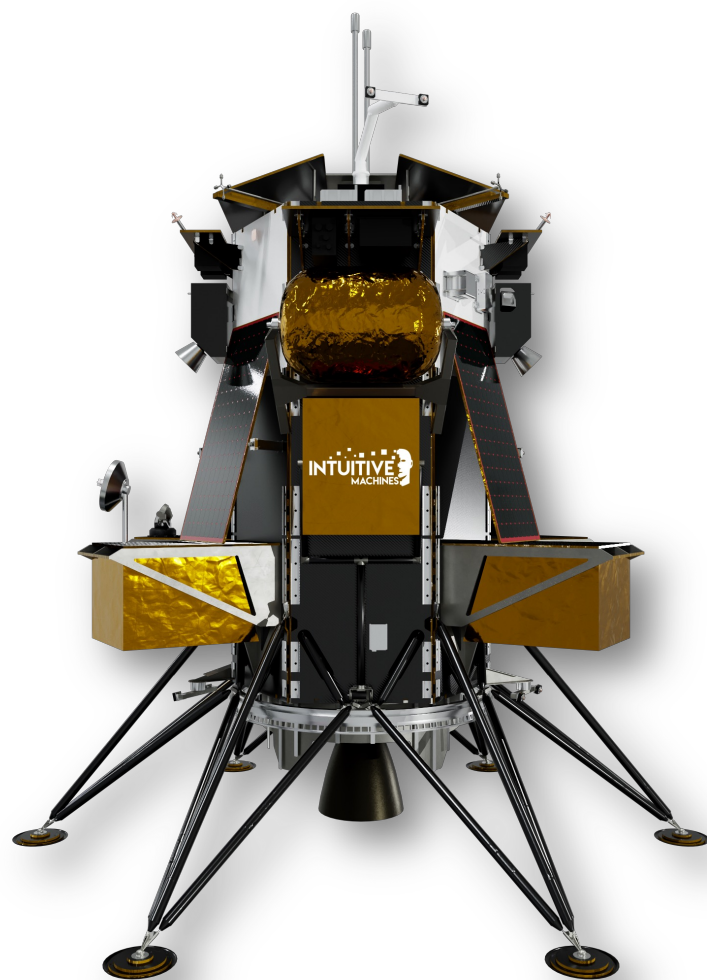


# CLPS Mission



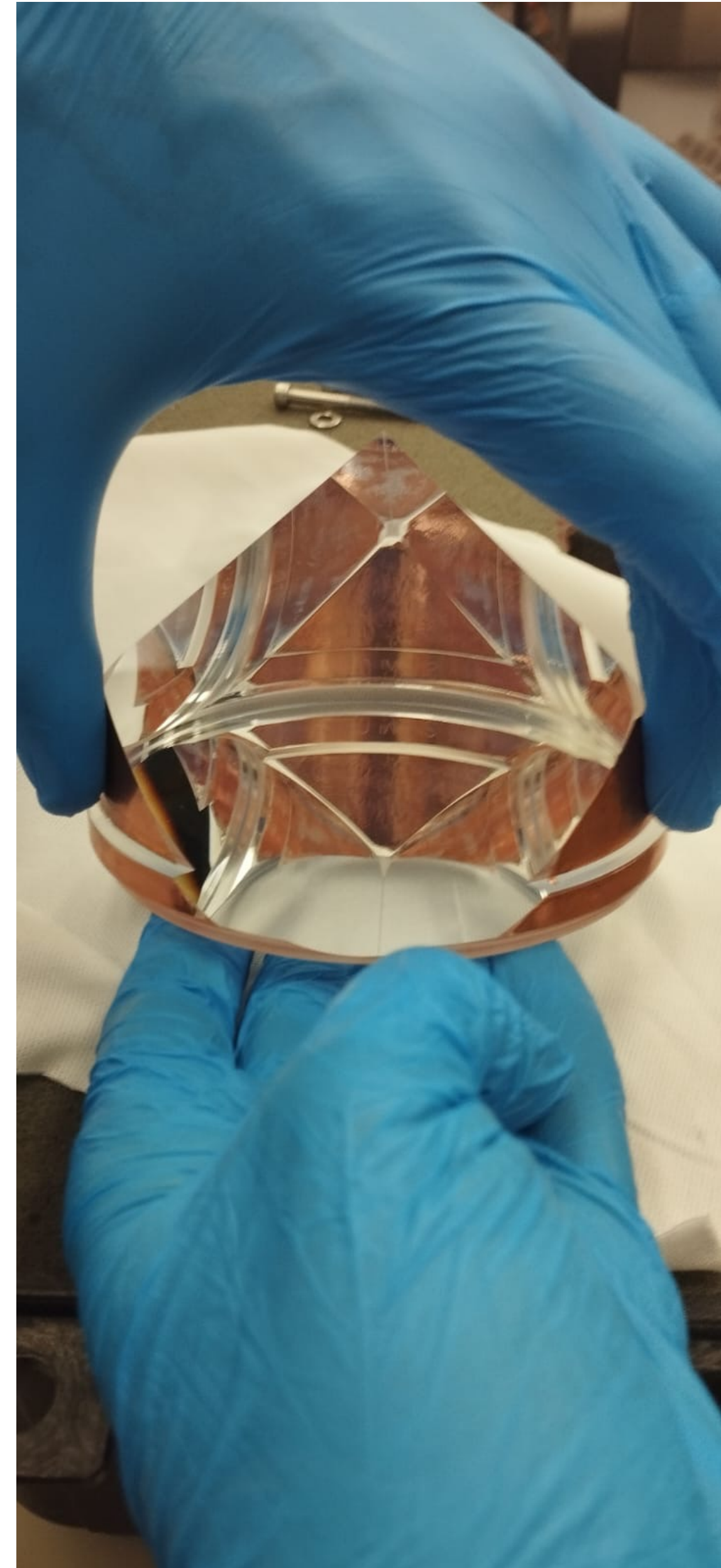
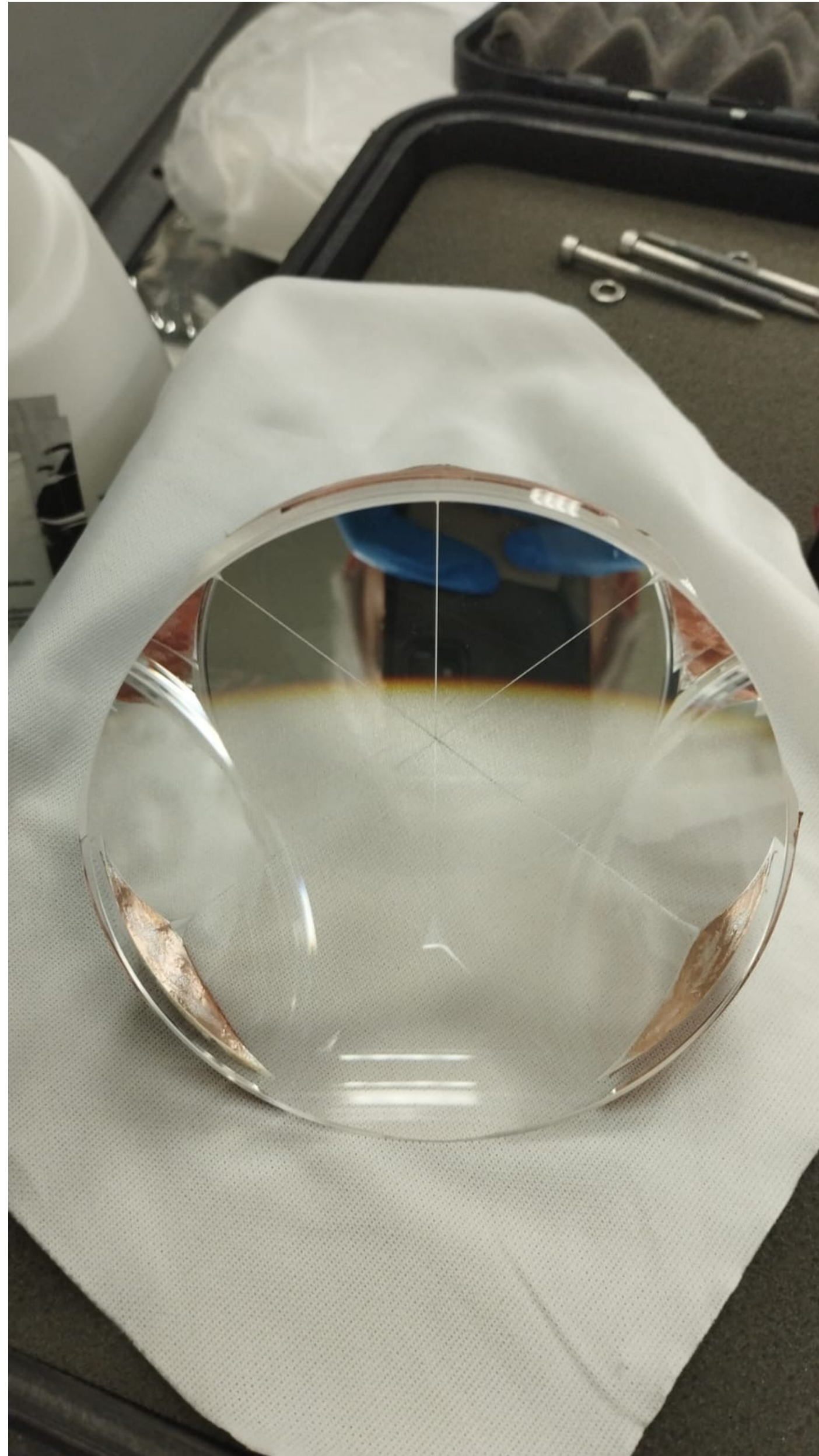
MPAc will fly, together with other 3 scientific payloads as part of NASA's Commercial Lunar Payload Services (CLPS) initiative and the Artemis program. The investigations aboard Intuitive Machines' Nova-C lander include exploration rovers, a high-energy particles detector and a magnetic field measurement device.

