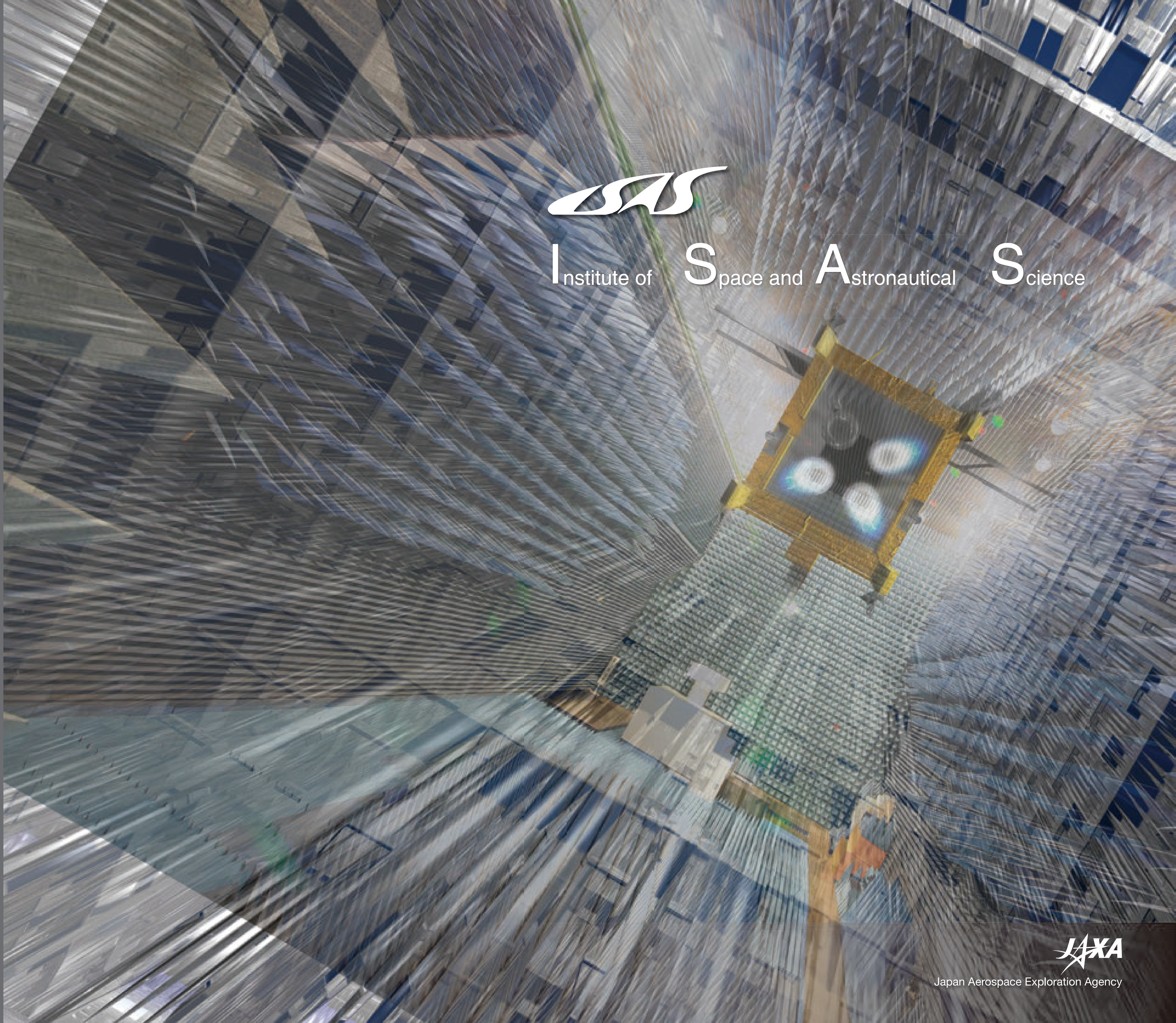
Institute of Space and Astronautical Science



Japan Aerospace Exploration Agency

Institute of Space and Astronautical Science

3-1-1 Yoshinodai, Chuo-ku,
Sagamihara, Kanagawa 252-5210, JAPAN

http://www.isas.jaxa.jp/

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Towards the Affluent Future Pioneered by Space Science

Greetings

Hitoshi KUNINAKA, Director General of ISAS

The Institute for Space and Astronautical Science (ISAS) has continued to take on challenges in new domains related to aircraft, rocketry, high-altitude atmospheric observations, space telescopes, and planetary exploration, while also revamping our organizations, members, and jurisdiction. Central issues for our plans include "astronomy over multiple wavelengths" and "planetary exploration founded on materials."

We will perform observations at wavelength ranges that are absorbed by Earth' s atmosphere—gamma-rays and X-rays, ultraviolet and infrared light, and radio waves—and in collaboration with ground telescopes, we will attempt to elucidate the 13.7-billion-year history of the universe. We will also send probes directly to other objects in our solar system, using in situ observations and sample returns to investigate the substances that constitute them, thereby revealing the processes that have occurred over 4.6 billion years of our solar system' s evolution. To make this possible, we will also advance research and develop technologies to support future space-oriented science and engineering.

ISAS encourages free and vigorous discussions that integrate science and engineering and builds consensus for mission planning. Then, with ISAS taking ultimate responsibility, it defines responsibility-sharing among participating organizations and takes the lead in systems development and space operations that enable better performance.

International collaboration has dramatically deepened over the past decade. Previous ISAS accomplishments have garnered respect from throughout the world, garnering sufficient recognition to be invited for participation in joint international projects. As these missions become increasingly large and complex, and as they extend into ever-deeper regions of space, strategic provision of Japanese expertise will aid in the realization of Big Science projects that could not be accomplished through the efforts of any single country.

We also implement measures to return our results to society. We actively publish scientific data acquired through our space activities and build systems and mechanisms that can be freely used. We furthermore strive to implement ground-based engineering technologies with high affinity for social activities.

As a core institute conducting space science researches

Missions of ISAS

The missions of ISAS aim to push ahead academic researches through the planning, development, flying experiments, operations and result production of characteristic and excellent space science missions consistently with the cooperation from universities, institutes in Japan and each foreign space institutes with the use of satellites, probes, sound rockets, big balloons and international space station.

