


ispace HAKUTO-R Mission 1 Debriefing



Agenda

- Opening message by Founder & CEO Takeshi Hakamada
- Explanation of landing analysis by CTO Ryo Ujiie
- Q&A



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Founder & CEO

Takeshi Hakamada



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Mission 1 Milestones

ispace has already completed 8 out of 10 milestones, verifying a large part of our lander technology and business model concept.

► Success 1

Completion of Launch Preparations

Completed 2022 Nov 28

► Success 10

Establishment of a steady system state after lunar landing

Incomplete

► Success 9

Completion of lunar landing

Incomplete 2023 Apr 25

► Success 2

Completion of Launch and Deployment

Completed 2022 Dec 11

► Success 8

Completion of all orbit control maneuvers in lunar orbit

Completed 2023 Apr 13

► Success 3

Establishment of a Steady Operation State

(*Initial Critical Operation Status)

Completed 2022 Dec 16

► Success 7

Reaching the lunar gravitational field / lunar orbit

Completed 2023 Mar 21

► Success 4

Completion of first orbital control maneuver

Completed 2022 Dec 15

► Success 5

Completion of stable deep-space flight operations for one month

Completed 2023 Jan 11

► Success 6

Completion of all deep space orbital control maneuvers before LOI

Completed 2023 Mar 17



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CTO

Ryo Ujiie



Mission 1 Landing Sequence

Phase 1

De-Orbit Insertion (DOI)

A short burst from the Lander's main propulsion system initiates the De-Orbit Insertion.

Velocity*

5800 km/h

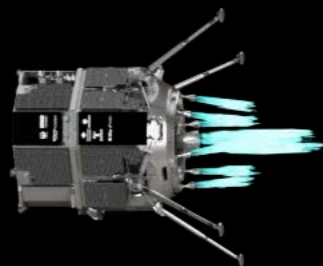
Altitude*

100 km

Estimated Time*

L-67 min >> L-66 min

*Estimated values. For illustration purposes only, not to scale.



Mission 1 Landing Sequence

Phase 2

Cruise Landing Phase

The Lander's main propulsion system remains inactive while the Lander's altitude decreases from approximately 100km to 25km.

Velocity*
6000 km/h

Altitude*
100 km >> 25 km

Estimated Time*
L-66 min >> L-13 min

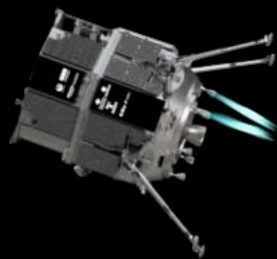
*Estimated values. For illustration purposes only, not to scale.

Mission 1 Landing Sequence

Phase 3

Braking Burn Phase

The Lander uses its main propulsion system to reduce its velocity, while the altitude above the lunar surface continues to decrease.



Velocity*

6000 km/h >> 380 km/h

Altitude*

25 km >> 3 km

Estimated Time*

L-13 min >> L-2 min

*Estimated values. For illustration purposes only, not to scale.

Mission 1 Landing Sequence

Phase 4

Braking Burn & Pitch-up Phase

The Lander continues to reduce its speed while it approaches its designated landing site, while taking a vertical orientation.

Velocity*

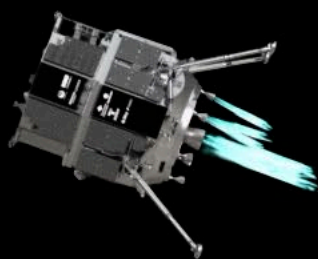
380 km/h >> 120 km/h

Altitude*

3 km >> 1 km

Estimated Time*

L-2 min >> L-1 min



*Estimated values. For illustration purposes only, not to scale.

Mission 1 Landing Sequence

Phase 5

Terminal Descent Phase

The Lander approaches the landing site vertically, while continuing to reduce its speed.

Velocity*

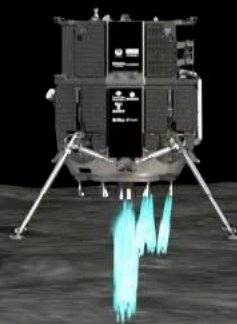
120 km/h >> 17 km/h

Altitude*

1 km >> 20 m

Estimated Time*

L-1 min >> L-20 sec



*Estimated values. For illustration purposes only, not to scale.

