

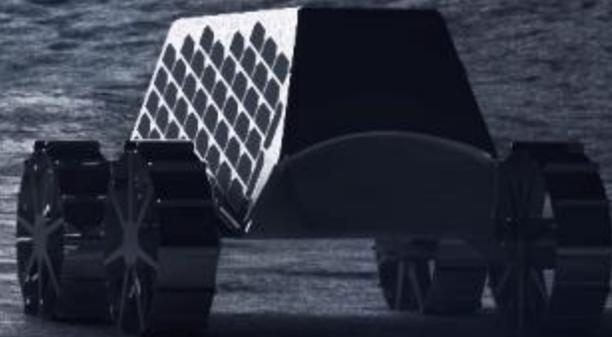


i s p a c e

Expand our planet. Expand our future.

Space Resources Roundtable

June 14, 2018

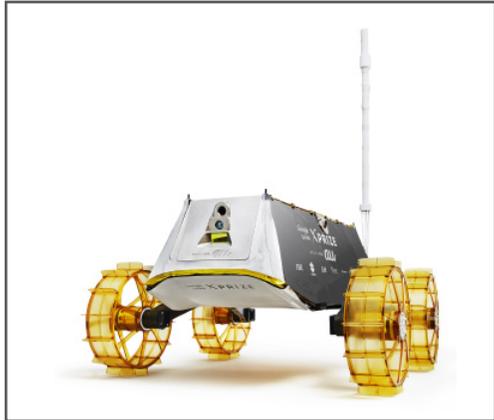


i s p a c e

Vision and Roadmap

Expand and sustain humanity's presence in space by utilizing resources available on the Moon

Space-ready Lunar Rover



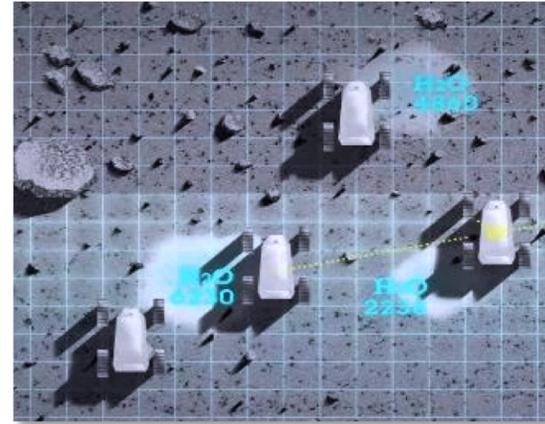
Completed qualification of 4kg Sorato lunar rover for Google lunar XPRIZE

First Private Lunar Mission



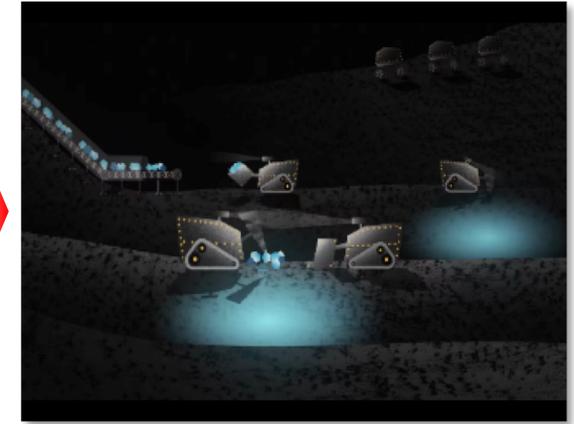
Demonstrate small-scale transportation to the lunar surface in 2021

Transportation & Data



Establish high-frequency, low-cost transportation to the Moon

ISRU-based Economy



Enable lunar ISRU and development of resource-based economy

Introduction to ispace

2017: a defining year

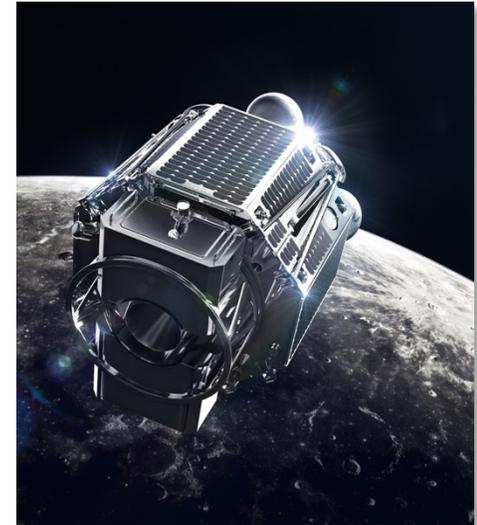
- Google Lunar XPRIZE finalist
- Sorato rover completed flight qualification
- Lander project held Systems Requirements Review
- Record Series A in Japan
- Opening of Europe office in addition to US and Japan
- Threefold growth to 60+ employees



