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

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

Kibo Utilization Network

↓Twitter

National Research and Development Agency
Japan Aerospace Exploration Agency,
Human Spaceflight Technology Directorate

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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.

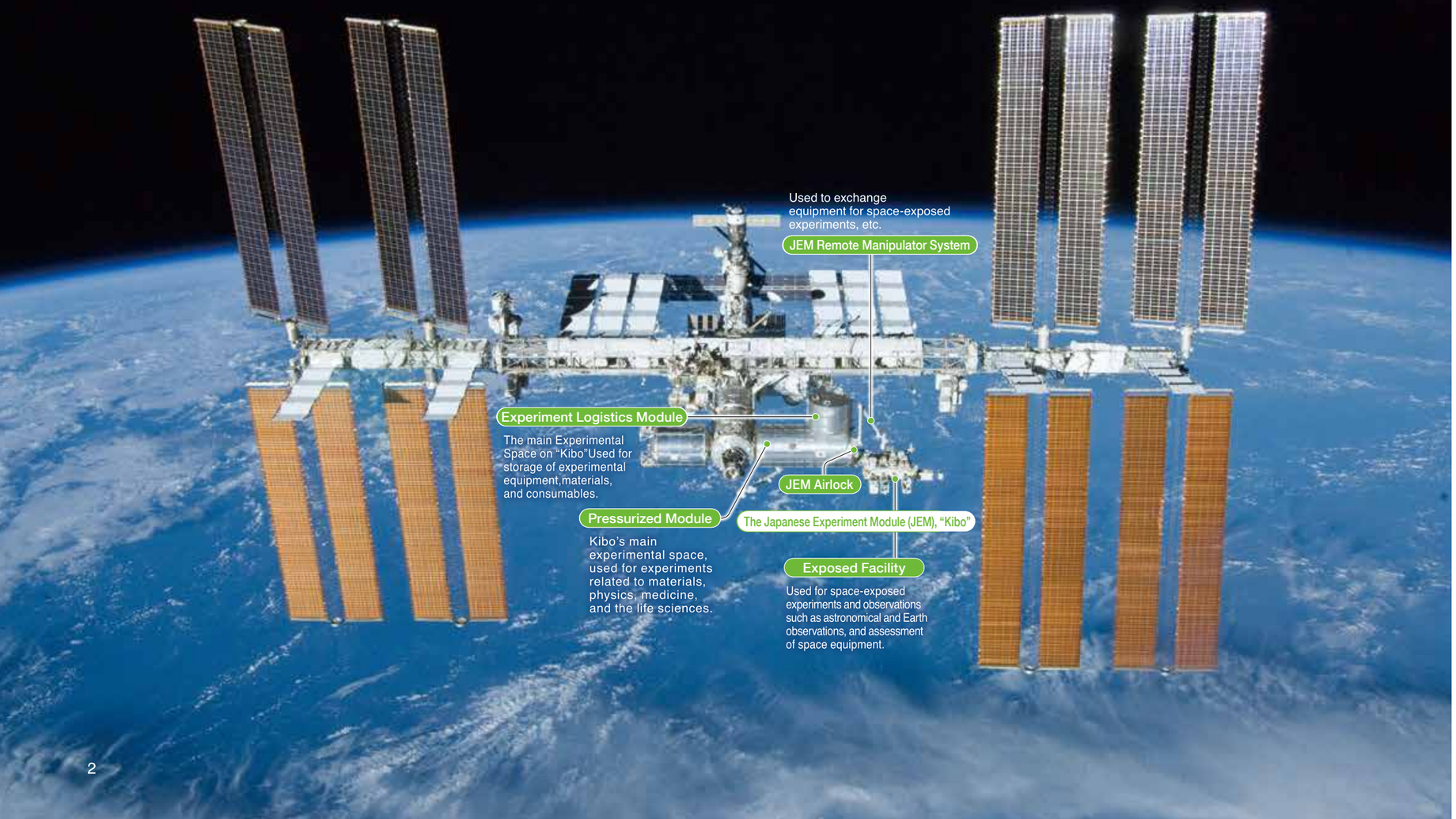
The JAXA Philosophy

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

Koichi Wakata
Vice President
Director General, Human Spaceflight Technology Directorate
Astronaut
Japan Aerospace Exploration Agency (JAXA)

