AEROSPACE TECHNOLOGY INSTITUTE

ACCELERATING AMBITION

Technology Strategy 2019

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The **Aerospace Technology Institute (ATI)** promotes transformative technology in air transport and funds world-class research and development through a multi-billion pound joint government-industry programme. **Our R&T portfolio consists of over 250 projects so far**, securing jobs, maintaining skills and delivering economic benefits across the UK.

This technology strategy builds on the UK's strengths and responds to the challenges faced by the UK civil aerospace sector. It provides a roadmap of the innovation necessary to keep the UK competitive in the global aerospace market, and complements the broader strategy for the sector created by the Aerospace Growth Partnership (AGP).

FOREWORD

BY GARY ELLIOTT, CHIEF EXECUTIVE

I am delighted to introduce the ATI's technology strategy 2019, *Accelerating Ambition,* which supersedes *Raising Ambition* published in 2016. It has been developed in close consultation with the Institute's advisory groups and sets out the challenges, opportunities, and priorities for UK aerospace research. It focuses on reducing environmental impact and raising competitiveness. It will guide how the ATI Programme and the work of the Institute evolve.

We will work with industry and the wider research ecosystem to support strategic programmes on the next generations of propulsion systems, complex aircraft systems, and aircraft structures. We will push for more ambitious technologies such as electrification and autonomy to address sustainability and mobility challenges. Future technologies will need to deliver benefits to the whole air transport system and so we have expanded our strategic scope to encompass air transport as a whole.

Public concern about the environment has risen markedly in response to clear evidence about the impact of humankind's activities. The UK Committee on Climate Change has recommended the UK urgently embrace a low carbon future, leading the government to commit to net zero greenhouse gas emissions by 2050[1]. At the 2019 Paris Air Show, seven of the world's largest aerospace companies recommitted to neutral carbon growth in aviation from 2020[2], along with the 2050 ACARE environmental goals[3]. Meanwhile, passenger traffic[4] continues to grow at 3 to 4 per cent annually, adding to the challenge. We support the Paris announcement which stressed the need for rapid advancement of high-impact technologies. This underscores how important the ATI Programme is to the future of aviation and the aerospace industry.

> **"WE WILL PUSH FOR MORE AMBITIOUS TECHNOLOGIES SUCH AS ELECTRIFICATION AND AUTONOMY TO ADDRESS SUSTAINABILITY AND MOBILITY CHALLENGES."**

The UK's aerospace industry plays an important and pivotal role. It supplies half of the large jet engines for widebody aircraft, almost all the wings for Airbus aircraft and a diverse variety of complex aircraft systems. These drive the efficiency of aircraft and lie at the heart of achieving a sustainable future. As the need for more efficient products intensifies, technological advantage will become even more critical to retaining market leadership. The UK is one of the biggest exporters of aerospace products and services globally. It has the potential to grow its market share by continuing to invest at scale in critical technologies.

Global competition in aerospace remains as intense as ever. The economic ascendancy of Asia continues, presenting new threats and opportunities to UK business. Brexit, along with strains in global trading relationships, has complicated the environment for business and the economy. Despite these uncertainties, the ATI provides stability, certainty, and opportunity, evolving with the market to keep the UK's aerospace

R&T ecosystem globally competitive. International businesses continue to invest in cutting-edge research through the programme, and there is growing participation by small and highly-innovative enterprises.

The drive to develop electrified aviation to transform mobility is gaining momentum. This, in parallel with autonomous control and scalable air traffic management, is expected to lead to rapid expansion of new markets. We will continue to work with industry and government on defining and delivering strategic programmes including the Future Flight Challenge, ensuring maximum synergy with the ATI Programme. The UK offers a first-class and open ecosystem for innovation, driven by entrepreneurial startups and a depth of aerospace expertise unrivalled in Europe. It has a world-leading network of universities and research organisations delivering ground-breaking new technologies. Within this, the ATI has an important role to play in developing the aerospace innovation ecosystem. We look forward to continuing our work with the Aerospace Growth Partnership, the Department for Business, Energy and Industrial Strategy, Innovate UK, wider industry and partner organisations.

We are extremely grateful for the support the Institute has received over the years and are excited about what we can achieve together.

“THE UK OFFERS A FIRST-CLASS AND OPEN ECOSYSTEM FOR INNOVATION, DRIVEN BY ENTREPENEURIAL STARTUPS AND A DEPTH OF AEROSPACE EXPERTISE UNRIVALLED IN EUROPE.”

Gary Elliott
Chief Executive

[1] *As adopted by UK Government from recommendation by the Committee on Climate Change in May 2019*
[2] *Air Transport Action Group (ATAG) environmental goals supported by IATA and at Government levels through ICAO and UNFCCC*
[3] *https://www.acare4europe.org/sria/flightpath-2050-goals*
[4] *Passengers carried*

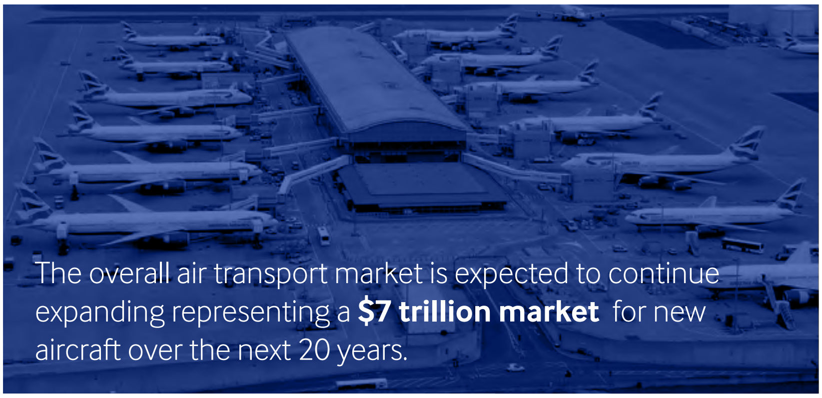
OVERVIEW OF PRIORITIES

AIR TRANSPORT VISION

The aerospace industry is at a pivotal moment and the UK can achieve competitive advantage if we work to improve the overall air transport system. Advances in propulsion systems, aerodynamics, materials and advanced systems have potential to deliver a step change in commercial aircraft performance and usher in exciting new air transport services to address our mobility needs.

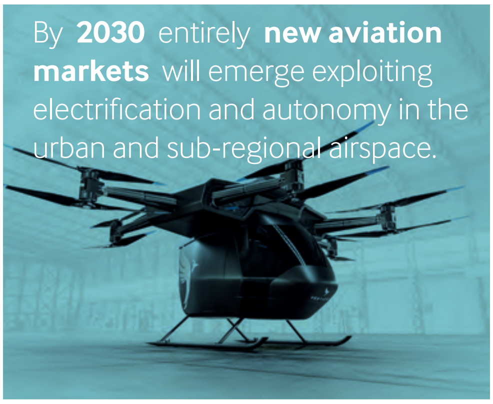
Setting an ambitious sustainability agenda	Address mobility challenges	Raise UK competitiveness

MARKET OPPORTUNITY



The overall air transport market is expected to continue expanding representing a **$7 trillion market** for new aircraft over the next 20 years.

The MRO market stands to benefit too, with forecasts projecting between **3.5%** and **4.5%** CAGR to 2030 and a 20 year value in excess of **$2 trillion**.



By **2030** entirely **new aviation markets** will emerge exploiting electrification and autonomy in the urban and sub-regional airspace.

Success depends on the ability to deliver **solutions** that make aircraft substantially more **efficient** and also tackle opportunities in new forms of sub-regional and urban air mobility.

The UK has a strong position from which to maintain its **technology leadership** and grow its **market share**.

The market faces substantial head winds such as environmental imperatives, availability of pilots, affordability, air transport system capacity and supply chain expansion.

VEHICLES

Aim: Maintain world-class design, analysis, development and certification capabilities to deliver competitive high-value systems for current and emerging markets

Retain and grow whole aircraft design and analysis capability	**Be a key player in the delivery of future sustainable commercial aircraft**	**Lead the way for sustainable air vehicles for urban and regional markets.**

PROPULSION AND POWER

Aim: Maintain world leadership in aircraft propulsion and power by developing the most efficient systems that lower environmental impact

Ensure the UK is at the forefront of delivering the next generation of low emission ultra high bypass ratio (UHBR) turbofan engines	**Leading hybrid gas turbine/ electric propulsion systems**	**Leading all-electric battery and fuel cell propulsion systems**

SYSTEMS

Aim: Grow the UK's capabilities in current and emerging high-value aircraft systems

Optimise the next generation of systems and equipment	**Accelerate smart connectivity and data systems leadership**	**Advance autonomous systems for efficiency and safety**

AEROSTRUCTURES

Aim: Maintain the UK as a world leader in aerostructures, including design, integration, manufacture and assembly of the most efficient wings and other high-value structures

Advance world-class capabilities for future integrated structures	**Grow capability in complex multi-functional structures**	**Design the next generation of smart assembly processes and tools**

CROSS-CUTTING ENABLERS

Aim: Drive progress on important and broadly applicable enabling technologies and capabilities through collaboration across and beyond the sector

Develop high-value design capabilities	**Develop advanced materials, manufacturing and assembly**	**Advance through-life engineering technologies**

AIR TRANSPORT VISION

The aerospace industry is at a pivotal moment and the UK can achieve competitive advantage if we work to improve the overall air transport system.

