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Predictive Maintenance

Real-Time Simulation Testing

DO-178C Part II


Cranfield's Hydrogen Integration Incubator

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# Maintaining Predictive Maintenance with Today's MRO Software

An essential role in modern aviation that enhances safety, reduces costs, minimizes unexpected component failures and improves overall fleet availability

Predictive maintenance with aviation MRO software is a key tool for MRO teams and airline operators. It plays an essential role in modern aviation by enhancing safety, reducing costs and improving operational efficiency. Transforming how airlines and MROs operate, it addresses key challenges such as unplanned downtime, data management and spare parts optimization, making it a vital tool for the industry.

Because aircraft systems are so complex, even minor issues can lead to significant operational disruptions. Forecasting maintenance shifts the focus from routine, time-based

*Graph below: Copyright: Maxa*

checks to data-driven, need-based interventions, which helps to reduce unplanned downtime.

The industry is acknowledging the positive benefits of predictive aviation maintenance software and its usage is growing. According to a market report by Hamburg, Germany-based IoT Analytics titled "Predictive Maintenance and Asset Performance Market Report 2023–2028," the global predictive maintenance market grew to $5.5 billion in 2022—a growth of 11% from 2021—with an estimated CAGR of 17% until 2028.

Using predictive maintenance with aviation MRO software solves challenges. "As aircraft are using more advanced avionics platforms with large volumes of data collected from nearly all aspects, gaining access and utilizing this data is integral to safe and smooth operations," says Justin Daugherty, Sr. Director of Aerospace Solutions at Maxa, Montreal, Quebec, Canada.

"Predictive maintenance in aircraft requires leveraging real-time data. [This includes] sensor data or performance data and can include real-time connectivity utilized by AI-driven analytics to predict potential failures before they occur, allowing maintenance teams to address issues proactively."

Monica Badra, Founder of Aero NextGen, Montreal, believes solutions for aircraft predictive maintenance, "address challenges by automating complex data analysis to identify potential failures early, helping manage component wear through optimal replacement timing, reducing costly aircraft on ground (AOG) events


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*Decision Assist for Mechanics by Leveraging Machine Learning. Copyright: RAMCO*

by scheduling repairs proactively, and optimizing inventory levels to avoid both shortages and excess stock. This improves overall maintenance efficiency, minimizes operational disruptions and reduces costs."

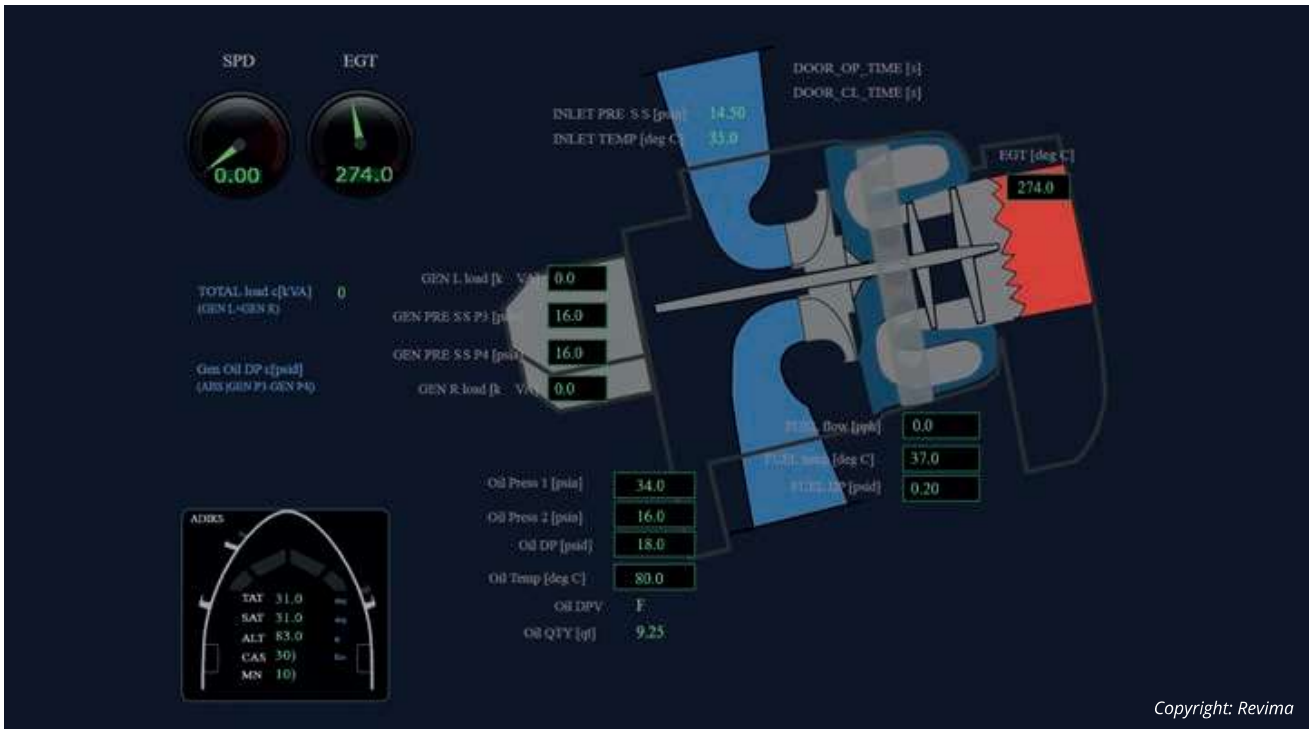
### What's Unique about Aviation?

