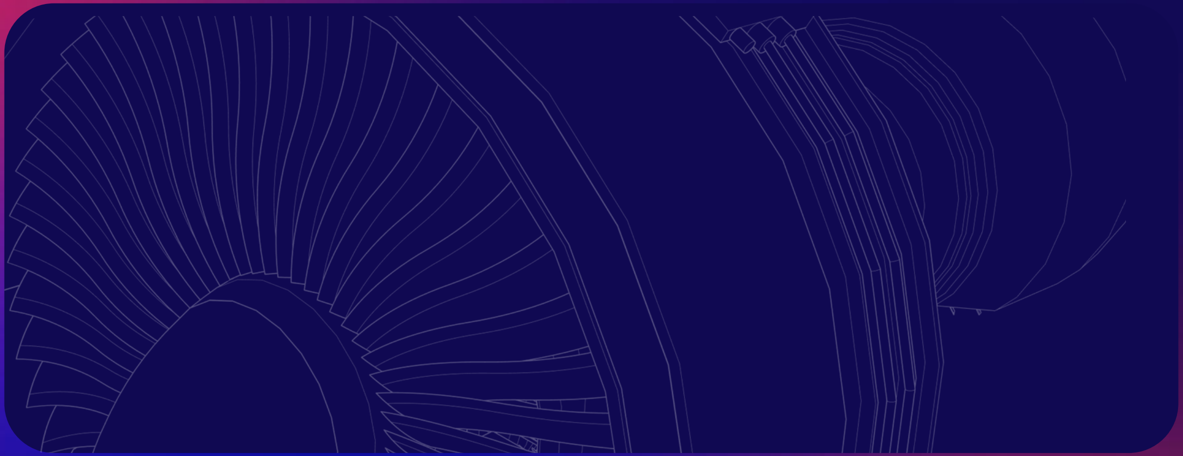
# ENGINEERING GROWTH IN AEROSPACE




**Jacqueline Castle**

Chief Technology Officer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Our vision for UK aerospace

# AEROSPACE IS AN ENGINE FOR SUSTAINABLE ECONOMIC GROWTH

Double the UK market from **$9 billion** to over **$18 billion** by 2035, creating high value jobs and global leadership in decarbonisation.

Our Mission

# TRANSFORMING AEROSPACE THROUGH TECHNOLOGY AND INNOVATION

- Strengthen UK competitiveness
- Increase content on next generation aircraft
- Reduce aerospace environmental impact through innovation

# ENGINEERING GROWTH: Delivering next generation aircraft technologies

- This UK national aerospace technology strategy provides an independent assessment of:
  - the market opportunity for the UK aerospace sector;
  - the aircraft and industrial technologies that need to be developed and matured for next generation programmes;
  - the investment priorities for our sector, including through the ATI Programme.

# NEW STRATEGY, BOLD VISION

## 2× Growth

In 2024, government and industry set out an ambitious plan to double the UK share of the global aerospace market by 2035.

