Asteroid explorer, Hayabusa2, reporter briefing

July 14, 2020

JAXA Hayabusa2 Project

Topics

Regarding Hayabusa2,

- Return to Earth

Contents

0. Hayabusa2 and mission flow outline
1. Current status and overall schedule of the project
2. Decision for the Earth return date
3. Spacecraft operation plan for Earth return
4. Re-entry capsule collection plan
5. Public relations and outreach plan for the Earth return
6. Future plans

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

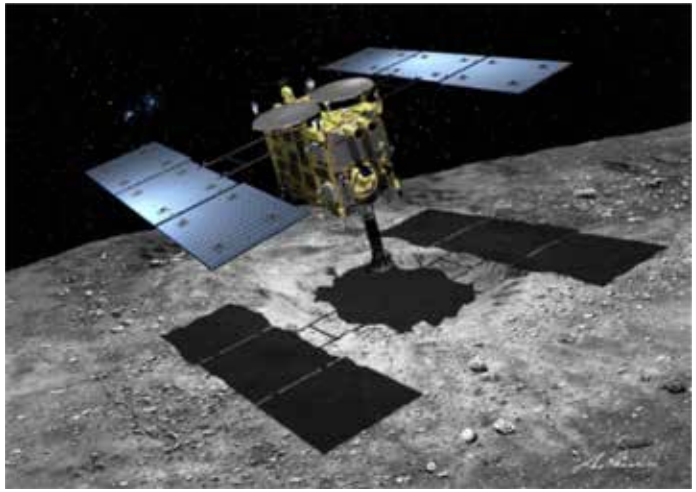
- By exploring a C-type asteroid, which is rich in water and organic materials, we will clarify interactions between the building blocks of Earth and the evolution of its oceans and life, thereby developing solar system science.
- Japan will further its worldwide lead in this field by taking on the new 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.

