

NSK Products for Aircraft and Aerospace Applications

NSK pursues performance and reliability, making the most of its comprehensive abilities and cutting-edge technology to play an active role in the aerospace industry.



NSK Delivers Higher Performance and Reliability

The NSK Group now produces about two billion bearings every year, holding an unshakable position as the global leader. But NSK's success is based more on quality and innovation than on quantity. Since 1916, we have built an extensive track record in developing new products that are always ahead of their time. Since the Company began supplying main shaft bearings for the first domestic turboshaft engine in 1942, NSK has been a leading supplier of bearings, actuators, and other products for aeronautic and aerospace applications. Our customers can depend on NSK's expertise for higher performance and reliability.

Courtesy of NASA

Superior Bearing Materials and Lubricants

High reliability and long life are achieved through the development of the finest materials. NSK works closely with its suppliers to improve the quality and performance of its bearing steel, lubricants, and other materials.



Bearing life test machine

Material and Tribology Technology

Material technology for enhancing reliability

- Wear-resistant SHX steel for high-temperature applications
- Highly corrosion-resistant ES1 and ES2 steels
- Non-magnetic and corrosion-resistant alloys (High-hardness titanium alloys)
- Highly reliable ceramic bearings



Scanning auger microprobe (SAM)

Field emission electron probe microanalyzer for surface analysis

Ultra-High Precision

Generally speaking, bearing rings and balls are manufactured to be as perfectly round or spherical as technically possible. However, the outer rings for jet engine bearings, which are used at high speeds and under light loads, are occasionally required to be slightly elliptical or triangular shaped. NSK manufactures such bearings using high-precision production and measurement technologies and equipment.



Bearing designed with elliptical outer ring

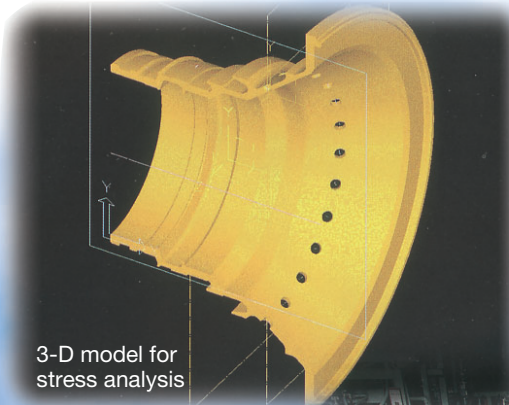


Ultra-High Precision

Talyrond roundness geometry instrument

Advanced Stress Analysis

In contrast to most other applications, aircraft and many of their components are inherently flexible structures. For this reason, the finite element method (FEM) and boundary element method (BEM) are used to obtain highly detailed and accurate stress and deformation analyses. This is essential to determine the effects of structural deformation on bearing loads and life. Such analyses are supported by and correlated with experimental test data to confirm their accuracy.

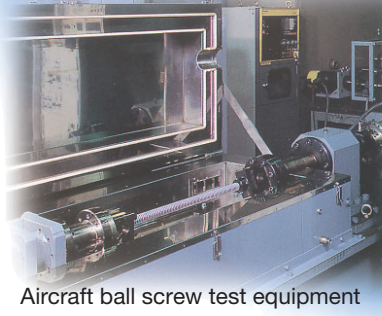


3-D model for stress analysis

Analysis and Evaluation Technology



Test-rig for jet engine bearings



Aircraft ball screw test equipment

Functional and Endurance Tests of Ball Screws

Ball screws for aircraft must operate with high reliability under heavy loads over a wide temperature range (-60 °C to +80 °C). Long testing periods are necessary to confirm endurance. NSK develops testing machines capable of facilitating durability and efficiency tests under harsh conditions. We strive for improved performance and also undertake theoretical analysis.

Testing under Realistic Operating Conditions

Aircraft engines and components subject bearings to very severe operating conditions. Depending on the application, the speed or temperature, or both, may approach the highest levels that bearings can endure. Other harsh conditions include strong shock loads, extremely high acceleration, and very low temperatures. Naturally, such extreme conditions must be accurately simulated in bearing tests and other products for aeronautical applications. NSK has the necessary facilities for such tests to meet the diverse requirements of customers around the globe.