## 3Gt

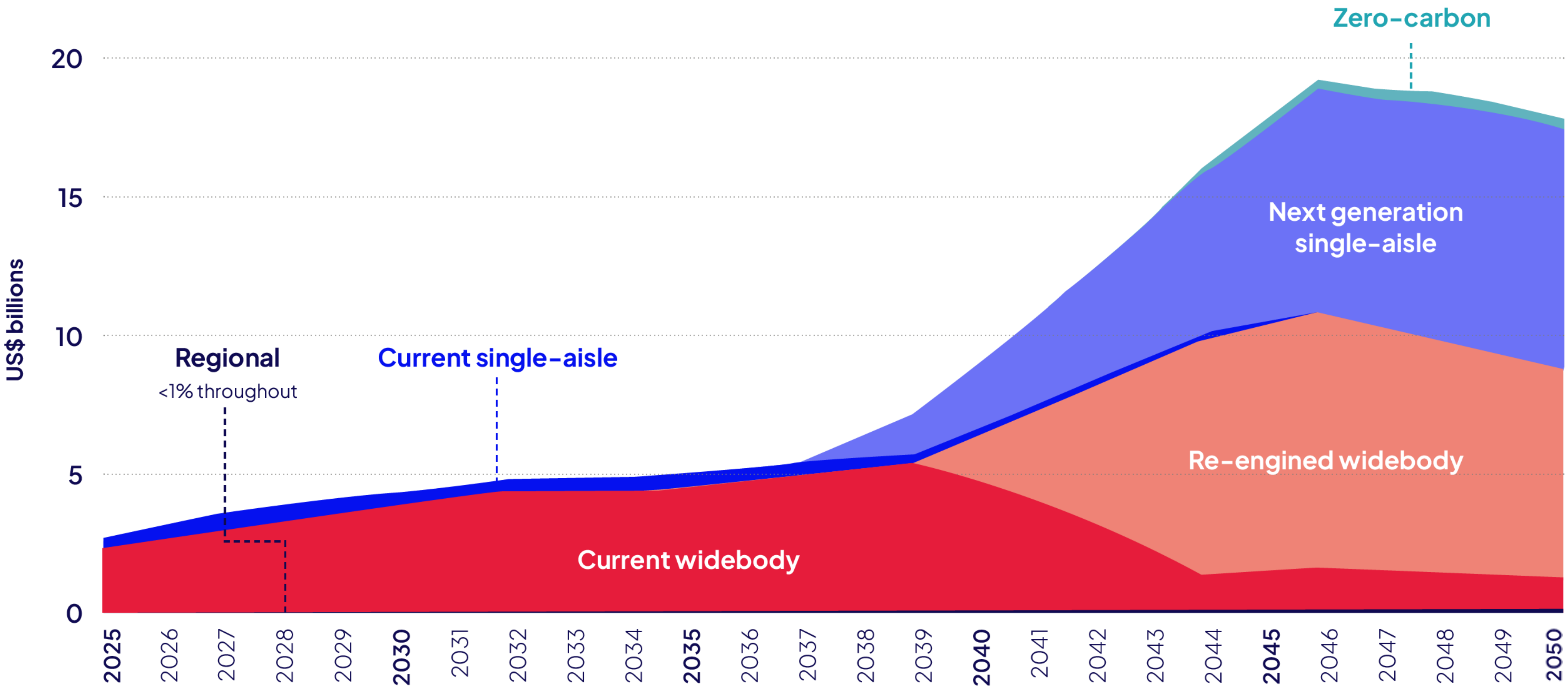
New aircraft technology and operational improvements have the potential to avoid 3Gt of carbon emissions by 2050 and 16Gt by 2070.

## £8bn

By 2035, the ATI Programme will have invested £8 billion of joint government industry funding in UK aerospace.

# PROPULSION

An opportunity to increase the total value of UK propulsion by a factor of six over the next 25 years to over $17 billion

