



Digital Aviation

MRO Innovation and Disruption

RESEARCH STUDY REPORT

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Research methodology

Capgemini conducted an aviation and aerospace maintenance, repair and overhaul (MRO)/service level management market research study, involving more than 380 aviation industry decision-makers at airline operators, regulators, MRO organizations, OEMs and other service providers, to understand: prevailing approaches to technical operations technology, which innovations are being pursued, and where value is being realized. The responses were gathered through online surveys as well as telephone interviews with C-level executives (40), vice presidents (42), directors (74), managers (138) and others (90) holding positions with airlines, MROs, OEMs and aviation service providers. The research was conducted between March and April 2017 across countries in North, Central and South America, Europe, APAC, and MENA.

Swamped by a Data Tsunami

A tsunami is a periodic series of gradually increasing waves. They are seismic phenomena, representing internal wave trains that build upon each predecessor, overwhelming everything in their path. The aviation industry – commercial and defense – is experiencing a data tsunami that is fundamentally changing flight operations, technical operations, and customer engagement.

The airline passenger experience and interaction with an airline has completely transformed in the last 10 years. From flight histories to loyalty programs to social-media feeds, the customer-facing side of the aviation industry uses data across an ecosystem of service providers to create tailored communication, service, and loyalty perks. Data works to deliver efficiency and drive profits.

While the change in operational and information data has been stark, the change in aviation operations has been more gradual due to various events over the “lost decade” from 2001 to 2014. This period would bear witness to 9/11, SARS, bankruptcies, mergers, the oil price spike, and the great recession, before the industry returned to profitability.

With maintenance, repair, and overhaul (MRO) accounting for 11% to 15% of an operator’s annual costs (and global industry spending forecasted to exceed \$73 billion in 2017),¹ aviation and aerospace organizations are at a critical juncture: collaboratively harness data or perpetuate a cycle of excess costs, inefficiency, and unrealized value. Similarly, defense sustainment runs even higher on a per aircraft operating-hour



The Digital Thread represents the digitization of product lifecycle and service lifecycle data and the connections between systems and organizations. Originating from design inception through prototyping, manufacturing, operation, in-service maintenance, repair and overhaul, as well as training and content support documentation. The key capabilities of the digital thread are simultaneously maintaining data and content interoperability for both human and machine consumption and connectivity across the multitude of use cases and ecosystem organizations.

Digital Twins are digital replicas of a particular asset's logical (as-designed) and physical (serialized as-operated) configuration and associated parametric data. The logical digital twin contains the allowed rules based configurations, parametric models and engineering limits of how an asset is designed to function within an environment; while the physical digital twin contains the as-maintained configuration and consumes sensor data, operating data, utilization data, maintenance data, environment data and effectivity changes in these parameters over an assets lifecycle. The digital twin is also a repository of an asset's total lifecycle history providing a single source of truth to technicians, lessors and regulators.

Digital Analytics are various methods, algorithms and tools that use digital twin data gathered over the digital thread for component failure prediction, predictive maintenance, case-based reasoning diagnostics, task prescription, component and asset prognostics, component pool health scoring, aircraft and fleet health management, fleet program enhancements, autonomic logistics and both operational and financial asset performance optimization. Digital analytics include artificial intelligence, machine learning, deep learning, cognitive computing and autonomic decision support.

basis, with global spend averaging \$78.4 billion over the next 10 years.²

This operational data has massive potential to deliver operational insights and customer value, if it is not left untapped. However, necessity drove airline IT departments to focus mainly on "keeping the lights on" over the "lost decade," maintaining legacy operational systems rather than developing strategic plans to adopt sophisticated digital tools.

More data promises new operational and information technologies and advanced analytics, ranging from enhanced asset utilization and customer engagement to lower operational costs. Despite this potential, airlines neither own nor control the entire digital thread necessary to fully exploit the insights available, nor do they currently have the time, skilled resources, or technology in place to do so.

