



The Perfect Return that Sent the *Hayabusa2* Control Room into a Frenzy: The secret to scoring “10,000 points out of a perfect 100” is to predict the difficulties and to be prepared with three options

Tsuda Yuichi, Professor at the Institute of Space and Astronautical Science (ISAS),
the Japan Aerospace Exploration Agency (JAXA)

Interview and text by Yamane Kazuma, nonfiction writer



Artistic illustration of the departure of *Hayabusa2*
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On a visit to the Institute of Space and Astronautical Science (ISAS) and the Japan Aerospace Exploration Agency (JAXA) in Sagami City, Kanagawa Prefecture on December 18, 2020, Hagiuda Koichi, Minister of Education, Culture, Sports, Science and Technology, announced some good news at the press conference.

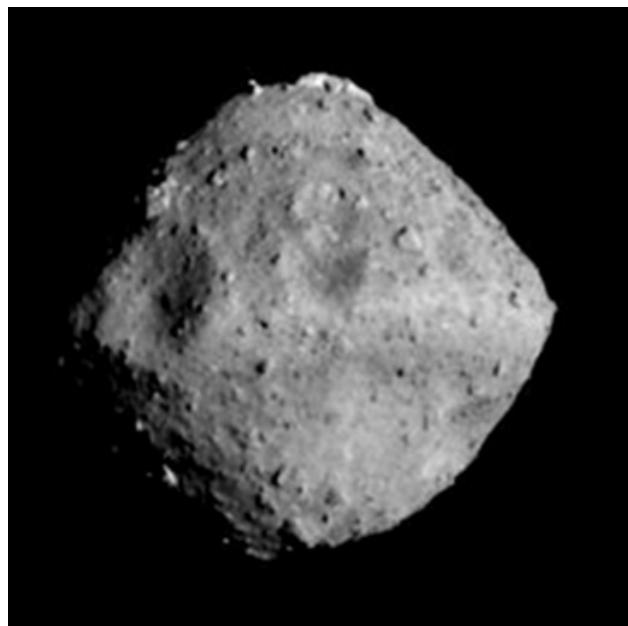
“The capsule brought back by *Hayabusa2* contains approximately 5.4 grams of soil samples collected from the asteroid Ryugu. This world-class technology has collected an amount that is fifty times above the target of 0.1 gram.”

The first-generation *Hayabusa* was the first time since the moon landings for humanity to achieve the spectacular feat of bringing back a sample from a celestial body, but that sample was no more than three tenths of a millimeter. Even so, planetary scientists produced major research results. For that reason alone, scientists are comparing these new samples, which weigh a little less than six one-yen coins (one gram each), to a dump truck full of rocks.

Hayabusa2 collected the samples from the asteroid Ryugu, which is only about 900 meters in diameter and shaped like an abacus bead. Ryugu is a C-type asteroid composed of rock that contains the carbon compounds that are essential for life. If we could collect soil samples, the expectation is that the analysis would throw light not only on the birth of the solar system, but also on the origin of life. Work to return a sample from a C-type asteroid had been gaining momentum since the first-generation craft was launched in 2003. However, as the development schedule of the first-generation craft was pushed back, the target asteroid changed and finally an S-type asteroid with silicon compounds was selected which was technically easier to reach. At that time, the project team planned to aim for a C-type asteroid after the S-type. *Hayabusa2* was thus developed to fly to a C-type asteroid from the beginning. Seventeen years after the first-generation craft, *Hayabusa2* has now achieved this long-cherished goal. I asked the *Hayabusa2* project manager, Tsuda Yuichi (45), about the six-year mission and how he is coming to grips with the great achievement.



