Team Hakuto’s Google Lunar XPRIZE Lunar Mission

Space Resource Roundtable, Golden CO

Kyle Acierno
Global Business Development Officer

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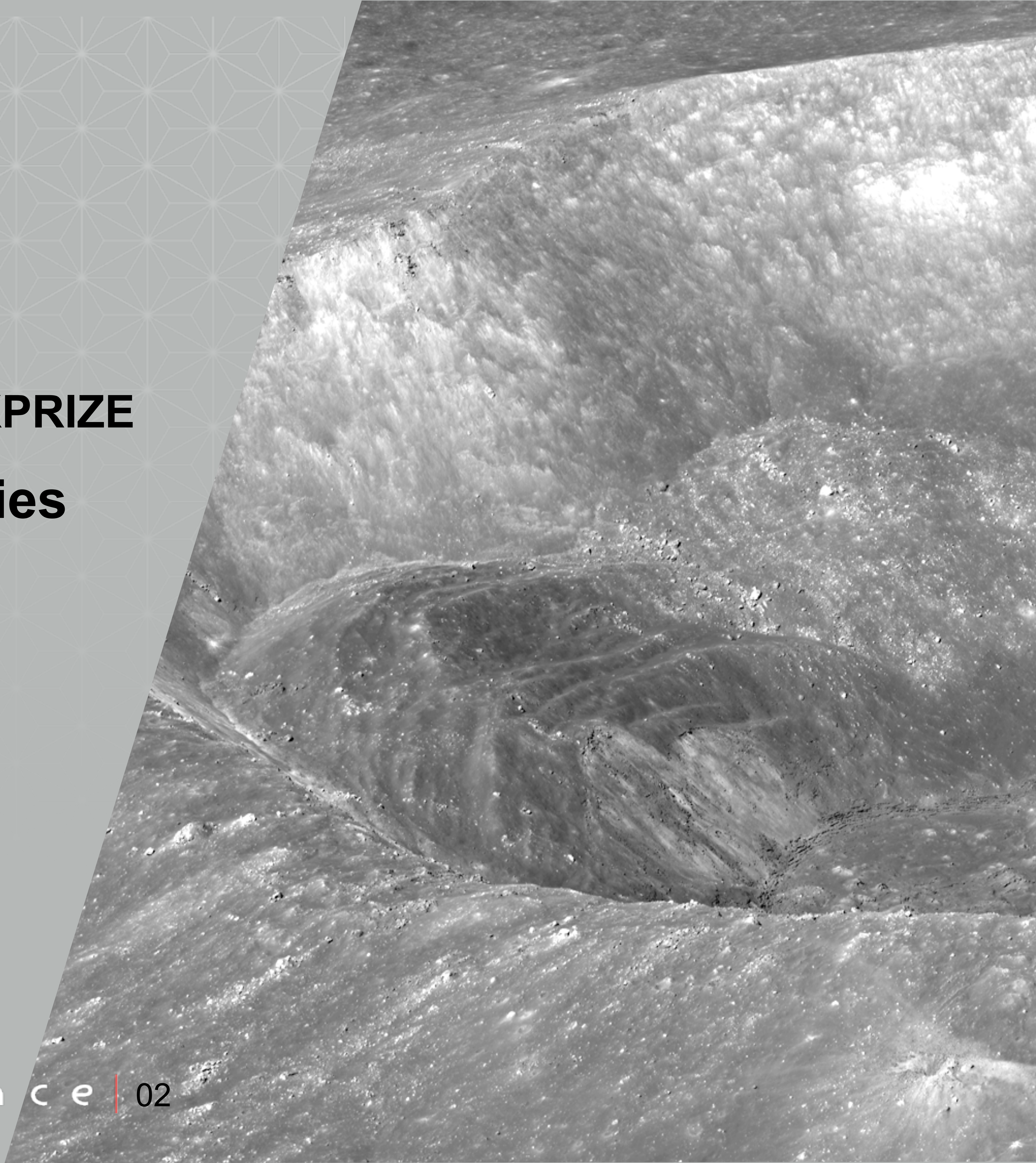

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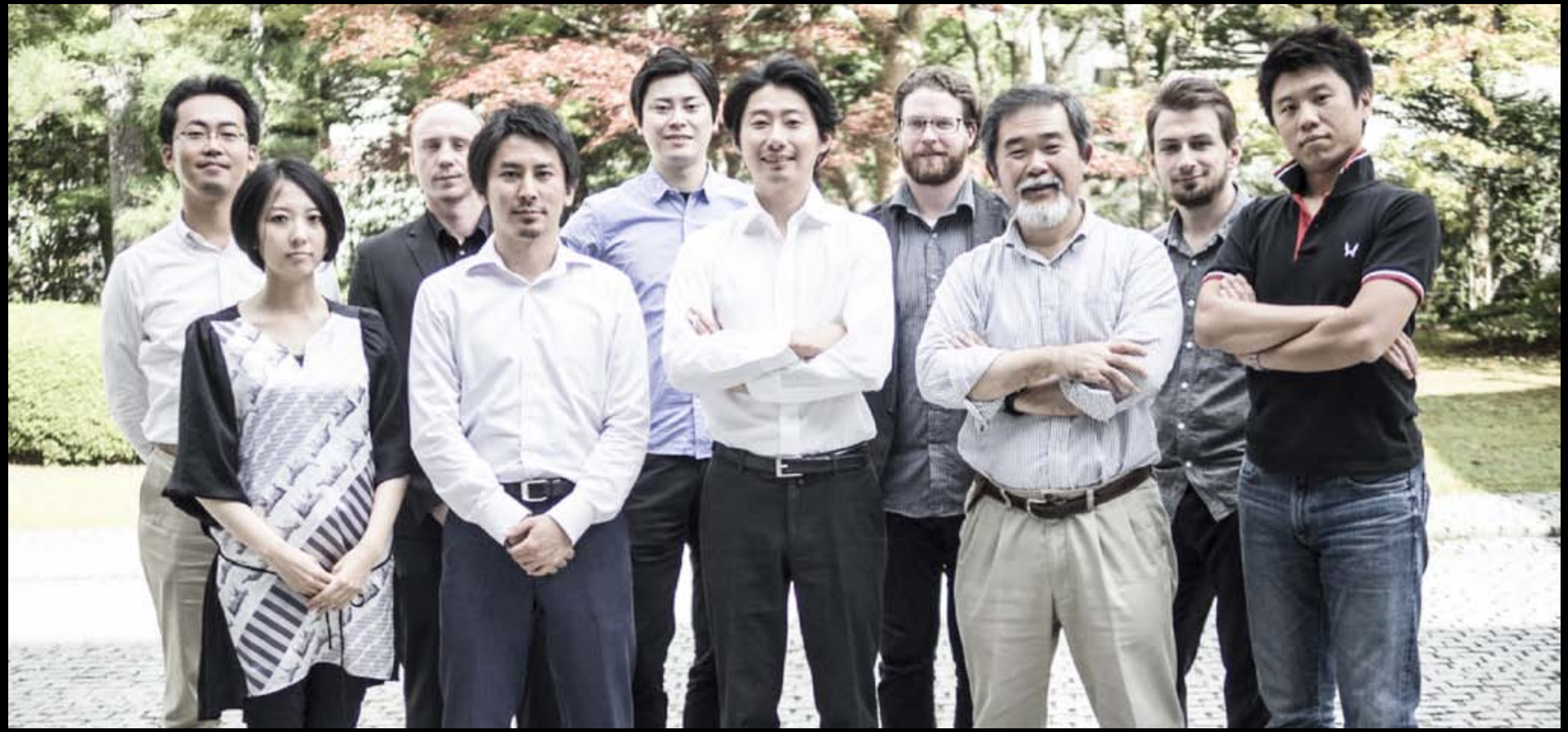


TOHOKU
UNIVERSITY

GOOGLE LUNAR XPRIZE
OFFICIAL TEAM

PRO BONO
MEMBERS

EXPAND OUR PLANET.
EXPAND OUR FUTURE.

Our mission is to locate and utilize resources necessary to extend human life into outer space

GOAL
TO BE THE WORLD'S LEADING LUNAR EXPLORATION COMPANY

- FOCUS ON UTILIZING THE MOON'S RESOURCES, ESPECIALLY WATER ICE
- FOLLOW AN INCREMENTAL, PHASED APPROACH
- SPECIALIZE IN MICRO-ROBOTIC SYSTEMS

FOCUS ON THE MOON'S RESOURCES

ICE

H20 Ice
Rocket Fuel
Breathable Oxygen
Drinking Water
Radiation Shielding

METALS

Al, Ti, Fe, Si
Infrastructure
Conductors
Ceramics
Solar Panels

PRECIOUS ELEMETNS

Rare Earth Elements
Platinum Group Metals
Gold, Silver, Etc
Moon Treasure

VOLATILES

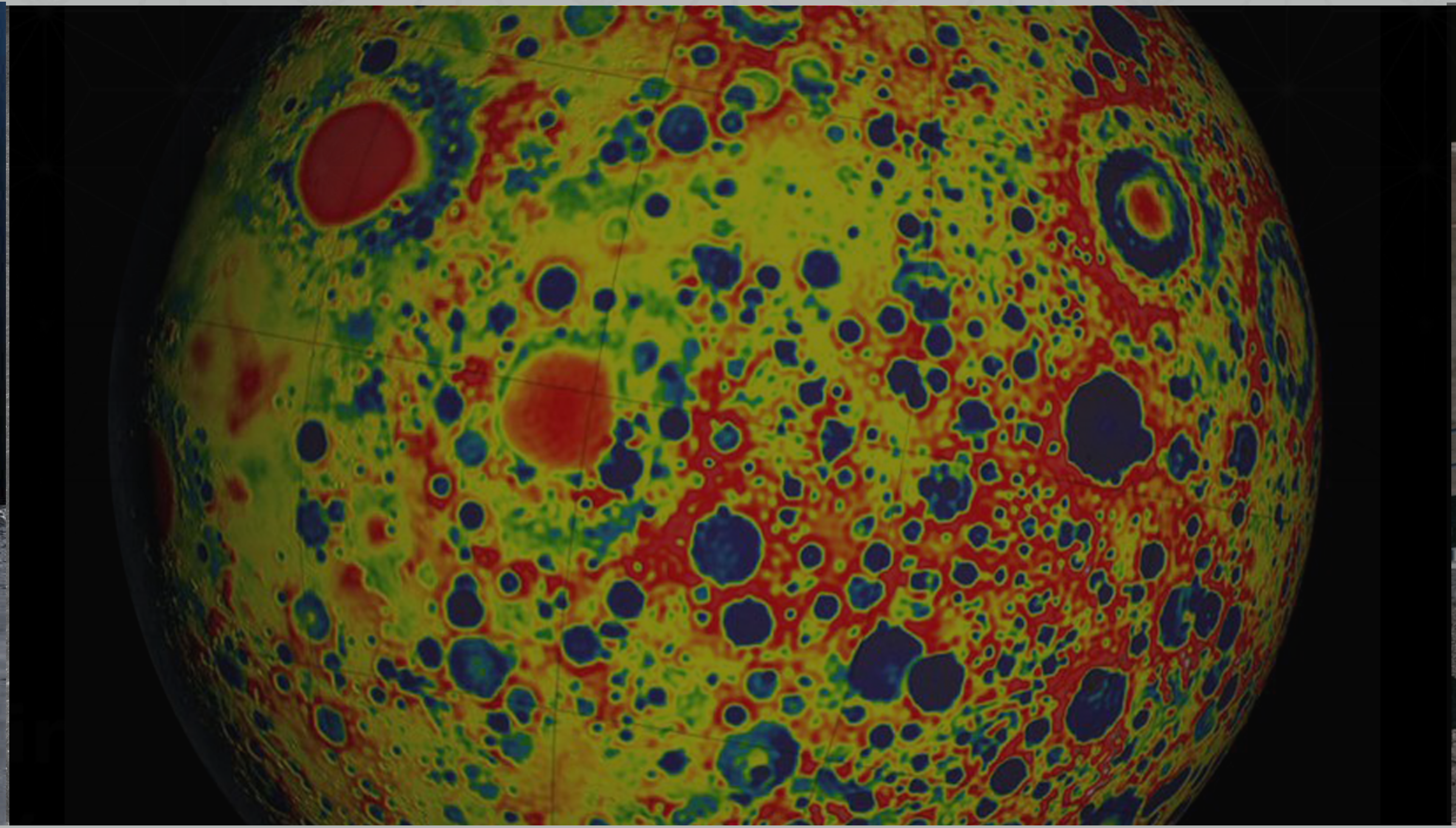
^{3}He, 4He, H2 , Carbon Compounds, N2,
Energy
Plant Growth
Air

