

MoonLIGHT-2

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

CSN2-LNF, 27th June 2022

Italian Participants:

INFN-LNF → ~ 10 FTE

INFN/University - Padova → ~ 2 FTE

INFN/University - Naples → ~ 5 FTE

ASI-Matera Laser Ranging Observatory → ~ 3 FTE (15 M€ infrastructure)

USA Participants:

University of Maryland College Park (UMD), MD

Harvard-Smithsonian Center for Astrophysics (CfA), MA

University of California San Diego (UCSD), CA

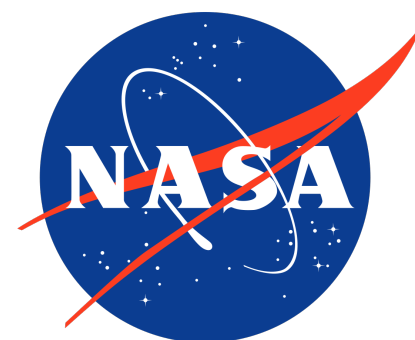
NASA-SSSERVI

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)

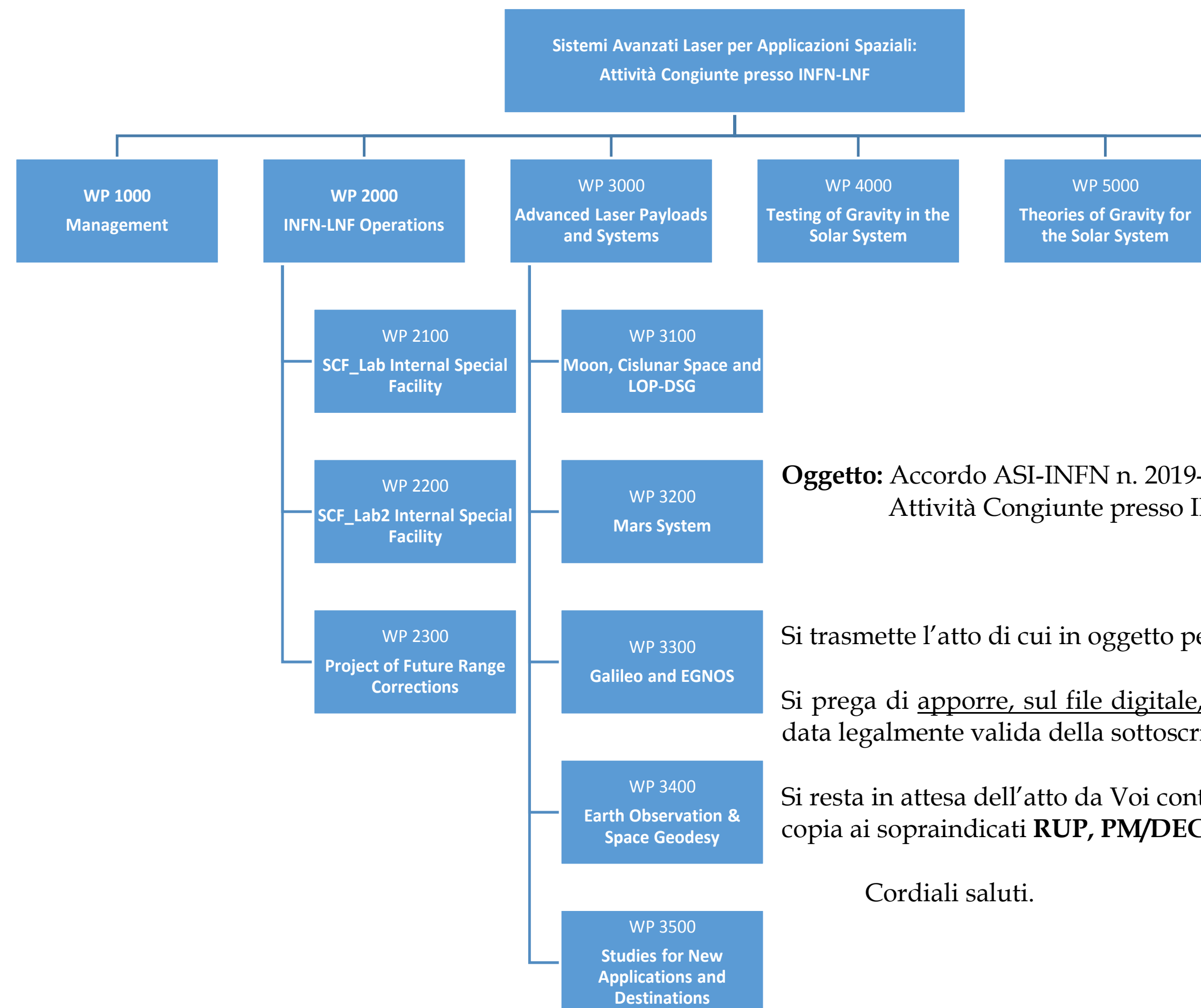


Spett.le
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Att.ne
Prof. Fernando Ferroni
Presidente

PEC: 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, 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 (490k€ for dual Earth pointing actuators)



ESA Contract No. 4000129000/19/NL/TFD

with

INFN - Laboratori Nazionali di Frascati

LUNAR LASER RETROREFLECTOR POINTING ACTUATOR

Selected

To flight:

PROSPECT Ion Trap Mass Spectrometer contribution to NASA CLPS

(Goddard Space flight Centre Lead – PI Barbara Cohen, OU Co-PI Simeon Barbar)

Laser Retroreflector

(INRF Lead – PI Simone Dell’Agnello)



For development initiation in open competition

Instrumented drill - down hole volatile extraction and regolith sintering

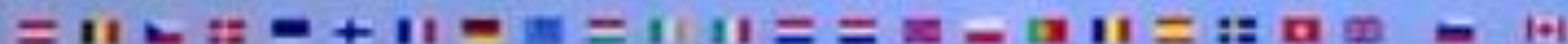
- Build on PROSPECT developments for small missions and rovers

