

 i s p a c e

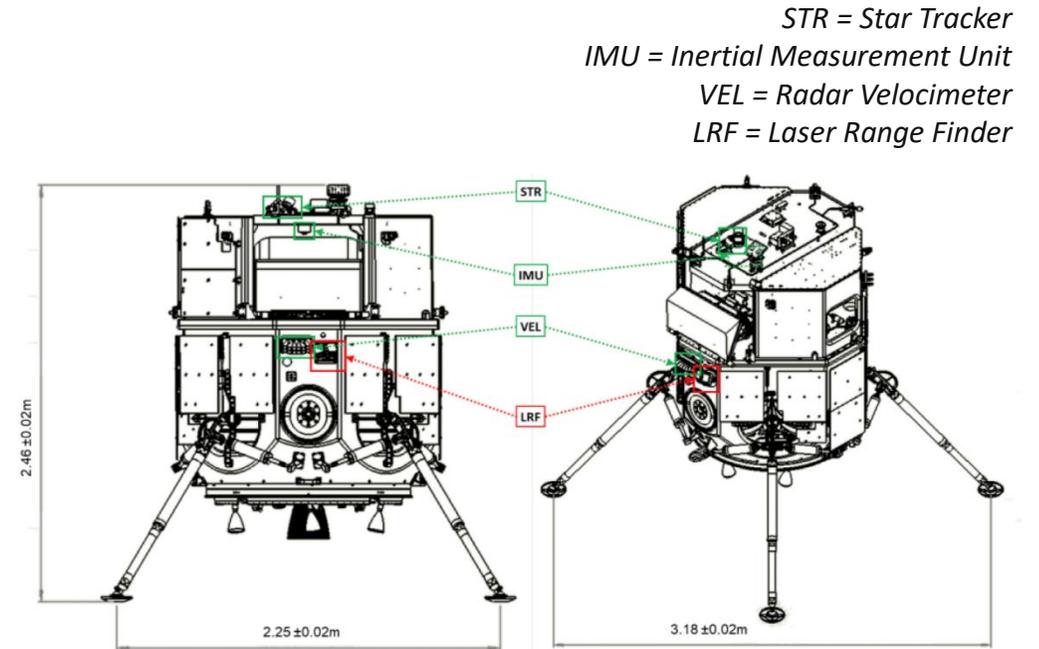
# External Review Task Force Report

March 27, 2026



# Background of the External Task Force

- On June 6, 2025, ispace's Mission 2 lunar landing failed.
- An analysis of flight data acquired up until the moment of the landing failure was immediately conducted. As a result, the company announced on June 24, 2025, that a hardware malfunction in the Laser Rangefinder\* (LRF) was the technical cause of the failed landing. (No software or other system anomalies, such as those in the propulsion or power systems other than the LRF, were identified.)
- The company took these two failures seriously, and, without dismissing the possibility that an internal perspective might be lacking, established an “External Task Force” to examine the situation from an external perspective**



*Hakuto-R M2 Lunar Lander and key sensors*

# Objective of the External Task Force

- ☀ To provide an independent third-party perspective on the validity of the company's internal technical cause analysis of the M2 landing failure and to provide additional insight on the technical and systemic factors that may have contributed
- ☀ To provide a set of third-party recommendations for future ispace missions and raise the maturity of lunar landing technology to a level sufficient for commercialization.
- ☀ To provide a third-party perspective to clarify ispace's current status (what ispace has / has not achieved) from an expert perspective, disclose it transparently, and maintain trust with all stakeholders (shareholders, customers, governments, etc.).

# Task Force Overview

- ☀ The taskforce consists of 12 members (see next page)
- ☀ The taskforce conducted activities for approx. 100 days, starting on September 10, 2025, with a total of five sessions held
- ☀ The taskforce reviewed technical documents prepared by ispace and conduct Q&A and discussions
- ☀ Based on the input of the co-chairs, it was decided to adopt the CAST methodology to analyze the M2 landing failure and formulate recommendations to ispace

# External Taskforce Members

 Consisting of total eight external members, lead by two co-chairs, and four internal members



**Olivier de Weck**

*Apollo Program Professor of Astronautics and Engineering Systems  
Associate Department Head of Aero Astro (Course XVI)  
Massachusetts Institute of Technology*



**Naohiko Kohtake**

*Professor, Grad. School of System Design & Management,  
Keio University  
Visiting Professor, Center for Design Research, Stanford University*



**Koji Yamanaka**

*Director of Space Exploration Center  
JAXA*



**Christopher N. D'Souza**

*Technical Fellow for Guidance, Navigation  
and Control, NASA*



**Miguel San Martín**

*Chief Engineer, Guidance and Control  
NASA Jet Propulsion Laboratory*



**Olivier Dubois-Matra**

*Guidance, Navigation and Control System  
Engineer, ESA*



**Takashi Makino**

*Member of ispace External Board of  
Directors  
former CEO of IHI Aerospace*



**Kevin Duda**

*Program Manager  
Draper Laboratory*



**Ryo Ujiie**

*Chief Technology Officer  
ispace*



**Jeremy Fix**

*Chief Engineer  
ispace-US*



**David Rousseleau**

*Safety and Product Assurance Manager  
Ispace – Liaison to Task Force*



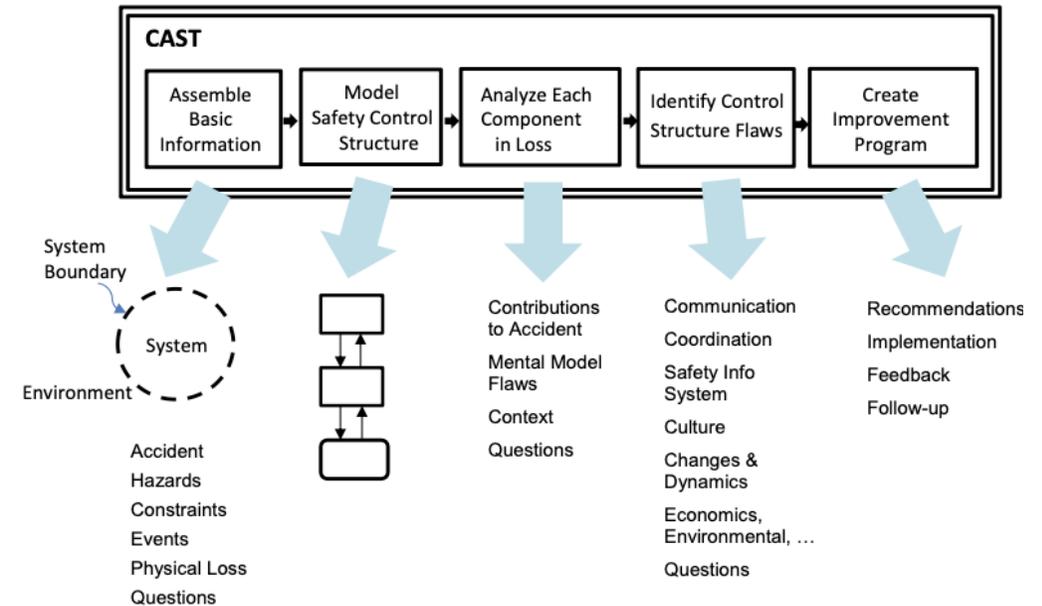
**Yoshi Hitachi**

*Executive Vice President, Japan  
Engineering Office, ispace inc.*

# CAST Methodology

**CAST methodology (Causal Analysis based on Systems Theory)** is an accident and incident analysis technique used to understand why a loss occurred in complex sociotechnical systems. It is based on the System-Theoretic Accident Model and Processes (STAMP) and views safety as a system control problem, including human behavior, management oversight, and safety culture, rather than just individual component failures. (ref. [CAST HANDBOOK: How to Learn More from Incidents and Accidents, by Nancy G. Leveson](#))