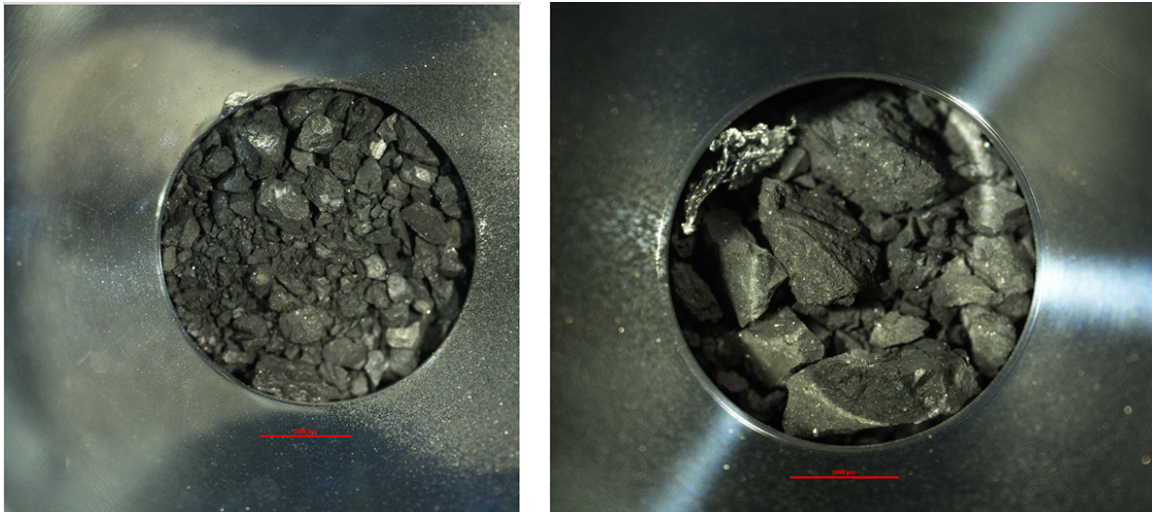
Launch of *Hayabusa2* / H-IIA F26 from the JAXA Tanegashima Space Center in Kagoshima Prefecture on December 3, 2014
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Photograph of Asteroid Ryugu taken by ONC-W1 on June 24, 2018 at around 15:00 JST.
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Yamane Kazuma: The 5.4 grams of soil samples are simply astonishing.

Tsuda Yuichi: On December 14, 2020, we confirmed a powdery black substance inside the container in the capsule, which was enough to send the project team into a joyful frenzy. The next day, I saw the images taken by the sample analysis team and I felt a strong emotion welling up inside me. In terms of the engineering, the technology was developed with the aim of collecting 0.1 gram, so I had not expected too much more, but I felt like shouting from the rooftops that we had won a contest that had gone on for a decade.



Optical microscope images of Room A (left) and C inside the container in the capsule
© JAXA

Yamane: Has there been a strong reaction from the rest of the world?

Tsuda: *Hayabusa2* delivered the [MASCOT](#) (Mobile Asteroid Surface Scout) lander, a small exploration robot jointly developed by the German Aerospace Center and the French National Center for Space Studies, to Ryugu. We heard from their team that we had written a key page in space history. One of the overseas *Hayabusa2* scientists congratulated us by joking that 5.4 grams is far too much and should they pick it up for us.

Yamane: I have interviewed scientists at several research centers in Japan who are waiting for the samples from Ryugu. Planetary scientists are probably dazed with joy thinking the research will not end in their lifetime.

The Red Shooting Star with Perfect Timing

Launched from the JAXA Tanegashima Space Center in Kagoshima Prefecture on December 3, 2014, *Hayabusa2* spent 505 days hovering close to the asteroid Ryugu (rendezvous navigation), which orbits the sun like the Earth does, and continued to perform a number of firsts for humankind. Then, shortly before 3 a.m. on December 6, 2020, the capsule, which had separated from *Hayabusa2*, landed in the Woomera Desert in South Australia (Woomera Prohibited Area) carrying the samples from the asteroid.



The Hayabusa2 fireball seen from the Northernmost station of the Direction Finding System (DFS)
© JAXA

Yamane: How did you feel when the capsule landed on December 6th?

Tsuda: I was in the control room at ISAS listening to reports from the local area and it was thrilling. I was so happy to see the fireball when the capsule heated up due to the friction as it reentered the atmosphere like a red shooting star in the sky. There wasn't even one second between the calculations and the appearance of the fireball. That fireball really proved that our project team was flying correctly. When the capsule had descended to an altitude of ten kilometers, we caught the radio wave beacon signal sent from the capsule to inform us of its position, and the moment I heard a loud voice saying "Beacon signal confirmed!" I couldn't stay still any longer.



Container collection work at the Woomera Desert in South Australia (Woomera Prohibited Area)
© JAXA

Yamane: The electronic equipment in the capsule worked well, even though it had been on standby for six years since the launch.

