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An *Airfinance Journal* special supplement

Guide to financing and investing in engines 2018

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What to consider when **investing in engines**

Engine investors need to be more reactive to changes than aircraft investors, as even a small change can impact the attractiveness of an asset.

Investing in engines is quite different to investing in aircraft. When investing in engines only, there is less of an emphasis on long-term contractual business, with power-by-the-hour contracts being an exception. Such contracts are risky for independent servicers, but less so for original equipment manufacturers (OEMs), which can control the parts supply. There are different customer bases to consider for engines and technical knowledge of the asset is needed to be able to spot opportunities.

Another major difference is that lessors in the engine market often do not get a chance to order engines directly from the OEMs, but instead gain most of their business through sale and leasebacks. Aircraft lessors routinely order aircraft from OEMs because the market and demand to own aircraft is big enough for lessors not to outcompete the OEMs when it comes to placing them.

Along with this, there is more volatility in the engine world compared with airframes as far as investor attractiveness is concerned. So, as an engine investor, you have to be more reactive to change, particularly when it comes to engine teardown and end-of-life solutions.

The V2500-A5, which powers the A321, is an example of a volatile engine. Although the powerplant is in high demand, if you were a company that owned it when all the airworthiness directives came out in the early noughties and more recently in 2016, it would have been seen as a poor investment.

In our annual engine poll on page 11, we sound out investors and ask their opinions on different engine types, looking at their investor appeal, remarketing value and residual values. Speaking to *Airfinance Journal* for the poll, Paolo Lironi, chief executive officer of SGI Aviation, advises against investing in V2500s unless it is a short-term investment, because he believes that shop visits for the engine type will start decreasing over the next nine months, thereby decreasing the need for spare engines.

It is hard to justify investing in an engine long term unless the asset is projected to have a steady customer base and shop visit activity over the next few years. The Pratt & Whitney PW1100 or Geared Turbofan is seen as a good long-term investment: it has a steady customer base and reached 500,000 flight hours on a fleet of 135 aircraft flown by 21 operators over the past year. That said, it has also been beset with technical difficulties since it came into service with Lufthansa in January 2016.

How to communicate an engine issue to the market as an OEM can be critical – either be open about the technical issues with the customers and accept the engine's faults, or claim that the problems have been fully addressed when they have not. The latter strategy can backfire, because it means that any technical issues make more headlines and have more of an impact on market sentiment towards the engine.

When investing in an engine, also consider the aftermarket and the role the OEM has in it. OEMs are often criticised by engine investors for being too involved in the aftermarket. The market is lucrative, but if an OEM has too much involvement in it, third-party suppliers take the hit: their material becomes less valuable and that can decrease the overall residual value of the parts.

OEMs seem to be taking more of the pie when it comes to the aftermarket and performing maintenance on the engine. Take Rolls-Royce and GE, for example. As we point out in our OEM solution feature on page 25, investors often see Rolls-Royce as being more aggressive in the aftermarket than GE Aviation, but recent financial results tell a different story. Of GE Aviation's 2017 revenue of $27.4 billion, $16.6 billion, or 61%, was accounted for by aftermarket services. Rolls-Royce's percentage of revenue from aftermarket work is lower, at 53%.

In the spare parts market, you are seeing more OEMs vertically integrate to cut out the middle man and increase their profits. For example, Rolls-Royce Partners Finance, the leasing subsidiary of Rolls-Royce, has been vertically integrating its business by more directly managing its used material department. As the lessor is the largest owner of spare V2500s, it can easily feed material into the parts business to sustain it.

For customers, there can be advantages of OEMs coming in with new products where they bundle services, but as assets trade, they want a competitive price point, and dominance of the aftermarket makes pricing less competitive.

Often OEMs will price support care packages at the newer end of the curve, leading to a disconnection between that and what others in the market are asking for.

Although many of the OEMs say they are taking steps to address perceived over involvement in the aftermarket, many engine investors are not yet convinced they will follow through with their promises.

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Rolls-Royce spends £227m on Trent accelerated maintenance activity

UK engine manufacturer Rolls-Royce says £227 million ($315 million) in total charges was recognised in last year's results for Trent 1000 and Trent 900 accelerated maintenance activity.

Rolls-Royce experienced an increased level of activity managing significant in-service engine issues on two engine programmes in 2017. This was principally because of lower-than-expected durability of a small number of parts for the Trent 1000 and the Trent 900 variants.

"These issues have required urgent short-term support, including both on-wing and shop visit intervention, which has resulted in increased disruption for some of our customers. This has been a dynamic situation. We have continued to progress our understanding of both the technical and operational issues and we are making solid progress with longer-term solutions, largely through re-designing affected parts," says the engine manufacturer.

These are expected to be fully embodied in the Trent 1000 fleet by 2022.

On the Trent 900, an extended life turbine blade is already being rolled-out into the current fleet with further re-designs underway. These will be available in 2020, says Rolls-Royce.

Total charges of £227 million (compared with 2016's £98 million) were recognised in the income statement for Trent 1000 and Trent 900 accelerated maintenance activity and £170 million (£90 million in 2016) in its cash flow.


Rolls Royce Trent 1000

Rolls-Royce says the anticipated annual cash impact of both the Trent 1000 and the Trent 900 is expected to broadly double from the total cash cost in 2017 of £170 million and reach a peak in 2018, as maintenance activity intensifies.

It is then expected to fall by about £100 million in 2019. The majority of the work will be undertaken in 2018 and 2019, although it is expected to be fully complete by 2022.

Rolls-Royce's engine fleet continued to grow, with more than 4,400 engines in active service at the end of 2017, up 7% on 2016. Invoiced flying hours increased by 12% compared with growth of 4% in 2016.

The Trent XWB-84 engine represents 6% of Rolls-Royce's in-service widebody fleet and has achieved more than 1.2 million flying hours. Rolls-Royce expects that the engine fleet will grow to about 1,000 engines over the next five years.

The Trent 700, which represents 36% of the manufacturer's total widebody fleet, continued to perform well in service, and achieved a dispatch reliability of 99.9%.

The Trent 1000 represents 11% of the manufacturer's widebody fleet, while the Trent 900 represents 8% of its total widebody fleet.

The RB211, Trent 500 and Trent 800 comprise 39% of the widebody fleet and continue to perform well in service.

2017 CFM orders **surpass 3,300** engines

Orders for CFM International's two product lines again achieved near-record levels in 2017, with the company booking orders for 3,344 engines, including 474 CFM56s (commercial, military and spares) and 2,870 LEAP engines (including commitments and spares).

The LEAP engine continues to be the powerplant of choice for new single-aisle aircraft, says CFM International, garnering more than 14,270 total engine orders and commitments (excluding options) since 2011.

Total CFM engine production remains at historically high rates, with the company delivering 1,444 CFM56 engines and 459 LEAP engines last year.

As the company continues the transition from CFM56 to LEAP production, the total number of CFM56 engines produced will continue to drop, with the full transition expected by 2020, at which time the company expects to be at a rate of more than 2,000 LEAP engines a year.

CFM will continue to build CFM56 spare engines beyond 2020 to support the in-service fleet and plans to produce spare parts for the programme until about 2045.

The LEAP engine surpassed 600,000 flight hours in less than 18 months of commercial service.

The first LEAP-powered aircraft entered into commercial service with Turkey's Pegasus Airlines on 2 August 2016. Since then, more than 210 LEAP-1A- and LEAP-1B-powered aircraft have entered service with a total of 33 operators on five continents. Overall, this fleet had logged more than 610,000 flight hours and 290,000 flight cycles as at 5 February 2018.

R-R launches **IntelligentEngine**

Rolls-Royce (R-R) launched its IntelligentEngine vision at this year's Singapore air show. The manufacturer says that the IntelligentEngine vision is based on a belief that the worlds of product and service have become so closely connected that they are now inseparable.

This trend was first identified when Rolls-Royce introduced the market-defining TotalCare® service in the 1990s and, since then, advancements in digital capability have accelerated this change and further blurred the boundary between the two.

The coming together of product and service, augmented by digital technology, offers Rolls-Royce a wealth of opportunities to improve the way it provides power to its customers, according to the engine manufacturer.

In addition to designing, testing, and maintaining engines in the digital realm, the IntelligentEngine vision sets out a future where an engine will be increasingly connected, contextually aware and comprehending, helping to deliver greater reliability and efficiency:

- connected – with other engines, its support ecosystem, and with its customer, allowing for regular two-way flow of information between many parties;
- contextually aware – of its operating context, constraints and the needs of the customer, allowing it to respond to the environment around it without human intervention; and
- comprehending – learning from its own experiences and from its network of peers to adjust its behaviour and achieve best performance.

The manufacturer says the IntelligentEngine vision enables Rolls-Royce to find new ways of pioneering power, whether that is through its engines installed today, through its future UltraFan® engine design, or even through the hybrid-electric concepts of the future.

It adds that Rolls-Royce's R2 Data Labs, a hub for data innovation launched in December 2017, will play a key role in achieving the aims of the IntelligentEngine. Using advanced data analytics, industrial artificial intelligence and machine learning techniques, "R2 Data Labs develops data applications that unlock design, manufacturing and operational efficiencies within Rolls-Royce, and creates new service propositions for customers".

GE designs fix for hundreds of LEAP engines

General Electric (GE) plans to replace a part in hundreds of recently delivered engines after uncovering a durability problem inside the turbines powering new Airbus A320neo and Boeing 737 Max aircraft.

The manufacturer has identified a fix for a previously disclosed issue with the new CFM LEAP engine, and the redesigned part will be incorporated into the production line from the second quarter, says Rick Kennedy, a spokesman for GE Aviation. More than 500 engines in service will be replaced or retrofitted during regular maintenance, he adds.

While not expected to result in further delivery delays, the fix adds a new complication to an unprecedented production ramp-up in GE's aerospace business as Boeing and Airbus increase output of their single-aisle aircraft. GE is trying to meet aggressive targets while fending off a challenge from United Technologies' Pratt & Whitney, which has also experienced faults with its new engine, the PW1000G.

AerCap sees past geared turbofan problems

AerCap is due to deliver about $6 billion of aircraft assets in 2018, but indicates the "level of delivery may be impacted by recent developments" on the Pratt & Whitney geared turbofan engine.

"It is too early to say what impact this latest issue will have on our 2018 delivery profile. What we can say is that the Airbus A320neo is delivering excellent fuel burn savings for our customers and it continues to be in demand," says Aengus Kelly on the 2017 fourth-quarter earnings call.

He adds: "This is evidenced by the strength of our forward-order placements. AerCap has now placed 170 A320neos. As a result of the demand we see for the aircraft, we exercised a follow-on option for 50 A320neos in December."

Kelly says that it is a "minority share of the population" that is impacted with a total of 43 engines on 32 aircraft, of which 21 aircraft have one of the affected engines on them.

"So the vast majority of the aircraft remain in service. The impact for us is in our delivery schedule... and we are working with Pratt & Whitney and through the issues."

Pratt & Whitney and Airbus are working on a plan to correct recently discovered issues with the geared turbofan high-pressure compressor parts that triggered an emergency order from the European Aviation Safety Agency (EASA).

EASA's order, issued on 9 February and based on an Airbus alert to operators, required operators to ensure no aircraft had two of the affected engines on one aircraft, and banned all extended-range twin-engine operations flights using any affected engines, effective immediately.

Spicejet signs $12.5bn CFM engine deal

Indian low-cost carrier Spicejet has signed a $12.5 billion agreement with CFM International that finalises the purchase of LEAP-1B engines to power 155 Boeing 737 Max aircraft, along with spare engines to support the fleet.

The airline also signed a 10-year rate-per-flight-hour agreement with CFM Services that covers all LEAP-1B engines powering Spicejet's 737 Max aircraft.

Under the terms of the agreement, CFM guarantees maintenance costs for all Spicejet's LEAP-1B engines on a pay-by-the-hour basis.

Spicejet now operates a fleet of 38 CFM56-7B-powered Boeing next-generation 737-family aircraft.

Airfinance Journal reported on 8 March that Spicejet would take 11 Bombardier Q400s this year.

Mobile delivers first A321neo

Airbus was on course to deliver its first Pratt & Whitney geared turbofan (GTF)-powered A320neo-family aircraft as *Airfinance Journal*'s Engine Guide went to press. The aircraft manufacturer recently received the engines for installation on the A321neo aircraft to be assembled and delivered out of its Mobile, Alabama, production facility.

"We are thrilled that the first A320neo-family aircraft to be delivered from the Airbus Mobile production facility will be powered by the GTF engine," says Pratt & Whitney's director of 30K programmes Doug Duke.

"This facility puts Airbus closer to their US-based customers and facilitates their goal to increase production rates – and we are here to support those advancements."

The aircraft was to roll out and perform its first flight before delivery to Hawaiian Airlines in March, making it the fifth GTF-powered A320neo-family aircraft in Hawaiian's fleet.

The Honolulu-based carrier's A321neo programme will run through 2020. The airline received its first A321neo aircraft from the Airbus facility in Toulouse, France, late in 2017.

The carrier has an order for 16 units and six purchase rights.

• Aircraft production rates will be debated at ***Airfinance Journal****'s inaugural Southeast Aerospace and Defense conference in Mobile, Alabama, on 25-27 June 2018.*

GE9X performs first flight

The GE9X engine lifted off on 13 March under wing of GE Aviation's 747 flying testbed in Victorville, California, for its first flight test. The engine that will power Boeing's new 777X aircraft took to the air for more than four hours on its first flight. During the flight, the aircraft and powerplant completed the entire test card and validated key operational and functional characteristics enabling the test campaign to progress in subsequent flights.

Certification testing of the GE9X engine began in May 2017. Beyond flight testing, the engine completed icing tests at GE Aviation's facility in Winnipeg, Manitoba, Canada, and continues crosswind testing at the Peebles Test Operation in Ohio. Engine certification is expected next year.

With almost 700 on order, the GE9X engine will be in the 100,000lb-thrust class and will have the largest front fan at 134 inches in diameter, with a composite fan case and 16 fourth-generation carbon fibre composite fan blades.

Other key features include: a next-generation 27:1 pressure-ratio 11-stage high-pressure compressor; a third-generation TAPS III combustor for high efficiency and low emissions; and CMC material in the combustor and turbine.

IHI Corporation, Safran Aircraft Engines, Safran Aero Boosters and MTU Aero Engines are participants in the GE9X engine programme.

Tap seeks spare engine finance

Tap Air Portugal is preparing to shortlist bidders for its Airbus A320 and A330neo spare engine financing. The airline will consider all methods of financing and indicates it will consider all proposals received.

However, in order to minimise transaction costs and to make the financing more cost efficient for financiers, Tap says its preferred option is to finance all of the spare engines being delivered in 2018 and 2019 in a single committed financing facility and proposals are requested on this basis. The Portuguese carrier will require the financing to be in place for the first delivery of a spare engine in May 2018.

The shortlist was available mid March, according to the request for proposals.

Tap's spare engine order consists of five CFM LEAP-1A engines for its A320neos and three Rolls-Royce Trent 7000 engines to support its forthcoming A330neo fleet.

Although the main focus of the request for proposals relates to the financing of the spare engines arriving in 2018 and 2019, Tap also welcomes expressions of interest for the financing of spare engines ordered for later years.

The carrier has placed a narrowbody and widebody fleet-renewal order with Airbus for 39 A320- and A321neo-family aircraft, as well as 14 A330neos.

Deliveries are due to start in March 2018 for the A320neo family and September 2018 for the A330neo, for which TAP is the worldwide launch customer.

Rolls-Royce's Goodson moves to SVP sales-lessors role

Simon Goodson, senior vice-president, sales and lessors, civil aerospace, Rolls-Royce

Simon Goodson has been appointed to the newly created joint role of senior vice-president, sales and lessors, civil aerospace, at Rolls-Royce, filling a position that became vacant with the retirement of senior vice-president Phil Harris in 2017.

Goodson was previously senior vice-president, lessors, at the UK engine manufacturer.

Previously an officer in the British Royal Navy, he spent eight years in the structured asset finance markets with Barclays Bank and ING Groep, before joining Rolls-Royce in 2003.

Between 2003 and 2010, Goodson worked in various roles at Rolls-Royce Capital, the group's customer financing arm within treasury, focusing on engine leasing, aircraft sales finance and structured finance.

Between 2010 and 2014, he joined investor relations to head up the group's activities with institutional shareholders.

In 2014, Goodson joined civil aerospace as senior vice-president, lessors customer team, responsible for all sales, commercial and customer services activities with lessors.

Rolls-Royce begins work on new testbed

As *Airfinance Journal* went to press, Rolls-Royce welcomed UK Business Secretary, Greg Clark, to Derby to celebrate the start of work on its new testbed facility.

The plans for the testbed were announced in June 2017 as part of a wider £150 million ($211.44 million) investment in UK aerospace facilities.

The new testbed, which is expected to be commissioned in 2020, will support Rolls-Royce's ongoing industrial transformation and will provide important additional capacity as the civil aerospace business continues to ramp-up engine production and deliver on a record order book.

