Special Features

Japan’s Technical Prowess

Technical excellence and team spirit are manifested in such activities as the space station capture of the HTV5 spacecraft, development of the H3 Launch Vehicle, and reduction of sonic boom in supersonic transport.

International Cooperation

JAXA plays a central role in international society and contributes through diverse joint programs, including planetary exploration, and the utilization of Earth observation satellites in the environmental and disaster management fields.
Welcome to JAXA TODAY

The Japan Aerospace Exploration Agency (JAXA) is positioned as the pivotal organization supporting the Japanese government’s overall space development and utilization program with world-leading technology. JAXA undertakes a full spectrum of activities, from basic research through development and utilization.

In 2013, to coincide with the 10th anniversary of its establishment, JAXA defined its management philosophy as “utilizing space and the sky to achieve a safe and affluent society” and adopted the new corporate slogan “Explore to Realize.” Underpinned by this philosophy, JAXA pursues a broad range of programs in the aerospace and research and development fields.

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To All Our Readers

My name is Yoshikazu Shoji, and on January 1, 2016, I was appointed as Director of the JAXA Public Affairs Department. I wish to express my appreciation to all of you who have taken the time to look at the latest issue of JAXA TODAY. JAXA carries out a substantial amount of its work in collaboration with many international partners. From that perspective, I recognize the importance of achieving an even deeper understanding of the programs pursued by JAXA among a broad range of people outside Japan.

The goal of JAXA TODAY is to provide an easy-to-understand, current snapshot of some of the key activities of JAXA. I am happy when a new reader of JAXA TODAY gains a greater level of understanding of the space development, space science research and aeronautical technology research undertaken by JAXA.

With this as a starting point, nothing would give me greater pleasure than this publication being helpful for generating a deeper knowledge of Japan as a country among our readers.

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Cover Story

H-II Transfer Vehicle 5 (HTV5) Awaits Separation from the International Space Station (ISS)

On September 28, 2015, in preparation for separation the following day, HTV5 is grappled by Canadarm2 and detached from the ISS.

© JAXA / NASA

Special Feature 1: Japan’s Technical Prowess

Activities of “Team Japan” Connecting the Earth and Space

We review some of the activities of “Team Japan,” including the successful capture of its primary component, Canadarm2, to safely grapple and separate the HTV. In particular, Japan’s original technology for spacecraft rendezvous and capture has become one of the world standards in this field. The technology involves using the ISS robotic arm (Space Station Remote Manipulator System (SSRMS); also known by its primary component, Canadarm2) to safely grapple and birth the HTV.

Since the European Space Agency (ESA) retired the Automated Transfer Vehicle (ATV) in February 2015, the mission of JAXA, NASA and Roscosmos, respectively. The H-II Transfer Vehicle (HTV)—nicknamed “KOUNOTORI” (white stork) in Japanese—is Japan’s resupply spacecraft for the ISS. It has established a sound track record of safely transporting a variety of large-scale equipment and high-volume supplies. Hence, the HTV program continues to grow in importance. In particular, Japan’s original technology for spacecraft rendezvous and capture has become one of the world standards in this field. The technology involves using the ISS robotic arm (Space Station Remote Manipulator System (SSRMS); also known by its primary component, Canadarm2) to safely grapple and birth the HTV.

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“Team Japan” Leverages Its Strength in Unity

The excellent level of coordination among “Team Japan” members has been a crucial factor driving the success of numerous important missions. Recent examples include the capture of HTV5—a particularly tension-filled operation—and the deployment of small satellites from Japanese Experiment Module (JEM) Kibo.

“KOJINOTORI” (White Stork) Flies to Its ISS Perch

HTV5 was launched from the Tanegashima Space Center (TNSC) on August 19, 2015. After a successful flight with no major hitches, the resupply spacecraft arrived at its Approach Initiation (AI) point, orbiting 5 km behind the ISS, on August 24 at 5:58 (Japanese Standard Time; JST).

The HTV Control Center at TKSC—headquartered by HTV lead flight director Mayumi Matsuda—was already in joint operations with NASA’s International Space Station Flight Control Room in Houston, Texas. In Houston, JAXA Astronaut Koji Tanaka had the role of Capsule Communicator (CAPCOM)—the lead communicator tasked with conveying instructions to the ISS. Onboard the ISS, JAXA Astronaut Koichi Wakata was standing by in his role of Flight Control Room in Houston, Texas. In Houston, in joint operations with NASA’s International Space Station HTV Control Center reported to Houston: “HTV is go for capture. HTV5 has arrived at its preassigned position, and everything is proceeding smoothly.” On hearing this, Astronaut Wakata immediately sent the command to the ISS to “Go for capture.” The reply from the ISS came from NASA Astronaut Kjell Lindgren, who was assisting Astronaut Yui. “We will now begin the capture of HTV.”

At 17:01 JST, HTV5 arrived at a point 500 meters directly below the ISS. From here, the HTV5 commenced its final approach. At 17:42 JST, HTV5 was in a stationary position relative to the ISS, orbiting 10 meters directly below. The HTV Control Center reported to Houston: “HTV is go for capture. HTV5 has arrived at its preassigned position, and everything is proceeding smoothly.” On hearing this, Astronaut Wakata immediately sent the command to the ISS to “Go for capture.” The reply from the ISS came from NASA Astronaut Kjell Lindgren, who was assisting Astronaut Yui. “We will now begin the capture of HTV.”