The biggest advantage of ISAS is that researchers of space engineering and space science cooperate with each other to research and develop, which means that engineers lead science missions with advanced technologies and new technologies that scientists expect can be developed efficiently.

- To solutions to the fundamental problems of the modern space science and make them common intellectual properties of the society
- To create and execute new exploration programs such as landing on celestial bodies like the moon, the Mars and its satellites and collecting extraterrestrial materials and going back to the earth through the close cooperation between space science and space engineering.
- To continuously evolve the space transportation system to execute missions with lower cost and higher frequency.
- To sustainably realize advanced space science missions with the cooperative structure that universities and institutes from both inside and outside the country work together according to the Inter-University Research Institute System.
- To cultivate talents to get involved in space development and researches on space science.
- To contribute to the space development of Japan including space utilization.

The ISAS is going to put scientific satellite and exploration programs which will become more and more large-scale and complicated in the future, into practice, through the cooperation with the engineers and researchers with excellent administrative abilities and experience from JAXA.
At the same time, by conducting demonstrations of advanced technologies promptly with the use of the Epsilon rockets, which is a way to execute missions with lower cost and higher frequency, we will make more contributions to the developmentnt o space exploration including the space utilization prompted by JAXA and private companies.

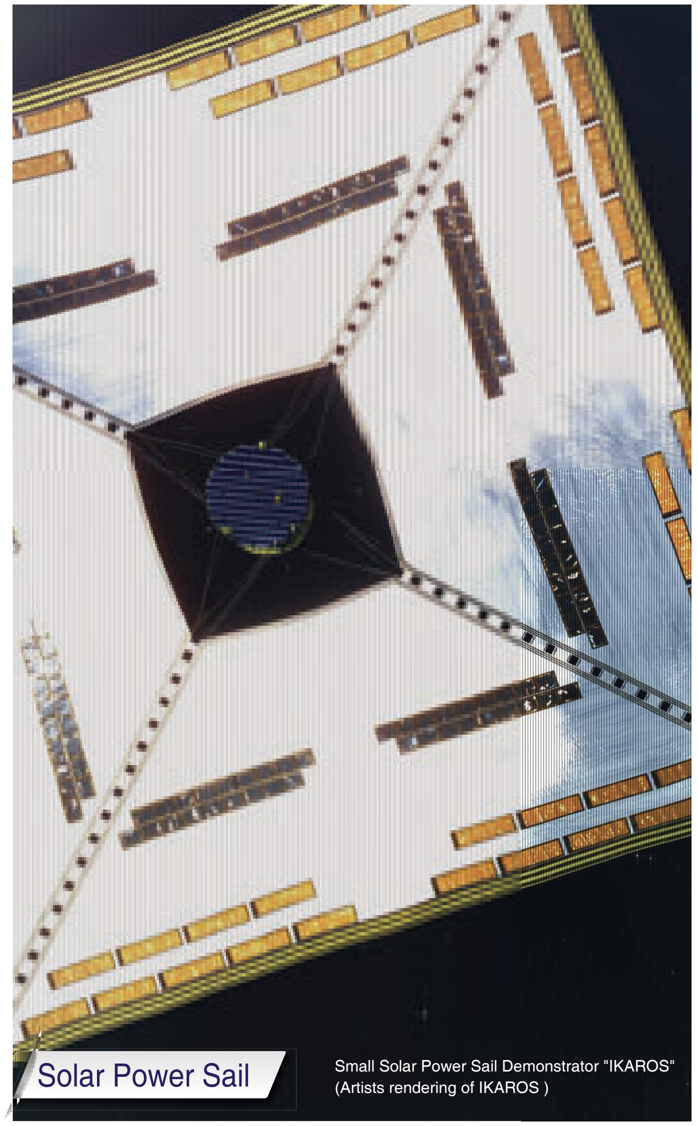
Researches and Development Making the Impossible Possible

"It is because of high risk that it is the frontier, and it is because of difficult projects that we can expect great achievements." Researchers with such a will are conducting researches every day. The space engineering is a treasure house of new technologies and it is expected to have great development in the future when successfully developed.

Space: The Frontier for Humankind

The space is still a frontier for humankind. The space requires for technologies under environments completely different in gravity, pressure or temperature from what are natural on the ground. To perform activities outside the atmosphere, facing all the engineering problems under sever or unknown environments, we have to keep developing new technologies with high reliability.
Space engineering consists of various specialized fields and we are pursuing extreme performance and reliability in each of them. However, it is not enough for us to design and realize advanced hardware such as rockets, satellites and probes by only developing advanced technologies in each field. To achieve a purpose, we have to harmonize each technology transversally as a system. The system integration to combine and harmonize these technologies is also an important subject of our institute.
The progress of space engineering has made direct contributions to the expansion of human' s area of activity and knowledge. At the same time, besides transportation, the progresses of space technologies have been integrated with communication, positioning and earth observation technologies and are closely related to our everyday life. With this background, our institute is conducting basic researches in the related fields of space engineering and is developing and demonstrating technologies that help to solve all the advanced problems not only in space engineering but also engineering in general.

Solar Power Sail



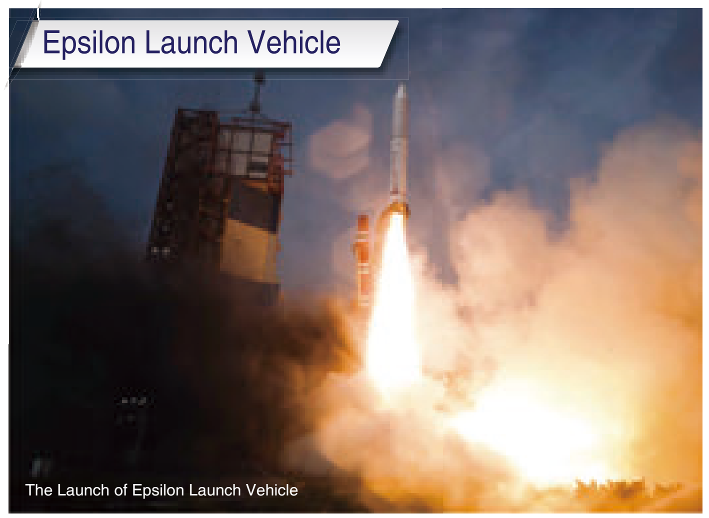
Small Solar Power Sail Demonstrator "IKAROS"
(Artists rendering of IKAROS)

With the combination of solar sail technology, which makes it possible to fly in the space with solar radiation pressure with sails deployed in the space, and the technology to operate the high-efficient ion engines with the power generated by thin film solar cells, we are creating new possibilities for solar system explorations in the future.

