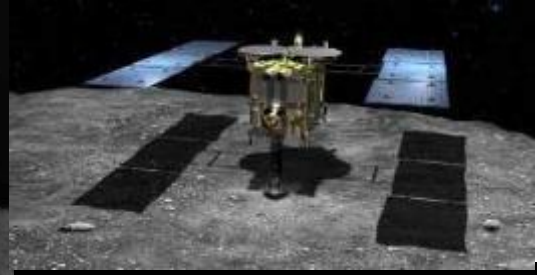
Achievements of Hayabusa2: Unveiling the World of Asteroid by Interplanetary Round Trip Technology



Yuichi Tsuda
Project Manager, Hayabusa2
Japan Aerospace Exploration Agency

58th COPUOS, April 23, 2021

Lunar and Planetary Science Missions of Japan

1980 1990 2000 2010 2020 Future Plan

Moon


1990 Hiten

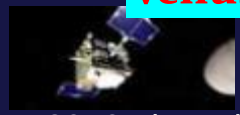

Lunar-A ×


2007 Kaguya


SLIM

Planets

Venus


2010 Akatsuki


2018 Mio

Mercury


1998 Nozomi ×

(Mars)


2010 IKAROS

Venus

Small Bodies


MMX

Phobos/Mars


2014 Hayabusa2

Asteroid Ryugu


1985 Suisei


1985 Sakigake

Comet Halley


2003 Hayabusa

Asteroid Itokawa


Destiny+

Comet Pheton

Flyby → Sample Return

Hayabusa2 Mission

- ✓ Sample return mission to a C-type asteroid “Ryugu”
- ✓ 5.2 billion km interplanetary journey.

