Asteroid explorer, Hayabusa2, reporter briefing

July 9, 2019

JAXA Hayabusa2 Project

Topics

Regarding Hayabusa2,

- 2nd touchdown operation

Contents

0. Hayabusa2 and mission flow outline
1. Current status and overall schedule of the project
2. The 2nd touchdown operation
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Overview of Hayabusa2

Objective

We will explore and sample the C-type asteroid Ryugu, which is a more primitive type than the S-type asteroid Itokawa that Hayabusa explored, and elucidate interactions between minerals, water, and organic matter in the primitive solar system. By doing so, we will learn about the origin and evolution of Earth, the oceans, and life, and maintain and develop the technologies for deep-space return exploration (as demonstrated with Hayabusa), a field in which Japan leads the world.

Expected results and effects

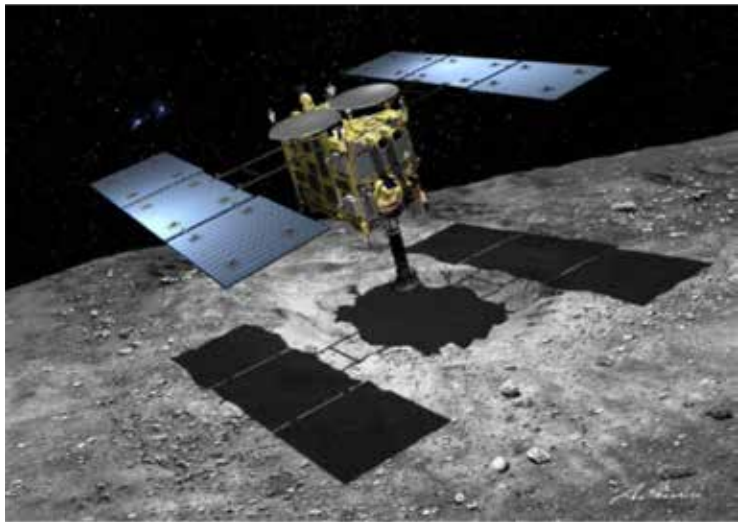
- By exploring a C-type asteroid, which is rich in water and organic materials, we will clarify interactions between the building blocks of Earth and the evolution of its oceans and life, thereby developing solar system science.
- Japan will further its worldwide lead in this field by taking on the new challenge of obtaining samples from a crater produced by an impacting device.
- We will establish stable technologies for return exploration of solar-system bodies.

Features:

- World's first sample return mission to a C-type asteroid.
- World's first attempt at a rendezvous with an asteroid and performance of observation before and after projectile impact from an impactor.
- Comparison with results from Hayabusa will allow deeper understanding of the distribution, origins, and evolution of materials in the solar system.

International positioning:

- Japan is a leader in the field of primitive body exploration, and visiting a type-C asteroid marks a new accomplishment.
- This mission builds on the originality and successes of the Hayabusa mission. In addition to developing planetary science and solar system exploration technologies in Japan, this mission develops new frontiers in exploration of primitive heavenly bodies.
- NASA too is conducting an asteroid sample return mission, OSIRIS-REx (launch: 2016; asteroid arrival: 2018; Earth return: 2023). We will exchange samples and otherwise promote scientific exchange, and expect further scientific findings through comparison and investigation of the results from both missions.



(Illustration: Akihiro Ikeshita)

Hayabusa 2 primary specifications

Mass	Approx. 609 kg
Launch	3 Dec 2014
Mission	Asteroid return
Arrival	27 June 2018
Earth return	2020
Stay at asteroid	Approx. 18 months
Target body	Near-Earth asteroid Ryugu

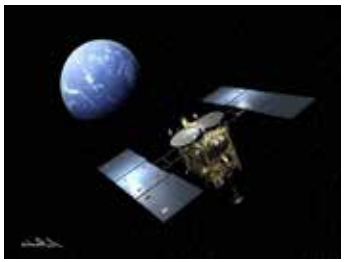
Primary instruments

Sampling mechanism, re-entry capsule, optical cameras, laser range-finder, scientific observation equipment (near-infrared, thermal infrared), impactor, miniature rovers.

Mission flow

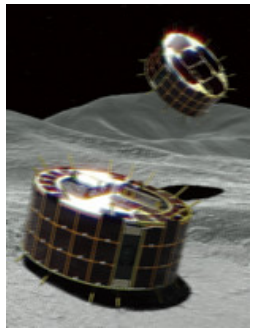
Launch
Dec 3, 2014

Earth swing-by
Dec 3, 2015

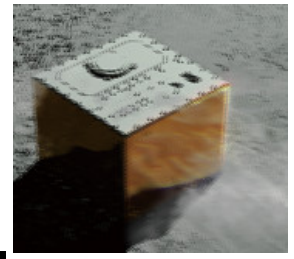


Ryugu arrival
June 27, 2018

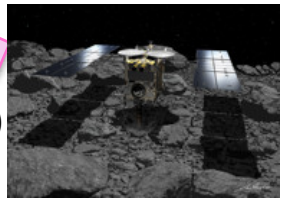
MINERVA-II-1 separation
Sep 21, 2018



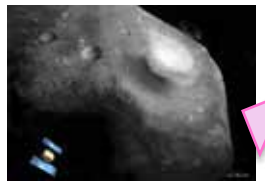
MASCOT separation
March 10, 2018



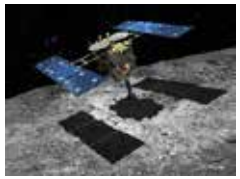
Feb 22, 2019



Impactor (SCI)
5 April, 2019



After confirming safety, touchdown at or near crater area to collect subsurface material.



Ryugu departure
Nov～Dec, 2019

Earth return
End of 2020

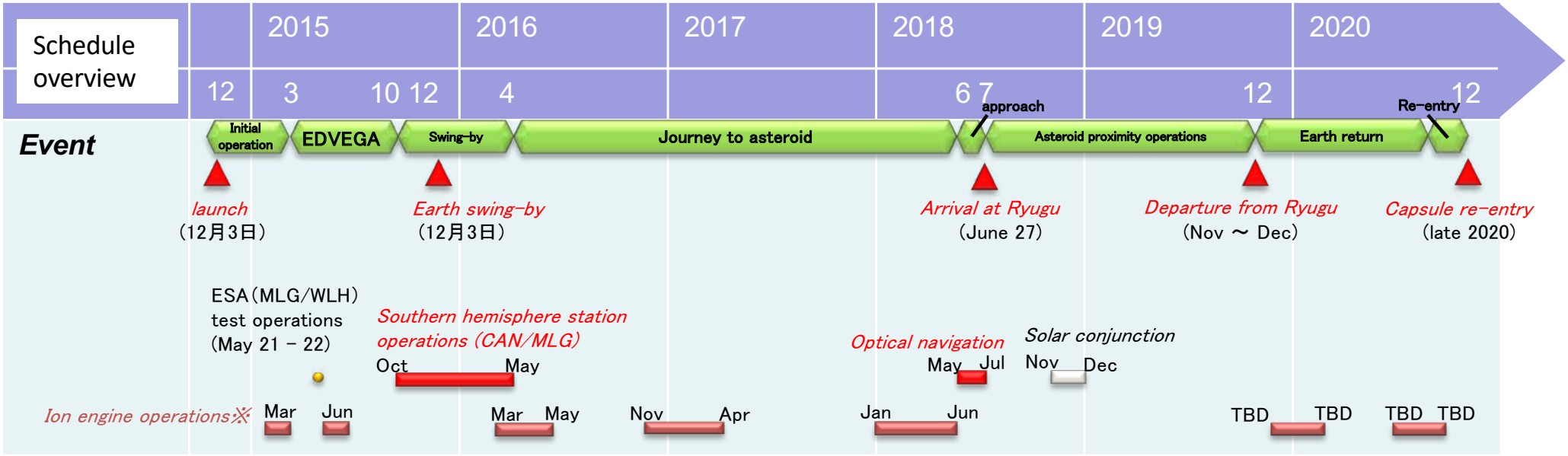
completed → **First touchdown**

(image credit: illustrations including spacecraft by Akihiro Ikeshita, others by JAXA)

