Welcome to the 17th edition of the Engine Values Book, which IBA has updated with current views on engine values, lease rates, maintenance costs, and maintenance information along with market data supported by IBA’s aviation intelligence platform iQ.

During 2018 the market has remained somewhat consistent to expectations with new entrants developing more significant roles in the market whilst mature examples have seen somewhat of a jump in demand due to various EIS issues.

The CFM International LEAP-1A and LEAP-1B on the A320neo and 737 MAX respectively have proven reliable engines despite some limited teething issues. The PW1100G on the A320neo has suffered continued problems, however, Pratt & Whitney has worked tirelessly to rectify this and 2019 looks likely to see AOG events reduce significantly. Operator feedback on both engines has been excellent outside of EIS issues, however, the PW1100G appears to offer a better margin on fuel burn if reports so far are to be trusted. Orders continue to remain strong for both with 5,781 A320neo aircraft and 4,626 737 MAX aircraft according to IBA.iQ.

A significant development in the market has been the takeover of Bombardier’s C-Series platform by Airbus which few could have foreseen. Rebranded as the A220, the aircraft is powered exclusively by Pratt & Whitney’s PW1500G, a derivative of the PW1000 family. The platform has made good progress in developing its narrowbody market share with current orders sitting at 473 aircraft. With some regional operators taking on the aircraft, along with narrowbody operators, there is strong potential for growth in the market which IBA is closely observing. So far issues remain limited thanks to a small operator base focussed away from the harsher operating environments, however, some limited overlap is expected though Pratt & Whitney are proactively putting fixes in place that have been developed on the PW1100G.

Moving to the widebody market, continued domination by the Airbus A330ceo and Boeing 777 families was expected though both have witnessed diminishing orders with the A330neo entering service with TAP and the 777X expected to enter service in 2020. These markets will bring with them the Trent 7000 and GE9X as their respective and exclusive powerplant options. The 787 proves increasingly popular amongst operators, however, the Trent 1000 issues have led to a significant market and order book shift in favour of the GEnx-1B which looks set to take two thirds of the market. As with Pratt & Whitney, Rolls-Royce has thrown everything into resolving these problems and 2019 looks set to be a year of recovery for the fleet with continuing reduction in AOG events. The A350 has had a remarkably smooth entry into service and continues to achieve strong orderbook demand for an aircraft of its size. The Trent XWB has likewise proven to be a reliable powerplant for Rolls-Royce.

This year has also been marked by the announcement from Airbus that they will be ceasing production of the A380 family. The aircraft has been a love it or hate it discussion point amongst enthusiasts since it entered service, however, it remains and engineering feat and a favourite among a small number of operators. As such, the GP7000 and Trent 900, which historically have seen very limited trading, are expected to see a value softening in the coming years.

The CFM56-5B, CFM56-7B and V2500-A5 markets continue to experience higher trading volumes and achieve strong premiums as we continue to experience the overlapping shop visit demand of first, second and even third run engines pushing MRO capacity to its limits. Rising fuel and interest rates look set to change the market outlook though this is still to be seen.
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<th>Section 7: Rolls-Royce</th>
<th>Section 8: Pratt &amp; Whitney Canada</th>
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<tbody>
<tr>
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<td>AE3007</td>
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<td>RB211-524</td>
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</tr>
<tr>
<td>RB211-535</td>
<td></td>
<td></td>
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<tr>
<td>Tay</td>
<td></td>
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<tr>
<td>Trent 500</td>
<td></td>
<td></td>
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<tr>
<td>Trent 700</td>
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<td></td>
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<tr>
<td>Trent 800</td>
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<td></td>
</tr>
<tr>
<td>Trent 900</td>
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<td></td>
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<td>Trent 1000</td>
<td></td>
<td></td>
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<tr>
<td>Trent XWB</td>
<td></td>
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</tr>
<tr>
<td>BR715 (Rolls-Royce Deutschland)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airworthiness Directives</td>
<td></td>
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</tr>
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</table>

The list includes various models of engines such as PW100G, AE3007, RB211-524, RB211-535, Tay, Trent 500, Trent 700, Trent 800, Trent 900, Trent 1000, Trent XWB, and BR715. Each model is referenced with a corresponding section number for detailed airworthiness directives.
Engine Valuation Methodology

Whilst the techniques used and the judgements made do not isolate every single influence and reduce it to a numerical value that impacts on the overall model, it is our view that the complexity of a purely mathematical approach would produce values that were overly sensitive to minor changes in the parameters feeding it. Consequently, IBA feels that, when making an assessment of engine value, there is still no substitute, for the blend of market research and intelligence, mathematics, and judgement based on the experience of the appraiser in this highly dynamic market.

