1-1 Mission Overview

What is the Asteroid Explorer “HAYABUSA”?

Asteroids are thought to be celestial bodies that preserve information from the time of the Solar System’s formation. If we collect a sample from an asteroid and bring it back to Earth to carry out precise research on it, we can gain some precious clues to understand the origin and evolution of the Solar System.

Bringing back a sample from a celestial body in the Solar System is called “Sample Return.” “HAYABUSA” is a probe to verify the practicality of acquired technology developed to archive future full-scale “sample return missions.”

Main 5 Missions of “HAYABUSA”

1 Ion Engines

“HAYABUSA” performs an interstellar flight with a newly developed ion engines.

2 Autonomous guidance and navigation

“HAYABUSA” recognizes its location using optical information and performs autonomous navigation to get closer to the target or to change positions.

3 Sample collection from the asteroid

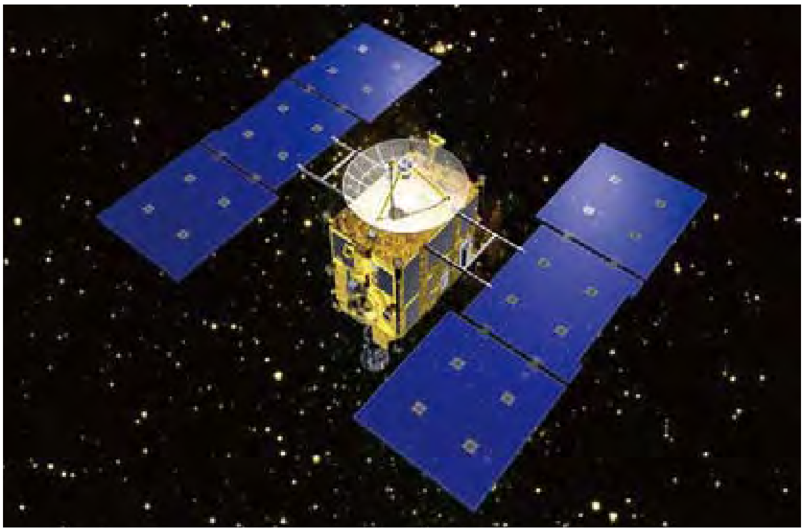
“HAYABUSA” lands on the asteroid, which has microgravity, to collect a sample.

4 Earth swing-by

“HAYABUSA” uses ion engines to fly as well as the Earth’s gravitational acceleration.

5 Reentry capsule

“HAYABUSA” brings back the Sampler Capsule to Earth.



“HAYABUSA” was launched aboard the M-V Launch Vehicle on May 9, 2003. It was accelerated by a swing-by of the Earth in May 2004 and reached its target Asteroid Itokawa on September 12, 2005, after traveling about 2 billion kilometers. In September and October that year, “HAYABUSA” completed the most remote-sensing and measurement of the geometry of Itokawa and made two landings in November to collect a sample from Itokawa.

Through scientific observations performed during “HAYABUSA’s” stay on Itokawa, various knowledge was obtained including on its gravity and surface condition. The achievements of “HAYABUSA” were featured in the scientific magazine, “Science.”

Asteroid Explorer “HAYABUSA”	
Weight (at launch)	510kg
Body dimensions	1.0×1.6×2.0m
Length of Solar Array Paddle	Approx. 5.7m
Launch: May 9, 2003 aboard the M-V-5	

Image of Asteroid Itokawa captured by “HAYABUSA”

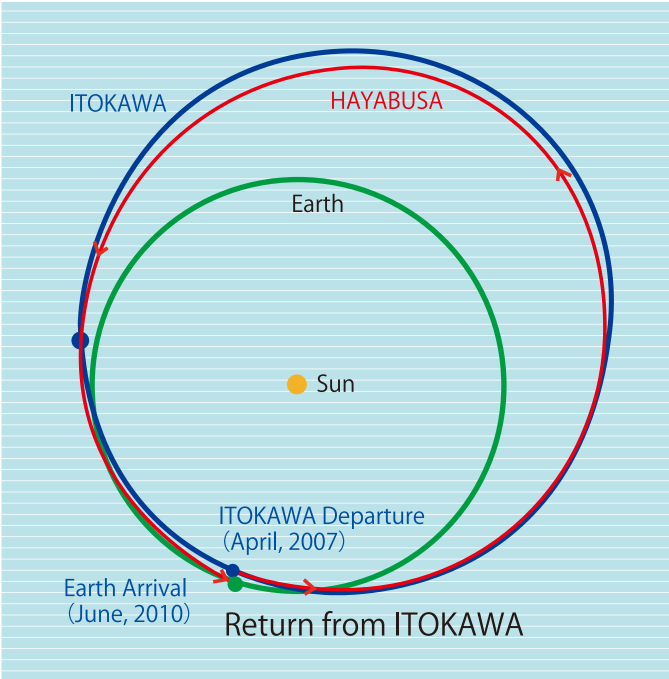
JAXA

Earth Return of "HAYABUSA"

After landing on Itokawa and collecting a sample, control of the "HAYABUSA" was lost due to a fuel leakage in one of its chemical engines that control the attitude. The situation became serious and communications died out over seven weeks, resulting in a considerable delay for the scheduled return to Earth of the "HAYABUSA."

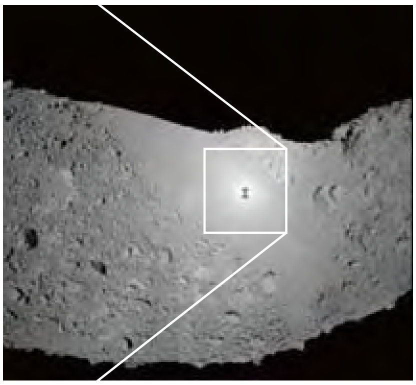
In April 2007, "HAYABUSA" fired up its ion engines to depart from the orbit of Itokawa and started heading back to Earth. However, the deterioration of these ion engines has been getting worse. "HAYABUSA" carries four ion engines A, B, C and D, but ion source A and neutralizers B and D have already become malfunctioned. Thus, "HAYABUSA" is presently operated with a combination of neutralizer A and ion source B.

Moreover, two of three reaction wheels to maintain the attitude are broken. Thus, its attitude is controlled by the remaining one reaction wheel and ion engines. Since its chemical engines are not available, ion engines are used alternately. The batteries to store electricity generated by the solar arrays have also malfunctioned, so "HAYABUSA" is only using electricity generated by solar arrays.



As you can see, "HAYABUSA" is extensively damaged, but the operation team on the ground has been coping with such trouble in order to lead "HAYABUSA" back home for its return to Earth in June 2010.

A shadow of "HAYABUSA" on Asteroid Itokawa and the target marker with the signatures of 880,000 people



Mission Attainment Level of "HAYABUSA"

① Start of ion engine operation (World's first simultaneous operation of 3 engines)	**Completed**
② 1,000-hour ion engine operation	**Completed**
③ Earth swing-by (First in the world with ion engines)	**Completed**
④ Autonomous navigation and rendezvous with Itokawa	**Completed**
⑤ Scientific observations of Itokawa	**Completed**
⑥ Landed on Itokawa for sample collections	**Completed**
⑦ Re-entry capsule reenters the atmosphere and returns to the Earth to be recovered	**Challenge**
⑧ Procurement of a sample of Itokawa	**Challenge**

There are two items remaining before the "HAYABUSA" mission is completed.

2-1 Earth Return of "HAYABUSA"

Maneuvering into re-entry trajectory

In November 2005, "HAYABUSA" landed on the asteroid Itokawa to collect a sample of its surface. Due to a fuel leakage in one of its chemical engines after the craft landed, "HAYABUSA's" return to Earth was heavily rescheduled. It has since overcome many difficulties and continues its journey back to the Earth.