Large commercial aircraft will continue to dominate air transport. To mitigate environmental impact, the industry must accelerate improvements in environmental performance of vehicles and flight operations. A new era of aviation is underway with potential to transform mobility, enabled by electrified propulsion, autonomy and airspace management technologies. This revolution will unlock the air as a route to deliver a broad range of new sustainable services. Achieving it will require much closer integration of the air transport system than is the case today. The UK will only remain a major player if it is at the forefront of these technologies and capabilities.

"THIS REVOLUTION WILL UNLOCK THE AIR AS A ROUTE TO DELIVER A BROAD RANGE OF NEW SUSTAINABLE SERVICES"

AIR TRANSPORT PRIORITIES

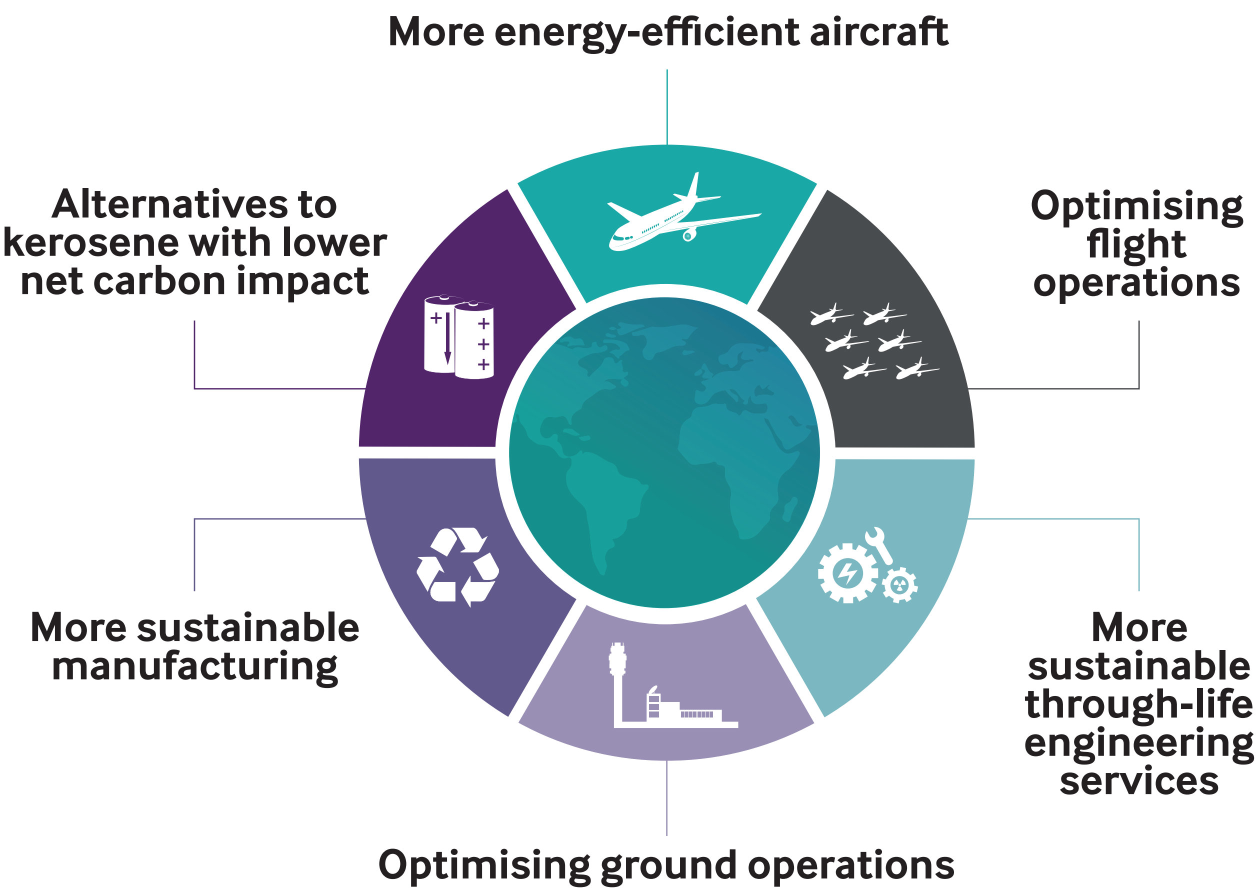
Setting an ambitious sustainability agenda

The UK aviation industry should continue to lead on responding to environmental imperatives.

Around 2 per cent of human-induced carbon dioxide (CO2) emissions come from the aviation industry[5]. Aircraft nitrous oxides (NOx) emissions and condensation trails further exacerbate the impact of aviation on global warming.

In addition, aircraft noise, NOx and carbon particulates impact the local environment around airports. The sector has committed to meet ACARE FlightPath 2050[6] and ATAG climate targets[7] which go some way to addressing these issues but must pursue these with more urgency and across the whole aviation system.

Large investments have been made in the UK and in Europe to address these environmental targets. However, achieving them remains challenging and further measures will be necessary[8], including:



[5] *ATAG facts and figures*
[6] *https://www.acare4europe.org/sites/acare4europe.org/files/document/Flightpath2050_Final.pdf*
[7] *https://www.atag.org/facts-figures.html*
[8] *Roland Berger, Megatrend 4: Climate change & ecosystem at risk*

Address mobility challenges

Air transport can make a major contribution to addressing mobility challenges and the UK must take the lead to access these opportunities.

Imagine a future where the skies are unlocked. Vertical take-off vehicles slash the time for people and goods to transit congested cities. Drones carry essential supplies for the emergency services and revolutionise access to data through aerial surveys. Conventional take-off aircraft exploit small airfields to provide new connections between regions.

This would transform the productivity of our economy, bringing all our regions and farthest flung communities closer together. It would create new global market opportunities for products and services, with those able to innovate fastest capturing the greatest share.

Realising this future requires an air transport system that does not add to the environmental impact of aviation. It necessitates affordable air vehicles that are electric, autonomous, safe, and able to operate in congested urban environments and beyond. They may have radically different architectures from current aircraft, designed for different missions and exploiting new technological capabilities. Many more air vehicles of different types will operate close to conventional commercial aircraft. New approaches to safety, security and efficient airspace management will be needed. These new markets and fleets will require new infrastructure for communications, ground operations for refuelling/recharging, maintenance and repair. New business models will evolve to exploit the benefits of this system.

It is the mission of the Future Flight Challenge to bring about these new markets. We will continue to work with industry and government to shape this challenge, whilst ensuring maximum synergy with the ATI Programme.

Raise UK competitiveness

The UK needs to raise its performance and collaborative activity at all levels of the supply chain.

The UK's aerospace industry needs the technologies, skills, tools, techniques and facilities to develop and manufacture world-beating products. High productivity will be essential to success.

We aim to strengthen the UK aerospace supply chain through more innovation in products and manufacturing systems that are differentiated, delivered faster, more affordable and more sustainable. We encourage businesses to leverage their capabilities, collaborate and position themselves for future opportunities outside their traditional markets where this makes strategic sense.

The ATI aims to accelerate technologies for improved aircraft performance and for more competitive design and production. In all areas of this strategy, the ATI works closely with the broader UK R&T ecosystem to ensure the programme exploits and contributes to other major UK initiatives.

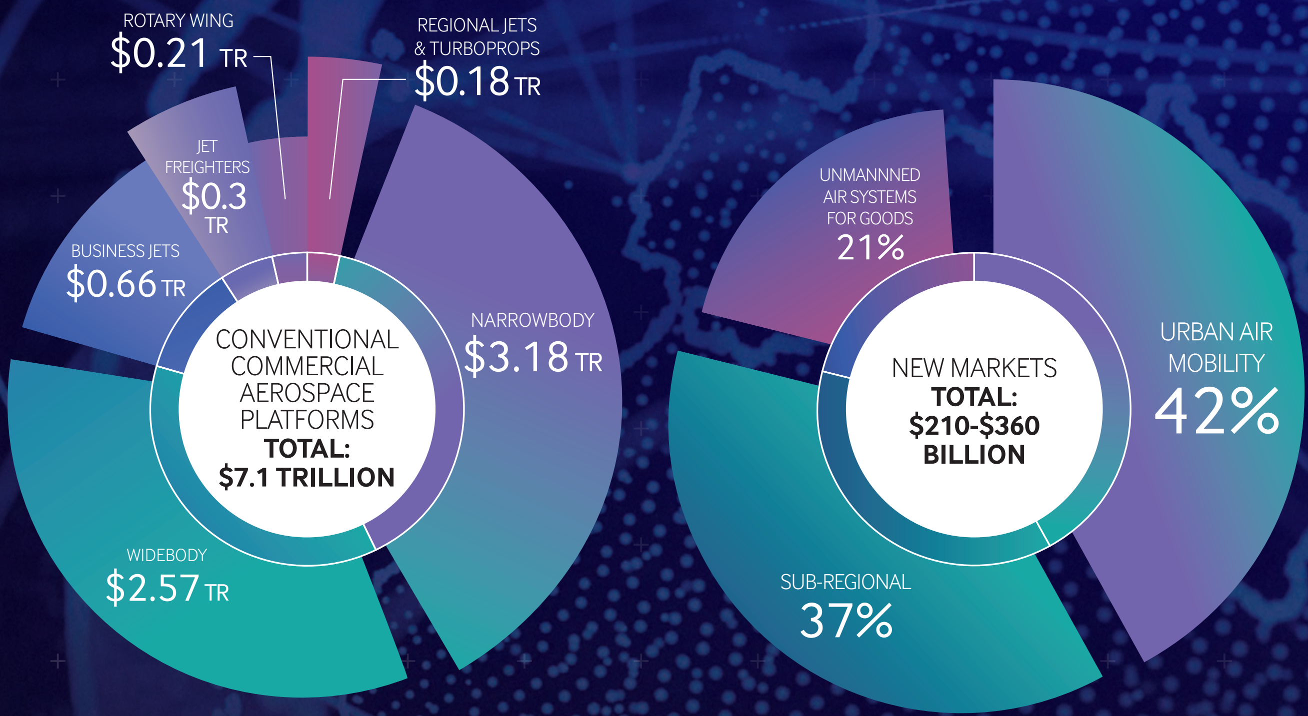
MARKET OPPORTUNITY

The overall air transport market is expected to continue its current rate of expansion over the next 20 years, driving growth in today's main fleet segments (widebody, narrowbody and regional aircraft) at approximately 3.4 per cent compound annual growth rate (CAGR). Narrowbody aircraft represent the fastest growing segment, with fleet growth closer to 5 per cent. Behind this expansion are rising global income levels, notably in developing economies, and societal desire to connect and travel.

