

Aircraft Programs

A. History of Aircraft Development and Production

While Japan's industry had been waiting for the rebuilding of aircraft production after World War II, the mainstream of the world's aircraft industry had already shifted to jet-powered aircraft. Competent engineers had been dispersed domestically and production facilities and equipment had been destroyed.

Licensed production of the F-86 fighter and T-33 trainer for the Japan Air Self-Defense Force (JASDF) with U.S. manufacturers played a key role in solidifying an industrial base for manufacturing aircraft in Japan.



F-4 fighter

Subsequently, in parallel with technology transfers and licensed production of such fighter and patrol aircraft as the F-4, F-15 and P-3C, the aircraft industry sought opportunities to domestically develop and produce such military aircraft as the T-1, T-2 and T-4 trainer, F-1 support fighter and C-1 transport.

Also, the industry sought such civil aircraft as the YS-11, the first civil transport, as well as other civil transport with Japan's indigenous technology.

The development of the F-2 support fighter, which the JASDF chose as successor to the F-1 support fighter in 1987, was started in 1988 by Japan-U.S.

joint development as a base aircraft with the F-16. Mitsubishi Heavy Industries, Ltd. (MHI) —the prime contractor— and Lockheed Martin (LM) of the U.S. worked together on the development of the F-2 support fighter.

In addition, this collaborative development modified and improved the performance of the F-16 fighter by installing advanced electronic equipment, including radar, adopting main wings made of a composite material, incorporating in new radio wave-absorbing materials and introducing other state-of-the-art technologies from both countries. In October 1995, the first flight of the initial prototype aircraft was successfully performed. The manufacture of its production model started in fiscal 1996, and the first F-2 combat squadron was deployed in March 2001.



F-2 fighter

As successor to the OH-6D light observation helicopter for the Japan Ground Self-Defense Force (JGSDF), the OH-1 development program was inaugurated in 1992. The OH-1 has the significance of becoming the first indigenous rotary-wing aircraft ever developed in Japan. Kawasaki Heavy Industries (KHI) was selected as the prime contractor and MHI and Fuji Heavy Industries (FHI) were appointed as joint partners. The OH-1 is also incorporated with various state-of-the-art technologies, which are beneficial to the needs of the 21st century. The first prototype was rolled out in March 1996, and succeeded in its first flight in August 1996. Three of the first OH-1 production models were delivered by KHI to the JGSDF in fiscal 1999 and are now deployed to JGSDF's aviation units.

FHI produced a helicopter-based UAV, a forward field observation system (FFOS), for the Technical Research & Development Institute (TRDI), and research funds have been allocated for future development.

The first international joint project for Japan was the 767 civil transport developed by Boeing. Five airframe manufacturers participated in a consortium for this national project.

It can be estimated that there are the following four major reasons for cooperation between companies in the U.S. and Japan.

- 1) Risk sharing
- 2) Enhanced capabilities through cooperation
- 3) Participation in development and market entry
- 4) Mutual profit-taking

The next big project was the international joint development of the Boeing 777, which started in 1991. The structure of partnership in Japan is almost the same as that for the 767. For the development of the

777, Boeing's 777 Division and Japan Aircraft Development Corporation (JADC) constitute the core promoting organizations. MHI, KHI and FHI are taking part in the development and production and playing the role of program partners. The total work share of Japanese firms will account for approximately 21% of the 777 structures.

Besides airframe manufacturers, some 30 manufacturers have also been involved in Boeing's civil transport programs as supplier and/or subcontractor.

Apart from these international joint projects, Japanese airframe manufacturers are taking part in subassembly and/or the manufacture of components of various models of U.S. and European airframe manufacturers, including Boeing, Airbus, Fokker and others, as subcontractors.

In the field of aeroengines, a large technology gap was produced between Japan and Europe/the U.S. after World War II due to the rapid shift of technological innovation to jet engines. Japanese engine manufacturers, mainly IHI, developed a J3 jet engine for domestic production of the T-1 trainer to close this gap, and later developed an F3 turbofan engine for domestic production of the T-4 trainer.

Production of the J79 engine for fighters also started under a technical license agreement with General Electric (GE), and subsequently the aeroengine industry has grown under licensed production of such engines as the F100 turbofan for the F-15 fighter and the T56 turboprop for the P-3C patrol aircraft, similar to the licensed production of airframes.