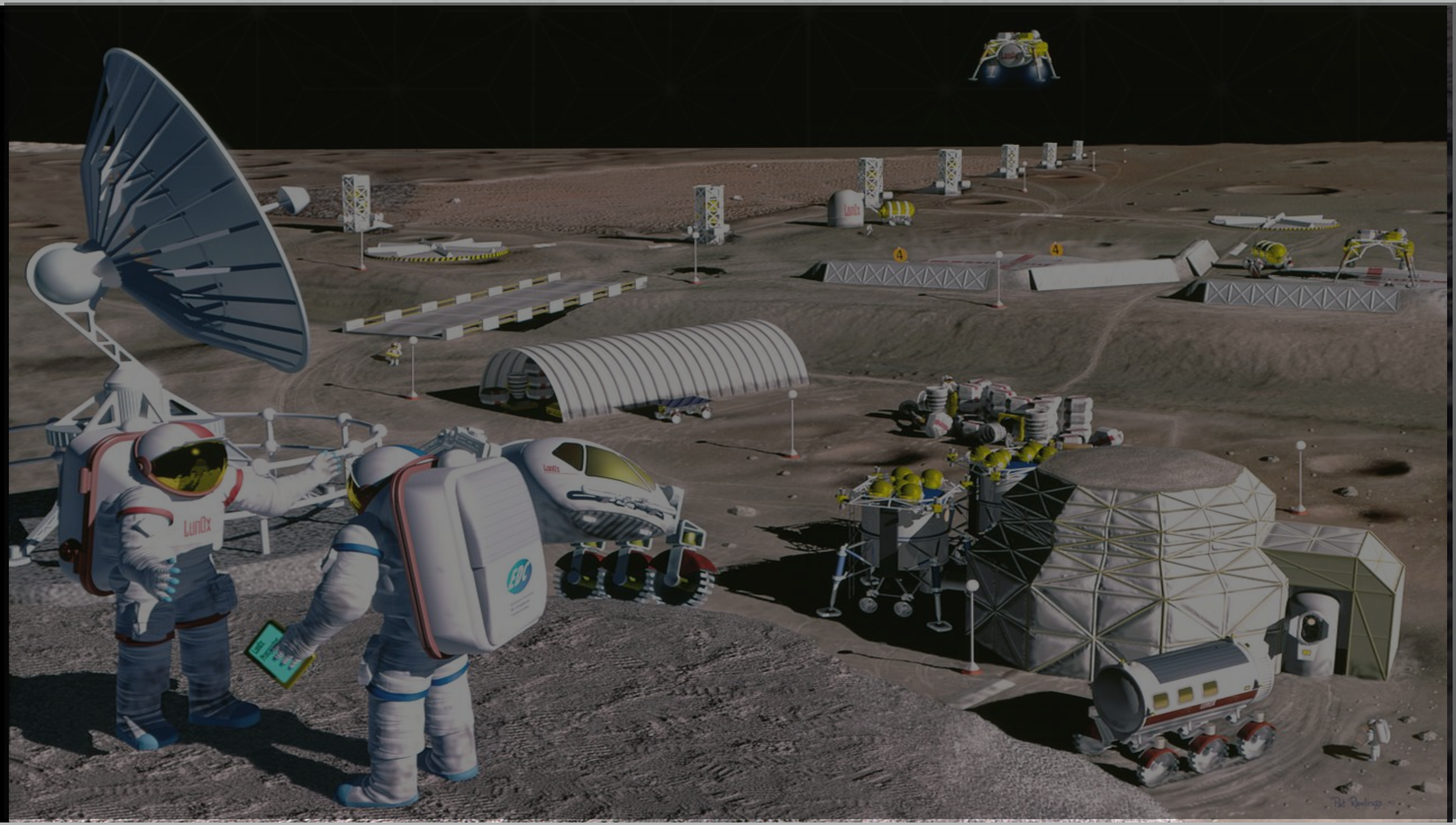
THE ISPACE 3 PHASED LUNAR EXPLORATION APPROACH

PHASE 1 2017

PHASE 2 2018 - 2023

PHASE 3 2024 - 2030





Google Lunar XPRIZE
Technology Demonstration

RESOURCE PROSPECTING & MAPPING
Build Engineering and Economic Models

RESOURCE EXTRACTION
Supporting the CISLUNAR Econosphere


PHASE 1
Google
LUNAR
XPRIZE®

Google Lunar XPRIZE

- Organized by the XPRIZE Foundation and sponsored by Google, the “Google Lunar XPRIZE” is an international $30 million competition to land a privately funded robot on the moon.

Google LUNAR XPRIZE®

Grand Prize

The $20 million prize goes to the first team that:

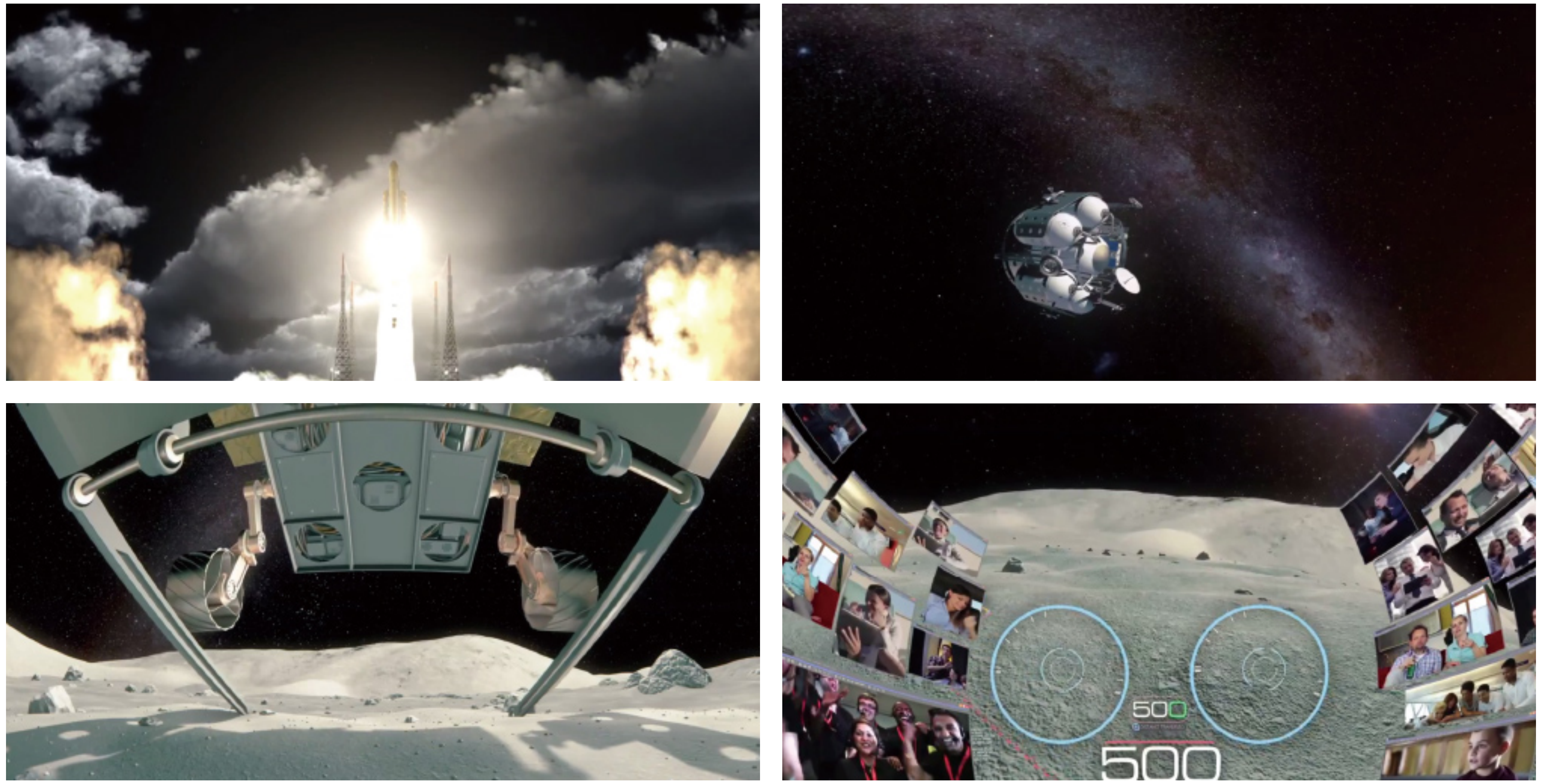
・Drives their rover for 500m on the moon

