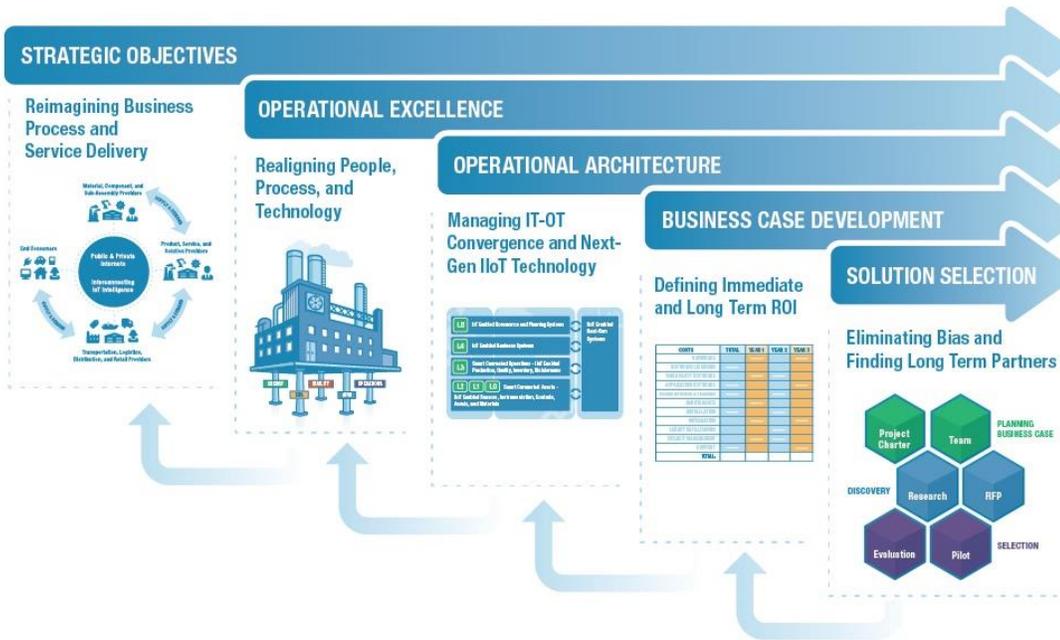


Research Spotlight

Why the A&D Industry Must Embrace Digital Transformation Now

The LNS Research Digital Transformation Framework



Once an A&D enterprise recognizes the need to pursue Operational Excellence with a Digital Transformation strategy, they must craft a systems architecture that extends across the entire business.

Whether referring to the increasing application of digital technology in manufacturing as Smart Manufacturing, Industrie 4.0, Next Generation Manufacturing, or Manufacturing Digitization, the simple fact is that manufacturing is undergoing an evolutionary step change. Like the three major industrial leaps of the past, moving from single craftsman (Gen 1) to the assembly line and powered systems (Gen 2) and the application of Programmable Logic Controllers (PLCs) and Distributed Control Systems (DCSs) (Gen 3) this next generation of manufacturing also employs new technology, and is being driven by information—digitally. For companies looking to make this Digital Transformation, LNS Research has developed a framework to help them understand how to evolve their systems.

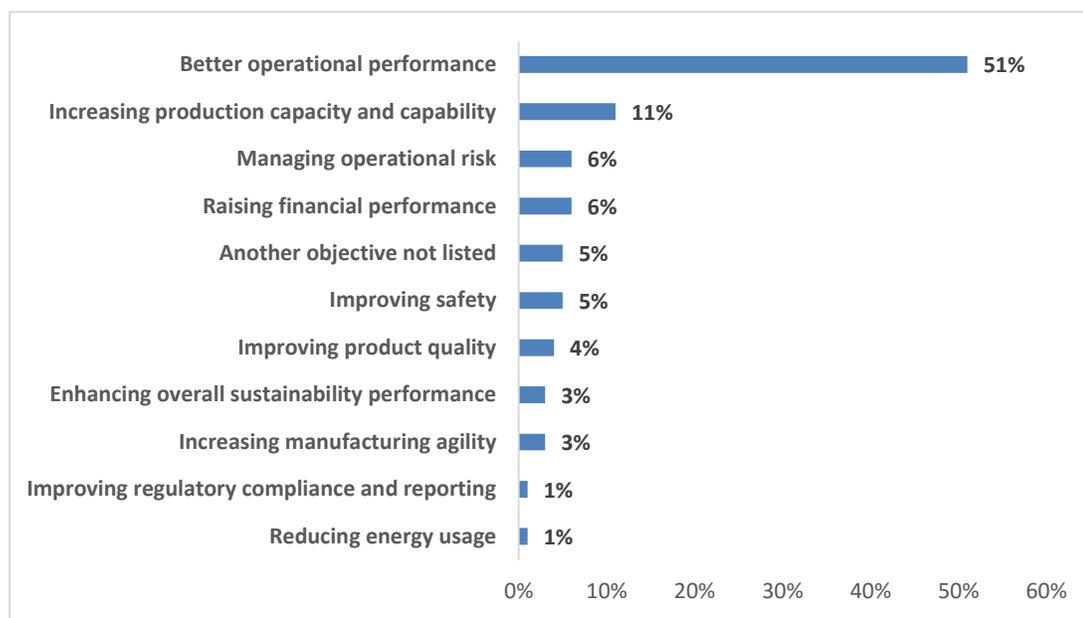
The overall concept is that Digital Transformation is driven by the need to pursue Operational Excellence. In virtually every research practice at LNS Research end-user surveys show that within the top three strategic drivers for adopting any business process improvement initiative (BPI), such as Asset Performance Management (APM), Manufacturing Operations Management (MOM), or Enterprise Quality Management Software (EQMS) is the desire to improve operational performance. In the APM area it is the top driver across all industries and in A&D specifically, with 51% of respondents identifying it as their number one driver, and over 80% having it in the top three drivers across all industries. In A&D increasing production capacity and manufacturing agility were the other top drivers.



