

**Aerospace Research and Development Directorate  
Japan Aerospace Exploration Agency**

# Organization

- Space Transportation Mission Directorate
- Space Applications Mission Directorate
- Human Space Systems and Utilization Mission Directorate
- Aerospace Research and Development Directorate
- Institute of Space and Astronautical Science
- Aviation Program Group
- Lunar and Planetary Exploration Program Group



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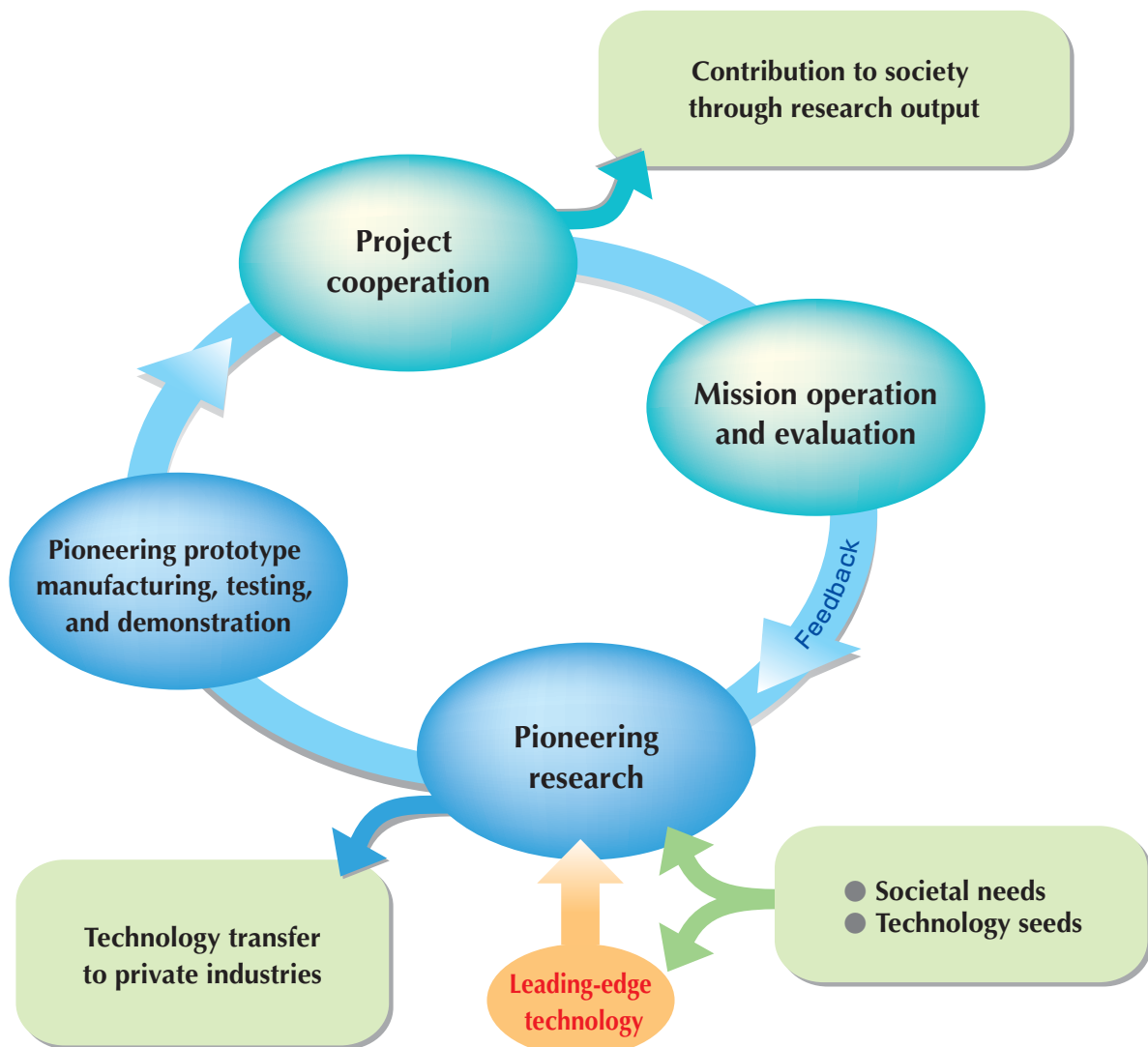
## Outline

The Aerospace Research and Development Directorate (ARD), as the central research and development organization of JAXA, is committed to maintaining and enhancing its technological capabilities while conducting fundamental research in aerospace fields.

- Leading-edge research and development of aerospace technologies based on world trends
- Technology development to meet societal needs
- Research and development of critical technologies for satellites, aircraft, and space systems
- Technical support for project success
- Installation, maintenance, and operation of testing and research facilities that make up Japan's infrastructures for space and aviation development.

## Role

ARD, as a center of excellence in Japan, creates, accumulates, and transfers fundamental technology through the following related activities.



# Guidance and Control Group

Guidance, control and dynamics are important fundamental technologies for spacecraft (rocket, artificial satellite, etc.). The Guidance and Control Group deals with technical problems in projects, aiming at surer execution of ongoing projects in these areas, while researching and developing new technologies required for the realization of future missions.

## Goal

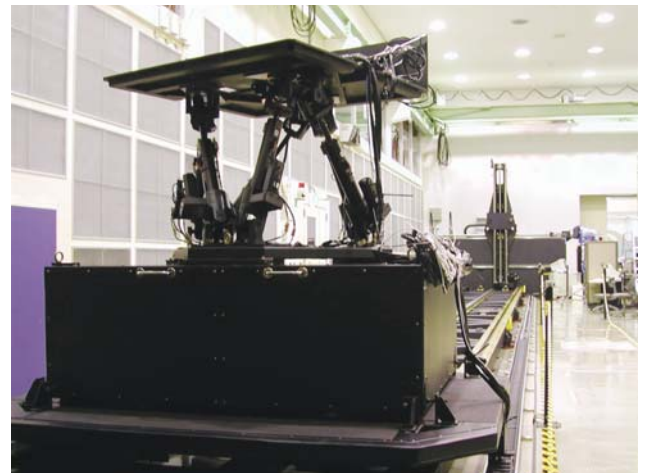
The group contributes to the success of various projects by solving technical problems and performing various evaluation tests on subsystems and components of attitude- and orbit-control systems at the request of scientists working on the projects. We are also researching the high-performance attitude-control system, a strategic common technology necessary to secure autonomy of the space activities in our country, and a space robot/rendezvous technology required for the expansion of future space exploration to circumterrestrial orbits, the moon, planets, etc.



Small hood for star tracker



Evaluation test of ETS-VIII sun sensor



Evaluation test of HTV rendezvous sensor

## Research Objectives

### 1. High-Performance Attitude-Control System

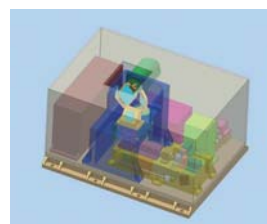
This group focuses on research to respond to diverse global trends and future mission requirements such as autonomous operation, longer service lives, and further reductions in size and weight. Current topics include a small high-performance, next-generation type star tracker (STT), fiber optic gyro (FOG), small high-performance GPS receiver, and high-performance reaction wheel. The goals are to reduce the size and weight and improving the precision and reliability of the attitude- and orbit-control systems of spacecraft.



High-performance FOG



High-performance wheel



Conceptual illustration of a rendezvous laser sensor



Image navigation sensor  
Ground experiment model

### 2. Research on the formation flight/rendezvous docking technology

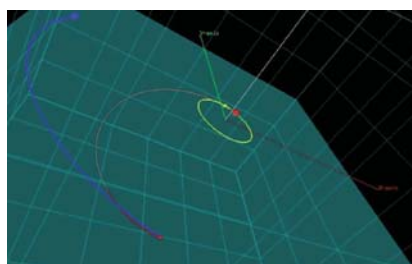
The group is further improving technologies demonstrated in the Engineering Test Satellite-VII (ETS-VII), including a rendezvous laser sensor for the H-II Transfer Vehicle (HTV), a high-accuracy relative navigation sensor, and a high-accuracy relative guidance control verification technology. The group is also developing formation flight technologies required for advanced missions, such as an X-ray telescope and rendezvous docking technology necessary for sample recovery from the moon surface, the replacement of units, and other orbital services.

# Trajectory and Navigation Group

This group advances projects by formulating algorithms for precision orbit determination, reviewing the practicability and feasibility of a wide variety of missions, including some for lunar and planetary exploration, and clarifying the system requirements in technical research in fields such as flight dynamics, orbit control, navigation, and positioning in relation to flying objects in space such as satellites, space probes, and rockets.

## Goal

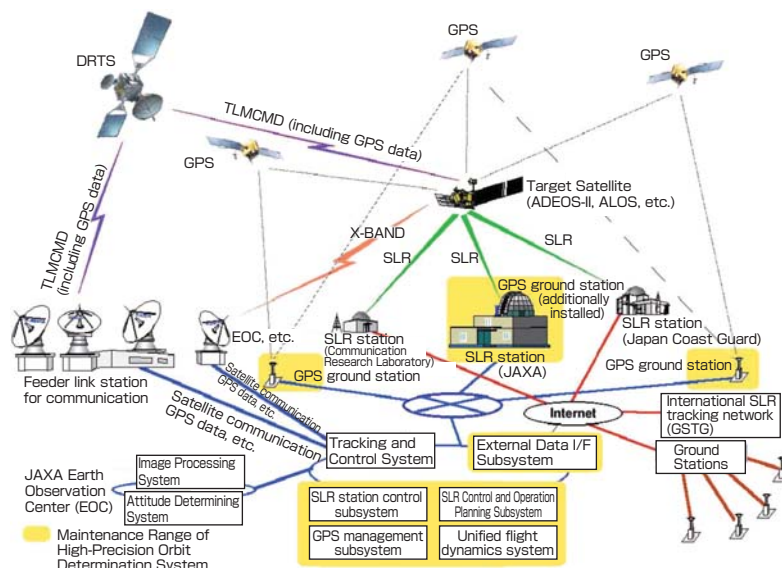
This group aims to configure a high-precision orbit determination system by carrying out kinematic analyses of satellites and rockets in the orbit motion. As it does so, it will also conduct calculations and analyses of various state quantities for reviews of the mission feasibility and systems to do with states for either projects yet to be formulated or for young projects just hatched. This group carries out research and development using technology platforms for orbits and navigation systems, such as algorithms to detect the expansion of minute space debris, and so on.