The Engine Values Book has therefore been constructed around the following criteria:

**Scope:** Engine variants associated with current production “modern technology western-built passenger and cargo aircraft” with an entry into service date of post-1980 and with a minimum population of 200 engines and/or 100 delivered aircraft.

**Method:** Determination of values includes account of replacement price, age, market condition, depreciation based on resale history and useful economic life. Engines are considered within the market segment to which they belong and compared with the competitor engines in the segment.

Engine values, rental rates and maintenance indicators are based on IBA’s own engine databases which have been built on information for various engine types routinely gathered and stored as part of IBA’s daily business.

**Assumptions:**
(a) current / balanced market condition with balance achieved at levels perceived appropriate for today’s market

(b) “standard / mid-time maintenance condition” (c) good / average physical condition (d) typical utilisation (e) standard / average specification unless otherwise indicated.
Value Definitions

Market Value is IBA’s opinion of the most likely trading price that may be generated for an engine under the market circumstances that are perceived to exist at the time in question. Market Value assumes that the engine is valued for its “highest, best use”, that the parties to the hypothetical sale transaction are willing, able, prudent and knowledgeable, under no unusual pressure for a prompt sale, and that the transaction would be negotiated in an open and unrestricted market on an arm’s-length basis, for cash or equivalent consideration, and given an adequate amount of time for effective exposure to prospective buyers.

Base Value is IBA’s opinion of the underlying economic value of an engine in an open, unrestricted, stable market environment with a reasonable balance of supply and demand, and assumes full consideration of its “highest, best use”. An engine’s Base Value is founded in the historical trend of values and in the projection of value trends and presumes an arm’s-length, cash transaction between willing, able and knowledgeable parties, acting prudently, with an absence of duress and with a reasonable period of time available for marketing.

In most cases, the Base Value of an engine assumes its physical condition is average for an engine of its type and age, and its maintenance time status is at mid-life, mid-time (or benefiting from an above-average maintenance status if it is new or nearly new, as the case may be).

Quick Engine Change (QEC) kit is defined as a collection of components and accessories installed into a bare engine to reduce the time required for installation of the entire powerplant onto an aircraft.

QEC kits can be categorised into three types: basic, neutral & full. A basic QEC includes all prime parts and accessories required for an engine test. A neutral QEC can be considered to comprise the basic kit plus sufficient specialist parts and accessories that will allow installation on an airframe but excludes any items relating to a specific aircraft or application. A full QEC comprises the neutral kit plus those items required for varying aircraft applications. In the case of basic and neutral, neither the thrust reverser nor the nose cowl is included. Each engine type should be considered unique in its QEC configuration and installation.

Values are shown as a range to bracket IBA’s view of neutral and full QEC kits and to reflect the different make-up of each kit as the components and accessories vary depending on the type of aircraft the engine will eventually power.

Typical Current Rental Rate (TCRR) is IBA’s opinion of the monthly lease rental as it relates to an arm’s length transaction between a willing lessor and a willing lessee for a single engine transaction. Values are shown as a range to bracket IBA’s view of short-term (18 months) to long-term (5 years) duration of rental.
Maintenance Definitions

Life Limited Part (LLP) Cost refers to IBA’s opinion of the basic cost of all of the engine’s life-limited parts (LLPs), assuming all-new parts.

Mean Time Between Overhauls (MTBO) represents IBA’s opinion of the average time, in flight hours, between major engine shop visits. This does not include unscheduled removals for reasons such as foreign object damage but it does include removals due to exhaust gas temperature (EGT) deterioration or LLP life expiry.

Basic Overhaul Cost is IBA’s estimated figure for an average workshop visit carried out under a “time & materials” basis. This includes labour for teardown, inspection, repair costs, material replacement and a degree of LLP replacement.

In most cases, the Base Value of an engine assumes its physical condition is average for an engine of its type and age, and its maintenance time status is at mid-life, mid-time (or benefiting from an above-average maintenance status if it is new or nearly new, as the case may be).