1. Current project status & schedule overview

Current status:

- A second touchdown will be performed from July 9 – 11. Preparation for touchdown is now complete.
- Today (July 9), the shift for the touchdown operation has begun. Today, we are making final preparations for the descent.



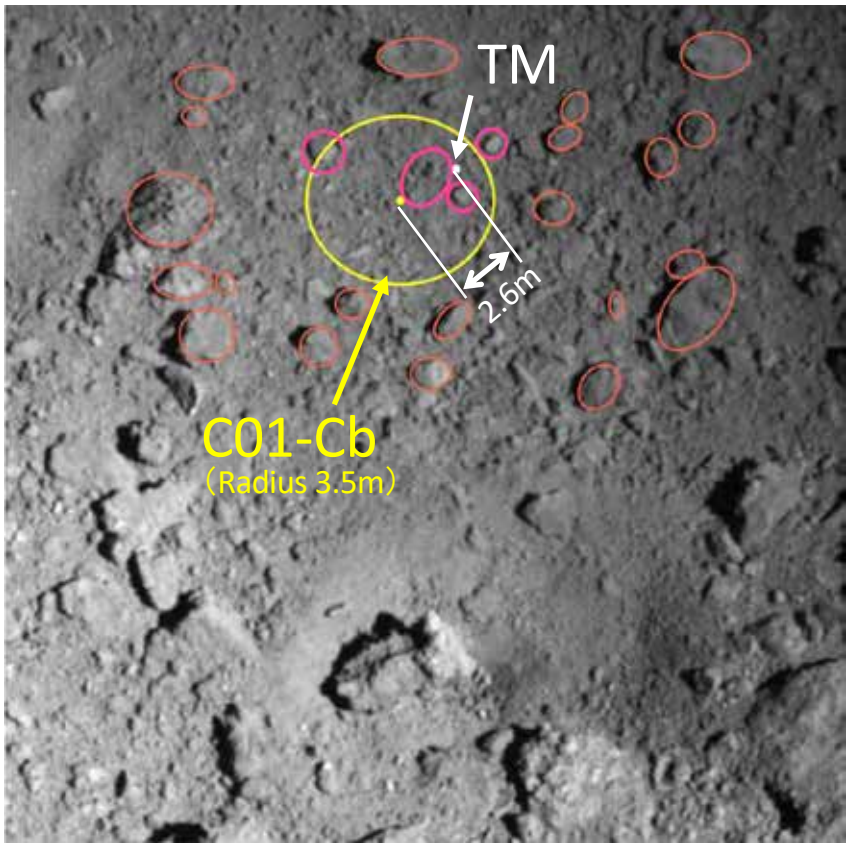
2. The 2nd touchdown operation

- 2nd touchdown operation：7/9～11
- Touchdown data & time：7/11 10:05 ～ 10:45 JST (on-board time)
- Touchdown location: C01-Cb (target marker drop area)

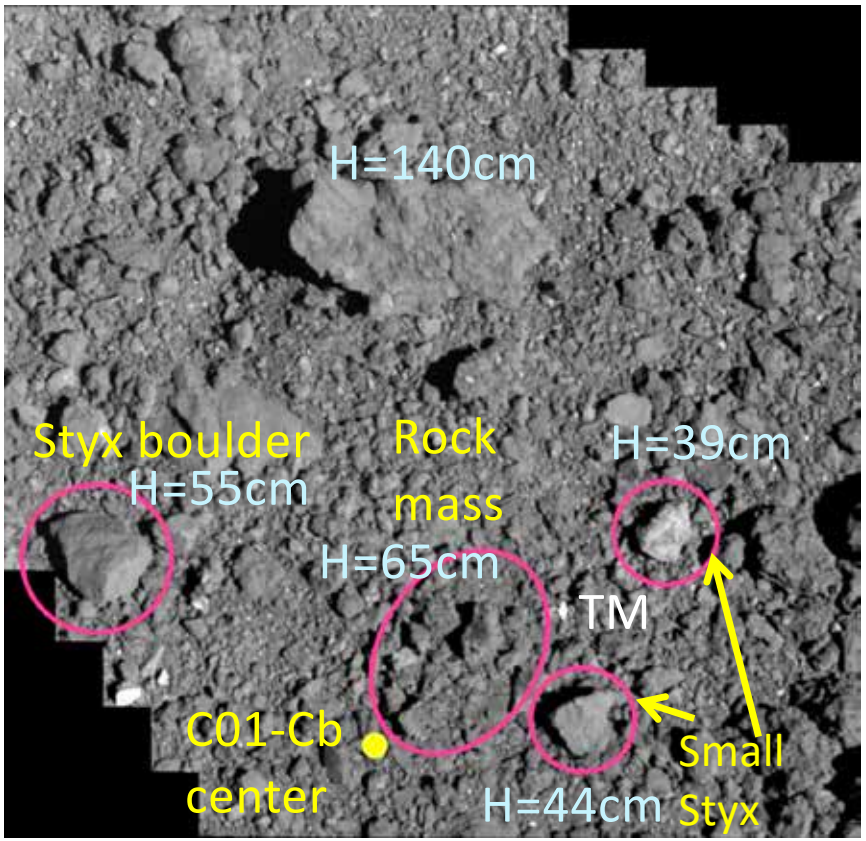
※ The operation is named ‘2nd touchdown‘ but denoted PPTD.