## Research Objectives

### 1. Research on High-Precision Orbit Determination Technology

This group researches high-precision orbit determination technology using precise position information with laser ranging and GPS (Global Positioning Satellite) systems, relative angle information using the very long baseline interferometer (VLBI), and other information, in addition to conventional satellite tracking data (range and doppler). The use of satellite position information such as GPS has already become widespread in public life, and more precise types of satellite positioning information are expected to become available in the future. This group aims to configure an orbit determination system that will make maximum use of GPS base stations and laser-tracking stations inside and outside Japan, within the context described above.

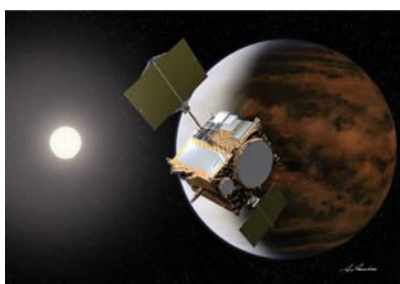


### 2. Research on a High-Sensitivity Space Object Detection System

Space debris are made up of physical bodies which, much like lesser planets or meteors incoming from space, fly through space without transmitting electric signals. Space debris are challenged to find from the ground, and its orbital motion is hard to be predicted. Though collisions with space debris are difficult to prevent, precautions must be taken to at least reduce the risk of space debris damage in the future. This group studies an analytic algorithm for detecting minute debris and unknown debris by various methods, such as the overlapping of multiple observation images.

### 3. Feasibility Study and System Concept Review for various Missions

This group is carrying out orbit designs and system requirement analyses for various missions. This table lists missions whose plans have just now been hatched, and full-fledged missions to be launched into space very soon.



Satellites	Projects	Purposes
Venus Atmosphere Observation Satellite	PLANET-C	Observation of the Venus atmosphere and meteorological phenomena
Super-Low-Altitude Satellite Technology Testing Equipment	SLATS	Technological demonstration of Super-low-altitude satellite around the earth (altitude of about 200 km)
Infra-red Radiation Observation Satellite	SPICA	Infra-red radiation astronomical observation at Lagrange's gravitational equilibrium point
Mars Environment Observation Satellite		Observation of atmosphere and high-altitude plasma of Mars

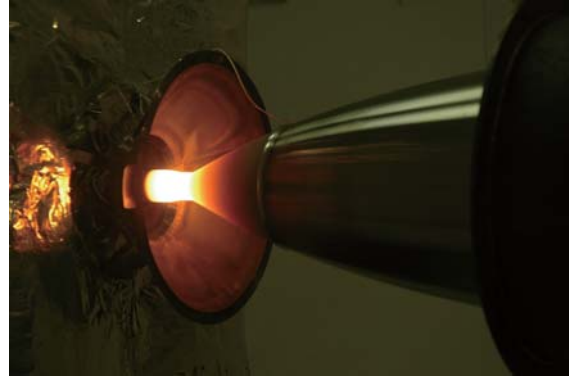
# Propulsion Group

Our objective is to construct robust propulsion subsystems and provide them to Japanese space development programs, such as satellites, scientific explorers and space station transfer vehicles. We continue to improve the reliability of subsystems and components, and study to realize the higher performance components that is necessary for future space programs.

## Goal

Any malfunction in propulsion subsystem is leading to the total loss of spacecraft and the mission failure. The target of our group is to eliminate such threats by supplying high-reliability propulsion subsystems to spacecraft.

1. Developing the propulsion systems and components to be installed aboard spacecraft.
2. Studying the reliability evaluation methods in order to improve the components and subsystems.
3. Studying and developing the next generation propulsion subsystems that will enhance the performances of spacecraft.



High-altitude firing test for the "Kizuna" 500-N engine

## Research Objectives

1. Developing propulsion subsystems for space programs.

We are participating in the project teams from the conceptual design phase, and supporting to conduct the development tests, assembly, verification of the flight quality, fueling at the launch sites and initial tracking and operations.



Valve reliability evaluation test facilities

2. Improving the reliability of propulsion subsystems

The group prevents failures of main components such as thrusters (engines) and valves, in order to ensure that the propulsion subsystems will function properly. We are analyzing the phenomena of chemical reactions, electromagnetic drive mechanisms and friction mechanisms etc.



Ion engine test facilities

3. R & D for the high performance propulsion system

We research and develop technologies and equipment for practical propulsion systems that will enable future spacecraft to load larger payloads and improve operability.



Large-thrust ion engine

# Fluid Dynamics Group

The Group conducts research and development to elucidate phenomena of air flow around aircraft, space planes, and other entities flying in atmosphere or in rarefied gases. The Group has been studying advanced and innovative aerodynamic technologies required for future-oriented aircraft since FY 2004.

## Goal

In its research on advanced wind-tunnel measurement technology, the Group sets targets for the practical technology-readiness levels to be attained while aiming for the accurate prediction of aerodynamic coefficients and heating rates, and technology improvements for thermal protection in the hypersonic speed flight environment of atmospheric reentry aircraft, and for advancing leading-edge technology on unsteady numerical analysis in turbulent regions. To

pursue these targets, the Group focuses on the following four issues.

1. High-Subsonic Magnetic Support Technology
2. R & D on Molecule Sensor Technology
3. Research on High-Accuracy Numerical Analysis for Turbulent Flow
4. Research on Reliability Improvement for a Thermal Protection System in a High-Thermal-Load Environment

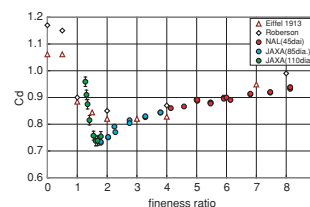
## Research Objectives

### 1. High-Subsonic Magnetic Support Technology

The Group has obtained a technology for measuring aerodynamic forces on rocket-shaped models using a magnetic suspension and balance system at Mach 0.40 and a total pressure of 130 kPa. We have also managed to achieve 6-axis control for a winged model and to pick out problems in aerodynamic force measurement (Fig.1 (a)). This balance system was used to examine the ratio (=diameter/length) of a finite circular cylinder model installed in parallel with the flow. The fineness ratio with a minimum drag (Cd) not seen in references affected by support rods was near a value of 1.6 (Fig.1 (b)).



Fig. 1 (a) AGARD-B model.  
The forces acting on the model were measured by one of the largest magnetic support systems in the world



(b) Drag coefficient versus the fineness ratio of a finite circular cylinder installed in parallel with flow

### 2. R & D on Molecule Sensor Technology

The Group has developed a high-speed-response-type pressure-sensing coating with a hydrophobic function that protects the coating against the effects of humidity. Experiments have been conducted to measure the time-dependent pressure distribution on the measurement surface of delta wing in a transonic speed region at a time resolution of 1 ms (Fig. 2a). The Group succeeded in clearly capturing the buffet non-stationary aerodynamics phenomenon generated on a model. The Group could also confirm quantitative agreement by simultaneous measurement using a built-in unsteady pressure sensor (Fig. 2b). This research is conducted jointly with Tokyo University of Agriculture and Technology.

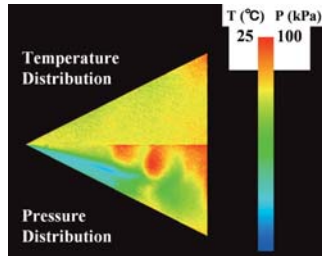
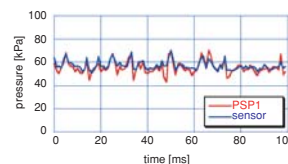


Fig. 2 (a) An image of pressure and temperature distribution (average image of 100 ms)



(b) Comparison of time waveforms of pressure fluctuation

### 3. Research on High-Accuracy Numerical Analysis for Turbulent Flow

For applying complex flows accompanying turbulent stalling, acoustic emission, etc. at high Reynolds numbers to futuristic issues in aerospace, the Group is researching a high-accuracy analysis technology by LES (large eddy simulation) and a multi-block technique, as well as an advanced analysis method based on a combination of the two approaches. Figs. 3a and b are analysis results around a high-lift device with a flap. The laminar-to-turbulent transition on the upper and lower surfaces of the main wing and on the flap are excellently grasped.

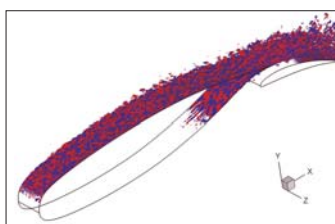
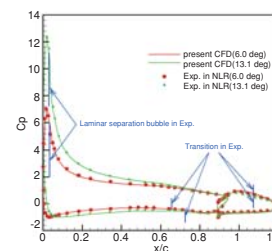


Fig. 3 (a) Vorticity distribution around an NLR7301 wing model with a flap ( $Re = 2.51 \times 10^6$ , attack angle = 13.1 degrees, Mach number = 0.185)



(b) Comparison between the average pressure coefficient  $C_p$  and the experimental value

### 4. Research on Reliability Improvement for a Thermal Protection System in a High-Thermal-Load Environment

To support the development of a thermal protection system used for the atmospheric entry capsule of a planetary exploration and reentry system with ground-landing capability, the Group is developing a flight environment prediction code and thermal protection system evaluation code while working to create a sophisticated ground testing technology. The figure on the right shows a graphite heating test within an induction-coupled plasma heated wind tunnel. Through this test, the Group became the first in the world to successfully determine the nitriding rate of carbon-based materials with high accuracy.



Fig. 4 Graphite heating test in an induction-coupled plasma heated wind tunnel.

# Advanced Materials Group

The broad field of advanced composite materials is an extremely important sector of engineering materials. The Advanced Materials Group deals with a variety of basic and applied research on advanced composite materials, including construction of a comprehensive material database, standardization of testing method, development of multifunctional composite materials and innovative technologies. The group is also active in development of advanced space materials and technologies for evaluating space environment resistance characteristics.

## Goal

The goal is to promote the practical use of the advanced composite materials required to achieve the lightweight and high-reliability aircraft structure and aerospace systems. Our group provides a comprehensive material database which is available on public internet website and various structural

testing facilities for aerospace industry. Furthermore, the group has strong collaborative relationships with universities external agencies and institutions in governmental, industrial, and academic sectors, and acquires fundamental technologies to meets industry demands.

