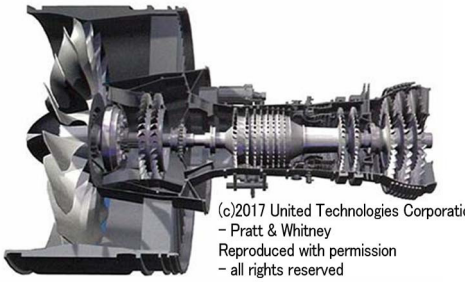
Efforts toward Development and Production of PW1200G Engine for MRJ



Source：PW1200G Data Card, Pratt & Whitney, http://www.pw.utc.com/Content/Press_Kits/pdf/ce_pw1200g_pCard.pdf, 2015.1.26

Mitsubishi Heavy Industries Aero Engines, Ltd.

Mitsubishi Aircraft Corporation has been engaged in the development of the Mitsubishi Regional Jet (MRJ), Japan's first domestically-produced commercial jet. Compared with other regional jets currently in operation, the MRJ cuts fuel consumption by more than 20% and realizes an advanced level of environmental compatibility along with reduced maintenance costs, thereby differentiating itself from its competitors. Included in the feature line-up is the engine, which is a Pratt & Whitney (P&W) geared turbo fan (GTF). As the first adoption in a commercial jet aircraft, the engine was developed specifically for this application, and acquired the type certificate under the name of PW1200G in May 2017. At the stage of mass production, Mitsubishi Heavy Industries Aero Engines, Ltd. (MHIAEL) will be responsible for the production of the combustor and high-pressure turbine disks, the final assembly, and the acceptance testing. This will be the first operation of the final assembly of newly-produced engines for commercial aircraft in Japan (the 6th in the world). This report presents the technological characteristics of the PW1200G engine and our ongoing projects including development and mass production.

1. Engine characteristics

1.1 Engine specifications

The PW1200G engine has two models: the PW1215G for the 70-seat class MRJ70, and the PW1217G for the 90-seat class MRJ90. Both have a bypass ratio of 9:1 and a fan of 1,422 mm in diameter. The MRJ collectively has reduced the fuel consumption by more than 20%, compared with other current regional jets. The PW1200G is the major contributor to this improvement (**Table 1**). It also sufficiently surpasses the latest emission standards of ICAO CAEP/8(Note) and achieves a noise footprint 40% smaller than its counterparts, which is substantially below the noise standards prescribed in Chapter 14 of ICAO CAEP.

(Note) ICAO: International Civil Aviation Organization
CAEP: Committee on Aviation Environmental Protection

Table 1 PW1200G specifications

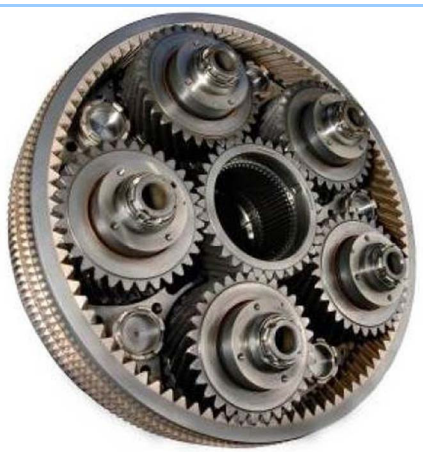
	Unit	Type	
Model Name	—	PW1215G	PW1217G
Fan Diameter	mm	1,422	1,422
Stages	—	1-G-2-8-2-3	1-G-2-8-2-3
Take off Rating	kN	66.6	75.6
Bypass Ratio	—	9:1	9:1
Flat Rated Temp.	℃	ISA+15	ISA+15
Aircraft Installation	—	MRJ70	MRJ90

Ref.：PW1200G Data Card, Pratt & Whitney, http://www.pw.utc.com/Content/Press_Kits/pdf/ce_pw1200g_pCard.pdf, 2015.1.26

1.2 Fuel economy performance and noise characteristics

The PW1200G is most characterized by its fan drive gear system with star gears, which is installed between the fan and the low-pressure compressor/turbine (**Figure 1**). The employment of this system enables the fan and the low-pressure compressor to individually operate at their

optimum speeds (**Figure 2**), thereby realizing improved efficiency and reduced noise (**Figure 3**). Furthermore, as the low-pressure turbine can also rotate at its optimum high speed, it has fewer stages and achieves better efficiency, thus contributing to the reduced weight and improved fuel economy of the engine. Compared with conventional turbofan engines, PW1200G is superior in terms of both thermal efficiency and propulsive efficiency. The overall efficiency has thus been markedly improved (**Figure 4**).



