Japanese Aerospace Industry
2021 - 2022

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THE SOCIETY OF JAPANESE AEROSPACE COMPANIES (SJAC)
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I Continuous Expansion of Japanese Aerospace Industry

After the end of the Second World War, the aerospace industry in Japan expanded steadily to satisfy its own defense requirements, but in recent years, participation in international joint development of civil aircraft has increased. In space operations, development of transportation and satellite systems has been promoted and increased. In this way, the Japanese aerospace industry is being continually advanced to stand alongside those in the US and EU.

1. Significance of Aerospace Industry

The aerospace industry is characterized by the following strategic components:

- By integrating advanced technologies with high-grade materials and components, the aerospace industry utilizes a wide range of supporting industries, and its technology also spreads to other industries, thus benefiting the economy as a whole.
- Through high-speed transportation, disaster prevention and other similar activities, this industry contributes to improve the daily lives of the people of Japan.
- As one of the most important components of defense, the aerospace industry is directly linked to national security.

T-4 Intermediate Jet Trainer (Kawasaki Heavy Industries, Ltd.)

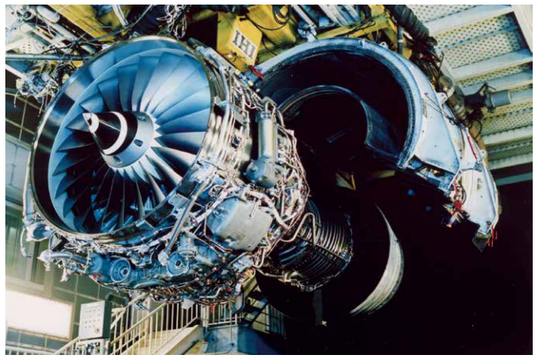
Mitsubishi SpaceJet at the Paris Air Show

2. Aircraft Related Activities

For a certain period after the end of the war, Japan was forbidden from any activities related to the development and production of aircraft, and our aerospace industry thus fell behind those of the US and Europe. Starting with the licensed production of defense aircraft, national development and production systems have grown. The development and manufacture of defense aircraft forms the foundation of the Japanese aerospace industry. In recent years the F-2 fighter (a joint Japan-US project), the OH-1 observation helicopter, the T-4 and T-7 trainer, and the US-2 search & rescue flying boat have been successfully developed and produced in this country. The P-1 Fixed-wing Maritime Patrol Aircraft has been in operation since 2013, and the C-2 Transport Aircraft has begun its delivery to the base in March 2017. Companies within Japan are participating in the manufacture of the F-35A fighter jet, helping to further strengthen the foundation of the industry in Japan. Delivery of the F-35A has begun in 2018. Moreover, the development of the next fighter (successor to the F-2) has started in 2020, by international collaboration led by Japan. And in 2021, development of the UH-2 Multipurpose Helicopter, successor to the UH-1J, has completed and will go into its operation.

Demand led by passenger transport is expected to grow steadily, and Japanese manufacturers are actively developing and manufacturing civil aircraft. Production volume has been on the rise in recent years, and civil aircraft manufacturing now outstrips defense aircraft manufacturing. However, by the pandemic of COVID-19 since the beginning of 2020 has brought sudden shrinkage to the civil aircraft market, and it is asumed severe situation to this field will continue for several years. In the 1960s, Japan focused on the YS-11 transport aircraft and other similar domestic development projects. More recently, international joint development has become mainstream due to the increase in aircraft development-related risks, as the demand of wide-body aircraft has grown globally. Currently, Japan is playing a central role in the development of aircraft such as the Boeing767, 777, 777X, and 787, and engines such as the V2500, Trent1000, GEnx, GE9X, PW1100G-JM, etc.

In the aircraft OEM business segment, we are proud of the HondaJet to become the most delivered business jet in its class. Together with the Mitsubishi SpaceJet, a next generation regional jet under development, Japanese aircraft are active in the world.



V2500 Turbofan Engine (IHI Corporation)

3. Space Related Activities

Japanese space-related projects are also world-standard projects. We have successfully developed launch vehicles such as the M-V, H-IIA/B, and Epsilon rocket, and in the satellite field we have contributed to the development of various engineering test satellites, marine and terrestrial observation satellites, communications, broadcasting and global navigation satellites, etc., including weather satellites such as the HIMAWARI 8 & 9.

The H-IIA/B launch service operations were transferred to the private sector, and by the H-IIA, the company performed a successful commercial launch of a Canadian communication satellite in 2015, UAE earth observation satellite in 2018 and UAE Mars spacecraft in 2020. This was followed by orders of Inmarsat communication satellite launch from the UK. The H-IIB rocket, an upgraded model of the H-IIA, was mounted with the unmanned H-II Transfer Vehicle (HTV) to carry supplies to the International Space Station, and all nine launches, from its first launch in 2009 to the last launch in May 2020, were successful. We have achieved an extremely high 98% launch success rate for the H-IIA/B launch vehicles. The Japan Aerospace Exploration Agency (JAXA) has also begun development of a new key rocket, the H3, to serve as the successor to the H-IIA/B. This new rocket will be highly competitive internationally. Together with the Epsilon rocket, the latest compact solid-fuel rocket, hopes are high for the further development of the Japanese rocket launching sector.

In the satellite sector, two satellites ordered by a Turkish government-run communications company are successfully delivered in orbit. Qatar has also placed an order for a communications satellite, and this was launched in November 2018. Japanese satellite manufacturers are using their advanced technical capabilities, high quality, and competitive costs to open up the overseas market. At the same time, with regard to domestic satellite demand, there is an expectation for planned governmental procurement, such as the shifting from the current four quasi-zenith satellites to a seven quasi-zenith satellite system in order to create a new Japanese global positioning system (GPS), the development of the Engineering Test Satellite 9 and the satellite successor to the ALOS-2, those are on the new Basic Plan for Space Policy.

In December 2020, HAYABUSA 2 has returned to the earth with the sample of the Ryugu asteroid.

Japanese companies are developing elemental technologies and striving to increase reliability while reducing costs.

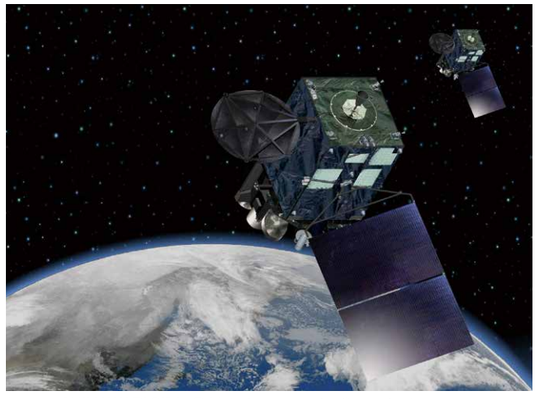


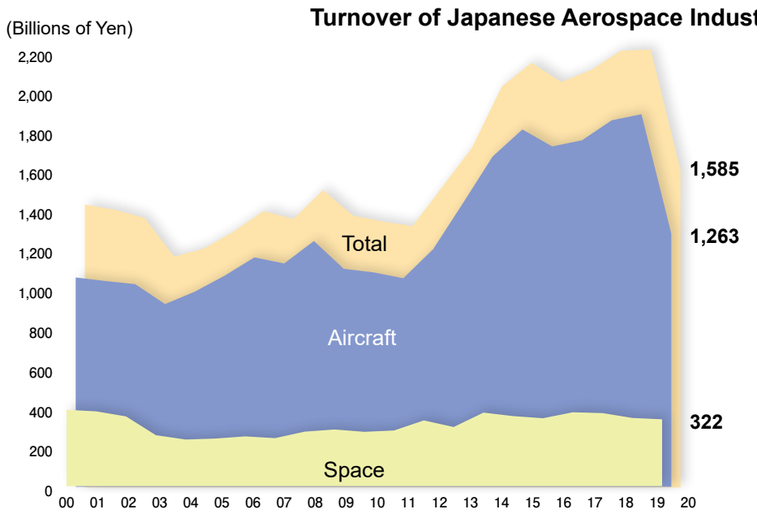
Image of HIMAWARI 8/9 in Orbit (Mitsubishi Electric Corporation)

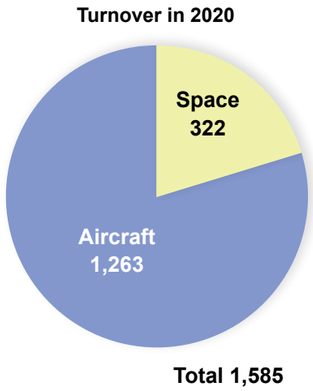
Launch of H-ⅡB (JAXA)

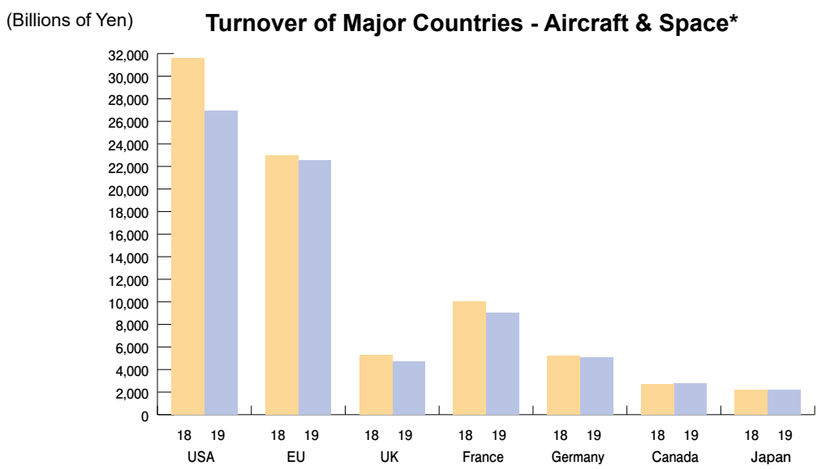
4. Aerospace Facts & Figures

The Japanese aerospace industry turnover in 2020 amounted to 1,585 billion yen. It decreased 27.9% from the previous year which was 2,197 billion yen. The breakdown of the turnover is 1,263 billion yen for the aircraft sector and 322 billion yen (Outlook amount) for the space sector. The value of production of the Japanese aerospace is primarily in providing aircraft components for commercial aircraft produced for overseas customers and defense aircraft. In recent years, the value of defense aircraft production has grown steadily or remained flat, in line with the Japanese Defense Budget. Looking at the value of commercial aircraft, the production of the Boeing 787 pulled up the overall output to the highest in the past in 2019, however the pandemic of COVID-19 has pulled down the production rate of the Boeing 777/777X and 787 to a significant level in 2020. Going forward, we are confident that the production value of aircraft will increase steadily all together with other projects like P-1 Maritime Patrol Aircraft and C-2 Transport Aircraft, those are going well. On the other hand, it is not easy to foresee a recovery from the air transportation dicrease caused by COVID-19 for a while. It is asumed that hard times for the aircraft industry will continue for several years.