The objective of this approach is to identify all, or at least as many as possible, technical and organizational control failures, in order to maximize the learning from an accident or incident. **The goal of CAST is not to assign blame but to explain and improve the future.**



**(A) Operating level**

1. Implement a Terrain Relative Navigation (TRN)

2. Take advantage of fuel remaining opportunity to reduce landing risk

**7****Recommendations****(B) System Development level**

3. Improve vendor selection process

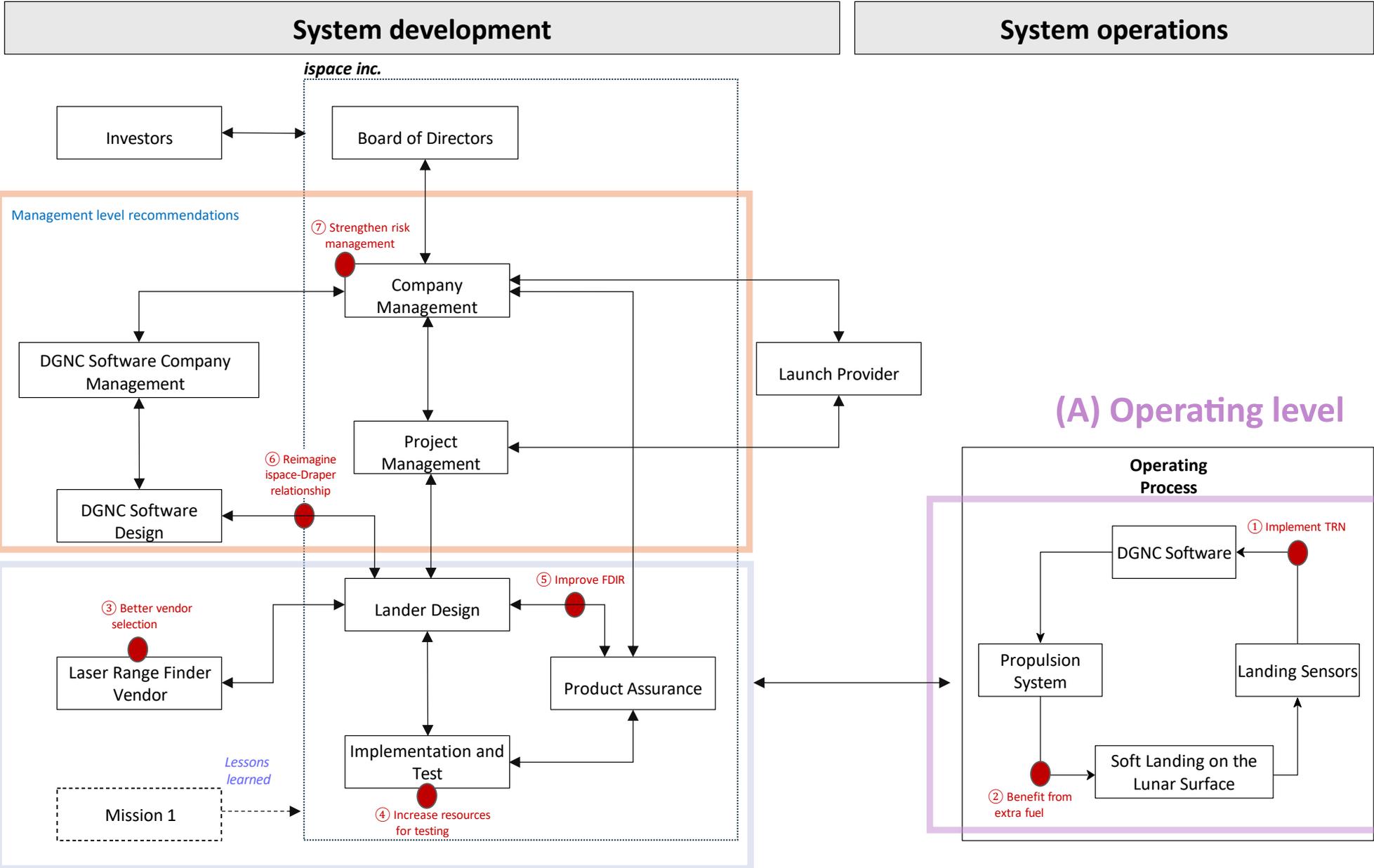
4. Increase project resources allocated for testing

5. Improve FDIR (Fault detection, isolation, and recovery) design and validation

**(C) Management Decision level**

6. Improve interaction between ispace and Draper

7. Reinforce company management risk approach



(C) Management Decision level

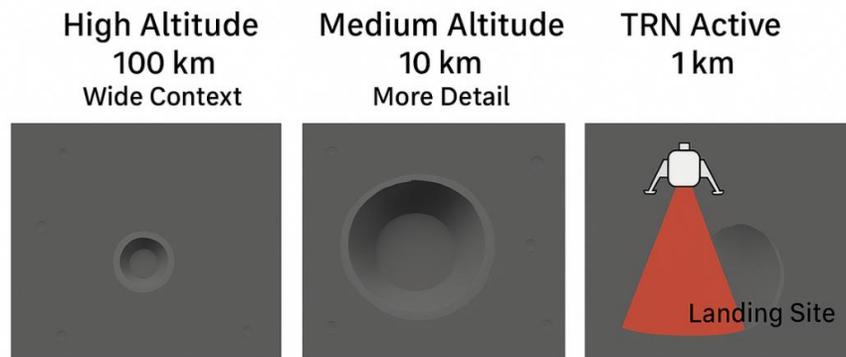
(B) System Development level

(A) Operating level

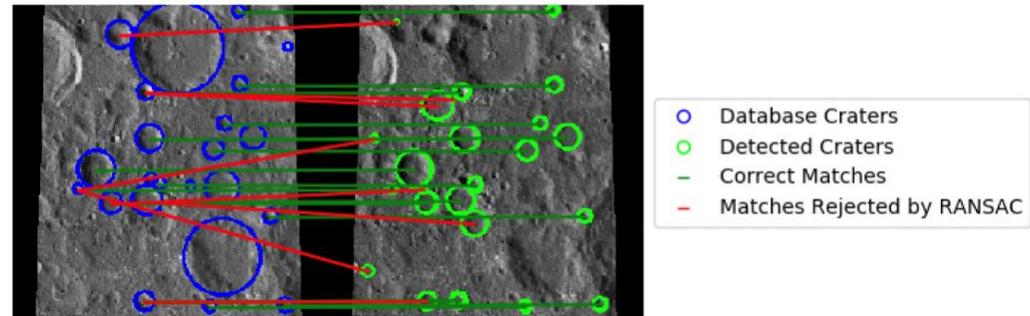
## (A) Operating level

# 1: Implement a Terrain Relative Navigation (TRN)

- ☀ To estimate its altitude during the descent, Mission 2 lander relied on IMU units, which leads to large propagation uncertainty, and on the LRF measurements, which is the only sensor providing accurate data
- ☀ Terrain Relative Navigation (TRN) here should be altitude independent in order to be really an additional source of altitude measurement, as it should not rely on an existing altitude estimation or measurement
- ☀ External Task Force recommends that a future lander should take advantage of TRN to estimate altitude and velocity (horizontal and vertical) to decrease dependency towards a single sensor type