Mission 1 Landing Sequence

Phase 6

Terminal Landing

Mere moments and several meters above the lunar surface, the Lander switches off its main thruster and relies on the assist thrusters to perform a controlled touch-down.

Velocity*

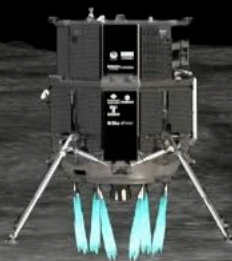
17 km/h >> 2.6 km/h

Altitude*

20 m >> 0 m

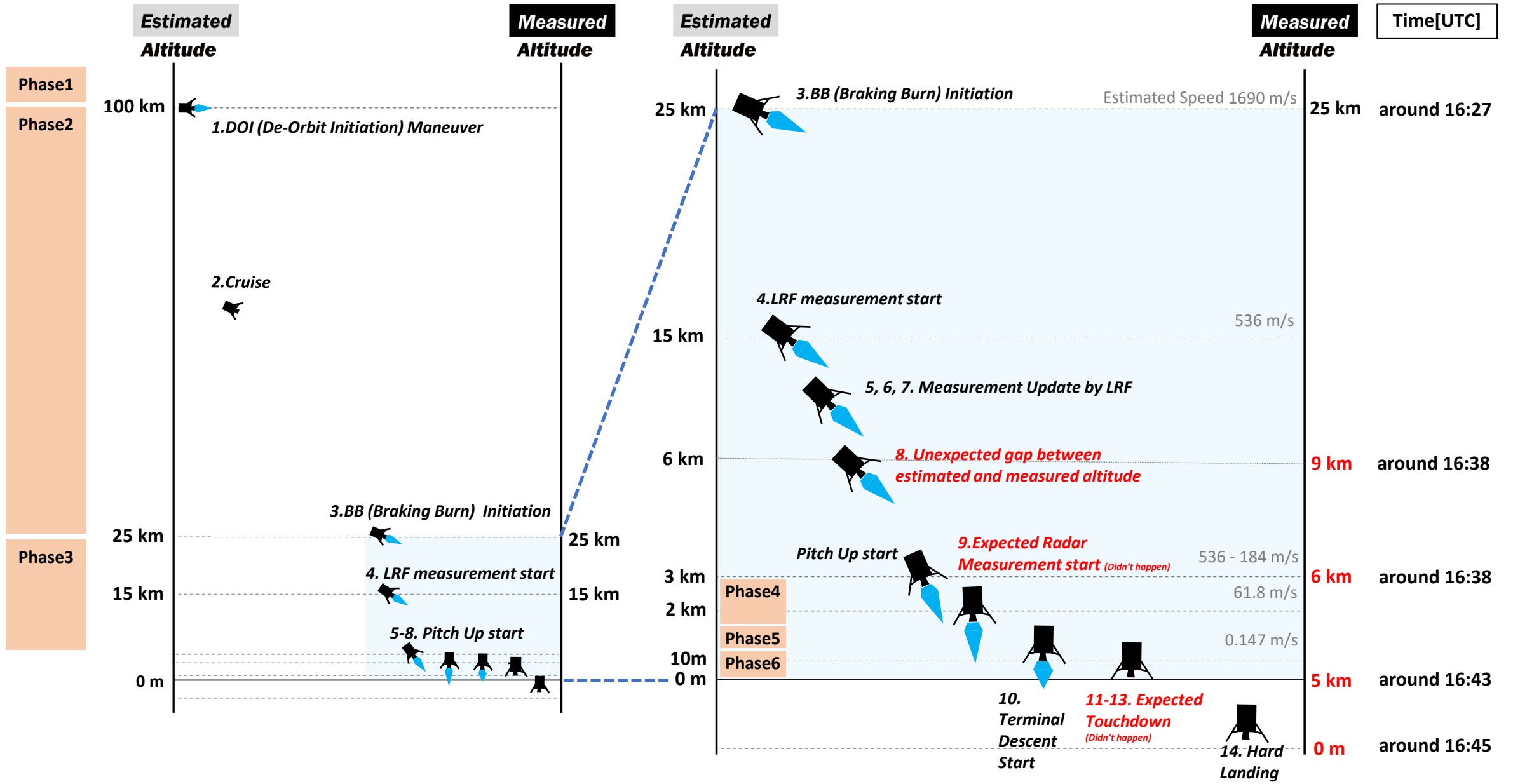
Estimated Time*

L-20 sec >> L-0 sec

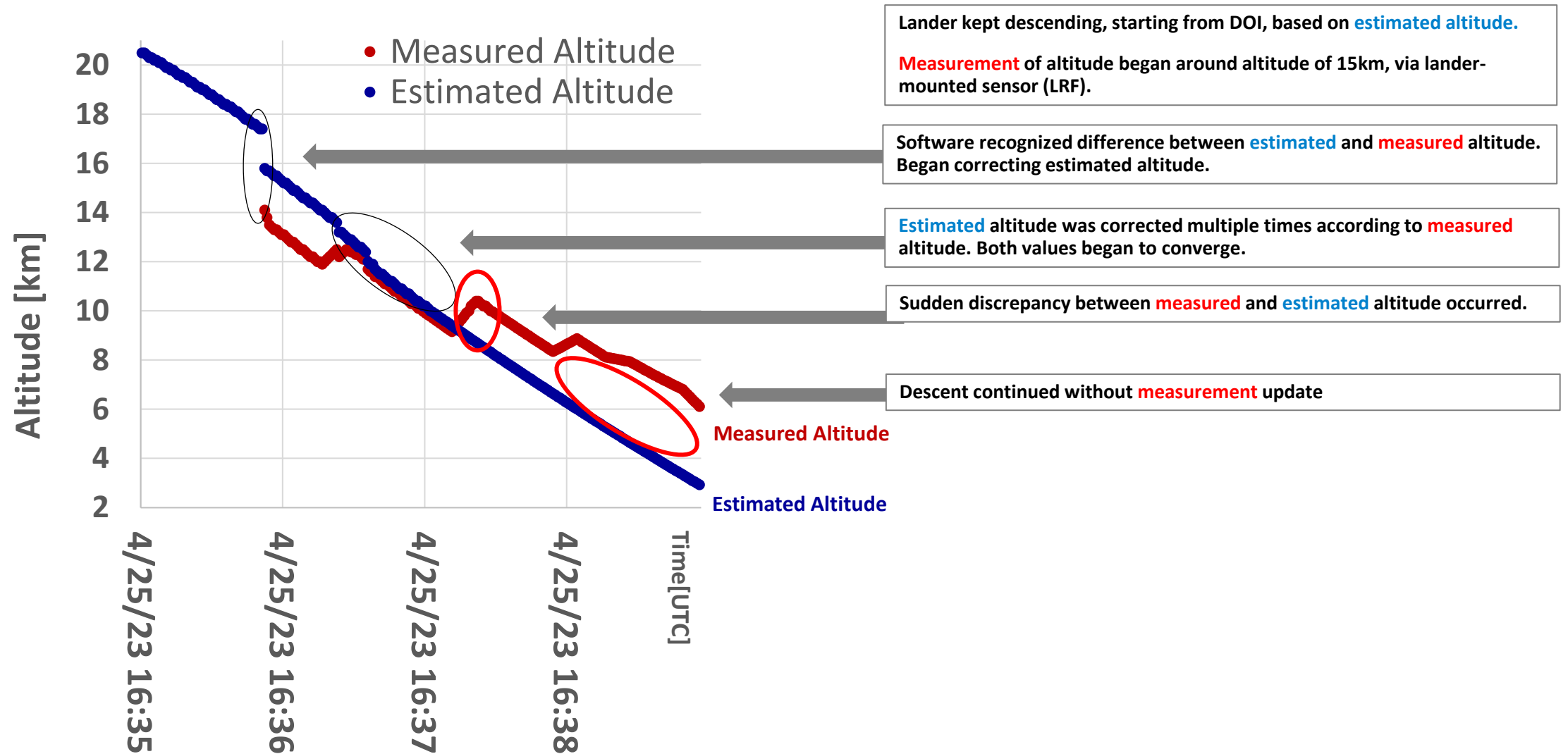


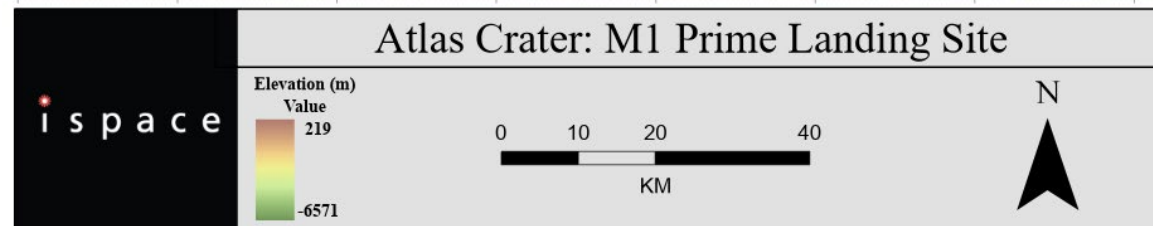
