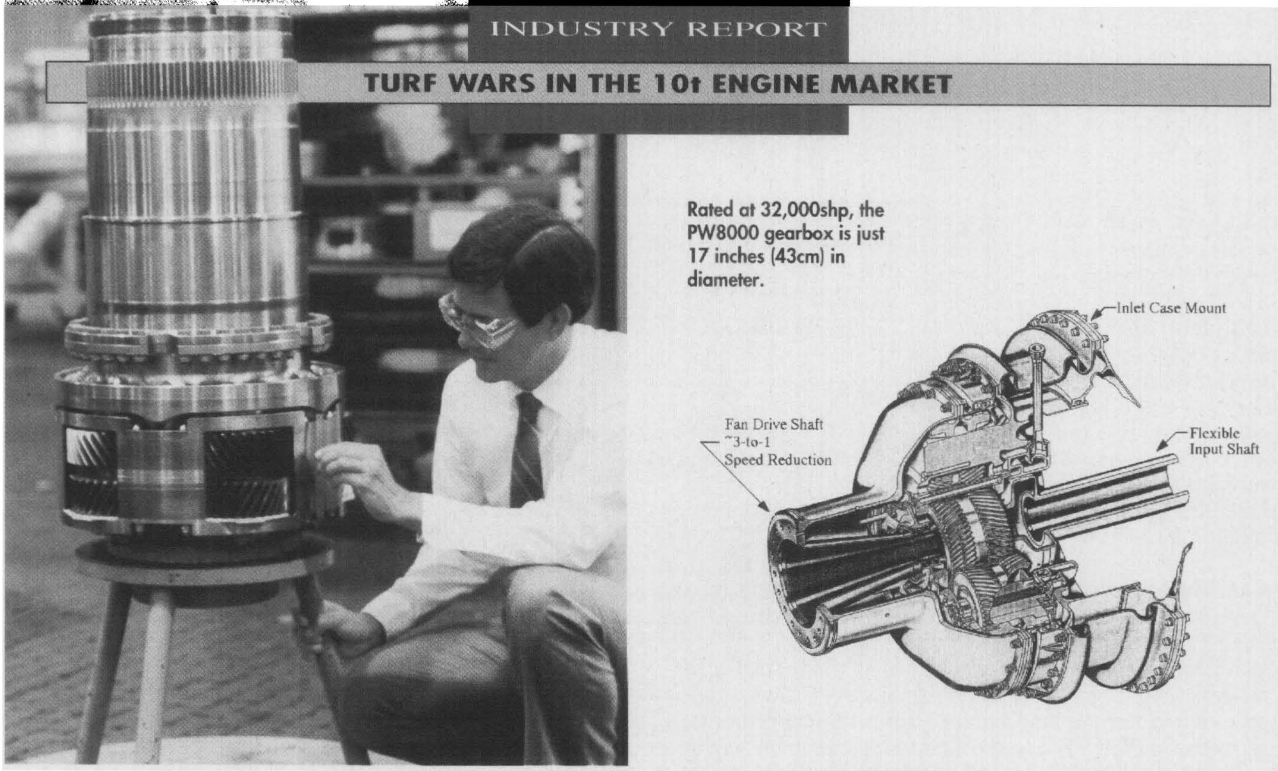
Sweetman, Bill;Sutton, Oliver
Interavia; Jun 1998; 53, 621; ABI/INFORM® Professional Advanced
pg. 25

INDUSTRY REPORT

TURF WARS IN THE 10t ENGINE MARKET



Rated at 32,000shp, the PW8000 gearbox is just 17 inches (43cm) in diameter.

Pratt & Whitney's surprise leap

The announcement of the PW8000 geared turbofan caught the industry unawares.

Planned as a follow-on to today's V2500 and CFM56, powering future developments of the A320 and, perhaps, a new-family 737, Pratt & Whitney's PW8000 breaks new ground in having a gear-driven fan and a higher bypass ratio than any current engine (11:1, versus 9:1 for the GE90).

