INSIGHT

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Introduction

This paper has been compiled to disseminate the findings of an aerospace sector consultation enabled through a collaboration with Composites UK, the trade body for the UK composites industry. The consultation aimed to identify the priority technologies needed for composite material exploitation, as well as the priority product areas for which composites are of interest across aircraft, structures, systems and propulsion components. The paper builds on work undertaken as part of the Composite Leadership Forum's 2016 Composites Strategy "Lightening the Load"1 which analysed the cross-sector opportunity for composites, with the outcomes of this paper identifying the priority technology challenges for the aerospace sector relevant to that strategy.

09 COMPOSITE MATERIAL APPLICATIONS IN AEROSPACE

EXECUTIVE SUMMARY

Composite materials have been utilised in the aerospace industry for many decades, initially in non-safety critical applications and more recently as primary structures, including fuselage and wing structures on the latest aircraft from Boeing, Airbus, and Bombardier. An ever-growing aerospace market presents major opportunities to the UK composites sector to develop products and technologies for current and future platforms, with the capability of composite materials becoming more advanced and suited to applications across the entire aircraft environment.

Globally, there has been a shift in the aerospace sector from metals to composites in recent decades. This increased usage of composites has been driven by the industry need to provide more fuel-efficient aircraft, predominantly through lighter, more efficient products, which also supports legislation and changing attitudes on aviation's impact on the environment. Improvements in composite design, certification, manufacturing efficiency and through life engineering services, as well as step changes in cost and quality of production systems have been key enablers in realising these opportunities and have allowed the composites industry to thrive. In this study, the products, technologies, capabilities, market, challenges and barriers for wider composite technology adoption have been considered and detailed.

KEY FINDINGS

Through a comprehensive industrial consultation undertaken for this paper, the ATI has analysed technological needs against a detailed aircraft market forecast to identify how the UK can continue to be a global leader in composite material applications. The ATI will work with the sector to highlight how they can take advantage of future opportunities. The key findings identified in this paper are:

Design & Analysis

- Improved design for performance and manufacture methodologies are essential, evolving design from 'blackmetal' to cost effective, integrated, optimised, functional components.
- Modelling and simulation techniques to deliver virtual testing, manufacturing and assembly are critical to reduce the cost of the introduction of new materials and parts.

Processes

- Cost effective production at higher volumes is critical, replacing prepreg/autoclave with dry or wet placement and dry fibre preform infusion, along with use of automation and digital/smart manufacturing.
- Improving cost efficiency of these processes will be delivered through technologies to reduce wastage, optimisation of processing kit to reduce power consumption and reconfigurable, intelligent handling and automation systems.

Materials

- Lower cost materials which reduce processing costs need to be developed – opportunities include thermoplastics, quick cure thermosets, lower cost fibres, intermediates and preforms.
- High performance composites requirements include functional capability (electrical, thermal, sensing), higher temperature capability (PMC, MMC and CMC) and through thickness performance.

Technology Enablers

- Uptake of composites will be facilitated through cost-effective integration of multi-material structures through techniques including joining, core technologies, tooling, jig-less assembly, automation and in-process inspection.
- Multifunctional composites are required with increased electrical and thermal capability, improved coatings, structural health monitoring and morphing capability.
- Additive manufacturing and graphene were identified by industry as potentially disruptive technologies to the composites industry.

Case Study – Multi Axial Infused Materials (MAXIM)

Funded by the Industrial Strategy Challenge Fund (ISCF) and part of the ATI programme, the £7.4 million four-year Multi AXial Infused Materials (MAXIM) project will develop progressive, cost-effective materials and manufacturing solutions for large aerospace and automotive composite structures. Hexcel is investing in expanding its Leicester plant by installing a state-of-the art machine for carbon non-crimp fabrics development and lab equipment for research into this technology. The company will be working closely with the National Composites Centre to leverage their expertise in material handling and part processing.

Hexcel's Thierry Merlot, President – Aerospace, Europe/MEA/Asia Pacific said:

"Investment in this project in Leicester will allow Hexcel to advance key Out of Autoclave technologies that can provide a step change in the cost-effective production of composite parts for commercial aircraft and passenger cars. The project will support the development of new materials that the aerospace industry in particular can adopt with confidence to meet the high build rate requirements for future programmes."

VISION FOR UK AEROSPACE COMPOSITES

Composites materials are critical to UK aerospace and to the industry's future success in whole aircraft, aerostructures, propulsion and systems markets due their ability to provide high-quality solutions for a range of products. It is essential for the UK to understand future requirements and support development of technologies and enabling capabilities in composites. This paper summaries a detailed study to assess composites technologies, providing industry with information on current composite developments in the UK and on future needs. The topics are intended to support the formation of collaborative industrial research projects, that position the UK aerospace composites industry competitively to take advantage of emerging high value global aerospace opportunities. These collaborations will also encourage the UK composites value chain to become better interlinked, spanning material research and formulation through to product manufacture, part integration and through-life support. The ATI will continue to work with Composites Leadership Forum and the UK composites community to realise these opportunities and provide a joined-up approach to maximise value to UK organisations.

