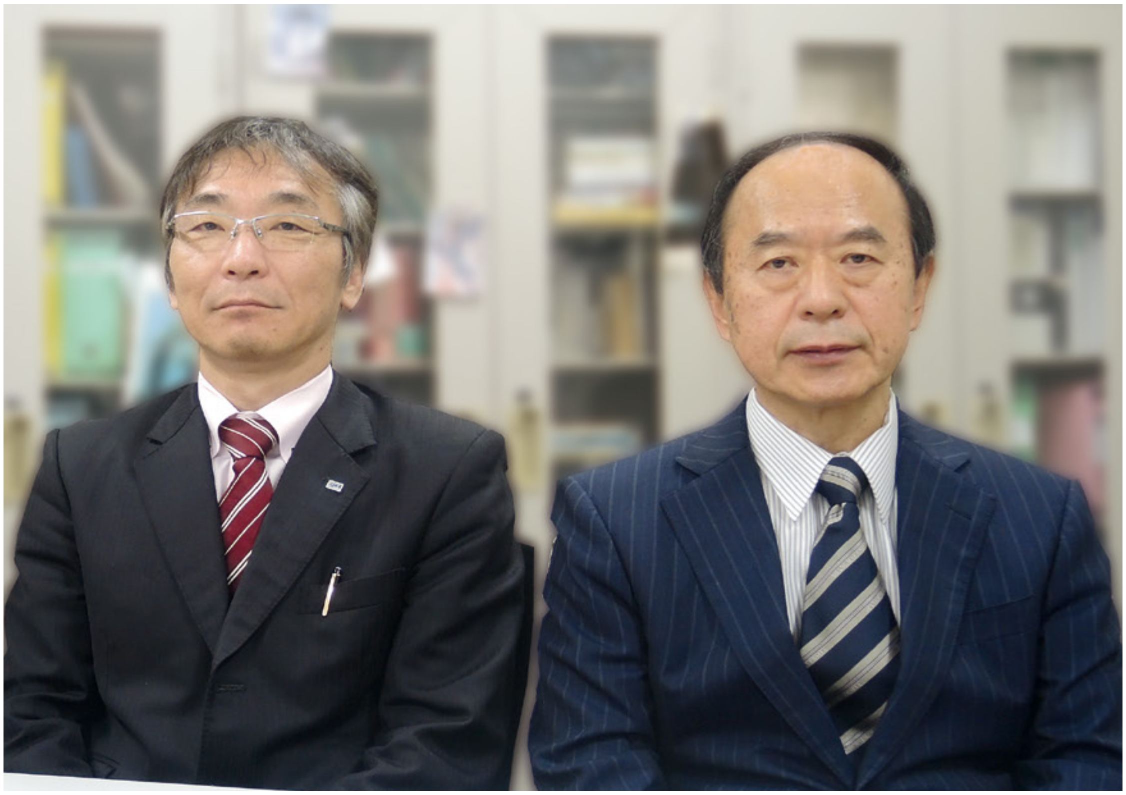
"Inferiority" Provides Opportunities for Innovation

— Working with Private Enterprises Based on Space Technologies and the Lessons Learned from Hayabusa



Guest: **Dr. Hitoshi Kuninaka**

Professor at the Department of Space Flight Systems,
Institute of Space and Astronautical Science
Director of the Space Exploration Innovation Hub Center,
Japan Aerospace Exploration Agency (JAXA)

Interviewer: **Hisaharu Obinata**

President and CEO, ULVAC, Inc.

On June 13, 2010, the first asteroid explorer Hayabusa returned to Earth safely. Having made a great impression on not only the Japanese public but also many other people around the world as well, this event is still fresh in the memory. It was so impressive that a film featuring this project was produced. Following on from this success, Hayabusa 2 was launched on December 3, 2014. Just one year later, on December 3, 2015, Hayabusa 2 used a method known as an Earth swing-by to change its path and accelerate towards its destination asteroid —called Ryugu— with the aim of bringing new results back to Earth. Japan's space research and development projects, including Hayabusa and Hayabusa 2, are supported by the Japan Aerospace Exploration Agency (JAXA). For this issue's "Executive Guest", Hisaharu Obinata, President and CEO of ULVAC, Inc., visited Dr. Hitoshi Kuninaka, a professor at the Department of Space Flight Systems, Institute of Space and Astronomical Science, JAXA (director of the Space Exploration Innovation Hub Center), who developed the ion engine, one of Hayabusa's core technologies, and asked him about his valuable experience with a focus on space research and development.

On June 13, 2010, the first Hayabusa returned to Earth in a blazing ball of fire (Courtesy of JAXA)

Introduction

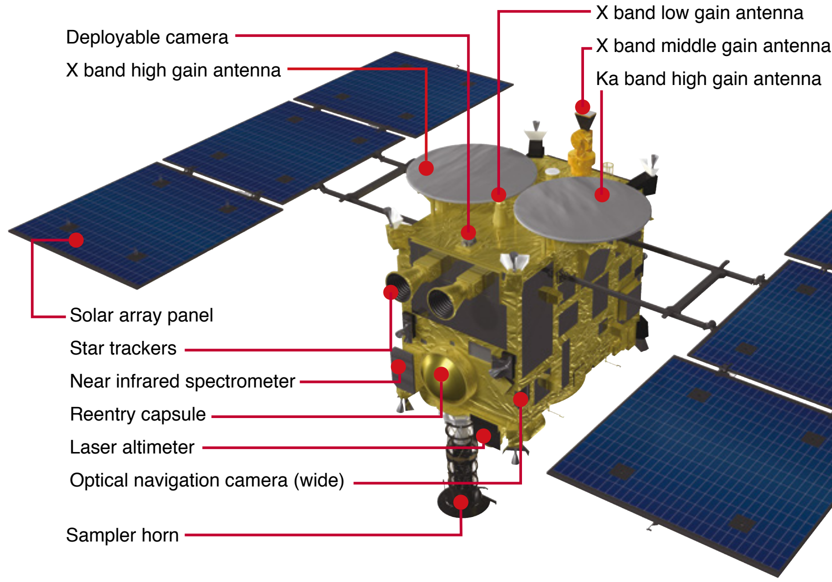
Planetary exploration technologies that employ an unmanned space probe have been developed in stages, as described below.