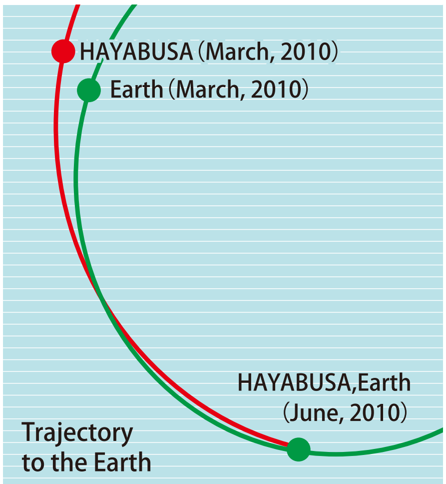
The goal for the "HAYABUSA" project is to bring back a sample from the asteroid and verify the technology required in the round trip to the celestial bodies in the solar system.

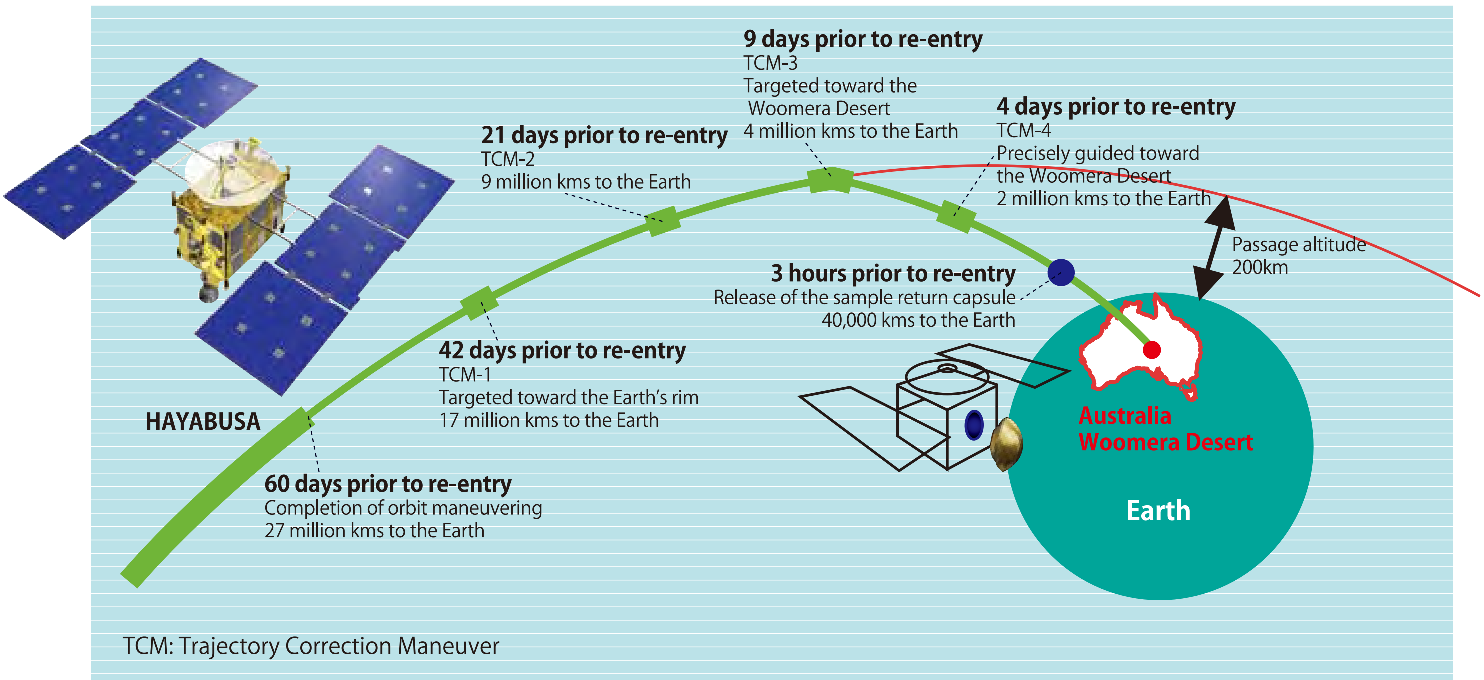
At 23:30 (ACST), June 13th 2010 "HAYABUSA" is going to challenge its last hurdle to meet its goal of returning to the Earth.

"HAYABUSA" release its sample return capsule.

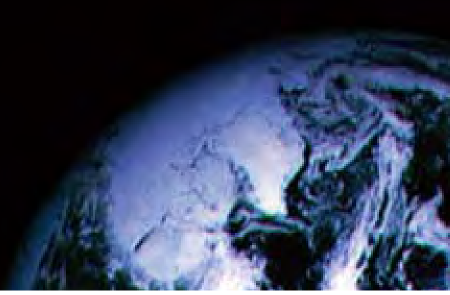
●When "HAYABUSA" approaches the Earth, operations for its re-entry into the atmosphere will be conducted as follows

60 days prior to re-entry	"HAYABUSA" will complete orbit maneuvering to return to the Earth using its ion engines. "HAYABUSA" will start an inertial flight and the precise orbit will be determined. At this point, "HAYABUSA" will be located 27 million kilometers away from the Earth.
42 days prior to re-entry	Trajectory Correction Maneuver No.1 (TCM-1) will be performed to inject "HAYABUSA" into the trajectory targeting toward Earth's rim. Distance to the Earth will be 17 million kilometers.
21 days prior to re-entry	Trajectory Correction Maneuver No.2 (TCM-2) will be performed to guide "HAYABUSA" precisely into the Earth's rim. Distance to the Earth will be 9 million kilometers.
9 days prior to re-entry	Trajectory Correction Maneuver No.3 (TCM-3) will be performed to change the target of the "HAYABUSA" to the Woomera Desert in Australia from the Earth's rim. Distance to the Earth will be 4 million kilometers.
4 days prior to re-entry	Trajectory Correction Maneuver No.4 (TCM-4) will be performed to guide "HAYABUSA" precisely to the Woomera Desert in Australia. Distance to the Earth will be 2 million kilometers.
3 hours prior to re-entry	"HAYABUSA" will release its sample return capsule. Distance to the Earth will be 40,000 kilometers.