At 19:22 JST, HTV5 temporarily ceased its ascent to confirm safety. At 19:29 JST, HTV5 was in a stationary position relative to the ISS, orbiting 10 meters directly below. The HTV Control Center reported to Houston: “HTV is go for capture. HTV5 has arrived at its preassigned position, and everything is proceeding smoothly.” On hearing this, Astronaut Wakata immediately sent the command to the ISS to “Go for capture.” The reply from the ISS came from NASA Astronaut Kjell Lindgren, who was assisting Astronaut Yui. “We will now begin the capture of HTV.”

After completing his long-duration mission as a member of ISS Expedition 44/45, Astronaut Kimiya Yui returned to earth on December 11, 2015.

Notes:
- HTVs separated from the ISS on September 29, 2015, and reentered the atmosphere the following day.
- After completing his long-duration mission as a member of ISS Expedition 44/45, Astronaut Kimiya Yui returned to earth on December 11, 2015.

Cubesat Deployment

On September 17, 2015, using the JEM Small Satellite Orbital Deployer (J-SSOD) on JEM Kibo of the ISS, two Cubesats were deployed—SERPENS (developed by the University of Brasilia and the Brazilian Space Agency) and S-CUBE (developed by the Chiba Institute of Technology). Among all of the ISS’ modules, only JEM Kibo—which has both an airlock and a robotic arm—is able to deploy Cubesats in this way.

S-CUBE was deployed at 21:02 JST by Astronaut Yui operating the deployment command aboard JEM Kibo. Then, at 21:12 JST, the JAXA Flight Control Team (JFCT) at TKSC issued the command that deployed SERPENS.

Collaboration with the United Nations Office for Outer Space Affairs (UNOOSA) to Promote the Use of Satellites

As of March 2016, a total of 90 Cubesats have been deployed from JEM Kibo. Apart from Japanese satellites, teams from a wide range of countries have utilized this service, including the United States, Vietnam, Peru and Lithuania. JAXA and UNOOSA initiated collaboration on September 8, 2015, to provide opportunities for the deployment of Cubesats. The two parties will cooperate in efforts to offer opportunities to developing countries for CubeSat deployment from JEM Kibo. This aims to contribute to progress in space-related technology in participating countries.

Message from Astronaut Wakata

“Thanks to Japan’s manufacturing technology—underpinned by a spirit of craftsmanship—along with the passion and wonderful teamwork of the entire international operational team, in space and on the ground, the HTV safely berthed at the ISS. It’s a fantastic result.”

Message from Astronaut Yui

“Thanks to the support I received from everyone, I was able to do my job roundly, and the capture of HTV5 was a success. I am proud to be Japanese, and I am proud of our team.”
JAXA is currently pursuing the development of Japan’s next-generation mainstay launch vehicle—the H3 Launch Vehicle. The H3 is expected to become the backbone of Japan’s space development program from 2020 onward. This project aims to develop a launch vehicle that is highly competitive internationally and establishes a strong commercial presence. JAXA is taking the lead in the development of key technologies and ground facilities essential for securing a high level of autonomy for Japan’s space program. Meanwhile, with the objective of developing a system with superior competitiveness in the commercial launch market, Mitsubishi Heavy Industries Co., Ltd. (MHI), is taking the role of prime contractor and is involved in system development from an early stage. Subsequently, at the operational stage, JAXA is aiming to realize a smooth transition to a structure based on the launch service provided by MHI. In this special feature, H3 Project Team Manager Masashi Okada, along with key members of his project team, discuss their aspirations for the development of the H3.

Special Feature 1:
Japan’s Technical Prowess
2020: The H3 Launch Vehicle Vision

What are the key criteria driving the H3 launch vehicle development project?

Our objective is to create a launch vehicle that is within easy reach for all potential customers and provides a high level of peace of mind. We also want the H3 to generate excitement and enthusiasm among people globally. It will boast world-class reliability while maintaining a very affordable cost structure. The H3 Launch Vehicle will also be highly competitive in the satellite launch market. To achieve this goal, the starting point for our development study was the launch vehicle’s operational concept. All key aspects of the H3 development project have been determined after careful consideration of customer opinions and needs. In addition to such design factors as launch vehicle configuration and launch capability, we considered factors that would determine the flexibility of services provided by the H3. For example, this included a focus on shortening the lead time between receiving an order and launch, as well as factors that would lead to an increase in available launch opportunities by halving the time required between launches.

Solid rocket booster (SRB-3)
The project includes development of the SRB-3, which follows the SRB and SRB-A as Japan’s third generation solid rocket booster. Development will focus on further simplifying the SRB-A. This will include such innovations as reducing the number of attachment points to the core airplane and replacing the predecessor’s movable nozzle with a fixed nozzle. Through such modifications, development will aim for improved reliability and reduced costs.

New 1st-stage engine (LE-9)
The 1st stage will be configured with either two or three 150-ton (in vacuum) thrust LE-9 engines. The combustion chamber pressure will be 10 MPa. This engine will generate the largest thrust capacity in the history of Japan’s liquid-propellant rocket-engine development. Development planning includes application of the expander bleed cycle—used in the 2nd-stage engine of the H-IIA Launch Vehicle—to thereby reducing the number of components needed. This will enable the H3 to achieve the twin goals of high reliability and low manufacturing cost.

Improved 2nd-stage engine (LE-5B-3)
Enhancement of fuel tank capacity makes the 2nd stage’s operational flight time longer than that of the H-IIA. As well, we are making improvements to the liquid-hydrogen turbo pump to further increase durability. The mixer for high-temperature hydrogen gas and low-temperature liquid hydrogen will also be upgraded, with the objective of enhancing engine fuel efficiency.

H3 Launch Vehicle

In fiscal year 2015 (FY2015; ended March 31, 2016), we were at the fundamental planning stage of the project. This is a vital phase in which the launch vehicle’s overall architecture is being determined. From FY2016 onward, we will enter a more detailed design phase. Since we are working with an extremely tight schedule, we have adopted a methodology for the H3 development project under which we thoroughly identify all potential risks at the design stage. We then implement strategies to eliminate or minimize such risks.

