

Introduction

This paper explores the potential for digital transformation in aerospace, and examines the maturity of the UK aerospace sector's digital capability. It has been informed by surveys of and interviews with industry leaders, both internal and external to the sector, conducted by the ATI.

Most aerospace organisations surveyed are embedding digital technologies, but principally to deliver incremental efficiency and productivity improvements. Many are not considering the potential to change business models; in this regard, aerospace is following - but it could be leading.



KEY FINDINGS

- Digital technology is here and playing an ever more important role in the economy – including in aerospace.
- Digital technology can transform the sector in many ways, and in this paper we highlight three areas:
 - integrating supply chains;
 - opening servitisation opportunities; and
 - enabling disruption through new product, delivery and commercial capabilities.
- Realising the opportunities of digital requires companies to acquire a range of capabilities, both technological and psychological.
- The Institute encourages companies to consider digital technology proactively, and offers a framework enabling them to assess where they stand in terms of opportunities and capabilities. The framework also addresses some barriers to adoption.
- The sector should focus now on technologies that enable a broad range of opportunities, including digital twin, the internet of things and big data analytics.
- Finally, the ATI proposes four ways in which the aerospace industry can catalyse change:
 - addressing the digital capability set;
 - leveraging the UK's digital eco-system;
 - stretching in and beyond the sector; and
 - adopting fast experimentation (fail fast, learn faster).

However, digital is not just for large companies at the top of the supply chain; Digital can deliver real value throughout the supply chain, driving productivity, quality and cost improvements. The benefits of linking the physical and digital worlds are significant. Despite this, our evidence suggests the adoption of digital technologies decreases down the UK aerospace supply chain.

So, what is holding the sector back? One often-cited issue concerns data ownership and security. To companies supplying major systems, data provides market power and differentiation. Data security also militates against sharing it. Yet if the sector is to unlock the potential of digital it will need to share data that offers mutual benefit, whilst not only maintaining but improving on standards of safety and security.

*“Digital can deliver **real value** throughout the supply chain, driving productivity, quality and cost improvements”*

The Institute's view is that the sector should urgently plan how to reap the opportunities of digital technology. Aerospace is a hugely data-rich industry. Therefore it should firstly understand the gaps in its data, develop virtual models, or digital twins, of its products, processes and services, enabling collection and processing of data. Data can lead to better product, process and service performance and support optimised manufacturing. Moving beyond the single company, digital technologies enable new relationships through the supply chain, optimising performance.

And to achieve maximum benefit, the sector must work with new partners, accepting new entrants from outside.

This requires commitment and investment. According to PWC, companies worldwide are set to invest approximately 5 per cent of their revenues annually on digitisation, equating to over \$907 billion per year. For the UK aerospace sector, with annual revenue of £31 billion, this would equate to spending £1.55 billion on digital projects.

Through the ATI's engagement with the sector we have seen that organisations are internally investing in commercially-available solutions in IT enterprise, simulation and connected manufacturing. Using the ATI project portfolio as a sample, around 35 of the 160 projects have a digital element and to date, around 3 per cent (£42m) of £1.4

billion committed to projects can be attributed to digital. Increased efficiency, as opposed to growth, is clearly the main focus of these projects.

The automotive example

Since 2003, Tesla has been developing products that push new boundaries in customer experience. Cars connect to a network database that Tesla uses routinely to update vehicle systems and enhance customer experience, performance and maintenance. Tesla is taking a novel approach to developing the market, making its electric vehicle patents freely available to accelerate adoption and set industry standards. The company is utilising the connectivity of its vehicles to develop and certify its autonomous technologies. Whilst relatively niche, Tesla provides a good example of a high-end disruptor that is building data into the heart of its product, utilising digital innovation to challenge and leapfrog its competitors.

