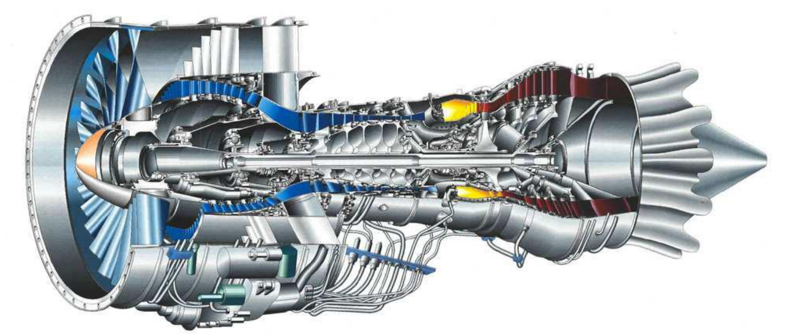
Pratt & Whitney PW6000

Turbofans
April 2019



Quick Specs:

Power Class:	22,000 – 24,000 lbst (98 – 107 kN)
Bypass & Pressure Ratios:	4.8-5:1 & 30-30:1
Airflow:	n/a
SFC:	0.370 lb/lbst-hr (10.5 mg/Ns)
Configuration:	1 F; 4A LPC; 6A HPC; Annular; 1A HPT; 3A LPT

Program Briefing

The PW6000 was developed by Pratt & Whitney to challenge the dominance of the CFM International CFM56 and the IAE V2500 in the 100- to 200-seat commercial airliner market. The turbine initially was selected as the sole powerplant of the Airbus A318.

Things began to unravel from there, however, as customer objections led to the re-inclusion of the CFM56 and then the technological risk proved to be near fatal as the initial five-stage HPC failed to perform as expected.

P&W subsequently moved to an MTU-designed HPC and now is only in service aboard the A318 for LAN Chile, the August 2005 launch customer. Final assembly of the engines took place at MTU's facilities in Hanover, Germany.

Engineering snafus notwithstanding, the PW6000 is expected to have a low cost of ownership through a lower parts count and materials advances. There are no outstanding orders for the A318/PW6000 so we are not forecasting further production.

Manufacturers

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Risk-Sharing Partners

- MTU Aero—HP compressor, LP turbine and final assembly of the PW6000 engine. The company's stake in the project excluding the assembly was 33% but has now increased to a reported 40%.
- Mitsubishi Heavy Industries—combustion chamber; MHI has a 7.5% risk-sharing stake in the program.

Summary Forecast

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
Units Produced	—	—	—	—	—	—	—	—	—	—	—
Value (then-yr $millions)	—	—	—	—	—	—	—	—	—	—	—

Subcontractors

A partial list of PW6000 subcontractors follows:

- Aero Decals, Palm Bay, FL, USA—placards, ID plated markings
- CSE, Brea, CA, USA—clamping devices.
- DuPont Vespel Parts & Shapes, Valley View, OH, USA—VSV bushings.
- Haskon Aerospace, Taunton, MA, USA—seals.
- Kirkhill Elastomers, Brea, CA, USA—clamping devices.
- Otto Fuchs Metallwerke, Meinerzhagen, Germany—forged disks.
- Aircelle (Hispano-Suiza/ Airbus)—A318 nacelle.
- Hamilton Sundstrand—Gearbox, FADEC, APU (APS3200 is an option).
- Honeywell—APU (Model 131 is an option).
- Howmet—castings.
- Laserdyne Systems, Champlin, MN, USA—laser material processing systems.
- Lee Products Ltd., Gerrards Cross, England—valves.
- Leistritz Turbomaschinen Technik GmbH, Nuremberg, Germany—compressor components.
- Neomet Ltd., Stockport, England—honeycomb seals.
- Omega Technologies Inc., Westlake Village, CA, USA—universal wrenches, sockets and adapters.
- Precision Castparts Corp., Portland, OR, USA—castings.
- PSI Bearings, Simi Valley, CA, USA—bearings.
- PTI Technologies Inc., Oxnard, CA, USA—filters.
- Reform Maschinenfabrik, Fulda, Germany—high-speed blade tip grinds.
- Schenck Trebel Corp., Deer Park, NY, USA—dynamic balancing machines.
- Sealtron Inc., Cincinnati, OH, USA—hermetic connectors.
- Simrit-Aerospace, Santa Ana, CA, USA—sealing products.
- Spincraft Inc., New Berlin, WI, USA—plugs, nozzles, anti-icing system.
- TA Aerospace, Valencia, CA, USA—clamping devices.
- Vitta Corp., Bethel, CT, USA—brazing materials.

Technical Description

Components

The PW6000 is a two spool, mid-range, civil turbofan:

Fan

Single, wide-chord fan with a 4.9:1 bypass ratio. The fan is 56.5 inches in diameter.