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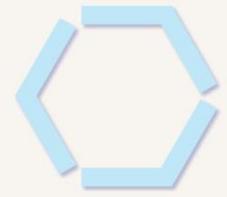
What is the number one strategic objective for improving asset performance in your organization?



Once an A&D enterprise recognizes the need to pursue Operational Excellence and that a Digital Transformation is the best path toward success they must craft a systems architecture that extends across the entire business, from the engineering and design functions, across the business systems, and reaching all the way to the shop floor.

In A&D the need for architecture also extends to the after-delivery service function as well since so many aircraft and defense systems have program lives measured in decades instead of months or years like in the consumer sector. Building the business case for and selecting the technology to support these initiatives as they fill in the architecture completes the framework.

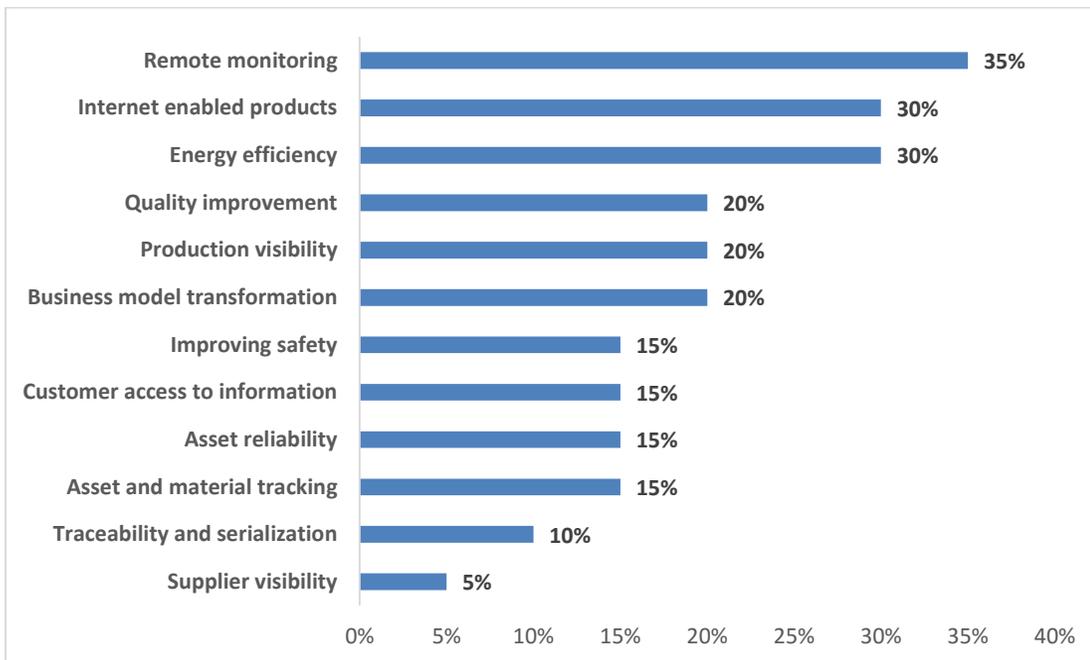
The challenge for the A&D industry going forward is that while the industry has an idea of how it intends to leverage Smart Connected Assets, as the charts on the following pages will display, there is a lack of understanding about how one of the key enabling technologies—the Industrial Internet of Things (IIoT)—impacts their businesses today.