The H3 will be the main launch vehicle supporting Japan’s future space development program. This project aims to create a launch vehicle that incorporates all technical fields in which Japan excels, underpinned by launch vehicle technologies accumulated in Japan to date. Although there will be many critical periods during the development process, together with our colleagues in the private sector we will strive to maximize teamwork and the potential of our team to achieve the best results possible.

You have said that you are planning for an initial test launch in 2020. At what stage of development is the project currently?

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Japan’s Launch Vehicle Technology Takes On New Challenges

The H3 will maintain a high level of reliability while realizing radical cost reductions and providing customers with a flexible launch service.

Fundamental Change in Thinking Drives H3 Development

The commercial objectives of the H3 Launch Vehicle development project put it on a fundamentally different footing from Japan’s launch vehicle development to date. The development partners are focusing on how the launch vehicle will be operated and how it will be marketed to potential customers worldwide. The H3 1st stage will offer the choice of either a two- or three-engine configuration. There will also be flexibility in terms of solid rocket boosters—either none, two, or four SRBs. This architecture will give customers access to a flexible launch service, with a key consideration being the potential maximum number of launches annually. We want to leverage Japan’s full technical capabilities to produce a truly state-of-the-art launch vehicle.

Enabling All Team Members to Put Their Heart and Soul into the H3

My job is in systems engineering—specifically, integrating systems throughout the launch vehicle and related facilities. I am tasked with ensuring that integrated systems match the mission requirements of the H3 Launch Vehicle. We are carrying out development using an integrated approach that considers the optimal place to deploy each function necessary to meet the mission requirements. This includes all aspects of the project, from the launch vehicle to ground facilities. Key strengths of the H3 are its simplicity and high reliability. Hence, we are striving to create a launch vehicle that will attract satellite orders from customers around the world. I believe that it is my job to ensure that all team members are able to put their heart and soul into the H3.

Development of a Simple and Low-Cost Engine Based on Original Technology

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Aiming for Simplicity and the Realization of a Low-Cost Solid Rocket Booster

If I were asked to describe our approach to the development of improved solid rocket boosters (SRBs) to be used with the H3 Launch Vehicle, I would say we are “aiming for simplicity.” One of the key features of the new SRB-3 is the mechanism used for separation from the main rocket airframe. The SRB-A, which is used with the H-IIA and H-IIB launch vehicles, has six separation points—braces and struts—between the main airframe and two separation motors. The separation motors generate the power to detach the booster outward from the main body. This structure incurs considerable cost in terms of both manufacturing and launch vehicle assembly operations. Hence, for the SRB-3 we will reduce the number of separation struts to three, each of which is furnished with a simple mechanism called a “separation thruster.” This mechanism is equipped with a pyrotechnic actuator to separate the booster outward from the launch vehicle body. I am working to fulfill my mission, which I believe is to develop an extremely competitive launch vehicle.
Special Feature 1: 

Japan’s Technical Prowess

A Genuine Step toward the Realization of the Next Generation of Supersonic Transport

—Japan’s capabilities for developing original technologies gain high visibility thanks to the success of the flight test demonstration of the low sonic-boom design concept—

To realize a new generation of supersonic transport, the reduction of sonic boom is one of the most critical issues that must be addressed. JAXA is pursuing this objective through the D-SEND project, which involves flight test demonstrations and evaluation of configuration design concepts and methods. In July 2015, JAXA carried out the second-phase D-SEND test (“D-SEND#2”) at the Esrange Space Center in Sweden. We discussed the significance of the success of this test with D-SEND project manager Kenji Yoshida.

Kenji Yoshida
Project Manager
D-SEND Project Team
Aeronautical Technology Directorate

The experimental aircraft used for the flight test demonstration applied JAXA’s original configuration design concept. For example, the nose had non-axisymmetric upper and lower surfaces, the wings used an optimal combination of twist-angle and camber distributions, and the aft fuselage had a wide shape. The test was a world-first flight demonstration in which nose and tail sonic booms were reduced while maintaining aircraft stability.

Contributing to the Formulation of International Standards

How do you plan to apply the success of this flight test?

Yoshida: The Committee on Aviation Environmental Protection (CAEP) within the International Civil Aviation Organization (ICAO) is currently deliberating on the formulation of international standards for sonic booms. The results of our second-phase demonstration test, which were reported to the Supersonic Task Group under CAEP in October 2015, received high technical evaluation. However, establishing environmental standards is a difficult process, and we believe that debate is likely to continue regarding what would be an acceptable level for the community and what constitutes an environmental standard.

A World of Supersonic Transport Just Moved a Step Closer to Reality

Have the issues standing in the way of a new generation of supersonic transport been resolved?

Yoshida: Supersonic transport faces issues within two broad categories—economic viability and environmental compliance. It would be premature to say that these issues have been completely resolved. The next generation of supersonic transport envisaged by JAXA would be a relatively small airplane. It would have a passenger capacity of 50, cruising at a speed of Mach 1.6, and the airplane would weigh some 70 tons. Based on such a model, in terms of economic performance, its aerodynamic drag would be 13% lower than the Concorde. Furthermore, we believe that the lightweight airframe and improved engines would potentially lower fuel consumption by around 20% compared with the Concorde. In the area of environmental compliance, since the weight of the airframe has a bearing on sonic boom, we estimate that by applying JAXA’s low boom design technology to such model, the sonic boom would be reduced to approximately 25% of that of the Concorde.