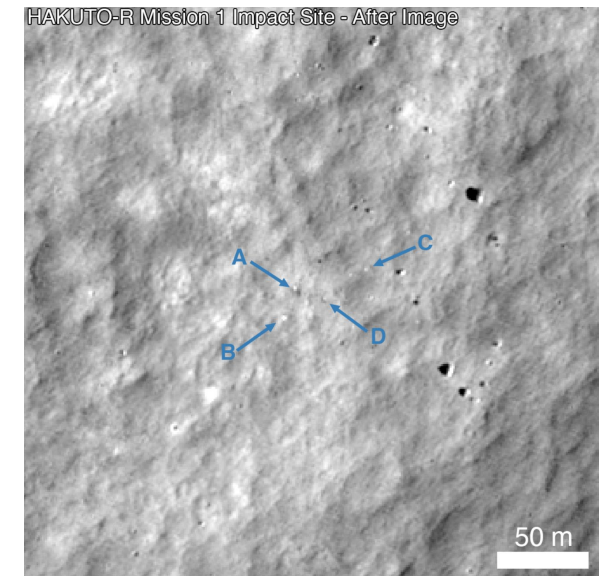
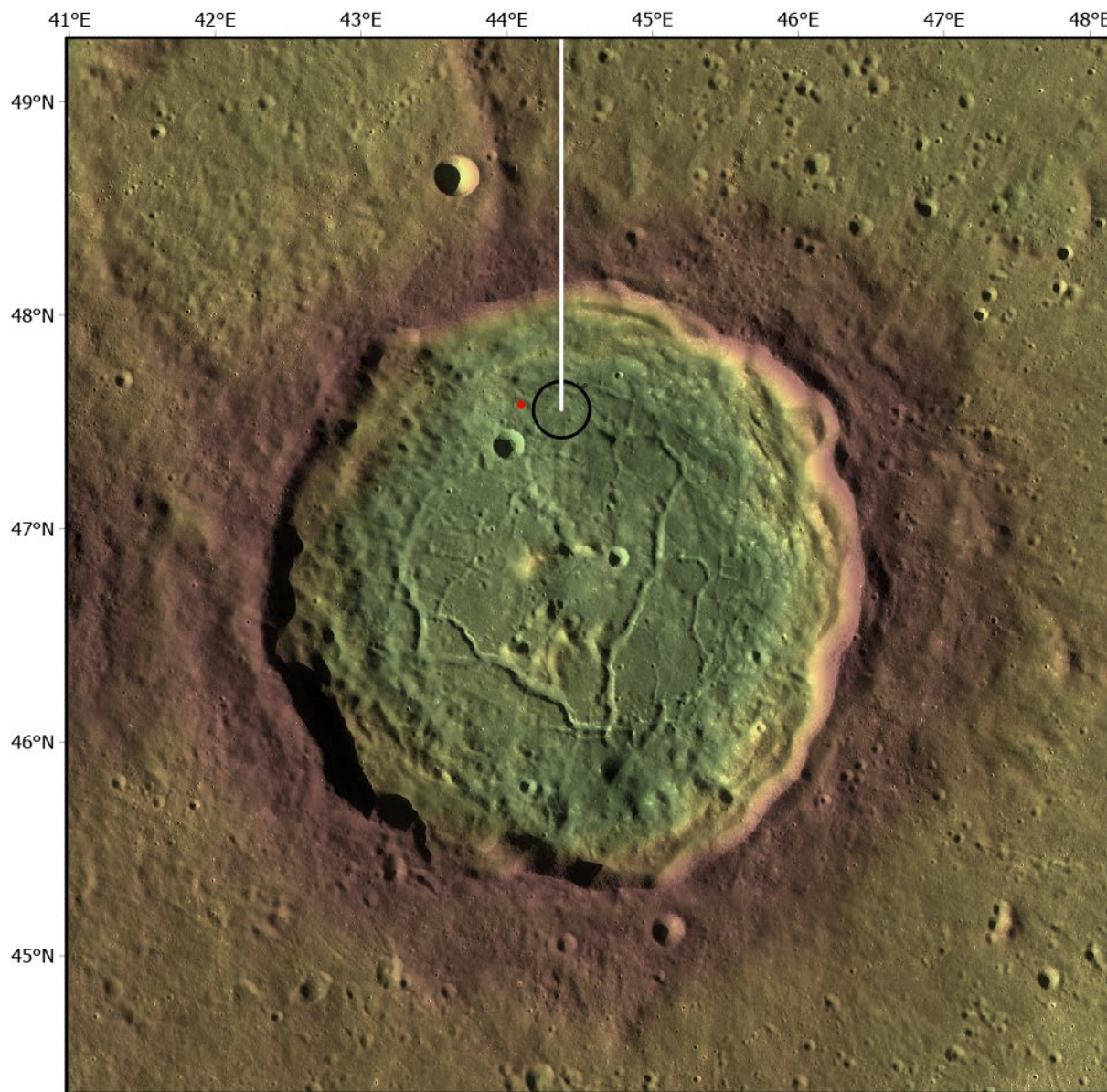
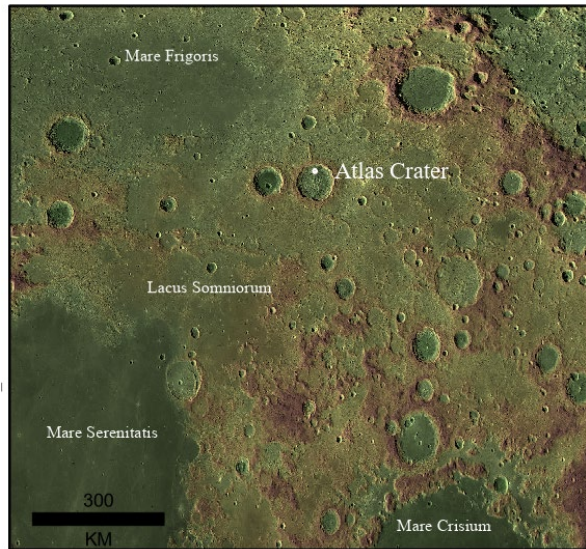
*Estimated values. For illustration purposes only, not to scale.