The landing site is Reiner Gamma, one of the most distinctive and enigmatic natural features on the Moon. Known as a lunar swirl, Reiner Gamma is on the western edge of the Moon, as seen from Earth (7.5°N, 59.0°W). It is still to be understood what lunar swirls are, how they form, and their relationship to the Moon's magnetic field.



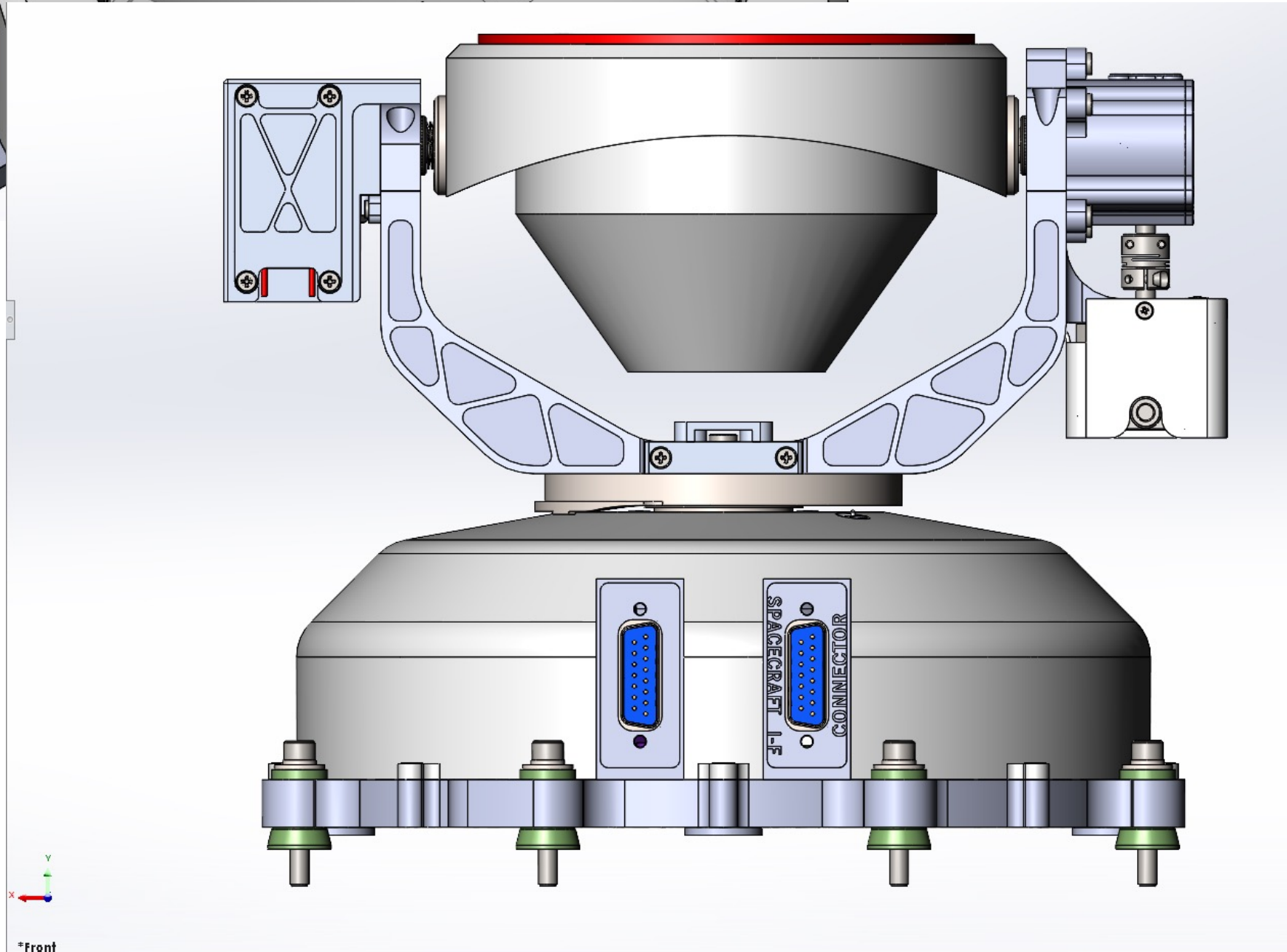