Staying at the Leading Edge of Technology Development

What is JAXA’s role from here on?

Yoshida: There are two aspects to our role—contributing through international cooperation and developing technology that is globally competitive.

Providing the results of this demonstration test to the ICAO is part of our international cooperation. We hope that this will help to bring about the opportunity for supersonic transport development. However, we estimate that the cost of such development—even for an aircraft of the scale envisaged by JAXA—will exceed one trillion yen ($8.3 billion). Of course, such a development project would take the form of a joint international effort. In other words, international competitiveness would greatly depend on how far we could expand our share of the development program. Japan holds patents related to the development of next-generation supersonic transport in such areas as the reduction of aerodynamic drag and low sonic-boom design technology. Consequently, if we can take the initiative from the design stage, I think that we should be able to expand our share of the development program.

With this in mind, we are taking a leading-edge approach to technology development. I believe that one of JAXA’s major roles is to lay the foundations for internationally competitive technologies, and then pass the baton to Japanese enterprises at the appropriate time.

Flight Demonstration of Low Sonic Boom Concept for Supersonic Transport Design

Please describe the research flow for reducing sonic boom.

Yoshida: Initially, in May 2011 we conducted the first-phase test of D-SEND (“D-SEND#1”) as a preliminary test. Based on the results of D-SEND#1, for the second-phase demonstration test we released an experimental supersonic aircraft from a large stratospheric balloon at an altitude of 30.5 km. The experimental aircraft—which utilizes JAXA’s original low sonic boom design technology—had a total length of 7.9 meters and weighed 1,000 kg. We measured the sonic boom generated by the aircraft to validate the design technology.

When an aircraft flies at a speed greater than the speed of sound—supersonic speed—shock waves are generated by many parts of the airframe. By the time these shock waves reach the ground, they become compressed with waves generated by the nose and tail of the aircraft. This causes two large pressure fluctuations to occur. On the ground we hear this as an explosive sound, or “sonic boom.”

The experimental aircraft used for the flight test demonstration applied JAXA’s original configuration design concept. For example, the nose had non-axisymmetric upper and lower surfaces, the wings used an optimal combination of twist-angle and camber distributions, and the aft fuselage had a wide shape. The test was a world-first flight demonstration in which nose and tail sonic booms were reduced while maintaining aircraft stability.

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Flight Demonstration of Low Sonic Boom Concept for Supersonic Transport Design

Please describe the research flow for reducing sonic boom.

Yoshida: Initially, in May 2011 we conducted the first-phase test of D-SEND (“D-SEND#1”) as a preliminary test. Based on the results of D-SEND#1, for the second-phase demonstration test we released an experimental supersonic aircraft from a large stratospheric balloon at an altitude of 30.5 km. The experimental aircraft—which utilizes JAXA’s original low sonic boom design technology—had a total length of 7.9 meters and weighed 1,000 kg. We measured the sonic boom generated by the aircraft to validate the design technology.

When an aircraft flies at a speed greater than the speed of sound—supersonic speed—shock waves are generated by many parts of the airframe. By the time these shock waves reach the ground, they become compressed with waves generated by the nose and tail of the aircraft. This causes two large pressure fluctuations to occur. On the ground we hear this as an explosive sound, or “sonic boom.”

The experimental aircraft used for the flight test demonstration applied JAXA’s original configuration design concept. For example, the nose had non-axisymmetric upper and lower surfaces, the wings used an optimal combination of twist-angle and camber distributions, and the aft fuselage had a wide shape. The test was a world-first flight demonstration in which nose and tail sonic booms were reduced while maintaining aircraft stability.

Contributing to the Formulation of International Standards

How do you plan to apply the success of this flight test?

Yoshida: The Committee on Aviation Environmental Protection (CAEP) within the International Civil Aviation Organization (ICAO) is currently deliberating on the formulation of international standards for sonic booms. The results of our second-phase demonstration test, which were reported to the Supersonic Task Group under CAEP in October 2015, received high technical evaluation. However, establishing environmental standards is a difficult process, and we believe that debate is likely to continue regarding what would be an acceptable level for the community and what constitutes an objective parameter.

A World of Supersonic Transport Just Moved a Step Closer to Reality

Have the issues standing in the way of a new generation of supersonic transport been resolved?

Yoshida: Supersonic transport faces issues within two broad categories—economic viability and environmental compliance. It would be premature to say that these issues have been completely resolved. The next generation of supersonic transport envisaged by JAXA would be a relatively small airplane. It would have a passenger capacity of 50, cruising at a speed of Mach 1.6, and the airplane would weigh some 70 tons. Based on such a model, in terms of economic performance, its aerodynamic drag would be 13% lower than the Concorde. Furthermore, we believe that the lightweight airframe and improved engines would potentially lower fuel consumption by around 20% compared with the Concorde. In the area of environmental compliance, since the weight of the airframe has a bearing on sonic boom, we estimate that by applying JAXA’s low boom design technology to such model, the sonic boom would be reduced to approximately 25% of that of the Concorde.

Staying at the Leading Edge of Technology Development

What is JAXA’s role from here on?

Yoshida: There are two aspects to our role—contributing through international cooperation and developing technology that is globally competitive.