Airworthiness Directive (AD)

Airworthiness Directives (ADs) have been included at the end of each section of the Engine Values Book. Recurring ADs are noted with a bullet and key ADs are further noted by the use of bold, red lettering. Key ADs, as defined by IBA, fall into one or more of the following categories:

- ADs resulting from an uncontained failure.
- ADs that reduce the life of components, LLPs and primary components.
- ADs requiring a correction of operational problems.
- ADs requiring piece part inspection programs of LLPs and usually resulting in a restricted operational life and/or driving components out of the engine at shop level.

These key ADs are usually associated with high costs in terms of operational disruption, higher material investment, or higher shop visit rates with possible increases in cost of each shop visit.
Disclaimer

IBA Group Limited (IBA) has prepared the enclosed Engine Values Book. The Engine Values Book is subject to the disclaimer below.

IBA has no present interest in the engines being appraised for the purpose of the Engine Values Book. At the date of the Engine Values Book, IBA does not anticipate acquiring any subsequent interest in the engines. Unless otherwise stated, IBA has had no prior interest in the engines. IBA’s appraisal of the engine is honestly held and the Engine Values Book shall be deemed advisory only, with such advice being solely to the extent noted in the Engine Values Book. To the fullest extent permitted by law, IBA assumes no responsibility or legal liability for any action taken, or not taken, whether directly or indirectly by the Client or by any third party, with regard to the engines and the Client agrees that IBA shall bear no such responsibility or legal liability in respect of the same.

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To the fullest extent permitted by law, in relation to the Engine Values Book, IBA shall bear no responsibility for any interpretation applied, inference made or conclusion reached by the Client or any third party.
Rolls-Royce RB211-535

The Rolls-Royce RB211-535C/E4 is a derivative of the RB211-22. The first RB211, a three shaft design, was certified in 1972 and was first used on Lockheed L-1011 aircraft. The RB211-535C was announced in February 1977 and it first ran in 1979. It was the launch engine for the Boeing 757 in 1982 and entered service in January 1983.

The RB211-535E4 was announced in 1980 with major changes from the -535C, having a wide-chord fan blade, increased reverse thrust and increased core efficiency through hot and cold stream mixing whilst, retaining the common nozzle assembly. The -535E4 first ran in March 1982 and achieved certification in December 1983. The -535E4 gained 120 minutes ETOPS rating in December 1986, after 250,000 hours of operation, which was later extended to 180 minutes ETOPS in 1990. In late 2012, all North American operators of the RB211-535 were required to replace cowlings on all of the engine fleet due to extensive cracking in the air intake cowls and the related structures due to metal fatigue. Typical specific fuel consumption is 0.663 lb/h/lb in the cruise phase for the -535C and 0.617 lb/hr/lb in the cruise phase for the -535E4.

At the end of its production life a total of 1,250 RB211-535 engines were delivered; of these, 824 active engines remain, which is just over 66% of the fleet, since last year this is a drop of around 1.67% compared to last year. Top operators including American Airlines, Federal Express, United Airlines and UPS. They continue to operate the engine due to the platforms niche market with no direct replacement (though the A321neo comes close). Poor condition examples will continue to be retired and parted out to feed the remaining fleet. Values of the RB211-535 have remained steady over the last year and this is expected to continue as the fleet matures over the coming years. It should still be stressed that good examples are few and far between, and as such, the best examples still command a premium.
# Rolls-Royce RB211-535

<table>
<thead>
<tr>
<th>Variant</th>
<th>Thrust</th>
<th>Flat Rating</th>
<th>SFC*</th>
<th>Aircraft Type(s)</th>
<th>Engines in Service</th>
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<tbody>
<tr>
<td>RB211-535C</td>
<td>37,400 lbf</td>
<td>29.0°C</td>
<td>0.663 lb/h/lb</td>
<td>757-200, -200C/-200PF</td>
<td>26 engines ▼10</td>
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<tr>
<td>RB211-535E4</td>
<td>40,100 lbf</td>
<td>29.0°C</td>
<td>0.617 lb/h/lb</td>
<td>757-200, -200C/-200PF</td>
<td>598 engines ▼2</td>
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<tr>
<td>RB211-535E4B</td>
<td>43,100 lbf</td>
<td>29.0°C</td>
<td>-</td>
<td>757-200, -200C/-200PF/-300</td>
<td>360 engines ▼6</td>
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<tr>
<td>RB211-535E4C</td>
<td>43,100 lbf</td>
<td>29.0°C</td>
<td>-</td>
<td>757-300</td>
<td>24 engines ■</td>
</tr>
</tbody>
</table>

*Specific Fuel Consumption (SFC) at cruise conditions.