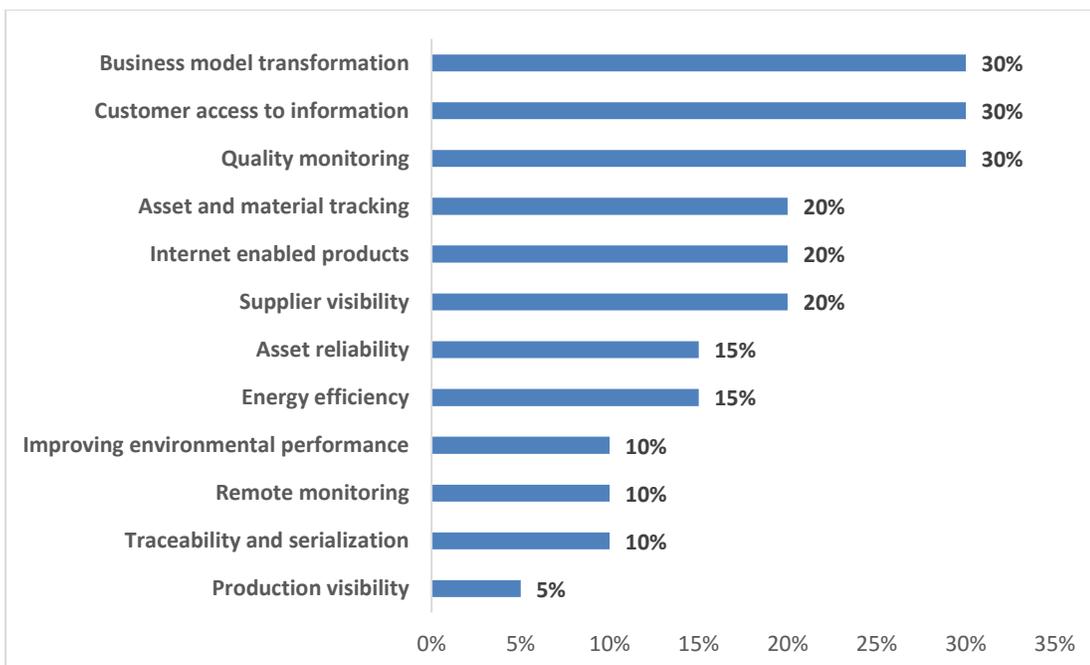
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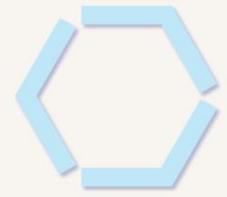
Why the A&D Industry Must Embrace Digital Transformation Now

What are the top IIoT use cases your company is pursuing today? (A&D)



What are the top IIoT use cases your company will start pursuing in the next year? (A&D)

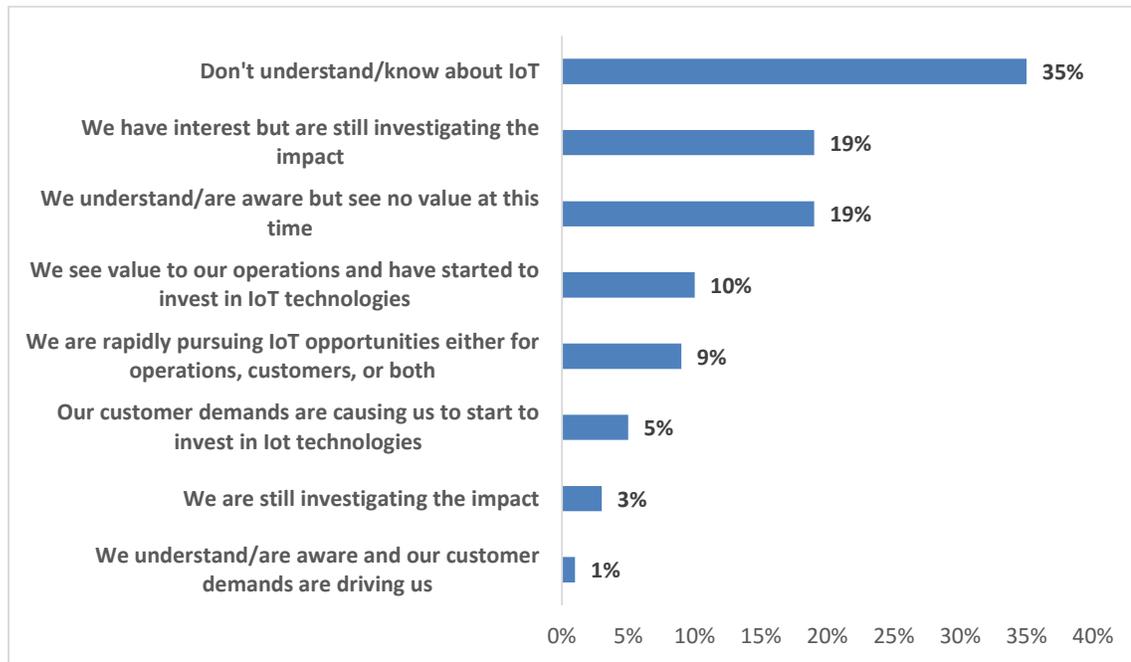




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Please indicate how the IoT is impacting your business today? (A&D)



This presents the A&D industry with both an opportunity and a challenge in the face of the business evolution that is occurring within the industry today.