Tsuda: It is the first mechanism to function after disconnecting from the asteroid explorer. There are engineers on the project team who have worked exclusively on switching on the electronic equipment and making sure it works six years after its launch. They looked really happy too.

Because of the COVID-19 countermeasures, the local capsule collection team quarantined for one week in Japan and then they spent two weeks in Australian hotel quarantine before going on standby in the desert, but they achieved the goal brilliantly. I am deeply grateful to them.

Separating the Capsule Is Like Curling

Yamane: Twelve hours before landing, the capsule separated from *Hayabusa2* at a distance of 220,000 km, which is more than half the distance between the Earth and the Moon. After the separation, the capsule landed squarely on target in the Woomera Desert without a single orbit correction. How is it possible to perform such miracles?

Tsuda: That's what is so interesting about orbital mechanics which I have been working on for a long time. The first point is how to find out the precise orbit of *Hayabusa2* in advance. The second point is how to bring the asteroid explorer closer to the Earth at high speed. Minister Hagiuda asked me the same question, and I explained that it's similar to curling. In curling, the player slides with the curling stone, adjusts the initial velocity, aims, and gently releases the stone. The asteroid explorer also hurtles towards the target at super high speeds. In other words, it is important to perform orbit correction before separation, rather than at the time of separation or after separation.

The first orbit correction was on September 17 when the asteroid explorer used its ion engine propulsion to aim for the landing area from a distance of 36 million kilometers (94 times the distance between the Earth and the Moon). The fourth and final orbit correction was done five days ago at a position that is 4.5 times the distance to the moon. I had full confidence in the result of the final orbit correction, so at a point 220,000 km from the earth, we triggered a small explosive device to separate the capsule and gently released it. It felt really good to be able to separate the capsule as calculated.

Yamane: It's the ultimate pleasure that ordinary people will never experience. (Laughs) In addition to the experts at JAXA, engineers at Fujitsu and NEC also contributed a great deal to the orbit.

Tsuda: We felt a strong connection with the corporate members. They were not just contractors, but project team members. The NEC and Fujitsu engineers calculated the orbit during the night based on data obtained from *Hayabusa2* in the daytime, and the next day, they sent orbit commands to *Hayabusa2*, so we felt as if we were all in it together. They are true professionals, and even if they don't have the time, they will rework the answers until they are confident about the accuracy. The JAXA team also did their own orbital calculations, so there was some fierce and fun competition with the corporate team. Many corporate staff from other companies than these two also participated. It is impossible to pay them enough respect for their spirit of professionalism and seriousness about the technology.

My Daughter Was Called to the Principal's Office

Tsuda was born in Hiroshima Prefecture in 1975, but he grew up in Sagami City in Kanagawa Prefecture where the Institute of Space and Astronautical Science (ISAS) is located. At the time of the launch of *Hayabusa2*, he was associate professor of the Department of Space Flight Systems, ISAS. In 2015, the year after the launch, he was appointed project manager.

ISAS was established in 1955 by the father of Japanese rockets, Dr. Itokawa Hideo (1912–1999), professor at the Institute of Industrial Science, the University of Tokyo. In 1970, a mere fifteen years after the inauguration, ISAS successfully launched *Osumi*, Japan's first and the world's fourth artificial satellite. Coincidentally, 2020 marked the fiftieth anniversary of that launch.

After enrolling at the University of Tokyo, Tsuda studied space technology and satellite engineering under Professor [Nakasuka Shinichi](#), known as the god of small satellites, at the graduate school of the university. Incidentally, Professor Nakasuka sent a congratulatory message to Tsuda saying, "Well done. I can't think what else to say." After obtaining a doctoral degree in 2003, Tsuda joined ISAS after the launch of the first-generation *Hayabusa* craft in the same year.

When Tsuda was in graduate school, he met and married a woman of his own age through an acquaintance. His wife teaches flower arrangement and they have a girl in the first year of junior high, another girl in the second year of elementary school, and a boy in the second year of kindergarten, so he is Dad to three children.



Professor Tsuda Yuichi (center) with members of his laboratory
© JAXA

Yamane: What did your wife say about the success of *Hayabusa2*?