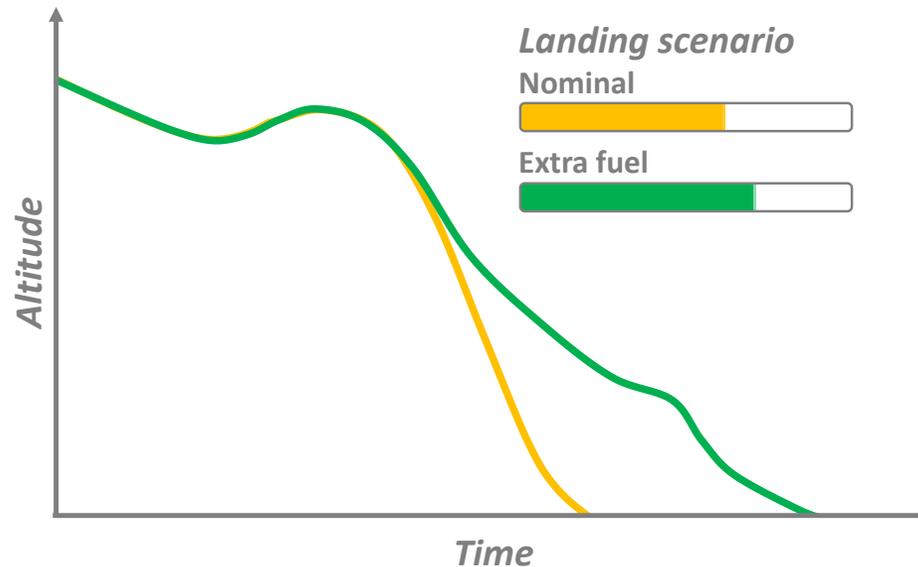
Terrain Relative Navigation (TRN): camera image features are matched to an onboard lunar terrain map to estimate position and altitude.



Downes, Lena M., Ted J. Steiner, and Jonathan P. How. "Lunar terrain relative navigation using a convolutional neural network for visual crater detection." In 2020 American Control Conference (ACC), pp. 4448-4453. IEEE, 2020.

## 2: Take advantage of fuel remaining opportunity to reduce landing risk

- At the time of EDL transition (start of the descent sequence), the lander had roughly 4% (in kg) extra propellant in the tanks, compared to the requirement given to Draper as maximum usable propellant
- It was not identified, at the beginning of the program, to be able to use the extra propellant likely available (from the minimum expected value)
- It is recommended to take advantage of the expected extra propellant availability, within the descent design, to allow a “safer” landing approach design



### 3: Improve vendor selection process

- Buying a sensor is not just buying a sensor, it's buying the company behind the sensor
- Such sensors are generally procured as black boxes with only terrestrial uses (mainly military), with low to no appetite by the unit manufacturer, to perform additional tests or even answer questions relative to use in space and landing environment.
- For such critical application, minimum collaboration from the unit manufacturer is critical to ensure correct understanding and modeling of the unit (as mentioned in above points)
- As a general recommendation, whatever the technical specification of a sensor, if the company behind it is not willing to collaborate (and willing to only sell it as a black box), ispace should try to find another sensor

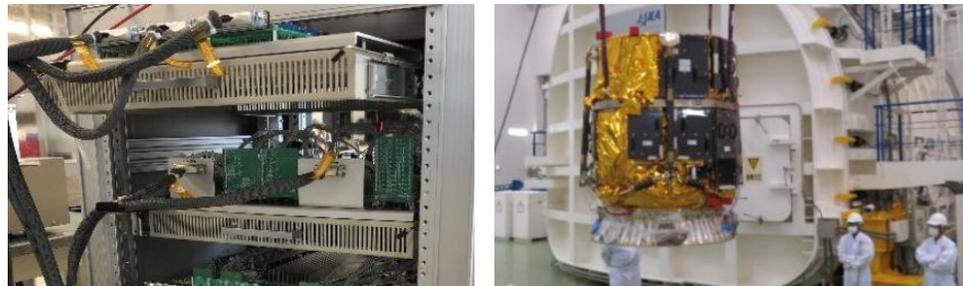
	Unit A	Unit B
<b>Technical Spec.</b>		
• Requirement A	✓	✗
• Requirement B	✓	✓
• Requirement C	!	✓
<b>Cost</b>	✓	!
<b>Schedule</b>	✗	✓
<b>Vendor Assessment</b>		
• Quality	✓	✓
• Willing to support?	✗	!

## 4: Increase project resources allocated for testing

- ⚙️ Initial project resource allocation should be reconsidered for sensor verification testing and model correlation
- ⚙️ During Mission 2, the LRF was tested and modeled as a black box, only defined by its performance specifications
- ⚙️ As a general recommendation, landing sensors, as well as any other units, should be tested and verified under representative conditions (TEST AS YOU FLY). Test limitations can prevent reaching realistic conditions and the system should be designed to operate successfully under the minimum validated conditions (FLY AS YOU TEST)
- ⚙️ For landing sensor, External Task Force recommends developing a physic-based model, supported by rigorous testing, allowing simulation of the unit behavior under the expected descent conditions and identification of more systematically possible limitations

*TEST AS YOU FLY*

*FLY AS YOU TEST*



*M2 ground testing*

## 5: Improve FDIR design and validation (Plan B)

- ❁ Fault detection, isolation and recovery requirements (FDIR), defined by ispace for the DGNC software design, included only the detection of a single sensor failure for each sensor type, and not both units' failure in the case of the LFR
- ❁ Therefore, DGNC software did not include a plan B or off-nominal scenario covering the low-performance issue encountered during M2 descent, although the risk of LRF low performance was identified
- ❁ External Task Force recommends ispace to implement a more robust FDIR strategy, covering the landing sensors under-performance, or common failure mode, feeding the lander system design and sensor performance requirements, allowing to implement systematic detection and design off-nominal scenarios

### DETECTION



### ISOLATION



### RECOVERY

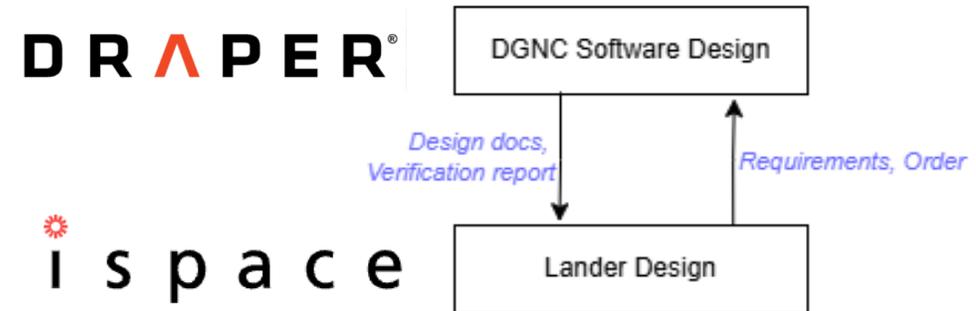


## 6: Improve interaction between ispace and Draper

# 7

Recommendations

- ☀ The working relationship between Draper and ispace was very good with good communication between engineers, back and forth, although the teams were working from different continents. Draper was given a clear scope of work and requirements and delivered as expected
- ☀ The decision by ispace to outsource GNC development to Draper can be evaluated as a reasonable direction from a business strategic perspective, especially during the early days of ispace in 2018
- ☀ However, GNC (including DGNC software) is not a commodity, it is part of the system. GNC must have an influence on how we fly the system and cannot be treated as an isolated sub-system
- ☀ In the future, Either ispace needs to hire more GNC engineers with prior experience and be able to consider more extensive failure and performance degradation scenarios, or Draper is given a larger responsibility within the program, acting as part of the system engineering team, for the requirement definition, sensor selection, performance verification and model validation

