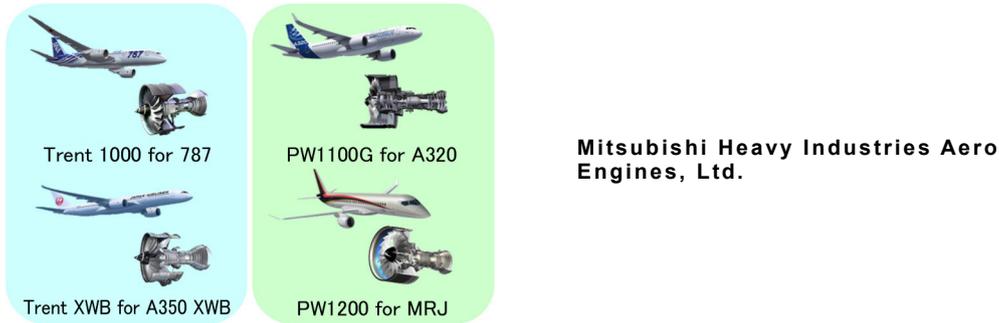


Global Presence of Civil Aero Engine Products from Mitsubishi Heavy Industries Aero Engines Ltd.



The market for civil aircraft, being boosted by increasing air transport demand in recent years, is expected to more than double in the next twenty years. In such a market environment, Mitsubishi Heavy Industries, Ltd. (MHI) considers civil aircraft engines to be a future high-growth sector, and has been working on the engine development, manufacture and repair business, taking advantage of its expertise in combustor modules, low-pressure turbine components and other parts.

In addition, MHI is taking part in engine projects for future mainstream aircraft, with Rolls-Royce (RR) for Boeing 787 and Airbus A350, as well as with Pratt & Whitney (P&W) for the Airbus A320neo and the MRJ (Mitsubishi Regional Jet), as an international joint development partner.

As the scale of its civil aircraft engine business expands much larger, MHI established a system that integrates sales, design, manufacturing and repairs, and formed Mitsubishi Heavy Industries Aero Engines, Ltd. (MHIAEL) on October 1, 2014 for the purpose of improving production capacity and the enhancement of capital strength through the introduction of external funds.

This paper reports on the new company’s efforts in the civil aircraft engine business.

1. Global aircraft market trends

Global air transport volume is growing on average by five percent annually. It is believed that this growth will also continue in the future, and transport demand is expected to double in the next twenty years. Accordingly, aircraft and engine demand are expected to increase and form a large market (Figure 1).

