Bringing Space Utilization Opportunity Closer

Space Is Your Laboratory

Exposed experiment and verification on the International Space Station

Experiments running now on the Japanese Experiment Module “Kibo” aboard the International Space Station!

JAXA
Explore to Realize

Do Space Experiments Seem Beyond Your Grasp? "Kibo" Allows Easier Access to Space for Your Experiments.

Most researchers likely consider space to be out of reach for their experiments. However, the Exposed Facility of the Japanese Experiment Module (JEM) "Kibo" on the International Space Station (ISS) provides various opportunities for experiments, components, parts verification, and other activities.

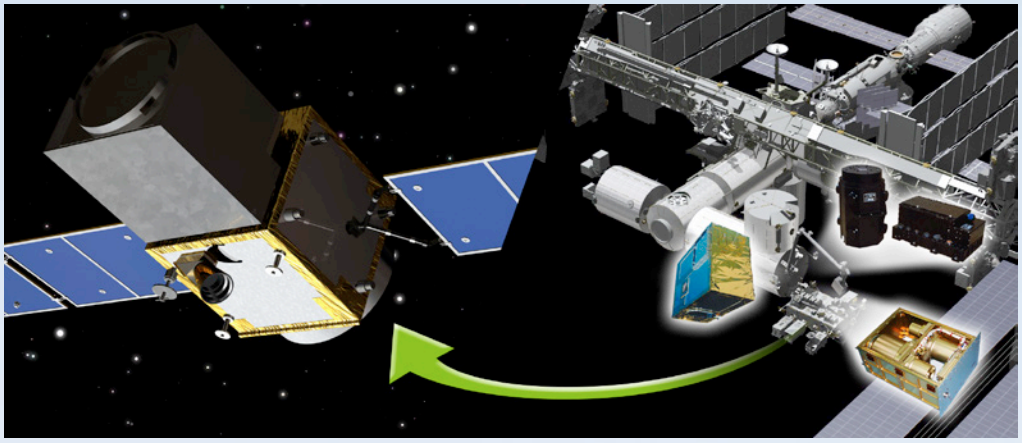
1 Using space as your laboratory opens up amazing possibilities

What can we do on the ISS?

The ISS allows for many new possibilities. The space environment at an altitude of 400 km is harsh—a vacuum with nearly no gravitational effects, filled with radiation and temperatures ranging from positive to negative 150 °C.
This enables testing of devices, components, and materials in the toughest environments. For example, this is the perfect place to test advanced observation sensors before launching them in a satellite.

Example 1 **On-orbit testing of a high-performance small GPS-Receiver (GPSR)/Wheel unit** **(p.6)**

Verification testing in space of a component planned for mounting on a small satellite



The ISS orbits the Earth in approximately 90 minutes and has a wide field of view. This makes it an effective platform for space-based Earth observation.

Example 2 **Capture video images using a high-definition video camera** **(p.6)**

Beautiful images captured from space are being used for education and disaster monitoring.

JEM Exposed Facility

❶ JEM Exposed Facility (JEM-EF)

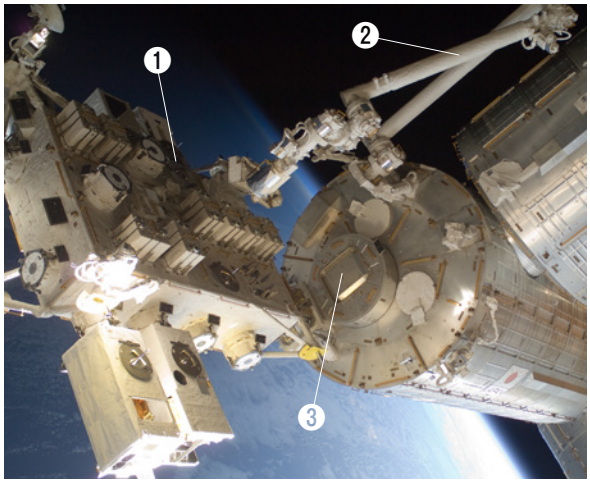
Experimental equipment can be exposed into space to perform experiments, like the intravehicular activity (IVA)-replaceable Small Exposed Experiment Platform (i-SEEP) and the Exposed Experiment Handrail Attachment Mechanism (ExHAM) (details on p. 3-4).

❷ JEM Remote Manipulator System (JEMRMS)

JEMRMS is a robotic arm used to exchange experimental equipments and deploy small satellites.

