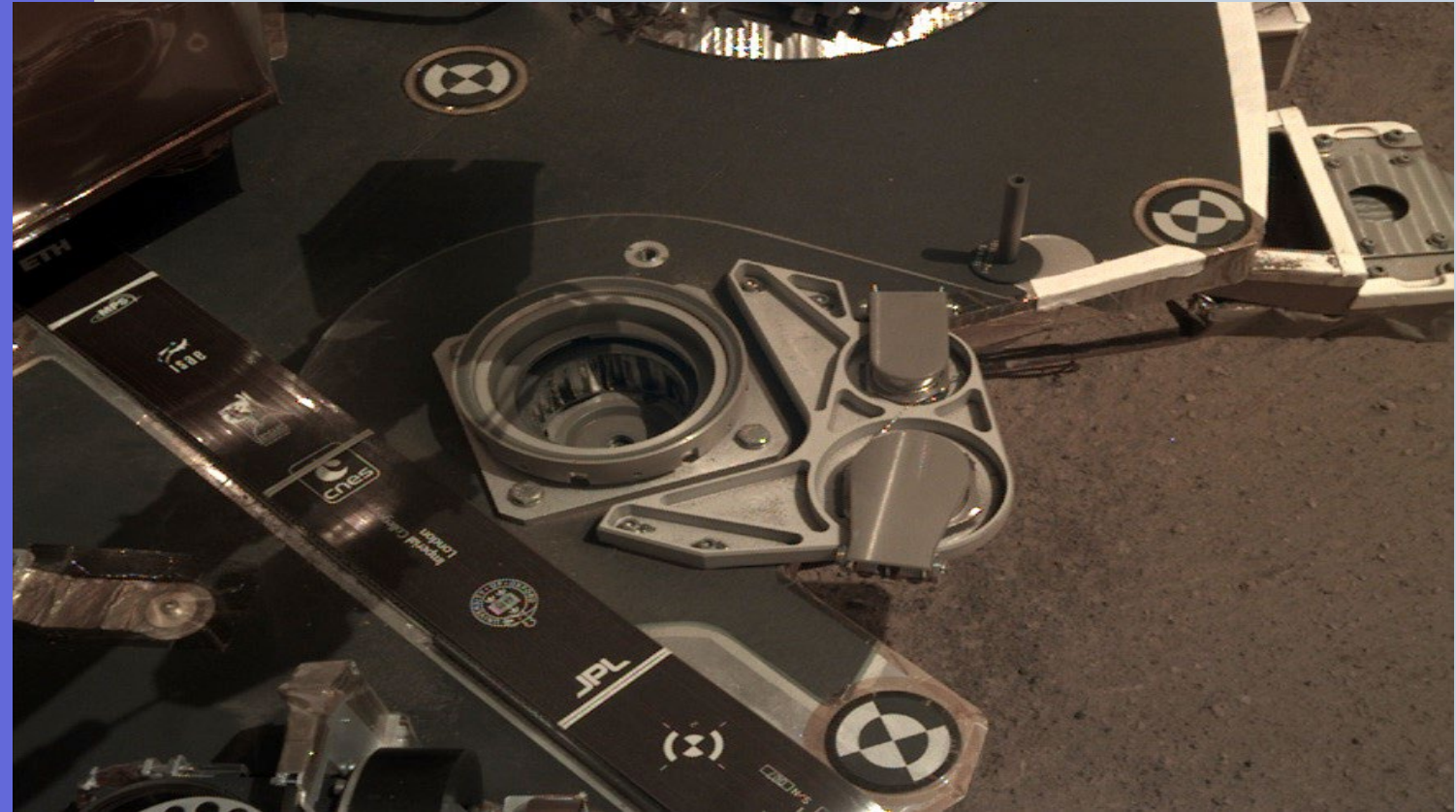


Oxford Physics Space Exploration

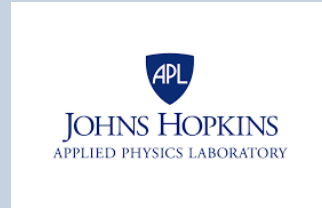
Oxford Physics Planetary Experiments

(With thanks to the numerous international teams we have worked with in the past, present and future)

Neil Bowles, Simon Calcutt, Pat Irwin, Carly Howett, Keith Nowicki

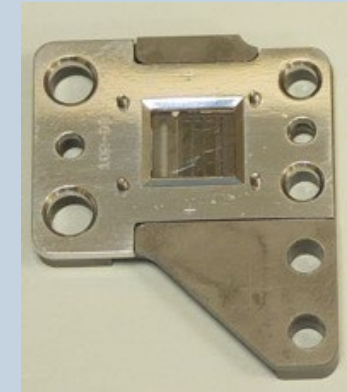
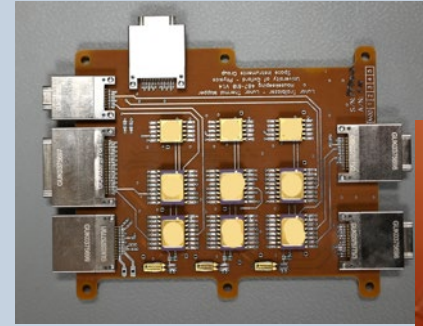
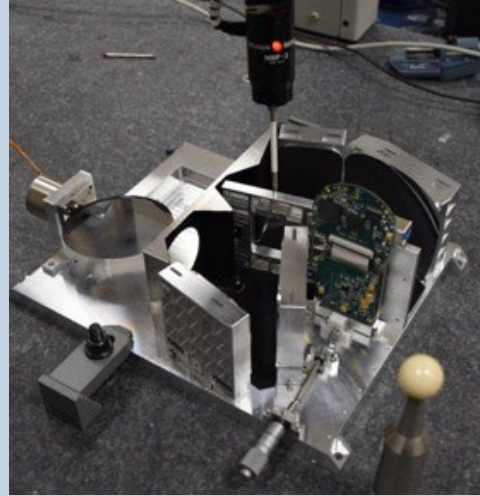


