Raising Ambition

Aerospace Technology Institute Strategy and Portfolio Update 2016

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Head of Technology Strategy and Integration
25th October 2016

AEROSPACE TECHNOLOGY INSTITUTE

The ATI

- The Aerospace Technology Institute (ATI) is the objective convenor and voice of the UK's aerospace technology community
- We define the national aerospace technology strategy
- We work closely with Government and industry to direct joint funding into aerospace R&T projects that align with the strategy
- The Comprehensive Spending Review of November 2015 extended the joint funding available to £3.9 billion over 13 years (to 2026).

AEROSPACE TECHNOLOGY INSTITUTE

Our mission & goals

Through strategic investment in differentiating technologies, secure the full economic potential of the UK aerospace sector

Technology investment

Providing technology leadership and maximising economic impact of R&T for UK aerospace

Provide Technology Leadership

Define a UK aerospace technology strategy that challenges industry, and create opportunities for advanced technology programmes to drive the growth of the UK aerospace sector

Maximise funding Impact

Drive the UK's aerospace R&T programme to maximise impact and embed benefits

Institute impact

Leveraging the Institute to add value in the sector

Convene strategic partnerships

Engage with a broad spectrum of stakeholders to challenge existing thinking, energise the UK aerospace sector and unlock new value

Elevate UK's international technology profile

Promote the advanced capabilities of UK aerospace technology and increase the UK's influence within European programmes and beyond

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Aerospace Growth Partnership set the course for continued success, leading to ATI

2012

Global opportunity & strategic areas:

- Skills
- Supply chain
- Technology
- Access to finance
- Engagement

2013

Mechanisms

- NATEP
- MSc Bursaries
- ATI & £2.1bn

2014

Company established

- CEO/Chair by Q2
- EMT in September
- ~10 staff

January 2015

Technology strategy framework

- Coherent market-aligned
- Focused on economic impact
- Initial technology themes

July 2015

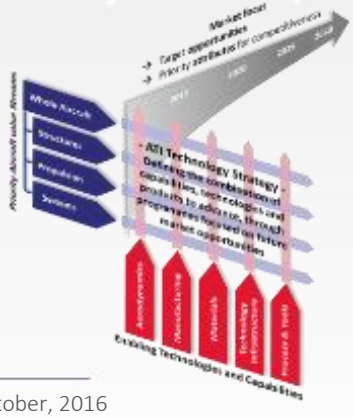
- 1st published strategy
- Institute embedded in strategic leadership of programme
- ~25 staff

Technology Strategy and Portfolio Update 2016

ATI Live Portfolio

July 2015

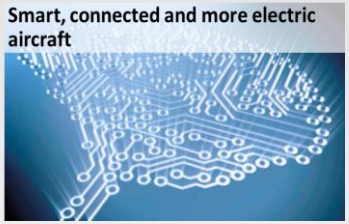
- 1st published strategy
- Institute embedded in strategic leadership of programme

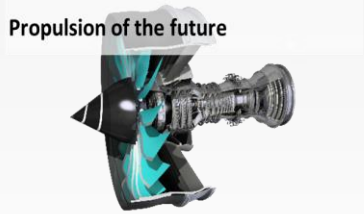


July 2016

- Technology strategy and Portfolio Update

The UK aerospace technology strategy





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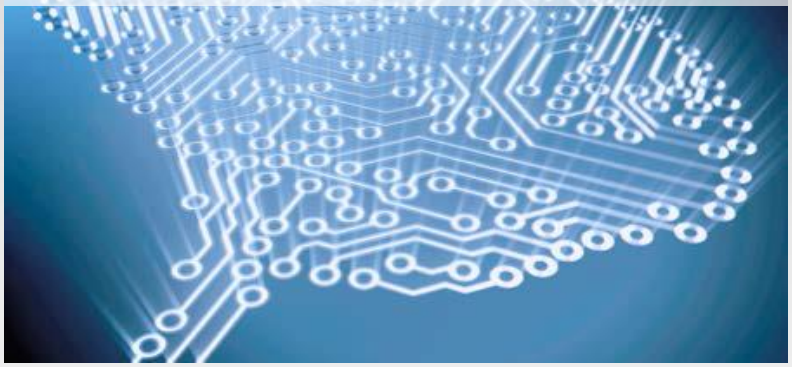
Four strategic technology themes

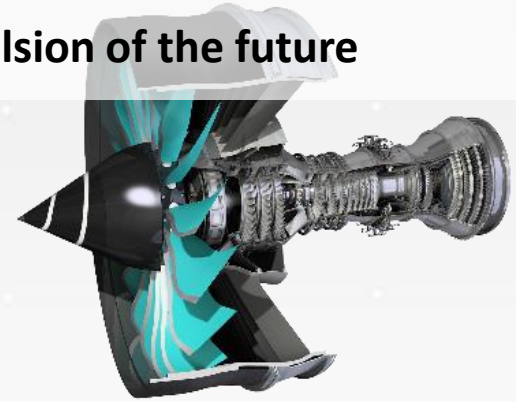
Aircraft of the future

Smart, connected and more electric aircraft



Aerostructures of the future

Propulsion of the future



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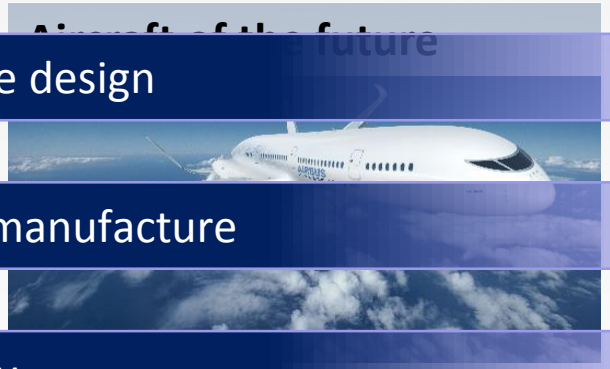
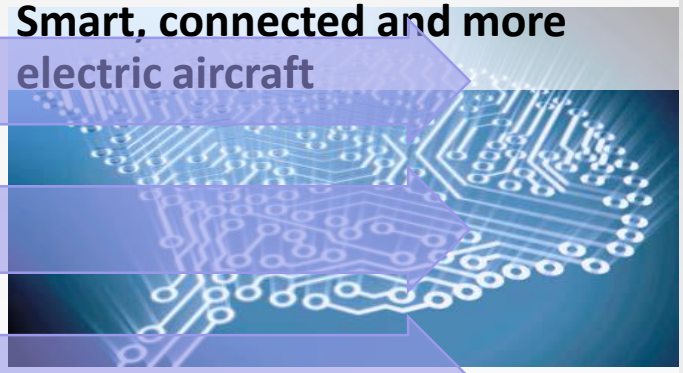
Cross cutting agendas

