CFM56 ENGINE OVERHAUL: BOOSTING RELIABILITY WITH LATEST TECHNOLOGICAL UPGRADES

The CFM56 engine overhaul involves comprehensive maintenance and upgrades aimed at enhancing the engine's performance and reliability. In an exclusive to Freighter Trends, the professionals shared that the CFM56 is a widely used turbofan engine in commercial aviation. Upgraded control systems enhance engine performance and fuel efficiency, allowing for better monitoring and diagnostics. Newer, more durable materials are used in parts like turbine blades, improving heat resistance and longevity. Upgraded engines consume less fuel, benefiting both airlines and the environment. OEMs can create advanced, cost-effective repair solutions for aging CFM56 engines, enhancing their reliability and extending their operational lifespan while managing costs effectively. Here are the details ...


Guillaume Limouzy

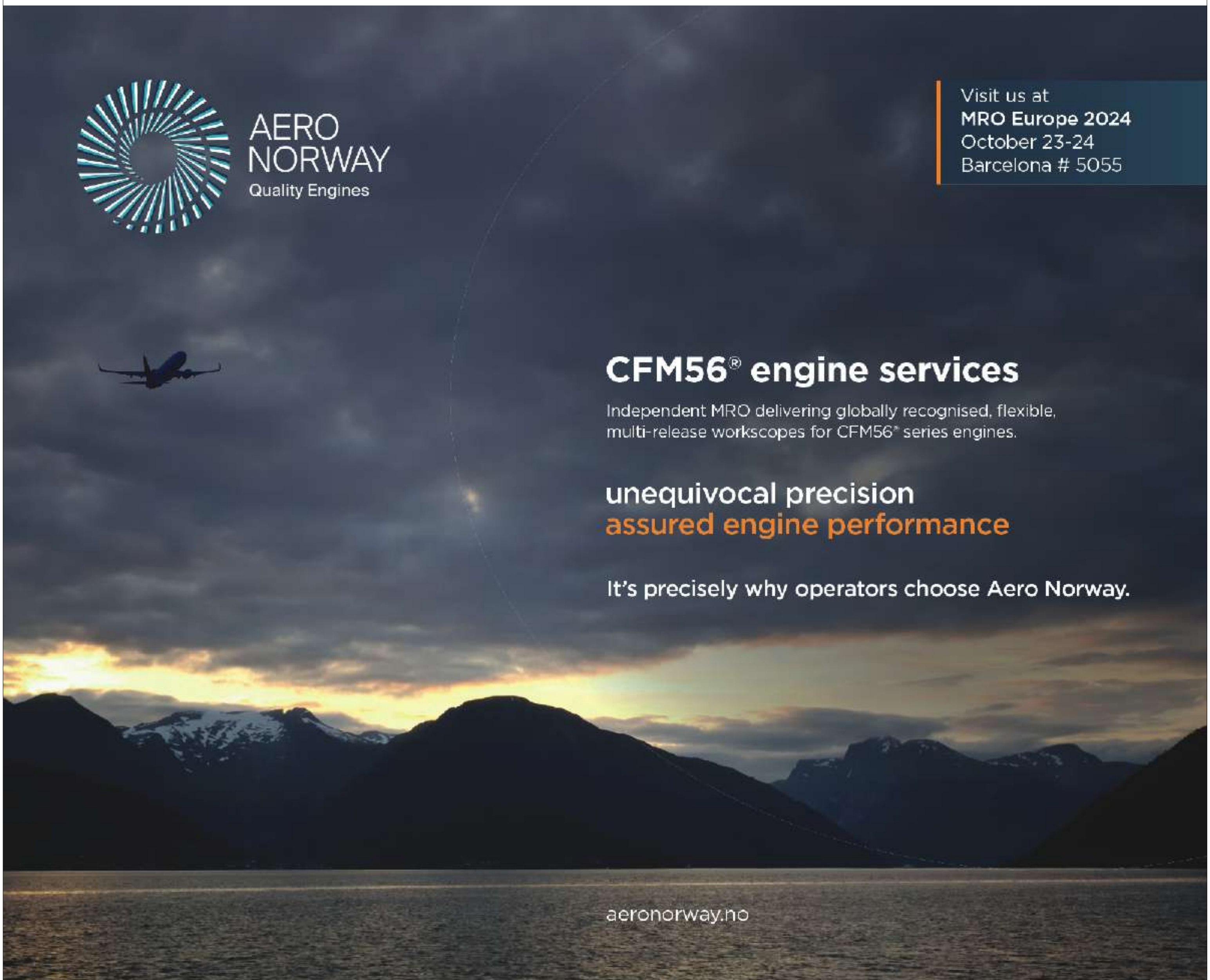
What are the differences you see between overhauling older CFM engines and next-generation CFM engines?

