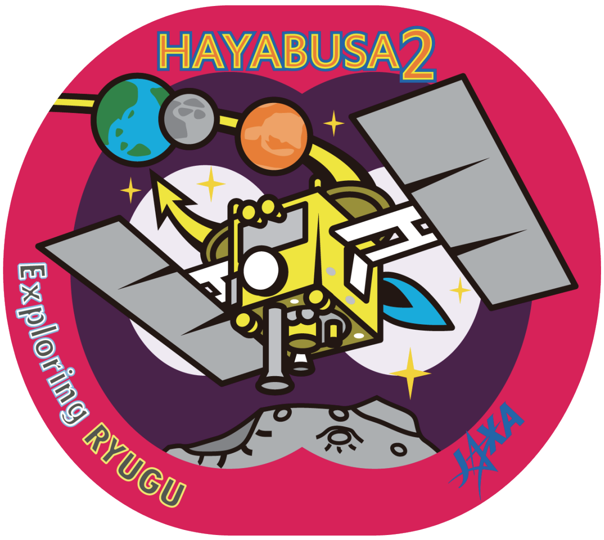
Hayabusa2 Information

はやぶさ 2

Fact Seet



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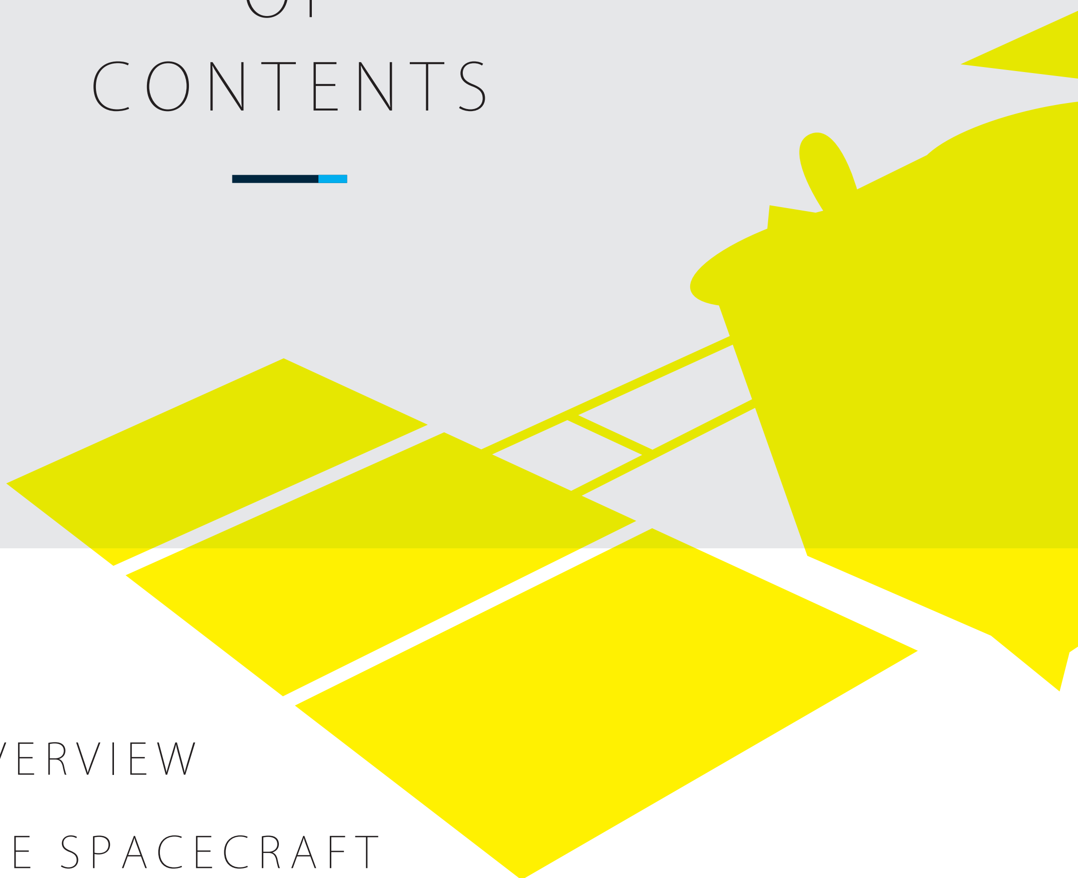


FOR MEDIA

HAYABUSA2 PROJECT

http://www.hayabusa2.jaxa.jp

JAXA PRESS RELEASE DISTRIBUTION SERVICE

http://fanfun.jaxa.jp/media/mail/index.html

ABOUT MEDIA REQUEST

http://www.isas.jaxa.jp/outreach/media/

CONTACT

http://www.isas.jaxa.jp/contactus/

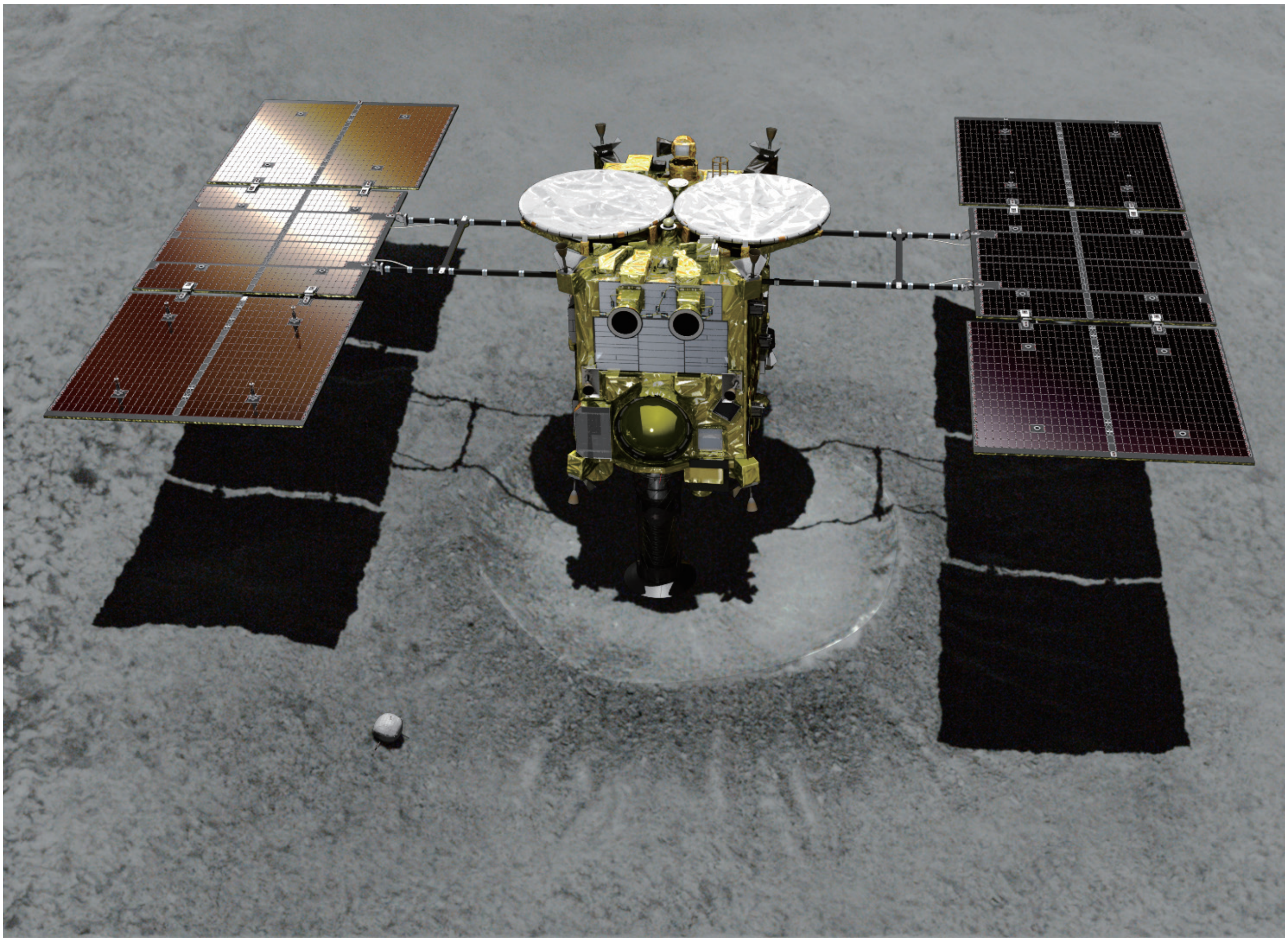
Twitter

@haya2e_jaxa @haya2kun

I.
OVERVIEW

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.



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.

MISSION SIGNIFICANCE

1.Scientific significance "Where did we come from?" Origins and evolution of the solar system and the building blocks of life

The materials that formed the Earth, its oceans, and life were present in the primordial cloud from which our solar system formed. In the early solar system, these materials were in contact and able to chemically interact within the same parent objects. These interactions are retained even today in primitive bodies (C-type asteroids), so returning samples from these bodies for analysis will elucidate the origins and evolution of the solar system and the building blocks of life.

2.Technical significance "World-leading technology" Continuance and development of Japan's unique deep-space exploration technologies

As the world-first asteroid sample return mission, the Hayabusa mission incorporated a variety of new technologies. Continuing that experience, we will establish technologies that allow more reliable deep space exploration. Taking on these new technical challenges will create new opportunities for the future.

3.Exploration significance "Exploring new frontiers" Effects including scientific innovation, contributions to industry and society, improved international presence, youth development

By entering these unexplored fields, we will create new scientific technologies, contribute to industry, and furthermore contribute to society by providing knowledge related to the issue of Earth-threatening asteroids, space resource utilization, and targets for manned exploration.

Mission objectives

- Scientific objective1 : Solving mysteries related to the processes of material evolution in the solar system We will investigate a type-C asteroid from a materials science perspective. In particular, we will elucidate interactions between minerals, water, and organic materials.
- Scientific objective 2 : Solving mysteries related to the evolutionary process of planetsWe will examine the formation process of asteroids through direct study of the integration of materials into asteroids, their internal structure, and subsurface material.
- Engineering objective 1 : Establishment of technologies for deep space sample return explorationWe will bring these technologies to maturity by improving their robustness, stability, and operability.
- Engineering objective 2: Demonstration of space impactor technologyWe will demonstrate collision of an impactor on a celestial body.

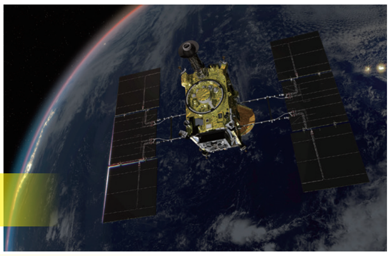
MISSION FLOW

PLANNED OPERATIONS

Launch

2014
3 Dec

- Depart Earth
- IES trial
- Begin IES-powered flight



2015
3 Dec

Earth swing-by

- Subsequent long-term IES operation
- Asteroid rendezvous by optical navigation

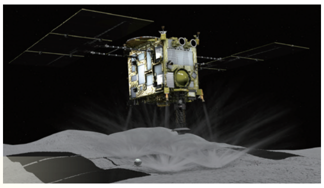
Arrival at asteroid

2018
27 Jun

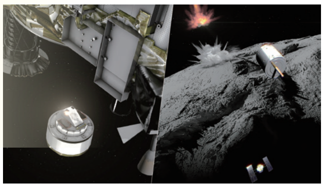
Examine the asteroid by remote sensing observations. Next, release a small lander and rover and also obtain samples from the surface.