・Sends HD-images&videos back to Earth

by the end of 2017

※Second prize: $5million

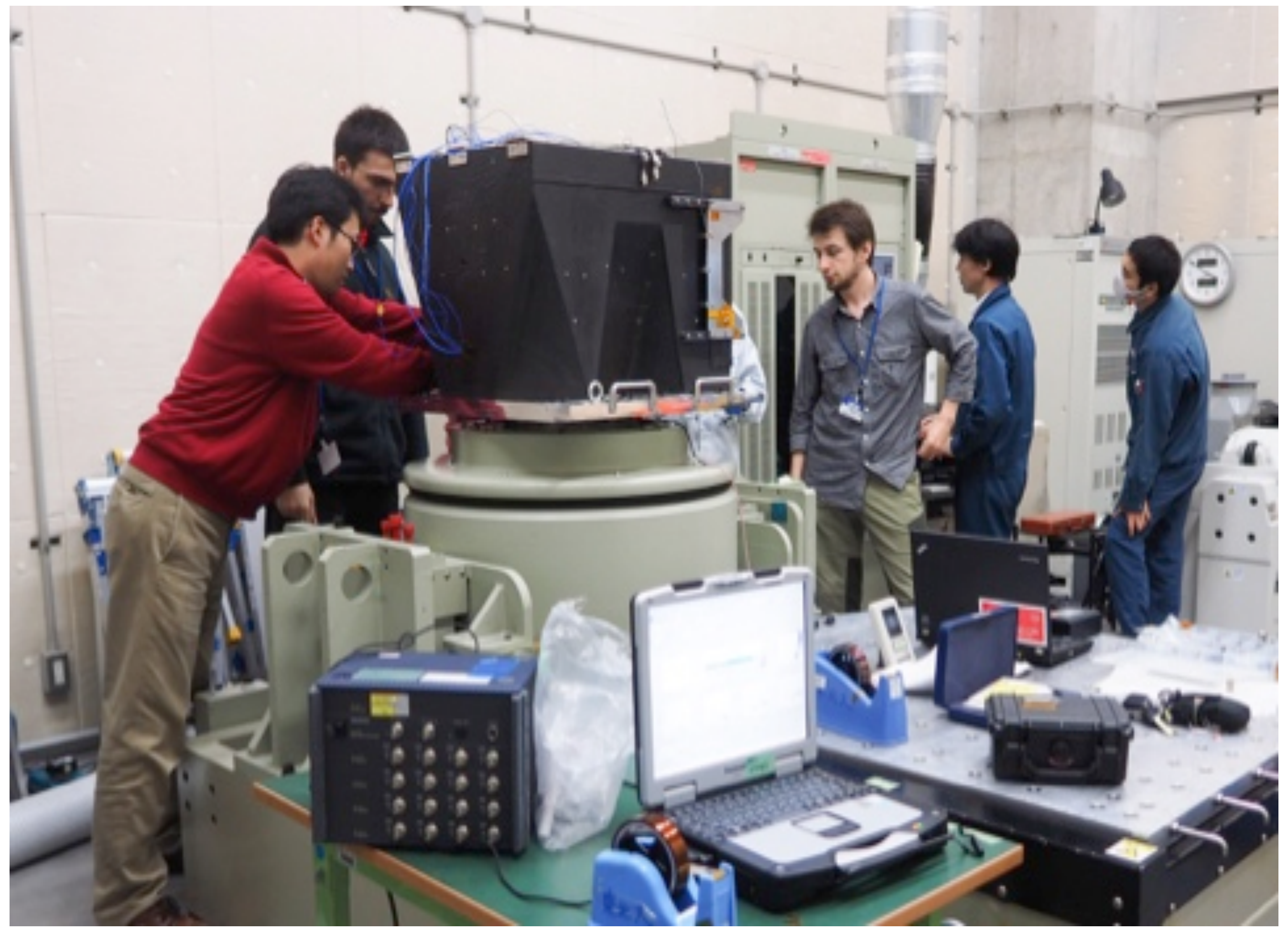
※Bonus Prizes add up to $5million



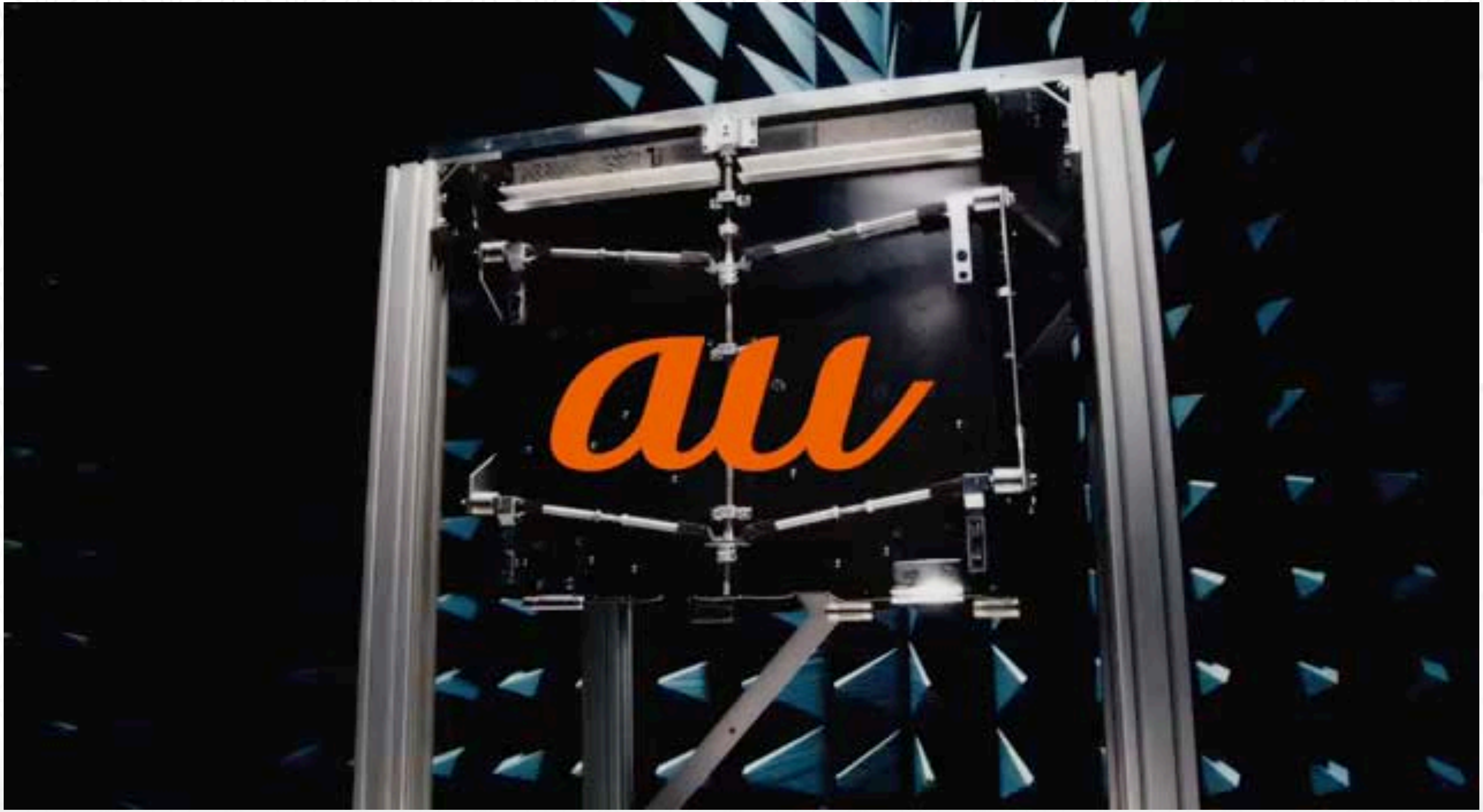
16 Teams from all over the world

Google Lunar XPRIZE Milestone Prize Winners

Google Lunar XPRIZE Milestone Prize



HAKUTO PARTNERS



Launch scheduled after the second half of 2017

- HAKUTO has announced to share a ride to the moon with Astrobotic, scheduled after the second half of 2017.

Launch Rocket

Scheduled launch will be carried out by Falcon 9

Lunar Lander

Perigine Lander developed by Astrobotic

Car-Pool

Our rovers will share the ride with Astrobotic

Launch scheduled after the second half of 2017

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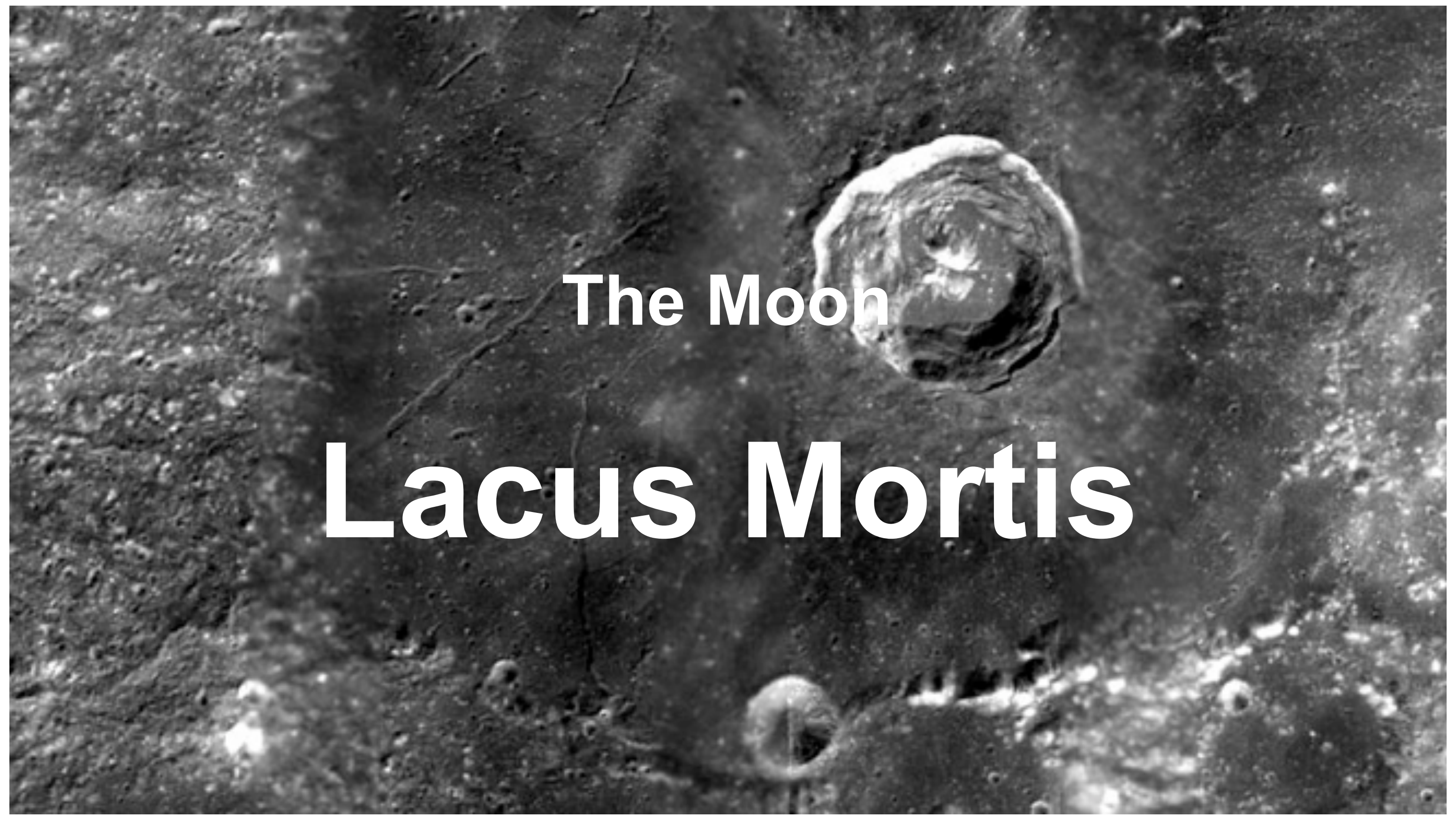
Scheduled Launch Site