Decent and landing GNC algorithm testing

- Build on PILOT-D flight instrument to advance competition in D&L tech

ESA UNCLASSIFIED - For Official Use

James Carpenter | 21/05/2019 | Slide 7

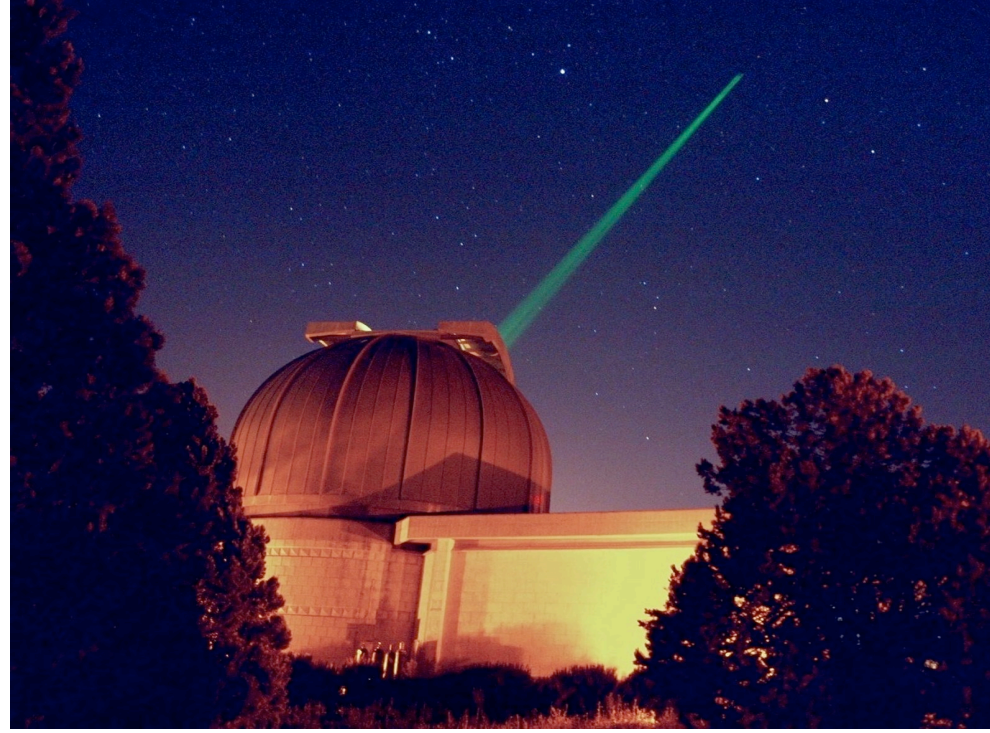


European Space Agency

Contract for development of MPAc (MoonLIGHT Pointing Actuator)

INFN Resp.: M. Muccino

The MoonLIGHT Experiment



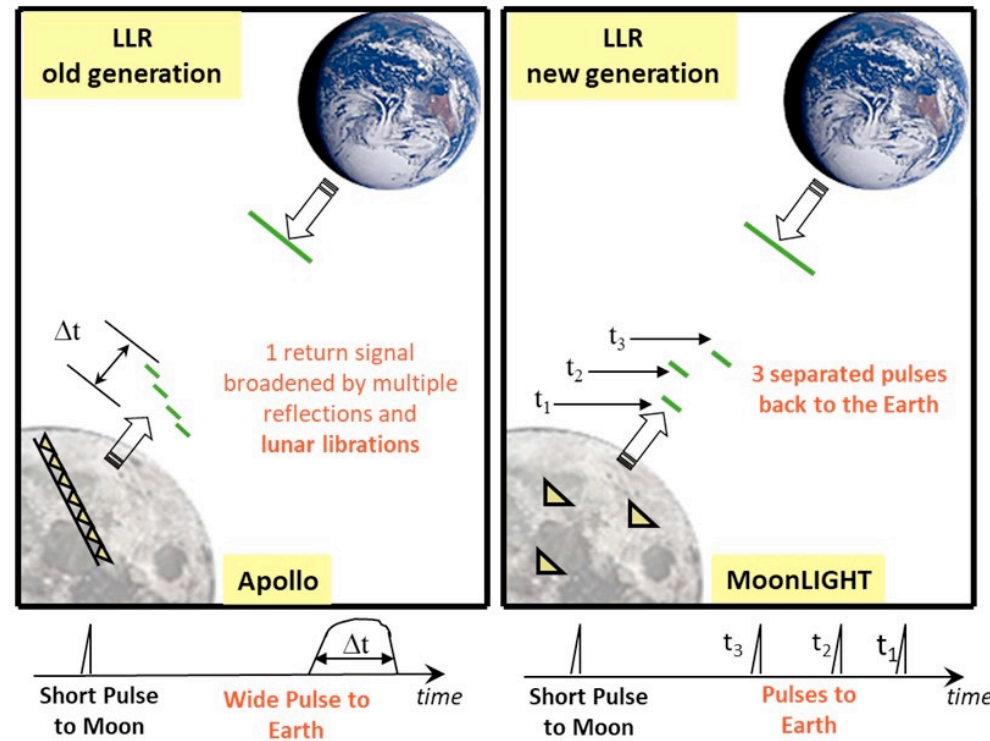
Apollo and Luna missions placed five arrays of CCRs on the surface of the Moon. These reflectors reflect light parallel to the incident beam. Through a technique known as LLR, it has been possible to perform high accuracy/precision measurements of the Earth-Moon distance by firing short-pulse laser from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