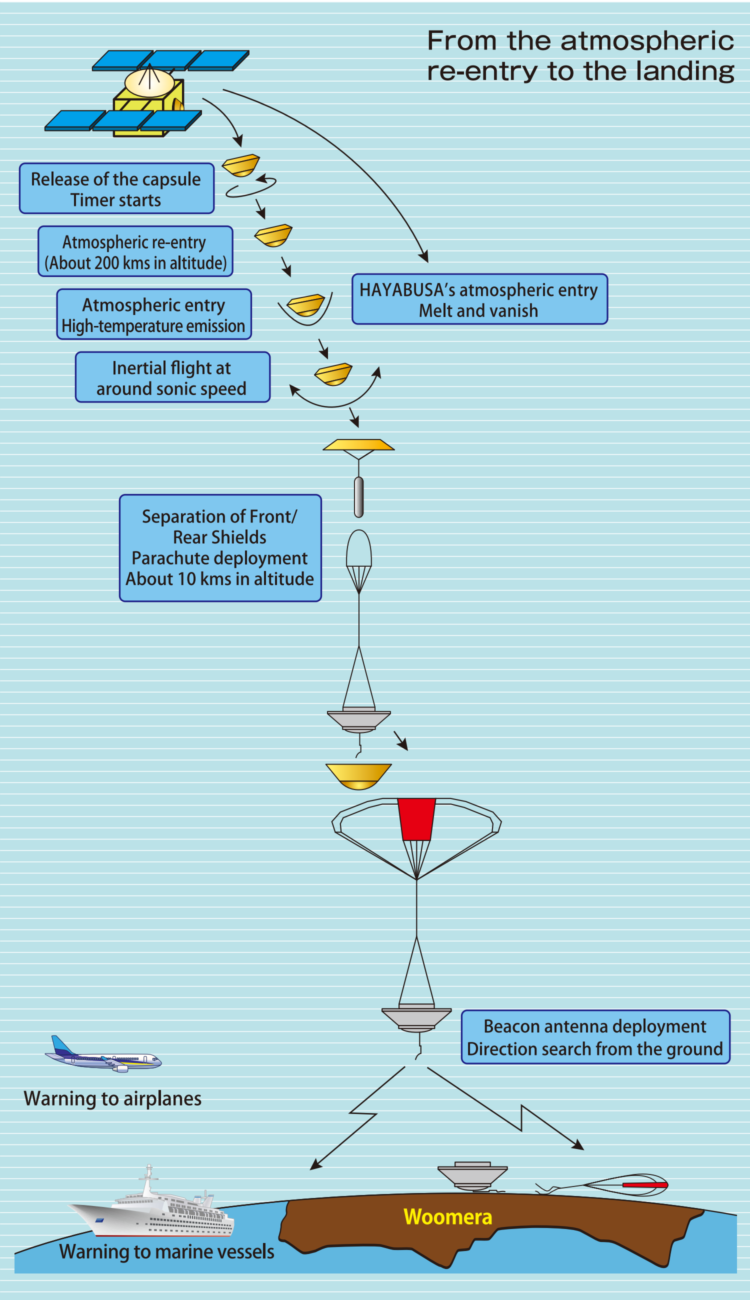




2-2 Earth Return of “HAYABUSA”



Recovery of “HAYABUSA” re-entry capsule

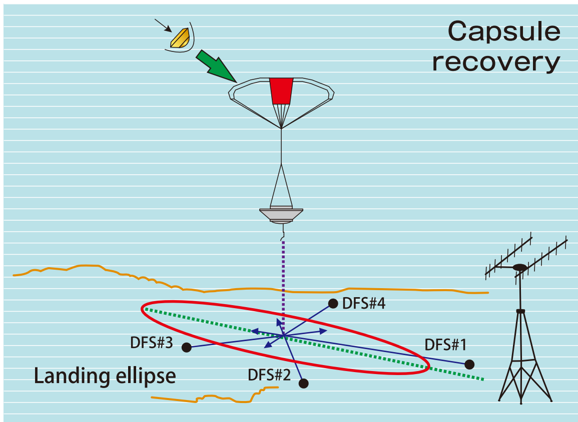


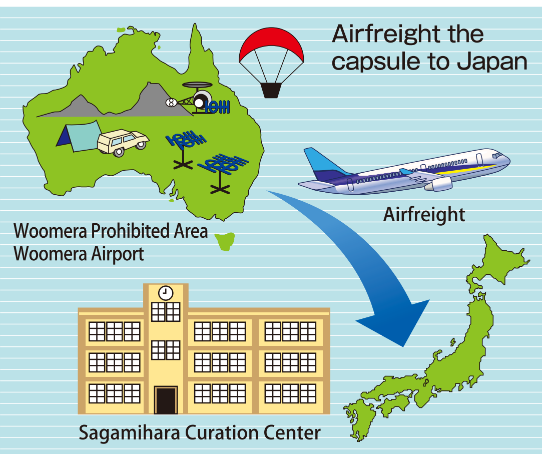
A sample return capsule released from “HAYABUSA” will reenter the atmosphere at an altitude of about 200 kilometers. Prior to it's landing, notification of its predicted landing spot and the date and time will be sent to airplanes and marine vessels.

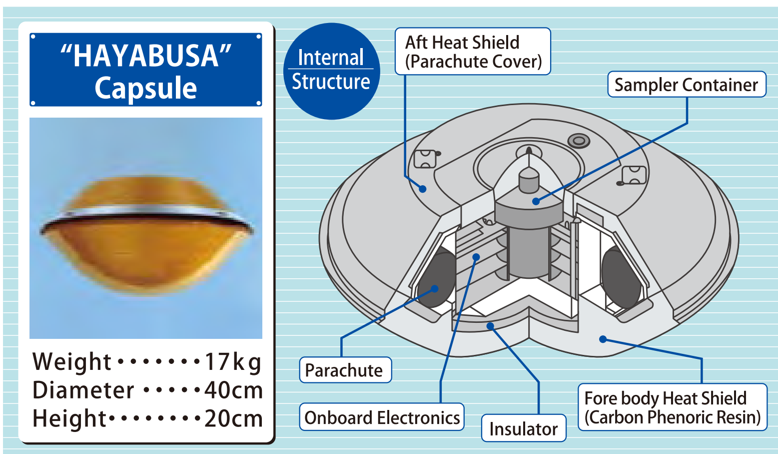
The sample return capsule is exposed to a much higher temperature than the Space Shuttle’s atmospheric re-entry. Its cooling system employs ablation cooling in which the heat-resistance material itself contracts while releasing the heat from the capsule. The “HAYABUSA” re-entry capsule requires material to resist heat so high that we’ve never experienced it before, thus carbon phenolic resin is employed.

Both the fore body and aft heat shields of the capsule will be separated at an altitude around 10 kilometers and the sampler container will start descending with a parachute. The beacon antenna is then deployed and the direction search of transmitting beacons is started on the ground. The descending time period with the parachute is about 15 to 20 minutes. Beacons will be transmitted after the sampler container lands on the ground.

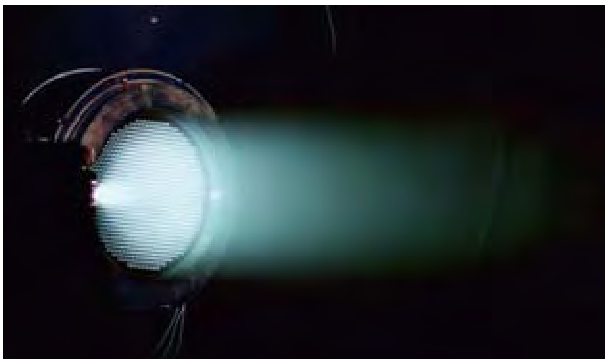
On the ground, Direction Finding Subsystems (DFS) will be located at four points around the designated landing area to search for the capsule’s landing point. Once the landing point is confirmed, the sampler container will be collected by a helicopter and a car.







Advanced ion engine



Injection of an ion engine (At ground test)

A chemical engine propels spacecraft while releasing high temperature gas generated from the combustion of the fuel and oxidizer, but a propulsion method to boost the acceleration to a higher speed is required when it comes to traveling in the vast area of the Solar System. Compared to a chemical engine, an ion engine has less propulsion power, but its fuel costs are extremely efficient and it is able to accelerate for a long period. An ion engine can’t be used for the launch from the ground as it has a week thrust, but during the interplanetary flight, an ion engine can reach extremely fast speeds if it keeps applying its jets.

An ion engine consists of mainly three parts. These are an “ion source,” where the propellant like xenon is plasmatized, the “electrode (grid)” to accelerate positively-charged ions and the “neutralizer” to make the high speed jetted ions become electrically neutral plasmas. If the spacecraft keeps injecting positively-charged ions, it will become negatively-charged and attract positive ions, preventing the spacecraft from propelling forward. Therefore, an ion engine requires a neutralizer.