LP Compressor

Four-stage compressor with inlet guide vanes.

HP Compressor

Six-stage MTU-developed advanced compressor.

The original plan was for a Pratt & Whitney-developed five-stage HP compressor.

Combustor

Single, annular combustor. Uses TALON II (Technology for Advanced Low NOx) technology

HP Turbine

Single-stage turbine with single crystal blades drives the HP compressor.

LP Turbine

Three-stage turbine with single crystal blades drives the fan and LP compressor.

Other Components

The engine features a Hamilton Sundstrand FADEC.

Specifications

(Imperial Units)

Model	Thrust (lbst)	Pressure Ratio	Bypass Ratio	Airflow (lb/sec)	SFC (lb/lbst-hr)	Fan Dia. (in)	Length (in)	Weight (lb)
PW6122A	22,100	26.1:1	4.9:1	n/a	0.360	56.5	108	4,950
PW6124A	23,800	28.7:1	4.9:1	n/a	0.370	56.5	108	4,950

(Metric Units)

Model	Thrust (kN)	Pressure Ratio	Bypass Ratio	Airflow (kg/sec)	SFC (mg/Ns)	Fan Dia. (m)	Length (m)	Weight (kg)
PW6122A	97.9	26.1:1	4.9:1	n/a	10.2	1.435	2.743	2,240
PW6124A	106.8	28.7:1	4.9:1	n/a	10.5	1.435	2.743	2,240

Applications

Engine	Aircraft	Engines per A/C
PW6122A	Airbus A318	2
PW6124A	Airbus A318	2

Marketing Data

Costs

Estimated Unit List Prices (current, except where noted)

PW6124A:	$4.1 million (2008)

The Competition

The most direct competitors to the PW6000 were the CFM International CFM56 and the International Aero Engines (in which P&W is a 33.3% stakeholder) V2500. Both engines overlapped with the PW6000 on the lower end of their power range.

The Rolls-Royce BR700 and General Electric CF34 competed with the PW6000 turbine on the upper end of their power band.

Order Book

PW6000 Family

Customer	A/C Model	A/C Ord./Del.	Engine Model/Notes
America West	A318	15/—	PW6000 (cancelled)
Frontier Airlines	A318	5/—	PW6000 (cancelled)
ILFC	A318	15/—	PW6000 (cancelled)

LAN A318 powered by the PW6000

LAN Chile (8/05)	A318	15/15	PW6000
Total		**15/15**	

Production History*

	2005	**2006**	**2007**	**2008**	**2009**	**Total**
PW6124A	—	5	13	16	—	34

**development & test engines not included*

Milestones

Date	***Milestone***
September 1998	PW6000 program launched
July 1999	First engine test
January 2002	First A318 flight
Nov. 11, 2004	PW6000 receives FAA FAR 33 certification
Dec. 14, 2004	A318/PW6124A makes first flight
June 2005	PW6000 gets EASA validation
August 2005	LAN Chile orders 15 PW6000-powered A318s
Feb. 27, 2007	First flight of a LAN Chile A318
June 2007	First A318 delivered to LAN Chile

Program Overview

Background

Initial Development

The PW6000 program was launched in tandem with the PW8000 geared fan in early 1998. Pratt & Whitney stated that it would initially develop the turbine with the first customer and would then move on to the other turbine. Airbus pulled the trigger on the PW6000 first with a contract to power the A318 110seat twinjet in April of 1999 (the PW8000 program never went into production).

Pratt's concept for the PW6000 was to design a brand-new core with much fewer moving parts, reducing complexity, acquisition and maintenance costs. In addition, the engine has been designed to meet all existing and anticipated noise emissions requirements.

One of the cost saving measures attempted by P&W engineers was to reduce the number of stages for the whole engine to 13, including the fan. This meant that they would use a five-stage HP compressor (reduced from an initial six) with an 11:1 compression ratio. This was designed using extensive computer modeling, and unfortunately, not enough real-world testing.

Despite the reluctance of Airbus to offer an alternative engine, fleet commonality concerns from CFM56 house Air France eventually forced the aircraft maker to break its exclusive arrangements and offer the CFM56-5B as an option.

P&W still managed to gain significant orders as its turbine was specifically designed for the power band needed on the smaller A318, while the CFM International engine was a down-rated version of a more powerful turbine.

New Compressor Design

Static tests for the engine began in August 1999. Things began to fall apart quickly. The five-stage high-pressure compressor (HPC) was not performing up to par. The company hoped to be able to make some modifications, but a series of improvements only served to narrow the performance gap, not close it. By July 2000, it was apparent that the company was facing a serious problem and the company publicly aired the issue, although still holding out hope for an in-house solution.