The first stage was the "fly-by," which involved the unmanned space probe observing a target celestial body while passing near to it. The second stage was the "rendezvous," which involved the probe approaching the target celestial body and observing it while adjusting speed and traveling along the same orbit as the target. The third stage was "landing," which involved the probe descending to the surface of the target celestial body to conduct observations. The most recent stage is the "sample return," which involves the probe bringing substances collected from the target celestial body back to Earth for analysis.

Hayabusa left a lasting impression on people around the world and attracted considerable attention by returning to Earth safely despite having to overcome a number of problems. In terms of its significance in the development of asteroid exploration technologies, it was the world's first explorer to successfully return a sample from a difficult to approach asteroid. It is said that the ion engine made a significant contribution to the Hayabusa's long journey through outer space and its eventual successful return to Earth.

Being able to return many samples from an asteroid, as Hayabusa succeeded in doing, fulfills the purpose of space research and development by helping to clarify the unknown —such as the origin of life, the structure of the universe, and the beginning of the solar system— and to get closer to learn about life, including humanity, and nature on Earth.

A return capsule containing minute particles collected from the Itokawa asteroid lands safely in Australia (Courtesy of JAXA)



Hayabusa 2 Viewed Obliquely from Above
(Courtesy of JAXA)

■ Table 1: Characteristics of the Ryugu and Itokawa Asteroids

	Ryugu	Itokawa
Date of discovery	May 10, 1999	September 26, 1998
Size and shape	Approx. 900 m in diameter; almost spherical	535 m × 294 m × 209 m; shaped like a sea otter
Rotation period	Approx. 7 hours and 38 minutes	Approx. 12 hours and 8 minutes
Orbital period	Approx. 1.3 years	Approx. 1.52 years
Orbital radius	Approx. 180 million km	Approx. 198 million km
Light reflectance	Approx. 0.05	0.25 on average
Color	Blackish	Gray (portions that have not suffered space weathering appear whiter than the surrounding portions)
Spectral type	C-type (it is presumed to contain water, organic substances and minerals)	S-type (minerals such as olivine, pyroxene, plagioclase, troilite, taenite, and chromite)

The Role of the Project Manager: To Encourage All Individual Project Members to Display Their Abilities to the Full and Make Decisions by the Deadline

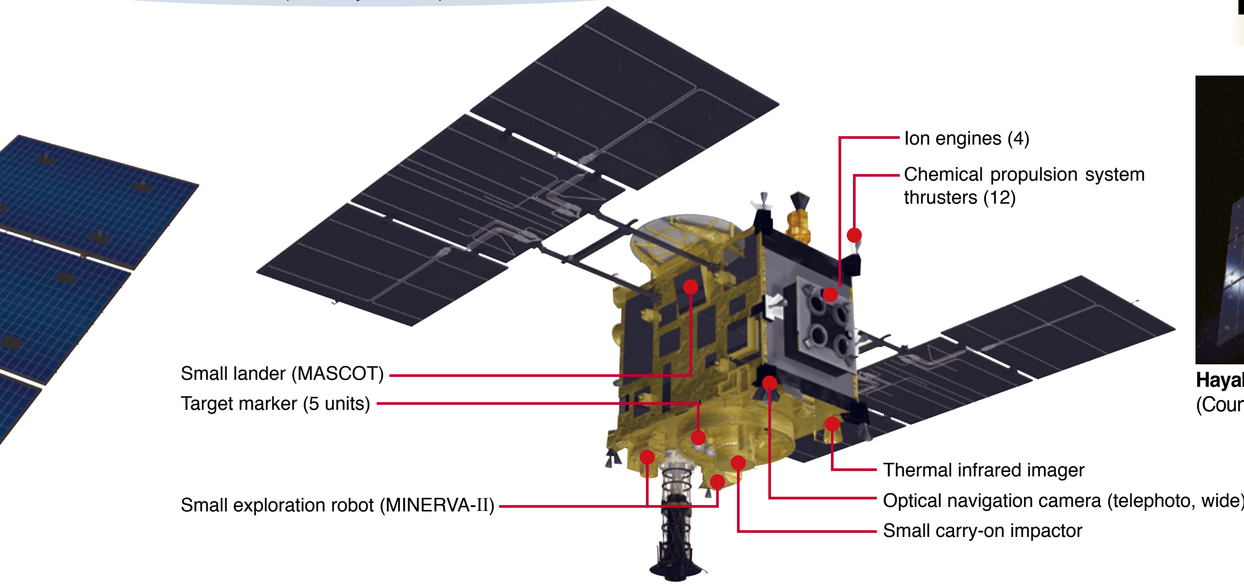
Obinata: The Hayabusa project brings together a wide range of specialized technologies. Since the project integrates such wide-ranging technologies, I imagine that many of them are not necessarily your specialty. Can you explain what you try to do when leading such a project team?