Cape Canaveral, Florida, where the Cape Canaveral Air Force Station is located

Mission Control Center

HQ of Astrobotic, located in Pittsburgh, Pennsylvania



Planned Landing Site

Lacus Mortis, where the presence of a lunar lava tube has been confirmed

Lacus Mortis

Micro-Robotics

HISTORY OF 4-WHEELED ROVERS AT THE SPACE ROBOTICS LAB

2002

2006

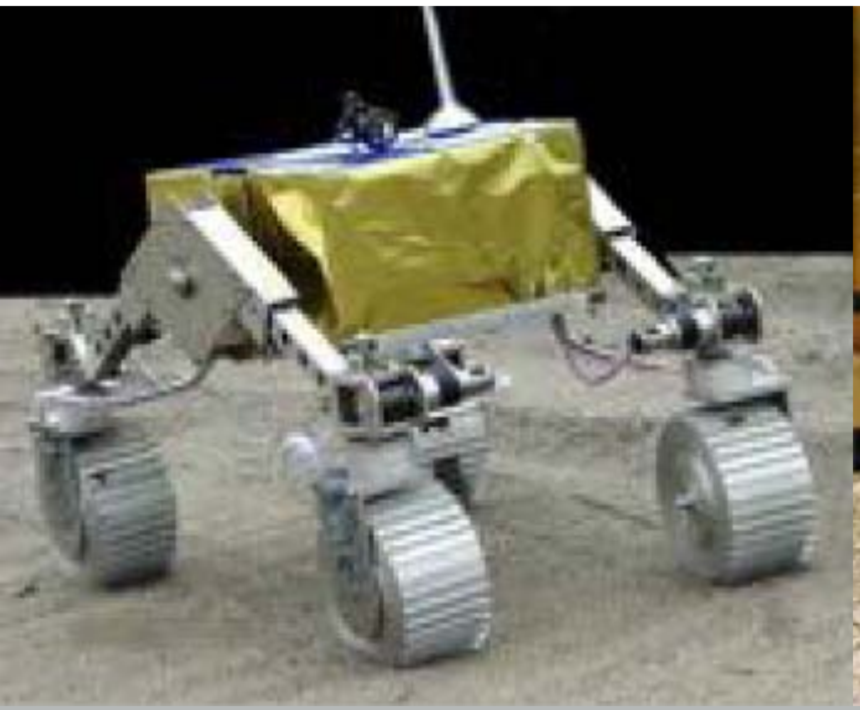
2010

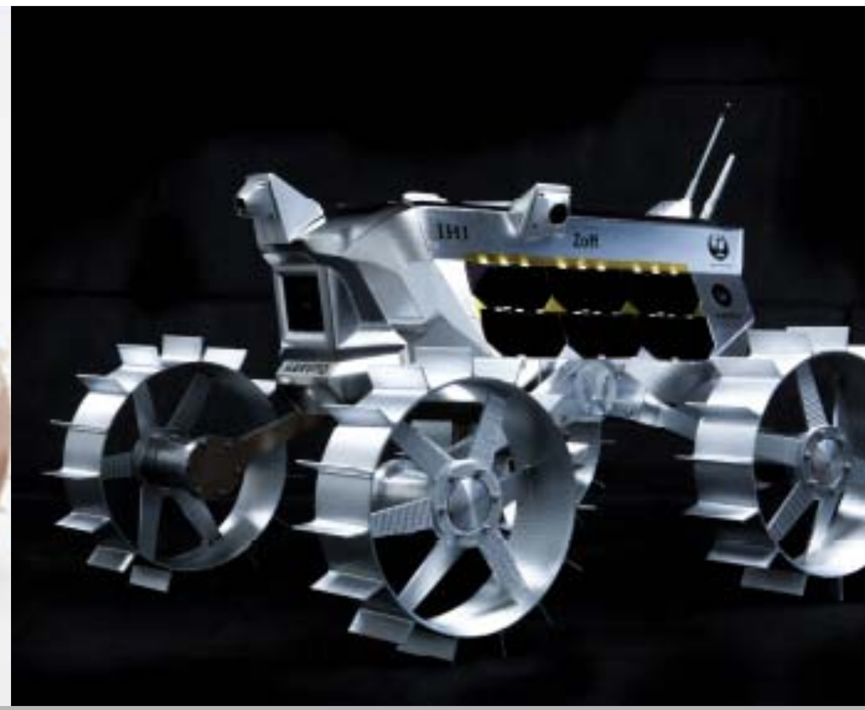
2012

2014

2015

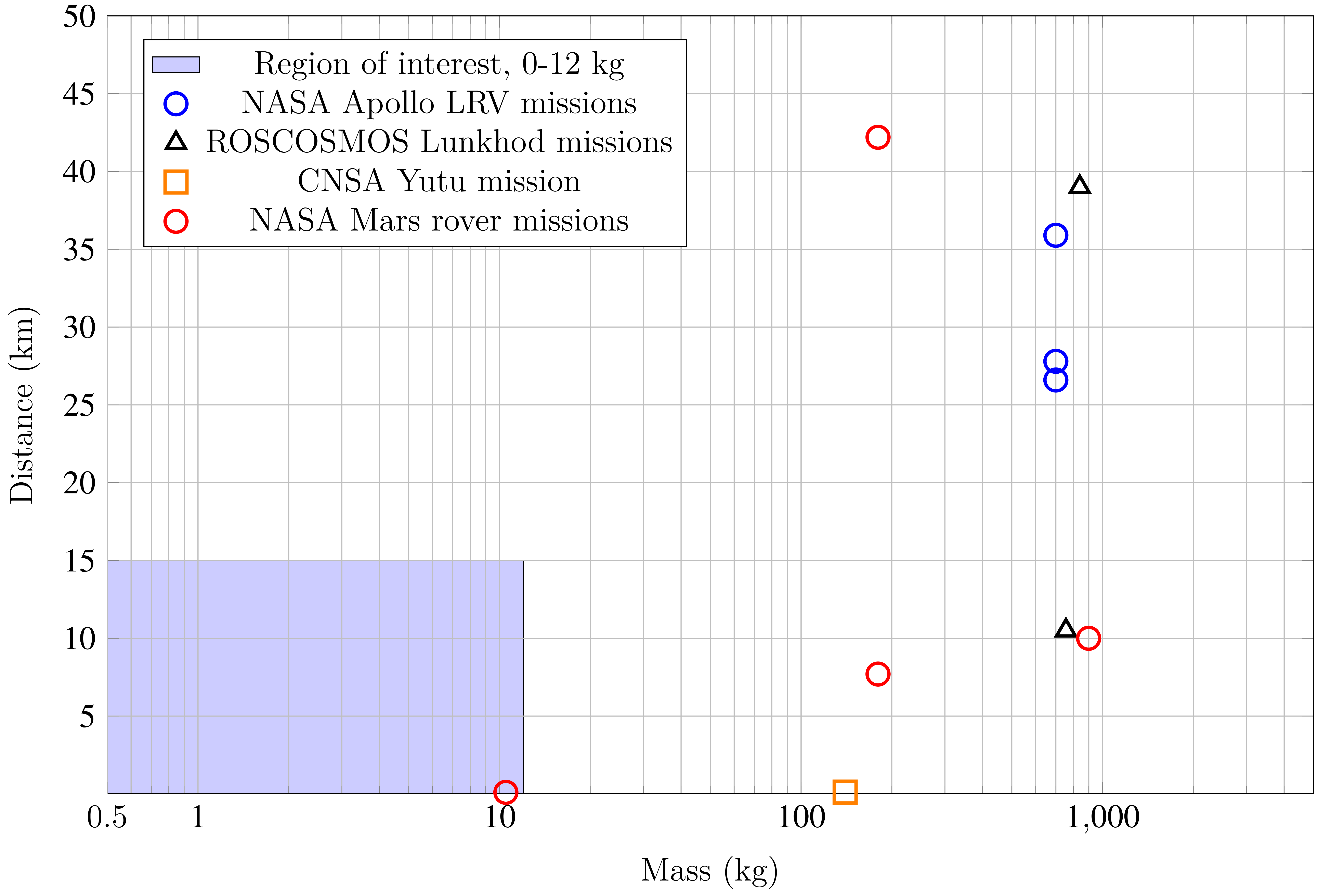
2016





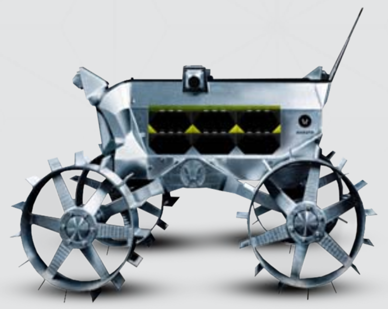
Goals

- Minimize the mass of a capable rover
- Minimize power consumption
- Create a scalable and modular design
- Create standards for microrover design



QUICK & COST EFFECTIVE ACCESS TO SPACE

900KG
CURIOSITY PLANETARY ROVER
NASA



4KG
HAKUTO PLANETARY ROVER
JAPAN

30KG
ASTROBOTIC PLANETARY ROVER
US

120KG
YUTU PLANETARY ROVER
CNSA

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MOONRAKER PFM 4KG

360º VISIBILITY

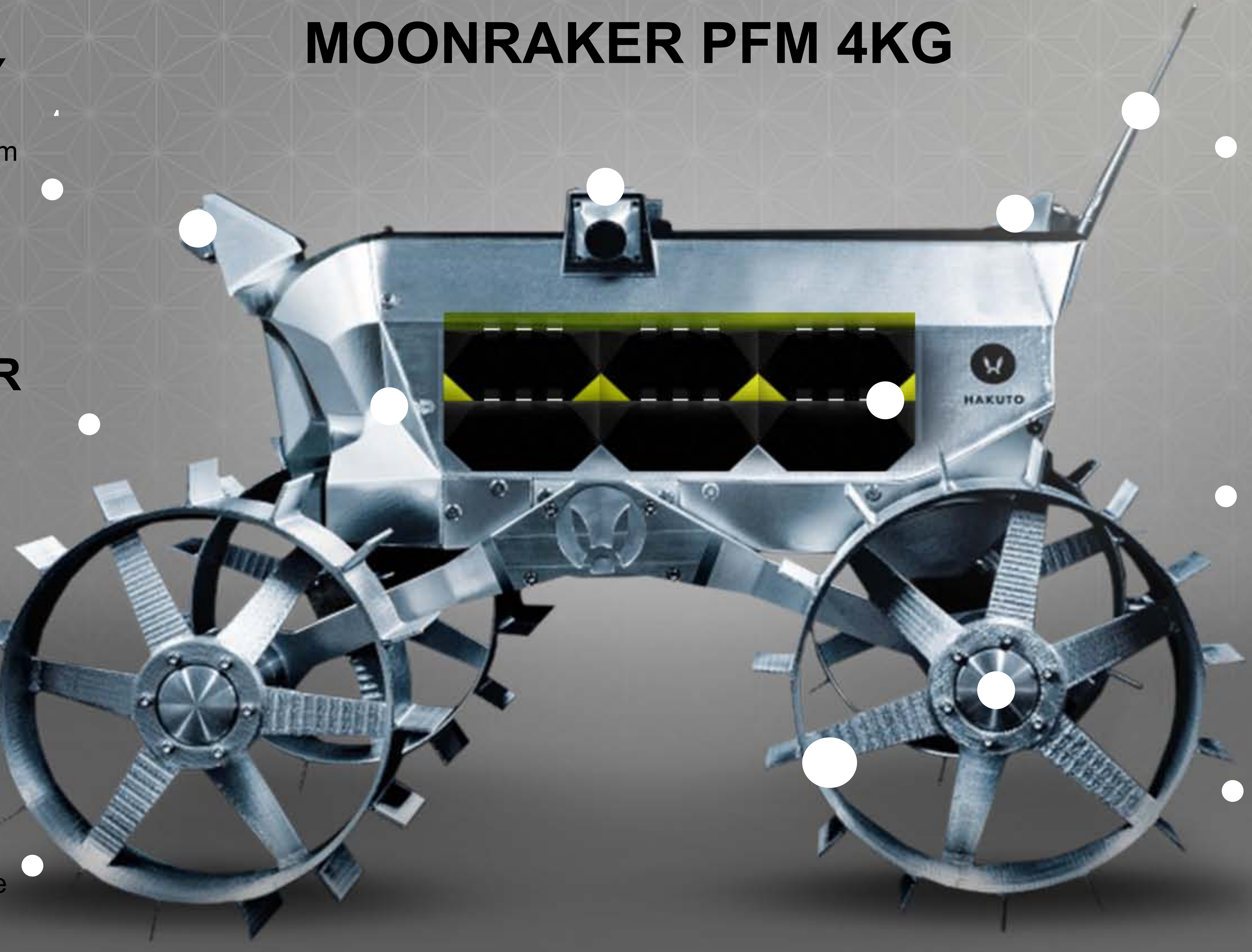
The rover's camera system uses four cameras that capture images from 360º for both research and maneuvering.

CARBON-FIBER ENFORCED PLASTIC

Carbon-fiber enforced plastic (CFRP), makes up the rover's body. It offers unparalleled weight savings and strength.

ULTEM RESIN

We've 3D printed the rover's wheels from ULTEM, which can handle extreme heat and offers strength and rigidity.



HYBRID COMMUNICATION

The hybrid communication architecture combines the 900MHz and 2.4 GHz frequencies for connectivity and speed.

SOLAR PANELS

Lightweight solar panels positioned on either side of the rover offer more exposure to sunlight.

WHEELS

The powder-like sand of the Moon presents new challenges for mobility, so we developed wheels with grouser tracks.