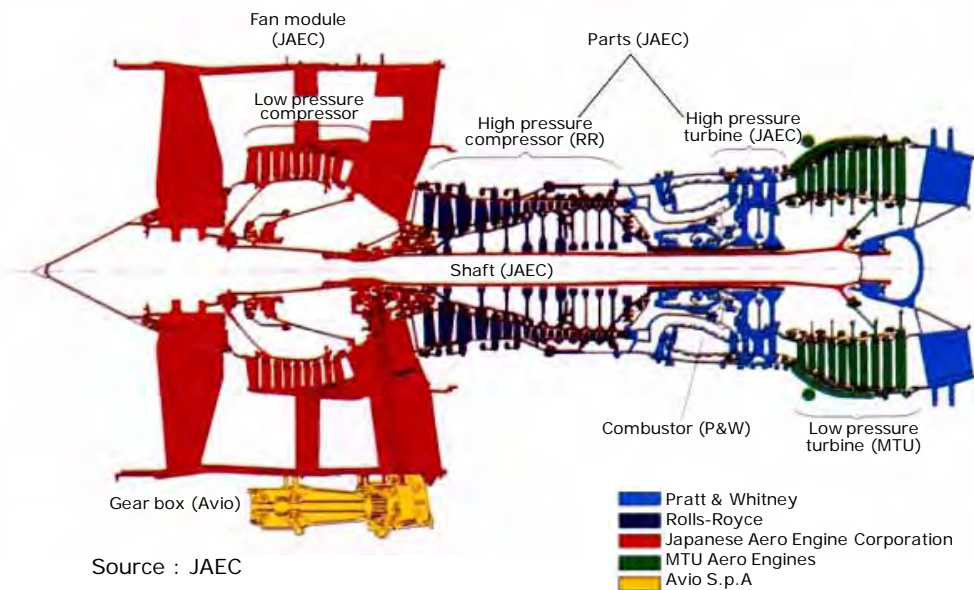
As for international joint engine development, the RJ500 turbofan engine, which had been initiated as an international joint development between Rolls-Royce and Japanese engine manufacturers, resulted in the V2500 project, which was launched in 1983 with the participation of the U.S., Germany and Italy. International Aero Engines (IAE), a new international joint venture, manages this development project. JAEC is the core organization representing the partners, namely, IHI, KHI and MHI.



V2500 turbofan engine

Apart from the V2500, JAEC agreed with GE to participate in an international collaborative program for the development of the CF34-8C turbofan engine as a dependable partner. This will most likely give the Japanese aeroengine industry an opportunity to tap into the engine market for regional and business jet planes.

V2500 Work sharing among IAE members



In parallel with those national programs, Japanese engine manufacturers, such as IHI, KHI and MHI, individually have been joining three large turbofan engine programs as a risk-sharing partner. IHI is a partner in both programs of GE's GE90 and Rolls-Royce's Trent, and is also an exclusive supplier of "long

shaft" for three models of Trent. KHI is involved in Rolls-Royce's Trent and Pratt & Whitney's (P&W) PW4000, while MHI is in partnership with P&W concerning the PW4000.

Furthermore, many Japanese manufacturers are shipping such products as instruments, avionics, sub-assemblies and components to Boeing, Airbus and others.

As mentioned, international tie-ups and cooperation have played a decisive role in the growth of Japan's aircraft industry.

Today, in the field of civil transport, international joint programs are inevitable from the viewpoint of spreading risk and securing market share, to meet the market's need for large and advanced aircraft, and to effectively cope with financial and technological risks.

Japan's aircraft industry will actively commit itself to promoting international collaborative and co-operative projects as its basic guideline for the future.