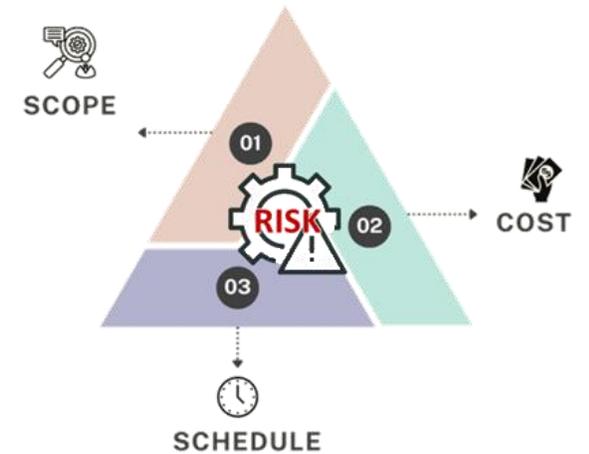


# 7: Reinforce company management risk approach

# 7

Recommendations

- For the particular risk of under-performing LRF sensor and its catastrophic impact on the mission, the residual risk was identified at DGNC software CDR and delta CDR, as well as communicated between Draper and ispace management
- However, management's risk perception, primarily in terms of its probability, is deemed not appropriate
- External Task Force recommends that risk processing and risk evaluation, at engineering and company management level, should be reinforced. At company's upper level, residual risk shall be assessed considering the possibility to delay a mission, to further reduce mission risk



**(A) Operating level**

1. Implement a Terrain Relative Navigation (TRN)

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**7****Recommendations****(B) System Development level**

3. Improve vendor selection process

4. Increase project resources allocated for testing

5. Improve FDIR (Fault detection, isolation, and recovery) design and validation

**(C) Management Decision level**

6. Improve interaction between ispace and Draper

7. Reinforce company management risk approach

# Essential Challenge as a Commercial Player



# ispace Counter measures

## (A) Operating level

- 1. Implement a Terrain Relative Navigation (TRN)
- 2. Take advantage of fuel remaining opportunity to reduce landing risk

## (B) System Development level

- 3. Improve vendor selection process
- 4. Increase project resources allocated for testing
- 5. Improve FDIR (Fault detection, isolation, and recovery) design and validation

## (C) Management Decision level

- 6. Improve interaction between ispace and Draper
- 7. Reinforce company management risk approach

## ispace Counter measures

1. Implement TRN based on JAXA/SLIM heritage from Series-3
2. Plan not only off-nominal scenario under the worst conditions but also more robust scenario under nominal conditions
3. Update critical component vendor selection criteria; cooperation/transparency to make the critical component “white box”
4. Expand Flight Operation Group to “Test & Flight Operation Group” which works on system level test preparation and execution as well as flight operation
5. Add “Mission Critical Failure Analysis” on FMECA in the FDIR design process
6. Newly establish “EDL (Entry, Descend, and Landing) division” in charge of vertically integrate EDL design from requirement to test, with support from external experts (e.g. JAXA and Draper)
7. Create a new management advisory panel called “Technical Risk Review Panel,” which can independently raise mission technical risk to the board.  
Improve the process of risk identification, risk qualification, and risk mitigation/reduction -> Make a correct risk culture

# WE-GO-BEYOND

- ☀ Repeated challenges and improvements within limited resources are the essential challenge for ispace, who must pioneer the space business in the private sector as a frontrunner
- ☀ What matters is not to eliminate risk and avoid it completely, but transforming risk into a manageable form through verification and learning, which we will lead to ispace's competitiveness and long-term corporate value
- ☀ We have a responsibility to learn sincerely from our failures. We ask for your continued encouragement and warm support as we take on these challenges



# Business Strategy Update

March 27, 2026



# Today's Summary

- 🔴 **Engine Change:** The lander engine will switch from the “VoidRunner” engine, which had been experiencing development delays, to an alternative engine
- 🔴 **Mission Quality:** In response to growing market demand for mission quality and development efficiency, will integrate the Japanese and U.S. lander models and transition to a new model
- 🔴 **Schedule Update:** Due to the two changes mentioned above, the launch of the next U.S. mission has been rescheduled for 2030 (ispace's next mission is in 2028)
- 🔴 **New Service:** “Lunar Connect Service,” launching a satellite network of 5 lunar orbiting satellites by 2030. First launch into lunar orbit as early as 2027.

# Lunar development accelerating, led by the United States and Japan



Credit: The white house



## Executive Order by the Trump Administration

- Achieve a crewed lunar landing by 2028 and establish a lunar base and a lunar nuclear reactor by 2030<sup>(1)</sup>
- Vigorously promote the construction of lunar outposts and resource development led by the private sector<sup>(1)</sup>



Credit: NASA/Joel Kowsky



## NASA's Acceleration of Private Lunar Exploration

- Focusing on the construction of a lunar base with an investment of approximately 3 trillion yen
- Accelerating robotic landings by leveraging the CLPS program



Credit: 内閣府



## Convening of the Japan Strategy Council Growth

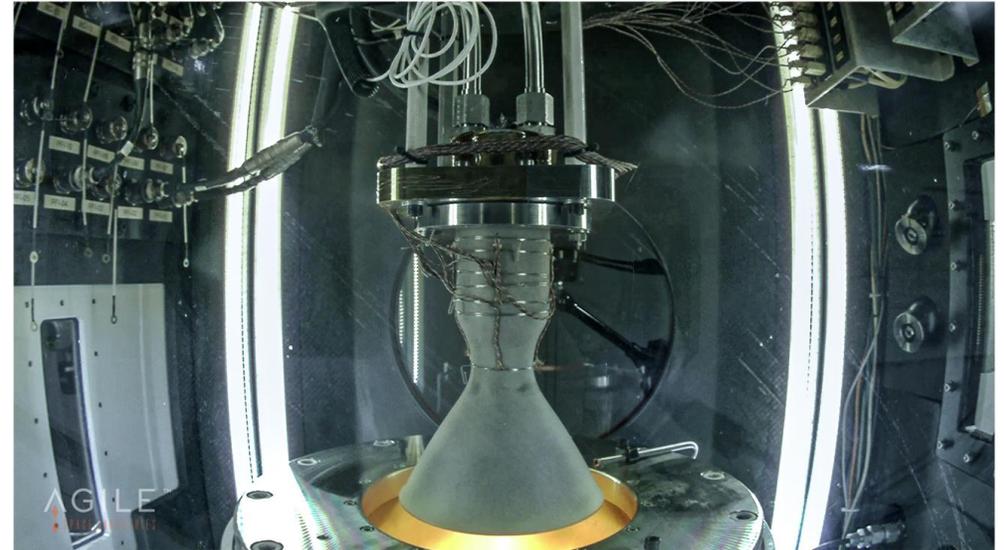
- A review meeting on the aerospace sector, chaired by Minister of State for Special Missions Onoda, was held
- CEO Hakamada proposed public-private partnership investment from the perspective of economic security