2. The 2nd touchdown operation

PPTD-TM1 image



PPTD-TM1B image



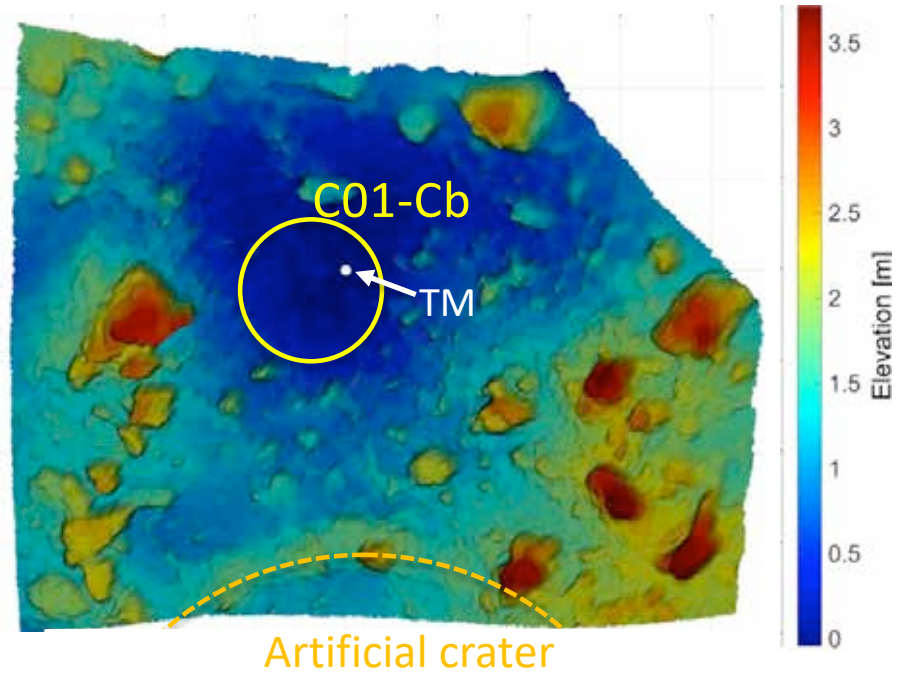
H is the highest estimated height value (worst scenario)

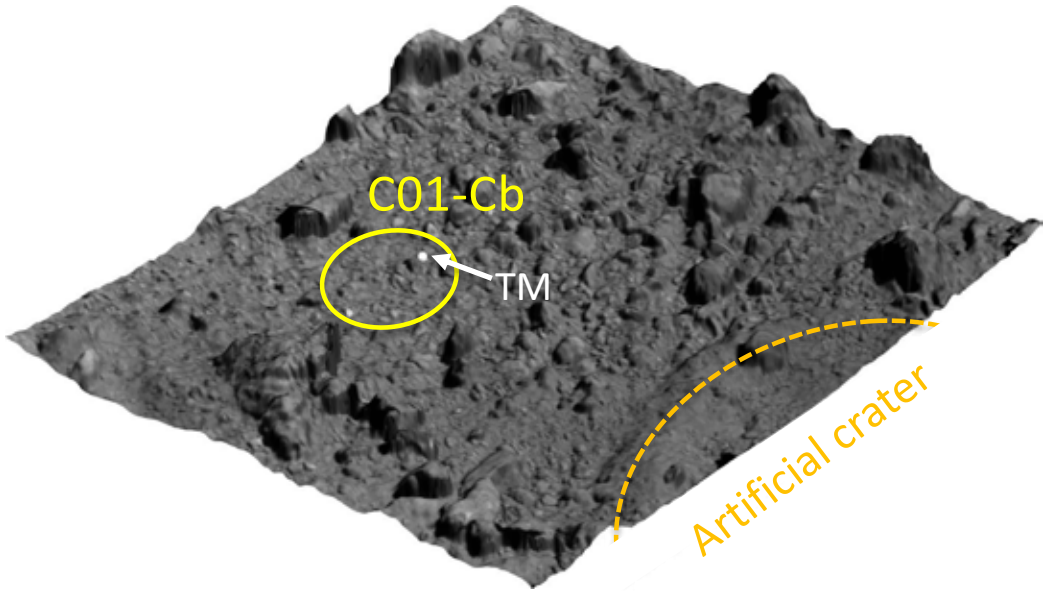
※ Boulder names are nicknames, not official names

(image credit：JAXA、University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST.)

