The GP7200

Power from Joined Forces

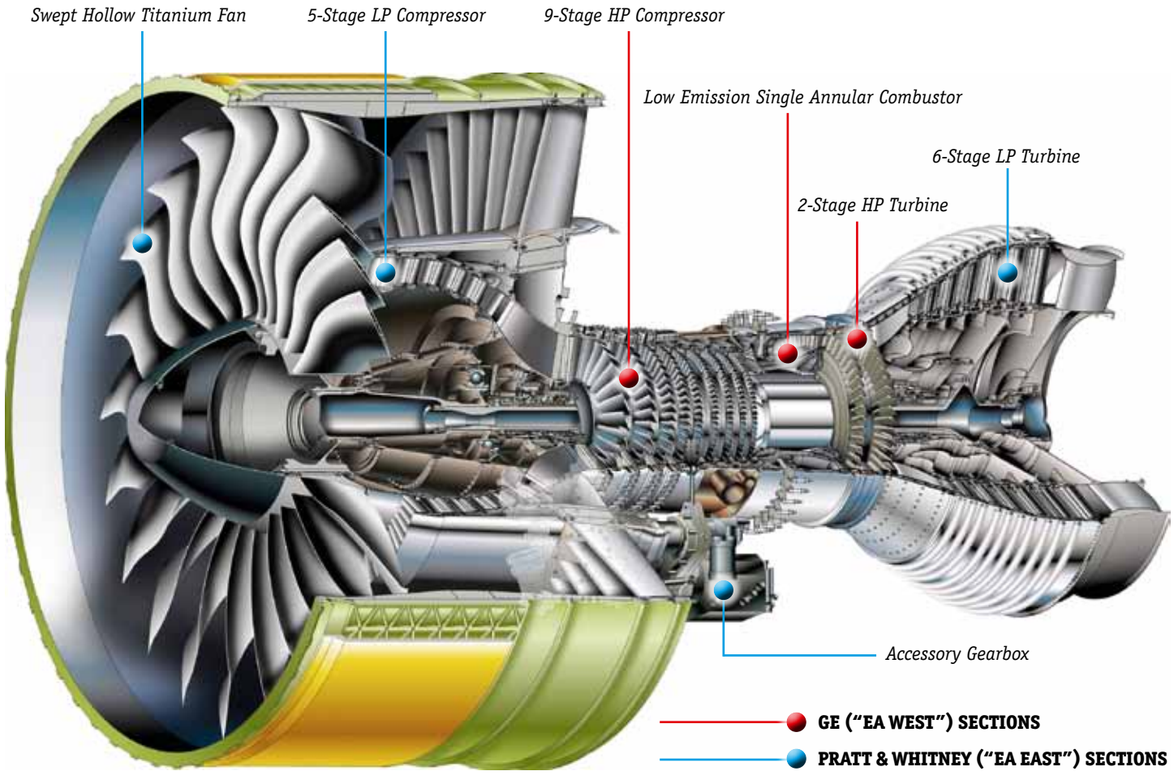
One of the prototype Airbus A380-800s flies over southern Europe during the certification trials for the Engine Alliance GP7200 power-plant. (all images Airbus unless stated)

One of the lesser-known ironies of the commercial aviation business is that the Engine Alliance GP7200 turbofan engine powering the Airbus A380 is the end result of a collaboration that originally came into being to produce a new engine for the Boeing 747. The Engine Alliance joint venture between General Electric and Pratt & Whitney (P&W), was originally created back in 1996 to develop an engine for Boeing's B747-500X and B747-600X projects, proposed larger versions of the original B747. "The impetus for the alliance… was that we [both] thought it was a niche market, and it didn't make sense to go it alone," said Mary Ellen Jones, President of the Engine Alliance during a recent interview with *Airliner World*.

Boeing decided not to pursue the B747-500X and B747-600X, unconvinced that a market existed for the larger aircraft – but Airbus soon began proposing the A3XX Super-Jumbo. When the European manufacturer decided to build the world's largest passenger jet in late 2000 and christened it the A380, the commercial impetus was there for Engine Alliance to develop the new GP7000 engine, in the form of the GP7200.