The A&D Industry Business Drivers in the Digital Age

The A&D industry is unlike many other industries in that it designs, builds, and supports comparatively high volumes of complex and expensive configure-to-order (CTO) products. The underlying complexity of these products, coupled with the CTO nature of the systems, has led to manufacturing systems that have not been nearly as efficient as those in other industries such as automotive or consumer electronics and durable goods.

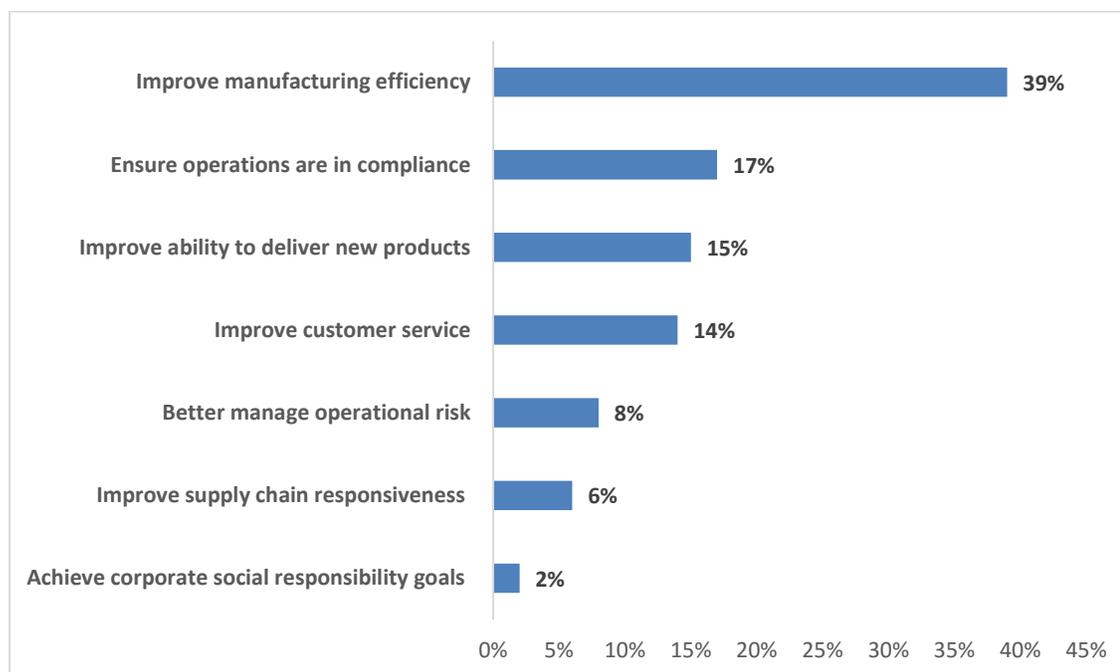
In both the commercial and defense elements of A&D this has driven costs upward and both commercial and government customers are demanding more cost effectiveness. As the chart on the following page will show, this has driven the A&D industry to make the improvement of manufacturing efficiency a top operational objective.



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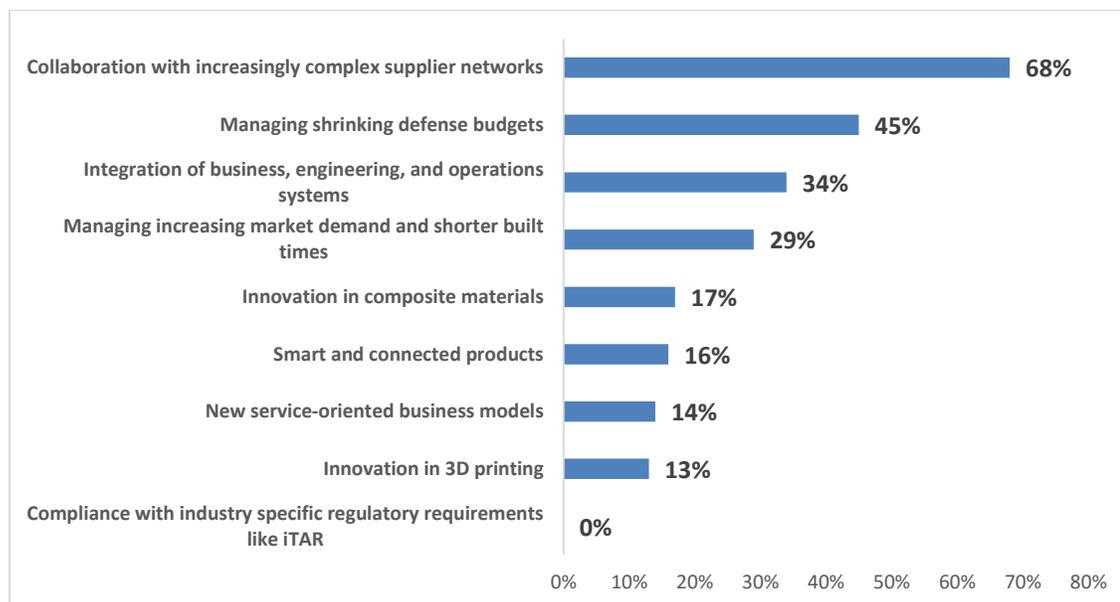
Why the A&D Industry Must Embrace Digital Transformation Now