The maintenance, repair and overhaul (MRO) market stands to benefit, with various forecasts projecting between 3.5 and 4 per cent CAGR. However, the market is facing growing headwinds from environmental challenges, trade disputes, pilot shortages and supply chain expansion pains to name a few. The latter is expected to drive further mergers and acquisitions to reduce costs and increase productivity.

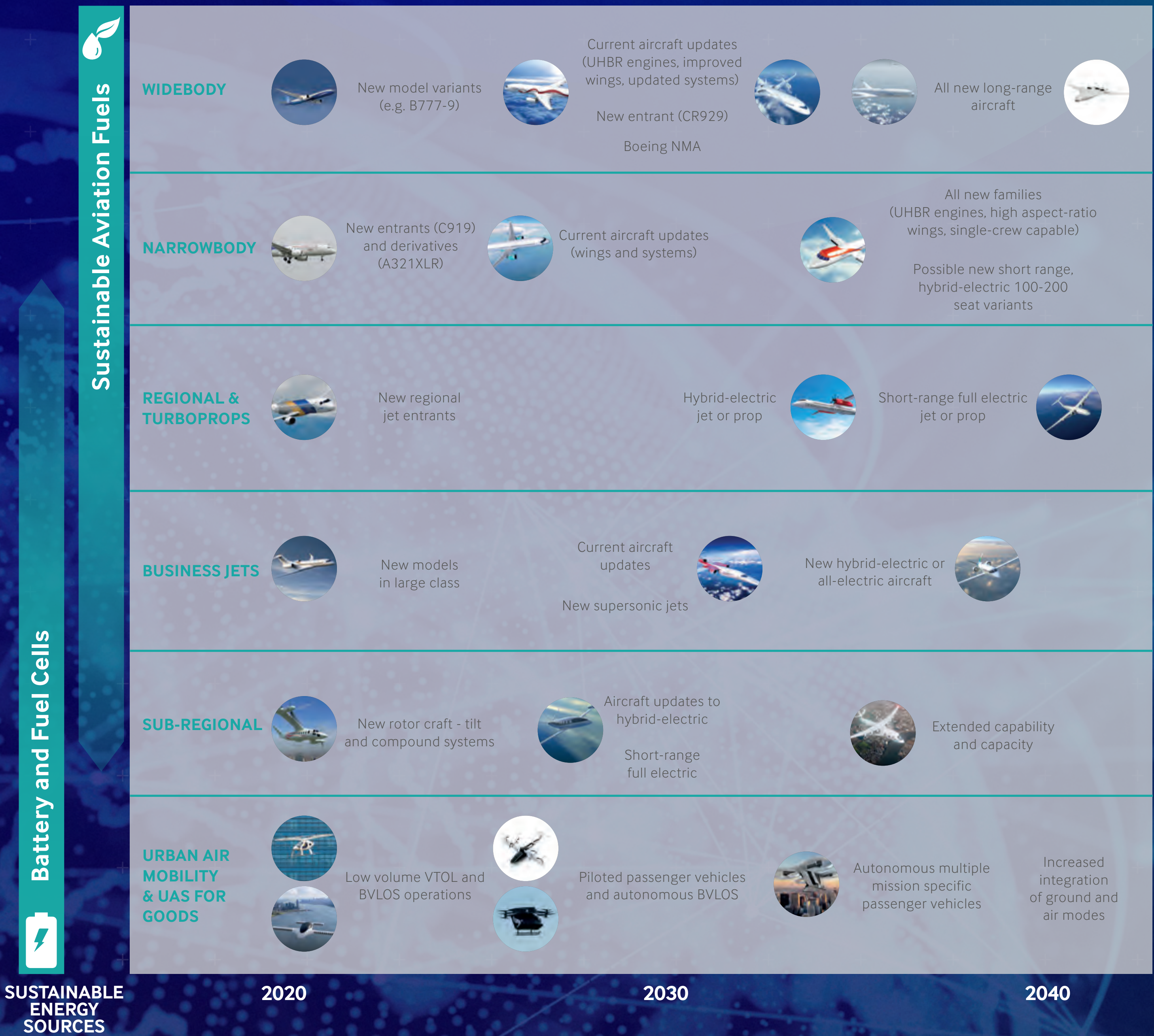
The value of commercial aircraft platforms over the next 20 years is expected to reach approximately $7 trillion, dominated by over 35,000 narrowbody and widebody air vehicles. Based on the ATI's own modelling, the UK can expect to compete for over $1.5 trillion of this market over the same period. The UK ranks amongst the top nations exporting aerospace products including all variants of Airbus wing, half of all engines sold for widebody aircraft, helicopters and a vast array of other advanced high-value systems within the structure and cabin.

20-year market projection (USD)



Figures are taken from the ATI's own analysis of published market forecasts.

Market Outlook



EXISTING MARKETS

WIDEBODY

The Airbus A350-1000 has successfully entered service and the re-engined B777 with higher aspect ratio wings and folding wingtips is scheduled to enter service in 2020. Boeing has been promoting a new medium-sized aircraft (NMA) to sit between the B737 and B787. The future of this concept remains uncertain and the industry awaits a formal launch. Airbus announced the end of the A380 programme due to unsustainable order levels. Russia and China are working on joint development of the CR929, with entry into service expected in the mid-to-late 2020s. Driven by the need for ever greater efficiency, the B787 and A350 aircraft could accommodate further engine and aerodynamic upgrades in the next 10-15 years. These would exploit next-generation ultra-high-bypass ratio (UHBR) engines and new wing designs using technology such as the folding tips featured on the 777X. We do not anticipate entirely new widebody aircraft until the 2040s, when new high-power hybrid propulsion and associated aerostructure technologies have been matured.

NARROWBODY

The A320 and B737 aircraft families dominate this market with target production rates approaching 60 per month. Recently re-engined variants of these aircraft brought around 18 per cent fuel efficiency improvement while avoiding the cost of developing entirely new platforms. However, both aircraft have experienced issues entering service. Expansion of point-to-point networks and low-cost carriers have driven demand for longer range variants such as the A321XLR, which aims to enter service in 2020. Airbus and Boeing are now primarily focused on reducing costs and resolving delivery problems as production rates increase. China continues to develop the C919, with an entry into service expected by 2021 or shortly after. The Bombardier C Series has been taken forward through Airbus as the A220 with reports of interest in a stretched version. Our base scenario for this sector puts entirely new airframes beyond 2030, when technologies such as hybrid-electric propulsion or high-aspect ratio wings could be exploited to achieve the next step in environmental performance. This does not rule out further technology insertion in the interim. In all respects, future designs will need to cater more effectively to the demands of higher rate manufacture and heavy automation.

REGIONAL JETS AND TURBOPROPS

Market growth for traditional regional and turboprop aircraft is generally expected to be subdued, some forecasts even projecting negative growth over the next decade. This trend is driven by the success of more capable and efficient narrowbody jets. However, technology could disrupt this trend. New electric aircraft, perhaps powered by hydrogen fuel cells or battery/jet hybrid systems, could provide a stepchange in efficiency to out-compete current single aisle aircraft on shorter routes.

BUSINESS JETS

The business jet market encompasses a broad mix of aircraft of varying range, size and capability. The market is led by Bombardier, Gulfstream and Dassault, and is expected to be worth $650 billion over the next 20 years, growing at around 3 to 3.6 per cent CAGR for the next 10 years. Buoyed by a growing number of high and ultra-high net worth individuals, the outlook for larger aircraft is strong and will drive continued innovation. This includes the prospect of supersonic jets. Boeing is investing in the Aerion concept, Gulfstream on a low boom demonstrator with NASA and BOOM aims to test a scaled demonstrator in the next few years. However, the cost and environmental impact inherent in supersonic flight will be a major barrier to the market. Discerning business jet buyers are attracted by performance and cutting-edge technologies, providing more rapid opportunities for innovative suppliers to reach market.

ROTARY WING

The civil and para-public rotorcraft market will be worth above $200 billion over the next 20 years. Most analysts project a growth of over 3 per cent CAGR for the early period. There is ample room for innovation including electric powertrains and architectures that increase speed and efficiency such as tiltrotor/tilt wing and compound aircraft configurations.