2. The 2nd touchdown operation

C01-Cb area



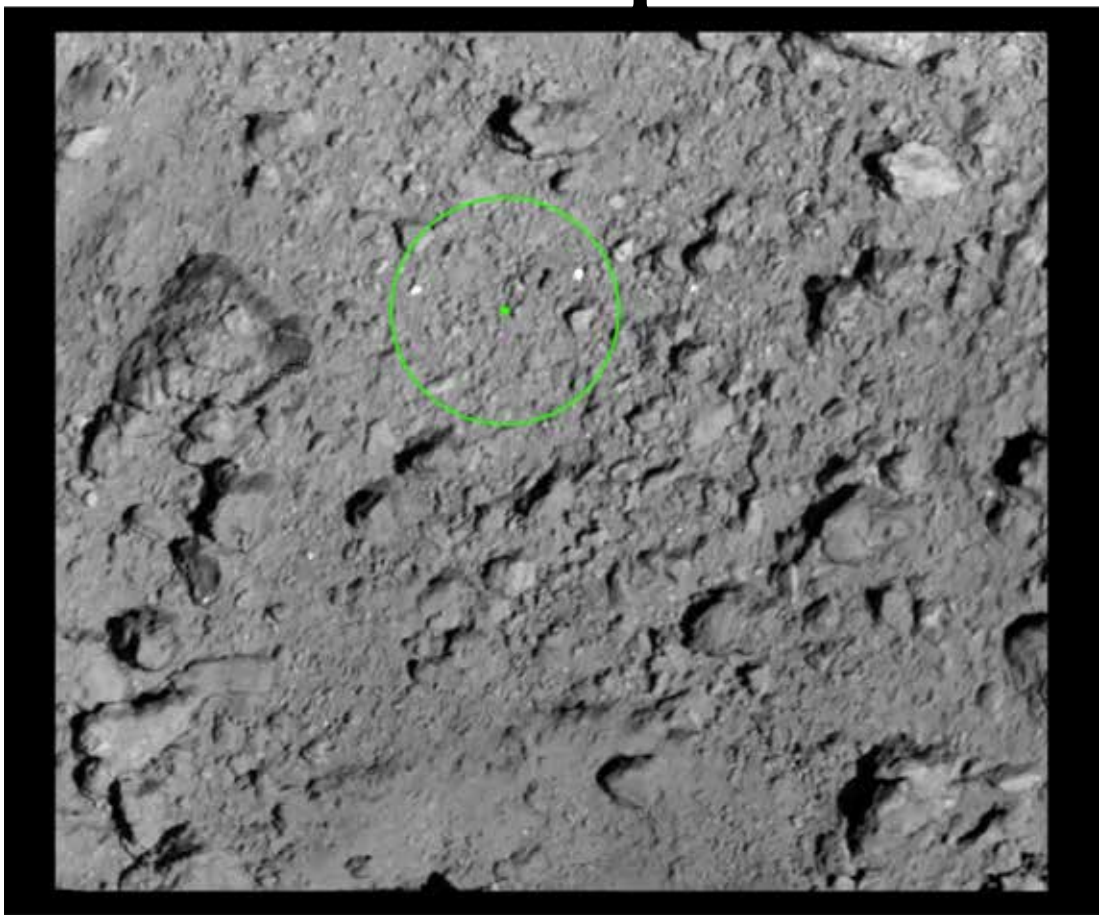


DEM（Digital Elevation Map）near the touchdown candidate point

（image credit：JAXA）

2. The 2nd touchdown operation

C01-Cb area



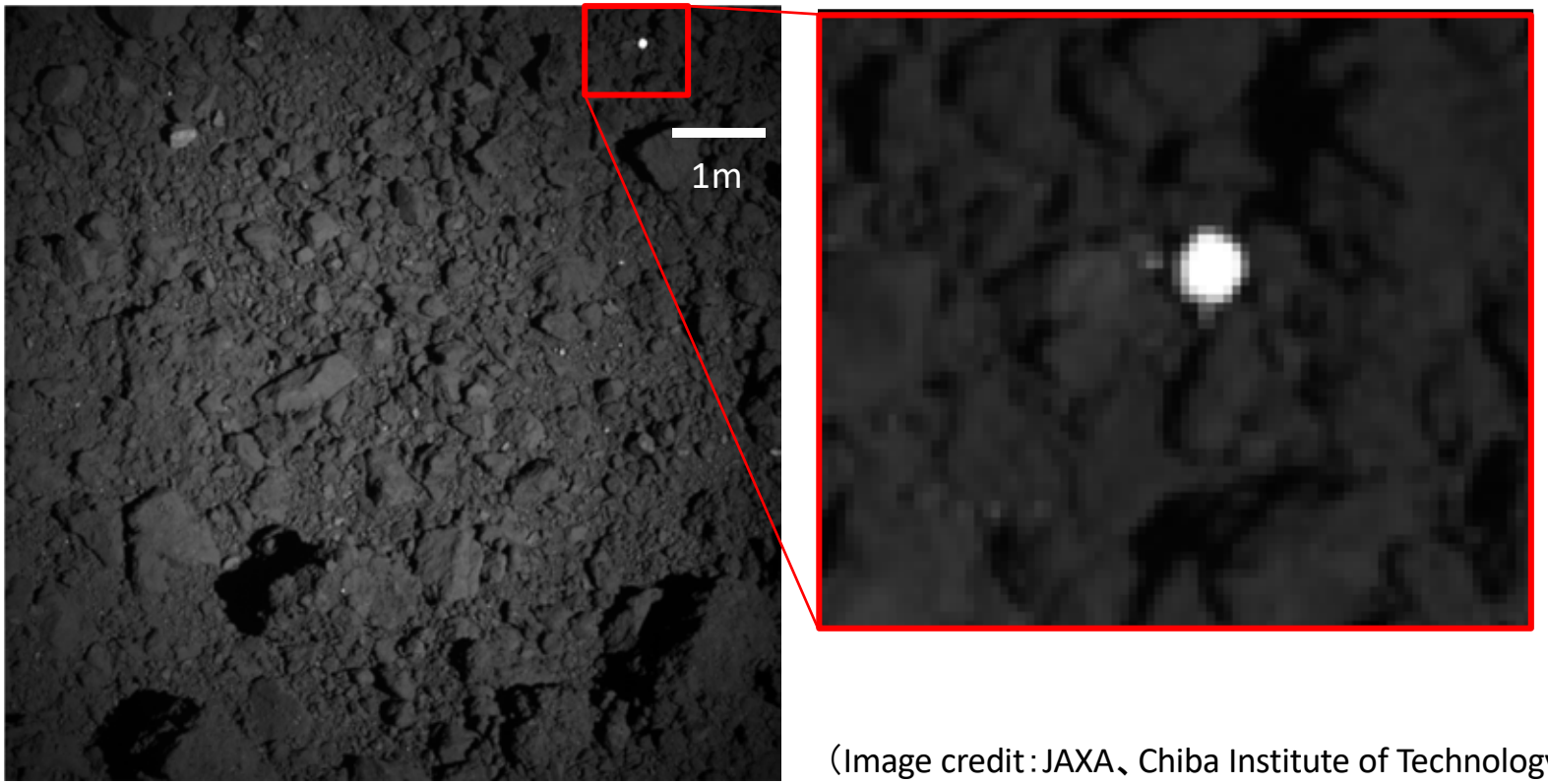
DEM（Digital Elevation Map）
near the touchdown
candidate point

（movie）

（image credit：JAXA、University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST., Kobe University, University of Occupational and Environmental Health)

2. The 2nd touchdown operation

Images taken with the ONC-T while rising during PPTD-TM1A

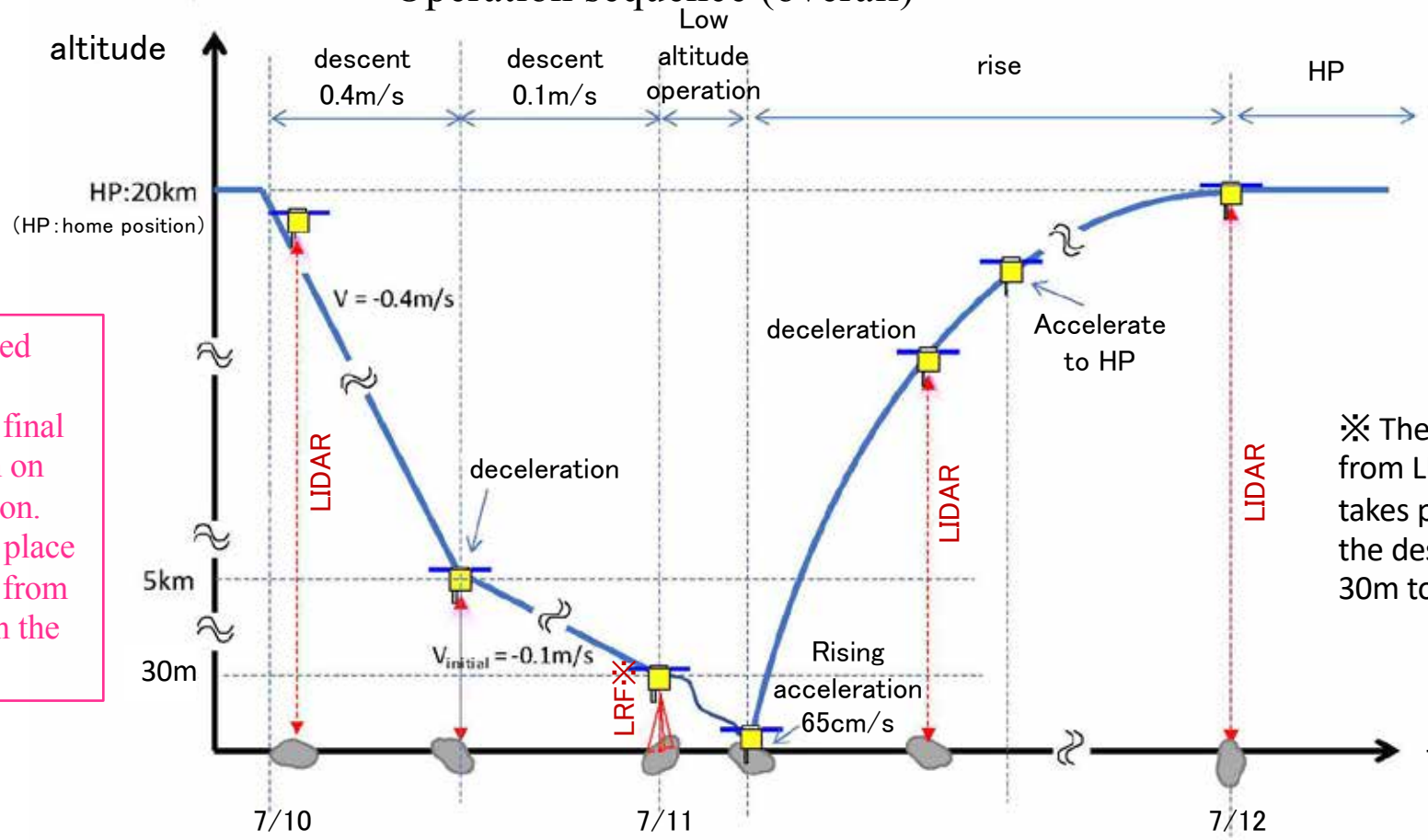


2019/05/30 11:26 JST (onboard time)
Altitude: 71 ～72m

（Image credit：JAXA、Chiba Institute of Technology, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Meiji University, University of Aizu, AIST）