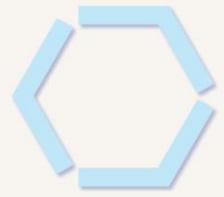
What is the top operational objective for your company? (A&D)



This is set against a background where the supply chain is growing more complex, budgets are constrained, materials and construction innovation is driving new products and capabilities, and customers are demanding smarter products and service support after delivery on a scale not seen before.

What are the most important trends impacting A&D companies today?





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In addition to the opposing and interconnected drivers and challenges in the A&D industry, like growing supplier networks, shrinking defense budgets, and the production of high-volume, CTO products, today customers in both the commercial and defense sectors have rising demands.

- A&D buyers are making decisions on the total cost to acquire and maintain aircraft and defense systems, which regularly have lifecycles of decades rather than months or years like other industries
- The visibility, analytics, and integrative capabilities offered by the Digital Transformation Framework are becoming critical in fulfilling these demands
- A&D suppliers need to update outdated systems and processes with cutting edge technology—Digitally Transforming their operations

A&D Data Model Opportunities During the Design and Manufacturing Phases

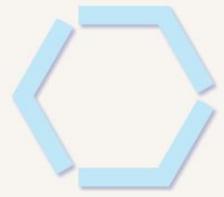
CTO equipment is expensive, complex, long-lived, and often mission-critical. As such, A&D is the birthplace of many Design for Sustainment (DfS) concepts such as Design for Reliability, availability, maintainability, system safety, cost, testability (diagnostics planning), logistics, and more. These DfS concepts are intended to provide predictability of adverse events at the component, sub-system, system, and system of system levels during systems engineering and product development. These predictions are intended to reduce reliance on testing-in performance by driving sustainment-enhancing product and operational changes earlier in the development process.

Unfortunately, many of the practices in use today, particularly in the defense community, have roots stretching back to the 1960s and 70s. Although enhanced and refined over the years, the approaches poorly predict true system performance. They can generate inaccurate and even misleading decisions regarding component selection, system architecture, and sustainment planning.

New and accurate DfS modelers have been deployed, such as new simulation techniques that support Prognostic Health Monitoring (PHM) and Condition-Based Monitoring (CBM) initiatives. However, much of the component and Line Replaceable Unit (LRU) reliability data being fed into these advanced simulators is generated by dated and inaccurate approaches. This was underscored by an internal Naval Surface Warfare Center study performed that identified that by far the most common form of reliability prediction used by its contractors leveraged obsolete and decommissioned military handbooks.

The DfS data is also underutilized in production planning and production execution, departing from best practices developed in the automotive industries. Little

Design for Sustainment (DfS) concepts are intended to provide predictability of adverse events at the component, sub-system, system, and system of system levels during systems engineering and product development.