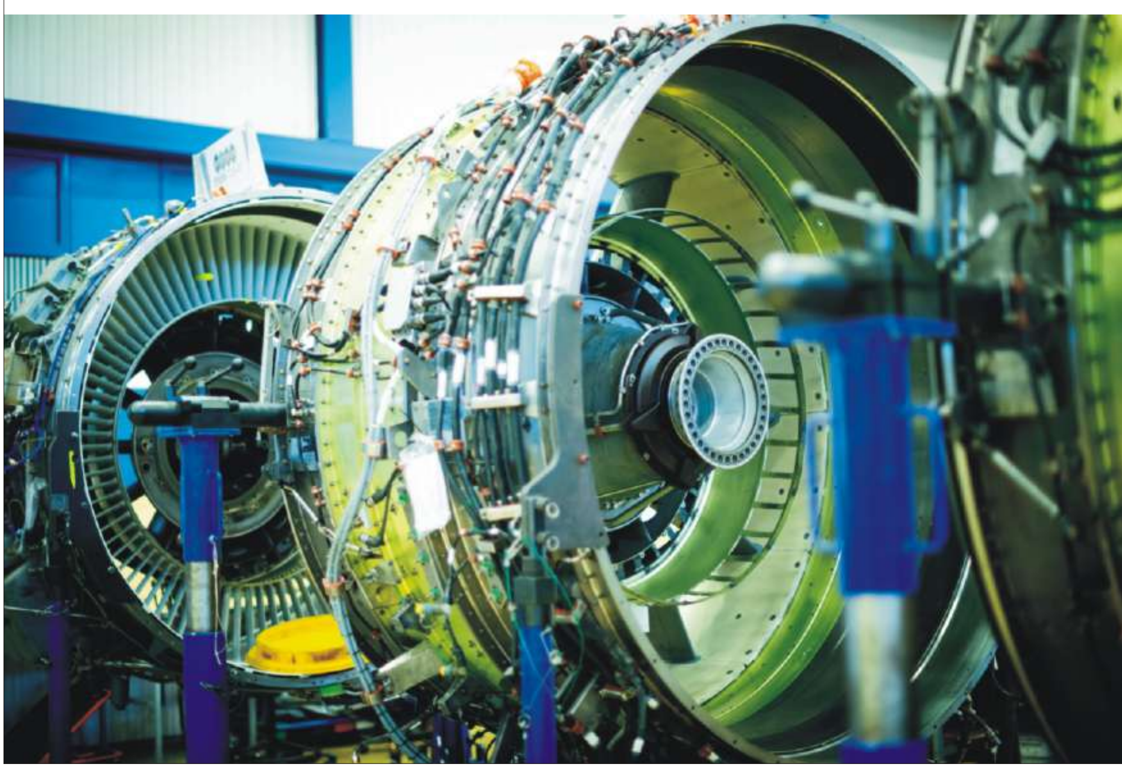
Guillaume Limouzy, Airlines Sales Director for Europe, Middle East, and Africa (EMEA), StandardAero's Airlines & Fleets division - In terms of the CFM56-7B, it is notable that the strongest demand – for both MRO and lease assets – is for the later Evolution and Tech Insertion (TI) variants, with the strong asset values associated with these models continuing to justify overhaul level (i.e. performance restoration) shop visits. The earlier single annular combustor (SAC) and double annular combustor (DAC) variants, while still in widespread service, are more likely to be supported through the use of short-build workscopes, module swaps and green-time assets.

Wasim Akhtar, Director of Engines, AJW Group : The market has a strong supply of USM for older CFM engines allowing operators to source components at a lower cost compared to new parts from the OEMs. This cost-saving opportunity makes overhauling older engines more financially feasible, particularly as these engines age and approach the end of their lifecycle. In contrast, next-generation CFM engines, being relatively new to the market, have a limited supply of USM. Operators are therefore often restricted to purchasing new materials directly from the OEM, making the overhaul process for these engines more costly.

The market for older engines is mature, with a broad network of independent MRO providers and OEM-affiliated repair facilities. Having more options provides operators with the flexibility to choose from multiple service providers, allowing them to negotiate better pricing and secure services that meet their specific needs. On the other hand, next-generation CFM engines, with their newer technology and designs, are serviced by only a handful of shops, often those affiliated with or certified by the OEM. This limited competition can lead to higher maintenance costs and fewer alternatives for operators seeking maintenance and repair solutions.

Lastly, MROs have amassed extensive data on older CFM engines over the years, enabling them to predict potential issues more accurately, offer cost-effective repair solutions, and optimise maintenance procedures. This allows MROs to provide spare engine options, ensuring minimal disruption to airline operations during overhauls. However, for next-generation CFM engines, this level of detailed data is still being gathered and with limited operational history MROs are still learning about the long-term reliability and repair needs of these engines, making it difficult to offer the same level of cost-effective maintenance





options. As a result, operators might face greater uncertainty regarding maintenance costs and longer turnaround times until more data becomes available.

Julián López Lorite – Commercial Director of Iberia Maintenance - The biggest challenge for all the MROs is to make the coexistence of traditional and future engines happen. It´s necessary to have the vision (and ambition) to prepare the business for the next-generation engines well in advance.

In the past few years, at Iberia Maintenance, we have worked hard to be at the forefront of the engine maintenance sector. In our engine shop, the legacy engines, such as the CFM56, the V2500, and the RB211-535, coexist with the new ones, such as the Pratt & Whitney GTF™. It


Dag Johnsen

has been possible thanks to an enormous investment in staff training and facilities adaptation -the layout of our engine shop has been adjusted to the new engines- and capabilities -to obtain all the certifications required for these new engines and their components.

AFI KLM E&M - Referred to our experience with CFM56-7B engine MRO, an engine is released from the TC holder (CFMi) in a specific configuration. During the life of an engine, modifications are released to improve reliability, safety, fuel consumption or durability of the engine even more. Older engines have many more modifications (Service Bulletins (SB)) that are applicable and can be performed during the life of the engine. These SBs could result in replacement of parts with newly designed parts, which can be expensive during the shopvisit, but improve the operation significantly making the SB worth implementing. Newer engines have many of these SBs incorporated from the factory release, having higher reliability during the shopvisits.

Christian Ludwig, COO, MTU Maintenance Zhuhai - The biggest difference, of course, is that older generation CFM engines have had decades to work out technical issues which inevitably come with any new generation of engine. Whereas there are very few surprises left when a CFM56 comes into the shop for maintenance, not too many LEAP engines have even 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 engines 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 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.

What new repair technologies could address the unique wear and tear of CFM56 engines in extreme environments?

Guillaume Limouzy - It will be interesting to see which technologies employed on the next-generation LEAP platform find their way onto the CFM56. With approximately 20,000 CFM56-5Bs and 7Bs still in service, this is a fleet which is going to remain in operation for decades to come, and CFM International has a strong track record of supporting its legacy platforms. CFM did of course introduce a new high-pressure turbine (HPT) blade for the CFM56-5B and -8B in late 2023, this new design featuring include increased wall thickness, optimized dovetail loading and tightened manufacturing tolerances. CFM also recently introduced a new HPT blade for the LEAP, following extensive testing of the blade in dusty conditions simulated to represent those encountered in the airspace over the Middle East.

Dag Johnsen, COO, Aero Norway - There are no specific new repair technologies to address wear and tear for engines operating in a "hot and harsh" environment, but the OEMs are continuously monitoring the endurance of the hot section and implementing design changes to extend the hardware time in service. There are also several steps the operators can take to minimise the wear and tear such as routine engine water washes to maintain the compressor efficiencies, utilise take-off derate whenever available, and more recently implement climb derate in the normal operation.

Julián López Lorite - More than the repair technologies, the improvement to reduce the wear and tear of the CFM56 engines in extreme environments will come from the SBs if they allow the implementation of different materials and coatings, which will raise the quality standards.

At Iberia Maintenance, we have several clients in this context, and we helped them with their engines, mitigating or reducing the impact and the deterioration in those circumstances – including extending the time on wing-, but for that, the SB needs to authorise the use of that material.

AFI KLM E&M - Repairs that are performed on parts of the engine have to be repaired in accordance with the Engine Shop Manual or other means of Repair Instructions, these can also follow out of the Service Bulletins (SB). Engines that have operated in harsh environments are exposed to polluted air and sand. The engine works by means of combusting air and extracting the energy from the combustion into propulsion. The combustion results in high temperatures in the engine, which makes in necessary to cool parts directly behind the combustor such as Nozzles, Blades and Shrouds. These parts have tiny cooling holes though which "cold" air forms a layer over the part protecting it from

direct contact with the combusted air. The "Cold" air still is several hundred degrees Celsius warm, which can result in melting sand or other pollution from the air, resulting in blocking the cooling holes of these parts. When the cooling is compromised, the degradation of these parts is significantly expedited leading to additional maintenance costs.
The repairs and SBs that are issued by CFMi (and other parties) are to for example either replace the old parts with enhanced material composition parts which can withstand higher temperatures, or have a new design which should result is more cooling or less blockage of the holes. It is for these operated engines highly recommended to follow the repairs and SBs which are developed for these wear patterns.

How could OEMs develop more advanced and cost-effective repair solutions for aging CFM56 engines?

Guillaume Limouzy - StandardAero's Component Repair Services (CRS) division already supports 775 repairs for the CFM56-7B, and almost 700 repairs for the CFM56-5B. The CRS team has extensive in-house repair development capabilities, and – following StandardAero's appointment as a CFM Branded Services Agreement (CBSA) services provider for the LEAP-1A and LEAP-1B – has also developed and industrialized more than 230 component repairs for the LEAP-1A/-1B. We fully expect the CRS team to play a significant role in developing additional cost-effective repair solutions for the CFM56 in the later stages of the engine's life, just as it has already been doing in support of the Rolls-Royce RB211-535 and other legacy platforms.

Wasim Akhtar, Director of Engines, AJW Group : The data accumulated over the years on older CFM56 engines reveals that these engines have the potential to operate effectively for longer periods. This knowledge could enable a shift towards more on-condition maintenance practices, where maintenance actions are based on the actual condition of the engine rather than on fixed intervals. By adopting this approach, operators could achieve more time on wing, extending the service life of their engines and reducing downtime, which in turn would lead to lower operational costs.

Additionally, the use of USM with the right life remaining and the latest Technical Instructions (TI) and Performance Improvement Package (PIP) part numbers can reduce the need for new materials during shop visits. By carefully selecting USM that meets these criteria, repairs can be made more cost-effective. This not only cuts costs but also ensures the engines are maintained with parts that are still aligned with the latest technological standards.

Older CFM56 engines also offer the flexibility to be customised according to the specific needs of the operator. Unlike new engines, which can only be built to the latest configuration, older engines can be tailored during overhauls to meet the unique requirements of different operators. By providing these bespoke solutions, companies like AJW could offer more targeted, effective, and economical maintenance options, further driving down the cost of ownership for operators.

Wasim Akhtar

Dag Johnsen - There are several non-OEM repair solutions, such as DER repairs, available for the ageing CFM56 engines. If the OEMs were more open to accepting and approving these types of repairs, it would greatly improve parts availability and lead to more cost-effective repair solutions.

Julián López Lorite - It is already known and in place with different names, such as End of Life solutions, for example. These programs include customized work scopes with less exposure, incorporation of more serviceable material, and module exchange, among others.

AFI KLM E&M - The repair development world is evolving in general. Besides from having more information from the engine due to advanced inspection technologies and AI enhanced data collection (see next question), the repair itself are becoming more reliable and more efficient. From learning how to have energy consumption in your process by introducing techniques like cold metal transfer, and cold spray, as to using robotics to aid in the tasks of the operators. These new technologies lead to higher reliability in the repair process and a more sustainable result.

Christian Ludwig - From an independent MRO perspective, we would always promote and support a collaborative approach between OEMs and MRO service providers to maximize capacity, expertise and, in turn, the cost-effectiveness and quality of solutions for customers.

How might the integration of AI and machine learning technologies transform the inspection and diagnostics processes at


Christian Ludwig

StandardAero?

Guillaume Limouzy - StandardAero has been investigating and employing AI and machine learning technologies for a number of applications across our enterprise. Areas of interest include scanning and analyzing engine documentation prior to induction; analyzing and prioritizing which engines require immediate MRO attention; optimizing workscopes; advanced diagnostics and prognostics associated with engine health monitoring (EHM); and maximizing just-in-time inventory efficiencies.

Dag Johnsen - The best opportunity I see of using AI and machine learning in the inspection and repair process is to utilise the data to predict and forecast repair and parts supplies needed.

Julián López Lorite - The MRO sector is still one of those in which the human factor is key, although it is true that technology and the application of AI and ML will help us to agile and optimize processes. For example, in the boroscope process, the IA can smooth and agile it.

Nevertheless, there is still a lot of work to do in technological development to be applied. Today, at Iberia Maintenance, we are in a process of continuous improvement whereby we are digitally updating all those processes and techniques in which we can apply new technologies. Hangar 51, IAG´s accelerator programme, plays a key role in this digitalization and transformation. This year, it is celebrating its eighth edition and has four categories to participate in: Sustainability, Safe & Efficient Operations, Seamless & Experiential Airports, and End-to-End Customer Experience Enhancement.

AFI KLM E&M - These new technologies could enhance AFI KLM E&M's future operations. AI-powered image recognition could support operators in performing highly repetitive inspections and time-consuming tasks. Borescope inspections at AFIKLMEE&M are currently supported by AI software, adding an artificial pair of eyes to the inspection via machine learning. By introducing new digital inspection technologies, machine learning algorithms could analyze vast amounts of historical maintenance data, enabling smarter decision-making. These advancements could transform inventory management by predicting the need for parts more accurately, thus ensuring availability of part. Additionally, Prognos ®, AFI KLM E&M predictive analysis program, facilitated by machine learning could identify potential failures, allowing for proactive interventions and minimizing aircraft downtime.

Christian Ludwig - Artificial Intelligence and machine learning have the potential of vastly speeding up the inspection process because engineers and technicians are able to exact extraordinary precision from these technologies.
They are already in use and establishing themselves as a great help to inspectors and other technicians. For example, new borescoping software uses AI to better pinpoint potential wear on components


Julián López Lorite

inside an engine. This is particularly helpful during on-site workscopes, where the working conditions can more challenging as opposed to the controlled environment of a shop floor.

How have supply chain disruptions and workforce shortages impacted turnaround times and costs for CFM engine overhauls?

Guillaume Limouzy - While we have not experienced significant workforce shortages (thanks in large part to our strong focus on employee training, e.g. via our San Antonio-based Training Academy and our partnerships with local technical colleges), we have encountered material supply disruptions as the supply chain continues its recovery from the impact of the pandemic. These disruptions have primarily been felt in terms of turnaround times: while our CRS team does offer extensive in-house component repair capabilities, there are still times where an engine's progress through the MRO process can be held up by a critical handful of parts.

Wasim Akhtar, Director of Engines, AJW Group : One of the most immediate effects of these disruptions is the increase in TATs for engine overhauls. The delays in sourcing necessary parts due to supply chain issues mean that engines spend more time in the shop, leading to extended downtime for operators. This not only disrupts operational schedules but also increases costs, as prolonged TATs often require operators to rely on spare engines or lease additional units to maintain their fleets.

Workforce shortages have had a further impact, particularly due to the lack of experienced staff who are familiar with both older and newer engine types. The retirement of skilled technicians and difficulties in recruiting and training new personnel have left a gap in expertise. The lack of experienced staff slows down the overhaul process, as less experienced technicians may take longer to complete tasks, further extending TATs and increasing costs.

The combination of supply chain disruptions and workforce shortages has led to higher scrap rates during engine overhauls. With experienced staff in short supply, there is a greater likelihood of parts being mishandled or improperly assessed, leading to more components being scrapped rather than refurbished or reused. This not only increases the cost of the overhaul due to the need for new parts but also adds to the strain on the already disrupted supply chain, creating a vicious cycle of delays and cost escalations.

Dag Johnsen - Supply chain disruptions can lead to longer turnaround times, reduced efficiency, and ultimately higher repair costs. Long turnaround times have a threefold impact on Aero Norway: 1) we may fail to meet customers' TAT (turnaround time) commitments, potentially resulting in TAT penalties; 2) a longer TAT will occupy a repair slot in our shop, delaying the induction of another engine and subsequently affecting our overall production targets; and 3) as with all repair shops, Aero Norway invests millions of dollars into the repair process, but customers typically do not pay the invoices until the engine is delivered. Therefore, the cost of the money tied up in the repair cycle can quickly accumulate.

Julián López Lorite - At Iberia Maintenance, we are so proud that we retained our talent during the COVID-19 pandemic, and, therefore, the business was ready to restart a its full capacity when the travel restrictions were eased.

In addition, since then, we have been increasing our staff which helped us to solve the workforce shortages that other MROs are experiencing. The material shortages are a different story and worldwide disruption. However, we implement different measures to mitigate the impact. For example, we have a highly skilled department specialized in developing new capabilities to repair engine parts in-house. This allows us to greatly speed up and adjust to the TATs, avoiding inconveniences derived from supply shortages and making us less dependent on the suppliers.

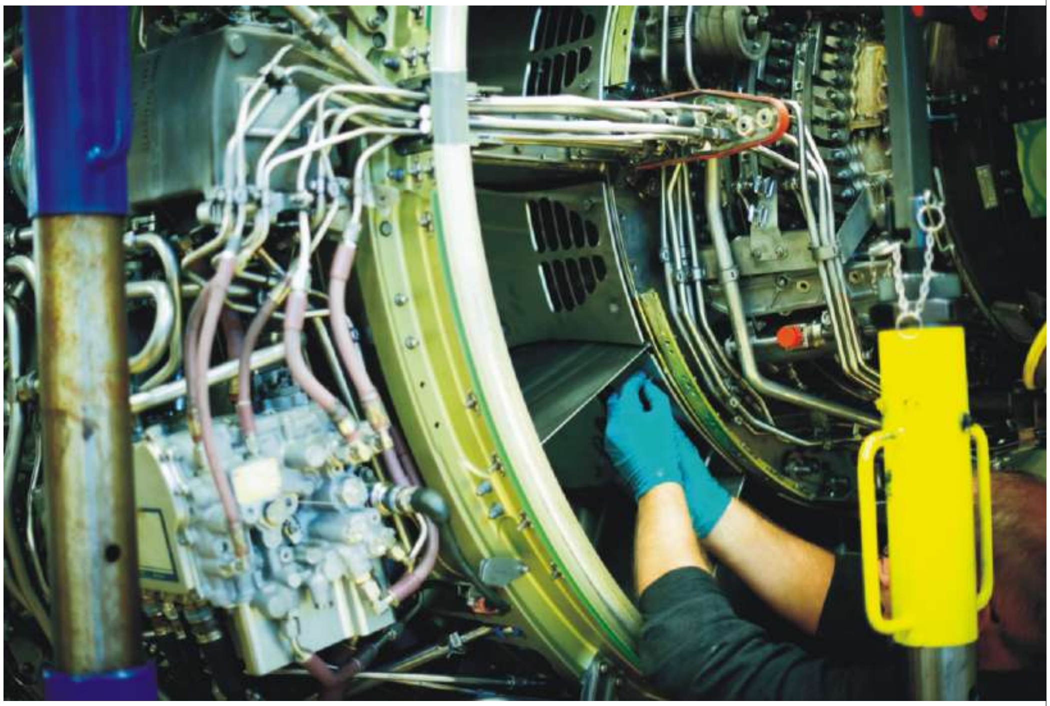
AFI KLM E&M - In the post-covid market it is difficult to comment on this question, as we are still in an unprecedented situation. In general we see part deliveries (new and repair) under a lot of pressure, while workforce shortage remains a challenge.

Christian Ludwig - For 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.

How is the focus on sustainability influencing CFM engine overhauls and the adoption of sustainable aviation fuel (SAF)

in the aftermarket?

Guillaume Limouzy – The CFM56 is already able to be operated on a 50:50 mix of SAF and Jet-A, and CFM continues to investigate the use of 100% SAF on the engine, with several supporting tests already performed. SAF represents a significant focus for StandardAero's environmental sustainability strategy and our own commitment to net zero 2050, including the use of SAF for engine testing, the use of SAF when refilling customers' aircraft prior to redelivery, and the development of specific MRO practices and component repair technologies as required to support engines run on 100% SAF.



Dag Johnsen – The biggest impact Aero Norway can have on the overall process with the focus on sustainability is to optimise the engine performance during the overhaul process making the engine as fuel efficient as possible resulting in less emissions. We are also heavily involved in recycling the removed material and nearly 100% of the scrapped parts are being recycled.

Most, if not all commercially available SAF fuels available today meet the common Jet A, and Jet A-1 standard fuel specifications (ASTM D1655) and although our test cell fuel consumption to certify an engine after overhaul is minute in comparison to an operator, we would welcome use of SAF if it was available in our region.

Julián López Lorite – As part of the IAG, our sustainability strategy has a clear destination: to achieve zero net emissions by 2050. This involves our business adapting and adopting sustainable measures framed in the Iberia Maintenance sustainability strategy developed in five pillars: water, volatile organic compounds and solvents, energy, waste and CO2. Regarding this last one, we are already using 5% of SAF in our test bench, which means that 115 tons of CO2 will be saved yearly. This milestone allows us to become the first Spanish aeronautical maintenance provider to continuously use this type of fuel in its engine test bench for commercial airlines.

AFI KLM E&M – Sustainability can be found on several aspects in engine maintenance and operation. From maintenance perspective, the parts that are installed in the engine are of high quality and very special material compositions. These are difficult to make, the process takes a lot of energy, bare metals and high technology methods. These parts allow for the engine to operate longer on-wing, resulting in less maintenance and thus more durable on that aspect. If the engine is eventually inducted for a shopvisit, the better the parts are, the less replacement parts and less repairs are required. Therefore if the parts are of higher quality and are less prone to wear, the long term durability of the engine, on-wing time and maintenance costs are improved. The development of additional repairs also contributes to this, because a replacement part requires new bare material and intensive production steps which is not required if the part can be repaired.

AFKLMEE&M partnered with GE Aerospace and SAF supplier Neste in performing the first inbound CFM56-7B ground test on 100% SAF in the KLM test cell at Schiphol East. Trials like these contribute to the necessary qualification and standardization of SAF. After the 100% SAF inbound test run the engine was inducted for overhaul as per maintenance requirement and no anomalies were observed.

Christian Ludwig – SAFs still have a lot prove, especially in terms of scalability to replace kerosene and the effects of long-term use in traditional aero engines, before we can make any declarative judgments on their impact on MRO. However, the aviation industry is taking on that topic in earnest and we are seeing more investments made into developing SAFs and their infrastructure, which bodes well for a more climate neutral future of aviation. MTU supports this development and all our test cells, including at Zhuhai, can be operated with SAF now.