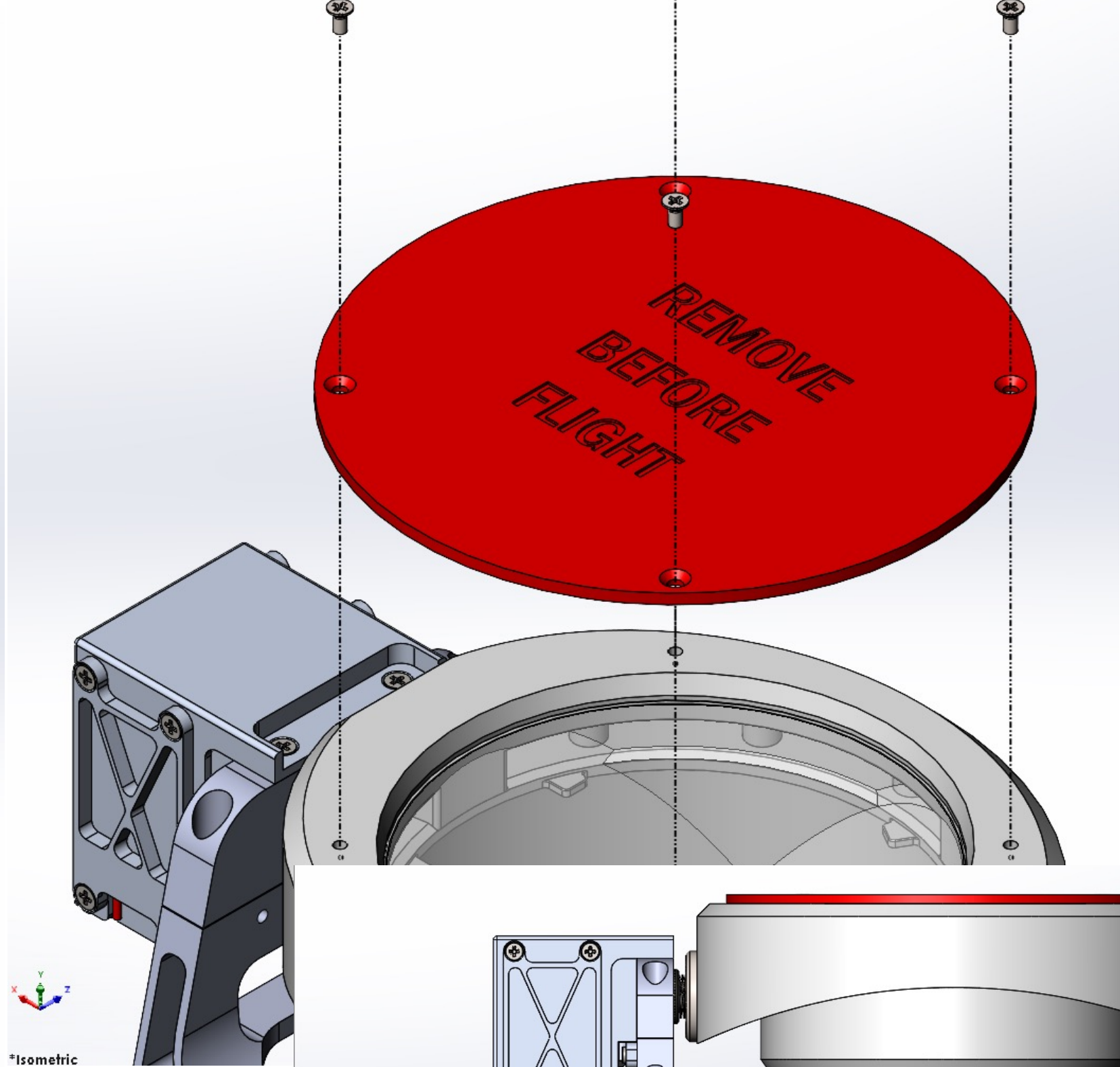
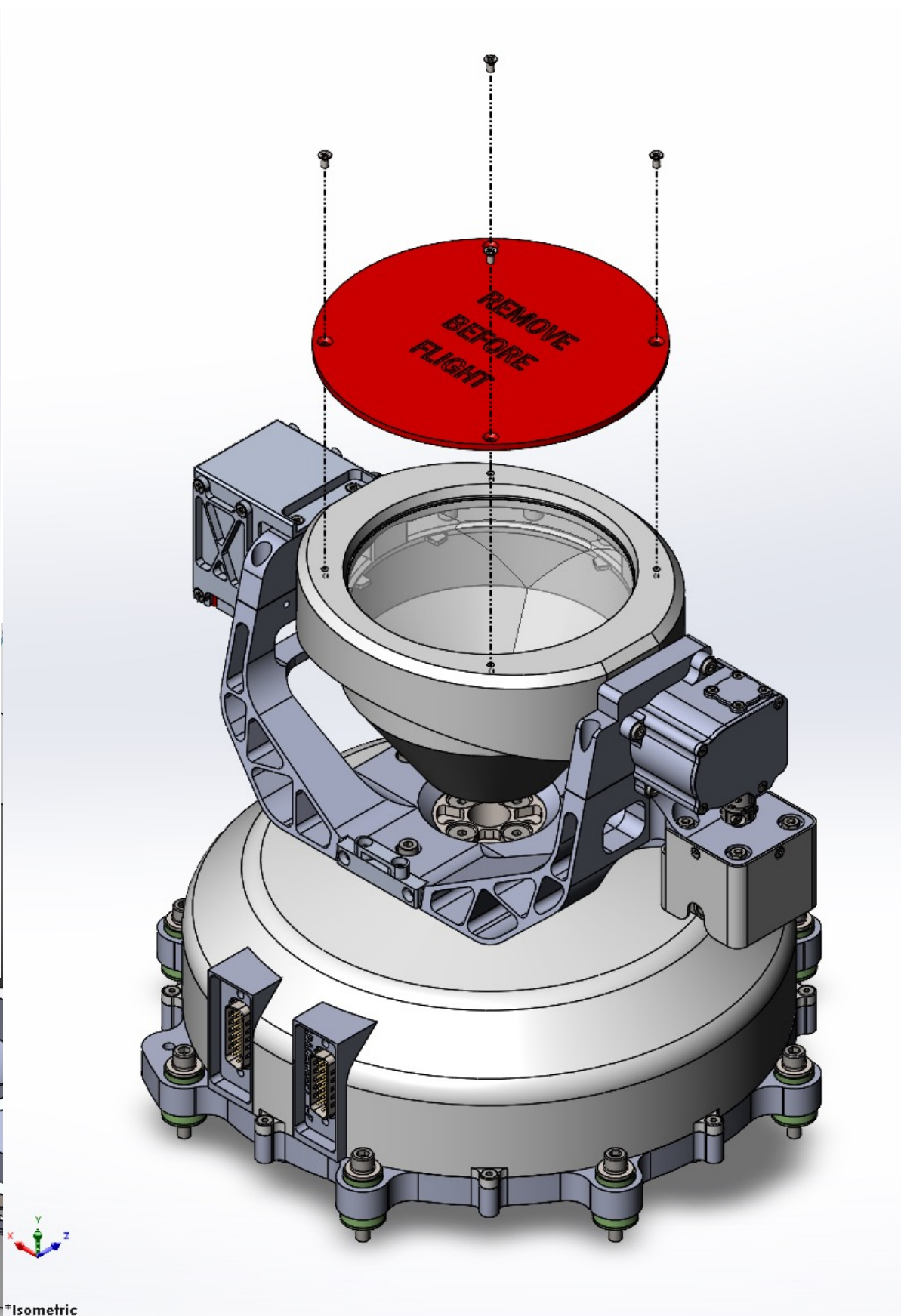
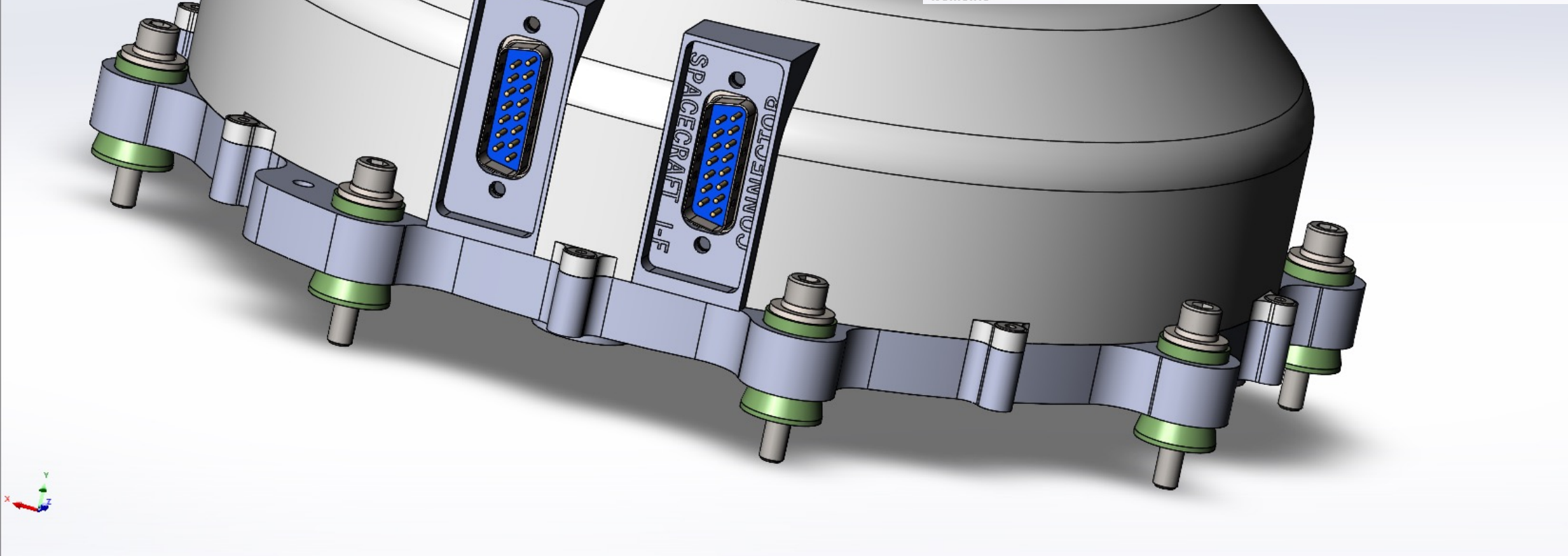
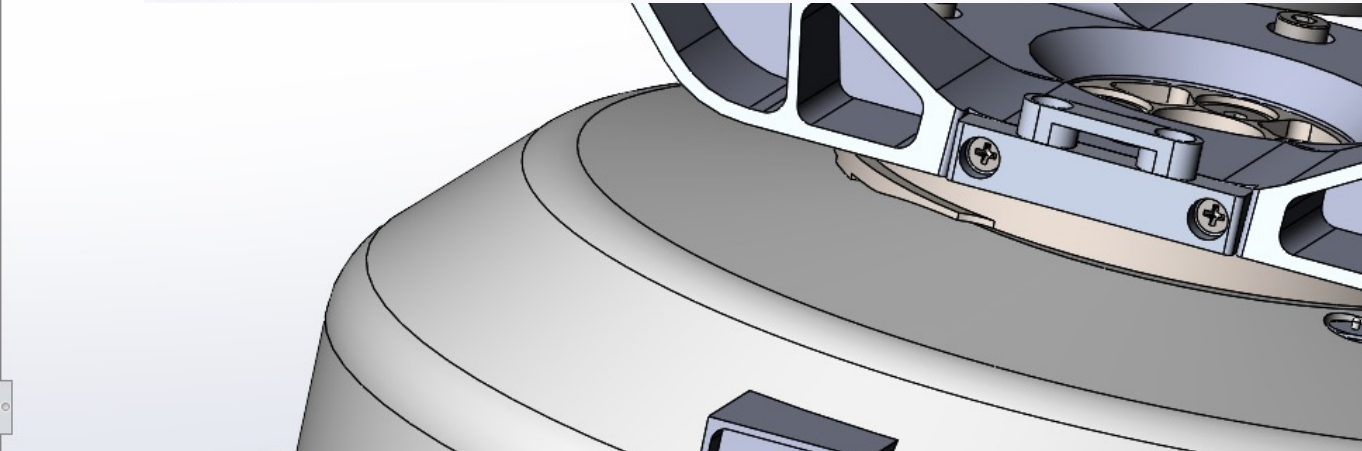
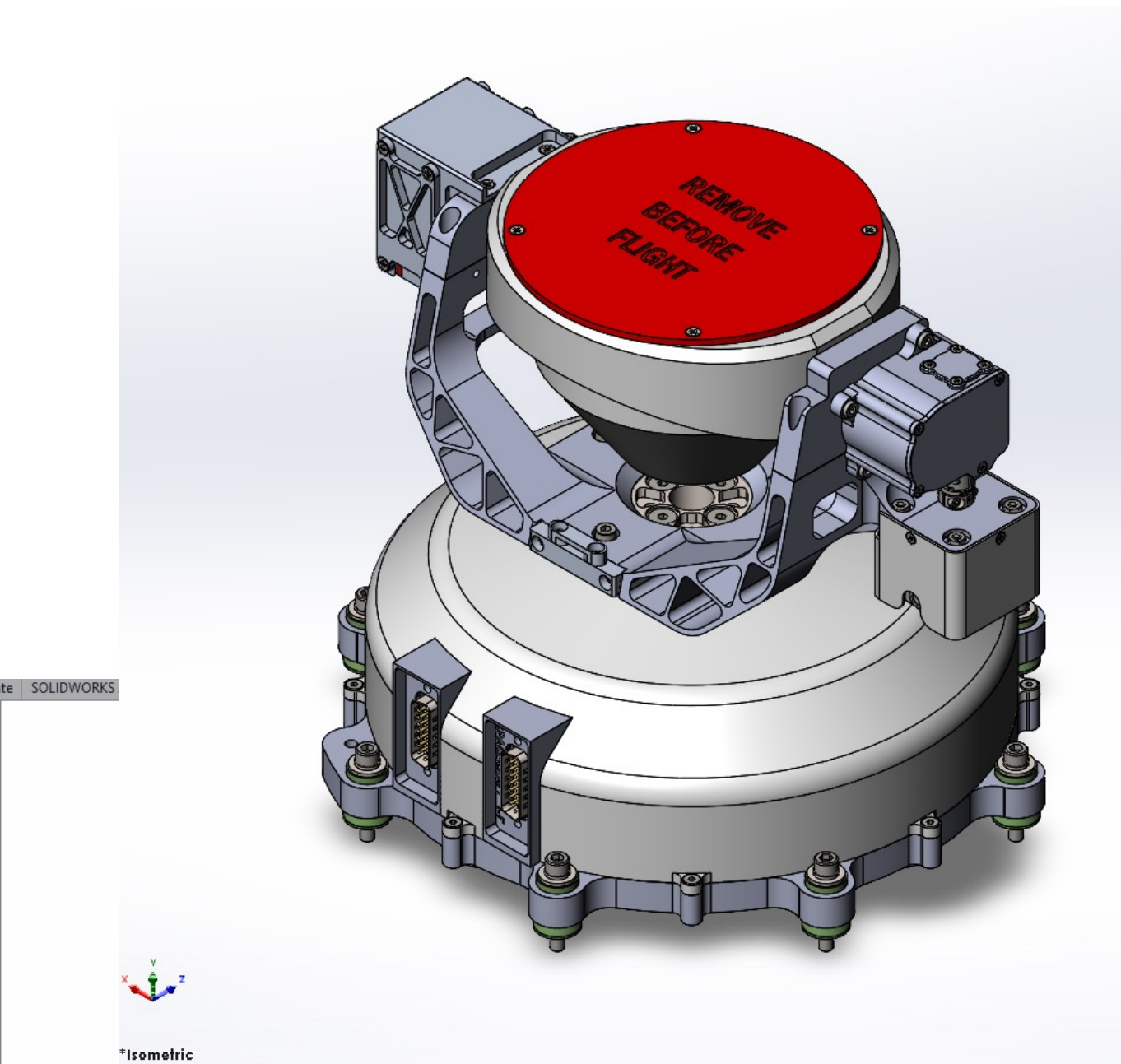