## Research Objectives

### 1. Construction of a database on advanced composite materials

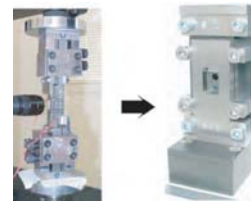
- Construct a database on the mechanical characteristics of advanced composite materials
- Manage the database to users in the governmental, industrial, and academic fields via the Internet (Registration system: Free of charge) <http://www.jaxa-acdb.com/>



Database top menu

### 2. Standardization of advanced composite material evaluation technologies and test methods

- Propose test methods for advanced composite materials such as carbon-fiber-reinforced plastic and continuous-fiber-toughened ceramic composite material to ISO and JIS
- Conduct round robin tests under close mutual cooperation with external organizations
- Develop the non-destructive testing techniques and numerical analysis techniques for composite materials

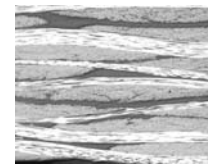


SACMA method      NAL method (proposed)

Proposal of small and low-cost test methods for Japanese Industrial Standards

### 3. Research on multifunctional composite materials

- Create heat-resistant polyimide composite materials, multifunctional composite materials, nano composite materials, etc.
- Evaluate the composite materials in extreme environmental conditions (e.g. extreme high and low temperatures, nano micro, etc.)
- Research and development of ultra-high-temperature-resistant ceramic composite materials



Cross section of a CFRP laminate fabricated by heat-resistant polyimide resin

### 4. Research on innovative application technology of advanced composite materials

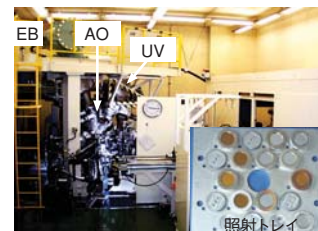
- Develop a technology for manufacturing new composite materials at low cost using advanced molding methods
- Establish type certification methods for aircraft composite structures manufactured by new technology
- Develop a fabrication method for superior impact-resistant and low-cost composite material



Demonstrator of the low-cost composite wing structure

### 5. Research on advanced space materials

- Evaluate the effects of the space environment (e.g. radiation, ultraviolet rays, electron beam, and atomic oxygen) on materials
- Research and development of shape-memory polymers, lightweight body panels, and atomic oxygen resistant resin
- Construct and manage a database on the advanced space material to the public (e.g. out gas data, safety verification test, etc.) <http://matdb.jaxa.jp>



Combined space environment test machine

# Structures and Mechanisms Group

The Structures and Mechanisms Group conducts research and development of structures of spacecraft and aircraft, and space mechanisms, which are exposed to harsh operational environments. The research and development covers a lot of ground, including environmental durability of nozzles and thermal protection systems, coupling problem of large-scale space structure's deformation and control, vibration caused by complicated aerodynamic forces, structures of space transport vehicles and satellites, and space mechanisms and tribology. The Structures and Mechanisms Group also play active roles in cooperation with various projects.

## Goal

The Structures and Mechanisms Group engages in wide spectrum of research and development, from aviation to space, where structures and mechanisms are exposed to variety of extreme environment, including cryogenic or high temperatures, aerodynamic loads or launching loads,

vacuum or corrosive environment. To achieve light-weight and high reliability of these structural elements and mechanisms, the group conducts research and development based on analyses and experiments. They also provide technical support to various projects.

## Research Objectives

### 1. Research on environmentally durable structures

The mechanism of mechanical degradations on the space and aeronautical structures under severe environments has not yet been identified. Our original facilities are developed to evaluate the environmental effects to the structures, under high temperature, multi-axial load and long-term factor, with high-power laser heating systems and a biaxial testing frame and others.

### 2. Research on structural vibration

As the scale of spacecraft is growing larger to meet the mission requirements, it becomes harder to get accurate modal parameters on the ground global vibration test before launch because of the gravity and atmosphere pressure. The group develops safe, efficient, and practical approaches to estimate dynamic characteristics from online data in actual operation.

### 3. Research on aeroelasticity

As the speed of aircraft improves, it is no exaggeration to say that how accurately an aeroelastic phenomenon represented by flutter vibration is identified determines the performance of an airframe. The group tries to establish a design technique of active control systems using the behavior of aileron unsteady aerodynamic force in the transonic speed range. The group also advances demonstration research through the flutter analysis of a supersonic aircraft with a complicated shape, as well as through wind-tunnel test.

### 4. Research on space structure technology

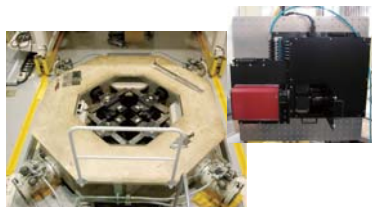
The Structures and Mechanisms Group provides technical support related to the structures of spacecraft and space transportation vehicle through cooperation with various projects. Also, the group conducts researches on measurement and control of spacecraft microvibration required for high pointing stability, as well as on highly thermal-stable structures using CFRP (Carbon Fiber Reinforced Plastics).

### 5. Research on space mechanisms

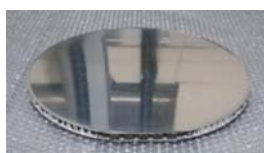
The group conducts basic technology research on mechanical components such as bearings. The group develops high-performance, reliable moving mechanical components, which are commonly utilized for satellites, including harmonic drive gear, slipping and low shock release device.

### 6. Research on space tribology

The group evaluates the tribological characteristics of space lubricants in simulated space environment to acquire performance data under various operating conditions. The group also conducts research on tribology in vacuum dust environment simulating the moon environment, and on new high-performance lubricants.



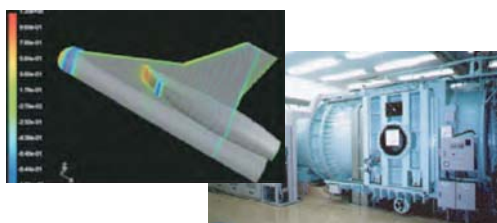
Biaxial load testing machine and laser heating unit



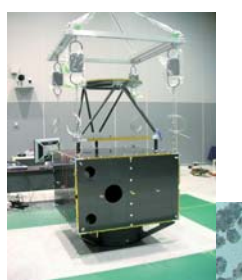
Zero thermal expansion/all-CFRP mirror



Harmonic drive gear



Transonic flutter analysis and test condition



Disturbance measurement test



Friction test in dust environment

# Thermal Systems Group

The Thermal Systems Group studies thermal control systems (TCS) with high performance and high reliability to meet the design requirements of advanced spacecraft missions. The group also studies space cryogenics to develop techniques to cool down optical detectors and telescopes in the coming generation of astronomical observation satellites with unprecedented levels of sensitivity and resolution. Further, we provide technical assistance to JAXA spacecraft projects through design reviews, thermal analyses and evaluation tests.

## Goal

### 1. TCS components and materials

We have been developing highly efficient, highly reliable space cryocoolers and innovative heat pipes (such as a loop heat pipe and a flat-type heat pipe) in order to acquire advanced thermal control technologies for flexible thermal management of future spacecrafts. Accurate thermal designs and adequate thermal margins require a thorough understanding of the properties of thermal control materials based on detailed investigations.

### 2. TCS designs

We review and validate the TCS design of ongoing JAXA projects to facilitate the steady development of spacecrafts and the accomplishment of missions. To contribute to future space missions, we investigate the feasibility and reliability of the required TCS in conceptual studies through thermal analyses and preliminary experiments.

## Research Objectives

### 1. Loop heat pipe (LHP)

An LHP is a promising two-phase heat transfer device expected to provide precise temperature control in spacecrafts and to cope with the high heat dissipation of onboard components. A conceptual schematic drawing of an LHP is presented in Fig. 1. Our group has studied a practical LHP with enhanced functions, with plans to apply it to the TCS of future spacecrafts such as astronomy satellites, broadcasting satellites, and lunar exploration rovers. Accurate temperature controllability, layout flexibility and efficient thermal transport are among the most important requirements. We have also designed and produced a breadboard model with a reservoir outside the evaporator, in order to provide temperature controllability and a shutdown function.

### 2. Mechanical cryocoolers

Based on cryogenic requirements of coming missions such as the next radio astronomy mission "ASTRO-G" (2012), the next X-ray astronomy mission "ASTRO-H" (2013), and the next infrared astronomy mission "SPICA" (2017), our group has developed highly efficient, highly reliable and low-vibration 1K-class, 4K-class, and 20K-class cryocoolers (Fig. 2) in cooperation with the Institute of Space and Astronautical Science of JAXA.

### 3. TCS designs

We have reviewed and verified the thermal design of almost all ongoing spacecraft projects in JAXA, including WINDS (Kizuna) (2008), the HTV (H-II Transfer Vehicle)(2009), the QZSS (Quasi-Zenith Satellite System)(2010), the GCOM-W1 (Global Change Observation Mission)" (2011), the GPM/DPR (Dual-frequency Precipitation Radar)(2013), and the Mercury exploration mission "BepiColombo/MMO(Mercury Magnetospheric Orbiter)" (2013). We have also been in charge of TCS development for small satellites such as the SDS (Small Demonstration Satellite) series (Fig. 3). We have been carrying out thermal design analyses and thermal vacuum tests through all development phases, in cooperation with the Space Technology Demonstration Research Center.

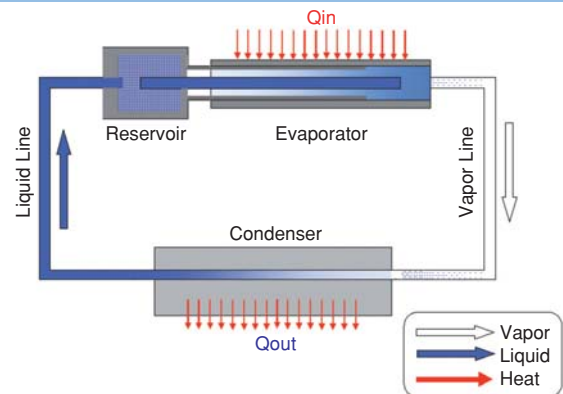


Fig. 1 Principle of the loop heat pipe

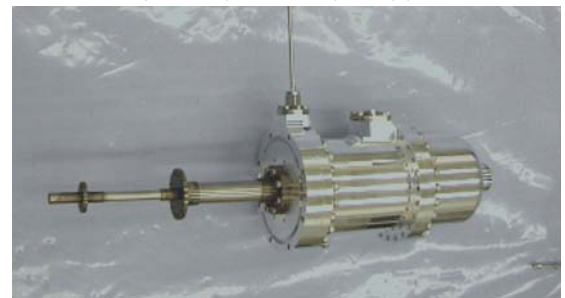


Fig. 2 Modified cold head of a 20 K-class two-stage Stirling cooler

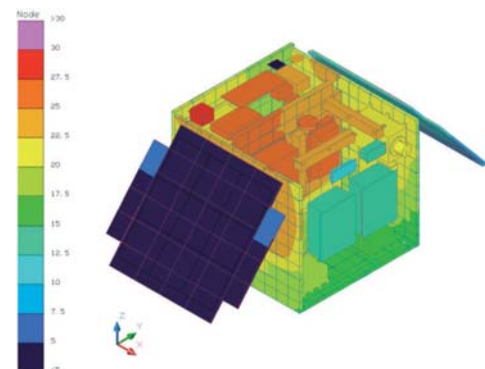


Fig. 3 Thermal design analyses of SDS-1

## Experiment equipment

1. Thermal fluid laboratory
2. Cryogenics laboratory

# Electronic Components and Devices Group

The Electronic Components and Devices Group researches and establishes basic technologies to improve the reliability and performance of space components crucial for space development and researches and develops important parts necessary for our country's space development programs. The group also endeavors to improve and maintain parts already developed by reflecting data obtained through demonstration satellites and ground tests, and by constructing a database on parts. In addition to supporting the selection and procurement of parts for each project, the group contributes to the international procurement of parts by releasing its database of parts to domestic and foreign space agencies, system manufacturers, parts manufacturers, and other organizations.