Predictive maintenance in the aircraft industry is unique, according to Jason Cordoba, Managing Director of CordobaQ, London, because of the critical nature of the systems involved, the strict regulatory environment and the extreme precision required in forecasting. "By accounting for factors such as system complexity, operational stress and regulatory compliance, predictive maintenance ensures the safety, reliability and efficiency of aircraft. Its importance in aviation lies in enhancing safety, minimizing costs, reducing downtime and extending equipment life—all of which are essential in an industry where precision and reliability are non-negotiable."

Yes, unique because of the high complexity and safety-critical nature of its systems; however, AI is helping with that. "Aircraft components must function flawlessly, making predictive maintenance crucial for avoiding in-flight failures and ensuring regulatory compliance," says Simon Miles, Head of AI, Aerogility, London. "AI-driven solutions such as Aerogility support this by analyzing large volumes of data created from aircraft operations. This proactive approach ensures that maintenance is done at the optimal time, reducing risks and ensuring system reliability."

Because the aviation industry is so highly regulated for safety and reliability, Saravanan Rajarajan, Director of Aviation Solution Consulting at Ramco Systems, Chennai, India, explains that predictive maintenance solutions must align with data collection and validation regulations. "Data processing and insights are validated. Aircraft systems in the areas of navigation, communication and control systems are critical for flight safety, which means the predictive insights should be highly accurate and tolerances for minor malfunctions should be exceptionally low or zero. Aircraft data are sensitive and proprietary, which adds an extra layer of uniqueness to predictive maintenance. The system should comply with data privacy and cybersecurity requirements to protect data integrity."

Miles believes many AI systems act as a "black box," where users cannot see or understand how decisions are made. In contrast, Aerogility's model-based AI provides clear, explainable outputs, allowing maintenance teams to trust the predictions and make better-informed decisions. A trusted, explainable approach gives airlines confidence in the recommendations. "By reviewing various factors, such as usage patterns and the availability of parts, model-based AI enhances



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## A Crucial Aspect and Success

A crucial aspect often overlooked is that implementing powerful predictive maintenance software, while necessary, is only part of the solution. The real challenge lies in managing situations where components showing normal operation are predicted to fail. This creates complex decision-making scenarios involving maintenance action selection, repair cycle management and return-to-service protocols. Success in aviation predictive maintenance demands a well-orchestrated ecosystem of collaboration. This includes seamless coordination between airlines, MRO service providers, OEMs, technology providers and aviation authorities. This interconnected network ensures effective implementation, regulatory compliance and optimal operational benefits.

