AEROSPACE TECHNOLOGY INSTITUTE

# Annual Review

2020/21

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# INTRODUCTION

Flight is critical to the UK: for trade, jobs, family ties and – vital for an island nation - links to the rest of the world. It is through the ATI that UK government and industry come together to tackle the principal issue facing flight in the future: decarbonisation. This is both a challenge and an opportunity and the UK, with its technical capability and research base, is well positioned to meet both.

The complexity of aviation development, the scale of funding required, the length of time needed to qualify new technologies and the global environmental imperative means private investment in aviation decarbonisation is best accompanied by government funding. The ATI brings strategic direction, technical expertise and independence of thought to this process, working with industrial and government partners to build competitiveness across the UK in the aviation of the future.

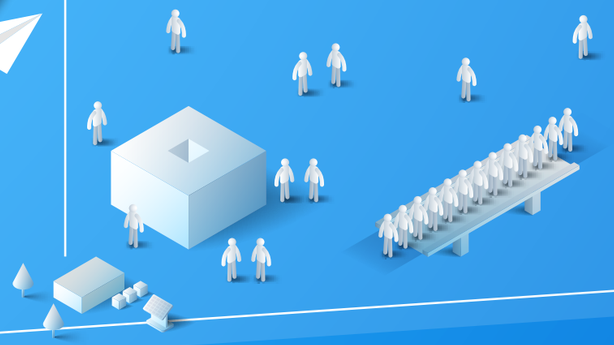
The Institute, established in 2013, has a strong track record. It has led ambitious R&D projects notably in the critical areas of propulsion and wings. It engages across UK manufacturing, academia and research to stimulate R&D activity and encourage innovation. Funded projects are chosen with Innovate UK and the Department for Business, Energy and Industrial Strategy (BEIS). Investment of around £300m per year is committed to 2026, with an extension to 2031 indicated. Total funds committed since inception now exceed £3.2bn, the latest benefits of which are set out from page 14. The Institute also works alongside key industry fora including the Aerospace Growth Partnership and the Jet Zero Council, providing thought leadership on all aspects of the future of flight.

The ATI sets a strategic agenda for aviation development and engages with the UK's research, academic and industrial partners to deliver it. With the overall goal of delivering economic benefits across the UK, the ATI funds a wide range of collaborative projects, the details of which are set out in this report. Thought leadership activites are delivered through in-depth studies such as 2021's FlyZero and the Boeing Accelerator programme along with regularly published INSIGHT papers which can be read at **www.ati.org.uk**.

# THE ATI: FULFILLING A UNIQUE ROLE

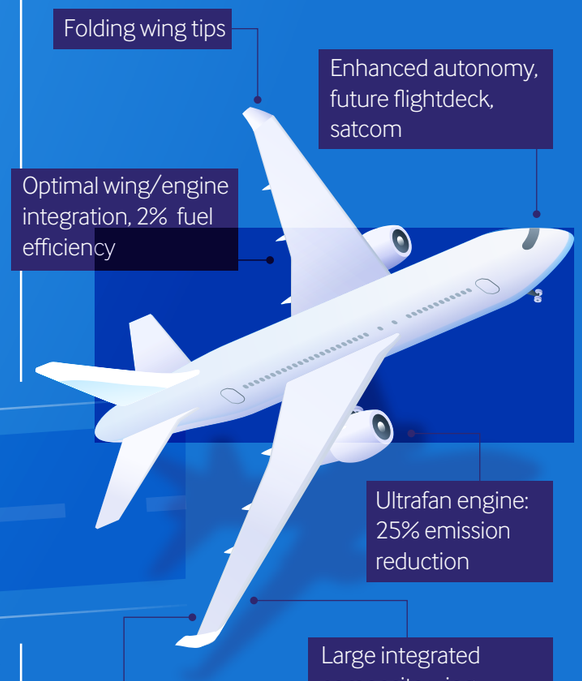
## THOUGHT LEADERSHIP

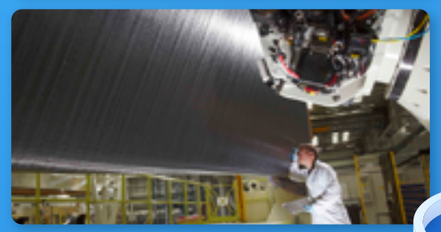
## ENGAGING THE GOVERNMENT/INDUSTRY/ ACADEMIA ECOSYSTEM



## REALISING FUTURE MOBILITY

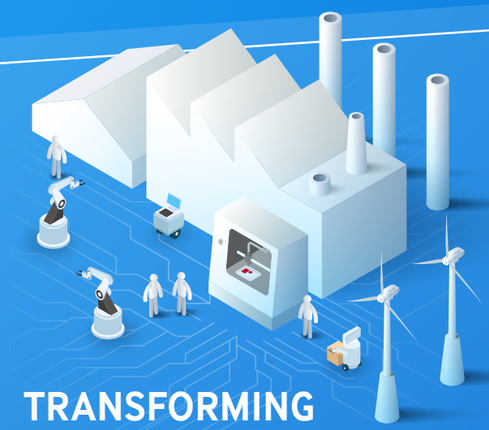
## MAKING AIRCRAFT MORE SUSTAINABLE



## CEMENTING THE RESEARCH BASE

+ Funding world-class open-access facilities
+ Developing the research base



## TRANSFORMING COMPETITIVENESS

+ Investing in highly automated digital manufacturing focused on sustainability

## DELIVERING ECONOMIC PROSPERITY ACROSS THE UK

## ACCELERATING THE PACE OF INNOVATION

ATI Boeing Accelerator

+ World's first civil aerospace accelerator

FLY ZERO

+ A unique collaborative project for zero-carbon aircraft

# HIGHLIGHTS OF THE YEAR


**Thought Leadership**
Publications on sustainability, advanced manufacturing and electrification.

FLY ZERO AEROSPACE TECHNOLOGY INSTITUTE

**FlyZero**
The FlyZero project engaged 100 experts from UK industry and transformed our understanding of zero-carbon-emission flight. The findings were published for the benefit of the UK aerospace sector.

**Infrastructure**
Investment in infrastructure continued with the official openings of GKN's Global Technology Centre, Rolls-Royce's Testbed 80 and Airbus's **AIRTeC** facility.

**Jet Zero Council**
The ATI took a leading role as a member of the UK government's council to further sustainable aviation.

**Project Milestones**
First flights of **HyFlyer** (ZeroAvia) and Rolls-Royce's **ACCEL** aircraft.

**ATI Programme Portfolio to Date**

**376** PROJECT PARTNERS

**81,000** JOBS SECURED

**£3.2bn** TOTAL FUNDING

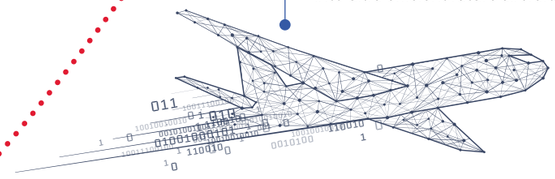
**Wing of Tomorrow**
Components for the first full-size demonstrator were delivered and assembled at AMRC Cymru.

ATI Boeing Accelerator

**ATI Boeing Accelerator**
The second cohort of startups successfully completed the programme.

**Regional Engagement**
Engagement continued with SMEs and local authorities in all regions of the UK.

**Modelling**
The ATI's modelling capability developed two single aisle and widebody models to provide insight into ultra efficient future aircraft.



**Equality, Diversity, and Inclusion**
ATI employees started a focus group to champion EDI issues and continue to uphold the ATI's commitment to the Women in Aviation and Aerospace Charter.

**International**
We engaged with the Netherlands, Canada and Germany and held an information day for EU funding.

**Spending Review Submission**
ATI submitted comprehensive case for future investment with robust economic and environmental data.

# CHAIRMAN'S FOREWORD

2020/21 has been an active year for the board. The sustainability of flight agenda has led to a surge in research and development in the industry and academia, as well as considerable focus from government. This has put the ATI centre stage as an independent body coordinating research in the sector and providing advice to the government. It has also created a full agenda for the board. The FlyZero project – described on pages 10-11 – has temporarily expanded the Institute by some 100 staff and enhanced its thought leadership credentials with industry, government, and the public at large. The pace of change in recent months, driven by FlyZero, CoP 26 and other developments has also highlighted the need for a fresh technology strategy for UK aerospace. This will be published in April 2022.