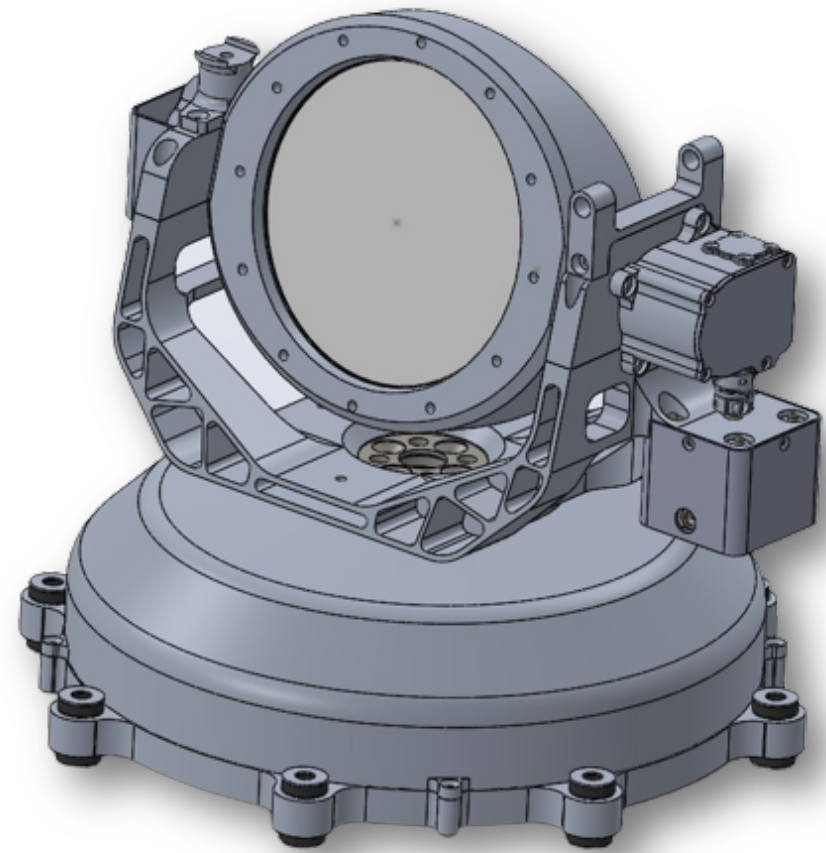
The aim of MoonLIGHT is to reduce the error contribution of LLR measurements by more than two orders of magnitude, taking LLR back to the situation where the error was dominated by the laser pulse.

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° , 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.

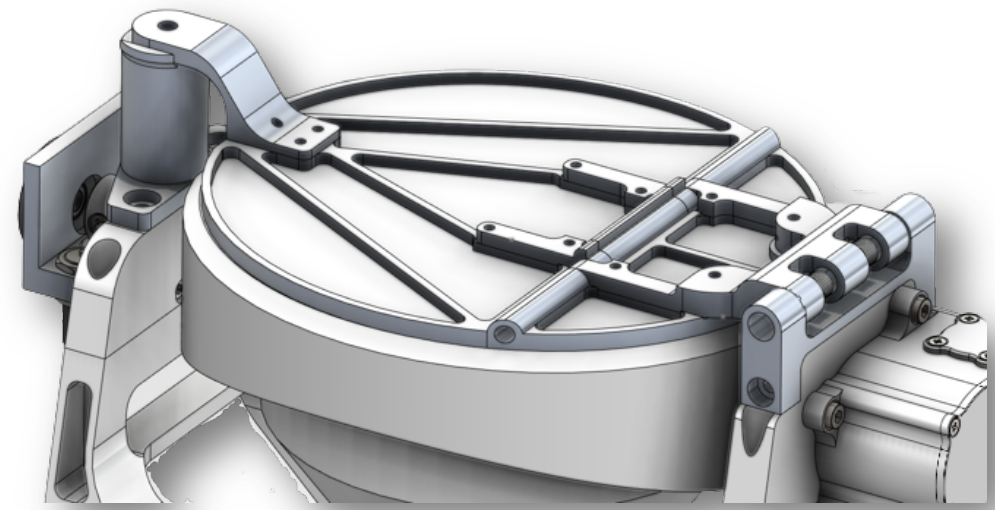
1. The CCR Housing contains the MoonLIGHT retroreflector and its integration structure.
2. The elevation frame, is responsible of the generation of the “Elevation” rotation and contains some actuators and sensors.
3. The base frame represents the interface with the lander and contains most of the electronics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



