The RB211-535E4

The RB211-535E4 engine was introduced on the Boeing 757 in 1984 and has since proved to be one of the world's most reliable large turbofan engines.

Launch of the RB211-535E4 marked the entry into service of the wide-chord fan blade, which has become the standard design of all medium and large commercial aero engines produced by Rolls-Royce and its collaborative ventures. The engine has become the airlines' first choice for the 757 fleets with 79 of 109 operators operating the -535E4 compared to 30 using the PW2037/PW2040 models. Those 79 757 535E4 operators fly 572 aircraft compared to 430 PW-powered aircraft, and of the 572 aircraft operated, an estimated 187 are under operating lease contracts.

The RB211-535E4 was certificated in July 1997 as the sole western powerplant on the Tupolev Tu-204. The engine has also been selected by Boeing as their proposal for the B52 re-engining programme. However, these programmes have not significantly impacted the market for the -535E4. The -535E4 has low operating costs, one of the longest on-wing lives and excellent reliability.

Since beginning production of the engine, two additional models have been added: the RB211-535E4-B and RB211-535E4-C but the most popular is the first model. The engine was designed in accordance with the traditional three-spool Rolls Royce design – low pressure compressor (including fan) driven by the low pressure turbine (LPT), a compressor and turbine intermediate (IP) and the high pressure rotor (HP).

The -E4 variant is one of the quietest engines in its class, enabling operations from airports where noise regulations could exclude other engines. Improvements over the original 1984 specification engine include the introduction of a scaled Trent combustor in 1999, giving still lower emissions and compliance with all planned environmental legislation.

Wide-chord fan blades provide greater strength and resistance to foreign object damage – such as collision with birds – and have set industry standards for reliability. Well over 18 million hours of operation have now been accumulated by the RB211-534E fleet.

Over the years, the -535E4 has been considerably developed. It has a remarkable performance record, and is in operation with airlines all over the world. The longevity of the -535E4 version is well known, with one engine on an America West Airlines' Boeing 757 accruing 2,047 days on-wing, flying over 12 million miles (the equivalent of 25 return trips to the moon) over 24,100 hours of operation and 8,742 cycles. The RB211-535 model was also the first Rolls-Royce engine authorised by the airworthiness authorities to operate under the ETOPS (extended twin-engine operations).

With the RB211-535, Rolls-Royce achieved its ambition of developing an engine with long on-wing life and low maintenance costs. America West and Icelandair have experienced 24,000 hour engines and Monarch Airlines had a 29,000 hour first-run engine.

Rolls-Royce has managed to jump from being a medium player in the market with the -524 variant and success of the -535 variant to being a major player in the wide-body market with the Trent family. The foundation for this jump was the -535E4's technical and commercial platform.

There is still scope to improve the -535E4 further and there was some discussion to upgrade it with the Trent 500 core, which could give a projected 8% decrease in SFC. The economic life-cycle of the 757 fleet could be extended if the upgrade of the engine SFC could be made, increasing it another 10 years.

Rolls-Royce RB211-535 Engine variants

Engine model	Number of engines currently operated	Number of flying aircraft
RB211-535E4	688	344
RB211-535E4-B	432	216
RB211-535E4-C	24	12

RB211-535E4 typical engine details

Bypass Ratio	4.3
Pressure Ratio	25.8
Fan Diameter	74.1 inches
Cruise Fuel Consumption	0.598 lb/hr/lb
Length	117.9 inches
Service entry	1984
Thrust Ratings	40,100 to 43,100 lbs

Over the last 24 months, there have been two airworthiness directives (AD) issued covering changes to the Group A critical part life limits applied at next shop visit and eddycurrent inspection of high pressure turbine disc for cracking. The Trent engine has had 12 ADs issued in the last 24 months. Other ADs from the last four years, which operators and lessors need to be cognisant of, are the radial drive bearing inspection, low pressure fuel filter and high pressure pump integrity improvement and introduction of increased low idle fuel flow governor. IASG believes that there is no evidence that the AD load represents an excessive workload or impediment to investments.

Availability of the -535E4 in the tertiary market is limited, with only six engines available for sale or lease with ACI, ELFC, Finova, RPK Capital and ACG. IASG is sure that Rolls-Royce Capital would also have engines available. The -535E4 has a developed market with predominantly lessors. The continuing low levels of used engine availability is driving values upwards. IASG is aware of one engine purchased and broken for spares. Typical values for half-life bare engines have been between $3m and $3.5m, with lease rates around $60,000 a month.

Maintenance costs are in the region of $90 to $120 per hour dependent on hours to cycle ratio and aircraft operating weight and thrust de-rated policy. Shop visit costs are estimated in the $1.4m to $1.8m bracket.

IASG believes that the RB211-535E4 is a reliable engine, with a sound investment potential, despite the limited spares availability and restricted choice of overhaul providers.

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