Source : Dr. Michael Winter, Chief Engineer for Technology, Pratt & Whitney, "A VIEW INTO THE NEXT GENERATION OF COMMERCIAL AVIATION (2025 TIMEFRAME) , AIAA Aerospace Today & Tomorrow", June 2013
https://www.aiaa.org/uploadedFiles/Events/Other/Corporate/2013_-_Aerospace_Todayand_Tomorrow/Winter.pdf, 2015.2.9

Figure 1 Fan drive gear system

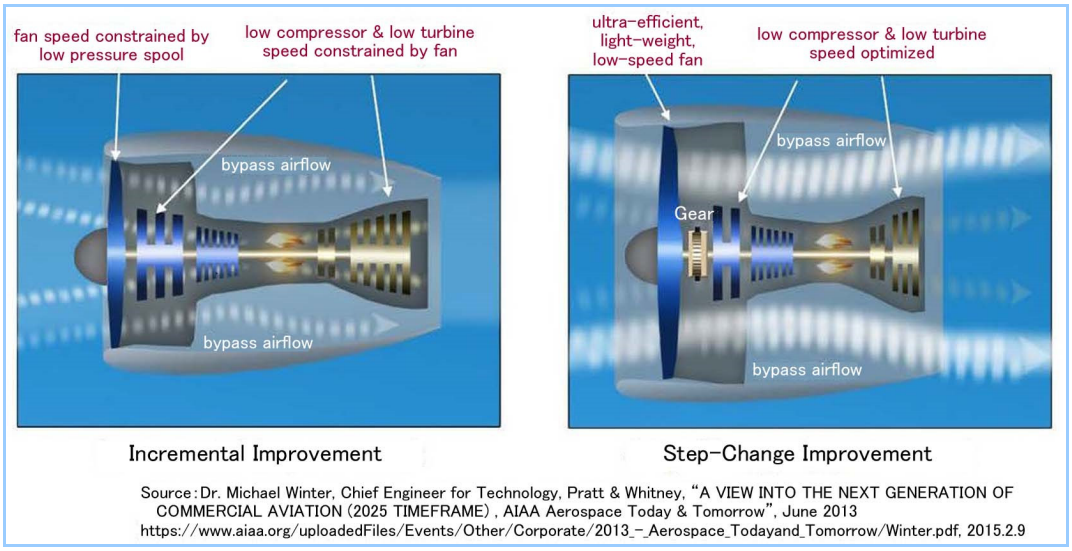


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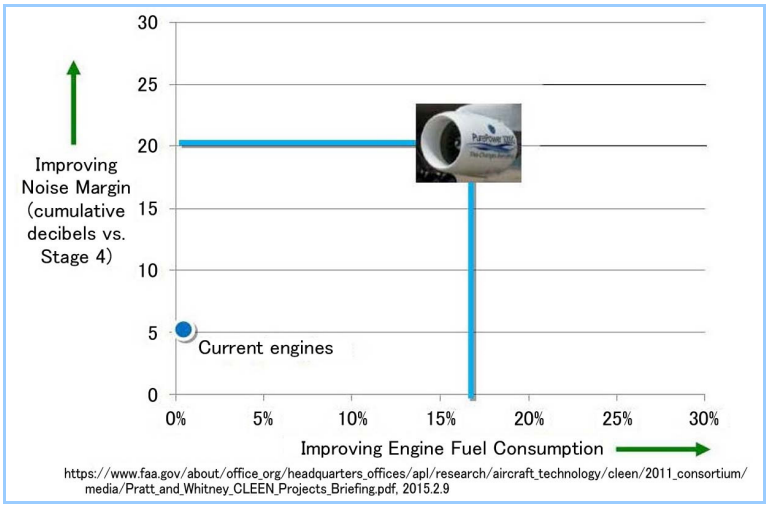
Figure 2 Comparison between GTF and conventional turbofan engine



https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/2011_consortium/media/Pratt_and_Whitney_CLEEN_Projects_Briefing.pdf, 2015.2.9