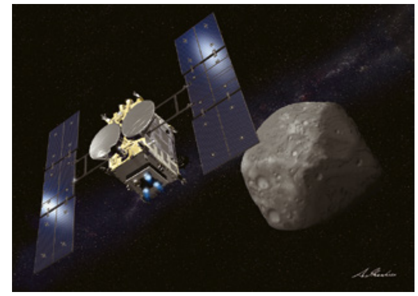
Kuninaka: It's true that there are many things I don't know (laugh).

What I try to do is to remind myself that first of all there are no supermen that are familiar with absolutely everything and that I am no superman myself. Given this, I tried to respect the judgment of those working at the project site as much as possible. I listened to their opinions in order to create an environment that would allow individual project members with specialized knowledge to display their abilities to the full.

Obinata: When I assumed the presidency of ULVAC, its employees were not very driven. Feeling the need to vitalize them, I strove to delegate authority in order to draw out their independence. I was extremely encouraged when I learnt that

Hayabusa 2 Viewed Obliquely from Below
(Courtesy of JAXA)





Hayabusa 2 approaching the Ryugu asteroid
(Courtesy of JAXA / Courtesy of Akihiro Ikeshita)

■ Table 2: Comparison of the Hayabusa 2 Asteroid Probe and the First Hayabusa Asteroid Probe

	Hayabusa 2	First Hayabusa
Dimensions of the main body without solar panels	1 m (width) × 1.6 m (length) × 1.25 m (height)	1 m (width) × 1.6 m (length) × 1.1 m (height)
Mass	Approx. 600 kg (including fuel)	510 kg (including fuel)
Date of launch	December 3, 2014	May 9, 2003
Carrier rocket	H-IIA rocket No. 26	M-V rocket No. 5
Communication frequency band	X band (7 to 8 GHz) Ka band (32 GHz)	X band (7 to 8 GHz)
Main exploration devices	Near infrared spectrometer, thermal infrared imager, optical navigation camera, laser altimeter, deployable camera, small carry-on impactor, sampler horn, MINERVA-II, and MASCOT	Near infrared spectrometer, fluorescent X-ray spectrometer, multiband, spectroscopic camera, laser altimeter, sampler horn, and MINERVA
Period of asteroid exploration	Approx. 18 months	Approx. 3 months
Collection of stone and sand	Twice on the surface and once below the surface	Twice on the surface
Return to Earth	November to December 2020 (scheduled)	June 13, 2010

your policy as the leader of this project was to draw out the abilities of individual members to the maximum extent possible.

By the way, project managers have to decide a lot of things in a short period of time, don't they?

Kuninaka: The duration of the Hayabusa 2 project was fixed, and its team members faced a mountain of tasks that needed to be completed at the climax of the project. Since nothing moved forward unless I made a decision, my job as the project manager was to make decisions quickly each day. This has something in common with corporate management. Corporate managers have to make decisions over a long period of time every time a problem arises. They have to examine all of the resources —including the time, personnel, and budget available— and all of the parameters closely, and then select the best of them.

In this project, however, the launch was scheduled for December 2014, so we had to create something acceptable by that deadline. Given this, we had to choose a maximum of one or two options from among the many candidates, put all of our resources into them, and solve any problems as inexpensively as possible in a short period of time. I could not place responsibility for the results on the project members, so I felt that my job was to make the final decision. In this sense, the job always put me in a tense situation.

Obinata: A company also employs many capable experts in fields such as accounting, finance, and development. If these experts are unsure what to do despite having considered the issue long and hard, the president should make the decision. In all other circumstances, I generally have no worries about leaving everything else to them.

I presume that it is extremely difficult for you to make a final decision on complicated issues if there are many stakeholders involved, and that this can put you in a difficult position.

Kuninaka: That's right. Since we had only three and half years before the rocket's launch for the Hayabusa 2 project, I had to make decisions on many things during that period. It proved difficult to obtain the budget we requested for the Hayabusa 2 project. In particular, we had a hard time because projects promoting science and technology faced difficulties in those days. In any event, we were not allowed to work slowly.

For the first Hayabusa project, I worked purely as an engineer, but for the Hayabusa 2 mission, I ended up taking on a managerial position.

Dr.**Hitoshi Kuninaka**

Professor at the Department of Space Flight Systems,
Institute of Space and Astronomical Science
Director of the Space Exploration Innovation Hub Center,
Japan Aerospace Exploration Agency (JAXA)

Born in 1960, Dr. Hitoshi Kuninaka graduated from Kyoto University in 1983 with a bachelor's degree in engineering. In 1988, he obtained his ph.D of Engineering from the University of Tokyo, and then went on to join the Institute of Space and Astronomical Science. In 2005, he became a professor at the Institute of Space and Astronomical Science. He also worked for the Department of Aeronautics and Astronautics, Graduate School of Engineering, University of Tokyo. In 2011, he became director of the JAXA Space Exploration Center, and in 2012, he was appointed program manager of the Hayabusa 2 project. In 2015, he took office as director of the Space Exploration Innovation Hub, a post that he holds to this day.