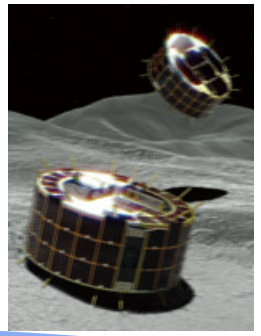
Mission flow

Launch
Dec 3, 2014

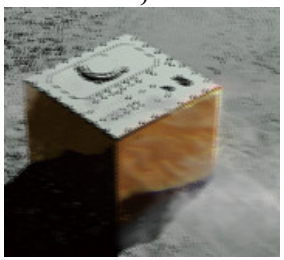
Earth swing-by
Dec 3, 2015

Ryugu arrival
June 27, 2018

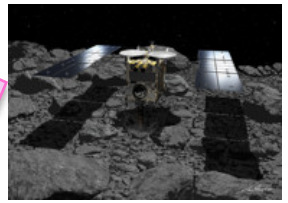
MINERVA-II-1 separation
Sep 21, 2018



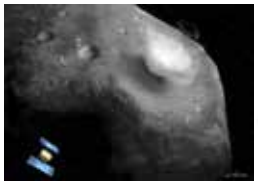
MASCOT separation
Oct 3, 2018



Target marker separation
Oct 25, 2018

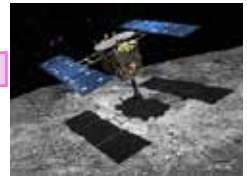


First touchdown
Feb 22, 2019



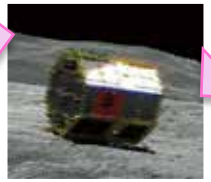
Impactor (SCI)
5 April, 2019

Target marker separation
May 30, 2019



Second touchdown
July 11, 2019

Target marker separation
Sept. 17, 2019



MINERVA-II2 separation
Oct. 3, 2019

Ryugu departure
Nov 13, 2019

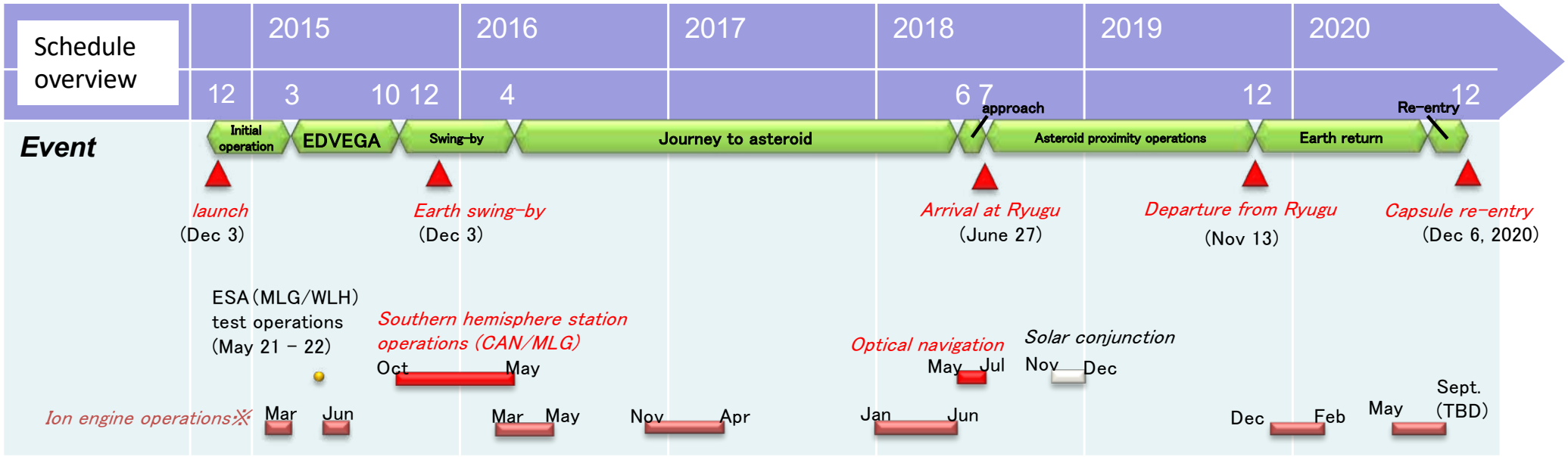
complete →

Earth return
End of 2020

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

1. Current project status & schedule overview

Current status:
- The 2nd ion engine operation that began on May 12 is continuing
- The works for the collection of the re-entry capsule are continuing.
- Scientific papers have been submitted and published



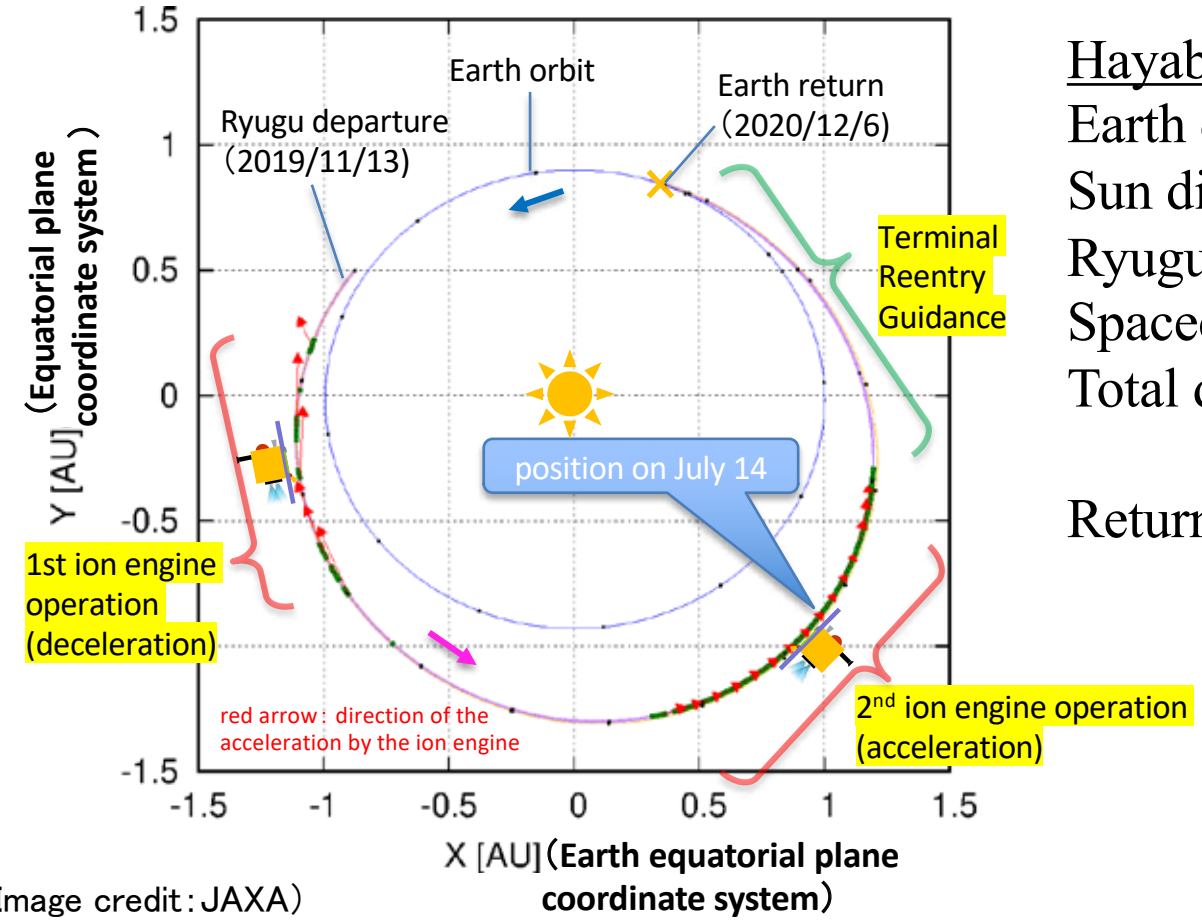
(image credit: JAXA)