Technology

1. Precise Measurements

The first prerequisite for high quality is precision, and that of course requires accurate measurements. NSK has the most sensitive instruments available for measuring dimensional accuracy and other physical qualities. At high speeds, precise geometric form is essential for proper balance of rotating parts.



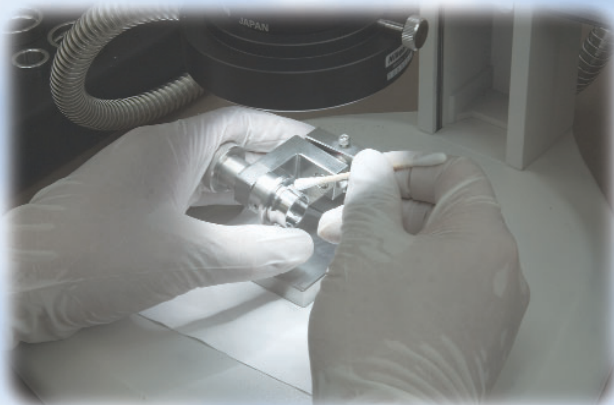
2. Nondestructive Testing

Bearing parts are inspected at each stage of production, from material acceptance to final assembly. This includes nondestructive testing, such as inspections utilizing magnetic particles, dye penetrant, eddy currents, and X-rays, as well as ultrasonic inspection and NSK's proprietary method of fatigue analysis. NSK also uses ultrasonic inspection technology for the ceramic rolling elements in its aircraft engine bearings.

- Dye penetrant
- Magnetic particle thickness and flaw detection
- Eddy current test
- X-ray
- Ultra-sonic thickness and flaw detection
- Automatic visual inspection



Production Control



3. Reliable Production Process Management

Absolute reliability is required for aerospace products. For this reason, NSK applies world famous cutting-edge manufacturing technology. We carefully manufacture products in accordance with manufacturing line working instructions and standards, and quality assurance process charts. Also, production records in accordance with process charts are maintained along with various test results. Employees with a thorough knowledge of manufacturing technology and extensive experience create products of genuine high quality.

4. Secure Record Control to Assure Quality

No business has more stringent quality-control requirements than the aerospace industry. NSK bearings, including their individual components, are completely traceable to specific processes, dates, machines, personnel, instruments, etc., by their serial numbers. Detailed histories of measuring and analysis instruments are also maintained.

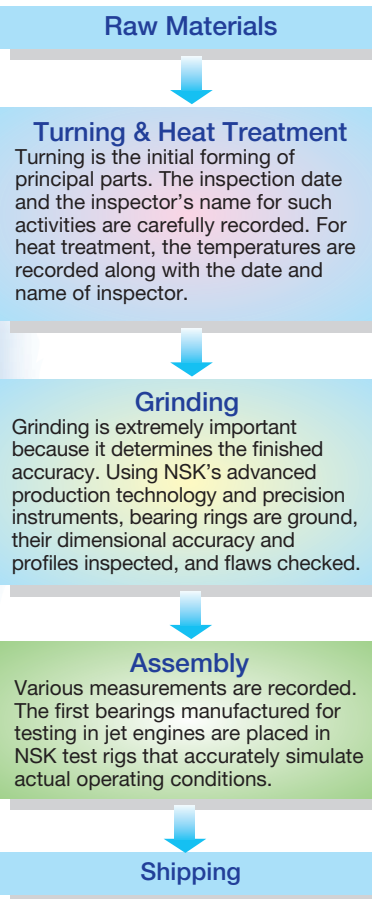
NSK Products for Aircraft and Aerospace Applications