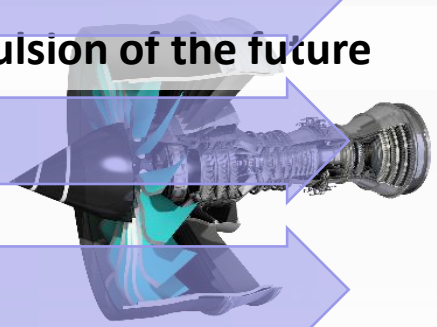
Strategic Technology Themes



Smart, connected and more electric aircraft



Propulsion of the future



High value design

Additive manufacture

Autonomy

Digital economy

Through life services

Infrastructure

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RAISING AMBITION

STRATEGIC TECHNOLOGY THEMES

The technology strategy drives the ATI R&T portfolio along four major technology themes aligned with future market requirements:

AIRCRAFT OF THE FUTURE

- Strengthening whole-aircraft design and system integration capability
- Understanding the potential of more radical aircraft architectures and the impact of technologies at the whole-aircraft level
- Accelerating development of enhanced safety, and more productive and autonomous aircraft

SMART, CONNECTED AND MORE ELECTRIC AIRCRAFT

- Enabling introduction of more electric systems
- Developing secure digital systems and communications
- Securing capabilities in fuel, landing gear and energy management systems

AEROSTRUCTURES OF THE FUTURE

- Strengthening the UK's position as a centre for large composite structures
- Raising levels of automation across manufacture and assembly

PROPULSION OF THE FUTURE

- Realisation of large ultra-high bypass ratio (UHBR) turbofan engines
- Enhancing the integration of advanced propulsion systems onto aircraft

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The technology themes address all aspects of the product lifecycle: design, development, production, through-life support and disposal. The following pages provide a high-level view of how the ATI portfolio is delivering against these and the opportunities for future research.
A number of these opportunities are consistent with the interests of adjacent sectors.
The Institute is actively engaging with the defence, space and automotive communities to explore joint technology development and exploitation. The Institute is also encouraging closer alignment between university research and the technological needs of industry, for example working with the Engineering and Physical Sciences Research Council (EPSRC) to exchange perspectives, help shape strategies, and identify opportunities for collaboration.

Bringing new technologies together as part of an integrated system is essential to positioning the sector competitively. Specifically, the Institute envisages the following major integration initiatives:

- **Ultra-high bypass ratio (UHBR) turbofan:** to validate an entirely new engine architecture; a full engine system with composite fan, power gearbox, high pressure core and accompanying manufacturing technologies will be tested, including the capability to effectively integrate this new generation of efficient engine onto aircraft
- **Integrated wing:** to validate the next generation of high-efficiency wing optimising the materials, structure, systems integration and associated high-productivity manufacturing systems
- **Integrated complex systems:** to validate in a virtual whole-aircraft environment the integration of UK advanced systems technologies, uniting the diverse systems industry and academic research base to network facilities and integrate technologies
- **Future propulsion concepts:** to investigate and evaluate the potential of large scale hybrid turbo-electric propulsion systems

These initiatives will stretch the sector's resources, capabilities and ATI funding, necessitating smarter use of existing national infrastructure and further capital investment.

They present an opportunity for UK suppliers to gain competitive advantage and are linked with the UK's high-value manufacturing agenda and factories of the future. This will require the Institute to take a more active role, driving an ambitious vision and coherent approach, particularly for wings and systems, but also for design integration capabilities and national infrastructure.

The Institute will drive these initiatives forward through consultation with stakeholders to form major new collaborative ATI R&T projects.

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In addition to the four main technology themes, the ATI and its advisory groups are pursuing several major cross-cutting agendas:

HIGH-VALUE DESIGN (HVD)

HVD encompasses the roles, tools, processes, activities and facilities that are needed for defining and integrating products. HVD is essential to securing UK aerospace leadership, enabling suppliers to tackle the challenges of future aircraft development, and influence high-value engineering work and its associated manufacturing. Ensuring the UK retains these HVD capabilities is pertinent during a period of reduced new aircraft development. Working with industry, the Institute has committed resource to define solutions which will secure this capability in the UK.

DIGITAL ECONOMY

Connectivity, new business models and lower-cost high-performance computing are transforming the industry, including: high-fidelity design; optimised flexible manufacturing; more autonomous flight; higher-capacity air traffic control; more intelligent through-life support. Connectivity brings the challenges of secure capture, management, analysis and exploitation of big data – mastering these is key to future value generation across the product lifecycle. The Institute contributed views to the Government's digital strategy and is working with the Digital Catapult, Turing Institute and a broad range of stakeholders to develop a coherent view of the way forward for aerospace.

ADDITIVE MANUFACTURING (AM)

AM enables truly functional design of mechanical components, unconstrained by conventional manufacturing technologies, with low waste. The relatively low production volumes in aerospace lend themselves to AM – for parts and tooling. Challenges remain, to increase production rates, and standardise machinery and materials. The Institute is coordinating the aerospace input to the national Additive Manufacturing Strategy, maximising synergies with other sectors.