The Japanese aerospace industry turnover is relatively small in comparison with that of the U.S. and EU. After a recovery from COVID-19, we anticipate that the export of airframes and engines for commercial aircraft will expand and also the space related production will grow.







*Please be noted, Turnover of Major Countries are in comparison of 2019 and 2018, due to the data announcement.

(1) Aircraft Business (Defense and Civil)

The turnover of airframes and related parts and accessories has decreased 299 billion yen, to 672 billion yen (53% of aircraft production). Engines and related parts decreased 294 billion yen, to 466 billion yen (37% of aircraft production), and related equipment decreased 13 billion yen, to 125 billion yen (10% of aircraft production). Looking at aircraft production by the type of demand, defense sector demand totaled 506 billion yen (40% of aircraft production). Export of civil aircraft came to 583 billion yen (46% of aircraft production). Previously, Japan's aircraft production relied heavily on demand from the defense sector. This trend has changed after 2013, due to the sales expansion of civil aircraft production, to lower the defense demand to around 30%. However, in 2020 COVID-19 pulled down the civil aircraft demand, and as a consequence the defense demand moved up.

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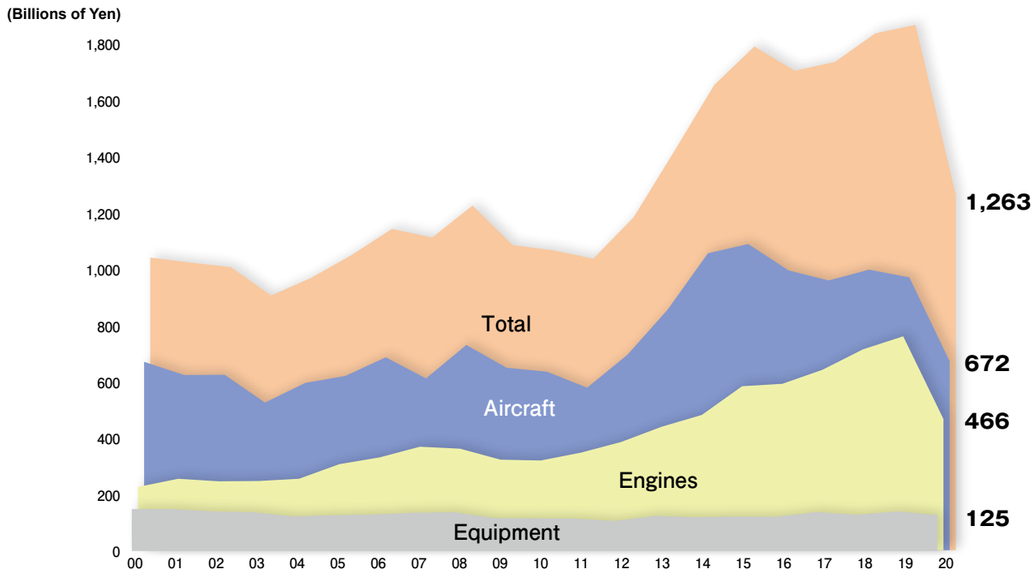
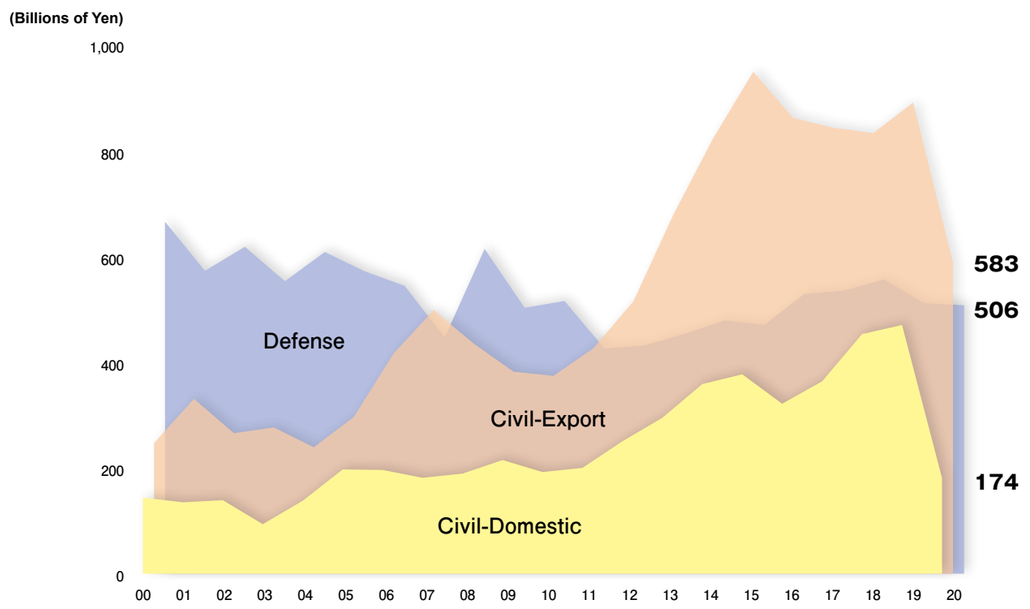
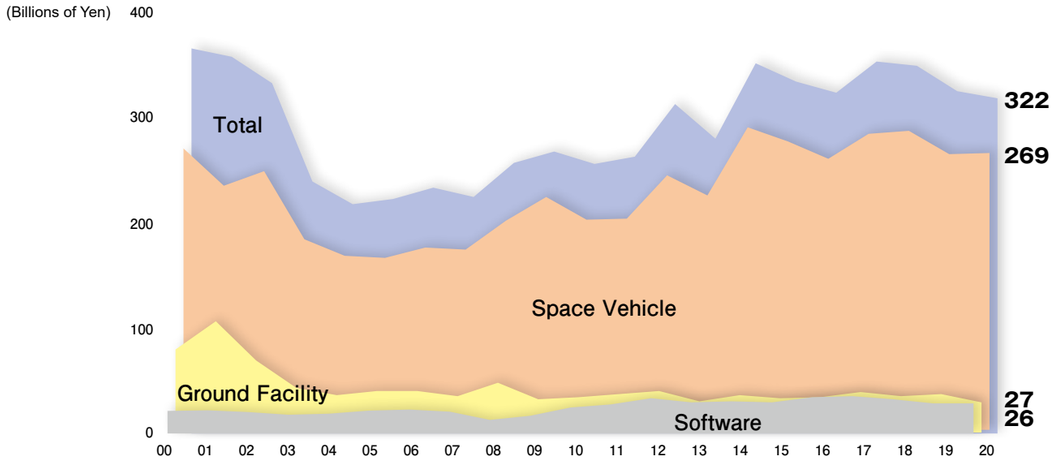




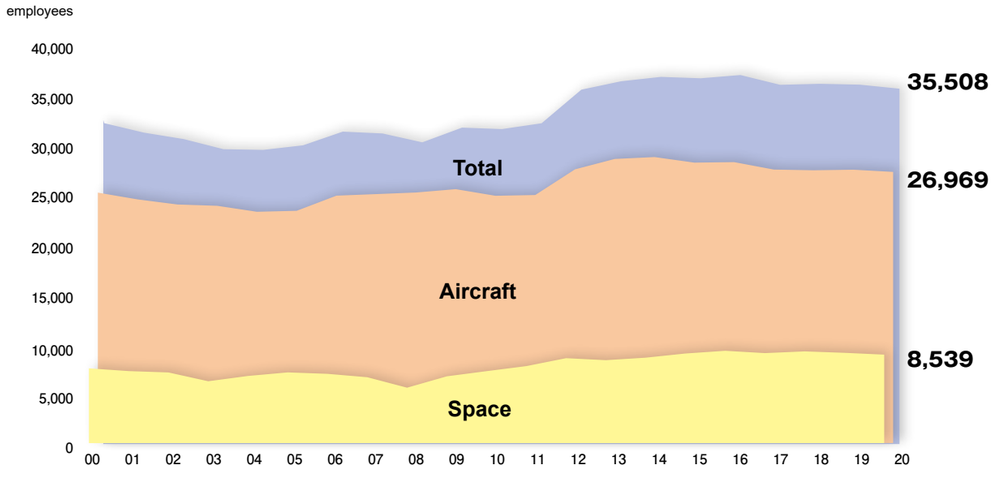
(2) Space Business

Space sector turnover in 2020 decreased 7 billion yen, to 322 billion yen (Outlook amount), and we expect that the continuous success of the H-II A/B rocket will help to increase demand in production, including the order from the foreign countries. And development of the new H3 rocket, the successor to the H-II A/B is underway, which is planned to be launched in 2022. Space vehicle (rocket, satellite, etc.) sector became approximately 84% of total space production.