Launch
Dec.3, 2014

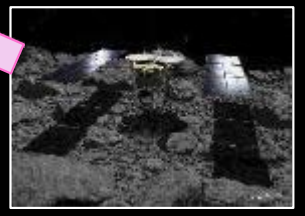
Earth Gravity Assist
Dec.3, 2015

Ryugu Arrival
Jun.27, 2018

MINERVA-II-1 Deployment
Sep.21, 2018

MASCOT Deployment
Oct.3, 2018

First Touchdown
Feb.22, 2019



Kinetic Impact
Apr.5, 2019

Second Touchdown
Jul,11, 2019

Target Markers Orbiting
Sep.16, 2019

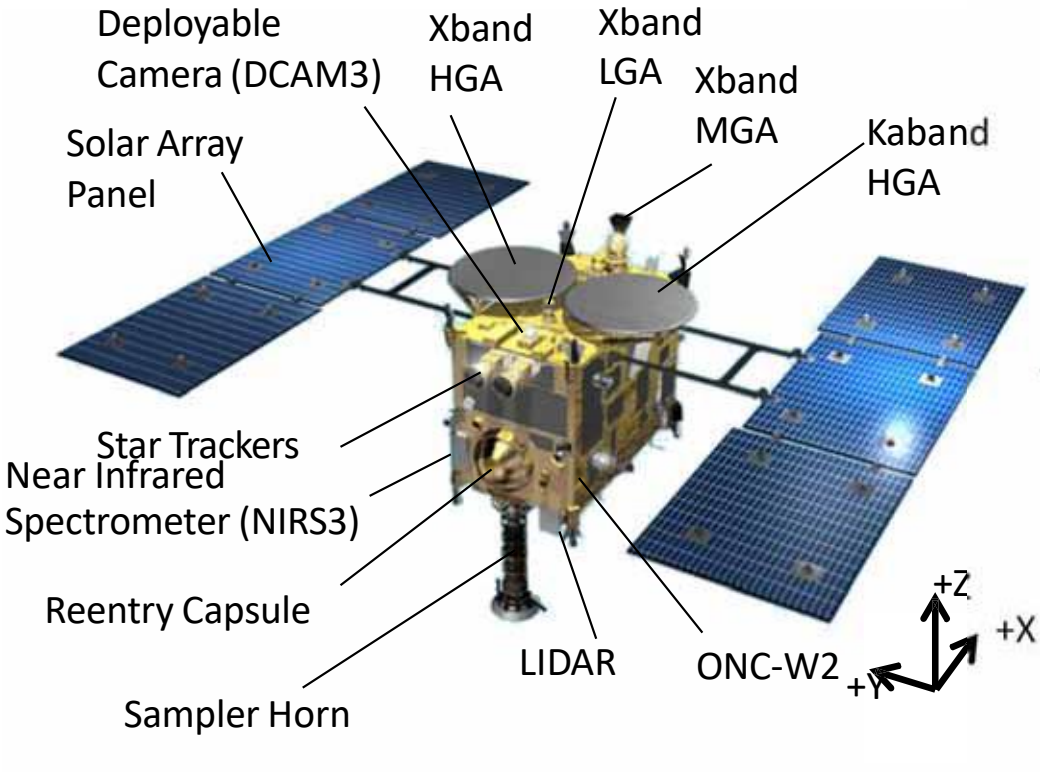
MINERVA-II-2 Orbiting
Oct.2, 2019

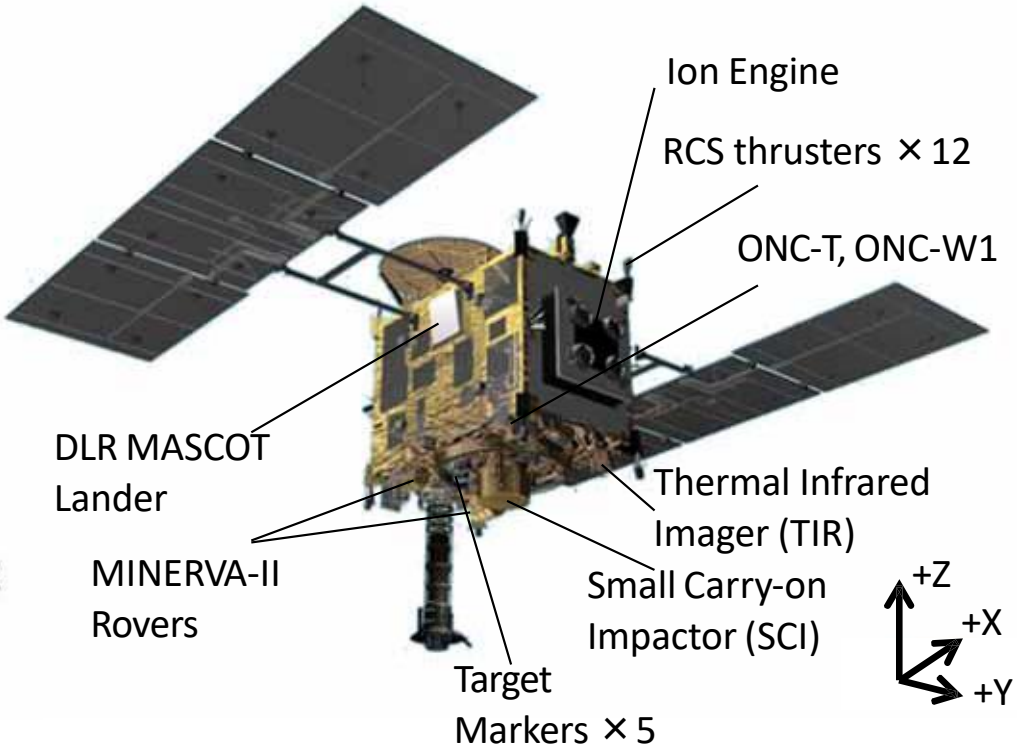
Ryugu Departure
Nov.13.2019

Earth Return
Dec.6, 2020

MD [D VIp srvlxp #534<#

Hayabusa2 Spacecraft Overview





Launch Mass: 609kg
Ion Engine: Total ΔV=3.2km/s, Thrust=5-28mN (variable), Specific Impulse=2800-3000sec. (4 thrusters, mounted on two-axis gimbal)
Chemical RCS: Bi-prop. 20N thrusters ×12 (6 DOF maneuverability)
Solar Array Paddle: 2.6kW @ 1 a.u.
TT&C: X-band Uplink, X/Ka-band Downlink, 8-32Kbps, X/Ka RARR&DDOR capability

International Collaboration in Hayabusa2

200+ Japanese researchers, 100+ international researchers

USA

1. NASA

- Tracking and navigation support by JPL
- Asteroid observation
- Sample exchange with OSIRIS-REx mission