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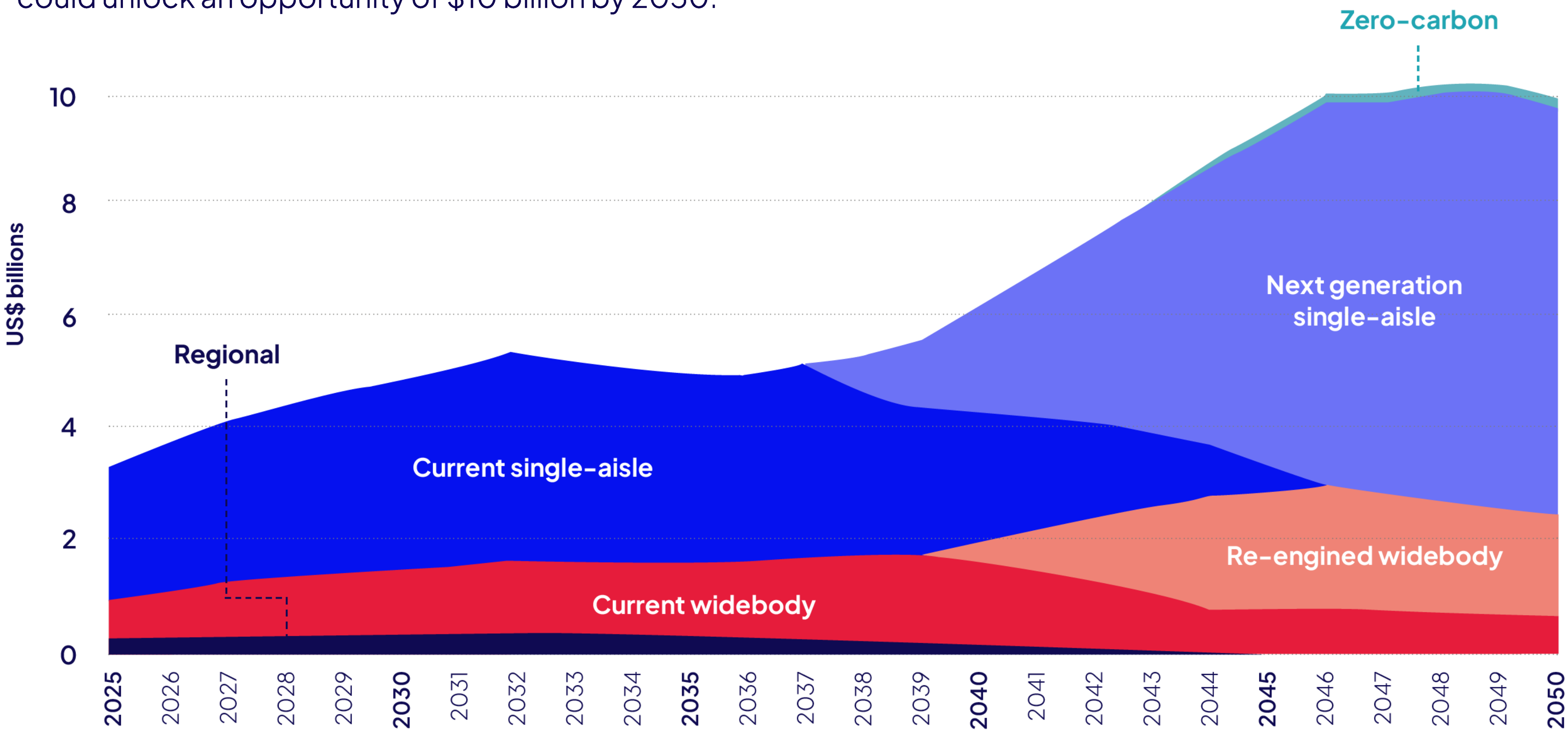
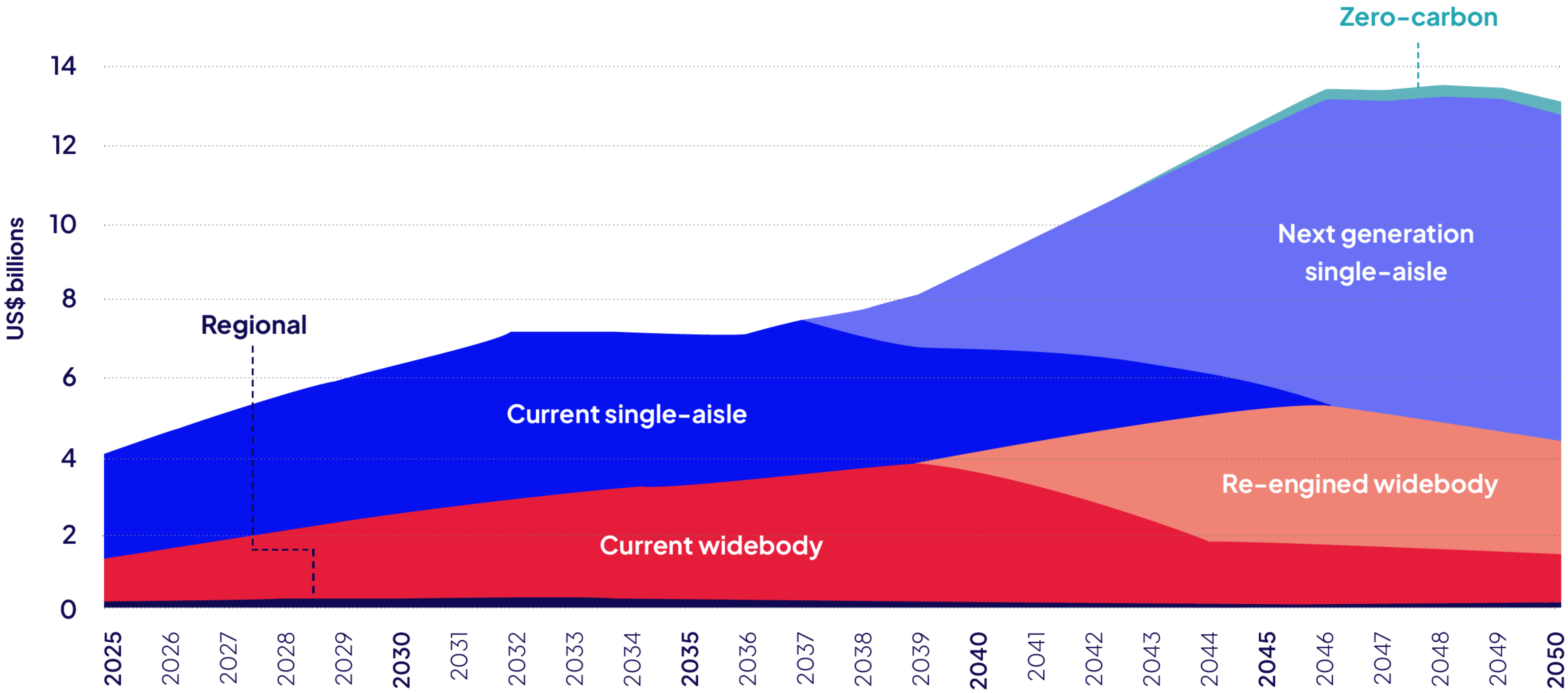
# AEROSTRUCTURES