Example Collaborations and Partners:



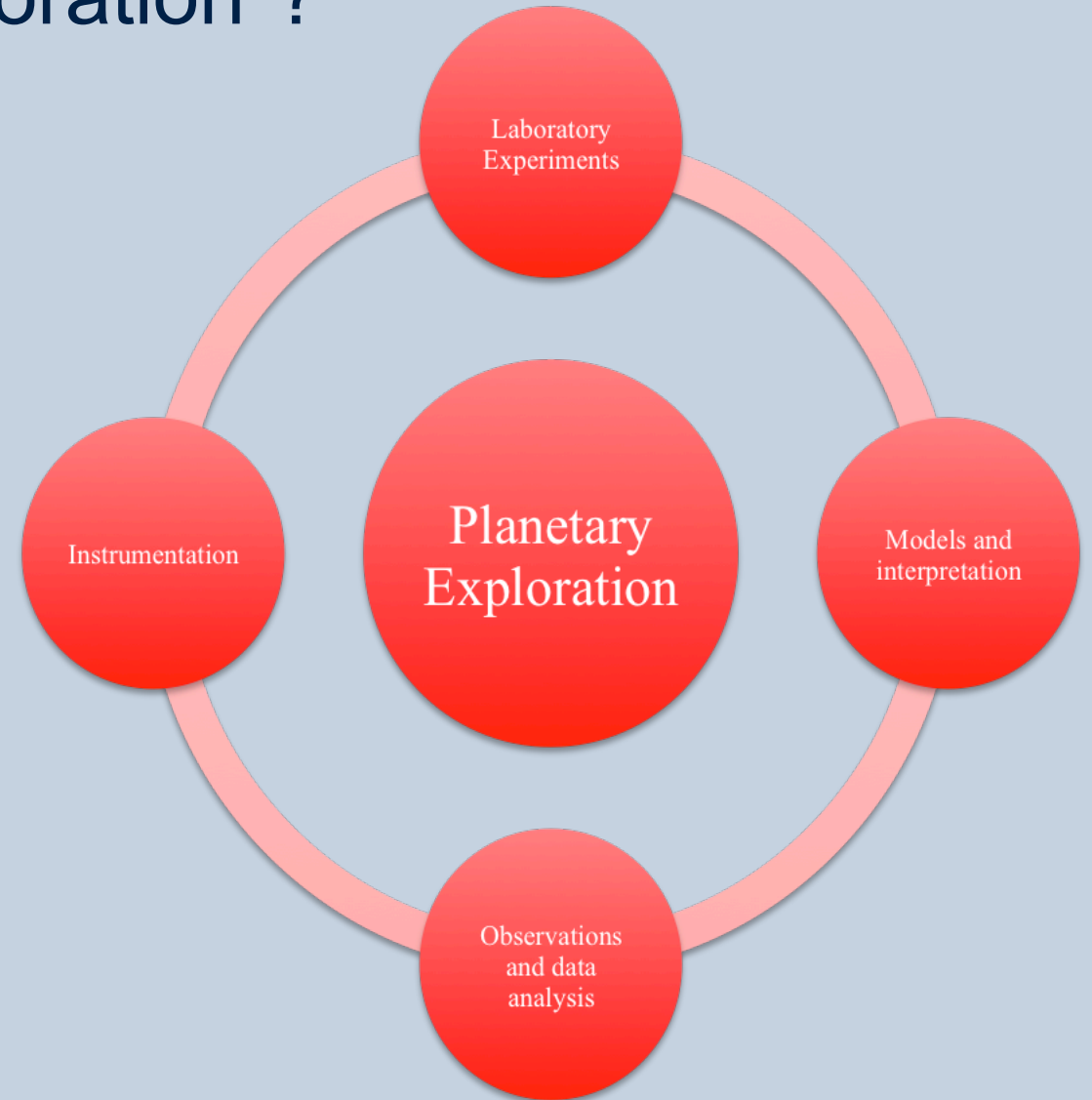
Space Systems capability in Oxford

- 50+ years of experience
- Sub-system and instrument design, test and build
- Mechanical design/analysis
- Optical design/analysis
- Infrared multilayer filters
- Electronics assembly
- Flight and ground software
- Thermal vacuum testing



What do we mean by “Space Exploration”?

- It means different things to different people!
- For space agencies it means something quite specific.
- And this affects how proposals/grants/contracts work.
- Here are some of our experiences.....



Which of these ESA missions are “Exploration” and which are “Science”?



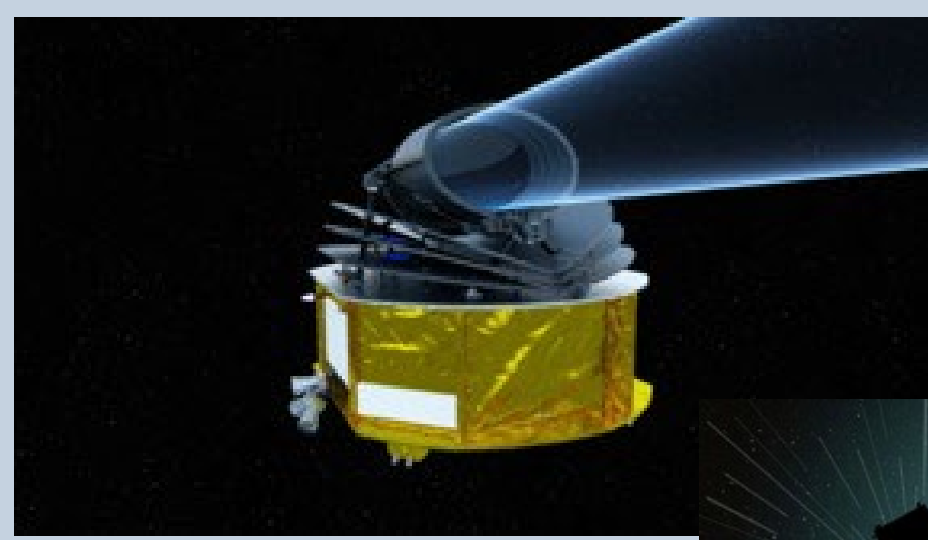
Mars Trace Gas Orbiter (ESA/ATG medialab)