(3) Employment

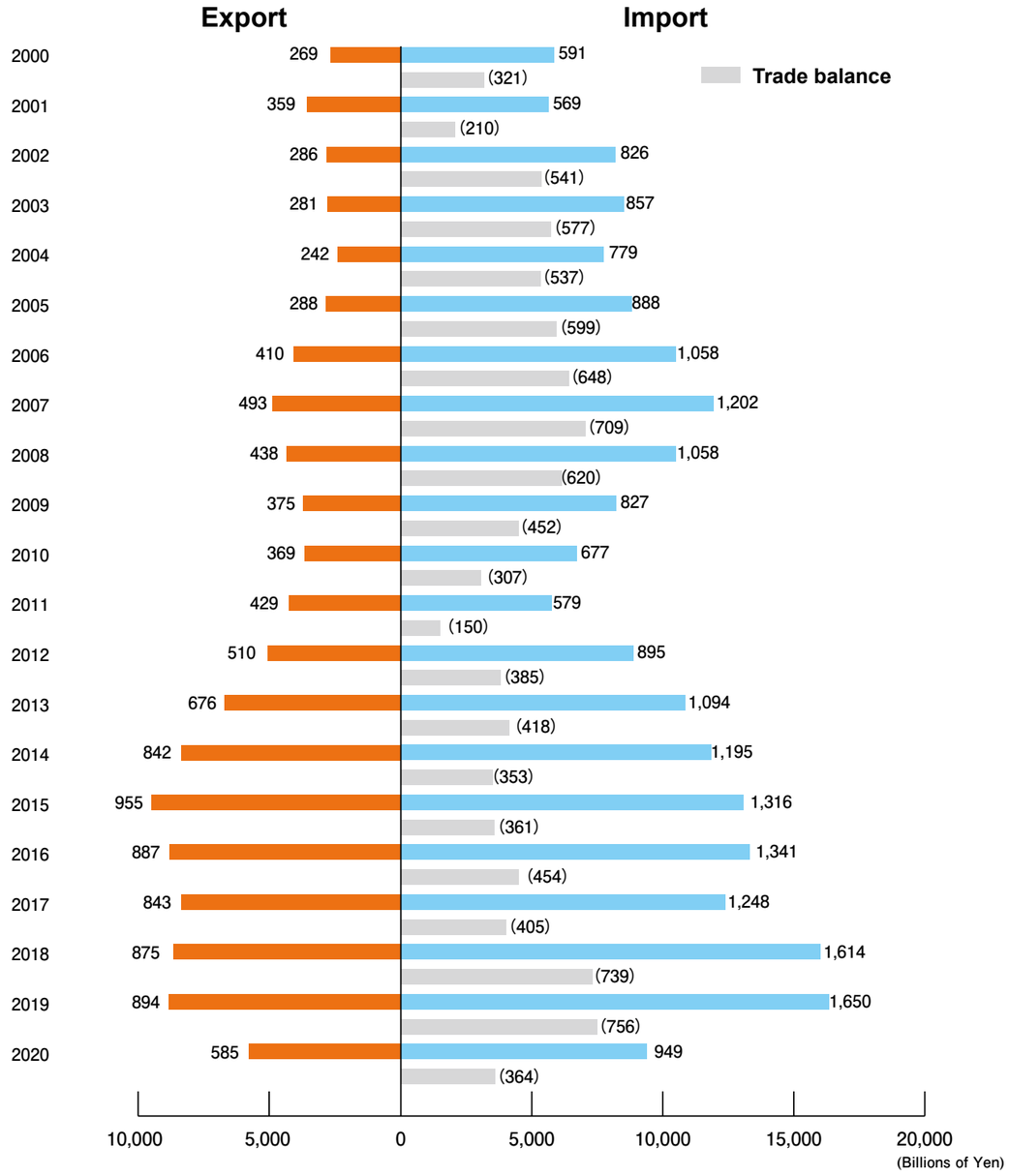
The number of employees in the aerospace industry continued on a downward trend (based on annual long-term averages)until 2005, however, after 2006, the number sometimes went up and down, but has graduallu increased, and it has been almost stable after 2014. The number of 2020 was 35,508. The aircraft sector decreased 223, to 26,969, and the space sector (Outlook amount) decreased 186, to 8,539.



(4) Foreign Trade

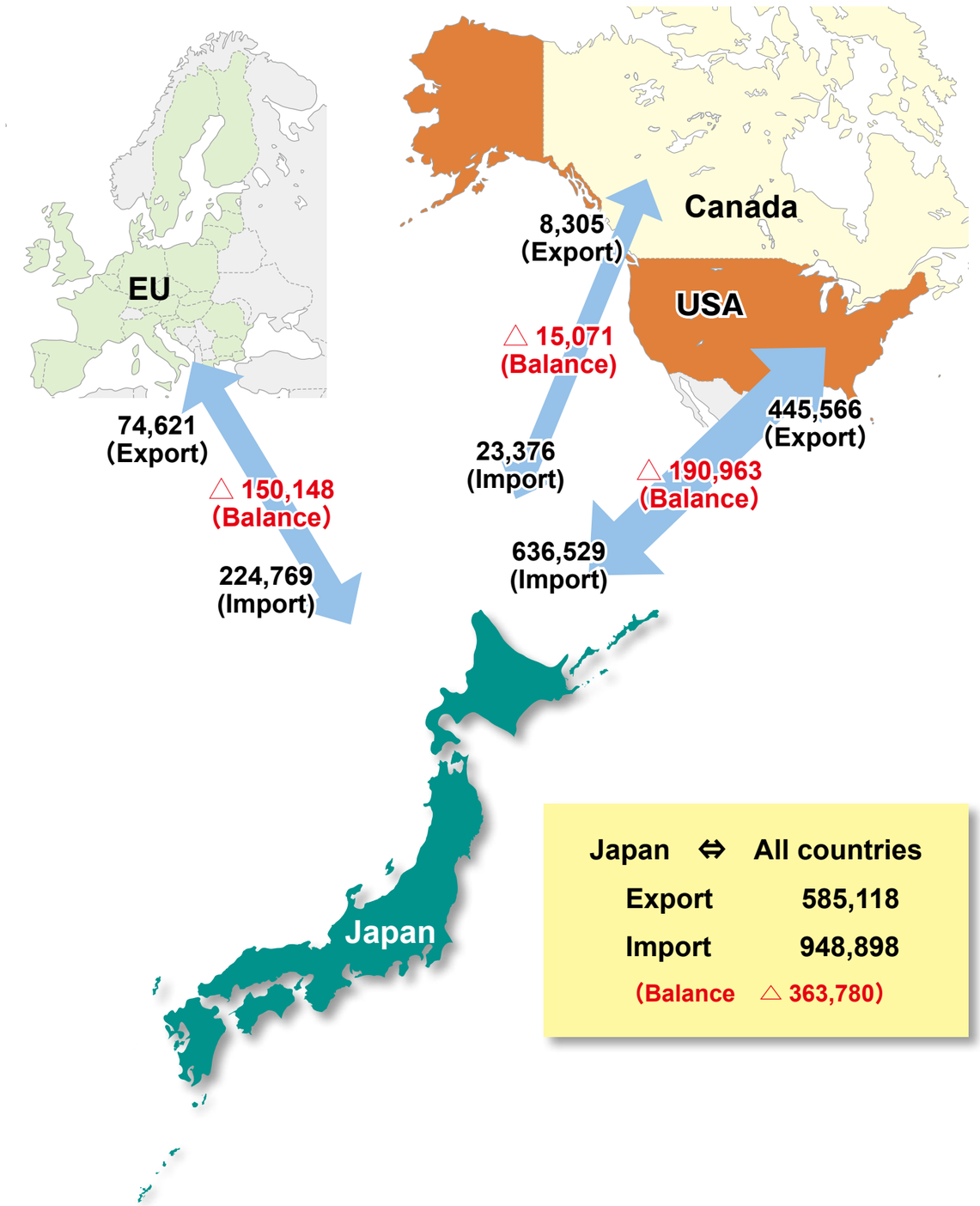
Expansion of the production of the Boeing 777 and 787 has a large impact on export of aerospace parts, and together with the international joint projects of aircraft engine such as the CF34, Trent, GEnx, PW1100G-JM and others, export from Japan has expanded. However, in 2020 COVID-19 brought a significant decrease in demand of the aircraft, and export amount has dropped to 585 billion yen. It is asumed this situation will continue for the time being.

On the other hand, imports of aerospace products in 2020, mainly from the U.S. and Europe, totaled 949 billion yen. As the result, aerospace foreign trade balance in 2020 amounted to negative 364 billion yen.



Japan ⇔ USA / EU (2020)

(Millions of Yen)



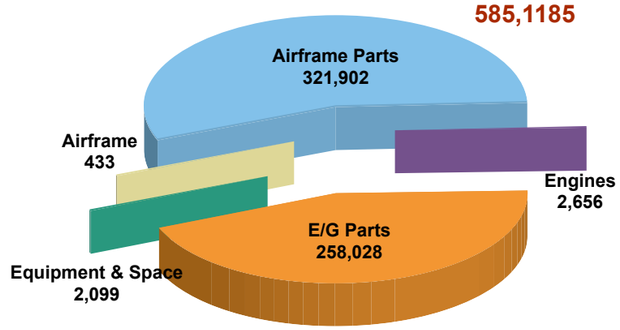
Japan ⇔ All countries	
Export	585,118
Import	948,898
(Balance	△ 363,780)

Export & Import – Destination and Type (2020)

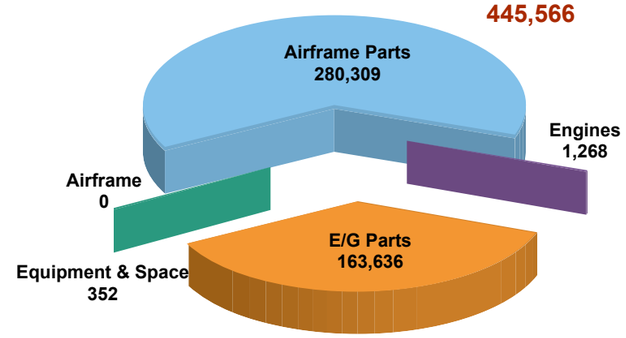
(Millions of Yen)