Tsuda: Just the ordinary “Congratulations.”

Yamane: That’s it?

Tsuda: Yes, it’s a bit casual, isn’t it? (Laughs) I was away from home a lot and she understood that I was doing my best, but I never had the time to talk about it in any detail. When the first touchdown didn’t go as planned and the long delays made me feel cornered, I couldn’t sleep even when I got home, or I would dream about the touchdown location. But I held it all in because I couldn’t talk about such troubles at home. My wife never asked me anything in detail, but she would make something a little special for dinner. (Laughs)

Yamane: What about your children?

Tsuda: They are very happy for me. My eldest daughter was unexpectedly called to the principal’s office at her junior high school. She was nervous and thought she might get yelled at, but when she got to the principal’s office, he said, “Your father is doing a great job.” She was a little dissatisfied because the praise was for her father not for her. (Laughs) I signed one of my books and gave it to the principal.

Touchdown Was the Biggest Difficulty

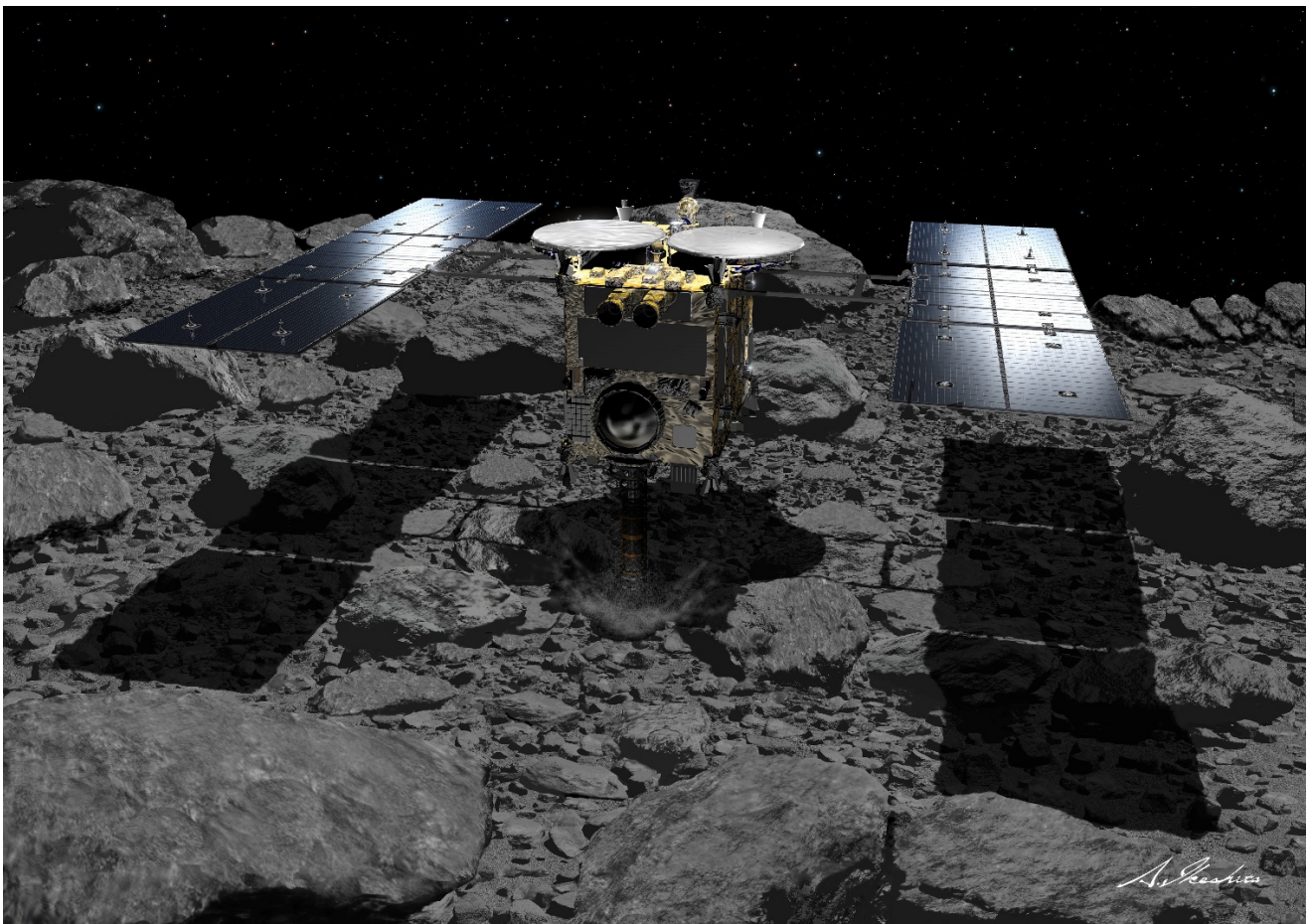


Image of the *Hayabusa2* touchdown
© Akihiro Ikeshita/JAXA

Yamane: What was the toughest part of operating *Hayabusa2* for about 2,000 days?

Tsuda: The first touchdown on February 22, 2019. The first-generation craft was dogged by a lot of difficulties, so with *Hayabusa2*, we felt the pressure to execute a perfect touchdown based on that valuable experience. It was extremely difficult.

Touchdown means that the asteroid explorer descends gently and ascends as soon as the sample mechanism at the bottom of the asteroid explorer comes into contact with the surface of the asteroid. The sample mechanism is called the sampler horn. It is one meter long, twenty centimeters in diameter, and shaped like a large clarinet.

The tip of the sampler horn touches the surface of the asteroid for a few seconds. At that moment, a small projectile (5 grams of tantalum metal) is discharged from inside the cylinder. The impact causes the soil on the surface to be blown into the clarinet where a sample is caught in the upper area and moved to the capsule for storage. Since the asteroid is an extremely small celestial body, it has almost no gravitational force, so even a small impact blows soil samples to the top of the cylinder.

Hayabusa2 arrived at the asteroid Ryugu on June 27, 2018. By October 2018, the No. 1 rover of MINERVA II (Micro-Nano Experimental Robot Vehicle for Asteroid) and the German-French exploration robot MASCOT were successfully separated and sent to the asteroid. On October 25th, a target marker was successfully landed near the planned touchdown point.