The full MRO data picture does not lie with any one type of organization. Operators, lessors, airports, OEMs, and MRO providers each hold a piece of the puzzle, making industry collaboration a mandatory step toward capitalizing on digital data-driven opportunities. But an ingrained culture of risk avoidance, security, and IP concerns has stunted attempts at data sharing.

Gaps in the Digital Thread

In 1661, Stockholms Banco, the precursor to the Swedish central bank, issued Europe's first banknotes on thick watermarked paper bearing the bank's seal and eight handwritten signatures. Today, Nordic countries – Sweden in particular – lead the world toward a cashless society. Across public and private sectors, paper money is becoming a thing of the past.

Throughout the aviation industry, organizations are being forced to manage exponentially larger volumes of data from disparate sources: sensor data from aircraft and mechanics, maintenance planning and execution information, and content data including paper and PDF task cards and records.

OEMs own petabytes of data on their products generated by their Product Lifecycle Management (PLM) systems and collected through voluntary sharing programs and contractual obligations. Airlines amass prodigious amounts of data from sensors and operational systems, only some of which (e.g. health monitoring information) are they required to share with third parties. On the other hand, MROs struggle to exchange data across their one-to-many relationships.



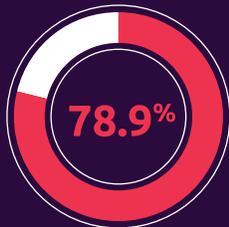
MRO data generation is accelerating – and organizations admit they lack the resources to keep up. **Seventy-three percent of airline and MRO leaders agree that the data volume, velocity, variety, and veracity exceed most operators' ability to effectively drive business value.**³

Airline operators, OEMs, lessors and airports as well as MRO providers and suppliers struggle to make sense or strategy out of data and do not have a history of working together to do so. A number of factors have led to this industry-wide bottleneck.

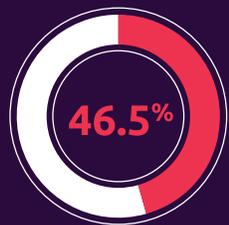
THE PAPER CONUNDRUM

Whether paper is physical or digital, it is an issue. The only true digital form that translates into data is XML. Most organizations still rely on XML-incompatible legacy systems – often anywhere from 10 to 40 years old – that fail to integrate with modern, standalone solutions for aircraft health management, prediction, or prognosis. This means that there is a stubborn dependence on paper and gaps in the digital thread.

The reliance on paper is pricey. Paper aircraft logs and maintenance records cost the global industry \$3.9 billion over the past 20 years⁴, exacerbating operational and technical inefficiency along the way. And though most airline and MRO executives (78.9%) intend for their businesses to be paperless within the next two years, fewer than half (46.5%) have allocated the capital to see these plans through.⁵



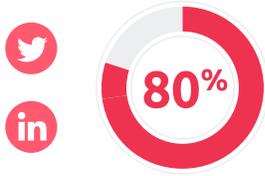
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Service Lifecycle Management (SLM) content is no longer simply for human consumption; it is equally designed and intended for machine consumption. Continued dependence on paper records undermines aviation organizations' ability to manage and share data. To achieve the objective of digital twins, machine learning-based prediction, case-based reasoning diagnostics, and prognostic prescription, these systems ingest JSON, a scaled down version of XML that makes paper and PDFs one of the top barriers to closing the gaps in the digital thread.

Across many industrial and manufacturing sectors, digital thread interoperability provides the capability to trace any change in form, fit, or functional configuration and utilization through an asset's product lifecycle: from design, manufacture and operation to in-service maintenance. But when important information related to any of these phases is maintained as paper or PDF content rather than in XML schemas, critical knowledge about the asset is lost. This is particularly true for long lifecycle aircraft in the defense arena, where a given tail number may have been assigned over 25 years ago but is still in service today, and slated to be in service for another 25 years.



Eighty percent (80.3%) of C-level aviation executives and vice presidents agree that plugging these gaps in the digital thread is essential to driving value yet 49.2% of all respondents said their company would not be paperless in the next 24 months.⁶ Ensuring data is structured for both human and machine consumption means taking paper and PDF out of the equation. Continued dependence on paper records prevents laying the foundation required for any form of digital innovation.