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AUTONOMY

Autonomous systems will be critical to reducing aircrew workload and enabling higher-capacity, safer air transport systems. Fully-autonomous vehicles offer cost advantages and will ultimately open up new applications – the Government has challenged the industry to accelerate their safe introduction and integration into controlled airspace to ensure the UK is in the lead. To deliver this vision, the UK will need to draw on the capabilities of its strong defence sector and emerging civil businesses. The ATI is focusing on autonomous technologies that offer broadest benefits in civil aerospace, for example, sensing and avoiding other aircraft. The Institute is supporting cross-sector knowledge transfer on the autonomous transport agenda, through engagement with the Transport Systems Catapult.

THROUGH-LIFE SERVICES

According to a 2016 study sponsored by BIS, the UK aerospace maintenance, repair, overhaul and logistics (MROL) segment is worth £16 billion per year. The ATI's MROL priorities include the development of technologies for integrated vehicle health management (IVHM), repair and inspection, as these can reduce cost and improve in-service availability. Through digital technologies, IVHM is enabling a transition to service-based business models. Additive manufacturing is being developed for repair of components. The recycling and disposal of large composite structures presents an opportunity that will require new technology solutions. There are gaps in through-life services technology and the Institute will work with stakeholders to understand these needs.

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AIRCRAFT OF THE FUTURE

This theme incorporates the design, integration, certification and operation of aircraft and their interaction with the broader air transport system.

The UK performs whole-aircraft design integration within the civil helicopter and defence segments, and provides leading capabilities through universities, independent research organisations and consultancy. The activity constitutes around 10% of the UK aerospace sector's direct economic activity, however the capabilities involved help to secure the sector more broadly.

Major aircraft subsystems designed and manufactured in the UK are shaped by whole aircraft design and integration. Aerodynamics, through simulation and test, determines the geometry of an aircraft and drives its structural and control needs. These capabilities are therefore important to the UK's position in the global civil aerospace industry, and underpin the UK's involvement in more radical aircraft architectures beyond 2030.

The global growth of aviation is driving the need for improved fuel efficiency through optimised flight trajectories, improved safety and security, and accommodation of autonomous systems. The Institute is working with other UK organisations and internationally to develop strategies and technology needs that help to position the UK at the forefront of air transport system development.

A number of initiatives are meeting aspects of these challenges, including:

- Advanced simulation and enhanced national technology infrastructure
- Flight deck systems to improve crew workload and situational awareness, linked to the development of airspace management through European and US initiatives
- Unmanned Aerial Systems (UAS), allied to the UK Government's Pathfinder programmes on accelerating introduction into controlled airspace

PRIORITY OPPORTUNITIES – A WHOLE-AIRCRAFT OVERVIEW

Over the next 15 years, demand for more fuel-efficient, greener and cost-competitive commercial jet aircraft will drive improved integration of more efficient turbofan engines. Demand for more efficient and quiet turboprop aircraft will also stimulate new technology. Future helicopters need to be faster, safer, quieter and cheaper to operate which will ultimately require new architectures. Securing whole-aircraft design and integration capability will be essential in this context, enabled by improved modelling tools, design processes and appropriate experimental facilities.

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The evolving civil UAS sector is focused on developing beyond visual line of sight platforms and the innovative business models enabled by these aircraft. The Institute is working with government, industry and academia to understand commercial opportunities for UAS.

EARLY-STAGE RESEARCH OPPORTUNITIES

Targeting beyond 2030, more radical aircraft concepts may harness boundary layer ingestion (BLI) and distributed propulsion systems to deliver further improvements in fuel efficiency and noise. The Institute will work closely with academic and research establishments to align fundamental research programmes, including:

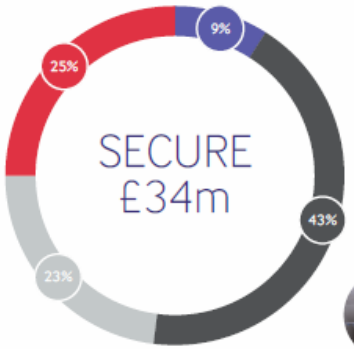
- New and novel whole-aircraft architectures and operational concepts
- Greater interaction between aircraft conceptual and air transport system modelling linked to the European Union's ACARE Flightpath 2050 goals
- Human factors in the flight deck
- Design and evaluation of the overall aircraft system to better leverage ongoing component and system research

CONCLUDING REMARKS

Enabling increased use of aero-elastic tailoring, laminar-flow systems and new types of propulsion system will be important to improving fuel efficiency and reducing noise of aircraft. Flight deck technologies will enhance the safety and productivity of flight operations. The air transport system will continue to evolve and demand new technologies – including the introduction of UAS operations in controlled airspace. The Institute is engaging with government and industry to support these developments.

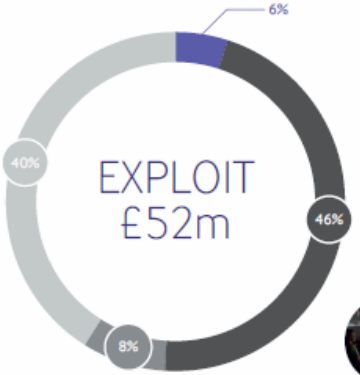
The UK's whole-aircraft capabilities are essential to the sector's overall success. The Institute is working to build a more strategic approach to sustaining and developing these capabilities, and with universities is shaping academic agendas around industrial priorities. It is also engaged in the Greener by Design initiative and Sustainable Aviation groups to contribute the Institute's whole-aircraft perspective.

AIRCRAFT OF THE FUTURE



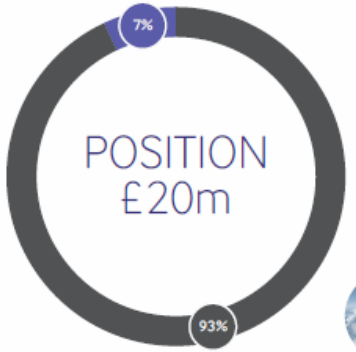
Project Example

Aircraft Research Association: Refurbishment of wind tunnel facilities, development of new gust, cavity and rotor rigs, and advanced measurement techniques.