Process Record

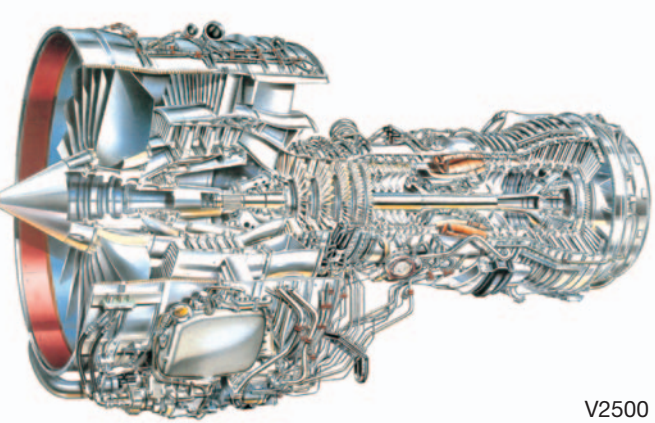


Main processes and record control



Solution

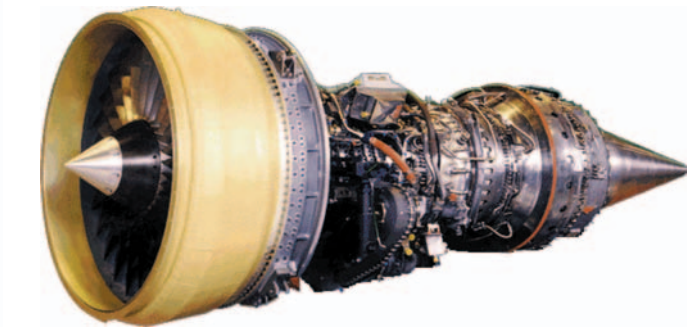
Jet Engine Bearings



V2500
Courtesy of JAEC

Jet Engine Bearings

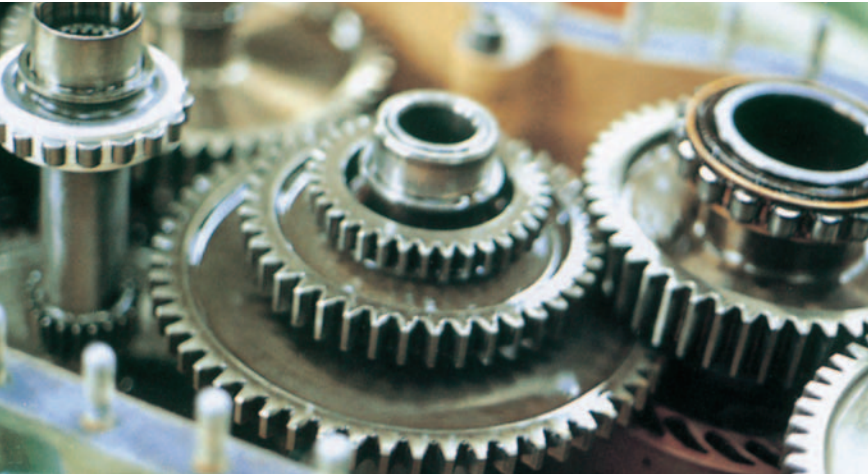
Bearings designed for use in jet engines are manufactured under the most stringent quality controls. NSK has years of experience in the design, testing, and production of bearings for nearly every jet engine built in Japan. Utilizing this experience, we have developed the technical capability and production expertise required to deliver bearings of the highest performance and reliability. NSK bearings have been installed in



CF34

almost all jet engines recently manufactured in Japan, including the CF34-8. Bearing designs are often required to have integrated components, such as flanges, squirrel cages, gears, and stub-shafts. As a result, design work becomes more complicated, and the analysis of bearing structural behavior, material selection, and production engineering must be carried out in greater detail.

Gearbox Bearings



Gearbox Bearings

Bearings for gearboxes in aircraft must sustain heavy loads and, at the same time, be small and light. NSK engineers are studying ways to reduce weight, including the use of such new materials as ceramics.

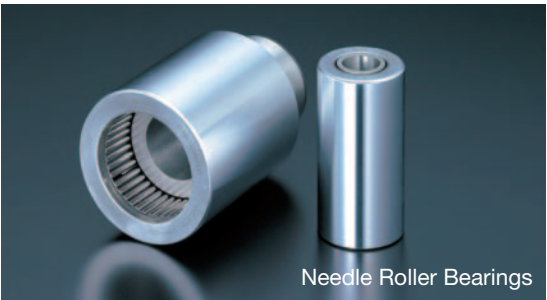
Airframe Bearings



Landing Gear Bearings



Control Bearings



Needle Roller Bearings

Landing Gear Bearings

Landing gear must sustain heavy loads, severe shocks, and extremely high acceleration during landing. Specially designed tapered roller bearings made of carefully selected materials are used for this application.

Control Bearings

Many deep groove ball bearings that are sealed and have spherical aligning seats are used on control rods in aircraft. They must sustain heavy loads and be capable of operating in harsh conditions, such as extremely high and low temperatures. They have spherical seats to compensate for the bending of rods,

special seals and lubricant for extreme operating temperatures, and special surface treatments to improve corrosion resistance.