Capable of testing a range of today's engines, including the Trent XWB and the Trent 1000, the facility will also serve as a base for testing UltraFan®, Rolls-Royce's engine for the next generation of aircraft.

The decision to invest in Derby, the home of Rolls-Royce's civil aerospace division, was underpinned by a constructive dialogue with senior union representatives in the UK and will help to sustain more than 7,000 Rolls-Royce jobs across the East Midlands.

Chris Cholerton, Rolls-Royce, president – civil aerospace, says: "We are proud to welcome the Secretary of State to Derby to celebrate this important milestone with us. It comes at a pivotal moment for our civil aerospace business as we ramp up production to record levels and look forward to completing a hat-trick of new engine launches, with the Trent 7000 set to enter service later this year. This new facility will not only give us the capacity and flexibility to deliver on our growth plans but also sustains employment across the region."

CFM achieves 20 LEAP engines weekly

CFM International reached record production levels in 2017, delivering 1,903 engines to customers. The US-French engine joint venture delivered 1,444 CFM56s and 459 LEAP engines last year.

In November, CFM International's president and chief executive officer, Gaël Méheust, said the supply chain reached the manufacturer's 2018 planned rate of 20 LEAP engines a week.

LEAP production will double in 2018 to about 1,100 to 1,200 engines as part of the ramp-up that will eventually lead to more than 2,000 LEAP engines a year by 2020.

In 2016, CFM delivered a total of 1,693 CFM56s and 77 LEAP engines as the company began transitioning to the new product line.

New geared turbofan problems hit S7 deliveries

Source: Sergey Anashkevitch

Russian carrier S7 Airlines has indicated that problems surrounding Pratt & Whitney's PW1100G engine will push back deliveries of additional Airbus A320neo aircraft. "You've probably heard that Airbus has problems, so there will be a delay on four planes, most likely," S7 co-owner Natalia Fileva told reporters in Sochi, according to Russia's Interfax news agency.

On 9 February, the European Aviation Safety Agency (EASA) issued an airworthiness directive after in-flight shutdowns (IFSD) or rejected take-offs of PW1100G engines with serial numbers P770450 or later.

"While investigation is ongoing to determine the root cause, preliminary findings indicate that the affected engines, which have high-pressure compressor aft hub modification embodied from ESN P770450, are more susceptible to IFSD," stated EASA.

The airworthiness directive requires the operational withdrawal of any aircraft powered by two of the affected engines, while those carrying just one of the affected engines are forbidden from extended over-water operations.

According to Airbus, almost one-third of the active fleet of A320neos is powered by one or two of the affected engines.

S7 already operates four A320neos on lease from AerCap and BOC Aviation, according to *Airfinance Journal*'s Fleet Tracker – none of those aircraft are affected by the EASA airworthiness directive, says Fileva.

In 2016, S7 signed leases for five A320neos with Air Lease, although it is not clear whether these are the aircraft that face a delay.

The airline also expects to receive another seven A320neos from AerCap, according to Fleet Tracker.

LEAP reigns supreme... for now

CFM engines for the Airbus A320neo and Boeing 737 Max topped *Airfinance Journal*'s annual engine poll, but some market participants anticipate further teething problems. **Jack Dutton** reports.

Delays and technical issues dominated the headlines in the engine market last year – and the Pratt & Whitney PW1100G (Geared Turbofan or GTF) was the main culprit. Despite the manufacturer's major role in two popular joint-venture programmes – the International Aero Engine (IAE) V2500 for the A320 family and the Engine Alliance GP7000 for the A380 – the PW4000 was the last successful commercial engine Pratt & Whitney developed and marketed on its own, way back in 1984.

In August 2000, Pratt & Whitney developed the PW6000 engine – which was not part of the IAE family – for the A318. It was not a success and lost out to the CFM56 on most of the limited number of A318 sales. Given Pratt & Whitney's long absence from new engine development, then, the GTF's bumpy entry into service was perhaps no surprise.

"There has been a big focus on the Geared Turbofan because of all the problems affecting the engine," says Paolo Lironi, chief executive officer of consultancy SGI Aviation. "Investors are not that eager to buy an engine now, apart from having the problem in finding a spare engine. The fact is that whoever is going to buy the engine now is going to [get one] pretty low in modification standard and therefore it is not so attractive."

The Connecticut-based original equipment manufacturer's technical hiccups helped boost the prospects of the PW1100G's competitor, the CFM LEAP-1A, over the past year. This increased focus on the latest CFM products was reflected in this year's engine poll: the LEAP-1A scored 6.6 out of seven for investor appeal, 6.4 for remarketing potential and 6.4 for residual values.

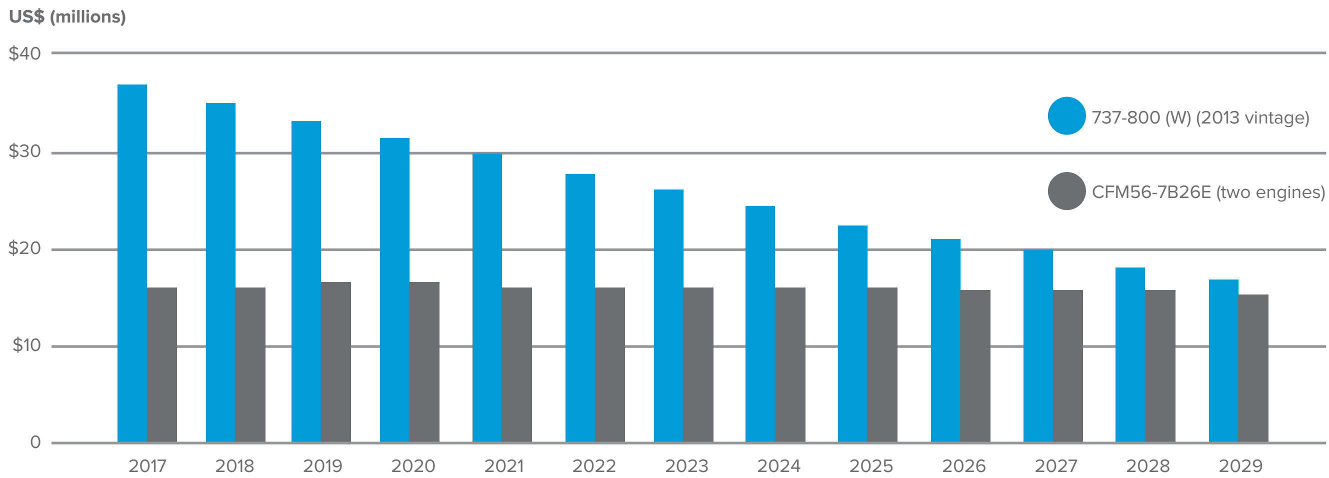
However, the LEAP-1B, which powers the 737 Max, led the way this year, scoring the highest across all three categories with 6.8 for investor appeal, 6.5 for remarketing potential and 6.5 for residual values.

This is the third year running the engine has come out on top. When it first did in 2016, it had barely entered service. But now the programme is in full swing, with CFM delivering 469 LEAP engines across its programmes in 2017. These represented a six-fold increase over the 77 LEAP-1A engines delivered to the A320neo family in 2016 and formed about a quarter of the 1,900 engines that CFM delivered overall to set a new annual record in 2017, according to CFM executive vice-president Francois Bastin.

> *"There has been a big focus on the Geared Turbofan because of all the problems affecting the engine."*
>
> **Paolo Lironi**, chief executive officer, SGI Aviation

Total engine value relative to aircraft value

Future base values 2017-2029 at 1.0% inflation (aircraft) and 2.5% inflation (engines)



Source: Avitas

Although many investors are concerned by the technical problems of the PW1100, the engine still scored highly in the poll, clocking in 5.5 for investor appeal, 5.4 for remarketing potential and 5.7 for residual value.

Addressing the issues

"I was expecting issues with the geared turbofan, but even I'm getting a bit concerned about the amount of issues the engine is having and the capability of Pratt to cope with all these issues," says Lironi. "I feel that Pratt is really struggling with all the issues that are happening at the same time."

As well as on the A320neo, Pratt & Whitney has put the GTF into service with the Bombardier CSeries and is due to see it flying on the Embraer E2 programme– grand ambitions after a rough year for the engine.

"For an organisation that has just a few field representatives and that let go the majority of experienced engineers just three or four years ago, I think it's a huge challenge," adds Lironi. "So I'm hoping that Pratt will be able to cope with one thing at a time and solve every technical issue they're having, but the road is very bumpy at the moment for them."

Lironi says that he expects polling scores for the GTF to improve next year as Pratt & Whitney solves the engine's technical problems. Although the LEAP is outperforming the GTF on all counts in the poll, many engine investors believe the CFM product is also due a few teething problems. Others believe that over time the GTF will offer better economics than the LEAP for fuel consumption.

"Watch this space," says Lironi. "The LEAP product is solid... but there are already some technical issues affecting the engine. It's not the perfect engine model yet. It does not have, at this moment in time, the same reliability of the CFM56."

The CFM56-5B, which covers the A320 current generation, performed strongly in the poll, rating 5.8 for investor appeal, 5.8 for remarketing potential and 5.7 for residual value. The CFM56-7B, which powers the 737NG, also performed well, reflecting ongoing strong demand for current-generation narrowbodies.

Communication with the market

The best-performing widebody engine in the poll was the GEnx, which powers the Boeing 787. It has improved on its scores from last year in all three categories, earning the praise of engine poll respondents.

"I think the GEnx is going to be a very popular engine for the leasing community," Troy Lambeth, chief executive officer of Abu Dhabi-based engine lessor Sanad tells *Airfinance Journal*. "We are seeing a lot more engagement on the GEnx front

Airfinance Journal's 2018 Engine Poll

	Investor appeal (out of 7)	Remarketing potential (out of 7)	Residual value (out of 7)
BR715 (717)	1.3	1.4	1.4
CF34-8C (CRJ)	2.9	2.9	2.9
CF34-8E (E-Jets)	3.7	3.7	3.7
CF34-10E (E190/195)	3.7	6.5	3.9
CF6-80 (747-400s, 767s)	3.3	3.5	2.9
CFM56-3C (737 Classic)	2.5	2.8	2.2
CFM56-5A (A320 Family)	2.4	2.3	2.3
CFM56-5B (A320 Family)	5.8	5.8	5.7
CFM56-5C (A340)	1.8	1.7	1.8
CFM56-7B (737NG)	5.9	6.0	5.8
CFM Leap-1A (A320neo)	6.6	6.4	6.4
CFM Leap-1B (737 Max)	6.8	6.5	6.5
GE90 (777)	4.7	4.5	4.3
GEnX (787)	5.9	5.7	5.7
GP7200 (A380)	2.1	1.8	1.9
IAE V2500-A1 (A320 Family)	2.4	2.5	2.5
IAE V2500-A5 (A320 Family)	5.8	6.0	5.8
JT9D (747s, 767-200)	1.6	1.5	1.6
PW1100G (A320neo)	5.5	5.4	5.7
PW127F (ATR72-500)	4.4	4.5	4.8
PW127M (ATR72-600)	4.4	4.5	4.6
PW150A (Q400)	3.9	4.1	4.1
PW2000 (757)	2.9	3.1	2.9
PW4000 (747-400s, 767s, 777s)	3.1	3.1	2.5
PW6000 (A318)	1.0	1.1	1.0
RB211-524 (767, 747-300, -400)	1.2	1.3	1.2
RB211-535 (757)	2.8	3.0	2.6
Trent 553 (A340-500)	0.9	1.0	0.9
Trent 556 (A340-600)	1.0	1.2	1.1
Trent 700 (A330)	3.8	3.6	3.6
Trent 800 (777)	2.4	2.4	2.6
Trent 900 (A380)	1.8	2.1	2.2
Trent 1000 (787)	5.1	5.0	5.4

Source: *Airfinance Journal*, March 2018 than we're seeing on the LEAP, but we fully expect the LEAP will be coming at the leasing market very soon."

Compared with the Rolls-Royce Trent 1000, which also powers the Boeing 787, the GEnx is generally viewed as the more favourable engine for the widebody by investors because the Trent has experienced technical issues. For example, Virgin Atlantic had to lease four former Air Berlin A330-200s at short notice late last year because it had to ground some of its 787s because of issues with the Trent 1000. However, investors expect the Trent to be on the rebound next year as Rolls-Royce deals with the engine's technical faults.

Lironi says the GEnx is also viewed more favourably because of GE's better customer support.

"The GEnx is also affected by some serious technical issues," says Lironi. "The difference between Rolls and GE, though, is GE is quite open about it, keeps informing the operators, and is more reactive and capable of coming up with a solution quicker than Rolls."

When there is a technical fault, GE makes a recommendation to replace certain parts or invites the operators to remove engines quickly and this usually does not make big headlines in the press, says Lironi.

An engine investor adds: "The normal Rolls-Royce approach is to say that there is no problem. If there is a problem, it's denied, then once they can't sustain their position anymore, it's already too late and operators are grounding aircraft. They get in the news; they get a bad reputation for it. It's mainly caused by Rolls' mentality and approach to the market rather than the product itself."

Although some investors believe Rolls-Royce is improving its communications about engine issues, many also feel that the UK original equipment manufacturer (OEM) is still behind its US competitor in this respect. The two OEMs' different design philosophies and relationships with the Federal Aviation Administration also come into play.

V2500 resurgence

The V2500-A5 significantly outperformed its older stablemate the V2500-A1 in the poll, nearly doubling its score in all three categories. There was a surge in V2500 shop visits last year dictated by scheduled overhauls and technical issues. More unscheduled removals increase demand for spare engines.

"That's what is happening on the V2500. Two years ago, the V2500 was really decreasing in value, but now, because of technical issues, has really increased in value, surprisingly," says Lironi.

He adds that SGI has seen plenty of trades on V2500s over the past year because of engine issues.

> *"The OEMs all have MRO [maintenance, repair and overhaul] strategies and they swell or shrink. I think sometimes it's dependent on the orderbook."*
>
> **Troy Lambeth**, chief executive officer, Sanad

"Personally, I don't recommend long-term investors to buy V2500s, but if they have a short investment term, it could be a good engine to invest into. We believe that the number of shop visits on the V2500 will start decreasing in the next nine months, and therefore the need for spare engines will also decrease, decreasing the value of spare engines."

OEMs' aftermarket role

OEMs have differing strategies when it comes to managing the aftermarket of their engines and allowing non-OEM parties to perform maintenance on the assets. Some OEMs tend to be more third-party-owner friendly while others tend to be more protectionist. The more protectionist manufacturers want their own kit to be put into repairs, meaning that if you are a third-party supplier which owns those assets, your material becomes less valuable. This can put pressure on residual values.

An engine's residual value is driven by the value of its parts. If there is no market for those parts, an investor cannot sell the engine and the value will sharply decrease. If there is an open market for maintenance, shops competing for business often will seek to lower costs by installing second-hand parts and therefore the value of used parts coming from engines being parted out will increase.

For engine types such as the Rolls-Royce Trent 700, the aftermarket has opened up in the past year. But there are many engine types where the OEM dominates the aftermarket, such as the Trent 800, Trent 900, Trent 1000 and the GEnx. However, many of these engines are still scoring well because they have large installed bases, large orderbooks and are young and in demand, making them attractive to invest in.

"The OEMs all have MRO [maintenance, repair and overhaul] strategies and they swell or shrink. I think sometimes it's dependent on the orderbook," says Sanad's Lambeth.

Comparing the approaches of GE and Rolls-Royce to the aftermarket, one engine investor says: "You saw how complex it became for Rolls in terms of how they tended to control everything in the aftermarket. GE, on the other hand, has always had a more open approach to let the market drive which direction they take, and I think the latter model, to be honest, is far more endurable as a model. We saw this with the ERJ145 engine, when Rolls really hit the cliff edge in terms of potential exposure."

OEMs can run into trouble if they get caught up in the euphoria of some of the initial deals for new engine types and do not adequately address the ability of second- and third-tier operators to take over the product later on in its life.

"Airlines want choice and airlines love choice," says one engine investor. "They will actively push for choice and do not like to think they are subservient to one source. I think some of the OEMs are forgetting this in the approach to the market."

Volatility in older types

The worst-performing engines in the poll are those for the aircraft in the most illiquid markets. For example, the Trent 900, which powers the A380, performed poorly, scoring about two out of seven in all three categories. The PW6000, which powers the increasingly obsolete A318, scored about one out of seven in all three categories.

One engine investor cautions: "These ratings, especially for the more mature engine types, can be somewhat volatile. For example, the V2500-A5 is in very high demand right now (which implies it is a strong investment); however, if you owned these when all the ADs [airworthiness directives] and other issues came out, your investment in them would have been negatively affected with exposure to the same.

"Another example: it would be great to have an RB211-535 in the current market, but owning them not too long ago would have been rough."

