The orbit of the ISS and Kounotori 2 as seen from Earth

The International Space Station: A world without borders, built through international cooperation

Japan Aerospace Exploration Agency
Human Spaceflight Technology Directorate

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A New Stage Has Begun for Humankind's Activity in Space

Harvesting the Fruits from "Kibo" for the Future of Society and Humanity

The International Space Station (ISS) Program began with a plan announced in 1984 by U.S. President Ronald Reagan. Under this program, 15 countries, including the U.S., Japan, Canada, European nations, and Russia, contributed to constructing a manned space station in orbit 400 km above the Earth. The station is approximately the size of a soccer field (109 m × 73 m), has a mass of around 400 metric tons, and six onboard astronauts.

Three decades have passed since the time when human spaceflight was just a dream for Japan. Today, however, seeing Japanese astronauts in space has become commonplace. The Japanese Experiment Module (JEM), known as "Kibo"—which means "Hope" in Japanese—has enabled various scientific experiments in microgravity that would not be possible on Earth, and has delivered many remarkable results.

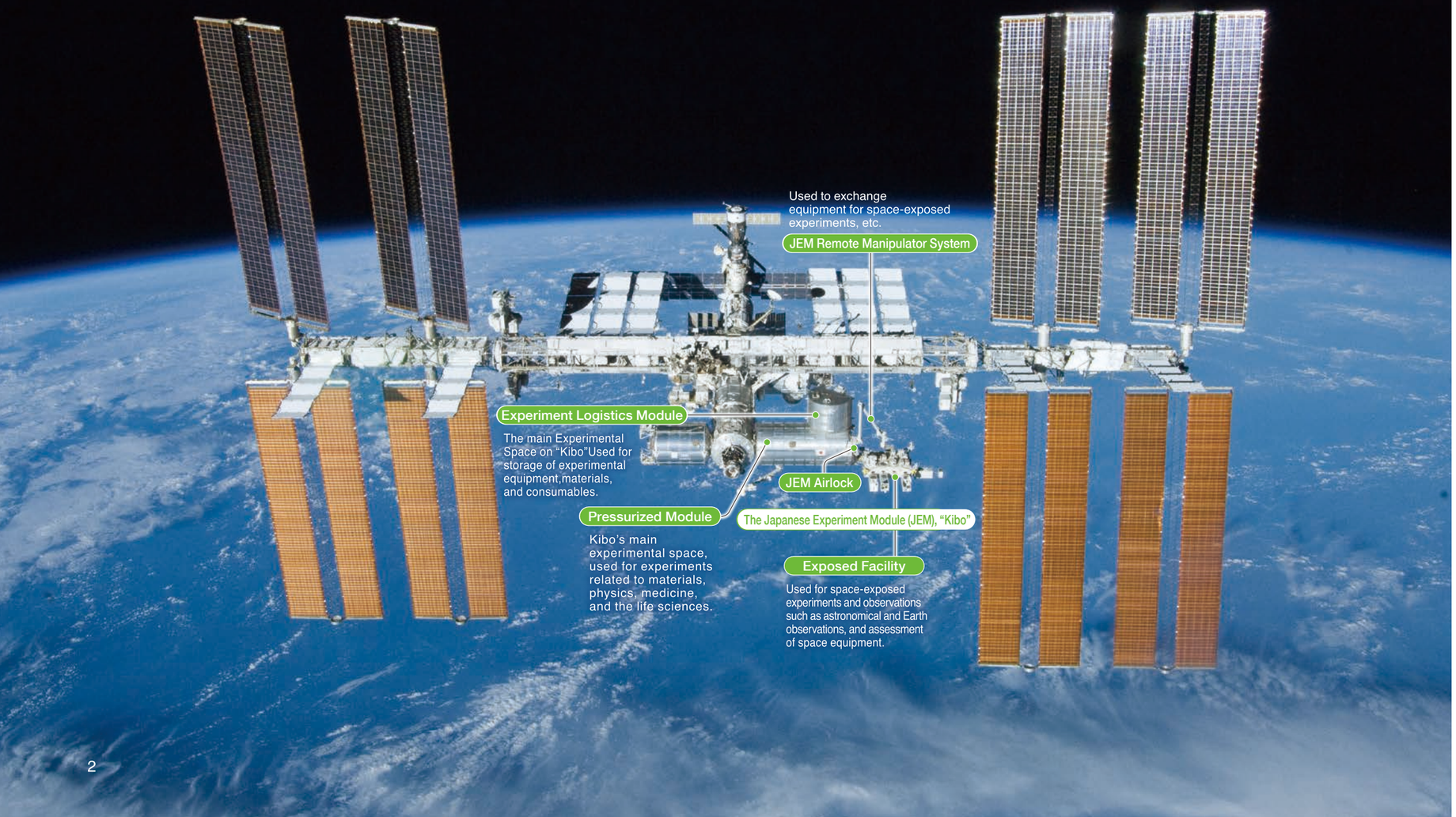
The JAXA Philosophy

Management Philosophy

"To realize a safe and affluent society using space and the sky."