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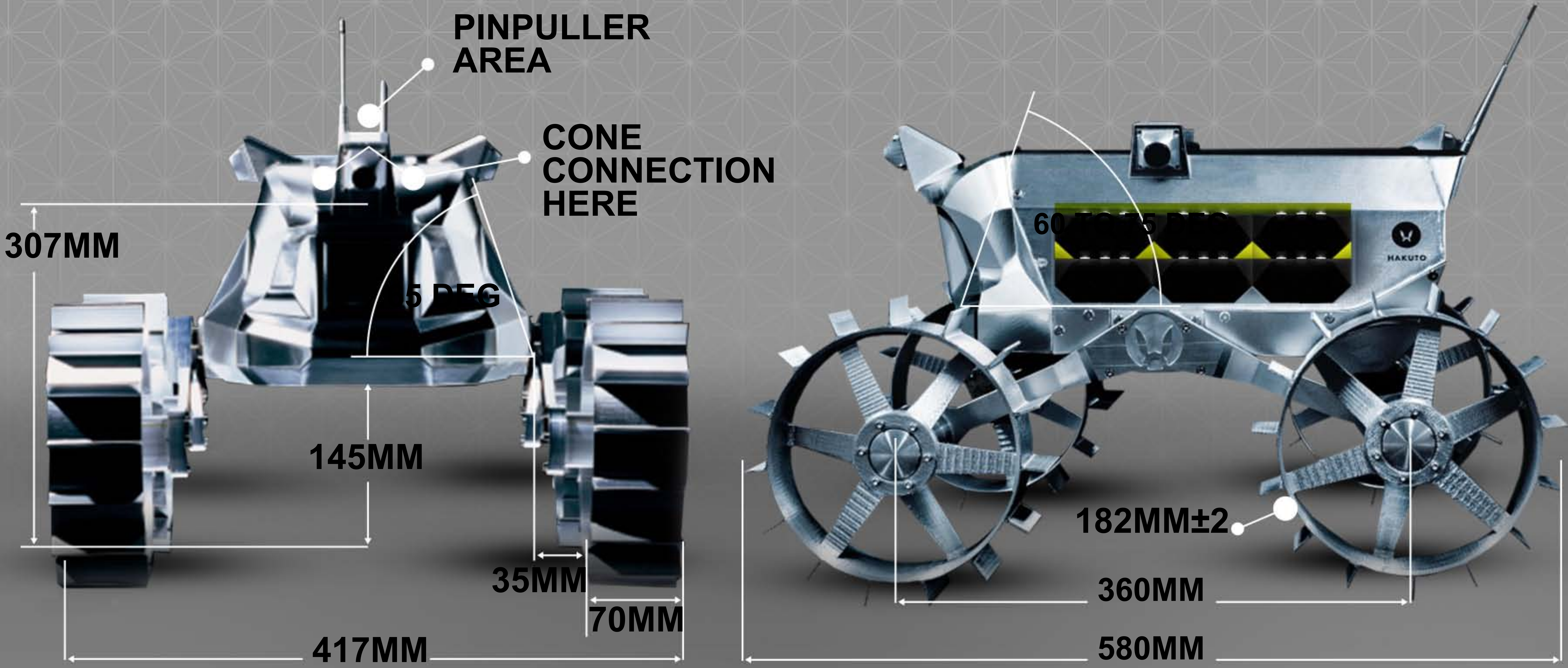
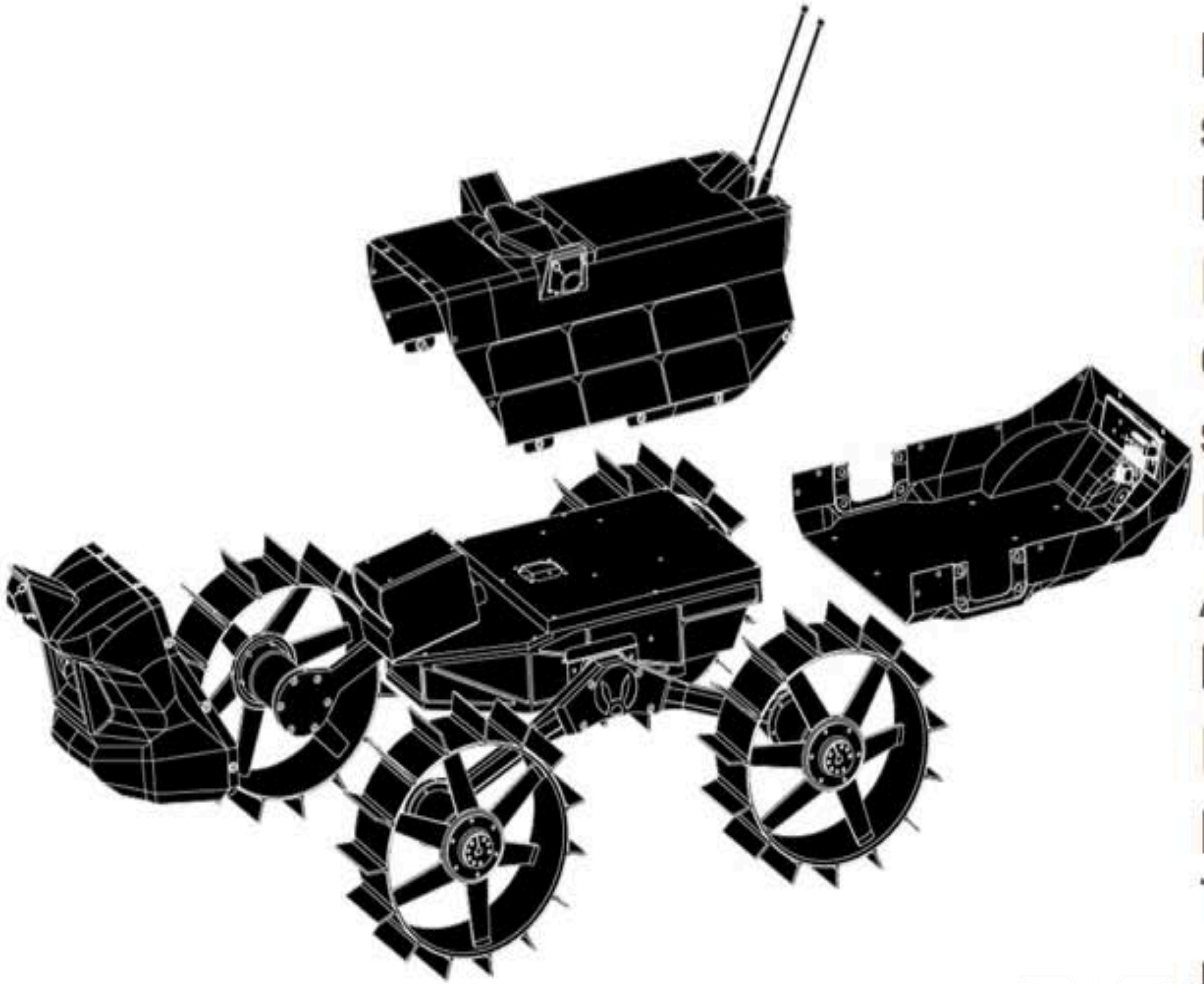
MOONRAKER PFM 4KG



Micro Rover Technology



■ MINITUARIZATION AND LIGHTWEIGHT

The rover highlights the strengths of Japanese engineering by fitting numerous complex components into a small space, miniaturizing technology while keeping a lightweight design.

■ CONSUMER PRODUCT APPLICATIONS

Commercial parts keep costs down and contribute to a smoother development process.

■ VIBRATION RESISTANCE

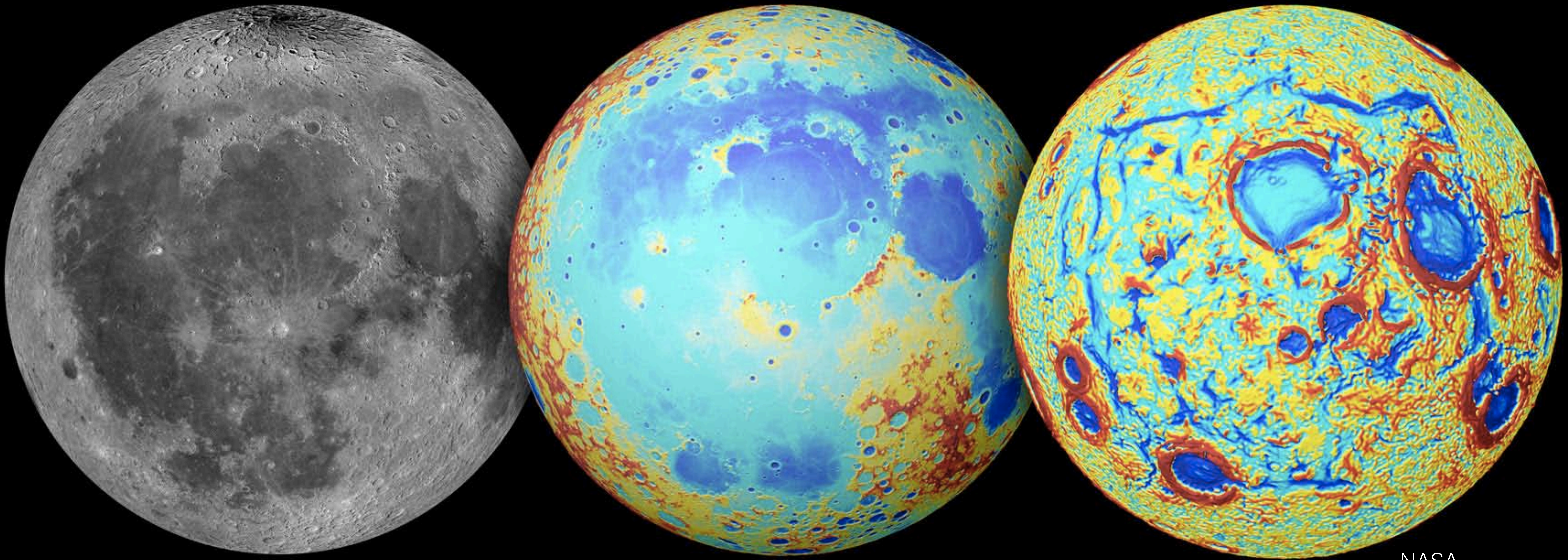
After considerable testing, the rover can withstand 14Grms liftoff vibrations.

■ THERMAL CONTROL

Lunar temperatures can range between -150º and 100º C. To compensate for this, silver coated Teflon covers the rover and helps keep inside temperatures stable.

PHASE 2

Prospecting and Mapping



NASA

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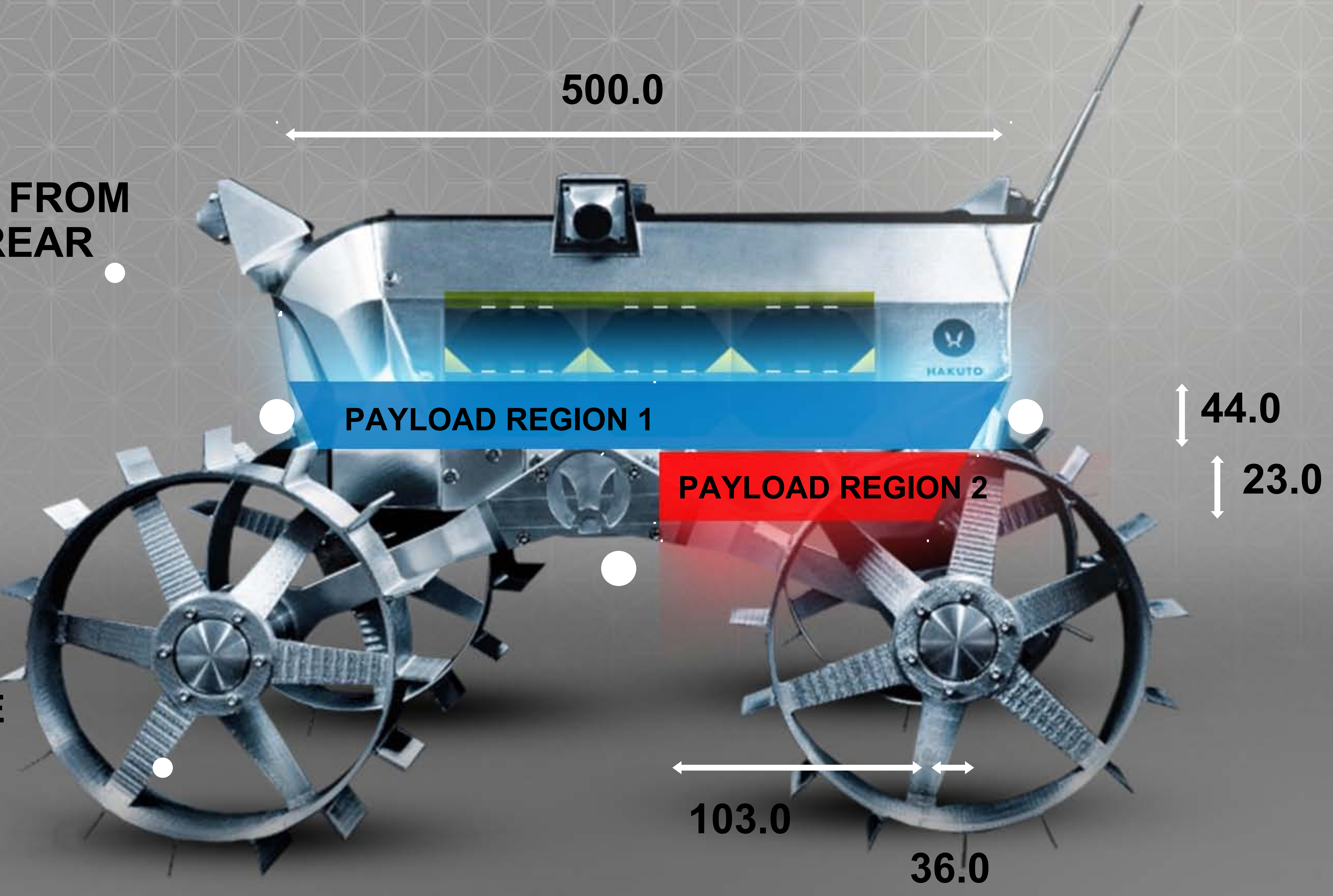
HOSTED PAYLOAD PROSPECTING