Older engine types experience more volatility in investor attractiveness than new types. These assets are a great investment if you own them when demand increases, but would be bad if you invested in them and saw demand drop thereafter, which could be triggered by anything from a slight uptick in oil prices to an OEM addressing delivery delays on new-technology engines. As a result, it can be much harder to predict what the market will be like for these engines in the long term than airframes.

The volatility in the more mature types of engine shows that investors must do their homework before investing in these assets.

2018 Engine Poll –
it's the residual, stupid

Joseph W O'Brien, chief commercial officer, ELFC, provides an overview of how engines in this year's poll can be rated.

Pratt & Whitney PurePower

"How can you rate more than 30 engine types for three different categories of value – investor appeal, remarketing potential and residual value – as the poll calls for?"

Joseph W O'Brien, chief commercial officer, ELFC

During the 1992 US presidential election, Bill Clinton's campaign used a phrase in speeches and political rallies against the campaign of George HW Bush for several months. The phrase "It's the economy, stupid" focused on the number one issue of the day for most of the US electorate. While completing the annual *Airfinance Journal* engine survey for 2018, I was reminded of this simple message.

How can you rate more than 30 engine types for three different categories of value – investor appeal, remarketing potential and residual value – as the poll calls for? Some of the engine types are no longer produced but have supported an aircraft fleet for more than 30 years, while others are at the initial entry-into-service production phase. Some engine types support large fleets with worldwide user bases and others could reasonably be described as specialist niche engines. The answer is to look at the core principle of all large-ticket asset leasing – residual value.

When an engine lessor acquires engine assets for long-term investment there are several factors to consider. Purchase price is paramount in this evaluation because it has the highest degree of influence on residual value. However, lessor depreciation policy, original equipment manufacturer (OEM) aftermarket support, maintenance reserves (or the lack thereof), airline utilisation, regional environment severity and lessee creditworthiness all play their own significant roles in reaching a lease end or investment end residual value. Technical acumen regarding condition, records review and modification status is also critical, particularly when acquiring used engines.

While considering these seven or eight influencing factors for 33 engine types, you could write the entire bimonthly issue of the magazine on this topic alone. To simplify though, you can deduce there are four or five individual segments in the engine market.

Evaluating residual value for the first segment may be the easiest. With the most populous fleets and engine types, the Boeing 737 family and the Airbus A320 family, there is a plethora of information available in the market. There are many users spread across the world, shop visit data is generally voluminous and easily obtained and confirmed, and perhaps, most important, there are lots of known trades of the assets with or without underlying leases regardless of whether the engine is attached to a wing or sold as a standalone asset.

The first poll question for the types, investor appeal, based on a rating of one to seven is complicated but easier in this segment than all of the other engine types. New investment at market prices today should be cautioned. However, if the price is reasonable, the engine types, the CFM56-5B and -7B and the V2500, remain attractive investments because the fleets will disperse further and continue to fly for a long time.

Investor appeal is scored four to five. On the question of remarketing potential, these engines are the premier assets of the day to own. As the entry-into-service issues for the replacement engines are worked out, demand for the types is at its highest in years.

Remarketing potential is scored at six to seven. The last category to value, residual value, is toughest to rate. Considering all the factors listed above along with a demanding and tough lessee base and competitor market, a prudent lessor should be able to rate residual value at four to five. Below that rating some risks were taken or decisions made that suggest lower returns might be acceptable to a lessor.

The second segment, the most interesting in the poll, is the new narrowbody engines, the CFM LEAP and Pratt & Whitney PurePower models. The orderbook for both types is incredible. The PurePower engine has sold more of the type at inception than the total engine sales of IAE in its 30-year history. The LEAP backlog stands at more than 12,000 engines.

Continued on page 16

These engines will be great assets to own long term but how to respond to the poll today in 2018?

Investor appeal is not great at the current time. Entry-into-service problems are significant as is normally the case for a new engine type. An investor must be cautious about any value diminution that might be associated with the early-production MSNs. Perhaps there are two scorings: short-term investor appeal is zero but long-term is six to seven?

Scoring remarketing potential is a similar problem. In the short term, remarketing potential does not exist. The manufacturers are supporting the product fully. In the long term, we expect scores would be much higher but difficult to predict. Once reliability is improved, remarketing opportunities may be limited until a first run of shop visits occurs.

Residual value will be strong but possibly not as robust as we see in the current narrowbody models. Why? The technology incorporated in both the LEAP and PurePower models may not have the same repair opportunities found in the components of the older models. For instance, the high ceramic content in the LEAP may require a full replacement protocol where all material removed is scrapped. That does not necessarily mean residual value will be lower but it certainly challenges the current model for engine residual value that incorporates a certain amount of used serviceable material that can be harvested from an older end-of-life engine.

The third market segment may be best described as older kit that still enjoys a sizable and sustainable underlying fleet. For purposes of discussion, the CF6-80B family is a good example of the type. The aircraft operated, the 747 and 767, are clearly in their twilight as passenger aircraft but there is a significant cargo market for the types and the engine is enjoying a revival and bump in value in 2018. Some of that value is simply from the need to harvest used serviceable material from run out engines and some maybe from what is termed as the Amazon effect, a new operator requiring a sizeable fleet for future cargo operations.

How do we rate that? There are mid-life lessors which know this market well and would respond as follows: investor appeal is all about price and creditworthiness now. There is no second or third run to recover from paying too high a purchase price or making a bad credit decision where the operator does not pay for time used. As the market is generally too efficient to allow bargain purchase prices, a rating of three to four is sensible at the right price with a good operator. Remarketing potential, however, is low, perhaps two to three, as the operator base continues to shrink.

GE Aviation GEnx Engine

"Purchase prices are high. The GE90 in full thrust, fully kitted configuration is more than $36 million. The GEnx, a newer type in the group, is generally at or about $30 million at full list price."

Joseph W O'Brien, chief commercial officer, ELFC

Residual value as noted is highly related to purchase price. At the right price a five to six score is warranted. If wrong, it could be a very poor investment indeed.

The fourth segment proves much more difficult to score. We would include all the widebody engines in the group except the variants for the A380. Although it is easily argued this is incorrect, the challenges across the types are similar and significant. Purchase prices are high. The GE90 in full thrust, fully kitted configuration is more than $36 million. The GEnx, a newer type in the group, is generally at or about $30 million at full list price.

Because of the high hour-to-cycle ratio, life-limited parts stacks are generally projected to have little or no replacement over the life of the engine. The user base is smaller and many of the programmes are dominated by comprehensive OEM support packages that include spares support.

Our ratings for a GE90 versus a Trent 772B or GEnx differ greatly but can be generally categorised as follows: investor appeal is highest with those more impressed by dollar ticket size than management challenges. In this category, a score of four to five is appropriate. For experienced engine lessors with diverse portfolios, three to four may be more appropriate.

Remarketing potential is tough. A score of two to three is warranted. Perhaps this is where the biggest challenge lies in the category. If you hold a long-term view, are patient and can afford to hold such an expensive asset off lease, opportunities will come. Depending on the type, that patience may be required for more than one year. Residual value scores for the category must be low, perhaps two to three given all the challenges.

The last segment, for want of time and space, includes the engine types with smaller fleets or specialist operations. This includes the regional jet engines, turboprop engines and the 717 and A380 variants. No doubt there are specialist lessors which would argue against such a grouping or the scoring. In this category, it is essential to know the operator base intimately to have investor success. Few mistakes can be made in order to avoid a poor investment.

Investor appeal is highly limited to such specialists and is therefore best rated at a low score of one to two. Remarketing potential is highly challenging and limited and therefore rated low as well – one to two. Scoring residual value in the group is all about price and depreciation policy. Prices should be low and depreciation more aggressive, although there is still a great deal of risk in investing in the types. A score of one to two is warranted because investors in the type will generally focus on an acceptable running return to minimal book value.

It is easily argued the categories and scorings are an oversimplification of an annual poll that presents a daunting task to complete. Many simply score the engine types they invest in but that is not the challenge presented. To score the whole of the poll, we must look at residual value and all of the factors and the respective weighting of each factor for each engine type.

As noted above, scoring 33 engine types with seven major categories of value to consider means each recipient needs to weigh more than 200 factors to respond in full. Few have the knowledge or time to do this. However, if you focus on the top 10 aircraft fleets and their subject engine variants, more than 70% of dollar value of the engine market can be scored and this is where the interests of most readers lie.

How best to invest? Know your risk appetite, understand the users of the engines invested in and employ competent staff in the legal, technical and marketing disciplines. In the engine world, residual value is the critical issue for any long-term investor.

Company Profile

Engine Lease Finance (ELF) is the world's largest independent spare engine financing and leasing company, specialising in the provision of flexible, short to long-term spare engine support packages for the airline industry.

Headquartered in Shannon, Ireland, ELF is owned by Mitsubishi UFJ Lease & Finance (MUL) based in Tokyo.

The ownership structure provides ELF with the underlying financing strength and stability required to satisfy the long-term financing needs of airlines and to meet the commercial challenges presented by today's rapidly changing world markets. ELF provides extensive funding at favourable rates, therefore ensuring low cost flexible financing for the airline. This strength is most recently demonstrated by the addition of more than one hundred and thirty engines from sale and leaseback and portfolio purchases worth more than $1.3 billion since the beginning of 2011.

ELF was founded in 1989 by its current CEO, Jon Sharp, with the purpose of satisfying the industry's demand for a quality, truly independent, engine leasing company providing operating leases for modern aircraft engines to airlines world-wide. After twenty-seven successive years of profits and portfolio growth the company now owns and/or, manages approximately 300 engines worth around $2.5bn. The current customer base includes more than 80 airlines and MRO organizations worldwide. ELF has served over 140 customers since its inception.

Our portfolio of spare engines consists of types from the following OEM's: CFM, IAE, GE Aviation, Pratt & Whitney and Rolls-Royce, enabling us to support our customers' Regional, Narrow-Body & Wide Body aircraft fleets, including E190, A320CEO, B737NG, A320NEO, B737MAX, A330, A340, B767, B787, B777 and B747.

ELF offers a comprehensive range of individually tailored financing and leasing-based products and services including:

- Spare Engine Purchase & Lease Back
- Medium & Long Term Operating Leases
- Short Term Engine SV Cover
- AOG Spare Engine Support
- Engine Acquisitions & Dispositions
- Engine & Portfolio Management Services

In addition to its Shannon headquarters, ELF has Sales & Marketing representatives based in Singapore, London, Dublin, Boston and Oklahoma.

Please visit www.elfc.com to learn more.

Engine aftermarket goes on the record

The aviation industry is already looking into how this new technology could be used to cut costs. **Alex Derber** reports.

Public interest in Bitcoin is at record levels and reams of news are dedicated to its volatile price swings, regulatory oversight and true value. Yet, even if the huge spike in demand for cryptocurrencies proves to be our era's version of 17th century tulip mania, there is no denying that Bitcoin's underlying technology is sound – and has wider application.

That technology, the blockchain, offers a database of events that is shared among a defined or open group. Known as a distributed ledger, this record is kept up to date and available to anyone with access to the chain, all the time. It is not controlled from, or stored in, any single location.

Each event in the blockchain, such as a transaction, forms its own block and carries a timestamp. Once the event is approved, it is connected to the immediately preceding block, thus creating a linear chain. Each person in the chain grants approvals automatically, but no-one can decline an event, and it is very difficult to alter a block. Once a block is approved, it is viewable by everyone with access to the blockchain.

The net result is an event log that is secure, transparent and verifiable.

The International Air Transport Association and the airline industry are already investigating how the blockchain could be used to cut costs and financial intermediaries out of payment processes, but distributed ledger technology could also revolutionise the aftermarket.

Engine records

As an aircraft ages, its engines account for an increasing share of its value, until the point where they account for almost all the value of the aircraft. An engine's value is determined by its type, condition and maintenance history. Yet even a popular engine operating perfectly will have minimal resale value if it is missing six months of maintenance history.

Nonetheless, it is common for engine histories to be incomplete or time-consuming to research. This is no surprise given the array of potential actors in the supply chain – manufacturer, operator, owner, maintenance provider, parts supplier, etc – and the complexity of the equipment. Much of an engine's value is in the condition of its life-limited parts, some of which may migrate between different powerplants. Each of these parts should show back-to-birth traceability to ensure an adequate maintenance history for the engine.

Blockchain would provide clear benefits for traceability. Take a high-pressure turbine blade, for example. The part is manufactured by the original equipment manufacturer (OEM) and installed on Engine 1, which is delivered to Airline A; Airline A operates the part for a number of cycles before discovering a fault; the part is replaced and sent to a maintenance, repair and overhaul (MRO) provider for repair; the MRO then installs it on Engine 2 under a maintenance contract with Airline B. Each of those events is recorded in the blockchain for all to see, so if, say, a lessor then acquires the aircraft with Engine 2, that part's history is available at the touch of a button.

Challenges

While blockchain is ideal for complex supply chains such as in aviation, the more people using the chain, the longer it takes to approve each block or event. The technology also consumes considerable processing power and energy. Each Bitcoin transaction, for example, is estimated to consume about 250KwH – enough to power a television for about 100 days.

Then there are problems specific to aviation, with ownership of data likely to be a key concern. Modern engines generate huge amounts of data from their battery of sensors – up to one terabyte a flight. Only a fraction of this is currently analysed and acted on, but it still contributes to the evolving sciences of predictive and preventive maintenance, which promise airlines lower costs and longer time on wing.

Accordingly, data is valuable, and OEMs and MRO providers guard the information they glean from in-service and aftermarket operations. How they would do so if an engine's events were available to anyone connected with it – which is, after all, the essential utility of blockchain's application to engine record keeping – is open to question. And even if only essential events, rather than detailed data dumps, are recorded in each block, these could still prove useful to a company's competitors.

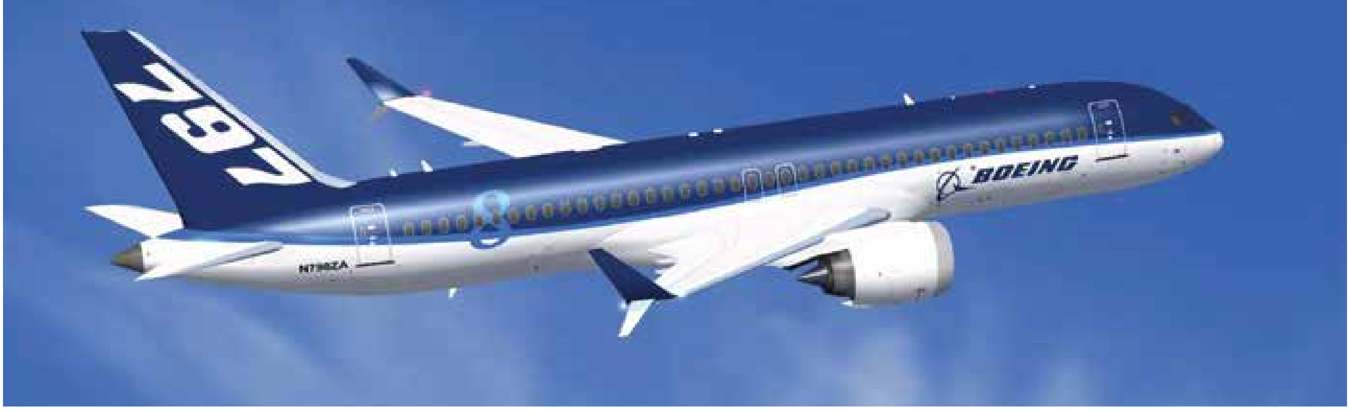
One solution might be hybrid ledgers, whereby certain events are encrypted and only viewable by the parties that need to see them.

Before such developments are considered, more prosaic hurdles must be overcome. Many maintenance histories are still in paper format and it will be a laborious process to collate them and order events so an engine's records can be transferred to the blockchain. Regulators must also be satisfied with the integrity of the process.

Still, digitisation is occurring already, so it makes sense for everybody to use the same underlying technology. If that technology is a distributed ledger, there are clear benefits for safety, reliability and ease of doing business in the engine aftermarket.

Boeing keeps **everyone guessing**

The US manufacturer is keeping its cards close to its chest about engine choices for its proposed new midsized aircraft, writes **Laura Mueller**.



Boeing has revealed rough plans for a new midsized aircraft (NMA); however, the US manufacturer has remained silent about whether it will offer a choice of engines on the widebody variant.

While Boeing executives have been discussing the proposed NMA for some time, they have not yet announced they are moving forward with the project. The manufacturer is putting together a business case to gain board approval to take the project from paper to the skies.

Last year, the Chicago-based original equipment manufacturer (OEM) created a programme office to support the NMA. It also appointed a former 787 executive to lead the initiative and push for a formal launch decision for the segment between the 737 Max 10 and 787-8 models.

Boeing's forthcoming aircraft, informally dubbed the Boeing 797, is expected to go through flight tests in 2024 and certification with service entry in 2025. The aircraft would have two variants: one with 225 seats, with 5,000 nautical miles of range; the other could seat 275 and fly up to 4,500 nautical miles.