## Goal

The group conducts the following activities with the aim of continuously maintaining the availability of necessary electronic parts at fair prices, for use in the spacecraft systems that our country needs to conduct unrestricted space activities: domesticating important parts; maintaining the competitiveness

of domestically produced parts in performance, quality, and price; continuously maintaining domestic part development capabilities; and reducing the impacts of activities and developments overseas, such as disruptions in procurement channels for parts.

## Research Objectives

### 1. Developing electronic parts

Parts that satisfy the performance and quality necessary for unrestricted space activities are sometimes impossible to procure, either domestically or from overseas. When parts are procured from overseas, lack of information sometimes makes it difficult to fully use them as intended. In these cases, the group tries to produce them domestically as highly strategic electronic parts. During part development, the group places emphasis on part evaluation work to check the quality (Fig. 1).

### 2. Research on radiation hardening of electronic parts

The impact of the radiation environment on electronic parts is by no means negligible in outer space. For this reason, the electronic parts used for spacecraft such as rockets and artificial satellites need to be radiation-tolerant. And with the constantly growing demand for miniaturization, lightweight designs, higher performance, and low development costs for spacecraft, the desire to apply state-of-the-art technology to spacecraft is growing in parallel year by year. The Electronic Components and Devices Group works collaboratively with the Japan Atomic Energy Agency and the National Institute of Radiological Sciences to research the impacts of radiation on semiconductor devices with structures made from new materials, and attempts to establish radiation-proof evaluation technologies (Fig. 2).

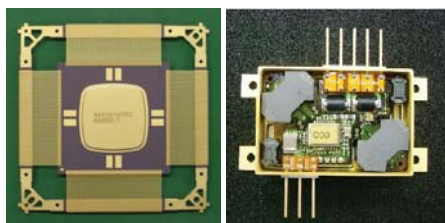


Fig. 1 Parts developed for space use  
(On the left: 200 MIPS 64-bit MPU. On the right: DC/DC converter)



Fig. 2 Irradiating equipment for single-event evaluation

### 3. Research on the applicability of commercial off-the-shelf electronic parts to space

The group conducts radiation and environmental tests to study the applicability of commercial off-the-shelf electronic parts and mounting technology to space. As an example, environmental concerns have recently restricted the use of lead. This causes a problem, as the terminals made without lead are highly susceptible to the growth of whisker-like metallic crystals. New measures need to be taken to facilitate the use of commercial off-the-shelf parts. The group carries out thermal-shock tests, as necessary, to evaluate whisker growth risk (Fig. 3).

The group also researches the evaluation items necessary for space electronic parts and the evaluation test necessary to guarantee quality. A foremost activity for the group is to conduct vibration, shock, and radiation tests on the Micro-Electro Mechanical Systems (MEMS) devices (parts with movable units using semiconductor technology) recently applied in automobiles and mobile phones, in order to evaluate their applicability to space. Work to design and test-fabricate MEMS devices is also underway within the group (Fig. 4).

The Electronic Components and Devices Group researches various element technologies, as well as high-density packaging technology to achieve the miniaturization and high performance of space electronic devices.

### 4. Promotion of international cooperation

Since the market for space parts is far smaller than that for commercial off-the-shelf parts, the group is aggressively promoting international cooperation to secure stable supplies of parts. Another fruitful task is to share important information on defects during the development of spacecraft at home and abroad, as well as on market trends, and to provide the information to users immediately. Capitalizing on orbital demonstration opportunities is critical for the widespread use of the parts already developed. For this reason, the group undertakes demonstration studies with the latest space electronic parts in outer space in cooperation with overseas space agencies.

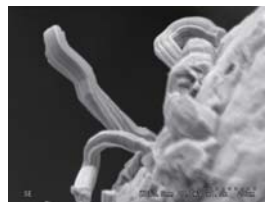


Fig. 3 Whisker growth

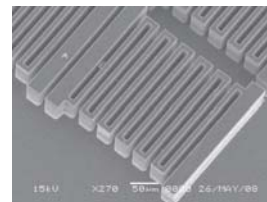


Fig. 4 Research on microfabrication technology (MEMS process)

# Space Power Systems Group

The Space Power Systems Group is studying ways to enhance the reliability and performance of electric power systems and power generating solar paddles for space application by reducing their size and weight.

The main research themes are as follows.

1. Research on technology for electric power systems and batteries for spacecrafts
2. Research on solar cells and solar paddle systems

## Goal

The group aims to realize electric power systems and solar paddles to achieve universal and secure success in current and future space missions. The systems have to be developed in order to contribute to make spacecrafts lighter as well as to flexibly meet diversifying space missions.

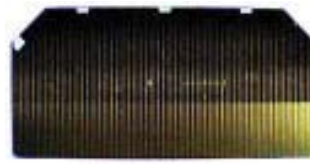
1. Realization of electric power systems by employing reduced-weight, higher-reliability, higher-performance power control components—as well as lightweight, high-performance secondary battery cells which have the large mass-impact.
2. Achievement of small-area, lightweight, low-cost and durable solar panels/paddles—utilizing high-efficiency, radiation-hard solar cells and also lightweight solar paddle structure which is optimized for flexible thin-film solar cells.



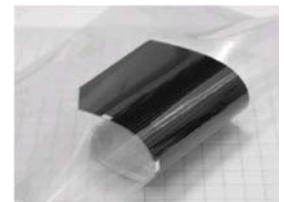
Image of a satellite (Advanced Land Observing Satellite: ALOS)



Lithium-ion battery assembly



InGaP/GaAs/Ge triple-junction solar cell



Prototype thin-film multi-junction solar cell

## Research Objectives

### 1. For High-Reliable, Small-Size, and Lightweight Electric Power Systems

- We are pursuing not only the realization of high-reliability and lightweight systems, but also the bus-architecture improvement, mounting-technique modification and bus-voltage optimization. This is to respond to specific requirements from space missions. Also, we are optimizing power-control components design, by means of fabrication and performance-evaluation of prototypes.
- For practical use, we are evaluating lithium-ion batteries which have high-energy density (twice that of conventional alkaline batteries), mainly in terms of a cycle-life performance test. In 2007, we have confirmed a cycle-life corresponding to 7 years in low Earth orbit. The test is still being continued.



Battery cycle-life test equipment

### 2. For Lightweight and High Specific Power Solar Cells and Paddles

- We are developing III-V multi-junction thin-film space solar cells. We aim to simultaneously achieve high-efficiency, radiation-hard, lightweight and low-cost. The development is based on Japan's original technology. In addition, we are studying radiation degradation behavior of solar cells and also radiation effects on semiconductor materials.
- We are investigating high-specific power solar paddles, which take advantage of the properties of the thin-film solar cells described above. Furthermore, we are trying to clarify charging/discharging phenomena occurring on solar paddles in a space environment, in order to attain a durable paddle design against damage due to discharge.



Solar cell performance measurement

# Telecommunications and Data Handling Group

Spacecraft collect various types of data as they carry out their missions in orbit. To use the data, it must be transmitted back to earth. Command signals must be sent securely to spacecraft, and accurate information on spacecraft conditions must also be sent back to earth to ensure normal operation. Sure and efficient communications and data handling between spacecraft and the ground are therefore crucial. The Telecommunications and Data Handling Group develops fundamental technologies for communications and data handling.

## Goal

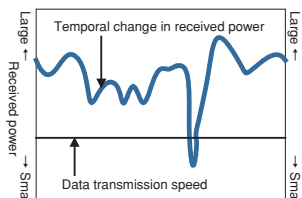
The communications and data handling system, a basic system for spacecraft, must be highly reliable. Better performance and more sophisticated functionality are vital to enable more flexible and advanced space activities in the future. And reducing the size, weight, and power consumption is consistently required for spacecraft. To respond to the foregoing, we are now researching ways to realize the following:

1. Higher speed and larger capacity space communications and data handling systems
2. Reduced size and weight and greater functionality of on-board antenna and communication equipment
3. Reduced size and weight and higher efficiency of on-board data handling equipment  
Reduced size and weight, higher speed, and larger capacity of on-board data recorder
4. Refined data-handling technologies based on more sophisticated algorithms for compression and error correction
5. Standardized and enhanced operability of the space data system

## Research Objectives

### 1. Space Communications and Data Handling Systems with Higher Speeds and Larger Capacities

To realize a more sophisticated communication system capable of meeting diverse communication requirements from a satellite system in the future, it will be necessary to improve communication speeds and quality in limited frequency resources. The group is working in this direction by studying a satellite communication system using an adaptive modulation technology employed in third-generation cell phones, etc.



Example of data transmission speed and change in received power in current communication system

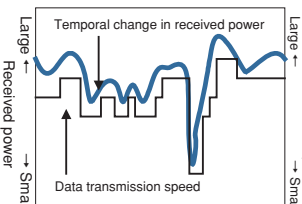
**Problems with current communication system**

- Transmits data at a fixed speed independently of the condition of communication.
- An inefficient system with excessive link margins when communication conditions are favorable.
- Circuit quality deteriorates when communication conditions are poor. In the worst case, the circuit disconnects.

**Advanced communication systems based on adaptive modulation technology**  
Securing higher speed, flexibility, and safety

### 2. On-Board Antenna and Communication Equipment with Reduced Size, Lighter Weight, and Higher Functionality

In space communication, two parties in communication are generally moving relatively to each other. Therefore, particularly with a strongly directional antenna, it is necessary to change its direction from hour to hour. The group is researching and developing a phased array antenna (APAA) capable of transmitting and receiving radio waves in an arbitrary direction without being moved, etc. The group is also promoting the research and development of communication equipment with reduced size, lighter weight, and high functionality using digital technology. The group is also promoting the research and development of communication equipment with reduced size, lighter weight, and high functionality using digital technology.



Example of data transmission speed and change in received power in satellite adaptive modulation system

**The system judges the condition of communication and sets the data transmission speed at an optimum value.**

- When the communication conditions are favorable, high-speed data transmission using a circuit margin is realized.
- When communication conditions are poor, circuit quality is ensured by switching the data transmission speed to a lower value.