Comet Interceptor (OHB Italia)

Science vs Exploration (1)

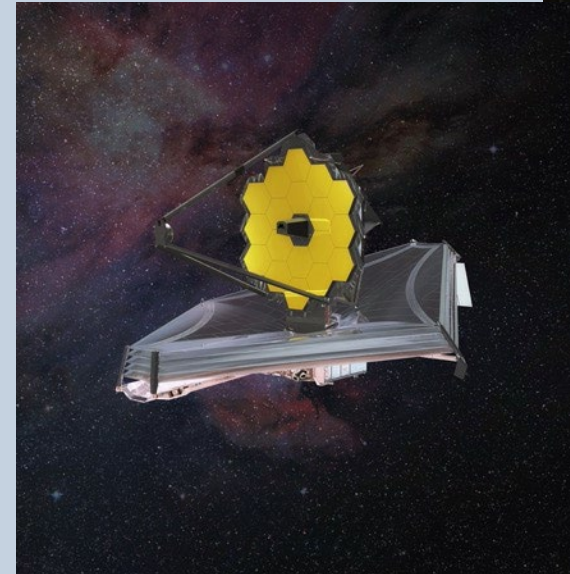
- Within ESA the big differences between space science and space exploration are how the funding works.
- The science programme is **mandatory**.
 - A member state joins automatically as part of ESA.
- Space science missions include
 - Euclid
 - Plato
 - BepiColombo
 - Gaia
 - Ariel
 - Comet Interceptor
 - JWST etc.
- Member states are part of the mission, but instruments tend to be funded by national governments/consortia



Ariel
(image:
AMC)



Comet Interceptor
UCL/MSSL



JWST (image:
Northrup
Grumman)

What is “Exploration”?

- For ESA (and NASA) it's anything that does or could involve humans...
 - So much more technology led.
- Within ESA it is called “Terra Novae” or the European Exploration Envelope Programme (E3P).
- It is a **subscription** programme, along the lines of pretty much everything else in ESA (e.g. telecoms, Earth Obs, etc.).
- From the UKSA:
 - “This programme encompasses the missions, the development of technology, and provision of science facilities, to prepare for and enable humans to live and work in Low Earth Orbit, in and around the Moon, and, one day, Mars.”

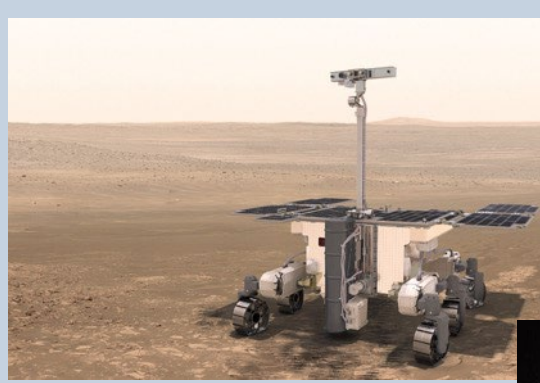
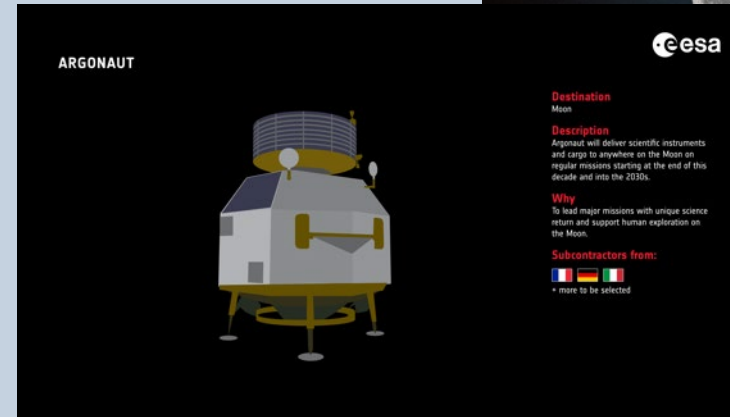