WHAT ARE COMPOSITE MATERIALS?

Composites are any material system consisting of two or more discrete materials that collectively provide properties that could not be exhibited by any of the constituent materials in isolation, most likely providing some form of performance improvement. The constituent materials within a composite work in collaboration to provide materials with strength, toughness, flexibility and density advantages that reduce weight and improve all-round performance of products. Composites provide many benefits over traditional materials including better strength to weight ratio, improved durability, added functionality and more freedom in design configurations.

Classification

Composite materials are typically formed of a fibrous reinforcement such as carbon or glass fibre, which provide strength and stiffness, embedded in a matrix material to provide the overall shape, support and toughness of the material.

The material properties are characterised by the type and composition of the fibre reinforcement and the matrix material, as shown in the figure 1 below.

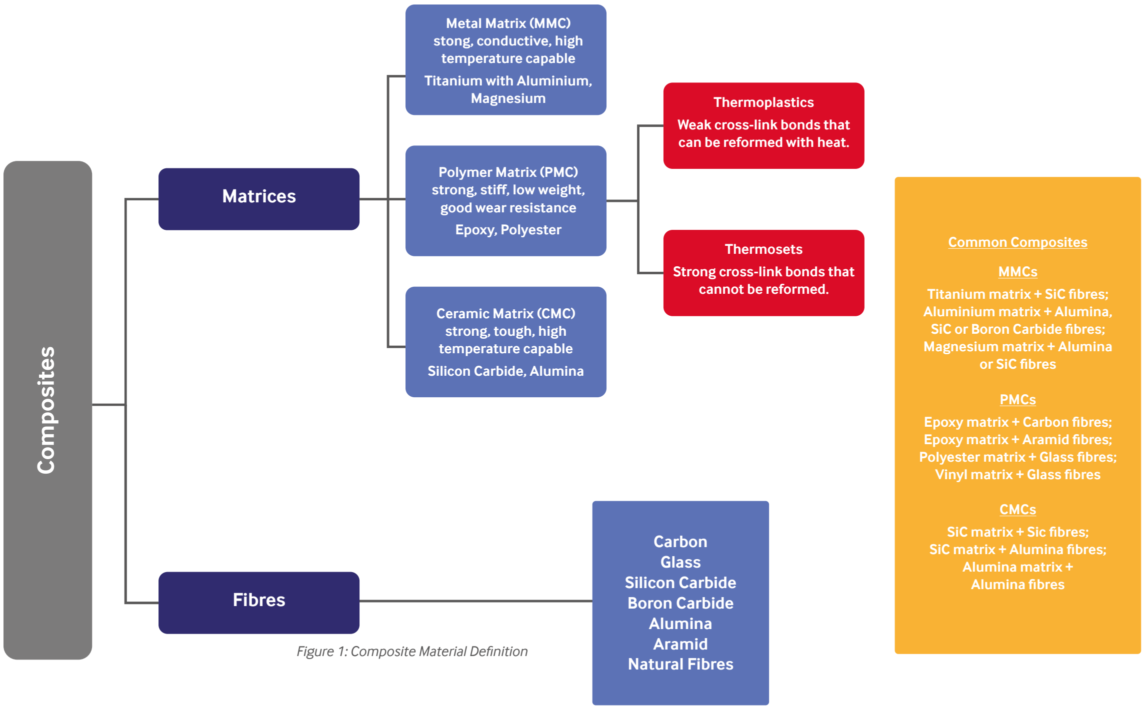


Figure 1: Composite Material Definition

Case Study – CTI Composite Fan Technology (SAMULET 2: Project 9)

The Rolls-Royce CTI (carbon/titanium) blades are a key feature of the Advance engine design, which will offer 20% less fuel burn and CO2 emissions than the first generation of Trent aero-engines; the blades and associated composite engine casings that help make up the CTI fan system could reduce weight by up to 1,500lb per aircraft – the equivalent of carrying seven more passengers. Rolls-Royce has been working across a series of partnered programmes to develop both composite fan blades and containment casing engineering technology and manufacturing technology for engine demonstration. Rolls-Royce worked with the National Composites Centre (NCC) and the Manufacturing Technology Centre (MTC) to develop an automated method for manufacturing a composite fan system. The advances made in these programmes have given Rolls-Royce the confidence to invest in a new pre-production facility in Bristol.

KEY CAPABILITIES IN AEROSPACE COMPOSITES

This Composite Materials INSIGHT has been formulated through consultation with industrial, academic and governmental stakeholders and has identified four principal areas of capability support in the composites value chain.