A primary board responsibility is to secure long-term funding for the organisation and its technology programme. The need for this has been highlighted as the scale and pace of research required to deliver zero-emission flight has become apparent. The ATI drew up a comprehensive and evidenced submission to the government's 2021 spending review, enabling the Institute to reiterate the fundamental value of R&D to aerospace and the UK economy at large; to quantify the potential benefits for the UK if it takes a leadership role in decarbonising aviation; and to clarify the consequences if we fail to take the initiative in a competitive world.

Delivering ambitious R&D projects and future strategies requires close teamwork with other organisations, and I am grateful to colleagues at the Aerospace Growth Partnership (AGP), the Department for Business Energy and industrial Strategy (BEIS) and Innovate UK for their support. This year has also seen broader links with the Department for Transport. Thanks also to the members of the advisory groups which give valuable support to the Institute by bringing different perspectives and challenge to our thinking. Our output would be much less rich without their contribution.

Finally, I am grateful to my fellow board members, whose commitment and input are so vital to the ATI's success. My thanks and best wishes go to our three independent directors Michael Harper, Deborah Keith, and Scott Tolson, whose tenures came to an end this year. All have played a crucial role on the board, on subcommittees and in offering advice to the executive. Michael and Deborah joined in the early years of the ATI and have done much to shape the organisation. In their place I am delighted to welcome Janet Collyer, Paul Everitt, and Ben Stocks. All bring a wealth of valuable experience to the ATI.

**Stephen Ball**
Chairman, ATI



# CHIEF EXECUTIVE'S FOREWORD

Aviation is transforming. Environmental concerns, Covid-19, and disruptive technology are changing the industry before us. The ATI is at the heart of this, influencing how aviation responds and how UK aerospace can adapt and prosper.

A good example was our FlyZero project which demonstrated the feasibility of carbon-free flight and unveiled three concept aircraft, one capable of flying 280 passengers up to 5,250 nautical miles. FlyZero has gained the interest of industry, academia, international partners, and the public. It has enhanced UK expertise, established new relationships for the ATI, and changed how the Institute works.

The ATI technology programme is reviewed on pages 14-29. Total funding reached £3.2bn to September 2021, up £300 million since September 2020, half from the government, half from industry. Twenty-seven new projects were started in year, with 198 projects live during the period. Our zero-emission flight portfolio saw exciting developments: ZeroAvia's hydrogen fuel cell-powered aircraft had its maiden flight, and Rolls-Royce's Spirit of Innovation became the world's fastest electric aircraft. We invested in important new R&D infrastructure, including Airbus's wing integration centre, GKN's technology centre, and Rolls-Royce's Testbed 80 – the largest in the world.

The ATI budget became virtually committed this year as the Institute approaches the end of its first phase in 2026. Consequently, a comprehensive submission was prepared for the government's spending review, revealing high ambitions in UK industry and academia to lead global efforts to decarbonise flight. Realising this would generate significant economic growth throughout the UK.

The ATI continued to stimulate fresh thinking. Our INSIGHT paper on sustainability demonstrates the scale and complexity of the environmental challenge, and we have developed new approaches and opportunities on additive manufacturing, tooling and forging. We have contributed to many public consultations, notably on decarbonisation. We are active in the Jet Zero Council (see page 12), and participate in other fora at regional, national and international levels. Looking ahead, we are updating our technology strategy (see page 12) and wider aviation thought leadership (see page 13).

Internally, the executive management team this year welcomed Nazia Hirjee as chief operating officer, Sophie Lane as chief relationships officer, and Harry Malins as chief innovation officer. They bring professionalism and fresh thinking, improving our diversity of thought and challenging the status quo. We have improved our focus on equality, diversity and inclusion, working with consultants to provide training and advice. IT systems have been updated to improve security and a team has considered the ATI's own carbon footprint. The Institute is stronger as a result.

I want to thank Stephen Ball and the board for their support; colleagues at the Department for Business, Energy and Industrial Strategy (BEIS) and Innovate UK for their partnership; and officials at the Department for Transport for their engagement. Most of all, I thank the ATI team who have shown resilience, imagination, patience and good humour in a challenging year.

Finally, I must thank James McMicking who left the ATI recently. James was with the Institute from its inception in 2014 and his influence can be seen in everything we do. We wish him all the best in his new role.

**Gary Elliott**
Chief Executive, ATI

**FlyZero was a £15m in-depth project to assess the feasibility of zero-carbon transatlantic flight by 2030. One hundred specialists were seconded into multi-disciplinary teams from across industry to develop the project and build the UK's decarbonisation expertise. The conclusions have been published and are available on the ATI website.**

The project team found that zero-carbon-emission flight will be feasible for large commercial aircraft and could begin commercially in the mid-2030s. For the interim, sustainable aviation fuel (SAF) will be needed, but green liquid hydrogen will be the principal fuel for zero emissions in the longer term.

Three concept aircraft were developed by the project: a smaller aircraft powered by hydrogen fuel cells; and two larger models, narrowbody and midsize, that would use gas turbines for propulsion. The midsize concept would be capable of flying 280 passengers 5250 nautical miles, putting all points in the world within one-stop range. The model shows that such an aircraft would offer significant environmental benefit, delivering carbon abatement of 4 gigatons (around four times current global annual aviation emissions) by 2050. The FlyZero team found that the UK aerospace supply chain is well placed to contribute to both hydrogen and SAF propulsion.

The results and findings of FlyZero are published as a series of detailed reports covering technology; fuels; aircraft concepts; commercial and market considerations; opportunities for the UK; and findings from offload work packages commissioned through UK industry and academia. These are available on the ATI website at **www.ati.org.uk/flyzero**. Regional roadshows to disseminate the results will commence in April 2022.

# FLYZERO CONCLUSIONS AND RECOMMENDATIONS: A SUMMARY

## CONCLUSIONS

1. Green liquid hydrogen is the optimum zero-carbon energy source for large aircraft and is expected to be cheaper than SAF from the mid-2030s, although SAF has an important interim role.
2. Zero-carbon-emission aircraft could occupy the regional, narrowbody and midsize markets. FlyZero has produced concept designs for all three. The midsize could reach all destinations with one stop. If introduced in the 2030s it could start a process to reduce cumulative $CO_2$ emissions from aviation by 4 gigatons (Gt) by 2050 and 14 Gt by 2060.
3. Technology breakthroughs are required in hydrogen fuel systems, tanks, gas turbines, fuel cells, electrical propulsion systems, aerodynamic structures and thermal management. Further research in climate science is also fundamental. New global aircraft certification and health and safety regulations will also be required.
4. By leading, the UK could grow its market share in civil aerospace by 2050 from 12% to 19%, its GVA from £11bn to £36bn and aerospace jobs from 112,000 to 154,000. Failure to act could see market share reduce to 5%, with £14bn GVA and 74,000 jobs.

## RECOMMENDATIONS

1. Industry and government should expedite the entry into service of large zero-carbon-emission aircraft. Industry should focus on technology and government on infrastructure and regulation. Urgent investment in technology and green energy infrastructure is required. SAF should be rolled out in the 2020s and early 2030s.
2. ATI and BEIS should create strategic mission-led R&D programmes to maximise UK capability and supply chain participation, and broker international collaboration to accelerate technology development.
3. Critical technologies must reach technology readiness level (TRL) 5-6 by 2025 to ensure that UK equipment is on the first liquid hydrogen-powered aircraft. Stimulating industry access to private finance would also support developments.
4. A cross-sector open-access hydrogen technology centre should be created to facilitate research into fundamental hydrogen behaviour, providing a centre of excellence for UK industry.
5. Incentives, pricing, and taxation to encourage sustainable aviation should be considered, along with using aviation tax or levy receipts to support zero-carbon aircraft developments.

# THOUGHT LEADERSHIP

Offering independent, expert thought leadership is a critical part of the ATI remit. We seek to maximise the creative and technological potential of the sector - making connections, enabling information sharing, fostering collaboration, and developing the culture of innovation. Through our relationships with industry and government, we connect the ecosystem, shape ideas, influence support networks and catalyse action with strategic impact.

FlyZero has been a good example of this, as was the Institute's campaign to connect the UK's tooling community, beginning with a nationwide capability survey followed by an online event to discuss the current and future tooling requirements in the sector. The event successfully linked suppliers with end users, with one Tier 1 supplier saying: "Some of the gaps we felt the UK had might not be as big as previously thought." Delegates were also offered B2B meetings and an entry in a tooling directory, which is available on the ATI website and will be further developed in 2022.

Thought leadership continued with two new INSIGHT papers, setting out a sustainability framework to guide investment into R&T projects offering potential sustainability solutions for air transport and a deep dive into near net shape technologies. A joint report into the challenges and opportunities for airports to host and enable hydrogen aircraft was developed with Airports Council International. Electrification of aircraft was explored in a joint report with Warwick Manufacturing Group. These multidisciplinary themes have also been examined by FlyZero. Visit **www.ati.org.uk** to view and download our publications.