Europe

1. DLR (Germany)

- Provision of MASCOT Lander
- Tracking support thr ESA
- Drop tower experiment

2. CNES (France)

- Provision of instruments aboard MASCOT

Australia

1. Australian Space Agency (ASA)

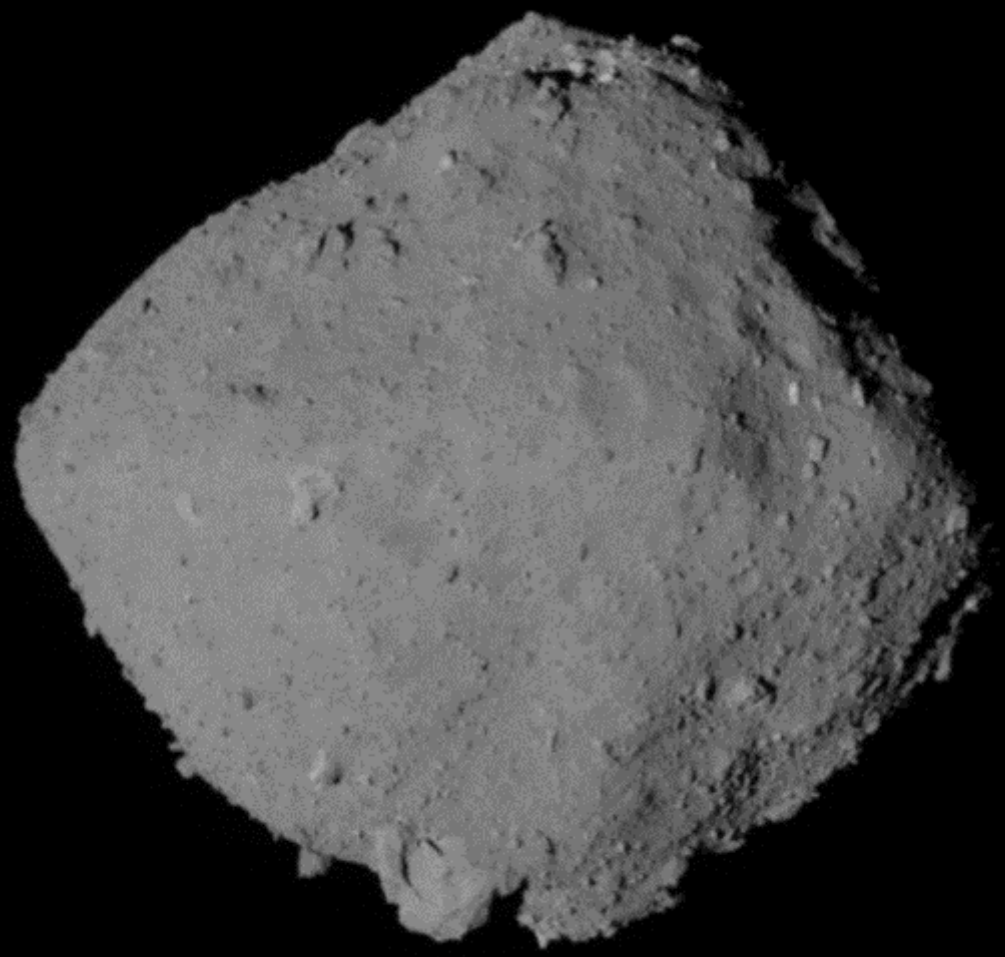
- Landing authorization

2. Department of Defense (DOD)

- Provision of Landing site

Arrival at Ryugu on June 27, 2018

- Top shape with a very circular equatorial bulge
- Spectrum type: Cb
- Diamter: ～900 m
- Mass: ～450 million ton
- Obliquity: ～8°
- Rotation period : P = 7.63 hours
- Reflectance factor（v-band）: 0.02
- Terrain: Very bumpy

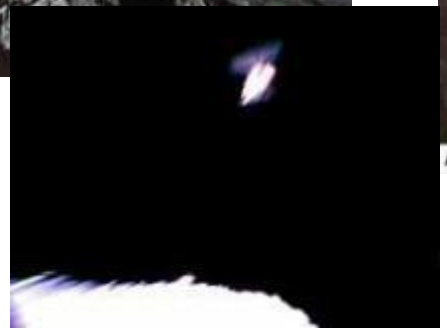


Accomplishments of Hayabusa2 (1/2)

