

# MRO 360°



## Work Horses CFM and LEAP Engine Maintenance

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LEAP engine maintenance at MTU Zhuhai  
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# The Power Workhorses

## Exploring the World of Maintenance for CFM International's LEAP and CFM56 Engines

By David Dundas

The CFM56 is the world's most commonly used jet engine for passenger aircraft with over 30,000 engines delivered, powering over 600 operators worldwide. Currently there have been more than 7,000 LEAP engines delivered, with an additional 20,000 as orders or commitments to buy. CFM56 engines are used in the twin-engine Airbus A320 family, in the first generation of the A340-200/-300 long-haul jet, and in the Boeing 737 Classic and 737 Next Generation. CFM International's advanced LEAP product line is the engine of choice to power the Airbus A320neo, the Boeing 737 MAX, and the COMAC C919.

With the popularity of these two engines, we decided to delve deeper into the world of maintenance to discover what it takes to ensure these remarkably complex feats of aerospace engineering continually operate both safely and efficiently. The following are invaluable insights provided

by four leading engine MRO organisations who have been kind enough to share their knowledge with us.

### What separates the LEAP from the CFM56 engine type in terms of design and maintenance?

The LEAP series, in simple terms, is an 'upgrade' of the original CFM56 engine that uses new technologies and materials, such as composites, to create a more efficient engine that requires reduced maintenance. However, there are far more complex differences, as outlined by Gunnar M. Sigurfinnsson, President, GA Telesis Engine Services Oy. "The LEAP engine indeed shares a structural similarity with the CFM56, but it incorporates significant advancements in design and materials. Utilising sophisticated software and supercomputers for optimisation has allowed engineers to enhance efficiency, reduce weight, and improve strength.

The introduction of advanced materials, including composites commonly used in military engines, plays a crucial role in this evolution. These composite parts offer advantages such as improved durability and reduced maintenance needs, which can significantly lower operational costs. Additionally, the engine's systems and functions have been refined through advanced modelling techniques, leading to better performance overall. This combination of innovation in materials and design marks a notable step forward in engine technology."

Christian Ludwig, COO MTU Maintenance, Zhuhai makes an extremely valid comment with regard to the fact the LEAP engine is so new, there is much still to learn with regard to maintenance requirements as many have yet to have their first overhaul. "The biggest difference, of course, is that older generation CFM engines have decades of reliable service behind them, whereas we are still getting



to know the operations and needs of new generations of engines. There are very few surprises left when a CFM56 comes into the shop for maintenance, but not too many LEAP engines have had their first overhaul yet. So, we are still learning about any potential differences. Operationally, we have fewer repair opportunities for piece parts on newer engine models to date, and material availability remains challenging, as is the case across the industry at this time. More complex designs and new materials also require even more skills and attention



Christian Ludwig, COO MTU Maintenance, Zhuhai

from our mechanics, which is also reflected in a slightly longer learning curve. Also worth highlighting is that there are new requirements for non-destructive testing that call for new and more advanced NDT technology to be introduced."

Jay Aiken, VP Sales for the Americas, Europe, the Middle East & Africa (EMEA), Standard Aero Airlines & Fleets team helps us get a far more technical and precise view of several of the key differences. " Key design differences between the LEAP and the CFM56 include the use of fewer booster and fan blades, a maintenance-free composite fan; a foreign-object damage (FOD)-resistant core for low high-pressure compressor (HPC) maintenance costs; advanced high-pressure turbine (HPT) blades with active clearance control and improved castings/cooling; reduced lean burn combustor exit temperature variation for improved HPT component durability; and advanced 3-D aero, cooling paths

and coatings. In terms of maintenance." Aiken further explains that: "CFM has fundamentally worked to ensure that operators benefit from a similar level of choice and competition to that associated with the CFM56 through the development of an open MRO ecosystem for the engine. The LEAP offers similar modular benefits to the CFM56 (i.e. fan/booster, core, LPT and accessories), though one difference is that the LEAP's life-limited parts (LLPs) include static parts (e.g., HPT and combustion cases). As with any new engine, LEAP operators have been experiencing a number of early service issues, though as the engine approaches maturity airlines are expected to benefit from the same exceptional reliability and time-on-wing already offered by the CFM56, notably thanks to an extended low-pressure turbine (LPT) life."

Bruce Ansell, Technical Manager Engine Division, APOC Aviation provides

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*Christian Ludwig, COO MTU Maintenance, Zhuhai*

a very clear and concise overview of the differences between the LEAP and CFM56 engines: "The introduction of new advanced materials is proving to be a game-changer in engine design - stronger, lighter, greater temperature resistance - all material properties can be further developed to meet new design requirements. The maintenance of these engines can be quite different from the legacy CFM56, although the overall design is familiar, the new materials are driving different inspection & repair techniques."