Boeing does not intend to use the NMA to compete with the Airbus A321neo. Instead, the US manufacturer launched the 737 Max 10 as its A321neo competitor. It is moving up in terms of range and capacity with its newest aircraft concept.

The OEM is targeting a 30% unit-cost improvement over its 757 and 767 models.

This would be Boeing's first clean sheet aircraft since the 787, which had a challenging development process. But will it follow the same protocol as the 787 and offer two types of engines for the NMA?

The Dreamliner comes equipped with Rolls-Royce Trent 1000s and General Electric GEnx engines. However, as *Airfinance Journal* went to press, Rolls-Royce reported an accounting charge of $315 million to cover repairs to the engines on more than 200 aircraft in Boeing's 787 fleet and compensation to airlines for aircraft taken out of service for the engine retrofits, which will continue through 2022.

The problems with the engines first appeared in 2016, when All Nippon Airways discovered that turbine blades inside the engine were corroding faster than expected.

Sole-source supply

Boeing has indicated it is in discussions with all three big engine manufacturers (CFM, Pratt & Whitney and Rolls-Royce) regarding the NMA but no decisions have been made. Whether it decides to offer an engine choice will depend on a number of factors, including the expected size of the NMA market.

Boeing officials have predicted about 4,000 units are needed in this space, while operating lessor Avolon expects potential sales of between 3,500 and 4,000 aircraft.

Whether those anticipated sales justify more than one all-new engine programme, Boeing and the engine manufacturers will have to decide. However, if Airbus also were to launch a clean sheet NMA aircraft, then a choice of engine programmes becomes more likely.

“I'd be surprised to see a twin-aisle aircraft that has the same economics as a single-aisle aircraft.”

Martin Woods, regional head of marketing Asia, Airbus

Rival response

Airbus has questioned its competitor's potential offering of a twin-aisle aircraft in the NMA segment.

“I'd be surprised to see a twin-aisle aircraft that has the same economics as a single-aisle aircraft,” said Martin Woods, regional head of marketing Asia, at *Airfinance Journal*'s Korean Airfinance conference in Seoul. “But let's see what the future brings,” he adds.

Woods indicates that Boeing has been “marketing the aircraft to customers around the region”.

While Airbus's marketing head "does not have a view on the particulars of the 797", he notes that Airbus has already an "effective" single-aisle middle-of-the-market aircraft. "We also have 1,700 A330s in the market today with 117 operators," he adds.

Rumours have it that Airbus is considering an enhanced A321neo as a potential rival to any Boeing NMA. An upgrade of an existing design rather than a new design would save it steep development costs.

A leading appraisal firm questions whether Airbus should respond to Boeing's proposed new midsized aircraft simply by enhancing its existing product line.

"There is a gap, a natural gap that needs to be filled, so I am not sure whether the A330 coming down… and the A321 coming up, fills the gap," said John Vitale, president and chief executive officer of Avitas, speaking at *Airfinance Journal*'s Korean event, adding: "Airbus claims the A321 has all this range and that they can put in as many seats as they are talking about. Well, no you can't in an equal comfort level."

However, Vitale acknowledges a possible further stretch by Airbus of its A321neo, the A322, or enhanced versions, such as the A321neo-plus, or even an A321neo-plus-plus, "pushes out the timing of the NMA aircraft".

Vitale recalls a similar move by Airbus when Boeing came to market with talks of an all-new narrowbody aircraft. "Airbus moved the needle with the Neo," he says, adding: "I think we all can agree it was a successful strategy for Airbus. However, he admits any move to enhance Airbus's existing programmes does not eliminate the "gap that needs to be fulfilled somehow".

He says: "But perhaps Airbus is waiting for a second-mover advantage to see what Boeing comes out with, so they can design something that is just a bit better with the second one."

Boeing has already a secured significant win for its NMA, after the cancellation of Hawaiian Airlines' A330-800 order. There are no orders for the A330-800 aircraft after the carrier's switch to an order for 10 Boeing 787-9s.

Scott Hamilton of *Leeham News* broke the story of the widebody swap in a report on 22 February. *Leeham News* indicated that Boeing's effort to displace the Airbus A330neo at Hawaiian is part of an "all-out, hand-to-hand combat campaign by Boeing to kill the A330neo programme in advance of the potential launch of the Boeing 797".

The smallest A330neo overlaps with the market for Boeing's NMA. The campaign has been underway for months and the outcome was expected, it adds. "Airbus offered to cut the price on the -800 and also offered the A350-900. The latter always was considered too big by carrier executives."

> *Airbus claims the A321 has all this range and that they can put in as many seats as they are talking about. Well, no you can't in an equal comfort level.*
>
> **John Vitale**, president and chief executive officer, Avitas

At the Korean event, Vitale of Avitas and David Tokoph, chief operating officer, Morten Beyer & Agnew, said they did not believe the A330-800 would be part of Airbus's product line in five years' time.

The two appraisers were asked for their views on the future of the widebody after the report that Hawaiian Airlines had swapped its order for an unspecified number of 787-9s. The carrier also has purchase rights for 10 additional 787s.

General Electric GEnx engines will power the 787-9s, and Hawaiian expects to take delivery of the first aircraft in the first quarter of 2021.

Speaking on a fourth-quarter earnings call, Air Lease chairman Steven Udvar-Hazy noted that while Airbus had a little scope to alter the A321neo, it was the lessor's belief that "with the current management changes and issues Airbus is facing" the stretch probably was not "their number one priority right now".

Service boost

While the number of engine sources on the NMA is unclear, an aerospace analyst is certain that Boeing will not being targeting the takeover of one of its major engine suppliers as part of an effort to triple its services revenue to $50 billion during the next five years.

"That's not a good move," said Kevin Michaels, president of Aerodynamics, in response to a question about whether Boeing is likely to buy GE Aviation now that its troubled parent is looking at strategic alternatives. "GE could get you to those sort of numbers, but it also comes with risks, such as eliminating Airbus [as a GE revenue stream]."

Boeing is looking to boost its service business and vertically integrate parts of its aircraft supply chain, but now all moves would make sense, adds Michaels, speaking at the Pacific Northwest Aerospace Alliance conference in February.

"At best, engines are a recipe for disaster, but that is where the big money is, especially if you want to get to $50 billion," he says. "Maybe Boeing shouldn't be turning wrenches on engines, but perhaps it will look to collect royalties in the engine aftermarket. I could see that conversation taking place."

Boeing's services unit revenue grew by 5.5% to $14.6 billion in 2017 and the growth rate is forecast to be even higher this year.

Boeing Global Services chief Stan Deal has indicated that part of the $50 billion target would "clearly involve" acquisitions.

The manufacturer recently formed a joint venture with Adient, an auto parts business, to develop and manufacture economy seats. Boeing says the move is in response to delays in seat production and capacity constraints from suppliers Rockwell Collins and Zodiac Aerospace.

Michaels points to nacelles as another possible area of vertical integration "that might make sense as Boeing already has the propulsion centre of excellence", he says, adding: "Airbus is also heading this way."

He also flags aircraft interiors, flight control computers because "Airbus has been making its own since the A380", as well as avionics, particularly aircraft data, as other areas of possible in-house integration for the manufacturer.

Michaels believes Boeing's push into the lucrative aftermarket has helped to fuel the merger of its largest suppliers, United Technologies and Rockwell Collins.

"Was this merger facilitated in part by Boeing wanting to vertically integrate? I think it helped. Collins has always said 'no' to everyone who wanted to buy it, but then in 2018 they say 'yes'. You need to ask why in 2018 they said 'yes'. Boeing's move was not the only reason, but it was part of the logic" he adds.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Shop visits get **more expensive**

Geoff Hearn looks at the market for engine maintenance, repair and overhaul, and finds it is thriving.

Engine original equipment manufacturers (OEMs) have tended to be more involved in the maintenance of their products than airframe manufacturers, and this has increased as engine technology has become more complex. The introduction of the latest-generation of narrowbody engines from CFM and Pratt & Whitney looks likely to increase further the manufacturers' participation in the maintenance of their respective engines.

Given the value of the engine aftermarket, the manufacturers' interest is unsurprising. Industry forecasts suggest that the civil aviation maintenance, repair and overhaul (MRO) market is worth about $70 billion annually, with engine maintenance expenditure representing about 40% of the total. It is predicted that the figure will reach more than $100 billion a year in the next 10 years and that the engine sector will account for an increased portion of the expenditure.

Despite this apparently healthy trend, there is arguably over-capacity on the supply side of engine MRO services, and some observers believe there will be more consolidation among the providers.

However, Richard Brown, principal, ICF, says that much of this overcapacity is attributable to organisations, particularly airlines, which have capability on a variety of engines, but are not in a position to compete effectively for third-party work. He believes that the top tier of engine MRO providers will see increasing demand and that the OEMs are keen to form partnerships to deal with this demand and spread the requirement for investment in engine-overhaul shops. "It's a good time to be an OEM-aligned engine MRO shop," he suggests.

The market dynamics for engine maintenance continue to evolve as technology becomes more complex and the introduction of engines such as the PW1100 and LeapX marks a further evolution.

New-technology engines, while much more fuel-efficient, are operating at ever higher temperatures and pressures, resulting in more expensive engine overhaul shop visits to restore and replace increasingly high-tech materials. This contributes to a higher growth rate in the value of the engine MRO market compared with the equivalent rate for airframe maintenance. ICF predicts that over the next 10 years engine MRO will increase by an average of 4.5% a year. The equivalent figure for airframes is 2.8%.

The complexity of modern engines has increased the requirement for engine overhaul shops to invest heavily in tooling and test equipment, while improved engine reliability has led to increased on-wing times, which in turn results in fewer shop visits. The net outcome is that there are fewer overhauls but the average cost of each one has substantially increased over recent years.

The combination has led to fewer overhaul shops and the virtual disappearance of completely independent providers of overhaul services for the latest technology engines. There are new facilities being set up but, in general, they involve some form of partnership with the OEMs. These can take the form of fully fledged joint ventures but, increasingly, OEMs are favouring commercial agreements on specific engine types, which may (or may not) allow the engine shop to compete with the OEM on other engine types.

Historically, as an engine type matures the diversity of suppliers of engine services increases. Whether this trend will be repeated for newer engine types is as yet unclear, but the sheer volume of single-aisle engines that will need overhauls suggests there will be scope for independent organisations to enter the market.

The key difference between engine and airframe maintenance is that the cost of engine overhaul is dominated by the cost of parts, whereas airframe maintenance is labour intensive. Estimates vary, but the industry consensus is that about 80% of an engine overhaul cost is attributable to the new parts required.

Unlike providers of heavy maintenance for airframes, engine shops cannot compete by leveraging lower labour costs. This means that engine manufacturers, which set spare-part prices, can effectively control the pricing of the overhauls of their engines.

This situation is mitigated to some extent by an increasing availability of surplus used parts (See Second life, page 26). This increased availability arises from the trend towards shorter lives for commercial aircraft and early part-out of airframes and engines.

The engine manufacturers appear to have won the battle to preclude the use of non-OEM parts-manufacturer approval (PMA) material, but there is little they can do to restrict the use of properly documented surplus parts. The size of the surplus parts market is difficult to quantify, but based on discussions for this article, *Airfinance Journal* believes it to be about five times larger than the PMA market.

> *"It's a good time to be an OEM-aligned engine MRO shop."*
>
> **Richard Brown**, principal, ICF

Surplus parts provide an opportunity for third-party MROs to compete on price with the OEM-aligned engine shops, particularly for more mature engine programmes, which represent a sizeable market.

ICF estimates that more than 50% of the current installed engine fleet (about 60,000 engines) comprises of powerplants for 1990s-technology aircraft. It forecasts that the installed fleet will increase by about 20,000 engines over the next 10 years.

The consultancy company's research also suggests that current-technology mature engines will still drive the majority of MRO demand past the middle of the 2020s.

Keeping the customer satisfied

A key recent trend, according to ICF, is that OEMs have been recognising that customer requirements change across the lifecycle of engines and are trying to become more competitive in the mature phase, by embracing surplus parts, and being more flexible in their overhaul workscopes – recognising that not all engines need to be restored to full-life condition.

All-inclusive fixed-price maintenance agreements are increasingly the choice of operators. This is particularly true for new-technology engines where quantifying maintenance costs is still difficult because of a lack of in-service experience. Operators are disinclined to expose themselves to the risks of unpredictability, albeit that manufacturer guarantees should mitigate such risk. Because they are more able to predict and, to some extent, control maintenance costs, manufacturers are in the strongest position to offer all-inclusive packages. It is difficult for third parties to provide such packages because they are exposed to the same risks as operators.

The take-up rate of all-inclusive packages on the LeapX compared with the CFM56 is indicative of the general trend. *Airfinance Journal* research suggests that 30% to 35% of CFM56 engines are covered by all-inclusive schemes, whereas virtually 100% of the LeapX engines already delivered are covered by the manufacturer's scheme.

While manufacturers and operators may see obvious benefits from the all-inclusive packages, they pose some problems for the aircraft financing community. In particular, the transferability of built-up reserves when there is a change of aircraft lessee has proved problematic. The OEMs have come under pressure to provide solutions to the financing community.

Rolls-Royce has arguably led the field in offering all-inclusive maintenance packages. The trend to high investment/low throughput has been evident for many years in the overhaul of large engines and has therefore been a factor in developing Rolls-Royce's strategy in the after-sales market. The extensive inclusion of its engines in all-inclusive programmes has caused some conflict with financiers, but the UK manufacturer has been working to keep the leasing community on-side and recently announced deals with AerCap, Avolon and DAE for its LessorCare programme.

The company says the programme comprises one single, comprehensive agreement for all of its Trent engine types, which gives lessors access to services throughout the engine lifecycle. As part of the programme, Rolls-Royce will provide transitions services to help aircraft move faster and more efficiently between leases.

As part of LessorCare, Rolls-Royce will offer its operating lessor engine restoration (Opera) service. These services are in the early stages of implementation and whether they fully resolve the engine maintenance issues faced by lessors and other financiers remains to be seen, but *Airfinance Journal* understands that other OEMs are coming under pressure from lessors to develop similar solutions. CFM has offered its portable maintenance for lessors (PML) programme for a number of years, but its profile has been low-key since its launch in 2012.

Third parties

Despite the difficulties of competing against the OEMs, some of the long-established third-party and airline MROs continue to build their presence in the engine overhaul and after-sales market. Most of the larger players offer an extensive range of services. There is, for example, a trend for the major MRO organisations to enter the engine leasing market.

The leasing capability tends to be targeted at short-term deals to support overhaul activities rather than competing with the more established engine finance companies, but it is indicative of the need for third-party MRO organisations to be innovative if they want to compete with the OEMs in the lucrative engine sector.

Manufacturers adapt to change

Engine OEMs are offering more innovative support packages to keep ahead of the game.

It's rare to see a new widebody engine sale unaccompanied by a maintenance contract with the manufacturer. Some 90% of Rolls-Royce Trent engines, for example, are covered by TotalCare support packages, most of which are agreed at the point of engine sale. In 2017 Rolls-Royce's services business grew 12% to constitute 53% of its civil aerospace revenues; the rest came from original equipment sales.

Other original equipment manufacturers (OEMs) are also expanding into the aftermarket, and while this trend was once largely confined to widebody powerplants, now narrowbody engine manufacturers are seeking a bigger piece of the pie. CFM, a joint venture between GE Aviation and Safran Aircraft Engines, reports that about half of its new LEAP engines are sold with long-term maintenance agreements, whereas only about a third of the active CFM56 fleet is maintained by either of the CFM partners.

Happily for independent maintenance, repair and overhaul (MRO) providers, as well as airline technical departments that offer third-party services, the CFM56 is the most popular engine in the world, which leaves a sizeable overhaul market to play for, one that also includes a big chunk of the IAE V2500 fleet. Supplementing this are services for mid-life and older engines, to which the manufacturers' long-term, cost-per-flight-hour (CPFH) support contracts are often unsuited. However, this is changing as OEMs home in on a section of the aftermarket sometimes previously left to other MRO providers.

Rolling with the changes

In February 2016, Rolls-Royce CEO Warren East explained the evolution of the company's aftermarket strategy: "If we've got an old engine that customers are only going to keep for a relatively limited period of time, then tying in a long period of service agreement doesn't make sense," he told investors.

"If we've got an old engine that customers are only going to keep for a relatively limited period of time, then tying in a long period of service agreement doesn't make sense."

Warren East, chief executive officer, Rolls-Royce

The average age of the Rolls-Royce Trent fleet is about seven years, but increasing numbers of early-build engines from the Trent 500, 700 and 800 lines are entering the mature phase of their lives.

"We have recognised the Rolls-Royce Trent engine fleet mix is changing," says Lesley So, head of marketing for aftermarket services, civil aerospace, adding: "In response, Rolls-Royce is transforming its services on a number of fronts and innovating to keep ahead of the game – with choice, flexibility, competition and capability core themes."