I am honored to lead the dedicated men and women in the Human Spaceflight Technology Directorate and the Space Exploration Innovation Hub Center starting in April 2018 as Vice President of JAXA. I appreciate your support and cooperation as I take on this challenging task of producing fruitful results and tackling new issues in the agency.

Notably, Japan's human space activities are now reaching a critical turning point. The recent expansion of space activities in many countries around the world including those led by the private sector underline the fast-paced changing environment that surrounds Japan.

Policy decisions on the utilization of low Earth orbit (LEO), including the ISS, and the forms of Japan's participation in future international space exploration beyond LEO are imminent. We, at JAXA, need to further develop human space technologies fully leveraging Japan's global competence, pursue the establishment of "Kibo" as a research and development base by providing more accessible utilization service, and expanding cooperation with private and other organizations, as well as steadily promote and accelerate the efficiency of the "Kibo" operation forecasting future LEO utilization.

In pursuit of these goals, I will place particular emphasis on the Human Spaceflight Directorate addressing the following three major challenges:

Challenge 1 concerns the production of new utilization services with the Japanese Experiment Module "Kibo" and promoting the commercialization of such services in cooperation with the private sector.

Challenge 2 concerns striving to realize automation and autonomous operation of routine tasks in space by making the best use of technologies, such as AI and robotics, in response to a diversified "Kibo" utilization.

Challenge 3 concerns the technical assessment of the international human space exploration beyond LEO and the LEO activities in the future.

In the international space exploration beyond LEO, we need to accelerate the development of technologies where Japan should establish its predominance; and, in LEO activities, we should consider a prompt response to user needs and demonstrate continued LEO utilization already in an early phase.

Currently, many companies and entrepreneurial ventures are interested in utilizing outer space. This trend dictates that the Human Spaceflight Technology Directorate of JAXA must actively enhance activities that help results from space exploration take root in society, as well as its arduous research and development intended to help raise awareness for the wide-ranging effects of commercialization and utilization through the operation of "Kibo".

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.