2. The 2nd touchdown operation

Operation sequence (overall)



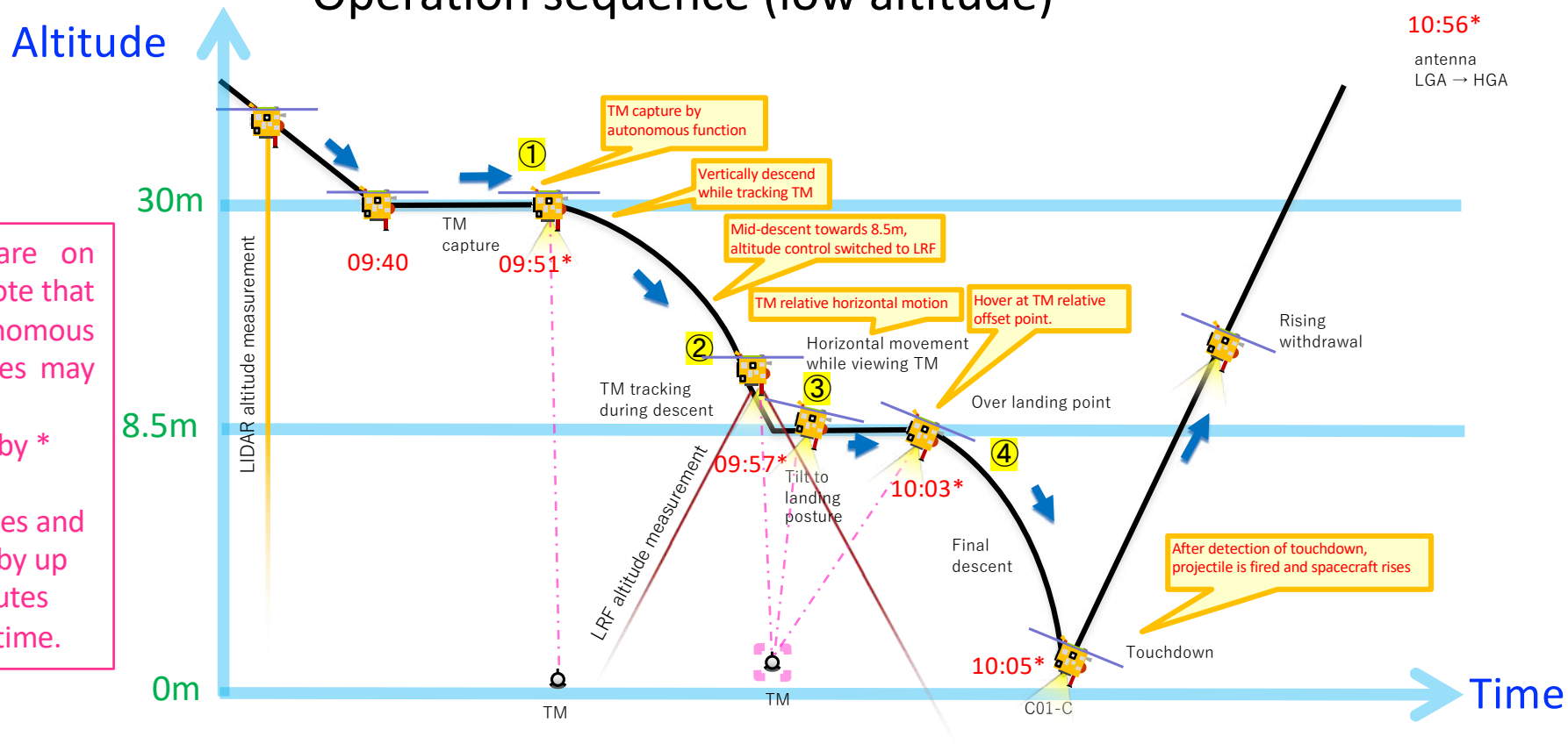
※Times are not fixed and may change depending on the final plan and situation on the day of operation.
* Touchdown takes place about 40 minutes from the time shown on the figure.

※ The transition from LIDAR to LRF takes place during the descent from 30m to 8.5m.

(image credit : JAXA)

2. The 2nd touchdown operation

Operation sequence (low altitude)



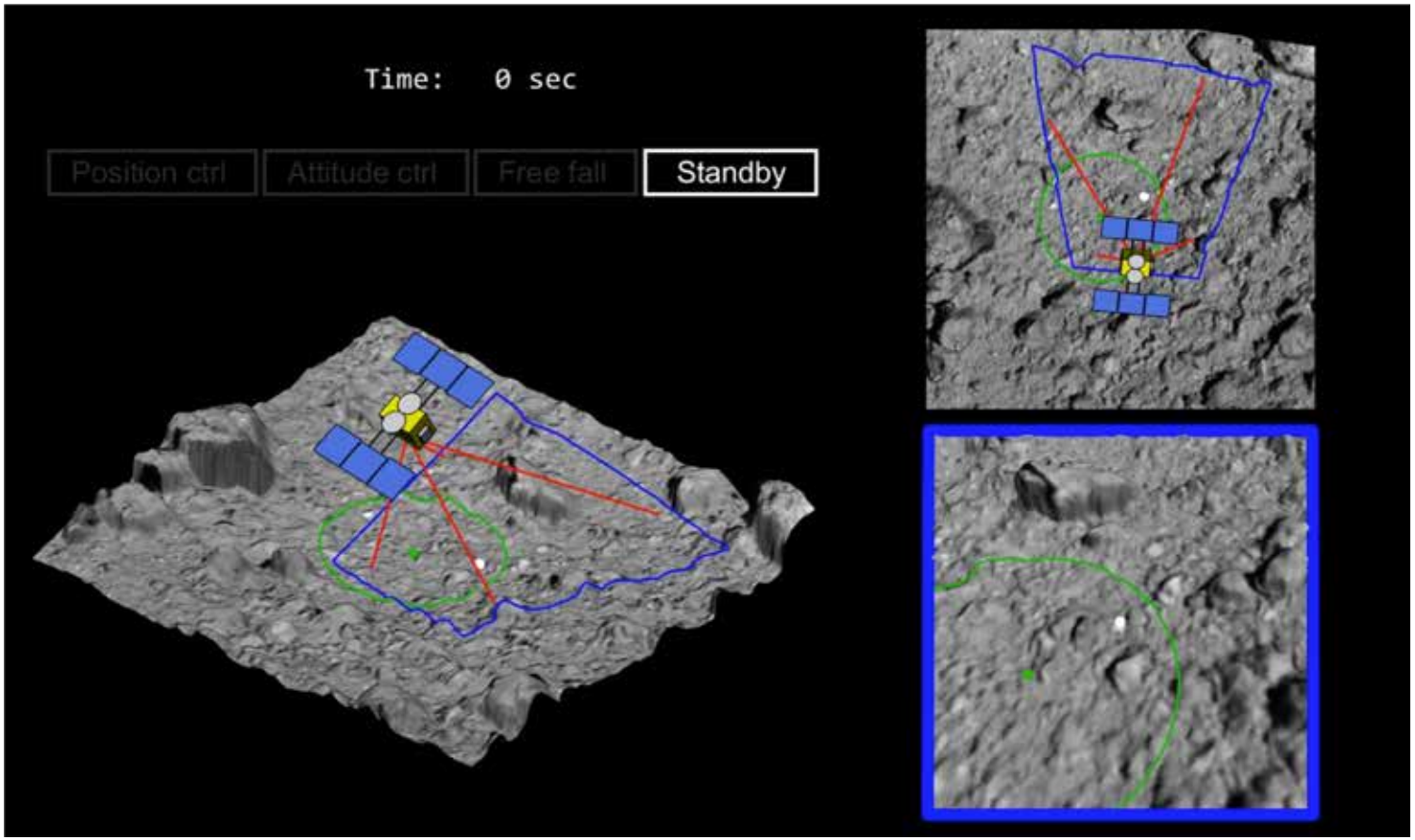
Times shown are on July 11, 2019. Note that due to autonomous control, the times may differ.
Times indicated by * are the earliest approximate times and may be delayed by up to about 40 minutes from the stated time.