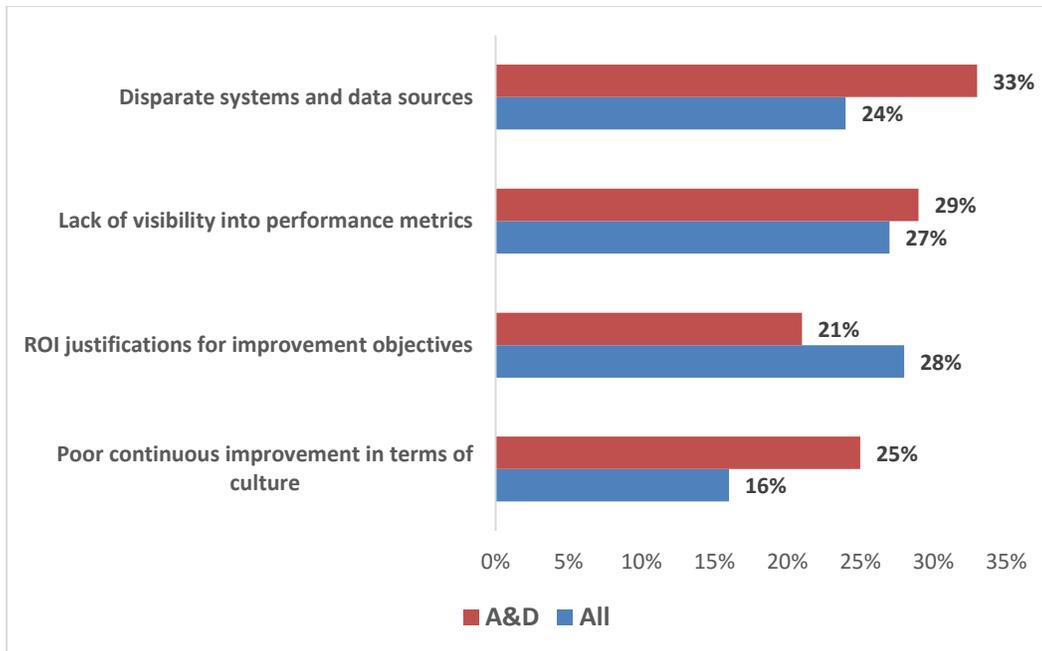


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knowledge of the systems level risks is communicated to manufacturing. A&D organizations disproportionately identify disparate systems and data sources and poor continuous improvement as top challenges for achieving key asset performance objectives.

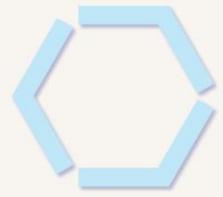
Top challenges in A&D



Digital Transformation provides industry with opportunities to transform DfS, production planning, and continuous improvement. It is well documented that decisions made during concept, systems engineering, and detailed design have the highest impact on product performance with the lowest cost. Industry must seize the opportunity to transform, starting in the development process, and leverage Big Data analytics and the IoT to generate new performance insights early in development, and new levels of accuracy in DfS decision making.

The MRO Challenge in A&D: Service After Delivery

Another key aspect of DfS is that it allows suppliers to actually meet the growing customer demand for full system-life support. As noted above, both commercial aviation buyers as well as government agencies are making purchasing decisions on the total cost to acquire and support the aircraft or defense system over the entire expected life of the program. In many cases this means that the supplier must assume the cost of after-delivery service or at least provide the support at a negotiated rate, with the supplier assuming the risk of above-expected support. To



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reduce the risk suppliers must adopt DfS but this alone will not be sufficient to ensure that they can profitably meet their support obligations.

With responsibility extending far beyond the end of the assembly line or even the delivery line, A&D manufacturers will need to maintain the Bill-of-Material (BOM) beyond the as-delivered BOM that is common today, to the as-maintained BOM, including all field retrofits and modifications. With the lifecycles of some systems, particularly defense airframes such as the B-52—now in its 61st year of service—becoming ever longer (the B-52 is expected to serve into the 2040s—for an 85- to 90-year life), the data management and record keeping problem will grow increasingly complex.

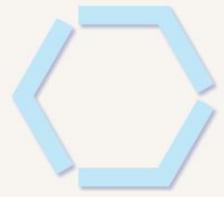
The ability to know exactly which parts, assemblies, and major systems compose the asset is essential to not only meeting cost requirements but the up-time and time-to-repair service level agreements (SLAs) that will undoubtedly be part of the support contract.

Just having this information will not be sufficient. Part of the solution must be to display the current as-maintained BOM details on a multitude of mobile devices, including augmented reality devices that will provide service technicians the ability to visually see the 3D transparent image so they can understand not only what parts and systems lie behind the access panel or aircraft skin but how to access them quickly with the least effect on adjacent parts or assemblies.

Finally, when suppliers assume support responsibilities for their products post-delivery, they will need predictive analytic tools that not only leverage the real-time IoT data from the product for diagnostic and CBM activities but with the capability to predict the best maintenance activities to be performed at every service interval to minimize cost, maximize uptime and, most importantly, ensure that the supported system is operating within the specified performance envelope at all times. This means mods must be coordinated with regular maintenance activities and the systems used for scheduling and recording all MRO activities feedback into the data management platform so the as-maintained BOM is accurate at all times.

Changing the Game: Using MRO to Sell Capacity Instead of Capital in Commercial and Redefining System Sustainability in Defense

While support after delivery is an extension of the current model in which suppliers deliver products, there are also new business models being enabled by Digital Transformation. In the consumer sector the impact of Uber on the taxi business or Airbnb on the hotel industry are well known Digital Transformation examples. In the



