# The 2nd Deep Space Workshop

## Key to Success, Lessons Learned, and Things to keep in mind for development in Deep Space Exploration


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2024.00.00

# Mission 2 Milestones

**Phase 4 of Success 9 was completed, and the lander continued its descent in a vertical attitude. However, telemetry was lost approx. two minutes before the scheduled landing time, indicating a hard landing**

(1) Success 9 is divided into six phases, with Phase 4 "Braking Burn & Pitch-up"

▶ **Success 1** ✓
Completion of Launch Preparations
**Completed on Jan. 14, 2025**

▶ **Success 2** ✓
Completion of Launch and Deployment
**Completed on Jan. 15, 2025**

▶ **Success 3** ✓
Establishment of a Steady Operation State
**Completed on Jan. 15, 2025**

▶ **Success 4** ✓
Completion of first Orbital Control Maneuver
**Completed on Jan. 17, 2025**

▶ **Success 5** ✓
Completion of Lunar Flyby
**Completed on Feb. 15, 2025**

▶ **Success 6** ✓
Completion of all Deep-Space Orbital Control Maneuvers before LOI
**Completed on Apr. 24, 2025**

▶ **Success 7** ✓
Enter Lunar Orbit
**Completed on May 7, 2025**

▶ **Success 8** ✓
Completion of all Orbital Control Maneuvers in Lunar Orbit
**Completed on May 31, 2025**

▶ **Success 9**
Completion of Lunar Landing Sequence
**Incomplete**

▶ **Success 10**
Establish Steady System State after Landing
**Incomplete**

HAKUTO-R

# Root Cause of Soft-landing Failure in M1 and M2



**While the cause of the soft-landing failure in Mission 1 was software, the cause of the failure in Mission 2 was hardware. Although both involved the same aspect of altitude measurement, the causes were different**

| Category | Mission 1 | Mission 2 |
|---|---|---|
| **Cause location** | Software (Landing and descent algorithm) | Hardware (LRF) |
| **Cause** | • Incorrect estimation of the altitude due to the terrain | • Delay of valid LRF measurements<br>• Insufficient deceleration due to the delay |
| **Factor** | • The consideration of the terrain constraint along the landing approach path was missing<br>• Insufficient consideration of the effect of the terrain in the software validation and verification | • LRF performance (the possibilities of having being degraded by in-flight environment or/and operational condition)<br>• Insufficient consideration, awareness, validation of the LRF performance under the dynamic conditions<br>• Effect of uncertain factors such as the lunar surface albedo |
| **Result (Vehicle behavior)** | • Continued unexpected hovering at the altitude of 5km for the terminal landing<br>• Resulted in the excessive propellant usage, free-fall from the 5km altitude | • Continued full-throttle braking from the altitude of about 1km with higher velocity (than designed)<br>• Resulted in hard landing due to the shortage of the deceleration distance<br>• The terminal speed (at the contact with the surface) was estimated as 50-72km/h |
| **Evaluation of the lessons from the previous mission** | N/A | • No terrain interference to the final approach performance<br>• The correct altitude estimation was kept with the good accuracy<br>• The algorithm modifications functioned properly |

# Lessons Learned from M2 and Corrective Actions

**Approx. two weeks after the landing failure, a thorough telemetry analysis was conducted, and determined that the LRF was the technical cause. Further factor analysis as part of the development of subsequent missions to be implemented.**

| Possible factors for the delay in obtaining valid LRF data (our assessment) | | Further possible factors (our assessment) |
|---|---|---|
| • Unexpected performance of LRF during the descent phase | ▶ | • Albedo characteristics |
| | ▶ | • Laser incidence angle and laser output |
| | ▶ | • Performance at high speeds |
| • Hardware failure or performance degradation of LRF during the flight | ▶ | • Deterioration due to radiation effects |


In the above photo, the red frame shows the LRF.
It is installed on the side of the lander.