PROTRUSION FROM FRONT AND REAR OF ROVER IS POSSIBLE



PROTRUSION FROM THE BOTTOM OF ROVER IS POSSIBLE

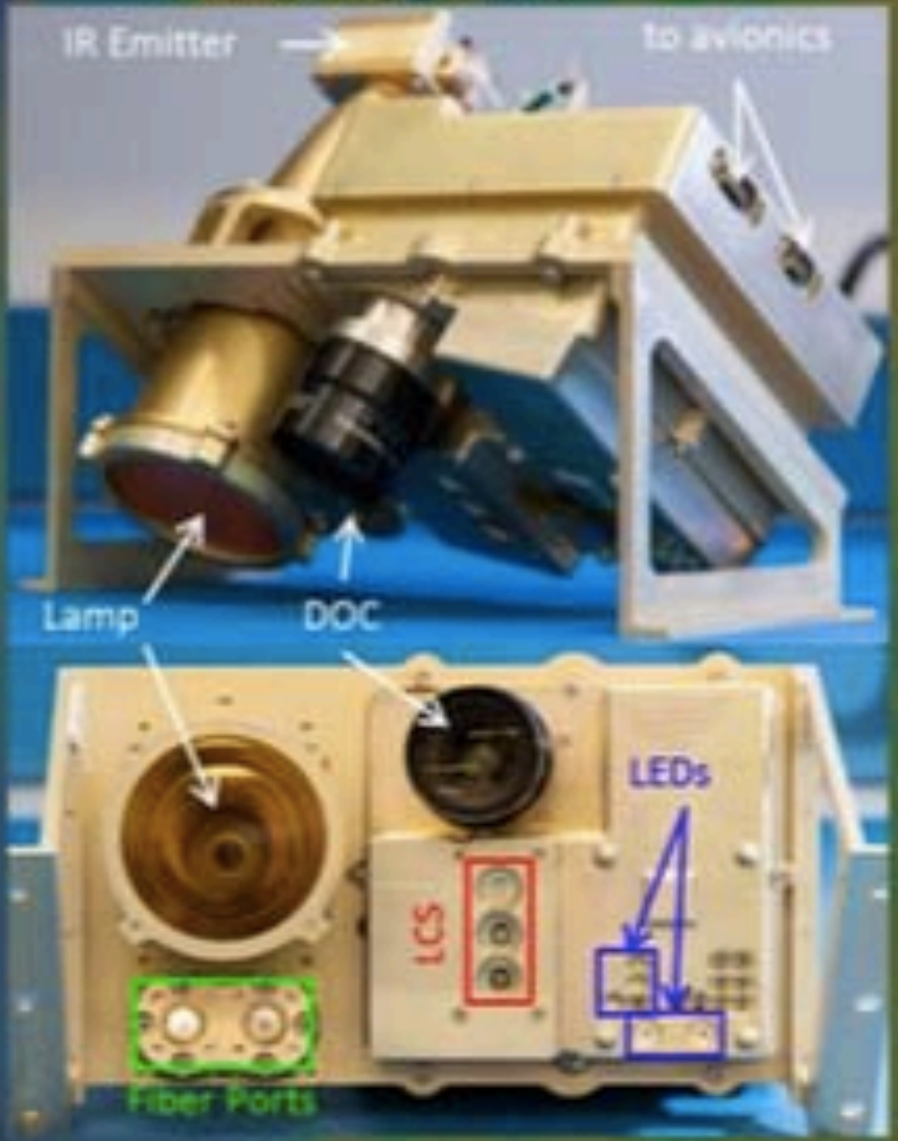
NIRVSS/NIRSpec

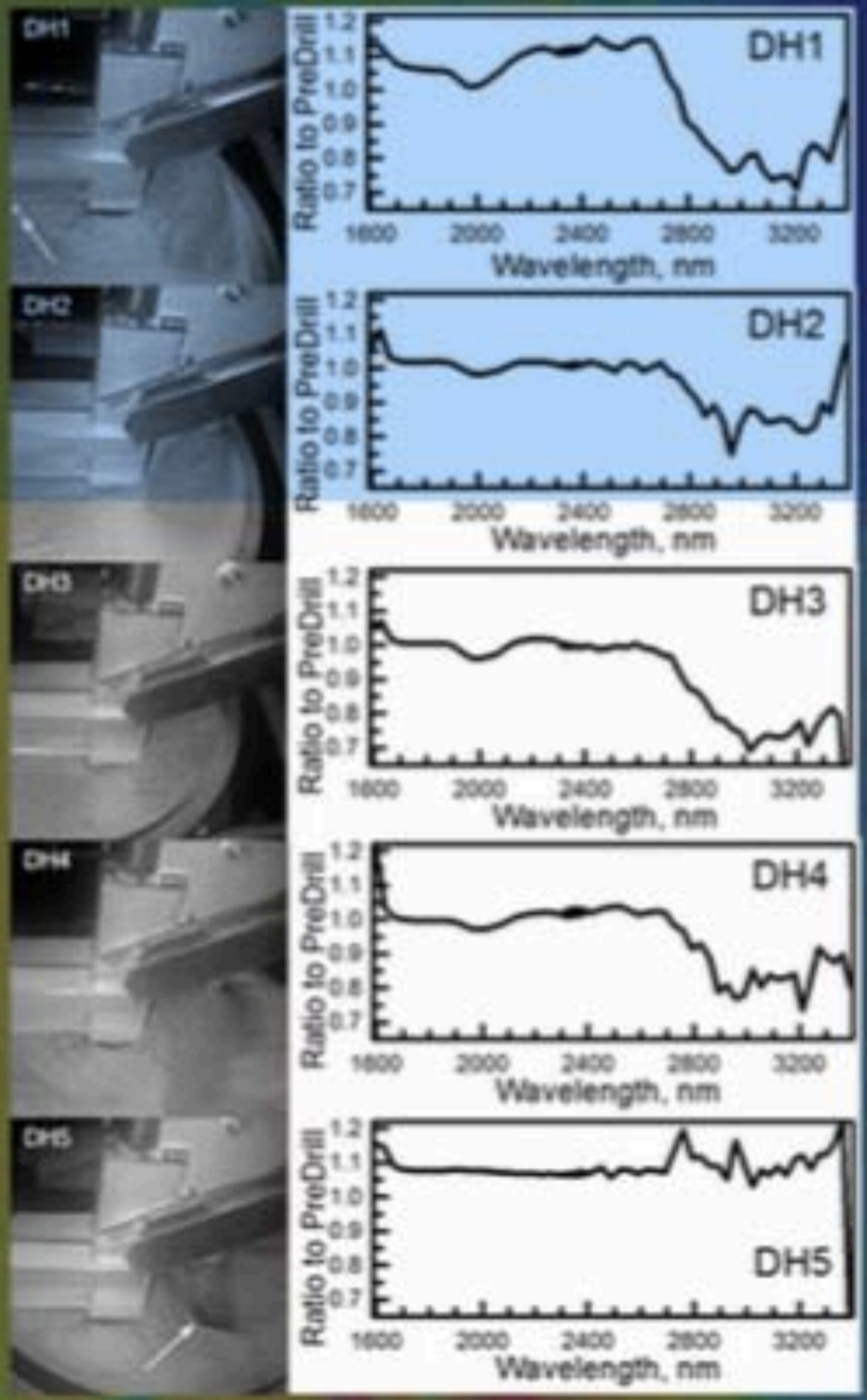
The Near-InfaRed Volatile Spectrometer System (NIRVSS) is designed to observe drill cuttings being deposited on the surface with spectrometers sensitive to volatiles, a camera, and radiometer to measure soil temperature. NIRVSS contains illumination sources enabling observations in unilluminated areas.
The background, false-color, image is a frozen lunar simulant prior to drilling was obtained by the NIRVSS DOC.