Although Boeing argued for years that the market demonstrated no need for an aircraft larger than the B747-400, in the end it ultimately decided that it did need to develop a larger B747 after all. This is now in flight-test as the B747-8F freighter and soon will take to the air as the 747-8 Intercontinental passenger aircraft. However, the B747-8 will be powered by a General Electric engine, the GEnx-2B. »

The GP7200 for the Airbus A380 is the result of a unique collaboration between two of the world's three biggest commercial-turbofan engine manufacturers. Chris Kjelgaard reports on the high-tech, high-bypass GP7200.



Development of the GP7200 from 2000 to late 2003 closely paralleled Airbus' detailed design effort for the A380. "We were in synchronisation with that development," recalls Jones.

The Engine Alliance received FAA certification for the engine on December 29, 2005, with the GP7200 actually being certified at 76,500lb (340.29kN) of take-off thrust rather than the 70,000lb (311.375kN) needed for the passenger A380, "because the [heavier-gross-weight Airbus A380F] freighter was in play at that time."

Work-share

The GP7200 is one of the most advanced commercial turbofan engines yet built. Its design represents a 50-50 split between GE and P&W. Each company also uses two supplier partners for its part in the programme: P&W uses MTU and Techspace Aero – a Belgian subsidiary of the SAFRAN Group – while GE uses Snecma (another SAFRAN subsidiary) and MTU. Meanwhile, another SAFRAN subsidiary Aircelle makes the exhaust nozzle.

The GP7200's fan, fan casing, low-pressure spool – which includes its low-pressure compressor (LPC) and low-pressure turbine (LPT) stages – and accessory gearbox are made by P&W. The fan and low-pressure spool are based on those in later models of the company's highly reliable PW4000 family, which power the B777-200 and B777-200ER. The GP7200's low-pressure spool features design advances in the form of 3-D-airfoil LPC and LPT blades and in blade materials.

Meanwhile, the high-pressure spool – which contains the high-pressure compressor and high-pressure turbine stages – and the combustor are GE designs. The combustor is a single-annular design – it is a ring that fits round the casing that contains the high- and low-pressure spools, and was developed from the low-emissions design created for the CF6-80. The high-pressure compressor and high-pressure turbine stages are scaled-down versions of those in the GE90-115B, according to Bill Blair, of GE who is Executive Vice President of the Engine Alliance.

GE assembles the high-pressure spool and combustor at its own facilities and ships the entire assembly to P&W's plant at Middletown, Connecticut. There, on the GP7200 final-assembly line, P&W integrates the GE high pressure spool and combustor with the fan module, the low-pressure spool, the gearbox and the exhaust nozzle and ships the complete engine to Airbus, which installs the engine on an A380 pylon, or direct to the customer as a spare powerplant. The architecture of the GP7200 features the fan and fan casing; five LPC stages and the accessory gearbox, which is driven by the low-pressure spool; nine HPC stages; the single-annular combustor; two HPT stages; six LPT stages; and the exhaust nozzle. Within the engine, the GP7200 features a profusion of technological advances to make it reliable and quiet in operation and miserly in terms of specific fuel consumption (SFC).

"We optimised the high-pressure turbine as well as the low-pressure turbine to get 11% to 13% better SFC than the CF6-80," said Blair. "It's 4% better than a 1990s-technology engine [such as the GE90-115B] in terms of installed cruise SFC. The GP7200 is the lowest-SFC engine in commercial service."

Fan and Low-Pressure Spool

Technological advance starts with the GP7200's huge fan, which has an 8.8 'bypass ratio' – the ratio of air which doesn't go through the engine itself to the air that does go through the core – and which produces the bulk of the thrust generated by the GP7200. According to Blair, the maximum amount of air that goes through the core of the engine each second is 360lb (163.3kg), at take-off. Given the 8.8 bypass ratio this means that the GP7200's fan pushes some 3,168lb (1,437kg) of ambient-temperature air plus 360lb (163.3kg) of core air behind it every second to produce the thrust required at take-off.