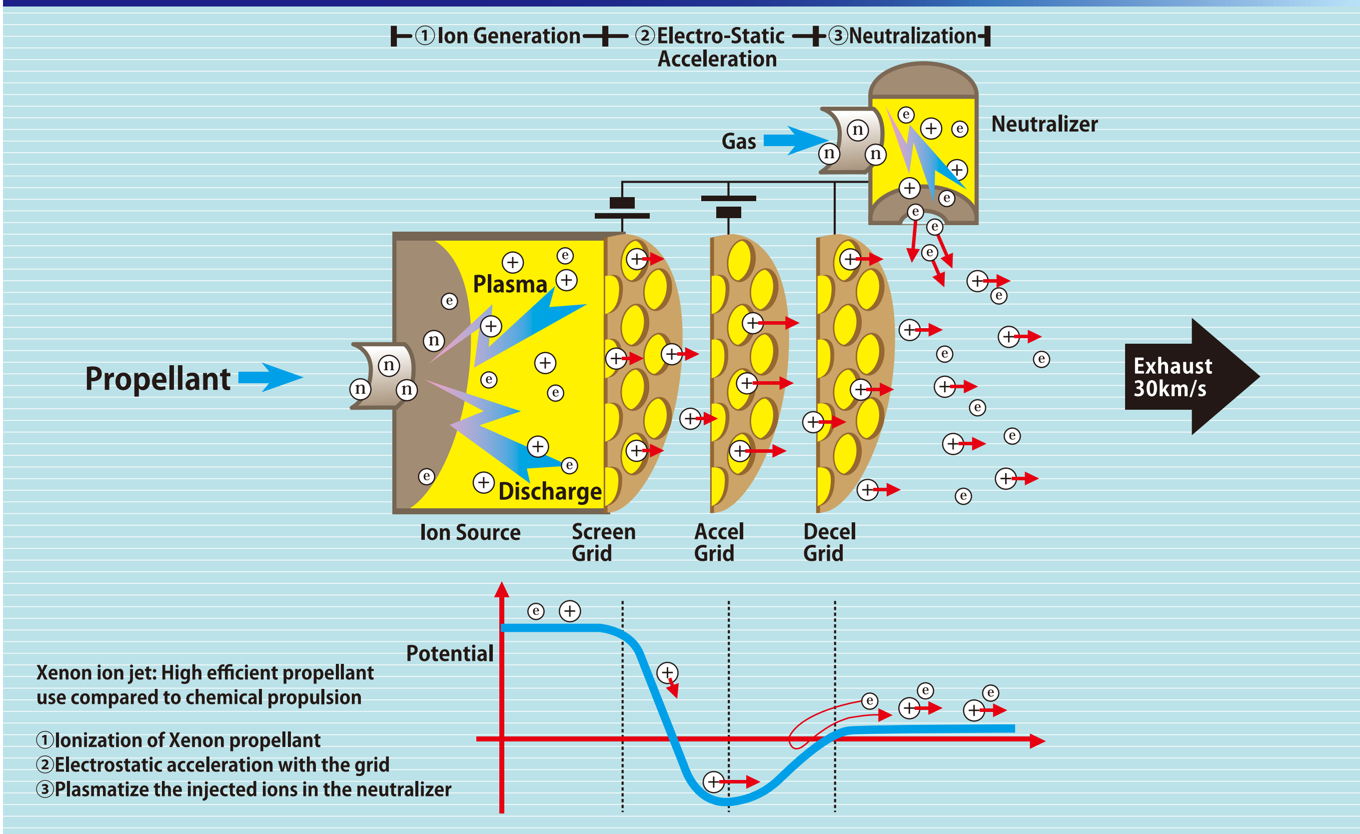
The main feature of the ion engines on “HAYABUSA” is using microwaves to generate plasmas. Existing ion engines generate plasmas by electric discharge, but in this method, the electrode galls influence the operating life. Thus, “HAYABUSA” employed this method to generate plasmas by using microwaves used in kitchen microwave ovens.

As for the electrode, molybdenum had been used up to now, but the problem was that it gradually galls when ions crash into it. Because of that, “HAYABUSA” now uses a compound material with durable carbon.

Through these technologies, the ion engines on “HAYABUSA” can triple their operating lives compared to existing ion engines. The success in the practical application of such ion engines marks a global first.

The return trip between the Earth and the asteroid takes years, so the ion engines of “HAYABUSA” were required to operate some 14,000 hours in space. They twice succeeded in 18,000-hour endurance tests on the ground.

Principle of ion engine



"HAYABUSA's" engineering results

Earth-asteroid round trip to be realized

"HAYABUSA" carries four ion engines, thrusters A, B, C and D. One of the four is a backup thruster and the other three thrusters are operated to propel the spacecraft.

To take a round trip from the Earth to Asteroid Itokawa, ion engines have to be operated for about 40,000 hours in total. In addition, "HAYABUSA" needs about 2,200 m/s orbit maneuver (quantity of acceleration by ion engines.) The ion engines of "HAYABUSA" are getting close to accomplishing these tasks.

However, these ion engines are deteriorating. "HAYABUSA" performed the first orbit maneuver from April 2007, when it broke away from the orbit of Itokawa, to October the same year. Subsequently, it started to perform the second orbit maneuver in February 2009. However, one of the ion engines made an abnormal stop on November 4 last year. That was due to the completion of the operation life of the neutralizer for thruster D.

Therefore, the ion source of thruster B, with a malfunctioned neutralizer, and the neutralizer of thruster A, on stand-by due to the bad condition of its ion source, were coordinated together to work as an ion engine. In this way, "HAYABUSA" rebooted its operations.

This cross-operation was enabled because we had built a circuit to connect each thruster under the assumption of such a possibility.

While operating the ion engines under this new configuration, "HAYABUSA" is trying to come back to the Earth.

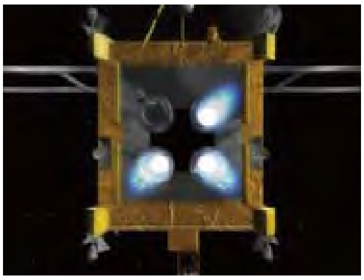
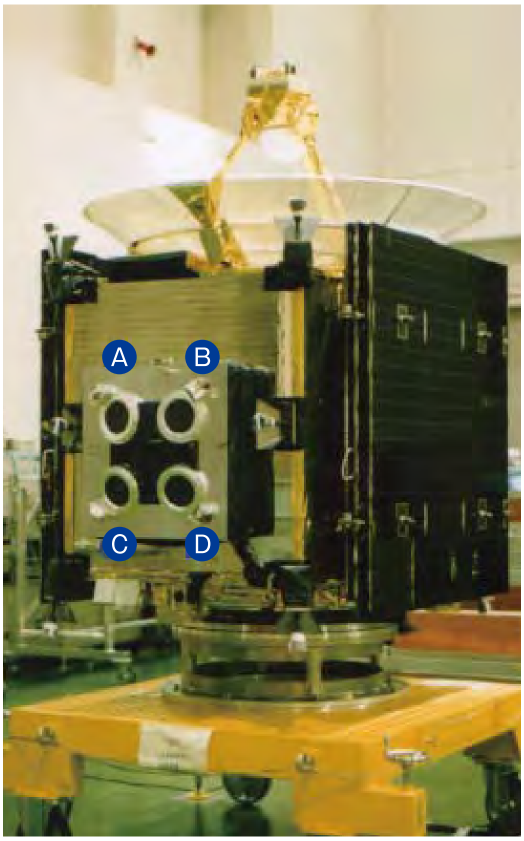


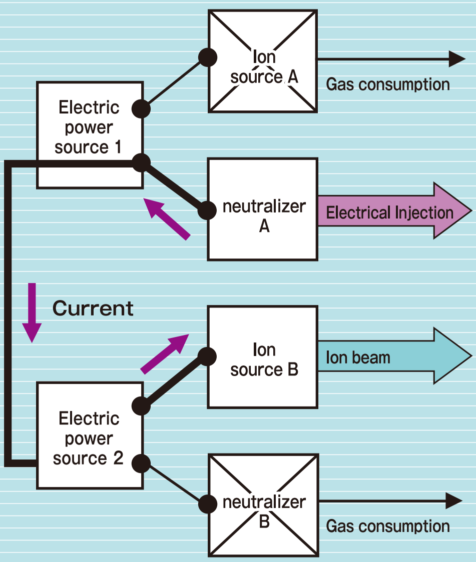
Image of "HAYABUSA" traveling with three ion engines in operation