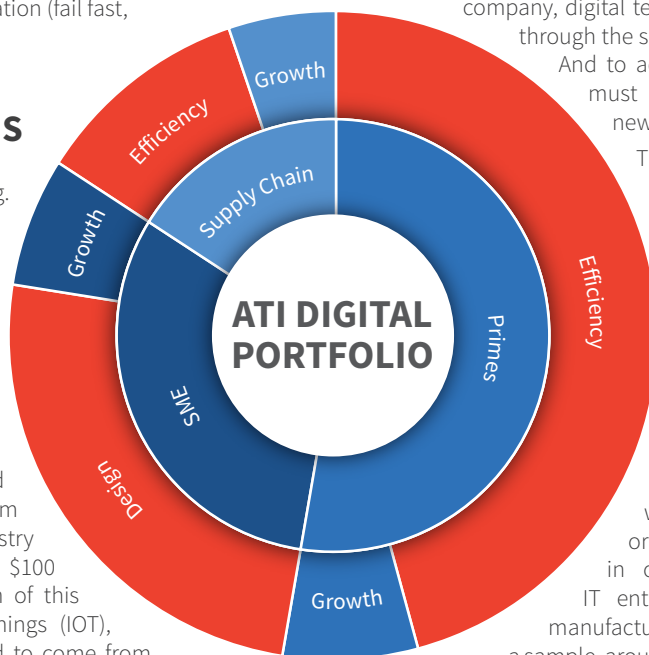
DIGITAL PERCEPTIONS

Digital is here. Digital is disrupting. Digital is transforming individuals, organisations and whole industries. The rise of new enterprises such as Airbnb and Uber is well documented, coming from left field to unhinge decades of tradition. New, customer-driven business models are challenging conventional approaches and regulatory systems. And for good reason - the World Economic Forum puts the value to society and industry of digital transformation at around \$100 trillion by 2025¹; some \$11 trillion of this will come from the internet of things (IOT), with a third of that value expected to come from manufacturing.

And what of aerospace, an industry that is over 100 years old and with formidable barriers to entry: is it impervious to these new models or is it next in line for an Uber-style shake up? Should the sector's approach to digital be driven by fear of a disruptive new entrant, or should it be focused on reaping the real benefits that are possible now?

According to our survey the sector believes that the aerospace sector will see gradual but fundamental changes to its business models. As digital capabilities mature, the relationships between airframe makers, suppliers and their customers will change.

OEMs and Tier One companies recognise both the opportunities and challenges of digital. Many larger companies are taking bold actions: creating new business functions to extract value; recruiting from non-aerospace backgrounds where digital capabilities have progressed more rapidly; and appointing a new type of executive - the Chief Digital Officer.



¹ <http://www.economist.com/news/business/21711079-american-industrial-giant-sprinting-towards-its-goal-german-firm-taking-more?fsrc=dg%7Ca>

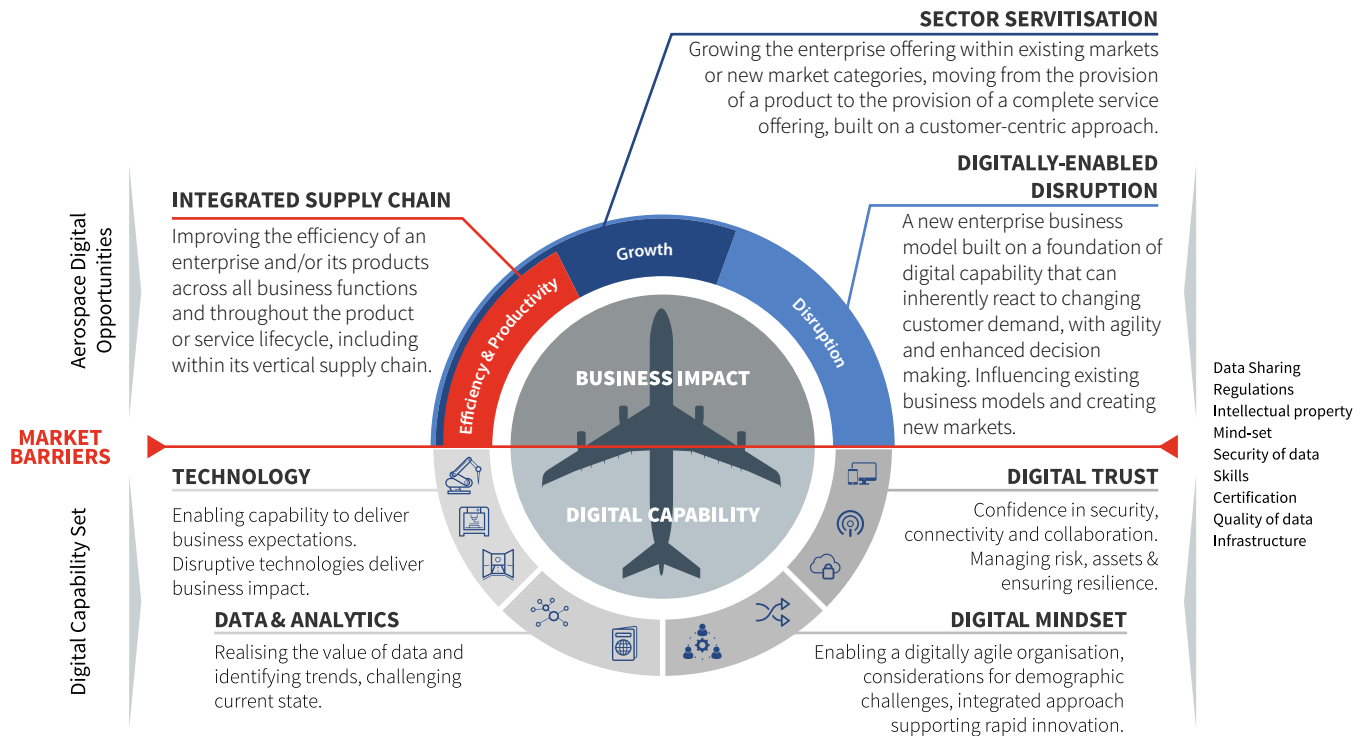
A DIGITAL FRAMEWORK FOR AEROSPACE

Using insights gathered from the sector, the ATI has created a simple framework representing the possibilities of digital technologies. It covers market-led business opportunities and capability needs. It enables companies to assess where they are on the digital journey and their direction of travel. It ranges from straightforward 'low hanging fruit', that should be the starting point for any business wanting to optimise its operations, through to high level, customer-oriented concepts.