- Maintain position
- Global mapping of the asteroid by proximity observations

- Landing practice & implementation
- Lander/rover separation
- Touchdown and sampling



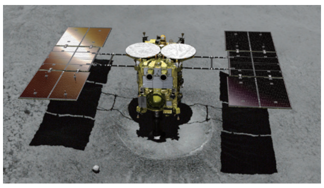
- Interim operations
- Impactor operations (crater creation)
- Debris / ejecta avoidance operations



Use an impactor to create an artificial crater on the asteroid’s surface -

After confirming safety, touchdown within the crater and obtain subsurface samples -

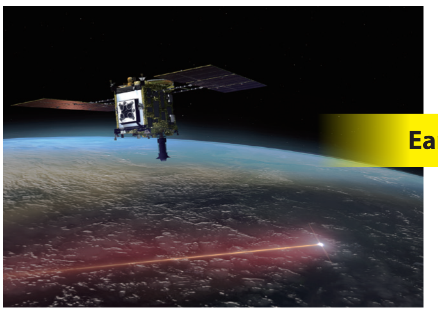
- Touchdown in artificial crater



Depart asteroid

2019
Nov~Dec

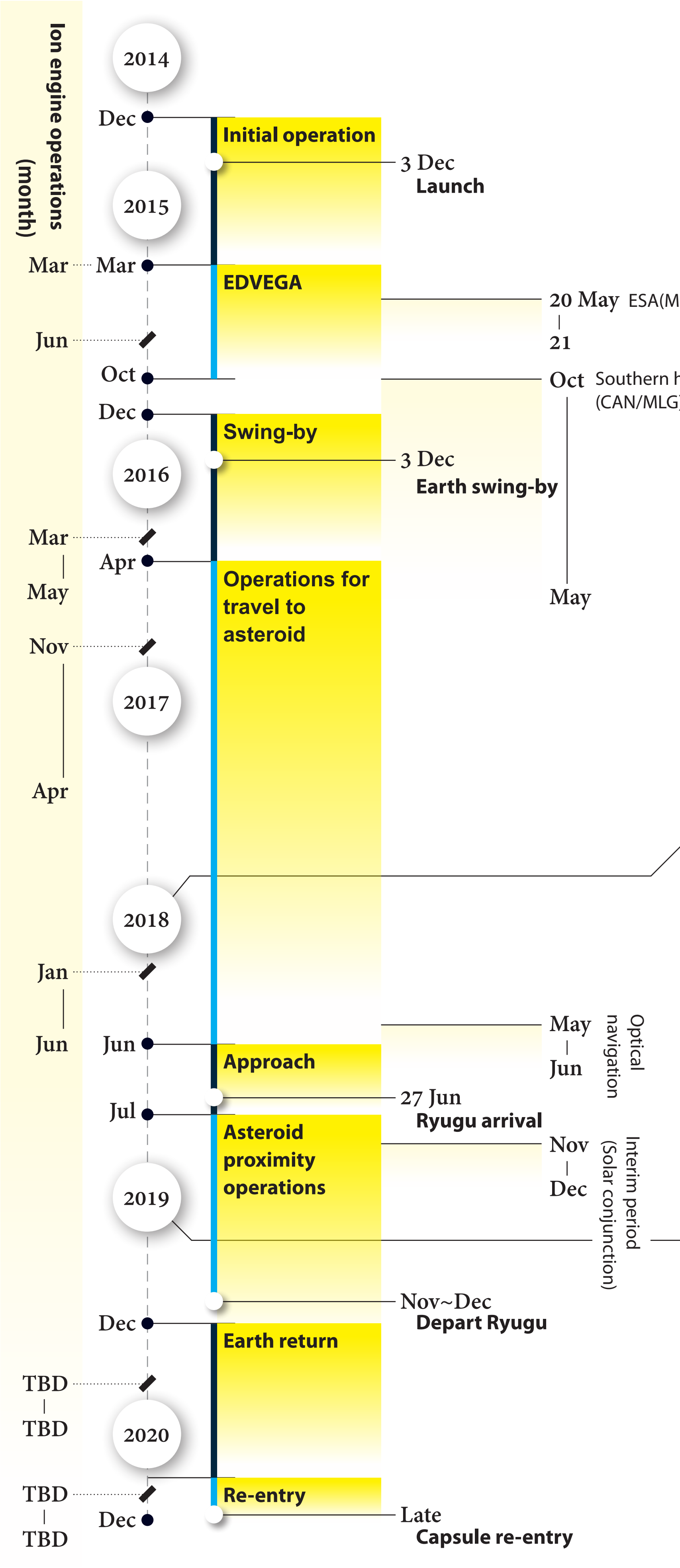
- Earth re-entry



Earth return

2020
Late

OVERALL SCHEDULE



Preliminary asteroid approach schedule

2018

Complete

10 Jan	-	Phase 3 ion engine operations begin
3 Jun	-	Ion engine operation ends
	-	Start of asteroid approach (dist. 3,100 km)
27 Jun	-	Arrive at asteroid (alt. 20 km)

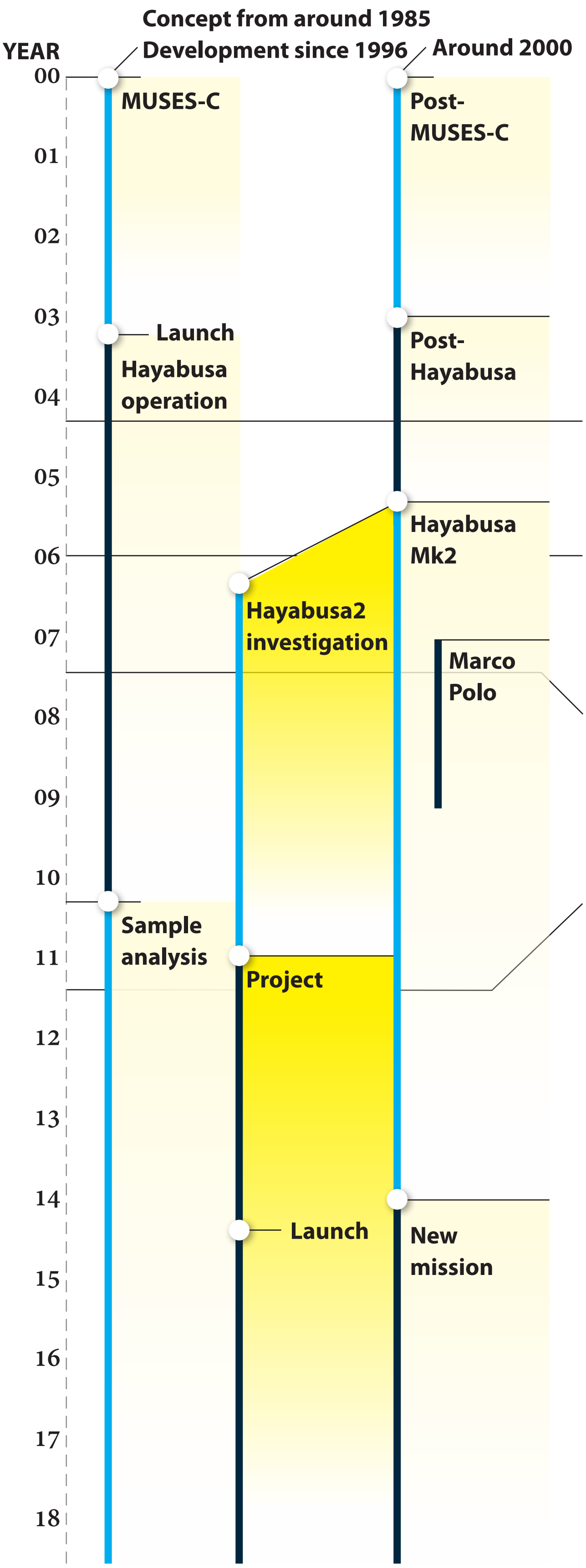
Est.

Last Jul	-	Medium altitude observation #1 (alt. 5 km)
Aug	-	Gravity measurement descent (alt. 1 km)
Last Aug	-	Decision of landing sites
Sep~Oct	-	Touchdown operation slot #1
	-	Rover descent operation slot #1
Nov~Dec	-	Interim operations (communication unavailable)

2019

Jan	-	Medium altitude observation #2 (alt. 5 km)
Feb	-	Touchdown operation slot #2
Mar~Apr	-	Crater creation operations
Apr~May	-	Touchdown operation slot #3
Jul	-	Rover descent operation slot #2
Aug~Nov	-	Stay in asteroid vicinity
Nov~Dec	-	Depart asteroid

HISTORY OF ASTEROID EXPLORATION PLANNING



Apr 2004
Launch of small body exploration working group

2006
Start investigation of Hayabusa2 mission
Started as a "revenge" mission for Hayabusa, initially as a "copy" spacecraft; target launch of 2010

2007/6
Launch of Hayabusa2 prep. team

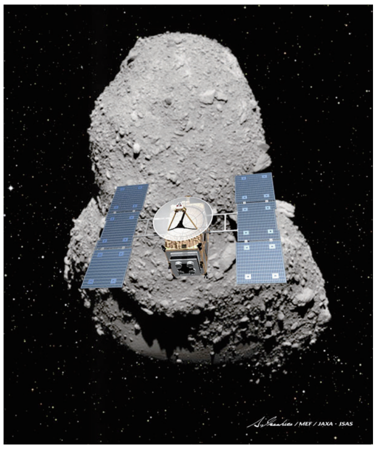
2011/5
Launch of Hayabusa2 project team

Hayabusa 2 reviews, etc.

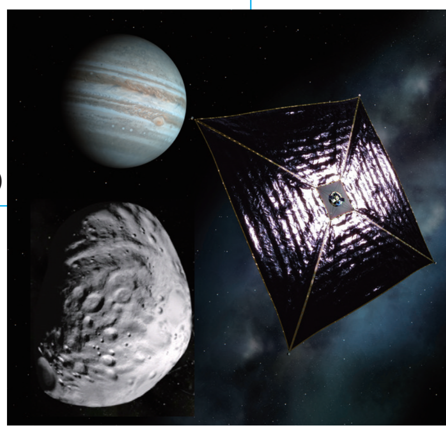
2006/10~11	- Mission definition review (MDR), system requirements review (SRR), system definition review (SDR) → 2010 launch
2009/6~7	- ΔMDR (mission scope expansion) → 2014 launch
2009/12	- SRR
2010/8	- Space Development Committee pre-evaluation #1
2011/3	- SDR
2011/4-9	- Preliminary design review (PDR)
2011/6~ 2012/1	- Space Development Committee pre-evaluation #2
2012/3	- Critical design review (CDR)

ASTEROID EXPLORATION AT JAXA / ISAS

2003~2010 **Hayabusa**



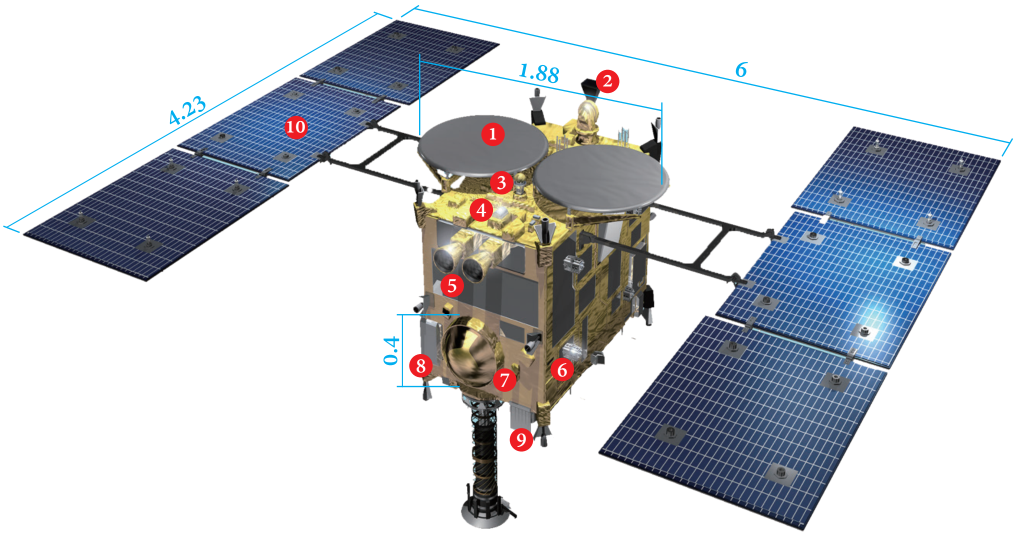
2011~2020 **Hayabusa 2**



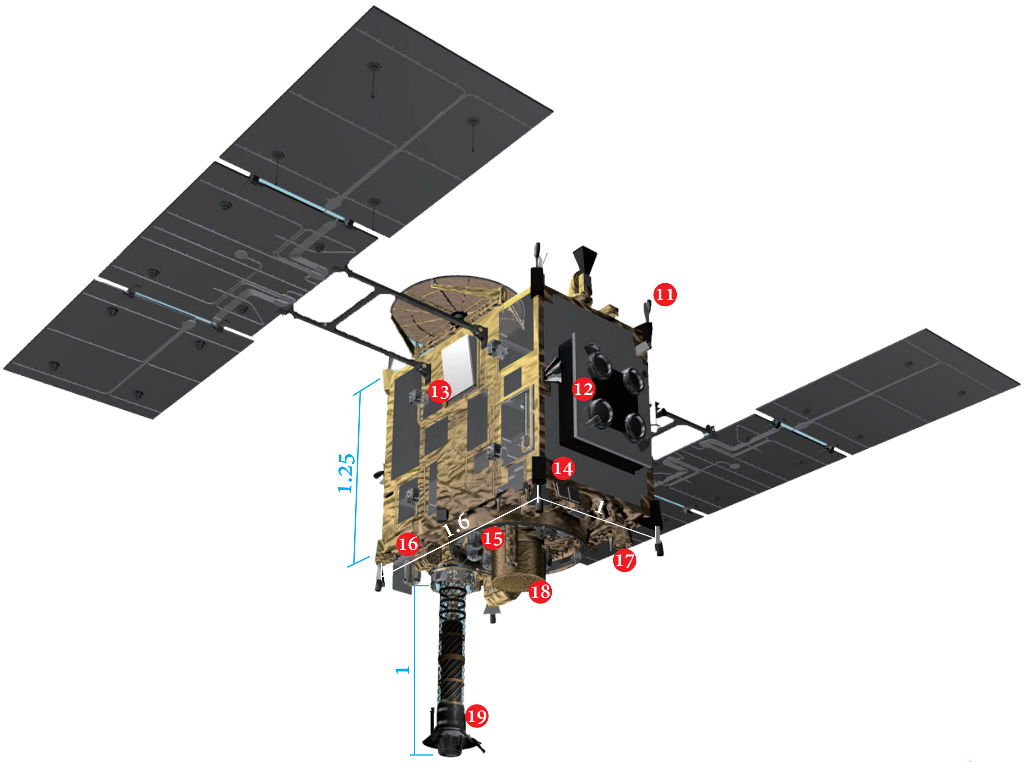
Subsequent missions

We are considering exploration of the Jovian Trojans by solar sail

II.
THE SPACECRAFT



1. X-Band High-gain Antenna
2. X-Band Medium-gain Antenna
3. X-Band Low-gain Antenna
4. Deployable Camera
5. Star Trackers
6. Optical Navigation Camera-Wide
7. Reentry CapsuleLaser Altimeter
8. Near Infrared Spectrometer
9. Laser Altimeter
10. Solar Array Paddle



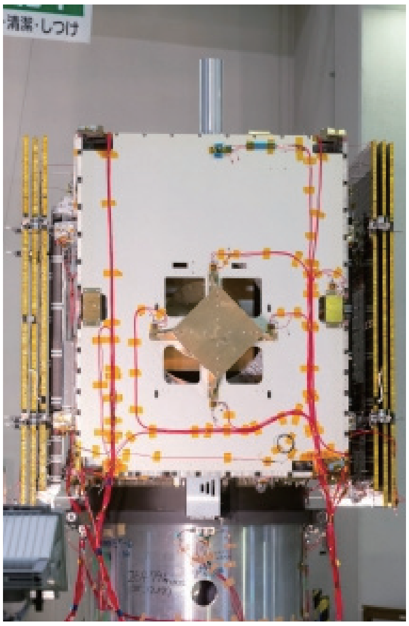
11. RCS Thrusters (12)
12. Ion Engine
13. MASCOT
    (Small Lander by DLR/CNES)
14. Camera-Telescopic & Wide
    (ONC-T, ONC-W1)
15. Target Markers (5)
16. MINERVA-II (Small Rovers)
17. Thermal Infrared Imager (TIR)
18. Small Carry-on Impactor (SCI)
19. Sampler Horn

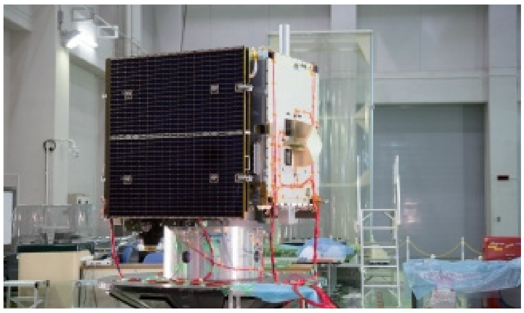
measurement unit (m)

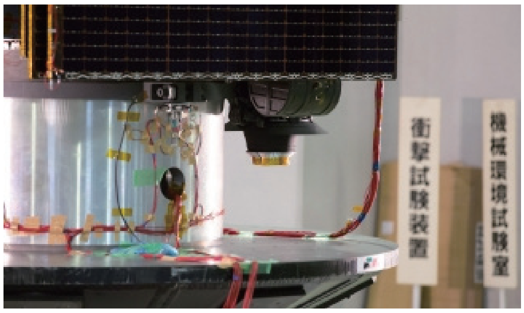
Size - Main body 1m×1.6m×1.25m
Solar paddle deployed 6 m×4.23m×1.25m

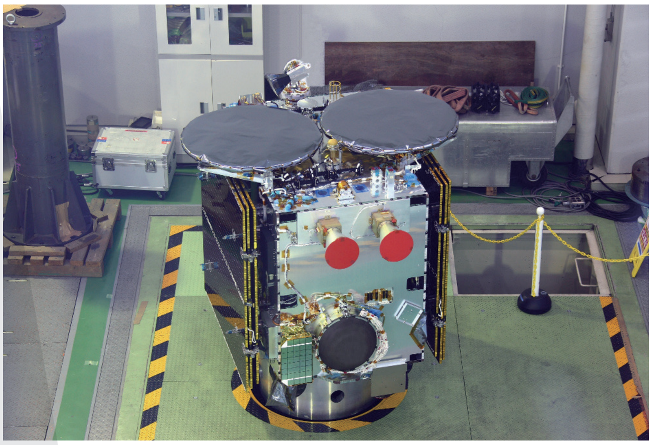
Mass - 609 kg (incl. fuel)