DISPARATE CONDITION MONITORING

The cost of off-board aircraft health management, diagnostics, prognostics and autonomic technologies that every OEM has invested millions in over the past decade is being passed onto operators via asset purchases, leases or directly through bundled service contracts.

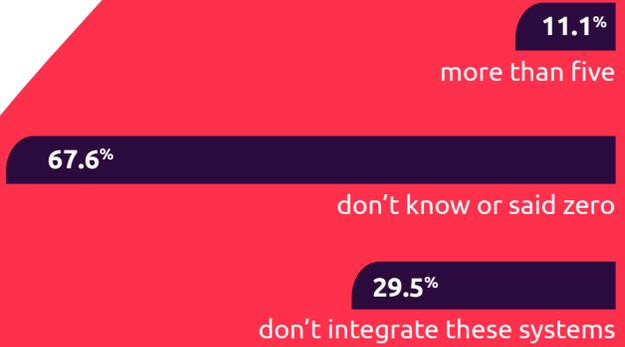
The majority of airlines have multiple fleet and engine types with multiple health monitoring systems; this causes challenges in training, decision-making, and maintenance. From an IT perspective, airlines need to connect multiple OEM systems generating actionable alerts with actual findings in the field.

When asked, 11.1% of those surveyed had more than five aircraft or engine monitoring systems integrated into their core MRO IT systems of record, while 67.6% did not know how many they had or said zero. And 29.5% of those surveyed said they did not integrate their health monitoring systems with their back-office systems.⁷

Receiving alerts through these health monitoring systems is valuable but the biggest benefit comes with integrating the alerts into the MRO IT system of record to validate them and start tracking corrective action data to support the next leap into prescriptive analytics.

One could argue that there has been a viral epidemic

How many aircraft or engine monitoring systems are integrated into core MRO IT systems of record?



of aircraft performance management “platforms” brought to market over the past couple of years from technology giants, aerospace manufacturers, airline-affiliated MRO operators and a plethora of big data advanced analytics startups. In 2017 alone, Airbus, Boeing, United Technologies, GE Aviation, Rolls-Royce, Lufthansa Technik, Air France Industries-KLM E&M and Thales have all unveiled platform-as-a-service solutions aimed at improving the aviation industry’s data sharing and advanced analytical capabilities.⁸

Approximately 41.3% of airline operators plan to maintain their current aircraft and engine monitoring systems over the next 24 months, suggesting that “Incumbents” are well-positioned with regard to maintaining their current market share and developing new performance management systems better tailored to airlines’ needs.⁹

However, over the same time period, 50% of respondents stated they intended to replace their current condition monitoring systems with an additional 8.7% either do not have or intend to eliminate the use of condition monitoring over the next two years. It is not clear how or with whom the 26.1% of operators who desire a single OEM agnostic solution are looking to internally build (15.2%) versus collaborate with other operators (10.9%).¹⁰

The good news for operators and MROs is that there are a plethora of new options for aircraft performance management on the market.

While these solutions illustrate a willingness to make up for years of digital stagnation, they are far from the common denominators needed to unite the digital thread between airlines, MROs, lessors and OEMs.

SNAPSHOT: CLOSING THE GAP



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of respondents stated they intended to replace their current condition monitoring systems



of operators desire a single OEM agnostic solution

STANDARDIZING STANDARDS

In hopes of bridging these gaps in the digital thread and instigating meaningful collaboration, industry associations have pursued normalization initiatives, namely ATA Specs 2000 and 2500 and ASD S5000F, to standardize the digital exchange of configuration, maintenance and lease data. Whether these efforts are effective will depend on organizations' awareness of them, but to date 71.7% of aviation decision-makers said they were not familiar with these standards, nor were they pursuing related internal digital standardization projects.¹¹

Awareness isn't the only obstacle complicating standardization. Developing, revising and finalizing neutral standards has always been a protracted process for the aviation industry. At best, these standards become guidelines for OEMs and aviation technology companies to formulate their own proprietary policies, making compliance a daunting task for operators that partner with multiple manufacturers.

