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Engine Values Book

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Welcome to the 18th edition of IBA's Engines Values. We have updated it with current views on engine values, lease rates, maintenance costs and maintenance information along with market data supported by IBA.*iQ*, our Online Platform which now provides engine values. In this year's editorial, we must of course recognise the recent and sudden onset of the Covid-19 pandemic. At the time of writing, we appear to be nearing the peak of daily new cases though much of this remains uncertain with the world's governments continuing efforts to promote self-isolation and quarantine. The aviation market has seen a steep drop in demand with some operators parking all aircraft and others parking up to 80% of their fleet. Future demand levels remain as yet uncertain, but we are monitoring the situation carefully. Naturally, due to the unclear conditions that lie ahead, the market has effectively been put on hold and as such all quoted values and lease rates provided in this edition refer to the market situation immediately prior to the Covid-19 outbreak.

The impacts of Covid-19 will be far reaching, affecting everyday lives of the world's population for several years. IBA spends a great deal of time assessing the relationship between base and market values, carefully considering short-, medium- and long-term factors. So, whilst market values can fluctuate, we remain confident in the continuing stability of base values overall. The variables here will typically be the duration and scale of the softening values, inevitably affecting some markets more than others. For 2020 the aviation landscape looks set to change dramatically and IBA will continue to closely monitor the market, providing advice and consultation to our clients throughout this trying period.

Looking at the year leading up to this point, 2019 was a strong performance year in the engine market and remained consistent with our expectations, albeit with market values rising above base for several engine types.

In the narrowbody market, the teething issues surrounding the early life of the LEAP-1A, LEAP-1B and notably the PW1100G appear to be coming to an end and they are proving to be reliable and fuel-efficient engines for their respective operator bases. 2019 was of course the year of the 737MAX groundings and, writing this commentary in March 2020, we are now one year into the grounding of the fleet. The knock-on effect, compounded by the continued shop visit demand, has been to see short-term demand for Boeing 737NG and 737 Classic aircraft and their respective engines to jump considerably along with some consequences for the A320ceo markets. Unsurprisingly, the CFM56-7B, CFM56-5B and V2500-A5 remain the engines seeing the highest trading volume, though demand for LEAP and PW1100G engines has grown noticeably.

Looking at widebody markets, the Airbus A330ceo and Boeing 777 families have both seen a notable softening in value from an aircraft perspective. Typically, this has a delayed impact on engine values, though we have seen some notable softening in these markets too. The Boeing 787 powered by the Trent 1000 and GEnx-1B continues to be a success though, of course, the issues surrounding the Trent 1000 and the considerable cost burden on Rolls Royce remains an area of concern. Feedback from Rolls Royce is, however, more positive and by all accounts we are nearing the light at the end of the tunnel with fewer AOG events. The Airbus A330neo aircraft powered by the Trent 7000 has so far entered the market relatively smoothly and orders picked up in 2019 after what had been a slow few years of orders for the type. The A350 powered by the Trent XWB remains a popular widebody choice with consistent order growth year on year and the engine has proved very reliable in service. Looking at Boeing's largest twin, the 777X continues to see slow order demand but testing of the platform and the new General Electric GE9X continues. Finally, the A380 has continued to soften and part out activity has started on earlier-build aircraft. The type is therefore destined to have a shorter operating life than expected. The aircraft remains a favourite amongst passengers, but operating costs have seen many operators reducing their exposure to the fleet.

Looking to the year ahead, we expect the economic and social impact of Covid-19 to be far-reaching and significant. We anticipate traffic demand will take time to recover fully and some airlines will fail to respond to government intervention. As such, typical demand for aircraft and engines will shrink and values and lease rates will soften, however, only until airlines want to avoid shop visit costs and turn to leasing instead. Whilst there can be a delay in this happening, the extent will depend on how many assets remain parked which can be utilised. Once they run out, and airlines continue to conserve cash, demand for spare engines will recover.

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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.

To the fullest extent permitted by law, IBA, its associated companies, subsidiaries, directors, sub-contractors, agents and employees are not liable for any oversights, errors or omissions in relation to the Engine Values Book.

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Rolls-Royce Trent 700

The Trent series of engines was launched in 1988 to meet the requirements of the Airbus A330 and Boeing 777 aircraft programs. The engine is based on a three-shaft layout which allows for independent sizes of cores to match the different fan diameters. This allows for a family of technologically advanced engines benefiting from a common design principle. This has produced a family of engines with a wide range of thrust that can power 747, 767 and 777 variants and A340-500/-600 together with the A380.

The Trent 700, produced originally as the 768 (67,500 pounds thrust) and later up-rated to 772 status (72,000 pounds thrust), powers the Airbus A330 wide-body twin jet aircraft. The original Trent 700 first ran in August 1990 and engine certification was achieved in January 1994. The engine was subsequently certified on the A330 in December 1994. The engine is also ETOPS approved with 90 minutes approval granted in March 1995, then extended to 120 minutes in December 1995, followed by 180 minutes in May 1996. The engine is FADEC and is flat-rated at 71,100 pounds at 30ºC. Compared to its competitors, the Trent 772 has demonstrated the best take-off thrust for the A330, together with a 5dB noise advantage and lowest overall emissions. In 2008, Rolls-Royce launched the Trent 700EP, aimed at reducing fuel burn and operating costs. The package is based on advances made in later build Trent family models.

The Trent 700 remains the engine of choice on the A330 fleet with well over 60% of the market share and 100% of the remaining orderbook. Fleet age remains low thanks to the late peak in production however as a maturing fleet values are declining. The aircraft fleet has seen a particular value drop though at this point there will be a lag in this impact on engine values. Debate remains around the aftermarket with Rolls Royce making strides to open this up to third parties though progress is still limited at this point.

Rolls-Royce Trent 700

Engine Variant Available					
Variant	**Thrust**	**Flat Rating**	**SFC***	**Aircraft Type(s)**	**Engines in Service**
Trent 768-60	67,500 lbf	30.0°C	0.584 lb/h/lb	A330-300	12 engines
Trent 772-60	71,200 lbf	30.0°C	0.584 lb/h/lb	A330-300	52 engines
Trent 772B-60	71,200 lbf	30.0°C	0.584 lb/h/lb	A330-200, -200F, -300	1,100 engines
Trent 772B-60EP	71,200 lbf	30.0°C	0.584 lb/h/lb	A330-200, -200F	288 engines
Trent 772C-60	71,200 lbf	30.0°C	0.565 lb/h/lb	A330-200, -300	280 engines

*Specific Fuel Consumption (SFC) at cruise conditions.

Airframe/Engine Combination			
Aircraft Manufacturer	**Aircraft**	**Engine**	**Worldwide Population**
Airbus	A330-200	Trent 772B-60	187 aircraft
		Trent 772C-60	69 aircraft
		Trent 772B-60EP	45 aircraft
	A330-200F	Trent 772B-60	63 aircraft
		Trent 772B-60EP	5 aircraft
	A330-300	Trent 768-60	6 aircraft
		Trent 772-60	26 aircraft
		Trent 772B-60	298 aircraft
		Trent 772C-60	71 aircraft
		Trent 772B-60EP	94 aircraft

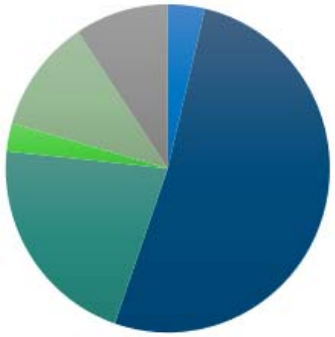
Rolls-Royce Trent 700

Active = 1,282

Parked = 112

Worldwide Distribution of Installed Engine Population

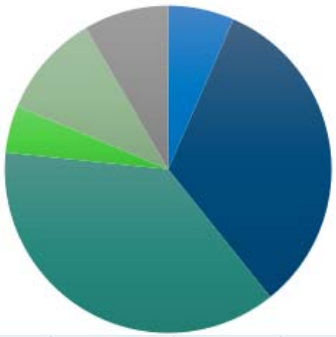
Total installed population 1,732 engines



Africa	64 Engines	3.70%
Asia Pacific	894 Engines	51.62%
Europe & CIS	370 Engines	21.36%
Latin America	48 Engines	2.77%
Middle East	194 Engines	11.20%
North America	162 Engines	9.35%

Worldwide Distribution of Operators

Total installed population 107 operators



Africa	7 Operators	6.54%
Asia Pacific	35 Operators	32.71%
Europe & CIS	40 Operators	37.38%
Latin America	5 Operators	4.67%
Middle East	11 Operators	10.28%
North America	9 Operators	8.41%

Current Market Value, Base Value, Typical Current Rental Rate (TCCR) & QEC

	Trent 772B-60 EP	
Market Value	Dressed	$8,400,000
Base Value	Dressed	$8,480,000
Typical Current Rental Rate		Low $120,000 per month High $150,000 per month
QEC		$2,050,000

All amounts in US$

Engine Maintenance Indicators

	Trent 772B-60 EP
Life Limited Part (LLP) Cost	$9,220,000
Average Cost of Overhaul	$9,200,000
Mean Time Between Overhauls (MTBO)	26,200 Flight Hours
Fleet Average Flight Hour/Cycle Ratio	4.4 FH/Cycle

All amounts in US$

Rolls-Royce Trent 700

Current Market Value & Base Values

Values in US Dollars (millions)
Annual inflation of 2.0% assumed

Type	CMV	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Trent 768	**4.650**	4.670	4.359	4.037	3.710	3.383	3.061	2.747	2.446	2.161	1.893	1.645
Trent 772	**5.800**	5.840	5.683	5.489	5.263	5.009	4.731	4.434	4.125	3.808	3.488	3.170
Trent 772B	**7.140**	7.120	7.001	6.834	6.622	6.370	6.081	5.762	5.419	5.058	4.684	4.305
Trent 772B EP	**8.400**	8.480	8.459	8.378	8.238	8.042	7.792	7.495	7.156	6.781	6.377	5.951
Trent 772C EP	**7.550**	7.570	7.443	7.266	7.041	6.772	6.465	6.126	5.762	5.377	4.980	4.577