2. The return date decision

- Date for Earth return is December 6, 2020 (Japan & Australia time)
  - JAXA has applied for the “Authorisation of Return of Overseas-Launched Space Object” (AROLSO); the permit required to land a space object in Australia.
  - The Australian Space Agency and JAXA are closely cooperating to obtain the AROLSO.
  - A joint statement by the Australian Space Agency and JAXA was issued as the work progressed, and the date of return to Earth was confirmed.
  - As work continues according to the joint statement, the AROLSO can be acquired and the above date for the Earth return confirmed.

3. Spacecraft operation plan for Earth return

Planned trajectory for return phase



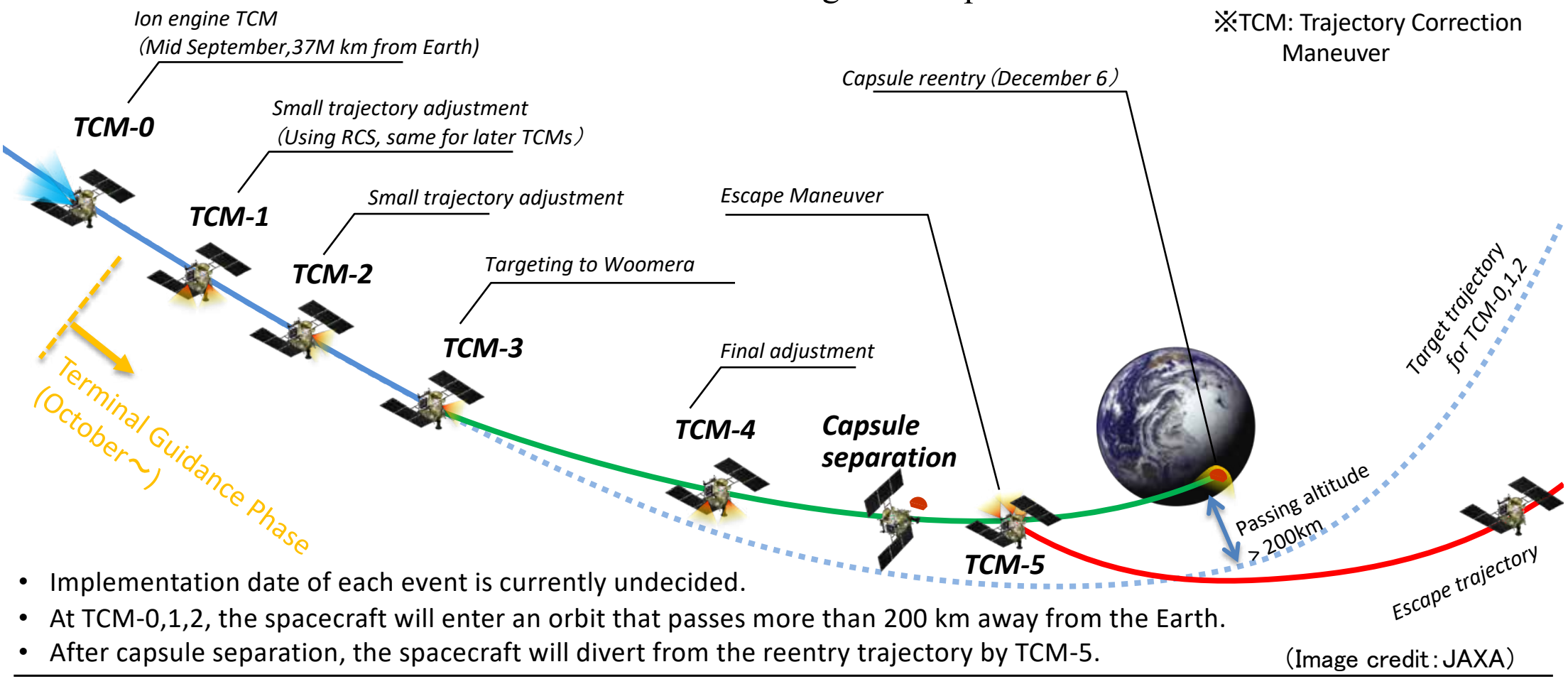
(Image credit : JAXA)