Action Declaration

- Jubilation for human society
  We will provide enjoyment and surprise to people by evolving our lives.
- Aspiration for creation
  We will always aim for higher goals and continue to be aspired for creation by facing up to and overcoming any difficulties.
- Responsibility and pride
  We will faithfully act with responsibility and pride to confidently meet the expectations of society.



Greetings

SASAKI Hiroshi
Vice President
Director General for Human Spaceflight Technology Directorate
Japan Aerospace Exploration Agency (JAXA)

Effective April 1, 2020, I have been assigned as JAXA Vice President and Director General for Human Spaceflight Technology Directorate. I am also in charge of Space Exploration Center and Space Exploration Innovation Hub Center at JAXA. Looking back on my career, until seven years ago, I was working for Human Spaceflight Technology Directorate and then experienced several other areas at JAXA, namely the strategic planning division, space science and space exploration. With my new role, I am thrilled to boost up Human Space Exploration toward the future.

Human Spaceflight Technology Directorate is engaged in expanding human activity areas, promoting full-scale utilization of the unique space environment mainly through the operation and utilization of the International Space Station (ISS) and returning benefits to humanity and activities on Earth.

Japan's human spaceflight activities, which started in the 1980s, have been challenging, with various efforts to acquire new human spaceflight technology, and to create utilization outcomes, that are different from rockets and satellite technologies. Those newly obtained technologies are not limited to each technical field, but also to the establishment of methods such as system engineering and safety and mission assurance. These have been applied to many fields beyond rockets and satellites. Human spaceflight activities have greatly contributed to the society as a pioneer of research and development.

After the on-orbit operation of the ISS that started in the 2000s, the assembly of the "Kibo" has completed, followed by the first successful "Kounotori" flight in 2009. Since then, for the past 10 years, the "Kibo" has continuously been operational, 24 hours a day, 365 days a year, overcoming the various international tensions and natural disasters. Furthermore, as a permanent experimental facility in low earth orbit, JAXA took the pioneering role to encourage the participation of, not only the academic circles but also various players such as industry, private venture companies, students, and have also provided space utilization opportunities to many countries other than the advanced countries in space activities which has become a commonplace throughout the globe today.

In addition, the Japanese astronauts are performing tremendous jobs on the ISS. Thanks to their outstanding efforts with our ground folks, I am proud to acknowledge that Japan has become to play an instrumental role in human spaceflight in the international regime. As a result, the United States has invited Japan to join the international lunar exploration program as one of their major partners.

While globalization is now expanding and the speed of change in the situation is remarkable, Japan will continue to take on important roles and responsibilities as a major country in human spaceflight technology development, and will continue to engage in challenging research and development and provision of such technology. We believe that this will lead to the expansion and advancement of science and technology, industrial promotion, and international cooperation, and will serve as a stepping stone for future space activities.

1. Reliable operation and progress of the ISS, the orbiting human outpost. In particular, we will promote international contributions and increase our presence, through steady resupply by "Kounotori", the safe operation and advancing utilization of "Kibo", and activities of Japanese astronauts.
2. Creation of utilization results and deployment of acquired technologies through collaboration with international partners, industry and academia. Carrying out various experiments, based on international cooperation and strategies, through the dual utilization concept of the Space Exploration Innovation Hub, as well as the collaboration with the scientific community. And, sharing the achievements widely, not limited to human spaceflight activities but also with the terrestrial society.
3. Developing visions and scenarios for future on-orbit human spaceflight activities and the Moon to Mars international space exploration. Presenting a vision for the next 20 years as an experienced expert, and proposing scenarios to enable Japan's Basic Plan on Space Policy that covers the basic plan for the next 10 years.

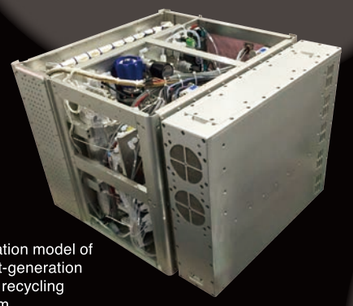
We will contribute to the human well-being and prosperity by pursuing the above efforts. I appreciate your understanding of our human spaceflight activities and I do look forward to your continued support and cooperation.