Figure 3 Fuel economy performance and noise characteristics

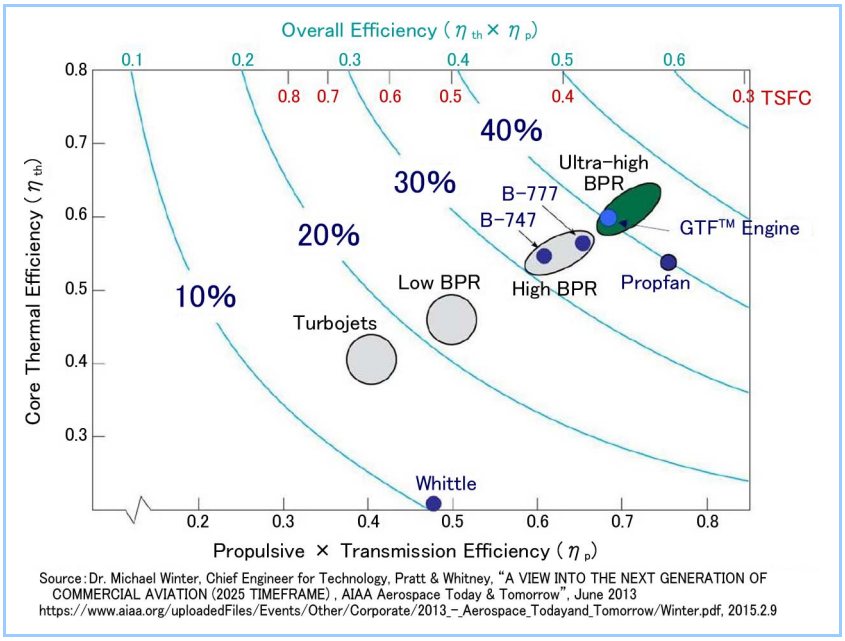


Figure 4 Overall efficiency

1.3 Emissions characteristics

The combustor in use is the 3rd generation of technology for advanced low NOx combustors (TALON-X), which was developed with P&W's original design concept of "rich-burn, quick-quench, lean-burn (RQL)." As the emission characteristics, PW1200G provides a margin of more than 50% to the ICAO CAEP/6 standards (**Figure 5**).

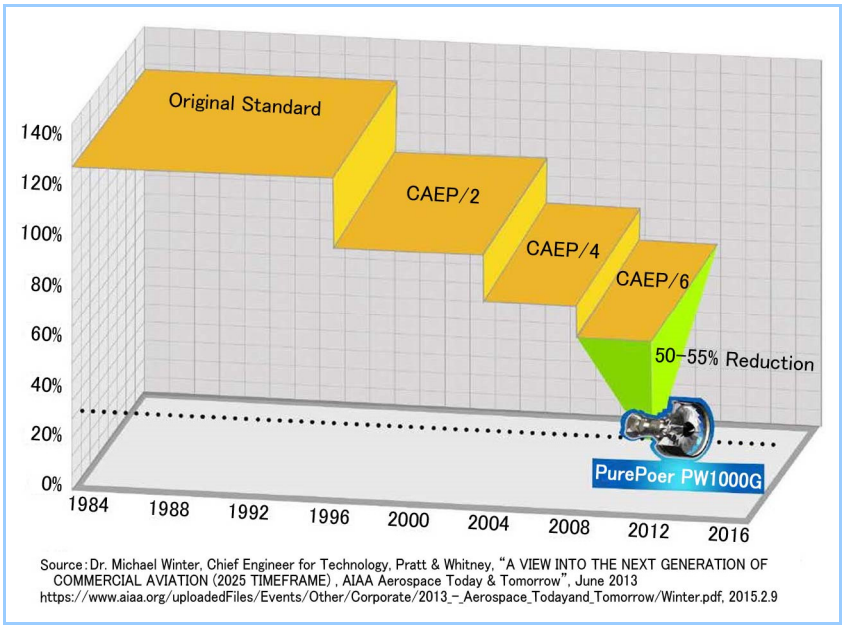


Figure 5 Emissions characteristics

2. Project in progress for development and mass production

2.1 Participation in the development

As in the agreement concluded with P&W in August 2012, the development/production of PW1200G combustor parts and high-pressure turbine disks, the final assembly of the engine and the acceptance operation testing will be conducted at the Nagoya Guidance & Propulsion Systems Works of Mitsubishi Heavy Industries, Ltd. (MHI), which is the current MHIAEL. While being engaged in the development, we are also proceeding with the project for mass production.

2.2 Parts production

The parts that we are in charge of producing are combustor components and high-pressure turbine disks. By utilizing not only our plants for production but also industrial clusters, we are building a system framework for mass production. To realize high temperature and low NOx, the combustor has a considerably increased number of air cooling holes in its panel, compared with the conventional one. To make it possible to perform high-quality processing at low cost, we have developed a high-speed laser processing technology with the help of MHI's Research and Innovation Center and Mitsubishi Heavy Industries Machine Tool Co., Ltd. The application of this technology to mass production is currently underway (**Figure 6**). Regarding high-pressure turbine disks, the use of powder metallurgical materials makes the machine processing very challenging, and we are also improving the technology necessary for the realization of stable production (**Figure 7**).

