PW400 0 types and certification dates

Aircraft

A310-300
A300-600
A300-600ER
767-200ER
767-300ER
767-300

767-300ER (HGWT
747-400
MD-11

• High gross weight
Note: The first number in each engine model
Airbus/1, 747/2, MD-11/3)

Engine model

PW4152
PW4156
PW4158
PW4050
PW4056
PW4050
PW4060
PW4256
PW4360

represents the engine series
the last two thrust (x 1,000lb).

Aircraft certification

June 1987
Nov 1988
Nov 1988

May 1988
March 1988
March 1988
2nd quarter 1988
4th quarter 1988
May 1990

the second the aircraft type (767/0,

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Aircraft certification

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The P W4000 will be available in versions producing from 50,0001b to 58,0001b thrust to power a range of aircraft

Engine orders/options

Type

A310-200ADV
A310-300
A300-600
A300-600R
A330
767-200ER
767-300
767-300ER
MD-11
747-400

Total

* Figures do not include GE

PW400 0

34/30
6/0
0/10

4/0
2/2

30/48
180/36

256/12 6

s latest order from Japan Ai

CF6-80C2

12/10
88/8
30/10
52/2
14/8
30/20
34/16
48/26
93/63
144/76 '

545/23 9

Lines for -80C2s to

RB.211-524

22/30

88/136

110/16 6

power five 747-400S on firm order

Sales figures reveal the PW4000 to be in a healthy position on the all-important MD-11 and 747-400, despite being, in effect, a year behind the CF6-80C2

responsibility for which has moved from
Fiat back to Pratt & Whitney in the
PW4000).
Tad Domagala, Pratt & Whitney's vice-
president for commercial product manage-ment, puts the PW4000 design concept thus: "the high spool uses the design philosophy extracted from the PW2037, and the low spool uses that from the JT9D-7R4, which has been very good in service. The 2037 uses JT9D low-pressure experience as well, so you might say the whole engine is based on PW2037 experience".
One of the most successful of the PW2037 hand-downs is the Hamilton Standard full-authority digital engine control (Fadec), which remains unique in airline service (GE plans to introduce Fadec in 1989). On the PW4000 the system controls more variables, as well as reducing fuel burn by an estimated 1 • 5 per cent, eliminating trim requirements, and providing a diagnostic capability.
The real change in the PW4000 over previous designs comes as a result of the major effort Pratt & Whitney has made to reduce maintenance costs, primarily by means of a dramatic 54 per cent reduction in parts count, but also as a result of particular attention to durability.
In the combustor, for example, Pratt & Whitney has introduced a machined ring burner which maintains better concen-tricity, reducing thermal distortion, and hence stress, on the (single crystal) high-pressure (HP) turbine blades. Other durability improvements over

the JT9D include stiffer engine cases, controlled-diffusion HP compressor blades (which have blunter, erosion-resisting leading edges) and relocation of the LP splitter further aft to improve dirt separation.
The parts reduction is achieved in two ways—by increasing the efficiency of the aerodynamic components, which means there need be fewer of them, and through changes in manufacturing technology, which have enabled some large components to be produced as one part instead of as several smaller parts which subsequently have to be joined together. Most of the parts cut occurs in high-maintenance components, such as turbine vanes and blades, and the combustor. The PW4000 has 20 fewer major flanges than the JT9D, 30 per cent less tubes and brackets, and 2,600 fewer fasteners. There are 23 per cent fewer airfoils overall than in the JT9D-7R4. This includes a massive 43 per cent reduction in the high-pressure turbine (traditionally a high maintenance area) achieved by eliminating disc bolts, splining both discs on to the low-pressure (LP) shaft, and doubling up parts functions wherever possible. A 27 per cent blade reduction in the HP compressor, 11 per cent in the fan section, 9 per cent in the LP turbine, and 2 per cent in the booster completes the list.

Pratt & Whitney bases its 25 per cent maintenance-cost reduction claim on what it calls the "maintenance material cost" of the top 15 high-value parts such as fan blades, outer and inner combustor

liners, and turbine aerofoils. Particular attention has been paid to extending the life of these components, and of other life-limited parts such as turbine discs. "It is well recognised that Pratt & Whitney produces discs that have the longest life, because of our very soph-isticated design system," says Domagala. "Our life prediction system has been accepted by the certification authorities," he adds, "which allows us to quote very long disc lives."

Aerodynamic improvements over the JT9D include advances that came out of the Nasa-sponsored Energy Efficient Engine (E3) programme, in which GE and Pratt & Whitney built and tested a number of advanced components.
The PW2037 benefited from E3 tech-nology principally in the HP compressor, which has a higher blade loading than previous Pratt & Whitney turbofans. The PW4000 core retains the controlled diffusion compressor blading introduced on the PW2037 and, although it is less aggressive, still rotates some 25 per cent faster than the JT9D core, and has a 10 per cent higher pressure ratio.
Pratt & Whitney has also introduced a new "thermatic rotor" HP compressor drum which reduces blade tip clearance by circulating compressor air internally to control disc expansion. Careful matching with the case design means that tip clear-ances can be minimised passively, instead of by means of a more complex active clearance control system. Active clearance control is retained on low and high-pressure turbines, and is controlled by the Fadec, as on the PW2037.
Service introduction of the PW4000 came last June on the first of Pan Am's 12 (firm) A310-300s. The engine is now flying on seven aircraft, including the first Sing-apore Airlines A310-300. The engine has experienced no problems to date. "It's been a very good introduction", says Domagala.
A ten-engine pacer programme keeps engine endurance hours ahead of airline service time. At the time of writing the PW4000 had built up around 7,750hr running time, including more than 21,000 operating cycles.
As the table shows, Pratt & Whitney lags GE by a substantial margin on engine sales to date, principally because of the CF6-80C2's earlier in-service date. The GE engine has also built up a considerable lead in running time on the big twins, which means it is nearer to compliance with Federal Aviation Administration requirements for extended range oper-ations (Erops). This is unlikely to affect long-term sales performance significantly, however, since the amount of engine/ airframe time required for Erops is consid-erable, and the PW4000 will soon accumu-late plenty of airframe time.
Pratt & Whitney will not disclose its investment in the PW4000 (gone are the days of the "billion dollar baby" slogan coined for the PW2037), but says that it
will be less than that of the PW2037 up to
certification. Overall programme costs
will be higher, though, because of the
number of applications for which certifi-
cation is being sought. B

34 FLIGHT INTERNATIONAL, 31 October 1