Together with the PW6000, a conventional turbofan with the same core, it will provide Pratt & Whitney with a family of modern, economical engines from 67 kN to 155 kN, that promise to offer significant improvements in airline operating economics. The PW8000, claims Pratt, will increase reliability while reducing operating costs, fuel burn and noise.

P&W will start detailed design of the engine this month (June), and could run the first engine as early as September 1999. However, the actual timing will depend on when there is an application for the engine — and the main reason that the company's rivals did not see the PW8000 coming is that there is no clear application for such a family of engines.

This may be about to change. The PW8000 will cover a range of 25,000 to 35,000lb thrust, suitable for aircraft between 120 and 180 passengers. With its 76-inch fan diameter the engine will fit the Airbus A320 family, but not under the wing of the current new-generation Boeing 737. Talks are taking place with Airbus to flight test the PW8000 on an A320 in the time period 2001, with production scheduled for two years later. An inservice date could be around 2005-7.

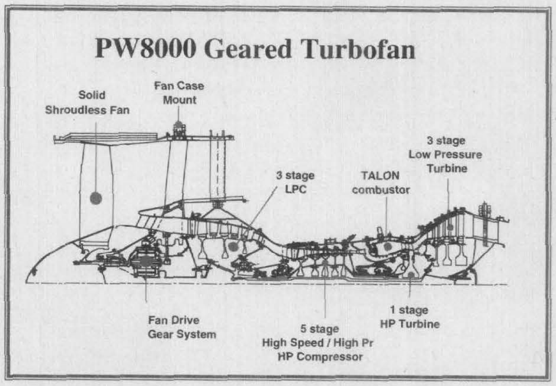
Pratt & Whitney says that is trying to position itself ahead of the market, so that it can produce new engines quickly enough to match the airframe manufacturers' development schedules. Engine companies have not tried to do this since the 1980s, when both P&W and GE invested heavily in high-speed propellers for Boeing's aborted 7J7 project. Now that Boeing and Airbus are taking less time to produce major derivatives and new aircraft, engine manufacturers may have to invest more in speculative technology developments unless they are confident that they can win business with derivatives.

P&W saw that it had few options left. The company's share of the gigantic market for narrow-body aircraft is in single digits (comprising P&W's share of the V2500 program and the PW2000) while CFM's share of the business expands inexorably.

Common core for a new family

P&W's strategy is to invest its earnings from the wide-body market in a new family, based on a common core, which covers a huge range of applications — almost the entire narrow-body segment from 80 to 180 passengers. The PW6000 core is already running. It shares some aerodynamic technology and design philosophy with the military F119, with a sharp reduction in the number of blades and stages compared with earlier engines. The geared fan concept is important to P&W's strategy, because it allows the common core to cover a significantly larger thrust bracket. The cost of developing the gearbox is more than offset by the ability to cover most of the narrow-body market with one core.

Gearing boosts performance because it eases a difficult compromise in engine design. The fan's tip speed cannot go much above 450 m/sec — above that point, noise starts to become unacceptable. As the designers increase the fan diameter in pursuit of more thrust, the tip speed limit means an ever lower rotational speed, so that each blade and stage in the low-pressure system can do less work. The result is that high-bypass, high-thrust engines have large and complex low-pressure compressors and turbines. Moreover, as the rotational speed slows down, the torque increases, demanding a stronger, thicker LP shaft which makes a poor match with a small, compact core.



The fan will rotate at about one-third compressor speed, and provide 90% of the engine's propulsive power

Gearing does the trick

Gearing solves the problem. The LP turbine and compressor spin faster, which means that they can be made smaller in diameter, shorter and simpler: the engine has 52% fewer compressor and turbine blades than a conventional turbofan, according to P&W. The speed of the fan can be optimized for noise, efficiency and structural considerations (P&W is talking about a 300 m/sec tip speed for the PW8000) and the LP shaft shrinks back to a normal size, making the core more compact and efficient. The low tip speed reduces noise — P&W claims a cumulative margin of 30dB below current rules — and the high bypass ratio boosts propulsive efficiency and reduces fuel burn by 9%. This is enough to make the A320 and A321 into transcontinental aircraft, and get the attention of airline financial officers.