Hayabusa2 Status as of July 14

Earth distance	92 million km
Sun distance	200 million km
Ryugu distance	4,040,000 km
Spacecraft speed	23.9km/s
Total distance traveled	4.92 billion km
	(320 million km to go)
Return phase ΔV	: 63% achieved

3. Spacecraft operation plan for Earth return

Earth final return guidance phase



- Implementation date of each event is currently undecided.
- At TCM-0,1,2, the spacecraft will enter an orbit that passes more than 200 km away from the Earth.
- After capsule separation, the spacecraft will divert from the reentry trajectory by TCM-5.

(Image credit：JAXA)

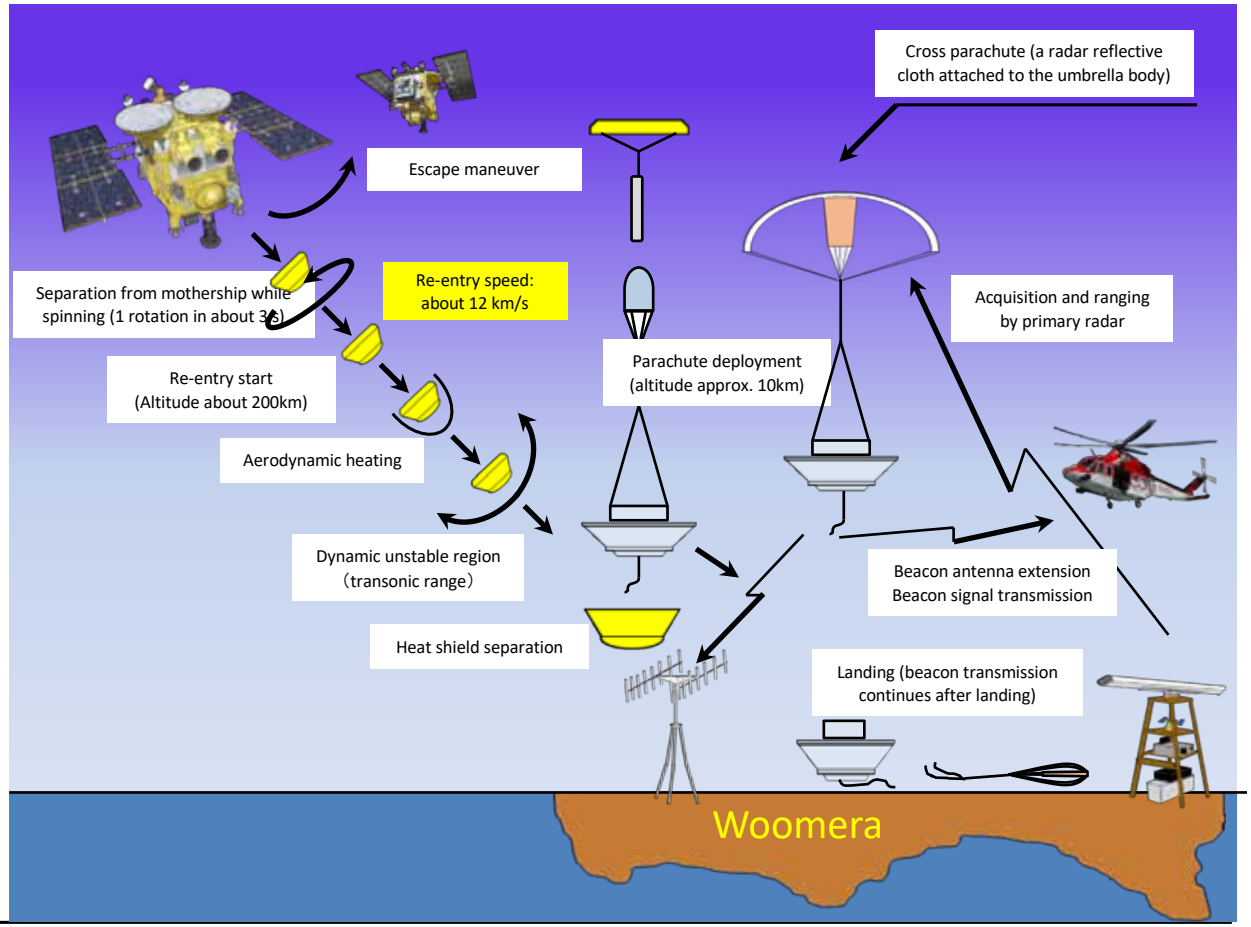
4. Re-entry capsule collection plan

Re-entry overview

■ Re-entry flight sequence

- Atmosphere re-entry
  (capsule only for Hayabusa2 re-entry)
  ↓
- Heat shied separation
  ↓
- Parachute opening
  ↓
- Beacon transmission
  ↓
- Landing