### How has the introduction of new materials impacted on the maintenance procedures of the LEAP engines when compared to the CFM56?

Bruce Ansell touches on a common theme, and that is the fact that new materials bring with them new challenges, though he feels that: "Maintenance processes have not changed to any great extent, the inspection and repair has differences and a thorough understanding of the component, and material limitations have to be learnt. The new materials are still being developed and show great promise for extended time on wing in the future." Meanwhile, Christian Ludwig looks more specifically at individual differences between the two engines: "New advanced materials can be found in many modules starting from the fan blades and the fan case, in some bearings, as well as some HPT shrouds and LPT blades stages. While those are all different in application, the impact on maintenance varies. They all have strict inspection criteria in common, but at the moment, the repair options are limited."

Gunnar M. Sigurfinnsson takes this a few steps further in that he feels new materials and components necessitate change in repair and inspection techniques: "The introduction of new materials and advanced components in engines like the LEAP does necessitate updated inspection and repair



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methods. While these innovations improve performance and efficiency, they can also lead to higher maintenance costs due to the complexity of the new parts and the need for specialized tools and training. Repairs may be more limited because some advanced materials or components can't be repaired easily and may need to be replaced instead. This could increase the frequency of part replacements, impacting overall maintenance strategies. However, the long-term benefits, such as reduced fuel consumption and improved reliability, often offset these initial higher costs. Balancing maintenance needs with operational efficiency is crucial for operators managing these advanced engines."

Jay Aiken concurs with Bruce Ansell that, ultimately, maintenance processes are not significantly different for either engine, but with certain exceptions: "While the use of ceramic matrix composites (CMCs) and other advanced materials in the LEAP does require the adoption of a number of new process and repair technologies, the engine MRO industry is used to embracing innovative procedures and capabilities as newer generations of powerplants are

introduced (an obvious example being the introduction of the CFM56 family 45 years ago). In StandardAero's case, we identified and assessed these new processes and repair technologies prior to engaging with the OEM for a LEAP CFM Branded Service Agreement (CBSA) license, and subsequently provided the CFM with a detailed plan of how we would stand up such capabilities. The resulting maintenance process is not significantly different than that for older engines such as the CFM56, though it does require the introduction of new tooling, processes and repair schemes – such as cold metals transfer (CMT) repairs and adaptive blending – along with the associated training for our technicians."

### What are the deciding factors between repairing or replacing parts and have new materials changed these?

The 'repair or replace' task is a key focus of what some MROs refer to as the 'Cycle 2' stage of the engine MRO process, this being the point at which you assess an engine's condition (following teardown and inspection) and then you detail a plan for its repair (thus enabling the provision of a cost estimate to the operator, and to order and 'kit' the parts required). Just as with older engines, the 'repair or replace' task on the LEAP is initially driven by wear criteria and parts replacement policies which have been agreed with the OEM and documented in the engine's repair manuals where a new component failure is encountered, the issue will be referred back

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*Gunnar M. Sigurfinnsson, President, GA Telesis Engine Services Oy*



CFM shop of MTU Maintenance Zhuhai

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to the OEM for assessment and guidance. Jay Aiken explains further: "With specific reference to whether a worn or damaged component should be repaired or replaced, this will depend on a number of criteria, including guidance provided in the repair manuals, the availability of an industrialized part repair, and the replacement cost of the component in question. The lack of an existing component repair doesn't necessarily mean that we will immediately switch to replacing the component – we may work with our in-house Component Repair Services (CRS) team and the OEM to assess the validity of developing a new repair – though the time involved in developing a new repair (and the cost involved) will clearly determine whether this is a practical course of action to take."

Bruce Ansell feels that the repair/replacement decision is no different than that for the CFM in that it will always come back to safety, time, money, and availability. He further adds that: "The limitations of any wear, or damage, are provided in the engine manuals, which advise if a part is repairable, or not, and the process to be followed. If anything would result in the engine being off wing longer than required, then a new component will be considered." Gunnar M. Sigurfinnsson

also urges caution as he points out that new parts and materials often come with stricter inspection limits compared to traditional components. This being due to their advanced designs and the need to ensure safety and performance under various operating conditions. He expands further when stating that: "... developing and implementing new repair methods can be a time-consuming process, which can lead to an increased reliance on component replacements during the initial phases of deployment. While this transition may lead to higher costs and more frequent replacements in the short term, it's crucial for manufacturers and operators to adapt their maintenance strategies accordingly. Over time, as repair technologies and inspection protocols evolve, there may be opportunities to mitigate these challenges and optimize maintenance practices. The initial investment in these new systems can ultimately lead to long-term gains in efficiency and reliability."

