Proudfoot

Emerging Technologies for Aviation MRO

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Realizing the Return on Emerging Technology In Aviation MRO

The aviation MRO industry is experiencing unprecedented penetration of leading-edge technologies which are aimed at improving efficiency, quality, cost, safety, and productivity in all phases of maintenance and in all aspects of delivery. Though the prevailing wisdom may suggest that adopting such technologies is certain to lead to improved performance and a financial return, the path to such a return can actually be quite unclear to many who are about to invest in such new and disruptive tools. Sometimes, it's like a shiny new toy. We want the tech but are not sure it will provide a return.

To improve decision making, Proudfoot has developed a framework for evaluating emerging technologies based on key attributes which will enable the MRO community to inform technological investment decisions more accurately, more holistically, and with an emphasis on clarifying what may be a complex path to ROI.

Recognizing The Challenges in Advancing Technology

Critically, we must first acknowledge that technological advancement in MRO faces three important challenges:

1. The industry is centered around a highly-specialized workforce that is rapidly aging, while leaning on a talent pipeline that's been on the decline for nearly 20 years.

2. Precise technical requirements and governmental regulations mean automation of any kind – be it robotics or predictive algorithms – need to meet a rigorous standard to find widespread adoption.

3. Underlying both of these challenges is the prevailing drive to get more and more productivity out of this shrinking workforce.

So, in deriving our criteria for evaluation of ROI and in evaluating these technologies along those lines, we've sought to keep these three factors at the heart of all considerations. Technology, of course, is only a tool – so we must consider how these tools not only create tangible, operational impact, but also how they impact the workforce that will be using them.

Understanding the Future of Business is (Still) People

At Proudfoot, we believe that the future of business is still people. It's easy to forget, but technology, analytics, and all of these new advancements are simply individual parts of the total operating model of an organization. As we've all seen firsthand, technology is impactful only insofar as it enables business leaders to unlock the power of their workforce. How your workforce leverages the

technology and realizes it's benefit is your key challenge as a leader.

Our MRO team identified 5 emerging technologies in the MRO space that have an important impact on people. These 5 can serve as examples for illustration to assist business leaders in understanding how technology can empower people to do their best work while providing substantial returns to their businesses.

The 5 Key Emerging Technologies in Aviation MRO

1. 3D Printing
2. Prescriptive Maintenance Modeling
3. Digital Twinning
4. Robotics & Drones
5. Blockchain

In order to provide significant ROI, these technologies must provide an organization with maximum impact across several key attributes, and so we've defined 7 criteria to evaluate each tool's ability to power up your operations.

1. Improved Personnel Safety
2. Increased Labor Efficiency and Productivity
3. Improved Workmanship to Promote Asset Reliability
4. Improved Process Flow (i.e. removal of non-automated steps)
5. Direct Material Cost Savings
6. Improved Technician Regulatory Compliance
7. Improved Decision Making

If implemented properly, and with the appropriate training and change management, these technologies have the most potential to positively and sustainably impact the way work gets done in the MRO industry.

3D Printing

Having already gained a toe-hold in aviation manufacturing, further refinement and adoption of this piece of tech could have wide-ranging impact on the aviation and MRO industries. Simply put, 3D printing has the potential to streamline

processes, reduce lead times, drive down inventory, and nearly eliminate fabrication errors. Also known as Additive Manufacturing (AM), 3D printed parts are already in use by names as big as GE Aviation who use AM to produce fuel nozzles for their LEAP engine model. And across the industry, more and more companies are looking to 3D printing for interior plastic components, ground support equipment, tools, and even flyable spare parts.

In the MRO industry specifically, the ability to manufacture "one-off" parts that scrap during the repair cycle or as a new failure mode late in the engine life cycle could have massive benefits. This could be a huge advantage for older aircraft and engines that are out of production: instead of struggling with long lead times to find and requalify components, 3D printers can simply create these new parts for a fraction of the cost, and in a fraction of the time – getting assets back to producing revenue faster.