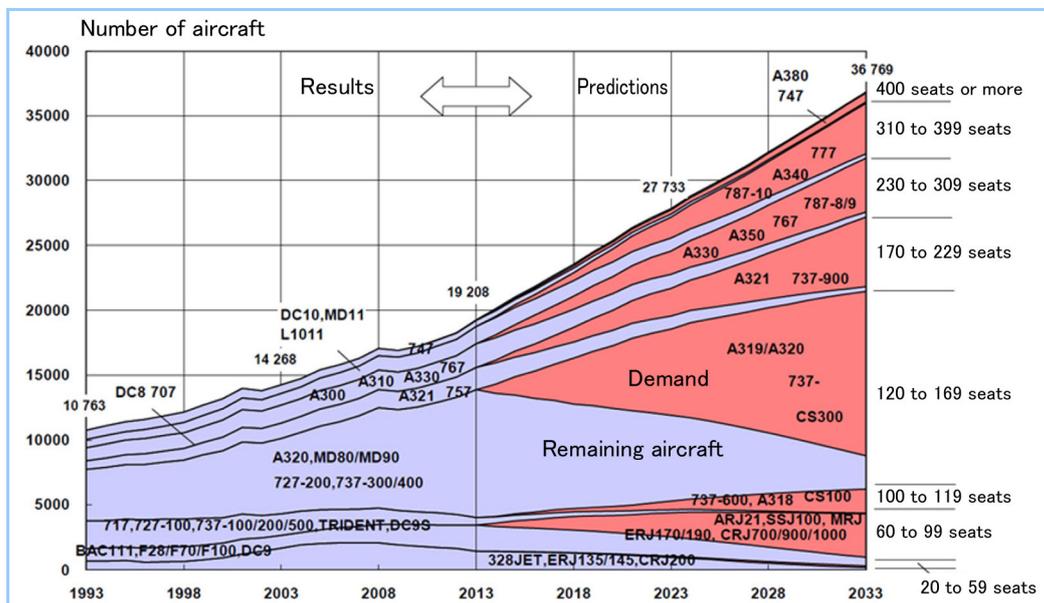


Figure 1 Market predictions for civil passenger jets

Source:- Worldwide Market Forecast 2014 -2033, page 30, March 2014, Japan Aircraft Development Corporation

Aircraft engines are required to have economic efficiency, safety, high quality, environmental adaptability, etc., in a market environment where aviation fuel prices have risen steeply and remain high and flight safety and quality must be ensured and improved, and where emission controls for noise, NO_x, CO₂, etc., are becoming stricter. Manufacturers are continuously developing technologies for the improvement of the maturity of engine performance and technology in order to acquire market share in this huge market.

In such a market environment, MHIAEL is taking part in the joint development of engine projects with RR and P&W in the combustor and low-pressure turbine sectors, in which the company has expertise.

2. Overview of civil aircraft engine business

The civil aircraft engine business of MHIAEL started from the subcontracted production of the turbine rotor blade for P&W's JT9D engine. Since then, experience has been accumulated and the business has been expanded through joint programs thru JT8D, RJ500, V2500 and PW4000 engines. Today, the company specializes in the combustor and turbine sectors for RR engines in the large engine field, and P&W engines in the small and medium engine field. In addition, the company is in charge of the assembly and testing of modules (combustors and low-pressure turbines) and entire engines and is making efforts to expand the business and improve capabilities of engines. In the repair field, MHIAEL receives orders for the repair of PW4000 engines for large aircraft from domestic and foreign airlines. The company is proceeding with the development and expansion of repair services as one of the mainstays of its civil aircraft engine business.

In addition, MHIAEL is taking part in national research and development projects in a proactive manner with an attempt to develop and acquire cutting edge technologies related to combustors and low-pressure turbines (Figure 2).