Image Credits:
ESA/SSTL/NASA

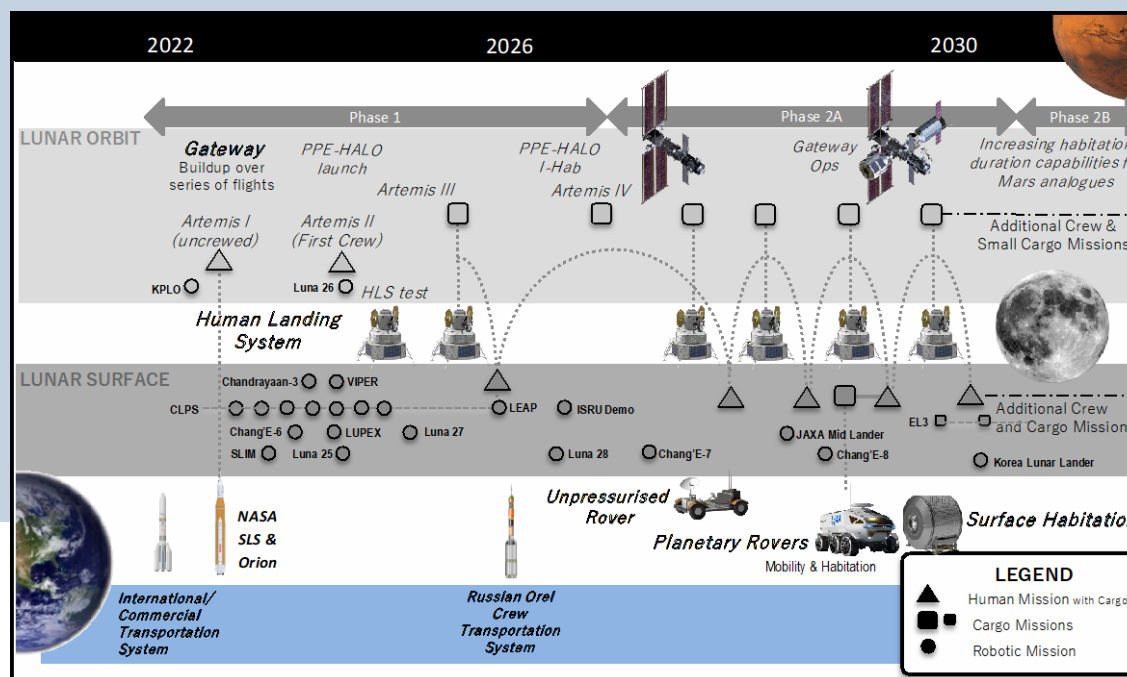


Moonlight
comms
demo
(SSTL)



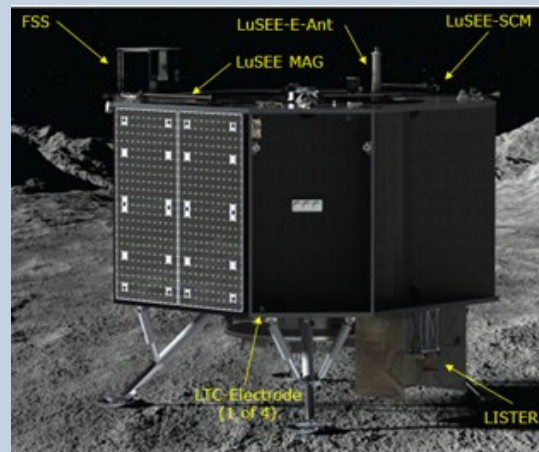
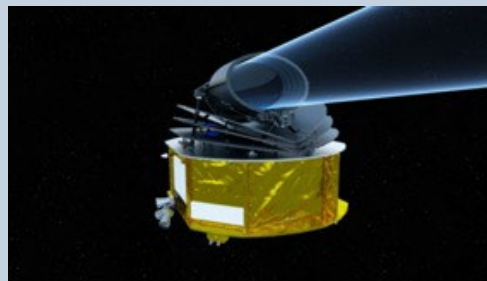
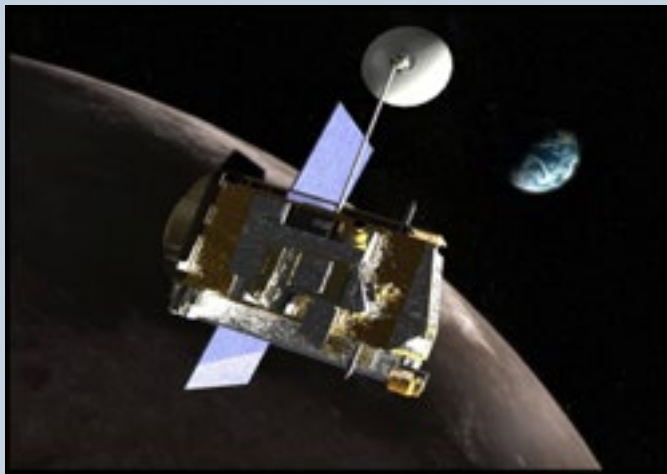
UK Space Agency

- Pretty much Tracks the ESA programme structures
- New bilateral and National Space Innovation Programme calls that connect to space science and exploration.
- Allows work with partner agencies such NASA/JAXA/ISRO
 - Can be tricky to navigate.
- Check with UK Space Partnership (<https://www.spacepartnership.org.uk>) for more info and linkage!
- Also, ISECG Global Exploration Roadmap, Artemis accords etc.



Space Instrumentation at Oxford Physics

Exploration leading to science, Science leading to Exploration

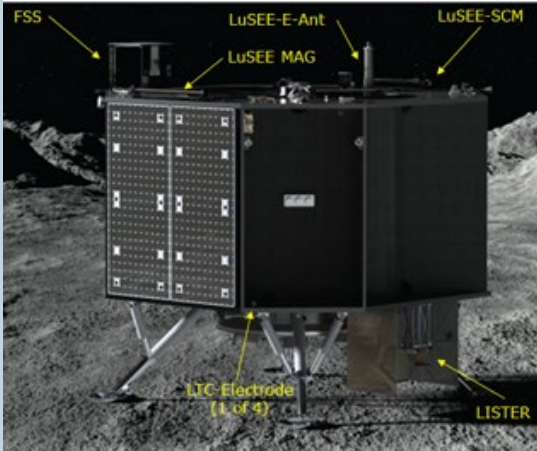
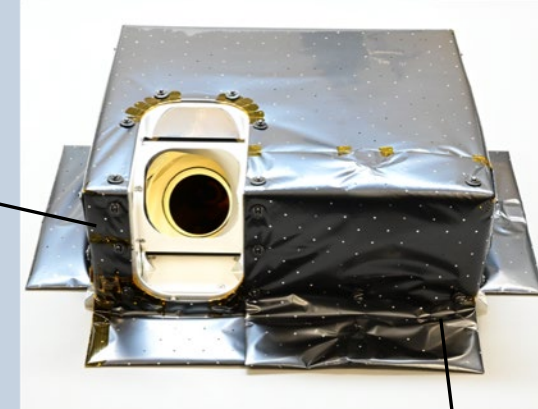
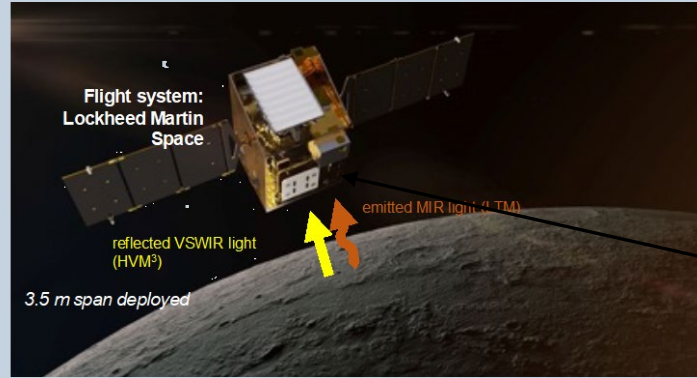