Design & Analysis

The conception of components and the assessment of their relative suitability for performing the required function. This may combine a range of design studies, simulations and tests to achieve the desired results and will be an iterative process, feeding back performance data and suitability in a manner that allows modifications to be implemented effectively. Activities include:

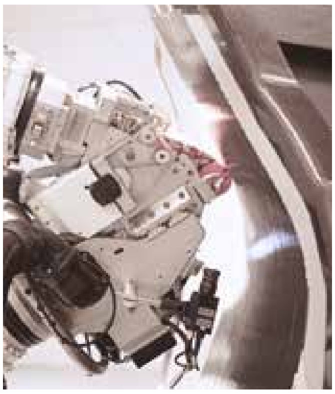
- Modelling and simulation of composite component performance, cost and life cycle
- Design factors including methodology, codes and standards, design for dis/assembly, manufacture, legislation/regulations, performance
- Testing and validation of composites performance against required criteria

Priority Technologies	Design for Manufacture, Design Methodologies, Manufacturing Simulation, Finite Element Analysis, Process Simulation, Part Integration, Performance Driven Design, Virtual Testing, Factory Simulation, Cost Modelling, Material Simulation, Residual Stress Modelling
Other Technologies	Design Codes & Standards, Software Integration, Legislation & Regulation

Processes

These are the activities undertaken to produce the composite parts and components, from sourcing of the raw fibre and matrix materials, through to their handling, shaping, formation, cure and post-processing to prepare the parts for integration into the aircraft. Factors that determine which processes are utilised include component design, material availability, cost, quality, time, experience and quantity. This is where most of the cost and resource is found for composite development and is the focus of many research and technology projects. Activities include:

- Dry fabric processes such as resin transfer moulding (RTM), filament winding and liquid resin infusion (LRI)
- Pre-impregnated fabric processes such as automated tape layup (ATL), automated fibre placement (AFP) and compression moulding
- Preforming processes such as braiding, ply cutting and layup
- Curing processes such as microwave, laser, infrared



Priority Technologies	Automated Fibre Placement, Automated Dry Fibre Deposition, Handling, Additive Manufacture, Liquid Resin Infusion, Out of Autoclave Prepreg, Layup Process, Reduce Heat-Cycle
Other Technologies	Low Pressure RTM, Braiding, Ply Cutting, Hand Layup Conversion Prepreg, Compression Moulding, Infra-Red Heating

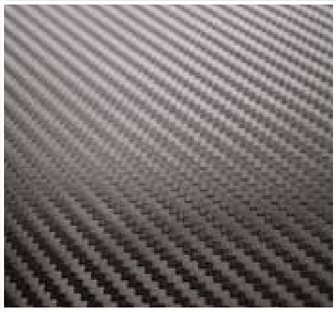
Case Study – Wing Integrated Leading Edge and Trailing Edge (WILETE)

This ATI supported project focused on the development of leading and trailing edge components and assembly technologies, supporting high-volume and low-cost composite wing manufacture, assembly and equipping. WILETE included a number of critical wing technology streams for Airbus including integration of LE and TE structures with the wing box structure, and integration of electrical systems including ice protection and flight controls. The project was supported by a selection of strategic and associate partners from respected research and industrial fields. The overall success and outcome of the project enabled Spirit AeroSystems to bring work back into the UK and win a contract with Airbus to produce new and innovative carbon-composite wing spoilers for its A320 aircraft.

Materials

There are various materials that form constituent parts of composite material systems. These are predominantly the fibres and matrices, but also includes additional materials that serve to improve the performance of the composite, such as additives. Activities include:

- Fibres, such as carbon, glass and Kevlar®
- Matrices, predominantly thermosets and thermoplastics such epoxy resin, polyester and vinylester
- Additives, such as graphene, carbon nanotubes and tougheners
- Types of intermediates, such as non-crimp fabrics, weaves



Priority Technologies	Thermoset Polymers, Thermoplastic Polymers, Non-Crimp Fabrics, Carbon Fibre, Woven, Graphene, Non-Woven, Tougheners, New Fibres, 3D Woven, Carbon Nanotubes
Other Technologies	Glass Fibre, Stitching/Tufting, Other Fibres (Biofibres, Silicon Carbide, Basalt), Recycled Carbon Fibre, Sizing, Bio-resins

Technology Enablers

There are several more specific processes and activities not captured under the general processes heading which consider the functionality of the structure, the equipment used in production and the quality assurance of the component. Activities include:

- Robotics and automation
- Factory Digitalisation
- Quality assurance processes to ensure standards
- Joining and assembly processes such as bonding, welding and mechanical fastening
- Other processes including factory automation, machining, coating, painting and recycling

Priority Technologies	Non-Destructive Testing, Tooling Technologies (Fabrication), Cycle Time Reduction, Functionality (Thermal & Electrical Conductivity), Machining, Factory Digitalization, Coating (Painting, Testing), Factory Automation (Robotics), Adhesives, Processing Equipment, Jig-less Assembly, Metrology, Fire Resistance, Hollow & Foam Cores
Other Technologies	End Effectors, Environmental Impact, Welding, Energy Efficiency, Consumables, Structural Health Monitoring, Honeycomb Cores

Case Study – NCC Capital Equipment (AutoProStruct, HiStruct, NTProStruct)

The National Composites Centre (NCC) is delivering a suite of ATI projects to implement state-of-the-art equipment for the aerospace industry and wider composites sector to position the NCC as a global centre of competence in large-scale and automated composite manufacture. Focussed around the next generation of composite structures for wing, aero-engine and propeller products, this investment will establish new capabilities for automated deposition, preforming, verification, high temperature resin moulding, large scale resin infusion and out-of-autoclave curing technologies, amongst others. All of this supports the digital transition of the UK composites industry, identifying and demonstrating high-value applications of I4.0 and embedded engineering knowledge within the sector.

