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Rivals unite — how the Engine Alliance JV flew

In 1996, they were commonly referred to as the Hatfields and McCoys of the jet engine business. The media gleefully watched from the sidelines as two aerospace superpowers — GE Aviation and Pratt and Whitney (P&W) — publicly slugged it out over multi-million dollar contracts to power the F-15 and F-16 fighters, the A330, 777 and other military and commercial aircraft. Spectators couldn't fathom a friendly conversation between the longstanding rivals, much less a successful joint venture (JV). Today the aerospace giants are proving them wrong. The Engine Alliance — a 50/50 joint venture JV between GE Aviation and P&W — has not only proven to be successful, the partnership leads the market in engine orders for the A380.

In the early 1990s GE and P&W, along with British manufacturer Rolls-Royce, invested hundreds of millions of dollars to design and produce mammoth, competing engines to power the 777. When Boeing announced plans to design and produce a modified 747 that could fly further and carry more passengers, GE and P&W each hoped to adapt their existing 777 engines — the GE90 and PW4000 respectively — for the proposed 747-500/600X aircraft. It soon became apparent, however, that a more extensive redesign — and significant additional investment — would be required.

"Both companies faced the same technical and financial challenges," Deb Case, GE spokeswoman, said. "They were interested in powering the new aircraft, but neither wanted to assume the costs and risks alone. A JV simply made good sense, technically and financially."

The companies received US and European approval to join forces on a new engine to power four-engined aircraft designed to carry 450 or more passengers. The Engine Alliance (EA) was born. The JV was officially announced at the 1996 Farnborough Air Show. Karl Krapek, former P&W president, described the new company as a "dream team of aerospace."

Six months later, Boeing cancelled the 747-500/600X programme due to insufficient market interest. Reluctant to disband the 'dream team', the Engine Alliance focused its attention on designing an engine for Airbus' proposed A3XX, which would ultimately become the A380.

After proceeding with an extensive development programme that included eight ground and flight test engines, the GP7200 received its FAR 33 engine certification in December 2005. Flight testing began in 2006 and the first GP7200-powered A380 entered service with Emirates on August 1, 2008.

How the JV works

"It takes more than a shared interest to create a successful alliance," Mary Ellen Jones, Engine Alliance president said. "Partners

whose technical skills complement one another are really in the best position to succeed," she added. "GE and Pratt & Whitney have very strong jet engine technologies that have come together beautifully to create a high-performing engine."

The GP7200 literally combines the best engine technologies of both companies. Its core is a derivative of the GE90 hot section, and its fan module and low-pressure sections incorporate technologies from P&W's PW4000 engines (see sketch A).

In addition to teaming with each other, GE brought in Snecma and MTU as partners on the GP7000 high- pressure compressor and turbine, respectively, and P&W contracted with MTU and Techspace Aero on the fan module and low-pressure turbine section, respectively (see sketch B).

The GP7200 core is manufactured at GE's Durham, North Carolina facility. That and other engine modules are shipped to P&W's engine centre in Middletown, Connecticut for final assembly and transport to Airbus headquarters in Toulouse, France.

EA personnel, who are seconded from the two member companies, are located at P&W in East Hartford, Connecticut (EA East), and at GE in Cincinnati, Ohio (EA West). Although member company campuses are used, the EA offices are located apart from the rest of P&W and GE. Team members are entirely EA-focused and constantly conscious of firewalls that allow only appropriate sharing of information. Mandatory refresher training helps ensure everyone remembers the non-disclosure terms of the EA agreement.

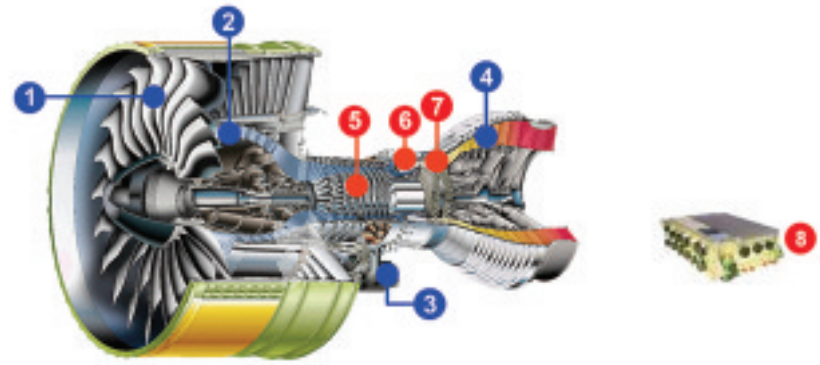
As with other JVs, the EA strives to maintain an equitable balance of representation from the member companies. The offices of the president and CFO are rotated equally between members of GE and P&W on a three-year plan. At the end of Jones' term, the role of president will be assumed by a GE executive. At that time, the CFO's position will be assumed by a P&W associate. The key functions of engineering, customer support, industrial management, quality, and sales and marketing are equally staffed at EA East and EA West.