Smart Lander for Investigating Moon

"SLIM" is a plan to demonstrate the landing technology for probes to land at where they want (an accuracy of 100 meters) with small probes so as to expand the possibilities of scientific explorations.

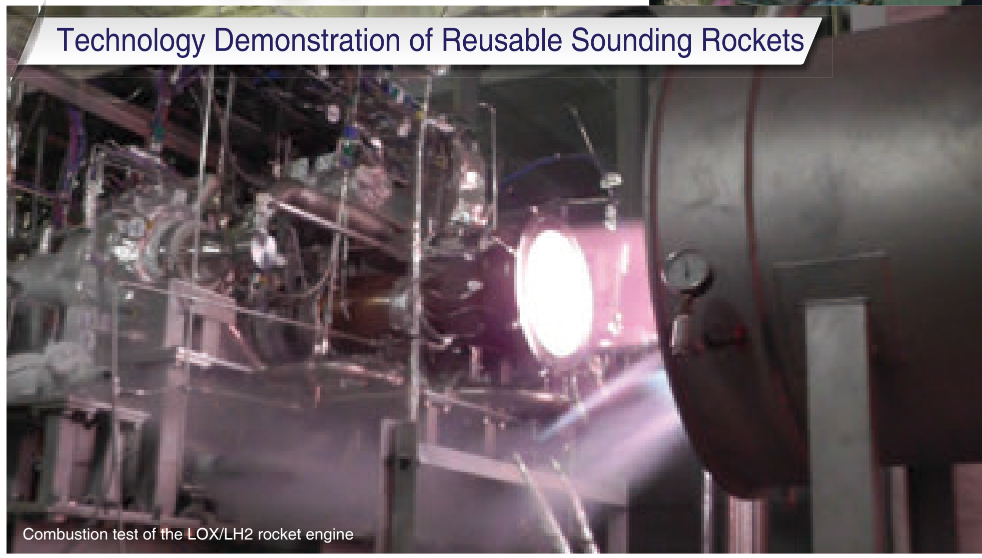
Epsilon Launch Vehicle



The Launch of Epsilon Launch Vehicle

The Epsilon Launch Vehicle was born with the concept to make it easier to launch rockets and to lower the threshold towards the space.

Technology Demonstration of Reusable Sounding Rockets



Combustion test of the LOX/LH2 rocket engine

To realize a high-reliable space transportation system like passenger planes with a low cost to do round trips frequently between the earth and space, it is important to reuse the body of a launch vehicle. Aiming at the future application, we are conducting researches and demonstration tests to use the reusable rockets as sounding rockets. We developed a rocket engine reusable for over 100 times with liquid hydrogen and liquid oxygen as fuels and succeeded in demonstration tests.

Sounding Rockets

Small rockets developed for various scientific experiments with about-10-minute ballistic flights. They are being widely used by most researchers for conduct space demonstrations in advance on innovative key technologies and technical verification of new flying bodies. They are also playing an important role for direct observations of the vertical structure of the upper atmosphere between 100-300km high which is difficult for artificial satellites as well as investigation of the initial behaviors of material generated under microgravity environment.

Sounding Rockets S-520

Balloons

Balloons have relaxed limitations on the size and weight of onboard devices, more chance to fly and is possible to recycle the onboard devices. To make full use of these features, we are conducting state-of-the-art ambitious or germinating experiments. Furthermore, we are developing the world' s most advanced next generation balloons for flying longer and higher.

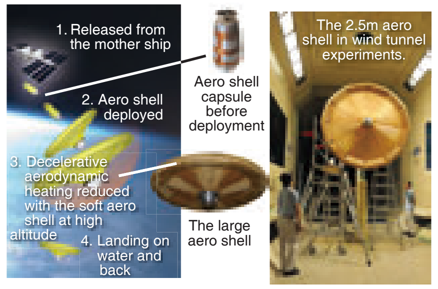
Technologies Supporting the Missions

The space science approaches the formation of the Universe, and even the origin of life. We make the challenging activities possible, and tackle the development of technologies that create new possibilities.

Technologies Supporting Deep Space Exploration

Atmospheric Entry System

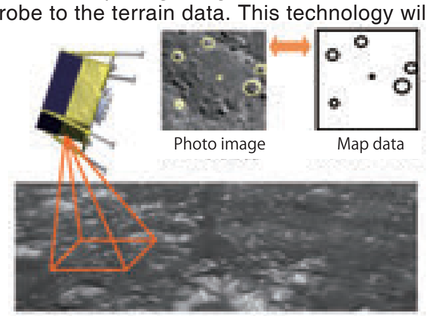
Looking toward the era when we do round trips between space and the earth actively or when we explore planets with atmosphere, we are researching and developing the atmospheric entry system. With the largest Arc-Heated Wind Tunnel, we research on heat-resistant materials and structures. In the re-entry capsule of "Hayabusa", the returned samples were protected from high temperature during atmospheric re-entry with a technique called ablation.



Furthermore, as the next generation atmospheric entry system, we developed a soft aero shell system. The airframe will not be exposed to the high temperature environment by deploying a big aero shell before entering the atmosphere.

Autonomous Image Navigation and Guidance Control

To get closer to or land on the celestial bodies away from the earth, autonomous functions are necessary. Because it takes a long time to communicate, it will be too late to wait directions from the ground. We are developing and improving automatic and autonomous control systems so that the probe itself can estimate its location with a high accuracy and even detect and avoid obstacles while comparing images from the camera installed on the probe to the terrain data. This technology will be not only applied to future solar system exploration but also widely used on ground.



Ion Engine

The ion engine gives power for a longer time with a lower cost and makes various and complicated applications of satellites possible. It is also a key technology for deep space exploration. The microwave discharge ion engines installed on "Hayabusa" achieved the world's longest operation for totally 40,000 hours.