Retaining UK workshare and growing the industrial supply chain could unlock an opportunity of $10 billion by 2050.



# AIRCRAFT SYSTEMS

The UK's diverse systems capabilities provide an opportunity to increase Original Equipment market value to $13 billion by 2050

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# ULTRA-EFFICIENT TECHNOLOGIES ROADMAP

2025 | 2030 | 2040 | 2050

## PROPULSION

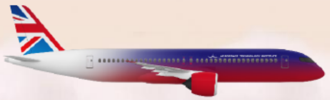
- Gas turbine durability
- High-pressure ratio small core
- Low-noise propellers and open fans
- Scalable, high power gearbox
- MW hybrid systems
- More-electric gas turbine
- Durable materials
- Alternative gas turbine architectures
- Advanced controls
- Low-noise propulsion and nacelle architectures
- Low-speed composite fan
- MW scale distributed power system architectures
- Low-emissions combustor
- High-temperature materials and coatings
- Alternative fuels gas turbine enablers and architecture
- Auxiliary power generation

## ADVANCED SYSTEMS

- SAF compatible materials and fuel system components
- Fuel systems
- High power density non-propulsive electrical machines
- AI-enabled onboard systems
- Electrical actuation systems
- More-electric, lightweight landing systems
- Fibre-optic and photonics based avionics
- Advanced systems for novel airframe configurations
- High-voltage power systems
- Cyber-secure avionics
- Cabin experience and connectivity
- Quantum-enabled avionics
- Bleed air-driven environmental control system
- Bleedless environmental control system
- Lightweight sustainable interiors
- High-integrity lightning strike protection
- Low-power ice detection and protection

## AEROSTRUCTURES

- Future wing and airframe configurations
- Folding wings and semi-aeroelastic hinges
- Airframe / propulsion integration
- Propulsion integration for new configurations
- High-aspect ratio wings
- Moveables and structures
- Load alleviation and flutter suppression
- Wing assembly and major component production
- Large thermoplastic aerostructures
- Low-drag surface materials
- Laminar flow structures and devices



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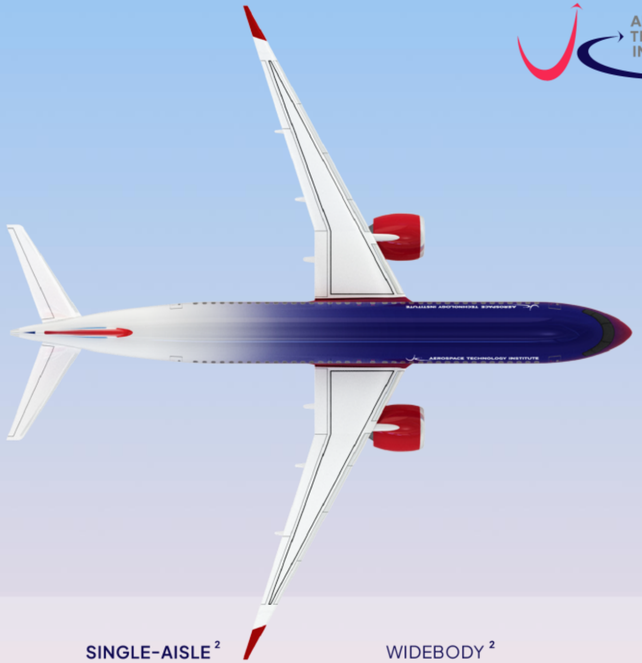
# ULTRA-EFFICIENT TECHNOLOGIES ROADMAP