GP7200 customers

The Engine Alliance won its first A380 engine order from Air France in 2001. Since then, Air France has increased its original order from 10 aircraft to 12 and EA has garnered orders for an additional 84 aircraft. The JV is now contracted to power 52 per cent of the186 firm A380s (with engine selections) on order.

By the end of 2010, EA expects to have 19 GP7200-powered A380s in service: Four with Air France and 15 with Emirates. Doric Asset Finance (Doric) became the first lessor with GP7200-powered A380s in its portfolio when it purchased two of the Emirates A380s in a sale-leaseback agreement. Korean Air is scheduled to receive its first A380 in 2011.

GE & Pratt & Whitney technologies in the GP7200 Turbofan



Pratt & Whitney	GE
1 - Swept hollow titanium fan	5 - 9-Stage HP Compressor
2 - 5-Stage LP compressor	6 - Low Emission Single Annular Combustor
3 - Accessory Gearbox	7 - 2-Stage HP Turbine
4 - 6-Stage LP Turbine	8 - FADEC III

In-service performance

The media is quick to criticise when the A380 experiences any technical issues, but the aircraft's reliability during its first 12 months in service was actually better than that of today's most-utilised widebody aircraft. The A380's dispatch reliability rate exceeded 98 per cent during its first year of service. Compared to the first year dispatch reliability ratings for the 747-400 (91 per cent) and the 777 (97 per cent), the A380's reliability has been remarkable.

The GP7200's performance is equally impressive. Since entering service with Emirates in 2008, the GP7200-powered A380 fleet has not experienced a single in-flight shutdown or aborted takeoff. The 12-month rolling average dispatch reliability rating for the EA-powered fleet typically exceeds 99.9 per cent.

These are numbers, Jones said, that are consistent with a mature engine. "It's the result of continuously testing these engines under extreme conditions to expose potential issues and resolve them before they can become problems for our customers," she noted. "It's also a tremendous tribute to the teamwork inherent in this GE-Pratt & Whitney partnership."

The specific fuel consumption (SFC) of the engine in service is one of its best features. Prior to service entry, the engine demonstrated it would perform better than its specification required. But analysis of the GP7200-powered A380s in service show that the engines are performing better still. Airbus notified EA in March, 2010 that it plans to revise the next GP7200 performance document to reflect a 0.5 per cent SFC improvement.

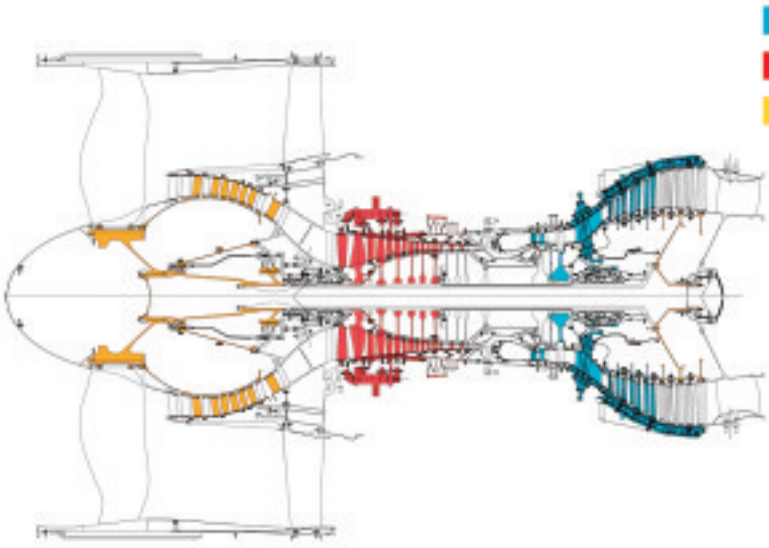
"We're very pleased with the engine's performance in service," Jones said, "but more importantly, our customers are."