Project Example

£10m+ invested in advanced intelligent flight deck with improved human machine interface research.



Project Example

Did you know the ATI can assess the impact of your technologies on representative aircraft to help you with your design and integration needs?

NEW ARCHITECTURES (Including demonstrators)

- Free flight (NextGen & SESAR) and 4D flight profiles
- Novel wing architectures integration (aeroelastic tailoring, high aspect ratio wings)

TOOLS & METHODS

- Flight deck human factors for reduced pilot workload
- Conceptual aircraft and air system modelling
- Advanced, faster multi-physics and multi-fidelity whole aircraft modelling (aerodynamics, aeroelastics, structures, noise, performance, icing)
- Advanced wind tunnel testing technologies including models, rigs and measurement techniques
- Faster, more affordable certification/qualification process improvements

KEY TECHNOLOGIES

- New technology developments for navigation, communications, safe flight (sense and avoid, all weather operations etc.), failure tolerance protocols
- Technology support for Government UAS Pathfinder programmes
- Loads control and aeroelastics
- Better use of composites and advanced materials

NEW ARCHITECTURES (Including demonstrators)

- New air vehicle architectures to leverage the benefits of laminar flow and flow control
- High speed rotorcraft
- UHBR equipped aircraft
- New air vehicle architectures for increased use of more electric systems

TOOLS & METHODS

- Advanced geometry handling
- Integration - powerplant, wing/engine, multi-prop wing, nacelle, rotors
- Appropriate multi-fidelity modelling and toolset for aerodynamics of novel configurations

KEY TECHNOLOGIES

- Simplified moveable surfaces and slatless leading edges
- Cabin noise reduction technologies

NEW ARCHITECTURES (Including demonstrators)

- Increased autonomy in transport and passenger air vehicles
- Large tilt-rotor
- More radical air vehicle architectures including blended wings, distributed propulsion, BLI
- Open rotor or advanced turboprop powered air vehicles
- New architectures for large all electric aircraft

TOOLS & METHODS

- Wind tunnel testing technologies including models, rigs and wind tunnels for distributed propulsion

KEY TECHNOLOGIES

- Distributed propulsion preliminary modelling on whole aircraft

Technology Development Opportunity Indicator

- Large Development Opportunity
- Moderate Development Opportunity
- Small Development Opportunity
- Technology Addressed

Cross-sector Opportunities

- Multi-sectoral
- Automotive
- Defence and Space
- Rail
- Energy (Power, Wind)

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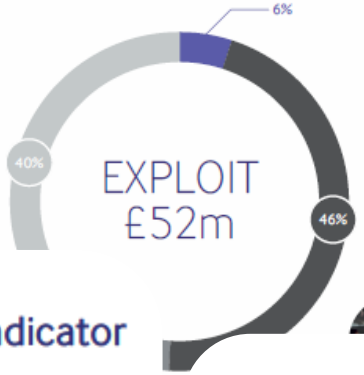
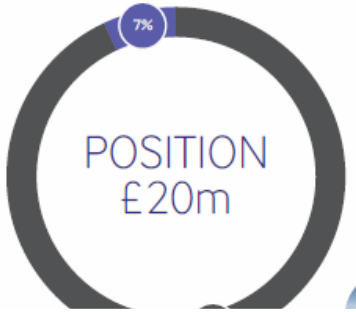
AIRCRAFT OF THE FUTURE





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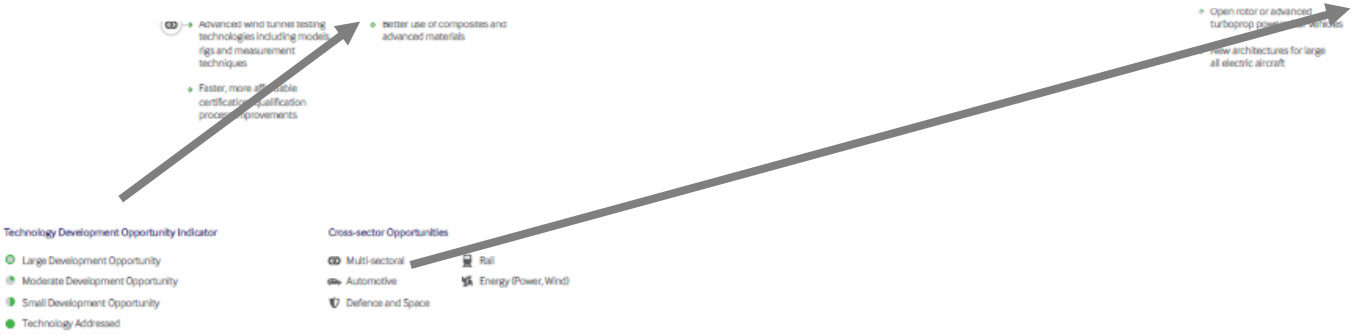

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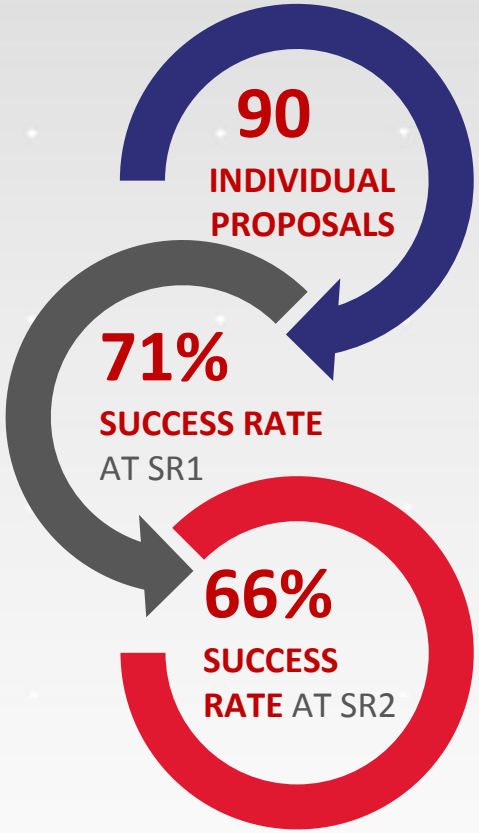
Headline ATI Portfolio Statistics