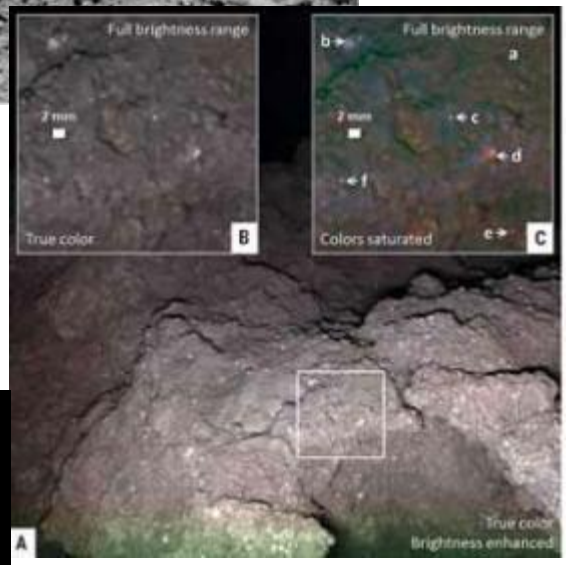
1. Mobile activity of exploration robots on small body
2. Multiple robots deployment on small body

MASCOT taken by ONC-W2

MINERVA-II-1A image

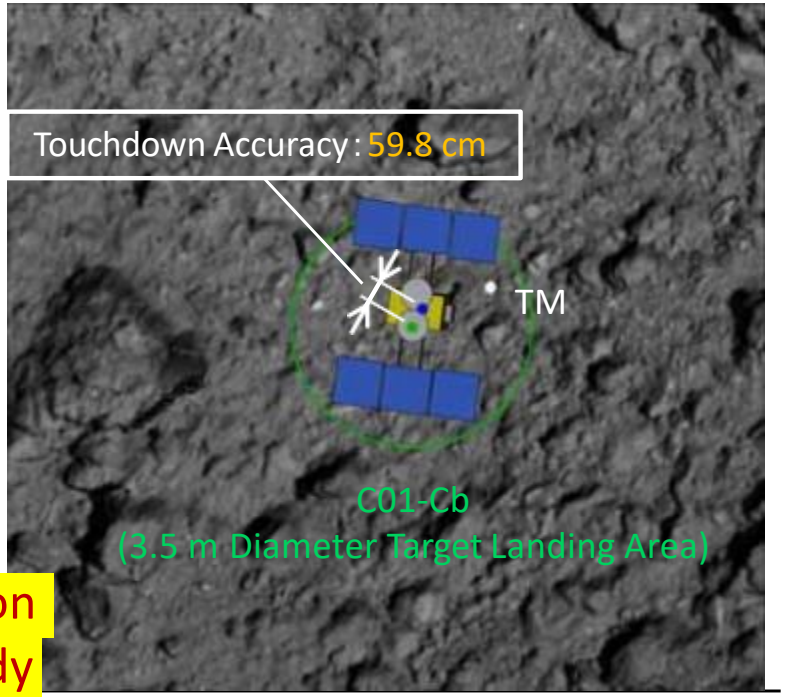


MINERVA-II-1A image



MASCOT images

CAM-H image at the 1st touchdown



Landing accuracy of the 2nd touchdown

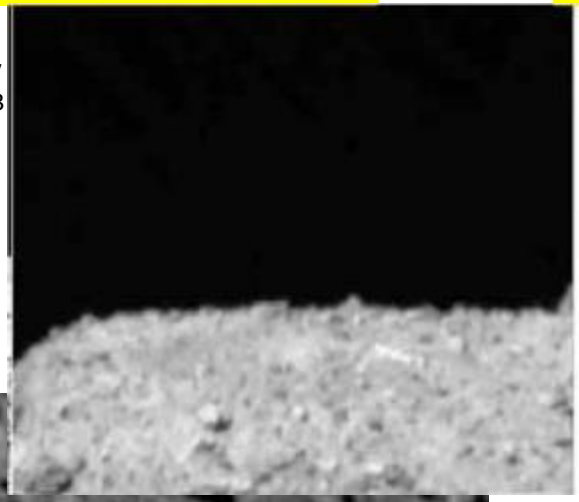
3. 60cm-accuracy landing and sampling on extra-terrestrial celestial body

image credit: JAXA

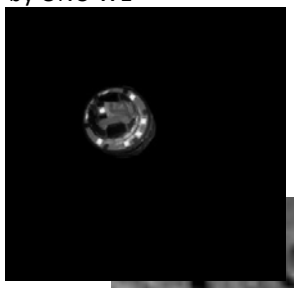
Accomplishments of Hayabusa2 (2/2)