The ATI has highlighted three key value creation themes, increasing in their sophistication and transformative potential: integrated supply

chain, sector servitisation, and digitally-enabled disruption. Each presents new opportunities for products, delivery, and business models. Realising these opportunities, however, requires four capabilities to be deployed: technology, data & analytics, digital mindset, and digital trust. There are also various barriers that can hinder innovation and the translation of digital capabilities into business value.

These opportunities, capabilities and barriers are shown in the diagram below and discussed more fully in the next section.



Case Study: Meggitt M4 Project

Meggitt is working with the Advanced Manufacturing Research Centre, Cranfield University, IBM and the Manufacturing Technology Centre on an ATI-funded programme to overcome the challenges associated with diverse, highly-complex product offerings supplied to the aerospace sector.

The programme capitalises on the integration of digital tools to enable multi-component work flows. It improves productivity and operational excellence through dynamic scheduling, generating simulations, the use of data analytics to predict capacity requirements and performance, and the visibility and traceability of components.

Shop floor operators are supported by fully-adaptable intelligent work benches, autonomous intelligent vehicles to provide 'smart box' sub-assemblies and component parts, digital work instructions, and smart tools including laser-projected guides to minimise error, control traceability and minimise unnecessary waste during the production process.

THE DIGITAL CAPABILITY SET (TECHNOLOGY, DATA & ANALYTICS, TRUST, MINDSET)

The digital capabilities are:

- Technology: physical or virtual systems that connect the world, generate information, host digital processes and deliver effect – Key concepts: digital twin; virtual digital models of products, processes or services that can be used to predict their properties and behaviours; internet of things – connecting all physical elements of a product, its manufacture and operation digitally through the internet
- Data & analytics: The codes and algorithms that process information, extract insight and make decisions – Key concept: big data analytics - use of algorithms, machine learning and data mining to extract value and inform decisions from very large data.
- Digital mindset: The organisational aspects, formal and informal, that enable people to effectively realise and deliver a digital value proposition.
- Digital trust: The means by which confidence, security and resilience are built into digital interactions.

Each capability should not be considered in isolation; each attribute influences the adjacent attributes, allowing for future growth and development.

Organisations can use this table to establish how their existing capabilities are matched to identify gaps in knowledge and capability that need to be explored.

Digital capability is scalable and can start with small changes to provide insight.

The following table describes some of the critical areas of focus against these and the role digital capability has in unlocking new market opportunities. Through industry-led workshops, the ATI has mapped the digital capabilities against the market opportunities.²

Capability/ Market Change	Aerospace competence	Integrated Supply Chain	Sector Servitisation	Digitally Enabled Disruption
Technology	Adding intelligence in the process + Digital twin (component to sub-system to full platform prognosis) + Adaptive intelligent processes + Flexible factory automation + Augmented and interactive reality + Artificial intelligence and system autonomy	     	     	     
	Connecting the digital and physical world + Internet of Things - connected intelligent systems + Instrumentation (minituarised, integrated and low cost) and data capture + High bandwidth connectivity (satellite, pseudo-satellite, networked aircraft and ground based links) + Tracking	   	   	   
Data & Analysis	Managing and processing data + Big data analytics (building to real-time analytics) + High Performance Computing + Data architecture & capacity	  	  	  
	Leveraging the flexibility of digital environments + Interactive object in a system + Virtual certification and virtual product life cycle + Autonomous analytics + PLM	   	   	   
Digital Trust	Confidence in sharing + Security of systems (cyber and physical) + Reducing uncertainty in data exchange/Block chains (To support data provenance and privacy) + Open secure platforms + Quantum encryption to mitigate cyber security hacking	   	   	   
Digital Culture (digital mindset)	Re-orientating around customers + Customer orientated development + Data driven design (Design for x, scenario modelling & existing product data sets) + Knowledge capture management - enhanced customer use cases	  	  	  
	Changing the route to innovation + Connected innovation + Rapid test-fail via virtual reality - design, manufacture, in-service + Rapid test/fail via flexible/customisable product + open-innovation models through strategic partnerships	   	   	   
DEVELOPMENT OPPORTUNITY INDICATOR  Large Development Opportunity  Moderate Opportunity  Small Opportunity  Capability Addressed				

Next we explore some of the key capability trends highlighted in the table above:

Digital Twin

Current state

Digital twins are virtual models of a product, process or service that can be used to predict their properties and behaviours. Throughout the life cycle of the product, process or service, data from the physical world is collected, processed and compared against the digital twin, continually verifying the model and enabling diagnosis and pre-emptive action to be taken in the physical world.