- Neil Bowles
- Simon Calcutt
- Carly Howett
- Keith Nowicki
- Katherine Shirley
- Rory Evans
- Greg King
- Jon Temple
- Waqas Mir
- Henry Eshbaugh
- Eloïse Brown
- Nick Elkington
- Tris Warren
- Aria Vitkova
- Bharvi Chikani
- Maisie Rashman
- Burtie Spry
- Kevin Olsen

Examples Oxford Lunar science and exploration



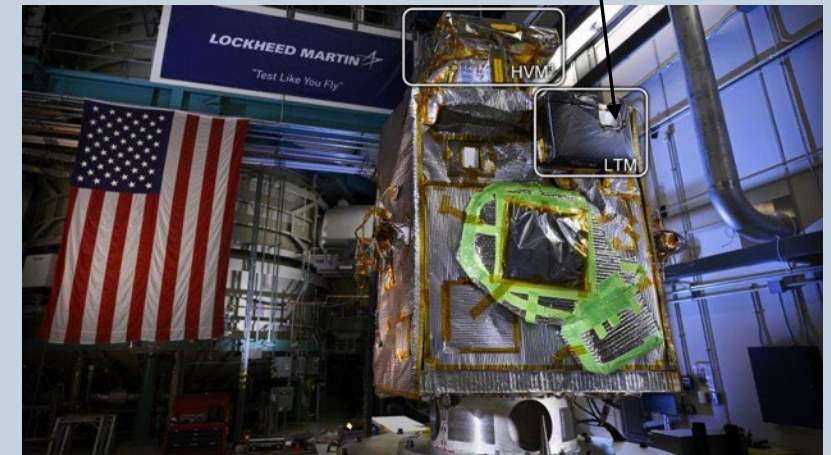
Lunar Reconnaissance Orbiter 2009 -



Far Side Seismic Suite (Drapper/JPL) 2025

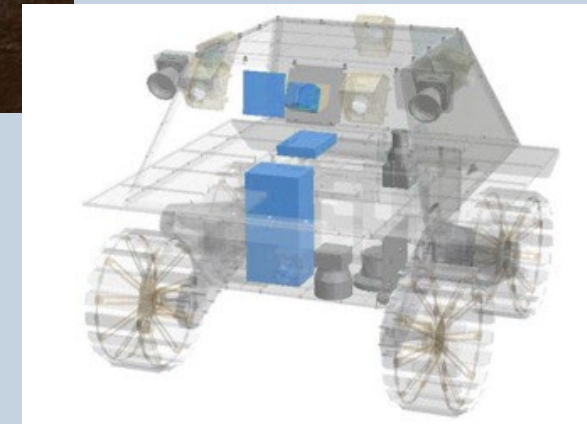
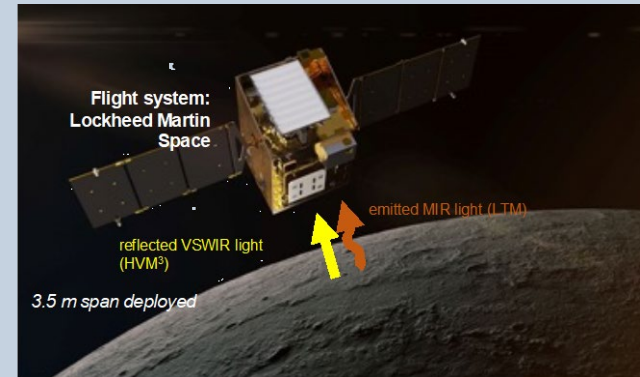
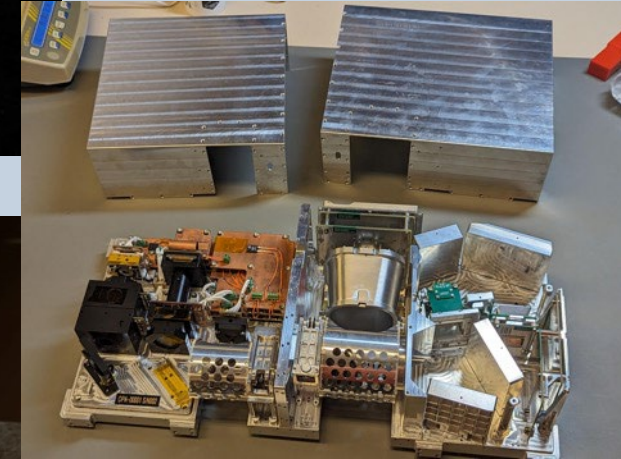
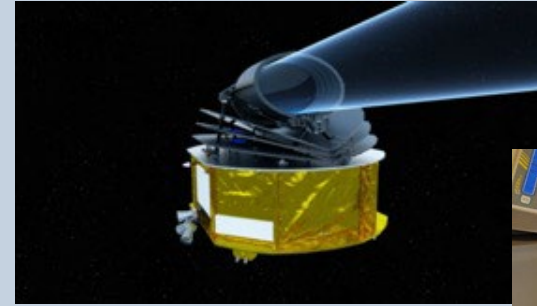


CSA LEAP Rover (thermal camera with JHU/APL/JPL) ~2027.