## Corrective actions based on the analysis of the above factors

**Corrective Actions for Landing Sensors**

- **Enhancement of verification strategy and plan** for landing sensors, including LRF
- **Improvement of the selection, configuration, and operation** of landing sensors, including LRF

**Broader Enhancement Measures**

- Establishment of an "**External Review Task Force**" including third-party experts
- **Expansion of technical support from JAXA**

# External Review Task Force



**Members of the "External Review Task Force" are currently being selected. Appointed two globally renowned experts as its co-chairs.**

- At present, two co-chairs have agreed to join the task force. Several other external members are currently being finalized
- The task force will be convened in the near future. After which we will conduct a review of our analysis of Mission 2 over a certain period of time

Co-chair of External Review Task Force

## Professor Olivier L. de Weck

Olivier de Weck is the Apollo Program Professor of Astronautics at the Massachusetts Institute of Technology where he is the Associate Department Head of Aero Astro. His research is in Systems Engineering with a focus on how complex technological systems are designed and how they evolve over time. He is a Fellow of INCOSE and AIAA and serves as Editor-in-Chief of the Journal of Spacecraft and Rockets

Co-chair of External Review Task Force

## Professor Naohiko Kohtake

Naohiko Kohtake is a Professor, Graduate School of System Design and Management, Keio University. Representative Director, Space Service Innovation Lab Cooperative. After serving as an associate engineer at JAXA and a visiting researcher at ESA, he assumed his current position. Chairperson, Subcommittee on JAXA, Council for National Research and Development Agencies, MEXT. Deputy Chair, Investigation and Safety Subcommittee, Committee on Space Development and Utilization. Former Principal, Keio Yokohama Elementary School. Visiting Professor at Stanford University (from September 2025)

Several other external members will be confirmed soon

# Mission 2 Summary – Key Achievements



**Achievement 1**

**Demonstrated consecutive reliable transportation capability to lunar orbit**

Following Mission 1, Success 8—completion of all orbital control maneuvers in lunar orbit—was achieved again in Mission 2, demonstrating the repeatability and reliability of transportation capability to lunar orbit

**Achievement 2**

**Acquired landing sequence data under different conditions through two separate missions**

Mission 1 did not achieve a soft landing due to a software issue that caused the lander to free-fall from an altitude of approx. 5 km. Based on the lessons learned, Mission 2 confirmed that the software functioned as designed, allowing the lander to descend while maintaining its landing attitude. Landing sequence data under different conditions was acquired through two separate missions

**Achievement 3**

**The deviation from the target landing site was within a 1 km radius, demonstrating the effectiveness of the guidance, navigation and control system**

Based on image of the landing site captured by LRO, the lander impacted at a location near 60.44N, 4.6W. Approx. 282m south and approx. 236m east of the target landing site. This confirms that the guidance, navigation and control system performed as expected up to the final descent phase

# Improvement from Mission 1



## Significant improvement in both development and operations[1] through the lessons learned from Mission 1

**Development Period[2] Reduced**

**Approx. 40%**

- Reducing Non-Recurring Engineering Tasks by using the same model as M1
- Lessons learned from M1 have led to improvement of manufacturing, assembling and testing procedures. **Fewer defects during development**, as well as **improvement of delivery management** of procured goods

**Development Cost[2] Reduced**

**Approx. 50%**

- Reducing Non-Recurring Engineering Costs by using the same model as M1
- Based on the experience of M1, **more efficient project management** reduced engineer's working hours and related labor costs

**Period from Launch to Initial Operational Phase Completion Reduced**

**Approx. 60%**

- Improved operations until the completion of the initial operational phase by applying lessons learned from M1 to M2
- M2 operation is **progressing smoothly** as it completed its initial operational phase at the earliest expected timeline after the launch

(1) Comparing the operational status as of Feb 12, 2025 with Mission 1.
(2) Launch costs for the use of external rocket is not included

(3) SRR (System Requirement Review): Review meeting to approve the start of system design after confirming consistency between business requirements and system requirements

# For the next mission - Series 3 Lander



Photos of the structural thermal model of tentatively named Series 3 lander under development with METI's SBIR grant