Early adopters are establishing the requirements to deliver this capability, digitising internal processes before establishing how data can be incorporated from suppliers and external sources.

Challenges

Products and processes involve multiple stakeholders. But consistency and accuracy of data are fundamental to the validity

of a digital twin. Overcoming this require greater co-ordination of operating practices and standards, and data architecture flexible enough to support future requirements.

Opportunities

A digital twin is a dynamic object, increasing in sophistication and fidelity throughout the life of a product. Establishing how data is collected, joined and analysed requires an overarching architecture. A digital twin is enabled by, and can support, other critical digital technologies, including IOT devices and big data analytics. For example, aggregating data, identifying outliers and linking this back to in-service components or early-life failed parts can help deliver improved route cause analysis to determine specific recalls as opposed to whole batch products.

As data sets are established and real-world measurements are used to validate simulated capability, the fidelity of information and the certainty with which new designs can be verified will tend to more virtual certification.

²The table is a sample only, based on the views of the UK's aerospace top-end (mostly tier-1) supply chain

Internet of things (IOT)

Current state

Great efficiencies can be made by digitising assets. IOT can help assess an organisation's overall equipment effectiveness (OEE) in real time. OEE is often used as a measure of supply chain capability. Many companies are utilising off-the-shelf IOT devices including RFID tags to provide operational prognostics, monitoring in-process performance, avoiding bottlenecks, and providing information on assemblies thus avoiding complex and time-consuming removal.

Challenges

Real-time global factory asset monitoring is commonplace in the automotive sector, but not in aerospace.

On board aircraft, wider adoption of IOT devices are limited to premium customers and managed on a separate system, avoiding the issue of connection to safety critical systems. Further developments are required, including managing data capacity, interoperability between new and legacy systems, and layers of security to support various interface opportunities (something that isn't available today). Security and preventing hacking is a key challenge of IOT devices and a major focus for every industry. Further challenges, including certification, updates and reconfiguration all need to be considered to support the pace of technology development.

Opportunities

There are many IOT devices with direct potential aviation applications, including measuring the performance of products and factories, putting sensors into passenger seats, personalising environmental conditions, and supporting semi-autonomous pilot operations through wearables.

Connecting the assets within an organisation is a first step in optimising their utilisation and effectiveness. Real-time data allows the organisation to predict and plan maintenance requirements, reducing time, manage utilisation and simulate scenarios to improve OEE.

The High Value Manufacturing Catapult is working with industry to establish how using simple IOT devices can deliver valuable information to support better decision making. For example, measuring the power usage of a machine can determine accurate utilisation. Connecting products and assets together can enable dynamic scheduling and flexible factory automation, where multiple products can be managed through the same factory.

Connecting workstations to products and processes can have a profound effect on quality, enhance operator capability and create a flexible, dynamic work area. Smart tooling links machine and operator via interactive tablets or augmented reality headsets. Laser positioning and labelling, combined with smart fixturing, can ensure processes are completed correctly with improved quality.

Big Data Analytics

Current state

Big data involves using algorithms, machine learning and data mining to extract value and inform decisions. Today aerospace companies collect vast – and rapidly increasing – quantities of data.

Big data analytics are being used today to improve decision making across the value chain, from measuring product performance to assessing the impact of weather on the supply chain and how it might affect downstream operations.

Challenges

Before analysing data, its fundamental architecture needs to be addressed. Data configurations are not always directly transferrable and legacy systems may no longer be supported. Translating input data into value can be difficult and requires skills not traditionally associated with aerospace.

Utilising data analytics to enhance product services can also be restricted by the ownership of data.

Opportunities

Relevant, accurate and insightful data imparts knowledge, facilitates decision-making in real time, and enables improvements across all stages of the product lifecycle.

Opportunities exist where data from real conditions can generate a virtual representation, analyse alternative scenarios quickly, and improve awareness of multi-disciplinary design decisions. For example, adaptive machining can utilise big data analytics to adapt manufacturing based on a range of input criteria, including environmental conditions, component attributes or tool wear.

In the long term, big data and machine learning can be used to react to events where new requests are dynamically scheduled to support real-time support and services to customers.

Virtual Certification

Current state

Virtual certification is used today in aerospace where the level of uncertainty is deterministic, qualified with safety factors that are an order of magnitude above and beyond the perceived worst case and traditionally backed up by certified test data.

Challenges

Whilst many businesses use simulation to inform design decisions, the fidelity of the data may often be insufficient to certify a whole product. The type certificate holder for any new certification relies on standards such as RTCA DO and the certification authority to derive requirements and establish compliance.

One key challenge facing wider adoption is the consistency of data architecture coupled with the fidelity of information required to achieve simulated certification. Businesses are working with regulators to develop pilot projects to tackle this.