	Time [UTC]	Events based on real-time telemetry monitoring	Events based on telemetry analysis
Phase 1	1 15:36 - 15:40	Start of DOI	
Phase 2	2 16:18	End of lunar occultation (reestablishment of communications)	
Phase 3	3 16:27	Start of Braking Burn	
	4 16:35	Correction of estimated altitude data based on measured altitude data (first LRF measurement)	
	5 16:35		Second LRF measurement
	6 16:36		Third LRF measurement
	7 16:36		Fourth LRF measurement
	8 16:38		Difference between estimated and measured altitude : over 3km (Measurement not reflected)
Phase 4	9 16:38	Transition to final approach	Velocimeter measurement did not start after altitude of less than 2 km (estimated altitude) was reached (measured altitude remained over 4km)
Phase 5	10 16:42	Transition to Terminal Descent	
Phase 6	11 16:43	Estimated altitude = 0 km	Measured altitude = ~5km
	12 16:44	Tank pressure decreases (sign of fuel running low) Lander loses attitude control and starts spinning	Start of free fall (based on doppler-shift measurement and telemetry)
	13 16:44	Confirmation of final telemetry	
	14 16:45	Loss of carrier signal	Time of hard landing

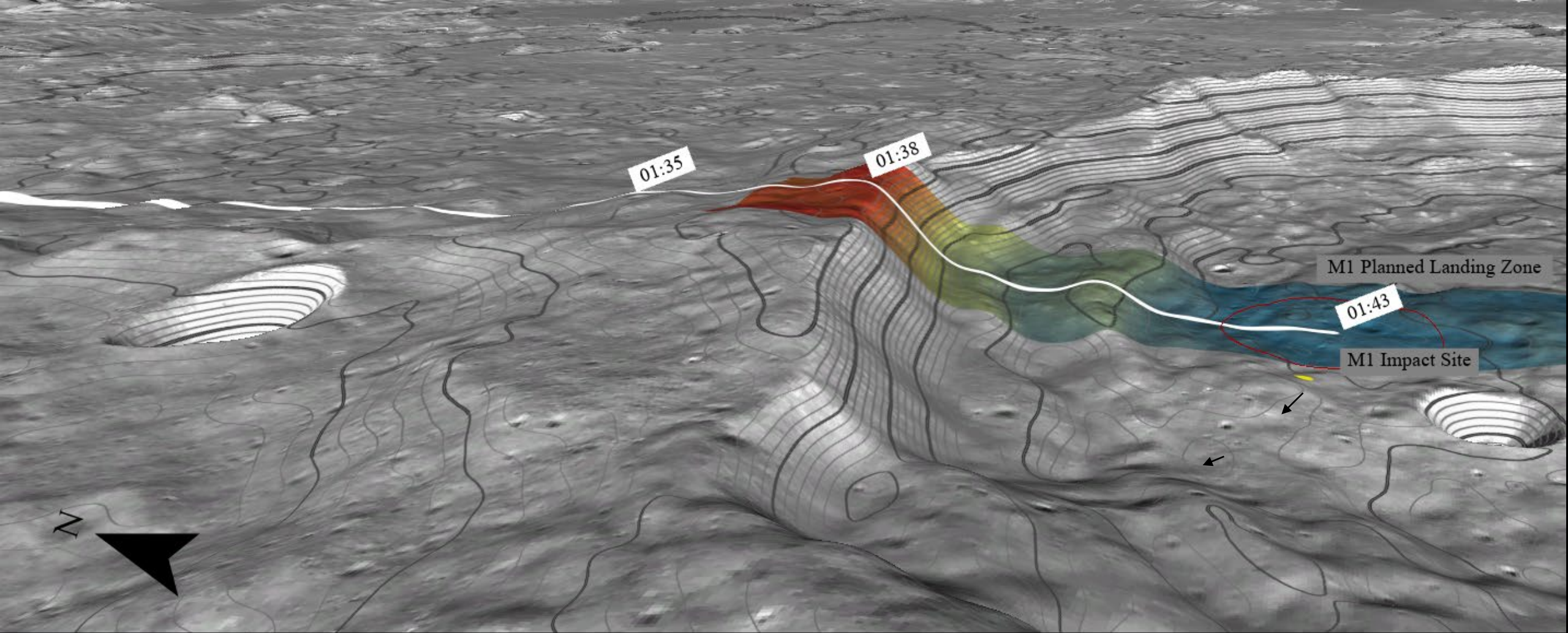


Measured Altitude and Estimated Altitude

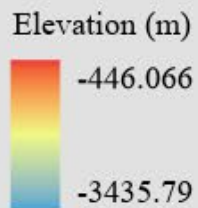




Credit: These images use data from the Lunar Reconnaissance Orbiter Wide Angle Camera (WAC; Robinson and others, 2010), an instrument on the National Aeronautics and Space Administration (NASA) Lunar Reconnaissance Orbiter (LRO) spacecraft. The WAC images have been orthorectified onto the Global Lunar Digital Terrain Mosaic (GLD100, WAC-derived 100 m/pixel digital elevation model; Scholten and others, 2012) to produce elevation maps of Atlas crater and the surrounding terrain.