**Vikram Singh,**
**New Services Program Director,**
**Revima, Rives-en-Seine, France**

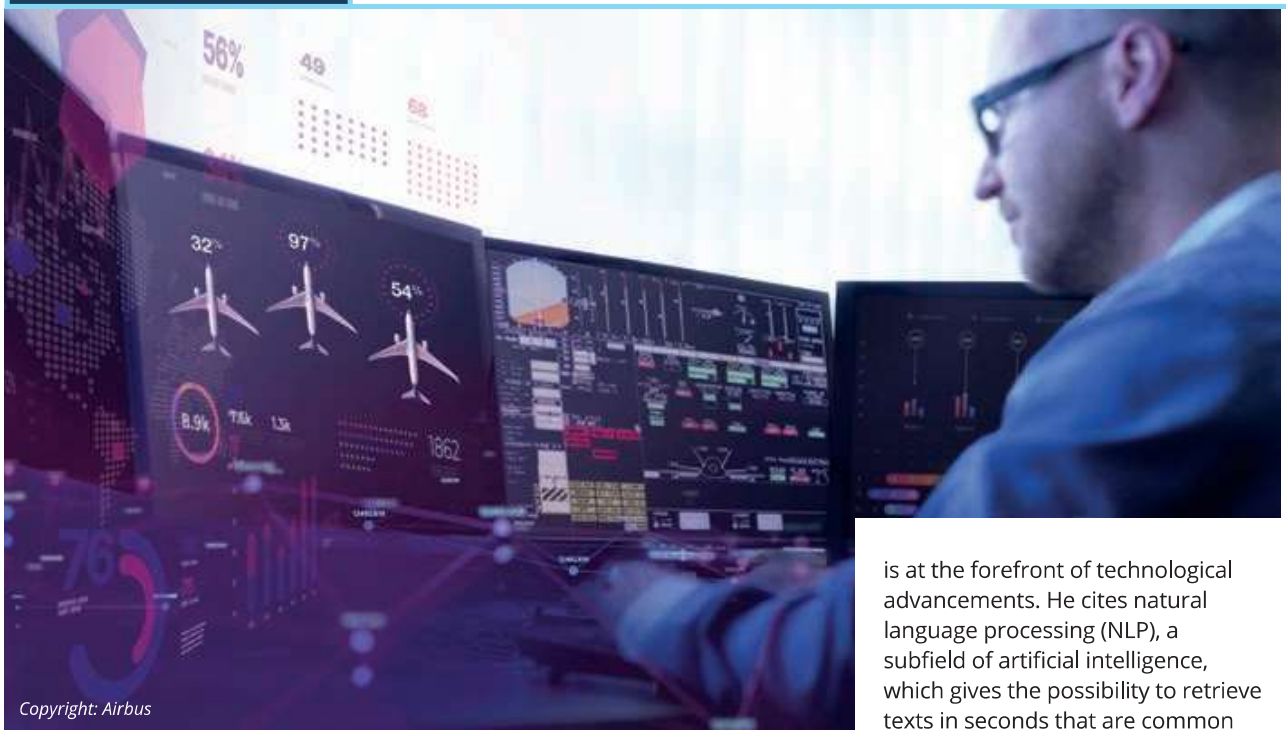
forecasting and planning, solving the challenge of balancing operational demands with maintenance needs. The great thing about model-based AI is that, from experience, maintenance teams can consider a series of what-if options and understand the behavior of different trade-offs. The impact of a particular part failure may, for example, result in bringing in the aircraft for maintenance earlier than expected."

David Marty, Head of Digital Solutions Marketing at Airbus, Leiden, Netherlands, agrees that as the latest generation of aircraft enters the market, the more the industry must deal with aircraft producing a high level of data. But, he contends the challenge is to turn this data into intelligence. "Often data tells us what happened and not immediately why a weak signal was triggered. With the information, we are able to prioritize, focus on key issues and find an approach to best implement a solution. All in all, data is becoming more and more powerful as a tool and together with our customers, we're committed to use this tool correctly to make flying safe and ensure stable operations. Predictive maintenance is the first step to optimize technical operations and eradicate technical cancellations and delays. The next step would be to leverage data analytics and digital capabilities to reduce direct maintenance costs and increase aircraft availability."