[Awards received]

2004 Technology Award for the microwave-discharge ion engine, Japan Society for Aeronautical and Space Sciences
2006 Space Pioneer Award to the Hayabusa Project Team, National Space Society
2007 Technology Award for the Hayabusa asteroid exploration mission, Japan Society for Aeronautical and Space Sciences
Best Paper Award for the paper on the ion engine, American Institute of Aeronautics and Astronautics
Best Paper Award for the paper on the ion engine, Electric Rocket Propulsion Society
2010 Electric Propulsion Outstanding Technical Achievement Award for the ion engine, American Institute of Aeronautics and Astronautics
58th Kikuchi-Kan Prize for the Hayabusa Project
Asahi Prize for the Hayabusa Project
Special Prize for the establishment of round-trip space technology in the Hayabusa asteroid mission, Minister of Education, Culture, Sports, Science and Technology
2011 Von Braun Award to the Hayabusa Project Team, National Space Society
Laurels for Team Achievement for the Hayabusa Project Team, International Academy of Astronautics
2012 Fellowship of the American Institute of Aeronautics and Astronautics
International SpaceOps Award for Outstanding Achievement to Hayabusa Operations Team, SpaceOps Organization
2013 Stuhlinger Medal, Electric Rocket Propulsion Society

Exploration of an S-type Asteroid by Hayabusa and a C-type Asteroid by Hayabusa 2

Obinata: The first Hayabusa targeted the Itokawa asteroid, while Hayabusa 2, which is currently still in outer space, is targeting the Ryugu asteroid. How did you decide on these targets?

Kuninaka: There are actually several types of asteroids. Those close to Earth are classified into two major categories: S-type asteroids and C-type asteroids. The "S" in "S-type" stands for "stone." These stony asteroids consist mainly of substances such as iron silicate and magnesium silicate. The "C" in "C-type" stands for "carbon," which also includes organic substances and water, so C-type asteroids are carbonaceous. The first Hayabusa was sent to Itokawa, an S-type asteroid, while the target of Hayabusa 2 is a C type asteroid.

The mission of the first Hayabusa was to prove whether Japan was capable of performing a round-trip asteroid exploration using only its own technology, so the target could be anything as long as it was an asteroid. Most of the asteroids that are easily accessible from Earth are of the S-type, so we selected an S-type one. The current mission, however, is to send a probe to a C-type asteroid. In fact, C-type asteroids that are close to and easily accessible from Earth are extremely rare, but one of these is called "Ryugu." The United States and the European Union are planning to reach other carbonaceous asteroids.

Obinata: When did you decide on the current target?

Kuninaka: The project was launched in 2011.

Saito: That was one year after the first Hayabusa returned to Earth, wasn't it?

Kuninaka: Yes. The work of finding new asteroids is also underway throughout the rest of the world, and if a new one is discovered, it is immediately analyzed to identify what type it is. At its own expense, JAXA has astronomical observatories observe asteroids that have just been discovered but have not yet been analyzed. For the current project, we started searching for C-type asteroids as long as ten years ago.

Following the Success of the First Hayabusa, Hayabusa 2 Has Attracted a Great Deal of Attention

Obinata: This type of project probably has a large budget, but in order to ensure the success of a project that involves a large number of people, it is important to set a goal or mission that is ambitious enough to unite them, isn't it?

Kuninaka: I think so. The target of the current project is extremely difficult to achieve and very challenging, but it's certainly an interesting mission that inspires everyone and makes people want to take part in it.

People in this field will already be aware of this, but it is important to get a place in the line for rocket launches. You cannot launch a satellite unless you have a place in the queue. This is a matter of great concern to us. If a problem occurs during development, the order of launches is adjusted. For the Hayabusa project, other missions said that they would be willing to give up their place for us —such was the appeal of the mission. Everyone knew that Hayabusa was an attractive project, but it was probably only Dr. Junichiro Kawaguchi, the then project manager, who envisaged that the project would succeed.

Since the first Hayabusa succeeded in returning to Earth in 2010 despite a number of twists and turns, the entire world has come to realize the objectives, significance, and value of asteroid explorations. The reason we succeeded in getting the Hayabusa 2 project underway in such a short period of time under these circumstances, despite facing a mountain of problems, was that the success of the first Hayabusa mission was shared among stakeholders in Japan and the rest of the world. This eliminated the need to explain the objectives and other details of the project, which spared us a great deal of trouble.

Obinata: The success of the Hayabusa mission was a particularly impressive achievement. But given the considerable reputation acquired by the first Hayabusa, wasn't it all the more difficult to handle the Hayabusa 2 project because people had such great expectations for it?

Kuninaka: I'm exaggerating a little, but it is true that we did become the focus of public attention when we carried out the project (laugh). We felt as if our every move was being carefully watched by the public.

Obinata: Since this is a matter of concern to the general public as well, the entire nation is watching you closely. But when I visited some of your research and development facilities and offices a while ago, it was clear that the project members were not enjoying any luxuries (laugh).

Kuninaka: The Space Simulation Chamber was especially built to be used in the durability tests for the first Hayabusa's ion engine. It was constructed within one or two years, but we had visited ion engine research institutes throughout the world during the preceding decade in order to observe chambers made specifically for conducting ion engine durability tests. We prepared so carefully that we were able to build JAXA's Space Simulation Chamber quickly. In case you didn't know, the cryopump we use to create an ultra-high vacuum is manufactured by ULVAC.

Obinata: Yes, I found that out at the laboratory a short while ago. Thank you very much for using our product (laugh).

The Space Simulation Chamber Helped Facilitate Durability Tests for the Ion Engine

Saito: When someone mentions outer space, we tend to think of an ultra-low temperature, a dark expanse of space or an extremely harsh expanse of space with powerful solar radiation. How do you cope with the heat balance required to ensure that satellites work in the harsh environment of space?

Kuninaka: Heat management in space is extremely difficult. In a satellite, heat is transported via heat pipes, thermal conduction, and the like, but in the end, all of the heat is converted into infrared rays and released throughout a large area. The service life of semiconductors and other electronic components will be shortened if their temperature rises, and they will break if it rises too high. The higher the temperature becomes, the easier it is to discharge heat because, according to the Stefan-Boltzmann law, heat is released in proportion to the fourth power of the absolute temperature. Fortunately, the ion engine uses practically no electronic components, so there are few problems if it is operated at high temperature. However, the engine uses a magnet that is resistant to high temperatures so that it will not fail under such conditions.