Lander Service

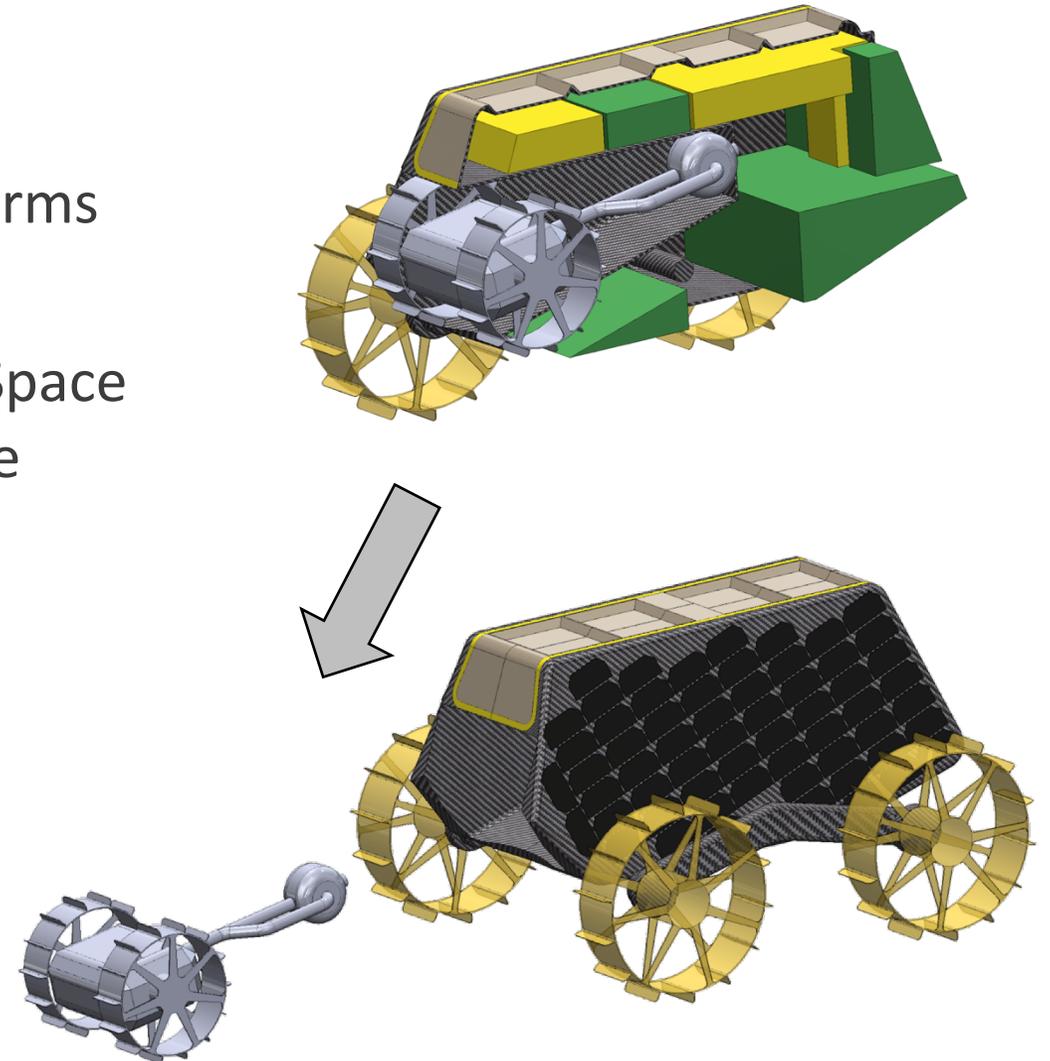
Fully Funded Development & Demonstration

- Philosophy: small-scale lander for maximum launch flexibility
 - Compatible as secondary payload on any GTO mission
 - Well suited for large scale exploration of the Moon
- Funded development and launch of two demonstration missions
 - Orbiting Mission in 2020
 - Soft-landing Mission in 2021
- Commercial payload delivery service
 - 30 kg of payload to lunar surface at all latitudes
 - RF Relay X-band downlink for HD Video
- Schedule
 - System Requirements Review held in November 2017
 - Preliminary Design Review July 2018



Rover Service

- ispace provides small-scale exploration platforms with flexible payload accommodation
- 10 year development at Tohoku University's Space Robotics Laboratory, commercialized at ispace
- New rovers based on Sorato design
 - 4 wheel rover: >3.5 kg total payload capacity
 - 2 wheel rover: 300 g payload capacity



Mission Value

Mission1-2

Reach the moon, explore lunar surface, and demonstrate technology.