THE PW8000 DRAWS ON TECHNOLOGY THAT P&W, MTU AND FIAT DEMONSTRATED IN THE ADVANCED DUCTED PROPELLER (ADP) ENGINE

The PW8000 design draws on the technology that P&W, MTU and Fiat demonstrated in the Advanced Ducted Propeller (ADP) engine in the early 1990s, but it is not an ADP. It has a lower bypass ratio and a higher fan pressure ratio, which eliminates the need for variable pitch; and it has a conventional reverser and solid titanium blades. The fan, gear driven off the LP spool, will rotate at about one-third compressor speed, and provide 90 percent of the engine's propulsive power.

Fiat developed the gearbox for the ADP and will be a partner on the PW8000, as will MTU. It transmits 32,000 shp, but the 3:1 ratio is modest, so the gearbox can be a straightforward planetary design. The ADP gearbox underwent extensive testing, including 1,000 hour in a full demonstrator engine.

Gearbox design and history of failures in seven turbofan and turboprop engines and two helicopters were analysed back to 1962. The results showed that most problems came from bearings, lubrication/cooling systems, and flexing of the gearbox during normal flight. The new gearbox design features small, light self-aligning bearings, a lubricating system that places oil only where it is directly needed, and which circulates it out of the gearbox as quickly as possible — to avoid a build up of heat. To cope with the flexing of the engine structure in flight, which tends to cause gear wear and cracking, engineers came up with a design to mount the gearbox on a kind of bellows, that resembles a large spring. This physically isolates the gearbox from the normal bending loads and keeps gear alignment precise. The PW8000 gearbox is just 17 inches (43cm) in diameter.

Full-scale tests, the equivalent of 18,000 flight cycles and 25,000 flight hours of normal service, were carried out by Pratt and FiatAvio, including a 40,000shp gearbox that ran without problems for over 500 hours at its rated loading.

The development of the PW8000 could lead to an interesting situation among the airframers— Airbus Industrie could find itself able to offer significant economic advantages to operators with a PW8000 under the wing of its A320 family. This in turn could push Boeing into the design of a totally new family, replacing the present 737, and possibly the 757, to accommodate the PW8000. This is the situation that CFMI will be seeking to head off.

BY BILL SWEETMAN AND OLIVER SUTTON

MTU SET FOR PW8000 STAKE

MTU President and CEO Rainer Hertrich is enthusiastic about the market potential for the PW8000, and, as a Pratt & Whitney preferred partner, intends to take a 20-25 percent stake in the programme. MTU earlier declined to go with the PW6000, and Hertrich acknowledges that progress on the PW8000 will depend on Pratt's common core development of the PW6000, since Pratt does not intend to start development of both engines simultaneously. The next priority is engineering design, and a demonstrator engine. The rate of progress will also depend on Airbus's 100-seater project, either with the Chinese, where the PW6000 is a prime candidate engine, or on the A319-M5, which could also take it.

MTU's contribution to the PW8000 will focus on capabilities in blisk technology, developed for the Eurofighter's EJ200 engine, on transonic compressor technology developed under Germany's 3e engine programme, and on earlier work on the LP turbine and compressor for Pratt's ADP demonstrator engine. MTU will also be preaching the advantages of its linear friction welding repair technology to the airline industry, which today may be more comfortable with traditional blade repair methods.

MTU is running a demonstrator core with a six-stage HP compressor, while Pratt is trialling a five-stage core. On the PW8000, MTU will bid for the LP turbine and LP compressor, both MTU core competencies, which Hertrich stresses are equivalent to today's HP stages, since air flow will be transonic.