# ATI AND THE JET ZERO COUNCIL

The Jet Zero Council, announced by the UK government in June 2020, brings together ministers and industry leaders to identify the wider issues in zero-emission flight. Emma Gilthorpe (COO Heathrow Airport) was appointed chief executive of the Jet Zero Council in March 2021. The Council has two main delivery groups: one for sustainable aviation fuels (SAF); and one for zero-emission aircraft. The ATI's CEO Gary Elliott is a Council member and leads the direction on zero-emission aircraft.

The Jet Zero Council allows senior aviation stakeholders in both government and industry to identify and discuss whole-system developments (including in aircraft, airports, fuel supplies, and air traffic) needed for zero-emission flight. Its early focus has been on the underpinning policies required to establish SAF manufacture and usage in the UK; and it is starting to consider issues around hydrogen infrastructure.



# FUNDING TO 2031 AND BEYOND

As the ATI has shown since 2013, the UK aviation industry can thrive with consistent government/industry investment, and the Institute recognises the importance of participating in periodic reviews of its purpose and expenditure.

Aerospace in the UK employs 265,000 staff (both directly and indirectly) and generates annual revenues of £25bn, virtually all of which is exported. Key regional centres include those in North Wales, Bristol, Derby, Belfast, East Lancashire and Ayrshire.

In its 2021 spending review submission the ATI argued that while flight decarbonisation is a global challenge, it represents a significant opportunity for the UK's academic, research and industrial base. The ATI was able to show an appetite amongst its partners to co-invest up to £650m per year in programmes focused on new forms of propulsion; more efficient aircraft design; and more fuel-efficient systems. Subsequent industrialisation would increase this level of private investment by a factor of 10.

The Institute showed that fully enabling the potential of the UK could increase aerospace's gross value added to the UK economy from around £8.4bn today to over £37bn by 2050 and create a further 120,000 high-value jobs. UK leadership could accelerate global adoption of zero-carbon aircraft by driving progress in critical technologies, with UK technology capable of delivering up to 18% of the global $CO_2$ savings possible in civil aviation.

The UK government has indicated that it will extend funding for the Institute from 2026 to 2031. It has also awarded £685m to the ATI Programme from 2022 to 2024. This is a welcome development for this long-term sector.

# TECHNOLOGY STRATEGY

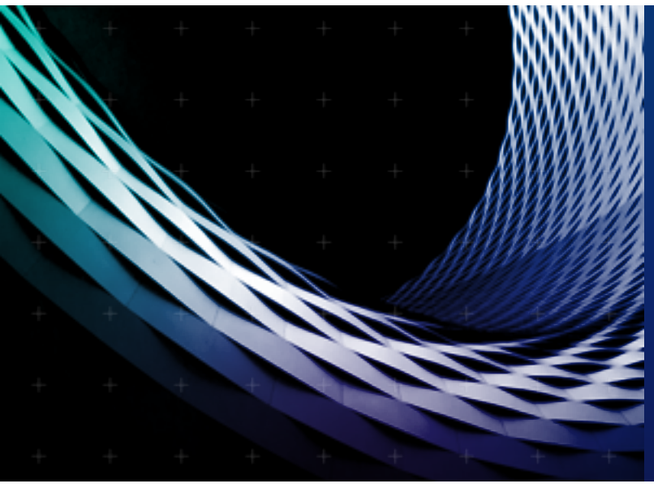
The ATI will publish a new technology strategy in 2022 *Destination Zero*, superseding *Accelerating Ambition* published in 2019.

Aerospace is at a pivotal moment. There is a mounting public consensus on the need for urgent action to mitigate carbon emissions and other climate-related harms. In 2019 the UK became the first major economy to sign into legislation a target for net zero emissions by 2050. Meanwhile, the sector is waiting to see how international travel is affected in the aftermath of Covid-19. Moreover, the industry is experiencing a period of disruptive innovation, with advances in engineering technologies and techniques opening the sector up to new opportunities and a new generation of start-ups.

The new ATI strategy will offer technical direction for the challenges facing aerospace if it is to meet the 2050 target; on likely market technology evolution and adoption rates; and on the consequential ATI Programme investment priorities. It will set the path towards achieving net zero carbon emissions for commercial aircraft by 2050 and positioning the UK as a leader in sustainable design, manufacture, assembly, and operations of future aircraft.

A broad approach to innovation will be necessary. Whilst more investment must go towards zero-carbon-emission technologies, maintaining progress on ultra-efficient aircraft technologies is also vital. And to succeed in both, UK aerospace will need to be at the forefront of a broad range of crosscutting enabling technologies. The strategy will urge high ambition in pursuing innovation in aerospace and make the case for maximising the potential of the sector by embracing collaboration across the aviation ecosystem and through cross-sector partnerships.

# THE TECHNOLOGY PROGRAMME



The heart of the ATI is its technology programme. Funding is delivered through several streams designed for different size organisations and total grant funding amounts. Funding is also available for international collaboration and capital investment.

Progress during the year in projects covering propulsion and power, systems, aerostructures and vehicles is set out over the next few pages. Investment in key UK infrastructure is described on pages 16-17.

## Aerospace Technology Institute (ATI) Programme

£3.9 billion to 2026

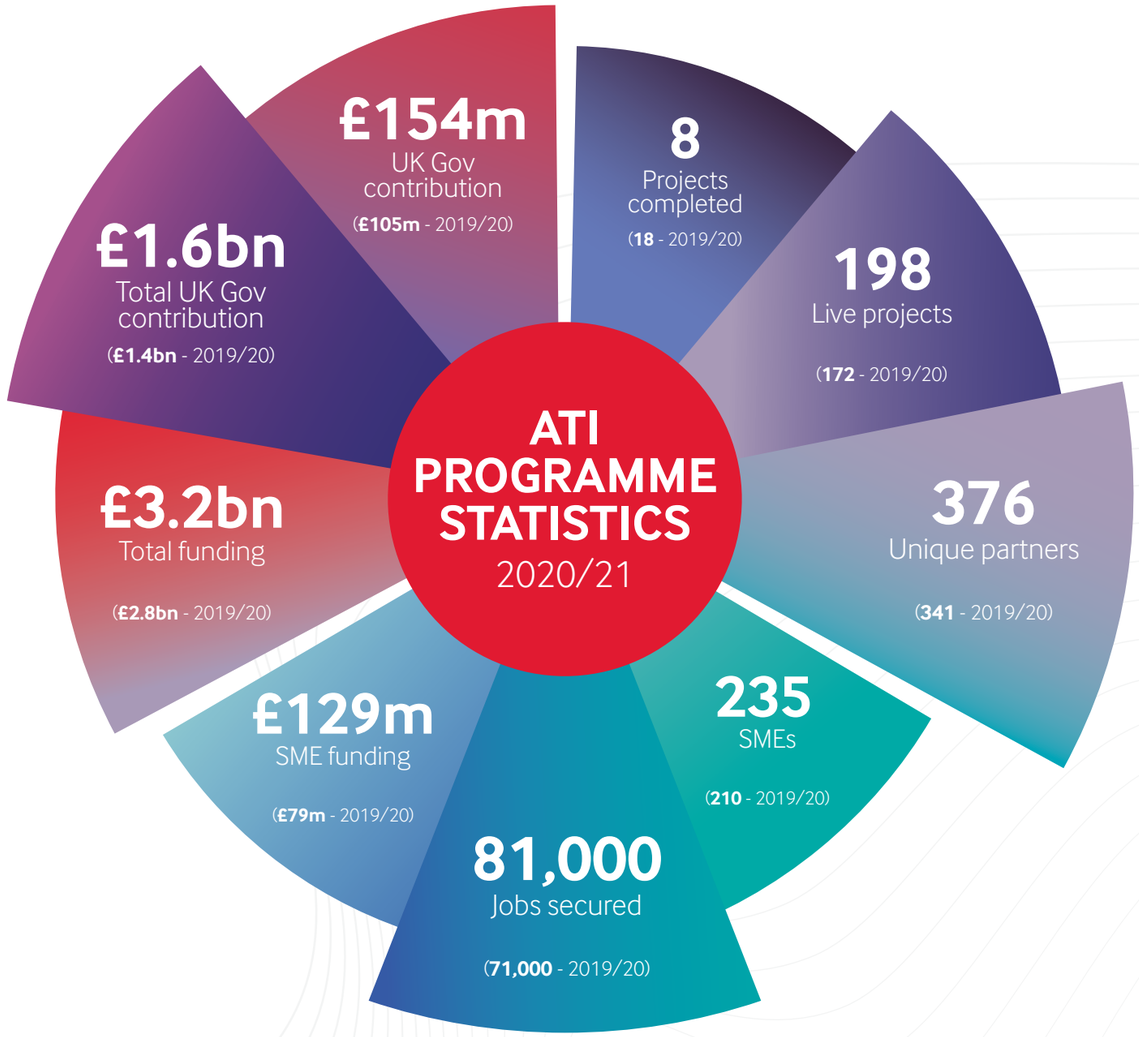
| ATI strategic programme | R&D funding for smaller business | NATEP | International bilateral funding calls | ATI Boeing Accelerator |
|---|---|---|---|---|
| **Key facts**<br>Total grant funding: **£1.9bn**<br>Annual budget: **£150m**<br>Project grant (avg): **£5.1m**<br>Project duration (avg): **3 yrs**<br>**TRL 3-6** | **Key facts**<br>Total grant funding: **up to £20m**<br>2019 call grant: **£8m**<br>Project grant: **£250-750k**<br>Project duration: **1-3 yrs**<br>**TRL 2-6** | **Key facts**<br>Total grant funding: **£13.7m**<br>Current programme: **£15m**<br>Project grant: **up to £150k**<br>Project duration: **up to 18 months**<br>**TRL 4-6** | **Key facts**<br>Total grant funding: **up to £2.25m**<br>UK-Sweden bilateral funding call launched in April 2020<br>**TRL 4-6** | **Key facts**<br>**£100k equity investment for start-ups**<br>3 month programme to support innovation in technologies for industry 4.0 for the UK's aerospace ecosystem |