The Value and Future That "Kibo" Brings to Us

Since joining the ISS Program, Japan has been acquiring manned space technologies through this permanent human base in space with research capabilities. We have sown seeds in the exploratory research stage, and are now entering the harvesting stage. We will continue to utilize the unique features and capabilities of "Kibo" to improve our daily lives, strengthen industry, and enhance international cooperation.

Developing technology that places Japan at the forefront of human space activities

Through the development and operation of "Kibo" and "Kounotori", Japan has acquired cutting-edge technologies related to human activities in space. Examples include technologies for environmental control, rendezvous and docking with manned spacecraft, system engineering of large-scale international projects, and manned mission safety. In the field of technology for human space activities, competitiveness and flight-proven results are important. Therefore, continuous developme nt with specific long-term goals is essential. JAXA is working toward long-term human space activities lasting beyond a one-year stay by advancing research and space-based validation of Japan's unique technologies for air and water recycling and health maintenance. Our goal is to provide the de facto standard for such technologies. "Kibo" and "Kounotori" are vital platforms for this work.



Validation model of a next-generation water recycling system

Space Seeds for the Asian Future 2013 educational experiment.

Using the space environment to create new knowledge and value

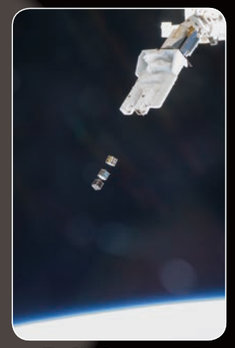
Since we began to utilize "Kibo" in 2008, we have focused on experiments that take advantage of the space environment, which has unique features such as microgravity and mixed high-energy radiation. Examples include biological experiments for developing medicine for osteoporosis, the production of high-quality protein crystals for the design of drugs with fewer side effects, the production of next-generation semiconductors, X-ray observations for understanding the origins of the universe, and the deployment of small satellites for new technology validation. In the future, we will apply the results of research in "Kibo" and the expertise accumulated through space experiments to new value creation. We will continue to improve features so that investment in research will be recognized as valuable not only to academics, but also to industry.

Image: NASA/Goddard Space Flight Center/Swift

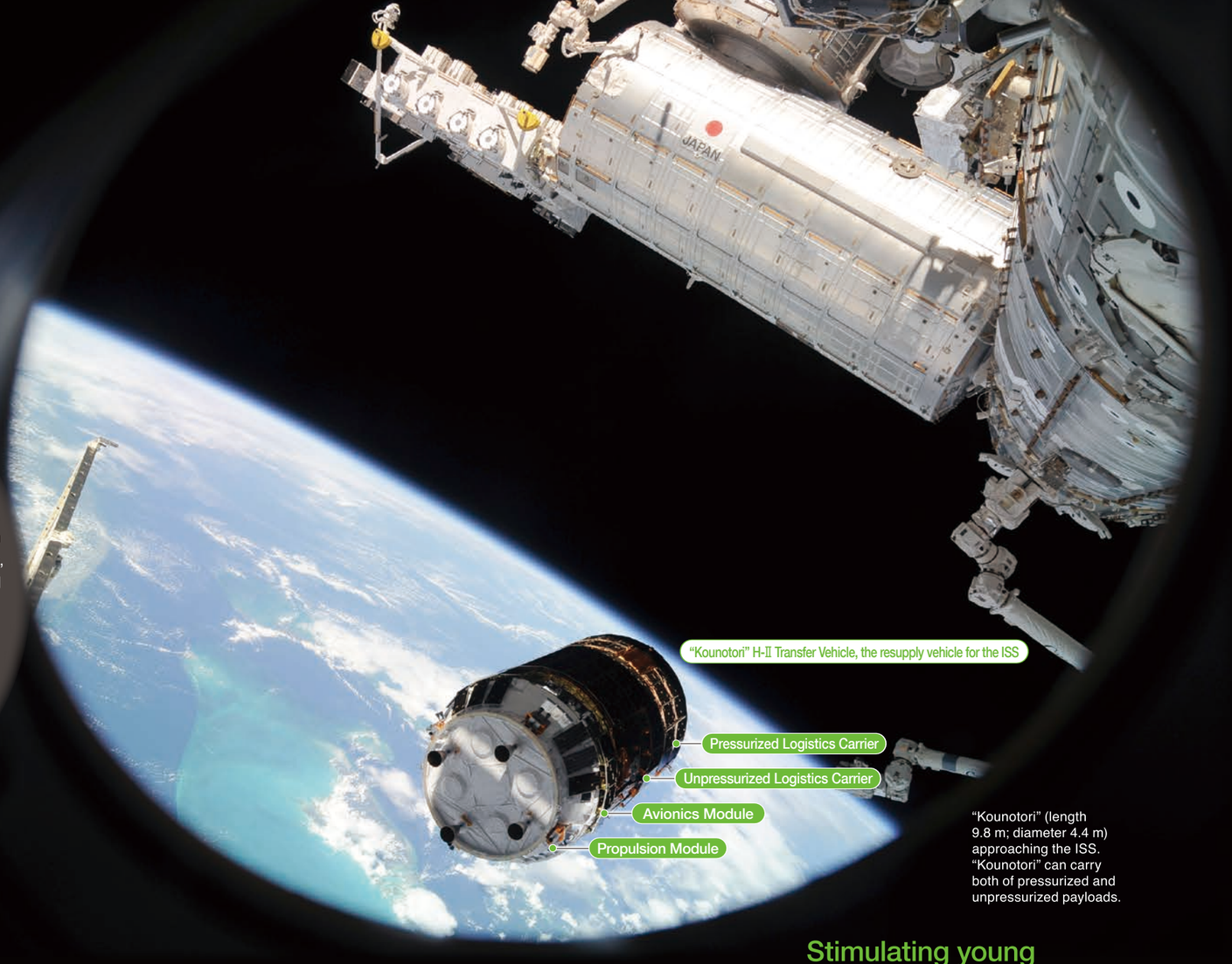
Artist's rendering of a black hole stripping gas from a neighboring star