B. Ongoing and Future Programs

(1) International Programs

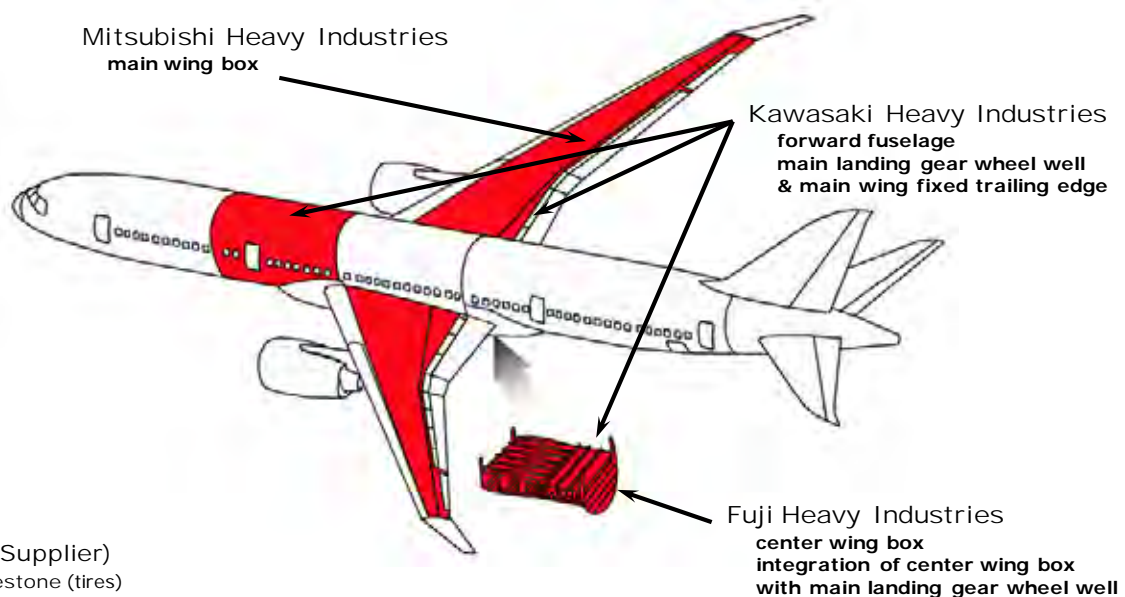
• Civil Aircraft

In October 2004, JADC, MHI, KHI and FHI signed a Memorandum of Agreement (MOA) outlining key terms and conditions for their participation in the development and production of the 787 Dreamliner with Boeing. In May 2005, Boeing and JADC, representing its three Japanese partners —MHI, KHI and FHI— signed formal contracts detailing their work agreements. In this project, MHI will be responsible for the main wing box. KHI will provide part of the forward fuselage section, the main landing gear wheel well and the main wing fixed trailing edge. FHI is focused on the center wing box and integration of the center wing box with the main landing gear wheel well. The total work share of Japanese firms will account for approximately 35% of the 787 structures and systems.



787 (Source: Boeing)

Boeing 787 Project



(Parts Supplier)

Bridgestone (tires)
GS Yuasa/Thales (lithium-ion battery system)
JAMCO (lavatories, flight deck interiors, flight deck door & bulkhead assembly)
Nabtesco/Hamilton Sandstrand (rack & panel)
Panasonic Avionics (cabin services system)
Sumitomo Precision Products (APU oil cooler)
Tamagawa-Seiki (sensor, DC motor)
Toray (TORAYCA® prepreg composites)

(Image: JADC)

The production of components and parts progressed along smoothly at the beginning and shipments to Boeing commenced, but with a production delay from Boeing, shipments from Japanese industries have been postponed. It is expected that this shipment delay is improved by the success of the first flight of last December.

Japanese industries participated in the A300, 310, 320, 330 and 340 series of the Airbus as subcontractors and/or suppliers.

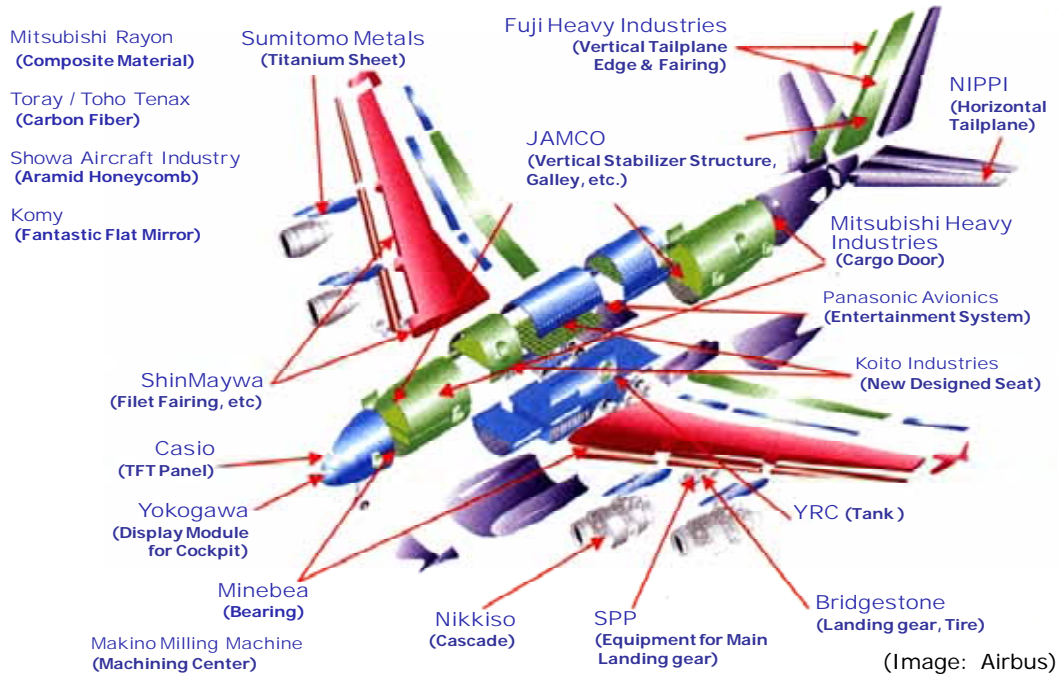
As of December 2008, 21 Japanese companies are participating in the A380 program that Airbus is producing, providing components and parts to the airframe, engines and equipment.