■ Landing location：
Woomera, Australia

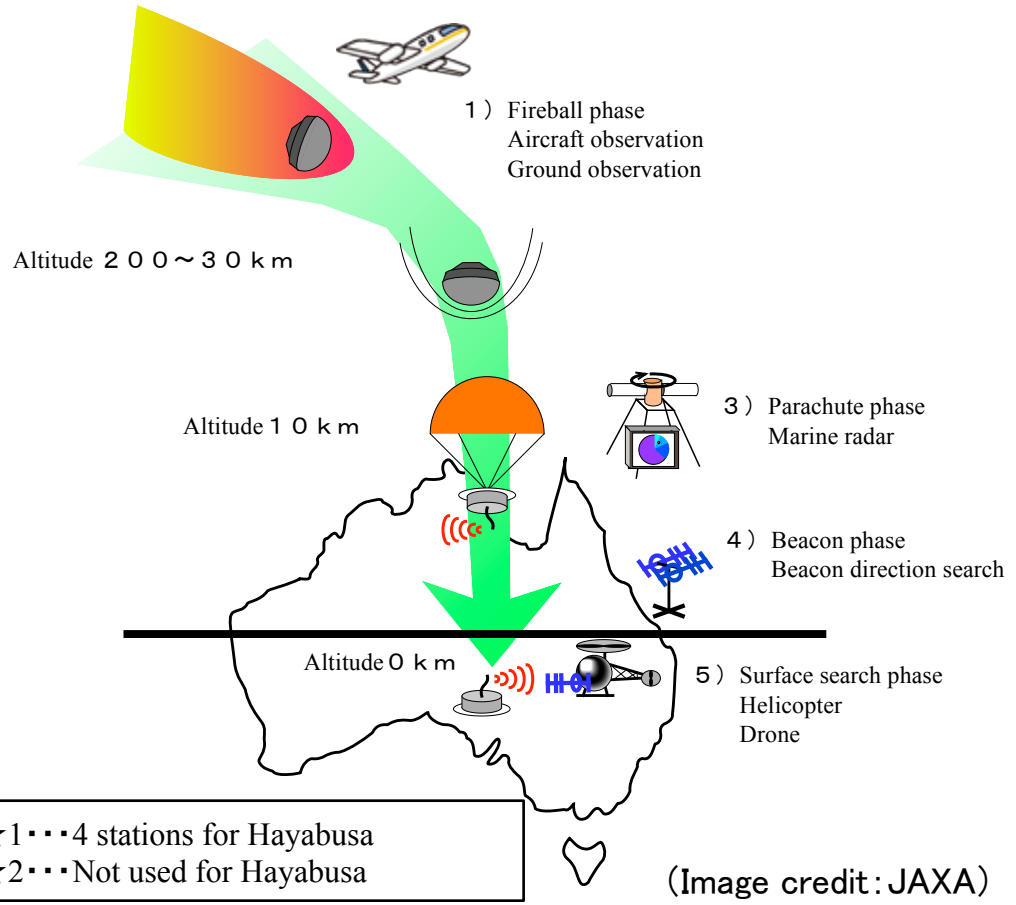


（image credit：JAXA）

4. Re-entry capsule collection plan

Collection operation overview

- Search (fireball phase)
  - Optical observation (ground)
    Measuring light trails from several stations (principal of triangulation)
  - Optical observation (aircraft)
    Measuring light trails from above clouds (unaffected by weather)
- Search (parachute phase)
  - Direction search (beacon)
    Beacon received at a total of 5 stations★1 (Principal of triangulation)
  - Direction search (marine radar) ★2
    Direction and distance can be measured.
- Search (surface exploration phase)
  - Direction search (helicopter)
    Search for beacon after landing with a helicopter
  - Drone★2
    Aerial view from the sky. Identification via image analysis.
- Transport
  - Safety process、disassembly
  - Collection of gas in capsule★2, transportation (to Japan)



★1･･･4 stations for Hayabusa
★2･･･Not used for Hayabusa

(Image credit：JAXA)