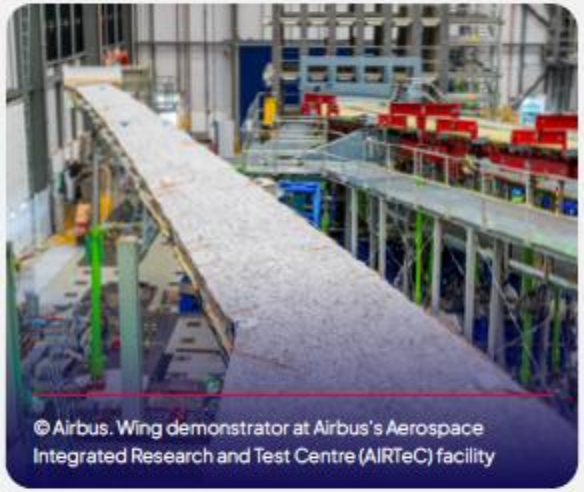
The ultra-efficient roadmap defines the technologies required to enable major fuel burn and emissions reductions including aerodynamics, propulsion, lightweight structures and systems. These technologies leverage national strengths, especially in engine and wing design, to boost competitiveness, deliver future aircraft performance and power growth.



## KEY DELIVERABLES

- **World-leading** next generation wing architecture and technologies
- Wing **high-rate production system** demonstrators
- **Next generation engine performance** and production rate demonstrators
- **Systems electrification** and **lightweighting technologies**
- **Hybrid engine** ground and flight demonstrators
- **100% SAF enabled** propulsion and airframe
- **Cyber-secure** future systems and avionics

| TARGETS[1] | SINGLE-AISLE[2] | WIDEBODY[2] |
|---|---|---|
| Fuel burn[3] | -25% | -20% |
| Aircraft weight[4] | -20% | -12% |
| Aircraft drag | -10% | |
| Engine time on wing[5] | 10,000 Cycles | 3,000 Cycles |
| Noise[6] | -65% | |



© Airbus. Wing demonstrator at Airbus's Aerospace Integrated Research and Test Centre (AIRTeC) facility

© Rolls-Royce's scalable ultra-high-bypass-ratio turbofan demonstrator, UltraFan®, has run to full power at Testbed 80 in Derby, paving the way for next generation opportunities.

*1: Targets are relative to the latest generation of in-service aircraft for each market segment*
*2: Clean-sheet new aircraft architecture*
*3: Fuel burn improvement is a combination of improved engine efficiency, aircraft weight and drag reductions. Values are taken from the ATI SAFAM and WiFAM aircraft models against their respective reference models (for more information, see the ATI toolkit).*
*4: Aircraft structural and systems mass*
*5: Equivalent cycles based on reference mission profile*
*6: Reduced perceived noise per aircraft operation by 2050 vs 2000s platforms in accordance with ACARE and ICAO goals.*

