Connected A&D: IOT driving new revenue in the aftermarket

The Internet of Things (IoT) has moved from vision to reality. Is yours coming together?
Introduction
In the emerging data economy, data is driving the future of profitability. The Internet of Things is how you connect to this future.

Amidst unprecedented production demand and service-oriented “power-by-the-hour” relationships, aerospace and defense (A&D) manufacturers must be more responsive, agile and coordinated than ever before. Maximizing revenue means keeping aircraft in the air as much as possible, optimizing the value of MRO, and fostering profitable, long-term client relationships. Aftermarket operational decisions require omniscience of the environment by combining thousands of facts at instant speeds, delivering insights into the palm of the hand of the decision-maker.

Information has become the magic that makes enlightened and super-fast decision-making possible. Within our lifetimes, we’ve seen information go from merely human observation to a digital ocean of data from instrumentation and information technology. We’ve seen little islands of analytics sprout up to support activities such as condition monitoring. We’ve seen success in connecting instrumented systems to help predict maintenance. But the totality of truly interconnected, ubiquitous, intelligent networks of machines, systems and parts hasn’t been realized—but we are so close. Not only can we see it, we have the blueprint and tools to make it happen.

This is the Internet of Things: constant, complete, integrated information culled from every moving part of the aftermarket operation—the aircraft, system, engine, machine, part, even person—and distributed in purposeful, useful ways to every human actor who can drive results, such as the pilot, mechanic, fleet manager, planner, sustainment agent, and more. The IoT links machinery with human decision-making and enables decision-makers to drive more profitability. There are hurdles to overcome to getting there—to be sure—but this is the time to create your IoT vision before it is handed to you by your competitors.

The opportunity for ubiquitous intelligence and connectivity
“May you live in interesting times” goes the ancient proverb. For the aerospace industry, though, interesting might be better termed exciting or even electrifying. The velocity and rising complexity for aerospace companies is constantly accelerating. At the forefront are rising customer expectations and demand. Aerospace companies are engaging customers in new recurring-revenue business models where the original equipment manufacturer (OEM) is responsible for how much airtime or downtime an asset sees. This puts continual revenue opportunities on the table for aerospace companies, but also brings with it the risk of losing money. The goal is to reduce MRO on any given aircraft, but also to raise the value of MRO for customers overall. In the aftermarket, the more accurately we can predict and act on maintenance and repairs, the more money we will make.

These relationships open opportunities to create more value-added services for airline and military customers. Can we help their pilots with better information? Can we help their ground crews operate better? Can we give their planners a better view of their fleet? How do we make the operator’s environment more aware, more reliable and more efficient? Many of these revenue-generating service opportunities come from a relatively new source: data that is captured continuously from sensors across every part of the aircraft.
This is a new magnitude of data that OEMs are now able to capture and turn into business value. This is machine data. Think aircraft sensors on key systems such as electrical power, air management, fuel, wheel/braking, flight data management, avionics, actuators and more. Additional details on aircraft speed, engine speed, flap conditions, or aircraft trajectory can be used together to correlate behavior and predict events. The more data sources that can be leveraged, the more opportunities for both uptime and new services become available. This data is valuable, and the smart manufacturer dearly desires to monetize it.

Inventory and resource management become key factors as fleet operators and their vendors and partners want to carry less inventory, yet never want to miss a needed part. Ensuring quality, reducing costs and improving safety are all evolving imperatives. Here, too, enter new data sources from tools, parts and the suppliers themselves as increasingly more of the operation becomes instrumented and connected through constant and ubiquitous connectivity.

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**Rise of the data economy**

Data, particularly IoT data, is evolving into a saleable, valuable commodity that can be monetized within the marketplace. Companies across industries are realizing that a new “data economy” is emerging where their valuable assets can be packaged in new ways, made into products and services, and be sold as profitable businesses or offerings in their own right.

This emerging data economy is already a lucrative and valued service with aerospace aftermarket services, as OEMs and system vendors find ways to package operational data and related services back to their customers for improved asset performance.

Because the IoT is currently nascent and developing, the opportunity of the data economy is likely also nascent and developing. The true revenue opportunities for aftermarket services are just beginning, and the path to its future revenues and value lies in a fully realized IoT.
The need to know, process, analyze and respond

Within this massive, evolving, high-value and high-risk environment are people who have to make important, speedy, informed decisions every minute. And every decision can have thousands to millions of dollars tied to it. These people need to know precisely and quickly what is happening in their MRO operation, flight, fleet or airports. They must be able to quickly process and analyze this information. Then, they must rapidly respond by creating immediate, value-generating action at every turn.