To round off this section, Christian Ludwig puts it nice and succinctly as he points out that LEAP maintenance is still a learning curve: "As the LEAP is a relatively young engine, entering service in 2016, we are still learning a lot about it from our shop visits at MTU Maintenance Zhuhai."

CFMI, as the engine OEM, would set the conditions and parameters in relation to repairs and replacements, so we take their lead on it and complement it with our expert inspections. That combination gives us the final guidance whether a part will be replaced or repaired."

### What is the perspective on the evolution of parts repair developments for the LEAP engine?

Bruce Ansell at APOC Aviation feels that where the whole process is concerned, little has changed for the LEAP engine: "The repair/replacement decision is no different to the CFM, it will always come back to safety, time, money, and availability. The limitations of any wear, or damage, are provided in the engine manuals, which advise if a part is repairable, or not, and the process to be followed. If anything would result in the engine being off wing longer than required, then a new component will be considered." However, Gunnar M. Sigurfinnsson at GA Telesis takes a different approach when considering new challenges brought by the LEAP engine and, in particular, supply chain problems. He comments: "Regarding supply chain issues and the current limitations in repair options. It's common for new engine models to face initial hurdles as MROs (Maintenance, Repair, and Overhaul providers) collaborate with the OEM (Original Equipment Manufacturer) to develop effective repair procedures. The ongoing dialogue between MROs and the OEM is crucial for addressing these challenges and ensuring



Bruce Ansell, Technical Manager Engine Division, APOC Aviation

“The CMC materials have significant possibilities, including 'self-healing' capabilities.”

*Bruce Ansell, Technical Manager Engine Division, APOC Aviation*

that repair capabilities are expanded. As these partnerships evolve and more data becomes available, it's likely that the repair options will improve, helping to alleviate some of the supply chain pressures and maintenance costs associated with the LEAP engine. Your insights into the industry dynamics are valuable, especially as these developments unfold."

Jay Aiken at Standard Aero advises that the company is heavily involved in a hands-on approach as parts repair development for the LEAP is gaining good momentum, ahead of an anticipated wave of initial performance restoration shop visits (PRSVs). He further points out that: "As a CBSA, StandardAero is able to contribute to the development and industrialization of parts repairs for the LEAP using the extensive capabilities of our in-house Component Repair Services (CRS) team, which has to date completed the industrialization of over 235 repairs. The focus of StandardAero's LEAP component repair effort is our dedicated Repair & Development Center of Excellence at our facility in Cincinnati, OH, and no less than five of our locations – including those in Cincinnati, OH, Kansas City, MO, Miami, FL, Palm City, FL and Cork, Ireland – are involved in the effort."

At MTU Maintenance, Christian Ludwig is clear that as with any new engine, there is still great potential for further repair development. He goes on to explain that: "While the LEAP-1A is ahead in terms of the number of industrialised repairs compared to the -1B variant, the respective gap between what we have in place at MTU for mature engines versus new engine types is still significant. New repairs are steadily

being introduced and MTU is continuously striving to acquire the capabilities for them. Shops like us have great capabilities developed over decades to support development and industrialisation in cooperation with and legitimisation by the OEMs."

### With only the LEAP engine now in production, what role will USM play in the life cycle of the CFM56?

By utilising USM, MROs can manage costs more effectively and enhance the overall economics of engine maintenance. The availability of these components allows operators to mitigate some of the financial burdens associated with major repairs or overhauls. As the industry continues to adapt, leveraging USM will be an important strategy for keeping maintenance costs in check while ensuring operational reliability. Gunnar M. Sigurfinnsson underlines that: "The use of used serviceable materials (USM) is critical for maintaining the CFM56 engine, especially regarding high-value components like life-limited parts (LLPs), high-pressure turbine (HPT) blades, and HPT nozzles. These parts can significantly impact maintenance costs, with replacements for these high-cost airfoils adding substantial expenses—often upwards of US\$3 million – to a shop visit." Bruce Ansell makes it clear that USM is key to keeping the CFM56 powered fleet flying, as the older variants no longer benefit from available new stock at the OEM, going on to say that: "It also means that these older engines can be rebuilt to meet a certain time, or cycle driven requirement, i.e., an operator only requires an aircraft for 5 more years. This being the case, the engine would be rebuilt with USM with 6-7k Cycles Remaining, instead of new components with 20k Cycles Remaining. The reduction in component prices is usually directly comparable to the new OEM price."