Needle Roller Bearings

Many needle roller bearings are used in aircraft because they offer maximum load capacity for their small size and weight, and they have been standardized to conform to MIL specifications. Highly specialized needle bearings were developed for the vanes and other components of afterburners. Other special designs have been developed for use in engines, flaps, slats, and other equipment.

Bearings for Aerospace Instruments and Controls



Miniature Bearings

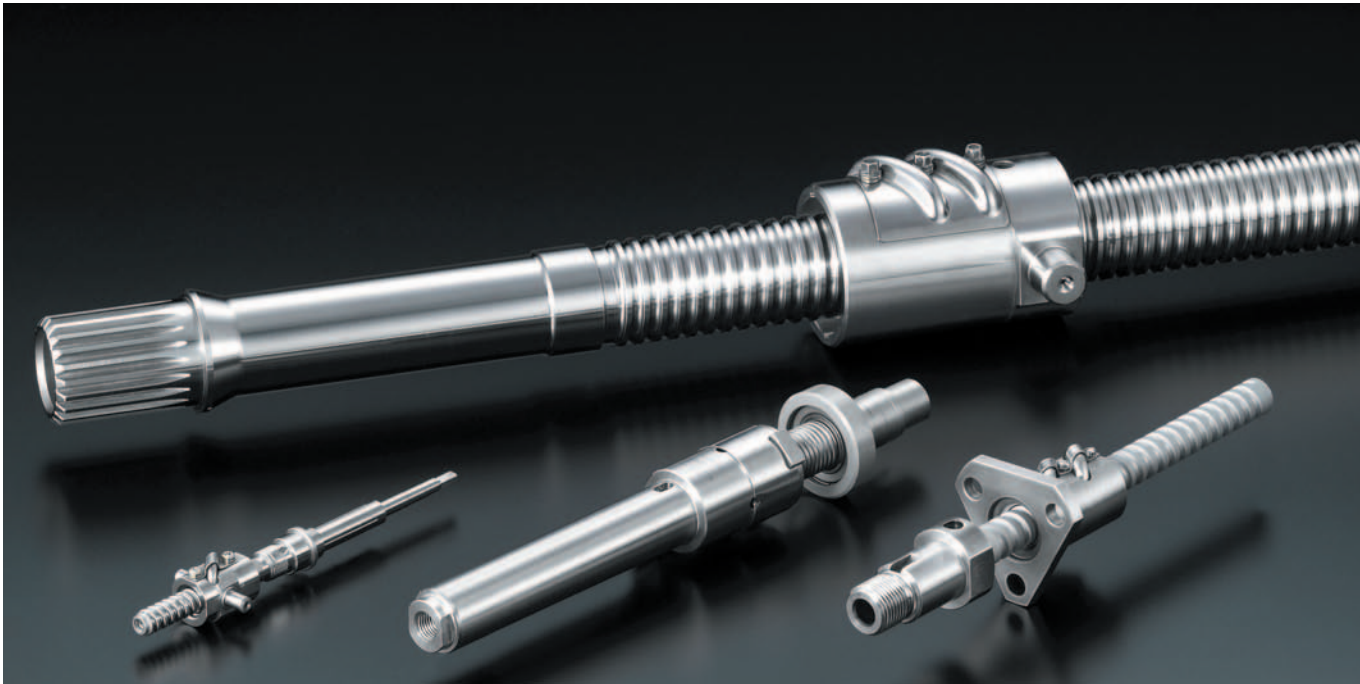


Bearings for Aerospace Instruments and Controls

Numerous miniature bearings are required in the instruments, controls, and other auxiliary equipment in aircraft and space vehicles. Examples include gyroscope rotors and gimbals, servomotors,

micrometers, and fuel supply equipment. Because of the critical nature of these applications, bearings must be produced under strictly controlled conditions to ensure maximum cleanliness, precision, and reliability.

Linear Motion Products for Aircraft



Ball Screws for Aircraft

The use of NSK's linear motion products has expanded in step with advances in aircraft, including jet engine nozzle controls, flaps, slat actuators, and stabilizer actuators. For severe environments and operating conditions, NSK inspects all materials

thoroughly and uses new technologies in surface and heat treatments. With outstanding reliability and know-how accumulated as a pioneer of ball bearings, NSK strives to meet a wide variety of needs.