More recent announcements affirm that purely agnostic collaboration is not being embraced. Though there are many collaboration solutions available to the industry, there is still a reluctance to use cloud-based platforms due to security and the inability to truly be perceived as agnostic collaboration solutions.

LIMITED HUMAN CAPITAL

The aging demographics challenge in the aviation, aerospace and defense industries is well-documented for engineers, machinist, mechanics and pilots; however, the demographics and skills gap in IT is not as well-identified.

In terms of business or information services, little investment has been made in human capital who are skilled and experienced in data lakes, platforms-as-a-service, micro-services orchestration, autonomic operations, data engineering or decision science.

As a result, most aviation organizations do not have the data science expertise to apply machine learning, deep learning or artificial intelligence (AI) to their information or conduct pilot programs required to embrace these new technologies. Companies that do use data for predictive or autonomic purposes are the exception to the norm: only 25% use data for basic time-series or resource forecasting; 20% for aircraft-level prescriptive prognostics; and 18.5% for asset performance management.¹²

Barriers to Digital Operations

At one industry trade show, a senior vice president of technical and fleet support posed a thought-provoking question: Why is it a debit card can be used at any ATM anywhere in the world and within seconds access personal banking records, yet finding a particular paper aircraft maintenance task record during a lease return can take a month or more?

In 2012, the Aviation Working Group (AWG) conducted a study for the International Society of Transport Aircraft Trading (ISTAT) on the economic impact of dissimilar technical requirements on aircraft transferability, estimating the cost across the aviation ecosystem to be \$7.3 billion greater than the preceding two decades and forecasted to reach \$10 billion over the next decade.¹³

Responses from the survey on major barriers preventing companies from adopting modern big data management and predictive maintenance capabilities revealed a disconnect between macro industry barriers and micro company concerns. In other words, while most executives in the industry understand and agree with the macro barriers and the value across the industry, the decision criteria change when they address this within their companies.

In the responses and follow-up interviews, centroid “silos” arose as central themes to describe the various barriers to innovation: financial silos, data silos, human capital and skill silos, operational versus informational technology silos, integration silos and plain old cultural inertia silos.

SIX OBSTACLES TO OVERCOME FOR DIGITAL TRANSFORMATION



Money: Investment capital and return on invested capital/business case was the number one cited barrier to undertaking initiatives. This is squarely dependent upon individual business models and individual situation and priorities. At the same time, respondents believe airlines benefit the most from monitoring systems (42.6%) and will benefit most from big data predictive maintenance solutions (51.7%).¹⁴



Skills and tools: The next-generation solutions and the skills required to effectively and efficiently use data analytics tools are not currently resident in most organizations and especially operators. One CIO stated that even if he could find experienced data scientists, he did not believe he could afford to hire them in adequate numbers.



Data, data, data: Data availability, quality and ownership were cited overall but the breakdown of respondents confirms that none (0%) of the operators feel data is an issue, whereas **OEMs and third-party service providers cited data issues at 52.9% and 40.9% respectively.**¹⁵



Quid pro quo: While not opposed to sharing data and creating feedback loops with OEMs and MROs, airline operators are reluctant to do so if there is no obvious benefit to their own organizations. Additionally, many operators believe that OEM solutions lack customer design input, focusing more on the needs of the OEM than operators and MROs who are too expensive and slow to innovate.



Preserving the digital thread: Designing aircraft monitoring, recording, and maintenance systems in isolation often results in unintentionally lost data. Even modern systems fail to fully protect data integrity within and across aviation organizations, preserving instead only the minimum data necessary for a particular process or output. For instance, every time XML files are converted to PDF, meta-data and large amounts of valuable intelligence are stripped away.