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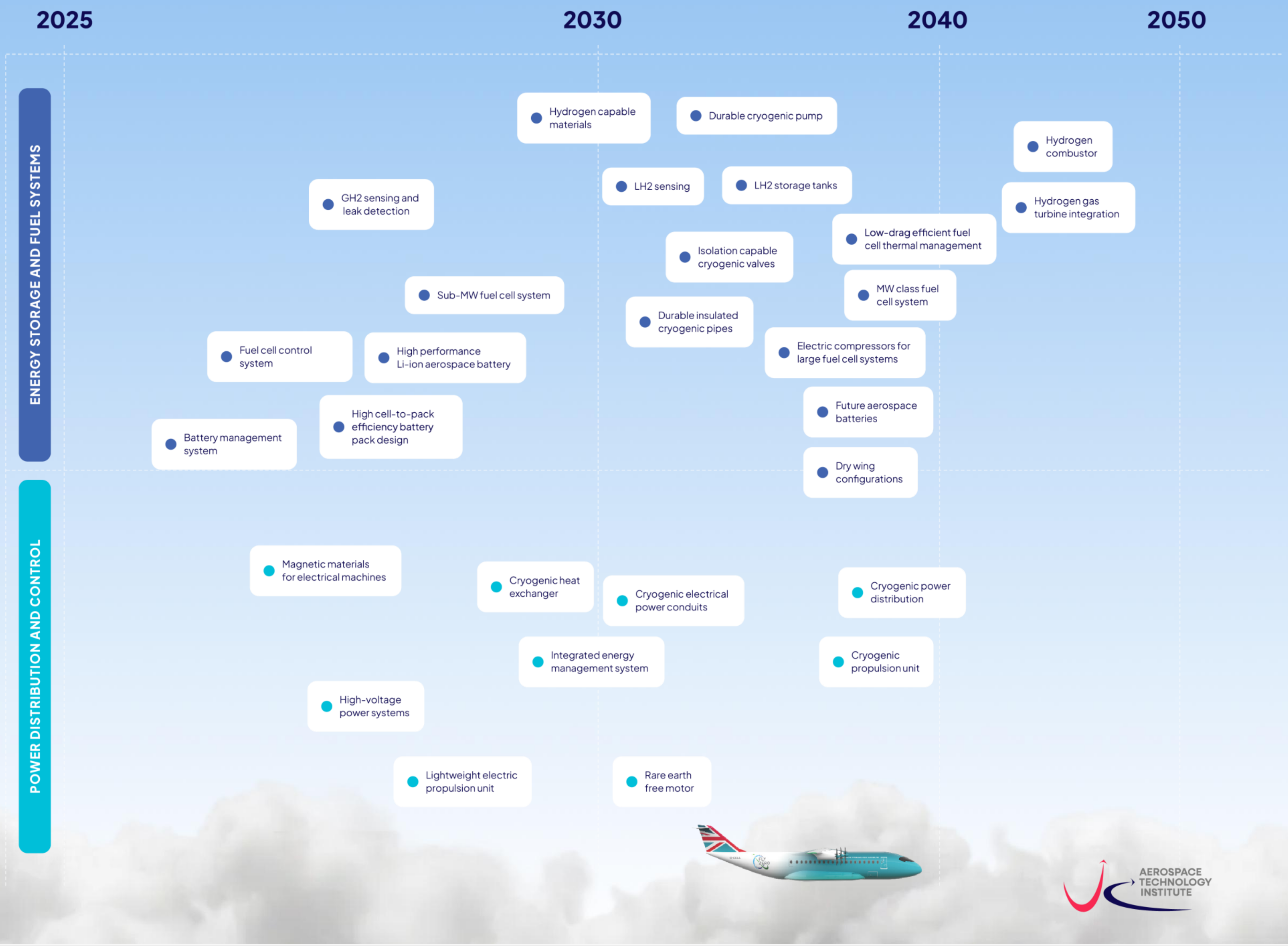
# ZERO-CARBON TECHNOLOGIES ROADMAP

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# ZERO-CARBON TECHNOLOGIES ROADMAP

The UK drives revolutionary research to secure long-term competitiveness in breakthrough technologies such as high-power electrification and hydrogen. The Zero-Carbon Technologies Roadmap defines the technologies needed to build on current progress and sets development milestones through 2050.


## KEY DELIVERABLES

- **Cryogenic fuel system** demonstrators
- Optimised **dry wing** design
- **Qualified materials** for cryogenic and hydrogen environments
- **Megawatt (MW) fuel cell** system demonstrator
- MW class **electrical power distribution** system demonstrator
- Cryogenic **electric propulsion** demonstrators

| TARGETS | 2030 | 2045 |
| --- | --- | --- |
| Fuel cell system performance | 2.5kW/kg | >5.0kW/kg |
| Aerospace battery energy density | 250Wh/kg | >500Wh/kg |
| Electric propulsion unit performance (MW plus scale) | 10kW/kg | 15kW/kg |
| Cryogenic H2 tank gravimetric efficiency | 40% | 75% |
| Electrical power system architecture | High-voltage | Cryogenic |

© Safran's ENGINeUS™ 100 electric motor, supported by projects AEPEC and SMPP, became the first electric motor certified by the European Union Aviation Safety Agency (EASA) to power new air mobility, with rotor and stator production in Pitstone.