How does the Oxford Physics instrument programme breakdown?

- Ariel
 - ESA Space Science, UKSA Space Science
- Comet Interceptor
 - ESA Space Science, UKSA Space Science
- Lunar Trailblazer
 - NASA SIMPLEX, UKSA NSIP bilateral
 - Should be in exploration?
- LAFORGE – Lunar rover instrument
 - NASA techdemo, CSA rover, UKSA Science bilateral
- Far Side Seismic Suite
 - NASA/JPL/Kinematics – Contract
- Science through STFC.
- Lots of report writing and review paperwork...



Lunar Trailblazer: A Pioneering SmallSat for Lunar Water and Lunar Geology

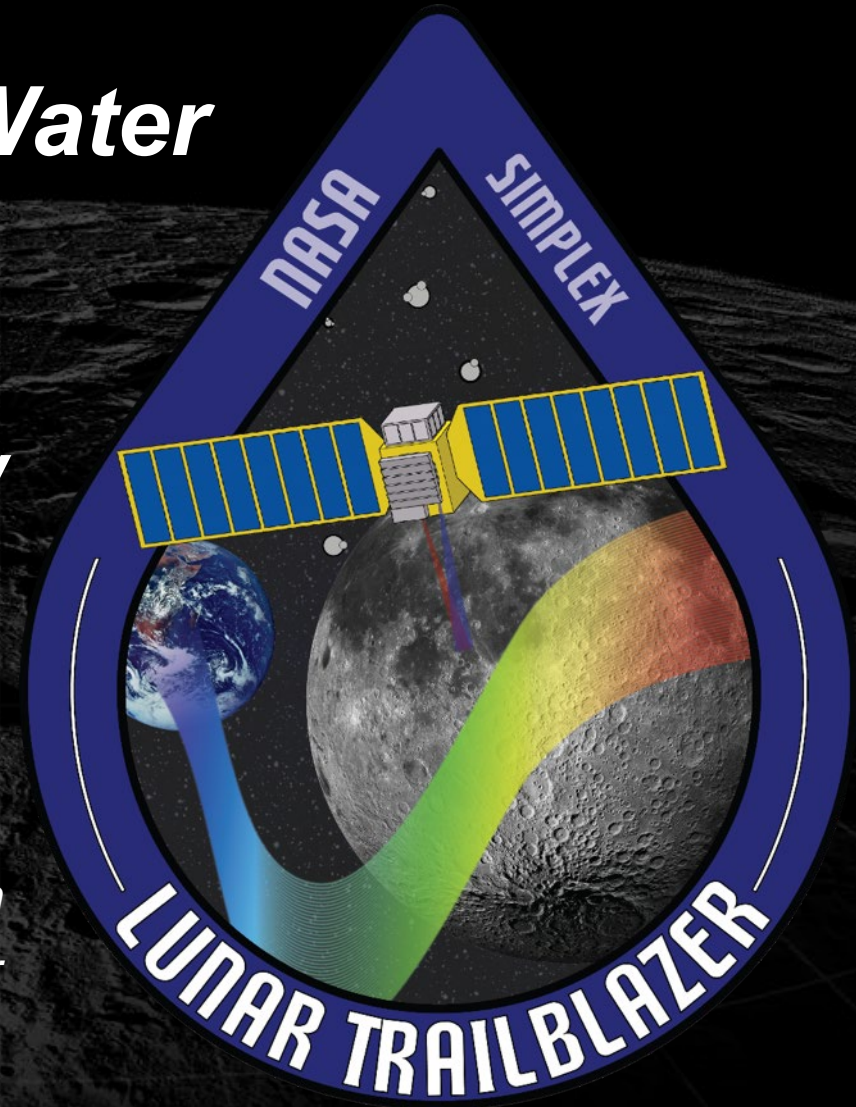
Mission Overview & Science Overview

Prof. Bethany L. Ehlmann (PI), Caltech
Neil Bowles, LTM Instrument Scientist

Science Team: R. Klima (Deputy PI; APL), D. Blaney (JPL), J. Dickson (Caltech), K. Donaldson Hanna (UCF), Christopher Edwards (NAU), R. Green (JPL), M. House (PCC), Carle Pieters (Brown U), David Thompson (JPL)

with thanks to the entire Lunar Trailblazer team

For more info.: trailblazer.caltech.edu Follow: [@lunartrailblazr](https://twitter.com/lunartrailblazr)





Lunar Trailblazer Smallsat Spacecraft & Instruments – NASA Planetary Science

Confirmed NASA SIMPLEX mission (Class D, 7120.5e)

Dispenser: ESPA Grande

Propulsion: Hydrazine

Lunar Orbit: 100±30 km polar

Science Orbit Duration: ≥1 year

Flight System Delivery: Autumn 2023

Launch Type: Rideshare (*IM2, 2024*)