⇒ The data transmission speed can be increased about 100-fold while maintaining the quality of communication.

Concept of communication system using adaptive modulation technology

### 3. On-Board Data Handling Equipment with Reduced Size, Lighter Weight, and Higher Efficiency

With the "data recording portion" in the data handling equipment, the group is researching and developing solid-state recorder with higher speed, lower power consumption and longer service life compared with conventional tape recorders and magnetic optical disks.

### 4. Refined Data Handling Technologies Based on More Sophisticated Algorithms for Compression and Error Correction

In a solid-state recorder, radiation causes SEU. The group is studying error control codes for efficient correction and detection of data errors due to this SEU, and developing encoding and decoding circuits. Other research focuses on a compression method suitable for moving images recorded by monitor cameras, etc.

### 5. Standardize and Enhanced Operability of the Space Data System

To improve the efficiency of satellite development and operation, the group is studying the advancement and standardization of data-handling technologies.



Tranceiver for small satellite



High speed multi-mode modulator



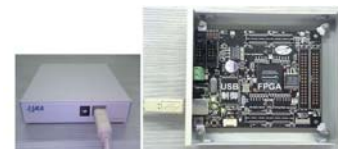
APAA installed on WINDS



Multi-mode integrated transponder



Solid-state recorder



Case 108(W)×125(D)×30(H)  
Prototype of error control circuit

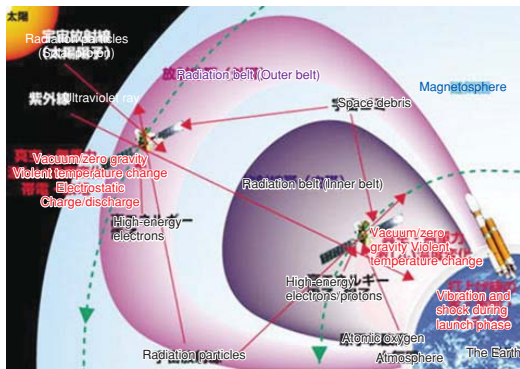
# Space Environment Group

The Space Environment Group researches space environment measurement technologies, develops on-board equipment, studies space environment models and supports satellite projects from design to operation. Topics include space environment analyses on orbital anomalies, anomaly prevention (space weather forecast and space environment warning), and other important aspects of satellite design criteria.

## Goal

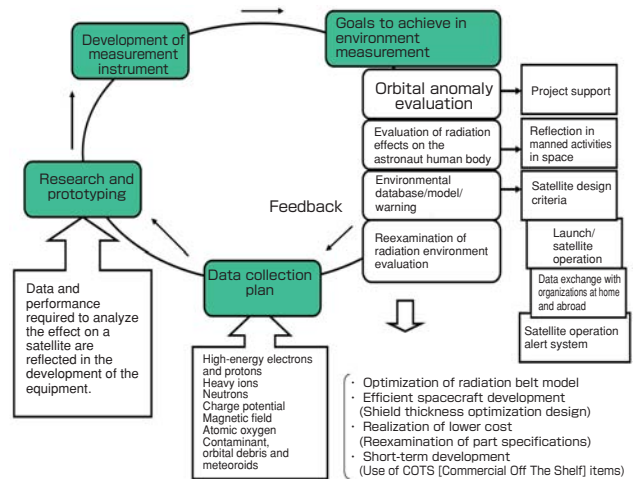
The group engages in the following tasks in its ongoing efforts to assist satellite projects at every stage of operation, from design to operation, using technologies for the high-accuracy prediction of space environmental conditions, analyses of orbital anomalies in the space environment and other important aspects of satellite design criteria.

1. Research on space environment measurement technology
2. Development of satellite-borne space environment monitor
3. Establishment of measurement network with space environment monitors
4. Opening measurement data to the public



Effects of space environment on spacecraft

### Purpose and Procedure of Environment Measurement



## Research Objectives

### 1. Development of Compact High-Performance Light Particle Telescope

The group is developing compact and lightweight instruments capable of accurately measuring energy, flux, directional distribution of light particles such as electrons, protons, deuterium, tritium, helium-3, and helium-4.

### 2. Neutron Dose Monitor

The group is developing a neutron dose monitor using a scintillation fiber stack.



Prototype of compact high-performance light particle telescope

### 3. Development of Satellite Potential Monitor

The group is developing a satellite potential monitor, which measure the potential from -10kV to +5kV.

### 4. Project Support by Space Environment Prediction

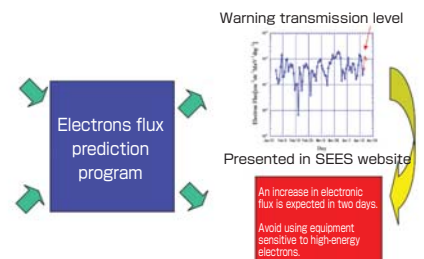
The group uses space environment measurement data to elucidate satellite defect phenomena for satellite operation and improve the technologies to transmit operational warnings on solar flares, sudden changes in the space environment, and so on.



ACE satellite (Solar wind velocity data) NOAA FTP server



DRTS (Electrons data) JAXA



Communicated by email with people involved in the operation Communication network, Satellite Operations Engineering Department

Geo-stationary orbit high-energy electrons warning system introduced in 2003

# Numerical Analysis Group

Numerical Analysis Group is one of the cutting-edge research groups for discipline engineering in the Aerospace Research and Development Directorate. Major missions of the group are focused on research and development of the advanced numerical simulation technologies using high-end computing systems, and their effective applications to JAXA's space and aeronautics programs. To this end, the group is conducting research on simulation technology for sound and vibration, combustion and turbulence, multidiscipline fusion etc. including the deep understanding of the fundamental physics as well as on the next-generation computing and networking.

## Goal

In sound and vibration research, we develop an analyzing method for the satellite vibration caused by sound inside a rocket fairing, a design technology for reducing noise by taking the helicopter blade problem as an example, an analyzing method on transonic buffet, and a fast analyzing method on sound propagation at the rocket launch..., and try to investigate the mechanism of noise reduction by the water sprinkling over the rocket launch.... In combustion and turbulence research, we aim at enabling the unsteady analysis of combustor subscale model of a rocket

engine by improving the combustion model used both of supercritical pressure combustion and droplet combustion. In multidiscipline fusion research, we try to promote the practical use of numerical simulation by enhancing the technologies concerning with grid generation, parallelization, platform, validation, etc. In the next-generation computing and networking, we develop the technology for fast and mass data transfer/sharing between remote places, and try to enhance the effectiveness of computing and data manipulation by using built-in technology.

## Research Objectives

### 1. Unsteady Flow/Sound and Vibration

Research on numerical simulation is performed to solve the problems in the field of unsteady flow, sound, and vibration, which commonly arise in the development of space/aircraft. Prediction methods for the vibration of satellite at rocket launch have been developed to improve the reliability of launch mission (Fig. 1). Design tools for low noise and high performance helicopter blade have also been built to reduce the noise impact on residents in densely populated area (Fig. 2).

### 2. Research on Simulation of Combustion and Turbulence

Numerical studies have been carried out to predict and evaluate combustion-related phenomena in aerospace propulsion systems: first, an unsteady simulation of a combustion flow field around an injector element (Fig. 3); second, a numerical study to understand and model the liquid fuel atomization process (Fig. 4). Studies on numerical methods and the modeling of turbulent flows have been also conducted based on detailed simulations of turbulence fine structures, with plans for application to full-scale aircraft analysis.

### 3. Research on Infrastructure Sophistication for Numerical Analysis

A remote file system and HPC-system hardware architecture are being researched to enable rapid processing and higher functionality in numerical simulation and data processing. The remote file system allows users to access files in the HPC-system from geographically remote sites. Research on HPC-system hardware architecture fits JAXA's application, so the architecture can process the application faster. A high-speed and high-reliability file system at the user level has been built and several experiments using the Pacific ocean network link, a long fat network, have been executed. And by operating a high-speed research and academic network, our organization has gathered and developed an array network management technique.

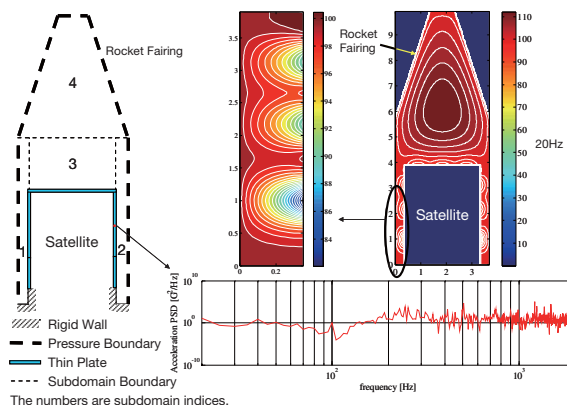


Fig. 1 Acoustic environment in rocket fairing and vibration on a satellite surface.

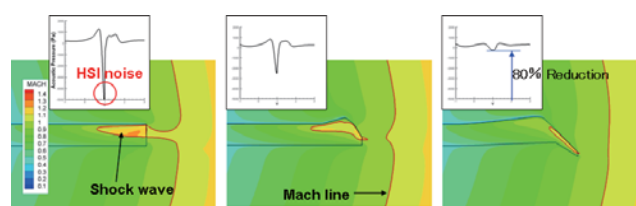


Fig. 2 Comparison of Mach contour and sound wave form among conventional and improved blade tip shapes.

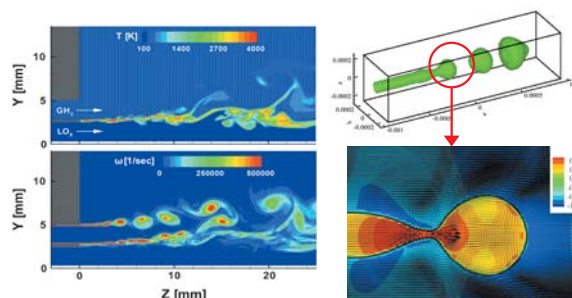


Fig. 3 LOx/H2 combustion flow around a co-axial injector element of a super-critical and cryogenic rocket engine combustor (upper, temperature; lower, vorticity).

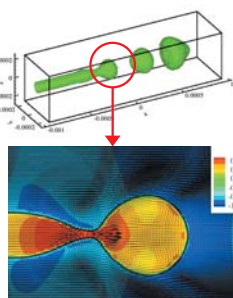


Fig. 4 Droplet breakup by propagative capillary wave.

# Space Technology Demonstration Research Center

The Space Technology Demonstration Research Center is conducting research to develop a 20- to 100-kg class small demonstration satellite at low cost in a short period of time. The newest equipment and components to enhance the performance and reliability of medium- and large-size satellites are essential. The purpose of developing the small demonstration satellite is to promptly experiment and demonstrate newly developed equipment and components in outer space and obtain flight performance. The center tries to fabricate satellites in serial form to continuously launch small demonstration satellites and help enhance the functionality and reliability of medium- and large-size satellites.