With further advancement of 3D printing technology, not only will productivity rise and costs drop, but the number of use cases will also grow. Damaged parts may be repaired by 3D printers instead of replaced, or several damaged parts may be replaced by one single part. All of this will lead to a decrease in repair costs and repair times, while keeping inventory down.

What remains to be determined is if the OEMs will license the technology to airline and independent MRO providers, and, if so, at what cost? As the technology advances it may also benefit PMA manufacturers to more efficiently manufacture more complex parts and bring them to market quicker. With 3D printing, the two real questions are when and how do you implement their use?: Look for the next generation of machines to start arriving within the next 1-2 years and be ready for rapid adoption by your people. How you prepare now will impact how rapidly you reap the benefits.

Evaluation of 3D Printing

#	Attribute	Score (1-5)
1	Improved Personnel Safety	3
2	Increased Labor Efficiency and Productivity	5
3	Improved Workmanship to Promote Asset Reliability	4
4	Improved Process Flow	4
5	Direct Material Cost Savings	5
6	Improved Technician Regulatory Compliance	3
7	Improved Decision Making	3
	Total	**27**

Prescriptive Maintenance Modeling

Predictive maintenance is not new to the MRO industry. Performance trend monitoring and analysis has been used on engines for the past 40 years in one form or another. As we know it now, predictive maintenance means analyzing and comparing data to historical trends, using benchmarks and best guesses to determine if a known failure mode is likely – and then performing the maintenance needed before there is a disruption in service or major damage occurs. However, improvements in cloud storage technology, artificial intelligence, and virtual reality mean the industry will move from predictive to *prescriptive* maintenance techniques.

With near-daily advancements in the "Internet of Things," and internet-enabled sensors now in abundance on most aircraft, data analytics can go much further in measuring aircraft health and performance. With literally billions of data points being measured and at their disposal, including temperature, pressure, vibration and performance outputs for engines and components across the aircraft, the use of advanced algorithms and machine learning AI can detect when components will start to degrade well before any fault messages appear.

This mountain of data, of course, is only useful with the data science to understand it and the engineers to turn information into a plan of attack. Prescriptive maintenance not only means more accurate predictions of maintenance events, it also means the ability to prescribe corrective actions – even tapping into the MRO's inventory management system to ensure that parts or rotables required

will be available when maintenance is performed. The combination of data science, artificial intelligence, and expert engineering means earlier detection of faults, a more in-depth understanding of aircraft health, and a more efficient approach lined up and ready to go as an aircraft is wheeled in for maintenance.

Your key question here should be "are your people ready to manage, interpret, make decisions and act on data?" How you develop the skill (make or buy) will be critical to the effective implementation of big and little data.

#	Attribute	Score (1-5)
1	Improved Personnel Safety	4
2	Increased Labor Efficiency and Productivity	5
3	Improved Workmanship to Promote Asset Reliability	5
4	Improved Process Flow	4
5	Direct Material Cost Savings	3
6	Improved Technician Regulatory Compliance	2
7	Improved Decision Making	4
	Total	**27**

Digital Twinning

In partnership with these advanced analytics tools, technologies like digital twinning – where real systems are digitally cloned to operate concurrently in a digital environment – mean prescriptive maintenance can actually be simulated in real time. The digital twin of a system, whether an engine or other complex aircraft component, is fed information in realtime using sensors in the physical system and can be used to both simulate scenarios and predict future failures. The digital model can be used to monitor components' operation and performance, and when problems arise with the system, they are identified in the digital twin, where simulations can be run to troubleshoot, analyze, and provide the maintenance actions required prior to its removal from service.

The improved ability to understand and simulate maintenance events before they happen will allow MROs to better manage inventory, plan efficiently, and maximize productivity. That's why many of the largest manufacturers, like Boeing, are all in on digital twinning as the new key to improved production efficiency across the lifecycle of their aircrafts. "We're moving to model-based engineering, digitizing our entire engineering and development system up front – including down into our supply chain – and connecting that with the production system and how we service and support to create value

for our customers," said Boeing CEO Dennis Muilenburg. And it's not just Boeing: Airbus and GE have also touted their use of digital twinning to improve design and development, first-time quality, and overall productivity.