Integrating the digital thread: When asked how many aircraft and engine fault and condition monitoring systems they have integrated with their maintenance system of record, 67.8% of airline executives said “none” or “don’t know”. For airlines with mixed fleets of airframes and engines, **82.4% said their operations must manage multiple unique OEM health-monitoring portals to derive value to the operation.**¹⁶

The opportunities and value creation to the overall aviation, aerospace and defense ecosystem are undisputedly significant. How much of that value can be realized by individual manufacturers, airlines, MROs or lessors at the enterprise level or aircraft level, and when and how much to invest are the key questions remaining.

Turbulence in Transition

Aviation is in a transitional period of technology turbulence post the “lost decade” of low innovation.

With high aircraft utilization, high load factors and compressed aircraft ground times at overcrowded airports, airlines are having to make maintenance decisions at increasingly higher rates. These decisions are not optimal given the silos of flight operations, crew operations, technical operations, airport operations and passenger engagement operations.



Connected digital aircraft are exacerbating the turbulence for maintenance and engineering operations to collect, process and act on increasingly complicated aircraft systems. Meanwhile operators and MRO providers are struggling to retrofit tools and services to meet the demand of highly complex digital aircraft and the volumes and wealth of data they produce.

However, the commercial and defense aviation industries have a long history of business innovation, technological leadership and data-driven operations. On the customer-facing side, airlines have leapt at the opportunity to embrace AI and predictive analytics to better understand and engage passengers. It is time for the MRO side of the industry to follow suit.

Pursued correctly, each organization in the engineering, maintenance and service parts value chain stands to significantly benefit from sophisticated data management, analytics and collaboration:

- Airlines need to unlock maintenance information that boosts mechanic labor productivity and, increases asset utilization, punctuality and reliability while lowering lifecycle costs. Military operators have the same focus as airlines yet with their high asset mobility, harsh operating environments and sophistication, should focus on improving the predictability of failures, adaptive maintenance programs and increasing asset-mission readiness.
- MRO providers, already grappling with low margins, need to use data-driven insights to create new service offerings, performance-based contracts and information services as well as driving new efficiencies into their maintenance process.
- With tighter military budgets, military depot-level and component-repair facilities need to invest heavily in advanced analytics to optimize their throughput and improve component reliability.
- OEMs, armed with their own intellectual property as well as customers' operational data, can bring bundled physical and technical services to operators while streamlining their physical supply networks. At the same time, manufacturers can use the full digital thread feedback loop to proactively address parts and services defects. Defense contractors, pressed to reduce sustainment costs while improving mission readiness, are facing tight military operating budgets. Model-based sustainment is a key differentiator, exploiting digital twin, digital thread and digital analytics to provide young military maintainers the tools needed to achieve these lofty outcomes.

As individual manufacturers and other vendors invest in their own proprietary platforms, operators that do not form alliances will ultimately absorb costs without benefits. Those that champion digital operations, within and outside their own businesses and effectively collaborate across partner ecosystems will forge a path toward more efficient asset use, operational agility, and profitability.

What's good for an entire aviation, aerospace, and defense ecosystem is good for individual participants.

Notes

- 1 "Civil Aviation MRO Market To Grow By \$10 Billion In 2017," Aviation Week & Space Technology, December 23, 2016. <http://aviationweek.com/aerospace-2017/civil-aviation-mro-market-grows-10-billion-2017>
- 2 "MILITARY FLEET & MRO FORECAST 2017," Aviation Week & Space Technology <http://aviationweek.com/2017-military-fleet-mro-forecast>
- 3 Aviation and Aerospace MRO/SLM Market research study, Capgemini, March 2017
- 4 Based on Capgemini analysis of industry data.
- 5 Aviation and Aerospace MRO/SLM Market research study, Capgemini, March 2017
- 6 Aviation and Aerospace MRO/SLM Market research study, Capgemini, March 2017
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- 8 "Digital Analytics for MRO Progressing on Several Fronts," Shay, Lee Ann. July 12, 2017. MRO-Network.com. <http://www.mro-network.com/maintenance-repair-overhaul/digital-analytics-mro-progressing-several-fronts>
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- 15 Aviation and Aerospace MRO/SLM Market research study, Capgemini, March 2017
- 16 Aviation and Aerospace MRO/SLM Market research study, Capgemini, March 2017



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