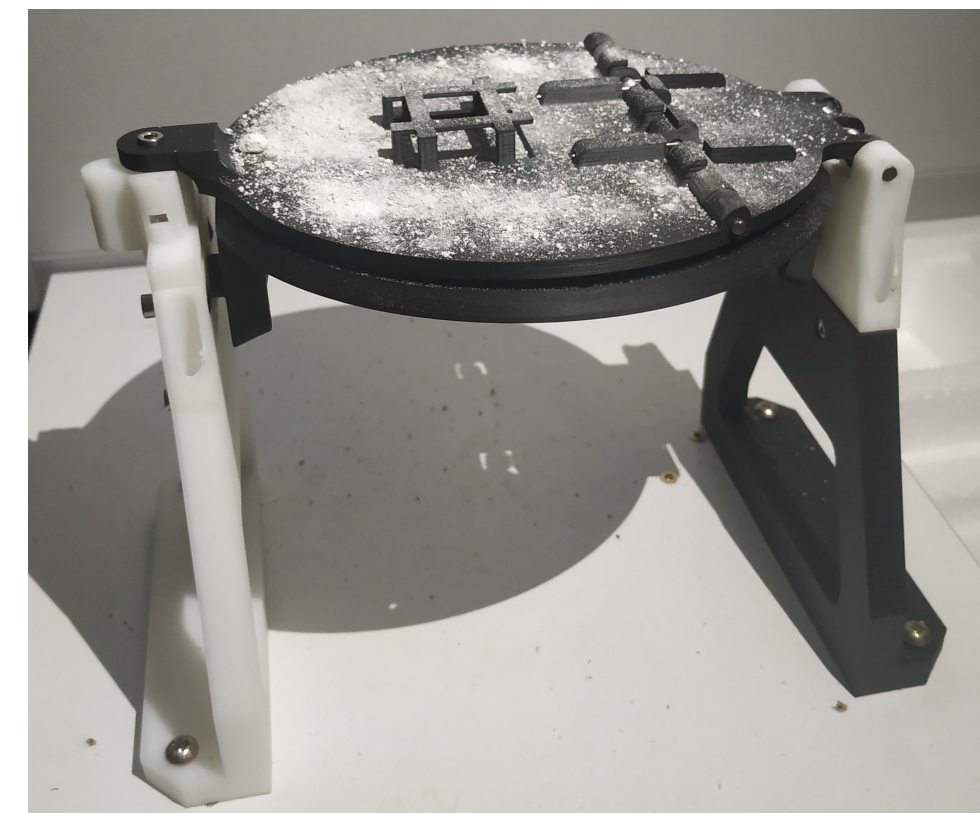
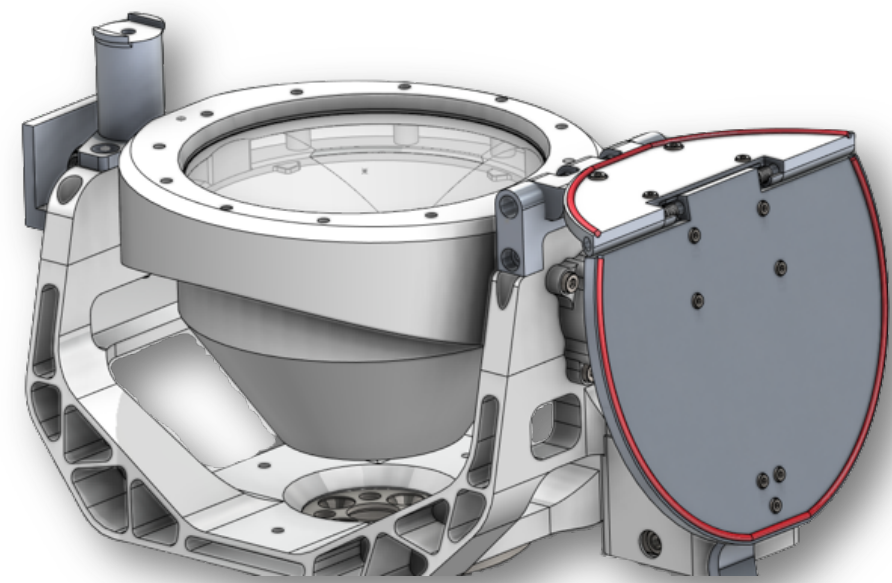
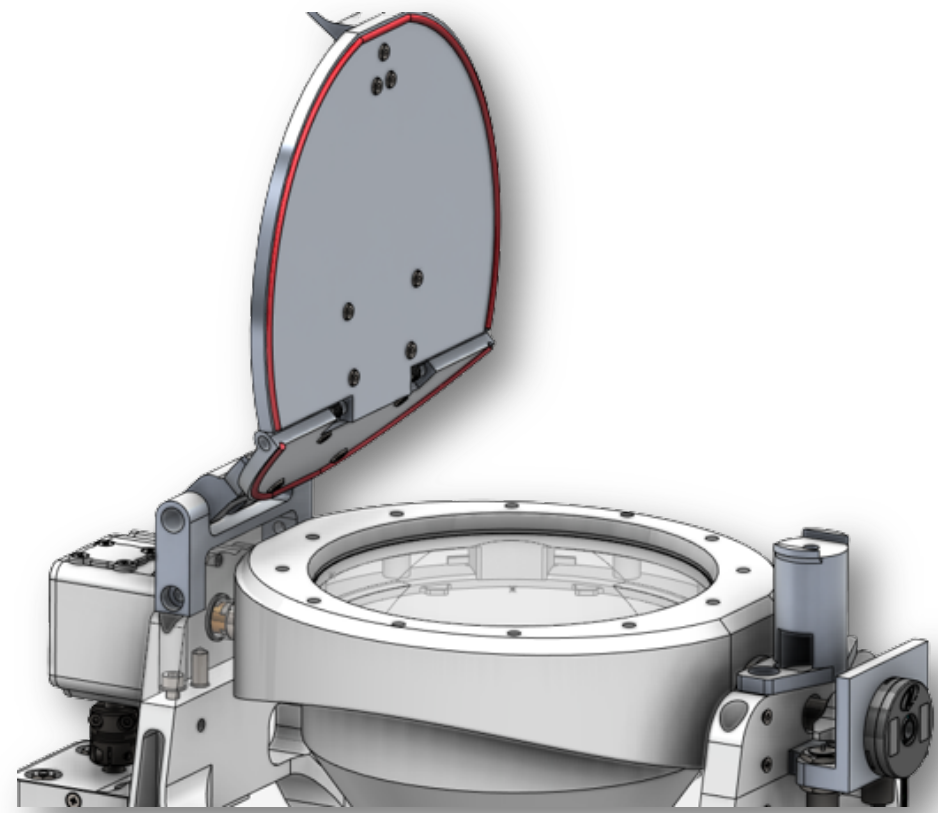
Dust Shield