Projects developed in the last 12 months…



WILL HELP TO SECURE OR GROW

15,000

UK HIGH VALUE JOBS

…are adding to an extensive technology portfolio

ATI PROJECTS ON CONTRACT: **160**

TOTAL VALUE: **£1.3BN**; GRANTS OF **£686M**

195 UNIQUE ORGANISATIONS

103 SME's DIRECTLY CONTRACTED

WITH MANY MORE SMES SUBCONTRACTED

Source: ATI Analysis of Innovate UK Public Data (5h August 2016)

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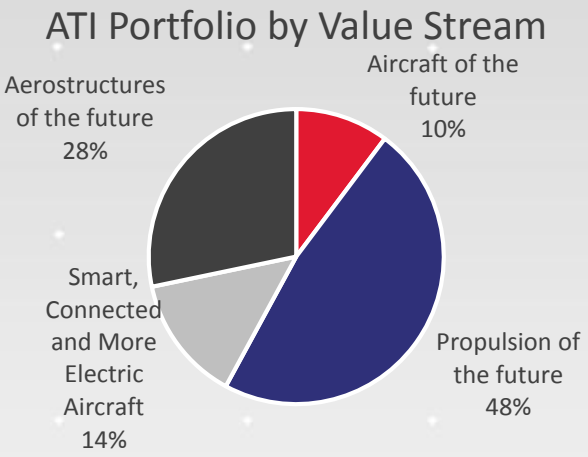
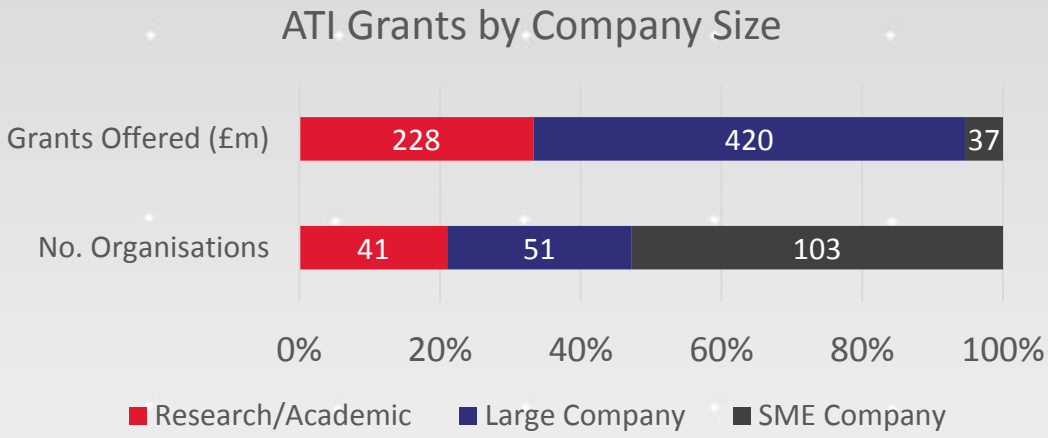
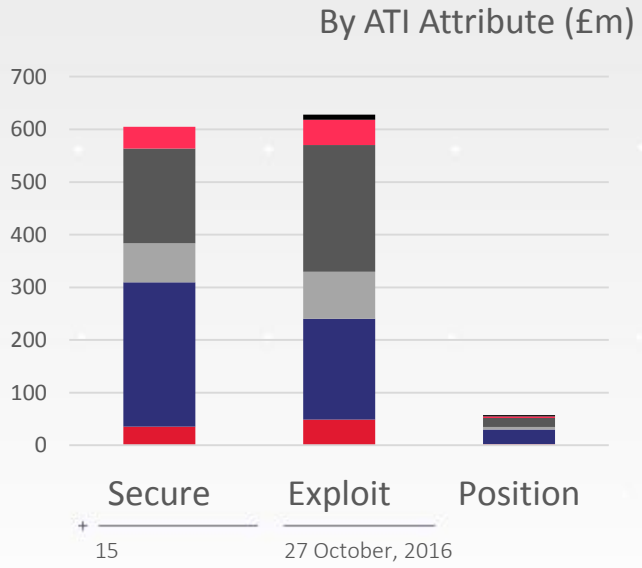
Key ATI Portfolio Statistics







- Passenger Experience
- Operational Needs & Flexibility
- Cost
- Environment
- Fuel Efficiency
- Safety

- ATI funding by value stream in line with UK aerospace sector turnover.
- Largest focus in portfolio on cost reduction and fuel efficiency projects
- Funding for exploit projects (5-10 years) has increased over the past months.
- >50% of the partners participating are SMEs, received >£35m of grant funding

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Concluding Remarks

Key aspects of our strategy update are:

- Deliver four major integration initiatives by 2020
- Develop strategies and delivery around cross-cutting themes
- Increase cross-sectorial exploitation
- Link to EPSRC in early stage research opportunities with emphasis on Position strategy
- Whole aircraft capability, whole aircraft design and systems integration engagement to exploit this capability
- Launch refresh on Infrastructure Strategy

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Detailed overview of Strategy Update

- Large and Moderate Development Opportunities

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1 AIRCRAFT OF THE FUTURE

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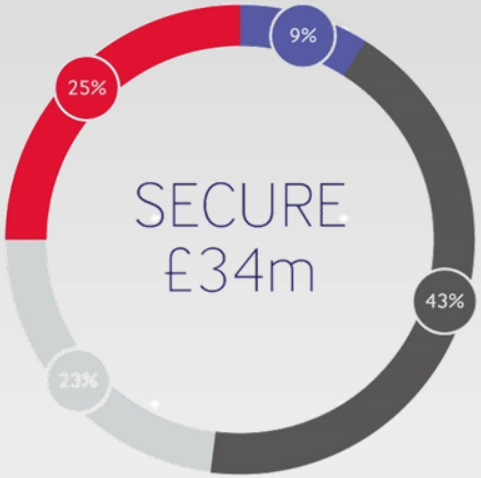
Aircraft of the Future