# MoonLIGHT+MPAc



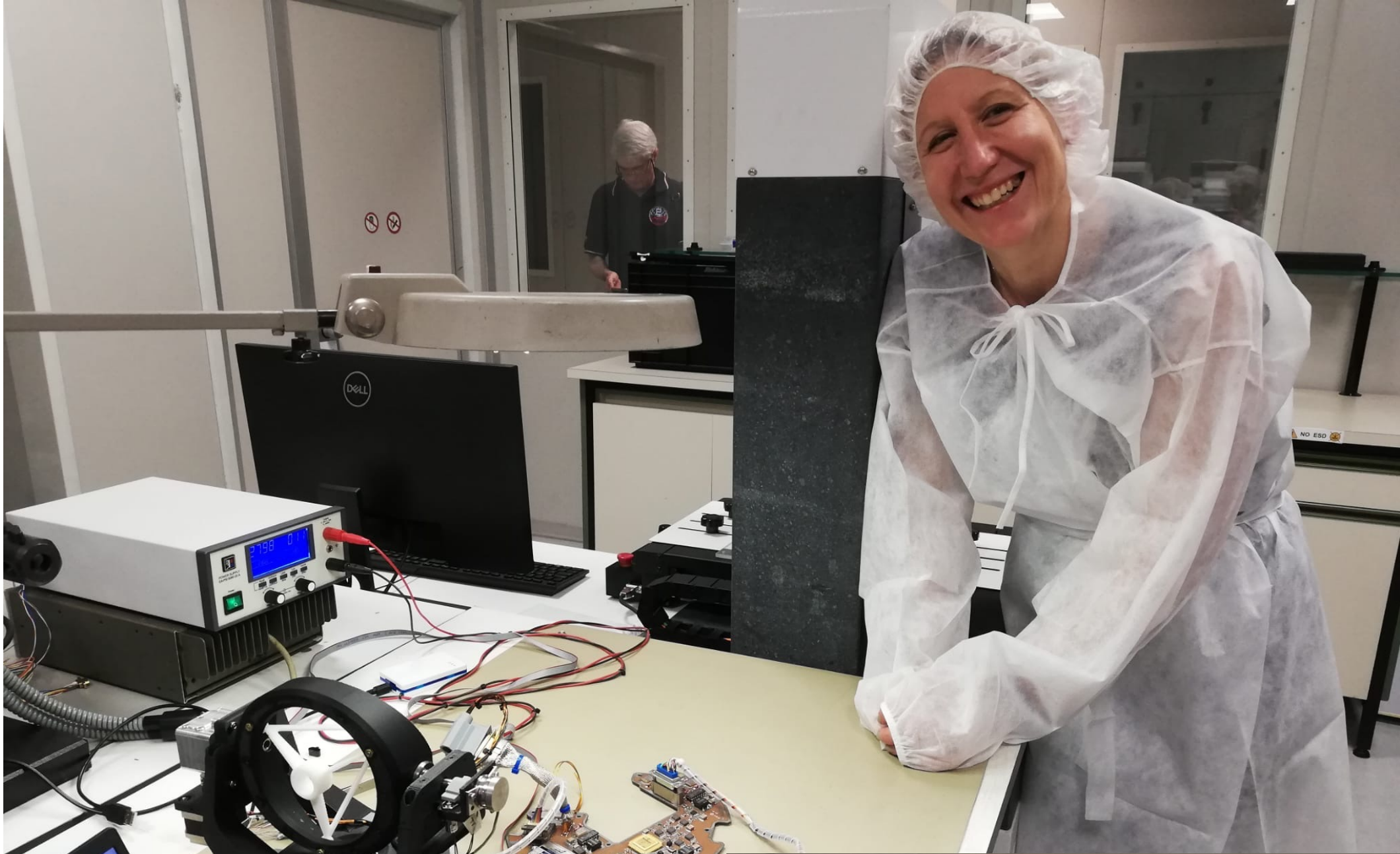
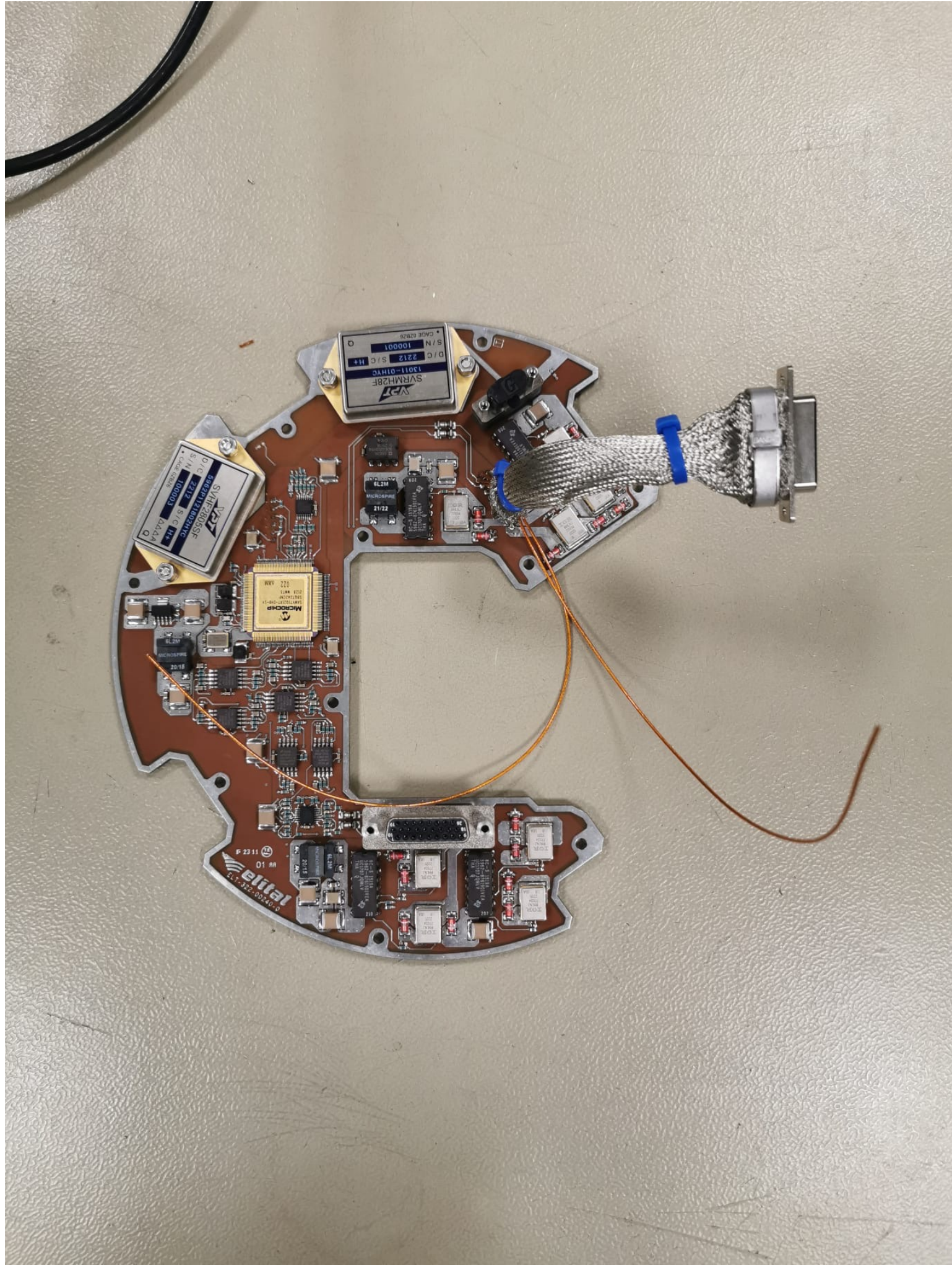