Enhancing Japan's international presence as one of the most advanced nations in space

Through the development and continued safe operation of "Kibo" and "Kounotori", Japan has established its position as one of the most advanced nations in space. As a result, we have an excellent reputation as a reliable and irreplaceable partner in the ISS Program. Japan is the only country in Asia to participate in the ISS Program, and we have established cooperative relationships with other Asian nations to provide a gateway for utilizing the ISS. We are also actively pursuing small satellite deployment and significant experiments in the field of life science. We wish to make JAXA the most desirable partner for space experiments, and to achieve this, JAXA will contribute to the development of the Asian region by using technologies and know-how from the ISS.



The Pico Dragon, a small satellite by Vietnam, deployed from "Kibo"



"Kounotori" (length 9.8 m; diameter 4.4 m) approaching the ISS. "Kounotori" can carry both of pressurized and unpressurized payloads.

Strict safety requirements in human space activities strengthen our technology, leading to industrial development

"Kibo" and "Kounotori" require high levels of safety, reliability, and quality assurance. Over 650 Japanese companies have contributed to the development of "Kibo" and 400 to "Kounotori", resulting in the refinement of technologies that provide a base for Japan's space industry.

For example, "Kounotori" realized world first safe and reliable capturing and berthing with the ISS using the ISS robotic arm. Pursuit of the uncompromising safety required for "Kounotori" has given Japan a technological boost. This docking method and the system have been adopted by U.S. spacecraft developed after "Kounotori".

Flight proven technologies used in "Kibo" and "Kounotori" improve the brand image of Japanese companies and appeal our technologies to the world.