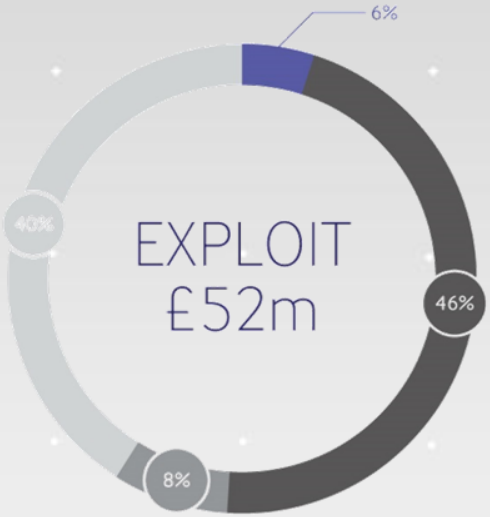
This theme incorporates the design, integration, certification and operation of aircraft and their interaction with the broader air transport system.

Key theme outcomes:

- Strengthening whole-aircraft design and system integration capability
- Understanding the potential of more radical aircraft architectures and the impact of technologies at the whole-aircraft level
- Accelerating development of enhanced safety, and more productive and autonomous aircraft

Aircraft of the future – Portfolio Summary





- Cost
- Environment
- Fuel efficiency
- Operational performance and flexibility
- Passenger experience
- Safety

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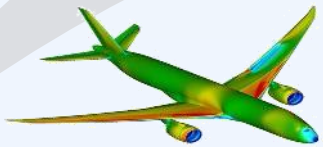
Aircraft of the Future – New Architectures

Aero-elastic tailoring and/or high aspect ratio wings

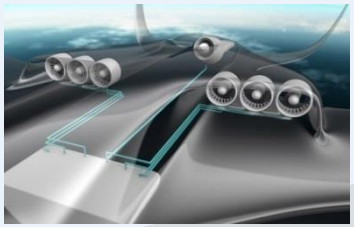
Free flight



High speed rotorcraft

Integrated UHBR

Laminar flow and flow control

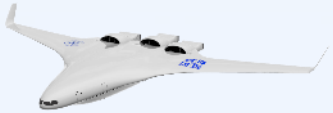


Novel air vehicle architectures for large all electric aircraft

Large tilt-rotor

Open rotor or advanced turboprop

Blended wings, distributed propulsion, and BLI



Secure | Exploit | Position

2015 | 2020 | 2025 | 2030 | 2030+

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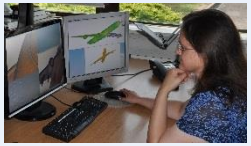
Aircraft of the Future – Methods and Tools

Flight deck human factors

Conceptual aircraft and system modelling

Advanced wind tunnel testing technologies



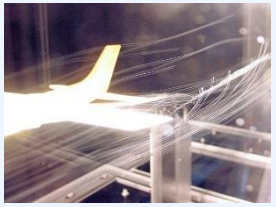
Multi-physics and multi-fidelity whole aircraft modelling

Certification qualification process improvements

Advanced geometry handling and modelling for aerodynamics of novel configurations

Powerplant integration

Wind tunnel testing technologies for distributed propulsion



Secure | Exploit | Position

2015 | 2020 | 2025 | 2030+

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Aircraft of the Future – Key Technologies

New technology developments for navigation, communications, safe flight

Loads control and aero-elastics

Better use of composites and advanced materials

Government UAS Pathfinder programmes

Cabin noise reduction technologies

Simplified moveable surfaces

Distributed propulsion preliminary modelling on whole aircraft

Secure | Exploit | Position

2015 | 2020 | 2025 | 2030+

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Whole aircraft capability

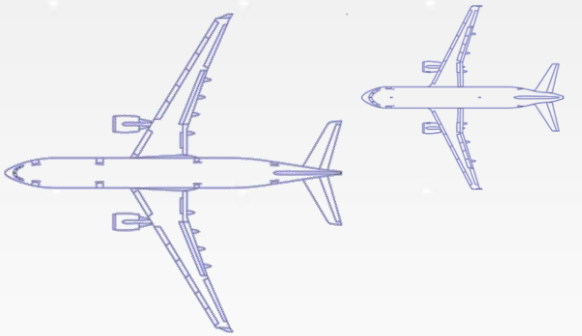
ATI's Whole Aircraft Capability

ATI Whole Aircraft Model Environment

Aircraft trade tables

ATI aircraft library

Validation with OEMs



Accessing ATI Whole Aircraft Capability

User-friendly aircraft trade tool, for UK aerospace

Quantified impact of technology on fuel burn and CO_2

- Individual companies
- Technology consortia
- Government
- Aerospace technology strategy
- Informing the debate on the market and future aircraft

New technology

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SMART, CONNECTED AND MORE ELECTRIC AIRCRAFT

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Smart, Connected and More Electric Aircraft

This theme encompasses a range of complex aircraft systems provided by UK businesses, specifically the technologies, tools, processes and facilities needed to develop and produce them.