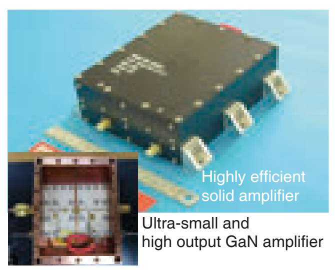
Delta-DOR

Delta-DOR (Delta-Differential One-Way Ranging) is a powerful navigation technique for interplanetary spacecraft. Delta-DOR uses two widely separated antennas on the ground, and measures the time delay between radio signals from a spacecraft and a distant galaxy (more precisely a quasar). By measuring the time difference with several tens pico second of accuracy, the position of the spacecraft 150 million km away can be determined with a few hundreds meter accuracy. The ISAS leads the recording technique of broadband radio signals, a component of the Delta-DOR. Our total performance is comparable with NASA/JPL and the world's highest.

Research Robot Technologies

To widely and fully explore the surface of moon and planets, mobile explorations are necessary. At first, we have to understand the environment of the target celestial body. For this purpose, we are researching vision system, image processing, terrain sensing, map drawing, image tracking and etc. To move to where we want to explore, we are as well researching path planning, obstacle detection and avoidance, advanced remote controlling and etc.

Ultra-long Distance Communication



Ultra-small and high output GaN amplifier

Deep space communication technologies are necessary for controlling probes over 100 million km away and sending important data to the ground and small, light and highly efficient performance is essential for the communication technologies for deep space exploration satellites. We are researching space nanoelectronics technologies to quickly apply the most advanced electronic information communication technologies such as compact GaN amplifier to miniaturized deep space exploration satellites.

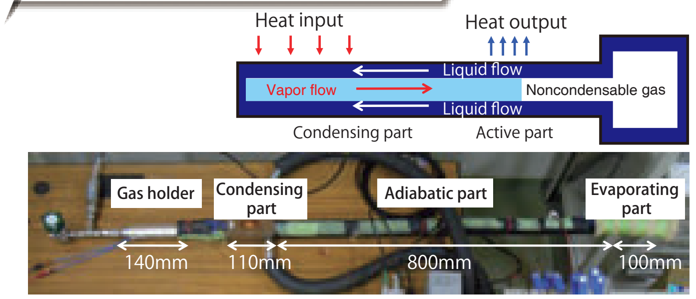
Advanced Observation Technologies

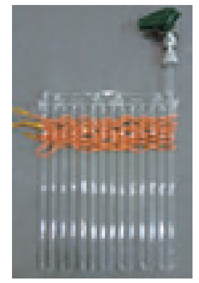
Stirling Cooler and Joule-Thomson Cooler

It is necessary to cool the detectors close to absolute zero to reduce noise to the utmost limit for observations with X-ray and infrared sensors. To reach 0.05K on the X-ray Astronomy Satellite "Hitomi" (ASTRO-H), besides liquid helium and adiabatic demagnetization refrigerator, we are also using Stirling cooler and Joule-Thomson cooler. With the use of these mechanical refrigerators, the lifetime of the on-orbit detector cooling system is greatly extended and it is planned that it will still be able to observe after all the freezing mixtures onboard get evaporated.

JAXA/SHI

Thermal Control Technologies

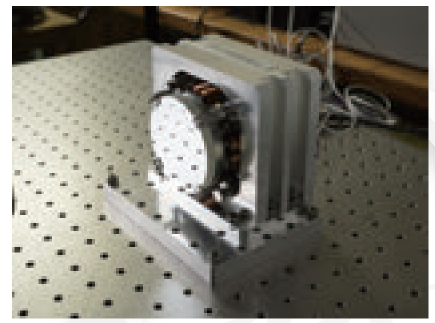




Light, power-saving and highly reliable thermal control devices are required for future planet explorations and missions like space telescope and small satellites. We are conducting researches on thermal control devices such as space loop heat pipes, self-excited oscillating heat pipes and variable conductance heat pipes.

Two-Dimensional Scanning Mirrors

The two-dimensional scanning mirror structure allows for the scanning of slits in two dimensions to make observations in a broad field of vision. Researchers created a prototype of a scanning mirror structure, which was an electromagnetic absorption type, to assess its performance by using ISAS facilities. The research team confirmed the validity of the design to measure tilt angle at high precision detection. The team also verified the design of low noise drive circuits. A mirror mechanism modeled on this scanning mirror is planned to install the SUNRISE-3 international scientific observation experiment (scheduled to be launched in 2021) with a mirror mechanism modeled on this scanning mirror.



Diffraction Limited Space Telescope

The diffraction limited (the theoretical highest resolution we can get considering the wave nature of light) space telescope technologies, all get together in the Orbiting Solar Observatory "Hinode". Particularly, such as the primary mirror of 50cm caliber with nearly no unevenness, the main mirror support mechanism that withstands the launching environment while not distorting the primary mirror, low expansion composite materials that keep the precision of primary mirror and secondary mirrors within several microns against the vibration during launching and on-orbit temperature changes, stabilizing images by removing the blurs resulted from shakes of satellites with adjustable mirrors and etc. With these technologies, we realized a breakthrough diffraction limited resolution of 0.2-0.3 arcseconds and we will also apply these technologies to the space telescope plans which require higher resolutions in the future.

Structure of the Solar Optical Telescope installed on "Hinode"

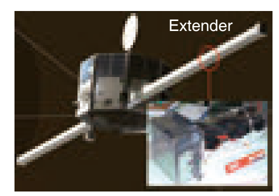
EUV Imaging Spectrometer

The EUV (Extreme Ultraviolet) is a wavelength region where we can get the clues to understand the environment of planet atmosphere and plasma. However, to make the optical system of the observation devices requires extreme high film deposition technology and polishing technology with an ultra-high precision of sub-nanometer level. With this technology, the primary mirror and diffraction gratings for EUV observation installed on SPRINT-A (Hisaki) reached the highest reflectance and wavelength resolution ever.

The EUV imaging spectrometer installed on Hisaki, Yoshioka et al., PSS, 2013

Magnetograph

Measuring magnetic fields is an essential technique for researching space plasma and the internal part of planets. We have made a lot of achievements through highly-precious magnetic fields measuring with scientific satellites such as GEOTAIL and SELENE and they are all results from high-performance magnetographs, light and long sensor extenders and reducing the magnetic fields of satellites. Furthermore, we have improved the resolution of magnetic fields measuring and developed magnetographs with higher radioresistance, which have been installed on the Mercury Magnetospheric Orbiter (MMO) (the BepiColombo project) and the Exploration of energization and Radiation in Geospace (ERG).



The magnetograph installed on the Mercury Magnetospheric Orbiter.