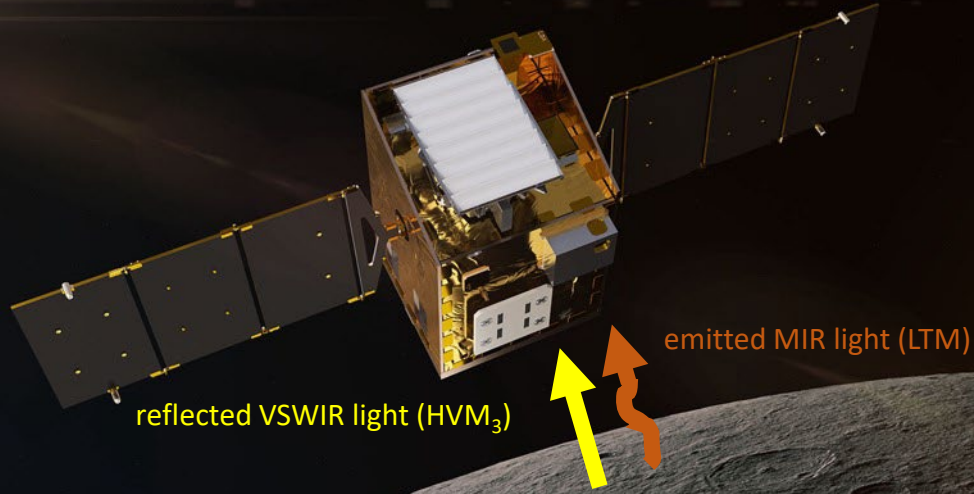
PI – Dr. Bethany Ehlmann, Caltech

Dep. PI – Dr. Rachel Klima, APL

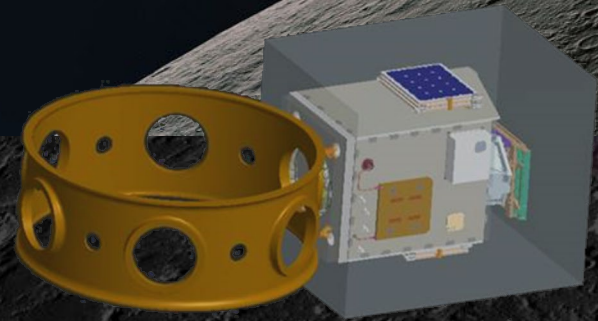
PM – Dr. Calina Seybold, JPL

Flight system: Lockheed Martin Space (Denver)

Mission Ops – Caltech IPAC (w/ student collaboration)



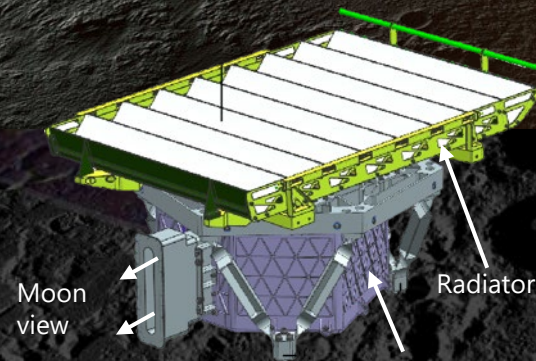
3.5 m span deployed



Launch Configuration

w/in ESPA Grande volume

MEV 210 kg



Housing for Optics+
Imaging Spectrometer
(active cryocooler within)

2 Payload Instruments (25 kg):

HVM³ (JPL)

High-resolution
Volatiles and
Minerals Moon
Mapper

50-90 m/pixel

0.6 – 3.6 μm @10nm

SNR > 100

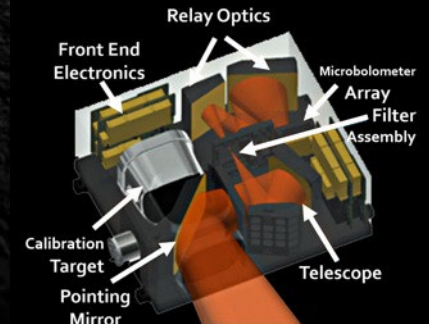
LTM (U. Oxford)

Lunar Thermal Mapper

40-70 m/pixel

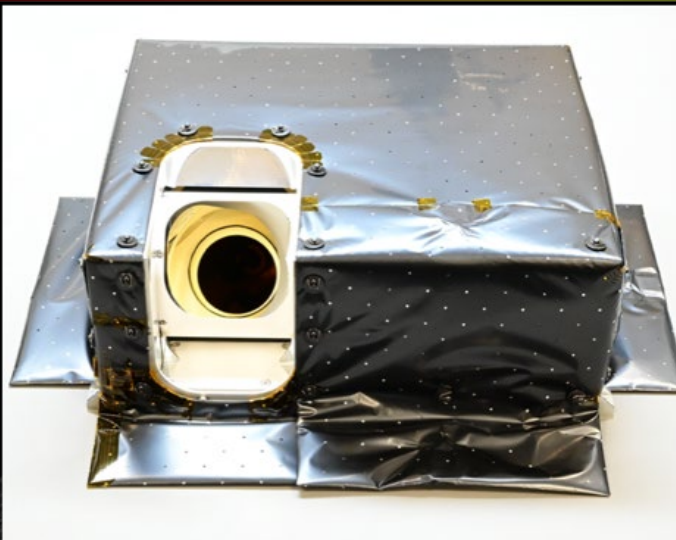
4 thermal channels (6-100 μm , +/- 2 K, 110-400K)

11 compositional channels (7-10 μm , < 0.5 μm)