JAXA Sagamihara Campus (Courtesy of JAXA)

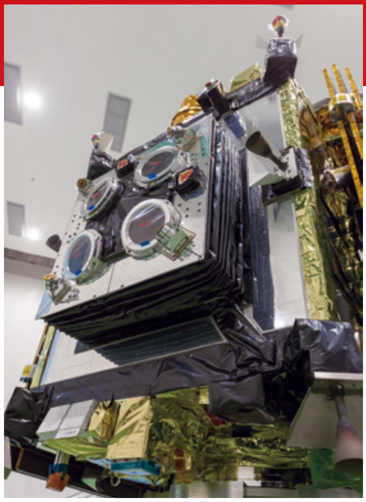
Overview (as of April 1, 2015)

Japan Aerospace Exploration Agency, a national research and development agency

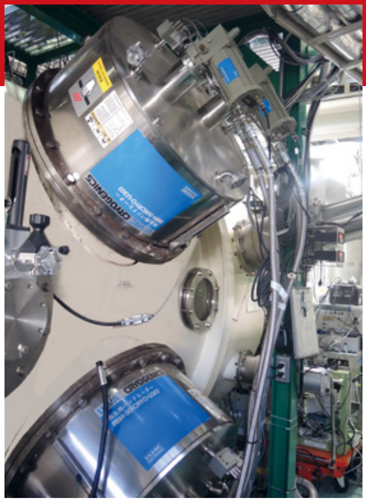
Location: 44-1, Jindaiji Higashimachi 7-chome, Chofu-shi, Tokyo
Established: October 1, 2003
Budget: ¥154.1 billion
Number of employees: 1,527 (as of April 1, 2015)
President: Naoki Okumura
Predecessors:
Institute of Space and Astronautical Science (ISAS)
National Aerospace Laboratory of Japan (NAL)
National Space Development Agency of Japan (NASDA)
Major bases:
Chofu (head office), Sagamihara (campus), Tsukuba, Tanegashima, and Kakuda (space centers), etc.
Profile:
The Japan Aerospace Exploration Agency (JAXA) is a national research and development agency that is responsible for Japan's aerospace development policy. Supervised jointly by the Cabinet Office, the Ministry of Internal Affairs and Communications, the Ministry of Education, Culture, Sports, Science and Technology, and the Ministry of Economy, Trade and Industry, JAXA is the largest of all Japan's national research and development agencies. It was formed in October 1, 2003 by combining the following organizations: t Institute of Space and Astronautical Science (ISAS); the National Aerospace Laboratory of Japan (NAL); and a the National Space Development Agency of Japan (NASDA). Its head office is located in Chofu City, Tokyo, where NAL was formerly situated.

Saito: At ULVAC, we use microwaves when we process something in a vacuum, but unlike with satellites, we do not operate machinery in a vacuum continuously for days or years. For your satellite, didn't you have great difficulty in terms of ensuring durability?

Kuninaka: Well, we conducted thorough durability tests for the first Hayabusa. The chamber was actually installed for that purpose. We conducted two-year durability tests twice. We continued the trial operation of the chamber except when its operation was suspended for maintenance. We spent about five years conducting durability tests, so we were able to observe the chamber's true capabilities. Our project is special; we develop the ideas ourselves, produce the prototypes ourselves, deliver them to ourselves, and use them ourselves. Manufacturers like ULVAC design and manufacture products that are subsequently used not by themselves but by the customer, so your responsibility is greater. Since we completed 20,000 hours of durability



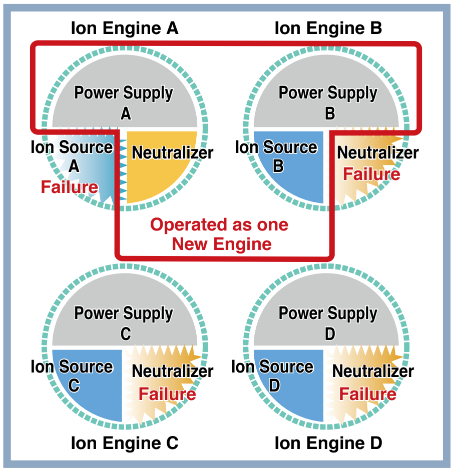
The four circular portions are ion engines (Courtesy of JAXA)



The cryopump incorporated in the space chamber, which played an important role in the durability tests (manufactured by ULVAC CRYOGENICS INCORPORATED)

A Cross-Networked Circuitry in the Ion Engines Helped Hayabusa Return to Earth.

An ion engine consists of three components: a power supply, an ion source, and a neutralizer.



As seen in the figure on the left, the cross operation combines the three undamaged components of ion engines A and B to enable them to operate as a new engine. As a result, the first Hayabusa was able to successfully return to Earth.

tests, we believe that we have created something that is more or less acceptable. We have satisfied ourselves that sufficient durability tests have been conducted. If you don't have confidence in your products, you cannot deliver them to your customers, can you?