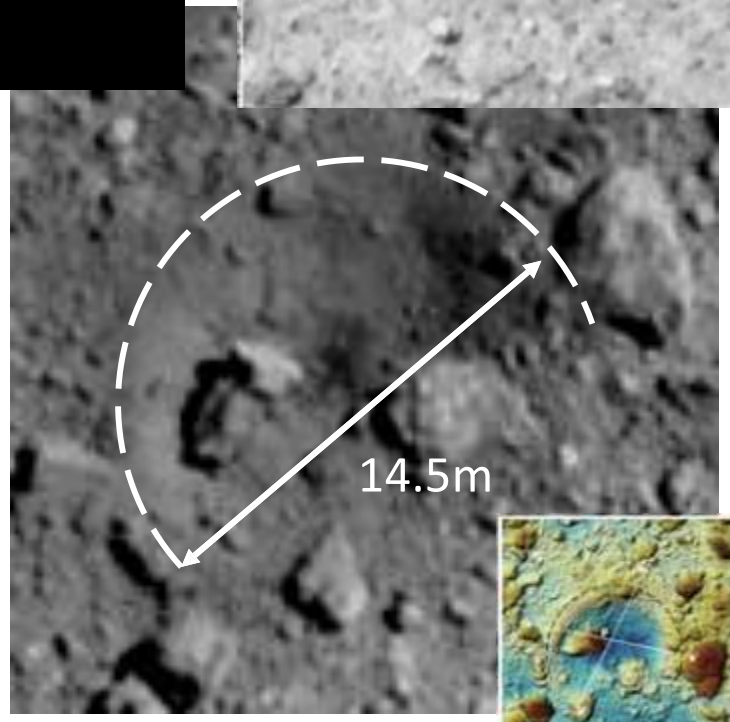
4. Artificial crater forming and detailed observation of impact process

Impact ejecta observed by DCAM3



Deployed SCI taken by ONC-W1

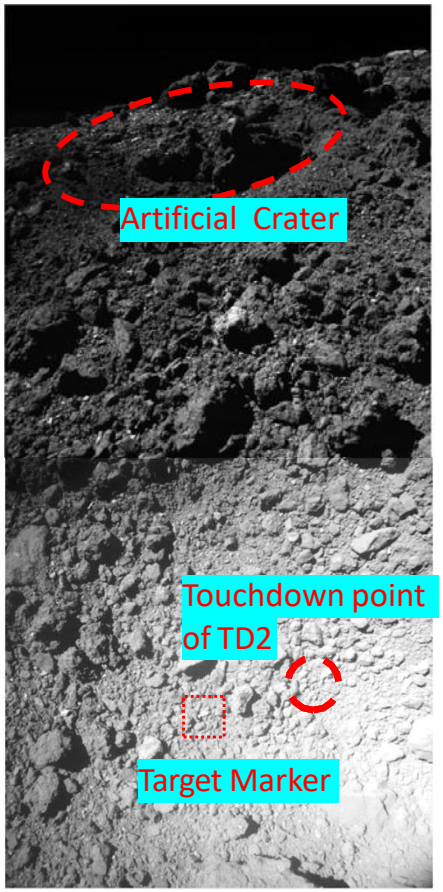




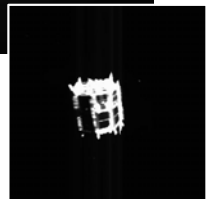
Artificial crater generated by SCI (above) and its digital elevation map (right)

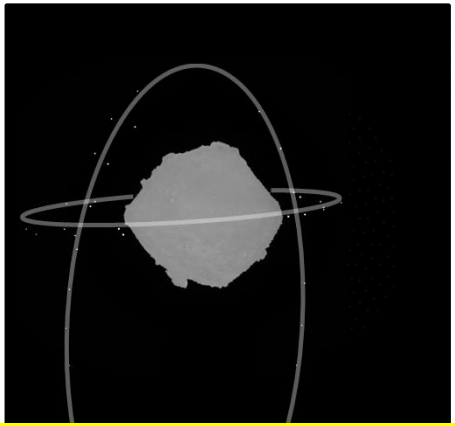
5. Multiple landing on extra-terrestrial celestial body
6. Access to subsurface material