A target marker is a ball with a diameter of ten centimeters (the craft is equipped with five balls) wrapped in a light-reflecting sheet. Since there are no markers on the surface of the asteroid, the asteroid explorer continues to make minute adjustment to its position while looking at the position of the target marker through the camera lens as it quietly and precisely descends at a speed of several tens of centimeters per second and moves toward the target point. This light-reflecting ball was invented and used for the first-generation craft.

This should have been all the preparation for the descent, but it took another four months before the first touchdown.

Tsuda: We examined the location of the touchdown by looking at thousands of images of Ryugu taken by *Hayabusa2*. However, it turned out to be extremely difficult to choose a suitable place for a safe descent because the surface is full of rugged rocks. *Hayabusa2* is about six meters wide with large solar panels covering both wings. If the edge of a wing hits a rock, the wing will snap and the mission ends then and there.

Yamane: The place you chose was only six square meters, about the same size as a 1DK apartment. Considering the width of the asteroid explorer, it seems like an unbelievably close shave.

Tsuda: It should have been possible to determine a numerically safe touchdown location by first creating a 3D model by image processing based on the photos. But it was completely impossible to use that method.

To guide the asteroid explorer with an accuracy of one centimeter, you have to calculate the effects of even the slightest gravitational pull. Since large rocks are a source of large gravitational forces, and small rocks of small gravitational forces, we ran the risk of *Hayabusa2* hitting the rocks a few centimeters away from the planned position if even the smallest force was not calculated precisely.

A State of Perfect Selflessness

Yamane: What was your solution?

Tsuda: The surface of Ryugu resembles a river bed full of rocks and we measured more than ten thousand rocks with a ruler. You can find out the horizontal size from photographs, but not the height or the vertical size of the rocks. So, we estimated the height based on the shapes of the surrounding rocks, but numerical values obtained in this way are fairly questionable. We were perplexed, but then we tried using stereoscopic images and shadows. Based on several hundred photographs, we obtained height data by measuring the length of the shadows when the rocks were exposed to sunlight. The science team members worked with scientists from several universities to devise this method.