Each one of the fan's 24 swept, 3-D-airfoil fan blades is made from titanium and is hollow, as are the lightweight, high-strength fan blades in the PW4000 family of large-turbofan engines. But while the PW4098 (the highest-thrust engine in the PW4000 family) has a 112in-diameter (284.5cm) fan, Engine Alliance quickly realised that in order to meet the very exacting 'Quota Count' (QC) noise restrictions imposed by BAA at London's Heathrow Airport, the partnership would have to make the GP7200's fan larger to increase its bypass ratio. Accordingly, P&W increased the diameter of the fan to 116in (294.6cm). This did the trick and the engine now comfortably meets Heathrow's QC0.5 departure and QC2.0 arrival measurements.

In the GP7200, the high centrifugal forces produced by the large fan diameter, the wide spaces between each swept fan-blade, the elliptical design of the fan hub and careful adjustment of the spacing between the fan and the compressor intake, ensures that no large-particle foreign object debris (FOD) enters the LPC. Instead, large-particle FOD is pushed round the side of the compressor intake and exits between the guide vanes at the rear of the fan casing, without entering the engine.

In any engine, if a fan blade breaks off the resulting imbalance creates vibration which has to be absorbed by the engine frame. Traditionally, this means that engine frames have had to be very stiff and heavy. However, the GP7200 engine frame features a new technology – a 'frangible bearing support' (FBS) which features fuse bolts that are designed to separate under large fan-imbalance loads. If a fan blade breaks off, FBS separation makes the frame less stiff and greatly reduces the imbalance loads transmitted to the engine mounts and pylon at high fan-rotation speeds. However, the fan's torque and thrust remain fully supported by the engine's main roller and thrust bearings. Using the FBS, the engine frame can be made much lighter than using a traditional design, according to Paul Smith, the »

Above • **A breakdown of the individual areas of expertise the two Engine Alliance partners - GE and Pratt & Whitney - bring to the GP7200 pwerplant.** (Engine Alliance)

Below • **A view of the Pratt & Whitney Middletown facility in the United States from an A380-800 flying overhead.** (Airbus)

Above Left • **Air Austral, the Reunion-based carrier, is the only A380 customer to select an all-Economy interior for its aircraft with seating for around 840 passengers.**

Above Right • **Korean Air will become the third operator of the GP7200-powered A380-800 when the first of ten aircraft enters service next year.**

Below • **Air France took delivery of its first A380-800 on October 30, 2009. It now operates three of the type and is due to receive one more before the end of this year.** (Air France)

Engine Alliance's GP7000 Programme Chief Engineer – East (he is employed by P&W).

In the LPC, the 3-D airfoil, swept-blade design of the first compressor stage pushes almost all small-particle FOD which enters the compressor out through the low-pressure bleed-air system, further reducing the chances of FOD entering the hot section of the engine and damaging compressor and turbine blades. Meanwhile, optimisation of the numbers of LPC and LPT blades and vanes has cut down noise and improved airflow through the engine.

High-Pressure Spool and Combustor

According to Paul Smith, the entire hot section – HPC, combustor and HPT – of the GP7200 represents a 15%-scale-down physically of the GE90-115B's hot section. This produces 72% of the core airflow of the GE90-115B. Like the GE90-115B, the first stage of the GP7200's nine-stage HPC is a 'blisk', or integrally bladed rotor, a one-piece compressor disc that greatly reduces wear and maintenance and cuts down on the number of parts the operator has to stock for engine overhaul. Using technology it developed for the GE90-115B family, GE designed the other eight HPC stages with low-aspect-ratio, 3-D-airfoil blades and vanes to improve the airflow through the HPC and effectively reduce to zero the risk of a compressor stall (neither the GP7200 nor the GE90-115B has ever had a compressor stall in service).

Although the GP7200's combustor is relatively simple compared with those of the GE90-115B and the GEnx, it features several technologies designed to reduce fuel burn and emissions of oxides of nitrogen (NOx). The lining near the front of the combustor – where initial fuel-ignition takes place – has what GE calls a 'nugget' design that features rolled rings of durable metal, which create a bumpy lining surface. However, the lining further back has multiple diffusion holes that allow a film of boundary-layer air between the lining and where combustion is happening. This reduces the amount of air necessary to cool the combustor while also reducing the overall temperature, allowing most fuel to burn in a lean manner that cuts down NOx emissions - the GP7200's NOx performance beats ICAO's forthcoming CAEP-6 standard by at least 14.5%.