## Goal

The Space Technology Demonstration Research Center will fabricate 20-kg and 100-kg class demonstration satellites in serial form. The satellites will incorporate both spin stabilization and three-axis attitude control technologies, depending on the onboard mission. The center also plans to establish an orbit control technology by researching and developing a propulsion system for small satellites.

### 1. 100-kg class demonstration satellite

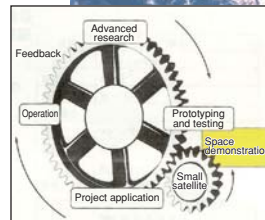
Full-scale small satellite for demonstrating equipment

### 2. 20-kg class demonstration satellite

Simplified satellite for components and small equipment  
 After advanced research, equipment and components are experimentally fabricated and tested as elements of the technology-enhancement cycle. A small demonstration satellite is positioned as a space demonstration tool for these equipment and components, before they are used in an actual project.



Small demonstration satellite 1 (Artists conception)



## Research Objectives

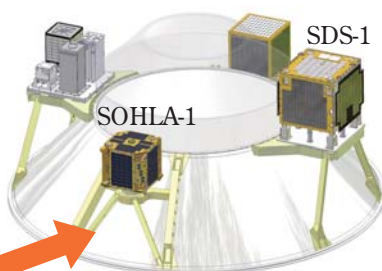
### 1. 100-kg class satellite

The major mission of the small demonstration satellite 1 (SDS-1) is as shown below.

- Multimode integrated transponder
- Space Wire demonstration module
- Advanced microprocessor orbital experimental apparatus

Item	Main specification
Size	700 x 700 x 600 mm square
Mass	Approx. 100 kg
Electric power	100 W or more
Attitude	In steady state: Solar orientation spin During the experiment: Three-axial control (inertial space fixing)
Communication	S band
Orbit	Approx. 660 km, an angle of inclination of 98°
Launch	Scheduled for fiscal 2008

Our main mission is to design and study the Small Demonstration Satellite 2 (SDS-2) with the next-generation star tracker and non-cooling infrared sensing device.



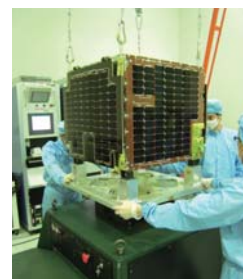
Each small auxiliary satellite is mounted at four positions on the lower rocket side of the main satellite.

### 2. 20-kg class satellite

We are designing a 25 cm x 25 cm x 50 cm small square satellite.

The Space Technology Demonstration Research Center launched the 50-kg class Micro LabSat 1 in December 2002 to acquire small satellite technologies, including spin stabilization, three-axis attitude control, and battery management. Shortly afterwards, all pre-planned experiments were successfully accomplished.

The center transferred the 50-kg class satellite technology to "SOHLA-1" from Astro-Technology SOHLA as part of an industry-government-academia collaboration. The same type of rocket is used to launch the "SOHLA-1" and SDS-1.



The satellite is fabricated in-house by younger staff researchers.



# Innovative Technology Research Center

The continuous advance of our country's space development in the years ahead will require advanced research and development on leading-edge technologies with an eye toward the future. The Innovative Technology Research Center works toward this end by conducting advanced mission research to create next-generation and future projects, advanced research and development of innovative technologies to meet the requirements of future missions, and support for ongoing projects to solve technical problems.

## Goal

As an advanced mission research activity, the Innovative Technology Research Center seeks to carry forward research and development on measures against space debris problems. Success in this effort will allow space activities to be safely sustained and contribute to the

qualitative expansion of the sphere of human activities. The center also conducts basic and fundamental research on base and flight systems to propose innovative aerospace systems, in order to contribute to the spatial expansion of the sphere of human activities.

## Research Objectives

### 1. Research on advanced mission

#### ● Research on countermeasures against space debris

The center advances research on debris observation, debris distribution prediction, and damage from debris collision to evaluate the risk of satellite collisions with debris. For drastic mitigation of space debris, the center is conducting research on technologies for a debris-remover system that will capture and de-orbit space debris. Some research focuses on component technologies for the system, such as an electrodynamic tether for a highly efficient propulsion unit.



Fig. 1 JAXA's Nyukasayama optical observation station

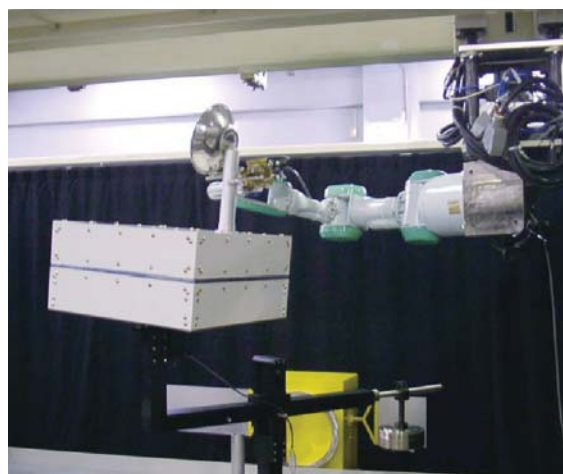


Fig. 2 Debris-capturing simulation test

### 2. Research on technologies for innovative base systems and flight vehicles

#### ● Research on manned space activity technology

The Innovative Technology Research Center furthers research with an emphasis on air and water reproduction technologies by applying nanotechnology, our country's forte. The center's achievements in this field will support future manned space activities.



Fig. 3 Sabatier reactor and oxygen reproduction equipment using water electrolysis

#### ● Research on frontier technologies

For future energy technology in aerospace applications, the center researches new power generation and storage devices such as Stirling engine and regenerative fuel cell. It also advances research with the goal of applying nano-material and nano-processing (nano-machining) technologies to space equipment.



Fig. 5 Linear electric power generator for free piston Stirling engine

#### ● Research on aeroassist guidance technology

The center furthers research to propose pioneering flight systems using innovative aerodynamic guidance technology such as space planes, aerocapture orbiters, and extremely-low-altitude satellites, by developing design tools for atmospheric entry systems and hypersonic flight systems.



Fig. 4 Development of aerocapture technology

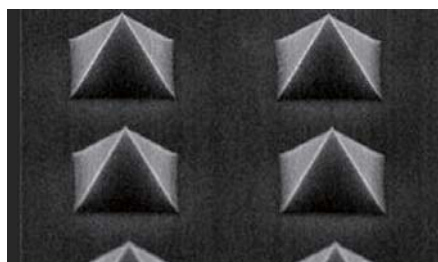


Fig. 6 Nano-processing (nano-machining) technology to be applied to a space electron source

# Robotics Research Group

The Innovative Technology Research Center promotes advanced research with an eye to continuously carry forward our country's space development into the future. The Robotics Research Group advances research on space robotics, a technology to enable challenging, high-level space missions with enhanced safety and economy. The space activities of humankind in orbit, on the moon, and on other planets are expected to greatly expand through the promotion of automation and autonomy by robots and the applications of robot technologies to support manned space activities.

## Goal

The Robotics Research Group advances research on the manned-activity support/substitute robots, which will be needed in manned space missions and the construction of large space structures. The group also researches

assembly, inspection, and maintenance technologies with the help of space robots, and conducts various project-supporting research by applying space robot technologies.

## Research Objectives

### 1. Research into manned-activity support robots

As our country's space activities expand, there will be an increase in operation and work to be performed by astronauts. The purpose of this research is to develop space robots that support, complement, and substitute manned space activities from safety and economic perspectives. Our group plans to conduct an experiment with a manned-activity support robot using an extravehicular experiment platform on "Kibou," a Japanese experiment module being developed by our country as a part of the International Space Station (ISS). In this experiment, our group is scheduled to demonstrate working and moving technologies essential to manned-activity support robots.

The Robotics Research Group is also developing a robot hand (Fig. 1) for accurate work applicable to both ground and space using the open laboratory system, a JAXA-private enterprises collaboration system provided by the Industrial Collaboration Department.



Fig. 1 Robot hand for accurate work

### 2. Research in free flying robot

In future space development, robots will be required to assemble large space structures such as space solar power generation satellites and international space stations, to inspect structure shapes and functions after assembly, and to perform maintenance. As things now stand, the manipulator arms and other space robots used to perform these jobs are mainly remote-controlled through human intervention. More generally, space robots are less advanced than ground-based robots in terms of both automation and autonomy. Our group is advancing the development of basic technology necessary to create robots to perform assembly, inspection, and maintenance in space. Of special note is a new image navigation guidance control algorithm under development as an element technology for free flying robots.

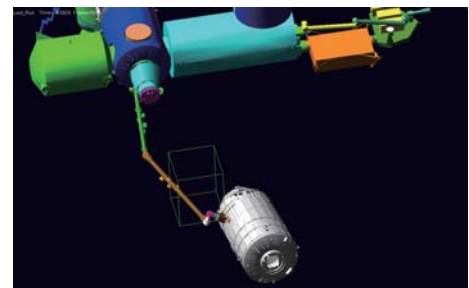


Fig. 2 Dynamics analysis of HTV while being captured by a robot arm

### 3. Project support research

Our research and development so far has helped us accumulate various forms of robot-related expertise. The application of this expertise to various projects of JAXA's other directorates will help JAXA attack many important problems. Our group measures the vibration of solar paddles of GOSAT (Greenhouse gases Observing SATellite) and performs HTV (H-II cargo transfer vehicle to deliver supplies to ISS) dynamics analyses when the space station robot arm catches the HTV (Fig. 2).

As an application of the free flying robot technology, the group also supports a project of a successor spacecraft to the asteroid exploration probe "Hayabusa." for its new image navigation guidance control.

## Major facilities

Our group uses facilities that simulate solar lighting environment on orbit to develop the image navigation guidance control algorithm (Fig. 3).

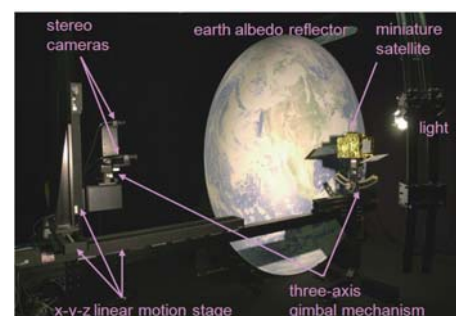


Fig. 3 On-orbit lighting environment simulator

# Advanced Mission Research Group

The Space Solar Power Systems (SSPS) is a system to collect solar energy with a large-scale solar collector installed in outer space, transmit the solar energy as either microwave or laser energy to the earth, moon, or an artificial satellite, and converted into electric power for use. The Advanced Mission Research Group researches energy transfer technologies with microwaves and laser beams, large-scale structure construction technologies for outer space, robot technologies, and other technologies to construct the SSPS.