Furthermore, Marty contends that predictive maintenance is at its early stage in the aviation industry, "While in contrast to that, already well developed in industries like retail, oil and gas and many others. "Predictive maintenance implementation is a real digital transformation project implying organization change, change management, etc. All Airbus customers having already engaged in predictive maintenance have confirmed the value in terms of reduction of technical operational interruptions."

### Predictive Innovations

Recent advancements in MRO software for aircraft predictive maintenance focus on integrating AI, IoT and digital twin technologies. AI and machine learning analyze historical and real-time data from aircraft systems, predicting failures more accurately than traditional time-based or reactive

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approaches. "IoT-enabled sensors offer continuous, real-time data monitoring, reducing the need for periodic manual inspections and lowering the risk of unexpected failures or AOG events," Badra says. "Digital twins simulate aircraft system performance under various scenarios, allowing maintenance teams to forecast potential issues without physical testing, saving both time and resources. Additionally, cloud-based platforms and collaborative dashboards centralize data and improve decision-making by providing stakeholders with a unified view of aircraft health and maintenance status."

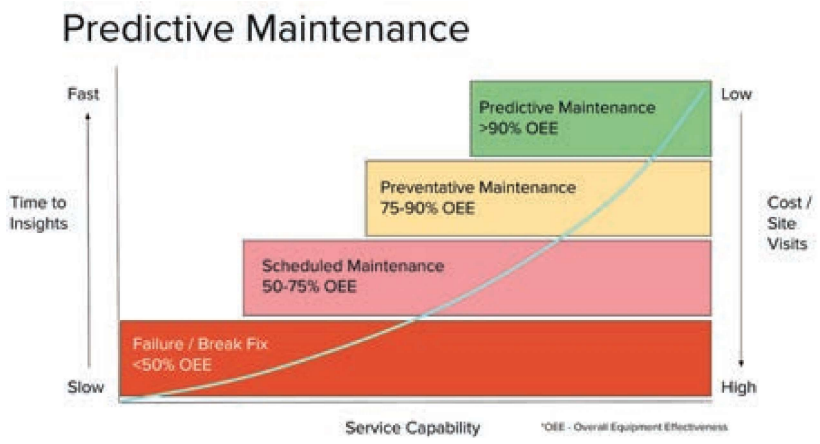
Cordoba agrees that AI-powered dashboards, machine learning algorithms, digital twins, IoT integration, cloud-based platforms, and advanced analytics—have revolutionized how maintenance is conducted. "These technologies help by enabling more accurate predictions, reducing human error, enhancing collaboration and ensuring more efficient use of resources. By replacing outdated manual processes and static data models, they optimize aircraft maintenance, reduce costs and increase operational reliability."

These innovations replace manual processes, scattered data sources and reactive maintenance methods with proactive, data-driven approaches. Badra adds that enhanced analytics for inventory management also optimize stock levels for aircraft components, reducing costs associated with excess or shortage of parts and making aircraft maintenance more efficient and cost-effective.

By integrating AI and machine learning into its MRO software, Maxa enables more accurate failure predictions based on historical and real-time data from aircraft systems. Maxa's platform continuously monitors aircraft health through IoT-enabled sensors, providing real-time insights that reduce the need for manual inspections and help prevent unexpected failures and costly AOG situations. "Through a centralized, cloud-based platform, Maxa offers collaborative dashboards that give stakeholders a shared view of maintenance activities and system health, enhancing decision-making and coordination," Daugherty says. "This suite of tools replaces outdated, reactive maintenance methods with a proactive, data-driven approach, ultimately reducing costs, improving operational reliability and streamlining inventory management for aircraft components."

Marty agrees that AI integration is at the forefront of technological advancements. He cites natural language processing (NLP), a subfield of artificial intelligence, which gives the possibility to retrieve texts in seconds that are common (logbook entries) and finally get recommendations based on airline fleets. Furthermore, he says there are increased capabilities to manage extended sensor data. "Time series through FOMAX — co-developed with Collins Aerospace — is an on-board connectivity solution that enables airlines to collect aircraft maintenance and performance data on-board the aircraft and automatically transmit it to ground-based operations, at a higher speed than previously possible, and in near-real-time.