Opportunities

Virtual certification could revolutionise the pace and costs of aircraft development. A large proportion of new product development cost is linked to qualification and certification. In other sectors probabilistic quantification methods are beginning to be used. The fidelity of real life environmental situations can be collected, measured and simulated using the digital capabilities described above.

Digital capability can provide far greater situational awareness at all levels in the product life cycle. Applying digital technologies up front can drive functional, physical and performance verification; for example, product tolerances can be accurately defined by specific reference to manufacturing process capability.

Digital capability presents an opportunity to increase the certainty of products and processes at all levels within product development to provide a more cohesive and transparent insight to all stakeholders in the process. Developing virtual certification within aerospace will enable more incremental development, increased rate, improved product performance, and more customer-orientated offerings.

³Definitions that describe some of the capability concepts explored in this table can be found at the back of this document

AEROSPACE'S DIGITAL OPPORTUNITIES

The digital opportunities can be viewed as a spectrum, increasing in their sophistication and transformative potential:

- **Integrated supply chain:** Improving the efficiency of an enterprise and/or its products across all business functions and throughout the product or service lifecycle, including within its vertical supply chain.
- **Sector servitisation:** Growing the enterprise offering within existing or new markets, moving from providing a product to providing a complete service, built on a customer-centric approach.
- **Digitally-enabled disruption:** Creating new business models and markets by deploying digital capabilities that react to changing customer demand, with agility and enhanced decision making.

Digitally-led market change	Sector Servitisation		Digitally-enabled Disruption
	Integrated Supply Chain	Sector Servitisation	Digitally-enabled Disruption
	<i>Evolution of product design, production and thru-life services to increase competitiveness.</i> Placing focus on digital integration of the supply chain.	<i>Servitisation of product-based business - cradle to grave product management.</i> Placing focus on digital integration across the aviation value chain.	<i>Flexibility and agility to react to new business opportunities, delivering customer-centric product and service offerings.</i> Placing focus on bottom-up customer-orientated innovation, including technology driven experiments and engaging out-of-sector agitators and start-ups.
Digitally-enabled business levers	New product capabilities + Virtual and multi-disciplinary product development and validation + Product co-creation New delivery capabilities + Automated and intelligent production systems, flexible and dynamic + Distributed & Dynamic Manufacturing + Industrial Market Place + Extended and connected enterprises in the supply chain New commercial capabilities + Dynamic product costing based on key attributes (linking the industrial market place to real time design iteration, material availability and manufacturing accuracy)	New product capabilities + Integrated customisable product offerings + Customer focussed services (e.g visualisation services) + Product co-creation + Circular design New delivery capabilities + Extended and connected enterprise across the aviation value chain + Connected platform - total product awareness for predictive and preventative maintenance and responsive operations + Automated sourcing and aggregated logistics solutions New commercial capabilities + Service/performance based contracts + No transfer of assets + Customer intimacy + Remanufacturing, disposal, end of life management	New product capabilities + Platform intelligence and asset pooling + Customised mobility solutions + Platform sharing New delivery capabilities + Integrated transport networks + Coordinated customer-centric extended enterprise New commercial capabilities + Rapid customisation and personalisation of products and services + Agility and flexibility to respond to new business offerings quickly + Established eco systems that can react quickly to changing customer expectations + Simplified and seamless sharing of data across the value chain supporting the agility of the supply chain + Integrated, simplified and enhanced trans-modal mobility

Case Study: Rolls-Royce

Rolls-Royce is working to coordinate all aspects of design, manufacture and through-life service data sets. It is doing this to proactively eliminate data silos, generate a more structured approach to data management, and improve communication between the many disciplines, tool sets and technology required to deliver state-of-the-art engine technology development.

A new overarching programme, DA-VINCI, links existing design and development programmes into a well-structured approach to data – including a digital twin for all the multi-disciplinary aspects involved in the digital representation of a specific physical engine. This layered approach allows the team to understand to the intricacies associated with each responsibility, where there are overlaps in data requirements and where there are gaps that may affect future design decisions.

By using a digital twin that matches the physical (as manufactured) attributes of an assembly or component in a virtual environment, Rolls-Royce is moving closer to simulating the behaviour of the model in different scenarios, establish the model's accuracy relative to physical testing, and move toward the ability to virtually certify future platforms.

Integrated Supply Chain

All businesses want leaner, more efficient operations that shorten lead times, improve quality, and deliver on time to customers. Digital technologies can help deliver these needs; however, many UK aerospace supply chain companies have not progressed as far, and need to accelerate to be globally competitive.

Companies should first apply basic digital capabilities; developing digital twins of their products, processes and services, connecting and collecting data from them through the internet of things, and drawing insights using big data analytics. These insights can guide actions to transform business performance. Digital capabilities can then enable new collaborative relationships throughout the supply chain, optimising supply chain performance. These steps can also deliver the foundation of a broader digital capability that could enable further transformation.