# STATISTICS YEAR ON YEAR

The 2020/21 programme invested £300m (£150m each contributed by government and industry) bringing the total invested to date to £3.2bn. Twenty-seven projects went to contract in the year, increasing the total number of live projects to 198.

The ATI now has 376 unique partners, with 25 SMEs joining in 2020/21. Over 60% of partners are now SMEs. All projects are collaborative, with many having three or more partners. Many also include academic or Catapult Centre partners. The Programme can show that it secures jobs across the UK aerospace supply chain; spreads capability throughout the sector; and generates valuable technology spillovers that benefit the wider economy.



# ATI INVESTING IN UK TECHNOLOGY INFRASTRUCTURE

KEY:
INDUSTRY
RTO/CATAPULT
ACADEMIA

## 1 QUEEN'S UNIVERSITY BELFAST

**Supply Chain Manufacturing Centre** (SCENIC) **- £5.0m**

Investment in a range of manufacturing research capital aims to increase the competitiveness of the UK supply chain for aerospace metal structural components. Located in an open access technology factory at the Northern Ireland Technology Centre (NITC), it will enable increased R&D by UK industry, particularly SMEs.

## 3 MANUFACTURING TECHNOLOGY CENTRE (MTC)

**Aerospace Research Centre** (ARC) **- £15m**

A collaborative environment focused on R&D of leading-edge aerospace technologies for the future. The facility enables the development of new full-scale manufacturing systems.

**National Centre for Additive Manufacturing** (NCAM) **- £4.2m**

Manufacturing, post-processing and digital facilities help de-risk the adoption of additive manufacturing and accelerate its uptake.

**Digital Reconfigurable Additive Manufacturing Facilities for Aerospace** (DRAMA) **- £11.6m** (ISCF)

A new metal powder bed facility and a range of assets have been developed to support UK supply chain companies in their adoption of AM.

## 6 GKN AEROSPACE

**Electron Beam Melting Development Cell** (Cell-EBM) **- £1.9m**

An electron beam melting (EBM) development cell provides an R&D environment for testing manufacturing processes.

**Global Technology Centre** (GTC) **- £32m**

This facility helps to bridge the gap between initial research and competitive manufacture, providing a collaborative working environment to deliver accelerated technology to market.

## 2 ADVANCED FORMING RESEARCH CENTRE (AFRC)

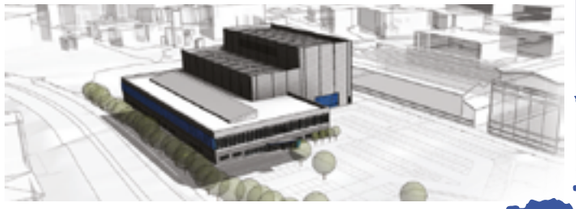
**High Temperature Hydraulic Forge** (HIVES) **- £6.6m**

HIVES is part of a wider investment into the FutureForge project that will transform one of the manufacturing sector's most important supply chains. FutureForge is jointly funded by the ATI, Scottish Enterprise, and the AFRC's High Value Manufacturing (HVM) Catapult funding.

## 4 BOEING UK

**Gear & Actuation Manufacturing Facility - £2.7m** (ISCF)

Boeing UK's first manufacturing site in Europe facilitates the development of manufacturing equipment for gear and actuator components for commercial aircraft.



## 5 AIRBUS UK

**Aerospace Integrated Research and Test Centre** (AIRTeC) **- £19.1m**

This advanced testing centre for large structural assemblies is central to the Wing of Tomorrow programme which is exploring the best materials, manufacturing and assembly techniques to help deliver more sustainable aircraft.

## 8 UNIVERSITY OF OXFORD

**Thermofluids Laboratory Upgrade** (Osney) **- £6.1m** (ISCF)

Upgrading these facilities will enhance research into cooling performance and hot stage technologies essential for the operation of high-pressure turbine stages of large civil engines and improve instrumentation and manufacturing capabilities.

## 11 ROLLS-ROYCE

**Proving Advanced Engine Concepts** (PACE) **- £6.3m**

Project PACE supports X-ray capability and tooling in Rolls-Royce's Testbed 80 to validate the next generation of large diameter, geared architecture engines. Rolls-Royce will deliver key capabilities into their indoor test bed facilities in Derby, including X-ray, image analysis and tooling for engine assembly.


## 7 NATIONAL COMPOSITES CENTRE (NCC)

**Innovation Capabilities** (iCAP) **- £36.7m**

iCAP is a suite of new technologies for the design and processing of composite materials from 1mm to 5000mm wide – by far the greatest range in the world.

## 9 ADVANCED MANUFACTURING RESEARCH CENTRE (AMRC)

**Large Scale Titanium Casting Facility & Ceramic Shell Facility - £15.4m**

A large-scale furnace can produce titanium parts up to 500kg and ceramic shell moulding facilities will produce large precision castings.

**Advanced Fast Make Casting Facility** (CastFast) **- £4.1m**

These facilities will research the use of additive layer technologies with investment casting for rapid production of aerostructures. This will enable components to be produced at lower cost, with shorter lead times, at higher quality and more sustainably.

**Flexible Robotic Machining** (FRoMHAA) **– £0.5m**

This aims to give UK aerospace unique capability in high accuracy robotic machining by combining an existing accurate robotic solution with world-leading expertise in CNC machine tool dynamics.

**Disruptive Textile Technology for Aerospace Applications (PERFORM) - £3.3m** (ISCF)

Supporting the work of AMRC Composites Centre, state-of-the-art equipment for composite preforming using disruptive textile technology will be used to develop solutions for joining, impregnation and process automation.

**Product & Process Verification Centre of Excellence** (PPV) **- £3.5m**

PPV forms a major part of the AMRC Cymru facility at Broughton. It targets innovations in data acquisition, visualisation and processing.

## 14 TWI

**Open Architecture Additive Manufacturing** (OAAM) **- £6.5m** (ISCF)

Three large scale and scalable platforms will enable aerospace manufacturers to develop and demonstrate advanced AM concepts in a collaborative environment.

## 16 IMPERIAL COLLEGE LONDON

**National Wind Tunnel Facility** (NWTF) **- £2.6m**

A collaboration across several UK universities to build intellectual capability around the use and exploitation of wind tunnels to support leading-edge research across multiple sectors. The investment has been used to develop the capabilities of 17 wind tunnels and open them to external users.

## 10 UNIVERSITY OF NOTTINGHAM

**Future Automated Aircraft Assembly Demonstrator** (FA3D2) **- £3.8m** (ISCF)

A national experimental testbed and technology demonstrator will allow aerospace manufacturing businesses to test, demonstrate and accelerate the implementation of innovative technologies to improve product quality and cost.

**High Performance Transmission Systems Test Facility** (2 Shaft) **- £2.6m**

A two-shaft test rig facility will research the effects of running aero engines at higher speeds and temperatures to meet efficiency targets.