## Goal

Solar energy is regarded as a stable, low CO<sub>2</sub>-emission energy source for the future. The SSPS is designed to transmit about 1 GW of solar energy per station (equivalent to the amount of electric power generated by a nuclear power station) from outer space to earth at low cost, for conversion into electric power for terrestrial use. The Advanced Mission Research Group conducts

experiments on the transmission of energy between grounds and from space to the ground, and on the assembly of structures for establishing large-scale structure construction technologies for outer space and energy-transmission technologies using microwaves and laser beams.

## Research Objectives

### 1. Space Solar Power Systems by microwave (M-SSPS)

To achieve M-SSPS, it is very important to enhance the efficiency of microwave power transmission units. In fiscal 2007, the group test-fabricated a 5.8-GHz band Class F amplifier using a GaN semiconductor device fabricated experimentally the year

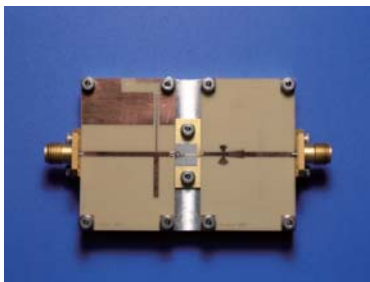


Fig. 1 Test-fabricated 5.8-GHz band Class F amplifier

### 2. Space Solar Power Systems by laser (L-SSPS)

Sunlight-laser beam direct conversion technology and laser energy transmission technology are very important to achieve the L-SSPS. The group is researching an enhanced-efficiency sunlight excitation solid laser using Nd/Cr-YAG ceramic laser material, improved output power, long-distance transmission with 500-meter laser transmission test facilities (Kakuda Space Center) (Fig. 3), and weather dependency on atmospheric transmission.



Fig. 3 Laser transmission test up to a distance of 500 meters (Kakuda Space Center)

### 3. Technologies common to the use of solar power

The SSPS requires a large structure assembled in orbit. A 2.5 km x 3.5 km elliptical condensing mirror, for example, must be assembled for the M-SSPS. To establish a technology to assemble such large structures, the group studies lightweight structural forms such as inflatable structures (Fig. 4) and researches robots to assemble and repair these structures.



Fig. 4 Test-fabricated inflatable structure

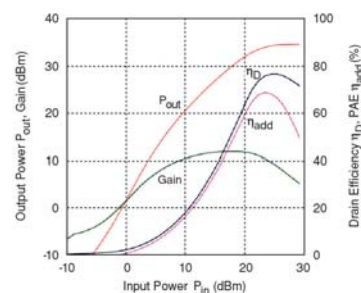


Fig. 2 Power-added efficiency ( $\eta_{add}$ ), drain efficiency ( $\eta_D$ ), and input-output characteristics of the 5.8-GHz band Class F amplifier

# Jet Engine Technology Research Center

The Jet Engine Technology Center researches and develops engine testing methods and takes charge of the construction, upkeep, operation, maintenance and management of large scale test facilities which are vital for aero-engine development but difficult for the private sector to maintain. We also handle fundamental researches on combustion measurement, high-performance turbomachinery, intelligent control, engine system concept, future propulsion systems, engine-performance-evaluation technology by advanced numerical analysis, and other areas for future high-performance aero-engines.

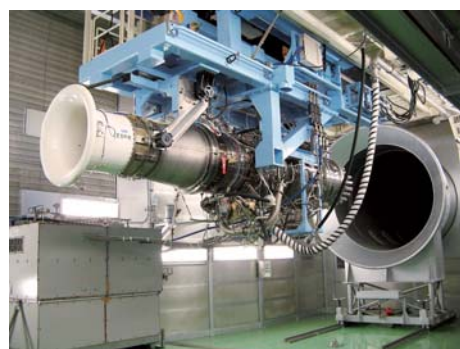
## Goal

Two programs aiming at the realization of domestically made engines have been started: JAXA's clean engine project and the "Research and Development for an Environment-Friendly Small Aircraft Engine," a fundamental technology program for civil aircraft promoted by NEDO and the Ministry of Economy, Trade and Industry. The center supports these projects by constructing new test facilities, conducting tests and evaluations using the equipment, and establishing fundamental technologies.

As a vision on aero-engines from a long-term point of view, the center is researching and developing key technologies for innovative engine systems such as a hypersonic turbojet engine and an electrified alternative aero-engine.

To reduce the development period, costs and risks, the

center is researching and developing an engine-performance-evaluation technology based on large-scale, highly accurate, advanced computer simulations.



ESPR engine installed in test cell

## Research Objectives

### 1. Fan Noise Analysis by CFD (Fig. 1)

The physical phenomenon of fan noise is a combination of three processes of noise (pressure fluctuation): noise generation by the interaction between rotor blade wake and stator vane, noise propagation inside the fan duct, and noise radiation from the nacelle. For its first project in this field the center is researching a three-dimensional unsteady CFD (Computational Fluid Dynamics) technology for the high-accuracy prediction of noise generation and propagation.

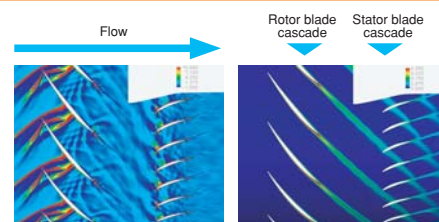


Fig. 1 State of sound wave generation/propagation and loss in the fan mid height cross-section

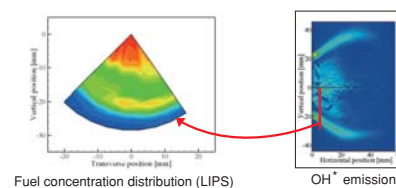


Fig. 2 Laser measurement and visualizing measurement in high pressure combustion test

### 2. NOx Emission Reduction from a Combustor by an Enhanced Measurement Technique (Fig. 2)

The spacial distribution of fuel, combustion product, and flow speed in a combustor are measured accurately by the laser measurement technique and the visualizing technique. A new combustion system for a low-emission engine is researched by understanding the essence of the combustion phenomenon based on detailed data.

### 3. Research on Hypersonic Turbojet Engine (Fig. 3)

A Mach 5 class hypersonic turbojet engine has been fabricated and tested. The technology to cool the incoming hot air at high speed flight is demonstrated using cryogenic liquid hydrogen. Moreover, research on hydrogen fuel control technology has been carried out in pursuit of the practical use of a hydrogen fuel jet engine, an engine suitable for the global environment.



Fig. 3 Hypersonic Turbojet (Sub-scale Demonstrator Engine)

### 4. Electrified Aircraft Propulsion System (Fig. 4)

The center has proposed an electric fan as a key element of an innovative aircraft propulsion system designed for enhanced environmental friendliness. A model of the electric fan has been constructed, and the operation principle—electric drive from the outer circumference side—has been demonstrated.

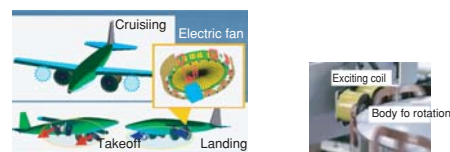


Fig. 4 Conceptual diagram of electric fan engine system and principle demonstration model

## Test Research Facilities

The center possesses the following testing facilities and makes them available for public use. A) high-pressure combustion test facility, B) General-purpose air source facility, C) sea level engine

test cell, D) high altitude engine test facility, and E) annular combustor test facility.

# Flight Research Center

Flight demonstrations are essential for the research and development of the following types of aerospace technologies: guidance, control, and navigation for aircraft and spacecraft; flight safety technology; and flight experiment and measuring technology. The Flight Research Center has a flight test technology and the following flight test equipment and facilities for flight demonstration: two propeller airplanes and a helicopter for experiments; flight simulators for airplanes and helicopters; and flight test sites in Chofu City, Tokyo and Taikicho, Hokkaido. The center maintains and improves its technology and equipment to meet the needs of flight demonstration both inside and outside of JAXA. The center also researches flight systems technologies to help solve short-term problems inside an outside of JAXA, and conducts advanced research aimed at social contribution over a long-term perspective.

## Goal

### 1. Needs-oriented research

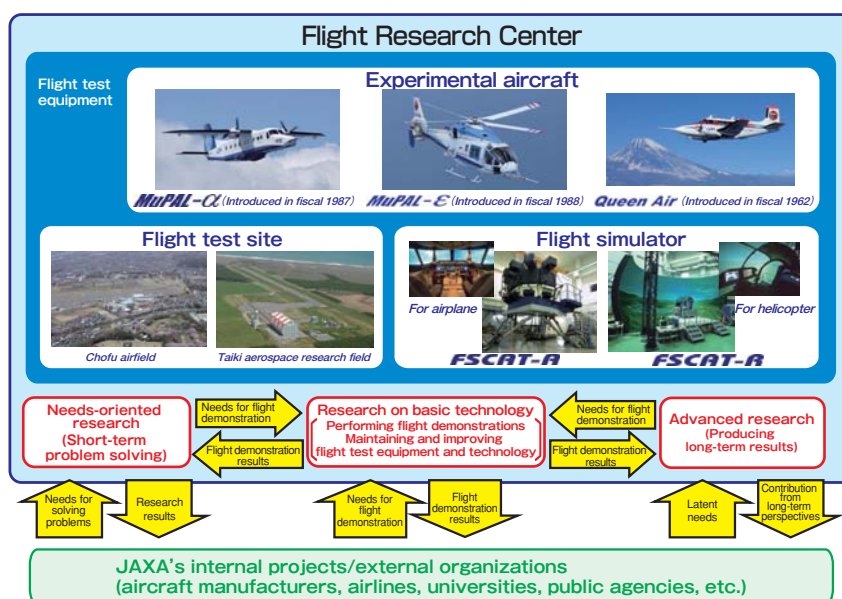
The Flight Research Center conducts needs-oriented research to solve short-term problems for JAXA and external organizations, and submits its results to those organizations when ready.

### 2. Research on basic technology

The center performs flight demonstration tests and maintains and improves flight test facilities and flight test technology to meet needs inside and outside of JAXA.

### 3. Advanced research

The center conducts advanced research on latent social needs in order to contribute to society from long-term perspectives.



