The Trent 500 – designed for the ultra long-haul

Maurick Groeneveld, **director of aircraft management at *Doric Asset Finance,* takes a look at smallest member of the Rolls-Royce Trent family.**

In June 1997, Rolls-Royce was selected by Airbus to satisfy its requirements for a higher thrust engine to power the stretched versions of the A340. The Trent 500 was developed by Rolls-Royce to be the exclusive powerplant for the A340-500 and the slightly longer A340-600. It combines elements from both the Trent 700 and the Trent 800. The fan diameter of the Trent 500 is the same as the Trent 700, whereas a reduced version of the Trent 800 core has been selected as core for the Trent 500. All the compressor and turbine airfoils in the Trent 500 use advanced 3D aerodynamics for improved efficiency. Like other RB211 and Trent engines, the Trent 500 also features a three-spool design. The first run of the Trent 500 was in May 1999 and certification was awarded in December 2000. The first flight of the Trent 500-powered A340-600 was in April 2001 and the first A340-600 was delivered to Virgin Atlantic Airways in July 2002. Although the Trent 500 is certified for 60,000lb thrust, the two thrust versions are the 53,000lb variant for the A340-500 and the 56,000 lb variant for the A340-600.

Fleet

With a fleet of about 125 Trent-powered A340s in existence, the number of installed Trent 500s is about 500 and it can be estimated that the total number of Trent 500 engines (covering both installed and spare engines) is about 600. The major Trent 500 operators are Lufthansa, Virgin Atlantic Airways, Iberia, Etihad Airways, Emirates Airline and Thai Airways. Etihad Airways and Thai Airways are the only operators which have both versions of the Trent 500 in their fleet. The entire fleet of Trent 500 engines has accumulated just over 10 million engine flight hours and about 1.2 million engine flight cycles. The lead engines of the Trent 500 have over 30,000 engine flight hours and 4,000 engine flight cycles. The aggregate number of engine flight hours of the global fleet of Trent 500 engines presently increases by two million engine flight hours per annum. The average flight duration for the Trent 500 engines is about 8.7 flight hours and most operators use their Trent 500 engines for flights of between eight and 10 flight hours. Singapore Airlines leads in using its Trent 500 engines on the longest sectors: the average flight duration is regularly close to 17 flight hours per flight!

Versions

As mentioned above, there are two thrust versions for the Trent-powered A340s that are in service. The 53,000lb rated Trent 500 (for the A340-500) is identified as Trent 553-61 or Trent 553A2-61. The 56,000lb rated Trent 500 (for the A340-600) is identified as Trent 556-61 or Trent 556A2-61.

According to Doric's understanding, the difference between the "A2" and the "non-A2" designation is linked with the embodiment of a package of modifications that enhance the performance of the "A2" engines. The Trent 553 and Trent 556 basically differ in thrust level. Both versions have the same turbine gas temperature (TGT) red line limit of 900 ˚C, which obviously implies that the Trent 500 rated at 53,000lb has a higher TGT margin than the 56,000lb rated one. About 25 per cent of the Trent 500 engines in service are rated at 53,000lb, whereas 75 per cent of the Trent 500 engines in service are rated at 56,000lb. In terms of operational experience, the Trent 500's performance retention looks satisfactory and the TGT deterioration is presently not a primary contributor to engine removals.

Technical issues

In managing Trent 500 engines, Doric has come across the following more significant issues:

- Cabin odour (oil smell): for some years now, Trent 500 engines have been generating cabin odour events. This has caused a number of engine removals. The intensity and frequency of this phenomenon varies and Rolls-Royce has been working on it with different concepts. In the mean time, the engine manufacturer has been able to find a solution for the majority of the cabin odour events. This is achieved by revised intermediate pressure compressor stage 8 (IP8) air tube assemblies with an increased tube size external diameter and complementary changes (SB RB211-72-G120), which addresses the primary source of the oil smell. The modification can be incorporated on-wing as well as in the shop. The majority of the engines are now modified and the modification looks successful. A secondary source of the oil smell is the intermediate gear box (IGB), which can leak across the hydraulic seal housing joint and the IGB/intercase joint, and Rolls-Royce is developing a solution to address this as well.
- High pressure turbine nozzle guide vane (HPT NGV) convex airfoil cracking: during regular inspections, cracking on the convex surface of the airfoil has been reported. This is caused by higher than predicted temperatures following local thinning of the airfoil thermal barrier coating in this area. Initially, extended limits have been provided by Rolls-Royce in combination with comprehensive borescope instructions (NMSB RB211-72-G240). In the mean time, Rolls-Royce has also developed a revised HPT NGV with improved leading edge convex surface cooling, which should address the cracking issue. The revised HPT NGVs are installed during shop visits and hospital visits (SB RB211-72-G232).
- Intermediate pressure turbine nozzle guide vane (IPT NGV) thermal distress: due to potential fuel spray nozzle blocking during operation, there is a chance that — when significant fuel spray nozzle blocking occurs — this may result in asymmetric thermal distress of turbine hardware. Accordingly, Rolls-Royce introduced in-shop manifold cleaning and flow check fuel of spray nozzles during each shop visit (Alert SB RB211-73-AG327). In the mean time, Rolls-Royce strongly recommends replacing (on-wing) the right hand fuel manifold (Alert SB RB211-73AG422) and an EASA AD is likely to be associated therewith. A modification to the design of the right hand fuel manifold assembly has reportedly been launched and could ultimately alleviate the requirement for that alert SB (and related EASA AD).
- Fuel pump bearing wear: wear is experienced on the faces of the bearing in the fuel pump (Mk3 version), which is leading to thermal distress and release of material into the hydro mechanical unit (HMU). This can ultimately lead to fuel pump and HMU removals. It is recommended that a revised fuel pump (Mk4 version) be incorporated during engine shop visits and — as a complementary modification — an upgraded Mk4 HMU also be incorporated (replacing the MK3 HMU) at the same moment.
- Spinner and spinner fairing polyurethane (PU) delamination: a new nose cone assembly and nose cone fairing assembly is now available (SB RB211-72-G102).
- Fuel Oil Heat Exchanger (FOHE): due to the