NEW MARKETS

Over 50 per cent of today's passenger traffic is on routes of less than 500 nautical miles (NM), many flown by narrowbody aircraft capable of 3500 NM or more, that could be replaced by new aircraft optimised for shorter routes. By 2030, we expect to see the emergence of entirely new aviation markets in the sub-regional and urban environments.

Rethinking aircraft and associated ground and air operations in the sub-regional context could bring substantial mobility benefits and lower environmental impact.

The concept of urban air mobility (UAM) has attained a higher profile over the last five years. Helicopters have long served flights into and around cities, and in this respect the concept is not new. However, the UAM ambition is to bring about mass-market solutions, many of which require vertical take-off and landing (VTOL) capabilities. Today there are in the order of 200 projects developing new electric aircraft concepts around the globe, attracting funding in the billions of dollars from angel and venture capital investors. Rotorcraft manufacturers are also considering the UAM market and will look to leverage many of the same technologies to improve the viability of their products. Only a handful of these are likely to succeed in the next ten years. Critical to their development and introduction will be the availability of skilled engineering resources, new infrastructure and new airspace management regimes. To gain societal acceptance, air vehicles and their operation will have to demonstrate no additional environmental impact and high standards of safety.

Together with technologies accelerated through the ATI, the UK's Future Flight Challenge aims to help these market concepts mature and bring about the required shift in airspace management and operations. The market potential is highly uncertain, but we estimate niche sub-regional and UAM operations for passengers and drone operations for goods to have a global potential of between $210 billion and $360 billion over the next 20 years.

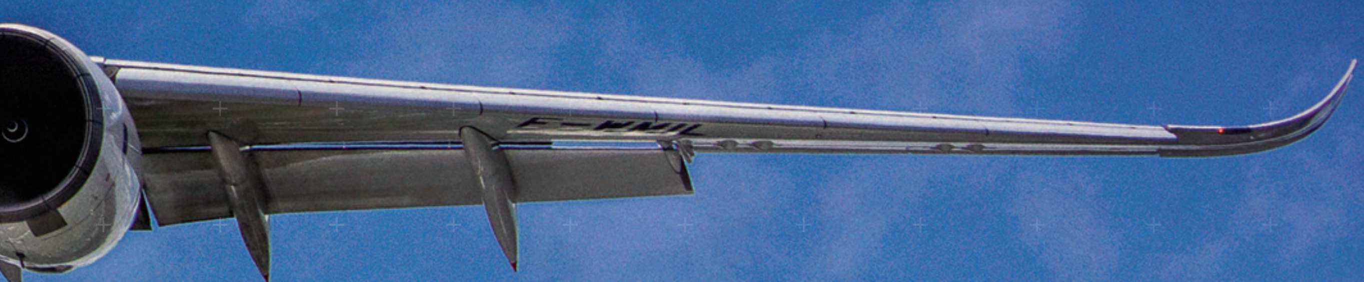
> **“BY 2030, WE EXPECT TO SEE THE EMERGENCE OF ENTIRELY NEW AVIATION MARKETS IN THE SUB-REGIONAL AND URBAN ENVIRONMENTS”**

VEHICLES

The UK needs to maintain world-class design, analysis, development and certification capabilities to deliver competitive high-value systems for current and emerging markets.

The UK designs and manufactures major elements of air vehicles including wings, engines and many other complex systems. The UK also has a thriving supply chain providing components, sub-systems and services across all market segments. Despite no longer assembling large commercial aircraft, it is critical that the UK retains a whole aircraft capability to understand which technologies to develop and how these may be integrated into the vehicle. Aircraft are becoming more complex and the full potential of new technologies will only be realised through early consideration of their impact at the whole aircraft level. The UK also has real opportunities to design and make new air vehicles for the emerging sub-regional and urban markets.

> **“AIRCRAFT ARE BECOMING MORE COMPLEX AND THE FULL POTENTIAL OF NEW TECHNOLOGIES WILL ONLY BE REALISED THROUGH EARLY CONSIDERATION OF THEIR IMPACT AT THE WHOLE AIRCRAFT LEVEL”**



VEHICLES PRIORITIES

Retain and grow whole aircraft design and analysis capability

The UK must protect and develop underpinning capabilities in air vehicle conceptual design and analysis.

The UK has the tools, testing infrastructure and skills required to understand the impact of new technologies at platform level. These need to be continually developed to keep pace with new technologies and aircraft concepts.

This means enhancing conventional aircraft modelling processes and methods and growing whole aircraft design capability for new markets.

Be a key player in the delivery of future sustainable commercial aircraft

The UK needs to establish itself as the global leader in aircraft technologies for propulsion, complex systems and structures that meet the challenges of sustainability.

The aviation sector has committed to meet challenging environmental targets. The UK has an important role in meeting these through the products and services it provides. Many of the new technologies, including hybrid propulsion and enhanced aerodynamics, will need to be demonstrated on physical and virtual models and ultimately in flight. These are formidable undertakings, and we will work with industry to support both UK and international collaboration opportunities.

To be affordable, the cost of production for new aircraft technologies must be radically reduced through streamlined engineering, design, manufacture, certification and processes for upgrades. Industry is already targeting a 50 per cent reduction in certification costs by 2050 relative to 2000. Reducing the time for aircraft development also improves time-to-market which is key for competitiveness. With increasing aircraft demand, allowing for ramp-up and improved production rates will also be a differentiator. We will seek collaborative approaches to deploy cutting-edge digital simulation and modelling tools to support these needs.

On the operational side, the ATI has established a route map to single pilot operation which will offer cost efficiency and address the limited supply of new pilots for an expanding market.

Lead the way for sustainable air vehicles for urban and regional markets

The UK needs to lead the next era of aviation by demonstrating sustainable, safe and cost-effective technologies and taking the exciting opportunities offered by new air vehicles.

New markets are emerging for sub-regional (inter-city) and urban (intra-city) air transport services. Vehicles will need to operate in densely populated areas alongside a wide variety of aircraft and ground vehicles. These operations will need to be sustainable, quiet, safe and cost-competitive against other modes of transport. The safety challenge could be addressed in part via increased automation and autonomy in aircraft and ground systems. These new markets are an opportunity for the UK to re-enter commercial air vehicle design, development and manufacture.

Although the projected market value is relatively small when compared to that of larger commercial aircraft, we will also aim to identify technologies that could be advanced and demonstrated in this emerging market that could scale to be applied later in large commercial aircraft.

Working with the sector, the ATI will push for early flight demonstrations incorporating cutting-edge propulsion and power including hybrid and all-electric propulsion and high levels of automation and autonomy. We will also encourage the development of high-fidelity digital twins and simulations. This work will evaluate environmental impacts, operability and safety and accelerate market entry.

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VEHICLES ROADMAP

DRIVERS	**Reduce Cost:** non- recurring cost, recurring cost, operating cost, disruption cost, disposal cost **Improve Energy Efficiency:** aerodynamic efficiency, weight, propulsion system efficiency, operational impact, parasitic losses **Protect the Environment:** climate impact, local air quality impact, noise, ground contamination, sustainability of manufacturing, materials impact **Meet Operational Needs & Flexibility:** performance, payload, availability, operational limitation impact **Enhance Passenger Experience:** passenger comfort, service quality, ticket cost **Improve Safety:** certification basis, tolerance to human error, verifiability, predictability, intrusion tolerance, environmental tolerance, risk of harm to staff in the manufacturing and operational environments

TARGET (EIS)

ENVIRONMENT	**CO2** (emissions per passenger kilometre, 2000 baseline): 75% reduction by 2050 **NOx** (emissions per passenger kilometre, 2000 baseline): 90% reduction by 2050 **Perceived noise** (aircraft level based, 2000 baseline): 65% reduction by 2050 **Aircraft movements emission-free when taxying:** Aircraft designed and manufactured to be recyclable **Net zero carbon emissions** for urban and sub-regional air vehicles
COST	**Certification cost** (2000 baseline): 50% reduction by 2050
SAFETY	Fewer than **one accident per ten million** commercial aircraft flights by 2050

TECHNOLOGY PRIORITIES (TRL 6)

2020-2025 | 2025-2030 | 2030-2035+

WHOLE AIRCRAFT DESIGN AND ANALYSIS CAPABILITIY

- Conceptual design for non-standard architecture e.g. High aspect ratio wings and non-conventional STOL/VTOL
- Noise modelling for novel architectures/ propulsion and new environments
- Propeller integration for multiple propellers in various configurations with augmented lift
- Well-to-wake emissions modelling for all energy sources
- Digital twin modelling for full aircraft and energy source lifecycle
- Modelling in-flight geometry changes e.g. folding wing tips
- Aircraft and propulsion system integration
- Faster, more connected, streamlined flight physics/aerodynamics capability

FUTURE SUSTAINABLE COMMERCIAL AIRCRAFT

- Development of sustainable drop-in fuels
- Hybrid electric aircraft demonstrators
- Folding wing tips
- Noise management technologies
- UHBR engines
- High aspect ratio wings
- Laminar flow wings
- Single pilot operations (cargo)
- Single pilot operations (passenger)

SUSTAINABLE AIR VEHICLES FOR URBAN AND REGIONAL MARKETS

- Fuel cell aircraft demonstrators
- Noise management technologies
- Hybrid electric aircraft demonstrators
- All-electric aircraft demonstrators
- Laminar flow wings
- Autonomous sense-and-avoid
- VTOL/STOL demonstrators
- Distributed propulsion and augmented lift
- Full autonomous capability