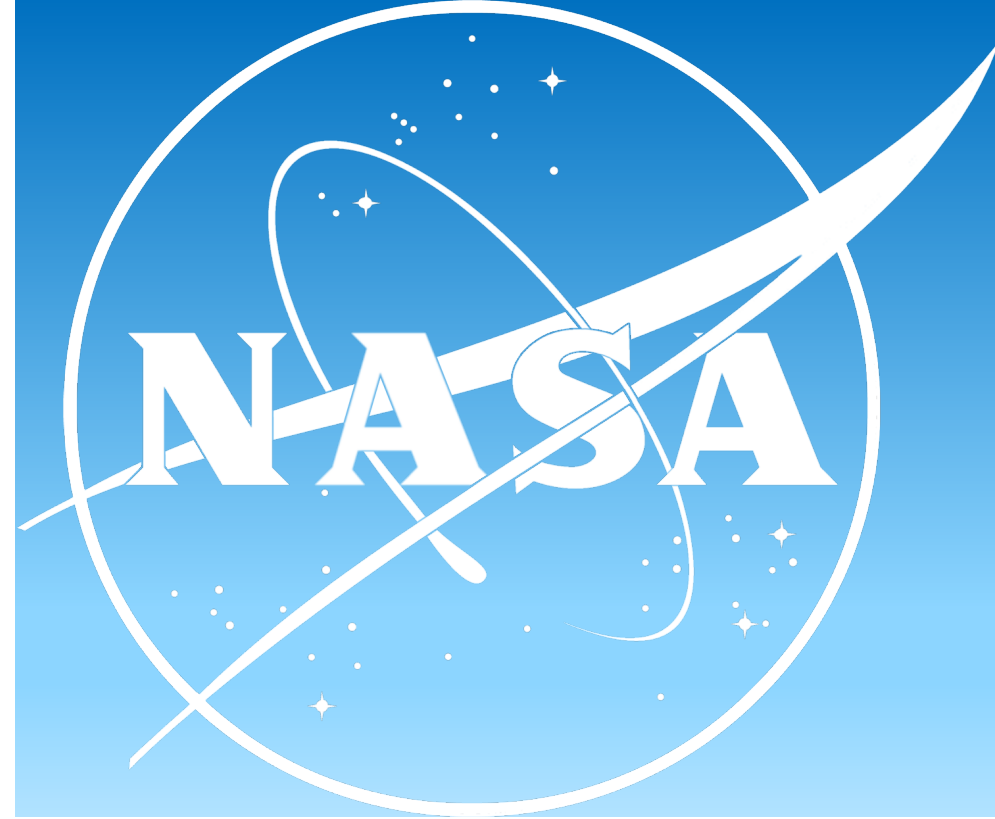
Lunar dust proved to be a challenge for many lunar projects. In particular, optical devices may see their performance degraded by the deposition of these particles. During 2021, the necessity of protecting MoonLIGHT from this danger was answered with the design of a removable dust shield.

The MPAc cover consists of a divisible plate pulled by torsion springs. Once the release mechanism actuator is activated, the cover folds by itself, representing no disturbance for the subsequent operations.

In order to study the behaviour of the dust shield during the aperture of the shield and individuate the possible flaws of the model, tests were made with a plastic prototype, allowing a faster evolution of the design.