Export

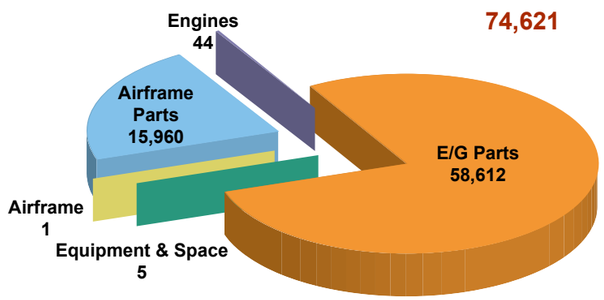
to All Countries 585,1185



to USA 445,566

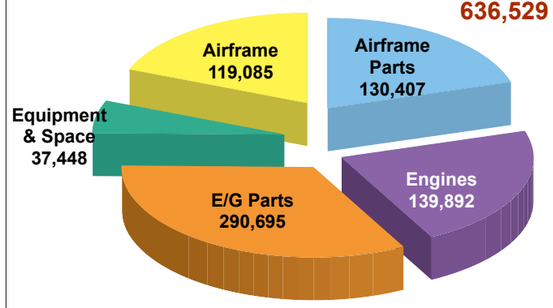


to EU 74,621

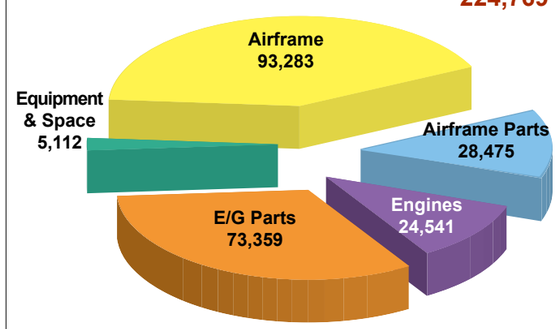


Import

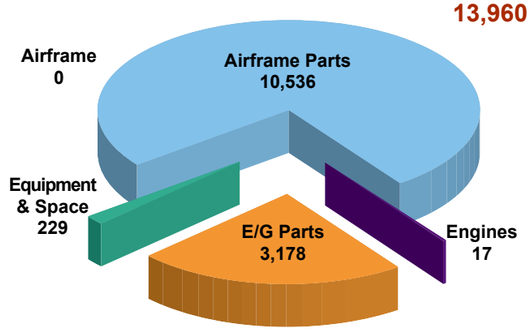
from USA 636,529



from EU 224,769



from ASEAN 13,960



II Japanese Aircraft Industry

Aircraft for National Defense

Japan's defense aircraft industry was reborn in 1952 with aircraft such as the F-86F and T-33A manufactured under license from the United States. In 1958, Japan's first jet trainer was developed and produced. Many significant steps in the advancement of the design and manufacturing technologies have followed. Today, Japanese aircraft manufacturers have their own capability to develop, produce and maintain a wide range of defense aircraft, such as fighter, transporter, patrol plane, trainer and search & rescue vessel, which has thus contributed to the national defense.

1. Most Advanced Fighter

• F-2
Developed jointly by Japan and the United States, the F-2 fighter is used in multiple roles, such as tactical air support, close air support and defensive counter-air operations. Highly regarded both at home and overseas, this fighter features a host of advanced technologies developed indigenously in Japan.

• F-35A/B
The F-35A (CTOL; Conventional Take-Off and Landing) is the latest fighter being introduced as the successor to the F-4 fighter. With the exception of a few completed aircraft, airframe and engine final assembly and inspection, as well as component manufacturing, are performed by Japanese companies. Participation in the manufacturing of the F-35A by Japanese manufacturers will contribute to strengthen the domestic business basis, and to support good operations. Delivery of the F-35A to the base has begun in January 2018.
And the F-35B, STOVL (Short Take-off and Vertical Landing) aircraft, will also be introduced.

2. Aircraft Development

Japan Ministry of Defense is currently developing, and operating the following types of aircraft:

• Search & Rescue Flying Boat
Development of the US-2 Amphibious Search & Rescue Flying Boat, successor to the US-1A, has started in 1996, and succeeded its first flight in December 2003. Delivery to the base has started in March 2007.

• Fixed-wing Maritime Patrol Aircraft and Transport Aircraft
Development of the P-1 Fixed-wing Maritime Patrol Aircraft, successor to the P-3C, and the C-2 Transport Aircraft, successor to the C-1, has begun at the same time in 2001. By this method, common processes of these two aircraft were shared and reduced overall development costs. The P-1 succeeded the first flight in September 2007 and started the delivery to the base from March 2013. The C-2 successfully completed its first flight in January 2010 and the delivery to the base has begun in March 2017.

• Unmanned Aerial Vehicles
The Ministry of Defense is working on the research of unmanned aerial vehicles. Studies to evaluate conversion of the F-104 Fighter for pilotless operation was performed, and the ministry has developed an unmanned aircraft research system with autonomous flight functions capable of automatic landing.

• Trainer
The Ministry of Defense has been designing and developing a trainer such as the T-4 and T-7 indigenously in Japan. Both the airframe and engine of the T-4 intermediate trainer was fully developed and produced in this country. Making the most of its excellent agility, the aerial-combat research aircraft (nicknamed "Blue Impulse") appeals to people with flying displays held at various air bases throughout Japan.

• The next fighter
The next fighter successor to the F-2, with the capability against future threat is under development. The development has started from 2020, by international collaboration led by Japan.

These technical capabilities of defense aircraft not only contributed significantly to the development and manufacture of civil aircraft as the ripple effect, but also have widely spread to other industries, and formed the basis of Japan's industrial technology.


C-2 Transport Aircraft (Kawasaki Heavy Industries, Ltd.)


F-2 Fighter (Mitsubishi Heavy Industries, Ltd.)


United States Air Force F-35A


US-2 Amphibious Search & Rescue Flying Boat (ShinMaywa Industries, Ltd.)


Unmanned Aircraft Research System (SUBARU Corporation)


P-1 Maritime Patrol Aircraft (Kawasaki Heavy Industries, Ltd.)


T-7 Primary Trainer (SUBARU Corporation)

Civil Aircraft for Steady Growth Expectations

Aiming at risk reduction and being market oriented, the development of civil aircraft is carried out in multinational projects. Japan is proactive in the joint development of the Boeing777, 787, and other models.
In the field of aircraft OEM business, the HondaJet is well known and operated worldwide. And the Mitsubishi SpaceJet is under development.

1. Increases in Demand for Passenger and Transport Aircraft

Worldwide demand for passenger aircraft expanded at a record pace from 2005 after recovering from a low economic growth following the September 11, 2001 terror attacks. The demand was boosted by China, India and other rapidly growing emerging economies, and by good performance of low-cost carriers around the world. The demand plunged again in the aftermath of the global financial crisis in 2008, then, recovering again worldwide demand for passenger aircraft from 2010.
And once again, in 2020, demand of passenger aircraft has decreased suddenly because of the COVID-19. After the recovery from COVID-19, this demand is expected to bounce back.

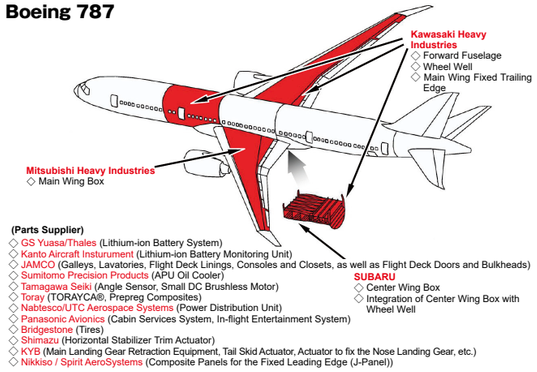
First delivery of Boeing 787 (All Nippon Airways Co., Ltd.)

Airbus A350 (AIRBUS)

2. Japan's Role in Multinational Development

Japanese companies are active in projects such as those shown in the following table (Participation in International Projects), and they play an important role in the global production of aircraft. Japan has been involved in multinational development of aircraft such as the Boeing767, 777, and 787, and has steadily increased its production share. In July 2015 Japanese companies were officially contracted to manufacture approximately 21% of the main structural components used in the new Boeing777X passenger plane. Many Japanese companies are also participating in the production of the Airbus A320, A330, A350 XWB, and A380.

Boeing 787



Boeing787 Industrial Participation (Japan Aircraft Development Corporation)

Airbus A350

Airbus A350 Industrial Participation (AIRBUS)

3. Domestic Development of Civil Aircraft

Japan developed the YS-11 60-seater transport aircraft in 1964 as the country's first independently developed civil aircraft. The MU-2, FA-200, FA-300 and MU-300 business jets followed during the period until 1980. And nowadays, the HondaJet has won the most delivered business jet in its class for four consecutive years from 2017, and currently over 170 HondaJets are operated worldwide. And the Mitsubishi SpaceJet (formerly MRJ (Mitsubishi Regional Jet)) which the program was launched in 2008, and the first flight has successfuly completed in 2015, is under development.

HondaJet Elite S (Honda Motor Co., Ltd.)

Participation in International Projects

Project	Area of participation	Scope of participation
Boeing 767	Forward fuselage, aft fuselage, main landing gear door, etc.	15% program partner
Boeing 777. 777X	Center section, center fuselage, aft fuselage, etc.	21% program partner
Boeing 787	Wings, center wings, front fuselage, etc.	35% program partner
Bombardier Challenger 350	Wings, main landing gear	RSP
Bombardier G 5000 / 6000	Wings, center wings, center fuselage	RSP
Bombardier CRJ 700 / 900	Nose and main landing gear system	RSP
Embraer 170 / 190	Wings and center wings	RSP
Gulfstream	Flaps and landing gear operation devices, etc.	Supplier
Airbus A350	Premium seats, ICE Galleys, carbon fiber, etc.	Supplier
Airbus A380	Cargo doors, vertical stabilizer structure material, carbon fiber, water tanks, etc.	Supplier

Helicopters and State-of-the-Art Technologies

As the largest user of helicopters after the US and three other countries, Japan develops and manufactures fuselages, engines and all other helicopter components. The technologies used in fuselage and transmission production in this country have an excellent reputation throughout the world. The rotor system is the most important part of these components, and Japan has successfully developed and produced a composite-material, bearing-less version of this system that makes full use of cutting-edge technologies. The Japanese aerospace industry is also proactively participating in multinational development projects.

1. Civil Helicopters

• BK117
The BK117 has been developed jointly with MBB of Germany (now part of Airbus Helicopters). This helicopter is used for flying medical services, police, firefighting, disaster aid, etc., and is a top seller in both domestic and overseas markets.

BK117D-2 (Kawasaki Heavy Industries, Ltd.)

• SUBARU BELL 412EPX
The SUBARU BELL 412EPX is joint development helicopter by Bell Textron of the U.S. and Japanese manufacturer. This multipurpose helicopter with the latest transmission is highly reliable even in sever conditions.

SUBARU BELL 412EPX (SUBARU Corporation)

• Japanese companies are currently participating in the following international joint development projects.

Participation in International Civil Helicopter Projects

MD902 (MD Helicopters)	Production of the transmission
AW139 (AgustaWestland)	High-speed gearbox (RSP)

2. Defense Helicopters

• OH-1 Light Observation Helicopter
The OH-1 is the first helicopter fully developed in Japan. And, it has been honored with the Howard Hughes Award by the American Helicopter Society. Featuring an all-composite, bearing-less rotor system, it benefits from extremely high maneuverability.

OH-1 (Kawasaki Heavy Industries, Ltd.)

• SH-60K Anti-Sub Patrol Helicopter
In addition to a newly developed high-performance rotor system and a ship-landing assist system, the SH-60K features a longer fuselage, and despite being an upgrade, it represents almost a complete redevelopment of the SH-60J.