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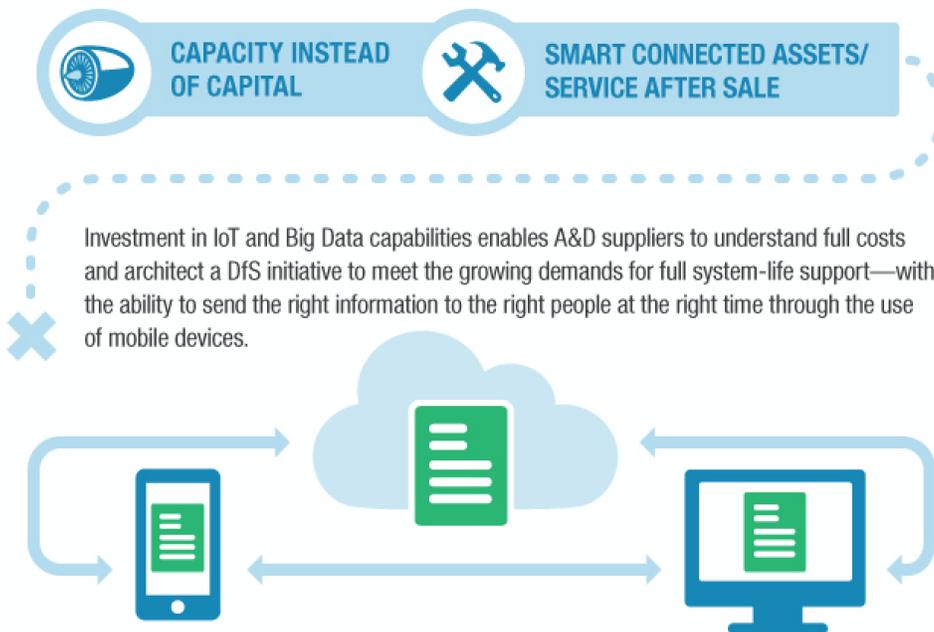
Why the A&D Industry Must Embrace Digital Transformation Now

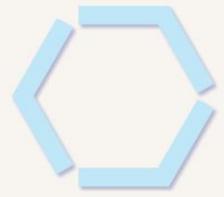
B2B or commercial world examples are less dramatic and do not capture the headlines in the same way Uber has. One of the challenges for manufacturers is that Uber is a service that effectively just transformed another service business—taxis. This has made it generally difficult for manufacturers in general to see the potential in Digital Transformation. However, some examples are starting to emerge such as [Joy Global in mining](#) or Rolls-Royce engines selling thrust to airlines.

In commercial aviation the idea of selling capacity instead of capital has already taken root in the engine business, but it is not inconceivable that an airline might buy passenger-seat-miles or pound-miles from an airplane manufacturer instead of an airplane in the future. The benefit to the airline is the transfer of much of the operational risk associated with aircraft operation to the supplier instead of themselves. For an A&D supplier to deliver this requires having accurate and reliable information about the aircraft beyond what is needed just to guarantee service or availability via service or support contracts.

Big Data and associated predictive analytics capability will be needed to model all aspects of aircraft operation such as fuel consumption and fuel prices. Complicating the model is that the A&D prime supplier may enter into similar arrangements with sub suppliers. For example, Boeing might have to subcontract the engine performance to GE or Rolls-Royce. The management of these complex relationships will require extensive data management capabilities across the entire value chain. Selecting the right tools and technology to do this will be critical.

In both the commercial and defense sectors of A&D, the future looks to be a mix of enhanced support services, diagnostics as a service, and capacity versus capital offerings.





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This capacity versus capital approach may not seem viable for the defense sector where the potential for loss from hostile activity (or even in training accidents) is ever-present but LNS Research believes the capacity versus capital model will appeal to government as well in better managing expenses and further extending concepts begun with Performance Based Logistics contracts. There are always ways to construct contracts that indemnify the provider from loss by the operator due to their direct actions. In the case of defense systems, LNS Research feels the trend will be to look at the capacity instead of capital model first in non-combat systems and support systems not exposed to hostile environments. As this becomes viable in the support roles there will be a transition to systems exposed to hazards as the legalities of combat risk are resolved.

So in both the commercial and defense sectors of A&D the future looks to be a mix of enhanced support services, diagnostics as a service, and capacity versus capital offerings, all of which will require a far greater set of data management and predictive analytics capabilities than A&D companies possess today.

SMART CONNECTED ASSETS

Converged Sensors, Instrumentation, Controls, and Assets

REAL TIME → PREDICTIVE → AUTONOMOUS

AWARE OF AND CAN REACT TO:

Design and Configuration

Internal and External Operating Conditions

Past Performance

Predicted Future Failure

MRO Inventory
(Internal and External)