❸ JEM Airlock

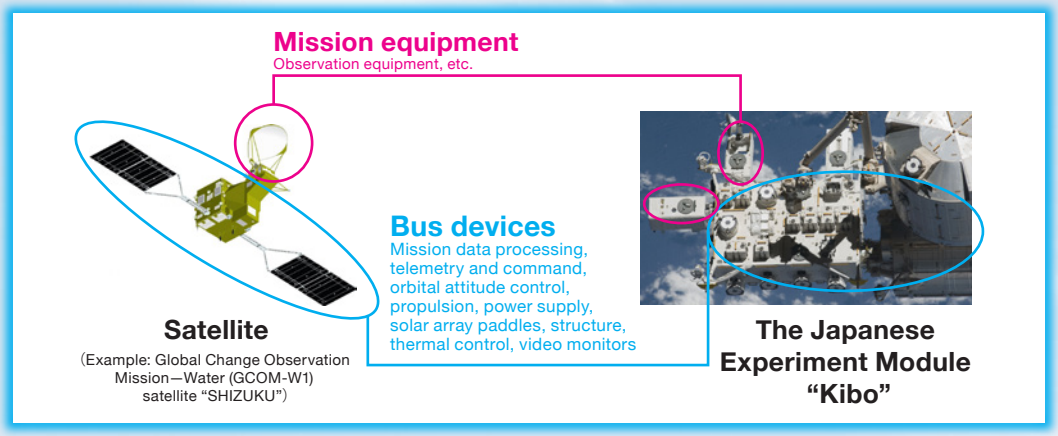
This airlock is used to transfer equipment between a pressurized module and Exposed Facility.



2 Benefits of experiments on "Kibo"

Benefit 1: The ISS provides power, communication functions and heat dissipation.

Functions equivalent to bus devices on a satellite (power supply to experimental devices, coolant circulation for device cooling, communications functions for data acquisition, etc.) can be provided from the ISS and JEM-EF, so technology verifications and experiments can be achieved by focusing on only mission equipment development.



Benefit 2: Flexible launch scheduling

4-5 launch opportunities per year using Japanese, U.S., and Russian vehicles.
The period between equipment handover to JAXA and launch can be as short as 2 months

Benefit 3: Reduced vibration level

Equipment is packed in a soft cushion bag that reduces vibration to about the same level as truck transport. So, there is less need for concern regarding anti-vibration measures.

Equipment is launched in cushion bags.

Benefit 4: Equipment can be returned after completion of the experiment

After experiments, samples and equipment can be returned to Earth for analysis and evaluation, as needed.