In January 2016 the OEM launched SelectCare, a new type of support deal designed to sit between its comprehensive TotalCare offering and ad hoc, one-off overhaul contracts. Via SelectCare, airlines pick the services they require across an agreed number of engine shop visits on a CPFH basis.

"This creates a new business model, where a customer continues to receive cost predictability, but takes on more time-on-wing risk," comments So.

Launch customer American Airlines picked SelectCare to replace the mix of TotalCare and MRO Services contracts that had previously supported its RB211 engines.

In late 2015, Rolls-Royce also launched TotalCare Flex, which offers asset value release and partial overhauls to allow sunset engines to reach the end of their service lives. Cathay Pacific was the launch customer for this service and was soon followed by other airlines, as well as lessor AerCap.

AerCap's signature was an important development, since traditional CPFH maintenance deals once sat uncomfortably with the leasing industry, partly because they complicated the transfer of assets between operators. They can also restrict engine lessors' ability to do certain sale-and-leaseback deals, says Jon Sharp, president of engine lessor ELFC. In such cases lessors demand a maintenance reserve to cover hours already burned off an engine, which means an airline might pay twice for maintenance: once via its original service contract with the manufacturer, and once to the reserve.

However, Rolls-Royce points out that one of the key benefits of its TotalCare Life service is that the engine is always fully reserved, meaning that the original operator or lessee has paid for the hours used. It adds that this reserve is fully portable to a follow-on operator or lessee should they take a long-term service agreement with Rolls-Royce. Furthermore, Rolls says, under its lessor-specific contracts the value of the reserve is transferable to the lessor at any time the aircraft is off lease.

"I don't think TotalCare deals restrict sale and leaseback (SLB) of engines or aircraft at all," says Ben Hughes, business development director of Rolls-Royce & Partners Finance - the OEM's engine leasing arm. "Independent leasing companies have done SLB of engines where there is a TotalCare in place with the operator."

Recognising it needed a tailored solution for lessors, in 2017 Rolls-Royce announced LessorCare, incorporating transition services, lifecycle asset management and customer support. For the OEM, it's an important development, since lessors now own about a third of the Rolls-Royce-powered widebody fleet, a share the manufacturer expects to rise to half once the current aircraft backlog is delivered.

Developed with input from AerCap, the service offers return condition management, remarketing support and maintenance value portability. "It allows lessors to pay for what they want, when they need it," says So.

AerCap, Avolon and DAE signed up as the first LessorCare customers in January 2018.

General manoeuvres

GE Aviation revamped its service offering about the same time as its British rival. In 2016, the US manufacturer consolidated its support options into four products:

- **TrueChoice Flight Hour**: the traditional long-term support contract, billed on a CPFH or cost-per-cycle basis.
- **TrueChoice Overhaul**: for customers which prefer to pay on a time-and-materials basis, this offers customised workscopes and materials solutions.
- **TrueChoice Transitions**: designed with lessors in mind, this service facilitates asset movements between operators with services such as green-time leases, engine exchanges, module exchanges, materials consignment and portability products. Twin goals are to maximise residual value and ensure maintenance spend remains proportional to the remaining life of the engine.
- **TrueChoice Material**: this offers component repairs and a huge stock of used serviceable material to help airline and independent MRO providers keep down the cost of overhauls.

"Our engine knowledge and analytics gives opportunities for tailored workscoping required to match engine maintenance to subsequent operating horizons," says Brian Ovington, director of marketing for GE Aviation Services.

"The fact is we have large fleets that entered and are approaching the mature phase in the past five years and our customers want solutions from us," he adds.

About a third of the GE and CFM fleet is covered by an OEM services contract, although Ovington says the company

"As the early Trent fleet engines continue to mature, Rolls-Royce has seen growing numbers of Trent-powered aircraft transitioning from their first owner or operator to second-tier airline operators."

Lesley So, head of marketing for aftermarket services, civil aerospace, Rolls-Royce

doesn't have set goals to increase this. "We don't have targets. Customers choose," he says.

Even so, in 2017 GE Aviation's revenue from services – which include spares sales and military engine support – increased to $16.6 billion, or 61% of the company's total sales. That's up from 52% in 2015 and more than services' equivalent share at Rolls-Royce, although direct comparisons are difficult since GE includes defence in its aviation services reporting.

Market impact

Since the start of 2016, when GE Aviation and Rolls-Royce introduced – or at least better promoted – alternatives to comprehensive, CPFH maintenance deals, their services revenues have risen 29% and 15%, respectively. How much of that growth is down to those alternatives is impossible to ascertain from the companies' financial statements.

Yet it is clear that years of relatively low oil prices have helped push up the average age of the global fleet, which means more opportunities for support of older engines. Consultancy IBA has calculated the average aircraft age rose from 8.9 years in 2006 to 11 years by 2016. The global fleet is also split between around 3,000 or so airlines and lessors, according to *Airfinance Journal*'s Fleet Tracker. Most of these are too small to afford new equipment, and are also unlikely to favour long-term CPFH support packages.

"As the early Trent fleet engines continue to mature, Rolls-Royce has seen growing numbers of Trent-powered aircraft transitioning from their first owner or operator to second-tier airline operators," observes So.

GE attributes last year's increase in services sales to higher sales of civil and military spare parts, as well as higher prices. Rolls, meanwhile, credits "increased engine flying hours and higher time and material activity", for its own rise.

The first to feel any impact from OEMs' expanded service offerings are likely to be independent and airline-affiliated maintenance providers, which tend to specialise in narrowbody and older-widebody engine types. Such providers exist in a state of 'co-opetition' with the OEMs, whereby they compete for certain maintenance customers, but are sub-contracted others as an authorised service centre of the manufacturer.

Arizona-based Standard Aero, for example, supports the General Electric CF34 and the CFM56 and is a GE authorised service centre.

"We see a trend of major engine OEMs looking to established, aligned partners to outsource mature platform engine MRO, component repair and component manufacturing," says Russell Ford, Standard Aero's CEO.

"On certain key customer accounts, OEMs are likely to continue to compete to be the prime interface," he adds. "We don't expect this to be more or less true going forward. However, our philosophy is that being aligned with the OEMs as value-added partners supporting their aftermarket approach will lead to opportunity for us."

Air France Industries KLM Engineering & Maintenance provides another example of co-operation. After its parent ordered 25 A350s in 2013, the MRO, already a specialist in another widebody engine, the GE90, wanted to add the A350 XWB to its capabilities, and sell maintenance services to third parties. Although Rolls-Royce resisted, several years of tortuous negotiations resulted in AFI joining the Rolls-Royce CareNetwork in 2017. So points to the CareNetwork as an example of how the Rolls-Royce aftermarket is shared with non-OEM maintenance providers.

It's also worth noting that the OEMs often sign new types of maintenance contract with repeat customers. "The majority of SelectCare, TotalCare Flex and LessorCare selections are from existing customers," states So. At GE, Ovington acknowledges competition for services with non-OEM providers, and says that customer choice "depends on the value we bring versus what non-OEM maintenance providers can".

It seems, therefore, that the market for maintenance of maturing engines presents opportunities for both OEM and non-OEM providers, although the latter should focus on forging relationships with the manufacturers to stay relevant.

Second **life**

Alex Derber looks into how growing supply and demand for used serviceable material is influencing the engine market.

Through the middle of this decade, a combination of cheap finance, new aircraft products and buoyant passenger demand led to a glut of aircraft orders and the accumulation of record backlogs with their manufacturers. At the same time, however, the price of oil plunged, causing many airlines to defer deliveries as it became viable to operate older aircraft and engines for longer.

Other factors contributed to this trend, notably the better-than-expected reliability of certain narrowbody engine types, and the delivery delays and technical problems that have affected some new-technology equipment.

According to *Airfinance Journal*'s Fleet Tracker, more than a quarter of the in-service CFM International fleet of about 12,000 engines is more than 15 years old. For Rolls-Royce, that figure rises to 43%, although the average age of Trent models is seven years, says the original equipment manufacturer (OEM). Almost one-third of General Electric engines are older than 15 years.

Operators of older engines enjoy lower capital costs, but face a dilemma when it comes to maintenance, because a full performance restoration can cost more than an old engine is worth.

A notable cost driver is the replacement of life-limited parts (LLPs). Maintenance, repair and overhaul (MRO) providers have developed various ways to mitigate such costs, one of the most important of which is the installation of used serviceable material (USM) rather than expensive new parts.

"USM has always been a major contributor to an overhaul cost-saving strategy," says Abdol Moabery, chief executive officer of Florida-based GA Telesis, an aircraft and engine asset manager and parts provider.

"It is difficult to justify new replacement parts in a mature engine when USM is available," he adds.

Used up

The USM market for engines was worth $2.7 billion in 2016 and is set to grow by about 6% a year to reach $5 billion in 2026, forecasts consultancy firm ICF.

"There has been significant growth in USM activities in recent years," says Patrick Holzkamp, head of purchasing engines and used parts for MTU Maintenance.

He adds: "Over the past couple of years there has been above-average fleet growth, and production rates in 2017 have not been high enough to cover demand. This, in combination with low oil prices, has meant that older aircraft have become attractive again to fill the demand gap."

Holzkamp also points to falling aircraft retirement rates and a wave of narrowbody engine overhauls as contributors to rising USM demand.

The most popular second-hand parts are often LLPs with enough cycles left on them to cover a complete engine run. Holzkamp says that high-pressure turbine (HPT) and high-pressure compressor airfoils are eagerly sought. That is no surprise given that a new set of CFM56-7B HPT blades sell for $1.16 million, versus about $700,000 for a used set.

"Demand is high, with CFM56-5B/-7B and V2500 USM through the roof," says

> *"Over the past couple of years there has been above-average fleet growth, and production rates in 2017 have not been high enough to cover demand. This, in combination with low oil prices, has meant that older aircraft have become attractive again to fill the demand gap."*
>
> **Patrick Holzkamp**, head of purchasing engines and used parts, MTU Maintenance

James Bennett, director of engine services for Aerfin, a UK company that specialises in solutions for end-of-life aircraft and engines.

This demand can spill over to less common engine types, such as the CFM56-5C, which powers the out-of-favour Airbus A340. Nevertheless, it shares about 150 part numbers with the more popular -5B and -7B, making it a popular candidate for teardown. In February, Iberia sold two CFM56-5C-powered A340-300s to disassembler KP Aviation.

Research by engine lessor ELFC found that the price of new replacements for selected LLPs on the CFM56-7B rose 62% between 2008 and 2014, and by 51% for certain V2500-A5 LLPs. Since materials can form up to 70% of the cost of an engine overhaul, such rises can have a huge influence on overall maintenance cost. However, industry experts question whether parts price inflation is driving demand for USM.

"One mustn't forget that the OEMs [which sell new parts] are the largest players in the USM market, so this topic is much more complex than just pricing of new material," says Holzkamp, adding: "Their use of USM is dependent on factors such as cost control, contractual commitments, management of material supply, as well as overall supply chain management."

Furthermore, Moabery points out that engine manufacturers, which might be expected to prioritise sales of new parts, have been active in USM for at least two decades, and are in large part responsible for the acceptance and growth of the market. This is all tied to the growth of engine service deals billed per flight hour, rather than on a time-and-materials basis, and under which the manufacturers lower their own costs by installing second-hand parts.

"Every OEM uses USM because it simply makes economic sense without compromising reliability," he says.

Of course, airlines have also played a key role. When USM was first introduced, it was mainly used to resolve aircraft-on-ground emergencies, and an airline tended to install surplus material from its own fleet only. Nowadays, in contrast, many large airlines have teams dedicated to sourcing USM globally, or they have set up relationships with parts providers to ensure a steady supply of USM.

One example is Delta Air Lines subsidiary Delta Material Services, which acquired a big chunk of inventory from parts provider Aeroturbine.

Sourcing USM

Increasing demand for engine USM has drawn new players to the market, but at the same time the supply of material has remained tight because of deferred retirements and the impressive reliability of engines such as the CFM56. "There is currently a supply shortage of teardown engines," says Moabery.

"Every OEM uses USM because it simply makes economic sense without compromising reliability."

Abdol Moabery, chief executive officer, GA Telesis

ICF forecasts 9,300 aircraft retirements in the next 10 years, of which more than one-third are expected to be the A320 and Boeing 737NG types that carry engines currently sought for part-out.

Holzkamp observes that "competition for teardown engines is strong" and cautions that the USM market is a risky business, where swings in availability, demand and technical standards can induce volatile pricing. MTU mitigates this, he says, thanks to its engineering and repair capabilities, as well as connections to asset owners and material suppliers.

Signals of teardown demand can be found in the ages of aircraft acquired for part-out. Traditionally, aircraft would serve for about 20 years before being sent to the desert or pressed into freighter service, but in some cases they are heading for part-out at a much earlier stage. In mid-2017, for instance, Aerfin tore down an A319 just 10 years old. A few months later, Touchdown Aviation acquired a 2004-vintage A319 powered by CFM56-5B engines for disassembly.

"Aerfin has torn down engines as young as 10 to 12 years old to support our material supply programmes with airlines and engines," says Bennett. "However, passenger-to-freighter programmes are also seeing the life of engines extended."

Given that most of the value of mature aircraft rests in their engines, it might be concluded that the engine USM market is driving ever-younger aircraft to the scrap yard. "Strong USM demand pushes down teardown ages – when there are engines available to tear down," says Holzkamp.

"The value of an operating engine still exceeds the teardown value, so the demand for USM is not the tail wagging the dog."

Abdol Moabery, chief executive officer, GA Telesis

That caveat is important because demand for current-generation aircraft outweighs demand for their components. "The value of an operating engine still exceeds the teardown value, so the demand for USM is not the tail wagging the dog," comments Moabery.

To ensure a continuous supply of USM, it helps to operate at scale. An MRO provider such as MTU, for instance, can leverage fleet-wide support agreements with large airlines to salvage material from retiring aircraft. "MTU Maintenance is also able to use ageing engines from its own lease pool as a natural pipeline of engines being dismantled for USM support," says Holzkamp.

GA Telesis has its own leasing pool to draw on, as well as important supply chain relationships. In January, for example, it contracted Aero Engine Solutions to supply OEM-repaired and serviceable CFM56-5B/-7B parts to its Helsinki overhaul shop.

Alternatives

USM is, of course, just one source of demand for older aircraft and engines, and just one of several strategies to lower the cost of overhauls. Mature passenger aircraft are also sought for freighter conversion, and MRO providers with the right engineering capabilities can offer repairs as well as replacements.

Non-OEM-branded parts, known as PMA parts, are another alternative. Yet their use can affect the residual value of assets, even though they are just as reliable as their branded counterparts.

Older engines are also sought for green-time leasing, whereby an engine is leased for a short period to burn off its remaining cycles or flight hours before part-out.

"Some engines' economic lifecycles are actually being extended for green-time leasing purposes," notes Bennett, who adds: "This is mainly driven by a combination of low oil prices and delays in the delivery of new-technology aircraft."

As an example of how green-time leasing can stand in for USM, Bennett flags up a short-term rental deal for a CFM56-5C4 involving Aerfin, SR Technics and Philippine Airlines. "For this engine type it was cheaper to exchange whole engines, and run them down on green time, than put the engine through a shop visit and use USM to repair the engine," he says.

Nonetheless, USM will remain a vital tool to keep down overhaul costs and extend the economic lives of maturing engines.

Moabery concludes: "Simply said, billions a year are saved by airlines using used LLPs."

A (serviceable used) part of the story

In summer 2016, Ben Hughes took over responsibility for the V2500-A5 parts trading business at Rolls-Royce & Partners Finance, the OEM-affiliated engine leasing joint venture. Since then, the business has grown quickly and has recently expanded into Trent 700 used parts.

Rolls-Royce & Partners Finance (RRPF) is the engine leasing company with the largest portfolio of V2500-A5 and Trent engines. RRPF has always supported the serviceable used parts market through the supply of carcass engines for tear down, primarily to its 50% shareholder, Rolls-Royce.

However, in 2015, RRPF directly entered the market after it purchased the V2500-A5 serviceable used parts business from Rolls-Royce. Other engine leasing companies have followed this trend of vertical integration.

The greatest challenge that independent parts traders suffer from is how to secure a steady supply of engines for tear down to replenish their stock. The strategic advantage that engine leasing companies have in this market is material supply. Engine leasing companies naturally have access to a steady stream of carcass engines from the older engines in their portfolios. This means that a parts trading business integrated with an engine leasing company can provide reassurance to its customers that it can continue to support them whatever the market conditions.

For the engine lessor, the used parts business also provides a useful way of expanding its services and deepening its relationships with existing customers. Used parts can become another valuable touch point with airlines, leasing companies and maintenance organisations.

I have been managing the RRPF used parts business since mid-2016. My experience up until this point had mainly been the structuring and selling of high-value long-term finance services for engines. These kinds of transactions are high-value, low volume and almost always customised to the asset, customer and engine type. My assumption walking into the used parts market was that the business would be the opposite of this, namely, low-value, high-volume and very standardised.