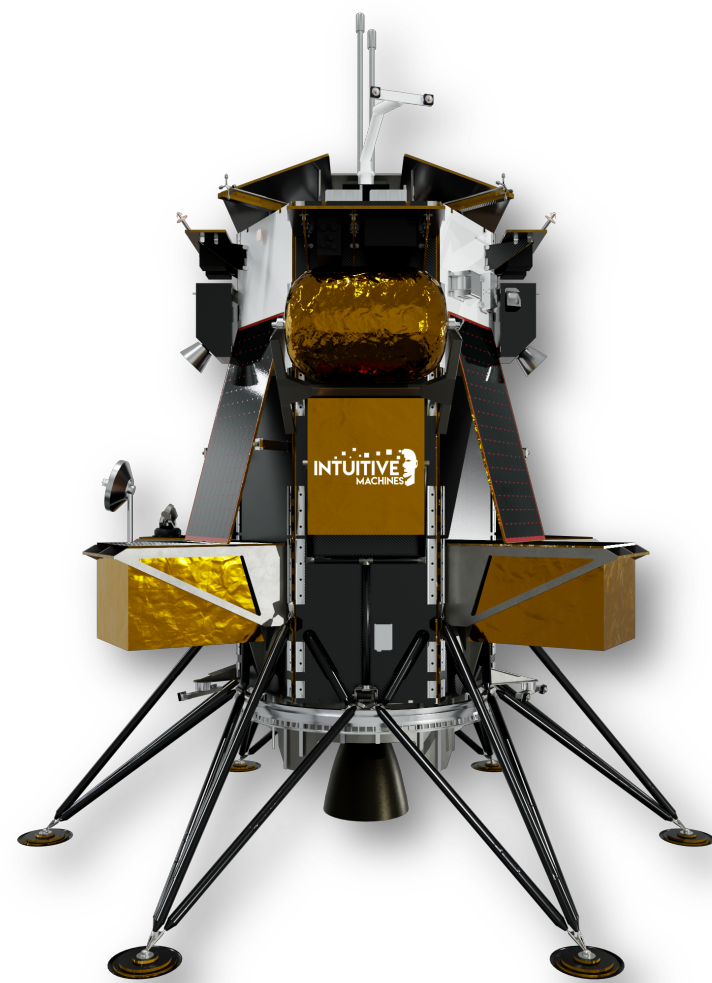


CLPS Mission

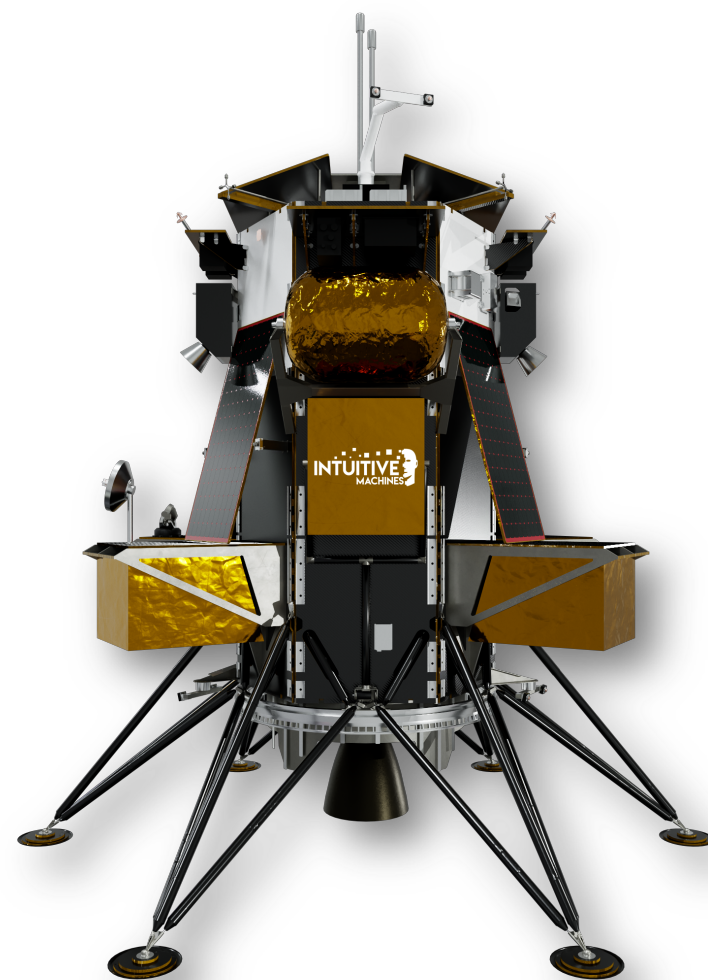
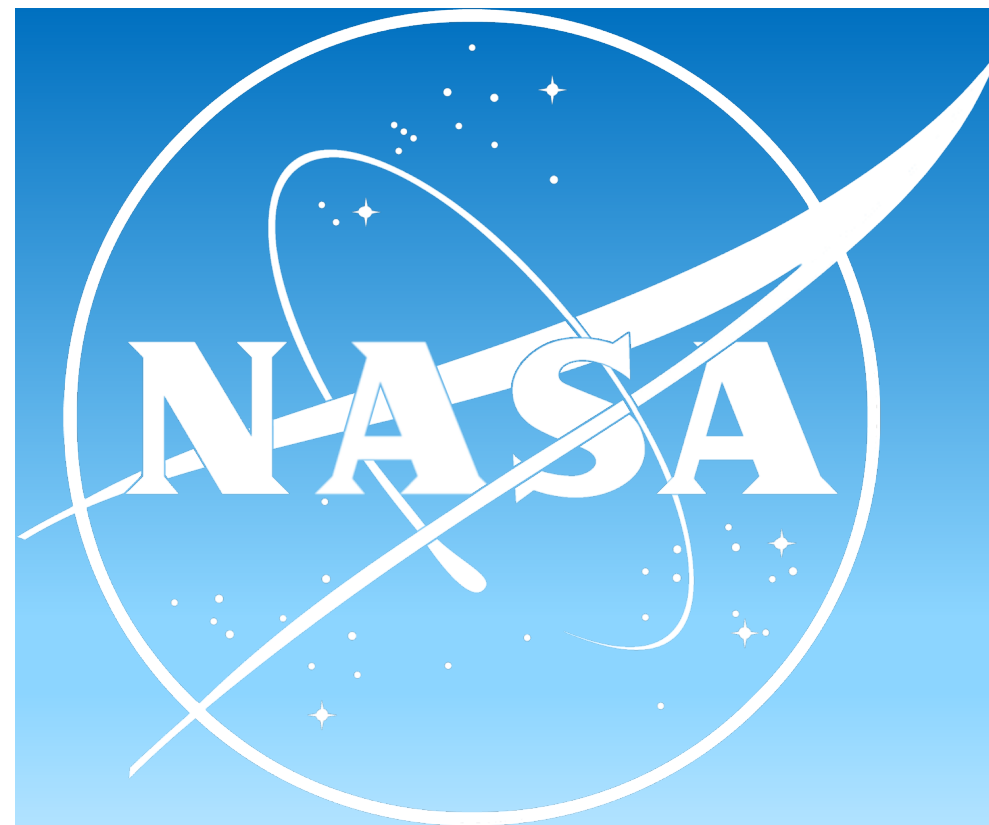


MPAc will fly, together with other 3 scientific payloads as part of NASA's Commercial Lunar Payload Services (CLPS) initiative and the Artemis program. The investigations aboard Intuitive Machines' Nova-C lander include exploration rovers, a high-energy particles detector and a magnetic field measurement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



CLPS Mission



CP11 Payload Collaboration Meeting

09:42

Request control | People | Chat | Reactions | More | Camera | Mic | Share | Leave

Participants: MM (Marco Muccino), LP (Luca Porcelli)

06/16/2022 CP-11 Payload Collaboration

- CP11 Landing Site paper:
 - LVx Lead paper, Focused on site selection, will work with JPL/Laura Kerber to include the CADRE Terrain Specifications Document v1.1 analysis, will begin end of Sept.
- CLPS-PDS Data Archive Support Service (DASS): [Verify PDS Naming Convention](#).
 - LUSEM: KASI data archive & PDS Planetary Plasma Interactions (PPI) node.
 - MPAc: Not in PDS, ILRS repository, CDDIS-NASA archive, and EUROLAS Data Center (EDC).
 - LVx: PDS PPI node: MAPS, VML, VMR. PDS CIS node: VCA, RMM, NavCam.
 - CADRE GPR: PDS Geosciences node.
- Rover Con-Ops Tool: JPL's AMMOS: MMGIS, ASTTRO
- CLPS Public Talks Direction:
 - Houston we have a podcast, episode 248, Lunar Vertex: <https://www.nasa.gov/johnson/HWHAP/lunar-vertex>
 - Please avoid speaking about other CLPS payloads you aren't affiliated with, avoid launch dates and timelines, and use CLPS "vendor" or "provider" instead of "partner" to remain consistent with the contractual relationships. Any questions? Contact Heidi or Ryan Watkins.
- LVx PDR update/lessons learned
- MPAc MRR with cover update/lessons learned
- Upcoming Payload Milestones
- IM-3 Launch Date: April 2024

Haviland, Heidi (MSFC-ST13)

CP11 Payload Collaboration Meeting

07:53

Request control | People | Chat | Reactions | More | Camera | Mic | Share | Leave

Participants: DN (Daniel Nunes), LP (Luca Porcelli)

Participants list: SC (Subha Comandur), LP (Luca Porcelli), CS (Chae Kyung Si), DN (Daniel Nunes), DB (Dave Blewett), DL (Dukhang Lee), GH (George Ho), JH (Halekas), HH (Haviland), JS (Jehyuck Shin), LC (Luigi Cacciapuoti), MM (Marco Muccino), RW (Watkins), YC (Young-Jun Choi)

Google Drive spreadsheet: <https://docs.google.com/spreadsheets/d/1ulYpt3a6-r4QcrPXm6mgEIJFnM9YneCD/edit#gid=2122613397>