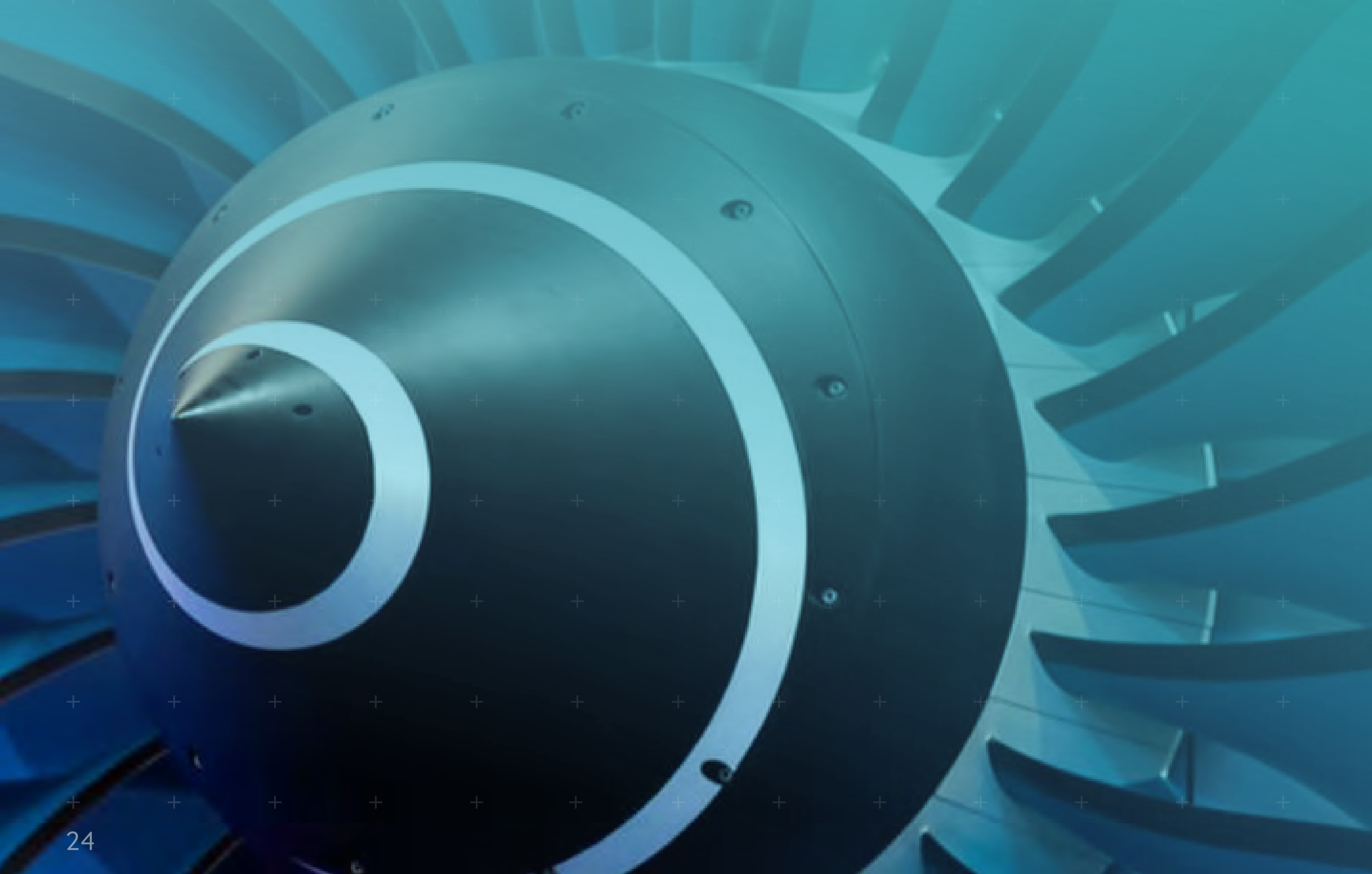
“NEW MARKETS ARE EMERGING FOR SUB-REGIONAL AND URBAN AIR TRANSPORT SERVICES”

PROPULSION AND POWER

Maintain world leadership in aircraft propulsion and power by developing the most efficient systems that lower environmental impact.

The development and manufacture of propulsion systems constitutes around 50 per cent of the sector's direct economic activity in the UK, concentrated in large high-bypass turbofan engines for widebody passenger aircraft. High-bypass turbofans have delivered the greatest reduction in environmental impact of aircraft over the last 30 years. A diverse UK supply chain produces components and sub-systems for engines in almost all market segments for domestic and overseas production and aftermarket services.

Market needs and environmental imperatives demand ever more efficient propulsion and power systems. The UK is well positioned to deliver these. A new generation of turbofan, turboprop and turboshaft engines will enter the market in the next five to ten years. Electrification offers new routes to further improve environmental performance, ranging from batteries and fuel cells for smaller short-range aircraft and urban air vehicles, through hybrid turbo-electric propulsion for larger short-range aircraft, to electrification of the propulsion system for long-range aircraft.



ZeroAvia's HyFlyer project, flight testing its hydrogen fuel cell powertrain prototype in a Piper M-Class airframe.

> **"MARKET NEEDS AND ENVIRONMENTAL IMPERATIVES DEMAND EVER MORE EFFICIENT PROPULSION AND POWER SYSTEMS"**

PROPULSION AND POWER PRIORITIES

Ensure the UK is at the forefront of delivering the next generation of low-emission ultra-high-bypass ratio (UHBR) turbofan engines

The next generation of UHBR turbofans will deliver a further 10 per cent in fuel efficiency and reduced noise. The UK must stay at the forefront of these developments to be a market leader, create a sustainable aerospace industry and secure the associated supply chain opportunities.

UHBR turbofans are aimed at making aircraft more efficient and quieter. The technologies to achieve this need to be demonstrated to technology readiness level (TRL) 6, in flight, by 2023 to be ready for market opportunities in the second half of the 2020s. There are formidable technical challenges to overcome in areas such as lightweight low-noise gear-driven composite fan systems, highly efficient multi-stage turbomachinery, lean-burn low NOx combustion, wall-cooled turbines and high-strength high-temperature materials. The aircraft integration challenges associated with these very large engines must also be overcome. These engines need to take advantage of bio and synthetic sustainable fuels when they become available. We will work with industry to secure the necessary capabilities and technologies to underpin this critical area of the UK's future aerospace industry.

Leading hybrid gas turbine/electric propulsion systems

The UK must secure leadership of hybrid gas turbine/electric propulsion systems that have the potential to usher in the next wave of propulsion efficiency.

These systems have greater potential to reduce environmental impact than pure turbofans. In these systems, gas turbines drive generators which connect to and power propulsors, which can be distributed across an aircraft. This can actively enhance aircraft aerodynamics together with propelling the aircraft. Careful optimisation is required at the system and whole aircraft level to ensure efficiencies are not outweighed by higher weight and cost. For longer-range products, a more electric UHBR turbofan provides opportunities to deliver environmental benefits beyond those of the baseline architecture post 2030.

To make these ideas work, the efficiency and power density of electrical power systems must be improved. They will require electrical power systems to operate at several kilovolts at high altitude, a formidable problem necessitating innovative insulation solutions. Technical innovations are required to address thermal management of high-power electrical machines and power electronics. We will work with the developing UK and international community in this area to support the evolution of concepts, technologies, infrastructure and system level demonstration.

Leading all-electric battery and fuel cell propulsion systems

The UK must secure the new opportunities offered by all-electric and fuel cell propulsion systems through bringing the necessary component technologies together with appropriate research infrastructure to mature and validate solutions.

For shorter-range flight, particularly in cities, there is huge global interest in battery- and fuel cell-powered propulsion. Battery-powered systems are simple and cheap but are limited by storage, capacity, weight, thermal challenges and recharge times. Fuel cells offer potentially better energy density and refuelling characteristics. All-electric systems may involve many propulsors across the vehicle, providing back-up in the event of failure. The ATI will work with other UK initiatives to support technologies for higher power density battery packs, electronics and electrical motors, along with lightweight thermal management systems. In collaboration with industry, the ATI will support the development of technologies, supply chain expansion, research infrastructure, and system level demonstrations for fuel cells and batteries. Critical research areas include power density, thermal management, hydrogen storage and electrical power delivery.