Accumulation of Impact ejecta around artificial crater



Artificial crater and TD2 point in one view



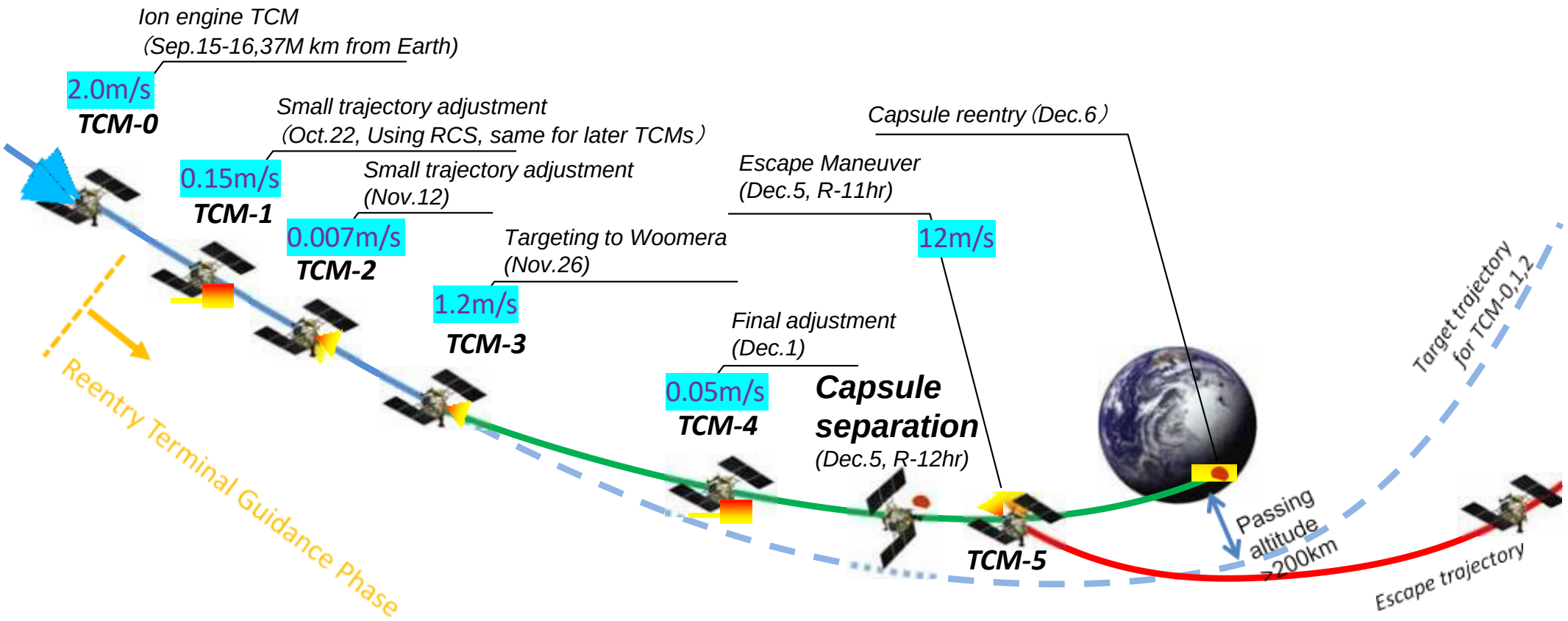


7. Smallest-object constellation around extra-terrestrial celestial body

image credit: JAXA

Reentry Terminal Guidance Phase

- 5 TCMs in the last 2 months before Earth return.
- The SRC was separated 12 hrs before reentry.
- The spacecraft diverted from the reentry trajectory 11 hrs before reentry.



Hayabusa2 has returned!

Coober Pedy, Australia, Dec.6, 2020, 2:28:48-2:29:11JST (Altitude 80～50km)

Sample Return Capsule recovery

Dec.6 (JST)