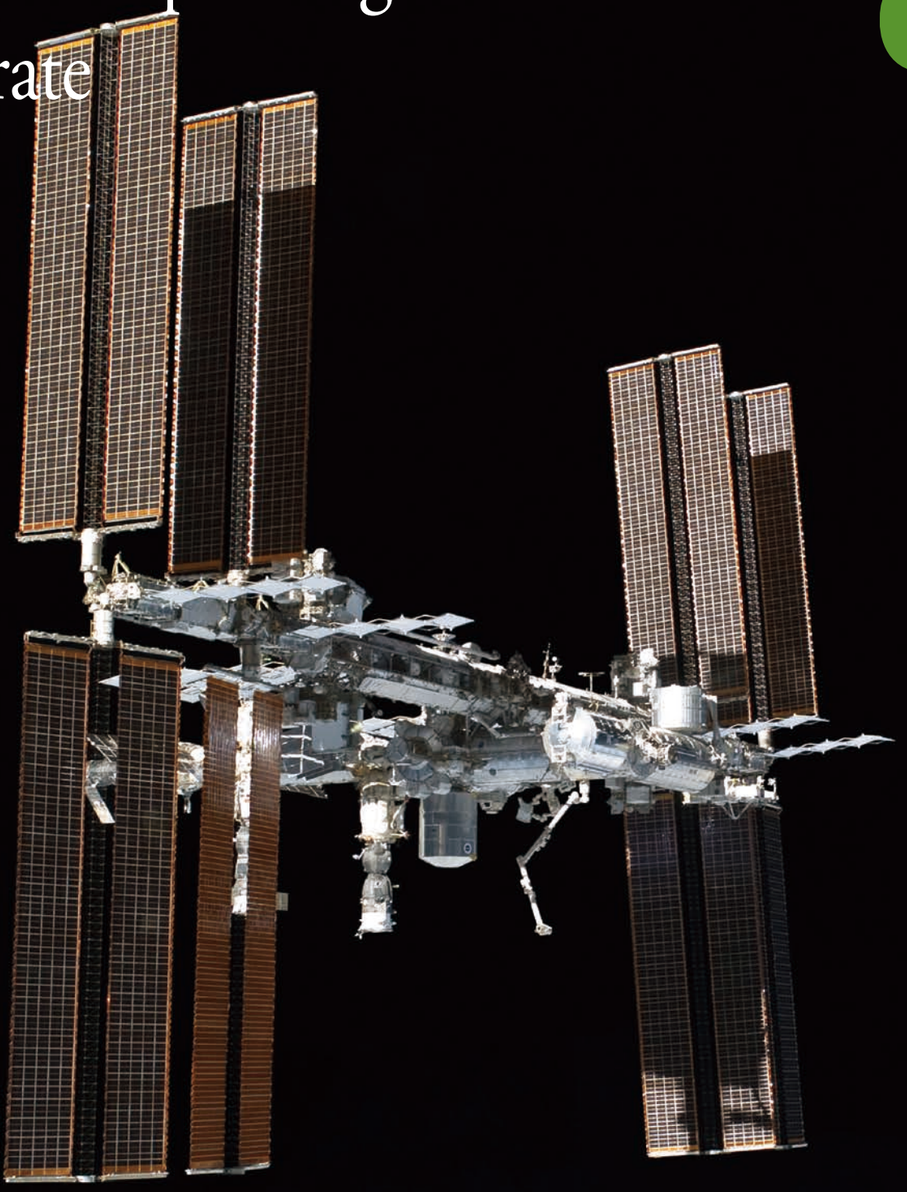
Stimulating young people's curiosity

JAXA provides many opportunities for young people to engage with the activities of Japanese astronauts and state of the art space technologies through direct communication with the ISS astronauts, their lectures, and articles in textbooks. These opportunities increase young people's interest in science and technology, and nurture the next generation. We will continue activities to stimulate young people's dreams and curiosity in science and technology.

Lecture by an astronaut

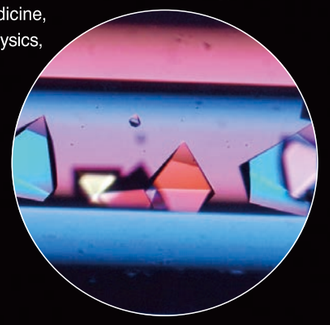
Activities of the Human Spaceflight Technology Directorate

By supporting the ISS, the JAXA Human Spaceflight Technology Directorate has contributed to Japan's strategy for science and technology and improving industrial competitiveness. We have also acquired technology that will be advantageous in international space exploration and space-related business, as well as in the cultivation of human resources.



Experiments in "Kibo"

"Kibo" is the largest laboratory on the ISS, and has unique features, such as its own airlock and robotic arm, that provide experimental environments both inside and outside the Pressurized Module. Through utilizing the space environment over the long term, we will demonstrate technology in the life sciences, space medicine, material sciences, physics, and the Earth and planetary sciences. We will also strive to contribute to science and technology and R&D for private companies.



High-quality protein crystals grown in "Kibo"

"Kibo" Mission Control Center

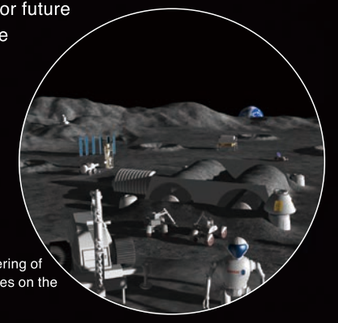
"Kibo" is operated by the "Kibo" Mission Control Center at the Tsukuba Space Center. Our flight directors and other mission control staff underwent rigorous training and certification to support ISS operations around the clock in three shifts in cooperation with the U.S. and other participating countries.