The big question here is whether your people can actively manage their business better by using digital twinning technologies, or whether it will be just another tool that keeps your managers' heads buried in a screen.

#	Attribute	Score (1-5)
1	Improved Personnel Safety	2
2	Increased Labor Efficiency and Productivity	4
3	Improved Workmanship to Promote Asset Reliability	5
4	Improved Processes Flow	3
5	Direct Material Cost Savings	4
6	Improved Technician Regulatory Compliance	3
7	Improved Decision Making	5
	Total	**26**

Robotics and Drones

The most direct answer to the MRO industry's labor challenges, the use of robotics technology and unmanned aerial vehicles to automate inspection, improve operational efficiency, and even assist wrench-turning processes could directly combat the industry's looming issues with skills shortages. Traditionally, the MRO industry has been slower to adopt wide-spread automation in line with other manufacturing sectors due to high regulatory and safety demands, a large amount of non-routine work, and lower volumes than, for example, car manufacturing. However, the technology and industry culture have begun to catch up.

Currently, MROs have started using robots and drones to automate visual checks in the inspection process, and many expect this practice to be widely adopted by 2020. With drone technology, an automated camera system can be used to inspect surfaces, identify any damage, and record the coordinates for further action by a mechanic or inspector. These systems can be setup and initiated by an inspector in a different section of an aircraft, and can run autonomously without human intervention, thereby reducing the number of inspectors, speeding up inspection times, and keeping workers safely on the ground.

Now this, of course, won't eliminate the need for techs and engineers, but adding drones to the inspection process allows for a safer and more efficient use of time, requiring workers merely to analyze drone data from the ground, and then decide on a course of action.

Meanwhile, advanced robotics technology and artificial intelligence

have been used to develop robots as diverse as an autonomous bot that transport parts around a facility, a snake robot that can travel through an engine to perform patch repairs, as well as larger robotic systems for polishing turbine blades. The variability inherent in MRO means we won't likely see the intensive levels of automation seen elsewhere anytime soon – but several of these robots could become mainstream industry standards within a few years.

As you roll out your robotics strategy, the question to ask is "do we have a change management strategy and roll out plan to ensure our people are skilled and capable to work in a digital environment?"

Evaluation of Robotics and Drones

#	Attribute	Score (1-5)
1	Improved Personnel Safety	5
2	Increased Labor Efficiency and Productivity	4
3	Improved Workmanship to Promote Asset Reliability	4
4	Improved Process Flow	2
5	Direct Material Cost Savings	3
6	Improved Technician Regulatory Compliance	3
7	Improved Decision Making	4
	Total	**25**

Blockchain

Blockchain technology is a digital ledger that records transactions in a distributed, permanent fashion, most popularly, for the moment, in the administration of Bitcoin transactions. While the public's belief and interest in cryptocurrencies has waxed and waned along with their ever-changing market prices, blockchain has remained a steady source of intrigue for industries as dissimilar as banking and manufacturing. Blockchain technology promises a permanent source of truth for all records, creating a backlog that is secure, independently verifiable, and stored in the cloud.

In the MRO world, each transaction related to an entity like an aircraft or engine is verified by all involved parties, then sealed and stored as an unchangeable block of data. As new blocks of data are added, they become part of the chain of data in a chronological order that can be traced back to the initial transaction – in an aviation setting, this means as far back as the initial build, aka "back to birth." This technology could be extended to include every transaction related to the MRO process and has applications for airframe and engine maintenance and repair records, including traceability for modification, ownership, and configuration information.