NIRSpec

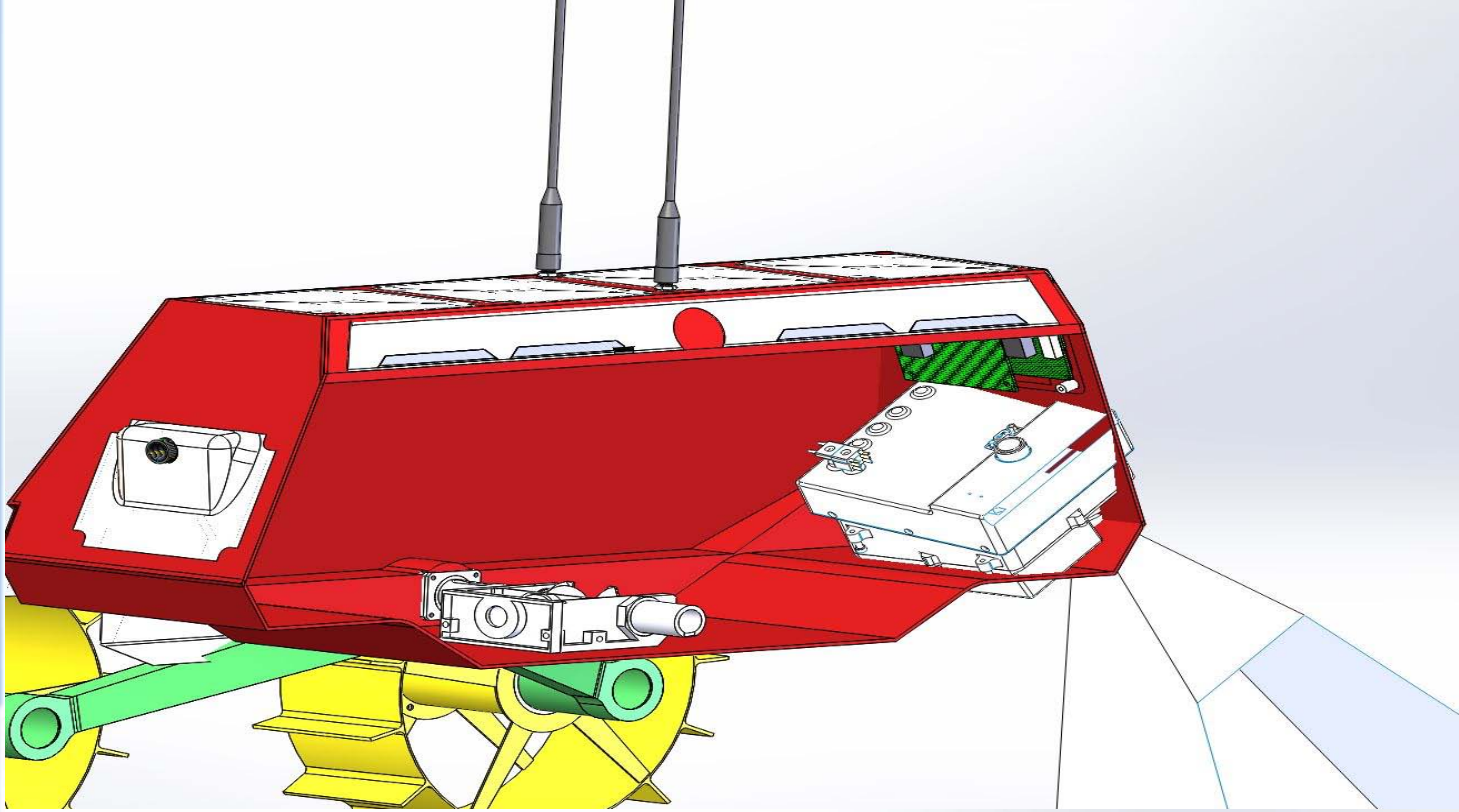
NIRVSS spectrometer box

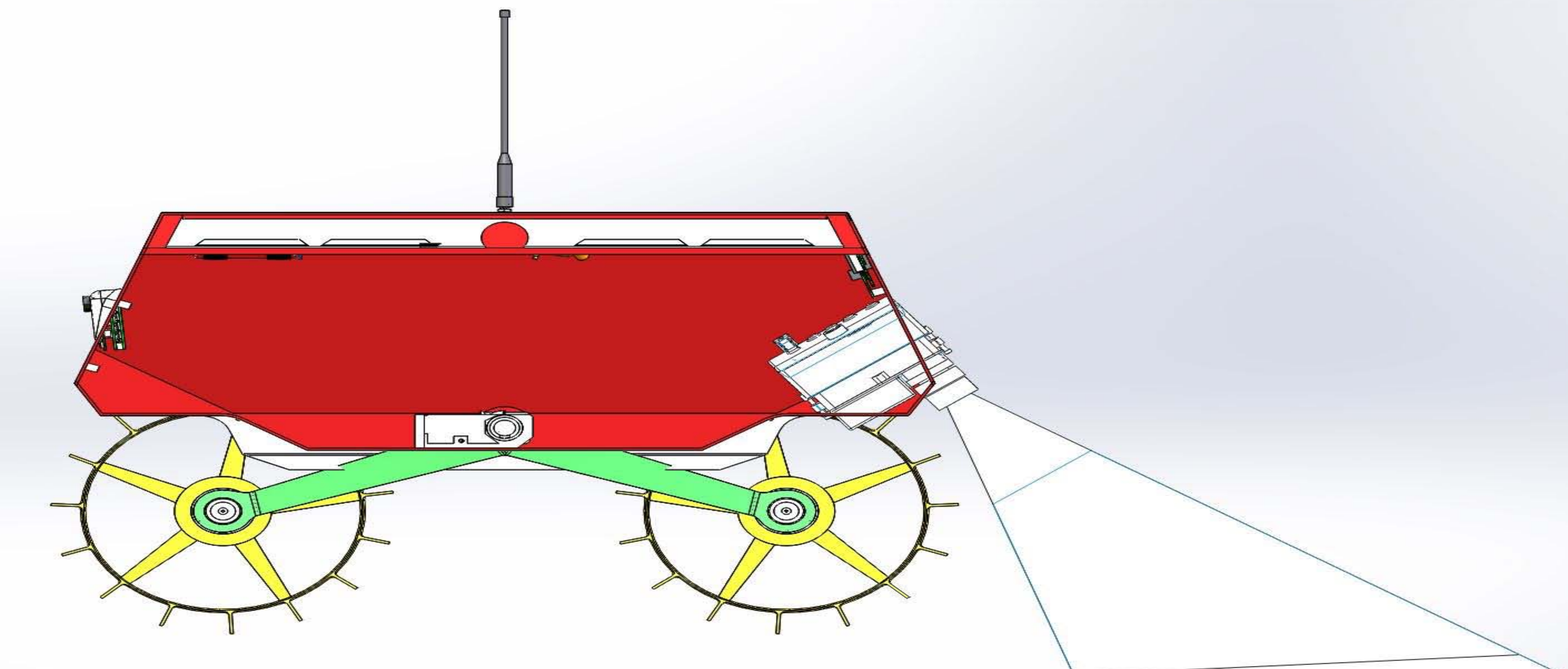
Bracket Assembly



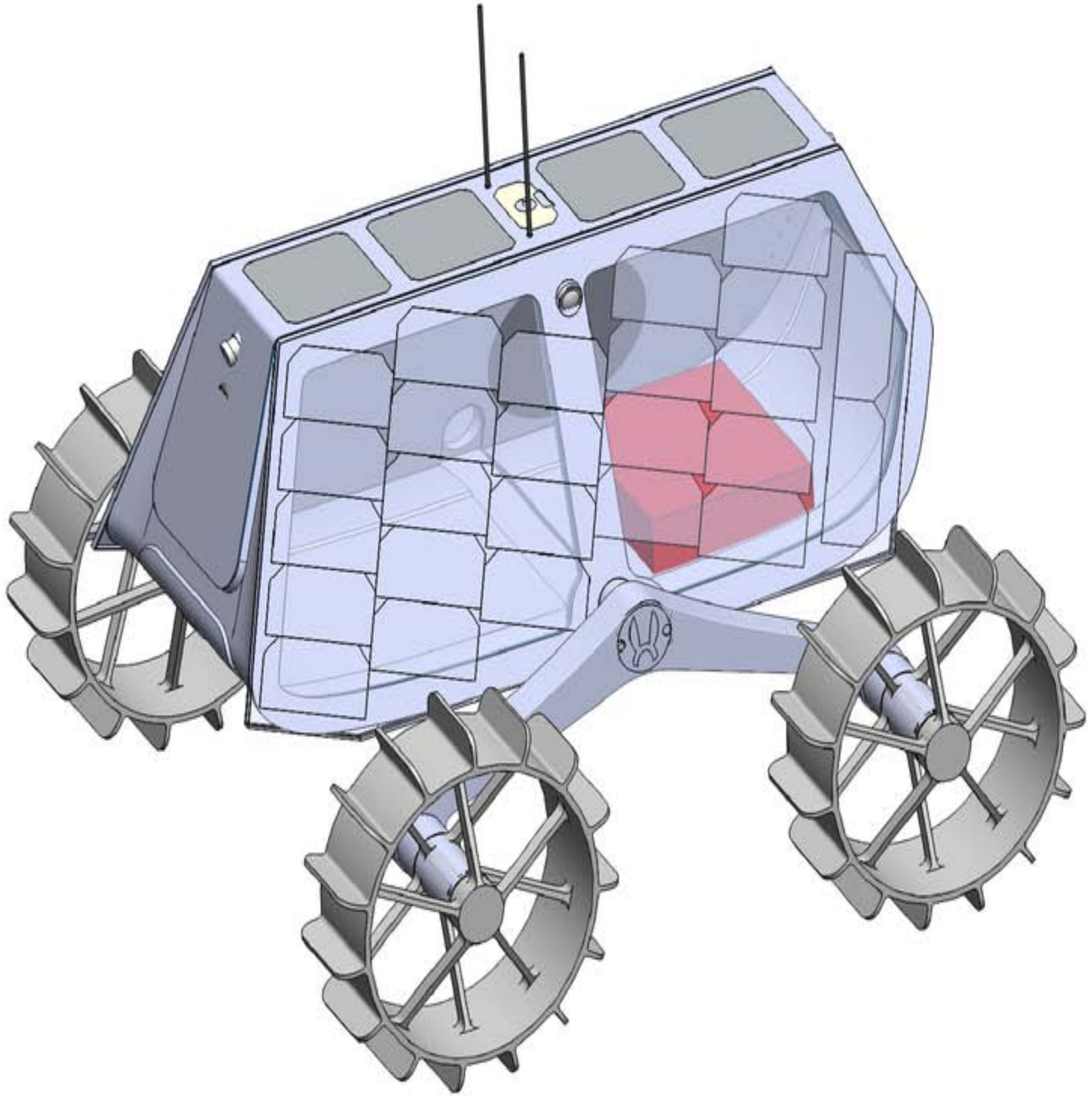


Images from each drill hole (DH) at 30 cm depth (left) and associated spectral averages (right) of a 5 wt. % H_2O doped LHT simulant. H_2O ice features at 2000 and 3000 nm are apparent in DH1-DH4, but absent in DH5 where the cuttings are filling a pre-existing hole.

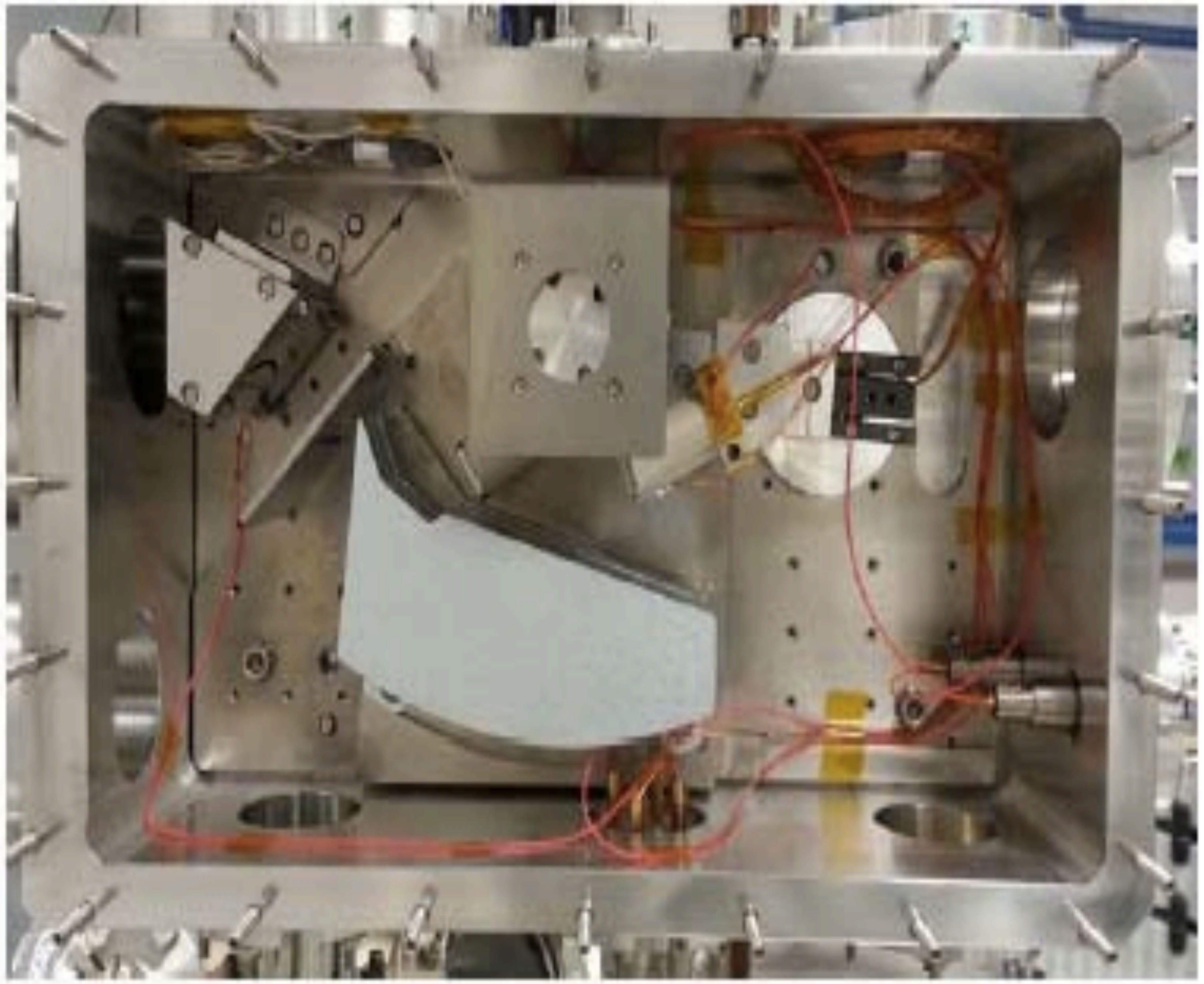




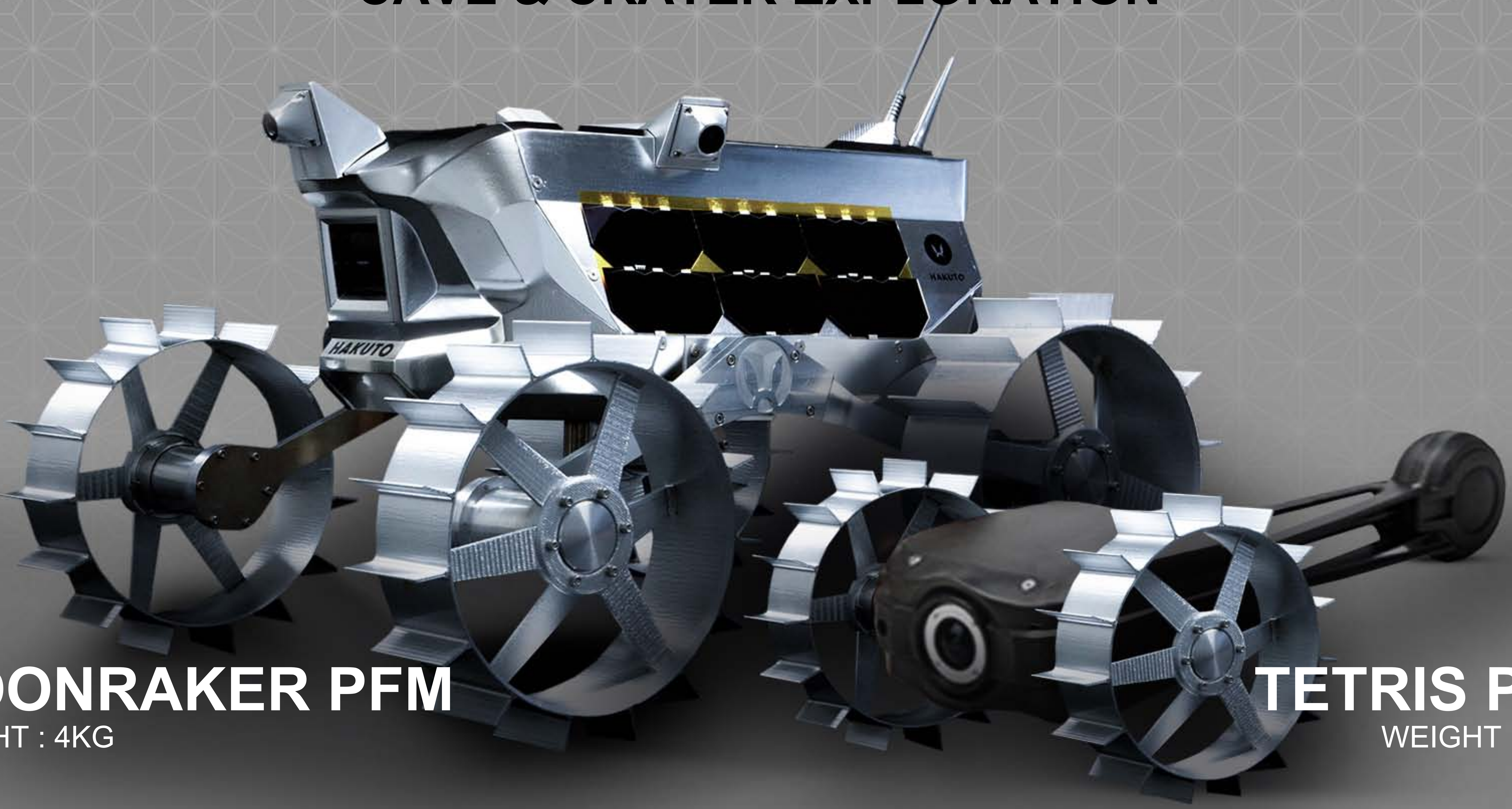
COMPACT HIGH-PERFORMANCE MASS SPECTROMETERS