PROPULSION AND POWER ROADMAP

DRIVERS

Reduce Cost: reduce waste, improved manufacturing productivity and better utilisation of resources/skills
Improve Energy Efficiency: improved propulsive efficiency through novel architectures
Protect the Environment: reducing CO2, NOx, nvPM, perceived noise, material usage and waste
Meet Operational Needs & Flexibility: resilient and efficiently-maintainable propulsion and power systems
Enhance Passenger Experience: reduce in-cabin perceived noise
Improve Safety: damage tolerance, intrusion tolerance, predictability, quality assurance

TARGET (EIS)

ENVIRONMENT

CO2 (% margin/fuel burn, 2000 baseline): 20% reduction by 2025, 25% reduction by 2035
NOx (% margin relative to AEP6, 2000 baseline): 55% reduction by 2025, 65% reduction by 2035
Perceived Noise (Propulsion, relative to Chapter 3, LR2 average): 30 EPNdB cumulative reduction by 2025, 36 EPNdB cumulative reduction by 2035

TECHNOLOGY PRIORITIES (TRL 6)

2020-2025 | 2025-2030 | 2030-2035+

ULTRA HIGH BYPASS TURBOFAN ENGINE

Starting 2020-2025:
- Lightweight, low speed, low noise composite fan system
- High pressure ratio, high efficiency gas turbine core
- Lean burn, low NOx combustion system
- Development of sustainable fuels
- High stress, high temperature materials
- Installation of large diameter UHBR system into short, slimline nacelle
- Advanced integrated heat exchangers and thermal management systems

Starting 2025-2030:
- Next generation composite fan system optimised to gas generator
- Powerplant system integration
- Adaptive control systems

Starting 2030-2035+:
- Variable pitch fan systems
- Variable area fan nozzle systems
- Novel, variable thermodynamic cycles

HYBRID GAS TURBINE/ELECTRIC PROPULSION SYSTEMS

Starting 2020-2025:
- Integrated hybrid propulsion concepts
- UK technology validation facilities for high power hybrid propulsion systems
- High power, high efficiency electrical machines and power electronics
- High voltage electrical systems for operation in high altitude environments
- Thermal management systems for electrical machines and power electronics

Starting 2025-2030:
- Advanced integrated hybrid propulsion concepts (BLI, distributed, embedded)
- Hybridisation of UHBR

Starting 2030-2035+:
- Lightweight cryogenic, superconducting, high power systems

ALL-ELECTRIC BATTERY AND FUEL CELL PROPULSION SYSTEMS

Starting 2020-2025:
- Integration of all electric propulsion systems in air vehicle concepts
- High power density battery power packs, power electronics and electrical motors
- Lightweight thermal management systems
- Lightweight fan and propeller systems

Starting 2025-2030:
- Integration of fuel cell propulsion systems in air vehicle concepts
- High efficient, safety critical fuel cell systems for propulsion

Starting 2030-2035+:
- Energy recovery systems

“A NEW GENERATION OF TURBOFAN, TURBOPROP AND TURBOSHAFT ENGINES WILL ENTER THE MARKET IN THE NEXT 5-10 YEARS”

SYSTEMS

Grow the UK's capabilities in current and emerging high-value aircraft systems.

The development and manufacture of aircraft systems constitutes around 15 per cent of the sector's economic activity in the UK. This is concentrated in landing gear and fuel systems, avionics and flight control and electrical systems. All of these make a vital contribution to the operational performance and efficiency of aircraft, which must be continuously improved to meet environmental standards. There are hundreds of specialised companies in the UK delivering these systems, their components and aftermarket services around the world. Expansion of services through digital technologies embedded within systems will enable further aftermarket growth. The R&T ecosystem in the UK offers a unique mix of capabilities for developing technologies including smart connectivity and autonomy for future air vehicles.

Greater autonomy in aircraft control will enable a new range of opportunities, from more sustainable fleet growth in the large commercial aircraft market to urban air mobility. System integration will be critical to this. Affordable, secure, safety-critical software development processes and tools will be required, including high-performance modelling capabilities for whole systems and their components. Cybersecurity remains at the core of ATI ambitions to ensure safety and reliability for systems.

> **“EXPANSION OF SERVICES THROUGH DIGITAL TECHNOLOGIES EMBEDDED WITHIN SYSTEMS WILL ENABLE FURTHER AFTERMARKET GROWTH”**

SYSTEMS PRIORITIES

Optimise the next generation of systems and equipment

The UK must deliver the next generation of aircraft systems technologies that are light, highly-efficient and highly-reliable to complement upcoming wing and propulsion systems.

Next-generation wing structures and UHBR turbofans are driving technology requirements for fuel, landing gear, flight control, ice protection and more electric systems. Technologies need to be demonstrated to TRL6 by 2023 to be ready for market opportunities in the second half of the 2020s. There are significant technical challenges to overcome to increase functionality whilst improving reliability and maintainability, to reduce the cost and time to certify products, and to cut recurring costs. Through-life upgrades will be key to reaping the benefits from new systems. Effective thermal management solutions and harsh environment components and materials will also be vital. The ATI will prioritise projects which demonstrate the integration and installation of new systems and equipment, continuing the replacement of mechanical and hydraulic systems with electric systems, and enhancing health monitoring and prognostics. The adoption of hybrid propulsion systems will introduce new installation and integration challenges. Development of bio and synthetic sustainable and other alternative fuels will drive new challenges in fuel handling and management. On-board electrical power systems will continue to evolve to meet future challenges for secondary power.

Accelerate smart connectivity and data systems leadership

The UK must accelerate its leadership in smart connectivity and data systems that enable an integrated digital transport system.

Communications and connectivity are becoming more important in aviation. The continued growth of commercial fleets is increasing airspace congestion. The introduction of new air vehicle markets, such as urban air mobility, will further this trend. Airlines will continue to seek new revenue streams by offering high-speed in-flight cabin connectivity. The introduction of 5G networks will require compatible on-board systems to improve ground-to-air data transfer. In the longer term, aircraft-to-aircraft connections will enable increased communications coverage and redundancy. Greater connectivity for on-board systems with the Internet of Things (IoT) increases the need for highly-secure cyber technologies. The ATI will support projects which demonstrate high-performance in-flight cockpit connectivity for aircraft control and information, and cabin connectivity for passengers.

Advance autonomous systems for efficiency and safety

The UK can capitalise on its capabilities to capture new opportunities in the expanding autonomous systems market.

Existing commercial aircraft depend on significant automation to ease flight crew workload and maintain safety. Today, pilots instruct automated systems to fulfil tasks that reliably produce the same outputs for given inputs. Future urban air vehicles will depend on autonomy to overcome the shortage of pilots, enhance safety through reducing human error, improve operational efficiency and reduce operating cost. Autonomous systems will have adaptive, artificial intelligence capabilities that permit responses within specific boundaries that are not pre-programmed nor defined in the design. The ATI will lead the advancement of autonomy in urban air mobility, paving the way for wider adoption of autonomy in larger commercial air vehicles, enhancing safety and efficiency.

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SYSTEMS ROADMAP

DRIVERS

Reduce Cost: reduce cost of certification and system affordability
Improve Energy Efficiency: minimise fuel consumption through leightweighting and energy management
Protect the Environment: minimise environmental impact through lightweighting and sustainable materials and processes
Meet Operational Needs & Flexibility: improve maintainability of systems and increased functionality
Enhance Passenger Experience: cabin environment improvements, increase passenger connectivity and entertainment
Improve Safety: increase automation and autonomy of vehicle control and cyber resilience to maintain aviation safety

TARGET (EIS)

	2020-2025	2025-2030	2030-2035+
SWAP-C size, weight, power & cost relative to 2018 values	50% reduction	75% reduction	85% reduction
CONCEPT TO QUALIFICATION 2018 baseline is ~7-10 years	6 years	4 years	2 years

TECHNOLOGY PRIORITIES (TRL 6)

NEXT GENERATION SYSTEMS AND EQUIPMENT

- Fuel systems for next generation wings
- Lightweight, high reliability landing gear systems
- Fuel systems for sustainable fuels
- Lightweight, high reliability flight controls
- Integration of battery and fuel systems for hybrid electric propulsion
- High efficiency ice protection systems
- Power electronics, electrical machines and energy storage for secondary electrical systems
- More electric aircraft systems
- Advanced aircraft health monitoring and prognostic systems
- Next generation environmental control

SMART CONNECTIVITY AND DATA SYSTEMS

- High performance in-flight cockpit connectivity for aircraft control and information
- Enhanced passenger experience through seamless connectivity from airport to flight
- Enhanced aircraft control and information connectivity through ad-hoc aircraft-to-aircraft networks
- High speed in-flight cabin connectivity for passenger information and in-flight entertainment
- On-board optical networks
- Wireless, energy harvesting sensor systems

AUTONOMOUS SYSTEMS

- Flight decks for reduced pilot workload
- Autonomous cockpit systems (large commercial aircraft)
- Autonomous cockpit systems (urban air mobility market)
- Autonomous ground infrastructure to support autonomous flight
- Automatic taxy systems
- Fully autonomous aircraft systems
- Autonomous taxy systems

2020-2025 | 2025-2030 | 2030-2035+

"COMMUNICATIONS AND CONNECTIVITY ARE BECOMING MORE IMPORTANT IN AVIATION"

AEROSTRUCTURES

Maintain the UK as a world leader in aerostructures, including design, integration, manufacture and assembly of the most efficient wings and other high-value structures.

The design, development and manufacture of aircraft structures, notably wings, constitutes around 25 per cent of the sector's economic activity in the UK. UK suppliers also export state-of-the-art components and sub-assemblies for nacelles, empennages and fuselages for all leading aerospace manufacturers globally. The UK possesses the right expertise, technology and infrastructure to be at the forefront of the design and manufacture of the next generation of lightweight, digitally enabled, multi-functional aerostructures. Advanced manufacturing techniques such as additive manufacturing and the use of composites enable greater component functionality, lighter and stronger structures and greater efficiency from the overall airframe. Improving aerodynamic performance and lowering structural weight is important to reducing the environmental impact of aircraft in the future.