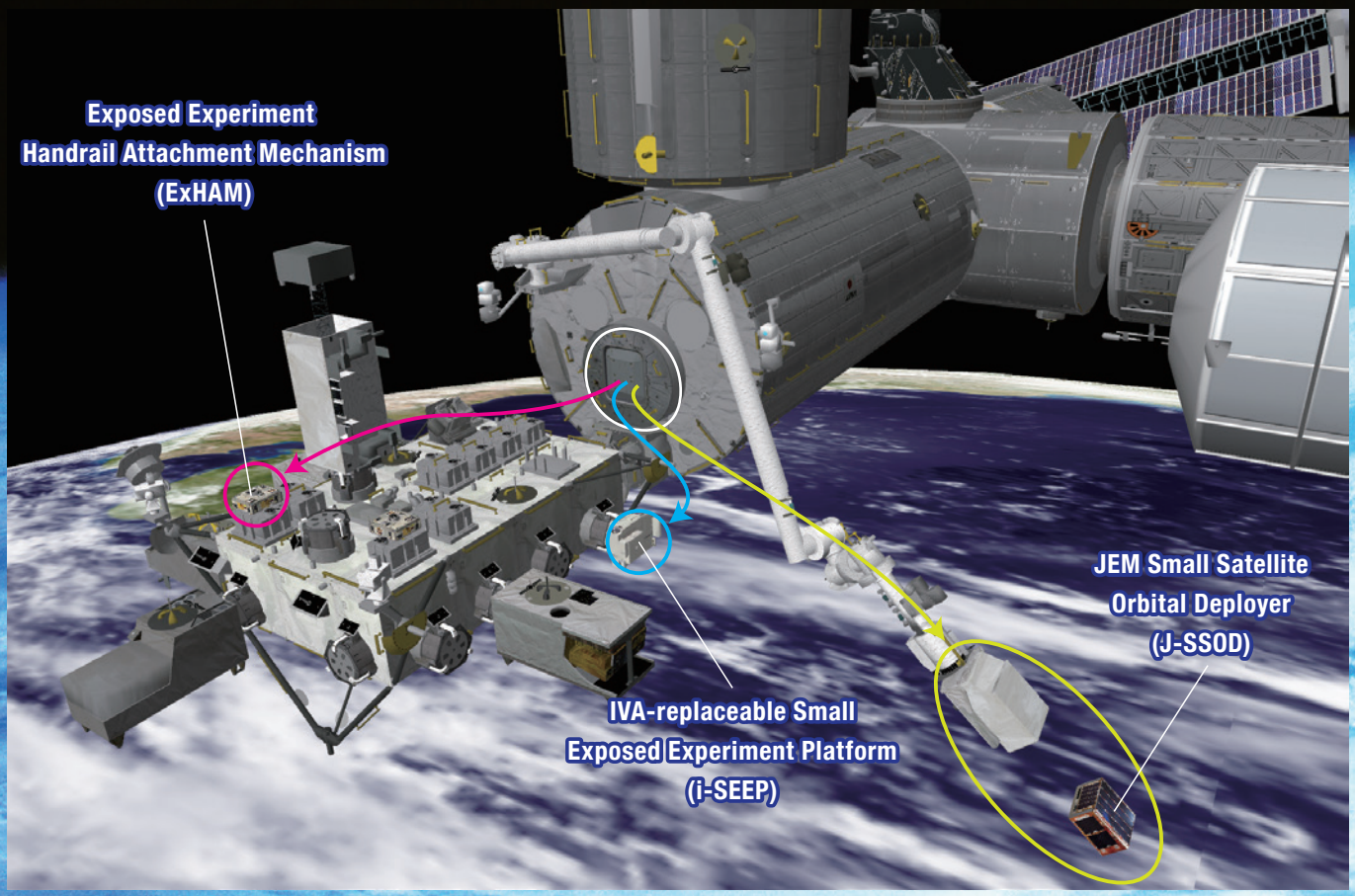
Main Experimental and Verification Methods aboard JEM-EF on "Kibo"

JEM Airlock and JEM RMS enable unique functions, providing opportunities to realize frequent, easy, and varied space experiments aboard the JEM Exposed Facility (JEM-EF).

The IVA-replaceable Small Exposed Experiment Platform (i-SEEP) provides power and communications resources, so only mission equipment needs to be developed. This allows for easier technology verifications and Earth and astronomical observations.

The JEM Small Satellite Orbital Deployer (J-SSOD) allows for deployment of small satellites from "Kibo". As of 2015, "Kibo" has deployed 90 domestic and international satellites for a variety of purposes, including communications, Earth observation, and technology verification.

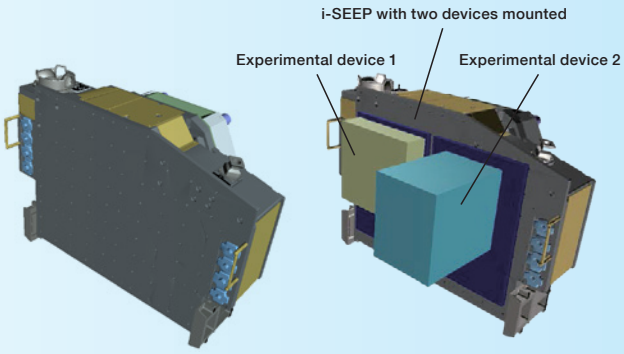
It was previously difficult to know how materials were actually damaged by the harsh space environment because of the difficulty of bringing them back to Earth for analysis. However, this problem is solved by the Exposed Experiment Handrail Attachment Mechanism (ExHAM), which can be easily moved by JEMRMS. Materials mounted on ExHAM can be taken into "Kibo" through the JEM Airlock and returned to Earth for analysis.



IVA-replaceable Small Exposed Experiment Platform (i-SEEP)

i-SEEP expands possibilities for exposed testing and verification of equipment for use in space, holding several payloads up to 50 cm × 70 cm × 35 cm each and 200 kg in total

Item	Characteristics
Power	28 V DC (rated) 2 ch, up to 200 W/ch
Communications	Mid-speed Ethernet, Ethernet II, or IEEE 802.3m 2 ch Wireless LAN: IEEE 802.11n, 1 access point Low-speed MIL-STD-1553B, 2 systems USB, USB 2.0, 2 ch Video NTSC, 1 ch
Downlink	Max 60 Mbps including overall equipment data
Heat dissipation	400 W (max.) (2 cold plates attached to experimental equipment) Cold plate temp.: 16–40 °C
Vibration environment	Launch 9.47 Grms Return 8.29 Grms (Values do not consider packaging for delivery. Typical packaged values are available separately.)