SH-60K (Mitsubishi Heavy Industries, Ltd.)

• AH-64D Fighting Helicopter
The AH-64D, which has distinguished information and fighting capabilities, is the successor model to the AH-1S, and in the operation it takes part as the core of the network-centered combat.
Under License Production.

AH-64D (SUBARU Corporation)

• MCH-101 Airborne Mine Countermeasures (AMCM) and transport Helicopter
The MCH-101 is the successor of the MH-53E, and it is based on the EH-101. It is used for AMCM and transport roles.
The AMCM system is integrated domestically.

MCH-101 (Kawasaki Heavy Industries, Ltd.)

UH-2 New Multipurpose Helicopter (SUBARU Corporation)

• UH-2 (Multipurpose Helicopter)
The UH-2, successor to the UH-1J, was developed by redesigning the latest and upgraded model of Japan and overseas companies' joint developed helicopter, which provides superior safety, operational readiness and wide cabin. In June 2021 development has completed and will go into its operation.

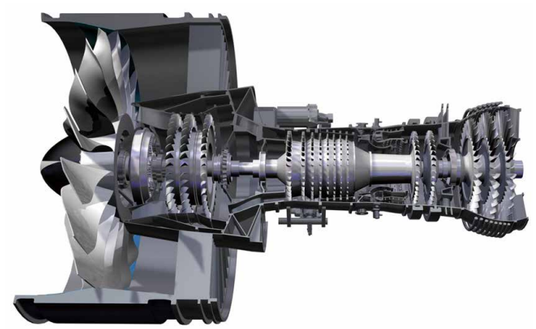
In addition, Japanese manufacturers produce helicopters under license, such as for the CH-47 (Boeing, heavy transport helicopter) and the UH-60J (Sikorsky, multipurpose helicopter).

Aircraft Engines

For the development of civil aircraft engines, Japan plays key roles in international joint development projects for such engines as the CF-34, Trent 1000, GEnx, PW1100G-JM, etc.
For the development of both defense and civil engine, several national projects are underway with the focus on developing advanced technology applications.

1. Civil Engines

Engine development requires an enormous amount of time, money and increasing risks of being outperformed against growth requirements. Because of such difficulties for any single company to endure, these projects very often become international joint development projects.
Since the participation in the V2500, we have continued to be involved in and a key player in these international collaborative projects, like the GE90, PW4000, Trent series and CF-34.
The status of participation has grown: In V2500 – design of the fan, and in GE90, PW4000, CF34-8 and CF34-10 – extended to compressor, combustor, turbine, and in Trent series – including design of FADEC (Full Authority Digital Electronics Control).
Japan's technical expertise has been implemented in almost every area of the engine. Japanese companies play an important role in the global joint development of the engines like the Trent1000 and GEnx for the Boeing787. Japanese companies are also taking part as the manufacturer of the low pressure turbine components of the GE9X engine, which is developed for the Boeing777X.
In addition, Japanese companies are participating in global joint development of the PW1100G-JM engine for the Airbus A320neo to achieve fuel-efficiency, low-pollution, and noise-reduction, with Pratt & Whitney (P&W) taking the lead.



PW1000G (P&W), to serve as the base for developing PW1100G-JM

Trent 1000 (Rolls-Royce)

GEnx (GE Aviation)

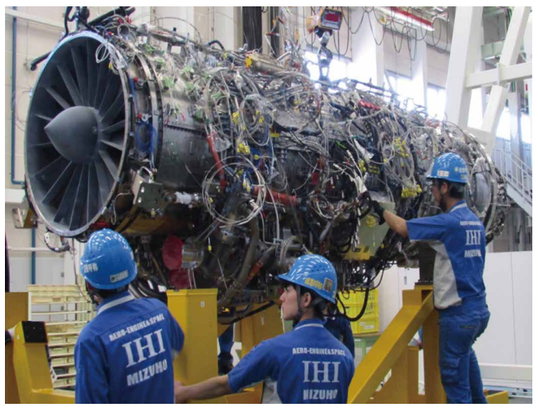
International Joint Development for Civil Aircraft Engine

Engine	Aircraft	Components developed	Level of participation
PW1100G-JM	A320 neo	Fans, low-pressure compressors modules, combustor, low-pressure shafts	Program partner 23%
Trent1000	787	Mid-pressure modules, combustor modules, low-pressure turbine vanes	RSP 15.5%
GEnx	787	Low-pressure turbines, high-pressure compressors, shafts and combustor cases	RSP 15% and subcontract
GP7200	A380	Coupling shaft	Subcontract
Trent900	A380	Low-pressure turbine blade	Subcontract
Trent500	A340	Mid- & low-pressure turbine vanes, compressor cases, turbine cases, etc.	RSP 5%
CF34-8/10	CRJ700/900, EMBRAER170/190, ARJ21	Low-pressure turbine module, high-pressure compressor rear stages, fan rotors, gearboxes, etc.	RSP 30%
PW4000	A310/330/340, 777	Low-pressure turbine vanes, disk, combustor, active clearance control, etc.	RSP 11% and subcontract
GE90	777	Low-pressure turbine rotor vanes disks, long shafts, etc.	RSP 10%
Trent700/800	A330, 777	Low-pressure turbine vanes, disks, long shafts, low-pressure turbine disks, turbine cases, etc.	RSP 2.7 to 4%
V2500	A320, MD90	Fans, low-pressure compressors, fan cases, etc.	Program partner 23%

2. Defense Engines

Regarding the engines of defense aircraft, both the F3-IHI-30 turbofan engine and the TS1-M-10 turbo shaft engine that were developed in Japan are used in the T-4 intermediate jet trainer and the OH-1 observation helicopter respectively. Furthermore, the F7-IHI-10 fan engine with a high bypass ratio, is selected and operated for the P-1 Fixed-wing Maritime Patrol Aircraft. And looking at research and development, following the success of the XF5-1 demonstration engine, an after burning fan engine with a low bypass ratio and has successfully completed the flight test as the engine of X-2 (Advanced Technology Demonstrator), development of the XF9-1 engine, aiming for the next fighter with maximum thrust of 15 tons, is underway. It is announced that the performance and functional tests are proceeding well, and through the further improvements we are looking forward to seeing this engine on the next fighter.

F7 (IHI Corporation)



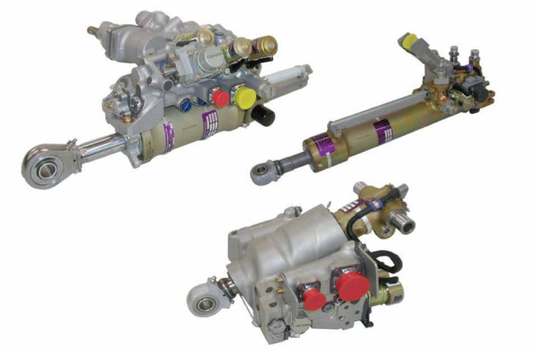
XF9-1 (IHI Corporation)

Japan's Highly Reliable Aircraft Equipment

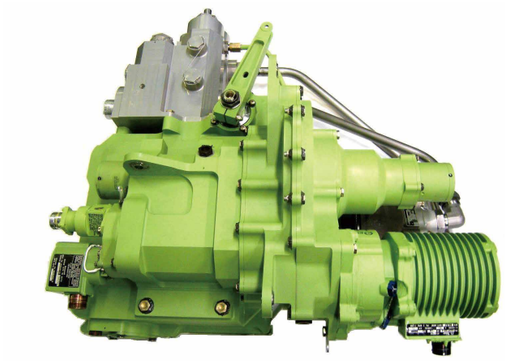
Along with the fuselage structure, a wide range of reliable equipment is required for the construction of an aircraft. In defense applications, Japanese manufacturers provide radar systems, digital control systems and other products, all of which make use of advanced technologies. For civil use, Japanese products, which are highly reliable in quality and delivery, have been well known by overseas OEM and customers. To participate in the international development project for the Boeing777, Japanese parts manufacturers, competing with overseas manufacturers, have taken orders for actuators, valves and many other types of equipment.

1. Hydraulic Systems

Hydraulic systems are used in flight controls, high-lift devices and landing gear for remote control operations. Japanese manufacturers supply the Boeing777 electronic flight control actuation systems, flap drive systems for the Boeing747-8 and flight control actuation systems.



Flight Conrol Hydraulic System (Nabtesco Corporation)



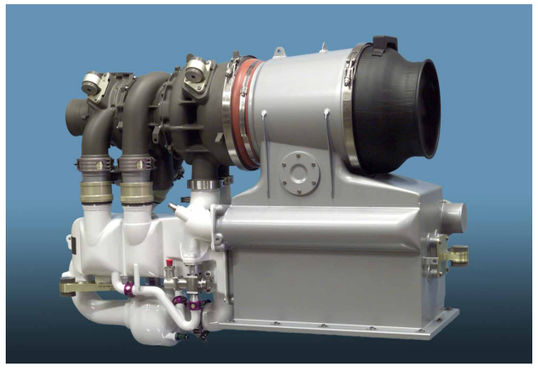
Flap Drive System (Shimadzu Corporation)

2. Cabin Pressure and Air Conditioning Systems

Cabin pressure and air conditioning systems protect passengers, crews and on-board equipment from changes in cabin pressure and temperature, and enable safe and comfortable flights. The cabin pressure and air conditioning systems for the Embraer 170 regional jet have been jointly developed by Japanese manufacturers and Collins Aerospace.

3. Avionics and Flight Control Systems

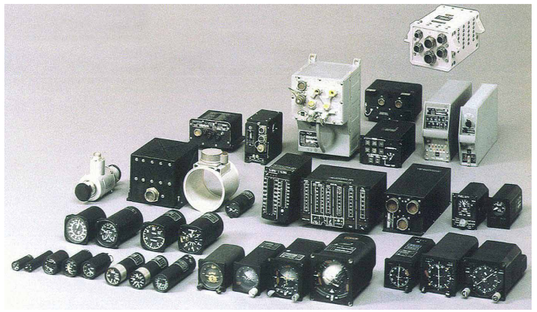
(1) Flight Systems
Modern aircraft deploy flight controls based on active control technology and a flight management system that uses advanced electronics. The mainstream flight control system is an electrically signaled control system called fly-by-wire. In Japan, the P-1 Fixed-wing Maritime Patrol Aircraft has been equipped with an optically signaled control system called fly-by-light.



