HIGH-POWERED TRENT XWB-97

Big sister

World-leading technology is being harnessed by the team working at the forefront of science and engineering to produce the new high-thrust Trent XWB-97 aero engine.

Since the beginning of this year, the Trent XWB-84 – the world's most efficient large aero engine – has been providing exemplary service on the new Airbus A350 XWB airliner. However, the forthcoming larger version of the aircraft – the A350 XWB-1000 – will employ a different version of the Trent family.

The -97, as its designation suggests, is a 97,000lb thrust Trent and is the more powerful sister engine of the -84. It is undergoing a rigorous test regime right now as it prepares for first flight later this year on an Airbus A380 flying test bed (FTB) and subsequent entry into service on the A350-1000 in 2017.

One man who has been intimately involved in the development of both the Trent XWB-84 and -97 is Simon Burr, most recently Director of Trent XWB Programmes and now COO for Civil Large Engines in Rolls-Royce.

Simon took over his role on the Trent XWB in 2014 and the priorities then were to get the -84 certified with a full 420 minutes Extended-range Twin-engine Operational Performance Standards (ETOPS) rating and to deliver it on time for A350 XWB service entry. Both of these were achieved and launch customer Qatar Airways received their first A350 XWB before the end of 2014.

Now the challenge is on for Simon to drive the -97 development to its successful conclusion.

And if you are thinking that this is just an upgraded version of the -84 and so does not require the same amount of development work, testing and proving, then think again. The -97 does of course have many attributes that are similar to its sister Trent, but it is also very different in some of the advanced technologies it employs to produce the extra thrust and optimum aircraft performance.

Cooling

According to Simon: "The Trent XWB-97 will be the highest thrust engine we have ever certified, the highest operating temperatures and the most advanced cooling systems we have ever designed in a civil engine. We are working at the leading edge of technology but that is what you do to produce the world's most efficient engines."

For the engine operators' point of view there is deliberately very little visible difference, or indeed operating difference, between the -84 and -97. They are designed so that the pilot flying experience is the same.

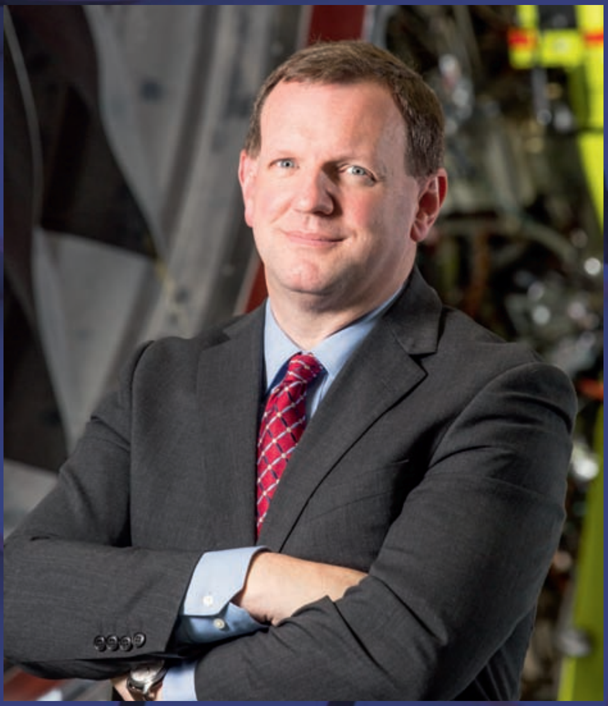
All the mechanical systems are the same for both engines, so from a basic maintenance point of view, the airlines will find that 80 per cent of the replacement line items and tools are identical. Physically the engines look the same; in fact you may need to look at the nameplate to tell the difference from the outside.

However, look inside the -97 engine and the changes are notable. The front fan has the same number of blades and is the same diameter at 118 inches but it runs around six per cent faster. The engine core has been scaled up in size to cope with the consequential increased airflow into the compressor and, in this engine, the combustor and turbines run hotter than in the -84.

Another difference in the -97 is the wider use of blisks (bladed disks) across both the high-pressure and intermediate compressors. Blisks improve aerodynamic efficiency, whilst having a reduced weight over conventional assemblies. The first stage intermediate compressor blisk of the Trent XWB-97 is the largest that Rolls-Royce has produced to date on a civil application.

The innovations don't stop at the compressor though, the high-pressure turbine gets additional technology too. "To get the performance and efficiency from this machine we need to grow the turbine temperature capability to a level higher than we have with any large aero engine in the past," says Simon. "Maintaining thermal efficiency at those higher temperatures is critical, so we've invested in new materials and coatings for the high-pressure turbine blades, but also employed an intelligent cooling system that provides the right amount of cooling air to the blade throughout the flight cycle. Modulating the cooling air means we can always operate at maximum efficiency, whilst protecting the turbine blade and maximising its on-wing life. We have undertaken very, very aggressive endurance testing on the turbine to make sure this happens.