Above • **Emirates Airline is the largest customer for the A380-800 having increased its commitment to 90 aircraft at the recent Berlin Air Show. It was the first airline to put the GP7200 into commercial passenger service when it received its first A380 in July 2008.** (Key Collection)

"TO DATE, THE GP7200 HAS WON 52% OF THE MARKET AMONG A380 CUSTOMERS, WHICH BY LATE MAY 2010 HAD SPECIFIED THEIR ENGINE CHOICES"

Mary Ellen Jones - President, Engine Alliance

Immediately behind the combustor, the two-stage HPT features several advanced technologies. All blades and vanes are made from Rene N5 directionally solidified superalloy, while the turbine disc (to which the blades are fitted) is made from an isothermally forged powder metal (R104, formerly ME3). All blades and vanes are treated with thermal barrier coatings very similar to those in the GE90-115B but applied in a more advanced way.

Inside each HPT blade and vane are new cooling-air-path geometries which, through rows of tiny holes in the blades' surfaces, force a boundary layer of relatively cool air (taken from the HPC) over the surfaces. The HPT blades and vanes have 3-D airfoils and GE has adjusted the gap between the HPT's first and second stages to increase airflow and optimise the balance of cooling air between the stages, improving durability and reliability. The combination of these technologies has proved so effective that the GP7200 HPT operates at a 'bulk metal temperature', which is about 70 to 80 degrees Fahrenheit lower than that in the GE90-115B, according to Paul Smith. Another HPT technology used is active clearance control (ACC). Managed by the third-generation, full-authority digital engine control (FADEC) software that runs the GP7200 and that monitors every aspect of the engine's maintenance health, ACC actively manages the gap between the tips of the HPT blades and the turbine casing in order to minimise any disruption to airflow that would reduce efficiency.

Portability, Power and Performance

The GP7200 was originally developed with the A380-800 Freighter in mind and as such has a much higher certificated thrust than is actually required for the passenger airliner. It is designed to be able to produce nearly 82,000lb (364.75kN) of thrust, and some 90% of the certification work for the engine was carried out at a maximum take-off thrust rating of 81,000lb (360.3kN), according to Bill Blair. Because most certification testing was performed at 81,000lb thrust, it would now only require a minor amount of flight-testing to certificate the GP7200 at that level, he said – the rest could be done by filing the necessary paperwork with the FAA.

According to Paul Smith, the engine has demonstrated 99.9%-plus reliability in service, the only issue (long resolved) being an 'oil hiding' problem in its first four months of service whereby Emirates Airline found some used oil was residing in the engine sumps rather than being scavenged for re-use.

Yet another feature of the engine is the ability to split the fan and casing from the core of the engine (otherwise known as the 'propulsor') so they can be shipped separately. Propulsor units can be mated with any GP7200 fan module without needing any high-power thrust-assurance checks. Together these features mean that not only can the engine be shipped on a freighter aircraft with a regular cargo door, but customers can also order most of their spare engines just as propulsor units rather than as complete engines with fan modules.

"To date, the GP7200 has won 52% of the market among A380 customers, which by late May 2010 had specified their engine choices," said Jones. So far there are two GP7200 versions – the GP7270 (rated at 70,000lb take-off thrust) and the GP7270E, rated at slightly higher maximum thrust for take-offs on very hot days. Not surprisingly, Emirates is a major customer for the latter variant.

By the end of 2009, the GP7200 had accumulated more than 100,000 flight hours and over 20,000 flights in commercial service. As more GP7200-powered A380s enter service, this will triple in 2010 to more than 300,000 flight hours and 60,000 take-offs. To date the GP7200 has caused no aborted take-offs and experienced no in-flight shutdowns, said Jones. It will be flying on 19 A380s (15 with Emirates and four with Air France) by the end of the year and in 2011 will enter service with Korean Air. It has also been ordered by Etihad Airways, Air Austral and ILFC.

The GP7000 family has only one application as yet, the A380. But even if it isn't chosen for another aircraft, according to Jones, "we are confident in the long life of the A380 programme. We see a very healthy market for this application." AW

Below • **Engine Alliance has secured more than half of all powerplant orders for the Airbus A380.** (Key Collection)

The GP7200 is designed to be able to produce nearly 82,000lb (364.75kN) of thrust. (Key Collection)