NASA Delivery Name	PDS Node	Estimated landing date (Calendar year)	Estimated duration of operations
Lunar Vertex: Magnetic Anomaly Plasma Spectrometer (MAPS)			
CLPS Payloads archiving in the PDS organized by NASA Delivery (TO = Task Order)			
TO_CP11		Q2 2024	13 days
Lunar Vertex: Magnetic Anomaly Plasma Spectrometer (MAPS)	PPI		
Lunar Vertex: Vector Magnetometer-Lander (VML)	PPI		
Lunar Vertex: Vertex Camera Array (VCA)	CIS		
Lunar Vertex: Rover Multispectral Microscope (RMM)	CIS		
Lunar Vertex: Mobile Autonomous Prospecting Platform (MAPP) Rover, NavCam	CIS		
Lunar Vertex: Vector Magnetometer-Rover (VMR)	PPI		
MoonLIGHT (Moon Laser Instrumentation for General relativity/geophysics High-accuracy Tests) Pointing Actuator (MPAc)	Not Archiving in PDS		
Cooperative Autonomous Distributed Robotic Exploration (CADRE) Science Payload, GPR	TBD, Geo		
Lunar Surface Environment Monitor (LUSEM)	PPI & KASI		
			3-4 months or longer

Haviland, Heidi (MSFC-ST13)

European Lunar Symposium 2022:

<https://sservi.nasa.gov/els2022/>



VIRTUAL WORKSHOP

24-26
MAY 2022

EUROPEAN LUNAR SYMPOSIUM



EUROPEAN LUNAR SYMPOSIUM



EUROPEAN LUNAR SYMPOSIUM

MoonLIGHT-2 x 2023

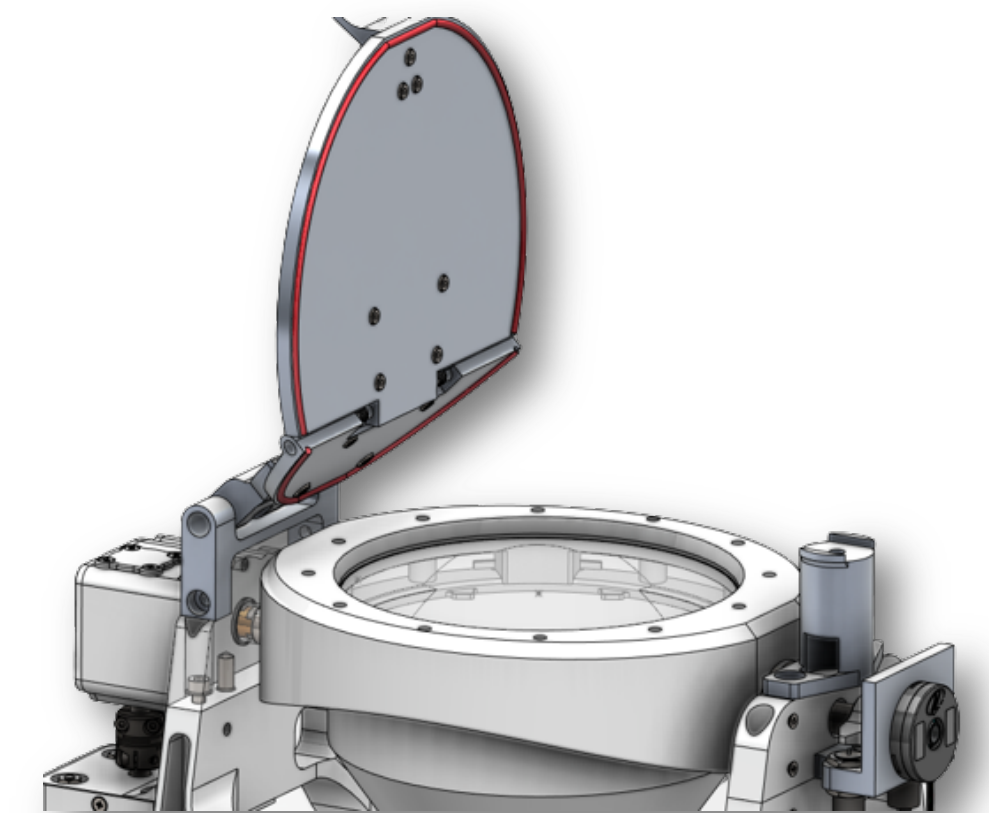
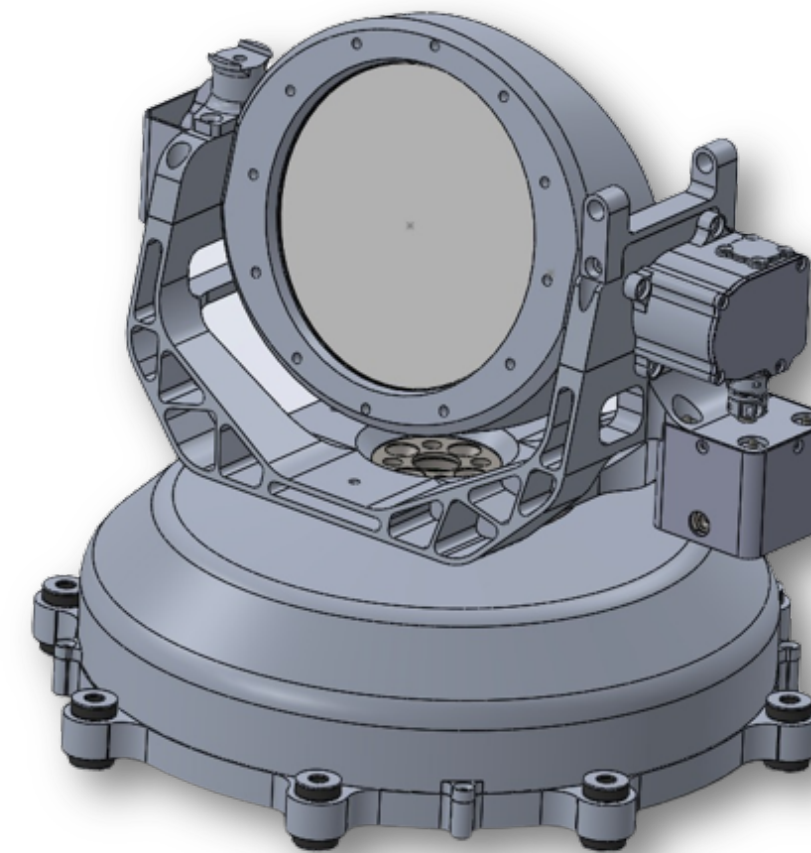
Objective: delivery of flight hardware to ESA/NASA for integration onboard lunar landers.