※①～④ checkpoints for autonomous judgements as to whether Hayabusa2 continues to the next sequence.

（credit: JAXA）

2. The 2nd touchdown operation

Motion of the spacecraft from an altitude of 8.5m



（16x animation)

（credit：JAXA）

2. The 2nd touchdown operation

Decision points during the operation

item	Ground time: JST () onboard time	Decision item
Gate 1	7/10 09:46	Decision on start of descent (@20km)
Gate 2	7/10 21:19	Start confirming whether to continue descent（@5km)
Gate 3	7/11 08:41	Start final descent judgement（GO/NOGO judgement)
HGA→LGA	7/11 10:01 (09:47)	Antenna switching
Gate 4	7/11 10:01	Confirm switch to LGA
TD2	7/11 10:18* (10:05*) *40 mins from here time	Touchdown
LGA→HGA	7/11 11:09 (10:56)	Antenna switching
Gate 5	7/11 11:09	Start check of the state of the spacecraft
Gate 6	7/11 22:04	Start confirmation of ΔV to return to home position

Transmission of information

- ・Ryugu images from ONC-W1
- ・Advanced data from LIDAR

- ・Confirm the probe speed with Doppler data

- ・Check with telemetry

※The indicated time is not fixed and may change depending on the final plan and situation on the day of operation. The time written by the Gate is the time to start judgment, and it may take some time for the final result to be determined.

2. The 2nd touchdown operation

Changes from the 1st touchdown sequence

- To counter the cloudiness of the optical system at the base of the spacecraft, the altitudes to begin tracking the TM and using LRF were set lower than in TD1.
  - The safety design either maintains or strengthens the level of TD1. As a result, the sampling achievement probability is slightly reduced.

- To shorten the sequence, the spacecraft attitude will switch to tail-up immediately after reaching an altitude of 8.5.
  - This is streamlined based on experience from TD1. In TD1, tail-up was just before the final descent.

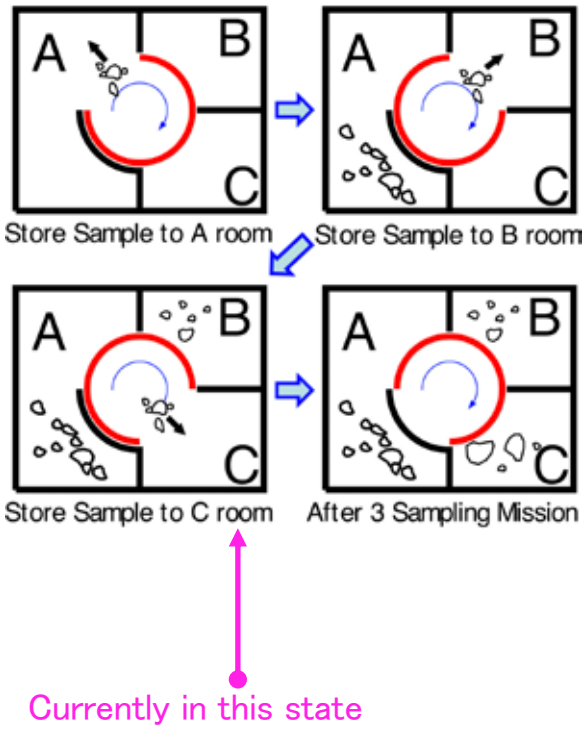
- As the TM and landing point are very close this time, the final descent for touchdown will be a vertical descent.
  - This improves landing accuracy. As the TM was further away during TD1, the final descent had to be diagonally downwards.

For other touchdown sequence design highlights, please refer to press briefings before the 1st touchdown (February 6 & 20, 2019) http://www.hayabusa2.jaxa.jp/en/enjoy/material/

2. The 2nd touchdown operation

Closing of catcher chamber B

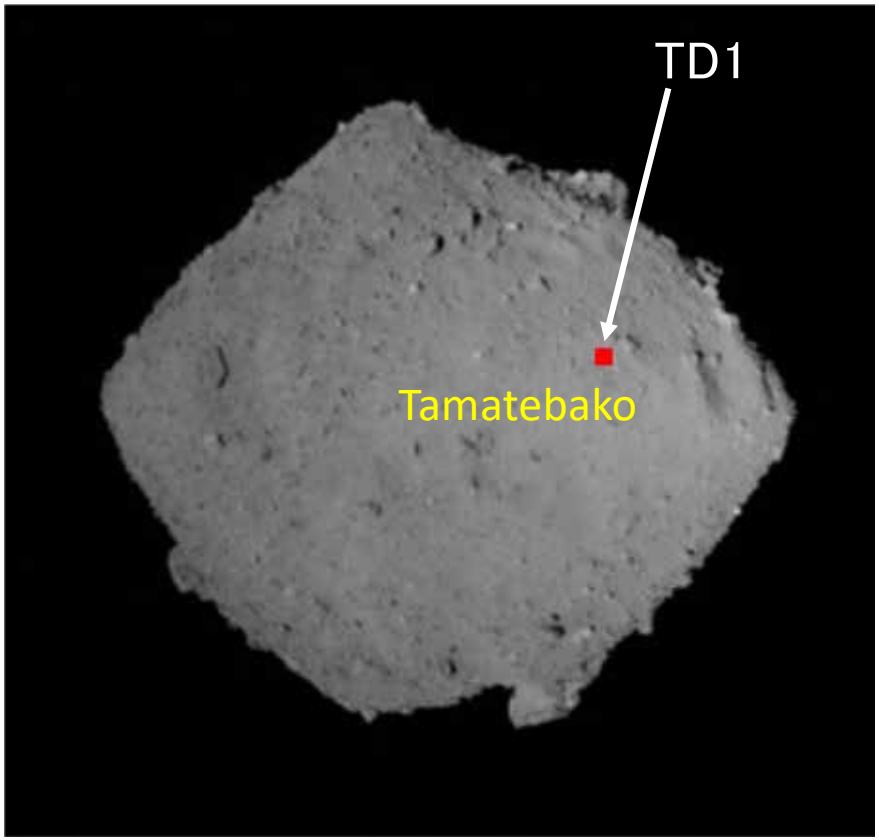
- During the operation on 6/24, the sample catcher was rotated to close chamber B.
- Chamber B was open immediately after the first touchdown (2/22). After this, the impact experiment (SCI) and a total of 7 descent operations were conducted.
- Chamber C is currently open.