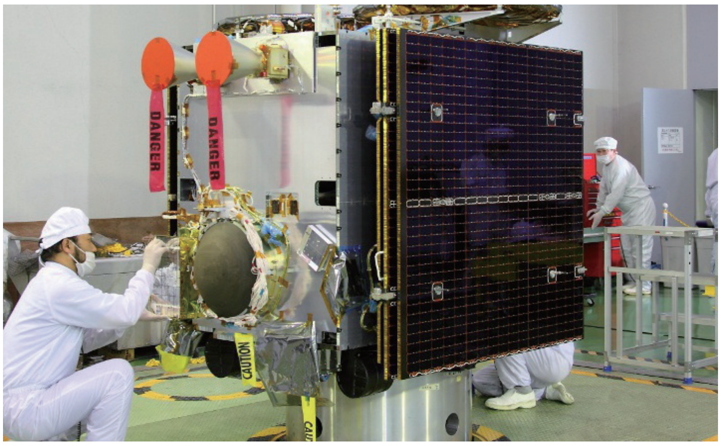
PRIMARY ENGAGEMENT TESTING



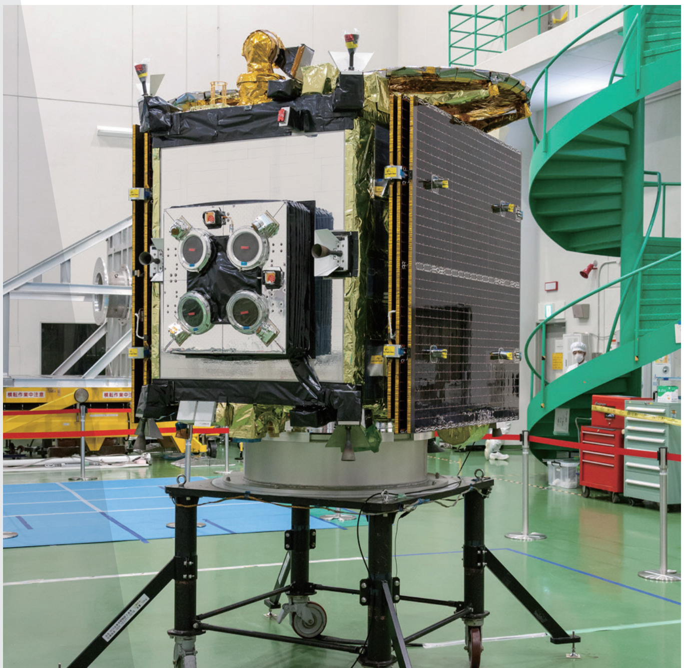




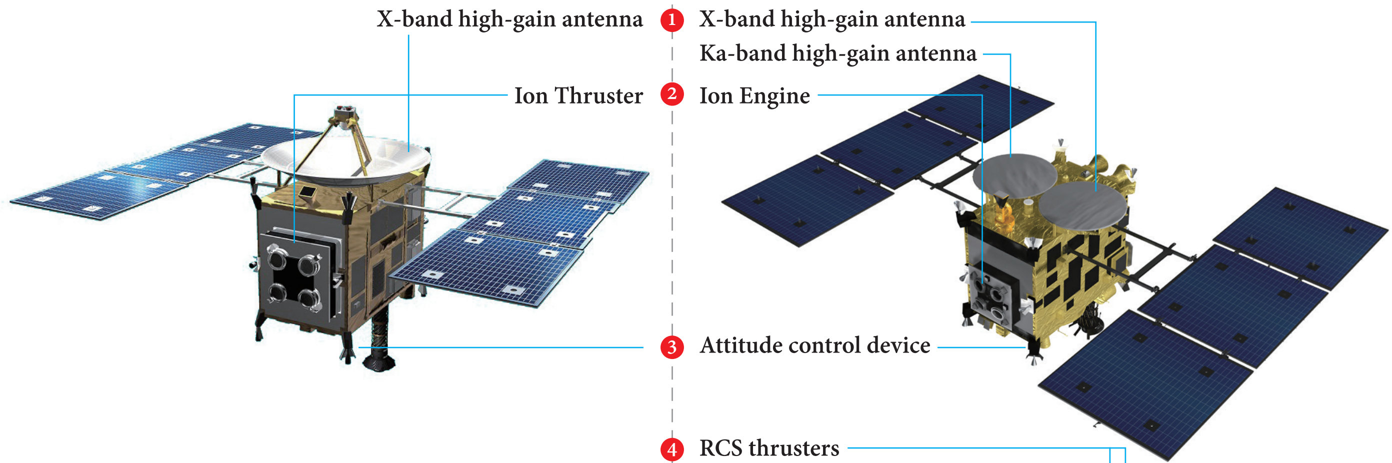


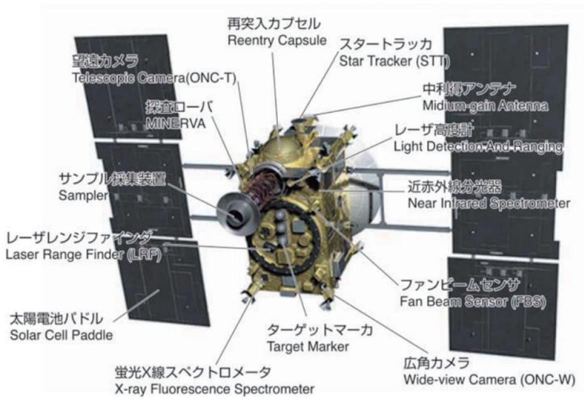


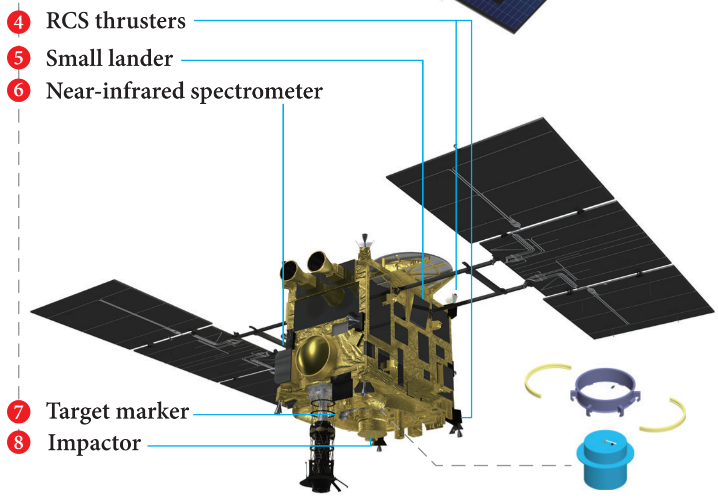
FLIGHT MODEL



HAYABUSA		HAYABUSA2
Approx. 1 m×1.6 m×1.1m	**Main body**	1 m×1.6 m×1.25m
510kg	**Mass (with fuel)**	690kg
9 May 2003 (M-V-5 rocket)	**Launch year and rocket**	3 Dec 2014 (H-IIA rocket flight 26)
13 Jun 2010	**Earth return**	Late 2020 (planned)
X-band (7~8 GHz)	**Communications frequencies**	X-band (7~8 GHz) , Ka-band (32 GHz)
Approx. 3 months	**Exploration period**	Approx. 18 months (planned)
2 (surface only)	**Samples**	3 (surface and attempted subsurface)
Near-infrared spectrometer, fluorescent X-ray spectrometer, multiband spectroscopic camera, laser altimeter, MINERVA, sampler	**Mission equipment**	Near-infrared spectrometer, thermal infrared camera, optical navigation camera, laser altimeter, MINERVA-II, MASCOT, impactor, separation camera, sampling device







1 Communication system
A new Ka-band communication system was added for high-speed communication. The high-gain antenna was made into a planar antenna.

2 Ion engine
Improved durability, stronger propulsion

3 Attitude control device (reaction wheel)
Two of the three installed on Hayabusa malfunctioned, so four are mounted on Hayabusa2 and further measures have been taken to avoid problems.

4 RCS thrusters
Improved propellant plumbing as a countermeasure against the malfunctions on Hayabusa and Akatsuki.

5 Mobile Asteroid Surface Scout (MASCOT) small lander
Developed in Germany and France for landing and data acquisition on an asteroid surface.

6 Mission equipment
Newly developed and improved equipment for exploration of a type-C asteroid.

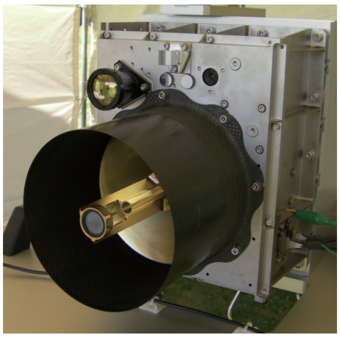
7 Target markers
Increased from three on Hayabusa to five on Hayabusa2 to realize a pinpoint landing.

8 Impactor
A new device for creating an artificial crater on the asteroid surface, then collecting subsurface materials.

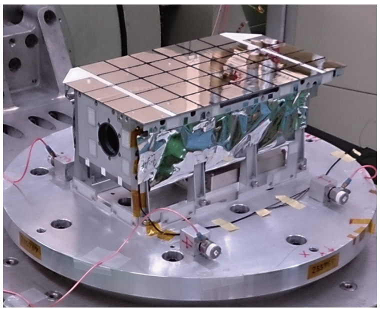
LIST OF MISSION EQUIPMENT

Equipment for scientific observation

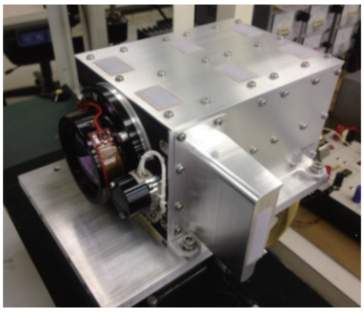
Optical Navigation Camera (ONC)
Telescopic and wide-angle cameras centered on visible wavelengths, with respective viewing angles of 6 and 60 deg. These are used for scientific observations and navigation.



Laser altimeter (LIDAR)
Measures the distance between the probe and the asteroid surface. Also acquires scientific data such as asteroid topography, gravity, and albedo. Measurement ranges are 30 m~25 km.

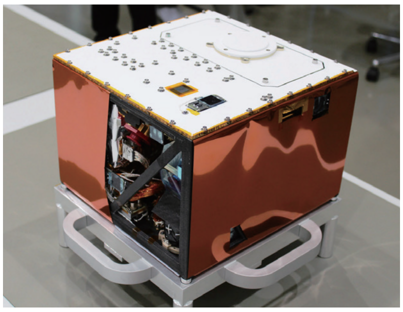


Near-infrared spectrometer (NIRS3)
Performs spectroscopic observations of near-infrared rays including the 3-micron band. The viewing angle is about 0.1 deg.

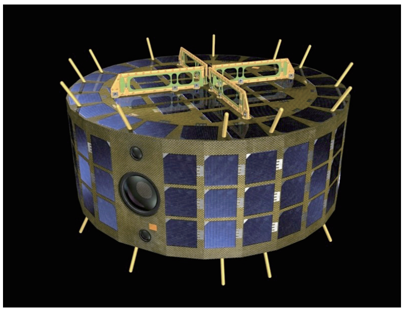


Thermal infrared spectrometer (TIR)
Images the asteroid at mid-infrared ranges including the 10-micron band. Viewing angle is a little over 10 deg.

Lander and Rover



Small lander (MASCOT)
Descends to the asteroid surface to acquire data through four observation devices. Created by DLR (Germany) and CNES (France). Observation devices: MicrOmega, MAG, CAM, MARA



Small rovers (MINERVA-II-1 (A, B), 2)
Descends to the asteroid surface for investigations. Three rovers similar to MINERVA mounted on Hayabusa.

Sampler and Impactor

Sampling device (SMP)
Acquires samples from the asteroid surface. Slight improvements over the Hayabusa sampling device.

Impactor (SCI)
Accelerates a 2-kg copper mass to 2 km/s to collide with the asteroid surface, forming an artificial crater.

Deployable camera (DCAM)
Separates from the spacecraft to image the impactor operation.

REMOTE SENSING EQUIPMENT

Optical Navigation Camera (ONC)

Images fixed stars and the target asteroid for spacecraft guidance and scientific measurements

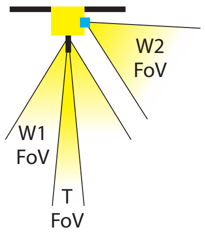
Scientific measurements

- Form and motion of the asteroid : Diameter, volume, direction of inertial principal axis, nutation
- Global observations of surface topography : Craters, structural topography, rubble, regolith distribution
- Global observations of spectroscopic properties of surface materials : Hydrous mineral distribution, distribution of organic matter, degree of space weathering
- High-resolution imaging near the sampling point : Size, form, degree of bonding, and heterogeneity of surface particles; observation of sampler projectiles and surface markings

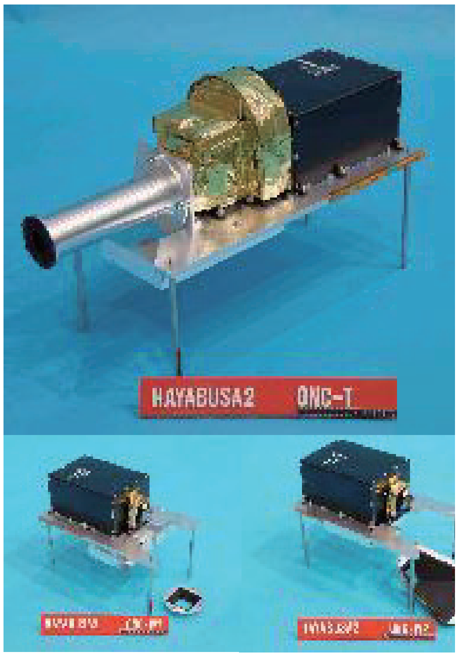
Elucidation of features of target asteroid - Distribution of hydrous minerals and organic matter, space weathering, boulders

Sampling site selection - Basic information on where to collect asteroid samples

Ascertaining sample state - High-resolution imaging of sampling sites



	ONC-T	ONC-W1	ONC-W2
Detector	2D Si-CCD (1024×1024 px)		
Viewing direction	Downward (telescopic)	Downward (wide-angle)	Sideward (wide-angle)
Viewing angle	6.35°× 6.35°	65.24°× 65.24°	
Focal length	100m~∞	1m~∞	
Spatial resolution	1 m/px @10-km alt. 1 cm/px @100-m alt.	10 m/px @10-km alt. 1 mm/px @1-m alt.	
Observation wavelength	390, 480, 550, 700, 860, 950, 589.5 nm, and wide	485~655nm	



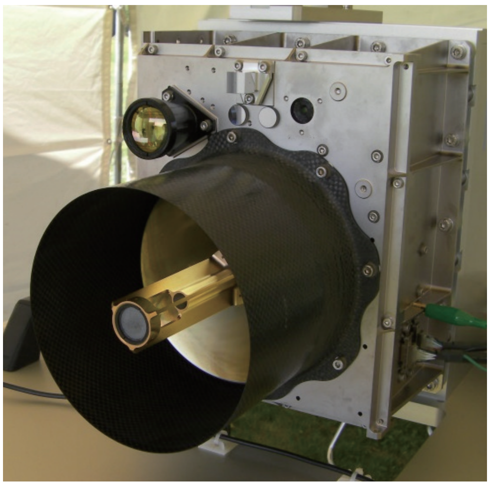
Light Detection And Ranging (LIDAR)

To measure the distance between the target and Hayabusa2 from 30m ~ 25 km

Scientific measurements

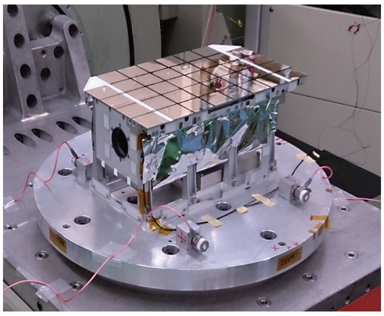
- Terrain and gravity field observations of the target asteroid
- Observations of albedo distribution at various surface points
- Observations of dust floating around the asteroid

- Pulse-type laser altimeter
- A pulse YAG laser with a 1.064-μm wavelength is emitted toward the target object, and the altitude is measured by measuring the return time of the laser beam.
- The LIDAR aboard Hayabusa 2 could perform measurements from 30m~25km.
- LIDAR is a navigation sensor used for approach and landing at a target, and a scientific observation device used to measure shape, gravity, and surface characteristics, and for dust observations.
- It also has a transponder function that can perform space laser ranging (SLR) experiments with ground LIDAR stations.



Asteroid form, mass, porosity, and deviation
Asteroid surface roughness
Dust floating phenomena

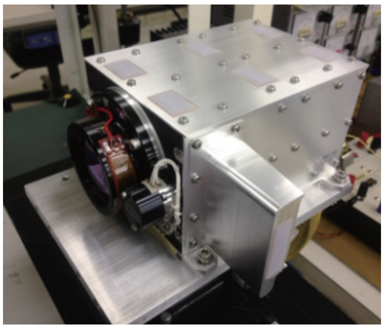
Near InfraRed Spectrometer 3µm (NIRS3)



Near-infrared Spectrometer in 3µm band：
investigates distributions of minerals on the asteroid's surface

Infrared absorption of hydroxyl groups and water molecules is observed in 3-µm band reflection spectra in the near-infrared region. NIRS3 investigates distributions of hydrous minerals on the asteroid surface by measuring reflection spectra in the 3-µm band.

Thermal Infrared Imager (TIR)



Imaging in 8~12µm：investigates temperature of the asteroid's surface

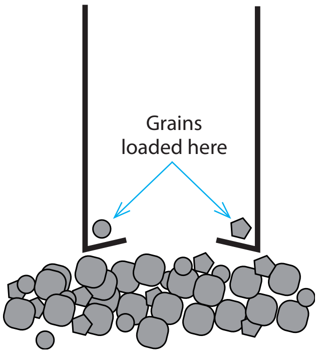
The surface temperature of the asteroid changes over the day, rising in sunlight and decreasing at night. Diurnal change in surface temperature is large in fine soils like sand and highly porous rock, and small in dense rock. We will examine the physical state of the asteroid's surface by 2D imaging (thermography) of thermal radiation from the asteroid.

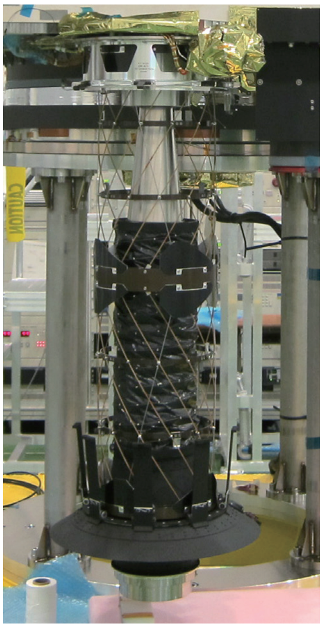
SAMPLER AND IMPACTOR

Sampler (SMP)

Device for acquiring samples from the asteroid surface

- The basic design is the same as that for Hayabusa. As soon as the tip of the cylindrical horn touches the asteroid surface, a small projectile is shot from within the horn and rising surface ejecta are caught in a catcher in the upper part of the horn.
- Sealing performance is improved in Hayabusa2; a newly developed metal seal system ensures that volatile gases can be brought back securely. Noble gases can also be collected.
- The sample catcher has been improved over that onboard Hayabusa, and now contains three chambers instead of two.
- As a further improvement in Hayabusa2, there are small folded parts on the tip of the horn, as shown in the figure. Grains of 1~5 mm are caught in these folds, and the catcher is designed so that samples continue rising when the spacecraft suddenly ceases its ascent, thereby entering the catcher. This provides a backup for sampling by projectile.

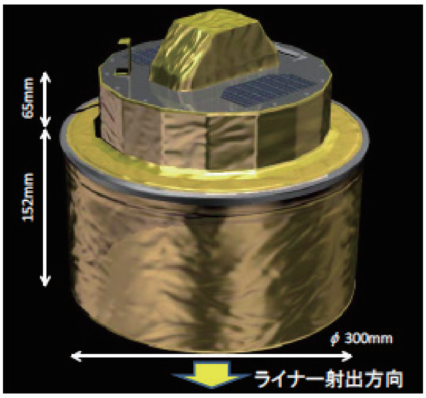




Small Carry-on Impactor (SCI)

Objective

- We will investigate the internal structure of the asteroid through surface changes before and after projectile impact. We will also conduct remote observations of the exposed subsurface material to investigate physical properties of the surface.
- We also perform sampling from craters formed by projectiles, collect "fresh" substances from beneath the surface, and investigate differences from surface materials.
- We will perform "space impact experiments" on actual asteroids to obtain data necessary for celestial collision science.



Crater creation: Impact with a high-speed projectile

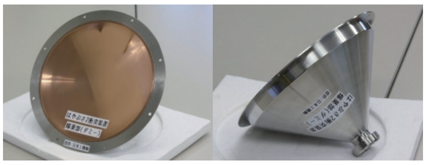
Can be performed with a mounted small, lightweight device.
Results in less soil contamination than methods using explosives to expose asteroid surface materials.
Impacting projectiles are made from pure copper so that they can easily be distinguished from substances present in asteroids.

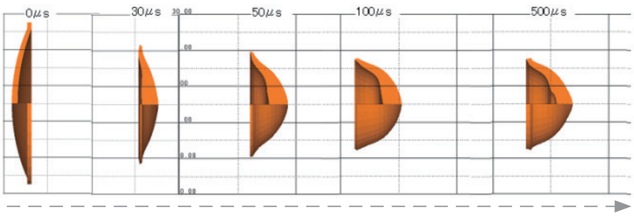
SCI structure

Form : Cylindrical (diameter 265 mm)
Liner (becomes projectile) : Pure copper
Explosive : HMX-type PBX
(plastic bonded explosive)
Mass : Approx. 9.5 kg (explosive : 4.7kg, liner : 2.5 kg)
Liner thickness : Approx. 5 mm

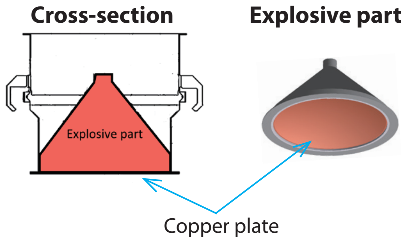
SCI technology

Application of technologies for molding explosive charges
Accelerates a 2 kg copper liner to approximately 2 km/s within approximately 1 ms





Copper plate (liner) deforms during flight



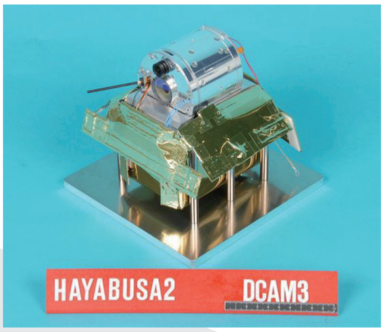
Deployable Camera 3 (DCAM3)

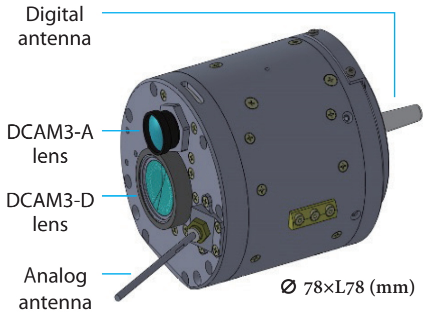
Engineering objective

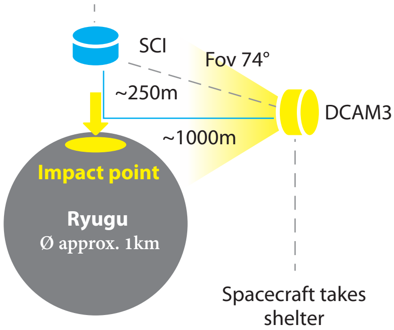
The spacecraft will be sheltering in a safe zone before SCI operation, and therefore has no way of confirming successful operations. SCI operations are thus confirmed by releasing a deployable camera before the spacecraft takes shelter and wirelessly transmitting acquired image data.

Scientific objective: On-site impact observation

- Continuous imaging of ejecta discharge will clarify relations between asteroid surface conditions and ejecta emission phenomena.
- We aim to identify the ignition point and the impact point of the impactor.
- The produced ejecta will clarify crater formation processes on the asteroid.





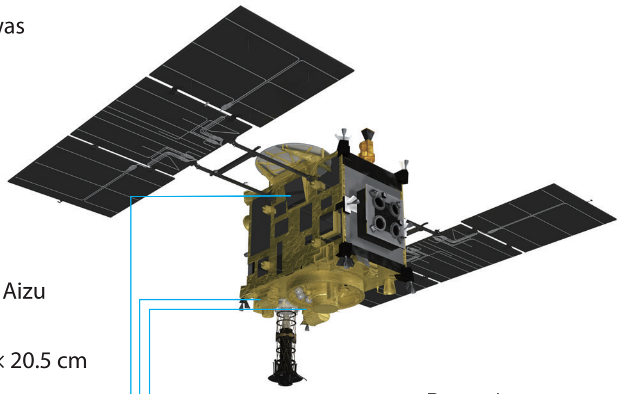


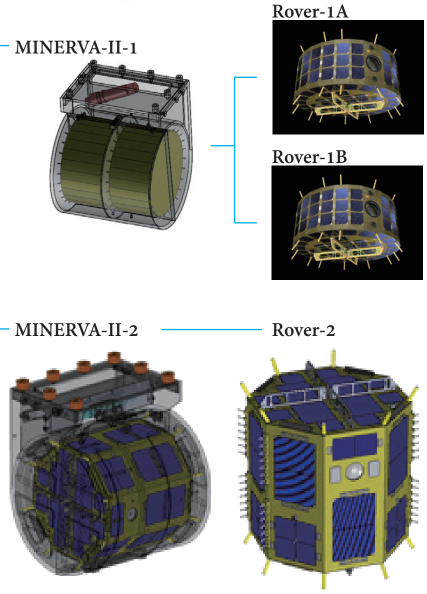
LANDER AND ROVER

MINERVA-II

Three robots will travel across and explore the asteroid surface.

- MINERVA-II-1 was developed by the team that developed MINERVA, which was aboard the first Hayabusa. It comprises two rovers, Rover-1A and Rover-1B.
- MINERVA-II-2, which carries Rover-2, is an optional device developed by a university consortium.





MINERVA-II-1

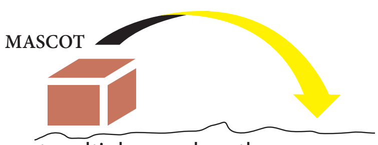
- Successor to MINERVA, which was mounted aboard Hayabusa.
- Purpose : Engineering demonstration of the movement mechanism
- Development : MINERVA-II team (ISAS) with cooperation of the University of Aizu
- MINERVA-II-1 carries two (twin) rovers
- Mass including the deployment structure is 3.3 kg Dimensions : 22.5 × 22.5 × 20.5 cm
- Rover mass : approx. 1.1 kg Dimensions: diameter 18 × 7 cm
- Two cameras (wide-angle and stereo)
- Temperature sensor and photodiode
- Accelerometer and gyro
- Explorers move by hopping to explore the asteroid surface

MINERVA-II-2

- Explorer robot developed by a university consortium. This is an optional, piggy-back device
- University consortium led by Tohoku University, co-developed with Tokyo Denki University, Osaka University, Yamagata University, and the Tokyo University of Science
- Total mass including separation mechanism : 1.6 kg
  Dimensions : 17.5 × 17.5 × 20.5 cm
- Rover mass : approx. 1 kg Dimensions: diameter 15 × 16 cm
- Mounted equipment include a camera, thermometer, photodiode, and accelerometer
- Four types of mobility systems are equipped:
  - Environmentally dependent buckling mechanism (Yamagata University)
  - Leaf-spring buckling mechanism (Osaka University)
  - Eccentric motor-type micro-hop mechanism (Tohoku University)
  - Permanent magnet-type impact generation mechanism (Tokyo Denki University)
- The exploration robot hops to move across and explore the asteroid surface.

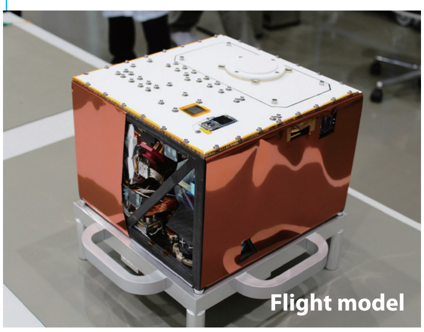
Mobile Asteroid Surface Scout (MASCOT)

- Created by DLR (German Aerospace Center) and CNES (French National Centre for Space Studies)
- Small lander with mass approx. 10 kg
- Carries four scientific instruments
- Can move only once, by jumping



Scientific instruments aboard MASCOT

Wide-angle camera (CAM)	- Imaging at multiple wavelengths
Spectroscopic microscope (MicrOmega)	- Investigation of mineral composition and characteristics
Thermal radiometer (MARA)	- Surface temperature measurements
Magnetometer (MAG)	- Magnetic field measurements



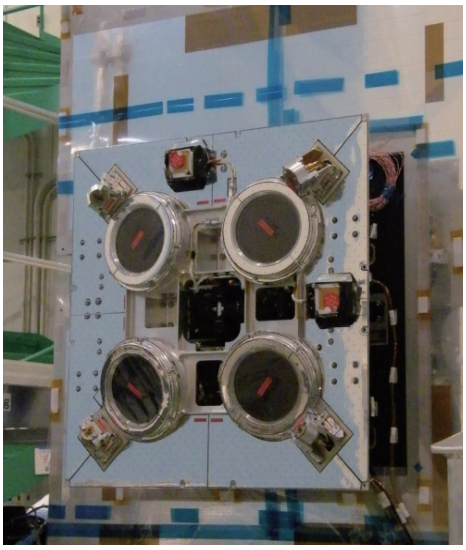
Flight model

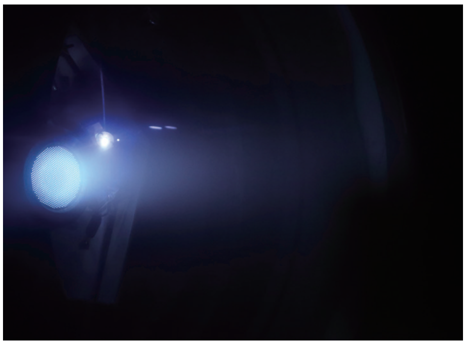
PROPULSION

Electric propulsion (Ion engine)

Name: μ10

- Converts xenon* into plasma (ions), which is accelerated by applying voltage.
- A microwave discharge system is used to generate ions.
- Four units are mounted, and simultaneous operation of three generates thrusts of up to 28mN.
- Approximately 60 kg of loaded xenon fuel, allowing acceleration up to 2 km/s.
- It is used to alter trajectories when cruising from Earth to the asteroid and back.



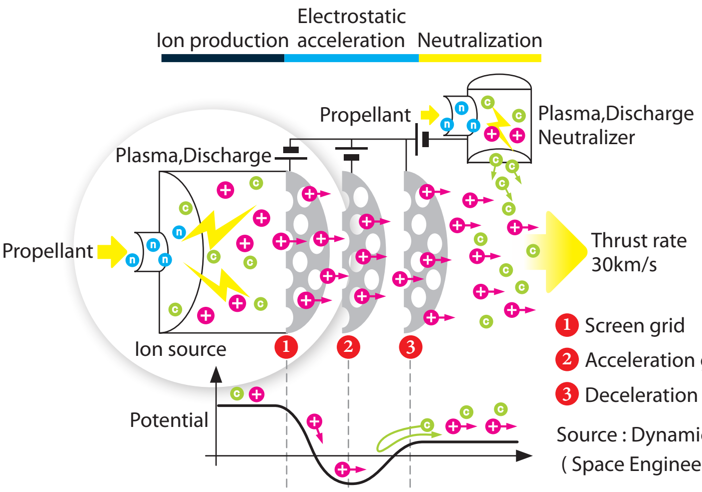


※ Why we use xenon

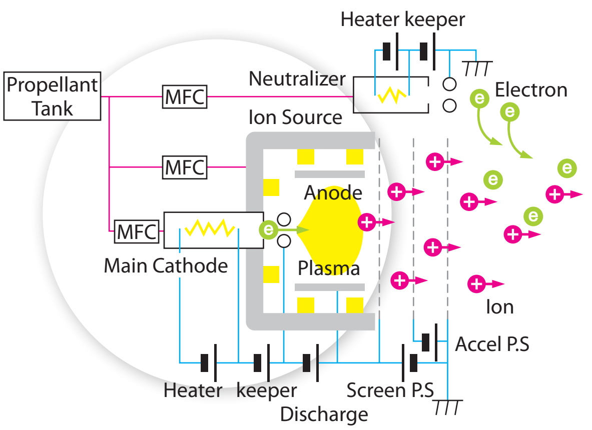
- Xenon is a monoatomic molecule, so its ionization voltage is smaller than that of gasses comprising two or more atoms. This increases the ratio of added energy that is used for acceleration.
- Reactivity is lower than that of other substances.
- Mass (atomic weight) is large, improving the efficiency of acceleration.

How ion engines work (Reference)

Different ion generation systems

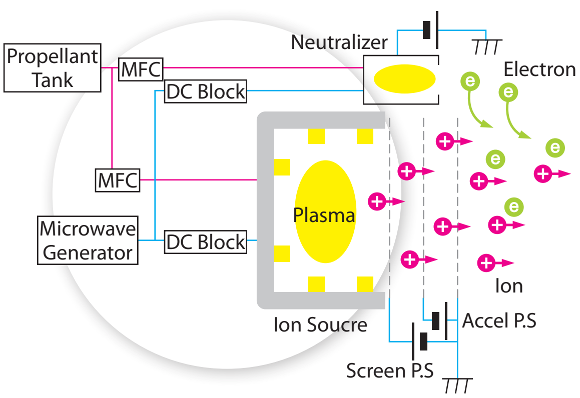


Source : Dynamic Navigation with Ion Engines
(Space Engineering Series 8), Corona Publishing (2006)



DC discharge method

※ The ion engine developed in the U.S., the U. K. and the former NASDA was a DC discharge Kaufman-type ion engine or a Ring-Cusped ion engine.

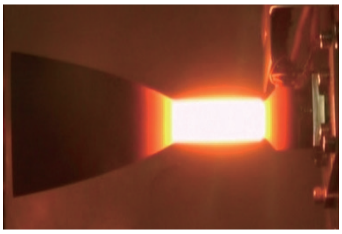


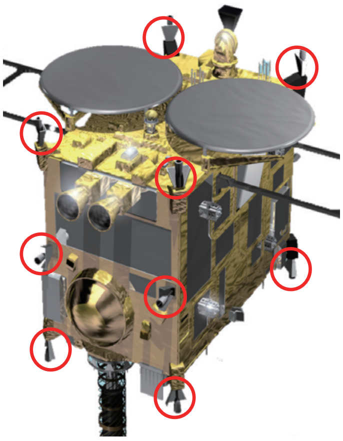
Microwave discharge method

※ The ion engine developed at the ISAS in Japan is a microwave discharge-type ion engine.