ISAS and Space Science

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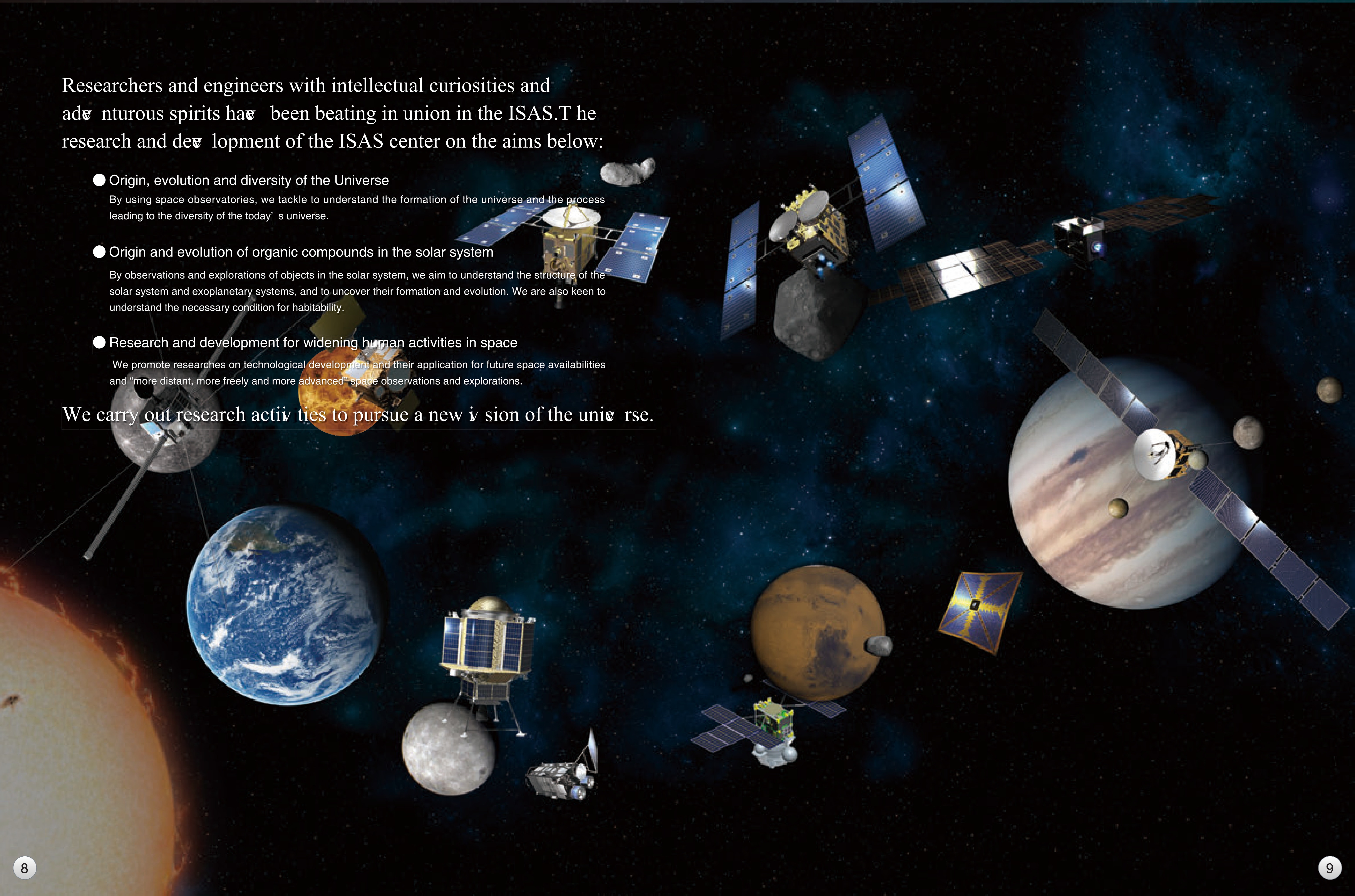
Researchers and engineers with intellectual curiosities and adventurous spirits have been beating in union in the ISAS. The research and development of the ISAS center on the aims below:

- **Origin, evolution and diversity of the Universe**
  By using space observatories, we tackle to understand the formation of the universe and the process leading to the diversity of the today's universe.
- **Origin and evolution of organic compounds in the solar system**
  By observations and explorations of objects in the solar system, we aim to understand the structure of the solar system and exoplanetary systems, and to uncover their formation and evolution. We are also keen to understand the necessary condition for habitability.
- **Research and development for widening human activities in space**
  We promote researches on technological development and their application for future space availabilities and "more distant, more freely and more advanced" space observations and explorations.

We carry out research activities to pursue a new vision of the universe.



Road-Map of Space Science

2005 | 2010 | 2015 | 2020 | 2025 | 2030

Research on the origin and evolution of the Universe

2005~ SUZAKU (ASTRO-EII) ~2015
Launch Vehicle：M-V
X-ray astronomy satellite to observe variety of X-ray sources over a wider energy range (from 0.3 to 600 keV)

2016 Hitomi (ASTRO-H) ~2016
Launch Vehicle: H-IIA
X-ray astronomy satellite to measure dynamics and composition of high temperature plasma in space

XRISM (X-Ray Imaging and Spectroscopy Mission)
X-ray astronomy satellite to measure dynamics and composition of high temperature plasma in space

ATHENA
Athena (Advanced Telescope for High ENergy Astrophysics) is an X-ray observatory mission lead by the European Space Agency

2006~ AKARI (ASTRO-F) ~2011
Launch Vehicle：M-V
Infrared astronomical observatory to obtain the all-sky survey data for studies on formation of planetary systems and formation and evolution of galaxies

SPICA (planning phase)
Next-generation infrared space telescope

2006~ HINODE (SOLAR-B)
Launch Vehicle：M-V
Solar-observing satellite developed to reveal the whole process of heating and magnetic activities across the Sun's surface and corona

LiteBIRD (planning phase)
Verification of the inflation theory based on measurement of the polarimetry of microwave background radiation

Research on the origin and evolution of our planetary system

2007~ SELENE ~2009
Launch Vehicle：H-IIA
Mission to obtain elemental and mineral compositions, topography and so on with high accuracy and resolution

2013~ HISAKI (SPRINT-A)
Launch Vehicle: Epsilon
Space telescope to observe planetary atmosphere and plasma in the magnetosphere with EUV