- WAC Contour: 500m
- WAC Contour: 100m
- M1 Impact Site
- ▭ M1 Landing Ellipse
- Flight Path Ground-track



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The NAC DTM was generated by J. Flahaut, C. Wöhler, S. Els, M.Ali-Dab using NASA LRO NAC: M1369081924

Measured Altitude and Estimated Altitude

Cause of continued descent without **measurement update**:



- The software identified a sudden significant change in **measured altitude** caused by a crater rim (cliff) as a “sensor malfunction” and stopped reflecting the **measured altitude** data. However, the sensor had actually correctly identified the crater rim.
- This filtering function (discarding **measured altitude** data that greatly deviates from the **estimated altitude** data) is a design feature intended to assure continuous stable operation in case of sensor hardware malfunctions.
- We assume that the cause for this issue was an insufficient inclusion of lunar surface topography along the landing approach route in simulations. (Change of target landing site after the Mission 1 critical design review has been another contributing factor.)

Future Improvement Plan

Improvements:

- Fine-tuning of detailed lander software design
- Improved terrain simulation range setting in test campaign
- Additional Radar Velocimeter field tests
- Early determination of detailed landing requirements and thorough simulation

Schedule and costs of improvements:

- Timeframe: Scheduled to be completed by end of current fiscal year (late March 2024)
- These activities have been considered as part of the process required for the development of Mission 2 since the beginning; additional work will be limited

Data acquired throughout Mission 1 and future applications

	Acquired data		Application towards future missions
Structure	<ul style="list-style-type: none"> ● Since the lander withstood launch and separation undamaged, the mechanical design and verification methods were proven. 	➔	<ul style="list-style-type: none"> ● Improvement of reliability during M2 and future missions through the established methods, able to withstand the harsh environment of space.
Thermal	<ul style="list-style-type: none"> ● Actual flight data of temperatures and heater power consumption throughout the mission. 	➔	<ul style="list-style-type: none"> ● More efficient thermal control in flight operations, by improving thermal analysis result based on flight data.
Communication	<ul style="list-style-type: none"> ● Actual communication performance data at a distance of up to 1.4M km from Earth, as well as the flight data of lunar interference on communication. 	➔	<ul style="list-style-type: none"> ● Optimized downlink planning for more efficient communication.
Electric Systems	<ul style="list-style-type: none"> ● Actual power generation performance data as well as deterioration of solar panels over long term of ca. 5 Months. 	➔	<ul style="list-style-type: none"> ● Reduction of redundant margins on power management and more predictable power management.
Propulsion	<ul style="list-style-type: none"> ● Operational data of propulsion system, including larger than expected thermal gradient between propellant tanks. Further, data on changes in monopropellant RSC thrusters over the attitude control of all flight phase. 	➔	<ul style="list-style-type: none"> ● More efficient propellant management and prediction of performance due to temperature changes. Smoother and more efficient operation of monopropellant RCS thrusters.
Onboard Computer	<ul style="list-style-type: none"> ● Operational data for all in-house-developed on-board computers. 	➔	<ul style="list-style-type: none"> ● Better estimation of radiation effects. Improvement of software for M2 (ongoing since M1 operation)
GNC	<ul style="list-style-type: none"> ● Space-Operational data of each navigation sensor. Data of changes in performance due to changes of control parameters in flight. 	➔	<ul style="list-style-type: none"> ● Establishment of a more robust control system. Improvement of algorithms/parameters for efficient propellant utilization (ongoing since M1 operation).
Payloads	<ul style="list-style-type: none"> ● Flight data (including in lunar orbit) of customer payloads, as well as image data of lunar surface and Earth captured by in-house developed ispace camera system. 	➔	<ul style="list-style-type: none"> ● Improvement of customer payload accommodation and further improvement of in-house camera image quality.









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Founder & CEO

Takeshi Hakamada

Explanation to our Customers

- **Explanation of detailed analysis of landing sequence to each customer.**
- **Mission 1 to be officially declared concluded based on confirmation with each customer to the final report.**
- **Flight data obtained up to Success 8 is being provided to customers based on individual contracts. Further considering individually how to apply data towards the future.**

Impact of Mission 1 landing on financial forecast

Impact on sales

- Short fall of Success 9-10 of Mission1 is expected to result in a decrease of approximately 100M JPY in anticipated sales from Mission1 customers (As the impact on Fiscal Year Ending March 2024 results is expected to be insignificant there is no change to the forecast)
- No impact on the sales contracts already concluded for Mission2 and Mission3
- No major changes are expected to be made to the outlook for future orders after Mission2 at the present

Impact on costs

- No significant increase in the cost of developing landers after Mission2 is expected at the present due to the failure of the Mission1 lunar landing