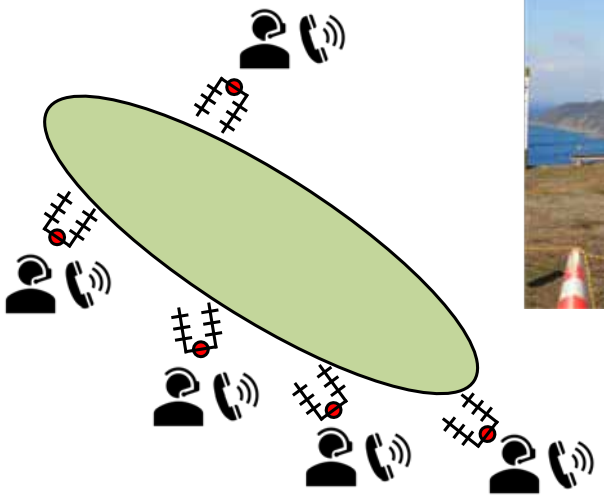
4. Re-entry capsule collection plan

Recovery at Woomera

Direction finding system：DFS

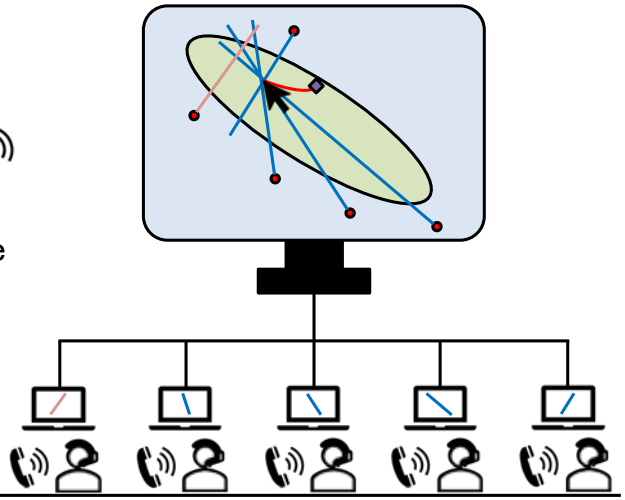
- After opening the parachute, the capsule descends & lands while transmitting a beacon signal.
- 5 antennae are placed around the expected landing area and the direction of the beacon signal source is identified.
- Since the antenna stations are 10s – 100s km apart and there is no communication network, the directions are all reported to headquarters using satellite phones.
- The intersection of the measured directions indicated by each of the 5 stations give the signal source (principal of triangulation)
- Once the capsule has landed, it cannot be detected by the ground antenna. After landing, search is conducted using an antenna mounted on a helicopter.

（image credit：JAXA）



Direction search concept diagram
Above：Predicted landing area. The beacon is received by 5 antenna stations.

方向探索用アンテナ



Right: Aggregation of the direction received by each antenna.

4. Re-entry capsule collection plan

Recovery at Woomera

Optical observation

- Backup if the parachute does not open or the beacon signal is not received.
  - Optical observation（ground）: Ground Observation System (GOS)
  - Optical observation（aircraft）: Airborne Observation

- Light trails at the time of re-entry into the atmosphere are observed from multiple points, and the re-entry orbit and landing point estimated from the observed azimuth and elevation.
- Only the light trails from the capsule
- In bad weather, ground observation will not be possible, so aircraft observation will be used.

Optical observation (ground)

Optical observation camera system

（image credit：JAXA）

4. Re-entry capsule collection plan

Recovery at Woomera

Marine Radar System：MRS

- Search with 4 marine radars.
- The fan beam antenna is rotated horizontally, and the direction and distance of the reflected wave from the parachute can be measured.
- The entire predicted landing area cannot be covered, but the central region of that area can be searched.
- This is a backup in case there is an issue with the beacon transmitter.

Marine radar system

（image credit：JAXA）

4. Re-entry capsule collection plan

Recovery at Woomera

Drone

- Aerial photography of the predicted capsule landing area from an Unmanned Aerial Vehicle: UAV.
- Images have to be taken within a fixed area and the program navigation is suitable for drone to capture continuous image without gaps.
- High-speed capsule recognition processing is performed on the captured images to identify the capsule.
- This will be used as a back-up in cases where the helicopter becomes difficult to fly or if the capsule cannot be found by DFS or MRS.

UAV

（image credit：JAXA）

4. Re-entry capsule collection plan

Recovery at Woomera

Steps after discovery

- Collected discovered capsule-related equipment
  - Body : instruments module
  - Front heat shield
  - Rear heat shield
- Capsule safety processing.
- Use the Quick Look Facility (QLF) to perform disassembly, gas sampling and simple analysis of the gas (new for Hayabusa2)
- Transport to Sagamihara Campus while maintaining sample cleanliness (details of the transportation method are still under consideration).