MARKET CHALLENGES

Today composite materials are utilised extensively across aircraft, with use becoming ever more widespread as materials and processes become more affordable and are better able to meet product requirements. The Illustratration on page 7 of this document demonstrates the current applicability of composites across both fixed and rotary wing aircraft. The global aerospace composites market was valued at \$11.5bn in 2015 and is expected to grow to \$24.8bn by 2025 with a CAGR of 9.1%. Closer to home, the UK's aerospace composites market was valued at £270m in 2015 and is expected to grow to around £1bn by 2020 and anywhere between £1.3bn and £3.5bn by 2030, depending on platform realisation, demonstrating strong opportunities for the UK composite sector.

\$68.1 Billion

Global cross-sector composite product market in 2015

Growing a CAGR 6.5% (1)

\$105.8 Billion (2020)

\$11.5 Billion

Global aerospace composite product market in 2015

Growing a CAGR 9.1% (3)

£24.8 Billion (2025)

£270 Million

UK aerospace compostie product market in 2015

Growing a CAGR 12% (1)

\$3.5 Billion (2030)

Today's newest wide-body commercial aircraft platforms, the Boeing 787 and Airbus A350, are around 50% composite by weight. Future aircraft platforms are highly likely to incorporate increased use of composite technologies across the airframe structures, systems and propulsion units. Based on the industry identified priority platforms within the wide body and narrow body product streams, the overall global market opportunity associated with these platforms is estimated to be around £1.4 Trillion over the 2017 to 2035 timeframe. According to a market model developed by the ATI, the products with most associated composite value were aerostructures (predominantly wing structures), nacelles and pylons, engines and landing gear. Aerostructures market opportunities within the 2017- 2035 timeframe are over £88 Billion, with more than 50% of the value associated with wings. Nacelles, pylons, engines and landing gears provide market opportunities of £51 Billion within the same timeframe. Figure 2 demonstrates the composites components market opportunity for each of these areas derived from the ATI market model from 2017-2035.

Product Area	High Value Products	2017-2019	2020-2024	2025-2029	2030-2035
Aerostructures	Wing box covers, ribs, centre wing box, front and rear spars, FLE details, LE slats, flaps, ailerons, spoilers, winglets	£10.2B	£20.2B	£17.1B	£40.1B
Nycelle & Pylon	Fan cowl door, thrust reverser, air inlet lipskin, inner acoustic barrel, cascades	£1B	£2B	£1.7B	£4B
Engine	Casing, fan blades, HP blades, OGVs, tailcone	£2.3B	£4.5B	£3.8B	£9B
Landing Gear	Wheels and brake systems	£2.6B	£5.2B	£4.4B	£10.3B