(1) <https://www.whitehouse.gov/presidential-actions/2025/12/ensuring-american-space-superiority/>

(2) <https://www.nasa.gov/commercial-lunar-payload-services/>

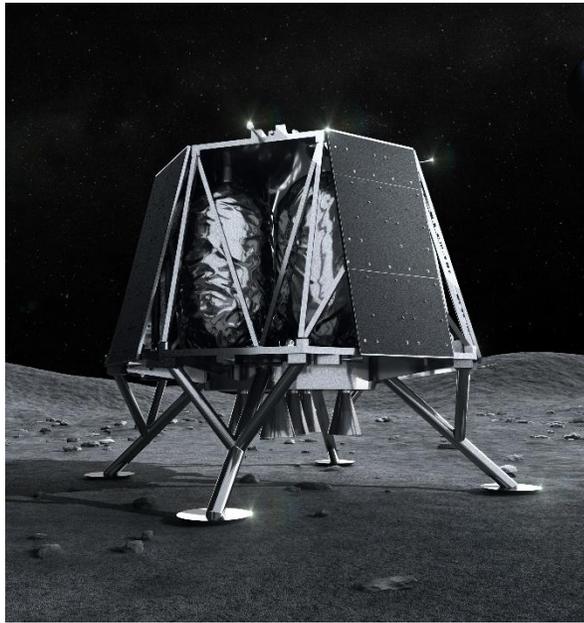
# Change of Engine

- ⚠ Development delays have occurred with the “VoidRunner” engine, currently being developed by U.S.-based Agile for inclusion in Mission 3 and later models
- ⚠ Following the decision to switch to a new alternative engine, the M3 development plan will also be revised
- ⚠ Landers used in M4 and later versions are also scheduled to be upgraded with the new engine



# Integration of Japan & U.S. Lander Models

- Two different lander models have been in development in parallel in Japan and the U.S.
- As demand for lunar development accelerates, customer expectations for improved mission quality and development efficiency are rising



**APEX 1.0**



**SERIES 3 LUNAR LANDER**

**Integration of Japanese and U.S. Landers**

**Revising the M3 development plan by migrating APEX 1.0 to a new model**

# Mission 3 Schedule Change

**2027**

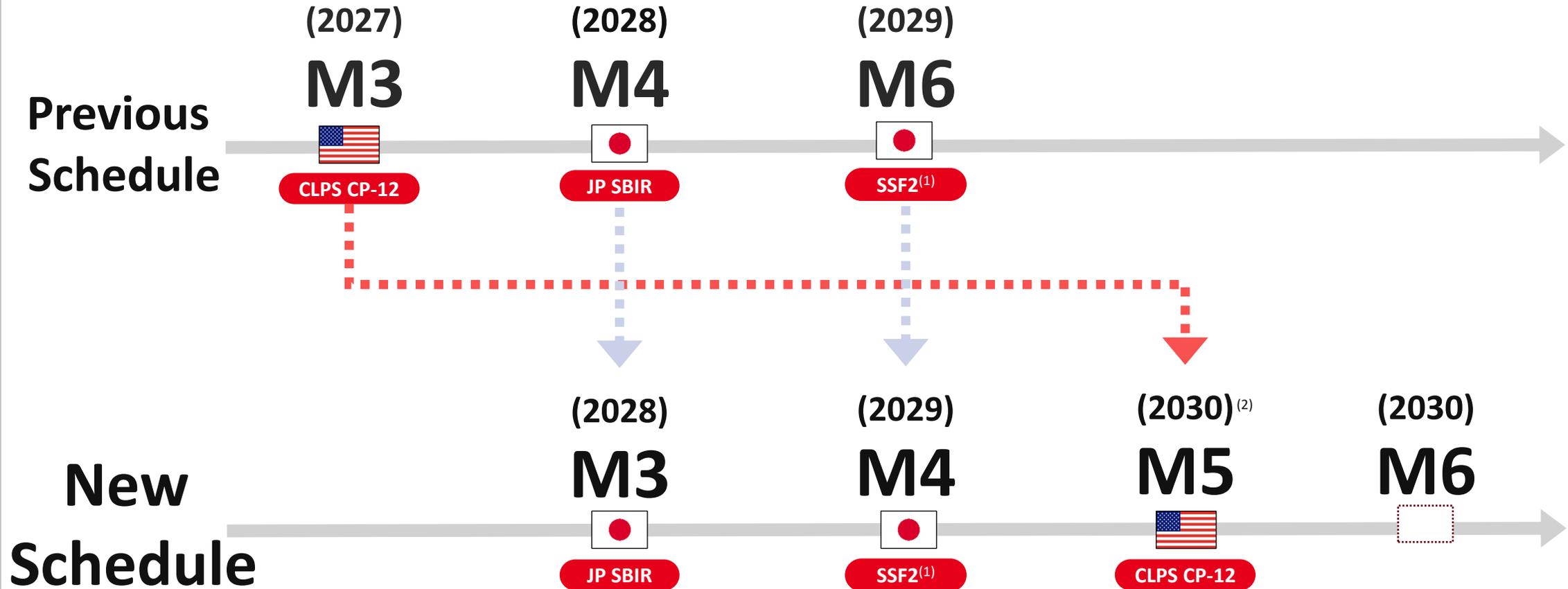


**New**  
**2030**

(1)

- **Engine Change**
- **Integration of Landers**  
( Upgrade from APEX 1.0 to the new model )

# Mission 3 Schedule Change



(1) Refers to the second phase of JAXA's Space Strategy Fund

(2) As this mission was selected for NASA's Commercial Lunar Payload Services (CLPS) task order CP-12 as part of Team Draper, the execution of CP-12 under the revised schedule is pending approval by NASA.

# Impact on Payload Customers



**Mission 3 was selected for NASA's CLPS Task Order CP-12 (as part of Team Draper).**

**We plan to finalize the specific terms of a contract with Draper/NASA in the near future**



**Following the changes, the mission will aim to make the most of the technical and operational insights and achievements gained from the previous two lunar landing missions**