### Airframe/Engine Combination

<table>
<thead>
<tr>
<th>Aircraft Manufacturer</th>
<th>Aircraft</th>
<th>Engine</th>
<th>Worldwide Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boeing</td>
<td>757-200</td>
<td>RB211-535C</td>
<td>1 aircraft ■</td>
</tr>
<tr>
<td></td>
<td>757-200C/-200PF</td>
<td>RB211-535E4</td>
<td>111 aircraft ▼1</td>
</tr>
<tr>
<td></td>
<td>757-200C/-200PF</td>
<td>RB211-535E4B</td>
<td>129 aircraft ▼19</td>
</tr>
<tr>
<td></td>
<td>757-300</td>
<td>RB211-535E4B</td>
<td>27 aircraft ▼2</td>
</tr>
<tr>
<td></td>
<td>757-300</td>
<td>RB211-535E4C</td>
<td>12 aircraft ■</td>
</tr>
<tr>
<td>Tupolev</td>
<td>Tu-204</td>
<td>RB211-535E4</td>
<td>4 aircraft ■</td>
</tr>
</tbody>
</table>

△Actual difference from last year (No. of Engines/Aircraft) ■ No change from last year
### Rolls-Royce RB211-535

#### Worldwide Distribution of Installed Engine Population

<table>
<thead>
<tr>
<th>Region</th>
<th>Engines</th>
<th>Percentage</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>16</td>
<td>1.59%</td>
<td>▲4</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>144</td>
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</tr>
<tr>
<td>Europe &amp; CIS</td>
<td>280</td>
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<td>Latin America</td>
<td>4</td>
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</tr>
<tr>
<td>Middle East</td>
<td>4</td>
<td>0.40%</td>
<td>▼2</td>
</tr>
<tr>
<td>North America</td>
<td>560</td>
<td>55.56%</td>
<td>▼30</td>
</tr>
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#### Worldwide Distribution of Operators

<table>
<thead>
<tr>
<th>Region</th>
<th>Operators</th>
<th>Percentage</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>3</td>
<td>3.66%</td>
<td>■</td>
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<tr>
<td>Asia Pacific</td>
<td>14</td>
<td>17.07%</td>
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</tr>
<tr>
<td>Europe &amp; CIS</td>
<td>27</td>
<td>32.93%</td>
<td>■</td>
</tr>
<tr>
<td>Latin America</td>
<td>2</td>
<td>2.44%</td>
<td>▼1</td>
</tr>
<tr>
<td>Middle East</td>
<td>2</td>
<td>2.44%</td>
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<tr>
<td>North America</td>
<td>34</td>
<td>41.46%</td>
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#### Current Market Value, Base Value, Typical Current Rental Rate (TCCR) & QEC

**RB211-535E4**

- **Market Value**
  - Bare Engine: $2,852,000
- **Base Value**
  - Bare Engine: $2,852,000
- **Typical Current Rental Rate**
  - Low: $35,000 per month
  - High: $55,000 per month
- **QEC**
  - $225,000 to $900,000

### Engine Maintenance Indicators

**RB211-535**

- **Life Limited Part (LLP) Cost**
  - $5,800,000
- **Average Cost of Overhaul**
  - $4,900,000
- **Mean Time Between Overhauls (MTBO)**
  - 22,000 Flight Hours
- **Fleet Average Flight Hour/Cycle Ratio**
  - 3.1 FH/Cycle

All amounts in US$; *Includes Fan Blades and Annulus Fillers
## Rolls-Royce RB211-535

### Current Market Value & Base Values

<table>
<thead>
<tr>
<th>Type</th>
<th>CMV</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
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<th>2026</th>
<th>2027</th>
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<tr>
<td>RB211-535E4</td>
<td>2.852</td>
<td>2.852</td>
<td>2.676</td>
<td>2.495</td>
<td>2.311</td>
<td>2.126</td>
<td>1.943</td>
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<td>RB211-535E4B</td>
<td>3.128</td>
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<td>2.737</td>
<td>2.534</td>
<td>2.332</td>
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<td>1.935</td>
<td>1.744</td>
<td>1.562</td>
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Values in US Dollars (millions)
Annual inflation of 2.0% assumed