Providing the results of this demonstration test to the ICAO is part of our international cooperation. We hope that this will help to bring about the opportunity for supersonic transport development. However, we estimate that the cost of such development—even for an aircraft of the scale envisaged by JAXA—will exceed one trillion yen ($8.3 billion). Of course, such a development project would take the form of a joint international effort. In other words, international competitiveness would greatly depend on how far we could expand our share of the development program. Japan holds patents related to the development of next-generation supersonic transport in such areas as the reduction of aerodynamic drag and low sonic-boom design technology. Consequently, if we can take the initiative from the design stage, I think that we should be able to expand our share of the development program. With this in mind, we are taking a leading-edge approach to technology development. I believe that one of JAXA’s major roles is to lay the foundations for internationally competitive technologies, and then pass the baton to Japanese enterprises at the appropriate time.
International Cooperation

Japan and Europe Cooperate to Investigate the Mysteries of Mercury—An Unknown World

BepiColombo is a joint mission of the European Space Agency (ESA) and JAXA to explore the planet Mercury. JAXA TODAY spoke to JAXA’s BepiColombo project manager Professor Hajime Hayakawa about the unique technical aspects and scientific significance of the mission. Professor Hayakawa also discusses the importance of international cooperation in interplanetary exploration.

Dr. Hayakawa received a Master of Science degree from the Department of Geophysics, Graduate School of Science, The University of Tokyo, in 1981. He participated in the development of the magnetosphere observation satellite Akibono, Giotai, and the Mars Explorer Nozomi. In 2006, he was appointed project manager for JAXA in the Mercury exploration mission BepiColombo.

Why have there been relatively few exploration missions to Mercury to date?

Hayakawa: Mercury’s close proximity to the sun gives it a very scorching environment. This means that not only is it difficult to send a probe to Mercury, but achieving a high assurance that the spacecraft and its instruments will survive while orbiting the planet is also a major challenge. Reaching Mercury and putting a satellite into orbit around the planet requires a huge amount of energy. Furthermore, the amount of thermal energy received from the sun by Mercury is approximately 10.7 times that of Earth. In addition, the very strong sunlight reflection and heat radiation from Mercury meant that in-orbit observations were considered to pose extreme difficulties.

What has been the most painstaking aspect of MMO’s development?

Hayakawa: The greatest challenge we faced was how to develop a space probe that could endure the severe heat conditions. After deliberating on the issue of heat dissipation, we decided to use mirrors on the spacecraft exterior to reflect away sunlight. Hence, we thoroughly considered the thermal radiative properties when designing the structure of the spacecraft. For example, the solar cell panels covering the upper half of the probe are fully covered with mirror material on the reverse surface.

What is the scientific significance of the exploration of Mercury?

Hayakawa: The entire Earth is a magnet, and its magnetic field is stable. Furthermore, if one compares the Earth’s magnetosphere and the size of the Earth itself, the ratio is approximately 10:1. Based on the flyby observations of Mercury carried out by NASA’s Mariner 10 spacecraft about 40 years ago, scientists have understood that Mercury’s magnetic field is quite weak. Those observations also revealed that when comparing the size of Mercury’s magnetosphere and the planet itself, the relative size of Mercury in relation to its magnetosphere is much larger than the corresponding ratio for Earth. Through the BepiColombo mission, we will of course seek to elucidate the environment around Mercury. However, we also hope that through comparisons with other planets we will gain a deeper understanding of the Earth’s environment.

What is your view of the importance of international cooperation in the field of interplanetary exploration?

Hayakawa: I think that international cooperation is going to become absolutely indispensable from here on. Within the BepiColombo project, JAXA and ESA each have their own space probe. However, regardless of which organization is developing the spacecraft, the optimal scientific instruments were selected as the payload for each probe from among the proposals submitted by researchers in both Europe and Japan. The BepiColombo project has become a model case for Japan-Europe international cooperation, and new missions are also getting under way, including the Jupiter Icy moons Explorer (JUICE) project to explore Jupiter.

Please explain the relationship between BepiColombo and the NASA MESSENGER mission, which completed surface observations of Mercury in 2015.

Hayakawa: Initially, MESSENGER was seen as a rival mission, but we are strengthening collaboration with MESSENGER. For example, since NASA began releasing observation data from MESSENGER, we have held joint workshops. MESSENGER’s observations have led to numerous new discoveries. There have also been many results that diverged greatly from pre-observation expectations. For example, the position of Mercury’s magnetic field is off by about 29% from the planet’s center, and the planet has a large inventory of volatile materials. Such discoveries have led to more questions, thereby posing new mysteries to be investigated. Obviously, one of the major roles of BepiColombo is to seek answers to such questions. At the moment, researchers from Japan and Europe are working together to consider observation methods using the project’s two space probes that will lead to the greatest possible output. I believe that the scientific value of the mission is increasing substantially.

In closing, is there anything you would like to say specifically to young researchers?

Hayakawa: I think it is important to maintain a strong sense of curiosity, and be driven by the desire of “wanting to know” the things that one does not yet understand. Mercury is a world full of unknowns, and new mysteries are being thrown up constantly. I believe that it is an exploration field offering a wealth of intellectual curiosity and challenges.

BepiColombo Project

This is a joint project by JAXA and the ESA to explore the planet Mercury. Two interplanetary space probes will simultaneously orbit Mercury to carry out comprehensive observations of the planet. JAXA will send the Mercury Magnetospheric Orbiter (MMO), while ESA will operate the Mercury Planetary Orbiter (MPO). Launch of these spacecraft is planned for 2017. The mission is named after Italian Giuseppe (Bepi) Colombo (1920–1984), a celestial mechanics scientist, mathematician and engineer at the University of Padua. Professor Colombo is well-known for his contribution to NASA’s Mariner 10 mission in 1974, the first interplanetary probe of Mercury.
Utilizing Earth Observation Satellites to Help Build a Better Future for Humankind

JAXA develops and operates a diverse array of satellites, including interplanetary probes, communications and global navigation satellites, and Earth observation satellites. Among these, the main functions and roles of Earth observation satellites are particularly important in both the environmental and disaster management fields, which can have a significant impact on society and people's daily lives. In this article, two JAXA managers outline some of JAXA's capabilities for international cooperation that further utilize such observation data.