Christian Ludwig is concise in his assessment of the situation: "Though it is true that production of CFM56s is over,

the engine is not going anywhere anytime soon, given how prolific and widespread its use is. This means that used serviceable material will be hugely important for the foreseeable future. It is the most popular engine of all time, so as long we have serviceable modules and parts on the market, we can expect it at our MRO shops in Zhuhai and Ludwigsfelde." However, Jay Aiken adopts a slightly more cautious approach to the role of USM to keep the CFM56 operational. "Used serviceable material (USM) certainly plays a role in supporting the CFM56 maintenance requirements of certain operators, though it is not a panacea. USM can help to bypass long lead times for certain parts, and it may also offer cost savings, especially for those operators who require engines to be "short built" for a specific number of engine flight cycles (EFCs). On the other hand, some operators (and their lessors) will prefer to use OEM-supplied new parts only, in order to ensure the build quality of the engine. More fundamentally, it may not be possible to source USM for all engine components, such as life-limited parts (LLPs): this issue is especially common at present due to the renewed popularity of CFM56-7B powered Boeing 737NGs and CFM56-5B powered Airbus A320neos as 'fill-ins' for delayed deliveries of new-generation narrowbodies."

### What about supply chain issues for the CFM56 or LEAP engine?

The consensus was pretty universal here, though the supply chain issues varied depending on the engine type. However, Bruce Ansell also touched on an additional side-effect of the discontinuance of the CFM56. He confirmed that APOC Aviation had encountered supply chain problems: "... specifically for the older CFM variants, with components no longer manufactured, and the OEM holding onto remaining stocks so as to meet their Operator Customer Support requirements, there is an acute shortage of some of the most common parts requiring replacement. This results



Jay Aiken, VP Sales for the Americas, Europe, the Middle East & Africa (EMEA), Standard Aero Airlines & Fleets Team

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Standard Aero CFM56-7 maintenance

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in additional engines being torn down for parts. The other factor is that the dwindling market for the older engines has prompted many MROs/Engine Shops to reduce their capability to maintain or repair these engines, as they instead invest large sums to get set up for the intake of new engines.”

At MTU Maintenance, Christian Ludwig adopts a slightly more positive approach to supply chain issues, seeing some light on the horizon: “For the CFM56, specifically, we have been witnessing some ease in the supply chain, though it remains to be seen if this trend will continue. In the recent past, supply chain disruptions and constraints have had an industry-wide impact on turnaround times and overall costs of engine maintenance, as have workforce shortages for those who, unlike MTU Maintenance, laid off staff during the pandemic. To mitigate these on-going challenges, we have focused on bolstering material stock levels, conducting repairs when possible, and investing in training programs to develop skilled technicians.” However, at Standard Aero Jay Aiken has been witnessing a mixed bag of problems across the board for both engine types.

“Our biggest supply chain issue related to the LEAP has probably been that of tooling, which reflects the current ramp-up of CFM’s open MRO ecosystem for the engine. The members of the LEAP CBSA ecosystem, while competitors, have attempted to minimize this issue by sharing tooling where practical, for the sake of the LEAP operator community. On the CFM56, we are experiencing long lead times on certain parts, which is driving TATs. These delays are largely driven by COVID-era supply chain disruptions, combined with the rapid ramp-up in output that the same suppliers have faced on new programs such as the LEAP. Our extensive in-house component repair capabilities do allow us to minimize the impact of parts shortages to some degree, as do the USM sourcing capabilities offered by our in-house asset management subsidiary, PTS Aviation.”

Gunnar M. Sigurfinnsson at GA Telesis is very much in agreement with Jay Aiken in that he is still witnessing problems which originate from the pandemic. He points out that: “The pandemic has had a lasting impact on supply chains across various industries, including aviation. Extended

lead times for new materials and longer turnaround times (TAT) at third-party vendors have become common challenges for the CFM56 engine maintenance process.

These delays can significantly affect the operational schedules of airlines and MROs, leading to increased downtime for engines and a ripple effect on overall fleet availability. As the industry continues to recover, addressing these supply chain issues will be crucial for improving maintenance efficiency and ensuring timely access to essential components.”

The LEAP engine certainly has ‘big boots to fill’ as the successor to the exceptionally popular CFM56 engine and that succession brings with it a whole raft of problems. From lack of OEM parts to balancing investment in CFM56 parts with investment in new equipment required to perform MRO operations on the new LEAP engine, challenges will abound. However, with the majority of changes between the CFM56 and LEAP engine being in materials used, the remaining similarities between the two mean that these challenges should not be too great to overcome.