Leading Hayabusa to Success by Leveraging a Uniquely Japanese Approach That Differs from That Employed by the United States

Obinata: Despite so many durability tests having been conducted, the first Hayabusa met with an unexpected accident when it landed on Itokawa. When we design equipment, we do everything possible to ensure success by taking additional measures in case the original idea fails. But this can make things overly complicated, thereby causing further problems. With limited weight and limited space in the Hayabusa project, you took various measures to prepare for unexpected events, didn't you?
Kuninaka: Since a satellite does not carry humans, we employ a design method that will enable it to cope with one failure. For example, if we have 100 items, we devise countermeasures on the assumption that one of them will suffer a failure (defect). If we assume that two failures will occur, we have to envisage 100 × 99 = 9,900 cases, and there is no way we can cope with such a large number of cases. The basic policy for space technologies used in unmanned spacecraft is for them to be able to cope with one failure. A policy known as "three inhibits" is used for manned spacecrafts. It aims to solve all possible problems by taking three measures. Therefore, different approaches are taken for manned and unmanned missions. Since it is an unmanned explorer, Hayabusa is operated using three ion engines with another installed as a backup on the assumption that one failure may occur.
Obinata: So that's why Hayabusa has four ion engines.
Kuninaka: Such sizing is an important issue that requires engineering insight. For example, if we are to structure the propulsion system for a satellite using one engine, we have to carry 200% because we need one more engine as a backup. If we cover the required propulsion with three engines, we need to carry only 133% in total even if a backup engine is added. The result is a lighter, smaller satellite. For this reason, how the satellite is sized is an important matter that requires engineering insight. Setting a satellite to a small size reduces the scale of the ground tests, allowing us to manage with a relatively small chamber.

At that time, the United States emerged as a rival by attempting to conduct space exploration using an ion engine. Starting later, the Americans were able to complete in just three years what it took Japan five to six years to achieve, and their launch took place earlier than the Japanese one did. We got angry (laugh).

Since American-built ion engines are large, their artificial satellites are equipped with only one. In Japan, we covered the propulsion needs with four small engines. In terms of scale, American-built ion engines are unquestionably superior, but we felt that we could use a different approach to that used by the Americans because we had as many as four engines. The ion engine works with a set made up of an ion source and a neutralizer. Since the Japanese satellite has four engines —each of which carries such a set— we firmly believed that ours would be superior because each of the neutralizers could be combined with other engines.
Obinata: That was what you refer to as a "cross-networked circuitry in the ion engine," which was a great achievement that led to the first Hayabusa being successful in the end.
Kuninaka: Such an innovative idea came about precisely because the United States emerged as our rival, prompting us to work harder.

Developing Highly Reliable Data Through Repeated Simulations

Obinata: At ULVAC, I always tell our developers that they must perform simulations properly in the design stage without fail when they develop new products. In the case of Hayabusa, engineers had to employ a combination of many specialized technologies, so the number of simulations that had to be performed was enormous. I imagine you had to make effective use of data obtained from many areas. How did you get on?
Kuninaka: The techniques used to build satellites have been

established to a certain extent, and they are assembled in stages. At first, fairly broad specifications are given, and as the detailed design progresses, various profiles become more real. Something real and concrete —rather than ambiguous figures— emerges. This process is repeated so as to put together the whole picture of the satellite.

Obinata: At our company, too, an unexpected result is sometimes obtained as we proceed with development, and this forces us to make a decision based on that result. What is important is to clarify whether such an outcome was obtained as a result of our best efforts. The reason is that the results of half measures may be meaningless.

Kuninaka: That's right. We have some students, and I check the results of their research every week. Some results include some very dubious figures, but I encourage them to develop more reliable data by letting them repeat the experiment several times while I offer them some ideas.

Evolving the Ion Engine Further by Rejuvenating the Research Teams

Saito: In the first Hayabusa project, you performed exhaustive durability tests for the ion engines and incorporated Japan's own unique ideas into them. Did you make any new attempts or introduce any new initiatives for Hayabusa 2?

Kuninaka: We were able to obtain a clear understanding of various space phenomena through our first ion engines and get various data through field activities. Based on these results, we decided that we wanted to create much better engines. I also made that a research assignment for our students.

Rejuvenating the research staff is another important issue that needs to be addressed. Since, just like other researchers, I am getting older, I want to rejuvenate the research organization. Even though we would like to hire young researchers, JAXA's budget is tight, so we have to make the most of external funds from NEDO and other organizations to recruit research personnel. Furthermore, since that was still not enough, we also encouraged companies that were willing to manufacture ion engines. This is also part of our indirect efforts to strengthen our human resources. At the same time, since it is a waste of resources to make such companies operate only in the Japanese market, we travelled overseas with their personnel to conduct sales activities.

Obinata: Are ion engines used in commercial rockets?

Kuninaka: American ion engines are used in commercial rockets, but the microwave-discharge iron engine I developed hasn't been yet. My ambition is to have it mounted on geostationary satellites. That would generate a large volume of sales. If it is used for commercial satellites, it will be mass-produced.

Hayabusa 2's Ion Engine Applies the Lessons Learned from the First Hayabusa

Kuninaka: In the past, there were three space-related organizations in Japan —the National Space Development Agency of Japan (NASDA), the Institute of Space and Astronautical Science (ISAS), and the National Aerospace Laboratory of Japan (NAL)— but these were all integrated to form JAXA in 2003. I was affiliated with ISAS, which worked on scientific satellites only, not commercial ones. Since NASDA developed many commercial satellites, I envied the organization, thinking that if I was working there, many of the ion engines I had developed would be used. In 2003, the three organizations were combined to form JAXA, which resulted in my field of activity expanding suddenly about 100 fold. The reorganization of the three organizations into JAXA was really beneficial to me.

Hisaharu Obinata,
President and CEO,
ULVAC, Inc.

Kazuya Saito,
Executive Officer and Manager of the Research & Development Planning Department, ULVAC, Inc.

Saito: Doesn't that also mean that you became the manager of the Hayabusa 2 project, and that such a change in position allowed you to look at things in new ways?