# INDUSTRIAL COMPETITIVENESS TECHNOLOGIES ROADMAP

2025 | 2030 | 2040 | 2050

## ADVANCED MATERIALS

- Rapid validation and qualification of novel alloys and processing
- Life and performance enhancing coatings
- Resilient composites
- Metal matrix composites for high loads
- Sustainable composite matrices for high-rate production
- Efficient qualification of new materials
- Sustainable alloys and composites
- Integrated material supply chains
- Performance enhancing hybridised materials

## DESIGN & VALIDATION

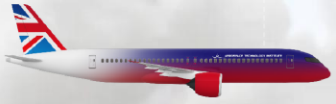
- High-fidelity, rapid design and simulation methods
- Aerodynamic and aeroacoustic testing
- Aero and noise simulation for novel architectures
- Methods for composite and metallic architectures
- Automated, data-enabled, design for X tools
- Icing modelling and analysis
- Rapid product qualification and certification
- Quantum in design and simulation
- Trusted AI in design and validation
- Multiphysics design tools
- Integrated intelligent structures
- Advanced design and manufacturing of unitised structures

## ADVANCED MANUFACTURING

- Joining of materials
- Evaluation and real time data analytics
- Rate-enabling subtractive manufacturing
- Sustainable composite and metallic processing
- Rate-enabling equipment, tooling and jigs
- Determinate assembly for large aerostructures
- One-way assembly and enablers
- High-rate assembly and disassembly of propulsion and systems
- Rapid large volume metrology
- High-rate manufacturing systems
- Scalable near net shape metallics
- Rapidly adaptable manufacturing lines
- Digital manufacturing and supply chains
- Autonomous connected facilities
- Extended laminar flow manufacturing technologies

## THROUGH-LIFE SUPPORT

- Material-to-product operational digital passport
- Prognostic and health management
- Tools and processes for maintenance productivity
- AI assisted assessment and decision
- Repair methods for advanced materials
- Composites and metallics recycling



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# INDUSTRIAL COMPETITIVENESS TECHNOLOGIES ROADMAP

Industrial competitiveness technologies are essential to realise the ultra-efficient and zero-carbon aircraft sustainability and economic benefits and maximise UK aerospace's growth. The roadmap defines research priorities to deliver the advanced materials, design methods and competitive manufacturing processes necessary to scale to meet rising production demands and advanced products for next generation aircraft.

©University of Sheffield AMRC's Composites at Speed and Scale (COMPASS) open access innovation facility, part of the High Value Manufacturing Catapult

| TARGETS | 2030[1] | 2045[1] |
|---|---|---|
| Gross value added per employee [2] | +15% | +80% |
| Resource intensity in manufacturing [3] | -10% | -60% |
| Rate capability for single-aisle [4] | 75 | 100 |
| Design and manufacturing lead time [5] | -10% | -50% |

1: Targets are relative to the 2025 baseline year.
2: Percentage increase in Gross Value Added (GVA) per employee on an annual basis. Calculation aligns with UK national productivity methodology.
3: Resources include material input, energy and time.
4: Monthly single aisle aircraft production rate targets for Airbus and Boeing.
5: Targets reflect consolidated stakeholder ambition. Lead time encompasses full design, engineering, and manufacturing cycle reduction.