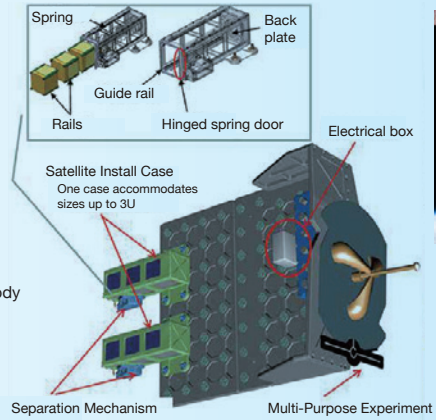
i-SEEP with no equipment mounted

IVA-replaceable Small Exposed Experiment Platform (i-SEEP)

JEM Small Satellite Orbital Deployer (J-SSOD)

The purpose of operation is up to you. J-SSOD expands opportunities to deploy small satellite from “Kibo”.

Item	Characteristics
Satellite size[1]	CubeSat 1U, 2U, 3U*1 50-cm-grade satellite: 55 cm × 35 cm × 55 cm
Load mass	CubeSat standard: < 1.33 kg per 1U; 50-cm-grade satellite: < 50 kg
Orbital altitude*2	Elliptical orbit with altitude of 380–420 km
Orbital inclination	51.6°
Ballistic coefficient	<100 kg/m2
Insertion direction	Nadir-aft 45° from ISS nadir side in terms of ISS body coordinate system (to avoid collision with the ISS)
Insertion velocity	1.1–1.7 m/s
Life expectancy on orbit*3	Approx. 100–450 days

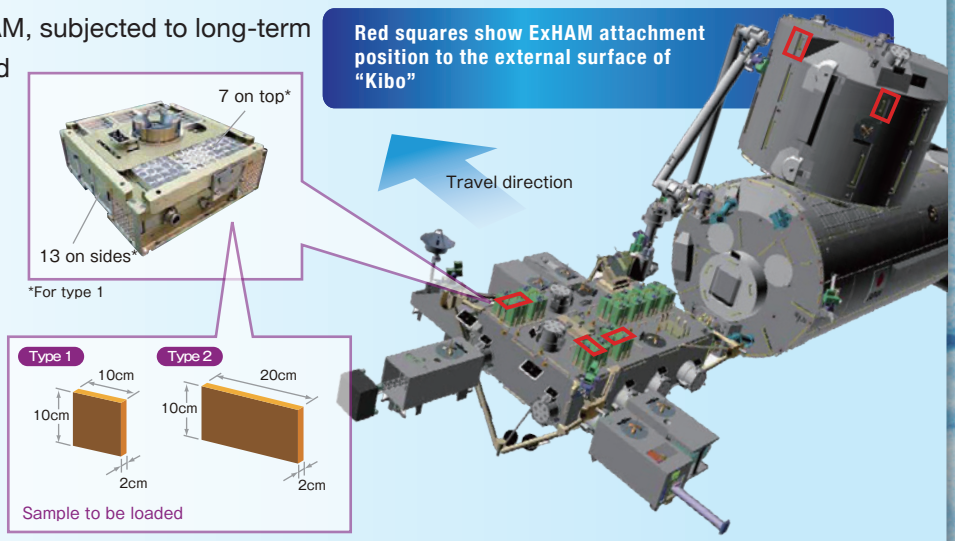


*1 CubeSat specification: 10 cm (W) × 10 cm (D) Height: 1U (10 cm), 2U (20 cm), 3U (30 cm)
*2 Depends on ISS altitude at time of deployment
*3 Depends on ballistic coefficient, release altitude, solar activity, satellite size, etc.

Exposed Experiment Handrail Attachment Mechanism (ExHAM)

Sample can be loaded on ExHAM, subjected to long-term exposure to space, and returned to Earth, for spacecraft development, capture of cosmic dust, etc.