"THE UK POSSESSES THE RIGHT EXPERTISE, TECHNOLOGY AND INFRASTRUCTURE"


SPIRIT
AEROSYSTEMS

AEROSTRUCTURES PRIORITIES

Advance world-class capabilities for future integrated structure

The UK needs to retain its leadership in highly-integrated structures through investing in technologies for advanced design, materials and high-rate manufacturing.

Aircraft production is expected to continue to increase to meet demand. To ensure the UK benefits from this growth, it must retain leading capabilities in the design and manufacture of wings and other structures. This will require advanced design methods and tools, and materials development, enabling improved functional design. These must support increased production rates and reduced costs.

Conventional manufacturing techniques have often constrained structural designs or led to sub-optimal components. Processes such as additive manufacturing and friction welding will enable components to be manufactured and assembled in many new ways. Future wing designs will take advantage of these processes, utilising more functional sub-components optimised to many parameters.

The ATI will support projects which develop state-of-the-art manufacturing processes and the associated design methods and tools.

Materials development is key to unlocking the full potential of composites and processes such as additive manufacturing. The use of composite materials on aircraft has steadily increased, accounting for some 53 per cent of the A350. Composite design techniques, such as aeroelastic tailoring, will allow components to manage aircraft loads more efficiently. Metal will retain an important role, including new alloys necessary to optimise additive manufacturing processes and material properties. The ATI will encourage the development of metals and composites technologies that can improve aircraft performance and reduce weight, and the rapid certification of new materials.

Grow capability in complex multi-functional structures

To develop and grow capability in the design and production of complex multi-functional structures, the UK must drive further collaborative programmes.

To create more efficient and cost-effective aircraft, systems and structures are becoming more complex and integrated. Structural components will be designed to fulfil multiple duties, supporting both systems and loads. Future structural components must therefore be designed with multi-functionality in mind.

The most demanding structural integration challenges are expected to come with the advent of new propulsion, power and energy storage systems, in addition to more complex aerodynamic features. An emerging trend is 'wire-in' composites, permitting the transmission of data or power through a structure and avoiding additional components or assembly.

The ATI will support technologies and projects which enable high power-density electrical systems to be fully integrated into the vehicle's structure – enabling weight reduction and efficient thermal management.

High-performance electrical actuation and the improved aeroelastic characteristics afforded by composites will allow future structures to morph into their most efficient shape throughout flight. Multi-functional structures are also needed for active laminar flow to improve vehicle aerodynamics. Designs will need to take advantage of new manufacturing techniques to improve the precision of joints and incorporate durable hydrophobic and protective coatings to mitigate wing icing and erosion. The ATI will support collaborative projects to address these manufacturing and operational challenges.

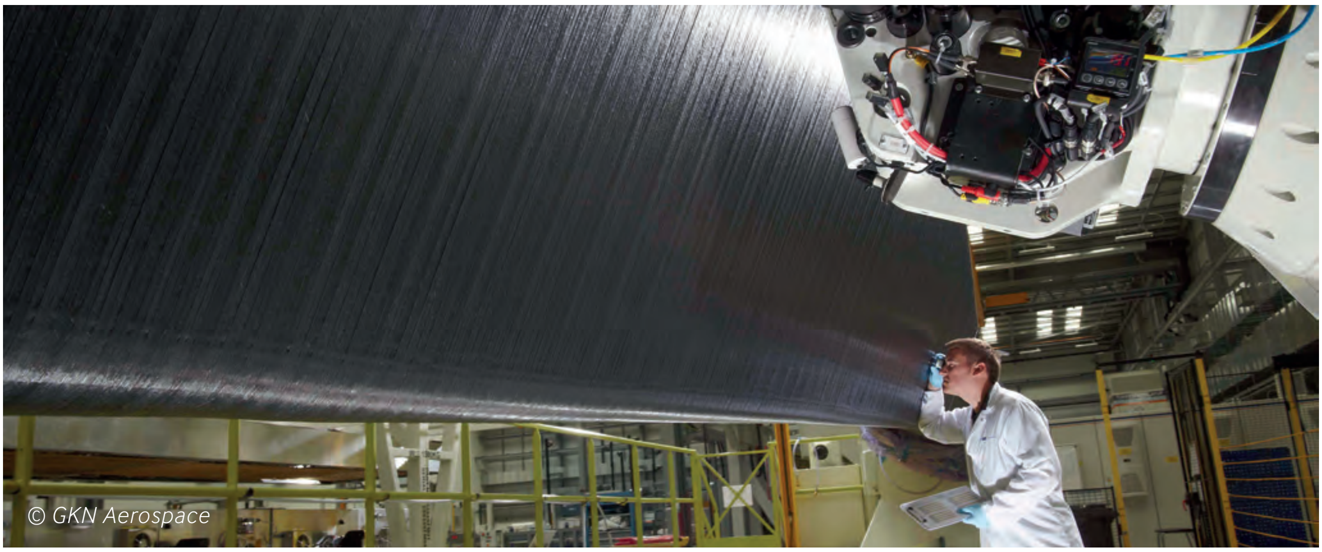
Design the next generation of smart assembly processes and tools

The UK must invest in technologies to transform aerostructure assembly from being manually intensive into a highly-automated, digitised and self-optimising operation.

To remain competitive, the UK must improve manufacturing precision and repeatability by developing the next generation of smart automated assembly processes, tools and flexible assembly cells.

Traditional airframe assembly and component sub-assembly is laborious, involving drilling, disassembly, fettling and shimming. In future, component assembly will be automated, with processes carried out from one side of the structure, increasing productivity and factory safety. To achieve this, the ATI will promote increased use of reconfigurable automation and other enabling technologies, such as large-scale metrology and one-way drilling.

The creation of high-fidelity learning models, through the continual input of live data, will enable highly precise and repeatable assemblies. These dynamic models will depend on connected assembly machines, factories and ultimately entire supply chains. Data shared across these networks can be used to update models and to bring together components with similar degrees of accuracy. These are the priorities for the assembly of large-scale aerostructures, but they also apply to the assembly of propulsion and system components.



AEROSTRUCTURES ROADMAP

DRIVERS

Reduce Cost: through-life costs via improved manufacturing productivity, reduced maintenance and designing for end-of-life recycling
Improve Energy Efficiency: reduce structural weight through greater integration, optimised structural designs and novel architectures
Protect the Environment: reduce buy-to-fly ratio of components and work towards a recyclable circular economy
Meet Operational Needs & Flexibility: easy and cost-effective repairs, damage tolerance, self-monitoring and self-healing structures, upgradeable components
Improve Safety: through crash resistant airframes, cabins and interiors and through improving damage tolerance and product durability/dependability

TARGET (EIS)

	2020-2025	2025-2030	2030-2035+
BUY-TO-FLY RATIO relative to 2019 baseline	20% reduction on average	35% reduction on average	50% reduction on average
PRODUCTIVITY RATES relative to 2019 baseline	20% increase	30% increase	40% increase
AIRFRAME WEIGHT relative to 2019 baseline	25% reduction on average	30% reduction on average	35% reduction on average

TECHNOLOGY PRIORITIES (TRL 6)

FUTURE INTEGRATED STRUCTURES

- Additive manufacturing, advanced joining and other near-net shape processes → Fully unitised, topologically optimised components → Functionally designed structural components
- Optimised composite usage → Composite aeroelastic tailoring
- Low cost composite tooling → Transformable, smart assembly tools & jigs
- Automated metal alloy development
- Improved maintenance through increased damage tolerance → Automated structural health monitoring → Self-healing aerostructures
- Use of in-service stress data for design → Streamlined test pyramid/virtual tests → Certification through virtual testing

COMPLEX MULTI-FUNCTIONAL STRUCTURES

- Integrated and embedded systems (Power, data) → Structural power: integrated energy storage & power generation → Multi-functional primary structure
- More electric actuation → Morphing secondary surfaces → Morphing primary structure (wing & nacelle)
- Structure to enable hybrid laminar flow → Structure to enable natural & hybrid laminar flow

SMART ASSEMBLY PROCESSES AND TOOLS

- Fastener-less components → Fastener-less, shim-less, assemblies
- Transformable, smart assembly tools & jigs → Automated assembly → Automated, reconfigurable and flexible one-way assembly
- Virtual assembly & dynamic modelling → Connected assembly jigs & fixtures → Connected supply chain and reactive assembly

2020-2025 | 2025-2030 | 2030-2035+

"TO REMAIN COMPETITIVE, THE UK MUST IMPROVE MANUFACTURING PRECISION AND REPEATABILITY BY DEVELOPING THE NEXT GENERATION OF SMART AUTOMATED PROCESSES, TOOLS AND FLEXIBLE ASSEMBLY CELLS"

CROSS-CUTTING ENABLERS

The UK aerospace sector needs to drive progress on important and broadly applicable enabling technologies and capabilities through collaboration across and beyond the sector.

Several themes vital to the competitiveness of UK aerospace have broad application, reaching in some cases beyond the sector. There are also opportunities for cross-sectoral collaboration in specific areas, such as electrical power systems. The ATI will seek collaborative approaches to steer research toward cross-cutting opportunities, including finding common ground with other industries.

Develop high-value design capabilities

UK aerospace must develop and implement new design capabilities to deliver the increasingly complex products and services of the future.