We also divided up the jobs with one team photographing the surface from a good angle, another team making the plans for the photography, and a third team measuring the size of the rocks based on the photographs. Initially, it took us one week to analyze one photograph, but later we were able to process several photos a day to obtain accurate data on more than ten thousand rocks. Like monks, the team members worked in a state of perfect selflessness.

Yamane: So that's why it took four months ...

Tsuda: Once we knew the exact size of the rocks, the young researchers were able to create a 3D model based on the measurements and use the information to identify a flat location where the asteroid explorer could safely touch down with an accuracy of one centimeter.

Stumped by the Touchdown Point

Yamane: It's work that takes your breath away.

Tsuda: The team was proud to have managed to map the unevenness of a celestial body 300 million kilometers away, twice the distance between the Earth and the sun, with an accuracy of one centimeter. The height of the boulders around the planned touchdown point caused us some headache. Seventy centimeters was the maximum allowable height of the boulders to avoid impact when landing the asteroid explorer, but the science team reported that the height was 73 centimeters. Our calculations had a little margin because the burden of responsibility would be on us if by some chance we failed. So, we tried to squeeze the figure a bit to see if it wasn't really 69 centimeters. (Laughs)

Yamane: As a result of the survey, you identified two candidates for touchdown points.

Tsuda: That's right. We found a possible location with a width of twelve meters just northwest of the 1DK.

Yamane: That's large enough for a 6LDK house or more. Why didn't you choose the safer landing spot?

Tsuda: Because it was a bit too far from the target marker that we had already dropped. That's why we chose a location that was quite small, but closer to the target marker over the one with plenty of room but further away from the marker.

Yamane: You still had some target markers, so could you not have dropped another one?

Tsuda: Actually, some people shared that opinion and we had some serious discussions, but we decided against it because having two target markers in close proximity might be misleading and cause confusion for the asteroid explorer. Then, on the unforgettable day of February 22, 2019, we succeeded with the first touchdown at 7:29:10 a.m. (Japan Standard Time). The countdown voice in the control room still echoes in my head. After that, *Hayabusa2* sent us image data of dust and sand particles flying up in the air, so I was certain that the sample collection had been successful. One year and ten months after that day, we were able to confirm with the naked eye that we had collected a much larger amount than expected.

Be Ready with Two or Three Options

Yamane: You must have had many heated discussions when confronted with difficulties, but didn't things get confusing when people argued against your decisions as project manager?

Tsuda: No, I was prepared for it because I knew that it would be impossible to avoid such disputes about *Hayabusa2*. I had already had discussions about various scenarios with the project team for one to two years before. Since the options are endless, it was obvious that it would take time to reach a conclusion if we had the discussions once the mission was live and meanwhile the confusion would continue. I put a lot of effort into identifying two or three courses of action that outlined the options for particular scenarios. Therefore, when we were actually confronted with difficulties, we had a choice of two or three scenarios, so the project team was able to make quick decisions without spending too much time on discussions. One of the good things about this mission was that we were able to make these preparations as a team.

Tsuda's method of discussing decisions in advance is based on a painful experience of failure in his youth. When he was a graduate student, he had a major failure when an improved communication device stopped working just before the launch of a CanSat, which is a satellite loaded in an empty soft drinks can. The experience with CanSat at the Nakasuka Laboratory taught him that to aim for a successful space mission, you must first look at what you have to do to avoid failure.

The major difference between the *Hayabusa2* team and the first-generation team is that the engineering team operating the asteroid explorer and the scientist team doing the research formed a scrum. Planetary scientist Professor Watanabe Sei'ichiro of Nagoya University joined the team as a scientist and shared the tension and excitement with the engineers in the control room. Tsuda had proposed a "Sasuke plan" where scientists work together with engineers to gain experience of supervising asteroid explorer operations. It was an intelligent move that aimed for deep mutual understanding. There is much to learn from the Tsuda style of management.

Hard-working Female Scientists

On April 5, about a month and a half after the first touchdown, *Hayabusa2* released an impactor that discharged a "shell" from the air to form a crater on the asteroid, an unprecedented feat in the history of

space development. The second touchdown near the crater on July 11 succeeded in collecting fresh, unweathered soil samples below the surface. These samples are included in the total 5.4 g.