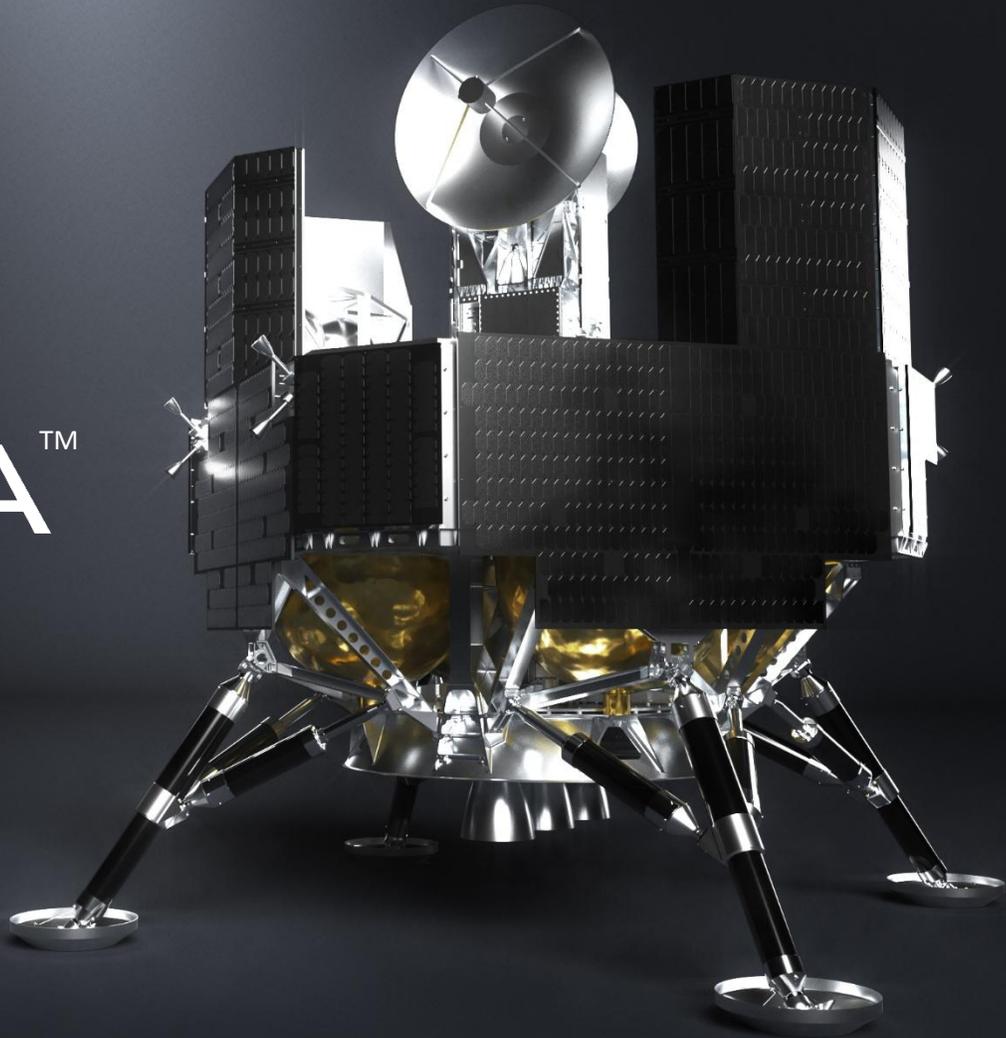


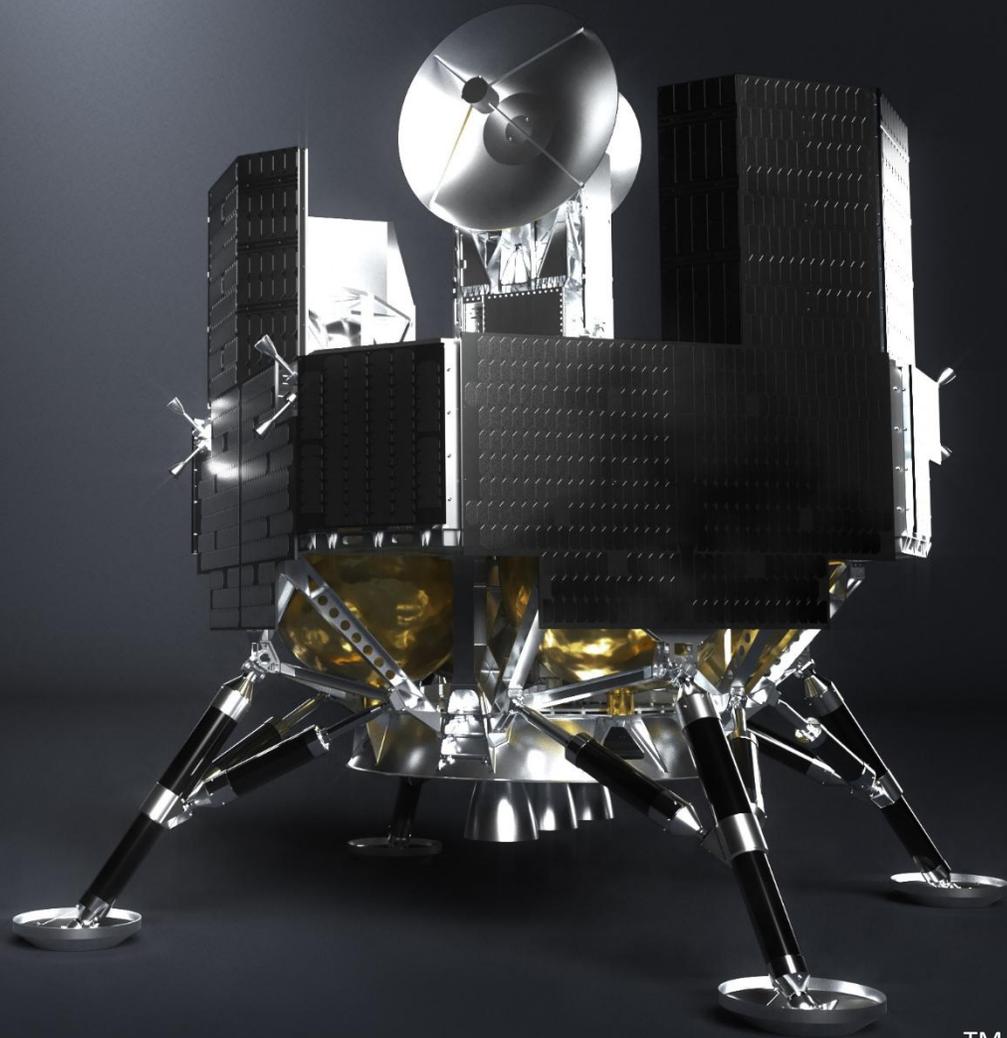
**Payload service contracts with existing commercial customers will be systematically amended**

# Impact on Operations (Cost)

- ⚙️ **The impact on performance for this fiscal year and beyond is currently being assessed**
- ⚙️ **Additional costs are expected to arise due to engine change, modifications to the M3 model, and schedule updates**