Several of the Japanese industries participating in this program include: MHI, supplying the front and aft lower cargo door; FHI, supplying the vertical tailplane (VTP) leading and trailing edges, as well as VTP tip and fairings; Nippi, supplying the horizontal tailplane tips; ShinMaywa Industries, working on the wing root fillet fairing and the wing ramp surfaces; and Bridgestone, supplying the tires.



A380 (Source:Airbus)

A380 Project (Portion of Parts supplied from Japanese Industries)



(Image: Airbus)

Japanese aircraft manufacturers are individually participating in international collaborative programs for the development of business and corporate jet airplanes, and playing an important role as a risk-sharing partner. For example, MHI is taking a vital role in developing and manufacturing the Bombardier's "Global Express." ShinMaywa is taking part in the development of the Gulfstream GV. KHI has been successfully engaged in the international collaborative program building the BK-117 medium helicopter in Japan and Germany, and has also joined the program of the Embraer ERJ-170 and -190 regional jet series and is manufacturing the main wing. FHI works with Raytheon on the "Hawker Horizon" and with Bell/Agusta on the "BA609" program.

It is expected that R&D on a supersonic transport (SST) and its propulsion system will create demand in the early 21st century. Japan has been exploring R&D and diverse studies for this aircraft. Studies include market research, environmental effect research and technical research focusing primarily on such environmental issues as particular noise, sonic boom and effects on the ozone layer. In addition, Japanese, four major European and American engine manufacturers have conducted R&D on a new propulsion system. Basic R&D on advanced composite structures for supersonic aircraft continues.

In 2005, GIFAS and SJAC reached an agreement on the joint research and survey of the next-generation SST and signed the Frame Agreement on the Cooperation Program. Both societies

plan research activities for technologies related to composite material structure and reduction of jet-engine noise to overcome difficulties unique to supersonic flight. In addition to the above societies, several research centers and companies in the aerospace sector of both countries will participate in the program. On the Japanese side, the participants include JAXA, JADC and ESPR.

Mutual progress reports of research works were made at the first workshop held in Tokyo, Japan, in 2006. The second workshop was held in Paris, France, in 2007.

Since 2006, progress on research works is reported at the annual workshop in either Tokyo or Paris.

• Engine

Boeing selected GEnx of GE and Trent1000 of Rolls-Royce to equip the 787. IHI participates with GE in joint development of GEnx, and is responsible for the low pressure turbine, the high pressure compressor and the mid-fan shaft. Furthermore, KHI and MHI are participating with Rolls-Royce in the joint development of Trent 1000. KHI is responsible for the middle pressure compressor module, and MHI is responsible for the combustor module and the low pressure turbine blades.

Airbus selected Trent1000 of Rolls-Royce and GP7200 of the Engine Alliance as engines for the A380. IHI and KHI are participating in the development of Trent 900 and GP7200 as subcontractors.

KHI and MHI will participate in the joint development of Trent XWB of Rolls-Royce to be installed in the Airbus A350XWB.

< Engine for 787 >

TRENT 1000 (Rolls-Royce)



Image Source :Rolls-Royce

(Participation of Japanese Companies)
 Kawasaki Heavy Industries (KHI)
 middle pressure compressor module
 Mitsubishi Heavy Industries (MHI)
 combustor module
 low pressure turbine blade

GEnx (General Electric)



Image Source :General Electric

(Participation of Japanese Companies)
 I H I
 low pressure turbine
 high pressure compressor, mid-fan shaft
 Mitsubishi Heavy Industries (MHI)
 combustor case

(2) Domestic Programs

• Fighter

The JASDF has moved forward with the modernization of F-15 fighters, and started the selection study of the successor that will replace the F-4 fighter, and is now carefully examining several overseas candidate fighters. Fighter technologies become the basic technology to all aircraft. As such, the new technologies acquired will have a considerable effect on the technologies of other aircrafts. Furthermore, TRDI continues with the study of such advanced key technologies as a highly maneuverable flight control system to be necessary for future fighter development.