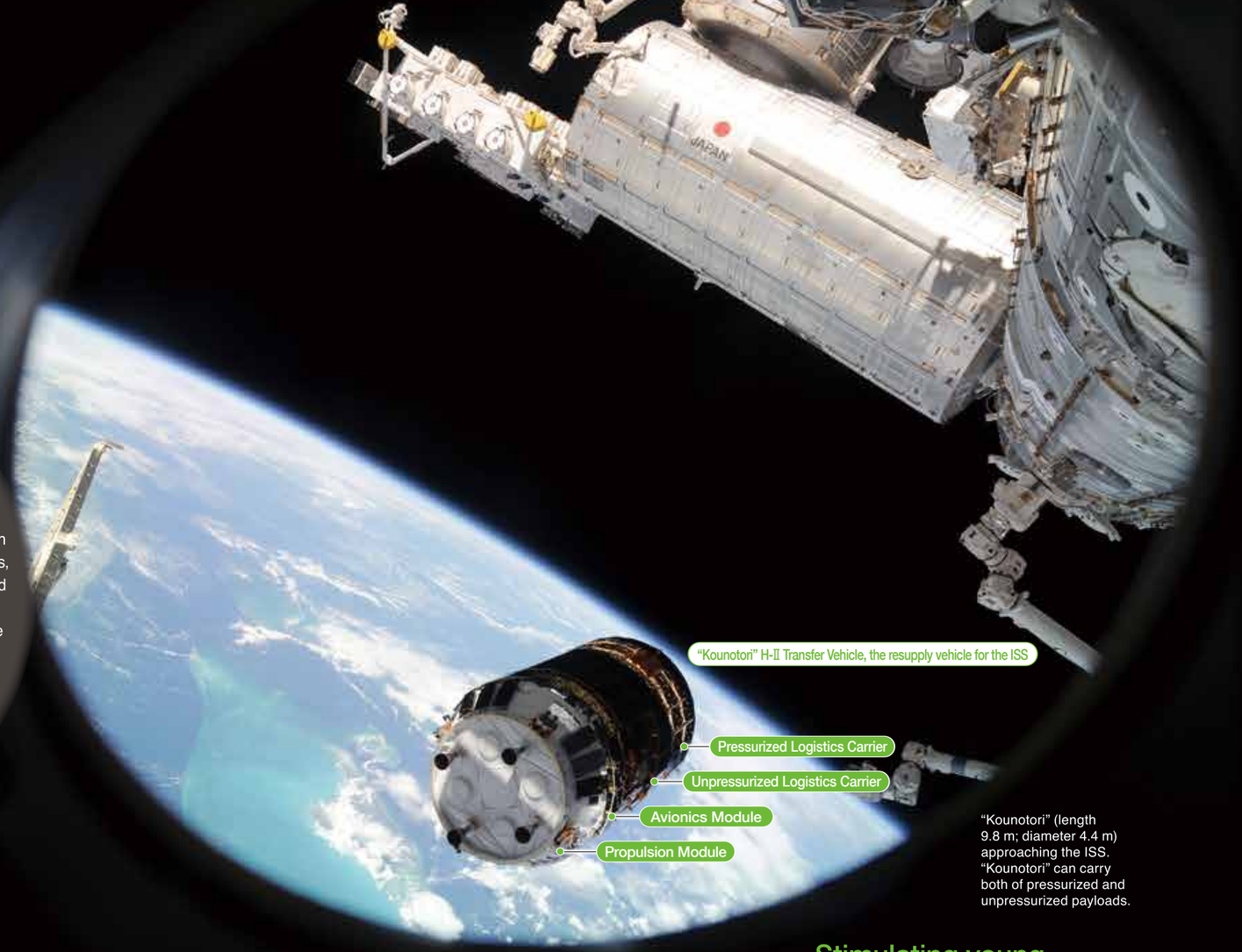
Image: NASA/Goddard Space Flight Center/Swift

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.

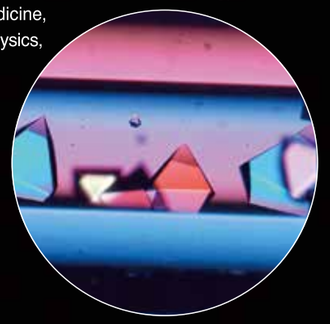
Lecture by an astronaut

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

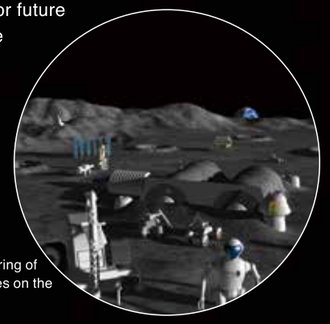
"Kibo" is operated by the "Kibo" Mission Control Center at the Tsukuba Space Center. Our flight directors and other mission control staff underwent rigorous training and certification to support ISS operations around the clock in three shifts in cooperation with the U.S. and other participating countries.