Recent years have witnessed the frequent occurrence of major natural disasters in Japan and abroad. To minimize the damage from such disasters, it is imperative to accurately and rapidly ascertain the damage situation. This is one of the missions fulfilled by Advanced Land Observing Satellite-2 (ALOS-2)—launched in May 2014 as the follow-on mission to Advanced Land Observing Satellite (ALOS). ALOS-2 helps to secure people's safety and livelihoods by providing observation data from space to support disaster management efforts.

ALOS-2 is a radar satellite whose primary payload instrument is PALSAR-2. This is a substantially upgraded instrument compared with PALSAR, which was carried by ALOS. PALSAR is an acronym for Phased Array-type L-band Synthetic Aperture Radar. Radar satellites have the ability to conduct observations anytime day or night, and the radio waves they emit can penetrate clouds and rain. ALOS-2 has sophisticated maneuverability and observation capabilities, which are effective for conducting observations following a disaster. For example, in addition to realizing very detailed observations, PALSAR-2 has "spotlight mode," which enables high-resolution observations of specific targets. The satellite's "revist time"—referring to the number of days necessary for the satellite to orbit the Earth and return to the same observation location—has also been greatly shortened. Furthermore, the spacecraft can rapidly adjust its attitude left and right about its roll axis to point the PALSAR-2 antenna when making observations.

The major earthquake that struck Nepal April 25, 2015, occurred just before a week-long holiday season in Japan. JAXA staff responsible for emergency satellite observations gave up their vacation time to respond to the earthquake, and I believe that JAXA personnel had to cope with considerable mental and emotional pressure. However, JAXA received letters of gratitude from United Nations agencies and organizations in Nepal after the crisis, and I am sincerely glad that we were able to respond to assist with the emergency. Of course, we cannot choose the timing or location of a major natural disaster—it is something that we must deal with to the best of our abilities. Programs for monitoring disasters from space should be built as an integral part of the social infrastructure to ensure that people are able to live secure lives with peace of mind. Hence, I think that it is essential to maintain an operational system capable of immediate response—24-hours-a-day, 365-days-a-year—to disasters that can strike suddenly anywhere, at any time.

At present, JAXA positions Sentinel Asia as a project for demonstrating the utilization of space technology. In the future, when Sentinel Asia completes its demonstration phase, we want to aim for the joint operation of a 24-hour system by participating countries and organizations. We see the possibility of establishing such a framework—which may be tentatively called "Sentinel Asia Center"—to take over from the current demonstration project. To realize this goal, JAXA is committed to continuing its leadership role in this sphere.
Special Feature 2: International Cooperation

Playing a Key Role in the Environmental Field

Global Satellite Mapping of Precipitation (GSMaP) for 9:00 a.m., September 10, 2015 (JST), produced based on observation data from the GPM satellite constellation, including (GPM-OPR).

Tackling Global Environmental Issues through International Cooperation

Humankind faces many environmental issues on a global scale. Hence, when viewing such problems, it is vital to do so from an international perspective rather than from the perspective of a single country. For example, the Global Precipitation Measurement (GPM) mission is a joint international mission to measure global precipitation at frequent intervals with a high level of precision. GPM aims to elucidate mechanisms leading to climate change and changes in the global water cycle. The mission comprises the GPM Core Observatory—which carries the Dual-frequency Precipitation Radar (DPR) developed by Japan—and a constellation of satellites. GPM was initiated by JAXA and NASA, and comprises an international consortium of agencies, including the European Space Agency (ESA), Centre National d’Études Spatiales (CNES), the Indian Space Research Organization (ISRO), the National Oceanic and Atmospheric Administration (NOAA), and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT).

Microwave radiometer observation data from Global Change Observation Mission–Water (GCOM-W1) is used by the Japan Meteorological Agency and other meteorological agencies worldwide, including in the United States, Europe, and Australia. The data is used in the preparation of daily weather forecasts for such applications as numerical forecasting, analysis of the paths and strengths of typhoons and other storms, and in the preparation of high-resolution sea surface temperature maps.

Observation data from the atmospheric concentrations of carbon dioxide and methane—principal greenhouse gases—are carried out by the Greenhouse Gases Observing Satellite (GOSAT). The effectiveness of data from GOSAT was cited in the Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC), and the data is proving useful in assessing the effects of greenhouse gas emission reductions, principally carried out by developed countries.

Collaborating with JICA in Ongoing Efforts to Conserve Tropical Rain Forests

The conservation of forests—which act as a sink absorbing carbon dioxide—is an effective means of limiting global warming. However, frequent illegal logging in Brazil’s forested regions has been a major problem leading to deforestation. From 2009 to 2011, JAXA collaborated with the Japan International Cooperation Agency (JICA) in its projects to protect forests in the Amazon basin. Images taken by Advanced Land Observing Satellite-2 (ALOS-2) are shown on page 15. Image data taken by Advanced Land Observing Satellite (ALOS)—the predecessor of ALOS-2—was provided to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). Even during the rainy season—which persists for almost half the year near the equator—ALOS was able to capture observations through cloud and rain. The image data proved to be a powerful tool in the battle against illegal logging, as ALOS data was able to identify the specific areas in which illegal logging was occurring.

In April 2014, JAXA and JICA signed a partnership agreement under which they plan to utilize aerospace technology with the objective of contributing to solutions to issues faced by developing regions as well as a range of global-scale issues. Based on this agreement, JAXA and JICA jointly announced the Initiative for Improvement of Forest Governance at the 2015 United Nations Climate Change Conference (COP21), held in Paris in December 2015. In accordance with this framework, JAXA and JICA will build a forest monitoring system using ALOS-2. Observation data from this monitoring system relating to global deforestation and forest loss will be regularly released through the JAXA web site and other resources. The partners hope that the monitoring system will help to curb illegal logging and contribute to limiting climate change.