Sector Servitisation

This involves the transition to selling a product as a service, requiring a different approach to business, different relationships and integration across the value chain. It is becoming increasingly common at the interfaces between aircraft operators and airframers and their major sub-system suppliers. It requires data sharing, which depends on the level of partnership, openness and shared benefits. It involves a transfer of duty, and risk, from the customer to the OEM through which the service is delivered.

In addition to the value created for customers (including certainty of costs, availability, service level, and features) the richer connection between the design, supply and operation of a product enables the service offering to evolve and grow.

Engine manufacturers have embraced this model such that their service businesses provide a major portion of their revenues – they allow operators to pay per hour of operation of their engines and

protect them against service interruptions, reducing risk to their businesses. The engine manufacturers' success has depended on working with airlines and building up their own overhaul businesses to gain access to operational data and use this to diagnose the health of the fleet and individual engines. Prognostics are used to aid decisions on when to take maintenance action, maximising engine on-wing life and minimising unplanned service interruptions.

Engine manufacturers are now using their fleet operational data to better inform future product designs and manufacturing. As these services-based enterprises develop, the potential for digital technology to optimise services at a system level (aviation transport system, fleet, aircraft, major aircraft sub-system) increases.

Digitally-Enabled Disruption

This step moves towards providing highly agile digitally-enabled customer-oriented services. Traditional corporations with bureaucratic legacy systems meet digitally-savvy new entrants who view the market very differently - lean, highly customer-centric, ready to build bottom-up and experiment rapidly; digital capability is the backbone of their offerings. To succeed here, incumbent organisations will need to collaborate with entrants from outside aerospace to deliver innovative products and business models. These may include offering multiple transport modes to deliver full mobility solutions.

For example, a recent white paper from Uber proposes end-to-end transport using autonomous 'air taxis'. It is a model in which Uber does not own or operate the product or infrastructure, only the service provision; Uber is working with NASA to develop this concept further.

Success for just one of these disruptive entrants could have a significant impact on commercial aviation – on the aviation transport system, aircraft and their sub-systems and components, demanding design, manufacture and certification to be executed at a pace far beyond anything exhibited in commercial aerospace to date.

DIGITAL BARRIERS IN AEROSPACE

Aerospace sector is a very regulated environment with high barriers to entry. These factors, along with the pace of aircraft development, are often cited as restricting change and impeding the application of digital technology.

Our survey found that most within the sector identify IP protection, data sharing and cyber security as the biggest barriers to transformation. However, our Market & Economic Advisory Group, made up of cross-sector participants, cited culture to be the biggest barrier.

We have examined some of the responses received below:

Data Sharing

Access to data only offers value if its purpose and use can be realised. Access to data that could enable change is restricted and owned by few companies – so how much of the data collected is actually being used? How much does it cost to acquire it? How much does it cost to share it? Does sharing it provide benefit to both parties? Is some of the data publicly available through other sources? Answering these questions and working across the value chain will enable change.

Intellectual Property

The advent of a connected world increases the need to safeguard intellectual property. One of the key risks cited by our survey was the concern that improving transparency between supplier and customer could reveal production methods, in effect a business's trade secrets. Digital tools, such as a block chain can identify how products and services are used, and can offer alternative ways of managing key commercial assets (such as IP) and establishing mutually-beneficial developments and more strategic relationships.

Cyber Security

Cyber security is an international multi-sector challenge that aerospace should not consider in isolation. The financial sector is the established leader in this field, and has pioneered block chain technology as one of the most secure methods of cyber protection, ensuring that the provenance and privacy of assets (finance, data, IP, ownership, etc.) are upheld.

Regulations

Regulation is cited as a barrier to the adoption of digital transformation. Digital technology provides a means of creating greater fidelity (more pertinent to real-world conditions) and identifying the provenance and accuracy of information. Support is also required to work with regulators and develop the tools required to validate new digital capabilities.

Culture

The results of our survey indicated that a conservative culture within the sector was considered to be a barrier to transformation, accentuated by demographic challenges, lack of skills to deliver digital capability and entrenched working practices. This is changing, but the pace of change is itself a cultural challenge. New graduates have digital skills but lack the practicality and knowledge of products and their application.

CATALYSING DIGITAL TRANSFORMATION

Positive action is needed. Organisations need to consider digital as a fundamental part of their business strategy. The level of change required is dependent upon the level of influence that organisations have within the value chain. Data is required at all levels within the supply chain to enable change.

The ATI has identified four ways in which aerospace companies can engage in digital transformation. It is important to note that they are not mutually exclusive and should not therefore be considered in isolation. Indeed, many digital activities rely on each other to deliver fully.