"HAYABUSA" carries four ion engines, thrusters A, B, C and D

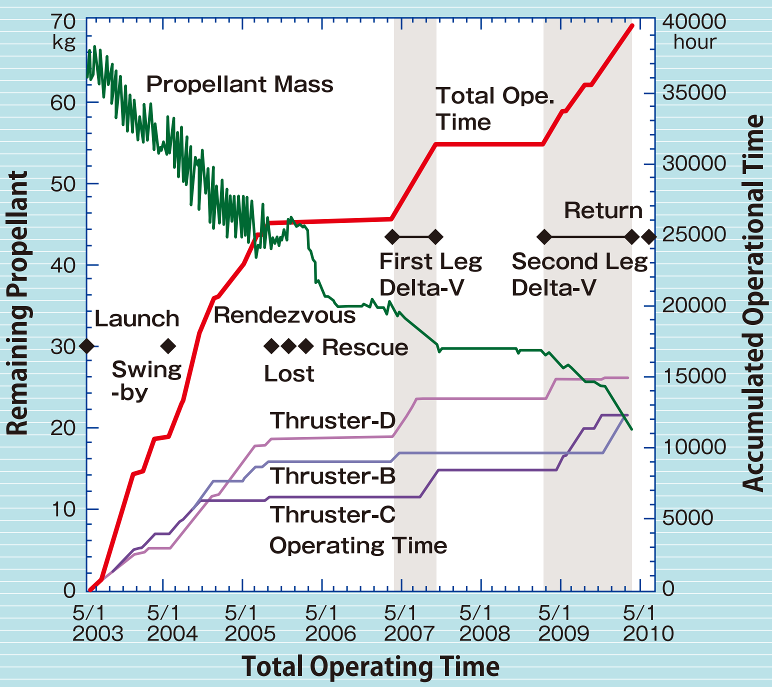
Cross-operation of ion engines

Ion source B and neutralizer A consist of an ion engine.



The operating time of the ion engine and the remaining amount of propellant.

Total operating time of the ion engine is getting close to the targeted time of 40,000 hours. A sufficient amount of the Xenon propellant remains.



4-1 “HAYABUSA’s” engineering results

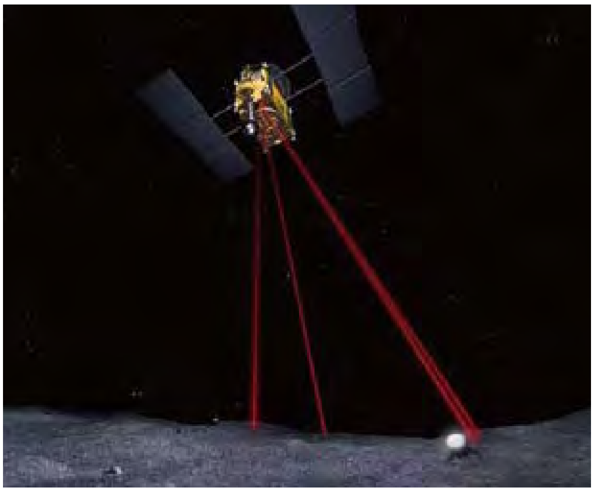
Attempted a sample collection with autonomous navigation

The “HAYABUSA” mission has kept the ion engines operated for a long time and archived the targeted amount of trajectory transformation as the probe now tries to return to Earth. On top of this success, the mission has also achieved various results in the engineering field.

Earth Swing-by

To travel toward Itokawa, “HAYABUSA” performed an Earth swing-by, in which it was accelerated while utilizing the gravity of the Earth. Gravity-assisted acceleration by the Earth is often performed by planetary probes, but the dual propulsion from the swing-by and the ion engines carried out by “HAYABUSA” this time marked a global first. After the launch, “HAYABUSA” maintained its path not too far from the direction of the Sun and operated its ion engines with enough electricity generation to keep its speed. After about a year from its launch, “HAYABUSA” performed the Earth swing-by to gain extra acceleration and transferred its trajectory toward asteroid Itokawa. Since the acceleration of the ion engines takes a long time, the trajectory needs to be determined accurately in order to perform the swing-by as planned, which “HAYABUSA” successfully performed.

Autonomous Landing



Final descend with the laser range finders

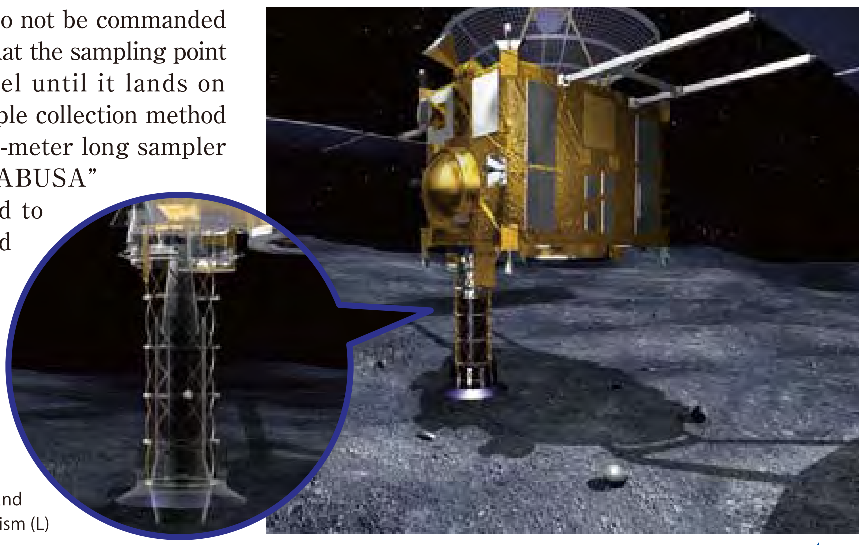
The distance from Earth to Itokawa is about three hundred million kilometers. Thus, even we send a command from the Earth, it will take about 40 minutes in a round trip. “HAYABUSA” needed to approach Itokawa while making decisions on its own at the time of landing. “HAYABUSA” calculated the distance to the surface of Itokawa from the data of the Laser Altimeter. The target marker previously dropped on Itokawa was captured by the camera to determine its horizontal position. “HAYABUSA” found out its own position in this way and descended onto Itokawa.

In addition, “HAYABUSA” needed to take a vertical attitude adjustment toward the surface of Itokawa in order to collect a sample from it. “HAYABUSA” carries four Laser Range Finders that face obliquely downward and it determines a vertical attitude toward the surface of Itokawa from the data difference between these four devices.

In this way, “HAYABUSA” autonomously maintained the altitude and the correct attitude toward the surface of Itokawa, and gradually descended. “HAYABUSA” landed on the Muses Sea and although the clearance for landing was only approximately 60 meters in diameter, “HAYABUSA” succeeded in a pin-point landing.

Sample Collection Technology

The sample collection from Itokawa can also not be commanded from the ground. “HAYABUSA” can not tell that the sampling point is covered with a monolith or sand gravel until it lands on Itokawa’s surface. Thus, this kind of the sample collection method was applied to “HAYABUSA.” Once the one-meter long sampler horn extended from the bottom of “HAYABUSA” touched on Itokawa, a bullet was launched to crush the monolith or raise a curl of sand gravel, which went through the internal path of the horn. The fragments that reached “HAYABUSA” were then sampled. Such a measure was taken because Itokawa’s gravity is extremely minimal and the probe can not be set on the surface of Itokawa.