- **2022 Results:**

- Milestones of constructions and tests for deliveries in 2023.
- Manufacturing Readiness Reviews (without and with Dust Cover) passed → road to manufacturing and testing of Engineering Models, Qualification Models and Flight Models open.
- European Lunar Symposium 2022 (<https://sservi.nasa.gov/els2022/>).

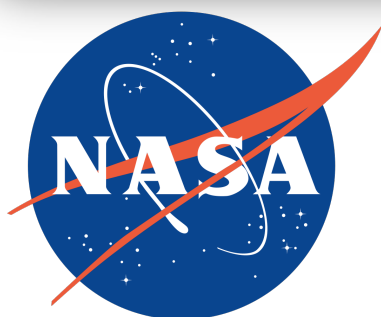
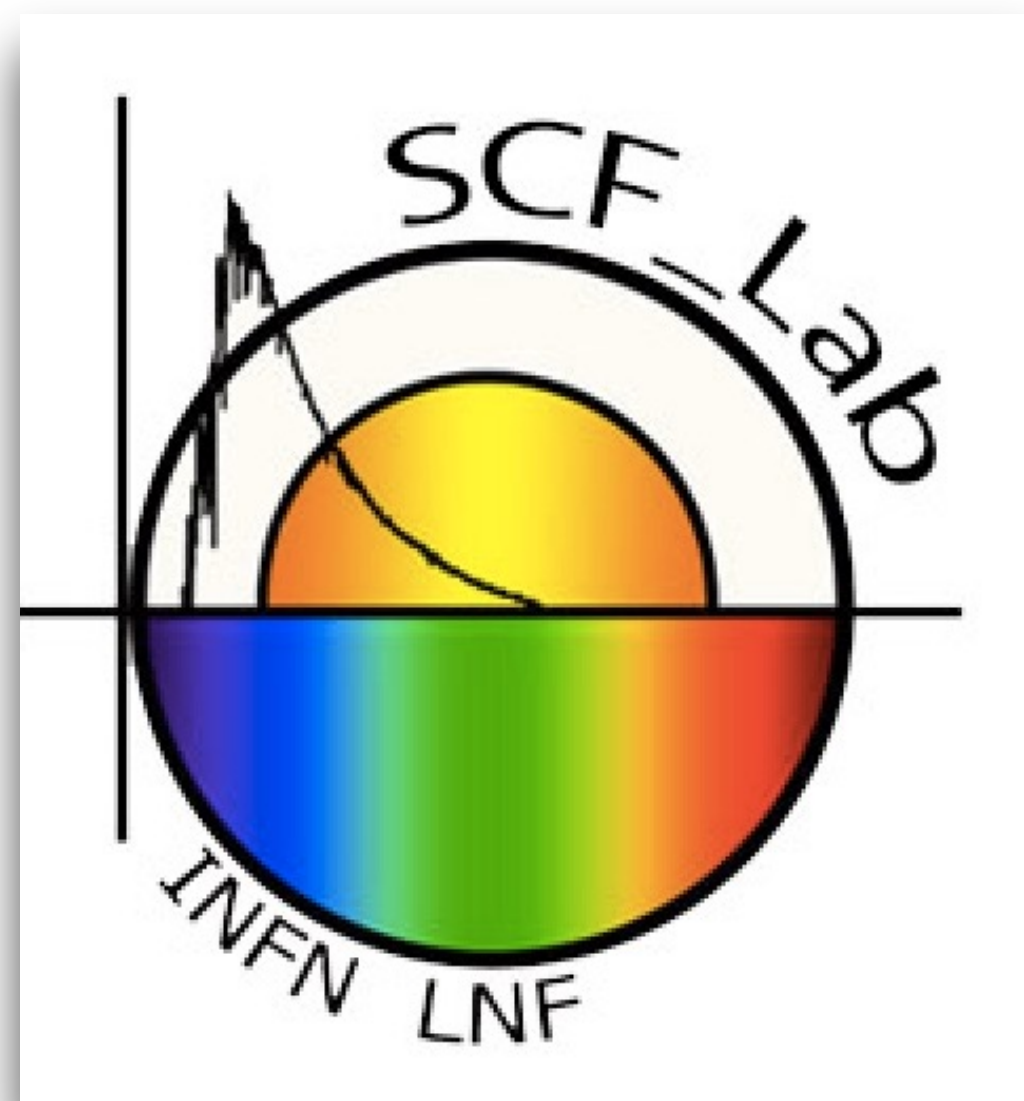
- **2023 Objectives:**

- Delivery of 'MoonLIGHT + MPAc + Dust Cover' to ESA.
- European Lunar Symposium 2023.



MoonLIGHT-2 x 2023

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



- **FTE (LNF):** ~ 8 FTE (Ricercatori/Tecnologi) e M. Traini (CA) 100%, M. Petrassi (CTER) 100%, L. Salvatori (CTER) 100%, M. Tibuzzi (CTER) 100%
INFN/University - Padova ~ 2.3 FTE: Villoresi+5
INFN/University - Naples ~ 4.6 FTE: Capozziello+6
ASI-Matera Laser Ranging Observatory ~ 3 FTE
- **Richieste CSN2 2023 (overall, TBD):** ~~missioni 35k, consumo 45k, altri cons 10k, inventario 10k, license SW 30k, apparati 80k, servizi 55k~~
- **Richieste LNF 2023 (mesi-uomo, TBD):** ~~Officina 1; SPCM 1; Elettronica 1; DT 1; Crio 1; Laser 1; ES 1~~
- **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