One-Way Clutches for Aircraft



One-Way Clutches for Aircraft

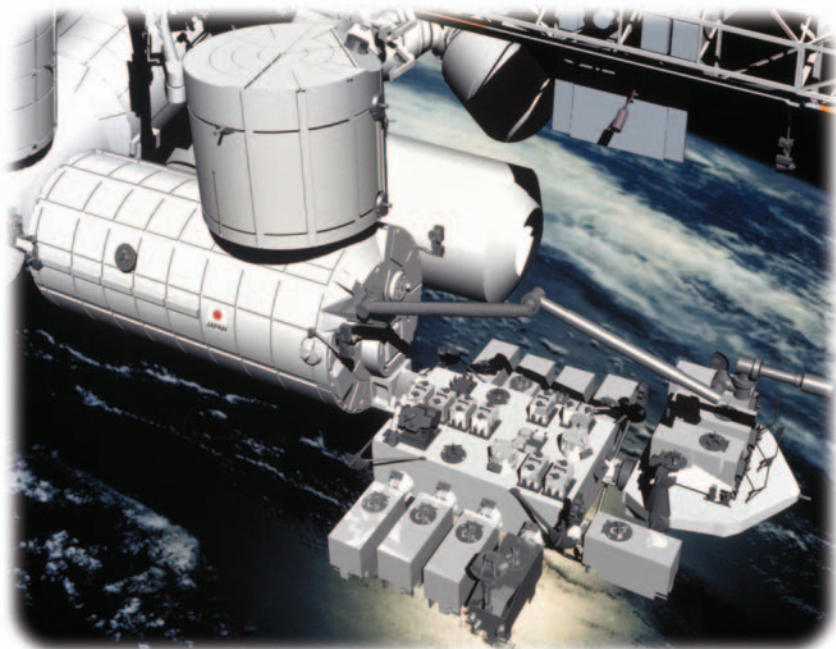
For aircraft one-way clutches, NSK selects optimum materials with superior abrasion and impact resistance, and carries out thermal and surface treatments that are analyzed in accordance with specified experimental environments. Due to this core technology, NSK has

passed material and parts assembling inspections as well as stringent inspection criteria for performance durability tests in certification approval that is applied to aircraft parts.

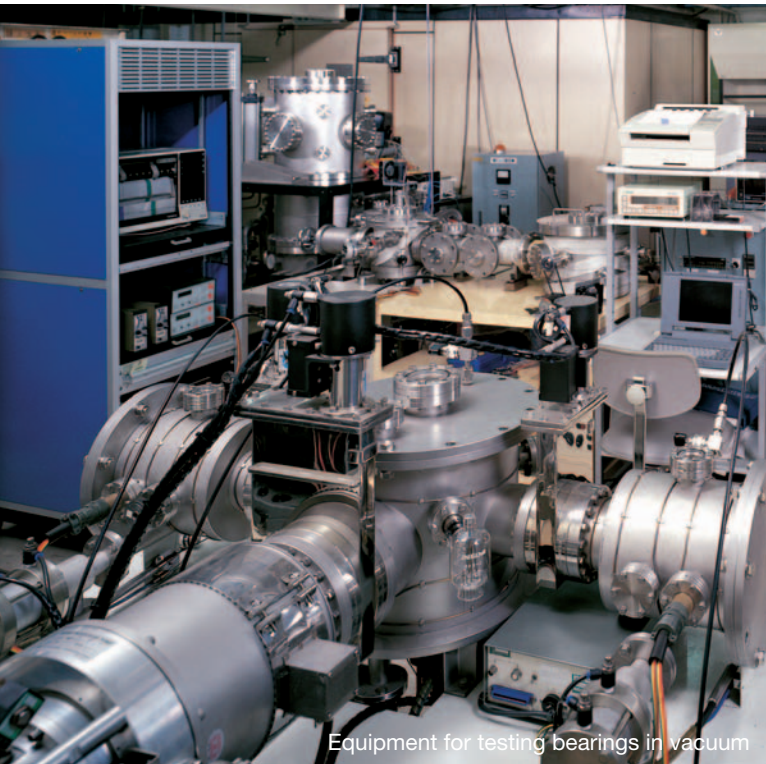
Satellites and Space Stations

In addition to rolling bearings, NSK is a leading manufacturer of linear motion products, such as precision ball screws and linear guides. The adoption of these products in aerospace applications is steadily increasing. They are now used for manipulators, open-and-shut mechanisms for the doors of logistic modules on the space station, jet engine nozzle controls, and flap