“HAYABUSA” landed on Itokawa (R) and the sample collecting mechanism (L)

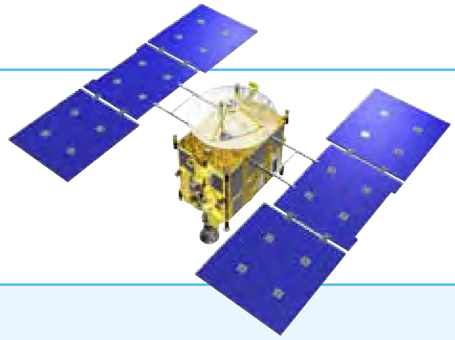
4-2 Operation of “HAYABUSA”

After overcoming many problems

The parabola antenna at the Usuda Deep Space Center

The operation of “HAYABUSA” is carried out from the control room at JAXA Sagamihara Campus. Communications between “HAYABUSA,” the monitoring of its condition, and the determination of its location are performed using the 64-meter parabola antenna at the Usuda Deep Space Center in Nagano Prefecture.

“HAYABUSA” has faced many problems on this mission, but the operation team has overcome these difficulties every single time while taking countermeasures as follows:



July, 2005	**The first reaction wheel malfunctioned**
October, 2005	**The second reaction wheel malfunctioned** The reaction wheels are a type of flywheel used to stabilize the attitude of the spacecraft. “HAYABUSA” maintains its attitude by keeping each of these three reaction wheels axially stable. After two of them malfunctioned, the landing-and-lifting operation on/from Itokawa in November 2005 was performed with just one reaction wheel available. After that, the chemical engine for attitude control also broke down, thus the attitude control of “HAYABUSA” has been performed with one reaction wheel and injections from the ion engines.
November, 2005	**Lost control of attitude and communications due to fuel leakage from chemical engine** On November 26, 2005, “HAYABUSA” performed the second landing on Itokawa, but after its lift off, fuel leaked from its chemical engine. As the leaked fuel turned to gas and gushed out in space, “HAYABUSA” lost its attitude. Due to this accident, communications were cut off over 7 weeks from December 9 that year. An injection of xenon gas was taken as a measure after the recovery of communications. Xenon gas was originally used as a propellant for the ion engines, but this gas was injected directly into space, which was nor originally planned. Communication with “HAYABUSA” has gradually recovered and miraculously reestablished around March 2006.
January, 2006	**Trying to return to Earth in 2010 with a new trajectory plan** The Earth return initially scheduled in 2007 was forced to be postponed. The operation team made a new trajectory plan and targeted a return to Earth in 2010, using one ion engine only.
June, 2006	**Attitude control utilizing solar light pressure** To control the attitude of “HAYABUSA,” a new method was undertaken. In space, “HAYABUSA” is under very weak pressure exerted by sunlight. The adapted technique is to control the attitude by utilizing this pressure. Through this method, the ion engine propellant, i.e., xenon gas, became unnecessary for the attitude control.
November, 2006	**Irregular stop due to ion engine’s deterioration** Even though the Earth return of “HAYABUSA” is becoming a reality, the operating life of its ion engines is close to an end. On November 4, 2009, the neutralizer of thruster D malfunctioned and the ion engines made an irregular stop. After this problem, the ion source of thruster B and the neutralizer of thruster A were connected together to form an ion engine and the operation was restarted with a new configuration.

“HAYABUSA” is finally approaching the Earth. The hurdles of atmospheric re-entry and recovery of the sampler capsule are still waiting at the end of the mission.

5-1 Recovery of "HAYABUSA" re-entry capsule

International cooperation advances recovery operation

Many space development projects are performed under international cooperation due to their high technology requirements and high cost. Japan and Australia have built up a close cooperative relationship in the field of space development. In 2002, we launched the Australian microsatellite FedSat to conduct various experiments including an observation on geomagnetic field lines aboard the H-IIA Launch Vehicle. We also co-hosted the Asia-Pacific Regional Space Agency Forum -11 (APRSAF-11) in Canberra in 2004.

The "HAYABUSA"mission was also conducted under such circumstances. "HAYABUSA" is on its orbit back to Earth thanks to cooperation with the U.S. National Aeronautics and Space Administration (NASA), the Australian Department of Innovation, Industry, Science and Research (DIISR), the Space Licensing and Safety Office (SLASO) of Australia, The Royal Australian Air Force (RAAF) and the RAAF Aerospace Operational Support Group (AOSG).

Backup from NASA

Communication with "HAYABUSA" is performed using a Japanese antenna when we can track it from Japan. When we need to monitor "HAYABUSA" 24 hours a day, we ask NASA to track down "HAYABUSA"using their Deep Space Network (DSN) antennas. We also ask NASA's Jet Propulsion Laboratory (JPL) to support us with a trajectory decision when we need to decide the precise orbit and operate "HAYABUSA"with special attention while comparing the orbit decided in Japan with their decision.

The Australian Government is supporting the recovery of the "HAYABUSA" re-entry capsule in the following ways:

Permission for the use of landing area

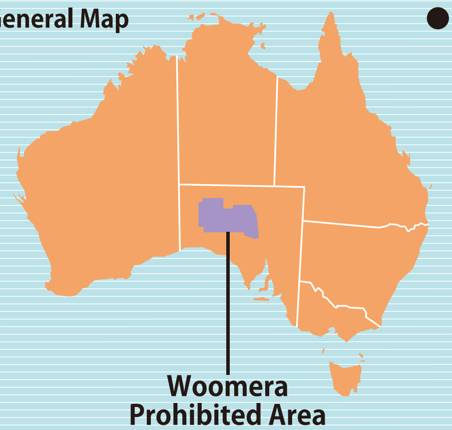
"HAYABUSA" re-entry capsule is scheduled to land within the Woomera Prohibited Area (WPA), a vast land and airspace area set aside in South Australia's remote north-western outback region for the test and evaluation of Defence systems, particularly air and space systems. The WPA is controlled by the Woomera Test Range, which is part of AOSG. The WTR is the largest land-based Defence and aerospace test range in the world and covers 127,000 km^2 (or about one third of Japan's national land area). JAXA has been working very closely with AOSG and the WTR since 2003, when landing permission in the WPA was granted by the Australian Government, to plan and prepare for a successful re-entry and recovery event for the Asteroid Explorer "HAYABUSA". JAXA and WTR Operations are now actively engaged as a team preparing the facilities and systems at the WTR that will ensure the best possible outcomes for a successful re-entry and recovery of the "HAYABUSA" capsule.

Landing permission for the re-entry capsule

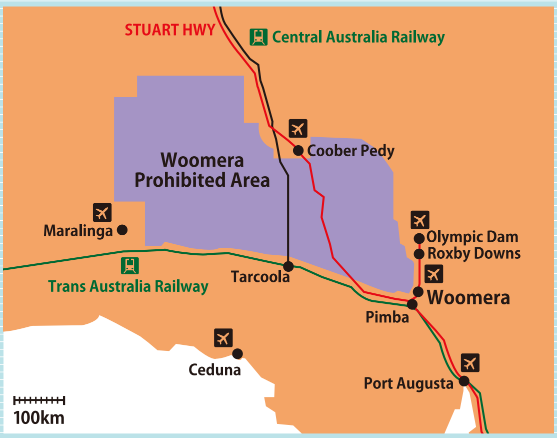
In Australia, there is a law on the necessary procedures for space objects that are returning to Australia and the Authorization of Return of Overseas Launched Space Object (AROLSO) is issued by SLASO. SLASO makes a general evaluation of the space object's various risks to Australia before issuing the AROLSO. JAXA submitted four required documents (plan for "HAYABUSA" return project, safety plan for the re-entry of "HAYABUSA" capsule, plan for the risk management for "HAYABUSA" capsule re-entry, and plan for environment conservation at "HAYABUSA" re-entry) for the SLASO evaluation and received the AROLSO from SLASO.