01 Address the Digital capability set (Technology, Data & Analytics, Trust, Culture)

- Identify how your organisation relates to your customers. Is the organisation advancing in integration, servitisation or disruption?
- Analysing current and future operational goals and determining the relative level of digital capability needed to catalyse change will highlight the gaps and opportunities to be explored.
- Establish the data requirements that can enable change. Investigate how data can be collected and managed; and how it might be used or shared securely by both internal and external stakeholders.
- Understand your organisation's ability to fulfil these ambitions and look outside for the support that is increasingly available.

02 Leverage the UK's digital ecosystem

Filling gaps in digital capability can be expensive and time-consuming. However, significant support is available. **Many of the organisations listed below can address the challenges identified in this paper:**

- The Digital Catapult is working with start-up hubs to develop support systems addressing all manner of challenges, including data analytics, cyber security and digital tool sets
- The Transport Systems Catapult is working with airlines and airports to establish transport network links and wider transport planning
- The High Value Manufacturing Catapult is working to establish a common digital strategy and to offer support to multiple sectors at all levels within the supply chain.

A series of initiatives and resources can support industry in developing digital capability:

- A new industrial digitalisation review was announced as part of the Government's Industrial Strategy consultation in January 2017, chaired by Juergen Maier, CEO at Siemens UK & Ireland. The group has been tasked with assessing how the UK can benefit from accelerated adoption of digital technology across advanced manufacturing.
- BSI and Cambridge University have recently concluded a digital manufacturing survey to establish key priorities. BSI is establishing a set of digital guidelines that industry can use to support a common approach and increase adoption of digital systems.
- The Digital for Manufacturing (D4M) and ADS Digital manufacturing Special Interest Group are industry-led working groups recently established to develop research projects, skill sets and diagnostic tool sets to evaluate capability across multiple sectors.
- The EU has published a strategy that evaluates the requirements for a digital single market. The policy provides a mechanism for changing regulation and embracing digital capability to drive productivity and growth in the EU. The three pillars of the policy identify improving access to digital goods and services, providing an environment where digital networks and services can prosper and leveraging digital as a driver for growth.

03 Stretch collaboration in and beyond the sector

- Successful collaboration depends on mutual benefit. Strategic partnerships can form within and beyond the sector.
- The same is true of the extended value chain; strategic relationships will provide a wider data set for evaluating product performance.
- Chief Digital Officers and their equivalents should strengthen networks across the sector and beyond to other sectors, to share challenges and search for areas where collaborative development opportunities and benefits can be realised.
- For smaller companies, Supply Chain 21 (SC21) and Sharing in Growth initiatives provide collaboration opportunities in which digital requirements can be realised.
- The ATI is working to further enhance international collaboration across its key strategic themes. Part of these collaborative opportunities extend to digital development, where the UK can support future export opportunities. There are also opportunities to develop capabilities with other sectors where a common approach can be applied to solve multiple applications.

04 Create space and safety for experimentation

At the heart of all business initiatives is the need to be agile, to test concepts, fail fast with minimum cost and maximise the learning opportunity – digital can accelerate this cycle. Through digital capability and the assimilation of data, new opportunities can be realised, simulated and evaluated in ways that would have previously been cost prohibitive or overly risky.

The ATI strategic approach, outlined in Raising Ambition, the ATI's Technology Strategy & Portfolio Update, launched in July 2016, is creating opportunities for digital development:

- Four priority initiatives are established for the sector. These offer the opportunity to develop digital capabilities and include ultra-high bypass ratio (UHBR) turbofan propulsion, integrated aero-structures, and virtual systems validation
- Five cross-cutting agendas - high value design, autonomy, additive manufacture and through-life services. These will require a digital mind-set to fully realise them.

The ATI will use the framework described in this paper to evaluate the digital capabilities needed for each of these initiatives and agendas and recommend which opportunities should be captured, whether specific to a particular initiative or where gaps and opportunities exist and cross-initiative collaboration can be identified.

NEXT STEPS FOR THE ATI

+

We know from our research that the prevailing opinion within aerospace is that traditional business models will continue to lead the development of digital capabilities in the near term. This paper sets out a framework by which organisations can assess their own capabilities and evaluate the necessary steps required to adapt to a digital transformational model. The ATI will continue to develop and share the model as a means of evaluating capability within the aerospace sector.

The Institute will also continue to work with the sector to facilitate the adoption and integration of digital technology by:

- Engaging with digital thought leaders to develop a network that builds and encourages participation in a digital framework and establishes digital opportunities for the sector
- Leveraging that network to enhance the UK aerospace strategy, examining new challenges and opportunities through a digital lens
- Briefing the sector more widely and promoting the ATI framework, engaging with the sector and wider digital community to maximise the UKs capability to deliver growth through digital transformation
- Expanding the maturity of the ATI framework through the engagement and evaluation of digital projects.