# MoonLIGHT+MPAc





**MoonLIGHT+MPAc**





## MoonLIGHT+MPAc





European Lunar Symposium 2023:  
<https://sservi.nasa.gov/els2023/>

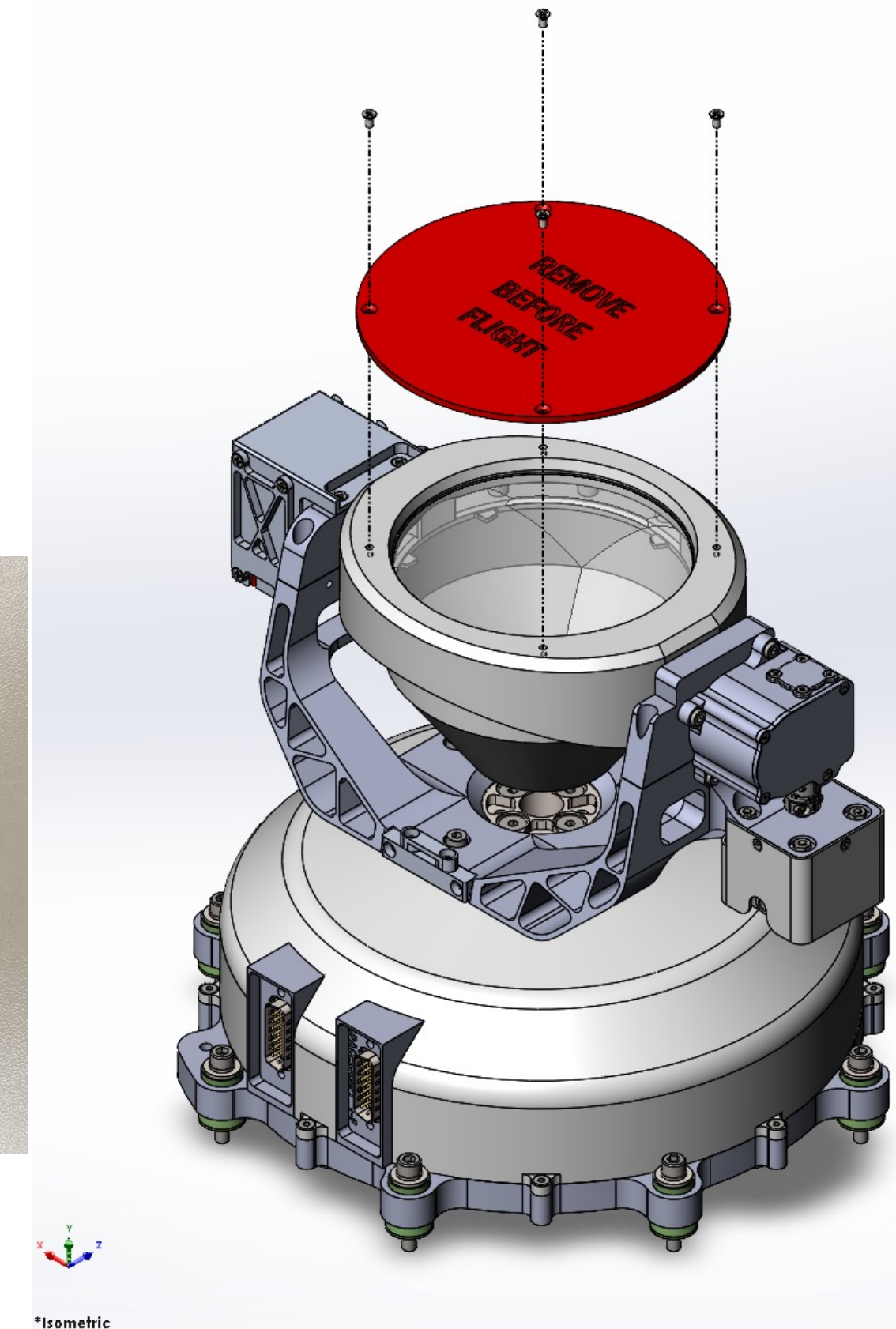
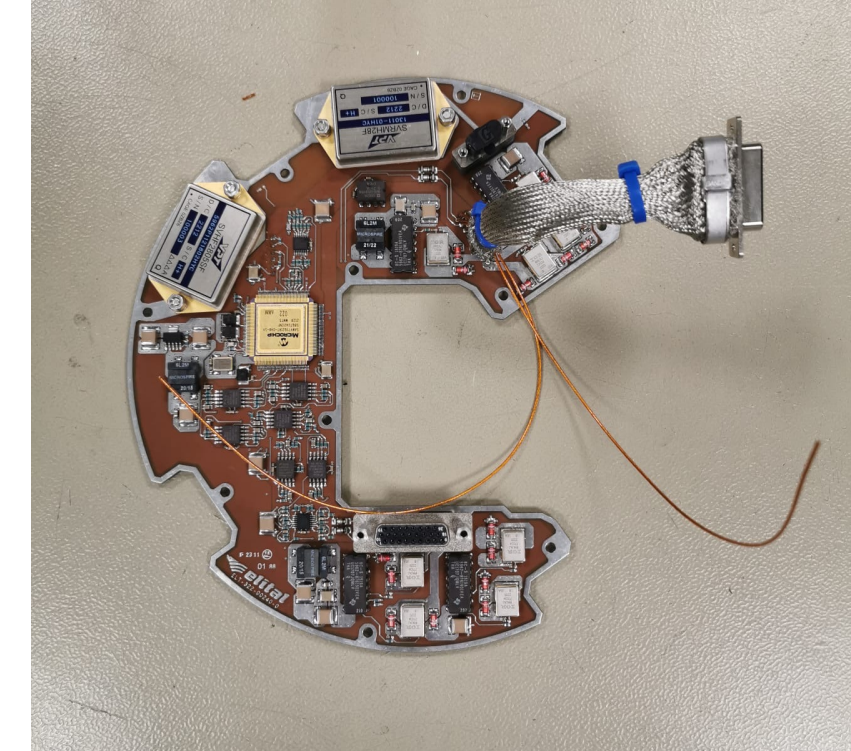
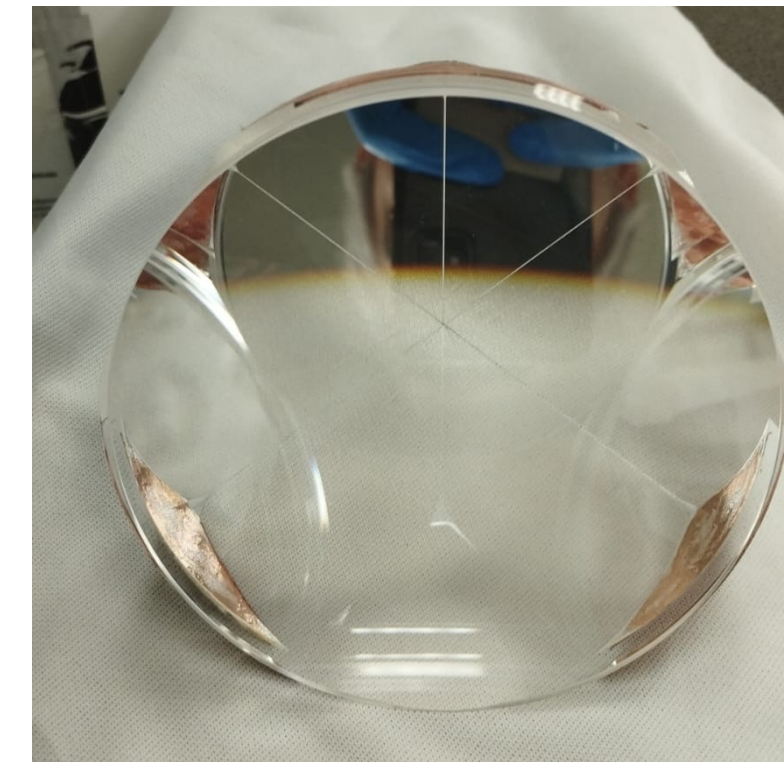