Mission3-

High-frequency, cost-effective lunar transportation platform.

inspace's delivery service enables:

- Wide resource exploration of the Moon
- Stepwise ISRU demos with discrete payloads

Time Line

ispace Europe

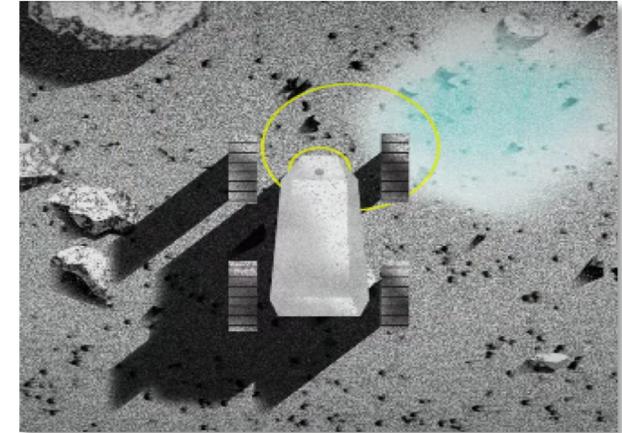
Already an active player in European space technology & policy

- Overview
 - Created 1 year ago to build upon synergies with the space resource initiative in Luxembourg and offer ispace services to the European market
 - Kyle Acierno, ispace EU Managing Director and Chairman of the Technical Committee of The Hague Space Resources International Working Group
- Research & Development
 - Simultaneous Localisation and Mapping for lunar rovers
 - Instrument maturation & co-development projects
- Mission Development & Operations
 - Polar Ice Explorer mission
- Next: Data Processing & Marketing
 - Resource-oriented science data products
 - Mineral Resource & Ore Reserve reports



Polar Ice Explorer

- The Polar Ice Explorer Mission is spurred by the desire to achieve ground-breaking science and exploration goals with an affordable commercial mission approach
- This is also expected to be the first public-private mission to explore the lunar poles for resources and generate maps of hydrogen deposits with 1 meter resolution
- Baseline mission: rover + neutron spectrometer
- Additional payload capacity (2-3 kg) is available for instruments that can further enhance the scientific and commercial value of this mission



Advancing knowledge on lunar water

Objective 1

- **Determine the local distribution and abundance of hydrogen in the subsurface regolith to be used for ISRU planning and orbiter data calibration**

Objective 2

- Characterize the form in which volatile species containing hydrogen are present in the subsurface regolith

Advancing knowledge of lunar environment

Objective 3

- **Assess the extension of the volatile-rich contamination produced by lander exhaustion plume**

Objective 4

- **Obtain soil mechanics information relevant for vehicle mobility, soil penetration, and the operation & maintenance of future ISRU equipment**

Polar Ice Explorer Pre-Phase A

Initial analyses indicate mission is feasible

- Target environment: permafrost areas
 - Traverse in “eclipse” requirement: >1 hour
- Surviving the lunar night is out of scope for this first mission
- Mechanical & Thermal
 - Initial analysis performed for eclipse cold-case
 - Will be the focus of Phase A design iteration
- RF subsystem
 - Lander acts as RF relay to ground
 - 1 km exploration radius

| | Polar Ice Explorer |
|---|--|
| Mission duration | ~8 days with 1 day of commissioning |
| Target region | polar, partially sunlit |
| Operations in Permanently Shadowed Region | Opportunistic |
| Payload | Neutron Spec., instrument of opportunity |
| Traverse | 2.5 km of total traverse w/ coarse H mapping |
| Analyses | 9 areas of fine mapping and sample analyses |

| | Current Best Estimate, kg |
|--------------------------|---------------------------|
| Enhanced Payload | 1.5 |
| Rover w/ baseline instr. | 7.8 |
| Interface to lander | 1.0 |
| Total | 10.3 |
| Margin to limit | 46% |

Opportunities for Collaboration

ispace seeks to advance ISRU with world-wide collaborations

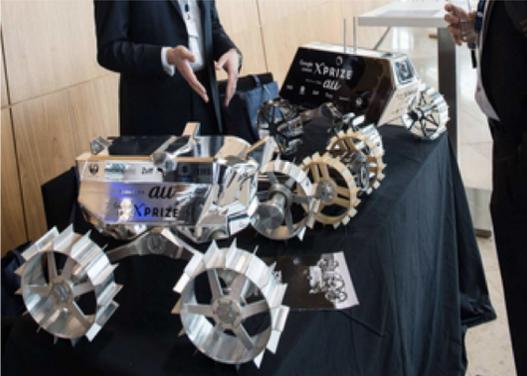
- Thanks to Luxembourg's Industrial Fellowship program, ispace Europe can partner with any university in the world to propose PhD and Postdoc research projects funded by PPPs
- Simultaneous Localisation and Mapping for lunar rovers (2017) in collaboration with University of Luxembourg
- Volatile and Ice-bearing Regolith Processing, Enrichment and Recovery (2018) in collaboration with Imperial College
- Reporting and Estimation of Space Resources and Ore Reserves (2018) in collaboration with University of Luxembourg and University of New South Wales
- ispace Europe is looking for partners to develop new instruments for resource exploration and payloads for stepwise demonstration of lunar ISRU



SPACE RESOURCES.LU

First-time FNR Investment in Space Exploration Projects

23/11/2017



For the first time, the Luxembourg National Research Fund (FNR) has committed funding to two space related projects contributing to the development of the SpaceResources.lu initiative.