Work flow after discovering the capsule (some photos from Hayabusa)

(image credit : JAXA)

4. Re-entry capsule collection plan

■Time line

- 2018/4 Launched the Hayabusa2 Recovery Operation Team
- 2018/11 Conclusion of capsule collection written informed consent
- 2018/12 Field survey @ Australia/Woomera.
- 2019/8 Announcement of planned collection from Australia/Woomera.
- 2019/8 Submit landing clearance application documents and continue planning adjustments
- 2019/12 Recovery rehearsal @ Australia/Woomera.
- 2020/7 Hayabusa2 return date announced.

Obtain the capsule landing clearance（Authorisation of Return of an Overseas Launched Space Object: AROLSO）in order to return to Earth.

■Overseas related organisations

- ASA: Australian Space Agency
  Capsule landing permit examination and support, coordinating office with Australian ministries.
- Australian Department of Defence (DOD）
  Support for management and recovery within the Woomera controlled area.
- US NASA：Aircraft observation support.

4. Re-entry capsule collection plan

Matters related to the novel coronavirus

In the present circumstances,

- As a measure against the novel coronavirus, Australia currently bands entry from abroad.
- Most international flights between Japan and Australia are suspended.

Under these circumstances, the joint statement between the Japan-Australia space agencies has been a significant achievement.

- The scientific and social value of the Hayabusa2 Earth return is extremely high. Additionally, expectations from the academic community for the returned Ryugu samples are also very high.
- Earth return and capsule collection work is highly valuable for deepening the relationship between Japan and Australia. The Australian Government has been actively supporting the implementation of the plan.
- The collection plan is possible while being compliant with the infection control measures for the novel coronavirus in both Australia and Japan.

We would like to thank the Government of Australia, NASA, the Ministry of Education, Culture, Sports, Science & Technology, the Japanese Embassy in Australia, customs and Sagamihara City among others for their strong support in formulating the recovery plan.

Please understand that in order to cope with the novel coronavirus, the execution of Earth return will be more restrictive than usual. Thank you for your understanding.

5. Public relations and outreach plans for Earth return

■Before returning to Earth

- Regular press briefings will update on the topics and circumstances at that time.
- Information will be shared on the JAXA website and SNS.
- Events will be held, such as the Talk Live.

■During Earth return

- We are considering a method of transmitting information as close as possible to real time (details will be reported once finalized).
- We are studying the possible methods for communication in this era of the novel coronavirus.

6. Future plans

■Operation schedule

2020/5/12/～　second ion engine operation

■Press and media briefings

2020/7/22/　Press briefing session online

Reference material

Joint statement between the Australia Space Agency & JAXA

Joint Statement
for
Cooperation in the Hayabusa2 Sample Return Mission
by the
Australian Space Agency
and the
Japan Aerospace Exploration Agency

14 July 2020

The Australian Space Agency (the Agency) and the Japan Aerospace Exploration Agency (JAXA) have been in close cooperation on JAXA's asteroid sample-return mission, 'Hayabusa2'. The sample capsule is planned to land in Woomera, South Australia and the Agency and JAXA are working towards the planned safe re-entry and recovery of the capsule containing the asteroid samples.

Recently, JAXA indicated that 6 December 2020 (Australia/Japan time) is its planned target date for the capsule re-entry and recovery. The Agency and JAXA are working through JAXA's application for Authorisation of Return of Overseas Launched Space Object (AROLSO), which will need to be approved under the *Space Activities Act (1998)*.

Successfully realizing this epoch-making sample return mission is a great partnership between Australia and Japan and will be a symbol of international cooperation and of overcoming the difficulties and crisis caused by the pandemic.

Dr Megan Clark AC Head, Australian Space Agency Melbourne, Australia	Dr YAMAKAWA Hiroshi President, Japan Aerospace Exploration Agency Tokyo, Japan

「はやぶさ２」サンプルリターンミッションにおける
豪州宇宙庁と宇宙航空研究開発機構の協力に関する共同声明
(仮訳)

2020 年 7 月 14 日

豪州宇宙庁と宇宙航空研究開発機構（JAXA）は、JAXA の小惑星サンプルリターンミッション、「はやぶさ 2」において密接に協力している。小惑星のサンプルを搭載したカプセルは南豪州ウーメラに着陸する予定であり、両機関はカプセルの安全な再突入と回収の実現に向け取り組んでいる。