JUICE
Mission to observe Jupiter and three of its largest moons, Ganymede, Callisto and Europa, in detail

1989~ AKEBONO (EXOS-D) ~2015
Launch Vehicle: M-3SII
Satellite to monitor aurora phenomena of the earth and Van Allen radiation belts for 26 years

2016~ ARASE (ERG)
Launch Vehicle: Epsilon
Mission to observe the radiation belt surrounding the earth and space storm variation

CAESAR (planning phase)
Sample return mission from a Jupiter-family comet, 67P/Churyumov-Gerasimenko

1992~ GEOTAIL
Launch Vehicle: Delta 2
Satellite developed in a Japan-U.S. joint project to study the structure and dynamics of the earth's magnetotail

BepiColombo(MIO)
Joint mission of the European Space Agency and JAXA. MIO measures the magnetic field of Mercury

2010~ AKATSUKI (PLANET-C)
Launch Vehicle: H-IIA
Venus climate orbiter to determine the dynamics of the Venus climate

Martian Moons Exploration (planning phase)
Sample return mission from Phobos or Deimos

2003~ Hayabusa (MUSES-C) ~2010
Launch Vehicle: M-V
Experimental mission on key technologies necessary for returning planetary samples

2014~ Hayabusa2
Launch Vehicle: H-IIA
Mission to explore a C-type asteroid and bring back its samples

DESTINY+ (planning phase)
Technology demonstration mission for interplanetary voyage

Technology Demonstration

2010~ IKAROS
Launch Vehicle: H-IIA
World's first solar powered sail craft to verify both technologies of photon propulsion and thin film solar power generation

SLIM
Technology demonstration mission for high-precision landing on the lunar surface

OKEANOS (planning phase)
Jovian Trojan asteroids exploration mission via solar power sail

EQUULEUS
OMOTENASHI
EQUULEUS: Demonstration of low-energy trajectory control techniques
OMOTENASHI: Demonstration of the technology for low-cost and very small spacecraft to land on the lunar surface

2014~ PROCYON
Launch Vehicle: H-IIA
The first deep-space micro spacecraft

Core Technology

GREAT (GRound station for deep space. Exploration And Telecommunication)
New station for deep space missions

2005 | 2010 | 2015 | 2020 | 2025 | 2030

Image credit : Akihiro Ikeshita, Univ. Tokyo, ESA

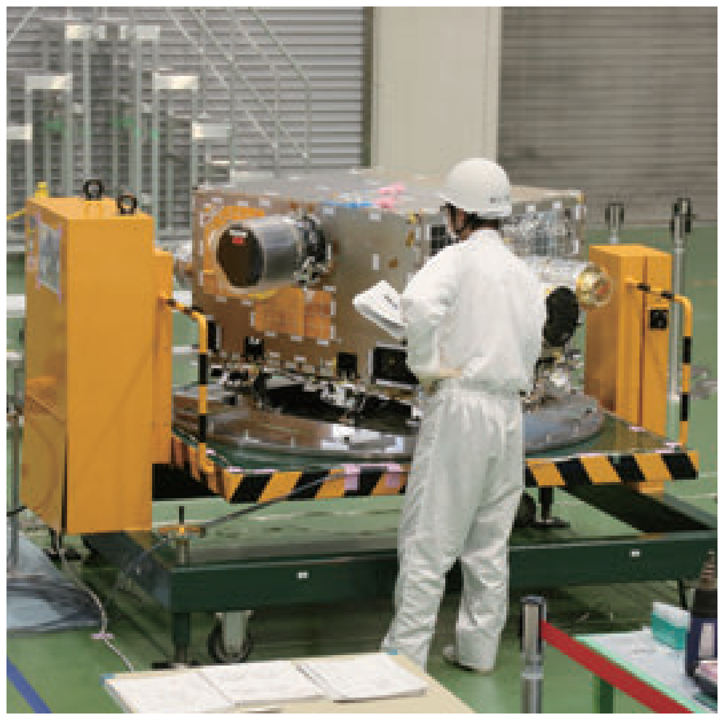
Becoming the Driving Force of Realization and Development

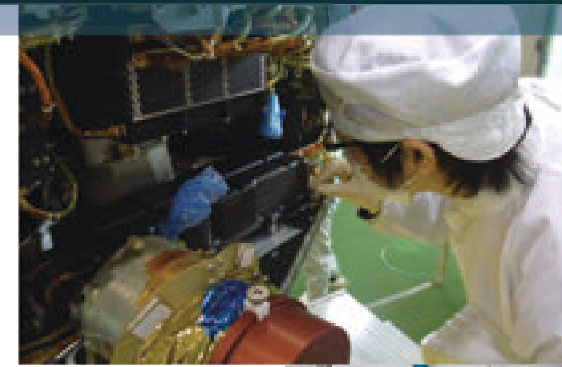
To keep making achievements in space science, where highly advanced technologies and knowledge are required, as well as to make satellites or probes with higher performance succeed, ISAS is cooperating with universities or other institutes both inside and outside Japan, and is cultivating human resources to bear space science in the future.

As the Core Institution in Space Science

ISAS was established in 1981 as a national inter-university research institute to play the role of the core institute of space science in Japan. Researchers are conducting researches in various universities and institutes in Japan. In the framework of the inter-university research system, researchers from universities are able to use the cutting-edge facilities in ISAS. Such inter-university research system is Japan' s own research system.

After becoming a member of the independent administrative institution JAXA in 2003, ISAS, same as universities, shows respects to the freewheeling thinking of the researchers, and is working as an inter-university research institute under the inter-university research system. Now, our institute is as well playing a role as the point of contact for international cooperation in space science in Japan and is promoting the cooperation and exchanges with institutes and researchers in other countries as an international center of excellence.