Combining Observation Data from Diverse Sources to Promote New Research

JAXA’s Earth Observation Research Center (EORC) is collaborating with national universities and research institutions in Japan to promote multidisciplinary applied research from FY2015 (commencing April 1, 2015) onward. This program aims to utilize observation data in an integrated way, not only from JAXA satellites but also from a broad range of other satellites, including Himawari 8—a geostationary weather satellite operated by the Japan Meteorological Agency. By combining satellite data and a global environmental model, the EORC aims to predict the process of change in the Earth’s environment. The objective of the research is to work toward finding solutions to issues across a variety of fields, including the water cycle and water resources, ecosystems and agriculture.

For example, in the agricultural field, by developing a new yield forecasting system that integrates a grain yield forecasting model with observation data from ALOS-2, GCOM-W1, Global Change Observation Mission–Carbon (GCOM-C), the GPM mission and other sources, JAXA is engaging in research that addresses such issues as future tightness in the supply and demand of food.

Utilizing Satellites to Help Build a Safe and Secure Society

Compared with manned spacecraft and the development of launch vehicles, satellites may seem somewhat mundane. However, using satellites to conduct observations of the Earth’s environment offers the potential to find solutions to issues faced by all of humankind in the future. Through satellite monitoring of the global environment, I hope that we can identify the causes of extreme weather events and discover methods for mitigating the damage from natural disasters. Hence, I hope that these efforts will help to build a society of the future in which people can lead safe and secure lives.
Moving beyond Its First Decade, JAXA Sets Course on a New Stage of Its Journey

Since JAXA’s establishment in October 2003 through the merger of three predecessor organizations, and the transition in April 2013 to a new legal status as a National Research and Development Agency, JAXA has steadily built up a record of accomplishments in the aerospace field and in research and development. In just over a decade, internationally JAXA has won a high level of trust as a space agency, reflected in such milestones as Astronaut Koichi Wakata’s appointment as the first Japanese commander of the International Space Station (ISS) in 2014, and the successful capture of Japan’s HTV5 resupply spacecraft when it made its rendezvous with the ISS in 2015—showcasing the capabilities of “Team Japan.” Let’s recap some of the highlights of the first dozen years of JAXA’s continuing journey.

**2003**

New Organization Takes Shape

JAXA commenced operations in October 2003 following the merger of the Japan Aerospace Exploration Agency (JAXA, predecessor to NASDA), the National Institute of Synthetic Chemistry, and the National Space Development Agency of Japan (NASDA).

**2004**

Hayabusa Heads to Asteroid Itokawa

The robotic probe Hayabusa set off to the vicinity of asteroid Itokawa on May 9, 2003, marking the start of a study aimed at providing data on the beginning of the solar system. Hayabusa’s mission included the release of a small boat called MASCOT and the capture of Itokawa by its gravity. After arriving in the vicinity of the asteroid in September, Hayabusa released MASCOT on September 27, and after spending five months in orbit, Hayabusa released its small boat onto the surface of Itokawa on June 27, 2005. MASCOT and Hayabusa’s collection of scientific data were returned to Earth in June 2010, providing valuable insights into the formation and evolution of the solar system.

**2005**

Flights Recommend

NASA’s Mars Exploration Rover Spirit made its first attempt to land on Mars on May 8, 2004, using a controlled descent with the help of an aeroshell. It was the first time that an aeroshell was used for a controlled entry on Mars, allowing the rover to safely descend and land on the planet’s surface, marking a significant step forward in Mars exploration technology. Spirit began its scientific mission on Mars on January 25, 2004, and continued to operate until 2010, providing valuable data on the planet’s geology and history.

**2006**

Four Satellites Enters Orbit

Utilizing Japan Aerospace Exploration Agency (JAXA)-developed technology, the first batch of four satellites (A-IB, A-IV, A-V, and A-VII) was launched on November 14, 2006, on a H-IIA rocket. These satellites were part of the J-PROBE project, aimed at developing new technology and conducting fundamental research in various fields such as geoscience, material science, and astrophysics. This launch marked a significant milestone in JAXA’s space exploration capabilities.

**2007**

NAGoya Heads for the Moon

Japan Aerospace Exploration Agency (JAXA) announced plans to send a robotic probe to the Moon in 2007, with the goal of testing the lander and robotic equipment that would be used for future manned missions. The lunar probe, set to be launched in 2007, would be the first time that Japan would send a robotic lander to the Moon, representing a significant step forward in Japan’s space exploration capabilities.

**2008**

Assembly of JEM Begins

The Japanese Experiment Module (JEM) began to take shape as part of the International Space Station (ISS) construction. The JEM, Japan’s first module for the ISS, was launched on May 30, 2008, aboard the Space Shuttle Discovery. The assembly of JEM began with the deployment of the Kibo Laboratory, with the other JEM modules following soon after, marking a major milestone in Japan’s participation in international space research.

**2009**

JEM Kibo and HTV6 Begin Cargo Flights

Japanese space station module Kibo (JEM) made its first cargo delivery flight to the International Space Station (ISS) on May 28, 2009, using a H-IIA rocket. This delivery was part of Japan’s effort to contribute to the ISS and improve its capabilities. The HTV6, Japan’s newest resupply spacecraft, was launched on December 20, 2009, and carried supplies and equipment to the ISS, marking a significant step forward in Japan’s space exploration efforts.

**2010**

Hayabusa Returns to Earth

Japan Aerospace Exploration Agency (JAXA) returned to Earth on September 27, 2010, after a successful mission to rendezvous with the asteroid Itokawa and conduct surface observations. Hayabusa had spent nearly seven years in space, collecting valuable data on the asteroid’s composition and surface features, and was the first Japanese spacecraft to successfully return samples from an asteroid.

**2011**

SHIZUKU Begins

Japan Aerospace Exploration Agency (JAXA) launched the SHIZUKU satellite on September 16, 2011, aboard a H-IIA rocket. SHIZUKU is a water cycle observation satellite that monitors the Earth’s water distribution and supply. The satellite has been instrumental in providing valuable data on the Earth’s water cycle, helping to improve our understanding of the planet’s water resources.

**2012**

Demonstration Flight of JAXA’s IKAROS

JAXA launched the Small Solar Power Sail Demonstrator (IKAROS), a solar sail demonstration mission, on May 17, 2012. IKAROS was designed to demonstrate the feasibility of using solar sails for space exploration, and it was the first time that Japan had used a solar sail for a space mission. IKAROS was successfully inserted into an Earth-like orbit, demonstrating the potential of solar sail technology for long-distance space travel.

**2013**

Dawn of a New Era

Japan Aerospace Exploration Agency (JAXA) launched the Akatsuki spacecraft on December 14, 2010, aboard a H-IIA rocket. Akatsuki is a Juno-class spacecraft designed to study Venus, and it is the first time that Japan has launched a spacecraft to study the planet. Akatsuki arrived at Venus in December 2015, and began sending back valuable data on the planet’s atmosphere and surface features.

**2014**

New Organizational Form of JAXA

JAXA reorganized its structure in 2014, becoming the Japan Aerospace Exploration Agency (JAXA). This reorganization aimed to streamline operations and improve efficiency, allowing JAXA to better focus on its mission to conduct space research and development.

**2015**

Strengthening of International Cooperation

Japan Aerospace Exploration Agency (JAXA) continued to strengthen its international cooperation efforts, partnering with other countries to conduct joint space missions and projects. These partnerships have helped to expand the scope and scale of JAXA’s space exploration activities, allowing for greater collaboration and knowledge sharing among international space agencies.

**2016**

New Organizational Form of JAXA

Japan Aerospace Exploration Agency (JAXA) continued to consolidate its organization and restructure its operations, focusing on improving efficiency and effectiveness. The reorganization aimed to streamline operations and improve coordination among JAXA’s various divisions, allowing for greater focus on its mission to conduct space research and development.
The JAXA Bangkok Office plays an important liaison role in JAXA’s communications and coordination with space agencies in the Southeast Asia region. In addition, the office functions as a base for Sentinel Asia—a disaster management support system in the Asia-Pacific region. In this interview, director of the JAXA Bangkok Office, Masanobu Tsuji, discusses the main roles of his office as well as his lifestyle in the Thai capital.

Please briefly introduce yourself.

I joined NASDA in 1985. From 1987, I was responsible for the development and operation of image processing equipment for Earth observation satellites. Part of my job involved converting data sent from Thailand into images at the Earth Observation Center (EOC) in Hatoyama, Saitama Prefecture, Japan. After NASDA launched Japanese Earth Resources Satellite (JERS-1) in 1992, it was decided that from 1993 we would carry out image processing in Thailand as well as Japan. I was tasked with installing the image processing equipment in Thailand, and subsequently I was dispatched to the Remote Sensing Technology Center of Japan (RESTEC) to instruct NRCT staff on how to use the equipment. This assignment involved me living in Thailand for approximately 18 months. I returned to work in Bangkok in March 2015 to take up my current role.

What is the role of the Bangkok Office?

In 2006, Sentinel Asia was launched as an initiative through the Asia-Pacific Regional Space Agency Forum (APRSAF) for disaster management support utilizing satellite data. A Sentinel Asia Project Office was established within JAXA’s Bangkok Office. JAXA and GISTDA jointly hold operational training sessions, and a mirror server has been installed within GISTDA to improve the system’s data access.

Since JAXA was established in 2003, there has been an increase in the office’s role in handling liaison and coordination with space agencies in several Southeast Asia countries, including Indonesia, Malaysia and Vietnam. In November 2016, the 23rd Session of APRSAF (APRSAF-23) will be held in the Philippines, and we anticipate an increase in opportunities for communication with the Philippines over the coming months.

Please tell us about your lifestyle away from work.

Thailand is in the midst of a cycling boom. In late-December 2015, a 23.5 km-long cycling path was opened in the area around Suvarnabhumi International Airport. On weekends, I enjoy riding around the course on the bike I brought over from Japan.

Has living in Thailand affected your self-identity as a Japanese person?

The travel sections of local bookstores in Bangkok feature guidebooks in Thai for a range of Japanese cities, such as Tokyo, Osaka, Sapporo, Sendai and Fukuoka. Sapporo, in particular, is a popular destination for Thai tourists, since they can experience snow. Here in Thailand, Japanese restaurant chains are expanding their store networks, and when I go to these restaurants I see far more Thai customers than Japanese. The things I have mentioned are quite typical in my neighborhood, so my self-identity as a Japanese person has not really changed.

Is there anything you would like to say to our readers in closing?

New technologies are helping to make society more affluent. A wide array of new services based on space technology are being launched in countries across the Asia-Pacific region. For example, Earth observation satellite data is used to support disaster management, and a global navigation satellite system (GNSS) underpins vehicle dispatching systems, such as those used for taxis.

The Bangkok Office will continue to serve as an interface for JAXA to enhance its cooperation with space agencies and institutions that use satellite data in the Asia-Pacific region.