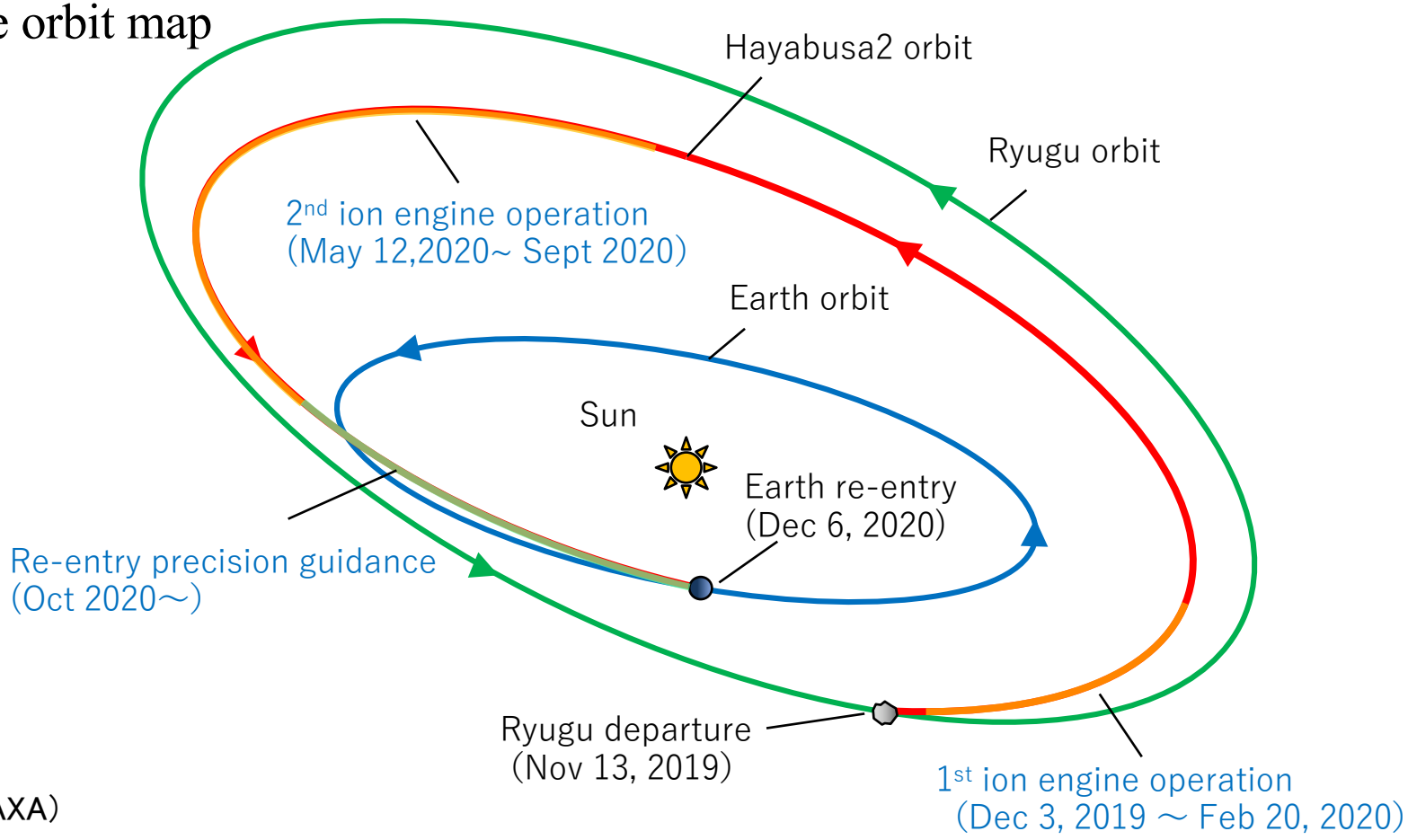
JAXA は、2020 年 12 月 6 日（オーストラリア/日本時間）をカプセルの再突入および回収の予定日として設定した。JAXA は宇宙物体のオーストラリアへの着陸許可（Authorisation of Return of Overseas Launched Space Object：AROLSO）を申請しており、両機関は現在その確認作業を進めている。同申請は、オーストラリアの宇宙活動法（1998 年施行）に基づき承認される予定である。

この画期的なサンプルリターンミッションを実現することは、豪州と日本の強力なパートナーシップそのものであり、国際協力および新型コロナウイルスの感染拡大により生じた困難・危機克服の象徴になるだろう。

メーガン・クラーク 豪州宇宙庁　長官 オーストラリア、メルボルン	山川　宏 宇宙航空研究開発機構　理事長 東京、日本

Return cruise operation plan

Return phase orbit map



(image credit：JAXA)