The successful development and steady operation of "Kibo" and "Kounotori" brought trust from international partners, and Japan has established a position of responsibility in space. We will continue to develop the technologies and human resources that will form the core of future international space exploration.

"Kibo" operations

Developing Future Space Technologies

Expanding our human explorations to the Moon, Mars, and beyond will require new technologies for extended space voyages. Through "Kibo" and "Kounotori", we are advancing the R&D of technologies for space medicine, environment control, and sensors to strengthen Japan's capacity for future international space exploration and space-related business.

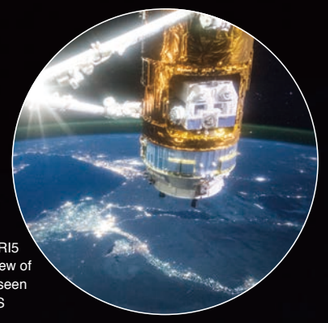


Artist's rendering of future activities on the Moon

Selection and training of Japanese astronauts

Japanese astronauts have collectively spent over 1000 days in space, placing us behind only the U.S. and Russia. JAXA has selected and trained 11 astronauts,11 of whom have traveled to space over 19 missions. A Japanese astronaut became the first Asian ISS commander. Through these activities, we are gaining top-level experience and expertise among leading nations in space.

Astronaut Kimiya Yui floating fresh fruit delivered by "Kounotori" during his stay on the ISS



KOUNOTORI5 and night view of the Nile as seen from the ISS

"Kounotori" operations

The ISS cannot be maintained without resupply missions. Japan's H-II Transfer Vehicle "Kounotori" performs this task. "Kounotori" is launched from the Tanegashima Space Center, carrying scientific equipment, test samples, food, and water. Only three countries have the capacity to carry supplies to the ISS: the U.S., Russia, and Japan. "Kounotori" has the largest cargo capacity in the world, and from 2016 it will be responsible for carrying the batteries that are a crucial part of maintaining the ISS. "Kounotori" not only contributes to the continuous operations of the ISS, but also plays a part in meeting new technical challenges, such as development of a re-entry capsule for sample return to Earth.

Astronaut Kimiya Yui operates a cell-culturing device in “Kibo”

Current and Future Outcomes from Space Environment Utilization

This section describes some of the experiments taking place in “Kibo” and what we are getting from these experiments. Many valuable outcomes are expected from future “Kibo” utilization.

Supporting a long-lived, healthy society

In microgravity, even healthy astronauts experience problems similar to those associated with aging, such as muscle and bone loss, but at even faster rates. Therefore, astronauts can serve as a model of accelerated aging, allowing us to search for ways to mitigate “locomotive syndrome” (deterioration of the locomotive system, including bone and muscle) that may be a key to extending healthy life.

In addition, without gravity-driven convection, we can grow larger and higher quality protein crystals in space. Such crystals are used to determine the detailed structures of proteins and contribute to structure-based drug design. We are exploring new research areas, such as epigenetics and regenerative medicine.

Photo: Tokyo Institute of Technology

Differentiating between two types of bone cells by using colored fluorescent proteins helps us learn the mechanism behind bone weakening.

Contributing to a prosperous, safe and secure life

Space technologies have various applications that can contribute to making our lives richer, safer and more secure. We are conducting many experiments that contribute to realizing a secure future world. such as observation of Earth environment from space, and research on plant growth in space that will improve crop cultivation on Earth.

Technologies acquired on the ISS have been applied worldwide, for example, in robotic surgery. In the future, by providing easily accessible opportunities for space experiments—such as confirming the durability of materials and demonstrating sensor technologies in space—we will make space accessible for various uses by more people.

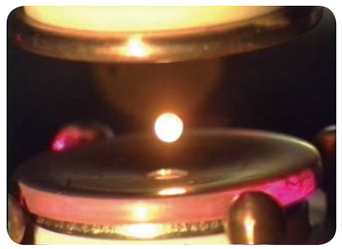
Arabidopsis thaliana (thale cress) cultivated on “Kibo” to improve Earth-based crop cultivation

Improving technologies in manufacturing

The microgravity environment of space allows us to perform activities that are difficult on Earth, such as creating materials and data acquisition. By utilizing absence of convection in space, we have obtained otherwise impossible results that are making considerable scientific contributions, such as producing large crystals for use in next-generation semiconductors and developing new materials such as high-quality gallium nitride semiconductors.

We are also tackling a wide variety of new technical challenges. These range from elucidating the mechanism behind producing smoother-tasting alcoholic beverages to measuring the accurate thermophysical properties of materials in their molten state, because in the microgravity environment, even very hot materials can be levitated easily without a container causing contamination.

Thus, the experiments in “Kibo” are producing innovations and technologies that help the manufacturing industry.



A high-temperature material levitated by Coulomb force in an Electrostatic Levitation Furnace on Earth. This allows to measure the properties of materials with high melting points.

Pioneering new fields

Humans were born into the gravity of Earth, and science and technology have been developed “with our feet on the ground.” The ISS is a unique facility for continuous microgravity experiments in space and observations that can be made only from space. This provides new viewpoints for various research fields, greatly contributing to scientific advancement.

Examples of this include elucidation of crystal growth mechanisms, many astronomical X-ray observations and new discoveries from meteorological observations spanning the Earth’s surface to high altitudes. In the future, this will extend to the exploration of dark matter and other pioneering investigations of the fundamentals of science that are possible only in space.

Ice crystals grown on “Kibo”. These crystals have much higher symmetry than those formed on Earth.

Expanding to unexplored space

Until recently, space development has been open to just a few countries. Now, there are a rapidly increasing number of countries launching satellites and engaging in human space missions. In the near future, we expect that space-based activities will become commonplace in many countries. We are developing various technologies for long-term human exploration of other celestial bodies, such as the Moon and Mars.

For example, we are developing methods for health management that will allow humans to live in space for long periods. In the search for methods to keep humans physically and mentally healthy, we are using an isolation chamber facility on the ground to evaluate the physiological and psychological effects of isolated and confined environments. We are also working on technologies for next-generation spacesuits, air and water recycling systems, and other technologies that will advance technological expertise for future manned space missions.

Next-generation spacesuits that are in development, part of research toward a lightweight spacesuit that can be used on the Moon’s surface.

Applying space-derived technologies

Japan’s space-derived technologies are expanding the potential to Earth-based applications and other countries. The new approach system for the ISS, called the Proximity Communication System, and docking method we have developed have been widely recognized and are now used by commercial spacecraft from the U.S., expanding Japanese companies’ business opportunities. The excellent performance of Japanese lithium-ion batteries, particularly on “Kounotori”, has led to them being adopted as the standard on the ISS—another example of world recognition of Japanese technologies.

Space activities contribute to the safety, reliability, and quality assurance of technology here on Earth. For example, the strict safety standaards developed for space industries are now being used in the aviation and automotive industries.Products developed for use in space have also been adopted as spin-off products on Earth including odor-reducing undergarments and cooling vest undergarments.

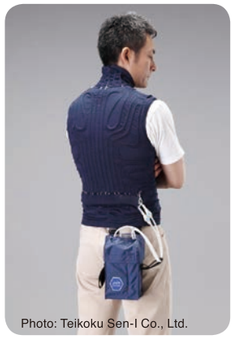
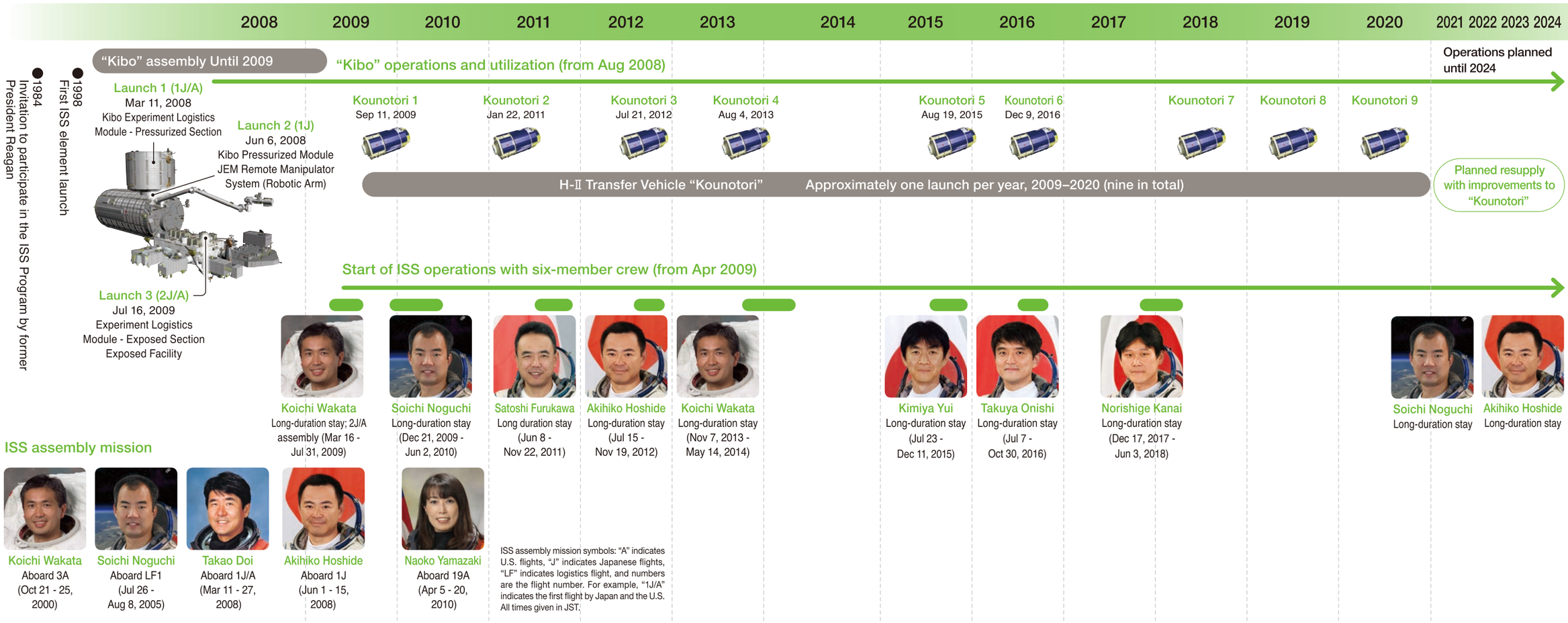