## 12 LOUGHBOROUGH UNIVERSITY

**National Centre for Combustion and Aerothermal Technology** (NCCAT) **- £10.8m**

These facilities enable researchers to work with industrial partners to develop the next generation of future, low emission, aerospace gas turbine combustion systems. Research will help develop step changes in technology that will be transferred into commercial combustion systems for use in 'leaner and greener' aircraft engines.

## 13 HEXCEL

**Multi Axial Infusion Materials** (MAXIM) **- £3.8m** (ISCF)

An R&T facility aimed at the development of a resin infusion approach will support large scale composite primary structures such as wing covers, spars and stringers and the optimisation of materials and processes to reduce cost.

## 15 Aircraft Research Association (ARA)

**Capital Equipment Projects** (Phases 1 & 2) **- £5.2m**

Upgrades to the world-class transonic wind tunnel facility included tunnel controls, high performance computing and additional capability for workshop model manufacture. Phase 2 delivered upgrades to acoustic measurement equipment and data acquisition systems.

**Aerodynamic Research Testing Capability & Data Enhancement** (ARCADE) **- £3.5m**

This project provided specialist testing rigs for load alleviation, hybrid laminar flow control and flat yaw capabilities.

## 17 UNIVERSITY OF CAMBRIDGE

**The National Centre in Propulsion and Power** (NCPP) **- £13.5m**

Based at the Whittle Lab, this facility is designed with the flexibility to scale rapid technology transfer to ~80% of UK's future propulsion needs. It will transform the UK aero-propulsion technology transfer process, making it faster, cheaper and more precise.

# PROPULSION & POWER

Propulsion and power represents around half the value of the ATI's R&D portfolio. It is advancing major efficiency gains in gas turbines and leading breakthroughs in electric and hydrogen-powered flight. Around 90 organisations are involved in power and propulsion projects, including 35 SMEs, six research and Catapult organisations and 17 in academia.

*ZeroAvia's HyFlyer II project*

ZeroAvia's **Hyflyer** project aircraft made its first flight at Cranfield in June 2021, followed by a world-first hydrogen-powered flight in August. The project has developed a novel hydrogen powertrain using batteries, hydrogen fuel cells, electric motors and gas storage. Further developments will support scale-up to larger aircraft, with **HyFlyer II** due to refit a 19-seat aircraft with a 600kW powertrain and carry out a zero-carbon flight of 300 nautical miles. The project creates a unique UK supply chain for future aviation with ZeroAvia (powertrain); Aeristech (air compression); and the European Marine Energy Centre in Scotland (green hydrogen and fuelling systems design). The **ACCEL** project's 'Spirit of Innovation' aircraft also completed its first flight from Boscombe Down in September 2021 and became the world's fastest all-electric vehicle (see case study below).

Rolls-Royce's **UltraFan®** demonstrator remains a key focus. It is the world's largest aero engine with potential to deliver a 25% fuel efficiency improvement. This project is now well advanced with many individual elements completed, and large-scale demonstrations begun. 2020/21 saw four further **UltraFan®** projects conclude, delivering ground-breaking composite fan cases, core engine structures, weight optimisation, and air and oil systems. The demonstrator build phase has launched and the first engine test is scheduled in 2022.


*Opening of Rolls-Royce's Testbed 80*

Rolls-Royce's Testbed 80, a major piece of research infrastructure, was opened in May 2021. It is the world's largest and smartest indoor aerospace testbed, and will support many ATI-supported projects, as well as utilising the **PACE** project, using advanced x-ray technology to see into engines while running.

Other projects have focused on future product capability and advanced disruptive tools and methods. **COLIBRI** (Collaboration Across Business Boundaries) will exploit artificial intelligence and machine learning to improve and speed up collaborative design. Dowty Propellers' Digital Propulsion project (**DigiProp**) has successfully demonstrated reductions in noise and weight, enhancing passenger experience and saving fuel, whilst the collaborative Meggitt-led **UHBR Thermals** project has achieved a breakthrough in heat management performance, a key enabler for ultra-high bypass ratio engines.

Important new projects launched in 2020/21 include GKN's **H2GEAR**, to develop a cryogenic hydrogen-powered electrical and propulsion system. Smart venting to help avoid contrail formation will also be explored. **H2GEAR** technology will be integrated into aircraft carrying up to 100 passengers and enable zero-carbon-emission auxiliary power units in large transportation aircraft. Blue Bear's **InCEPTion** project will develop a safe, scalable, modular, power-dense, and quiet all-electric propulsion module combining batteries and fuel cells. This will accelerate the electrification of aircraft carrying up to 30 passengers.



**Rolls-Royce has also initiated a series of projects including:**

- **REINSTATE** involves eight partners to develop a portfolio of sensing, inspection and repair techniques for aeroengines with application to other industrial sectors.
- **LUCIA** (Large UltraFan Composite Integrated Aerostructures) will push the boundaries of composite technology to unlock significant weight savings.
- **FANTASIA** (Future Noise Technologies and Systems Integration Analytics) will ensure that future engines achieve required noise levels. New techniques in engine design and testing will replace expensive existing methods and give early indications of design suitability.
- **CORDITE** will improve the aerodynamics of the core systems of ultra-high bypass ratio engines, reducing fuel burn and emissions.
- **COGS** will develop hybrid metallic composite aeroengine delivering significant weight reduction and transferability to other sectors.


*UltraFan® power gearbox*

## CASE STUDY

***Project Acronym:***
**ACCEL**

***Project title:***
Accelerating the Electrification of Flight

***Project partners:***
**Rolls-Royce** (lead partner), **YASA, Electroflight**

***Cost:***
**£6.89m, 2018-2021**

The **ACCEL** project aimed to design, build and flight test a high performance electric powertrain providing a unique and detailed understanding of the potential for electric flight and the propulsion systems and components involved. The 'Spirit of Innovation' aircraft completed its first flight from Boscombe Down in September 2021 and became the world's fastest all-electric vehicle when the world speed record attempt was certified in January 2022. It reached a top speed of 555.9 km/h (345.4 mph) over three kilometres, smashing the existing record by 213.04 km/h (132mph). It also achieved 532.1km/h (330 mph) over 15 kilometres – 292.8km/h (182 mph) faster than the previous record. Knowledge gained from the project will provide data and insight into future future electric power and propulsion systems and hybrid-electric commuter aircraft.

**"ACCEL demonstrates that strategic investment in UK technology can achieve world-beating results. This achievement of Rolls-Royce, Electroflight and YASA will resonate for many years and inspire the next generation of aerospace engineers. ATI is proud to have played its part in that. Congratulations to the whole team."**

*– Gary Elliott, CEO, Aerospace Technology Institute*

# SYSTEMS

Extending the electrification of aircraft systems is a key focus along with further developments in undercarriages, fuel systems, and flight systems in the cockpit. Around 169 organisations are active in systems projects, including 20 in academia, seven research or Catapult organisations and 84 SMEs, boosting the UK's supply chain.

SAFRAN's **MEGCAP** project has improved thermal management of aircraft starter-generator electrical machines (see case study) while **SMPP** (Scaleable Multi-Platform Power Systems) is developing technologies for power generation, distribution and conversion to support more electric aircraft.

**Aerospace Electrification: Accelerating the Opportunities.**

The ATI and Warwick Manufacturing Group published a joint report detailing the challenges that must be addressed in the journey to electrifying aerospace. Three critical challenges were examined: energy storage, machines and drives, and systems integration. High-level recommendations for each area were produced, setting a baseline for future industry collaboration, and defining the opportunity for the UK supply chain. View or download at **www.ati.org.uk**.


SAFRAN's **Large Landing Gear of the Future** project has continued to improve the design, manufacturing operation and cost of ownership of landing gear systems.

Airbus's **FAST** (Fuel Architecture and Systems Technology) project has developed fuel sub-system technologies capable of integrating with next-generation wings.

Air quality sensors and air management technology developed through Honeywell's **U-CAIR** project have improved cabin air quality and reduced operational costs through increased fuel economy.

The GE-led **Open Flight Deck** project has built on previous work to develop new aids to optimise flight crew workload and improve situational awareness to extend safe operations.

*Open Flight Deck project*



# CASE STUDY

***Project Acronym:***

**MEGCAP**

***Project title:***

More Electric Generation & Controls for Aircraft Power

***Project partners:***

**Safran Electrical & Power, Barden Corporation, MEP Ltd, MTD, 3T Additive Manufacturing Ltd, 3D Systems Europe Ltd**

***Cost:***

**£8.31m, 2017-2021**

*Electrical power system component produced through additive manufacture.*

Recognising the demand for more capable electrical power systems, **MEGCAP** aims to improve aircraft starter-generator capability with high reliability, greater efficiency and low-cost manufacturing.