Woomera Prohibited Area MAP

●General Map



●Detailed Map



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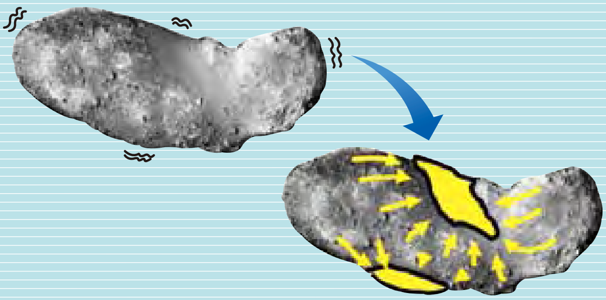
Revelations from observation data

Itokawa viewed closely from “HAYABUSA” is an asteroid of unimaginable shape. The surface of Itokawa is covered by so many boulders and rocks. Meanwhile, there were some smooth spots covered with very small rocks. Observations revealed that Itokawa’s density, 1.9 g/cm^3, is extremely low compared to other asteroids and Itokawa can be considered as a rubble-pile asteroid that has many grikes on it. Itokawa is thought to have been formed by a recollection of debris due to gravity, after the parent body, which originated from planetesimals formed in the early stage of the Solar System’s formation, was broken into pieces through a crash. According to observations of Itokawa’s surface with on-board observation devices, several facts have been revealed such as Itokawa’s similarity to a meteorite usually called a LL-type chondrite, as well as its consistency in element composition in different places, and that it’s a primitive celestial body that contains elements of an ancient era.

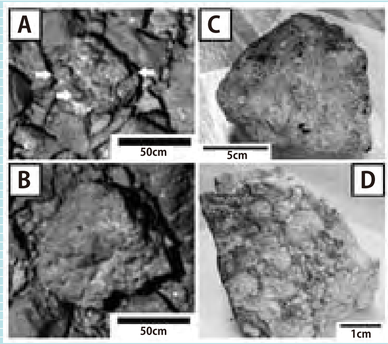
Discovery of the movement of boulders and rocks

Itokawa crashed into another meteorite and has been shaken many times. The boulders and rocks were separated into sizes like they were screened. As a result, smaller rocks were gathered in the lower parts of Itokawa.



Similarity between LL chondrites and Itokawa’s rocks

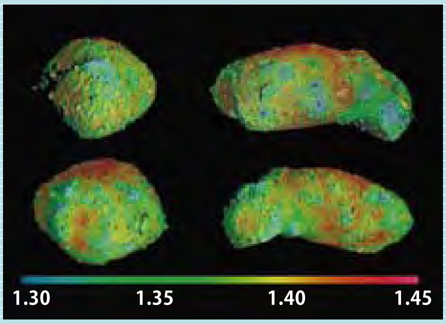
Many meteorites fall down to Earth from space, but among these meteorites LL-type chondrites has been revealed to be very similar to the rocks of Itokawa.



A B Rocks from Itokawa
C D LL chondrite

Brighter parts are fresher parts

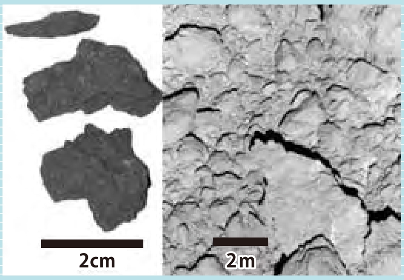
It is considered that the darker parts are areas exposed to a lot of sunlight and meteorites and that the brighter parts are where the darker parts fell off to reveal the fresh parts inside of them.



Red shows the darker parts and blue shows brighter parts in the image.

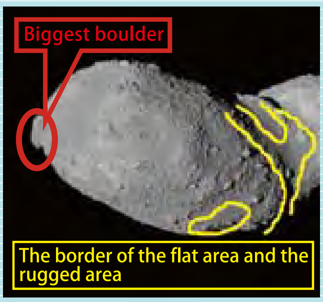
Collision destruction is occurring just like these in the lab

It is known that the number of smaller fragments from a collision drastically increases. Research results on the rock distribution on the surface of Itokawa reflected this tendency. The shapes of these masses of boulders were very similar to fragments created in a laboratory experiment.



L: Rock fragments created in an experiment
R: Image of a boulder on Itokawa’s surface

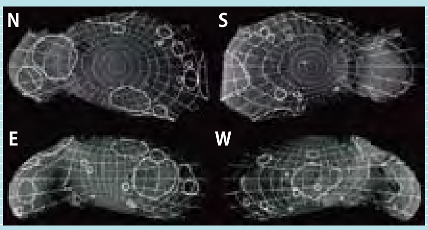
Itokawa could be created from a bigger parent body than itself



Masses of boulders are usually believed to be fragments created during the formation of the craters on the surface of a celestial body and there is an empirical principle between the size of a crater and the largest fragment that could be released from it. However, the largest boulder on Itokawa (nicknamed “Yoshinodai”) has a diameter of 50 meters, thus it was supposed to be released from a much bigger crater than the biggest crater on Itokawa’s surface. From this, Itokawa is believed to have been created when a bigger parent body than Itokawa crashed onto another celestial body and the broken pieces were collected.

Itokawa was born hundreds of millions of years ago

A crater is formed from the impact of a meteorite. Thus, you can estimate the time range when an area was formed as an area with many craters is old and one with fewer craters is new. Itokawa also has these craters, though not as many as the Moon. According to these craters, the time range of Itokawa’s origin was calculated and we found out that it was born between several tens of million and hundreds of millions of years ago.



White circles show candidate craters

6-1 Sample analysis

Initial analysis at the curation facility

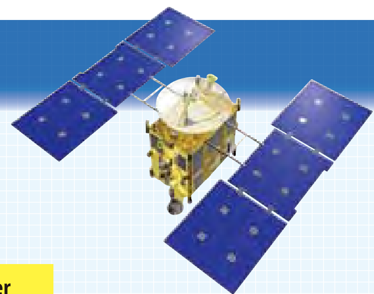
The clean chamber at Sagamihara curation facility. Sample retrieving, observation, and distribution will be performed here.