Figure 2: Composite Opportunity Value Analysis

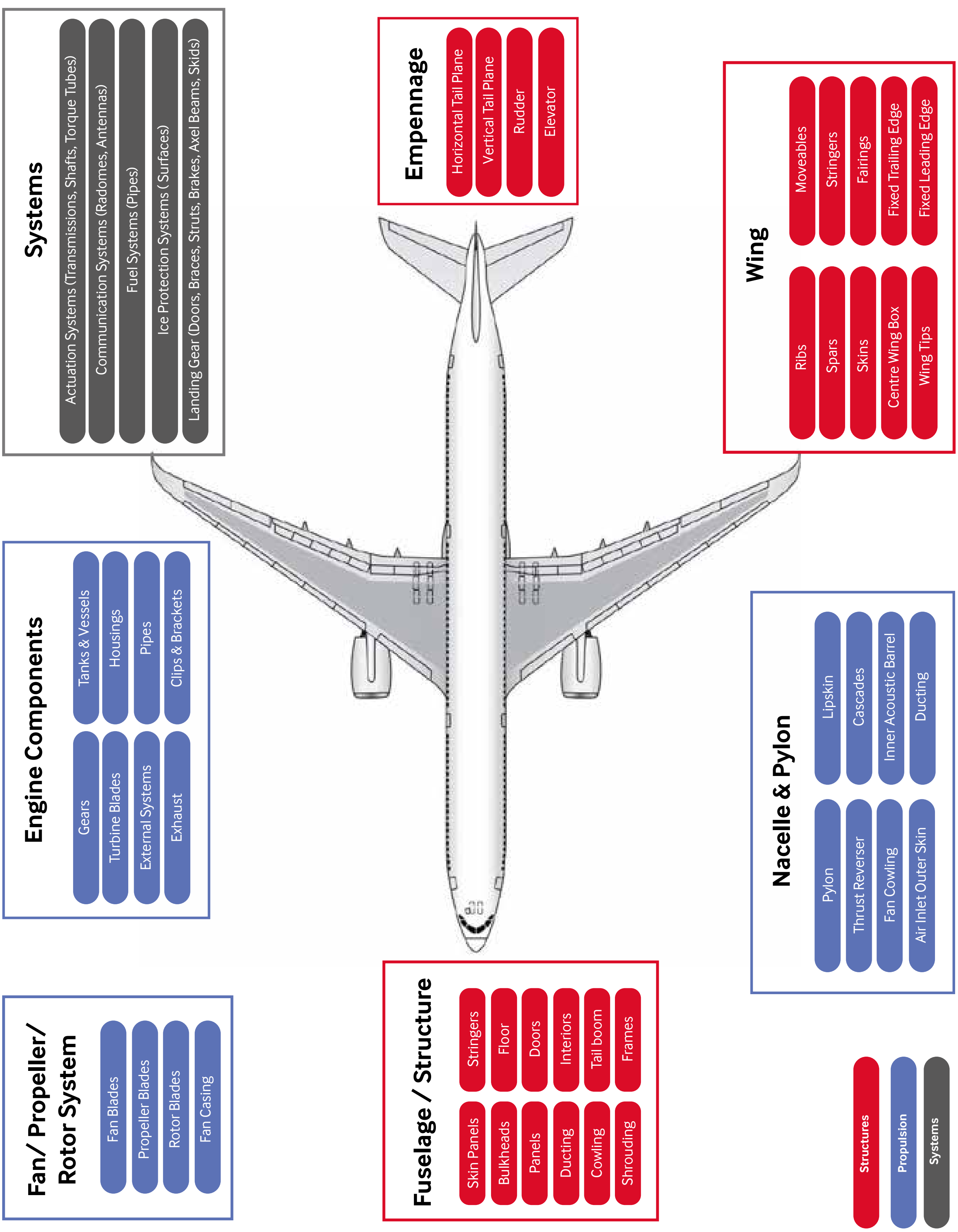


Figure 3: Current Aerospace Composite Products

Platform Opportunity Roadmap

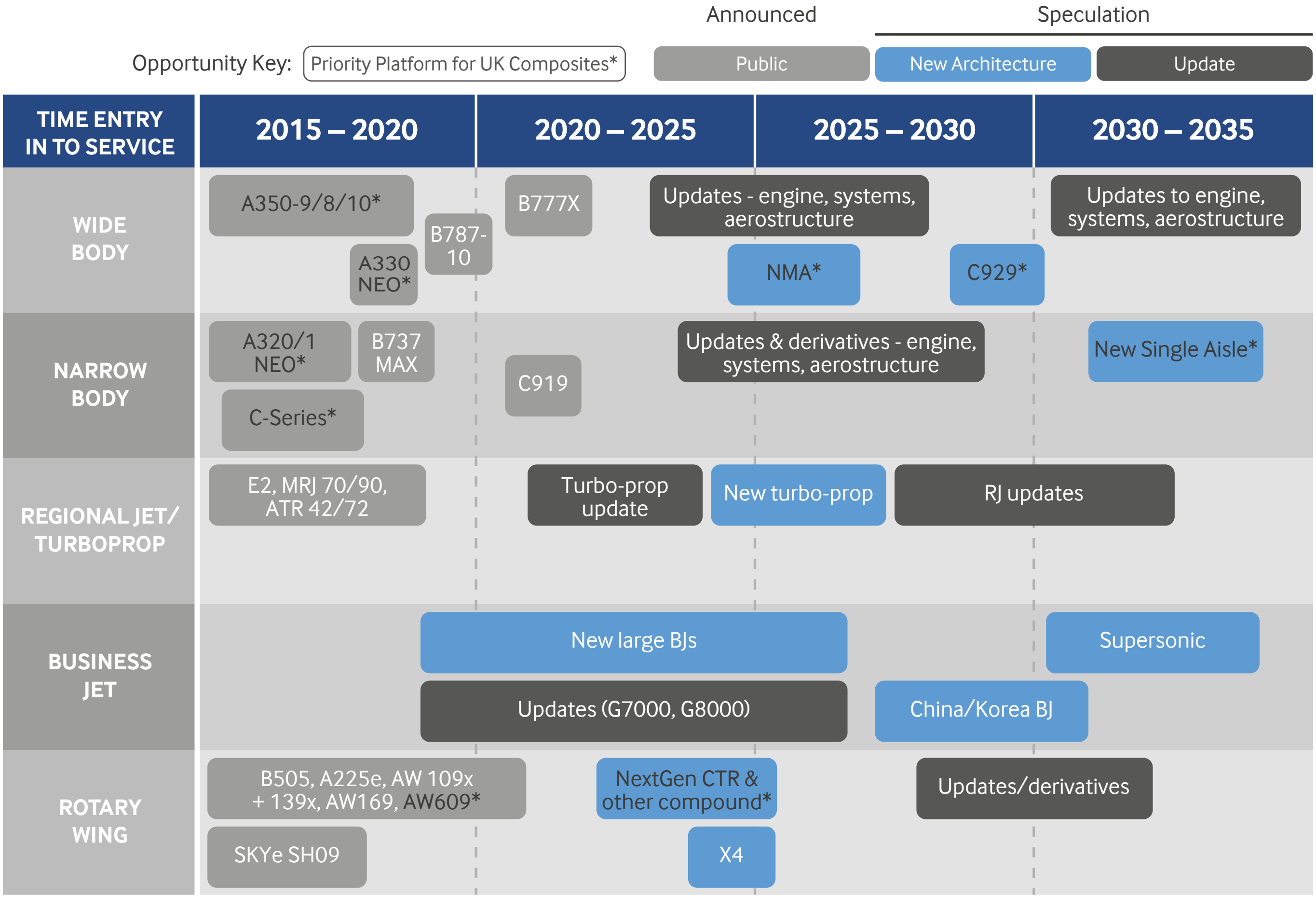


Figure 4: Platform Opportunity Roadmap

To understand the potential high value opportunities available to the UK aerospace composites sector moving forward, it is important to consider the broader civil aerospace market outlook and what the platform opportunities are likely to be. There is continued expectation in the market to improve fuel efficiency and hence reduce the environmental impact and costs of operation of aircraft. There is also a requirement to produce high performance aircraft with long-range point-to-point capability for both wide and narrow-body aircraft. Composites are fundamental in meeting these needs. The potential for future new and updated platform development programmes across aircraft segments presents significant opportunities to the UK aerospace supply chain and the composites industry will be at the centre of this in providing high-performing, smart, low cost solutions.

- The wide body segment is expected to be characterised by moderate to major updates to existing platforms in the near term, with large, efficient and more complex composite structures required to achieve the performance targets for these aircraft.
- Boeing are considering an NMA – New Midsize Aircraft – medium range aircraft of 200 to 250 seat capacity, entering service around the middle of the next decade. This will probably be heavily based on already proven composite technologies
- The narrow body market is likely to see moderate updates over the next 5-10 years, with potential new wing structures and new ultra-high bypass ratio engines being integrated into existing platforms. By the 2030s, new aircraft may exploit new propulsion and more-electric systems with implications for composite structures.
- In the regional segment, there is potential for new turboprop aircraft using advanced composite propellers and structures, to deliver cost competitive solutions.
- There may be potential for new medium to large business jet platforms over the next 20 years subject to market demand, requiring high-class, efficient composite materials.
- The helicopter market is likely to be characterised by new faster and longer-range platforms, with large composite structural and rotor elements.

Market Needs and Trends for Composites

Based on the market outlook described, the table below summarises likely market needs that will drive the use of composites by ATI strategy technology theme across secure, exploit and position timeframes. The specific composite requirements within some of the areas described below remain to be defined. However, each is likely to offer opportunities to exploit UK composite technologies and capabilities.

Technology Theme	Secure (0-5 years)	Exploit (0-10 years)	Position (0-15 years)
Aircraft of the Future	**Key Opportunities**		
	• Novel wing architectures integration with increased composite content.	• New air vehicle architectures with more electric systems with lightweight composite structures.	• New architectures for large all electric aircraft with lightweight composite structures.