Air Conditioning System (Sumitomo Precision Products Co., Ltd. / Collins Aerospace)

(2) Navigation Systems
Navigation systems locate the exact position of aircraft in flight and direct them to their destinations safely, quickly and without fail. Japanese manufacturers produce inertial navigation systems and GPS receivers.

(3) Flight Deck Systems
A flight deck system consists of flight instrumentation, attitude displays and audio and visual warning systems. Installed in a cockpit, the system is operated by pilots. Japanese manufacturers supply liquid crystal displays for the Next-Generation Flight Deck Systems for the Boeing787 and Airbus A380.



Aerospace Instruments (Yokogawa Electric Corporation)

Head-up Display (Shimadzu Corporation)

Cockpit Display(Yokogawa Electric Corporation)

4. Power Supply Systems

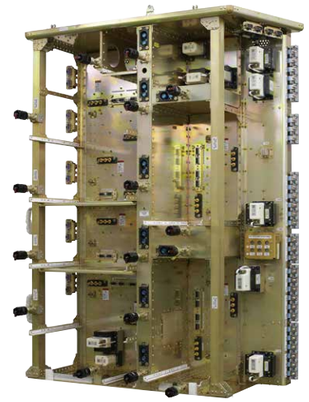
Power supply systems for today's aircraft require high voltage and large capacity to meet diversifying needs and to keep pace with technological advancement in the industry. Japanese manufacturers have teamed up with Collins Aerospace to develop power distribution units for the Boeing787.

5. Landing Gear Systems

Landing gear systems for the Bombardier CRJ700 and CRJ900 have been jointly developed by Japanese manufacturers and Collins Aerospace. Japanese manufacturers also supply landing gear systems for the Mitsubishi SpaceJet. And in addition, radial tires for the Boeing777, 787 and Airbus A380 are also supplied by Japanese manufacturer.

6. Other Systems

Japanese companies are currently active in the development and production of simulators.



Power distribution units (Nabtesco Corporation)

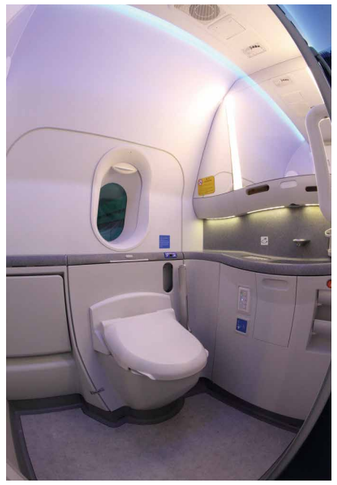
Landing Gear (Sumitomo Precision Products Co., Ltd.)

Cabin and Interior Systems for In-Flight Comfort

In the field of cabin and interior systems, Japanese manufacturers respond to customer requirements and apply the latest technologies in the development of the world's best products. Products of Japanese manufacturers, such as galleys, lavatories, aircraft seats and in-flight AV systems that optimally match the passengers' needs, have an excellent reputation with a large worldwide market share. Japanese manufacturers can continue to lead the world in terms of technical achievements for cabin and interior systems.

Aircraft Seats (JAMCO Corporation)

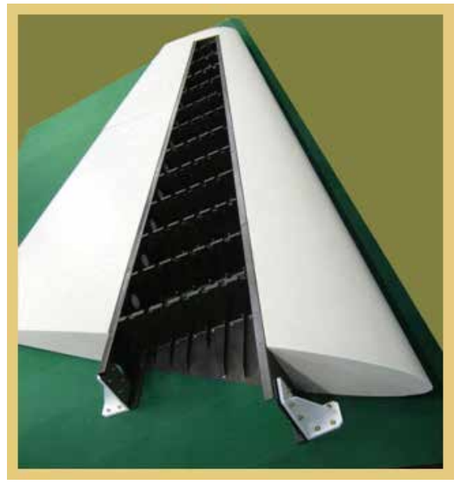
Aircraft Galley (JAMCO Corporation)



Aircraft Lavatory (JAMCO Corporation)

Advanced Aircraft Materials

Composite material, such as carbon fiber reinforced plastic (CFRP) in particular, are expanding and are becoming widely used.
Japan accounts for 70% of the world carbon fiber products for CFRP and supplies main wings and center wing box etc. for the Boeing787, which consists of 50% of composite material.
Titanium alloys are also expanding and are becoming widely used following back of the composite material, which is used for jet engine components, such as fan casing and turbine blade.
These components are manufactured with the Japanese excellent precision forging and casting technologies.
The Mitsubishi SpaceJet is under development, fully utilizing these advanced aircraft materials.

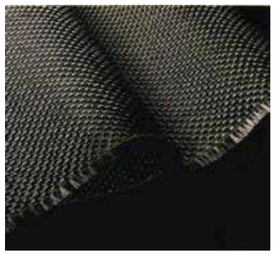


The composite main spar of the vertical stabilizer for Mitsubishi SpaceJet (actual size test component) (Mitsubishi Aircraft Corporation)

Mitsubishi SpaceJet (Mitsubishi Aircraft Corporation)

V2500 Turbofan Engine (IHI Corporation)

Carbon Fiber Materials (Toray Industries, Inc.)



Carbon Fiber Materials (Toray Industries, Inc.)

V2500 Fan Case (Kobe Steel, Ltd.)

Ⅲ Japanese Space Industry

World Class Rockets

Japan is continuously maintaining and operating rocket launch, tracking, and control functions in order to keep its independent space development and utilization capabilities. Japan continues to operate the H-IIA, which rivals any of the world's top-class liquid propellant rockets in terms of both track record and costs, and is receiving orders for the launching of foreign satellites. Japan has also succeeded at developing the Epsilon rocket, a solid-fuel rocket designed to be compact, offer high performance levels, and low cost.

Japan's first space experiment was conducted in 1955 with the testing of a 20-cm pencil rocket. Since then, we have fully applied our technical strengths, and this effort has allowed Japan to take its place among the world's leading space-exploration nations.

1. Liquid Propellant Rockets

In 1975, Japan successfully launched the N-I with the assistance of the United States. Following this, development of the N-II and H-I were advanced with the aim of improving both performance and the level of domestic production; accordingly, 1994 saw the successful launch of the H-II, a launch vehicle that was produced completely in Japan. Using liquid hydrogen as fuel and liquid oxygen as an oxidizing agent, this rocket's engine offered extremely high levels of performance.

In 2001, the Japanese H-IIA was successfully launched, and in the process, it became Japan's primary large-scale launch vehicle. This rocket was developed by the Japan Aerospace Exploration Agency (JAXA), and the launch business was transferred to a private company in 2007. The successful launch of the H-IIA launch vehicle No.44 in October 2021, together with the success of all nine launches of the H-IIB launch vehicles brought our successful launch rate to 98.1%. We are receiving orders for the launch of foreign satellites, and we anticipate that Japan will soon be active on the global stage. Since 2014, development has been underway of the new H3 key rocket, and plans are underway for the launch of the H3 launch vehicle No. 1 in 2022.

Study of H3, the Next Generation Launch Vehicle (JAXA)

The development of the LE-9 first stage engine is critical for the H3, and the ground firing tests are proceeding as planned. In order to ensure the reliability of the H3, improved versions of existing engines (for the second stage rocket, the LE-5B, and for the solid-fuel rocket booster, the SRB-3) with proven track records will be used for the later stage rockets. It is aimed to cut costs by half and reduce work times in order to follow the H-IIA in securing further launch orders from foreign satellites.

Principal Japanese Launch Vehicles

No.	Specifications	H-ⅡA	H-ⅡB	H3 (plan)	Epsilon
1	Length	53 m	57 m	63 m	26 m
2	Diameter	4.0 m	5.2 m	5.2 m	2.6 m
3	Gross weight	289 t	531 t	574 t *2	95.4 t
4	SSO launch capability	approx.3.6 t	—	4.0 t or above *1	0.59 t
5	LEO launch capability	approx.10 t	approx.16.5 t	—	1.2 t
6	GTO launch capability	approx.4.0 t	approx.8.0 t	6.5 t or above *2	—

Gross weight: Not include payload weights
SSO: Sun synchronous orbit
LEO: Low earth orbit
GTO: Geostationary transfer orbit

*1:with no solid-fueled boosters
*2:with 4 solid-fueled boosters

2. Solid Propellant Rockets

Japan developed the global top class M-V solid-fuel rocket, which achieved success on a global scale through the launch of scientific satellites, solar observation satellites, and astronomical observation satellites such as the HAYABUSA, however the operation of this rocket has finished in 2006.

The Epsilon launch vehicle was developed as a compact, high performance, low cost next-generation rocket which uses elements of the M-V and H-IIA. The first Epsilon launch vehicle prototype was launched successfully from the Uchinoura Space Center in Kagoshima Prefecture in September 2013. The development of the Epsilon launch vehicle represents a new era of development, including innovative new technologies such as self-inspection and mobile operation, while making good use of the technology of existing rocket motor. Expectations are high for its use as a delivery system for small satellites, a segment which is expected to see a great deal of future growth. In December 2016, Epsilon No.2 has launched ERG Satellite "ARASE", in January 2018, Epsilon No.3 has launched small high resolution radar satellite "ASNARO-2", in January 2019, Epsilon No.4 has launched "RAPIS-1" (RAPid Innovative payload demonstration Satellite 1), and in October 2021, Epsilon No.5 has launched "RAISE-2", all successfully.

Launching of Epsilon No.4 (JAXA)

3. Launch and Control Facilities

Satellite tracking, command and control in Japan are carried out at three communication centers and three tracking centers, the most important of which are the launch facilities at the Tanegashima Space Center and the Tsukuba Space Center. Furthermore, these installations represent a complete system for the launch, command and control of satellites.


Uchinoura Space Center (JAXA)


Tanegashima Space Center (JAXA)

Satellite Development

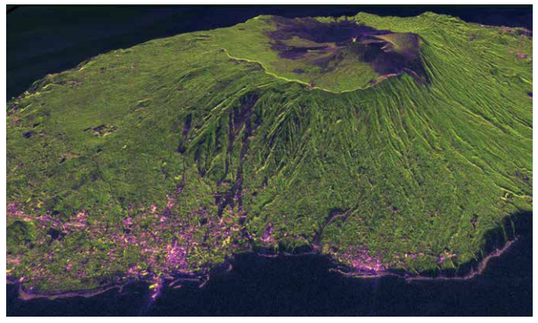
The most imperative usage of space is to assure national security, social peace and activities. In 1970, Japan launched its first satellite, OOSUMI, becoming the fourth spacefaring nation to launch a domestically manufactured satellite using a rocket of her own. Then in 1977, Japan successfully launched a geosynchronous orbit satellite. With technical capabilities rating among the best in the world, Japan is currently receiving orders from overseas for satellite launches, and is involved in the development and production of satellite systems, onboard sensors and components.