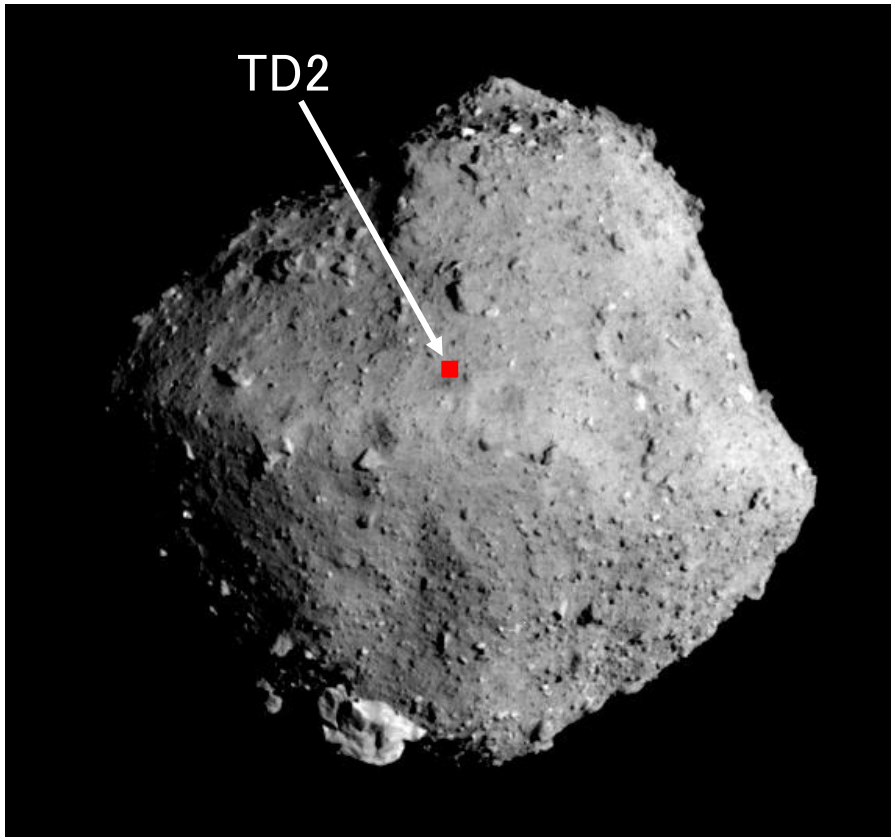


（image credit：JAXA）

2. The 2nd touchdown operation

Location of the first (TD1) and second (TD2) touchdowns

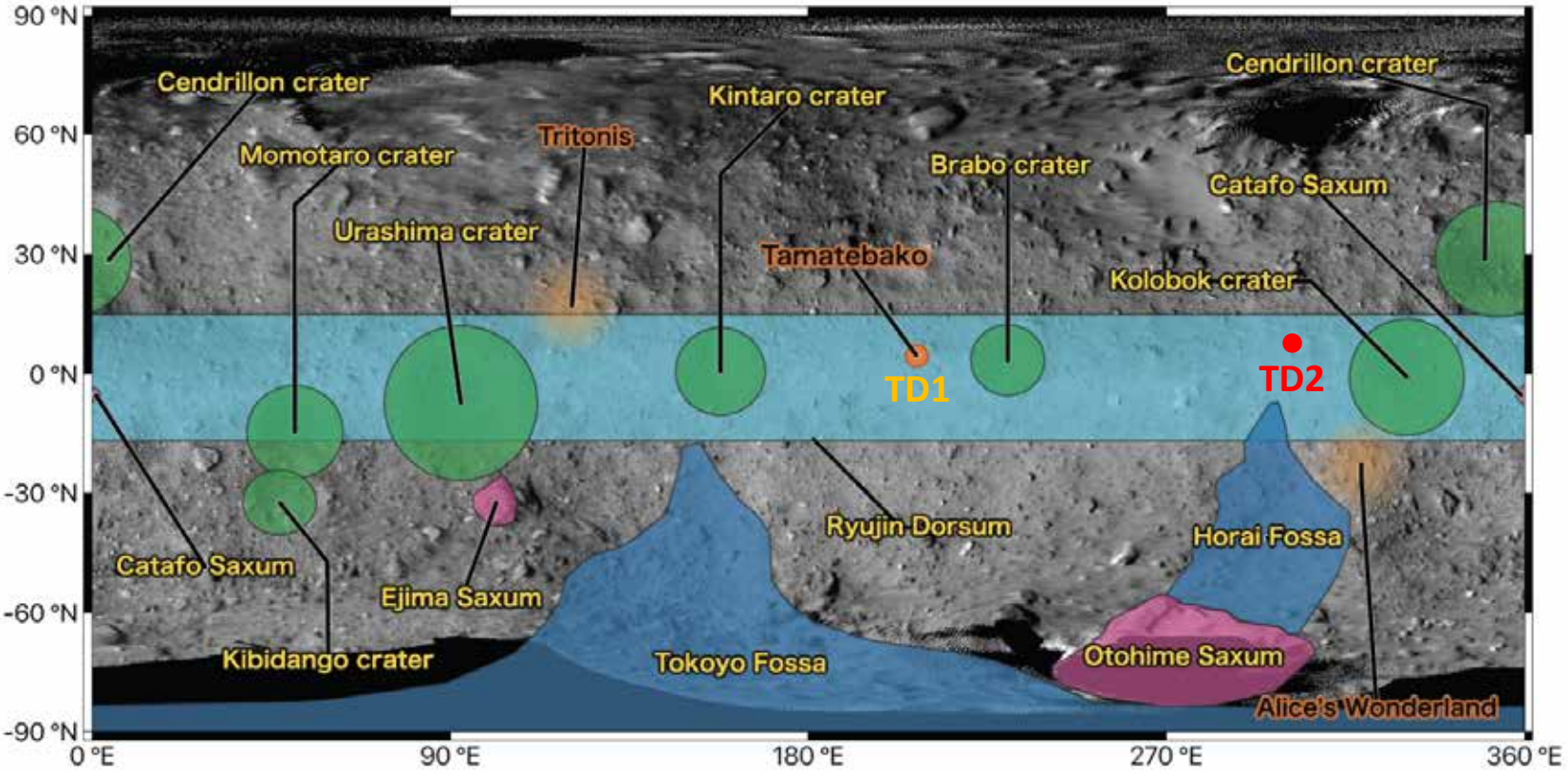




（image credit：JAXA、University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST.）

2. The 2nd touchdown operation

Location of the first (TD1) and second (TD2) touchdowns



Note: Tritonis (landing site for MINERVA-II1), Alice's Wonderland (MASCOT landing site), Tamatebako (first touchdown point) are nicknames and not recognised by the International Astronomical Union (IAU). Other places names are official names recognised by the IAU.