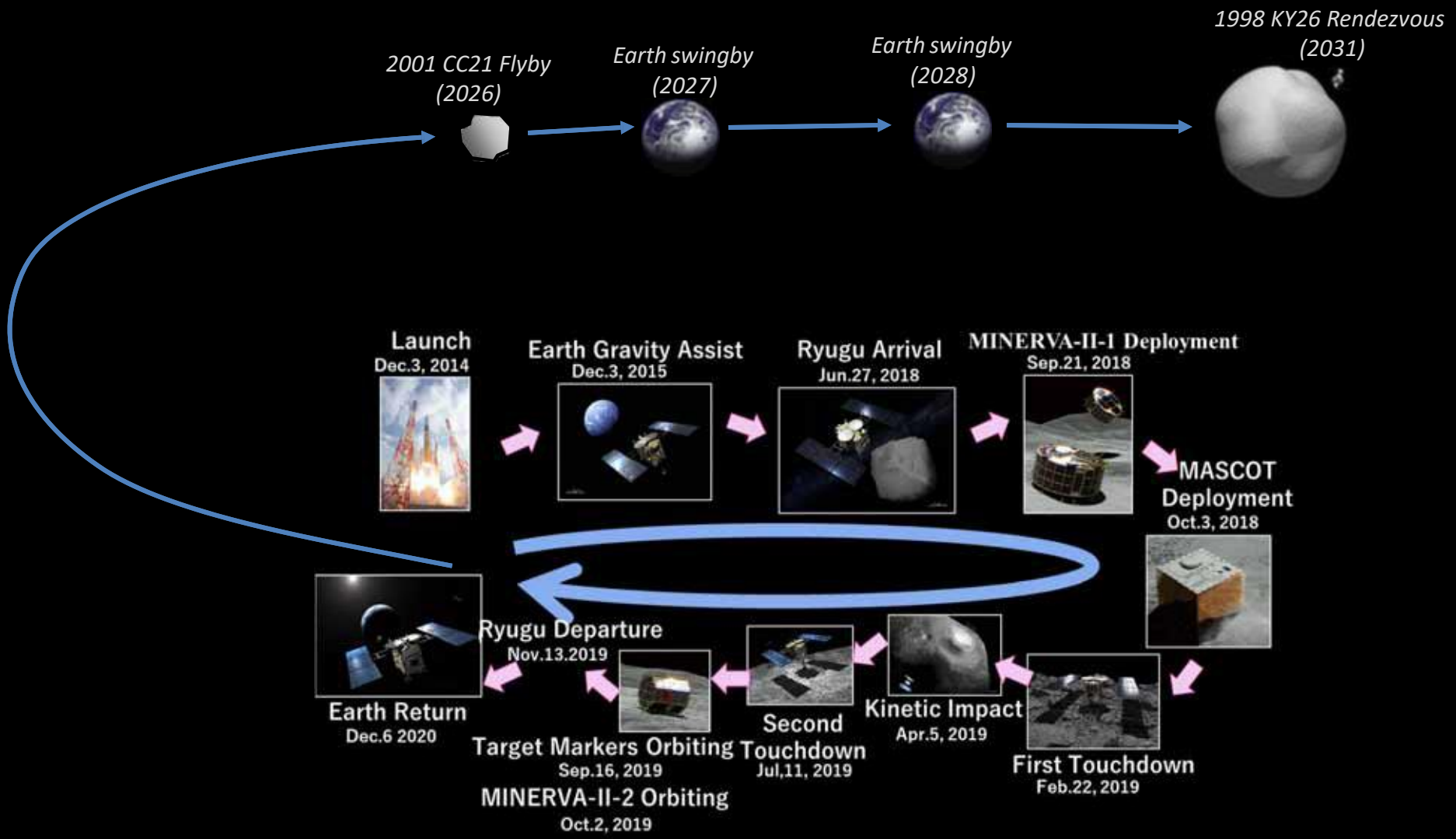
02:28	SRC reentry
02:32	SRC beacon signal detected
02:54	SRC landed (loss of beacon signal)
04:47	SRC found
08:03	SRC arrived at Quick Look Facility
11:13	Fore-heat shield found
12:31	Aft-heat shield found
Dec.7	
22:30	SRC shipped to Japan
Dec.8	
11:27	SRC carried into curation facility

57hr!
(requirement 100hr)


Ryugu samples found in the sample container!
Sample yield : 5.4g (requirement: 0.1g)

Hayabusa2 Extended Mission

- ✓ Multi-swingby + solar electric propulsion
- ✓ Pursuing for *Planetary Defense* technologies and sciences
- ✓ High speed flyby of asteroid 2001 CC21
- ✓ Rendezvous to fast rotator asteroid 1998 KY26



Significance of Hayabusa2

Science

Space Exploration Engineering

Planetary Defense

Planetary Resource

Hayabusa2 is pushing forward the boundaries of small body surface activity

ACCESS / ROVING / SAMPLING / IMPACTING


Launch Mass: About 4,000 kg
Mission Duration: About 5 Years
Launcher: H3 Launch Vehicle
Target Launch Year: JFY2024
MMX
Martian Moons eXploration
The sample return mission from the Martian moon, Phobos


Thank you for your attention