The entities most ripe for impact are MRO providers and leasing companies, as their current requirements for documentation are extensive. The traceability of each part includes not just where the part originated, but where each aircraft or engine has been installed, as well as where it was repaired, any modifications accomplished, total time and cycles, and repair intervals. In the current state, if any of the paper trail is lost or misplaced, the part is rendered useless and has no value. With all transactions automatically stamped and verified and in the same place, Blockchain can solve significant headaches around documentation, storage, file transfers, and, most of all, waste.

MRO providers can benefit from a reliable way to research the lineage of engines inducted into their shops, including configuration and current status of any airworthiness issues – regardless of where it was repaired in the past. Leasing companies would benefit by using the Blockchain to track aircraft configuration and modification changes when an aircraft moves from one lessee to another. And all industry participants would benefit because Blockchain provides a single source for all transactions, providing accountability, accessibility, and transparency. The key is that each transaction block is verified by the user and sealed, so the possibility of data being forged or corrupted is minimized.

Other benefits include:

- Reduction in physical documentation storage
- Compressed document review time
- More effective tracking of critical components
- Preservation of asset value due to reduced loss of traceability
- More efficient aircraft bridging processes from operator to operator
- Potential for the elimination of unapproved or bogus parts
- Improved transparency of traceability in the parts marketplace

Evaluation of Blockchain

#	Attribute	Score (1-5)
1	Improved Personnel Safety	3
2	Increased Labor Efficiency and Productivity	3
3	Improved Workmanship to Promote Asset Reliability	1
4	Improved Process Flow	4
5	Direct Material Cost Savings	2
6	Improved Technician Regulatory Compliance	5
7	Improved Decision Making	2
	Total	**20**