（credit：JAXA）

3. Scientific significance of performing the 2nd touchdown

■ Collection of sub-surface material

- Black material from Ryugu
- Degeneration process of surface material from solar wind or cosmic rays
- Mixing process on asteroid and its time scale

■ Collection from multiple sites

- Regional heterogeneity of celestial bodies
- Increase the amount of sample

4. Message from the Director General of ISAS / JAXA

So far, Hayabusa2 has achieved 1) asteroid rendezvous, 2) deployment of exploration robots and acquisition of surface data, 3) 1st touchdown, 4) artificial crater generation and from this, returned many results. We believe that sample acquisition was achieved during the 1st touchdown. When considering whether or not to perform the 2nd touchdown, it could be said that cancelling the 2nd touchdown and prioritising the return to Earth was the safest option for securing the early successes. On the other hand, if the second touchdown is successful, subsurface material can be collected and scientific results further enhanced. However, this comes with the possibility of serious damage or a crisis that could threaten the return to Earth.

We therefore carefully reviewed whether the accuracy requirements of the 2nd touchdown and that of the spacecraft performance fell within the conditions that were available at the 1st touchdown. From this, we confirmed that it was extremely likely that we could safely secure a 2nd touchdown with the current capabilities of the Hayabusa2 team and spacecraft. Therefore, ISAS will implement a 2nd touchdown with attention to both the “challenge” and “safety” components. We believe that success in this challenge will be a catalyst for advancing many future space science and exploration programs.

Director General, ISAS Hitoshi Kuninaka

5. Upcoming events

■ Operation plans

- 7/9～11：2nd touchdown operation

■ Press and media briefings

- 7/11 8:30～17:30 Press center opens @ Sagamihara campus
- 7/11 14:00～15:00

  Press conference on the implemented touchdown @ Sagamihara campus

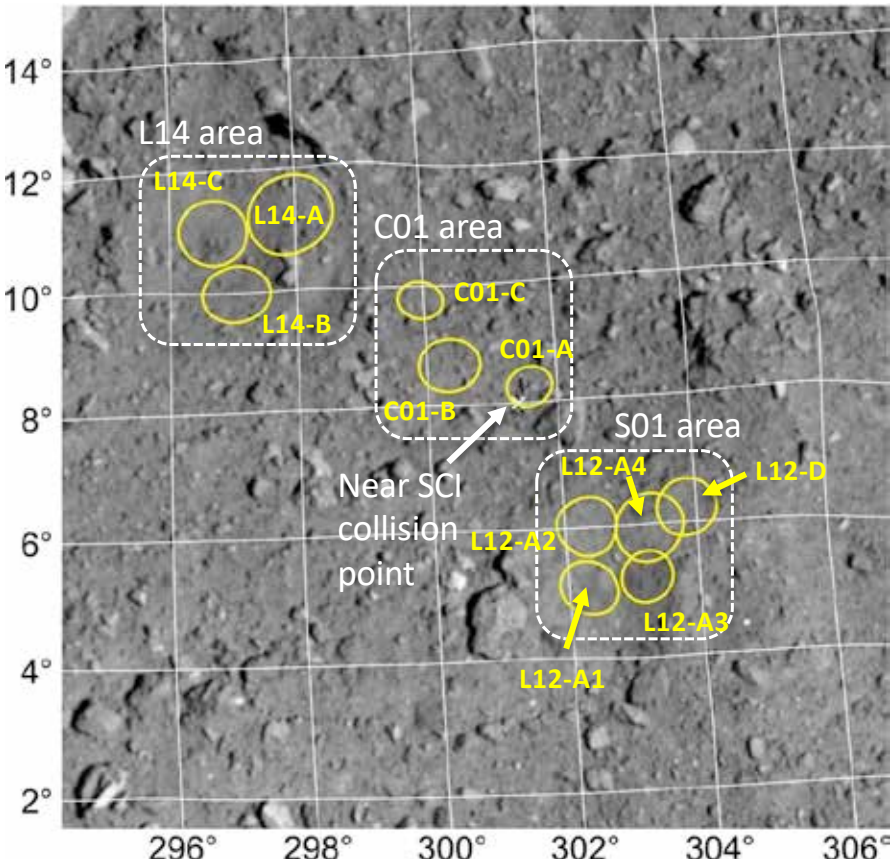
（Applications for participation in the press center and press conference closed on June 25）

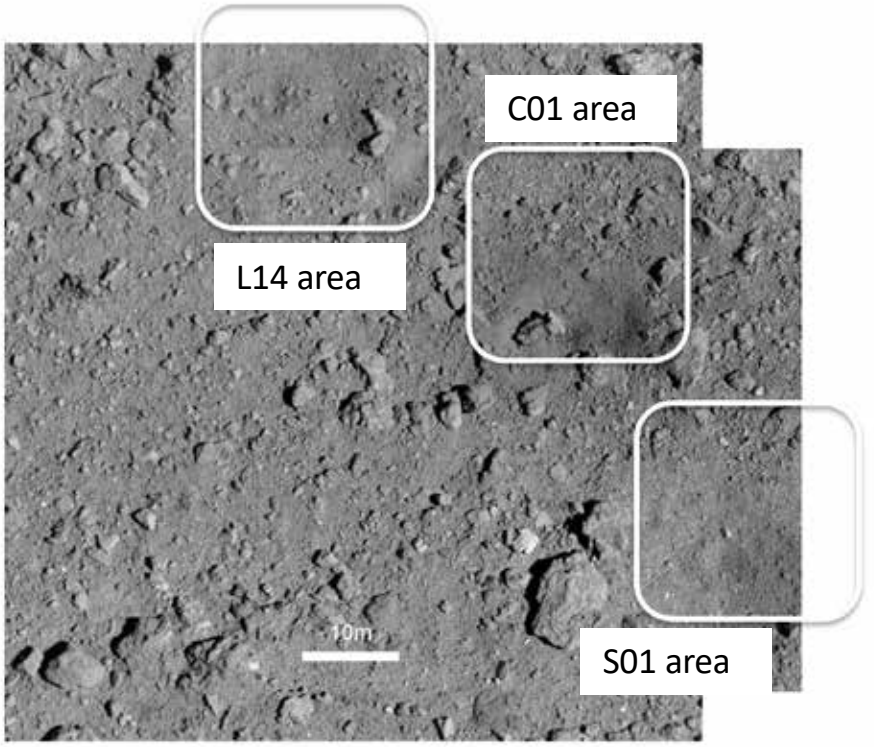
Reference material

Process for judging if the 2nd touchdown was feasible

- From May ~ June 2019, JAXA/ISAS discussed the scientific significance, state of the spacecraft and sequence confirmation, the reliability and risk regarding the 2nd touchdown operation with Hayabusa2.
- By 2019/6/20, the results of the examination by Hayabusa2 were summarized and discussed by the team.
- On 2019/6/21, the decision was judged at ISAS.
- On 2019/6/25、the decision was reported to JAXA management.
- Judgement of touchdown implementation:
  - High scientific value of a subsurface sample collection
  - Confirmation of the feasibility of a sufficiently safe touchdown operation by the spacecraft in its current condition.
  - Confirmation that there is no hindrance to subsequent operations even if the amount of light received by the optical system is further reduced during the second touchdown.

Touchdown candidate sites





(image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST)