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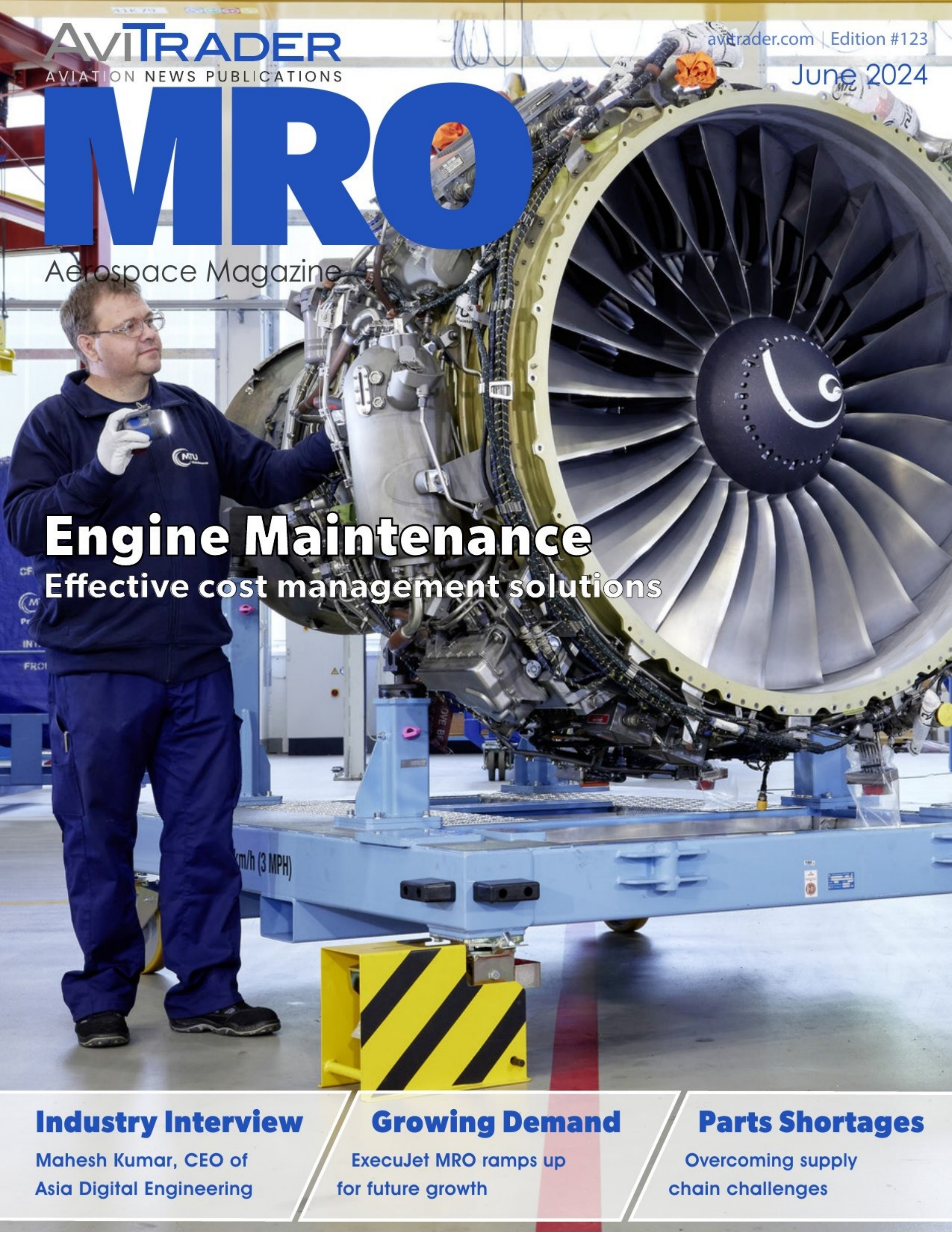

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Effective cost management solutions

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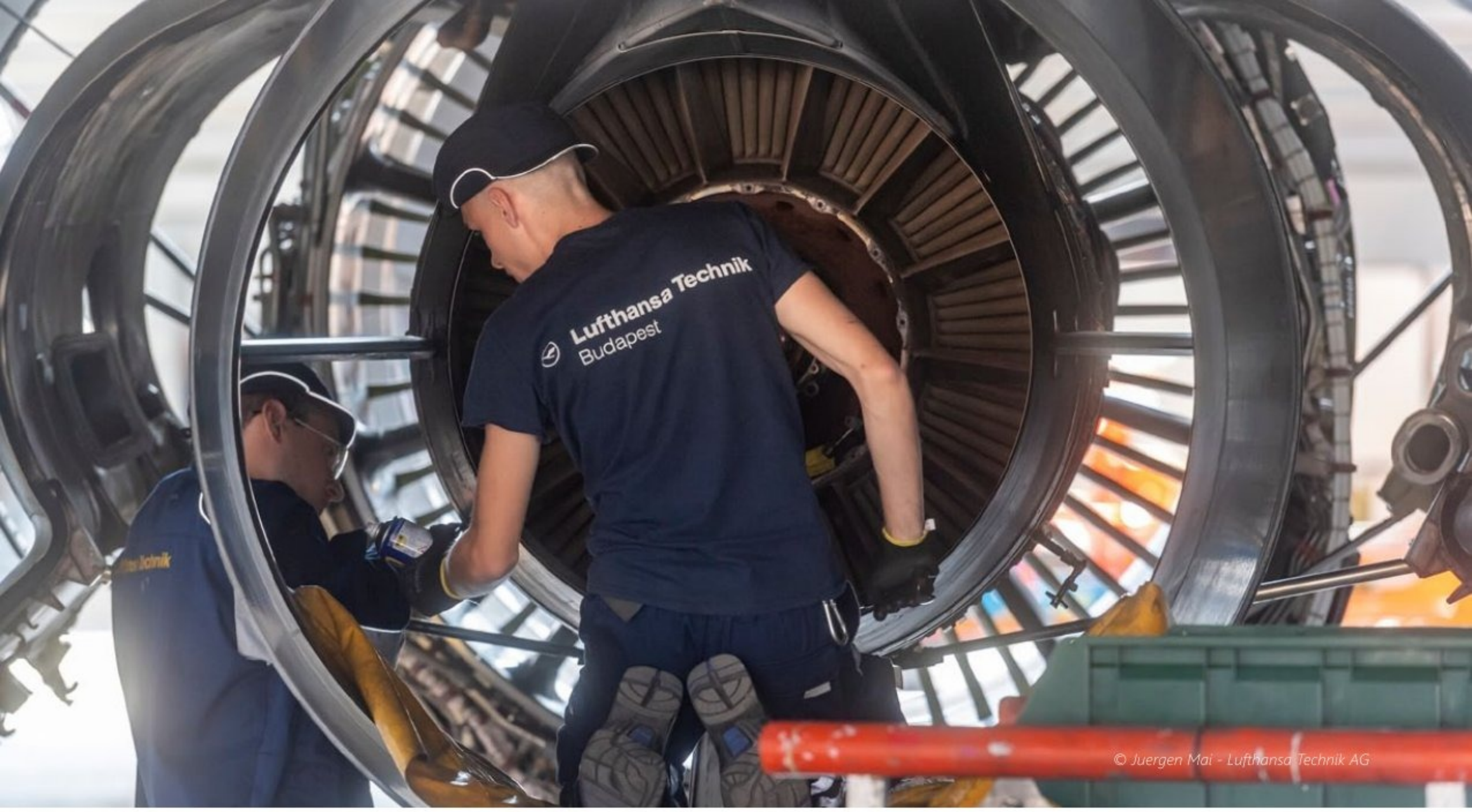

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Keeping the Cost of Engine Maintenance Down

By David Dundas

There is no question that the cost of engine maintenance is high. However, it is not simply a case of accepting that as an unavoidable fact, but instead there is a need to continuously explore all avenues that could lead to even the smallest reduction in these costs. Over an engine's lifespan, small savings today can add up to massive savings over a ten-year period. But where can savings still be made? We asked some of the players in engine MRO for their thoughts and opinions on elements of engine maintenance costs. This included the importance of smart work-scoping and proactive LLP planning, how used serviceable material can help reduce the maintenance cost of mature engine types, and we also asked them to share any thoughts they may have on how to reduce the cost of aircraft engine maintenance without compromising safety or performance standards.

Primary factors affecting the cost of engine maintenance

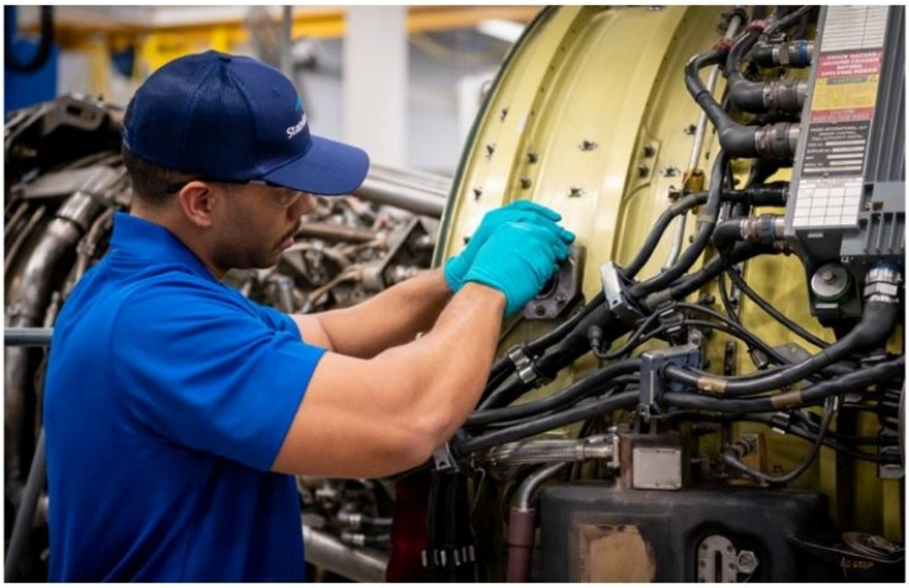
Clearly some aspect of engine maintenance are appreciably more costly than others. We wanted to know what principal factors contributed to the high costs of engine maintenance.

The issue is not limited to the level of workscope and age or usage of the internal hardware, the level of workscope will ultimately drive the amount of internal engine sub-modules and hardware that are exposed to inspection. In particular Simon Walker, Senior Vice President Technical at AerFin points out that:

"Turbomachinery materials (usually metal alloys) and complex aviation components are expensive to replace, and the repairs are often considered proprietary by the OEM which keeps the cost base high." He also comments that: "as with anything mechanical, the more you use it and with a potential environmental 'adder', the

> "Turbomachinery materials and complex aviation components are expensive to replace."
>
> *Simon Walker, Senior Vice President Technical, AerFin*

Simon Walker, SVP Technical, AerFin



CFM56-7B © StandardAero

higher the chance the mechanical parts will need replacing. There is only so many times certain parts such as fan blades, HPT blades, combustors, NGV's can be repaired and will need to be replaced to maintain operating reliability durability and safety."

From a company's perspective, the primary factor contributing to high costs when overhauling an aircraft engine will likely be scarcity in the marketplace for specific items. Consequently, as Arild Myklebust, Supply Chain Manager at Aero Norway comments, this can lead us "to use new, or more expensive USM material, e.g. LLPs with higher cycles remaining than what's needed, to meet the build specifications. We are also still influenced by suppliers not being able to meet our demands on TAT due to lack of manpower, broken down equipment or lack of raw material. This also leads us to buy newer or high-cost items, and ultimately, our inventory suffers due to exchanging parts and being left with items not imminently needed." This is backed up by Julius Bogusevicius, Head of Engine, Airframe and Materials Services at FL Technics who feels that a shortage of used service materials (USM) drives up the price of maintenance, while "One major factor is the high utilization of engines, especially in narrow-body aircraft like the CFM56-5B/7B, PW1100, V2500-A5, and LEAP-1A/1B. This leads to a high number of shop visits, and the industry is not fully prepared for this demand." He adds that: "new material prices have escalated significantly, with engine OEM catalogue prices for LLPs increasing by 10-12% annually over the last three years."

Operating an engine in extreme environmental conditions (hot, dusty, and sandy environments) will have consequences in deterioration at a much higher rate in comparison to engines operating outside of such environments, causing a lower time on wing and higher maintenance cost is a common problem. At Pratt & Whitney, Kevin Kirkpatrick, vice president of Global Aftermarket Operations and Oliver Boro, Technical Consultant Engines at AMROS Global are of a like mind. "The latest jet engine technology requires more advanced materials and specialised coatings leading to advanced repairs which drive higher manufacturing and maintenance costs. Importantly, some of the strongest growth in aviation demand will be concentrated in the regions of the world with hot and harsh operating environments, which are especially challenging for engine durability," Kirkpatrick comments, while, according to Oliver Boro: "As the engine matures (Engine Age), the maintenance costs for an engine increase. First-run engines have longer time-on-wing compared to second- or third-run engines. Over the course of its operations, more parts will deteriorate resulting in higher maintenance costs at every subsequent shop visit. Operating at higher thrust (Engine Thrust Rating) increases the cost of engine maintenance: higher EGT deterioration, higher fuel flow and lower time on wing. Shorter flights (Flight Length) put more thermal stress on the engine as it is subjected to more take-off and climb conditions."

From a slightly different perspective, Fabian Schön, Director, Engine MRO Programs at MTU Maintenance sees the depth of the workscope and the material to get the engine into serviceable condition during shop visits as interconnected. He highlights the fact that: "Depending on the engine type, material costs can range

> "The latest jet engine technology requires more advanced materials and specialised coatings leading to advanced repairs."
>
> *Kevin Kirkpatrick, Vice President Global Aftermarket Operations, Pratt & Whitney*

Kevin Kirkpatrick, VP Global Aftermarket Operations, Pratt & Whitney


Abhijeet Dey, Director of Asset Management, Setna iO

> *"Older engines require more frequent inspections, repairs, and component replacements."*
>
> *Abhijeet Dey, Director of Asset Management, Setna iO*

up to 80-90 percent of the total shop visit expenditure. High-quality parts and components build the base of long-lasting and safe operation of an engine, and that comes with a price, especially if there is a replacement of life-limited parts."

Moving on, supply chain, regulatory requirements, operating environment and engine age as all are capable of being direct contributory factors to the high cost of engine maintenance. Abhijeet Dey, Director of Asset Management at Setna iO specifically points to the fact that: "Many of the current engines in operation are part of aging fleets. Older engines require more frequent inspections, repairs, and component replacements to ensure continued airworthiness, increasing maintenance costs over time. As the engine ages, more parts will deteriorate resulting in higher costs at every subsequent shop visit."

> *"Using new parts substantially contributes to higher cost of maintenance."*
>
> *Desean Palmer, Senior Director of Material Management, VAS Aero Services*

But what about the most likely culprit – aircraft parts? It would make sense for the high cost of these to be one of, if not the greatest contributing factor to the increased cost of engine maintenance. Both Peter Wheatley, Vice President & General Manager – CF34/CFM56 with StandardAero's Airlines & Fleets team and Desean Palmer, Senior Director of Material Management at VAS Aero Services seem to lean in this direction. Peter Wheatley breaks down the costings of an engine shop visit as follows: material accounting for 70-80%, repair parts 10-20%, and labour 10-20%. He then goes on to further explain: "There are various reasons for this: aircraft engines famously adhere to the razor blade business model, with powerplants often sold at deeply discounted margins due to cost targets set by the aircraft manufacturer, and/or to competition from competing aeroengine offerings. As such, the engine OEM relies on high spare parts margins to recoup their losses, and to finance research and development into the next generation of powerplants." Desean Palmer on the other hand advises that "Often, a core engine restoration will require the replacement of Life Limited Parts or other critical parts, such as HPT hardware. Using new parts substantially contributes to higher cost of maintenance. Other cost drivers include low yields on material repairs, lack of available USM parts, unforeseen increases in new part catalogue list prices, and higher labour costs."

Desean Palmer, Senior Director of Material Management, VAS Aero Services

The effects of technological advancements and innovation on aircraft maintenance

This is another area that can impact on the cost of aircraft engine maintenance, and we were keen to find out in greater detail where leading MRO operators were leveraging technological advancements and innovation to have a positive impact on the cost-effectiveness of engine maintenance practices.

The goal of innovation in engine MRO should be to continue delivering the same quality of work more efficiently and with fewer resources, which then hopefully reduces turnaround time and the overall costs for the engine operator. How can this be done? Maybe as Fabian Schön suggests… "Developing in-house repair capabilities for high-value parts can lower the cost by avoiding third-party vendors and having to additionally wait for repaired parts to return for assembly."

Then you have companies like Pratt & Whitney which are looking to modernise and transform operations, including digitalization and investments in cutting-edge technologies such as AI, machine learning and automation. Kevin Kirkpatrick explains: "On the shop floor of our MRO facilities, we are introducing new technologies and equipment to drive productivity and reduce turnaround time. For example, Pratt & Whitney recently announced two technology accelerators -- centres of excellence in Singapore and Florida -- to advance MRO performance. Some of these technologies involve data analytics as well as robotics, advanced inspection, connected factory and digital twins."

It has, over time, become clear that enhanced reliability, condition monitoring maintenance and remote monitoring have been positively impacted by technological advancements and innovation on aircraft maintenance. So how does Abhijeet Dey see the situation? "Engines with better materials have longer lifespans and reduced susceptibility to wear and tear that requires less frequent maintenance, thus yielding cost savings over the engine's lifecycle," he comments, adding that: "By monitoring key parameters such as temperature, pressure, vibration, and component wear, maintenance activities can be tailored to the specific needs of each engine, optimizing resource allocation and reducing unnecessary maintenance costs." As for an excellent example regarding technological advancements, Desean Palmer provides just what is needed. "… the ability to view an engine's real time operating parameters can reveal how it may be deteriorating over time. When the engine EGT margin erodes to the point where it can no longer perform at higher thrust levels as intended, knowing this condition allows the maintenance planning team to remove the engine and operate it in a lower thrust capacity, extending the on-wing life of the engine," he explains. Digitalisation and advancements in new technologies and innovation are also at the core of Aero Norway's strategy, as Arild Myklebust makes clear. "Additionally, it involves improving our digital communication with customers, ensuring they can access information about their shop visits more quickly and reliably. We recognise that these new technologies improve our operations and communication, but we must focus on delivering true customer benefits, such as cost savings. Implementing technologies like AI, or other digital platforms, takes time to ensure they are robust enough to support our business effectively."

Advancements in engine technology are typically driven by two objectives: an improvement (i.e., reduction) in specific fuel consumption, which also reduces CO_2 emissions by an equal amount; and an increase in time on wing (or time between overhaul, i.e., TBO). According to Peter Wheatley, "These objectives may be achieved through the use of advanced materials, allowing the engine to be operated at higher temperatures while extending the durability of the engine. As TBOs are extended, the importance of regular maintenance practices such as engine washes becomes ever more important, to ensure that the engine's operating efficiency is maximized between shop visits."

Then we have the benefits of additive manufacturing, also known as 3-D printing, which is becoming more and more prevalent in the production of engine parts. This is advanced technology which allows the creation of complex and customized engine parts and components using layers of material. This is confirmed by Oliver Boro who comments that: "3-D printing can enable faster and easier repairs and replacements, as well as the development of new designs and materials that can enhance engine performance and efficiency. This technology can offer several benefits for aircraft engine maintenance, such as reducing costs, waste, and inventory, increasing flexibility and innovation, and improving quality and durability."

Perhaps the focus should be more on the smart approach to engine maintenance, work-scope planning, and shop visit management rather than on just tools or

> "It involves improving our digital communication with customers."
>
> *Arild Myklebust, Supply Chain Manager, Aero Norway*

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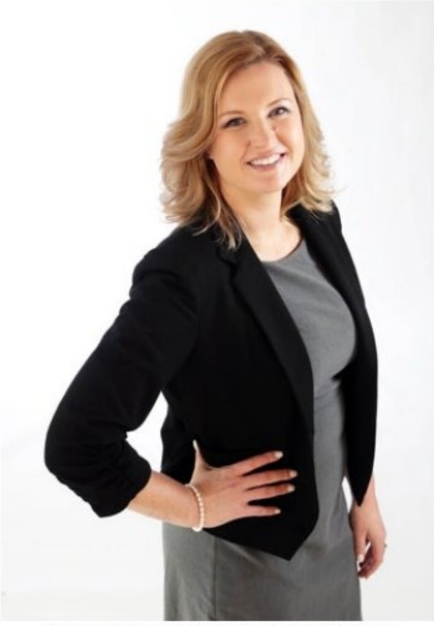


Nicole Jenkins, Chief Manufacturing Engineer, MRO, GE Aerospace

> "That kind of data provides a much better predictive capability for when the engine needs to be removed."
> *Nicole Jenkins, Chief Manufacturing Engineer, MRO, GE Aerospace*

equipment and, as Julius Bogusevicius puts it, "For new-generation engines, a cycle of high utilisation followed by performance restoration is typical. However, for matured engines like the CFM56-3/5/7, more optimal scenarios often exist,"

Meanwhile, Nicole Jenkins, Chief Manufacturing Engineer, MRO, GE Aerospace has the final word on the matter as she explains what happens at GE Aerospace where technology investment is "focused on infusing new capabilities into our global internal component repair and overhaul component repair facilities to support the more than 1,000 repair industrialisation projects we complete annually. Each of these NPI projects are in support of increasing the amount of repaired parts going into our maintenance events in support of our customer's cost of ownership. These can either be in the form of process improvements to reduce rework and increase repair yield or decrease our repair turnaround time ensuring it meets committed turnaround times."

How MRO organisations leverage data analytics and predictive modelling to forecast maintenance needs

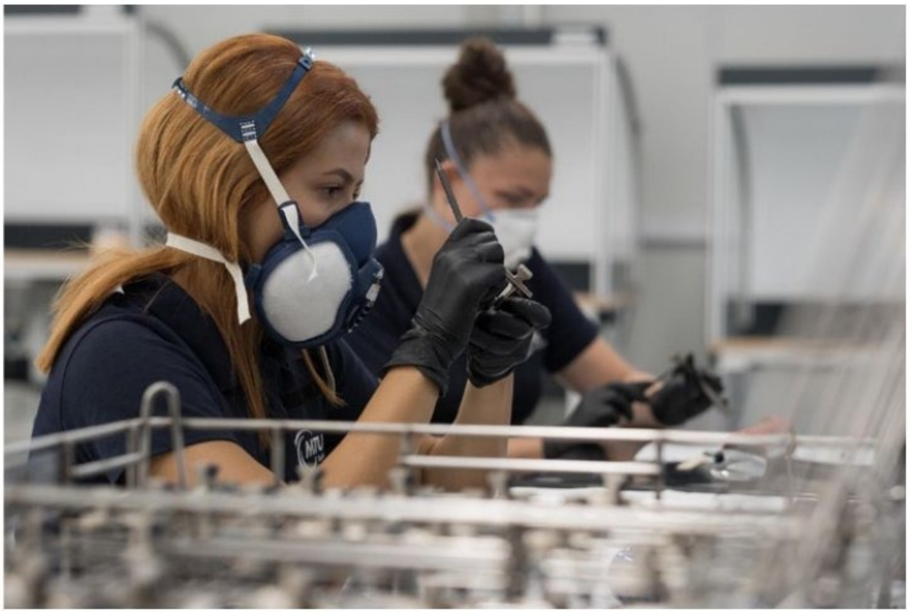
The next area we wanted to explore was that of how leading MRO operators leverage data analytics and predictive modelling to forecast maintenance needs and optimise spending on aircraft engine maintenance?

Data analytics is the process of examining data sets to find trends and draw conclusions about the information they contain. Predictive maintenance is a specific application of data analytics. Engine sensors can continuously monitor the condition of the engine, relaying real-time data to maintenance teams. Consequently, as Oliver Boro explains: "This data can then be analysed to identify trends and predict when engine parts might fail or require servicing. As a result, maintenance can be scheduled proactively, reducing unscheduled ground time and the associated costs."

Of course, as quick-turn activities and modular solutions become more popular, traditional shop visit forecasting methods, such as using LLP life, mean time between removal and typical exhaust gas temperature deterioration are no longer accurate enough. As Julius Bogusevicius points out: "Many engines were built with non-traditional standards, necessitating an individual approach for engine analysis. Future work-scopes may need to be more creative than standard core performance restoration."

As an example, GE Aerospace's Blade Inspection Tool (BIT) is equipped with an AI-enabled camera which produces a lot of objective measurement data against a subjective inspection. It is hugely beneficial because it creates an archive of the evolution of the hardware and service through time. As Nicole Jenkins explains: "That kind of data provides a much better predictive capability for when the engine needs to be removed which is great for the customer, because we avoid unplanned engine removals."

As for how MTU Maintenance tackles the situation Fabian Schön clearly explains: "... we work closely with customers to garner as much technical information as possible about each and every engine



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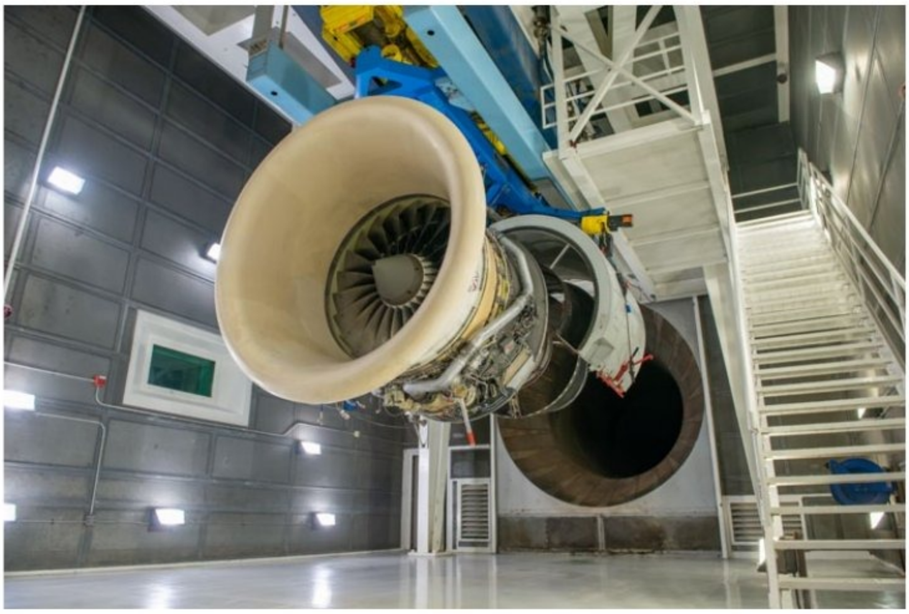


RB211-535 on test © StandardAero

and can create a tailor-made maintenance strategy with our in-house developed engine fleet management software CORTEX. That requires factoring in a number of variables: age and make-up of the fleet, the environments in which it operates, maintenance history, expected changes to the fleet and others." Alternatively, Arild Myklebust confirms that digitalisation and advancements in new technologies and innovation are at the core of Aero Norway's strategy. "We recognise that these new technologies improve our operations and communication, but we must focus on delivering true customer benefits, such as cost savings. Implementing technologies like AI, or other digital platforms, takes time to ensure they are robust enough to support our business effectively," he says.

Digital capability translates to efficiently supporting of Pratt &Whitney's customers as they care for the customers' engines throughout their lifecycle. "With our engine health management platform ADEM™ (Advanced Diagnostics and Engine Monitoring) – which employs a suite of web-enabled software tools to provide expert analysis of engine health data for more than 10,000 engines in service – we create customised, intelligent workscopes, provide early warning detection focused on preventative maintenance, and improve visibility into the overall health of the fleet," Kevin Kirkpatrick explains, while Abhijeet Dey focuses more specifically on maintenance strategies. "Based on the precise forecasts generated by our advanced predictive models, we can strategically optimize maintenance strategies to significantly minimize costs, all while prioritising the reliability and safety of aircraft engines. This involves giving priority to critical maintenance tasks, and efficiently managing inventory of spare parts and components. By analysing real-time data from engine sensors and historical performance data, our models can reliably predict when essential maintenance tasks, such as inspections, repairs, or component replacements, are likely to be required."

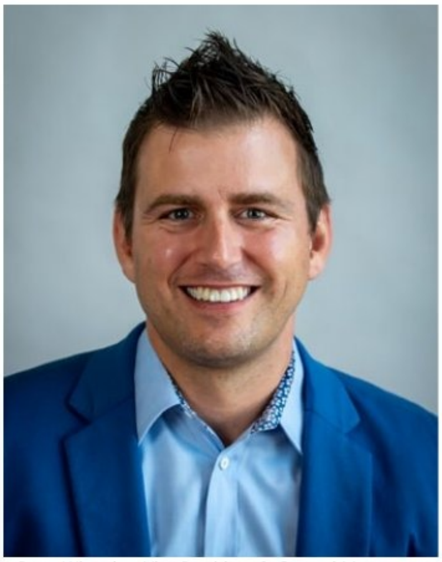
It should be clear that engine health monitoring (EHM) is extremely valuable in making operators aware of any potential unscheduled removals which may be necessitated, prior to potentially costly AOG events actually occurring. Peter Wheatley expands on this: "StandardAero has decades of experience offering EHM data analysis services for a broad range of engine platforms, from the PT6A and PW100 to the CFM56 and V2500, and up to the CF6-50/-80. We work closely with OEMs to ensure real-time knowledge of fleet demographics, which feeds into our data analysis activities and improves the reliability of predicted events."

> "We work closely with OEMs to ensure real-time knowledge of fleet demographics."
>
> *Peter Wheatley, Vice President & General Manager – CF34/CFM56, StandardAero*

The importance of smart workscoping and proactive LLP planning

Another area we wanted to explore was the importance of workscoping and proactive LLP planning and how that could reduce maintenance costs on a long-term basis.

AMROS Global's Oliver Boro points out that full workscopes address most of the fixes needed while returning an almost new engine and are costly in general. However, he then explains: "Workscope optimization is needed to ensure airlines can maximise the cost-benefit of each unique shop visit - and this is highly dependent on the actual removal reason of the engine, the airline's operating requirements for the fleet, and



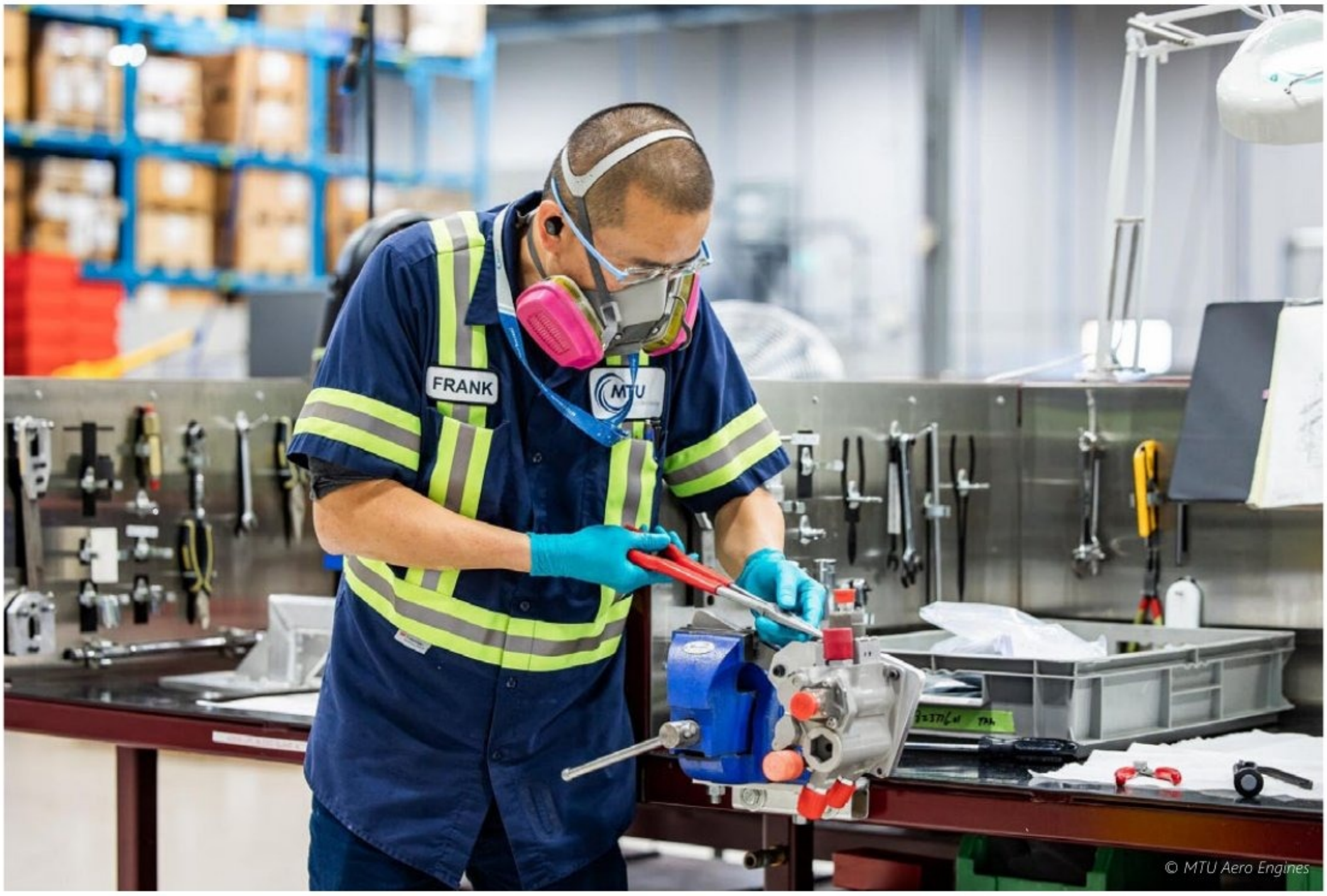
Peter Wheatley, Vice President & General Manager – CF34/CFM56, StandardAero any future fleet plans concerning the airframe the engine is operated on."

Tailored work-scoping, both in the shop and on-wing, are considered to be essential to match maintenance budgets with expected engine time-on-wing and residual value, underlining that mature engines often require different work-scopes than classic performance restoration. This is further highlighted by FL Technics' Julius Bogusevicius: "Successful planning involves preparing with the necessary modules and parts and using individual analytics for each engine. The landscape of the parts business will also change as engines with such an approach are often built for lower LLP standards, leading to increased demand for lower LLP stacks or modules with lower LLP cycles remaining. Choosing the right maintenance shop, such as FL Technics Engine Services, which specialises in quick-turn activities and module changes, is also important for flexibility and efficiency."

> "When we see stubborn supply chain constraints that lead to longer TATs, it crucial to exactly plan out workscopes and the material needs during SVs."
>
> *Fabian Schön, Director, Engine MRO Programs, MTU Maintenance*

Of course, successful planning involves preparing with the necessary modules and parts and using individual analytics for each engine, advising also that the landscape of the parts business will also change as engines with such an approach are often built for lower LLP standards, leading to increased demand for lower LLP stacks or modules with lower LLP cycles remaining. Aero Norway's Arild Myklebust feels that: "Proactive LLP planning from a purchasing point of view is very important, it gives the project planners and the buyers more time to search the USM market for parts which provide the exact fit for the workscope and give good value to the customer. The market is difficult because everyone is looking for the same components and with the limited availability, finding exact or very close matches is time-consuming and not always possible."

There again, not every workscope must necessarily be conducted as a shop visit and that sometimes smaller repairs or maintenance tasks can be done on- or near-wing at a hangar by MTU Maintenance's global ON-SITEPlus service teams, saving the customer significant costs. Fabian Schön adds that: "when we see stubborn supply chain constraints that lead to longer TATs, it crucial to exactly plan



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> "USM is very helpful in reducing the overall maintenance cost of mature engines."
>
> *Desean Palmer, Senior Director of Material Management, VAS Aero Services*

out workscopes and the material needs during SVs."

For some, smart workscoping is all about closely aligning the workscope with the needs of the engine. Patt & Whitney's Kevin Kirkpatrick explains that the company has developed a full suite of workscopes, including project visit / quick turn workscopes for removals for localised issues; for example, performing a focused bearing compartment modification to address an oil leak. He also highlights that: "Proactive workscoping and LLP planning begin with our Customized Engine Maintenance Plan (CEMP) developed with each operator well in advance of a shop visit. This defines the workscope necessary to meet target time on wing requirements. The overall intent is to optimise the workscope and LLP build standard to minimise overall cost of ownership." You can also enhance work-scoping efficiency by grouping related maintenance tasks together to minimise downtime and labour expenses while ensuring thorough maintenance coverage. For LLP management, Setna iO's Abhijeet Dey advises you to: "Establish effective systems to monitor and manage the usage and remaining life of Life Limited Parts (LLPs) from acquisition to retirement, including scheduling timely replacements or overhauls."

One shouldn't lose sight of the fact that smart workscoping and proactive LLP planning is important to allow operators both to minimise their maintenance costs and to avoid any operational issues associated with engine shortfalls. Peter Wheatley points out that: "In the case of StandardAero, our engineering team works with operators to develop a customised workscope for each shop visit to maximise time on-wing in the most economical way possible, based on the specific number of cycles required."

To round things off, Desean Palmer at VAS Aero Services highlights the importance of proper work scoping and LLP in order to reduce maintenance costs. "Doing so helps prevent removing an engine too soon because of SB/AD requirements, EGT margin deterioration or an engine reaching its LLP limit before its time. Work scoping and planning also lead to developing an appropriate end-of-life solution for an engine which can maximise its residual value," he comments.

How USM can help to reduce the maintenance cost of mature engine types

The cost of used serviceable material (USM) plays a significant role in the overall budget for mature engine type maintenance. We were interested in seeing how MRO enterprises perceived the obvious benefits.

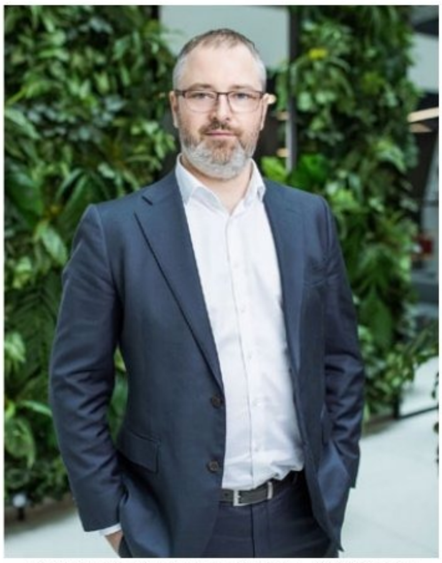
Kevin Kirkpatrick acknowledges the problems associated with the pricing of USM based on the part and its pedigree, but that one has to also accept that: "The actual savings recognised for a given shop visit is typically much less because for many parts, new material is the only viable option," while Desean Palmer advises that: "USM is very helpful in reducing the overall maintenance cost of mature engines, as USM affords operators and engine owners the option of purchasing air-worthy used parts at a lower, sometimes negotiated price, instead of purchasing a new part at full list price."

Abhijeet Dey is quick to point out that: "As engines age, their performance deteriorates due to the aging of engine materials. After the first shop visit, installing new parts is going to be less effective, and the time on wing (TOW) remains lower. Therefore, the achievable TOW with new parts for a first-run engine is going to be much higher than for a second- or third-run engine. This is why the use of USM makes it more viable for older engines, as it provides a more cost-effective solution per cycle."

It is clear to see that used serviceable material (USM) may offer a number of benefits to operators, not only in terms of helping to reduce costs but also by reducing turn-around times (TATs), e.g., in the event that new parts are not readily available, but Peter Wheatley also points out that: "Component repair & overhaul (CRO) also plays a key role in minimizing costs and TATs, and our in-house Component Repair Services division offers extensive CRO capabilities across a wide number of engine platforms."

One of the major challenges is that the price difference between USM and new parts is significant and the more USM used on engine maintenance the greater the effect on repair cost. We then have the problem with mature engines. As Arild Myklebust identifies: "Certain CFM56 engine parts are no longer available or extremely difficult to get hold of, so to meet the build specification it can be difficult to get hold of suitable LLPs. This forces us to either buy new or look for possible DER/ PMA parts as alternative offers." To counterbalance this, Oliver Boro provides an excellent example of where savings can be made by: "swapping used modules with time-continued or 'green time' modules taken from a disassembled engine. This is cheaper than repairing or replacing parts and performing full maintenance on the original module. This can generate large savings, especially if it avoids replacement of LLPs at high cost", while Julius Bogusevicius provides two interesting suggestions. "Given the hot USM market, planning and procuring in advance is crucial. Using maintenance providers that support USM materials during shop visits can also help reduce costs," he comments.

The fact that readily available USM keeps turnaround times in check makes it highly sought after, so many businesses will do everything to make sure stock levels are adequate and replenished continuously. Fabian Schön states that where his own



Julius Bogusevicius, Head of Engine, Airframe and Materials Services, FL Technics

company is concerned, it is: "actively collaborating with industry partners to acquire entire aircraft in order to source new stocks of used material, especially for legacy engines such as the GE90-110/115B."

Reducing the cost of aircraft engine maintenance without compromising safety or performance

Finally, we asked our contributors for any advice they may have on how to reduce the cost of aircraft engine maintenance without compromising safety or performance standards. This is what they recommended:

Oliver Boro advises: "Analysing data from various sources, including sensor data and maintenance records can enhance safety by identifying potential issues before they become critical. This proactive approach contributes to the overall safety and reliability of aircraft operations," while Julius Bogusevicius suggests that: "For mature engines like the CFM56 and V25s, consider different maintenance scenarios rather than following the same approach. Options include classic shop visits, tailored work-scope/continued-time approaches, modular repairs/changes, or mixed scenarios. Engine asset management decisions, such as engine purchase, exchange, or lease, can also help optimise costs while maintaining safety and performance standards."

Fabian Schön is very clear: "Healthy stock levels of used serviceable material and having in-house repair capabilities goes a long way to keep maintenance costs down because daily operations are not as reliable on the market for supply. For us at MTU Maintenance, it helps that we also have more than four decades of experience in engine MRO, so we know how to put all these factors into a tailor-made constellation for airlines and other engine operators."

Kevin Kirkpatrick recommends that: "airlines work closely with their engine OEMs to optimize their operations and maintenance plans. As an OEM, we recommend thrust guidelines for flight operations to maximize engine operational efficiency, minimizing stress on the engine resulting in longer time on wing and reduced maintenance cost," adding that: "Over the years, airlines have embraced the use of take-off derate if the conditions allow. With the latest generation of engines, we also see an additional maintenance cost benefit from using climb derate whenever possible. We are actively working with operators to provide this guidance."

Abhijeet Dey advises that one should "Ensure a reliable engine health condition monitoring system is in place, create a smarter engine maintenance workscope, increase the usage of USM where possible without compromising engine performance or safety, create a strong supply chain process with reliable suppliers, and finally, ensure the OEM operating guidelines are followed", while Peter Wheatley has three recommendations: "to plan well ahead when it comes to engine MRO, especially given the high demand currently seen for shop visits; to choose an OEM-authorised MRO provider, thereby ensuring that the services provided are in line with the OEM's recommendations (and utilising OEM parts and repairs); and to make use of EHM in order to help avoid unscheduled removals and in-flight shutdowns."

Desean Palmer puts it clearly by suggesting that one should: "invest in proper maintenance planning which will reduce maintenance intervals and associated costs," while adding: "I would recommend the use of USM material wherever and whenever possible. The savings over the cost of new parts can be significant, and the re-use of serviceable parts enhances a programme's sustainability."

It is clear that for the time being the cost of aircraft maintenance is going to remain at a challengingly high level. However, it is also clear that there are several options that can be taken that can help mitigate the cost of aircraft maintenance that can make a difference to the bottom line in the profitability of MRO operations.

> "Analysing data from various sources, including sensor data and maintenance records can enhance safety by identifying potential issues before they become critical."
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> *Oliver Boro, Technical Consultant Engines, AMROS Global*

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