## Research Objectives

### 1. Needs-oriented research

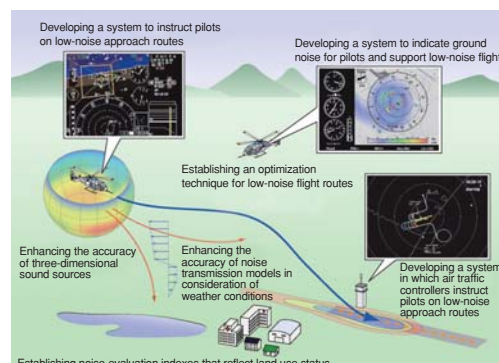
Though helicopters are much in demand, problems with noise and the threats they pose to safety limit their actual use. To increase the use of helicopters, the Flight Research Center researches technologies for supporting disaster-relief operations, as well as low-noise and all-weather helicopter flights. As part of JAXA's project, the Flight Research Center researches and develops flight systems technology to support R&D on the domestic production of the environmentally friendly high-performance small passenger airplane, all-weather high-density operation technology, and the silent supersonic technology demonstrator promoted under the Aviation Program Group.

### 2. Research on basic technology

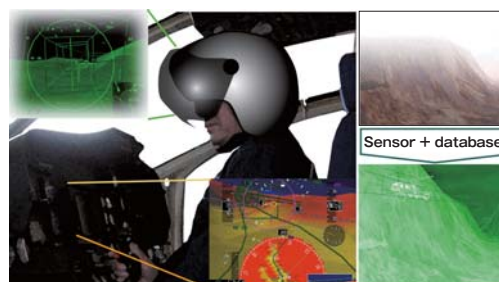
Our country has yet to develop a jet-FTB technology (flight demonstration technology using jet airplanes). This is an important task for the future, as jet-FTB technology is essential for R&D on the jet airplane, the main player in air transportation of this age. The center carries out basic research to establish a jet FTB technology, to improve flight demonstration with existing propeller airplanes and helicopters, and to develop simulation technologies. The center also demonstrates a fault-tolerant flight control technology to safely land malfunctioning airplanes during flight demonstrations using its flight test facilities.

### 3. Advanced research

To achieve completely autonomous air transportation in the future, the center conducts research to improve the reliability and autonomy of unmanned aerial vehicles, improve the automation and autonomy of manned aircraft, and enhance flight control system designs and evaluation technology as bases for automation and autonomy. As part of advanced research, the center places emphasis on research on a visual information support technology for pilots.



Research on helicopter low-noise flight technology



Visual information support system for rescue helicopters

# Wind Tunnel Technology Center

The Wind Tunnel Technology Center (WINTeC) uses and manages eleven wind tunnels of various sizes and types, from a low-speed tunnel to a hypersonic type. WINTeC also researches and develops the new testing technologies applied in its wind tunnels. These tunnels have been used for development tests on almost all aircraft produced in Japan, as well as many Japanese rockets.

In all forms of testing, WINTeC endeavors to satisfy its users based on its accumulated experience and technologies.

New testing technologies to meet the refined and diversifying needs of the day are always being developed.

## Goal

The Wind Tunnel Technology Center will maintain, use, and manage JAXA's wind tunnel facilities to ensure that they contribute as much as possible to the development of aerospace technology in our country. The Center will also enhance testing technology in response to users needs through research on standardization, the advancement of wind tunnel testing technology, and research on wind tunnel aerodynamics. In the future we plan to make necessary modifications to these facilities to ensure that they consistently exhibit their true capabilities in aerospace technology development.

### WINTeC wind tunnels

6.5 m×5.5 m low-speed wind tunnel	0.5 m hypersonic wind tunnel
2 m×2 m low-speed wind tunnel	1.27 m hypersonic wind tunnel
2 m×2 m transonic wind tunnel	0.44 m hypersonic shock tunnel
0.8 m×0.45 m high-Reynolds-number transonic wind tunnel	750 kW arc-heated wind tunnel
1 m×1 m supersonic wind tunnel	110 kW ICP-heated wind tunnel
0.2 m×0.2 m supersonic wind tunnel	



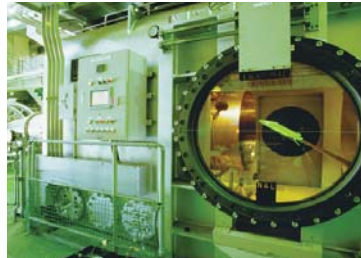
6.5 m×5.5 m low-speed wind tunnel



2 m×2 m transonic wind tunnel



1 m×1 m supersonic wind tunnel



1.27 m hypersonic wind tunnel



750 kW arc-heated wind tunnel

## Research Objectives

### 1. Standardization at wind tunnels

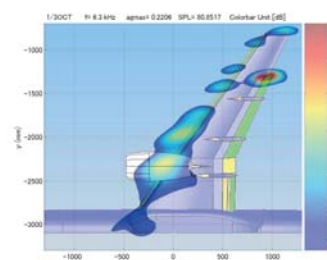
The Center maintains, uses, and manages JAXA's wind tunnels under JAXA's medium-term plan (2003 to 2007). The objects are to consistently enhance user satisfaction by accepting more entrusted tests under the Center's quality management system.

### 2. Advancement of wind tunnel test technology

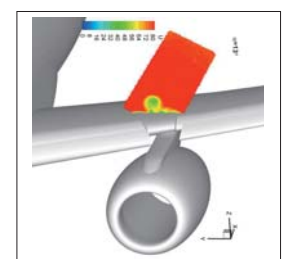
As new wind tunnel test technology, the Center researches and develops model surface pressure measurement technology (PSP technology), space velocity field measurement technology (PIV technology), boundary layer tripping / transition detection technology, etc.—technologies for which there are high user needs—and puts them to practical use in a large wind tunnel for the development of actual aircraft.

### 3. Research on wind tunnel aerodynamics

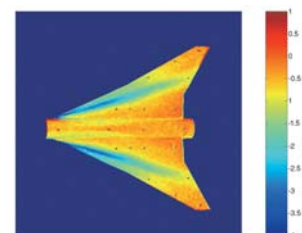
The Center develops wind tunnel technologies to elucidate the characteristics required of individual tunnels, to improve measurement accuracy, to correct for tunnel wall interference, to measure noise emitted, and so on.



Noises emitted from the various parts of a wing

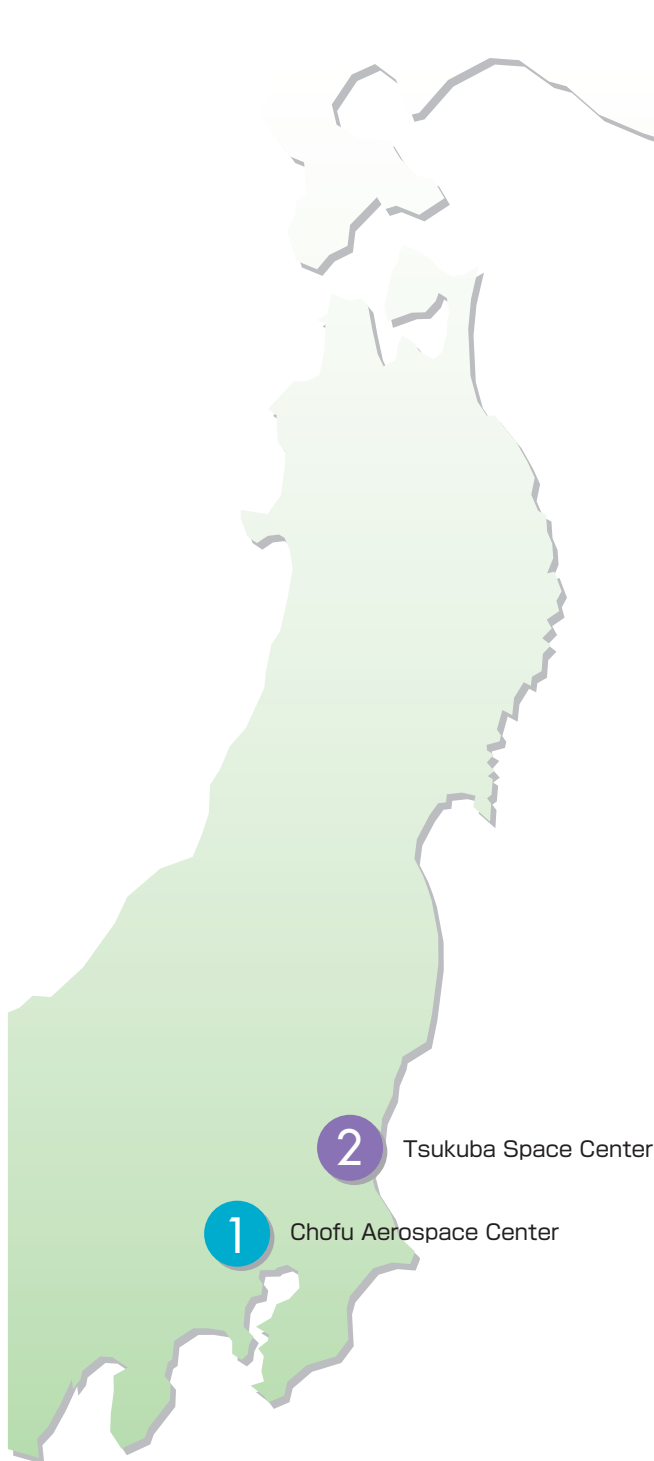


A vortex behind the engine nacelle measured by PIV



Pressure distribution measured by PSP

# ARD Field Centers



## 1 Chofu Aerospace Center

The Chofu Aerospace Center (CAC), where ARD is headquartered, aims at establishing the cutting-edge technologies through fundamental and applied R&D providing breakthroughs for the aerospace systems. Large test facilities are utilized for various research and development activities conducted by inside and outside JAXA.



Chofu Aerospace Center  
7-44-1 Jindaiji Higashi-machi,  
Chofu-shi, Tokyo 182-8522  
Phone: +81-422-40-3000



Chofu Aerospace Center  
Aerodrome Branch  
6-13-1, Osawa, Mitaka-shi,  
Tokyo 181-0015  
Phone: +81-422-40-3000

## 2 Tsukuba Space Center

## 1 Chofu Aerospace Center

## 2 Tsukuba Space Center

The Tsukuba Space Center (TKSC) plays an important role in research and development of spacecraft and tracking telemetry & control of launched satellites. ARD at TKSC supports JAXA's rocket and satellite projects; conducts R&D on space equipment; and conducts pioneering research on future space projects.



Tsukuba Space Center  
2-1-1 Sengen, Tsukuba-shi,  
Ibaraki  
305-8505  
Phone: +81-29-868-5000

**Aerospace Research and Development Directorate  
Japan Aerospace Exploration Agency**

7-44-1 Jindaiji Higashi-machi, Chofu-shi, Tokyo 182-8522  
Phone: +81-422-40-3000 FAX: +81-422-40-3281

JAXA website [http://www.jaxa.jp/index\\_e.html](http://www.jaxa.jp/index_e.html)

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