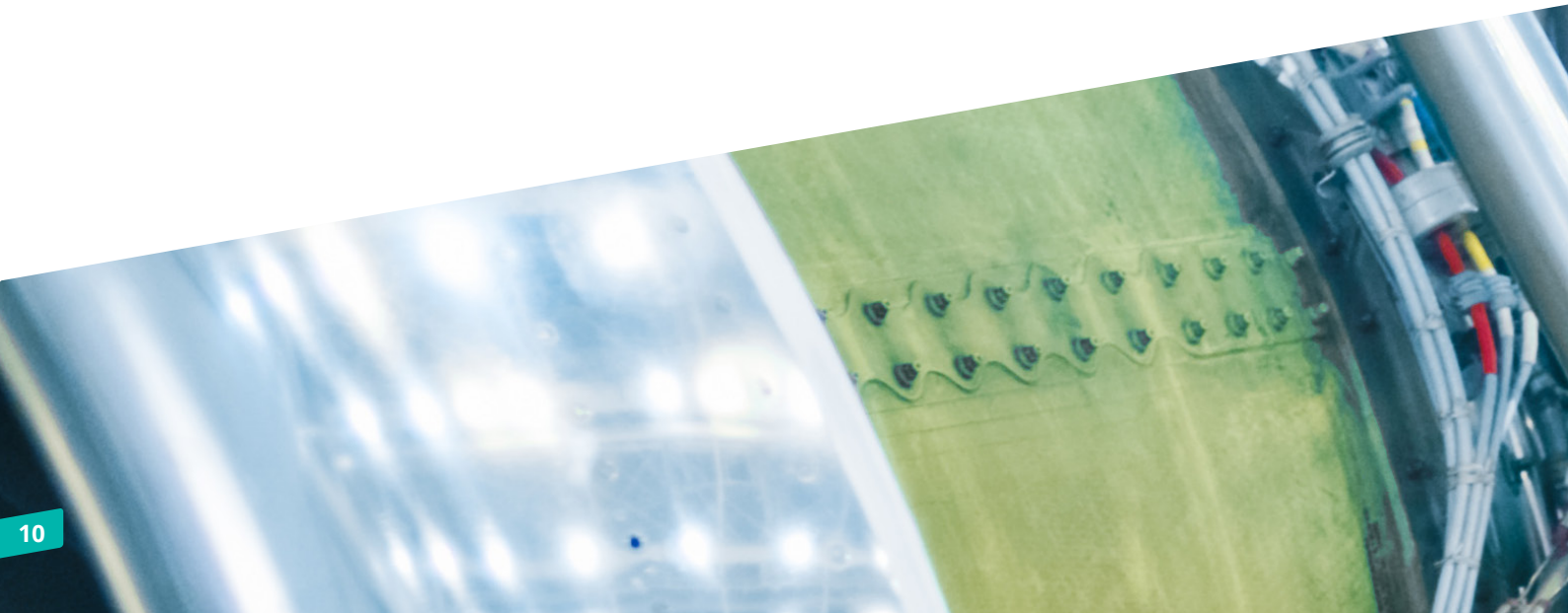
Summary

Evaluation of all 5 Emerging Technologies – where should you place your bets?

Emerging Technology	Impact
3D Printing	High
Prescriptive Maintenance	High
Digital Twinning	Medium
Robotics and Drones	Medium
Blockchain	Low

These 5 emerging technologies all have varying impacts on safety, productivity, quality, cost, compliance and decision making. For airlines and third-party MRO providers looking to reduce costs or combat an aging workforce, all of these technologies can lead to large scale efficiencies – but in the near-term, prescriptive maintenance algorithms and drone technology may have the largest impact. With the most market penetration to date, these two technologies have the potential to drastically improve planning, maximize manhours, and cutdown on maintenance time when you wrap the right skills and behaviors around them. With less troubleshooting and less time spent crawling on and around an aircraft, not only do these provide efficiency advantages, but they provide immediate impact on safety, keeping people on the ground and only working on exactly the areas that need work.

As far as direct material cost savings go, 3D printing has the highest upside, especially for airlines with aging fleets, or MROs working on assets toward the end of their lifecycle. Digital Twinning, however, and the ability to identify and simulate issues in advance can also lead to significant savings when it comes to reduced time trouble-shooting components and “no trouble found” nuisances. This is amplified with highly effective decision making skills. Furthermore,



Blockchain's ability to lock-in back to birth records can help OEMs and the like to combat major problems with unapproved parts.

Asset reliability will be impacted most directly by digital twinning and prescriptive analytics. As the industry moves closer to a paradigm of aging mechanics and less-experienced inspectors, an in-depth understanding of the health and safety of an aircraft through analytics and artificial intelligence will place less onerous demands on labor – though it will require new skills in future hiring profiles. And of course, blockchain technology will allow for better and more efficient record keeping, as well as easier controls for regulatory compliance.

How Proudfoot Can Help

Humanize. Optimize. Digitize.

Of course, any tool or technology – no matter how advanced – is still only as good as the people implementing and using it. As with any transition to a future state, processes must be , defined, streamlined, and improved so that the new technology is applied to best practices. And when implementations do take place, change management, coaching, and leadership are essential to workforce buy-in and user adoption.

Proudfoot specializes in helping organizations transform their operations, and much of our work focuses on engaging people in major change, garnering all-important buy-in, enabling workers from all levels of the organization to step up to the challenge, and making sure new tools are energizing a culture of excellence. Of course, much of that entails delivering a deep understanding of how new tech will directly impact operations both on macro and micro levels.

All of these new technologies will require significant capital investments – and all too often those investments underperform, as processes revert back to old ways of working, redundancies appear, and workers get frustrated. With our unique experience in people-first transformations, active management training and coaching, and change leadership, Proudfoot has a track record of assisting clients through major technology jumps, ensuring current and future state processes are well understood, employees are well trained, and new tools are setup for success.

"We're moving to model-based engineering, digitizing our entire engineering and development system up front – including down into our supply chain – and connecting that with the production system and how we service and support to create value for our customers,"

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To our very core, we understand the people element of transformation. We introduce new capabilities, and we employ the power of your people to create performance multipliers and an engaged culture. Recognized for our speed and the magnitude of benefits we generate for our clients, we have been doing it — not just planning it — for more than 70 years.

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