Professor Tsuda Yuichi (front row, second right) and project team after announcing the world's first successful attempt to make a crater on an asteroid, Ryugu, April 5 2020
Photo: Yamane Kazuma

Yamane: We must not forget that unlike the first-generation craft, which had a lot of breakdowns, *Hayabusa2* has not had any major troubles over a period of six years...

Tsuda: Exactly. For example, we have had zero problems with the ion engine, which failed many times in the first-generation. This is the outcome of repeated careful experiments and improvements.

Yamane: I heard from Nishiyama Kazutaka (Associate Professor at the Department of Space Flight Systems, ISAS) that Usui Miyuki is one of the people who contributed to extending the life of the ion engine.

Tsuda: She researched ion engines at the laboratory of Professor Kuninaka Hitoshi (currently Director General of ISAS) for two years when she was doing her Master's degree, and after that she worked for

NEC, which makes ion engines. Since she knows both organizations, she has worked tirelessly to build bridges between ISAS and NEC for the *Hayabusa2* project. Another woman who worked very hard on the project is Ogawa Naoko who is in charge of the Attitude and Orbit Control Subsystem (AOCS).

Yamane: What is Ogawa's job?

Tsuda: She works on the camera that allows the asteroid explorer to automatically recognize the target marker on touchdown. She participated from the development stages. Ogawa had the heavy responsibility of uploading the data captured by the camera to the computer for attitude control of the asteroid explorer and precisely controlling the descent and movement of the asteroid explorer. She was key to the touchdown operation. There are many other excellent and promising female aerospace engineers.

Yamane: Perhaps it will not be long before we have a female project manager for planetary exploration.

In the past, the project managers for Halley's Comet, Mars, asteroids, and the Venus explorer launched by ISAS were mainly in their 50s and 60s, but Tsuda was appointed to the asteroid explorer mission when he was 39, making him the youngest project manager ever. Many of the core members of the project team were born in the 1970s, the same decade as Tsuda, so *Hayabusa2* was a mission by a younger generation who were mainly in their 40s. Before and after the return of the first-generation *Hayabusa*, the project manager [Kawaguchi Junichiro](#) repeatedly said, "If the plans for the successor *Hayabusa2* are not realized as soon as possible, the experience we gained from *Hayabusa* will not be passed on to the next generation. Japan's planetary exploration technology will fall behind the rest of the world by twenty years if there is a gap in passing on the experience."

However, at the time, the Democratic Party of Japan (DPJ) administration crushed the plans for *Hayabusa2* even though *Hayabusa* had been the first to achieve the feat of bringing back a sample from an asteroid. Although the plan was subsequently revived, the launch date for reaching the asteroid (Ryugu) was approaching due to the positional relationship with the earth. If you miss the launch window, you will not have another chance for several years. So, Professor Kuninaka, who had worked on the first-generation craft, passed the baton to Tsuda who realized the long-cherished dream of bringing back a sample from a C-type asteroid by leveraging the experience accumulated by the generation before him.

Next to the Satellites of Jupiter and Saturn

Yamane: Toei Company, Ltd. made the movie *Hayabusa: Haruka naru kikan* (*Hayabusa: The Long Voyage Home*) based on my book *Wakusei tansaki Hayabusa no daiboken* (*The great adventure of the asteroid explorer Hayabusa*), which describes the seven years of the first-generation craft. When the capsule from *Hayabusa2* landed successfully in the middle of the night, I received an email from the film producer, Kikuchi Atsuo, who said, "Last time it was *The Long Voyage Home*, but this time it will be *Hayabusa2: The Perfect Voyage Home*."

Tsuda: That makes me happy! Please make the movie. The first-generation had a series of failures and breakdowns. I also had experience with the first-generation. Manufacturers usually experience failures and problems in the beginning, but prototypes evolve by investigating the causes and making

improvements. Your point that the first-generation *Hayabusa* and *Hayabusa2* are a linked mission is absolutely correct. *Hayabusa2* could never have got to this point on its own. I would like people to understand that this is what difficult projects are like and to continue with the plans in the future.

The Next One Is Expected in Ten Years

Yamane: What is the next dream you would like to realize?