# NON-$CO_2$ TECHNOLOGIES ROADMAP

2025 | 2030 | 2040

## FUEL CHARACTERISTICS (FOSSIL, SAF, H2 OR ALTERNATIVES)

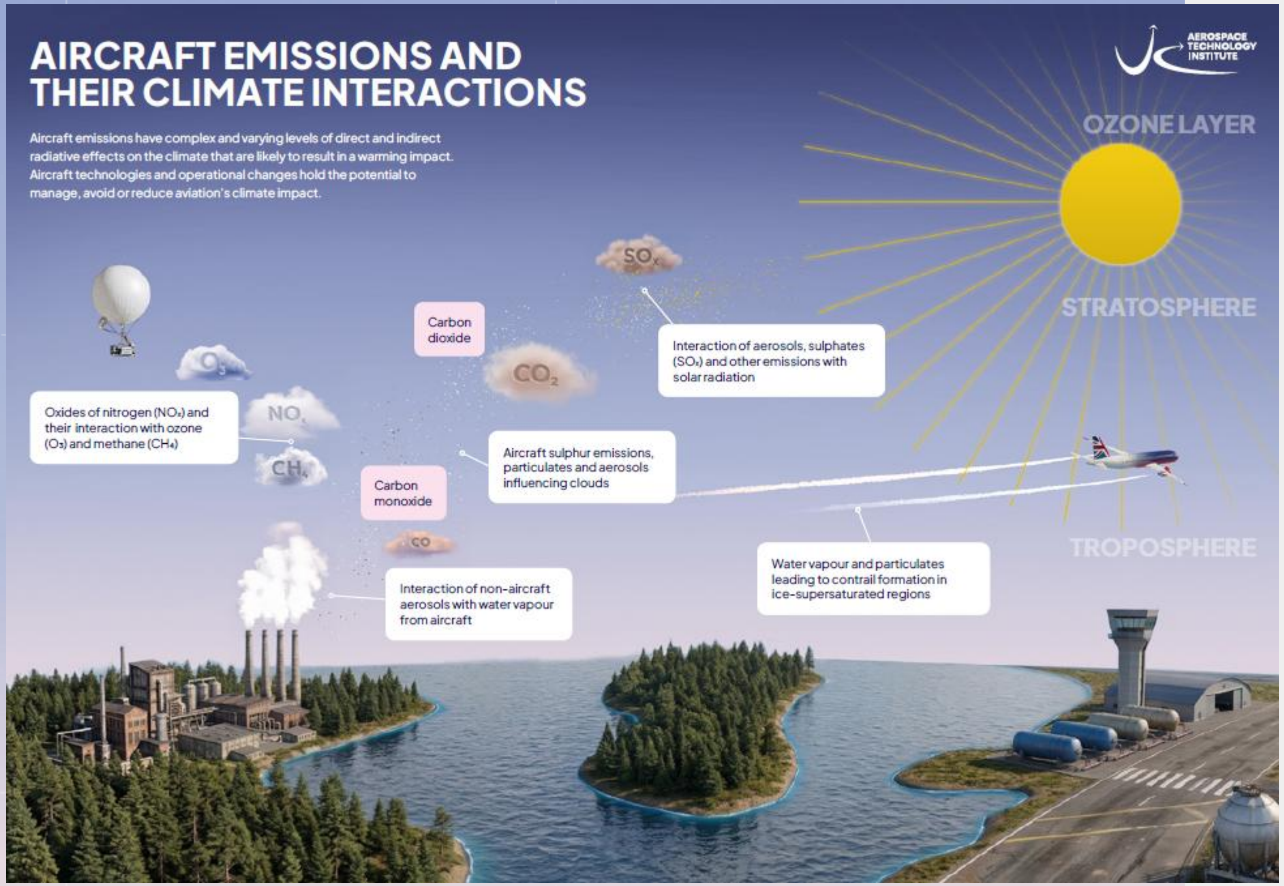
- Modelling / testing of fuel hydro treating / de-sulphuring influence
- Modelling / testing of SAF particulates influence
- Modelling / testing of fuel aromatic content influence
- SAF pathways data for trade studies
- Drop-in versus non-drop-in SAF data for trade studies
- Modelling / testing of optimal SAF blends utilisation logic
- Modelling / testing of hybrid fuels utilisation logic

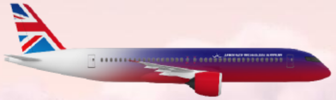
## AIRCRAFT TECHNOLOGIES

- Emission management instrumentation
- Water vapour release systems and controls
- Engine combustion
- Engine controls
- Fuel management technologies for hybrid and dual fuel systems

## KNOWLEDGE, DATA & OPERATIONS

- Data to inform particle size as nuclei for contrails
- Modelling / testing of $NO_x$ at cruise altitude
- Modelling / testing of water vapour from $H_2$ combustion
- Modelling / testing of water vapour from $H_2$ fuel cells
- Modelling / testing of combustion correlation with contrails
- Through-life modelling of emissions
- Climate data to understand $CO_2$ and non-$CO_2$ trades
- Data management systems for flight operations
- Operational testing / implementation based on findings



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# EXPLORE THE INTERACTIVE TECHNOLOGY ROADMAPS

# INVESTING FOR UK AEROSPACE

## 2030

The UK must prepare for the launch of a next generation programme at the end of the decade

Wings and engines represent the biggest levers for improving efficiency and reducing emissions

Maximising UK value relies on increasing competitiveness

Technology, regulation and infrastructure need to be developed at the same pace

# THANK YOU