This critical “need to know” requirement has spawned a multi-decade effort to get real facts from the machines and equipment they use. Instrumentation and sensors were gradually integrated into engine parts and systems to get real data beyond what basic human observation could muster. By getting a detailed and longitudinal view of actual aircraft metrics over time, the ability to perform condition monitoring became possible. Models were made to develop better performing maintenance schedules. As sophistication grew, the ability to predict maintenance needs at the individual aircraft, system and part level became a reality. The desire for and use of data has grown—as has the sophistication of the methods, analyses and tools in order to use this data effectively.

The evolution of IoT—from islands of insight and fiefdoms to IoT

Evolution of the Internet of Things

Yesterday  Today  Tomorrow

Islands of Insight

- System and vendor spot solutions for individual systems
- No integration/connection
- Many potentially measurable things not included

Fiefdoms of Data

- Connections between some systems depending on vendor
- Data ownership and control issues
- Few standards, little integration

Internet of Things

- Universal connectivity and integration
- Complete inclusion of everything measurable
- Objective, neutral network
- Innovative data governance/operating model

The evolution of IoT—from islands of insight and fiefdoms to IoT
In the past, machine data, instrumentation and analytics were deployed sparingly and in isolation, creating “islands of insight,” as illustrated in the previous image. In these islands of insight, an operator or analyst could monitor just isolated spots of the operation or aircraft. The view was not nearly inclusive of everything that could be measured, and connecting data across systems could be challenging, even if the results were valuable.

Today, we often see “fiefdoms of data” where more machine data is integrated, but data ownership issues and the owner of the monitoring or analytic systems create boundaries that prevent OEMs and their client operators from getting a unified picture across their operation or fleet. These boundaries can block many valuable analyses, such as discovering or predicting possible causations or correlations between analytics fiefdoms that can’t be integrated. This is a disservice to the client operators who are denied a complete and integrated view of their environment. To the OEM, opening up these fiefdoms is an opportunity to provide valuable client services if they can do it either first or best.

**Tomorrow: The rise of the Internet of Things**

The next step is building the Internet of Things for aerospace environments. For pretty much everyone, the IoT is still in its infancy in terms of adoption and maturity. This said, tomorrow isn’t a distant science-fiction vision; it’s ready now. The aerospace IoT provides universal connectivity and integration across all equipment, providing the operator with new and more comprehensive views of their fleet and operations. The IoT is exhaustive in its inclusiveness, meaning anything that can be measured and analyzed for value is measured and analyzed. It’s an objective, neutral network. Like the Internet of People, all are welcome to build their applications and connect them, and therefore the same standards and protocols are used as its foundation.

The goal of the aerospace IoT is to establish a modular, information-driven infrastructure integrating sensory inputs, computational intelligence, information exploitation, and reliable and secure communication to transform aircraft systems and environments to be more aware, more reliable and more efficient. In a complete vision for the aerospace IoT, the following components are needed:

**Instrumentation and sensors everywhere:** The ability to capture deep, comprehensive machine data is essential, and sensors are the way to do it. On the aircraft they can be in the engine monitoring pressure, movement, rotation, heat and so on. The various systems of the aircraft (engine, fuel system, landing gear, avionics, power, air and so on) are instrumented at this point. Operationally, sensors can be on key high-value tools, ground equipment and other important assets. Valuable tools and spare parts can be tagged with radio frequency identification (RFID) to track their location, deployment and use. For example, one manufacturer tags all tools just to be sure that they aren’t accidently left inside the repaired aircraft where they may cause damage. Even people, despite not being machines, can be tagged to track personnel location for availability or safety. Video and image data might hold future possibilities for analytics also.

**Pervasive connectivity:** The ability to get constant, uninterrupted data in any location—be it on the ground, in the air, at the hangar, within supplier operations and so on—is critical to get a complete and actionable picture of the aircraft or environment. Historically, pervasive connectivity has been problematic, but getting better as cell and networking technology has expanded and become more pervasive. As aircraft are already implementing consumer Wi-Fi in the air, connections to flying aircraft for IoT purposes have become more feasible. This also means that compression technology is crucial: smaller data packets ensure better transmission over lower or less reliable bandwidth connections.
**IoT platform and security:** The foundation for the IoT is a neutral, product-agnostic platform that can connect and integrate the entirety of devices, from connecting every sensor with every database to connecting every application with every interface, rapidly and securely.