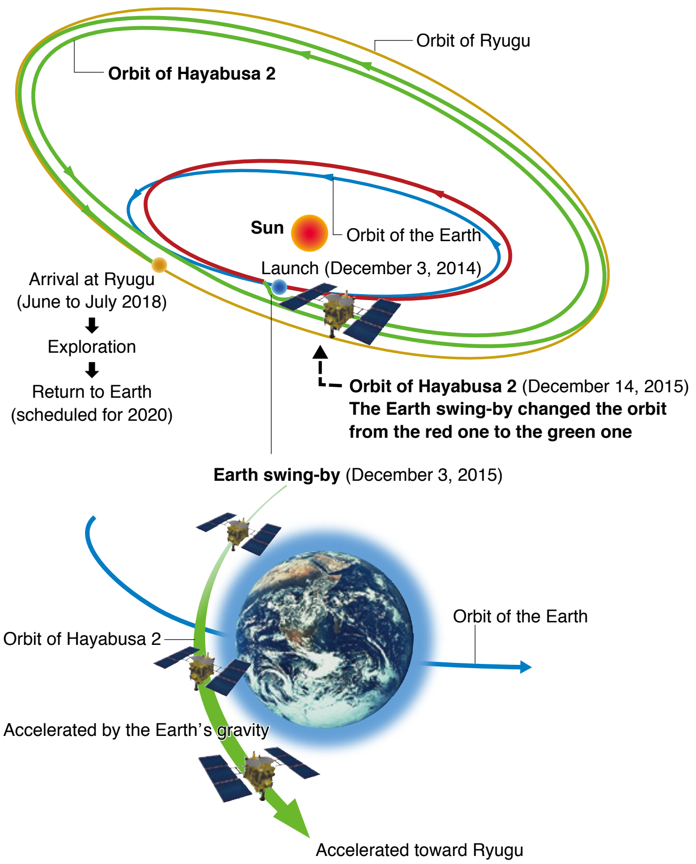
Kuninaka: The challenge we face for the Hayabusa 2 project is the number of things we can concentrate on creating in a short period of time. The situation forced me to make decision after decision after decision. It was a rather restricted life (laugh).

On reflection, the ion engines used on the first Hayabusa were not perfect. If they had been perfect, we would have been able to make advance preparations more easily, but since the explorer's return —which had initially been scheduled for June 2006— was postponed to 2010, we were concerned about whether the postponement might affect the project or not. We took several measures based on such assumptions, but we still didn't know whether these measures would really work. The delay meant that more tasks were assigned to the ion engines. Attitude control, which was originally performed without using the ion engines, now had to be performed using the engines, and this forced Hayabusa to employ a cross-networked circuitry in the ion engine in order to return to Earth.

We had tried employing a cross-networked circuitry in the ion engine using an experimental model, but we had not done so using an actual model to confirm whether it worked.

Obinata: In various kinds of development competition scenarios, even if our competitor clearly exceeds us, we still

■ Overview of a Swing-by Using the Earth's Gravity



■ Positional relationship between Hayabusa 2 and the Earth at the time of the swing-by

rack our brains to try and develop something that will rival or surpass them. That was how you developed the idea of a cross-networked circuitry in the ion engine, wasn't it?

Kuninaka: I also think it's important to work hard together —after all, the grass is always greener on the other side of the fence. Inferiority does, in a sense, provide us with opportunities to develop such new technologies. When we announced that we would use a microwave-discharge ion engine for the first Hayabusa, overseas researchers said that we would never be able to do so. Even lecturers at Japanese universities said the same. It may sound a bit paradoxical, but if saying "You can if you try" is a form of positive encouragement, then saying "There is no way you can" is a form of negative encouragement. If you use negative encouragement in a clever way, employ the feeling of vexation as a springboard, and do your best, you will be able to achieve what you previously considered to be impossible.

Hayabusa 2 was based on the obstacles that the first Hayabusa overcame, so as the December 2014 launch approached, we proceeded with its development with plenty of confidence. Since this is also a science and technology project, however, we can't be sure that we will be able to find solutions in real time. The only thing we can do is to apply the best scientific and technological knowledge that is available at the time. New knowledge may emerge five or ten years later that makes us realize that the decisions we made five or ten years before were wrong. This often occurs in the field of science and technology, and it is unavoidable. The reason for this is that what we were trying to clarify was beyond human knowledge at the time.

Demonstrating to Young Children How Attractive Space Development is While Giving Them a Glimpse of the Future

Obinata: Recently, ULVAC established the new Future Technology Research Laboratory (for details, see pages 18 and 19 of this magazine). Our aim is to consider what we will, or should be able to, achieve in 10 to 20 years' time and to identify now what will sustain our future growth. I'm sure you're developing various visions based on a close look at what things will be like in 10 or 20 years from now, but what inspires you to envision what will be needed in the future?

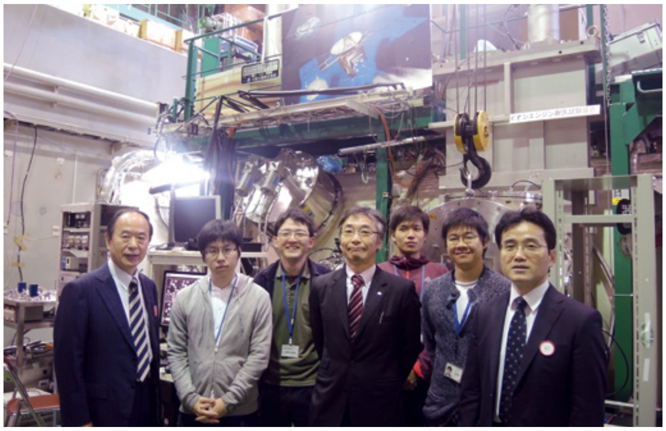
Kuninaka: It comes from considering what I will be doing in my job in the immediate future or in 3, 5, or 10 years from now. What inspires me is that this process may take 20 years or it may be realized very quickly. In addition to research and development, my job includes education in the form of instructing postgraduate students. I am constantly thinking about what research assignments I should give to new students, and I always come up with such assignments —including a more in-depth study of technologies that are close at hand— from flashes of inspiration and ideas that spring to mind.