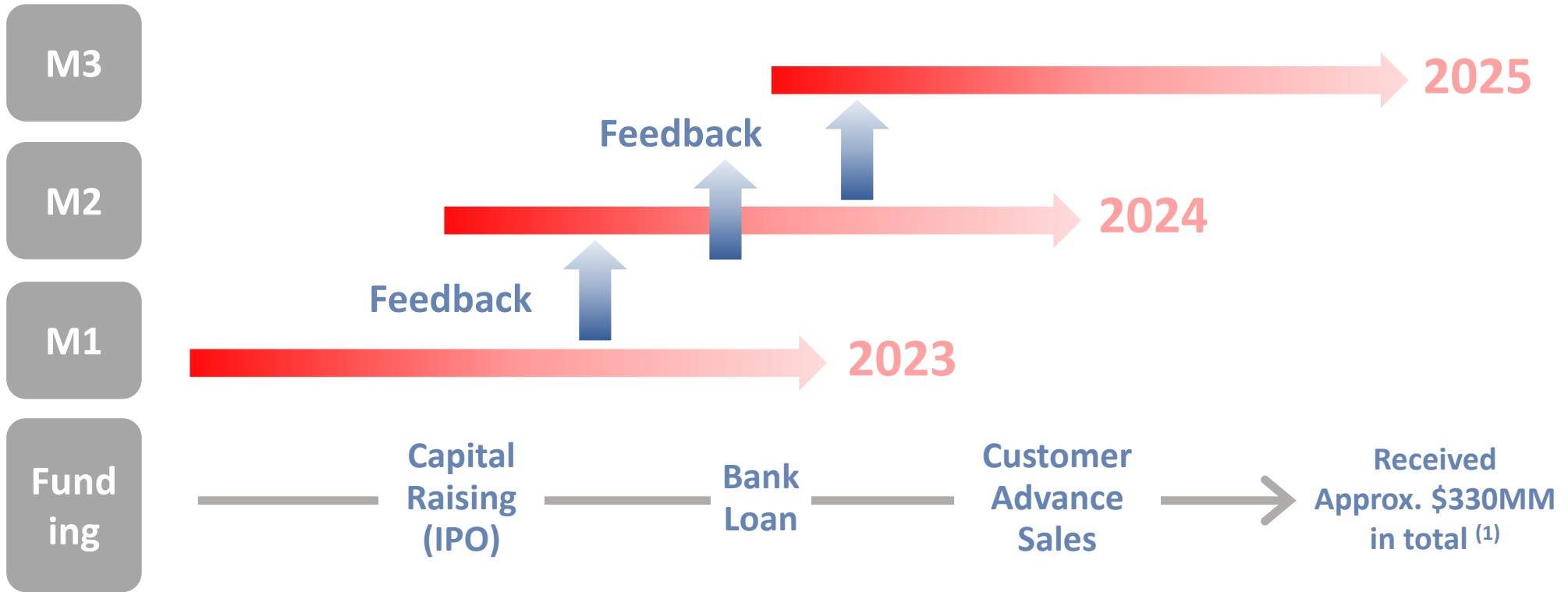
Impact on mission schedule

- No changes to the launch schedule for Mission2 in 2024, Mission3 in 2025, or beyond at the present

Other impact

- Lunar insurance has been concluded with Mitsui Sumitomo Insurance Company, Limited. Expecting to receive the insurance payment, which has not been confirmed at this time. The amount is not reflected in the forecast for Fiscal Year Ending 2024

Sustainable Business Model



- Develop multiple missions in parallel based on a business model with continuous missions by securing budgets from investors, financial institutions, and customers.
- Findings from missions are fed back to the next mission in a timely manner and at a high frequency to increase the maturity of the technology. Continuous missions will be executed in a relatively short period of time.
- Developed the world's first lunar insurance with Mitsui Sumitomo Insurance Company, Limited, covering the liability period from the launch of Mission 1 to data transmission after landing on the lunar surface.

Never Quit the Lunar Quest

Q&A



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Founder & CEO


Takeshi Hakamada



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CTO

Ryo Ujiie



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Director & CFO

Jumpei Nozaki



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Mission 1

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for joining!**

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