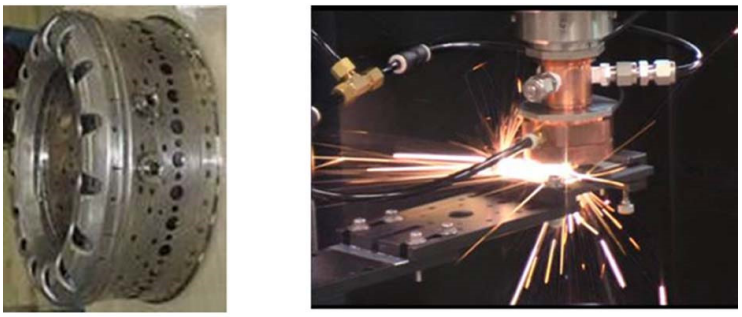


Figure 6 Combustor and high-speed laser processing

Figure 7 High-pressure turbine disc

2.3 Engine assembly and testing

The final assembly of the engine and the receipt operation testing will also be our responsibility. The assembly machines and test facilities are in the process of being set up (**Figure 8**).

For the final assembly system, a portion of the area at the plant will be exclusively used to combine several parts into a single kit, and an assembly line utilizing the pulse flow method will be ready for operation. These efforts are expected to help visualize the progress of ongoing assembly work. We are proceeding with the introduction of an assembly procedure and examination recording that makes the best use of IoT, as well as a production management system and configuration management system, while making arrangements to enable these systems to be operated cooperatively with P&W. The improvement of the assembly capacity for handling mass production has been planned. For the engine test, the existing engine test cell has been renovated and test cell correlation has also been performed. The final assembly line will be put into operation this year, the preparations including equipment procurement from P&W and worker training are

taking place. We are in the process of acquiring the certificates from authorities such as the U.S. Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA), as well as establishing the necessary quality assurance system.

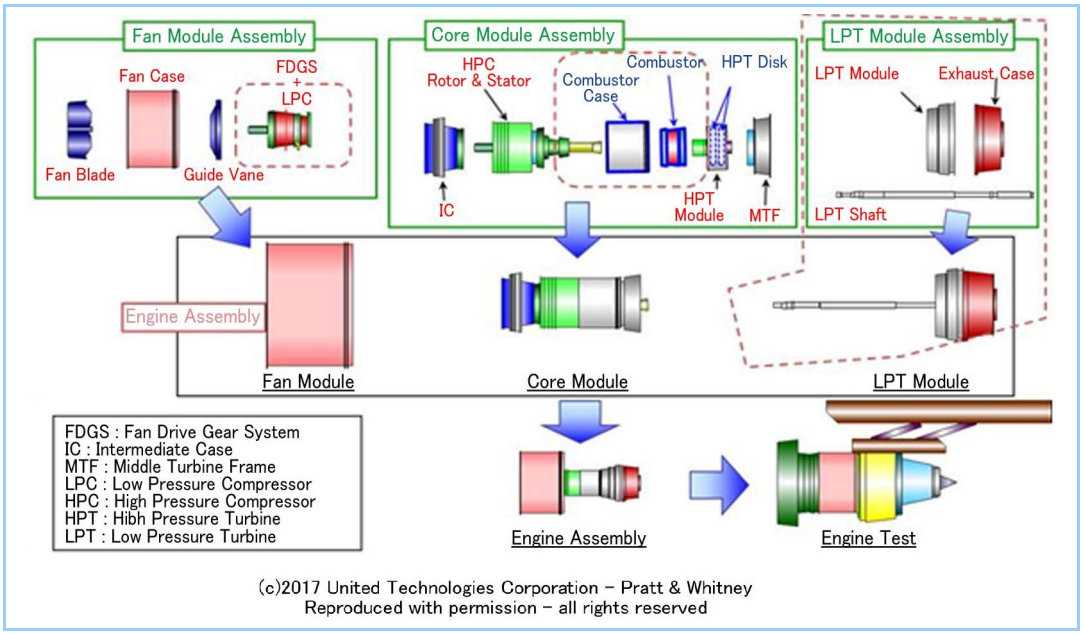


Figure 8 Modular structure and schematic diagram of the entire engine assembly

3. Future direction

We are all united to make every system related to the production of engine parts, assembly and testing ready by the time of the commencement of MRJ commercial flight operations. Turning this project into an opportunity, we look to substantially expand our aircraft engine business to offer total services including repair. We will continue to make company-wide efforts to bring about the success of the MRJ business.