Cultivating Researchers and Engineers of the Next Generation

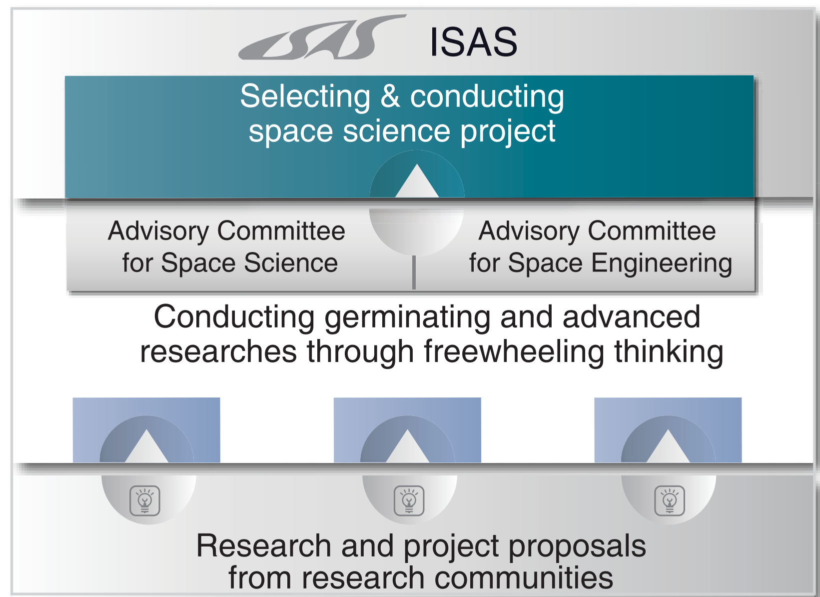
To develop academic researches and scientific technologies, it is necessary to nurture the young researchers and engineers who will be in charge of our future. In ISAS, we are teaching graduate students from Space and Astronautical Science of Soukendai (Graduate University for Advanced Studies) and other universities, received according to the Special Collaborative Fellowship for Graduate Students System.

In our institute, researchers of space science and of space engineering, all work together to realize their common dream of conquering the space with the wisdom of mankind. It is a distinctive feature of the education in ISAS that one can learn a broad knowledge of advanced space engineering and space science (space observation and exploration) which will be very helpful in the future.

Additionally, students participate in international cooperative researches or large-scale projects conducted together with many universities and institutes including foreign ones. We as well expect that the students and young researchers to acquire the ability to plan advanced scientific satellite projects and to conduct researches and projects in international teams besides a wealth of knowledge on space science.

Selection of space science projects in Japan

- Studies under the inter-university research system
- Project creations & competitive selection of a mission

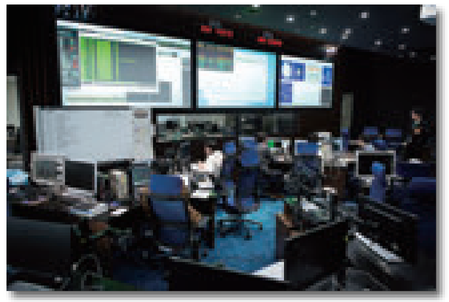


The ISAS and Other Faciliti es in JAXA

Sagamihara Campus

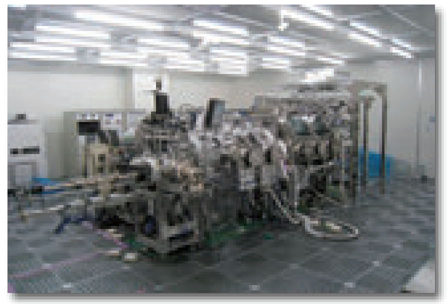
Sagamihara Campus

The old ISAS was established in April 1981 as a national inner-university research institute and the Sagamihara campus opened as the center base at the same time in Sagamihara-shi, Kanagawa Prefecture, Japan. There are the Research/Administration Buildings, the Environmental Test Building (for development and testing of onboard equipment for rockets and satellites), the Experiment Facility Building, and etc. After becoming a part of JAXA in 2003, it continues to play a role in the inner-university research system in Japan. Parts of the Space Education Center and Sokendai are also located here.



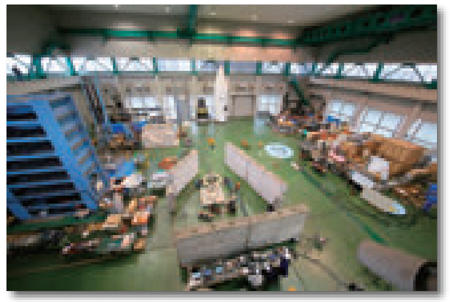
Operations Room Connecting the Ground and Space

With the Usuda Deep Space Center and Uchinoura Space Center as the ground control office, we operate the earth orbiting satellites and planetary probes.



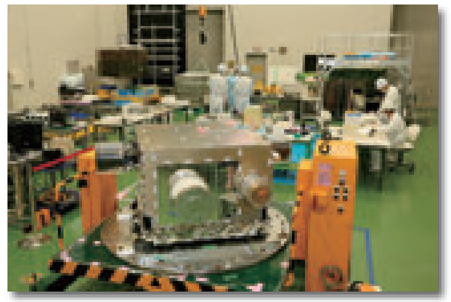
Curation facility dealing with extraterrestrial materials

There is a facility (curation facility) for recording and initially analyzing the samples brought back from the small planet Itokawa by Hayabusa.



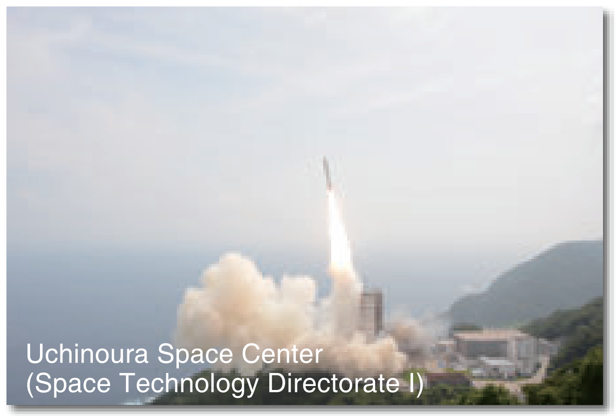
Structure and Mechanics Test Building

Here we test the strength and rigidity of rocket elements and satellite structures, the functions of rocket inter-stage joints and nose fairings, etc.



Flight Environment Test Building

We assemble scientific satellites and probes in the clean room and run performance and function tests here before launch.