# ULTRA™





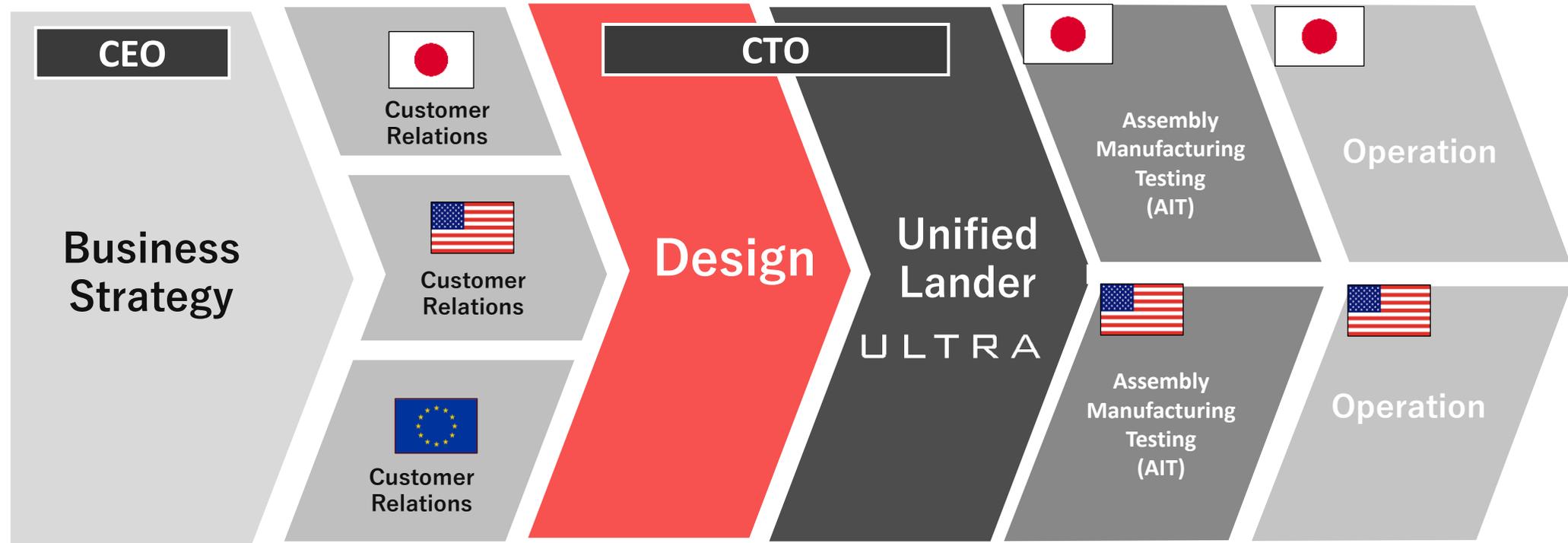
# ULTRA™

- Based on development know-how for large landers, pioneered by APEX 1.0
- Series-3 capitalizes on insights gained from previous two missions



- Aims to maximize quality
- Improves development efficiency through single integrated model

# Restructuring of Global Development Framework



- ☀ Staffing levels and personnel assignments across operations in both Japan and the U.S., will be implemented through structural reforms with the aim of maximizing lander quality and reducing costs company-wide.



 By establishing a manufacturing infrastructure in the United States, a structure was created capable of meeting U.S. domestic sourcing requirements



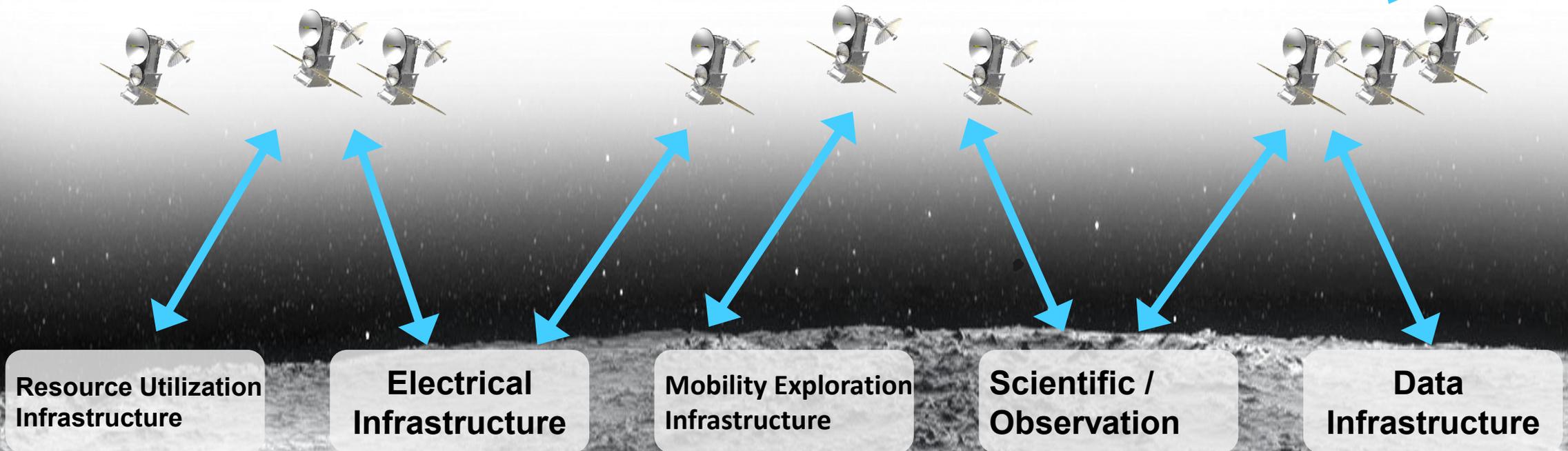
inspace's Lunar Orbiting Satellite Service

# Lunar Connect Service



# Types of Services offered

- As lunar transportation and construction of lunar infrastructure gain momentum, demand for services utilizing lunar satellites is expected to accelerate
- Communications, positioning, observation, space situational awareness (SSA)



# **Lunar Connect Service**

# Expected Services to be Provided

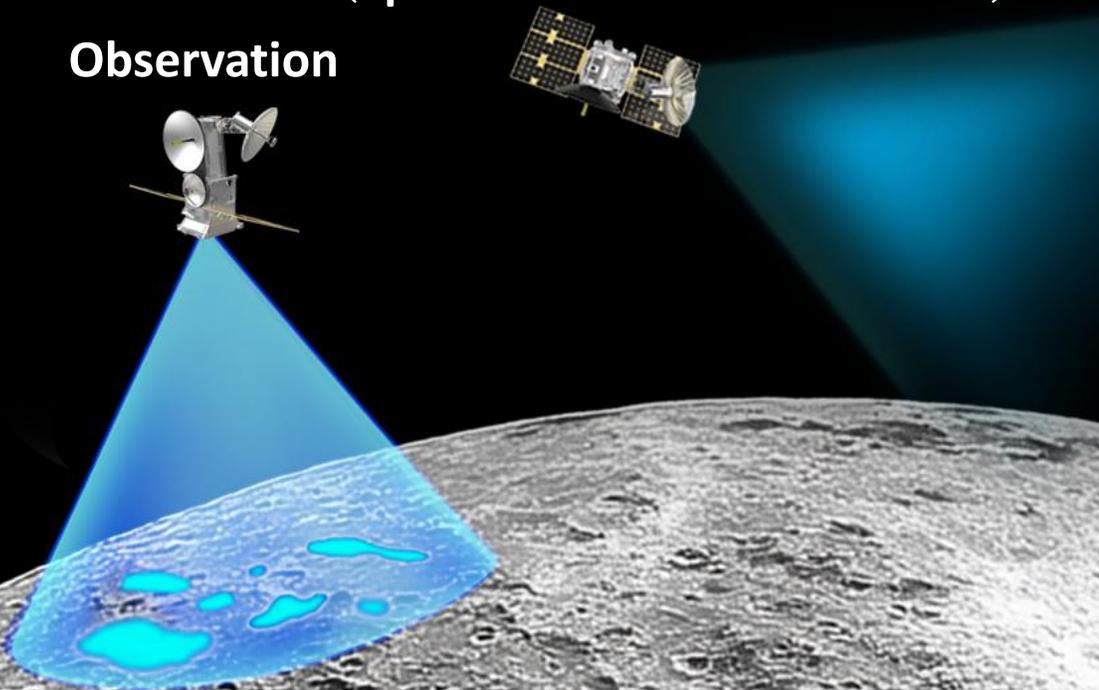
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## Data Service