Key theme outcomes:

- Enabling introduction of more electric systems
- Developing secure digital systems and communications
- Securing capabilities in fuel, landing gear and energy management systems

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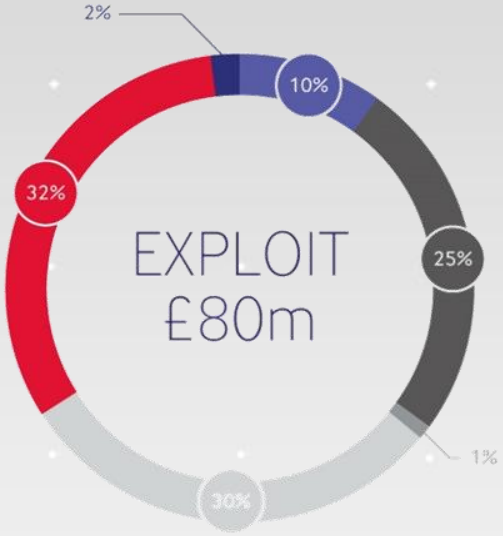
Smart, Connected and MEA– Portfolio Summary



- Cost
- Environment
- Fuel efficiency
- Operational performance and flexibility
- Passenger experience
- Safety

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Smart, Connected and MEA – New Architectures

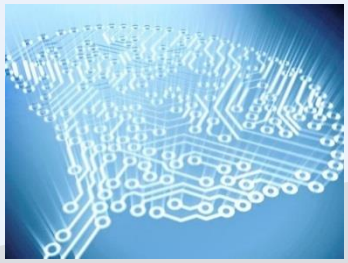
Open systems avionics architecture

Multifunctional systems and components

Smarter communications

More electric aircraft

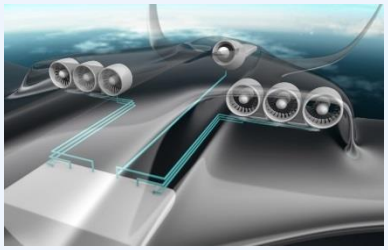
Distributed avionics



Autonomous air vehicle systems validation platform

Embedded sensors and actuation in components

All electric aircraft



Secure | Exploit | Position

2015 2020 2025 2030+

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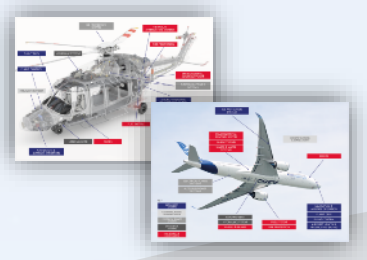
Smart, Connected and MEA – Methods and Tools

Integrated thermal design for systems

Electronic/ electrical component failure and EMC prediction models

MEA systems integration & demonstration facility



Real time simulation with hardware in the loop

Modelling of non-propulsion power systems

Complex systems multi-dimensional optimisation

Virtual modelling - Systems

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Smart, Connected and MEA – Key Technologies

Advanced landing gear systems

Thermal management

Actuation

Power-dense power electronics

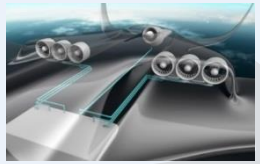
Scalable high bandwidth communications

Scalable electrical power systems and low power equipment with energy harvesting

Integrated sensor systems

Advanced cabin noise and vibration attenuation

Engine control systems (hardware and software)



Superconducting electrical systems

High performance energy storage and recovery

High integrity fault-tolerant solutions

Secure	Exploit	Position

2015 2020 2025 2030+

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AEROSTRUCTURES OF THE FUTURE

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Aerostructures of the Future

Key theme outcomes:

- Primary and secondary structural component leader
- Driving new materials formulation, component manufacture, assembly, & systems installation
- Factory of the Future IP for reconfigurable facilities
- Key player in highly efficient product development capabilities to minimise design, V&V, & industrialisation phases

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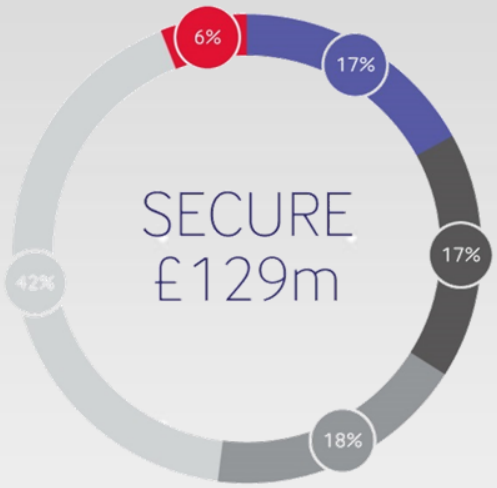
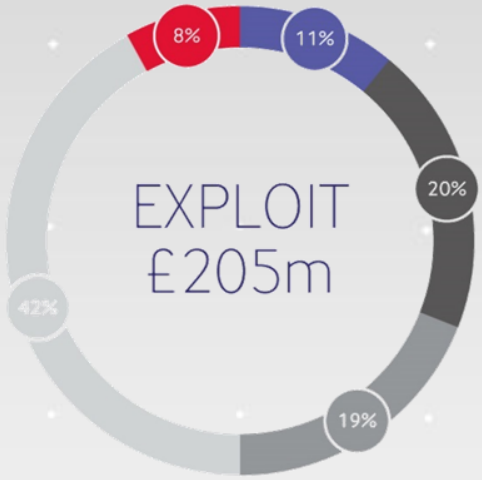
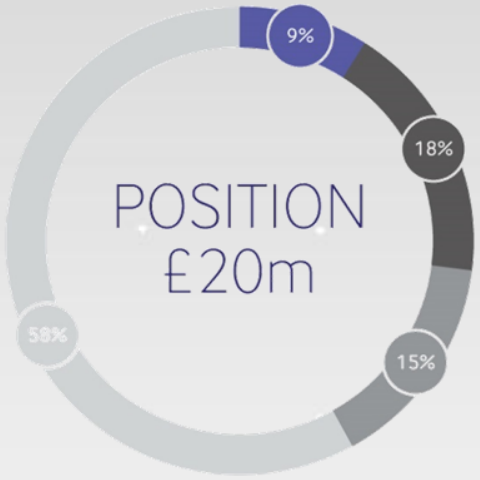
Aerostructures of the Future – Portfolio Summary







- Cost
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- Safety

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Aerostructures of the Future – New Architectures