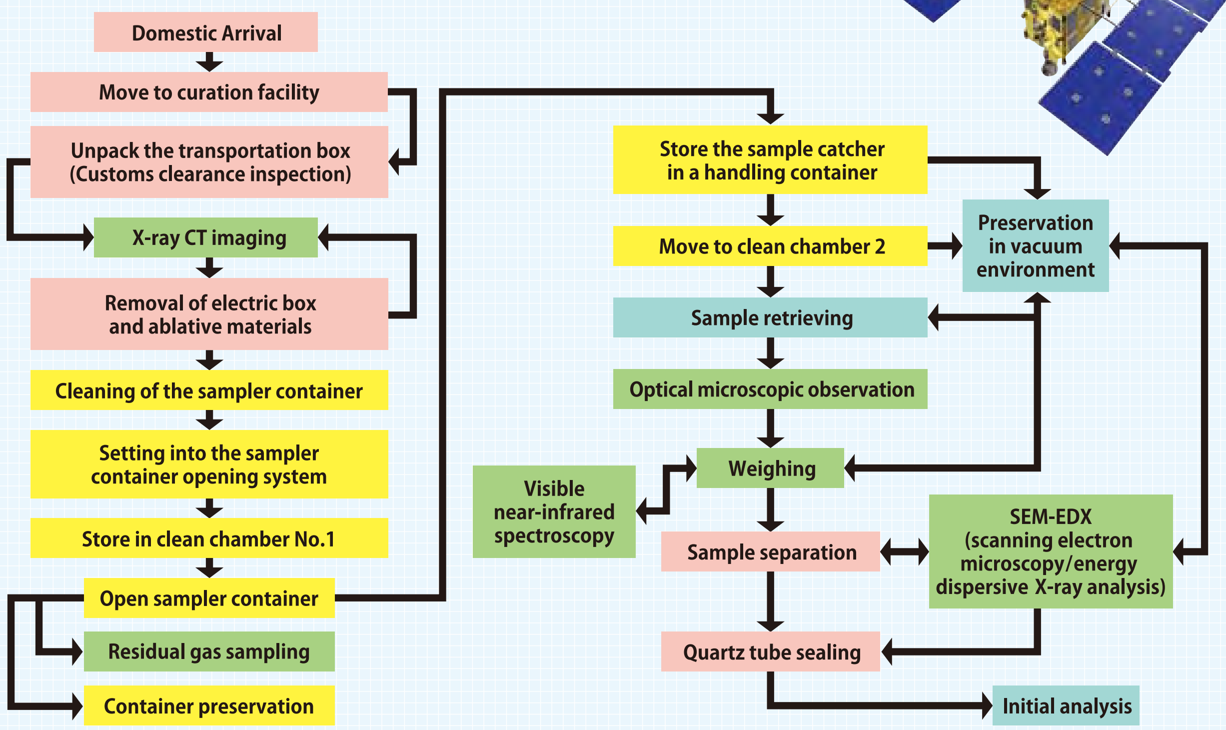
Meteorites and cosmic dust that fall onto the ground will be contaminated by terrestrial materials until they are found. From where they came in the solar system is also unknown. The sample from asteroid Itokawa, collected by "HAYABUSA," is different from these meteorites in that has very little exposure to terrestrial materials and the place where the sample was collected is definite. Thus, the retrieving, preservation and distribution of the Itokawa sample will be performed under conditions of the least possible exposure to terrestrial materials.

Once the sample container arrives in Japan it will be transported to the planetary sample curation facility in Sagamihara campus of JAXA. There, the container will be first cleared to remove any materials attached to it during the container recovery on the ground, and then introduced into clean chamber No. 1. The container will be opened in here and the sample catcher will be stored in a handling container to be moved to clean chamber No. 2. After that, the sample will be retrieved from the sample catcher.

A retrieved sample will be observed with an optical microscope and a visible near-infrared spectrometer and then stored in the quartz container. Initial analysis to investigate the chemical characteristics and mineralogical composition will also be carried out using a part of the sample. This initial analysis is going to be performed through cooperation between universities and researching organizations.

Flowchart of procedures at the curation facility





6-2 Sample analysis

What can a sample from Itokawa reveal?

The information that Itokawa's sample will bring to us.

Through returning a sample collected from Itokawa to the Earth and conducting research, we will be able to acquire further information on Itokawa. The information we can acquire from research on the sample from Itokawa includes the following:

Itokawa's surface material

The sample will tell us what type of meteorite is celestial body Itokawa related to, when was if formed and what kind of material is it made from.

Itokawa's parent bodies and its recollection process

The sample will tell us what are the parent body of Itokawa, which became its material for formation, how were they destroyed, how were these broken pieces put together again and the process of Itokawa's formation will be understood.

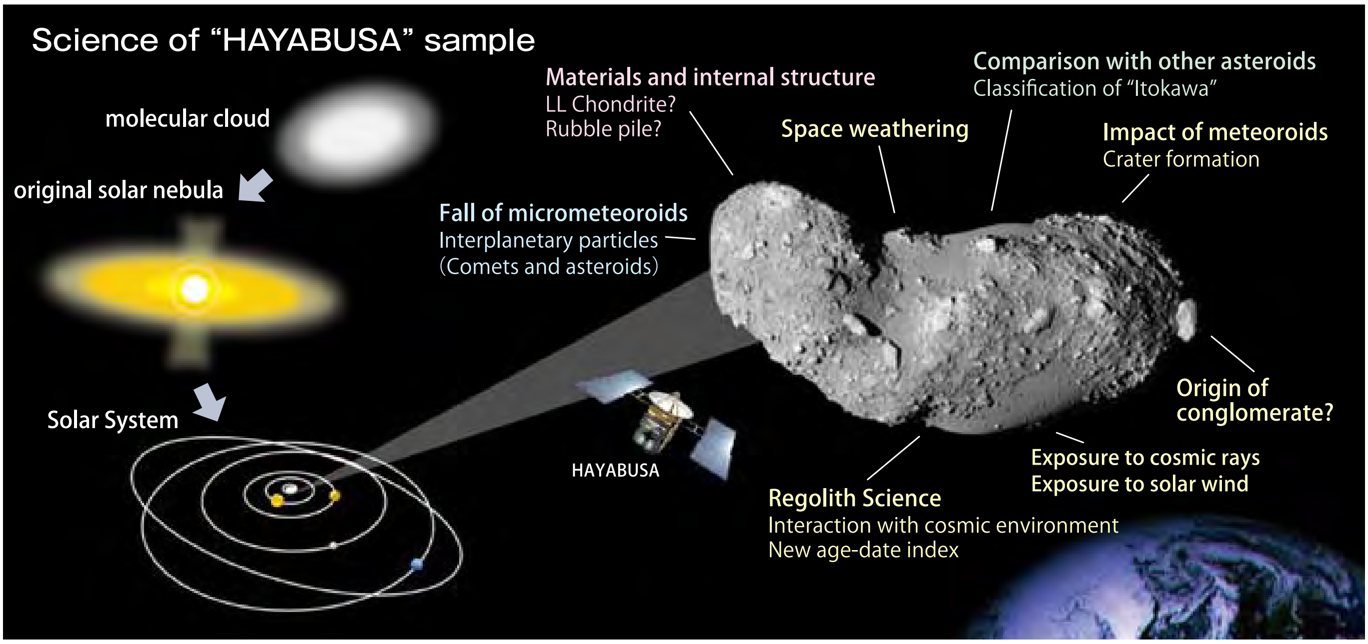
External substances fell on Itokawa

The sample will tell us if there any substances on its surface that came from the other celestial bodies apart from Itokawa. If there are, we can acquire information related to the other celestial bodies and the history of the Solar System.

Interaction with cosmic environment

The sample will tell us what kind of changes have been caused to the surface of Itokawa by solar wind and cosmic radiation while existing in the Solar System. We can understand the process of space weathering and the composition of solar wind.

By researching a sample from Itokawa, precious information related to the origin and evolution of the Solar System can be acquired.



Sample analysis to be performed by an international team

The Joint Science Team (JST) will initially make a precise analysis on the data acquired by "HAYABUSA." In addition to Japanese scientists, the JST is composed of scientists from the U.S. and Australia. As for the discoveries from the "HAYABUSA's" landing on Itowaka in 2005, various facts were tracked down as a result of the JST's initial analysis and research. If "HAYABUSA" could bring back the material from Itokawa's surface, the JST will carry out the initial analysis after confirming what kind of material it is.

From "HAYABUSA" to "Successor of HAYABUSA" project

Although one last task remains to recover the sample from Itokawa, we believe that "HAYABUSA's" mission to develop and verify the technologies required for the sample return from the asteroid is almost accomplished. "HAYABUSA" is paving a path for the forthcoming Age of Exploration in space through a round trip between a celestial body in the Solar System.

In order to understand the origin and evolution of the Solar System, asteroid explorations and sample returns are expected to bring us extremely precious information. JAXA is currently planning a successor based upon the results from "HAYABUSA." Itokawa is classified as an asteroid in the S-type group, but the "Successor of HAYABUSA" is planning scientific observations on a much primitive asteroid and its sample return.