Raw Material

Supplier Performance

Customer Requirements

Environmental Impact

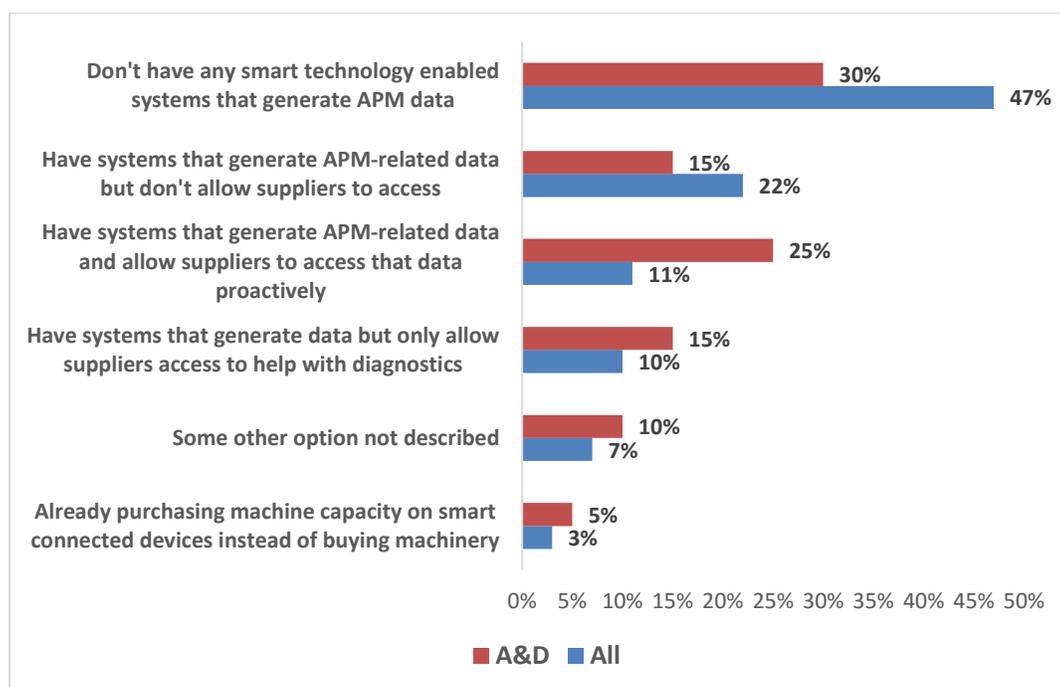




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Which statement best describes your attitudes toward APM service provided by the vendors of smart connected devices in your facility?



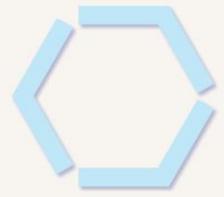
Steps A&D Needs to Take to Embark on the Digital Transformation Journey

The Aerospace and Defense industry has been a pioneer in concepts of Reliability, Availability, Maintainability, and Safety. However, while certain A&D systems have successfully made the jump to a digital operational model, the industry has been slow to embrace Digital Transformation as a concept. Conversely, non-A&D industries are more rapidly embracing Digital Transformation due to competitive pressures, growing availability of commercial big data tools, and democratization of newly available rich data such as consumer sentiment and social data.

The A&D industry's product, process, and supply chain complexity creates opportunities for Digital Transformation in three dimensions:

- Laterally across systems
- Vertically throughout the supply chain
- Across the product lifecycle

This three dimensional view of Digital Transformation will enable broader adoption of product servitization, increased competitiveness, and the potential for industry disruption. While manufacturers can and should independently pursue Digital



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Transformation, the regulated nature of A&D requires that industry and government also adapt to enable improvements in long-standing processes and foster innovation.

Recommendations

Manufacturers

- Manufacturers must leverage a framework such as LNS's Digital Transformation framework to successfully identify and deploy Digital Transformation projects, with a focus on product servitization.
- Manufacturers must invest in smart factories in order to build smart products, such as smart aircraft. A part of this initiative will be to improve the transfer of DfS and development data such as structures and configurations to manufacturing.
- Manufacturers should consider the move from expensive-to-maintain and evolve homegrown Big Data systems to an increasingly capable set of flexible commercial offerings.

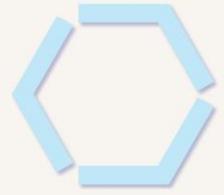
Industry

- The aviation Industry must adopt data transfer protocols that can distribute Big Data's volume, variety, and velocity between operators and the supply chain.
- Data must be democratized to encourage participation of the supply chain and stimulate data-led innovation.
- Current DfS data is inaccurate. Democratization of data must extend to MRO and DfS data in order to address fundamental inaccuracies in DfS inputs that lead to poor design and MRO decisions.

Government

- Government bodies must encourage Digital Transformation by standardizing DfS and Big Data requirements to avoid government-imposed data and process silos. While defense departments have been mandating COTS (Commercial Off The Shelf) and deploying PBL contracts as efforts to increase cost-effectiveness of defense programs, these programs have operated in many ways as silos, which increases costs and slows innovation.

Industry disruption has been a hallmark of Digital Transformation. A&D is an industry with highly complex, well-maintained, and mission critical equipment. Depending upon the point of view, this makes A&D manufacturers either particularly well positioned to derive value from Digital Transformation or



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particularly at risk for disruption from earlier adopters from within its ranks. Those manufacturers that want to remain competitive must prioritize Digital Transformation and consider the impact it will have on their future business interests.

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Authors:

Dan Miklovic, Principal Analyst, dan.miklovic@lnsresearch.com

Dan Jacob, Research Analyst, dan.jacob@lnsresearch.com