**Edge analytics:** A ton of useful data is made completely useless with even the slightest bit of latency. Even a few seconds can render some data useless. For example, if the data says a fuel line is about to burst, it’s not nearly as useful after the line actually breaks. In the IoT, edge analytics are enabled so that data is collected and analyzed in real-time at the spot of the instrument, skipping the need to be loaded into a distant analytics platform, providing alerts and alarms of real-time events so they can be acted upon quickly.

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**Weather data is critical**

Weather data, for example, might be one of the most powerful indicators of externalities affecting machine behavior available to us. IBM strongly believes this and has invested heavily in weather data, going as far as acquiring The Weather Company in 2016.

**Big data (including external data):** The data collected from the thousands of sensors and instruments—many potentially capturing data by the second—will produce tremendous volumes of data. This machine data is valuable on its own, capturing such measures as exhaust temperatures, throttle settings, vibrations and so on, but becomes even more valuable when combined with other data sources. These sources might include air traffic control, maintenance history, flight schedules, various personnel (pilot, mechanic), engine configuration, inventory databases and more.
In our experience, for example, measuring only machine data resulted in prediction accuracies of only 60–65 percent. When other data was included, accuracy jumped to 90–95 percent.

**Advanced analytics:** The value of IoT data is obviously not just collecting and having it, but turning it into valuable business insights that can drive real-time decisions, such as driving operational planning, providing alerts and alarms using real-time data, providing descriptive analytics for reporting and modeling (what has happened in the past), providing predictive analytics (what will happen in the future) and even providing prescriptive analytics which help determine what should be done next. Analytics capabilities rely on a series of technologies, including leading analytics platforms, visualization tools, databases, data warehouses, data quality and extract, transform and load (ETL) systems, and other technology components.

**Cognitive analytics and unstructured data:** Cognitive computing is a super-powerful new technology that combines massive amounts of unstructured data, artificial intelligence (AI), machine learning, natural language processing and more to create intelligence and expertise from data such as pilot reports, specs, repair tickets, dictionaries, manuals and more. Much of this data might reside with the fleet operator. Cognitive works with predictive analytics, which lets you know when something is going to happen, and cognitive, which can rapidly tell you what to do about it. For example, when a part is predicted to fail and need replacement, the cognitive application can quickly recommend a repair solution, provide the exact instruction, find replacement inventory and suggest alternatives.

**Mobility, apps and interfaces:** Human interfaces to the IoT and the analytics tools should be pervasive. No longer trapped on the desktop, IoT and analytics tools will be on mobile devices, tablets, wearables and anywhere and everywhere work is being done. Interfaces should have elegant, intuitive experiences and visualizations that enable human actors to quickly understand the environment and interact with it seamlessly.

**Cloud delivery:** The IoT will largely live in the cloud, meaning that local infrastructure (such as servers and processors) will not be needed and the scale and efficiencies of the cloud will be available to the network.

This list of components is not a technology architecture but instead highlights the most prominent new attributes that have yet to come together. When they do, the Internet of Things becomes a reality and a whole host of new business activities and value can be realized.

**Relationships versus technology: Are data ownership, operating model and governance immediate challenges and opportunities?**

In the current state, many vendors—mostly OEMs or sub-vendors—have launched only spot analytics solutions in only certain areas, mostly to support their specific product or product set. This multitude of spot monitoring and analytics solutions at best has created the “islands of insight” or “fiefdoms of data” as we discussed earlier. It has not yet resulted in a true Internet of Things that operates like the Internet of People that we know: a universally available and connected Internet that is available for all for better usability and functionality for everyone.

This creates a service dilemma for fleet operators (for example, airlines and military) who must draw up multiple different networks, platforms and interfaces to access their analytics from their various vendors. For example, they might use one application to do predictive monitoring on one system (say, fuel) on one brand of aircraft, and use another application to view condition monitoring on another system (say, engine) on the same aircraft. They can’t easily put the data together between systems, or across the fleet, to gain more accurate and valuable views of their assets and ultimately improve their overall performance and profitability. Multiply this by the numerous vendors,
sub-vendors, systems and so on, and the end user’s experience can be a muddled and confusing mass of different systems, all failing to find the correlations, causations and so on that integrated data and analytics across systems can bring.