# MoonLIGHT-2 x 2024

**Objective: delivery of flight hardware to ESA/NASA for integration onboard lunar landers.**

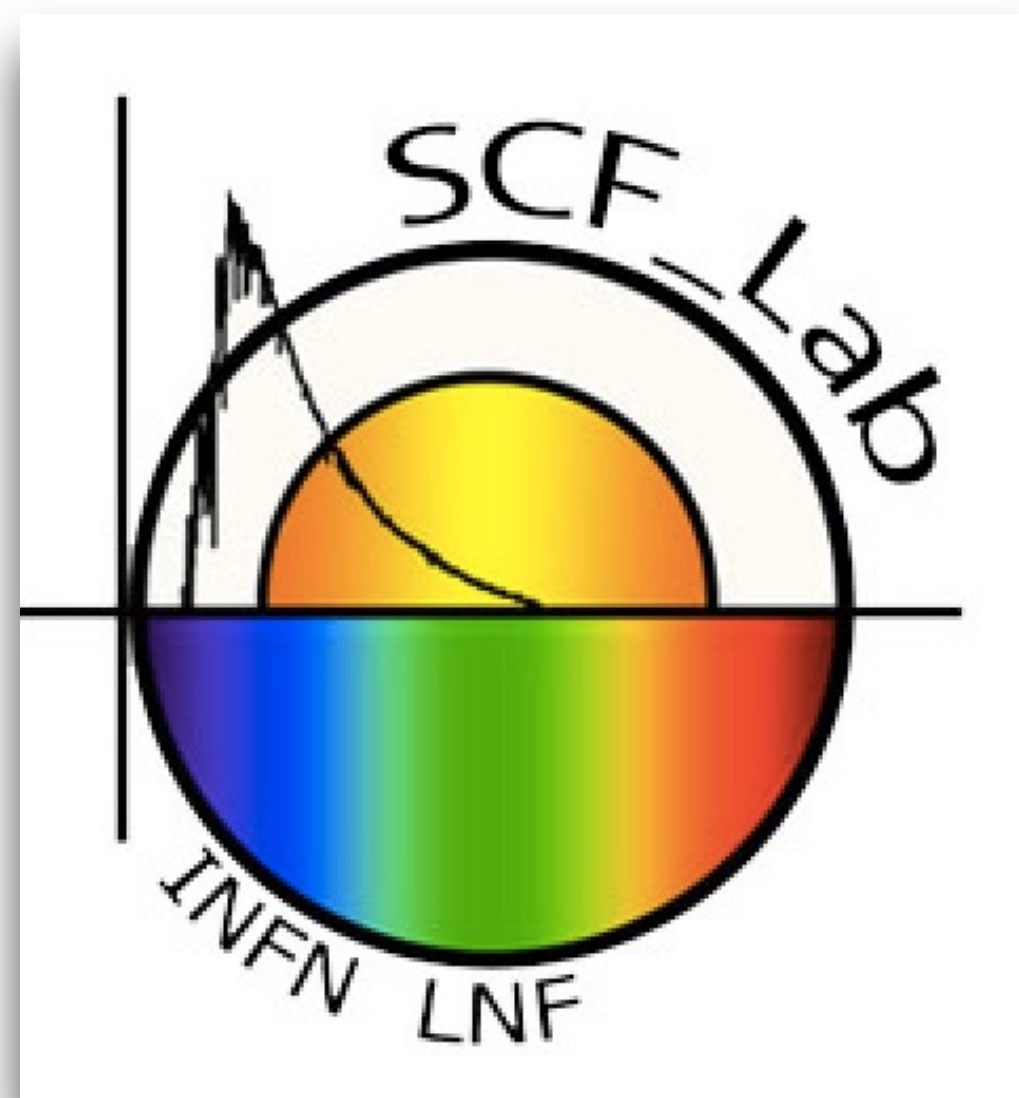
- **2023 Results:**
  - Milestones of constructions and tests for deliveries in 2024.
  - Manufacture and test of Engineering Models, Qualification Models and Flight Models ongoing.
  - European Lunar Symposium 2023 (<https://sservi.nasa.gov/els2023/>).
- **2024 Objectives:**
  - Delivery of 'MoonLIGHT + MPAc + Dust Cover' to ESA.
  - European Lunar Symposium 2024.





# MoonLIGHT-2 x 2024

**Objective: delivery of flight hardware to ESA/NASA for integration onboard lunar landers.**



- **FTE (LNF):** G. Bellettini (50%), G. Bianco (50%), S. Dell'Agnello (100%), L. Filomena (100%), M. Maiello (100%), R. March (80%), M. Montanari (100%), M. Muccino (100%), L. Porcelli (60%) + personale TA 'dedicato'
- **Richieste CSN2 2024 (overall, TBD):** missioni ...k, consumo 30k, altri cons ...k, inventario ...k, license SW 30k, apparati ...k, servizi ...k
- **Richieste LNF 2024 (mesi-uomo):** richieste fatte dal Joint Lab
- **Fondi Esterni:** Joint Lab INFN-Frascati with ASI-Matera, 1.5 MEuro; ESA, 250kE+240kE=490kE for dual Earth pointing actuator (MPAc) and Dust Cover