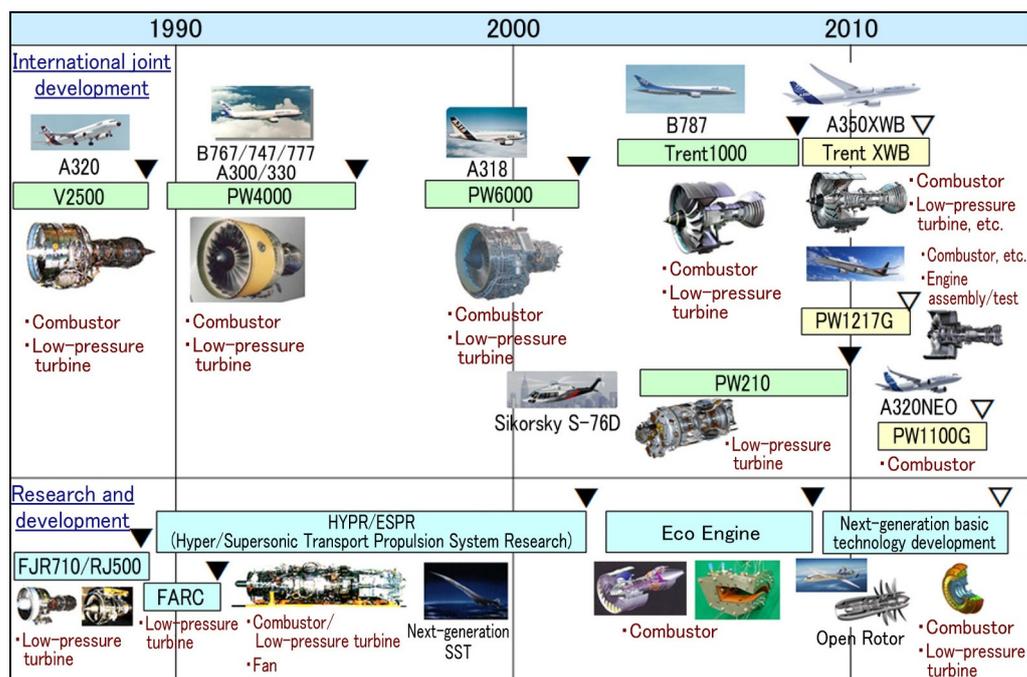


Figure 2 Civil aircraft engines and main products of MHIAEL

Currently, MHIAEL participates in the programs of major production engines including the PW4000 (for the Boeing 767/777 and other aircraft), the V2500 (for the Airbus A320), the Trent 1000 (for the Boeing 787). It is also involved in program for engines under development including the Trent XWB (for the Airbus A350) and Trent 1000-TEN (derived from the Trent 1000) large aircraft engines, as well as the PW1100G (for the Airbus A320neo) and PW1200G (for the MRJ) medium aircraft engines.

The development of such engines is proceeding as expected. The Trent XWB has succeeded in its first flight and is in the stage of type certification for the airframe, aiming at the commencement of commercial operation in the second half of fiscal 2014. The Trent 1000-TEN is being developed to improve performance based on the Trent 1000. Progress in the development of

the PW1100G is aimed at the commencement of commercial operation in fiscal 2015. The PW1200G for the first prototype aircraft for flight testing has been delivered to Mitsubishi Aircraft Corporation.

The large engine repair business is expanded mainly with the PW4000. The main customers include Thai Airways International Public Company Limited (94-inch engine), All Nippon Airways Co., Ltd., and Japan Airlines Co., Ltd. (low-pressure modules of 112-inch engines). MHIAEL has received successive repair orders from these airlines.

For these production hardwares as well as development hardwares are mainly manufactured in Factory 5 (**Figure 3**) and assembly and repair is mainly performed in Factory 6. MHIAEL eagerly promotes the enhancement of cost competitiveness by proceeding with the introduction of line production and the improvement of process control for parts manufacturing, and through the establishment of the optimum combination of dock and flow line for assembly and repair.



Figure 3 Main factory for civil aircraft engines
(Factory 5 of MHI Nagoya Guidance & Propulsion Systems)

3. Efforts for improvement of global competitiveness and development of technologies

Civil aircraft engines that require a light-weight and compact structure consist of components with complicated shapes. In particular, the combustor and turbine components that MHIAEL is responsible for use heat-resistant, nickel-based superalloy, and therefore important technological elements for these components include advanced manufacturing and processing technologies for difficult-to-machine materials. Accordingly, the realization of such technologies with low cost, short lead times, and high quality is the key to maintaining and enhancing the company's international competitiveness. For that purpose, MHIAEL continuously promotes the introduction and development of cutting edge technologies, the development and application of advanced production control systems and methods, and the drastic improvement of processes.

For the introduction and development of cutting edge technologies, in particular, MHIAEL is moving forward with the development of innovative design and manufacturing technologies being supported by the MHI Technology & Innovation Headquarters and Machine Tool Division. For example, MHIAEL is proceeding with the employment of laser drilling technology for the cooling hole cutting process* of combustor heat-resistant panels, using a laser optical control method.

* The latest aircraft engines, which must operate at higher temperatures and give off lower emissions, tend to have a larger number of smaller cooling holes on the combustor heat-resistant panel. To attain the highest level of cost competitiveness globally, a significant reduction in the processing time of cooling holes (to one third of the current level or less) is required.

Apart from this, MHIAEL is advancing the development of innovative material manufacturing methods, new materials and innovative repair technologies. The company is continuously enhancing innovative design, manufacturing and repair technologies, with in-house and external technology seeds to maintain and enhance international competitiveness for combustor and low-pressure turbine sectors, as well as aftermarket repair field which are the company's forte.