Enhanced and next-generation predictive maintenance capabilities are forcing operators to revisit data platforms and data quality. Rajarajan explains the first step in implementing predictive maintenance is assessing the data capabilities and quality of the source systems. "Existing infrastructure should have a clear process and workflow to collect the right data, and collected data should be governed by the right workflow controls. The second step is training the AI systems in different data types, the context of data and the relationships between structured and unstructured data sets, which has to be correlated meaningfully through training. Accuracy issues require constant intervention from the data engineers and business until the AI systems bring in real value."

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## Capitalizing the Cloud

Cloud-based software enables real-time data collection and manages the volume and velocity of the data needed for predictive maintenance. "The cloud enables centralized data storage, scalable analytics and real-time collaboration across global fleets, which are essential for the Industry 4.0 revolution," says Suyash Joshi, Senior Developer Advocate, InfluxData, San Francisco. "It integrates advanced tools like AI/ML and digital twins, transforming MRO operations into more agile and proactive processes."

"Cloud technology has been a fundamental enabler for predictive maintenance in aviation, revolutionizing data sharing capabilities among collaborators in a secure environment," says Vikram Singh, New Services Program Director, Revima, Rives-en-Seine, France. "This technology has created an effective platform for cross-organizational collaboration while providing robust frameworks to manage intellectual property rights and data ownership concerns."

Cloud-based systems provide the scalability and flexibility to run advanced AI/ML programs for faster processing and scaling of data over time. "Cloud-based systems also provide the foundational block to connect to the external ecosystems and leverage the data along with in-house data for prediction," Rajarajan says. "The API-based protocol is essential for ensuring seamless software collaboration for the organization. Thereby, the key data are received and shared."

The cloud has transformed MRO software for aircraft predictive maintenance by providing scalable, centralized platforms that enhance data access, collaboration and storage. With cloud-based systems, real-time aircraft data from multiple aircraft can be seamlessly collected, processed and analyzed in a single, secure environment.

Daugherty believes "This enables MRO providers and airlines to access predictive maintenance insights from anywhere, improving responsiveness and allowing for quicker, data-driven decision-making. Additionally, cloud-based storage reduces dependency on on-premise servers, offering greater scalability and reducing IT infrastructure costs. By simplifying data management and enhancing accessibility, the cloud enables a more proactive and efficient approach to aircraft predictive maintenance, minimizing downtimes and improving fleet reliability."

The cloud has significantly impacted MRO software for aircraft predictive maintenance by improving data accessibility, enhancing collaboration and offering scalability for processing vast amounts of data. "It reduces costs, strengthens data security and accelerates innovation in predictive maintenance capabilities," Cordoba says. "By moving from traditional, on-premise systems to cloud-based platforms, MRO providers and airlines benefit from faster decision-making, more accurate predictions, and a more efficient and cost-effective approach to managing aircraft maintenance."

**By Mark Robins**

### Advances in Predictive Maintenance for MRO Software

In recent years, the field of predictive maintenance for MRO software in aerospace has witnessed several advancements:

- **AI/ML Algorithms:** Advanced machine learning models are now capable of analyzing vast amounts of historical and real-time data from aircraft systems to detect patterns indicative of potential failures, helping operators address issues before they escalate.
- **IoT Sensor Integration:** Aircraft are increasingly equipped with IoT sensors that continuously monitor critical systems, such as engines, avionics and hydraulic systems. The integration of this sensor data into MRO software allows for real-time insights and more precise maintenance schedules.
- **Time Series Data Analytics Platforms:** Tools like InfluxDB provide the ability to ingest, store, and query high-resolution time-stamped data. This is crucial for monitoring trends, identifying anomalies, and correlating events across systems over time. By leveraging time series databases, MRO solutions can transition from rigid, schedule-based maintenance to dynamic, condition-based approaches.

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