• Transport, Search and Rescue Aircraft

The development of the P-X and the C-X began in 2001 with the intent of replacing the P-3C and C-1. It is expected that the P-X will assist Japan's defensive power through its ability to gather surveillance information, while the C-X will serve as the principal means of air transport for a rapid-reaction force to regional emergencies. KHI was selected as the prime contractor for both models, which will be developed in parallel. In July 2007, the prototype models of both aircrafts were rolled out, and the first prototype model of the P-X (XP-1) was delivered in August 2008 after first success flight in September 2007. The prototype model of C-X (XC-2) succeeded in the first flight in January, 2010 and was delivered in March 2010.

Some airframe components, accessories and avionics are designed as common use to both the P-X

and C-X. The Japan Maritime Self-Defense Force (JMSDF) plans to install the XF7 turbofan engine that IHI and other industries are domestically developing for the P-X.



XP-1 fixed-wing maritime patrol Aircraft



P-3C Patrol Aircraft



C-1 Transport Aircraft



XC-2 transport aircraft

ShinMaywa produced the "US-1" Search and Rescue aircraft for the JMSDF, and has succeeded in the development of an improved model, the "US-1A KAI," in December 2003. The four turboprop engines made by Rolls-Royce are installed in the US-1A KAI. Mass production of the US-1A KAI has begun as the "US-2" Search and Rescue aircraft.

• Helicopter

FHI was appointed prime contractor for the licensed manufacture of the Boeing AH-64D attack helicopter for the JGSDF in 2002. Additionally, the T700-701C engines of GE Aircraft Engine Company were selected for the AH-64D.

Similarly, KHI is building the airframe and engine of the MCH-101 minesweeping and heavy-lift helicopter as the successor of the MH-53E for JMSDF by license. MHI is prime contractor in the development of the SH-60K patrol helicopter —a substantial upgrade from the SH-60J for JMSDF. MHI began mass production of the first helicopter in summer 2005, and is currently manufacturing the SH-60K.



AH-64D helicopter

• Trainer

The T-7 is the trainer of the JASDF and is equipped with turboprop engines for noise reduction as well as modern equipment that offer a high degree of trainability. FHI was appointed prime contractor for the manufacturing of the T-7.



T-7 trainer

- Civil Aircraft

MHI exhibited a full-scale mock-up of the MRJ's cabin at the 2007 Paris Air Show, showing it for the first time on the world stage to aircraft and airline industries. In addition, MHI made a decision to ATO (authorization to offer) of the MRJ and began conducting sales activities. MHI established Mitsubishi Aircraft Corporation (MJET) in order to begin taking orders and conducting sales activities for the MRJ. MJET is responsible for the design, acquisition of type certification (T/C), sales and customer support for the MRJ, while MHI is responsible for manufacturing both the prototype and production of the aircraft.

The MRJ is the 70–90 seat class next generation regional jet that offers top-class operational economy and outstanding cabin comfort. To date, MHI/MJET signed LOI (Letter of Intent) for orders totaling 125 aircraft. MRJ partners include Pratt & Whitney (providing PurePower® PW1000G engine), Parker Aerospace, Hamilton Sundstrand, Rockwell Collins, Nabtesco, Sumitomo Precision Products, Spirit AeroSystems, Aerospace Industrial Development Corp., and Eurocopter. The first flight is scheduled for 2012, and first delivery in 2014.



MRJ aircraft (Source : MHI)

METI and Japanese industries continue joint R&D on “Environment-Friendly Small Aircraft Engine” to acquire the technologies necessary to conform to environmental requirements for the next-generation of small-size aircraft. IHI, MHI, KHI, Japanese Aero Engines Corporation (JAEC) and the Engineering Research Association for Supersonic Transport Propulsion System (ESPR) are participating in this engine program.

In addition, Honda is developing the HondaJet, a compact business jet equipped with two HF120 turbofan jet engines. Honda announced the production and sales business of HondaJet in July 2006, and plans the first flight in 2010.