Chemical propulsion system

- The chemical propulsion system is used for attitude control (reaction wheel unloading, safe hold), fine trajectory modifications, and orbital control at the asteroid.
- The thruster is a 20 N two-component system using fuel (hydrazine) and an oxidizer (MON-3).
- There are 12 thrusters in total: 4 on the upper (+Z) surface, 4 on the lower (–Z) surface, 2 on the surface with the ion engine (+X), and two on the surface with the capsule (–X).
- The thruster system has a redundant construction.
- Approximately 48 kg of propellant is carried.





Chemical propulsion system: Changes from Hayabusa

- Countermeasures against leaks that occurred immediately after Hayabusa touchdown (second time)
  ➡ **Improved valve cleaning methods and airtightness tests, fewer welding locations, review of welding procedures, etc.**
- Countermeasures against freezing in both pipe systems that occurred after Hayabusa leak
  ➡ **Separation of piping routes for the A and B systems and independent heat control**
- Countermeasures against orbital insertion failure by the Akatsuki Venus orbiter
  ➡ **Full separation of fuel and oxidizer pressure regulating systems**
- Measures for realization of the Hayabusa2 impactor mission
  ➡ **Confirmation of long-term thrust (collision avoidance) and short-pulse thrust (landing within craters)**
- Other changes
  ➡ **Metal diaphragm oxidant tank changed to a surface tension device ※**

※ What is a surface tension device?
This device uses helium gas to apply pressure when extracting oxidant from its tank, ensuring that only oxidant fluid, not helium gas, is extracted. Its naming comes from the fact that it utilizes surface tension of the oxidant.

ATTITUDE AND ORBITAL CONTROL SYSTEM

Attitude and orbital control system (AOCS)

The AOCS is responsible for attitude control of the probe and navigation near the asteroid.
Component devices are described below.

AOCU - Attitude and orbit control unit

AOCP - Attitude and orbit control processor

1 Attitude detection sensor

- Coarse Sun Aspect Sensor (CSAS)
- Star Trackers (STT)
- Inertial Reference Unit (IRU)
- Accelerometer (ACM)

3 Asteroid relative position measurement sensor

- Laser altimeter (LIDAR)
- Laser Range Finder (LRF)

2 Image processing component

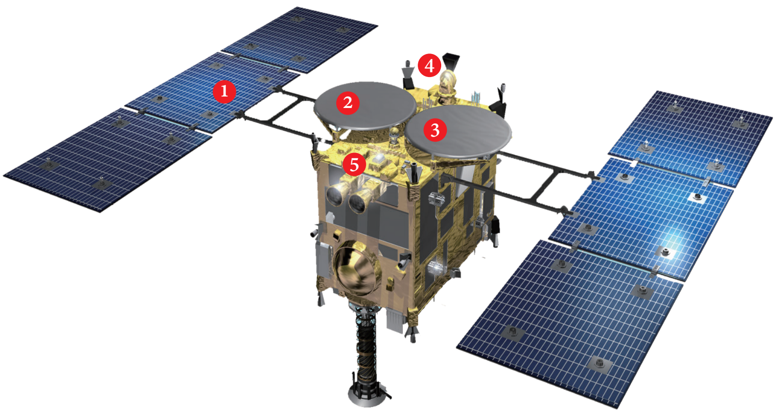
- Optical Navigation Camera (ONC)
- Digital electronics (ONE-E)

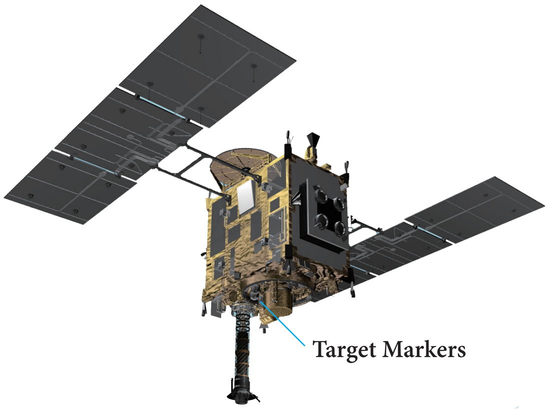
4 Attitude and orbital control

- Reaction Wheel (RW)
- Reaction Control System (RCS)

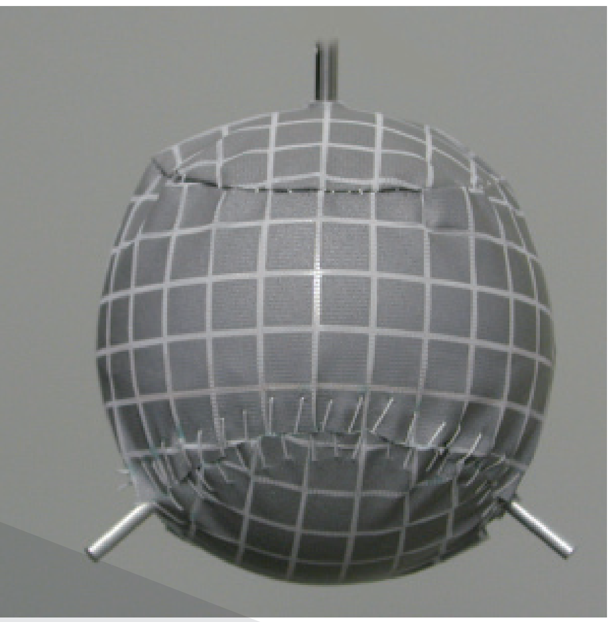
5 Other navigation equipment

- Flashlight (FLA)
- Target Markers (TM)
- Drive (DRV)





Target Markers



- Target markers descend to the satellite surface before touchdown as artificial landmarks. The explorer descends while flashing a strobe to recognize the target markers.
- Markers are fashioned like beanbags, with a large number of pellets in a soft enclosure, to prevent the marker from bouncing on the asteroid surface.
- The outer material is highly reflective.
- Hayabusa2 carries five target markers (Hayabusa carried only three).
- Thin sheets with names inscribed are contained within.

Shine white in sunlight

ELECTRICAL SYSTEM AND SOLAR ARRAY PADDLES

Electrical system

In sunshine, electric power generated by the solar array paddles is supplied to onboard equipment while the battery is charged. In the shade, the battery stably supplies equipment with power throughout the mission.
Following the Hayabusa design, this system provides reliability and improved power supply. An outline of primary power supply system equipment is shown below.

Solar Array Paddles (SAP)

- Converts sunlight into electricity for supply to mounted equipment
- A high-efficiency 3-junction solar cell is used
- 3-panel × 2-wing construction produces 1460 W @1.42 AU

Series-switching regulator (SSR)

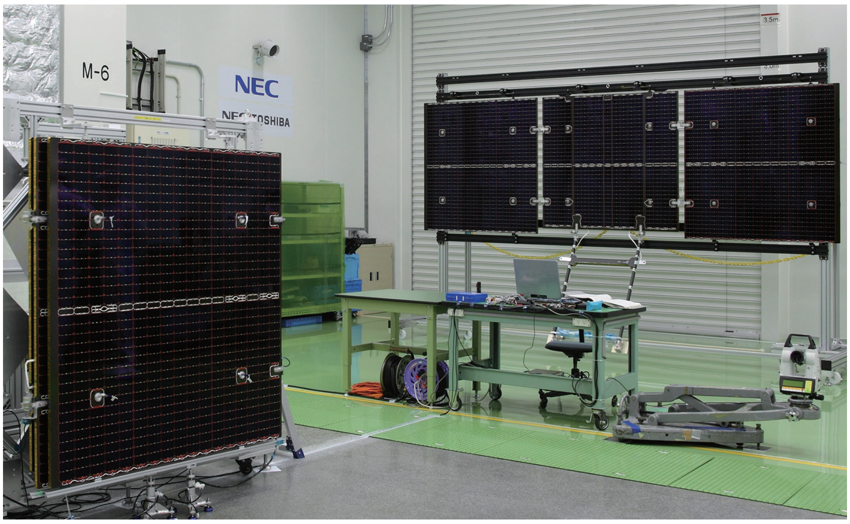
- Stabilizes and controls SAP-generated power for supply to mounted equipment via the PCU

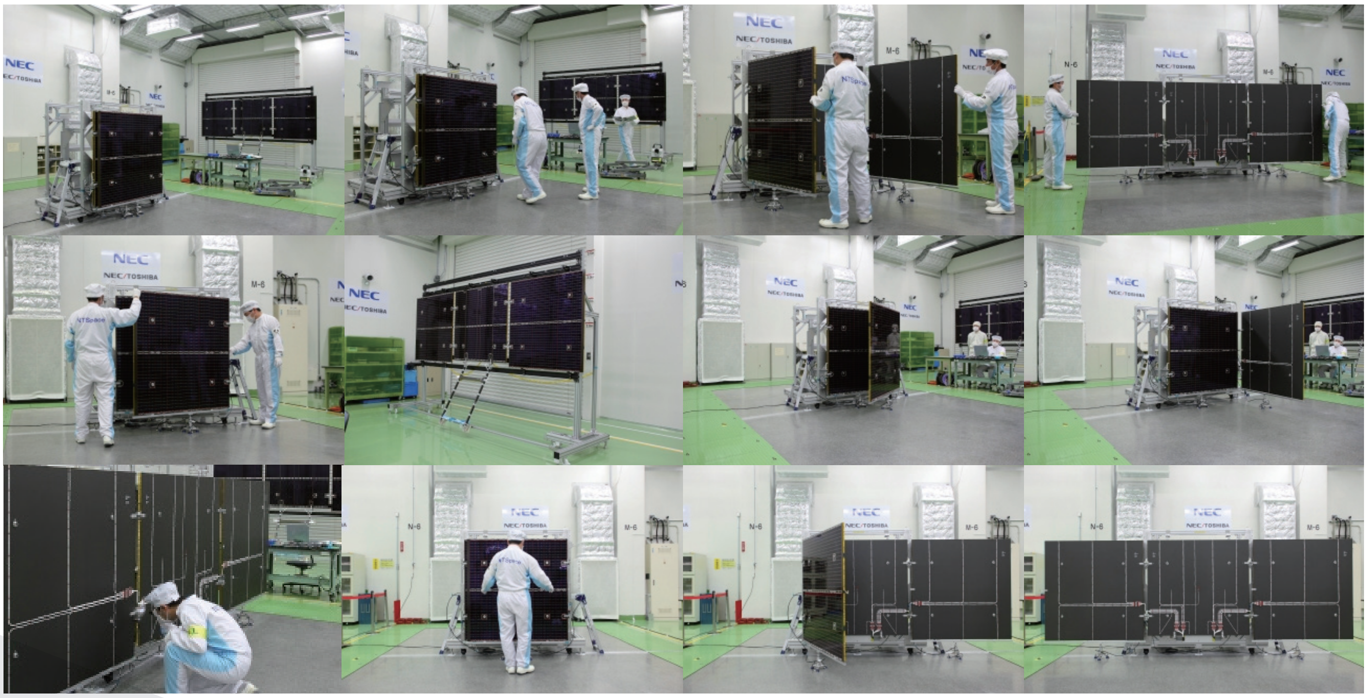
Power control unit (PCU)