However, every part has a story. A few parts have enjoyed a simple life flying with a single airline in easy-going regions such as Europe. Most have had a more interesting life history, taking in different airlines, multiple thrust ratings, the occasional severe operation and several repairs. This makes the business interesting but also challenging. The challenge is to make the complex as simple as possible. Quality technical records are critical, as is pricing and great customer service.

The value proposition for buying serviceable used parts is simple and attractive. Seventy percent or more of the cost of a performance restoration shop visit is material. Used parts trade at a significant discount to new parts and therefore using such material will generate substantial cash savings at each shop visit. The use of what are in effect recycled materials is also arguably a very responsible way to reduce the environmental impact of mature engines.

The market has recognised this value proposition and demand for serviceable used material is growing. The V2500-A5 used material market is only really getting started with at least as many, if not more, shop visits to come as have been completed to date. There are about 6,500 engines in service and the majority have not reached their second shop visit yet. As the engine leasing company with the largest portfolio of V2500-A5 engines, we are excited about the potential of the market for serviceable used material coming from our engines.

We are also just starting to see the budding development of a market for Trent 700 used material. This engine is the most popular type on the very flexible A330 aircraft with more than 1,600 engines in service. The current operator base is diverse and there is a sizeable number of aircraft owned by leasing companies. As the larger first-tier airline fleets fragment, it is likely that smaller operators will want value focused maintenance services built around serviceable used material, as well as low-cost access to spare engines and rotable components. RRPF's increasing capability in used parts will enable us to support customers wanting such integrated asset-based services.

We have started to write a new chapter of the RRPF business in the world of used parts. It has always been an important, if indirect, part of our business, but now we are an active market player with a deep supply of material, broad customer relationships and increasing capability. Our parts business is growing significantly from a low base. We are seeing increasing demand and are working hard to meet and exceed our customer expectations. We are excited about the potential of the serviceable used parts market for our V2500-A5 and Trent 700 engines. Serviceable used material is now very much part of the story of Rolls-Royce & Partners Finance.

"The challenge is to make the complex as simple as possible. Quality technical records are critical, as is pricing and great customer service."

Ben Hughes, Rolls-Royce & Partners Finance

Three new engines in quick time

Airfinance Journal examines the UK manufacturer's latest offerings: the Trent 1000-TEN, the Trent 7000 and the Trent XWB-97.

UK manufacturer Rolls-Royce is on course to introduce three widebody new engines in less than nine months.

In February, the Trent XWB-97 was the second new Rolls-Royce widebody engine to enter into service in less than two months after the Trent 1000-TEN took to the skies at the end of last year powering the Boeing 787 Dreamliner. A third new engine, the Trent 7000, is also set to enter into service later this year.

Trent 1000-TEN

The Trent 1000-TEN (Thrust Efficient New Technology) was launched on Boeing 787 models in November, celebrating a hat-trick of firsts when it powered the first flight of the Boeing 787-10, having been the powerplant for the debut flights of the 787-8 and the 787-9.

The engine is an evolution of the current Trent 1000, which received certification in August 2007. Entry into service was delayed to September 2011 after a series of delays to the 787 programme.

It is designed to power all variants of the 787 family, including the new 787-10 model. It entered into commercial service on 23 November with Norwegian, Scoot and Air New Zealand.

The Trent 1000-TEN has been developed with the use of technology derived from the Trent XWB programme for the Airbus A350, as well as Rolls-Royce's Advance engine research effort. The engine incorporates new technologies to deliver increased thrust and improved efficiency for the aircraft.

The Trent 1000-TEN powered an 18-hour test flight during which a 787-8 aircraft drew a giant outline of the aircraft across the US. It features a scaled version of the A350's Trent XWB-94 and Advance 3 core technology.

Fuel burn is reduced through its improved intermediate pressure compressor where the rear stages spin at higher speeds. Rolls-Royce designed an improved version targeting at least 2% better fuel burn than the current Trent 1000 Package C, and the manufacturer says the engine offers up to 3% lower fuel burn than the competition.

The 10:1 bypass ratio is the highest of any Trent, making it the quietest engine on the Boeing 787 aircraft today.

More than 85% of the engine's thrust is generated by the 2.8-metre diameter fan.


The Trent 7000 engine, which powers the Boeing 787

Trent 7000

The Trent 7000 was first introduced in 2014 at the Farnborough air show and uses a mix of elements from other engines that are either in use or under development. It is the seventh iteration of the Trent family of turbofans and is based on the Trent 1000-TEN architecture from the 787 models and the technology of the Trent XWB-84/-97s that equip the A350-900/-1000s.

The Trent 7000 will offer a thrust range of 68,000lbs to 72,000lbs and exclusively power the Airbus A330neo, the new engine version of the A330 family. TAP Portugal is the launch customer for the type and will receive its first A330-900neo by mid-2018.

The engine comes with a 20-blade, 112-inch fan compared with 97 inches for the Trent 700 that is 20 years older. It has the highest bypass ratio of any Trent engine. The overall pressure ratio increased to 50 from 36 as thermal efficiency improves thanks to Trent XWB core compressor technology.

The larger fan and higher bypass ratio need a low-pressure turbine with two more stages and, as a result, the engine will be 3,500lbs (1,600kg) heavier.

The Trent 7000 contributes to the A330neo's 12% fuel burn improvement compared with previous-generation aircraft, despite the additional weight and the extra drag from the wider diameter.

The engine is a step change in performance from the Trent 700 variant with specific fuel consumption reduced by 10% – twice the bypass ratio.

The lower fuel burn also means lower emissions, and the Trent 7000 meets both current and proposed future emissions standards for aero engines, as well as those for noise.

Trent XWB-97

The Trent XWB-97 engine, the latest and most powerful variant of the Trent XWB, entered service on 24 February 2018 with Qatar Airways' inaugural flight between Doha and London Heathrow.

The 97,000lb-thrust engine, which exclusively powers the A350-1000, builds on the success of the 84,000lb-thrust version of the Trent XWB, which had completed 1.3 million flying hours (at 20 February 2018) while achieving the best-ever widebody entry into service performance with a 99.9% dispatch reliability.

While there is very little visible or operational difference between the two Trent XWB engines, the higher thrust version employs a range of advanced technologies to produce extra thrust and optimum aircraft performance.

The front fan has the same number of blades and is the same diameter, at 118 inches, but will run about 6% faster. The engine core has been scaled up in size to cope with the consequential increased airflow into the compressor and the combustor and turbines will both run at higher temperatures.

The engine also features new materials and coatings for the high-pressure turbine blades, as well as an intelligent cooling system to ensure expected performance and efficiency can be delivered at the higher temperatures generated within the turbine.

The Trent XWB-97 engine features the same nacelle and the same engine architecture, but Rolls-Royce had to deliver an extra 13,000lbs of thrust. That thrust comes from the fan and compressor rotating more quickly, which the turbine needs to work harder to do that.

Rolls-Royce improved the fan system by getting more air flow through the same diameter, and grew physically the core of the engine. The manufacturer also inserted more materials and coatings to protect the engine life.

It wanted to maintain the commonality with the Trent XWB-84 model, by keeping commonality for the engineers. The manufacturer maintained the line replaceable units and toolings. It wanted commonality for the pilots, who fly the engines, and commonality for the airlines, which operate them.

The flight tests involved 10 development engines, running for three-and-a-half years and accumulating more than 11,000 simulated flight cycles.

At the Qatar Airways A350-1000 delivery, Rolls-Royce chief executive officer, Chris Cholerton, said the manufacturer would deliver one Trent XWB every working day at its peak from its facilities in Derby, England, and Berlin, Germany. "The Trent XWB-97 engine will be based on the Trent XWB-84 engine version, which was based on solid foundations."

The Trent XWB-84 has recorded more than 1,700 sales and accounts for just under 40% of Rolls-Royce group's orderbook. Both engines will be produced on the same assembly lines.


The Trent XWB=97 engine, which powers the Airbus A350-1000

Data-enabled technologies bolster lessors' engine management to effect major bottomline impact

Lessors are progressively utilising asset information-related enabling technologies to more effectively track engine status, location and future expectations, differentiating themselves from the competition and maximising maintenance revenue.

Engines constitute the chief drivers of lessors' maintenance cash flows. Engine performance restorations (PRs) tend to cost more than $2 million for narrowbody and $6 million for widebody aircraft, with life-limited parts (LLPs) adding another $3 million to $6 million to a lessor's cost base. Having up-to-date information and concrete expectations for engines is imperative for lessors to sustain a formidable competitive advantage.

Zeevo Group principal Joey Johnsen explains that "lessors can use this knowledge to reduce exposure, minimise top-up liabilities and maximise maintenance revenue – it all comes down to determining information important to your company's financials and deploying the right tools and processes to derive major bottomline impact".

Lessors can significantly improve their operations through enhanced asset focus:

- having accurate and current data on an engine's status;
- being apprised of an engine's current location (ie, is the engine in shop and to which aircraft it is attached);
- producing an accurate outlook of PRs and LLP replacements; and
- developing custom dashboards to visualise engine data better and leverage this information to manage end of lease or life plans.

Know your engine status

Shedding light on an engine's status with real-time and accurate data is the cornerstone of asset management. This strengthens a lessor's position over a wealth of facets for asset management, such as lease negotiations and portfolio management.

"When your engine data is stale, you are prone to getting blindsided by massive expenses – especially in case of repossession," says Angela Geremia, Zeevo Group's head of technical operations advisory services. "No one wants to find out last minute that a returning engine is in worse condition than expected – leading to excessive top-up liabilities and costly expenses to make it re-leasable."

Securing the engine data is no small task. It requires accurate reporting, verifiable data entry and buy-in from the relevant team members. Lessors implement a number of tools and procedures to obtain accurate engine data:

- create **standardised utilisation report templates** for lessees and establish a utilisation portal integrated with an asset management system to automate data entry and minimise errors;
- establish **automated data validation** and **notifications** to identify false data entry;
- develop **repeatable training material** to streamline onboarding for roles with high turnover;
- implement and maintain **a robust records management system** to enable stakeholders to go back to the source; and
- design **custom user-friendly interfaces** to empower greater buy-in from responsible parties.

"When your engine data is stale, you are prone to getting blindsided by massive expenses – especially in case of repossession."

Angela Geremia, Zeevo Group's head of technical operations advisory services

Custom dashboards that use visuals to filter out the noise and illustrate the information most pertinent to the decision makers

Know where your engines are

A lessor's ability to track an engine's location is only as good as the information received and captured within an asset management system. Defined procedures, workflows and notifications can keep the relevant stakeholders apprised, reducing the need for last-minute investigations of where their engines are or will be located.

Lessors utilise several methodologies to achieve comprehensive engine tracking:

- **use lessee provided records**, such as certificates of release and utilisation reports, to initiate workflow notifications for technical managers to keep them in the loop for engine status/location changes and alert them when they need to reach out to a lessee for clarification;
- **establish procedures for obtaining intelligence on a lessee's fleet plan** to devise a strategy for engine management that can help a lessor better understand what they are remarketing and help the lessee manage their fleet to avoid costly engine PRs;
- **integrate in-house systems** to keep the finance, technical and accounting teams on the same page.

Know your engine outlook

Forecasting solutions can be complex, but with the right tools and data lessors can provide solid maintenance forecasts to equip decision makers with the pertinent information allowing them to define an optimal fleet plan. "Having an event forecast with all of its associated cash flows enables lessors to pinpoint the best deals and avoid wasteful expenses," says Ethan Ross, Zeevo Group's senior manager and in-house maintenance forecast expert. "Forecasts boost the understanding of upcoming expenses and top-up liabilities; for example, the expected condition of an LLP stack at return. They also inform fleet plans to maximise reserves balances so that excess balances can be released to revenue."

Some essential elements to include in an engine forecast are:

- **well-defined assumptions**, including PR costs, mean time between repair (MTBR) and average utilisation;
- **tools or systems integrated directly** with asset management system; and
- **baseline and "what-if" scenario forecasts**.

Visualise your engine outlook

A key tool for robust engine data and maintenance forecasts is custom dashboards that use visuals to filter out the noise and illustrate the information most pertinent to the decision makers. A comprehensive strategy for engine placement with solid footing allows a lessor to optimise its asset management, reducing costs, increasing revenue and enabling greater flexibility.

A number of business intelligence tools exist that pull data from multiple systems to create custom graphs and charts to:

- easily **visualise your engine outlook**;
- **identify areas of risk** and unnecessary shop visits to avoid;
- determine strategies for engine swaps to **maximise each engine's life**; and
- allow lessors to **refine future strategies further and learn from past mistakes** by showing how expectations changed between year-start and year-end.

Build your fleet plan

At the center of any aviation leasing company's business is asset management — and engines are where a lessor stands the most to gain or lose. Zeevo Group has been working with a number of global leasing companies to identify and deploy business intelligence tools that are tailored specifically to their needs, boosting their forecasting capabilities and bolstering their day-to-day decision-making.

Johnsen concludes: "Having a robust fleet plan allows a lessor to enter each year in a position of strength, limiting those costly surprises along the way. By implementing some of these tools and procedures, lessors can step out of the dark and illuminate the future."

AIRFINANCE JOURNAL EVENTS

2018
Event Calendar

Conference	Date	Location
New York School of Aviation Finance	11-13 April 2018	New York
7th Annual Japan Airfinance Conference	19-20 April 2018	Tokyo
38th Annual North America Airfinance Conference	15-16 May 2018	Miami
16th Annual China Airfinance Conference	14-15 June 2018	Shanghai
New: Inaugural Southeast Aerospace & Defence Conference	25-27 June 2018	Mobile
Summer School of Aviation Finance	02-04 July 2018	Cambridge
New: Inaugural US Valuations and Leasing Conference	11-12 September 2018	Chicago
New: Latin America School of Aviation Finance	11-12 September 2018	Mexico City
14th Annual Latin America Airfinance Conference	13-14 September 2018	Mexico City

www.airfinancejournal.com/events

Financing widebody engines for start-up investor

Airfinance Journal's Deals of the Year 2017 nominations feature White Oak Commercial Aviation, a newcomer in the engine leasing space, acquiring a portfolio of 20 widebody engines.

AIRFINANCE JOURNAL AWARDS

Global Awards, Miami, 16 May 2018

White Oak Global

At the end of 2017, White Oak Global Advisors completed a $550 million transaction with GE Capital Aviation Services (GECAS) to buy and immediately lease back 20 widebody aircraft engines.

To facilitate this transaction, and to strengthen and grow White Oak's financing capabilities for aviation companies, it created White Oak Commercial Aviation, an affiliated entity of White Oak which is wholly owned by its institutional investors.

"As aviation continues to grow domestically and internationally, we saw a great opportunity to apply White Oak's expertise in lending to businesses that are the bedrock of economic growth by creating a new aviation-focused group," says White Oak Global Advisors' chief executive officer and co-founder Andre Hakkak.

US bank CIT Group provided a $422 million senior secured loan financing to White Oak Commercial Aviation. The loan supports White Oak's purchase of 20 engines.

"This transaction provides us a foundation to strengthen and grow our focus on providing financing solutions for aviation companies," adds Hakkak.

The transaction utilised a special purpose borrower with an innovative pari-passu first lien loan-type structure for loans from the commercial lenders and affiliates of the investor.

The loans were secured by 20 engines, leases with respect to the engines, related insurance rights and other collateral. GECAS is the servicer for the engines.

The assets financed comprised two Rolls-Royce Trent 970-84 engines, seven General Electric GE90s and 11 GEnx engines.

Borrower: White Oak Commercial Aviation and WO-Ireland

Amount: $550 million

Arranger/lender: CIT as sole lead arranger, book runner, agent and a lender; National Westminster Bank as collateral agent and co-syndication agent; KeyBank National Association as documentation agent and co-syndication agent; and SunTrust Equipment Finance & Leasing Corp as co-syndication agent.

Lawyers: White & Case as New York law counsel to CIT, partner Michael Smith and counsel Frank Schoen; Vedder Price as New York and Delaware law counsel to the borrowers and the borrower parties, shareholder Thomas Zimmer and senior associate Clay Thomas; Holland & Knight as New York law counsel to General Electric Company, GECAS, partners William Piels and Audrey Sung.

Collateral: Two Trent 970-84 engines, seven GE90s and 11 GEnx engines.

Advisers: Walkers Global as Irish law counsel for CIT; Daugherty, Fowler, Peregrin, Haught & Jenson, as deal FAA and Cape Town counsel; Dillon Eustace as Irish law counsel to the borrowers and the borrower parties; Kim & Chang as deal Korean law counsel.

Innovation: The unitranche pari-passu first lien loan structure was a novel application for a transaction of this size and complexity. The first lien loans from affiliates of the investor were subordinated in payment priority to the first lien loans of the commercial bank lenders and pledged to the commercial bank lenders pursuant to an intercreditor agreement. If certain trigger events occur, the pari-passu lien structure will convert into a first and second lien structure.