The partners bring different strengths including thermoplastic moulding and prismatic machining. Copper alloys for additive manufacturing improve the power generation of the electrical motors. Lightweighting significantly speeds up production line processes. These skills and strengths are combined to produce niche components for the aerospace market. The result is improved electrical power generation for propulsion and other energy applications.

**"The project has allowed us to develop relationships with the other partners. Improving cross-collaboration allows us to solve each other's problems as well as opening markets to us within the greater SAFRAN group and potentially export abroad."**

*– Phillip Davis, Project Manager for MEGCAP, MEP*

**New Systems projects begun in 2020/21:**

- The **CONVERGENCE** project led by Moog delivers a structured approach to implementing a digital thread through the manufacturing process, increasing efficiency, capacity and helping the UK to secure future high-value work. The results will be disseminated through a Smart Factory Learning Centre and a SME Digital Handbook.

- **ECLAIR** (Enabling $CO_2$ reductions by better bLeed AIR management), led by Honeywell, will advance cabin air management technology and provide the market with next-generation environmental control systems.

- **Advanced eVTOL diagnostic device** led by Vertical Aerospace will produce a prototype smart-diagnostic charge device for eVTOL aircraft batteries. Using new electro-chemical methods, it will deliver improved in-flight safety and performance and assist in future certification of battery systems.

# AEROSTRUCTURES

Outstanding progress was made on the UK's structures capabilities in 2020/21. The first **Wing of Tomorrow** full-size demonstrator was assembled at AMRC Cymru, delivered by the Catapult network and supply chain and included delivery of significant elements by key partners Airbus, the National Composites Centre, GKN Aerospace and Spirit AeroSystems. This demonstrated the feasibility of producing optimised structures and manufacturing single aisle wings at high rate.

The ATI engaged with the High Value Manufacturing Catapult to initiate "sprint" projects focused on controlling manufacturing costs. Subjects included SAF, one-way assembly, ceramic composites, hybrid direct energy deposition additive manufacturing and casting. Projects worth £4.3m were approved with participation from 48 organisations across industry, academia and the catapult network.

In conjunction with the FlyZero project, ATI's structures team launched a working group on hydrogen storage tanks, pulling experts together from the aerospace and space industries, RTOs, and the Health and Safety Executive. The group is establishing the requirements for these future systems to help position the UK as a leader in their design, development, and manufacture.

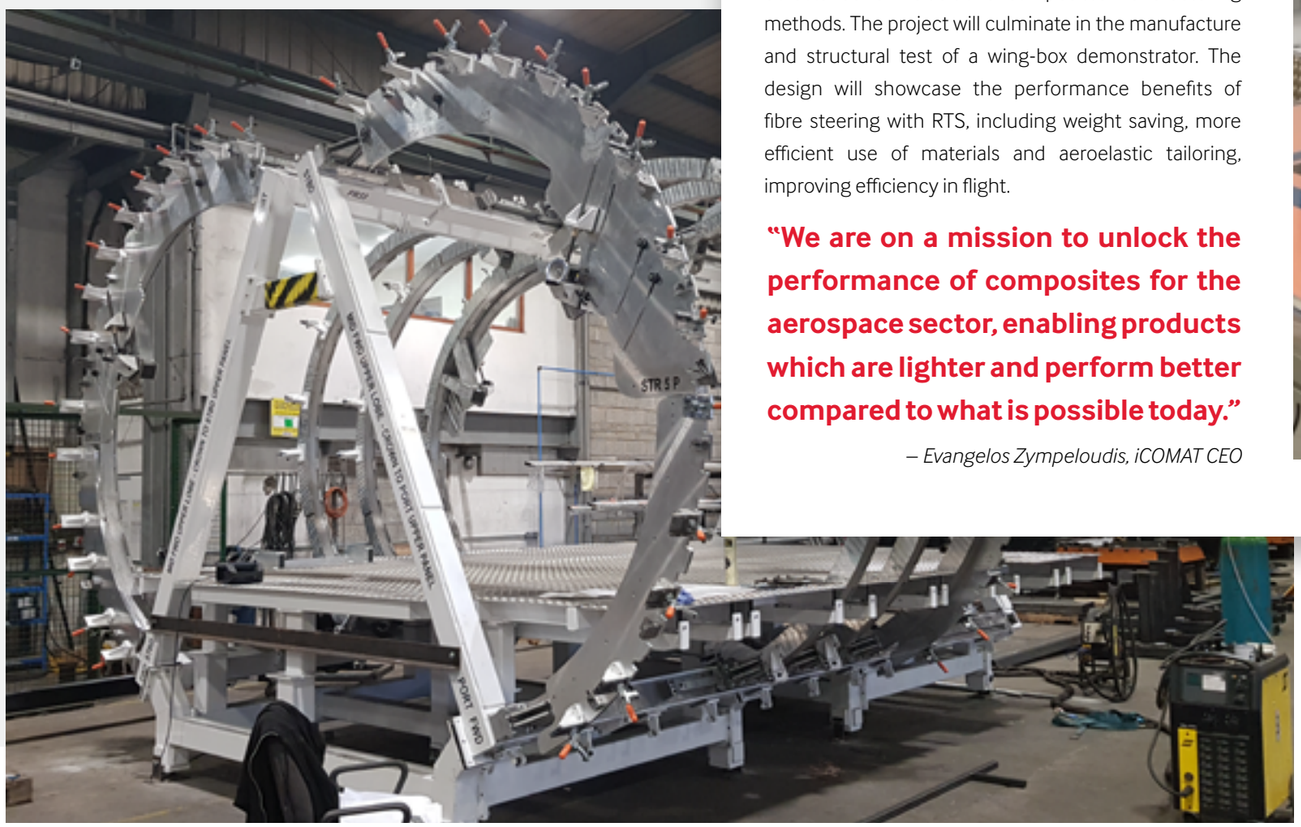
The ATI led a working group focused on UK tooling capability to conduct a survey of the industry, deliver a webinar and publish a directory, which is available on the ATI website.

**New projects in metallics, additive manufacturing and high-rate composite manufacturing include:**

- The **OAAM** (Open Architecture Additive Manufacturing) project scales up three directed energy deposition additive manufacturing (AM) technologies. The systems and state-of-the-art research facilities to be developed by the project will offer a fully quantifiable process and access to a simplified, lower risk route to industrialisation.

- **ASCEND** (Aerospace and Automotive Supply Chain Enabled Development) is an industry-led cross-sector consortium focuses on accelerating UK composites capability for single aisle, business jets and future mobility markets (including electric and hybrid propulsion aircraft).

- **MASTER** (Metallic Aerospace Structures Technologies for Eco-social Returns) will eliminate tens of thousands of fasteners from aircraft structures and improve sustainability analysis in technology decision-making.



*Fuselage assembly fixture, Datum*



# CASE STUDY

***Project Acronym:***

**MASCoTS**

***Project title:***

Manufacturing and Advanced Simulation of Rapid Tow Shearing

***Project partners:***

**iCOMAT, MSC Software, Daptablade, TWI**

***Cost:***

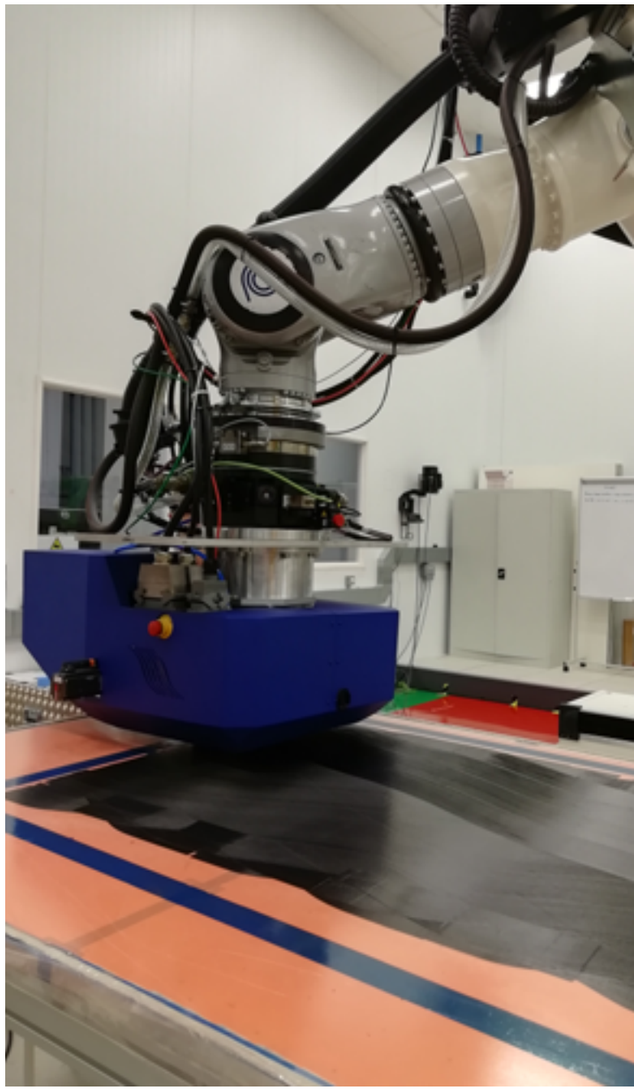
**£886k, 2020-2022**

This project will develop the software and machinery required to enable composite designs with curved fibre paths, potentially providing a step change in lightweighting, performance and manufacturing productivity for the next generation of aerostructures.