Step change technology validation platform to maximise productivity

Test capability for integration

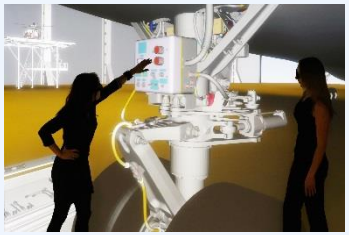
Disruptive conventional planform architectures

Next- gen technology validation platform

Functionally graded/ topologically optimised architectures utilising advanced materials

Next generation material formulation solution

Architectures on disruptive planforms



Secure | Exploit | Position

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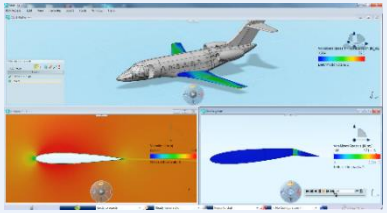
Aerostructures of the Future – Methods and Tools

In-line monitoring and process control for composite, metallic and hybrid material formulation and conversion



Predictive behaviour & performance analysis of materials

Advanced structural modelling and validation testing for components

Use of methodology to optimise energy consumption for manufacturing & assembly process

Integrate design, test and simulation toolsets

Virtual aircraft for structures, manufacturing, assembly

Secure | Exploit | Position

2015 | 2020 | 2025 | 2030+

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Aerostructures of the Future – Key Technologies

Advanced joining

Close coupled, simulation and physical test validation

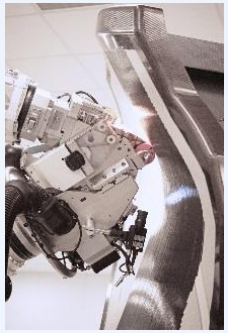
Productivity/ rate flexibility enablers

Novel joining technologies

Reconfigurable & intelligent automation (V&V + manufacture)

Multifunctional materials

Self-monitoring structures



Damage tolerant/ self-healing structures

Factory of the future – rapid reconfiguration utilising intelligent swarm automation

Secure | Exploit | Position

2015 — 2020 — 2025 — 2030+

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4

PROPULSION OF THE FUTURE

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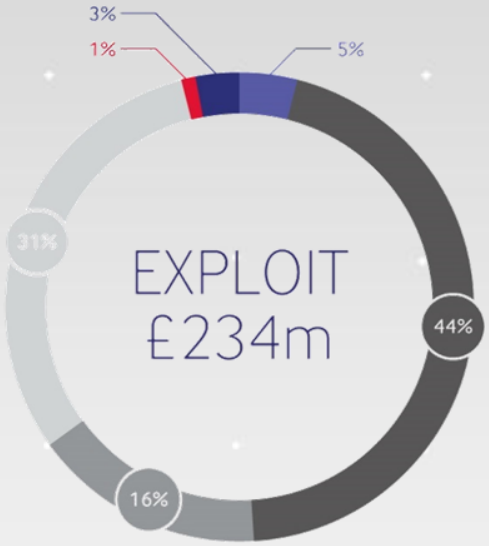
Propulsion of the Future

This theme encompasses the propulsion products and capabilities provided by UK businesses, specifically the technologies, tools, processes and facilities needed to develop and produce them.

Key theme outcomes:

- Realisation of large ultra-high bypass ratio (UHBR) turbofan engines
- Enhancing the integration of advanced propulsion systems onto aircraft
- Development of future hybrid turbo-electric propulsion systems

Propulsion of the Future – Portfolio Summary



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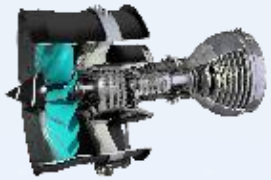
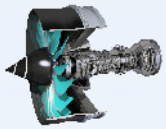
Propulsion of the Future – New Architectures



Lightweight fan system validation platform

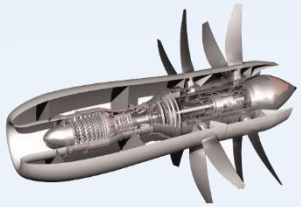
Advanced core demonstrator

UHBR geared turbofan

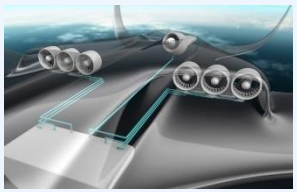


Lean burn combustion validation platform

Advanced propellers



Variable pitch for UHBR geared turbofan



Open rotor

Hybrid turbo-electric and distributed propulsion including flight test validation

Secure | Exploit | Position

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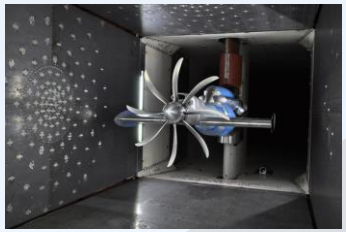
Propulsion of the Future – Methods and Tools

Improved manufacturing, measurement and inspection processes for gears



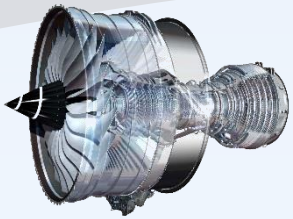
Prediction of noise sources for new architectures

Ice crystal engine test capability

Composites failure prediction models

Advanced multi-physics and multi-fidelity modelling

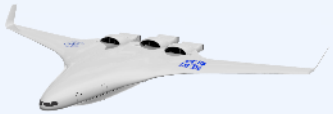
Virtual modelling – whole engine (thermo-mechanical)



Engine control modelling in real time

Complex thermodynamic cycle model validation

Boundary layer ingestion test capability



Secure | Exploit | Position

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Propulsion of the Future – Key Technologies

Environmental engine protection

High temperature turbines (CMCs, cooling)

Low loss engine air and oil systems

Automated assembly for propulsion

Integrated UHBR nacelle systems

Advanced cooling / heat exchanger

Active helicopter rotor blades, hub and transmission systems

Advanced powerplant transmissions, structures and drives

Joining dissimilar materials for propulsion

More electric propulsion systems

Advanced propulsion control strategies

Ultra-low emissions combustion systems

Secure	Exploit	Position

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