- Distributes and controls power from the SSR to mounted equipment
- Controls and manages power for recharging the BAT

Battery (BAT)

- Provides power through the PCU as needed while in shade, etc.
- Eleven inline-mounted 13.2 Ah lithium ion batteries



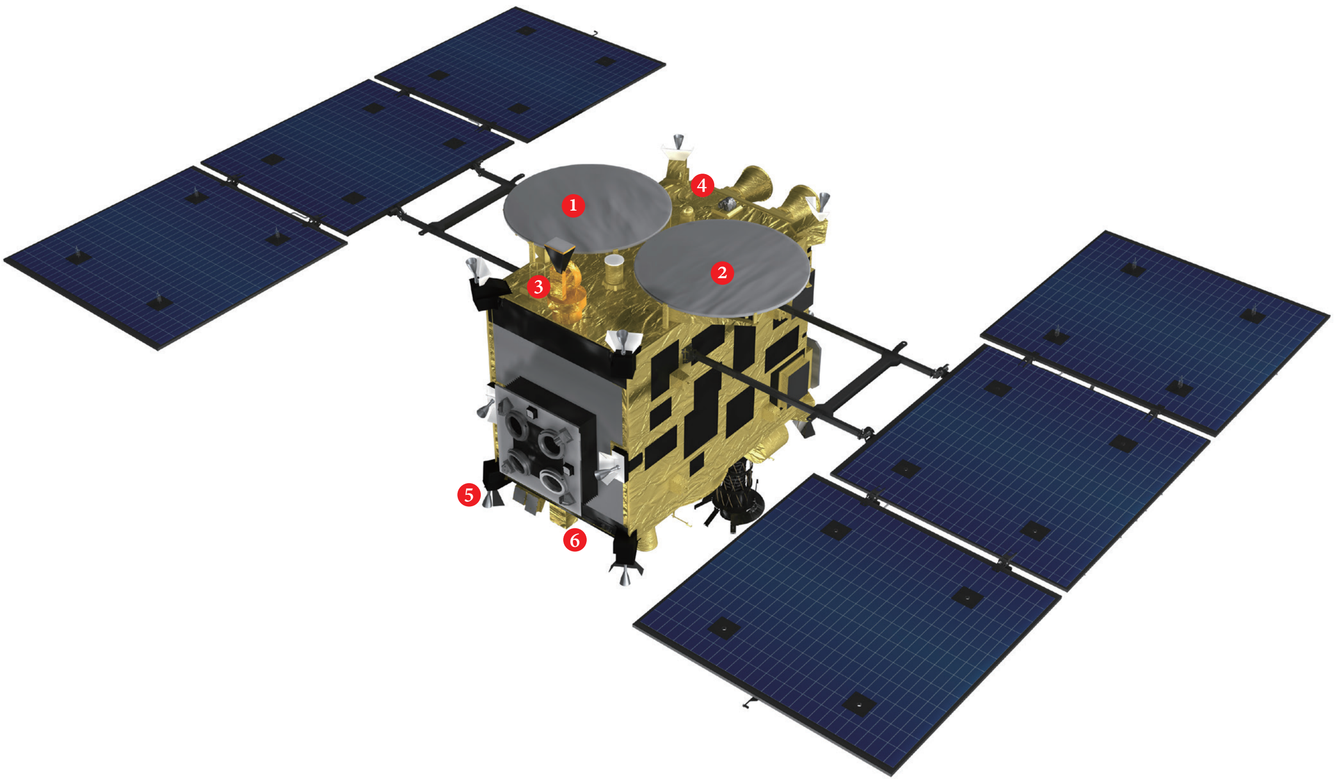


COMMUNICATIONS (ANTENNAS) AND OTHERS

Communications (antennas)

- X-band (8 GHz) waves are generally used for communication with ground stations.
- There are three types of X-band antennas : high-, mid-, and low-gain.
- The Ka-band (32 GHz) is used to transmit data from scientific observations to Earth after arrival at the asteroid.
- Approximately four times more data can be transmitted via the Ka-band than by the X-band. However, transmissions are highly affected by weather (attenuation due to rain is high).
- Bit rates are 8 bps~32 Kbps.

※ What about Ka-band reception?
Ka-band radio waves from planetary explorers currently cannot be received at tracking stations in Japan, so we use overseas tracking stations.



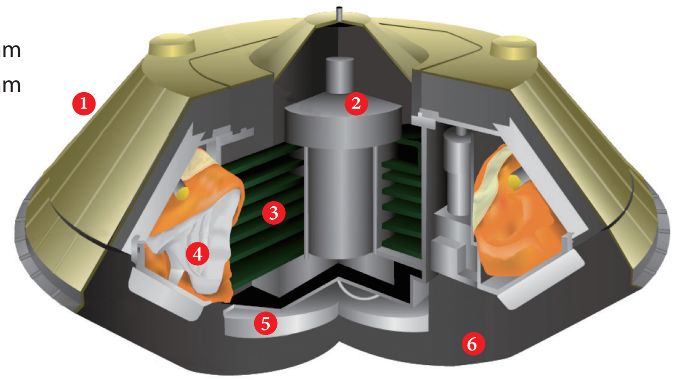
1. Ka-band high gain antenna (Ka-HGA)
2. X-band high-gain antenna (X-HGA)
3. X-band mid-gain antenna (X-MGA)
4. X-band low-gain antenna (X-LGA-A)
5. X-band low-gain antenna (X-LGA-B)
6. X-band low-gain antenna (X-LGA-C)

※ Detailed descriptions of the following systems are omitted here:
Structural system: Overall spacecraft support
Thermal control system: Manages spacecraft temperatures
Data processing unit: Processing and control of all data
Electric instrumentation: Wire-connecting equipment
Digital Electronics (DE): Processes data from scientific sensors (ONC, TIR, NIRS3, DCAM3)

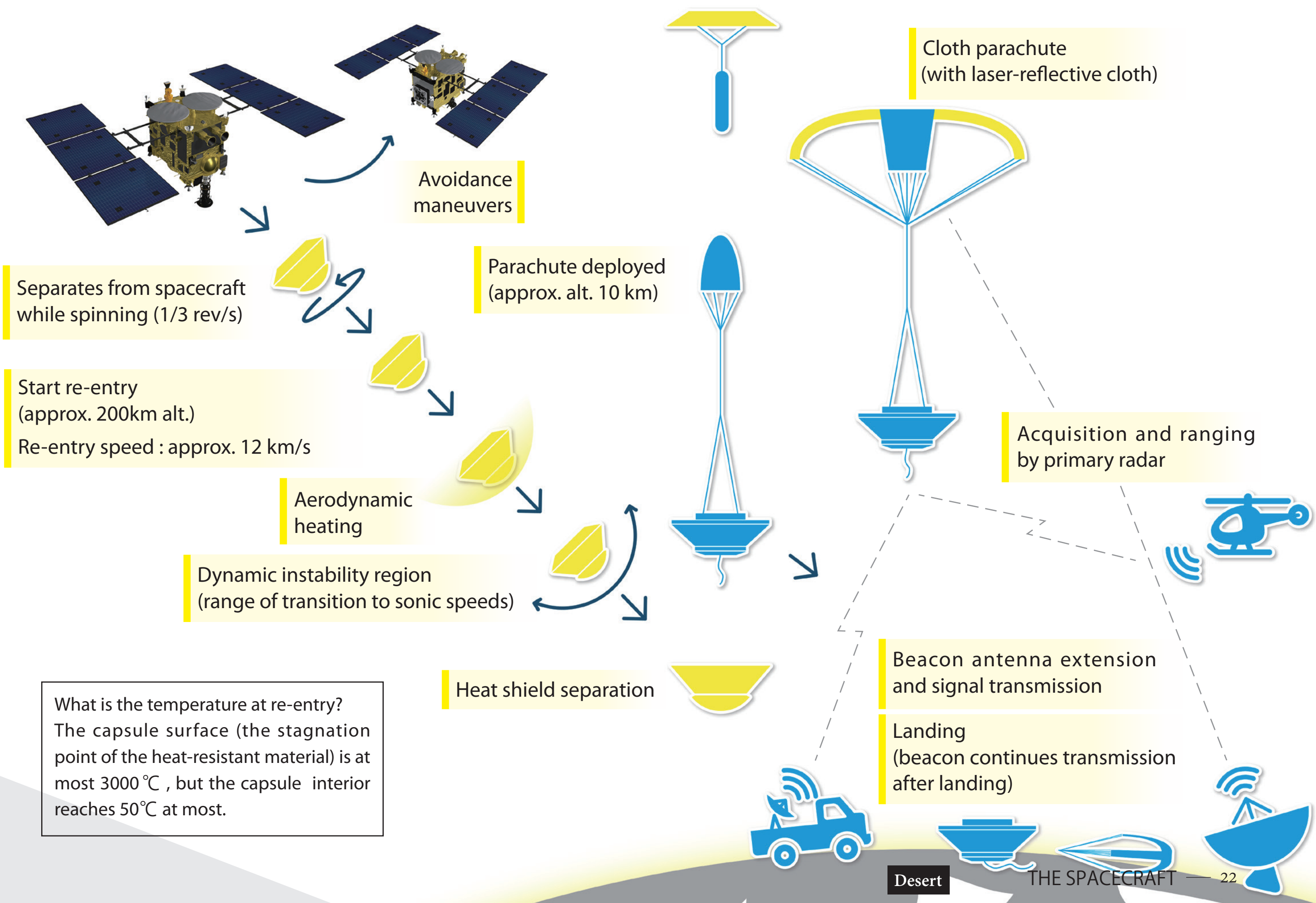
Re-entry capsule

- At the very end of the Hayabusa 2 mission, a capsule carrying a container filled with asteroid samples will re-enter the Earth's atmosphere at 12 km/s and be collected on the ground.
- The capsule separates from the spaceship while spinning at one revolution per 3 seconds. It gets very hot due to atmospheric entry (in technical terms, it passes through a corridor with aerodynamic heating of 14 MW/m^2). It opens a parachute at an altitude of about 10 km, allowing it to gently descend and land while outputting a beacon signal for positional search.
- Fundamental design is nearly the same as that in the first Hayabusa, but mounted equipment, parachute deployment trigger (signal), and reliability of associated equipment have been improved.
- The Riparian Environment Management Model (REMM) is newly added, and will measure acceleration, rotation, and internal temperatures during flight.

Mass - approx. 16 kg
Diameter - approx. 400 mm
Height - approx. 200 mm



1. Rear heat shield (integrated with parachute cover)
2. Sample Container
3. Electronic
4. Parachute
5. Insulator
6. Front heat shield FWD-TPS (Carbon Phenolic)



What is the temperature at re-entry?
The capsule surface (the stagnation point of the heat-resistant material) is at most 3000℃, but the capsule interior reaches 50℃ at most.