Contact us

For further information on digital transformation in the aerospace sector please contact info@ati.org.uk

REFERENCES

- Davies, R. (n.d.). Industry 4.0 Digitalisation for productivity and growth. European Parliament.
- Edd Grant. (2016). Big data's dark side. *Engineering & Technology*, 33-35.
- Frost & Sullivan. (2015). Mega Trends Digitising the Auto Industry.
- Government, H. (2013). Seizing the data opportunity - A strategy for UK data capability. Department of Business, innovation and skills.
- Government., H. (2013). Information Economy Strategy.
- Oliver Wyman. (2016). MRO Big data - Innovation and adoption in aviation MRO. Oliver Wyman, Authors: Tim Hayland, Chris Spafford, Andrew Medland.
- OliverWyman. (2016). Digital Industry.
- Peplow, D. M. (n.d.). Distributed Ledger Technologies: beyond block chain. UK Government, Government office for science.
- Rolls-Royce streamlines jet engine design with Isight. (2011, jul 18). Retrieved from SAE International: <http://articles.sae.org/10018/>
- Wyman, O. (2015). Incumbents in the Digital World.

Acronyms

CAA	Civil Aviation Authority
MRO	Maintenance Repair and Overhaul
ECM	Engine Condition Monitoring
OEM	Original Equipment Manufacturer
R&T	Research and Technology
SME	Small and Medium Enterprise

Acknowledgements

Thank you to all who contributed to the paper through participation in the survey, one-to-one interviews or workshops, and to all who provided advice on key developments or trends.

The Aerospace Technology Institute

The Aerospace Technology Institute is at the heart of UK aerospace research and technology (R&T). Working collaboratively with government, industry, research centres and academia, the ATI sets the national aerospace technology strategy to reflect the sector's vision and ambition. The ATI is backed by a joint government-industry commitment to invest £3.9 billion in R&T to 2026. The ATI strategy is focused on ensuring UK aerospace is a global leader in aircraft wings, large aircraft engines, complex aircraft systems and new architectures for both fixed and rotary wing aircraft.

The Institute recognises the value of digital capability to the aerospace sector and the urgent need to accelerate exploitation of this fast-paced and dynamic capability across all sectors of the UK economy. The Institute is proactively engaging Government, its agencies and Catapults (such as the Digital and Transport Systems Catapults) as well as the rich and diverse research base. By working strategically and collaboratively across sectors the Institute is helping to unleash the digital economy to power UK growth.

DIGITAL TERMS OF REFERENCE

Big Data Analytics

The process mechanism for examining large data sets. Analysing data from multiple sources helps users to discover new business implications that are otherwise hidden in the data sets, informing decisions and providing the certainty to act.

It enhances the fidelity of data, and can also include data on attributes beyond the product (such as environmental measurement or the performance of similar products). It exposes users to data sets far beyond those considered in today's regulatory requirements.

Block Chains (aka Digital Distributed Ledger)

A decentralised database that stores a registry of assets and transactions in a peer-to-peer network. Transactions are secured via cryptography and then locked into blocks of data, cryptographically linked together and secured. The register is stored and managed by custodians across the network, an open infrastructure that stores assets securely.

The most notable user of block chain technology is the bitcoin currency. Block chains can store and manage many different assets (such as, IP, ownership of assets, certificates, and data). Block chain technology is used to ensure the provenance and privacy of assets are maintained.

Cyber Security

As a body of technologies, policies and safeguards designed to prohibit unauthorised access to cyber assets. Today's cyber security is based on the process of encryption - constructing and analysing protocols that prevent third parties accessing the data. As the processing power needed to crack encryption becomes cheaper and more readily available, it is inevitable that the generation of new encryption processes will become more complex.

Digital

The translation of collected data (cyber or physical) into knowledge or awareness that can be acted upon to generate value.

Digital Transformation

The accelerated evolution of business activity enabled by digital capability and technology.

Digital Twin / Digital passport / e-DNA

A fully-defined digital record of the attributes that define a product or component throughout its entire product life cycle; a virtual representation of reality.

The data generated is accumulated in layers: a virtual representation of the product as designed, of the product as delivered (how the product achieved its design constraints) and the collective data of the product's performance in service.

Storing this data in a data-rich architecture provides users with information that determines appropriate action; for example, providing prognostic information on the maintenance requirements for a component at any point during its service life to predict early failure and mitigate unplanned maintenance to aircraft fleets.

Industry 4.0

Cited by some as the fourth industrial revolution, Industrie 4.0 originated in Germany as a national programme to boost manufacturing productivity through the application of cyber-physical systems. Today the term has changed to emulate this success across the entire product lifecycle and is internationally recognised as a term to define the application of digital tools into an engineering setting.

Internet of Things (IOT)

Defines the connectivity of objects through a communication protocol. Everything from a watch to the condition of a shipping container in the middle of the ocean can be tracked, monitored and configured via the internet.

It delivers real-time knowledge of an environment the user wants to control. The development of sensors and communicating technologies such as 5G networks provide low-cost opportunities. Over six billion connected devices are reported to have been commercialised last year alone.