"We're delighted to be one of the main GP7200 operators," Adel Al Redha, Emirates EVP engineering and operations, said. "The in-service experience of the engine has proven to be meeting the performance and reliability expectations set by the manufacturers." Doric

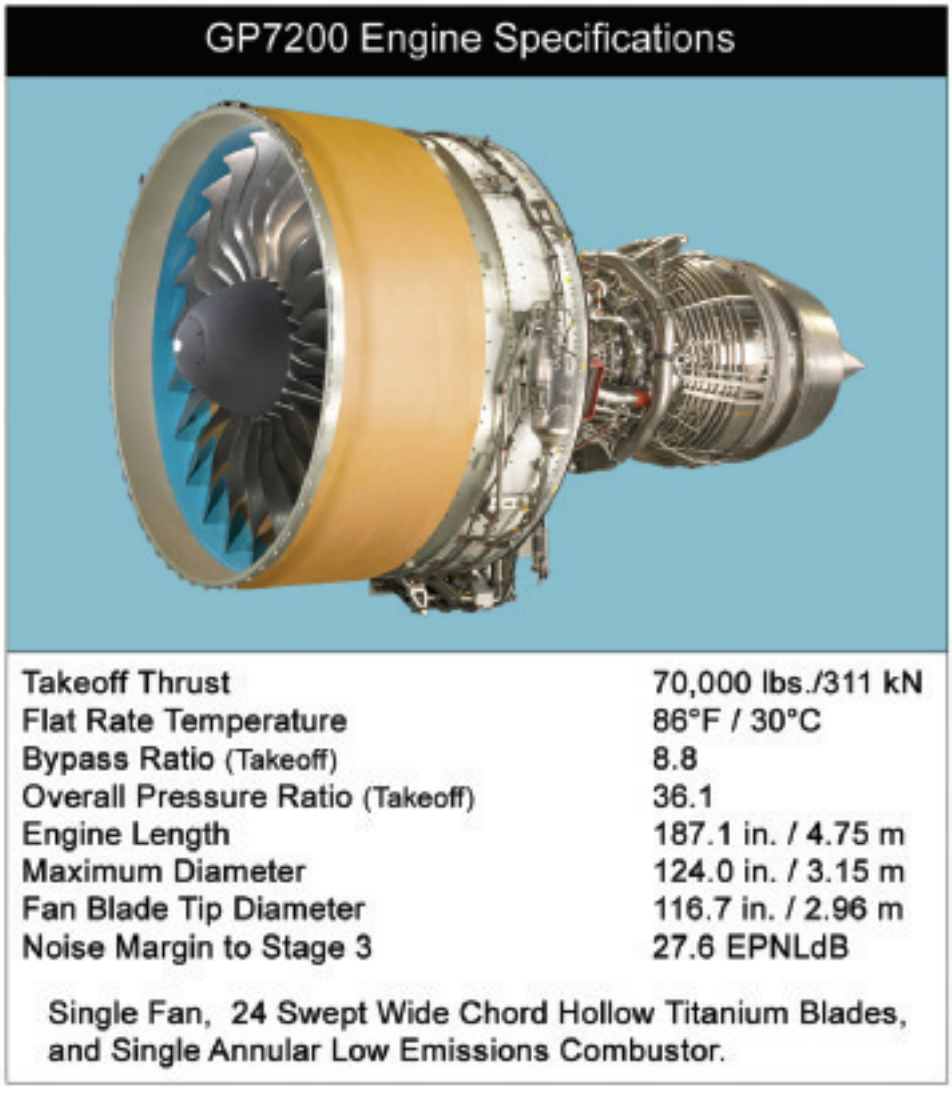
Engine Alliance customers include:

Airline firm orders:

Air France	12
Emirates	58
ILFC	4
Korean Air	10
Etihad	10
Air Austral	2



GP7200 Revenue share participants



is also pleased with the engines. "What we have seen up to now with the GP7200 points to a very promising time on-wing, even in a demanding operating environment," Maurick Groeneveld, Doric Aircraft management director, commented.