**Size**
Approx. 3.6m tall by 3.3m wide (standing, including its legs)

**Mass**
Approx. 1,000kg (Dry: unfueled)

**Design Payload Capacity**
Up to hundreds of kg

**Development Progress**

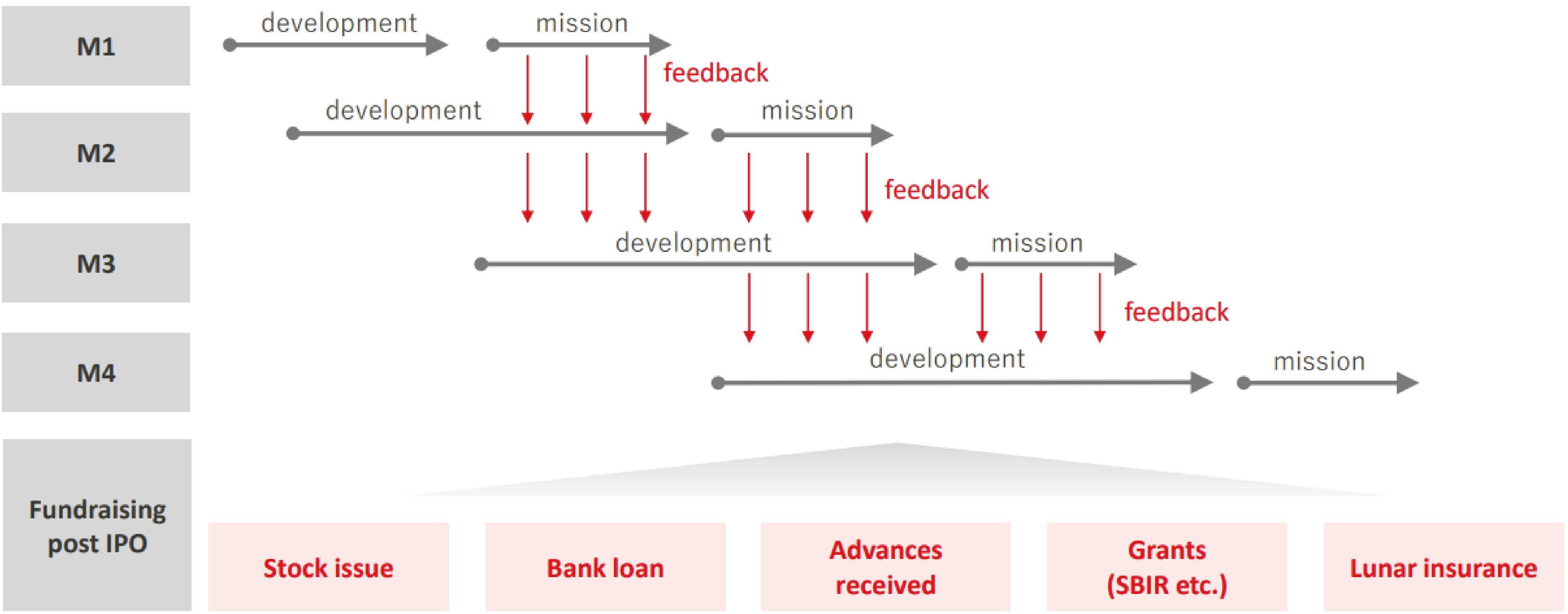
- Vibration testing, to verify resistance to intense vibrations such as those experienced during rocket launch, using a structural thermal model has been completed.
- Drop weight test has been conducted for structural system.
- Thermal control system and structural system tests are currently underway