The unitranche structure was akin to institutional enhanced equipment trust certificate notes in that two classes of debt investors share the collateral at the same level from a security interest standpoint. This marks an innovation for the aircraft bank lending market.

Timing: The timing from mandate to signing/closing (which occurred simultaneously with respect to a total of 14 engine assets) was a significant accomplishment, particularly because this deal involved cross-border coordination and multijurisdictional legal and tax implications.

Size: The transaction was the largest of its kind dealing solely with commercial widebody engines. Other bank transactions are more narrowbody engine focused. The financing was the largest bank execution of this type and involved a large pool of assets, providing an alternative to institutional market financing.

Complexity: The transaction involved syndicate banks from the US, the UK and the Middle East, and was oversubscribed at close.

Overcoming obstacles: The structure provided enough flexibility for the servicer to interface with its customers and manage the assets while providing the lessor and the lenders with rights appropriate to their positions. The underlying leases included head-leases and sub-leases with international lessees.

Aeromexico commercial loan insured by Swiss ECA

The $68 million facility has strengthened ties between the airline and the MRO company.

Aeromexico

Law firm White & Case advised JP Morgan on the circa $68 million facility for Aeromexico for the purpose of financing the purchase of certain goods and services from SR Technics Switzerland. The commercial contract relates to the provision of engine maintenance services rather than the provision of goods.

The facilities are insured by Schweizerische Exportrisikoversicherung (SERV), the export credit agency of Switzerland.

The $68 million, 95% SERV-insured loan facility for Aeromexico consists of two tranches, one for past engine services and one for future engine services, with a combined weighted average life of about 18 months.

The arranged structure enables the support of a new contract and strengthening of the business relationship between Aeromexico and the supplier. The performance of the supplier and attractiveness of the financing structure has led to expanded business with SR Technics and the airline, including maintenance services on a new model of aircraft not previously contracted between the parties.

Borrower: Aerovias de Mexico (Aeromexico)

Amount: $68 million

Arranger/lender: JP Morgan Chase Bank, North America, London branch as arranger, lender and agent.

Lawyers: White & Case (English law borrower counsel to the borrower); Clifford Chance (English law lender counsel to the lender); Nader, Hayaux y Goebel (Mexican law lender counsel to the lender); Lenz & Staehelin (Swiss law lender counsel to the lender).

Collateral: Engine services under MRO contract.

Export credit agency: Schweizerische Exportrisikoversicherung (Swiss ECA or SERV).

Innovation: The transaction was the first SERV-supported buyer credit in the aviation sector.

Size: The SERV insurance loan facility is the largest export credit agency-backed maintenance, repair and overhaul (MRO) financing of 2017.

The deal team worked with the export credit agency (ECA) to maximise the financing amount and tenor, while meeting Aeromexico's size and tenor goals.

Complexity/overcoming obstacles: The challenge was to structure a solution that would support the new contract and business relationship between Aeromexico and SR Technics Switzerland, without disrupting the existing payment terms and business relationship between the airline and the supplier.

Rewards of investing in engines

Jose Abramovici, global head of asset finance group Crédit Agricole Corporate & Investment Bank, talks to *Airfinance Journal* about the bank's strategy for investing in engines.

Crédit Agricole Corporate & Investment Bank (CA-CIB) is the market leader in engine financing for airlines and engine leasing companies, having a strong expertise across a variety of financing markets ranging from traditional commercial bank loans to engine securitisations.

CA-CIB has been exposed to different markets over the past two years. The French bank has closed some commercial financings with lessor Asia Aviation Capital for a total of 14 spare engines leased to Airasia as mandated lead arranger and co-arranged engine spares for Silkway as part of a two Boeing 747-8F Ex-Im deal. The bank was also a participant in a revolver credit facility in 2016 for Willis Lease Finance.

Last year, CA-CIB acted as joint mandated lease agent for refinancing 14 Rolls-Royce Trent engines.

The bank has closed more than 320 spare engine financings arranged with 14 airlines.

When it comes to approaching the engine market, Jose Abramovici, global head of asset finance group at CA-CIB, says the economic life of a jet engine is only limited by the market for the airframes it supports and can achieve longer life than a given airframe, subject to proper overhaul maintenance.

The life of the engine is following three phases:

Phase 1 – from the introduction of the engine into service until the end of production run of the aircraft type it supports.

Phase 2 – begins when the aircraft on which the engine is installed is no longer in production.

Phase 3 – begins when the engines and the aircraft they support are retired from the global fleet.

Abramovici says engines have typically showed stronger value retention than aircraft over time. The future values of engines are decreasing at a slower rate than the aircraft they support.

"Engine values are smaller than aircraft values, therefore there is generally no need to tap the syndication market widely."

Jose Abramovici, global head, Crédit Agricole Corporate & Investment Bank

"In the first phase of an engine life, the value of the engine and the demand for spare engines increase with the growth of the aircraft fleet size. In the second phase, the need for replacement engines and spares continue to sustain a certain level of demand. In the final phase, the value of the engine will decline steeply as the aircraft they support are withdrawn from service," he says.

To him, the difference between financing engines and aircraft resides in the fact that a high proportion of the value of the engine lies in its maintenance status.

"Therefore, the servicing is critical to maintain the collateral value," says Abramovici, adding: "During an engine overhaul, the life-limited parts can be replaced in order to recover almost full value and extend the life of the collateral for a very long time. Engine financing requires a periodic monitoring of loan to values based upon maintenance-adjusted value.

"Unlike aircraft, engines will not need reconfiguration work to be placed with other operators. It is easier/faster to remarket an engine in good maintenance condition than to remarket an aircraft.

"In the case of spare engines for a US carrier, if you get Section 1110 protection, you can structure the financing on an 'all-or-nothing' basis, which means than the airline cannot 'cherry pick' among the engines which served as loan collateral. In case of default, the lenders could confiscate the entire spare engine pool and this would be a big problem for the operator because it could face operational problems without its spare engines available. Spare engines are essential to operate an airline, therefore an airline would rather return surplus aircraft to lessors than to default on an engine loan."

Abramovici says engine financings are generally shorter tenors than aircraft financings. He estimates engine tenors between three and seven years. Engine asset-backed securitisation (ABS) financings can offer very long tenors, like aircraft ABS transactions.

"Engine values are smaller than aircraft values, therefore there is generally no need to tap the syndication market widely," he says.

The engine leasing community remains important for banks. Over the past 10 years, the bank has arranged almost $700 million through facilities and debt tranche financings.

Abramovici says banks would analyse the credit of the engine lessor and the quality of the collateral for full recourse financings.

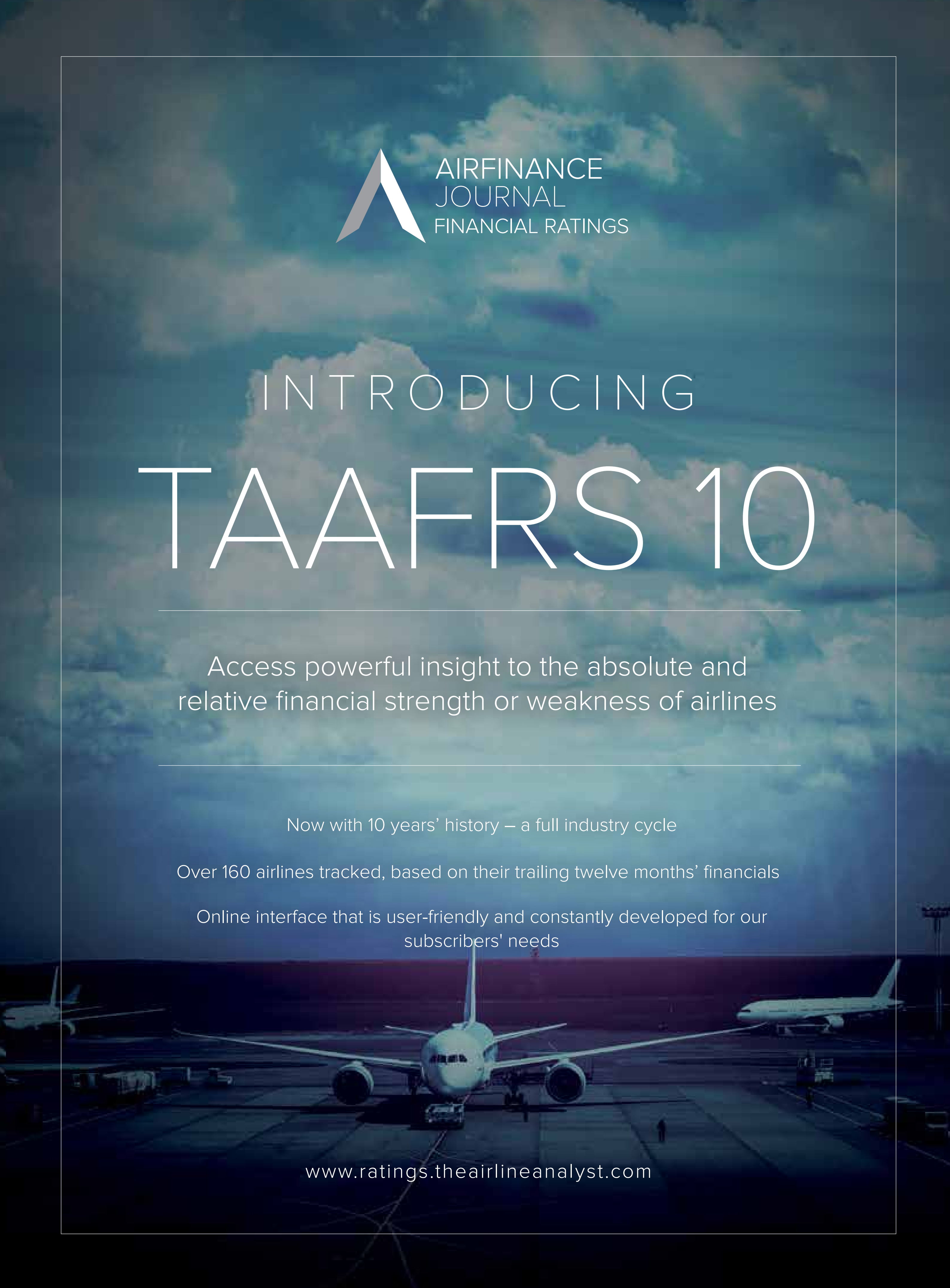
He adds: "Non-recourse financing for a lessor is more complex and we prefer to deal with a strong servicer with some 'skin in the game' by way of partial equity or some liquidity facility support."

OEM	Engine	Fair Market Value ($m)	Base Value ($m)	Monthly Rental ($000)	QEC Value Range ($m)	LLP Cost) (new) ($m	Overhaul (ex LLP) ($m)	MTBO	FH:FC
CFM	CFM56-3B1	$0.500m	$0.500m	$0.025m	$0.025 - $0.100	$3.100m	$1.250m	9,000	1.4
CFM	CFM56-3B2	$0.600m	$0.600m	$0.030m	$0.025 - $0.100	$3.100m	$1.900m	8,000	1.4
CFM	CFM56-3C1 - 23k	$0.900m	$0.900m	$0.035m	$0.025 - $0.100	$1.300m	$3.110m	8,000	1.4
CFM	CFM56-7B22	$3.540m	$3.540m	$0.047m	$0.600 - $1.800	$3.540m	$2.475m	28,000	1.8
CFM	CFM56-7B24	$4.180m	$4.180m	$0.056m	$0.600 - $1.800	$3.540m	$2.475m	27,000	1.8
CFM	CFM56-7B26	$4.790m	$4.790m	$0.065m	$0.600 - $1.800	$3.540m	$2.475m	25,000	1.8
CFM	CFM56-7B24E	$6.520m	$6.520m	$0.060m	$0.600 - $1.800	$3.540m	$2.475m	31,500	1.8
CFM	CFM56-7B26E	$7.410m	$7.410m	$0.070m	$0.600 - $1.800	$3.540m	$2.475m	30,500	1.8
CFM	CFM56-7B27E	$7.730m	$7.730m	$0.080m	$0.600 - $1.800	$3.540m	$2.475m	27,500	1.8
CFM	CFM56-5B5/P	$3.790m	$3.790m	$0.045m	$0.700 - $2.300	$3.640m	$2.720m	25,500	1.7
CFM	CFM56-5B4/P	$5.130m	$5.130m	$0.059m	$0.700 - $2.300	$3.640m	$2.720m	24,500	1.7
CFM	CFM56-5B4/3 PIP	$6.800m	$6.800m	$0.075m	$0.700 - $2.300	$3.640m	$2.680m	28,000	1.7
CFM	CFM56-5B3/P	$5.710m	$5.710m	$0.065m	$0.700 - $2.300	$3.640m	$2.720m	21,500	1.7
CFM	CFM56-5B3/3 PIP	$7.460m	$7.460m	$0.080m	$0.700 - $2.300	$3.640m	$2.680m	25,000	1.7
CFM	CFM56-5C4/P	$1.800m	$1.800m	$0.040m	$0.100 - $0.800	$3.720m	$2.610m	13,500	6.0
EA	GP7200	$10.500m	$10.500m	$0.140m	$1.100 - $1.900	$8.090m	$6.250m	20,000	8.0
GE	CF34-3B1	$1.100m	$1.100m	$0.025m	$0.185 - $0.500	$1.800m	$1.020m	11,500	1.3
GE	CF34-8C5	$2.760m	$2.760m	$0.040m	$0.500 - $0.600	$2.700m	$1.500m	11,000	1.3
GE	CF34-8E5	$3.300m	$3.300m	$0.045m	$0.800 - $0.900	$2.700m	$1.500m	11,000	1.3
GE	CF34-10E6	$5.200m	$5.200m	$0.065m	$1.370 - $1.900	$2.300m	$1.350m	13,500	1.3
GE	CF6-80C2B6F	$2.590m	$2.590m	$0.055m	$0.300 - $0.600	$7.300m	$3.440m	16,000	6.0
GE	GEnx-1B74/74	$16.720m	$16.720m	$0.240m	$1.800 - $4.200	$8.000m	$6.500m	19,500	6.0
GE	CF6-80E1A3	$9.420m	$9.420m	$0.150m	$1.300 - $2.500	$10.630m	$4.220m	15,000	5.0
GE	CF6-80C2D1F	$1.700m	$1.700m	$0.045m	$0.300 - $0.600	$7.300m	$3.440m	16,000	6.0
GE	GE90-115BL	$22.480m	$22.480m	$0.230m	$1.200 - $2.500	$12.100m	$8.000m	21,000	6.5
GE	CF6-80C2B1F	$2.140m	$2.140m	$0.040m	$0.300 - $0.600	$7.300m	$3.440m	16,000	6.0
IAE	V2527-A5	$5.080m	$5.080m	$0.070m	$0.700 - $2.500	$3.840m	$2.480m	16,400	2.0
IAE	V2527-A5 Select	$5.710m	$5.710m	$0.080m	$0.700 - $2.500	$3.840m	$2.630m	20,000	2.0
IAE	V2533-A5	$5.940m	$5.940m	$0.080m	$0.700 - $2.500	$3.840m	$2.480m	11,100	2.0
IAE	V2533-A5 Select	$6.870m	$6.870m	$0.090m	$0.700 - $2.500	$3.840m	$2.490m	12,100	2.0
PW	JT8D-219	$0.500m	$0.500m	$0.020m	$0.070 - $0.080	$2.190m	$2.000m	9,000	1.5
PW	PW4060	$2.400m	$2.400m	$0.042m	$0.300 - $0.600	$7.090m	$4.500m	17,500	6.0
PW	PW4168A	$3.920m	$3.920m	$0.110m	$0.700 - $1.800	$9.010m	$5.500m	17,000	6.0
PW	PW4090	$6.500m	$6.500m	$0.150m	$1.000 - $2.500	$14.840m	$11.500m	19,000	7.0
RR	AE3007	$0.710m	$0.680m	$0.020m	$0.085 - $0.280	$1.900m	$1.150m	6,700	1.1
RR	Tay 650-15	$0.830m	$0.830m	$0.022m	$0.100 - $0.300	$1.290m	$1.750m	9,500	1.1
RR	BR715A	$2.700m	$2.700m	$0.042m	$0.300 - $0.900	$2.120m	$2.300m	12,350	1.6
RR	RB211-535E4	$3.100m	$3.100m	$0.050m	$0.450 - $0.900	$5.450m	$4.700m	22,000	3.1
RR	Trent 1000-J2	$17.120m	$17.120m	$0.230m	N/A	$7.250m	$7.250m	23,000	4.7
RR	Trent 772B-60EP	$8.570m	$8.570m	$0.140m	$2.000 - US$2.050	$8.620m	$8.900m	26,200	4.4
RR	Trent 895	$9.110m	$8.280m	$0.170m	N/A	$10.840m	$9.200m	19,000	5.4
RR	Trent 556-61	$4.400m	$3.550m	$0.110m	$0.200	$8.320m	$6.450m	22,000	8.4
RR	RB211-524T	$2.000m	$1.900m	$0.025m	$0.200 - $0.700	$5.900m	$6.400m	24,250	6.5
RR	Trent 970	$14.900m	$14.900m	$0.170m	$0.600	$9.560m	$7.250m	25,225	9.3