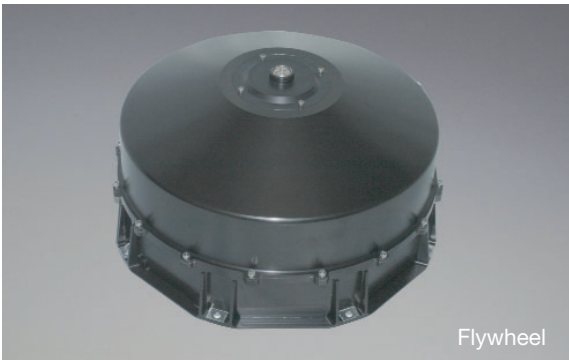
and slat actuators for aircraft. Since operating conditions for these products are often severe, NSK has developed techniques for improved metallurgy, surface treatment, and inspection. NSK will seek to find innovative solutions for the hostile environment in space and will adopt its results for better linear motion products.



©JAXA



Equipment for testing bearings in vacuum



Flywheel

Courtesy of Mitsubishi Precision Co., Ltd.



Satellite

Courtesy of NASA

Reaction and Momentum Wheels

NSK bearings are used for the wheel assemblies required to maintain the stable attitude and constant speed of satellites in geosynchronous orbit. These bearings provide high reliability, extremely long life, and

low, stable torque. NSK provides the ultra-precision manufacturing technology (including optimized surface topography), experience, and quality that meet the highly technical requirements of the aerospace industry.

Liquid Propellant Flow-control Valve



Liquid Propellant Flow-control Valve

Liquid Propellant Flow-control Valve

Liquid-fuel rocket engines use liquid propellant such as hydrogen and oxygen. NSK's cryogenic flow-control valves for liquid propellant use the high-precision technology required for these valves to operate without any lubricants.



Ball Screws for Vectors Propulsion Nozzle

Ball Screws for Vectors Propulsion Nozzle

Ball screws are used in actuators that control the direction of propulsion of a jet. NSK provides products with high reliability based on a vast accumulation of technology. In order to meet requirements, including severe atmospheric conditions (from normal atmosphere to high vacuum), heavy loads, and highly precise positioning at high speeds, NSK selects optimum materials and uses comprehensive technologies, such as thermal treatment and precision processing, and the lubricants required for specific conditions.

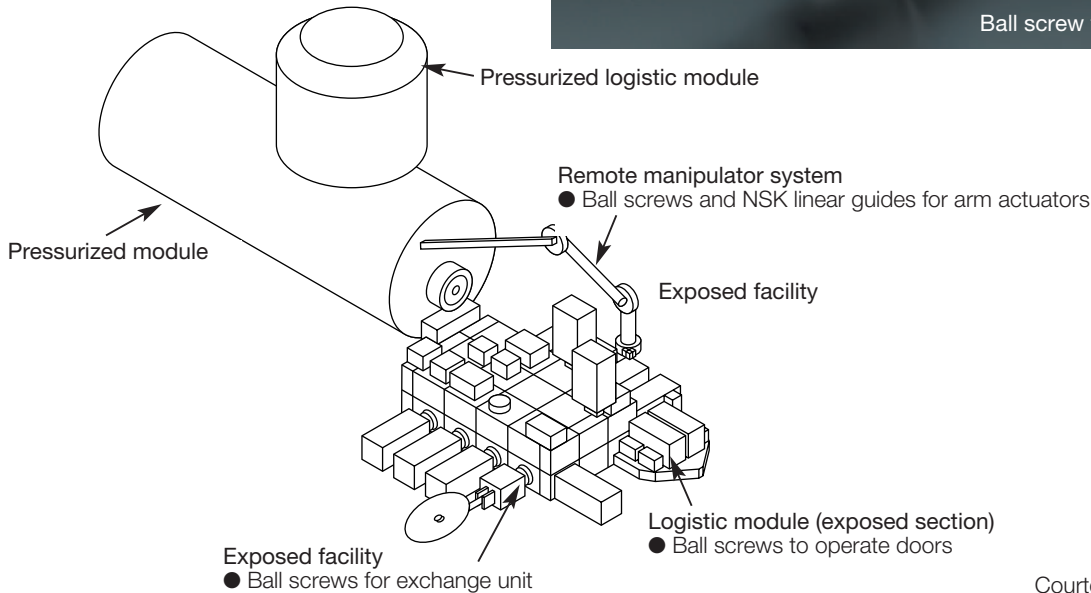
Linear Motion Products (NSK Linear Guides and Ball Screws)