As a back-up plan was put into motion the company looked to MTU, already responsible for the LP compressor, to come up with a replacement, six-stage HP compressor.

All but one of the announced A318 engine selections went with the PW6000.

Flights tests aboard a Boeing 720 test-bed and incremental performance improvements led P&W to go ahead with its own design in September 2000.

The decision ended up coming back to haunt P&W as it was finally forced to dump its in-house design more than a year later and start a new, 30-month development program for a replacement HP compressor. This delayed the entry into service date to mid-2005.

The immediate result of the announcement of the problem was the defection of the A318 launch customer, Frontier Airlines, to the CFM56 engine.

In mid-2002, P&W finally decided to use the MTU HDV12 design. MTU has HP compressor expertise from its work on the Eurojet EJ200 and was partially funded by Germany's Engine 3E research program. MTU is also developing the HPC design for the P&WC PW800 family. The company will design and test the compressor under the German AFTI research program.

First Flight

The results of ongoing static and flight test of the modified engine were successful and the PW6124A made its first flight aboard an A318 on Dec. 9, 2004. Airbus was quoted as saying the engines performed "exactly as anticipated" during the two-hour 52-min flight.

Final Assembly Moves to Germany

To reduce costs, move production closer to the A318 assembly site in Hamburg and to increase European content, the final assembly of turbines have been moved to an MTU facility in Germany. This increased MTU's share in the program to close to 40%.

Initial Order Book Erosion

Several initial PW6000 customers cancelled their orders, not to move to the CFM56, but to up-size their aircraft to larger A320 family models.

PW6000 Gets EASA Validation

In June 2005, Pratt & Whitney successfully achieved European Aviation Safety Agency (EASA) engine validation on the PW6000. This is the first “all new” engine to be validated by EASA since the agency’s establishment in September 2003.

The PW6000 had earned US Federal Aviation Administration (FAA) FAR 33 status on Nov. 11, 2004. The engine achieves all current and planned environmental regulations worldwide, including noise and emissions metrics.

First Real Order

In August 2005, LAN Airlines, based in Chile, became the launch customer for the Pratt & Whitney PW6000 engine. LAN’s engines will power 15 firm Airbus A318 aircraft for a total of 34 engines (30 installed and four spares). A long-term maintenance agreement is included.

In addition, LAN Airlines has signed with Pratt & Whitney to power up to 10 option aircraft. If LAN exercises all options, it would mean an additional 56 (50 installed and six spare) engines.

The first Chilean aircraft flew in February 2007 and was delivered to the airline in June 2007. All firm-order aircraft now have been delivered.

MRO

Maintenance, Repair & Overhaul

Due partially to reduced parts count, P&W maintains that the typical engine does not have to visit the shop before almost six years of service. The company is targeting 30% lower overall maintenance costs than a comparable CFM56 engine.

Pratt offers various MRO options including full "cradle to grave" service for the turbine.

Current Developments

Further Applications?

The PW6000 was provisionally selected to power the Bombardier BRJ-X 110-seat regional jet. The program was shelved in late 2000 in favor of the CRJ 900.

The company considered offering the PW6000 as a re-engine option for legacy Boeing 737s, but the post 9/11 increase of inactive/parked aircraft scuttled those plans.

The PW6000 was also offered as an option to power the now-cancelled Chinese AE-100 airliner concept.

Teal Group Evaluation

What started off as an announcement of a bold redesign of the Pratt & Whitney product line with an aggressive core (PW6000) and geared technology (PW800), became somewhat of a debacle with the failure of the P&W five-stage compressor design. The technology lead that the company hoped to gain evaporated as incremental upgrades of rival turbofans narrowed the performance advantages of the engines. Perhaps more sadly, the failures somewhat stifled the spirit of innovation in the company, and industry. The good news is that the remedial MTU design seems to be up to snuff.

Unfortunately, the problem for P&W (and Airbus) is the weakness of the A318 versus the new/cheaper

100-seat regional jets. The economics of an up-sized RJ are hard to match by an aircraft that has many of the structural components and systems necessary to carry almost 200 people,

Nonetheless, the LAN Chile selection of the PW6000 was a godsend for Pratt. It kept them in the big fan business a little longer.

The PW6000 still had a bit part in the resurgence of Pratt's commercial big fan business, however. The core of the engine served as the basis for the PW1000G geared turbofan (GTF) demonstrator. And now, production GTFs (with an all new core) have gone into service aboard the CSeries and A320neo.

Production Forecast

Units	Thru 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
PW6124A												
A318	34	—	—	—	—	—	—	—	—	—	—	34

Value ($ Millions)*	Thru 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
PW6124A												
A318	139.4	—	—	—	—	—	—	—	—	—	—	139.4

**then-year dollars*