Source: IBA, April 2018

Aircraft Model	Engine Options
717-200	BR715A1-30
	BR715C1-30
737-10	LEAP-1B25
	LEAP-1B25C
	LEAP-1B27
	LEAP-1B27C
	LEAP-1B27CB2
	LEAP-1B28
	LEAP-1B28B1
737-300	CFM56-3B1
	CFM56-3B2
	CFM56-3C1
	CFM56-3C1-20K
	CFM56-3C1-22K
737-300QC	CFM56-3B1
	CFM56-3B2
	CFM56-3C1
	CFM56-3C1-20K
	CFM56-3C1-22K
737-300SF	CFM56-3B1
	CFM56-3B2
	CFM56-3C1
	CFM56-3C1-20K
	CFM56-3C1-22K
737-400	CFM56-3B1
	CFM56-3B2
	CFM56-3C1
	CFM56-3C1-20K
	CFM56-3C1-22K
	CFM56-3C1-23.5K
737-400SF	CFM56-3B1
	CFM56-3B2
	CFM56-3C1
	CFM56-3C1-20K
	CFM56-3C1-22K
	CFM56-3C1-23.5K
737-500	CFM56-3B1
	CFM56-3B1-18.5K
	CFM56-3B2
	CFM56-3C1
	CFM56-3C1-18K
	CFM56-3C1-20K
	CFM56-3C1-22K
737-600	CFM56-7B20
	CFM56-7B20/2
	CFM56-7B20/3
	CFM56-7B20E
	CFM56-7B22
	CFM56-7B22/2
	CFM56-7B22/3
	CFM56-7B22E
	CFM56-7B26
	CFM56-7B26/3
	CFM56-7B26E
737-7	LEAP-1B21
	LEAP-1B23
737-700	CFM56-7B20
	CFM56-7B20/2
	CFM56-7B20/3
	CFM56-7B20E
	CFM56-7B22
	CFM56-7B22/2
	CFM56-7B22/3
	CFM56-7B22E
	CFM56-7B24
	CFM56-7B24/2
	CFM56-7B24/3
	CFM56-7B24/3B1
	CFM56-7B24E
	CFM56-7B24E/B1
	CFM56-7B26
	CFM56-7B26/2
	CFM56-7B26/3
	CFM56-7B26E
	CFM56-7B26E/B2
	CFM56-7B26E/B2F
	CFM56-7B26E/F
	CFM56-7B27
	CFM56-7B27/3
737-8	LEAP-1B21
	LEAP-1B23
	LEAP-1B25
	LEAP-1B25C
	LEAP-1B27
	LEAP-1B27C
	LEAP-1B27CB2
	LEAP-1B28
	LEAP-1B28B1
737-800	CFM56-7B24
	CFM56-7B24/2
	CFM56-7B24/3
	CFM56-7B24/3B1
	CFM56-7B24E
	CFM56-7B24E/B1
	CFM56-7B26
	CFM56-7B26/2
	CFM56-7B26/3
	CFM56-7B26/B1
	CFM56-7B26E
	CFM56-7B26E/B2
	CFM56-7B26E/F
	CFM56-7B27
	CFM56-7B27/2
	CFM56-7B27/3
	CFM56-7B27/3B1
	CFM56-7B27/3B1F
	CFM56-7B27/3F
	CFM56-7B27/B1
	CFM56-7B27E
	CFM56-7B27E/B1
	CFM56-7B27E/B1F
	CFM56-7B27E/F
737-800P2F	CFM56-7B24
	CFM56-7B24/2
	CFM56-7B24/3
	CFM56-7B24/3B1
	CFM56-7B24E
	CFM56-7B24E/B1
	CFM56-7B26
	CFM56-7B26/2
	CFM56-7B26/3
	CFM56-7B26/B1
	CFM56-7B26E
	CFM56-7B26E/B2
	CFM56-7B26E/F
	CFM56-7B27
	CFM56-7B27/2
	CFM56-7B27/3
	CFM56-7B27/3B1
	CFM56-7B27/3B1F
	CFM56-7B27/3F
	CFM56-7B27/B1
	CFM56-7B27E
	CFM56-7B27E/B1
	CFM56-7B27E/B1F
	CFM56-7B27E/F
737-9	LEAP-1B25
	LEAP-1B25C
	LEAP-1B27
	LEAP-1B27C
	LEAP-1B27CB2
	LEAP-1B28
	LEAP-1B28B1
737-900	CFM56-7B24
	CFM56-7B24/2
	CFM56-7B24/3
	CFM56-7B24E
	CFM56-7B26
	CFM56-7B26/2
	CFM56-7B26/3
	CFM56-7B26E
737-900ER	CFM56-7B26
	CFM56-7B26/3
	CFM56-7B26E
	CFM56-7B26E/F
	CFM56-7B27
	CFM56-7B27/2
	CFM56-7B27/3
	CFM56-7B27/3B1
	CFM56-7B27/3B1F
	CFM56-7B27/3F
	CFM56-7B27E
	CFM56-7B27E/B1
	CFM56-7B27E/B1F
	CFM56-7B27E/F
747-400	CF6-80C2B1F
	CF6-80C2B5F
	PW4056
	PW4062
	RB211-524G
	RB211-524G-T
	RB211-524H2
	RB211-524H2-T
747-400BCF	CF6-80C2B1F
	CF6-80C2B5F
	PW4056
	PW4062
	RB211-524G
	RB211-524G-T
	RB211-524H2
	RB211-524H2-T
747-400ER	CF6-80C2B5F
	PW4062
747-400ERF	CF6-80C2B1F
	CF6-80C2B5F
	PW4062
	PW4062A
747-400F	CF6-80C2B1F
	CF6-80C2B5F
	PW4056
	PW4062
	RB211-524G
	RB211-524G-T
	RB211-524H2
	RB211-524H2-T
	RB211-524H
747-400ISF	CF6-80C2B1F
	CF6-80C2B5F
	PW4056
	PW4062
	RB211-524G
	RB211-524G-T
	RB211-524H2
	RB211-524H2-T
747-8	GEnx-2B67
	GEnx-2B67/P
	GEnx-2B67B
747-8F	GEnx-2B67
	GEnx-2B67/P
	GEnx-2B67B
757-200	PW2037
	PW2037M
	PW2040
	RB211-535C
	RB211-535E4
	RB211-535E4-B
757-200 ETOPS	PW2037
	PW2037M
	PW2040
	RB211-535C
	RB211-535E4
	RB211-535E4-B
757-200PCF	PW2037
	PW2037M
	PW2040
	RB211-535C
	RB211-535E4
	RB211-535E4-B
757-200PF	PW2037
	PW2037M
	PW2040
	RB211-535C
	RB211-535E4
	RB211-535E4-B
757-200SF	PW2037
	PW2037M
	PW2040
	RB211-535C
	RB211-535E4
	RB211-535E4-B
757-300	PW2040
	PW2043
	RB211-535E4-B
	RB211-535E4-C
767-200ERF	CF6-80A
	CF6-80A2
	CF6-80C2
	CF6-80C2B2
	CF6-80C2B2F
	CF6-80C2B4
	CF6-80C2B4F
	CF6-80C2B6F
	CF6-80C2B7F
	JT9D-7R4D
	JT9D-7R4E
	JT9D-7R4E4
	PW4052
	PW4056
	PW4060
767-200F	CF6-80A
	CF6-80A2
	CF6-80C2B2
	CF6-80C2B2F
	JT9D-7R4D
767-300	CF6-80A2
	CF6-80C2B2
	CF6-80C2B2F
	CF6-80C2B4F
	CF6-80C2B7F
	JT9D-7R4D
	PW4056
	PW4060
767-300ER	CF6-80C2B2
	CF6-80C2B2F
	CF6-80C2B4
	CF6-80C2B4F
	CF6-80C2B6
	CF6-80C2B6F
	CF6-80C2B7
	CF6-80C2B7F
	PW4052
	PW4056
	PW4060
	PW4062
	RB211-524H
	RB211-524H-T
767-300ERF	CF6-80C2B2
	CF6-80C2B2F
	CF6-80C2B4
	CF6-80C2B4F
	CF6-80C2B6
	CF6-80C2B6F
	CF6-80C2B7
	CF6-80C2B7F
	PW4052
	PW4056
	PW4060
	PW4062
	RB211-524H
767-300 ERP2F	CF6-80C2B2
	CF6-80C2B2F
	CF6-80C2B4
	CF6-80C2B4F
	CF6-80C2B6
	CF6-80C2B6F
	CF6-80C2B7
	CF6-80C2B7F
	PW4052
	PW4056
	PW4060
	PW4062
	RB211-524H
	RB211-524H-T
767-300F	CF6-80A2
	CF6-80C2B2
	CF6-80C2B2F
	CF6-80C2B7F
	JT9D-7R4D
	PW4056
	PW4060
767-400ER	CF6-80C2B7
	CF6-80C2B7F
	CF6-80C2B8F
777-200	GE90-76B
	GE90-85B
	GE90-90B
	PW4077
	PW4084
	TRENT 875
	TRENT 877
	TRENT 884
777-200ER	GE90-85B
	GE90-90B
	GE90-92B
	GE90-94B
	PW4074
	PW4084
	PW4084D
	PW4090
	TRENT 884
	TRENT 890
	TRENT 890B
	TRENT 892
	TRENT 892B
	TRENT 895
777-200LR	GE90-110B1
	GE90-110B1L
	GE90-110B1L1
	GE90-110B1L2
	GE90-115B
	GE90-115BL
	GE90-115BL1
	GE90-115BL2
777-200LRF	GE90-110B1
	GE90-110B1L
	GE90-110B1L1
	GE90-110B1L2
	GE90-115B
	GE90-115BL
	GE90-115BL1
	GE90-115BL2
777-300	PW4090
	PW4098
	TRENT 892
	TRENT 892B
777-300ER	GE90-115B
	GE90-115BL
	GE90-115BL1
	GE90-115BL2
777-8	GE9X
777-9	GE9X
787-10	GEnx-1B64
	GEnx-1B67
	GEnx-1B70
	GEnx-1B70/75
	GEnx-1B74/75
	GEnx-1B76
	GEnx-1B76A
	TRENT 1000-C
	TRENT 1000-D
	TRENT 1000-G
	TRENT 1000-J
	TRENT 1000-M
	TRENT 1000-N
787-3	GEnx-1B54
	TRENT 1000-E
787-8	GEnx-1B54
	GEnx-1B58
	GEnx-1B64
	GENX-1B64 (PIP I)
	GENX-1B64 (PIP II)
	GENX-1B64 (PrePIP)
	GEnx-1B67
	GEnx-1B70
	GEnx-1B70/72
	GEnx-1B70/75
	TRENT 1000-A
	TRENT 1000-C
	TRENT 1000-D
	TRENT 1000-E
	TRENT 1000-G
	TRENT 1000-H
	TRENT 1000-L
	TRENT 1000-P
787-9	GEnx-1B64
	GEnx-1B67
	GEnx-1B70
	GEnx-1B70/72
	GEnx-1B70/75
	GEnx-1B74/75
	GEnx-1B76
	GEnx-1B76A
	TRENT 1000-A
	TRENT 1000-C
	TRENT 1000-D
	TRENT 1000-G
	TRENT 1000-J
	TRENT 1000-K
	TRENT 1000-M
	TRENT 1000-N
	TRENT 1000-Q
A300-600RF	CF6-80C2A5
	CF6-80C2A5F
	PW4158
A318	CFM56-5B8/3
	CFM56-5B8/P
	CFM56-5B9/3
	CFM56-5B9/P
	PW6122A
	PW6124A
A319-100	CFM56-5A4
	CFM56-5A5
	CFM56-5A5/F
	CFM56-5B3/P
	CFM56-5B4/3
	CFM56-5B4/P
	CFM56-5B5
	CFM56-5B5/3
	CFM56-5B5/P
	CFM56-5B6
	CFM56-5B6/2
	CFM56-5B6/2P
	CFM56-5B6/3
	CFM56-5B6/P
	CFM56-5B7/3
	CFM56-5B7/P
	V2522-A5
	V2522-A5 SelectOne
	V2522-A5 SelectTwo
	V2524-A5
	V2524-A5 SelectOne
	V2524-A5 SelectTwo
	V2527-A5
	V2527-A5 SelectOne
	V2527-A5 SelectTwo
	V2527E-A5
	V2527M-A5
	V2527M-A5 SelectOne
	V2527M-A5 SelectTwo
A319neo	LEAP-1A24
	LEAP-1A24E1
	LEAP-X
	PW1124G
A320-100	CFM56-5A1
	V2500-A1
A320-200	CFM56-5A1
	CFM56-5A1/F
	CFM56-5A3
	CFM56-5B4
	CFM56-5B4/2P
	CFM56-5B4/3
	CFM56-5B4/3B1
	CFM56-5B4/P
	CFM56-5B5/3
	CFM56-5B6/3
	CFM56-5B6/P
	V2500-A1
	V2527-A5
	V2527-A5 SelectOne
	V2527-A5 SelectTwo
	V2527E-A5
	V2527E-A5 SelectOne
	V2527E-A5 SelectTwo
	V2530-A5
	V2530-A5 SelectOne
A320-200 pre 1993	CFM56-5A1
	CFM56-5A3
	V2500-A1
A320neo	LEAP-1A24
	LEAP-1A26
	LEAP-1A26E1
	LEAP-1A29
	LEAP-X
	PW1124G
	PW1127G
A321-100	CFM56-5B1
	CFM56-5B1/2P
	CFM56-5B1/3
	CFM56-5B1/P
	CFM56-5B2
	CFM56-5B2/P
	CFM56-5B3
	V2530-A5
A321-200	CFM56-5B1
	CFM56-5B1/2P
	CFM56-5B1/3
	CFM56-5B1/P
	CFM56-5B2
	CFM56-5B2/3
	CFM56-5B2/P
	CFM56-5B3
	CFM56-5B3/2P
	CFM56-5B3/3
	CFM56-5B3/3B1
	CFM56-5B3/P
	V2530-A5
	V2530-A5 SelectOne
	V2530-A5 SelectTwo
	V2533-A5
	V2533-A5 SelectOne
	V2533-A5 SelectTwo
A321neo	LEAP-1A30
	LEAP-1A32
	LEAP-1A32B1
	LEAP-1A32B2
	LEAP-1A33
	LEAP-1A35A
	LEAP-X
	PW1130G
	PW1133G
A330-200	CF6-80E1A2
	CF6-80E1A3
	CF6-80E1A4
	CF6-80E1A4/B
	PW4164
	PW4168A
	PW4170
	TRENT 772B-60
	TRENT 772B-60EP
	TRENT 772C-60
	TRENT 772C-60EP
A330-200F	CF6-80E1A2
	CF6-80E1A3
	CF6-80E1A4
	CF6-80E1A4/B
	PW4164
	PW4168A
	PW4170
	TRENT 772B-60
	TRENT 772B-60EP
	TRENT 772C-60
	TRENT 772C-60EP
A330-300 HW	CF6-80E1A3
	CF6-80E1A4
	CF6-80E1A4/B
	PW4168A
	PW4170
	TRENT 772-60
	TRENT 772B-60
	TRENT 772B-60EP
	TRENT 772C-60
	TRENT 772C-60EP
A330-300 LW	CF6-80E1A2
	CF6-80E1A3
	PW4164
	PW4168
	PW4168A
	TRENT 768-60
	TRENT 772-60
A330-800	TRENT 7000
	TRENT 7000 TBD
A330-900	TRENT 7000
	TRENT 7000 TBD
A340-200	CFM56-5C2
	CFM56-5C2/F
	CFM56-5C2/G
	CFM56-5C2/P
	CFM56-5C3
	CFM56-5C3/F
	CFM56-5C3/G
	CFM56-5C3/P
	CFM56-5C4
	CFM56-5C4/P
A340-300	CFM56-5C2
	CFM56-5C2/F
	CFM56-5C2/G
	CFM56-5C2/P
	CFM56-5C3
	CFM56-5C3/F
	CFM56-5C3/G
	CFM56-5C3/P
	CFM56-5C4
	CFM56-5C4/P
A340-500	TRENT 553-61
	TRENT 553A2-61
	TRENT 556-61
	TRENT 556A2-61
A340-600	TRENT 556-61
	TRENT 556A2-61
A350-1000	TRENT XWB-97
A350-800	TRENT XWB-75
	TRENT XWB-84
A350-900	TRENT XWB-75
	TRENT XWB-84
A380-800	GP7270
	GP7270E
	TRENT 970
	TRENT 972

Source: Avitas, April 2018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