Obinata: What kind of environment should persons in higher positions try to provide, or what should they do, to encourage engineers to have flashes of inspiration?

Kuninaka: They should give them opportunities to envisage what technologies should be available in the future. Everybody is probably very busy, so if you are told by your superior to do a particular job, you will think only about that job at all times because you are required to deliver results within one or two weeks. Of course, their immediate jobs need to be done, but what is important is to encourage your subordinates to think and envision what things will be like in 10 to 20 years' time.

Space projects must be implemented over a long period of 10 to 20 years. I often have the opportunity to give lectures to children, who may go on to become researchers themselves in the future. On such occasions, I always use a chronological table as a visual aid to show what JAXA currently plans to achieve in its space development projects within the next 10, 20, or 30 years. Junior high school students and high school students will graduate from university and find a job 10 years from now, and 10 years after that, they will be working at the frontline of their organizations. At that time, the space development projects that I explain will be underway, so they should develop their talents in order to be able to contribute to such projects. If they are interested in space development, they should start to prepare themselves now.

I always speak to children in this way in order to inspire them.



With the Space Chamber in the background, Dr. Kuninaka (center) poses for a group photo with students involved in the development of ion engines.

Obinata: I see. The idea is to encourage young engineers to come up with ideas on their own initiative by showing them what space development will be like 10 or 20 years from now.

Creating New Technologies Jointly with Private Enterprises with Outer Space as the Keyword

Saito: Having served as manager of the Hayabusa 2 project, what exactly are you doing now?

Kuninaka: We recently established a new department called the Space Exploration Innovation Hub Center, and I am working there with the support of the Japan Science and Technology Agency. I am chiefly in charge of joint technology research and development projects with private enterprises. Our primary objective is to promote technological developments that will contribute to the commercial activities of private enterprises. Since this is part of JAXA's business, we do, of course, select technologies that can be used in space when we undertake joint development.

Saito: You must have trouble making arrangements for technology development.

Kuninaka: We have to find projects that will serve the purpose of the business. Fortunately, I believe that JAXA is delivering satisfactory results as a national research and development agency. The government's intention is that JAXA should share with private enterprises the schemes, expertise, knowledge, and equipment that it has developed through its space development projects.

A few decades ago, innovations often occurred, which resulted in things changing rapidly. Today, however, research and development has reached a saturation point worldwide in that we have an environment that prevents new innovations from being created easily. Old customs and inflexible ways of thinking do not lead to the creation of new innovations. Conversely, new ideas may emerge if we ask private enterprises to come up with something new using outer space as the keyword. If we think in this way, some unconventional ideas may emerge that can be used effectively in business. This is what is meant by JAXA's call for the joint idea development that I described earlier.

Obinata: If we develop new ideas in earnest by linking our business with space projects, JAXA may be able to make use of them.

Kuninaka: I sincerely hope that you will propose something new to the Space Exploration Innovation Hub Center. If you propose something that is suitable for your business model and it meets JAXA's vision for the future of space development, it will certainly be used.

Saito: Satellites float in the vacuum of space, but ULVAC provides a variety of technologies by creating vacuums on Earth. We do not have any specific ideas at the moment, but we would certainly like to submit some proposals to JAXA in the future.

Our Next Vision: Using Jupiter's Gravity to Explore Planets Farther Away

Obinata: Finally, can you tell us about your vision for the future?

Kuninaka: Given that I am involved in space development, my next target is Jupiter. The gravity of Jupiter is strong because it is the largest planet in the solar system, which would allow us to use a maneuver known as a "gravity assist" or a "Jupiter swing-by." The United States has sent Voyager and other explorers to Saturn and Pluto, but when they send probes beyond Jupiter, the probes always travel via Jupiter to make use of its gravity to achieve a stronger swing-by. If explorers are launched to go farther out into the solar system, they always need to go via Jupiter. Being able to reach Jupiter using Japanese technologies would provide us with opportunities to go beyond it. Developing routes to Jupiter independently will open up the way to going farther afield, in much the same way as European navigators discovering the Cape of Good Hope did during the Age of Discovery.

Obinata: If so, you will need ion engines with an even higher level of performance, won't you?

Kuninaka: We will have to create more fuel-efficient ion engines. We have already started research and development into this. In addition to ion engines, we are steadily preparing new technologies that will allow us to reach Jupiter.

Obinata: How many years will it take before such technologies are available?

Kuninaka: That will depend on whether a budget is appropriated for this project, but we would like to realize them in the 2020s.

Obinata: It would be absolutely wonderful if the return of Hayabusa 2 and the launch of the next Jupiter mission would coincide with the Tokyo Olympics and Paralympics.

Kuninaka: I will have retired by then (laugh). I am currently interested in how I can interest young children in space projects. That is another job of mine. For space projects, successors cannot be produced unless their development starts during their childhood.

Obinata: That is truly a cosmic vision full of dreams, isn't it? I sincerely hope that you will enjoy great success as you aim to reach Jupiter. Thank you for taking the time to talk to us today.