- ExHAM can be attached onto the external area of “Kibo”. (External dimensions: approx. 45 cm × 10 cm × 27 cm; mass: approx. 12 kg)
- Samples 10 cm × 10 cm (type 1) and 10 cm × 20 cm (type 2) are available.
- Up to 7 samples can be attached to the upper ExHAM surface, 13 samples on the sides.



Project Flow

Project Start

Call for experiments

Applications for experiments are accepted from universities, research organizations, and companies.

Experiment selection

Experiments are selected based on their expected results.

Consideration of experimental conditions

The details of space experiments are cooperatively determined by researchers and JAXA.

Launching to the ISS

Equipment and samples are transported to the ISS in a packaged state.

Performing experiments on "Kibo"

Experiments are performed on "Kibo". All obtained data can be downlinked to Earth.

Sample return to Earth and handover

Upon request, samples and equipment (other than satellites) can be returned to Earth and handed over to the user for analysis.

"Kibo" is a laboratory that allows for unique experiments in space. JAXA has accumulated technology and know-how related to manned space missions to support new ideas for R&D using the space environment.

Q What are the details of the space environment outside the ISS?

A High vacuum (10^{-5} Pa; 1/10 billionth the atmospheric pressure of Earth), mixed high-energy radiation (ultraviolet rays, etc.), atomic oxygen, wide temperature range (±150 °C), etc.

Q What is the orbit of the ISS?

A The ISS orbits at an altitude of approximately 400 km, in an elliptical orbit with inclination 51.6° at a torque equilibrium attitude. The ISS orbit degrades by approximately 200 m per day on average due to atmospheric resistance, so re-boosts are periodically performed. The actual orbital altitude thus varies between 350km and 460km.

Q Will JAXA operate small satellites?

A Satellite operation is the responsibility of the user.

Q How long can small satellites remain in space?

A Assuming satellite release at an altitude of 400 km, a CubeSat re-enters the atmosphere after approximately 250 days, and 50-cm-grade satellites after approximately 1.5 years, ending the mission. Lighter satellites and those with larger surface areas subject to atmospheric resistance will fall from orbit sooner.

JEM Exposed Facility Usage Examples

Video acquisition via high-definition video camera

Video recording using a commercial camera, mounted on the first-generation i-SEEP.
Image acquisition starts in 2016.

Goals

- **Acquisition of video images for public relations and education**
  Exposed observation of rendezvous with a transport unit and detailed images of the Earth's surface have many uses for public relations and education.
- **Disaster observation**
  Conditions related to disaster situations can be provided to relevant agencies, aiding in rescue and recovery operations.
- **Verification of a commercial product in space**
  Verification is performed of whether commercial products (such as high-definition video cameras) can be used for extended periods in space.

Images from a high-definition video camera (acquired during a previous mission)

A large low-pressure vortex against the blue Earth

Flooding of the Amur River (natural disaster observation)

Winter in northern Japan and the Tsugaru Strait

On-orbit verification of a high-performance small GPS-R/Wheel unit

In-space verification of equipment for small satellites. Mounted on the first-generation i-SEEP, with verification starting in 2016.

Goals

- **Commercial product verification**
  In-space verification of the GPS/Wheel Demo Unit comprising consumer products. Verification result prompts utilizing low-cost commercial units/parts for small satellites, leading industry expansion and improvement of the industrial competitiveness of satellite parts manufacturer.

Small satellite deployment missions

Various small satellites developed by universities and private companies worldwide have been deployed from "Kibo".

Goals

- **Technology verification for high-speed communications, meteorological data acquisition, space debris measures, etc**
- **Video image acquisition and Earth observations using a thermal infrared camera.**
- **Human resource development aiding the training of personnel for space development in Japan and other Asian countries.**

CubeSats deployed into space

Material exposure missions

Direct exposure of materials for space-related products, followed by collection, analysis, and evaluation.

Goals

- **Development of new materials for use in space**
  Investigating the results of exposing various materials to the radiation and other harsh conditions of space contributes to the creation of new durable materials with excellent properties.
- **Appraisal of highly reliable materials**
  Direct exposure to space environments allows evaluation of highly reliable materials.

A materials exposure mission started in 2015

National Research and Development Agency

Japan Aerospace Exploration Agency

Human Spaceflight Technology Directorate

JEM Small Satellite Orbital Deployer (J-SSOD)
http://iss.jaxa.jp/en/kiboexp/jssod/
Exposed Experiment Handrail Attachment Mechanism (ExHAM)
http://iss.jaxa.jp/en/kiboexp/ef/exham/

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