# Sustainable Business Model



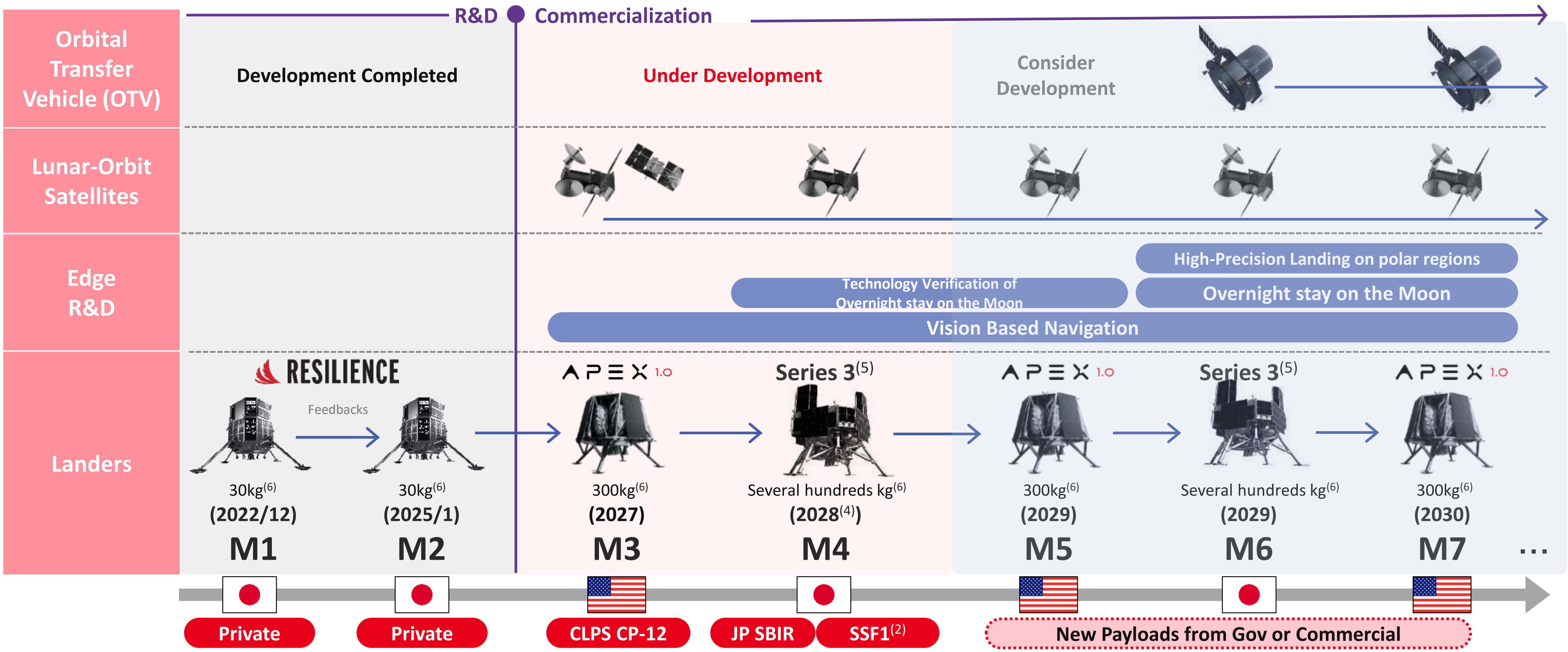
**Established a strong financial foundation through various funding methods.**

**ispace's business model:**
**Developing multiple missions in parallel while securing funding through diverse financing approaches.**



# Missions Roadmap

## Diversify services to accelerate commercialization




Above is our estimation of mission and schedule as of October 6, 2025., and may be change.

(1) Indicates JAXA's SSF Phase 2nd
(2) Indicates JAXA's SSF Phase 1st
(3) We have not officially decided to apply these clients, and there is no guarantee of us winning the contracts for those we have applied.
(4) Initially, we have agreed with METI and SBIR office for launching within 2027, however, based on our company's current development plan as of 2025/10/6, the launch is expected to be within calendar year of 2028. This change is still under discussion with related ministries and SBIR office, official change of schedule will be determined after approval of Minister of Economy, Trade and Industry.
(5) Estimation as of October 6, 2025. The name is subject to change in the future. The lander design described in this materials is subject to change.
(6) Maximum Payload Capacity.