Trent 500 Characteristics

LPC	**1 fan stage**
IPC	**8 stages**
HPC	**6 stages**
Combustor	**annular combustor chamber**
HPT	**1 stage**
IPT	**1 stage**
LPT	**5 stages**
Fan Diameter (inches)	**97.4**
Length (inches)	**155**
Dry weight (lb)	**10,660**

Like the RB211, the Trent 500 features a three-spool design.

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The Trent 500 received its certification in December 2000.

possibility of fuel restriction at the FOHE cooler matrix (like what occurred with the similar design Trent 800 FOHE), a revised FOHE needs to be installed (Alert SB RB211-79-AG346). This Alert SB must be accomplished on all Trent 500 engines within 6,000 engine flight hours after 10 July 2009 (EASA)/03 May 2010 (FAA) or by 01 January 2011, whichever is the sooner. This Alert SB is covered by EASA AD 2009-0257 and FAA AD 2010-07-01.

Shop visits

It can be estimated that the Trent 500 engines would be able to remain on-wing for around 3,000 engine cycles (for first run engines) and for around 2,500 engine cycles (for second and subsequent run engines). In reality, however, particularly for the first run engines, the above on-wing periods are not being achieved as the Trent 500 engines require a replacement of the HPT disk, which presently has a certified life of 2,600 engines (see below). Shop visit cost of Trent 500 engines should not be underestimated as — according to Doric — the price of a refurbishment shop visit is very expensive compared with engines of a similar thrust level. Fortunately, the long average flight duration of the Trent 500 is able to somewhat lower the high shop visit cost impact when expressed in an hourly rate. This also makes the cost per event somewhat less visible, particularly since many Trent 500 engines are covered by flight-hour agreements.

Life limited parts management

As with other Rolls-Royce engines, Rolls-Royce is splitting the life limited parts into Group A and Group B parts. The Group A parts cover the typical life limited parts in an engine (disks, shafts etc.), whereas the Group B parts cover the fan blades and the annulus fillers (note that the annulus fillers presently have no life limit). Although most of life limited parts in the Trent 500 engines have a certified life of 10,000 flight cycles, there are some Group A parts which presently have a significantly shorter certified life. These Group A parts are the HPC stage 1-4 drum (with 5,000 cycles), the HPT front cover plate (with 4,000 cycles), the IPT disk (with 5,000 cycles), the LPT disk stage 3 (with 7,990 cycles) and the HPT disk (with 2,600 cycles). The HPT disk's certified life is causing the engine to go into the shop significantly before it would have, had this HPT disk's certified life been higher (see above). Rolls Royce is working on extending the certified life of the HPT disk (from 2,600 cycles to 3,000 cycles) and it is likely that during the second half of 2010 Rolls-Royce will make more details about this life extension available.

Support

There are three engine shops, which are certified for Trent 500 maintenance and repair. These shops are Hong Kong Aero Engine Services Limited (HAESL) in Hong Kong (HAESL is a joint venture between Hong Kong Aircraft Engineering Company Limited (HAECO), SIA Engineering Company (SIAEC) and Rolls Royce), Singapore Aero Engine Services Private Limited (SAESL) in Singapore (SAESL is a joint venture between SIAEC, HAESL and Rolls Royce) and N3 Engine Overhaul Services GmbH & Co. KG (N3 EOS) in Arnstadt (Germany). N3 EOS is a joint venture between Lufthansa Technik and Rolls-Royce. With Rolls-Royce having a stake in each of the engine shops, it effectively controls the maintenance market of the Trent 500. Based on today's fleet size of Trent 500 engines and the lack of any new orders for Trent 500 powered A340s, it can be expected that the number of Trent 500 engine shops will not increase. According to Doric's assessment, most of the Trent 500 engines are under long term dollar per flight hour maintenance support agreements ("Total Care Agreements") with Rolls-Royce, which is using its network of engine shops to do the maintenance and repair of the engines.

Conclusion

The Trent 500 is a modern and reliable engine. Like any other engine, it does have some issues, but Rolls-Royce either has a solution in place or is working on it. For example, for the cabin odour issue Rolls-Royce has a solution in place and the majority of the engines have been modified. The short life of some of the life limited parts, particularly the HPT disk, has caused a somewhat shorter time on-wing than would have been possible based on the Trent 500's performance. Through its network of engine shops, Rolls-Royce has been able to control the maintenance market for the Trent 500 and unsurprisingly many Trent 500s are under long-term maintenance support agreements. ■

Doric Asset Finance, with offices in Frankurt, London and New York, provides proactive, hands-on asset management and remarketing services to owners, investors, financiers and operators of aircraft and engines. Aircraft and engines under long term asset management include aircraft the Airbus A320-family, the A330/A340 family, the A380 and the 777, and CFM56-5, the Trent 500, the GE90-115 and the GP7200 engines. The company also performs asset management activities via project assignments with a more limited scope, such as aircraft inspections and technical records audits.