Worldwide customer support

Emirates, Air France and Korean Air, all customers with engines in service or preparing for service entry, are active participants in the EA's airline working group (AWG), a team comprised of EA engineering and customer support leaders which meets periodically to review the engine's performance and develop improvements. These and other EA customers have full access to the GE and P&W member companies' worldwide customer support networks, for comprehensive coverage around the clock. "When customers choose the GP7200 they have the option of selecting either member company as their single point of contact for aftermarket support," notes Mike Hoffmeister, EA customer service director. "This is just one additional way our JV is an advantage for them."

The EA team sought input from its customers very early in the programme, with particular attention paid to maintainability and logistics. For example, the vast majority of GP7200 line replaceable units (LRUs) are readily accessible and designed to be replaced within four hours.

Borrowing a best practice from the GE90, the GP7200's fan and propulsor were designed to be separated for shipping to enable the large engine to fit into a variety of aircraft. "We've modularised the engine so you can take it apart with minimal tooling," John Romprey, EA quality manager, said. By design, any given GP7200 propulsor will assemble with any GP7200 fan. "This also allows for shipment of just a propulsor for off-station engine changes," Romprey explained. "The customer doesn't always need or want a full spare engine, so this approach helps them to manage their inventory costs and also provides great transportation flexibility."

Technical issues

All jet engines experience at least a few technical issues upon entry into service and the GP7200 is no exception. All issues are addressed with a rigorous root cause analysis and corrective action plan, which is then reviewed with customers, to ensure they are resolved. For example:

- Three months after entry into service an engine experienced an oil hiding event. The oil pressure reading briefly dropped and returned to normal, indicating that oil was

temporarily hiding somewhere in the engine. The root cause was attributed to a low baffle clearance in the oil tank. Existing oil tanks were inspected for sufficient clearance and the assembly procedure was modified to ensure adequate baffle clearance on future builds.

- In 2009, an engine experienced rapid oil loss that was caused by a fracture in a scavenge tube fitting. The fracture was caused by high cycle fatigue in the fitting. A bracket was added to the system to reposition the scavenge tube, effectively reducing the dynamic response.

- After a year in service, several piston rings were found loose or missing during a routine engine inspection. These piston rings form a floating seal between the turbine centre frame (TCF) casing and the oil service lines that penetrate the TCF outer shell. The piston ring's loose fit was attributed to premature wearing of the case cover plate and an excessive lead in the chamfer at the assembly interface. The assembly interface was redesigned to eliminate the lead in the chamfer and the TCF cover plate material was changed from Titanium to Inconel to improve the wear characteristics of the joint.

Emissions and noise

At development, the GP7200 was required to comply with CAEP4 emissions requirements and London Heathrow QC4 noise standards. The engine's emissions are well below CAEP4 allowable levels and also meet the more stringent CAEP6 limits with margin.

In order to meet the stated QC4 noise requirements, the GP7200 was configured with a 2.8m (110 in.) diameter fan that produced a bypass ratio of 8:1. This would have easily allowed the engine to meet QC4, but customers demanded that the A380 meet the more stringent QC2 noise requirements. Subsequently, the fan diameter was expanded to 2.96m (116.7 in.) effectively increasing the bypass ratio from 8:1 to 8:8. As a result, the GP7200 meets QC2 departure noise limits and QC0.5 limits on arrival. European Aviation Safety Agency (EASA) certification test data confirmed the GP7200 is the quietest engine on the A380.

The GP7200-powered A380 may even be too quiet. Four months after Emirates received its first aircraft, It was reported that the Emirates crew was finding it difficult to sleep on the A380 due to the lack of engine noise, which they typically rely on to drown out passenger cabin sounds.

A look ahead

The Engine Alliance enjoys a fuel burn advantage today, but realises it must continually explore ways to increase fuel efficiency to maintain its competitive advantage tomorrow. Since entering service, the GP7200 has lost 150lb of weight and EA engineers are working to trim it even more.

The EA also continues to run fleet leader engines in the factory to identify potential issues and improvements. Additionally, as each EA customer prepares to enter service the AWG will grow, increasing the influx of ideas for enhancements.

"We want to ensure the GP7200 remains competitive for its current use on the A380 and for any potential aircraft derivatives as well," Jones said, "EA East and West are completely aligned when it comes to maintaining the GP7200's advantage".

"Completely aligned" is a notable achievement for two companies who weren't supposed to get along. ■