Major applications

- NSK linear guides and ball screws for the docking mechanism of an experimental satellite
- Open-and-shut mechanism for the doors of the pressurized logistic module (JEM)
- NSK linear guides and ball screws for arm actuators of the remote manipulator system (JEM)
- NSK ball screws for the exchange unit of the exposed facility (JEM)

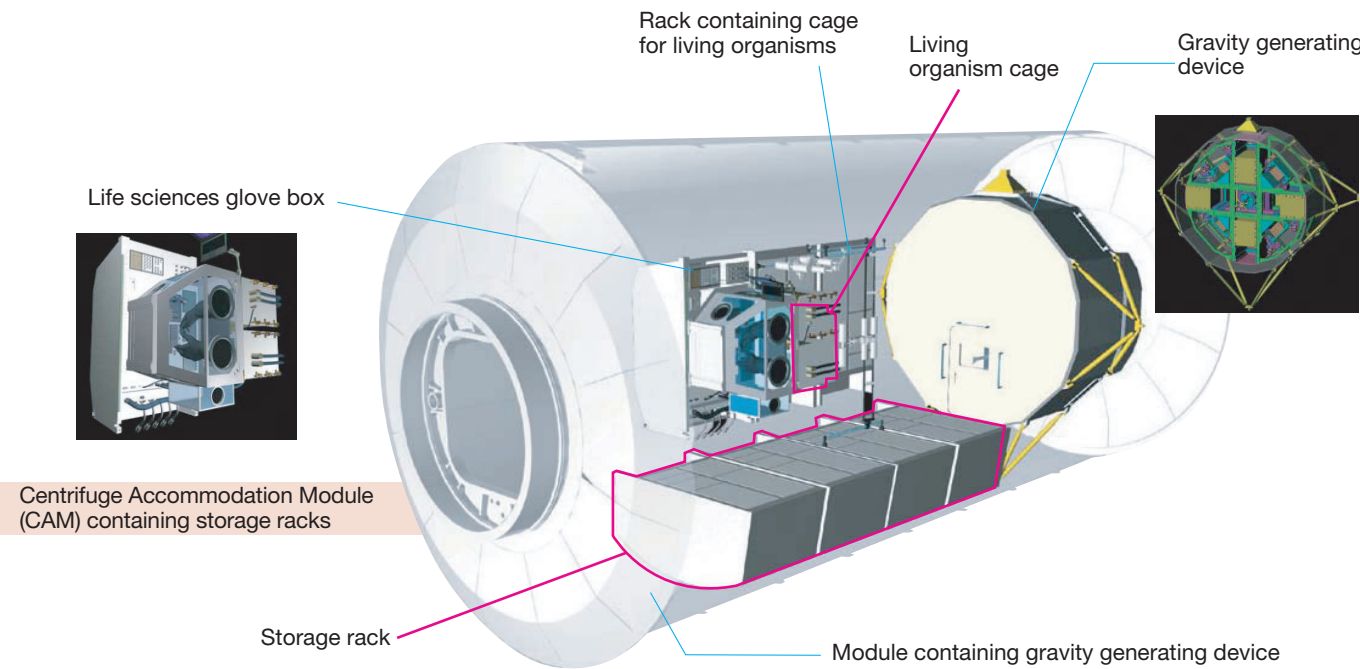


Ball screw for space



Courtesy of JAXA

Centrifuge Rotor Bearings and Linear Motion Parts



Courtesy of JAXA



Centrifuge Rotor Bearings and Linear Motion Parts

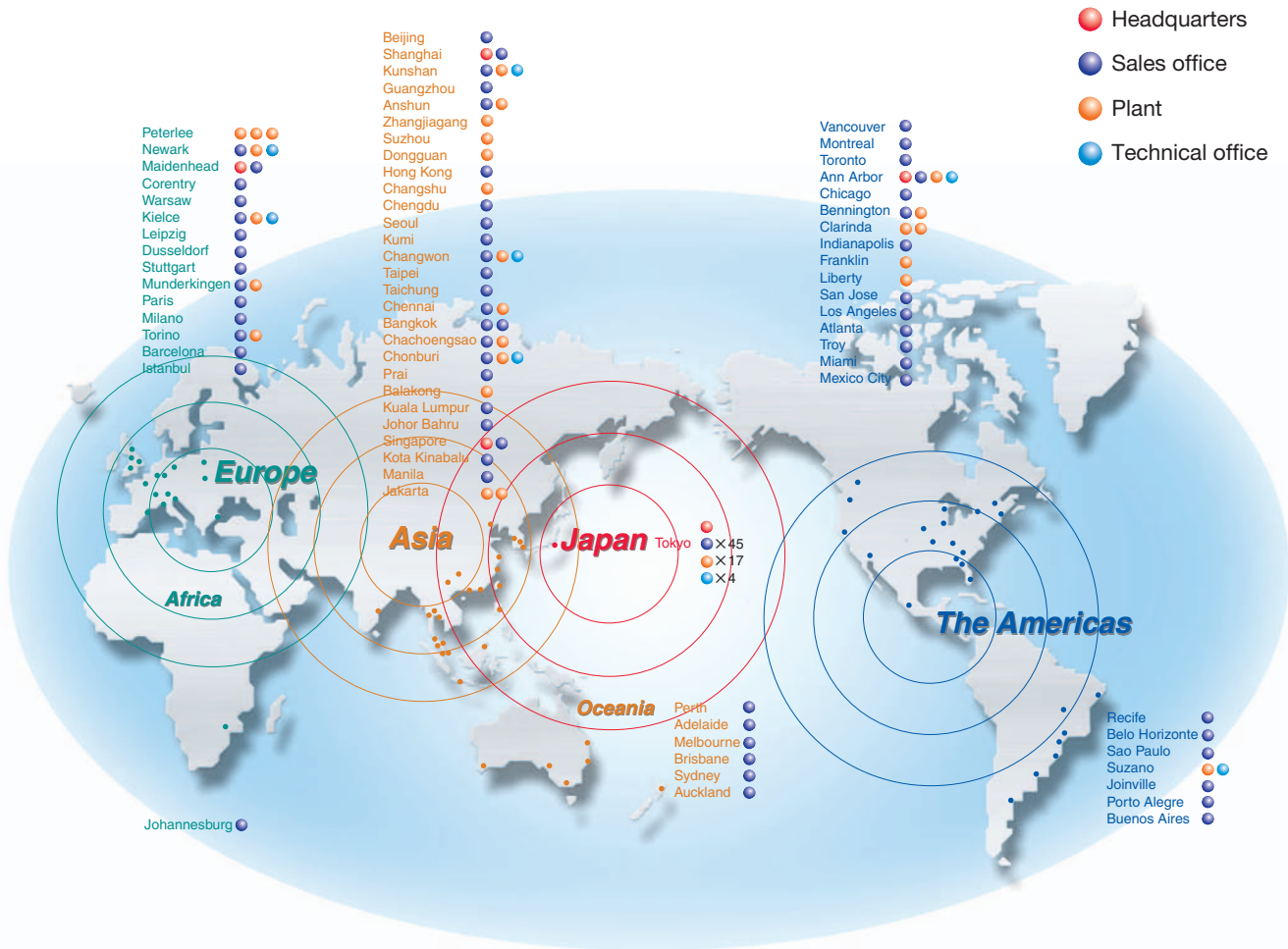
There are plans for a variety of space experiments to be conducted aboard the International Space Station (ISS). The Centrifuge Accommodation Module (CAM) has a specially designed centrifuge rotor that provides artificial gravity at levels of 0.01G to 2G and accommodates up

to four habitats where researchers will investigate how living organisms change in microgravity environments, such as the Moon and Mars. The ISS centrifuge rotor uses NSK main-shaft bearings and linear motion products.

Global User Service

NSK has a network of sales branches, plants, and technical centers covering the globe. Constantly gathering the latest information from these operations, NSK is aggressively promoting a Global Network Management system to provide optimum and high-quality products. We

have also established a global support system to accurately meet customers' requests. NSK provides users with high-quality aerospace products, substantial technological assistance, and comprehensive support.



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