Developing an advanced prototype of iCOMAT's Rapid Tow Shearing (RTS) head will minimise manufacturing defects found in traditional composites manufacturing methods. The project will culminate in the manufacture and structural test of a wing-box demonstrator. The design will showcase the performance benefits of fibre steering with RTS, including weight saving, more efficient use of materials and aeroelastic tailoring, improving efficiency in flight.

**"We are on a mission to unlock the performance of composites for the aerospace sector, enabling products which are lighter and perform better compared to what is possible today."**

*– Evangelos Zympeloudis, iCOMAT CEO*



# VEHICLES

The ATI's whole aircraft capability enables the UK to understand how individual technologies can be integrated into a vehicle and what benefits they offer at aircraft level. The full potential of new technologies will only be realised through early consideration of their impact at the aircraft level, and subsequent optimisation across systems and sub-systems.

The ATI's online Fixed Trade Calculator tool was updated for 2015 aircraft standards. It enables basic technology comparisons in terms of fuel burn, operating cost and $CO_2$ impact and is provided free-to-use for the UK aerospace community.

The ATI continues to grow its aircraft modelling capability; the Single-Aisle Future Aircraft Model (SAFAM) has been further developed to incorporate an updated engine and forms a reference 2030s aircraft platform. A Widebody Future Aircraft Model (WiFAM) is also currently being finalised. This work supports the assessment of future technology opportunities and sustainability modelling. A sub-regional turboprop aircraft model has been developed for evaluating concepts which incorporate electrified propulsion and their market opportunities.

The ATI's Whole Aircraft team played a leading role in the creation of FlyZero and support the project team's aircraft modelling activities. The ATI will build on these capabilities to enable the continued independent evaluation of future technology, commercial and sustainability opportunities for increasingly complex aircraft integration challenges and market scenarios.

**The ATI's online Fixed Trade Calculator tool was updated for 2015 aircraft standards. It enables basic technology comparisons in terms of fuel burn, operating cost and $CO_2$ impact and is provided free-to-use for the UK Aerospace community. www.ati.org.uk/resources/tools**



## CASE STUDY

*Project Acronym:*
**IDP**

*Project title:*
Initial Demonstration Platforms

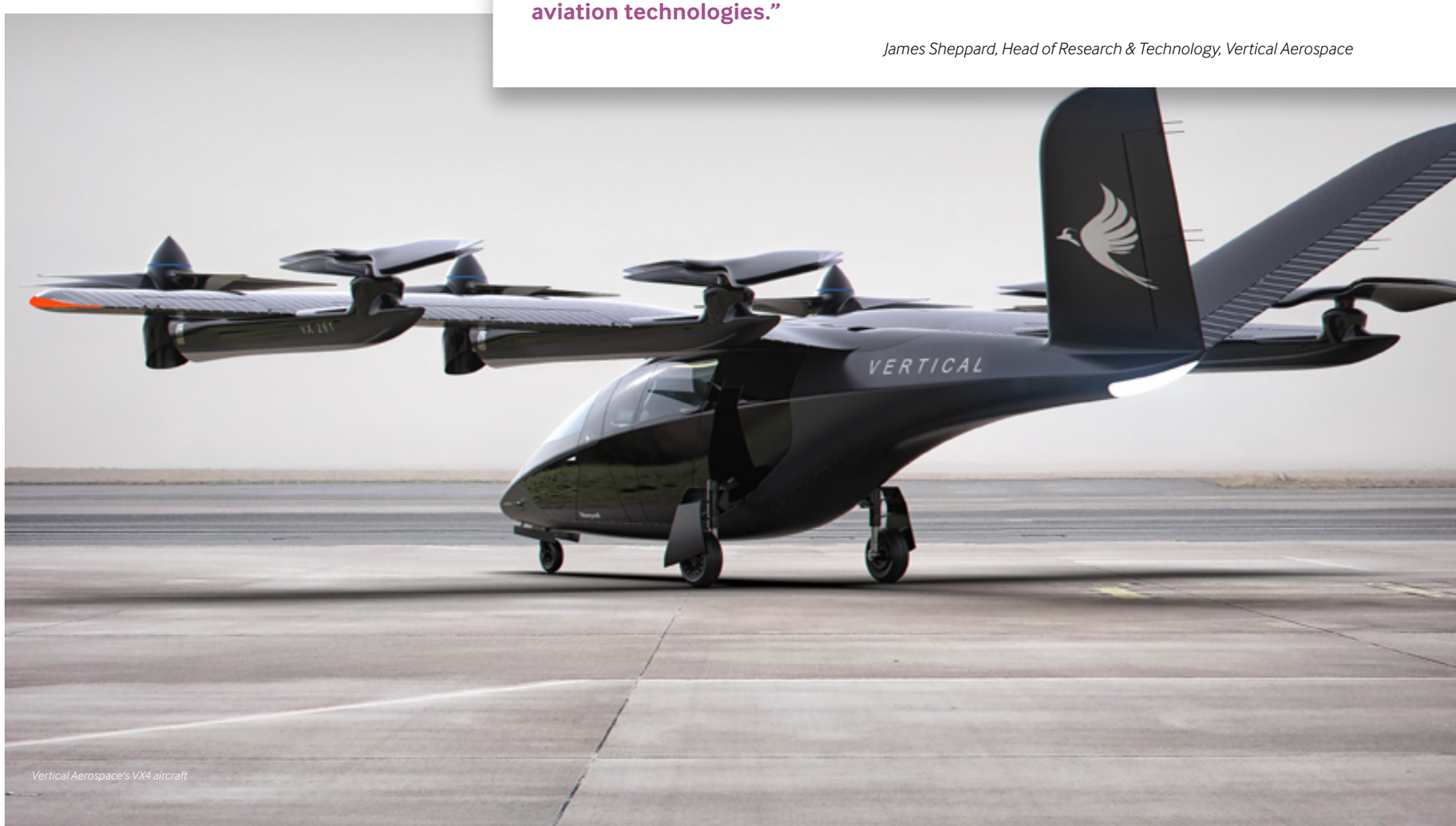
*Project partners:*
**Vertical Aerospace Group**

*Cost:*
**£23.76m, 2020-2022**

Electric Vertical Take-off and Landing (eVTOL) aircraft are a new and emerging segment within the aerospace industry. The **IDP** project will allow Vertical Aerospace to explore, develop, and mature a range of sustainable aviation technologies and demonstrate them using a variety of platforms including part scale rigs and wind tunnels, full-scale test rigs, and flight testing of its initial VX4 demonstrator eVTOL aircraft.