Tsuda: Ryugu is a near-Earth asteroid with an elliptical orbit that comes close to the Earth, but nearly one million asteroids have their main orbits in the main-belt between Mars and Jupiter. Returning a sample from one of those asteroids is an unprecedented challenge, so I would like to try that. Another dream is to land on and explore the satellites of Jupiter and Saturn. If we pulled that off, it would be a major flagship mission. We are in an interesting position that could allow us to embark on such a new stage.

Yamane: It is said that there is water on the satellites of Jupiter and Saturn, and that they may be home to archaeobacteria, which are the same primitive life forms found in the deep waters of Earth. If you brought back such “extraterrestrial life” from there, it would be one of the greatest events in human history. I’m hoping that the *Hayabusa2* project team will be able to pull it off...

Tsuda: The first issue is whether we can create an environment where we can have such discussions with the government and the citizens of Japan. There is the problem of the cost, but in terms of technology alone, I think that even if it is not possible to bring back “extraterrestrial life” itself, it is possible to bring back samples of direct evidence of extraterrestrial life by using the methods and technologies developed by the *Hayabusa2* project team.

There was a long delay before I could start the interview with Tsuda. While I was waiting, there was some sort of commotion in the air, which turned out to be a message confirming that the capsule delivered by *Hayabusa2* contained a large volume of black sand-like particles. *Hayabusa2* achieved the cherished goal in the seventeenth year of the project. To share this moment with Tsuda was a great joy for everyone who has watched over this project.

Meanwhile, *Hayabusa2*, which delivered a treasure chest filled with a large volume of sample, is traveling out of the Earth’s orbit and heading for the next celestial body: the mysterious asteroid 1998 KY26 (provisional designation), which has an estimated diameter of only 30–40 meters and rotates at the high speed of once every ten minutes. I look forward to seeing what kinds of surprises are waiting for us when *Hayabusa2* arrives at its destination in July 2031.



Yamane Kazuma, nonfiction writer

Translated from “Sonotoki Kantei wa ‘Purojekuto maneja ga akasu hiwa: Hayabusa2 ‘Kanseishitsu de furueta “Kanpekinaru kikan”’—‘Hyakutenmanten de ichimanten’ no himitsu wa ‘Nankan pointo no yosoku’ to ‘santaku no yoi’ (Secrets Disclosed by the Project Manager: The Perfect Return that Sent the Hayabusa2 Control Room into a Frenzy—The secret to scoring “10,000 points out of a perfect 100” is to predict the difficulties and to be prepared with three options),”Bungeishunju, February 2021, pp. 144-154. (Courtesy of Bungeishunju, Ltd.) [August 2021].

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Born in 1975. Graduated from the Department of Aerospace Engineering, Faculty of Engineering, the University of Tokyo, and completed the doctoral program in the Department of Aerospace Engineering, the same graduate school. Ph.D. (Engineering). In 2015, he became the youngest project manager in history (Hayabusa2 project). Specializes in space engineering, aerospace dynamics, and solar system exploration. His papers include "Achievement of Asteroid Landing by Hayabusa2", The Japan Society for Aeronautics and Astronautics, Vol. 67, No. 9 (2019). "Hayabusa2 The Truth of the Strongest Mission" is the first book he published.

YAMANE Kazuma

Nonfiction writer

Born in 1947. Graduated from the Faculty of Foreign Languages, Dokkyo University. A nonfiction writer, Mr. Yamane anchored a NHK TV program “Midnight Journal” (1990–1992) and “Mirai-ha Sengen (Declarations of a Futurist).” His serial articles “Metaru kara no jidai (An Era of Metal Color)” for a weekly magazine won the Japan Creation Award 2008. General Producer for Aichi Prefecture Pavilion at EXPO 2005 Japan. His publications related to science and technology include *Metaru kara no jidai* (24 volumes), *Supaboenkyo ALMA no sozoshatachi* (Creators of Super telescope ALMA), *Rikagaku-kenkyusho 100 nenme no kyodai kenkyukikan* (RIKEN, 100th year of the prestigious research institute). His publication *Wakusei tansaki Hayabusa no daiboken* (The great adventure of the asteroid explorer *Hayabusa*) was made into a movie featuring Hollywood star Watanabe Ken. In 2020, the Fukui Prefectural Varve Museum, of which Mr. Yamane is the special chairman, received the Japanese Association of Museums Prize, the No. 1 award among all museums in Japan.