	Other Opportunities		
	• Higher aircraft production rates, requiring efficient composite processing capabilities. • Simplified moveable surfaces and control mechanisms to reduce weight.	• New air vehicle architectures with improved laminar flow capabilities through design and manufacturing improvements. • High speed rotorcraft with composite structures and blades.	• More radical air vehicle architectures enabled by enhanced composite design and integration. • Large tilt-rotor platforms with composite structures and blades. • Advanced turboprop powered aircraft with composite propellers.
Aerostructures of the Future	**Key Opportunities**		
	• Simplified architectures to achieve composite rate enablement and reduce manufacturing costs.	• More efficient wing and fuselage structures with advanced design and integration of composite materials.	• Advanced composite structures with morphing capability.
	Other Opportunities		
	• Lighter, more efficient nacelle structures through increased composite application.	• Self-monitoring composite structures with embedded sensing capability. • High performance, multifunctional composite materials.	• Self-healing composite structures with advanced repair capability.
Propulsion of the Future	**Key Opportunities**		
	• Lightweight composite fan and rotor/ propeller systems including containment elements.	• Ultra-High Bypass Ratio Engines (UHBR) with larger diameter composite fan systems and slimline, lightweight nacelle structures.	• Ceramic Matrix Composites for turbine blades and other components.
	Other Opportunities		
	• Advanced lightweight transmission, compressors, turbines and external systems, utilising advanced composite materials with high temperature capabilities.	• High temp Ceramic Matrix Composites for hot static components. • Metal Matrix Composite rotating components • Active helicopter composite blades with morphing capability. • Advanced high-strength, lightweight composite propellers.	• Hybrid turbo-electric and distributed propulsion systems utilising lightweight composite structures and elements. • More electric propulsion systems with associated lightweight composite supporting structures.
Smart, Connected and More Electric Aircraft	**Key Opportunities**		
	• Multifunctional, multi-material systems and components to enable weight reduction and achieve performance improvements.	• More electric aircraft systems with composite structures and elements.	• All electric aircraft systems with composite structures and elements.
	Other Opportunities		
	• Integrated thermal management systems utilising enhanced composites. • Advanced, lightweight composite landing gears and structures. • High performance ice protection systems within composite structures. • Harsh environment electronics, sensors and components embedded in composite elements.	• Cabin noise and vibration attenuation systems enabled through enhanced composite design. • Next generation fuel systems with composite tanks, pipes and control elements. • Integrated sensor systems within composite structures. • Advanced actuation systems with composite elements.	• High performance energy storage and recovery systems utilising composite elements.