"You are always balancing durability against efficiency in designing aero engines but we have over 80 million hours of Trent experience behind us. This is a robust engine built on



"We are working at the leading edge of technology but that is what you do to produce the world's most efficient engines."

Simon Burr, COO for Civil Large Engines

process for design, manufacturing and testing. That holistic thinking has got us to where we are today and that makes us really confident in this engine.

"You also need to bear in mind the job it is being asked to do. The -97 will power a long-haul aircraft with a range of over 8,000 nautical miles. So it will spend a lot of time at cruise and do fewer take-off and landing cycles than shorter range aircraft," he adds.

The -97 development programme has also featured components produced by additive layer manufacturing (ALM, or sometimes commonly known as 3D printing). Rolls-Royce claimed a world record for the largest aero-engine component assembly ever manufactured in this way with a 1.5m diameter front bearing housing for the -97. The ring of ALM vanes form the inlet to the engine's core and each vane has an intricate series of heating passages inside them that can be used by an anti-icing system to protect the engine during adverse weather conditions.

Freedom

"We did it as a demonstration of our capability," says Simon. "There are two real benefits to ALM," he says. "The lead time in engine development is dramatically reduced and the design freedom it offers as opposed to conventional casting or machining, both could be significant. Pure design freedom with ALM means that you can now design complex components that could only be made by this manufacturing technique. So for example, we could have complex internal paths and passages now that would have been impossible to make with traditional manufacturing methods.

"However, there are real considerations to be overcome. Once you have productionised a component via this method then you are committed, as it can only be made in

> ***"The -97 will power a long-haul aircraft with a range of over 8,000 nautical miles."***

According to Airbus

- **Measuring nearly 74 metres from nose to tail, the A350-1000 – scheduled to enter service in 2017 – is the longest fuselage version of Airbus' all-new family of widebody jetliners, which is designed for high efficiency, maximum reliability and optimised performance.**
- **In a typical two-class configuration, the A350-1000 seats a total of 369 passengers with a range of 8,000 nautical miles.**

Increased efficiency

- **Trent XWB-97 engines will provide additional payload capability and range, along with 97,000lbs of thrust on take-off – making it the most powerful engine ever developed for an Airbus aircraft. With these specially-tailored Trent XWB powerplants, the A350-1000 will be capable of supporting the development of long-haul routes for emerging markets such as Shanghai-Boston or Paris-Santiago.**

Above A Trent XWB-97 arrives in Canada for cold weather testing.

Bottom left Assembly of a Trent XWB-97.

Left It's tough work in freezing temperatures for the test engineers.

this way. You also need to have enough machines that are fast enough for the production process. Lastly, you need a stable and adequate source of atomised metallic powder that you can trust. I think there is more work to be done on ALM but it is an enticing technology."

So, although the ALM-produced front bearing housing will be in the development -97 engines, it won't be in the initial production engines.

Endurance

As of today, there are four engines running in the development programme for the -97. The first development engine conducted proving runs up until September of 2014. It provided a lot of useful data to the development team and that engine will now go on and do major tests such as 'bird strike'.

A second engine is in Canada completing its cold weather and icing running. A third engine has been performing endurance work and has also been x-rayed on a test bed in Derby, UK. Dynamic x-rays show the behaviour of the components inside the engine as it operates, which can help prove the design theories by effectively giving the engineers 'eyes-on' the inside as the engine runs. The fourth engine in the development programme will be used for performance work.

All of this is in the build up to the fifth engine being employed on the Airbus A380 FTB.

"We are doing no simulated altitude testing on this engine programme, all altitude work will be done by the FTB. You can argue that this has advantages. Airbus get to see the extended testing as it's on their aircraft and it de-risks the subsequent flight testing on the A350-1000 airframe.

"On the -84 there were five flight test aircraft but on the -97 programme there are three. Airbus will still have a lot of tests to do on the A350-1000 though. They will conduct around 75 per cent of the tests on this airframe that they did on the previous A350 version, but by that time we will have flown the engine so much on the A380 FTB that we should have completely de-risked the propulsion system."

Airbus is due to fly the first A350-1000 for the first time in 2016. Rolls-Royce is currently building the first flight engines for that event.

"Our focus at the moment is to get all the regulatory ground testing done on the engine that we need to in order to begin flight testing on the A380 FTB later this year," says Simon.

Author: David Howie is Director of Brand for Rolls-Royce. He joined the company from a marketing consultancy and prior to that was a press officer.