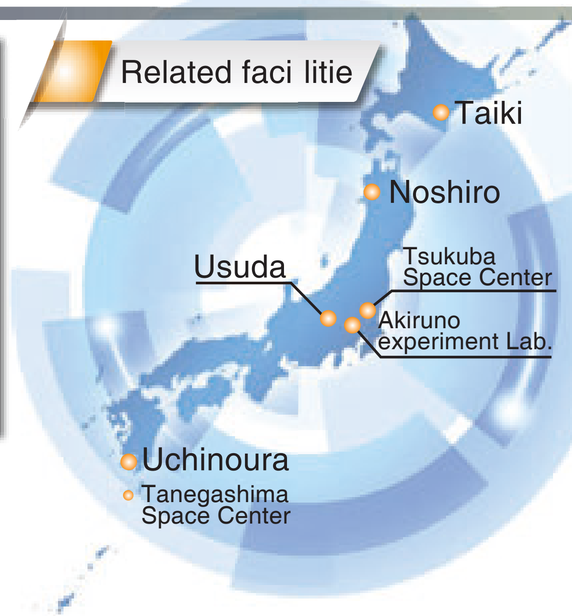
Uchinoura Space Center
(Space Technology Directorate I)

The Uchinoura Space Center located at the Osumi Peninsula in Kimotsuki-cho, Kagoshima Prefecture and we launch and track sounding rockets and scientific satellites and receive data from them here.

Usuda Deep Space Center
(Space Tracking and Communications Center)

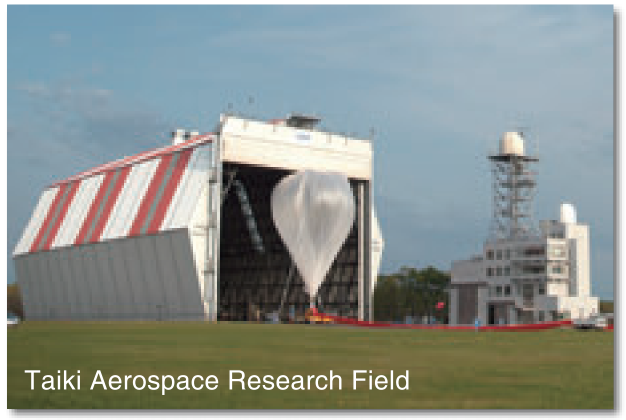
It is a facility located at Saku-shi, Nagano Prefecture, Japan for tracking and operating deep space probes towards celestial bodies such as other planets in solar system. It is equipped with a 64m-diameter parabolic antenna and the VLBI (Very Long Baseline Interferometer) is also used for observations.

Related faci litie



Noshiro Rocket Testing Center

Noshiro Rocket Testing Center has performed a wide range of static firing tests of solid rocket motors. There are also facilities for developing future high-performance engines.



Taiki Aerospace Research Field

The Taiki Aerospace Research Field, which is a base for cooperation between the town of Taiki, Hiroo-gun in Hokkaido and JAXA, is located in the Taiki Multi-Purpose Aerospace Park. From 2008, scientific balloon-borne experiments that used to be performed at Sanriku is being performed here.

Becoming the Driving Force Mission

ISAS emphasizes public outreach activities that make our world-class academic achievements widely available as public knowledge. Our goal is to share with society our R&D results along with the process leading up to our achievements.

Getting the Word Out

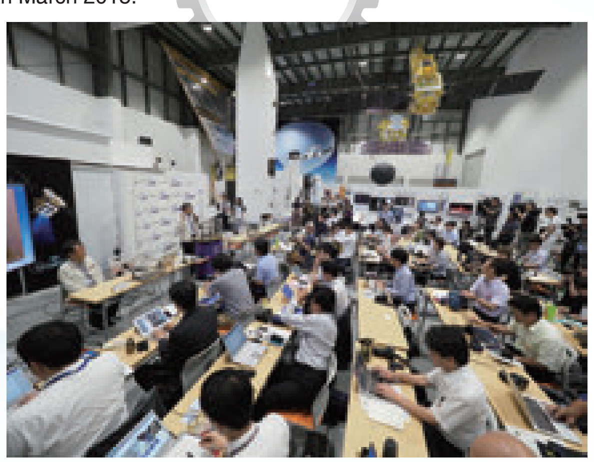
To disseminate to society the world-class scientific achievements of ISAS in an easy-to-understand manner, we have created a system centered on the Director of Education and Public Outreach under the directive of our director. We constantly strive to improve the quality of information dissemination. Our outreach activities are evaluated by a public relations committee that includes members from JAXA's public relations department and external members.

Important roles of our public relation and outreach activities include sharing not only the significance of our R&D, but also a sense of excitement. We try to provide as many opportunities as possible for directly interacting with our researchers and staff, and to disseminate information through media coverage, websites, and messaging services. We cooperate with science museums nationwide from the planning stage in holding various events. Such activities have helped maintain interest in the space sciences, even after the decline of the burst in enthusiasm that followed Hayabusa's return to Earth.The number of visitors to ISAS has steadily increased to about 70,000 per year.

We also place special emphasis on activities for community collaboration. We are actively engaged in collaborative projects with the businesses and facilities of the citizens and city of Sagamihara, where our Sagamihara Campus is located. Such continuing activities increase interest in the space sciences among those who would otherwise have no contact with them, creating a ripple effect starting in academic and social education.

Press Briefings

We hold briefing sessions on projects and outcomes for news organizations. The photograph shows the Mercury Magnetospheric Orbiter (MMO) aircraft, presented at the scientific satellite clean assembly room in March 2015.



Communication Hall for Space Science and Exploration

Communication Hall for Space Science and Exploration. This is the core facility on the Sagamihara campus for cooperation between industry, academic researchers, and the government; regional cooperation; cooperation with schools; and cooperation with scientific museums. Development items and prototypes actually used in research and development are displayed here and one can learn about the cutting edge of space science. This facility aims to be a nationally representative hub for the dissemination and exchange of space science information.

Space Science Lectures

Each year during Japan's Golden Week holidays, we hold lectures about the cutting edge of space science and screen movies created by ISAS. At these events, researchers discuss their work and answer questions about the scientific goals of new missions and the engineering research for realizing them.

Your Space Mission

"Your Space Mission" is an experiential event in which high school students spend one week at our Sagamihara Campus engaging in the consideration and proposal of a space mission. Through this event, students learn the basic research skills of thinking, deciding, and working on their own. After participating in these events, some go on to become space science researchers themselves.

space science

Open Campus Days

In this annual fair, there are number of researchers presenting activities such as devising experiments, demonstrations, and exhibitions. In recent years, the event has attracted over 10,000 visitors in two days.