This problem is not fundamentally a technology problem. The technologies listed previously have few shortcomings in an ideal IoT.

The current state and origin of this dilemma certainly makes sense. Individual vendors, at least in the short term, seem to have very little interest in relinquishing their perceived competitive value of their data islands and fiefdoms. Even within their own organization, coordinating aftermarket data and analytics portals across programs and systems might be difficult, much less with other competitive vendors.

IBM believes that the future of IoT will show a different setup, with more flexible ecosystems and collaboration scenarios than it has now, with data control working in new ways. The benefit to the end users will be significant, and the ability for individual vendors to vastly increase the value of their aftermarket data will likely improve with an IoT, not be diminished. This projected improvement is because the value of the analytics provided can be much more robust with more complete and more integrated data, regardless of its origin.

The fundamental new vision must have a new, viable and compelling business and governance model. This new operating and governance model must address several key issues:

**Data ownership:** Currently, data ownership is split between vendors and operators and can be a highly contested and protected entity. All vendors are rightly super-protective of data ownership, and it is often a critical component in their current value propositions and revenue models, sometimes even to the seeming detriment of their clients. How can data ownership be rectified in such a hotly protected environment?

**Industry standards, taxonomy and semantics:** A true IoT will require common standards, definitions, protocols and so on for easy and effective integration between data systems and applications. If each vendor continues with proprietary methods, the value of IoT will be lost in a quagmire of painful—and hard to justify—workarounds. Who will set and encourage the right set of industry standards?

**Governance and business model:** In an IoT with many actors, it is crucial that all players abide by the standards and the rules set forth for fair and equitable play. The use of data, including its storage, its reuse, its financial remuneration and so on, will need to be monitored and enforced. Processes for dispute resolution and restitution might be needed. Rules might also be needed to determine who can play and who decides the players. There might be contracts and legal elements. Maybe even a payment system. How do we determine and implement the right governance model and processes?

**Common IoT technology enablement platform:** Finally, just like the standard Internet, the aerospace IoT will require a common, neutral technology enablement platform that everybody connects up to. Whether it is centralized with a neutral provider or distributed, the backbone and connecting technology must be common, infallible, secure, high-performing and scalable and include all of the features that are unique to the aerospace industry (such as enabling data gathering from remote areas such as the sky). How will this platform be decided upon, implemented and maintained?
IBM has more questions than answers at this point. We don’t currently know what the vision of this operating and governance model will be. Will it be an industry consortium of the top players? Will it be a solution that a dominant OEM offers to the industry for a fee? Will it be a bottoms-up phenomenon, with an island of insight and fiefdoms joining together in the short term? Will a scrappy industry-funded startup or joint venture make a play? Will the fleet operators come up with their own approach? We have some ideas on how it might work, but we don’t currently know. Still, this is a critical challenge and opportunity.

For the forward-thinking aerospace OEM, this uncharted territory can be an opportunity for advantage. The first mover in the IoT arena will likely get to make the IoT “in their own image”, directing features and standards that benefit them first. They will be able to set the operating and governance model; this will require some bold thinking, some strategic risk, and the ability to move beyond a short-term “protectionist” mentality where local data ownership is the main driver. The opportunity is there, and we believe it will be captured by some early mover.

**Making the IoT real in the field: IoT aerospace and defense solution areas**

The real business value in the aerospace IoT comes not from ideas like sensors and connectivity, but how the newly connected analytics applications will change day-to-day business operations and performance. Following are the top-level solution areas for operations and services (that is, providing services to fleet operators in aftermarket operations).
**Operations and services**

The IBM Industry Solution portfolio in the Connected Platform domain enables differentiating and revenue-generating aftermarket services offered to fleet operator clients of the OEM. We believe these capabilities are the most compelling for IoT as they can immediately impact revenue, drive new value to operators, and are in the most need for new connectivity outside of the enterprise. The information from active aircraft, including their maintenance, is also very valuable information to feed back into the enterprise in areas such as manufacturing, supplier management and engineering. Some possible capabilities in these areas include:

**Asset availability and performance optimization:** Applications in this area focus on keeping aircraft in the air and minimizing downtime. By using IoT data and analytics, OEMs can predict and plan for expected and unexpected maintenance requirements, help fleet operators manage their entire fleet (for example, fleet planning, scheduling, deployment, maintenance planning) and provide comprehensive data on keeping the fleet reliable and optimized. Capabilities include:

- Fleet management and tail allocation
- In-service fleet reliability analysis
- Unscheduled aircraft maintenance

**Service management optimization:** IoT information can be used to optimize the maintenance operation for fleet operators to improve asset uptime and availability, optimize repair crews and facilities, predict maintenance needs, and help balance workloads, resources and schedules. Material management can be improved using sophisticated analytics on IoT data, ensuring that the right part is available at the right place and time, all while reducing overall inventory holdings. Capabilities include:

- Scheduled maintenance
- Planning and execution
- Material management

**Aerospace IoT platform**

The foundation for the aerospace IoT is the platform. This standardized, neutral operating platform provides the central connection and processing point to gather all data from the sensors and data-producing systems, to connect them to analytics applications, edge analytics, cognitive capabilities, compression technology and others, and to deliver them to user interfaces and devices. In IBM's high-level vision, the enablement platform must combine several technology capabilities and applications, as illustrated in the following diagram.

![Illustrative High-Level Aerospace IoT IT Architecture Diagram](image-url)
Like all worthwhile and complex technology initiatives, deploying a successful IoT solution is a journey. The first step is to create a compelling vision and business case for IoT, starting with the real business benefits such as how day-to-day work will be improved, how key business objectives are realized, how efficiencies can be made, how new revenue-generating services can be created, and how real financial value will be added to the bottom line. This vision must then be turned into a plan, including a blueprint for what will be built, identified gaps to close, and a deployment roadmap that maps activities, resources, milestones, investments and schedules for deployment. All of this must be justified with a rigorous and comprehensive business case that codifies benefits and return on investment (ROI).

**Aerospace IoT in action: Airbus harnesses fleet data to deliver a new level of insights and value-added services to its airline customers**

Airbus saw the value in transforming its airline services with a Smarter Fleet Solution made with IBM. Airbus deployed big data capabilities and advanced analytics to drive operational efficiency, improve fleet data management and rapidly deliver new services to meet the rising demands of its airline customers.

To get there, Airbus and IBM took an iterative solution approach that followed a joint roadmap. A unique combination of software and services from both Airbus and IBM was leveraged to create a smarter fleet solution for maintenance analysis, fuel efficiency, documentation, tail allocation and mobility. The solution enhanced data capabilities and integrated key management processes to improve M&E and flight operations.

The Smarter Fleet Solution also connected a host of solutions to the cloud, including engineering, maintenance, airport operations, OEMs, logistics and more. The power of the cloud enhanced the connectivity of capabilities, delivered deeper business insight from data and integrated real-time decision-making to improve operations across silos.

The resulting solution helped Airbus realize its common vision to meet its customer expectations by delivering optimized fleet management and operations. As a result, Airbus:

- **Enhanced operational efficiencies**, helping airlines manage aircraft more effectively and improve customer service through big data, advanced analytics and asset optimization
- **Improved fleet data management** by enabling enhanced capabilities to drive efficiency and enhancements in operations
- **Enabled rapid integration of existing and new services and solutions** driven by today’s growing volumes and complexities of operational big data

According to Airbus’ EVP of Customer Services, Didier Lux, “This agreement with IBM is a major step in the implementation of Airbus’ aim to provide airlines with strong added-value innovative services for their long-term business development. Our customers will soon benefit from the most advanced information management solutions to address their engineering, operational and maintenance needs.”

**Conclusion**

The IoT connects everything: aircraft, engines, systems, machines, equipment and even humans. Mostly, though, it can connect smart aerospace to new revenue streams, faster business outcomes, competitive advantage and improved profitability. The evolution of analytics capabilities is currently at a transformation point: the islands of insights and fiefdoms of data are ready to be broken down and reconnected into a powerful vision of ubiquitous connectivity and unprecedented analytics capabilities that incorporate data like never before. The IoT is no longer just a vision; it’s ready to become reality. The aerospace company that acts now will be the first mover, setting the pace for the industry and its customers, dictating how the industry will connect, and ultimately how the future will play out. It’s exciting stuff. Let’s watch it take off.
For more information
To learn more about IBM’s offerings for the Internet of Things, please contact your IBM representative or IBM Business Partner, or visit the following websites:


Additionally, IBM Global Financing provides numerous payment options to help you acquire the technology you need to grow your business. We provide full lifecycle management of IT products and services, from acquisition to disposition. For more information, visit: [ibm.com/financing](http://ibm.com/financing)

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