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

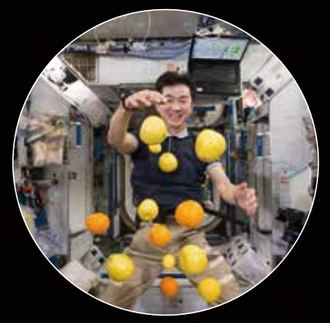
Expanding our human explorations to the Moon, Mars, and beyond will require new technologies for extended space voyages. Through "Kibo" and "Kounotori", we are advancing the R&D of technologies for space medicine, environment control, and sensors to strengthen Japan's capacity for future international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

2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

● 1984 Invitation to participate in the ISS Program by former President Reagan

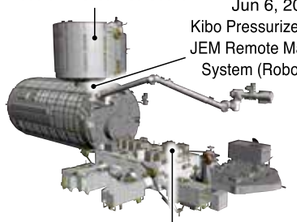
● 1998 First ISS element launch

"Kibo" assembly Until 2009

"Kibo" operations and utilization (from Aug 2008) → Operations planned until 2024

Launch 1 (1J/A)
Mar 11, 2008
Kibo Experiment Logistics Module - Pressurized Section

Launch 2 (1J)
Jun 6, 2008
Kibo Pressurized Module
JEM Remote Manipulator System (Robotic Arm)



Launch 3 (2J/A)
Jul 16, 2009
Experiment Logistics Module - Exposed Section
Exposed Facility

Kounotori 1 Sep 11, 2009
Kounotori 2 Jan 22, 2011
Kounotori 3 Jul 21, 2012
Kounotori 4 Aug 4, 2013
Kounotori 5 Aug 19, 2015
Kounotori 6 Dec 9, 2016
Kounotori 7
Kounotori 8
Kounotori 9

H-Ⅱ Transfer Vehicle "Kounotori" Approximately one launch per year, 2009–2020 (nine in total)

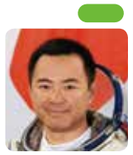
Planned resupply with improvements to "Kounotori"

Start of ISS operations with six-member crew (from Apr 2009)

Koichi Wakata
Long-duration stay; 2J/A assembly (Mar 16 - Jul 31, 2009)

Soichi Noguchi
Long-duration stay (Dec 21, 2009 - Jun 2, 2010)

Satoshi Furukawa
Long duration stay (Jun 8 - Nov 22, 2011)



Akihiko Hoshide
Long-duration stay (Jul 15 - Nov 19, 2012)

Koichi Wakata
Long-duration stay (Nov 7, 2013 - May 14, 2014)

Kimiya Yui
Long-duration stay (Jul 23 - Dec 11, 2015)

Takuya Onishi
Long-duration stay (Jul 7 - Oct 30, 2016)

Norishige Kanai
Long-duration stay (Dec 17, 2017 - Jun 3, 2018)

Soichi Noguchi
Long-duration stay (about six months from the end of 2019)

Akihiko Hoshide
Long-duration stay (about six months from May 2020)

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

President

- **Human Spaceflight Technology Directorate** — International Space Station oversight
  - **Management and Integration Department** — International coordination, risk management, public education and outreach
  - **JEM Mission Operations and Integration Center** — "Kibo" operations management, future technologies development
    - CALET Project Team
  - **HTV Technology Center** — "kounotori" maintenance design, procurement, operations, and future technologies development
  - **HTV-X Project Team**
  - **JEM Utilization Center** — "Kibo" utilization promotion, implementation, and results dissemination
    - JEM Utilization Planning Group
    - Kibo utilization Promotions Office
  - **Astronaut and Operation Control Unit** — Astronaut activity support, space medicine research
    - Astronaut Operations Support Group
    - Astronaut Medical Operations Group
    - Space Biomedical Research Group
    - Astronaut Group
  - **Human Space Safety and Mission Assurance Office** — Safety and reliability assurance
  - Japan Aerospace Exploration Agency Houston Office
  - Japan Aerospace Exploration Agency Moscow Office
- Space Technology Directorate Ⅰ
- Institute of Space and Astronautical Science
- Aeronautical Technology Directorate
- Research and Development Directorate
- Other general management divisions, etc.

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 (2018): ¥154 billion
- Staff (as of Mar 2018): 1525
- Offices: 20 domestic, 5 overseas

Night view and Sirius seen from ISS

Photo: JAXA/NASA