Photo: Teikoku Sen-I Co., Ltd.

A cooling vest undergarment developed through spacesuit research.

Japan's participation in the ISS Program



ISS assembly mission

Koichi Wakata
Aboard 3A
(Oct 21 - 25, 2000)

Soichi Noguchi
Aboard LF1
(Jul 26 - Aug 8, 2005)

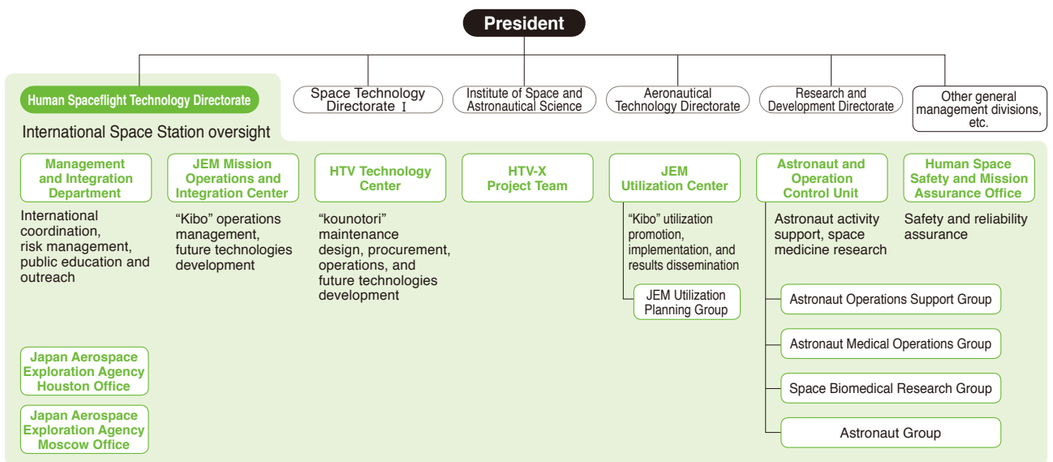
Takao Doi
Aboard 1J/A
(Mar 11 - 27, 2008)

Akihiko Hoshide
Aboard 1J
(Jun 1 - 15, 2008)

Naoko Yamazaki
Aboard 19A
(Apr 5 - 20, 2010)

ISS assembly mission symbols: "A" indicates U.S. flights, "J" indicates Japanese flights, "LF" indicates logistics flight, and numbers are the flight number. For example, "1J/A" indicates the first flight by Japan and the U.S. All times given in JST.

Organization of the JAXA Human Spaceflight Technology Directorate



About JAXA

The Japan Aerospace Exploration Agency (JAXA) was established in 2003 through combination of the Institute of Space and Astronautical Science (ISAS), the National Aerospace Laboratory (NAL), and the National Space Development Agency (NASDA). In Apr 2015 it became a National Research and Development Agency with the goal of maximizing Japan's R&D achievements and contributing to technology advancement in the world

- Budget (2019): ¥155.6 billion
- Staff (as of Apr 2019): 1546
- Offices: 20 domestic, 5 overseas

Night view and Sirius seen from ISS
Photo: JAXA/NASA