1. Weather Satellites

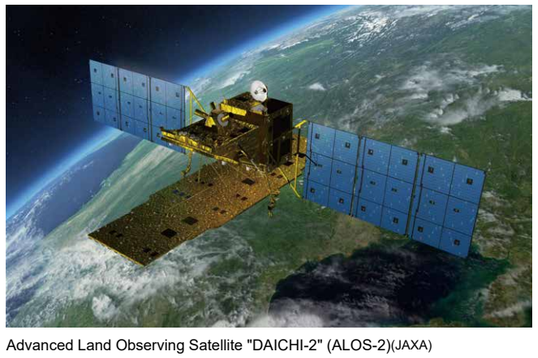
The first satellite launched for practical use by Japan was the HIMAWARI weather satellite of 1977. Following this, a total of seven weather satellites were put into operation, allowing valuable weather-related information to be supplied domestically and throughout the Asian region.
As a successor to these earlier weather monitering satellites, HIMAWARI 8 was launched in October 2014, and has been in operation since July 2015. HIMAWARI 9, a same satellite with HIMAWARI 8, was launched in November 2016, as the standby satellite in orbit.

2. Remote Sensing

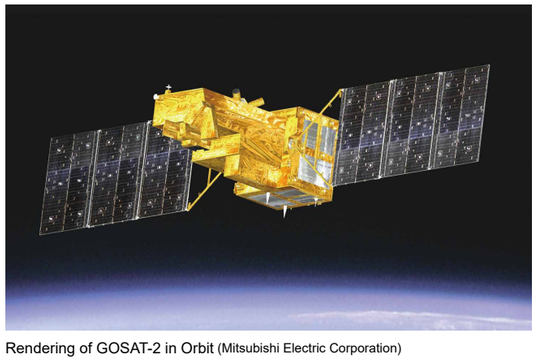
The importance of remote sensing missions such as global observation and resource surveying is expected to become ever more important. In the global monitoring sector, the Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2) was launched in May 2014. It features PALSAR-2, a terrestrial visualization radar with a higher resolution and wider monitoring area than the sensor of former satellite DAICHI. Since November 2014 it has provided observation data used for mapping, regional observation, disaster condition assessment, resource exploration, and more. Its observation data has been successfully used to confirm changes in topography before and after the September 2014 eruption near the summit of Mount Ontake, as well as ash fall conditions. The Global Precipitation Measurement (GPM) satellite launched in February 2014 contains the Japanese-developed Dual-frequency Precipitation Radar (DPR), which has been used to provide observation data to the public since September 2014. Numerous satellites, including the SHIZUKU water circulation monitoring satellite, launched in May 2012, have been launched as part of the GPM mission, led by the U.S. and Japan. These satellites are providing global precipitation data every three hours to related organizations for use in weather forecasting, flood prediction, and other individual purposes.



Izu-Oshima island observed by "DAICHI-2" (ALOS-2)(JAXA)



Advanced Land Observing Satellite "DAICHI-2" (ALOS-2)(JAXA)



Rendering of GOSAT-2 in Orbit (Mitsubishi Electric Corporation)

The Radar Earth Observation satellite "ASUNARO-2" which was compatible with small size, light weight, low cost, high resolution by restricting lifespan, observation width and function than the conventional satellite, was launched in January 2018, and its taken image has been released in March.
Development of the Greenhouse gases Observing SATellite-2 "GOSAT-2" was launched in October 2018, and the data has been released to the public since August 2019.

3. Communication & Broadcasting Satellites

Japan has launched the SAKURA series of communication satellites and the YURI series of broadcasting satellites, and has developed the technologies which enable to make practical use of satellites. Satellites made in foreign countries used to dominate the Japanese market, however successes like the exclusive receipt by Japanese companies of orders for the TURKSAT-4A/4B and the Es'hailSat satellite help to advance Japan's competitiveness in the international market.
The development of the next-generation Engineering Test Satellite 9, aiming 2023 launch, is underway and the purpose is to develop and verify the upgranding satellite and communication missions, so as to further strengthen Japanese international competitiveness.

4. Quasi-Zenith Satellite Systems

Positioning information is used in various applications, such as vehicle navigation systems and GPS-equipped mobile phones. Usage of this information is expected to continue to grow. Japan currently uses primarily U.S. GPS, but the Quasi-Zenith Satellite-1 "MICHIBIKI" was launched in September 2010 for complementary and augmentation services.
In 2017 satellites 2 through 4 has been launched, and in November 2018, precision GNSS service has started. In addition, satellites 5 through 7 are scheduled to be launched in 2023, to create the seven-satellite structure. And continuous development and operation are planned afterwards.

Quasi-Zenith Satellite-1 " MICHIBIKI" (JAXA)

5. Other Projects

Japan is also participating in using satellites for astronomical observation and space science exploration, as well as for technology validation. The HISAKI Spectroscopic Planet Observatory for Recognition of Interaction of Atmosphere, launched in September 2013, is attempting to shed light on the universal and particular characteristics of the Jovian magnetosphere by performing spectroscopic observation of extreme-ultraviolet rays from earth orbit.
HAYABUSA 2, a successor to the highly successful HAYABUSA (MUSES-C) science exploration spacecraft, was launched in December 2014, and has reached the Ryugu asteroid in June 2018, where to collect the information to research the birth and the evolution of our solar system and the materials of life. In February and July 2019, HAYABUSA 2 has succeed in touching down to the Ryugu, and sample were collected successfully. In December 2020, the capsule of HAYABUSA 2 has landed on the desert of Australlia and the sample analysis started.

TURKSAT-4A/4B (Mitsubishi Electric Corporation)

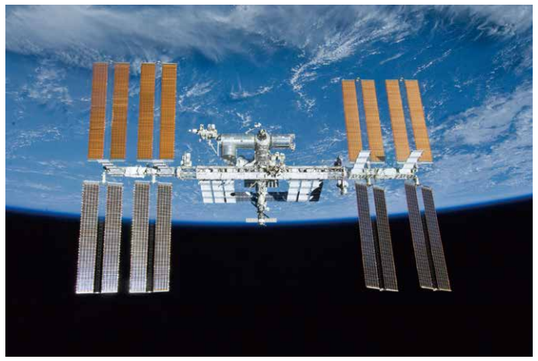
Asteroid Explorer HAYABUSA 2 (Illustration by Akihiro Ikeshita)

Contribution to the International Space Station

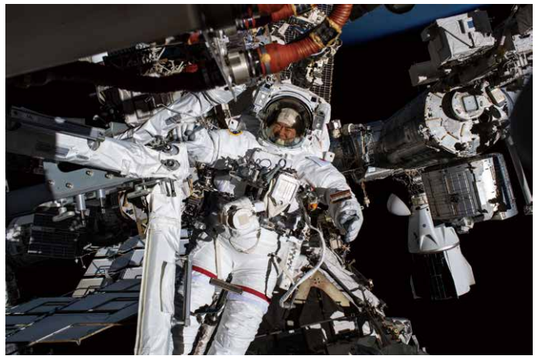
Japan has participated in the International Space Station project, jointly operated by the U.S., Russia, Japan, Canada, and the European Space Agency (ESA), from its inception. We have also supplied the KIBO Japanese Experiment Module. We are also making significant contributions to the completion and operation of the ISS project by supplying it via "KOUNOTORI" H-II Transfer Vehicle (HTV).

1. International Space Station

Orbital assembly of the International Space Station (ISS) began in 1999, and was completed in July 2011. Japan has supplied the KIBO Japanese Experiment Module (JEM), the largest ISS space experiment module. KIBO was delivered to the ISS by the space shuttle, and began full-fledged operation from July 2009. KOUNOTORI, a space station supply vehicle, then began transport of experimental devices and materials.
A close approach system designed in Japan for docking KOUNOTORI is used in the U.S. cargo delivery spacecraft Cygnus.
Many Japanese astronauts, such as Koichi Wakata, Soichi Noguchi, Naoko Yamazaki, Satoshi Furukawa, Akihiko Hoshide, Kimiya Yui, Takuya Onishi, and Norishige Kanai were on duty at the ISS and have taken part in assembly of the KIBO and docking operations for the H-II Transfer Vehicle. Astronaut Koichi Wakata served as the first Japanese commander of the ISS for six months, starting in March 2014. And from April to November 2021, Astronaut Akihiko Hoshide has returned to ISS by the Crew Dragon spacecraft, the new spacecraft of U.S., as the commander of the ISS for six months mission.
It is annouced that the service of ISS will be extended to 2024.
In October 2019, Japanese government has announced to take part in NASA's Lunar Gateway project which will seek to establish an orbital research and staging station that NASA plans to proceed by international collaboration. Japan is well experienced through the missions of ISS and we are looking forward to seeing Japanese technology will also take part in this new space field.

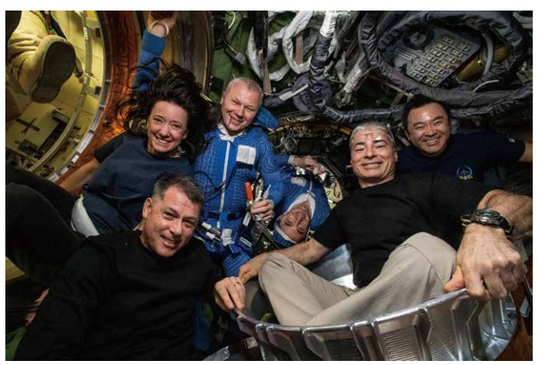


International Space Station (ISS) (JAXA/NASA)



Astronaut Hoshide on extravehicular activity (JAXA/NASA)

KIBO, Japanese Experiment Module (JAXA/NASA)



Astronaut Hoshide and 65th ISS expedition crew members (JAXA/NASA)

2. H-ⅡB and HTV contribute to deliver supplies to ISS

In 1997, Japan began development of an unmanned cargo transporter to carry supplies to the International Space Station (ISS). In 2003 we began research and development on the H-IIB, an unmanned cargo transporter.
The first H-IIB has successfully launched the first KOUNOTORI in September 2009.
After that, the second KOUNOTORI was successfully launched in January 2011 and the third in July 2012. From the launch of the fourth KOUNOTORI in August 2013, launches are handled by the private sector, and continuing to the launch of the ninth KOUNOTORI in May 2020, all have successfully launched.
There were two consecutive ISS supply launch failures, the April 2015 launch of the Russian Progress spacecraft and the June 2015 launch of the American Dragon spacecraft, but with the launch of Progress in July 2015 supplies were finally successfully delivered to the ISS.
The next unmanned cargo transporter launch was the fifth KOUNOTORI in August 2015. This launch, which drew a great deal of attention, was successful, proving the high reliability of the H-IIB and KOUNOTORI. The ninth KOUNOTORI, lanched successfully in May 2020, was the last launch. The new model (HTV-X) with a radically altered structure which will cost only half of the current model is under development for ISS and Gateway supply mission.