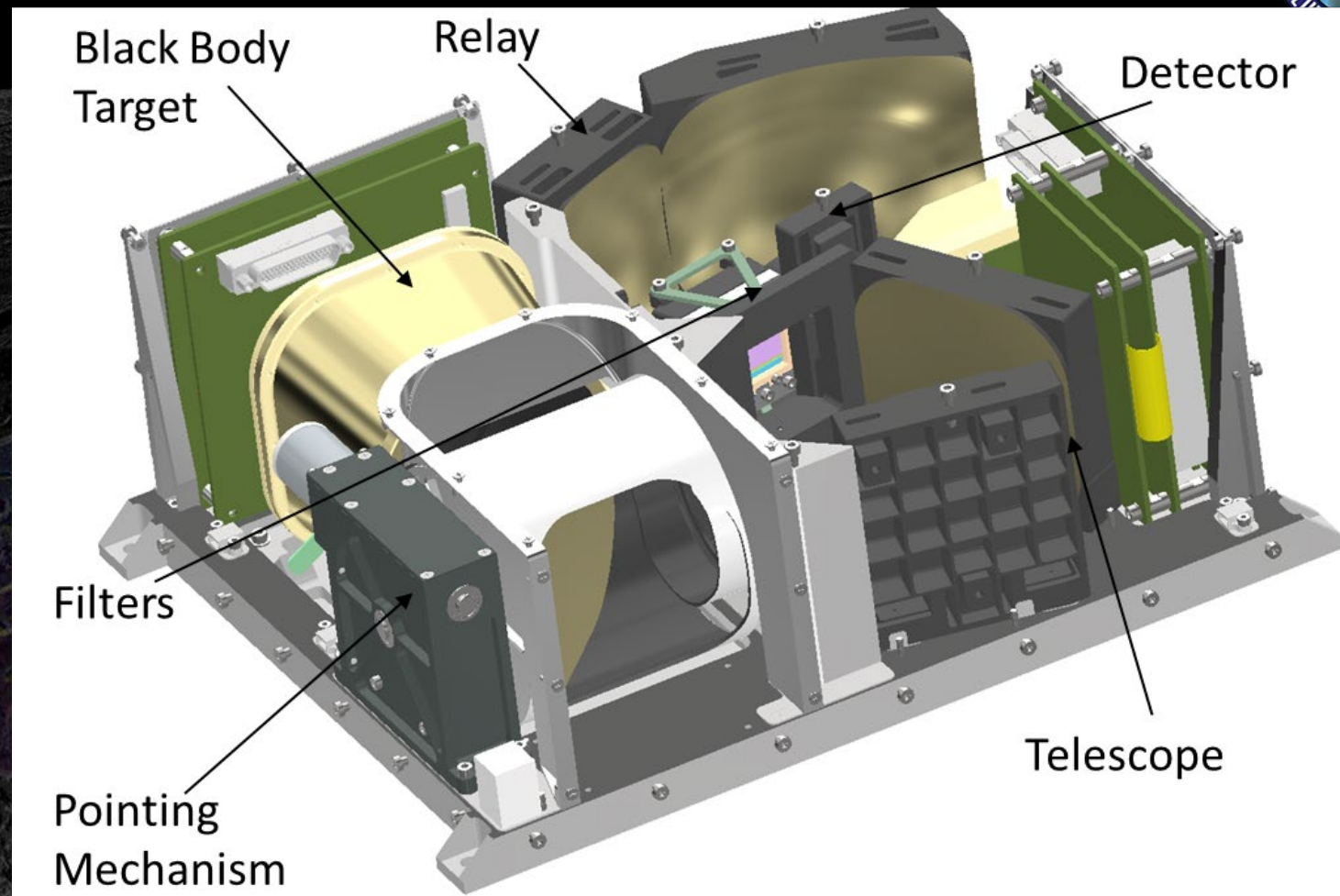


This document has been reviewed and determined not to contain export controlled technical data.

LTM Overview



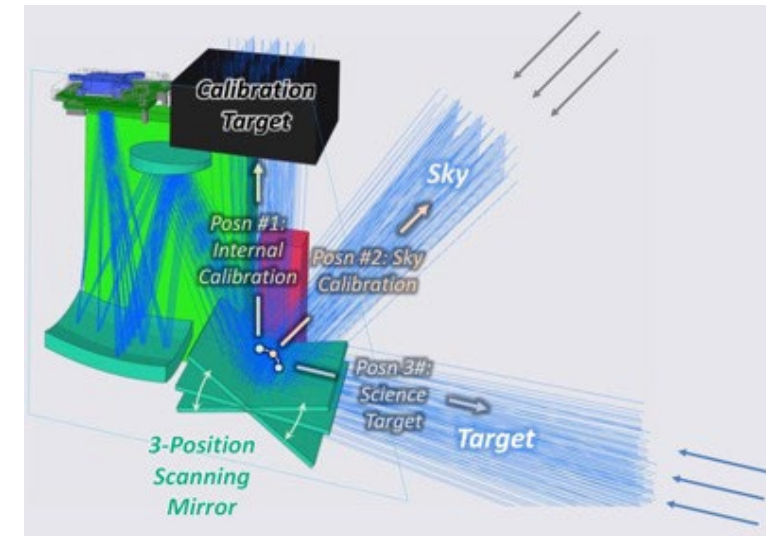
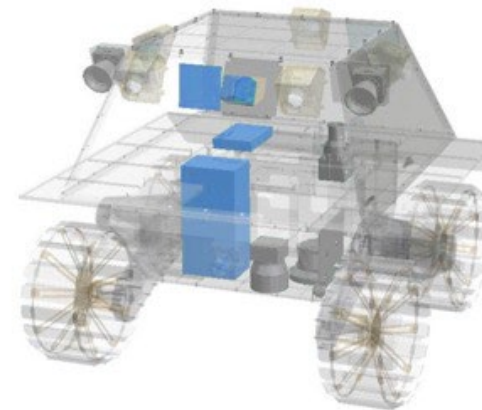
- LTM is a filter radiometer. With 15 channels including 4 thermal and 11 compositional
- An onboard black body target allows radiometric calibration before and after every observation
- The detector is an **uncooled** microbolometer with a gold-black coating for broad spectral performance



This document has been reviewed and determined not to contain export controlled technical data.

The LEAP Lunar Rover

- LEAP Lunar Leap Accelerator Program
- Small ~30 kg class rover delivered to the lunar surface via CLPS initiative.
- Science goals:
 - Map possible local distributions of sub-surface water ice.
- Instruments:
 - Neutron Spectrometer (LHANS)
 - Frozen Regolith Observation and Science Tools (FROST)
 - Lyman-alpha imager
 - Multi-spectral imager (LED driven illumination system)
 - Higher spatial resolution multispectral imager
 - Radiation micro-dosimeter
 - **LAFORGE (Lunar Advanced Filter Observing Radiometer for Geologic Exploration) thermal imager (NASA contribution, led by APL).**
- **Current status:**
 - Selected by CSA
 - Successful System Requirement Review
 - Prime (Canadensys) selected November 2022
 - NASA confirmed LAFORGE as US contribution December 2022



What do we mean by “Space Exploration”?

- Technology enables exploration
 - Exploration enables science
 - All form a virtuous circle.
-
- Onwards!