Table 1: Market Product Needs

TECHNOLOGY CHALLENGES

Table 2 details some of the key technology challenges pertinent to the UK aerospace composites industry, and the foreseen technology solutions relevant to those challenges across the secure, exploit and position time frames. The final column in this table indicates the relevance of each of these challenges against ATI Whole Aircraft Attributes.

	ATI Theme / Key Challenge	Secure (0-5 years)	Exploit (0-10 years)	Position (0-15 years)	Cost	Operational needs & flexibility	Fuel efficiency	Passenger experience	Safety	Environment
KEY MARKET NEEDS	Aircraft of the Future	Novel wing architectures integration with increased composite content.	New air vehicle architectures with more electric systems with lightweight composite structures.	New architectures for large all electric aircraft with lightweight composite structures.						
	Aerostructures of the Future	Simplified architectures to achieve composite rate enablement and reduce manufacturing costs.	More efficient wing and fuselage structures with advanced design and integration of composite materials.	Advanced composite structures with morphing capability.						
	Propulsion of the Future	Lightweight composite fan and rotor/ propeller systems including containment elements.	Ultra-High Bypass Ratio Engines (UHBR) with larger diameter composite fan systems and slimline, lightweight nacelle structures.	Ceramic Matrix Composites for turbine blades and other components.						
	Smart, Connected & More Electric Systems	Multifunctional, multi-material systems and components to enable weight reduction and achieve performance improvements.	More electric aircraft systems with composite structures and elements.	All electric aircraft systems with composite structures and elements.						
DESIGN & ANALYSIS	Improved design for manufacture	Residual stress modelling and design for assembly/ disassembly.	Use of process and cost modelling to inform design know-how.	Multi-scale (material through to factory) modelling to ensure design optimises manufacture.	✓					✓
	Enhanced simulation and analysis tools and techniques to reduce testing pyramid.	Improved codes, standards, simulation validation and enhanced testing capabilities.	Integrated design, test and simulation toolsets integration.	Virtual aircraft for structures, manufacturing and assembly.	✓					✓
	Continued improvements in performance driven design.	Use of simulation to inform material and product design and performance.	Part integration and design methodology.	Fully optimised configurations and deployment.	✓		✓			
PROCESSES	Cost effective, higher volume composite processing technologies.	Low cost tooling, out of autoclave process, wet or dry fibre/tape lay and preform infusion.	Novel heating/curing systems, material/preform handling.	A range of cost effective processing techniques for high volume, high performance structures.	✓		✓			✓
	More efficient part and assemblies manufacturing systems.	Technologies to reduce cycle times. Near net shape production and in-process NDT to reduce waste.	Development of production kit to optimise energy consumption, reduce wastage for manufacturing processes.	Processes to reduce power and resource consumption.	✓					✓
	Cost effective automated manufacture, assembly and inspection of composite parts.	Smart handling systems, in-process NDT, advanced robotics.	Reconfigurable and intelligent automation systems.	Composites factory 4.0 – rapid reconfiguration, mixed product, automation & digital manufacturing.	✓				✓	✓
MATERIALS	Lower cost through reduced materials cost with properties that also reduce processing costs.	Quick cure thermoset resins, thermoplastics, optimised dry fibre materials, binders and preforms.	Lower cost carbon fibres and intermediates for higher production rates.	New innovative, low cost continuous and discontinuous reinforcing fibres.	✓					
	High performance materials.	Enhanced functionality (graphene, carbon nanotubes).	Through thickness performance improvement (3D woven, z-pin, stitching).	New higher performance fibres and resins.					✓	
	Low environmental impact fibre and matrix production.	Materials with reduced cycle time.	Low environmental impact thermoplastic and thermoset resins and fibres.	Recycled carbon fibre. Bio fibres and resins. Aspire to closed loop recycling.						✓
	Higher temperature capability.	Use of additives/ coatings for higher temperature performance	Development of new higher temperature PMCs, CMCs and MMCs.	Applications of optimised multi-material systems.			✓			
TECHNOLOGY ENABLERS	Multifunctional composite components and structures.	Improved surface treatments and coatings. Increased electrical and thermal conductivity.	Integrated structural health monitoring.	Integration of morphing capability within primary structures.			✓			
	Lightweight multi-material structure production capability.	Novel joining, core technologies and tooling. Finishing techniques. Robotics/automation	End-effectors for in-process inspection, quality verification jig-less assembly. Human/Robot integration	Fully automated, multi-material structures production system.	✓		✓			
	Increased interval of inspection through improved monitoring.	In-line monitoring and process control/ modification. In service monitoring.	Improved in-service Structural Health Monitoring (SHM) and big data analytics.	Fully integrated, smart, self-monitoring structures. Data management and AI decision making algorithms.	✓	✓			✓	

2018 — 2020 — 2025 — 2030 — 2035+

Technology Road Map 2018: Technology Challenges

Whole Aircraft Attributes: Cost: · Operational needs & flexibility: · Fuel efficiency: · Passenger experience: · Safety: · Environment:

BARRIERS TO TECHNOLOGY ADOPTION

As well as the specific technology challenges identified through consultation, industry identified and ranked the most significant barriers to greater adoption of composites in the sector, with the results detailed in table 3 below.