SSA

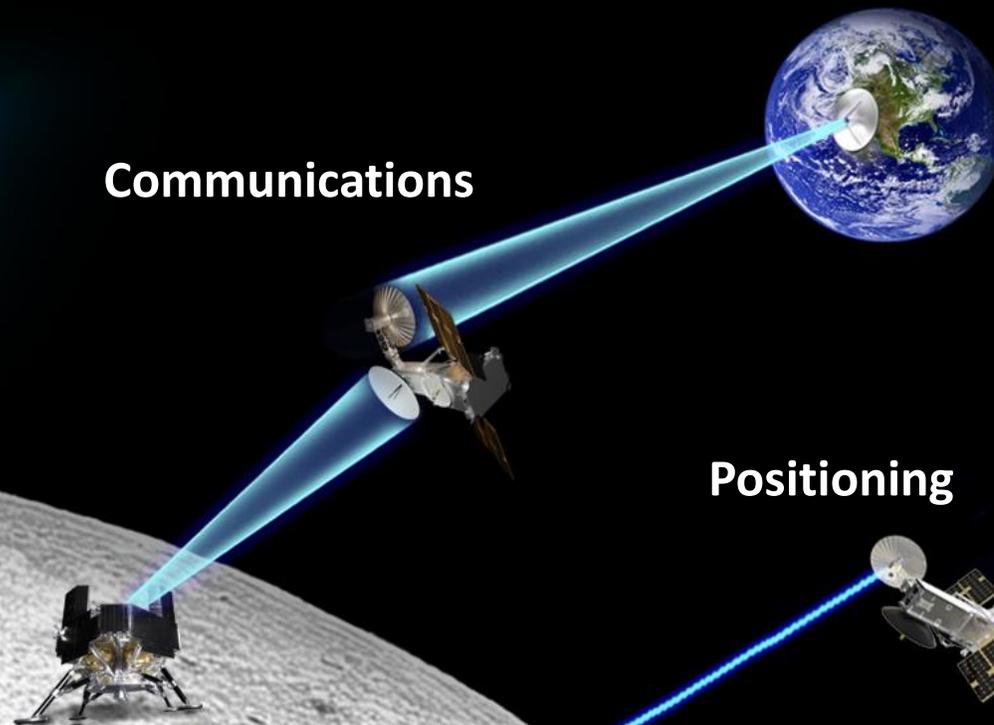
(Space Situational Awareness)

Observation

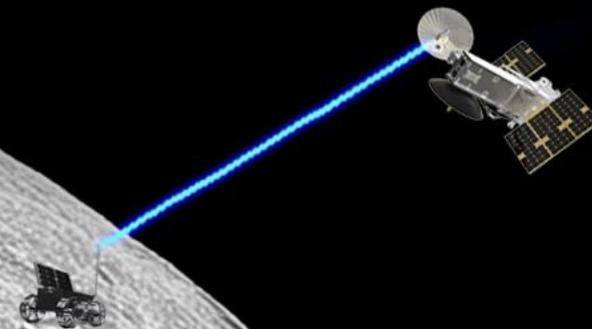


## Lunar Connect Service

Communications



Positioning



# Estimated annual market size for the 2040s

(Internal estimates)

~\$266M  
USD

~\$1.0B  
USD

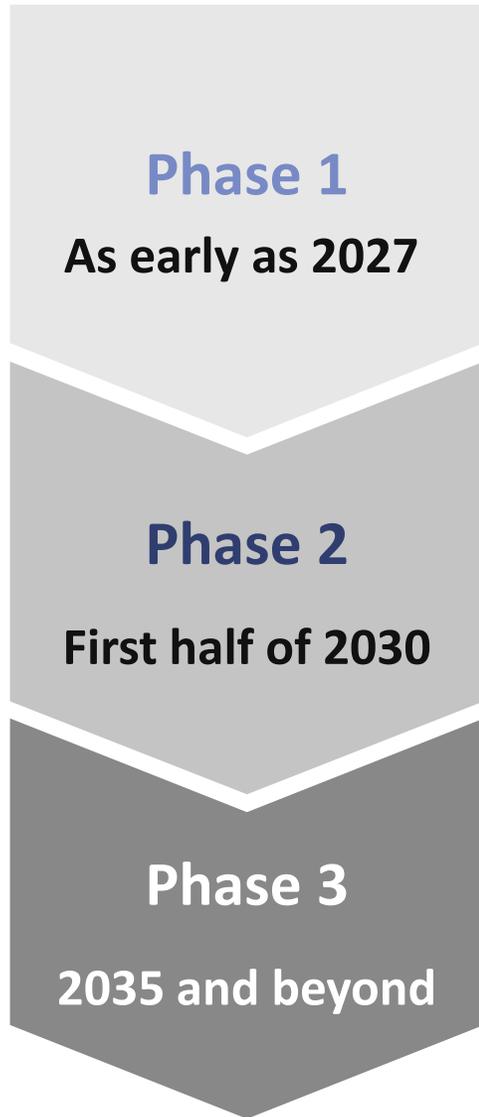
~\$1.2B  
USD

~\$600M  
USD

 According to internal estimates, the market is expected to exceed at least \$3 billion USD (450 billion yen) annually by the 2040s

- Communications Services: Estimates of projected data rate demand (Gbps) and projected unit prices for the 2040s, based on information from a U.S. concept study (Luna-10)
- Positioning Services: Estimate of the number of positioning nodes (users) and the projected unit price for the 2040s, based on information from a U.S. concept study (Luna-10)
- Observation and SSA Services: Based on projections, estimated based on the number of contracts and unit prices associated with the provision of these services, as anticipated for the 2040s.

# Expanding services scheduled to launch as early as 2027



Participation in  
Telecommunications Services  
(Includes trial elements)

Launch of trial  
communication and positioning  
services compliant with  
international standards

Launch of Positioning Services  
Enhanced Technical Advantages  
Commercialization

- Planned to launch at least five proprietary satellites into lunar orbit by 2030
- Planned to launch communication and observation services as soon as possible, with broad coverage focused on the Moon's far side
- As a first step, **ispace has reached an agreement with U.S.-based Argo Space Corp.** for a delivery of one satellite to lunar orbit using their in-space transportation vehicle. ispace aims to place five satellites into lunar orbit and commence communication services as early as 2027



- **Signed a memorandum of understanding with KDDI** to proceed with joint discussions regarding the operation and use of ground stations on Earth



# New Mission Schedule

	(Completed) 「R&D Phase」	Lunar Landers & Satellites 「Early Commercialization Phase」		Expected to Improve Profitability 「Mass Production Phase」			
Orbital Transfer Vehicle (OTV)							
Lunar Satellites							
Lunar Landers	  (2022/12) M1	 (2025/1) M2	  (2027) M2.5	 (2028) M3	 (2029) M4	 (2030) <sup>(3)</sup> M5	 (2030) M6
Primary Customers (Government Contracts)	 Private	 Private	 JP SBIR SSF1 <sup>(1)</sup>	 SSF2 <sup>(2)</sup> MAGPIE	 CLPS CP-12		

(1) Refers to the first phase of the Space Strategy Fund established by JAXA

(2) Refers to the second phase of JAXA's Space Strategy Fund

(3) As this mission was selected for NASA's Commercial Lunar Payload Services (CLPS) task order CP-12 as part of Team Draper, the execution of CP-12 under the revised schedule is pending approval by NASA.

# Summary

- ❁ **The decision was made to switch from the “VoidRunner” engine, which had been experiencing development delays, to an alternative engine**
- ❁ **In response to growing market demand for mission quality and development efficiency, the Japanese and U.S. lander models have been consolidated, and a decision has been made to transition to a new model**
- ❁ **As a result of these two changes, the launch schedule for the next U.S. mission has been revised to 2030 (ispace’s next mission is scheduled for 2028)**
- ❁ **The “Lunar Connect Service” will place one satellite into lunar orbit as early as 2027, with a total of five company-owned satellites to be deployed by 2030**

**WE - GO - BEYOND**

# ULTRA™