Aircraft are becoming more complex and integrated. Rising engineering costs, from concept through validation and certification, is holding back innovation. Great improvements can be achieved through expanding the use of digital capabilities. This means leveraging artificial intelligence, modelling and computing to optimise processes, systems and manage information. Supply chains will need to work more closely to facilitate rapid and effective design and development. Physical testing must be reduced where possible, with greater use of simulation and advanced statistical

analysis. New test facilities will be needed to validate new models and technology. We refer to this collection of activities, and the associated capabilities, as high-value design. It reaches across industries developing the most complex systems. Since 2017, aerospace has been working with businesses and industry councils in defence, automotive, maritime, pharmaceuticals and energy to share challenges and align ambitions. The ATI will continue to support these efforts.

Develop advanced materials, manufacturing and assembly

To be globally competitive, the UK supply chain must remain at the leading edge of material science, advanced manufacturing and assembly processes.

Manufacturing for aerospace is often more technologically challenging than for other sectors. High-performance materials can be difficult to process. High levels of precision are required in components. Stringent quality standards must be met throughout manufacture, up to assembly of large complex systems. However, volumes are relatively low compared with many other industries, bringing cost and automation challenges. To tackle these, the UK must continue development of high-performance materials, low-cost and intelligent automated manufacturing systems and connected factories.

The ATI will work with the UK's High Value Manufacturing Catapult network and the broader manufacturing sector to support delivery of these technologies.

Advance through-life engineering technologies

To secure a share of the expanding through-life engineering service opportunities, UK businesses must develop their technologies and capabilities in conjunction with novel business models.

The ATI estimates the market for through-life engineering services in civil aerospace to be worth almost $2.5 trillion over the next 20 years. It includes performance optimisation of air vehicles during their service, efficient and effective repair of systems and components, and end-of-life repurposing, recycling and disposal. Success in this market depends on maximising the availability, predictability and reliability of products at the lowest possible through-life cost. Increasingly, firms are deploying high-fidelity digital twin models of products that tie together data from their original design, manufacturing history and in-service performance. Artificial intelligence monitors and interprets this sea of information to recognise impending issues. This data and insight will become increasingly important to the design of future products or upgrading of in-service systems. It is also important that the industry seeks to maximise use of end-of-life hardware, recycling or repurposing materials in sustainable ways. The ATI will work to encourage the development of technologies for enhanced through-life engineering including digital twins, repair, recycling, and sustainable design of future products.

	CROSS CUTTING THEMES		OTHER APPLICABLE SECTORS
HIGH VALUE DESIGN	METHODS & TOOLS	+ USE OF IN-SERVICE DATA FOR DESIGN + IN SERVICE <-> DESIGN FEEDBACK LOOP + DIGITAL TWIN & VIRTUAL SIMULATION	Automotive, Space, Construction, Nuclear, Oil & Gas, Off-shore Renewables
	STANDARD AND CERTIFICATION	+ VIRTUAL TESTING + VIRTUAL CERTIFICATION	Automotive, Space, Construction
	INFRASTRUCTURE	+ MAINTAIN AND BUILD WIND TUNNEL CAPABILITIES + MAINTAIN AND BUILD STRUCTURAL TEST CAPABILITY + DEVELOP FACILITIES FOR HIGH VOLTAGE SYSTEM TESTING	Automotive, Space, Construction, Oil & Gas, Off-shore Renewables
ADVANCED MANUFACTURING	MATERIALS	+ OPTOMISED COMPOSITE USAGE + AUTOMATED METAL ALLOY DISCOVERY AND DEVELOPMENT	Automotive, Space, Construction, Nuclear, Oil & Gas, Off-shore Renewables, Agriculture
	MANUFACTURING & ASSEMBLY	+ RAPID INSPECTION & NDE/NDT + IN-LINE PRODUCT & PROCESS VERIFICATION + ONE WAY ASSEMBLY + FULLY AUTOMATED AND FLEXIBLE CELLS	Automotive, Space, Construction, Nuclear, Oil & Gas, Off-shore Renewables, Agriculture
	INDUSTRY 4.0	+ CONNECTED MACHINES AND FACTORIES + DYNAMIC FACTORY SIMULATION AND MODELLING + INTEGRATED SUPPLY CHAIN	Automotive, Space, Construction, Nuclear, Oil & Gas, Off-shore Renewables, Agriculture
THROUGH LIFE ENGINEERING	MRO	+ PREDICTIVE MAINTENANCE + DIGITALLY LINKED VEHICLES AND MRO CAPABILITY	Automotive, Space, Construction, Oil & Gas, Off-shore Renewables, Agriculture
	DIGITALLY ENHANCED VEHICLE	+ INTEGRATED VEHICLE HEALTH MONITORING + STRUCTURAL HEALTH MONITORING	Automotive, Space, Off-shore Renewables
	END OF LIFE	+ RECYCLABILITY OF COMPOSITES, METALS & PLASTICS + CIRCULAR ECONOMY	Automotive, Space, Off-shore Renewables

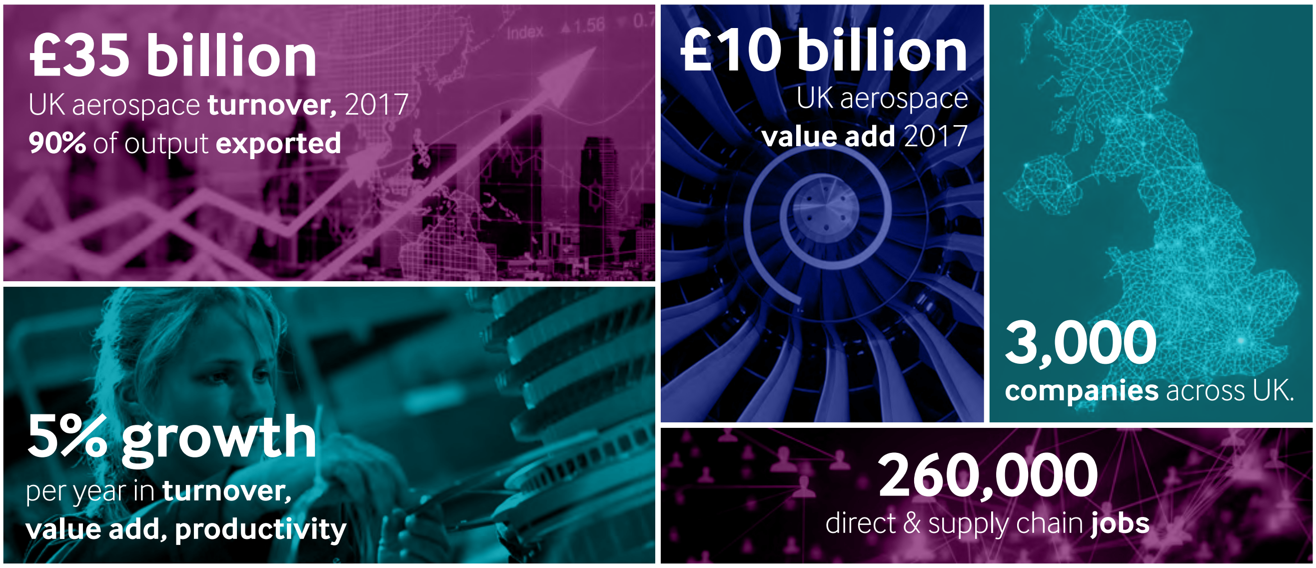
KEY: AUTOMOTIVE, SPACE, CONSTRUCTION, NUCLEAR, OIL & GAS, OFF-SHORE RENEWABLES, AGRICULTURE

“HIGH-VALUE DESIGN REACHES ACROSS INDUSTRIES DEVELOPING THE MOST COMPLEX SYSTEMS”

ECONOMIC IMPACT

The UK has one of the largest aerospace industries in the world. Investment in 2017 hit £2.5 billion, of which £1.5 billion was R&T. The UK Government contributed approximately £225 million to this, with £150 million through the ATI and £75 million from other sources. For every pound government invests, industry can go on to invest as much twelve pounds.

The contribution the sector makes to the national economy has been growing at around 5 per cent per year since 2008. Steady improvement in productivity has kept employment broadly stable. The average value added per aerospace job is £90,000 – the sector is one of the most productive in the UK economy and average wages are the highest within UK manufacturing.



Based on ATI Programme investments through to 2026, the UK economy could benefit by as much as £114 billion up to 2035, creating and safeguarding 95,000 direct and supply chain jobs. Part of this benefit is derived from spillovers from aerospace R&T to the wider economy. Evidence shows that returns from aerospace research are as much as four times larger outside the sector as the returns to the aerospace sector itself. Collaborative ATI-funded projects encourage these spillover benefits.

CLOSING REMARKS

Civil aerospace matters to the UK. It is a highly-productive sector featuring complex technology, high-skills work and integrated supply chains; its economic contribution goes well beyond its own boundaries. The Aerospace Technology Institute seeks to maximise these benefits against a background of rapidly increasing concern over the environment; fierce global competition; ever-increasing demands from airlines and passengers for safer, quieter, cleaner, and cheaper aircraft; and the prospect of a transformation in air mobility. Meeting these demands and keeping the UK at the forefront of the industry require constant investment in innovation.

Accelerating Ambition responds to that challenge. It is an ambitious plan to enable, shape and accelerate progress through major new research initiatives.

The Institute has worked in close collaboration with a wide range of stakeholders in aerospace and beyond to update the technology strategy. It works in conjunction with other initiatives driven by the Aerospace Growth Partnership and Innovate UK. Together, they constitute a long-term programme to meet the complex needs of the sector, making the UK a globally competitive place for the aerospace industry.

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