Table 3: Composite Barriers

DESCENDING ORDER OF IMPORTANCE

Barrier	Description
Cost	Finance is the main barrier, with non-recurring costs (entry), recurring costs (materials), R&D investment and access to capital equipment all amongst the highest rated issues.
Capability	Capability in terms of skills, resources, supply chain readiness and technology infrastructure also ranked highly, with supply chain being the biggest concern for supporting increases in production.
Technology Development	Composite technology capabilities such as design, modelling, simulation, materials, processes, automation and general R&D intensity must all be developed to enable composite adoption to grow.
Materials Data	Lack of appropriate and available materials data to validate application and provide learnings from previous application.
Intellectual Property	Concerns over IP protection may prevent organisations from forming mutually beneficial collaborations.
Material Systems	The cost and complexity of moving to new materials systems – consequently, materials systems can persist for multiple product/platform cycles.
Competing Metallic Technologies	Metallic materials performance and cost capabilities have continued to improve through continual research and development, driven by competition from the emerging composites industry.
Aerospace Platform Development	Increasing time gaps between new platform introductions, making it difficult to maintain capability, expertise and resources.

NEXT STEPS FOR THE ATI

The ATI will work to identify suitable opportunities across aerospace, with other national programmes and with other sectors for composite technologies that generate technology impact and economic benefit for the aerospace sector. The ATI will coordinate relevant activities and disseminate insights to organisations positioned to deliver these requirements.

Our industrial consultation highlighted the need for industry to focus on a new innovation cycle for composites technologies for scalable, flexible, cost-effective, digitally connected composite manufacturing systems, compatible with high rate aircraft programmes without compromising on performance benefits. This Insight report is the start of a process where ATI will work with CLF and the UK composites community to facilitate collaborative industrial research projects aligned to challenges and technology solutions identified to stimulate growth in the sector and position the UK aerospace composites industry to take advantage of emerging high value global aerospace opportunities. The priority technology and supply chain development requirements to realise these opportunities are summarised in table 4 below, with the technology requirements considered over short and long term.

Capabilities	Technology Development		Supply Chain Development
	Secure/ Exploit	Position	
Design & Analysis	• Improved design for performance and manufacture methodologies to evolve from 'black metal' to cost-effective, integrated, optimised, functional components.	• Modelling and simulation techniques to deliver virtual testing, manufacturing and assembly to reduce the cost of introduction of new materials and processes and accelerate product development cycle.	• Enhance UK design capability through active linkages to activities such as High Value Design and development of in-house design tools and knowledge.
Processes	• Develop cost effective, higher volume production technologies, replacing prepreg/autoclave with dry or wet placement and dry fibre preform infusion.	• Factory of the Future - use of reconfigurable, intelligent handling, automation and digital/smart manufacturing.	• More UK-based Tier 2 moulders with high volume production capability. • Access to appropriate capital and support for post-TRL6 development.
Materials	• Development of lower cost intermediates to reduce processing costs – e.g. new textile and preform structures. • Exploitation of graphene enhanced composites to deliver performance improvements.	• Development of lower cost materials to reduce costs – e.g. thermoplastics, quick cure thermosets and lower cost fibres. • Materials to deliver increased performance and functionality including electrical & thermal conduction, sensing, higher temperature capability (PMC, MMC and CMC) and through thickness performance. • Capture disruptive technology space emerging on composites additive layer manufacturing.	• Develop UK-based materials production capability and capacity. • Link into 'Materials for Future Mobility' ISCF Group and continue the development of advanced composite materials through innovation programmes and knowledge sharing, through relevant support opportunities. • More integrated materials supply chain to support aerospace product rates.
Technology Enablers	• Smart, innovative tooling technologies. • Process verification in high rate production. • Exploitation of additive manufacturing for both part and tooling production.	• Multifunctional composite structures including improved coatings, structural health monitoring and morphing capability. • Joining technologies to facilitate multi-material structures.	• Increase UK-based tooling capability and capacity. • Take advantage of cross-sector composite capabilities and knowledge and other development activities.

Table 4: Next Steps

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[1] **Composites Leadership Forum – Lightening the Load (The 2016 UK Composites Strategy)**

[2] **Aerospace Technology Institute – Raising Ambition (Technology Strategy and Portfolio Update 2016)**

[3] **Transparency Market Research**

PHOTO CREDITS

GE Dowty; Bombardier; GKN Aerospace; AMRC; Spirit AeroSystems; NCC; Airbus; Hexcel; Rolls-Royce

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WHO WE ARE

The **Aerospace Technology Institute** (ATI) is the objective convenor and voice of the UK's aerospace technology community. The Institute defines the national aerospace technology strategy that is used to focus the delivery of a £3.9 billion joint government-industry funded aerospace technology programme.

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