Prototype



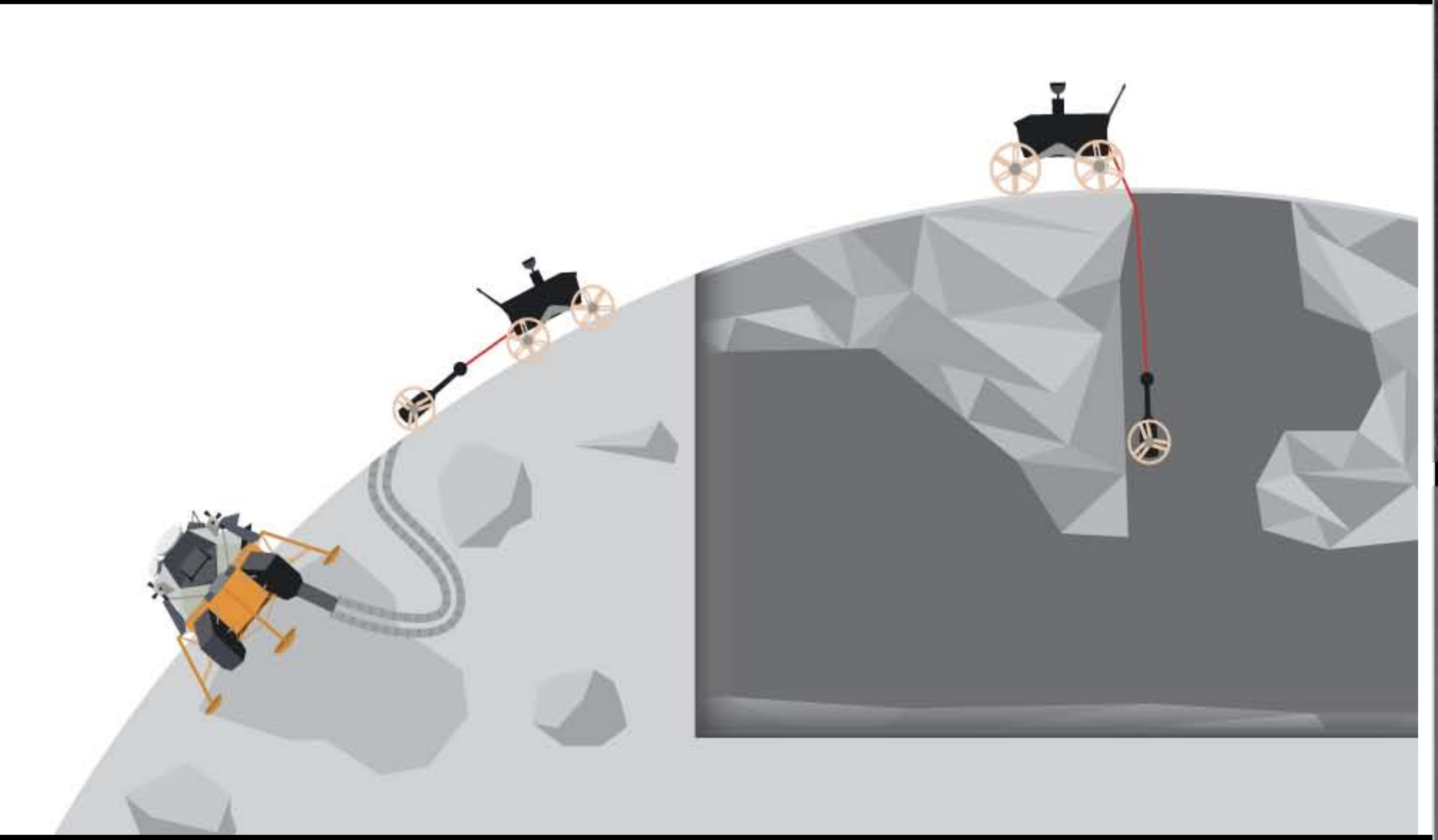
CAVE & CRATER EXPLORATION

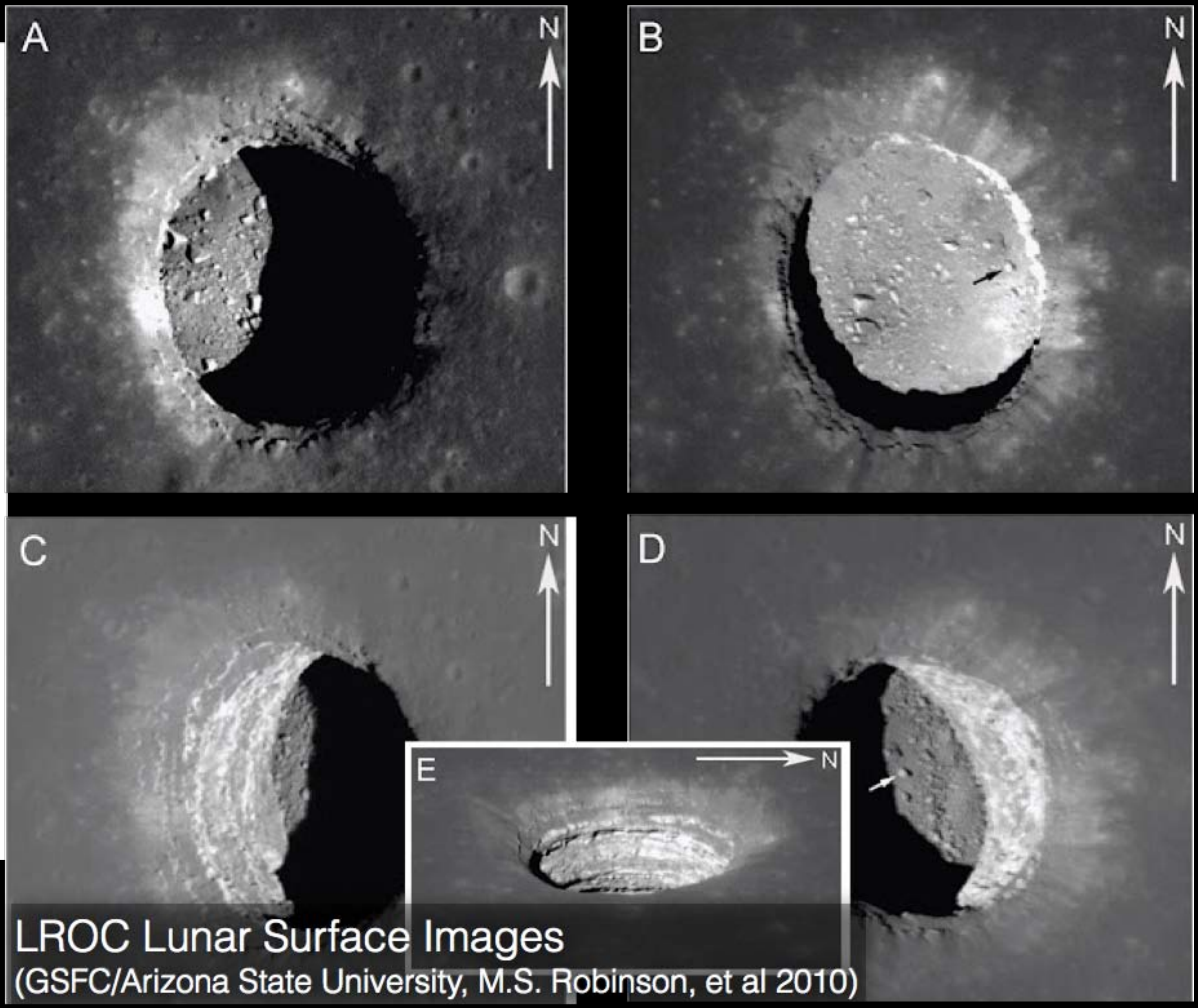


MOONRAKER PFM
WEIGHT : 4KG

TETRIS PFM
WEIGHT : 1.5KG

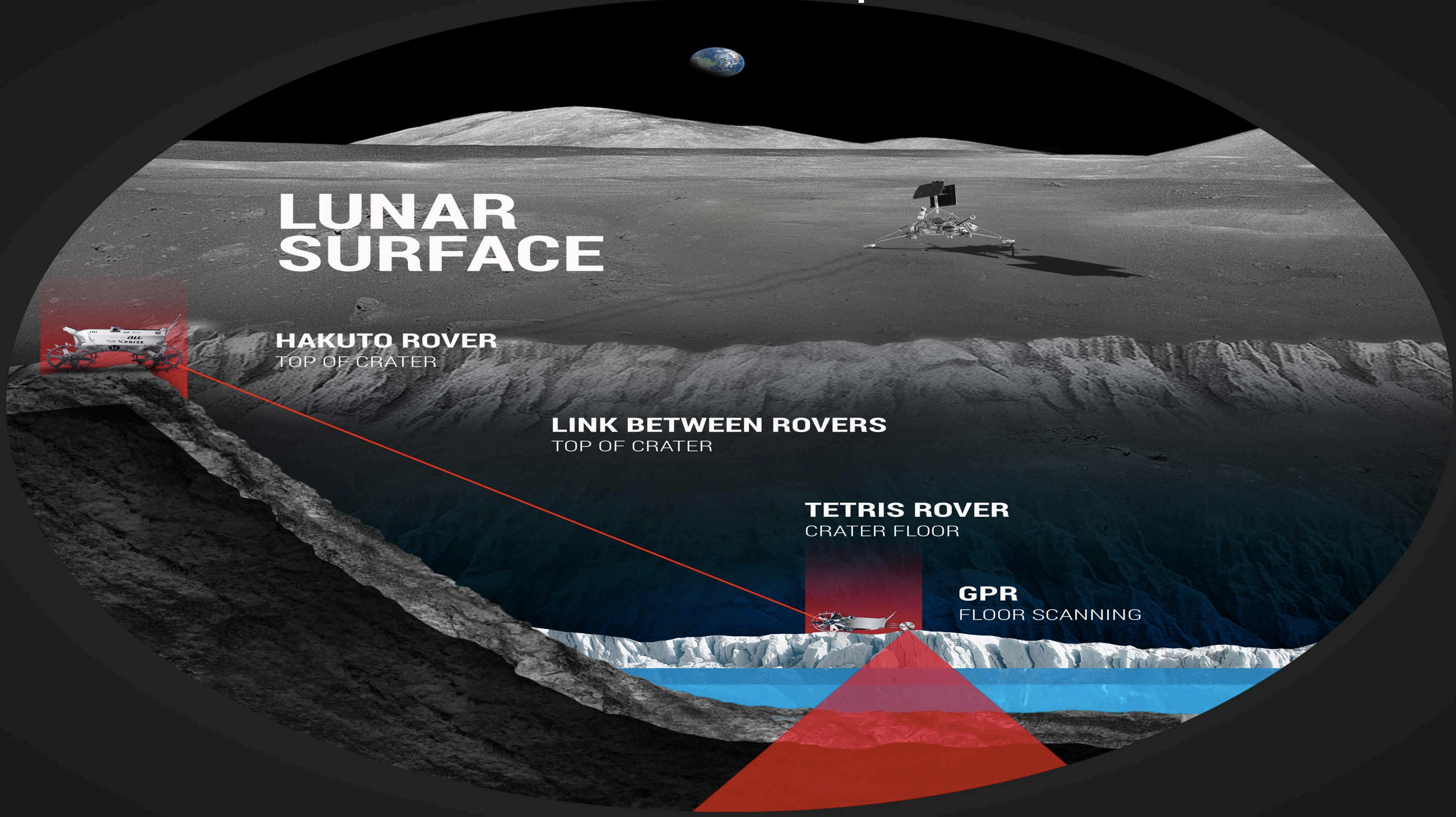
FUTURE MISSIONS: Lunar Skylight OR Crater Exploration





LROC Lunar Surface Images
(GSFC/Arizona State University, M.S. Robinson, et al 2010)

FUTURE MISSIONS: Crater Exploration



CAVE & CRATER EXPLORATION TEST

PHASE 3

SUPPORTING THE CISLUNAR ECONOSPHERE

THANK YOU FROM

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