H-IIB No.4 (JAXA)

KOUNOTORI No.9, unmanned space station supply vehicle (JAXA/NASA)

Launch of H-IIB No.4 (JAXA)

Ⅳ The Society of Japanese Aerospace Companies

The Society of Japanese Aerospace Companies (SJAC), founded in 1952, at the reopening year of Japanese aviation industry, has contributed to the growth of our aerospace industry through its various activities, as listed below.

Organization

General Assembly
Regular members: 87
Associated members: 46
Total members: 133

Board of Directors
Comprises the Chairman, Vice-Chairman, Directors, and Supervisors

General Executive Committee
Consultative body under the Board of Directors
Consist of Directors and major member companies

Committees
Branch: 1
Committees: 6
Extra committees: 10

Secretariat
President and Senior Vice Presidents and staff members

*Member companies are involved in the development, production, maintenance and trading of devices, materials and related services for aircraft, rockets, satellites.

1. Industrial Policies Promotion

- Participation and support in reviewing Japan's aerospace administration.
- Negotiation with relevant government ministries and departments with respect to budget and system reviews for Japan's aerospace industry.

SJAC General Assembly (May 2021)

2. Industrial Foundation Buildup and Maintenance

- Wide range of survey, research and development activities
- Investigation of the domestic and overseas aerospace industries status quo
- Search of trends in aerospace technology
- Research and development of future aeronautic technologies
- Review of technical standards (i.e., JIS, ISO, etc.)
  SJAC operates as the aerospace evaluation branch of Japanese Industrial Standards (JIS). Also through SJAC, the Japan Aerospace Quality Group (JAQG) operates as an implementation monitor for quality assurance systems in compliance with IAQG, the de facto standard of the aerospace industry.
- Management of EDI (Electric Data Interchange) centers
  SJAC-managed electric procurement ordering systems are now used by approximately 300 companies in the Japanese aerospace industry.

Annual Deligation Dispatched to Norway (February 2020)

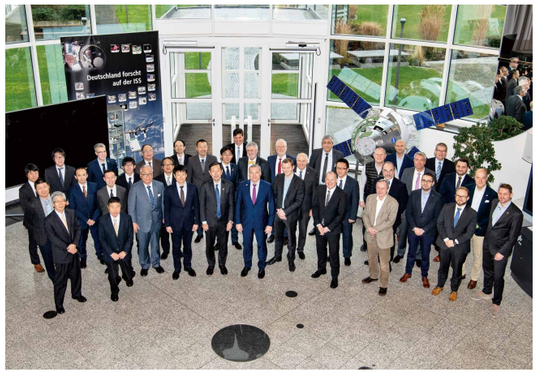
IAQG Meeting in Berlin (October 2019)

3. Cooperation with Overseas Aerospace Industries

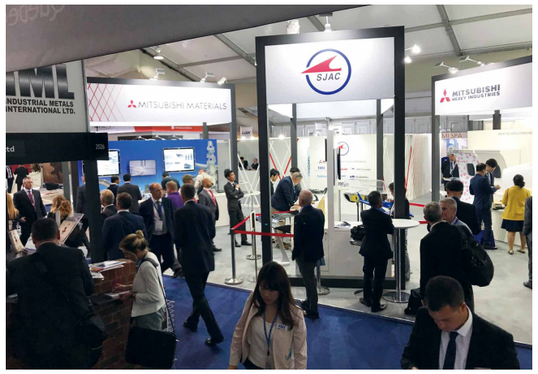
SJAC, participating in such international exhibitions that take place in Paris and Farnborough, holds meetings for interaction with the U.S., EU and other foreign industries, thus promoting international cooperation in the aerospace industry.

Major Aerospace Industrial Associations in the world

Countries / Regions	Industrial Associations
Worldwide	International Coordinating Council of Aerospace Industries Associations (ICCAIA)
U.S.A.	Aerospace Industries Association of America (AIA)
Europe	Aerospace and Defense Industries Association of Europe (ASD)
U.K.	Advancing UK Aerospace Defence and Security Industries (A|D|S)
France	French Aerospace Industries Association (GIFAS)
Canada	Aerospace Industries Association of Canada (AIAC)

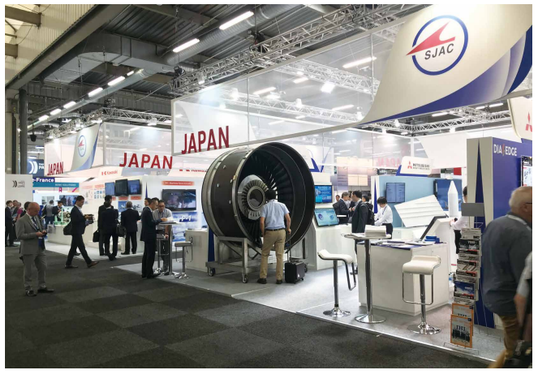


Space Industry Workshop in Germany (February 2020)



Farnborough International Air Show (July 2018)

The top management greeting with AIA at Paris (June 2019)



International Paris Air Show (June 2019)

JAPAN INTERNATIONAL EXHIBITION AEROSPACE 2024

URL https://www.japanaerospace.jp/en/

4. Japan International Aerospace Exhibition

The Society of Japanese Aerospace Companies (SJAC) holds an international exhibition with the participation of the world's major aerospace companies and authorities.
This is the largest aerospace exhibition in Japan which contributes to promoting business and to getting to know the capability of Japanese aerospace industry, and the raising of interest among young people.
SJAC will hold the "Japan International Aerospace Exhibition 2024" (JA2024) in the fall of 2024 as the 16th exhibition.
Large numbers of world's major aerospace companies, aviation clusters, authorities and research institutions participate in this exhibition.
Many diverse aerospace seminars and symposiums are planned in this exhibition and JA2024 is focusing on business and provides a cross-industry, global business meeting place for decision makers of companies, government policy makers and participants include defense community.

◆ "Japan International Aerospace Exhibition 2024 (JA2024)"

Date : Fall of 2024
Venue : Venue at Tokyo area
Programs : Indoor exhibition, B to B meeting, Seminars and Symposiums, Public Day Events
Organizer : SJAC

Previous "Japan International Aerospace Exhibition 2018 TOKYO (JA2018 TOKYO)" result is as follows:

◆ "Japan International Aerospace Exhibition 2018 TOKYO (JA2018 TOKYO)"

Date : November 28 (Wed) ～ November 30 (Fri), 2018 / 3 Days (Trade Days only)
Venue : Tokyo Big Sight
East Exhibition Hall 7 & 8 (15,000㎡) and Conference Tower
Programs : Indoor & Outdoor exhibition, B to B meeting, Seminars and Symposiums
Organizer : SJAC, Tokyo Big Sight Inc.
Exhibitors : 520 companies and organizations (17 countries / regions)
Participants : 27,458 / 3 Days (Visitors 19,937 / 3 Days, Exhibitors 7,521 / 3 Days)

Please refer to the Japan Int'l Aerospace Exhibition HP, https://www.japanaerospace.jp/en/

"Japan International Aerospace Exhibition 2018 TOKYO (JA2018 TOKYO)"

5. Other Activities

SJAC regularly communicates with the relevant government offices, and it also maintains a good relationship with the public through the publishing of superior publications. SJAC also publishes publicity materials such as the monthly magazine "Aviation and Space (Japanese)" and "Japanese Aerospace Industry (Japanese and English)," to introduce the aerospace industries of Japan. SJAC also owns the website (www.sjac.or.jp), to introduce its activity, and moreover SJAC takes part in the operation of the website (www.skyworks.info), to help the young people to understand about the Japanese aircraft field.
In addition, SJAC gets in contact with and coordinate with relevant government ministries, departments, universities, laboratories and groups.

SJAC MEMBER COMPANIES (As of December 1, 2021)

REGULAR MEMBERS 87 Companies

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AERO ASAHI CORPORATION
ALL NIPPON AIRWAYS CO., LTD.
CHUBU NIHON MARUKO CO., LTD.
COMMERCIAL AIRPLANE COMPANY
DAICEL CORPORATION
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JAPANESE AERO ENGINES CORPORATION
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NEC CORPORATION
NEC SPACE TECHNOLOGIES, LTD.
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NIKKISO CO., LTD.
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NIPPON AVIONICS CO., LTD.
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NOF CORPORATION
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NTN CORPORATION
RENESAS ELECTRONICS CORPORATION
SAKURA RUBBER CO., LTD.
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SHIMADZU CORPORATION
SHINMAYWA INDUSTRIES, LTD.
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THE JAPAN STEEL WORKS, LTD.
THE YOKOHAMA RUBBER CO., LTD.
TOHO CO., LTD.
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TOSHIBA ELECTRO-WAVE PRODUCTS CO., LTD.
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UACJ CORPORATION
YAMAHA MOTOR CO., LTD.
YDK TECHNOLOGIES CO., LTD.
YOKOGAWA ELECTRIC CORPORATION
YOSHIMITSU INDUSTRY CO., LTD.

ASSOCIATED MEMBERS 46 Companies

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BAE SYSTEMS (INTERNATIONAL) LIMITED
CHUDEN CTI CO., LTD.
CHURYO ENGINEERING CO.,LTD.
CSP JAPAN, INC.
DELOITTE TOHMATSU CONSULTING LLC.
EXPLORER CONSULTING JAPAN INC.
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HIGH-RELIABILITY ENGINEERING & COMPONENTS CORPORATION
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SOJITZ CORPORATION
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TOKYO BIG SIGHT INC.