**"The IDP project is an exciting opportunity for Vertical to investigate and overcome many of the fundamental challenges present in this new class of electric aircraft. The project is creating key knowledge and capabilities which will be essential for us as we continue to develop and mature our aviation technologies."**

*James Sheppard, Head of Research & Technology, Vertical Aerospace*

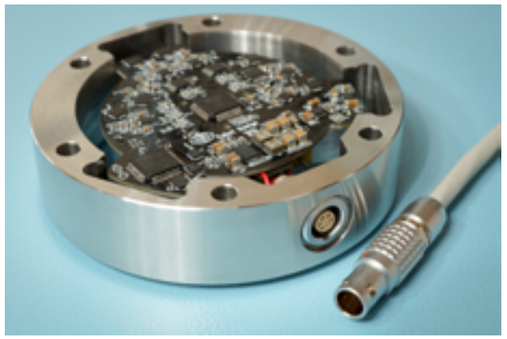



*Vertical Aerospace's VX4 aircraft*

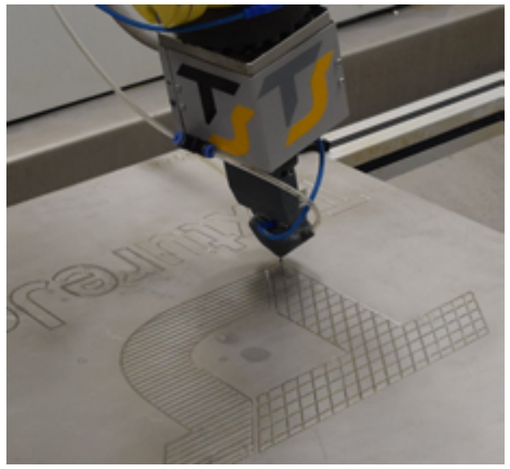
# NATEP

NATEP targets companies inexperienced at R&D. It funds small projects and provides in-kind support to set up and run them. It also engages potential customers (or end users) interested in exploiting the resulting technology. Demand continues to rise for NATEP's unique blend of support. Following two successful phases of NATEP, a third phase was launched in August 2019 with £15m public support through the ATI budget, and has so far awarded funding to 53 projects, with two further calls in the autumn of 2021 and the spring of 2022.

Programme benefits include enhanced visibility to potential customers through events such as the Boeing Innovation Forum in September 2021, where nearly one third of invited companies were NATEP participants. Case studies and project videos are available at **www.natep.org.uk**.



*Cabin Interior Monument Load Cell*



*STREAM - Surface Texture Re-tooling for Efficient Aerospace Manufacturing*

**"I am delighted that the value-add delivered by the NATEP team continues to support our beneficiaries to form, deliver and disseminate their technologies. NATEP's unique blend of funding and mentoring is critical to the success of the projects and we are very pleased to see continued commitment from the UK government in supporting the aerospace supply chain in the UK. NATEP is an established part of the ATI portfolio and a key route for directing R&D funding to smaller businesses, who may not be familiar with government funding or R&D project delivery."**

*Harriet Wollerton, Programme Director, NATEP*



# INTERNATIONAL

The ATI champions UK interests in aerospace development, but in a global industry the UK must cooperate with international partners. Collaboration with overseas partners can close technology gaps; enable research to be scaled up; and open access to overseas supply chains. The Institute remains engaged at a global level to identify where the UK needs further investment to remain competitive and entrench UK leadership in key technologies.

There is significant interest from the sector in remaining active in collaborative EU research and development. In anticipation that the UK that the UK will participate as an associated country in Horizon Europe, the Institute and ADS held a well-attended information day. We will look to hold further information days, as well as providing the sector with EU updates via ATI newsletters, regional events and the International Advisory Group.

The Institute continues to have positive conversations with countries including Canada, the Netherlands, Norway and Sweden on the possibility of future joint funding.

We have increased cooperation with the EU's new partnership for Clean Aviation and increased our level of information sharing with NASA. This has been particularly valuable for FlyZero, allowing technologists to compare and contrast approaches concerning net zero emissions technologies.

The ATI continues to represent the interests of the UK aerospace sector on key international and European groups and committees.

# ATI Boeing Accelerator

**The ATI Boeing Accelerator has supported innovative start-ups to break into the UK's aerospace ecosystem, bolstering growth and competitiveness. The second cohort of 10 companies completed the programme successfully between January and March 2021.**

This year's focus was on sustainability with capabilities ranging from novel production of hydrogen to reducing emissions using behavioural science-based software for pilots. The participants graduating from the programme benefitted from:

- £100,000 equity investment from The Boeing Company
- First-hand access to strategists, technical experts from the ATI, Boeing, GKN Aerospace and Rolls-Royce
- Mentoring from a global network of experienced entrepreneurs, mentors and investors
- Access and introductions to a network of angel investors, venture capital firms and the wider aerospace industry.

This year's programme took place virtually and founders from across the world joined the interactive sessions through internet-based meetings.

## APPLICANTS

**40%** female and minority ethnic-founded

**40%** from outside the aerospace industry

**40%** first-time founders

**20%** re-applicants

## START-UPS

**6** of the start-ups are sustainability-based

**2** focused on Industry 4.0

**2** focused on energy

**3** continents – Europe, North America and Australia



# COHORT 2

**HiiROC**
(Hull, UK)
Unique plasma technology enables low-cost and low-emission synthetic fuel and hydrogen production.

**MIME Technologies**
(Edinburgh & Inverness, UK)
Remote medical software to support in-flight medical events and emergencies, specifically designed for altitude.

**Datch**
(San Francisco, US)
An intelligent voice AI for industry, enabling frontline workers to capture system information using voice in real time and intelligently integrating into company databases.

**AireXpert**
(Buffalo & Minneapolis, US)
Provides real-time collaboration tools for airlines and other aircraft operators to reduce delays, lower labour and operating costs, and reduce compliance risk.

**Productive Machines**
(Sheffield, UK)
Delivers software that maximizes sustainability of machining processes by reducing costs, eliminating waste and improving productivity.

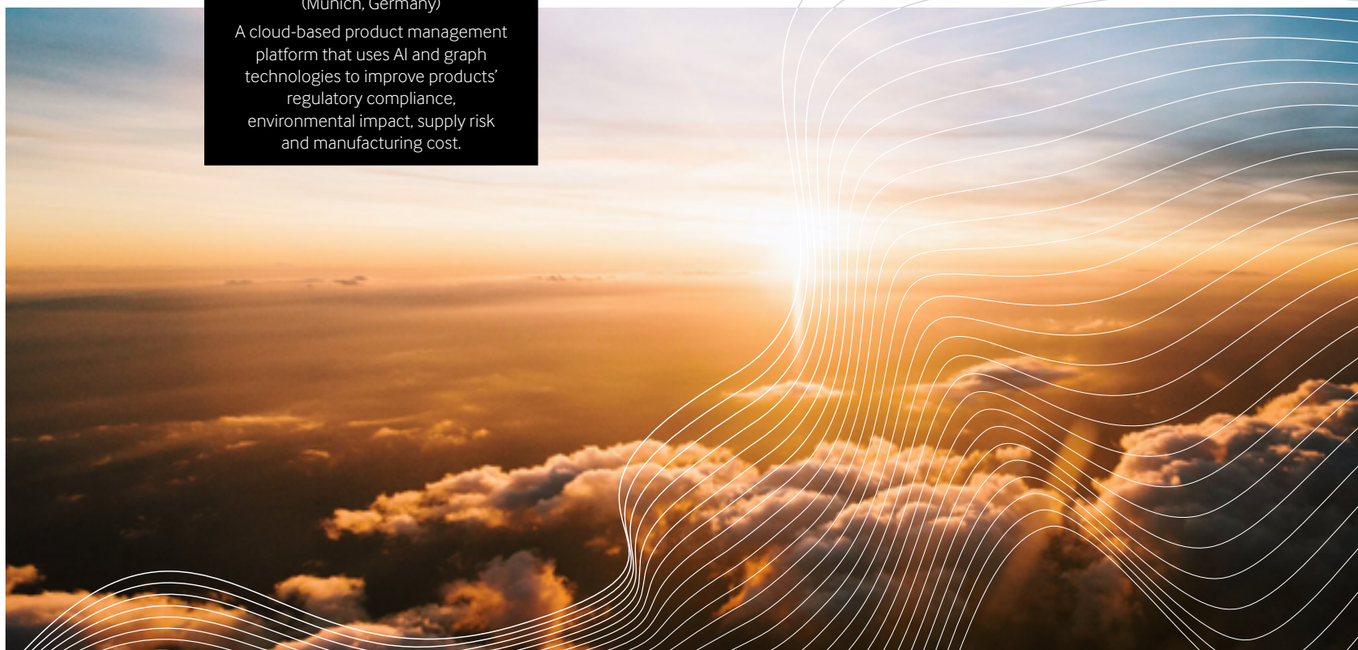
**Phycobloom**
(London, UK)
Using synthetic biology to force algae to secrete oil, thus reducing the cost of biofuels.

**SensaWeb**
(Queensland, Australia)
Enables real-time radiation monitoring.

**Ai Build**
(London, UK)
Has developed an AI-powered software platform to accelerate additive manufacturing processes and make them more reliable.

**Signol**
(London, UK)
The world's first software using behavioural science to reduce airlines' greenhouse gas emissions.

**Makersite**
(Munich, Germany)
A cloud-based product management platform that uses AI and graph technologies to improve products' regulatory compliance, environmental impact, supply risk and manufacturing cost.

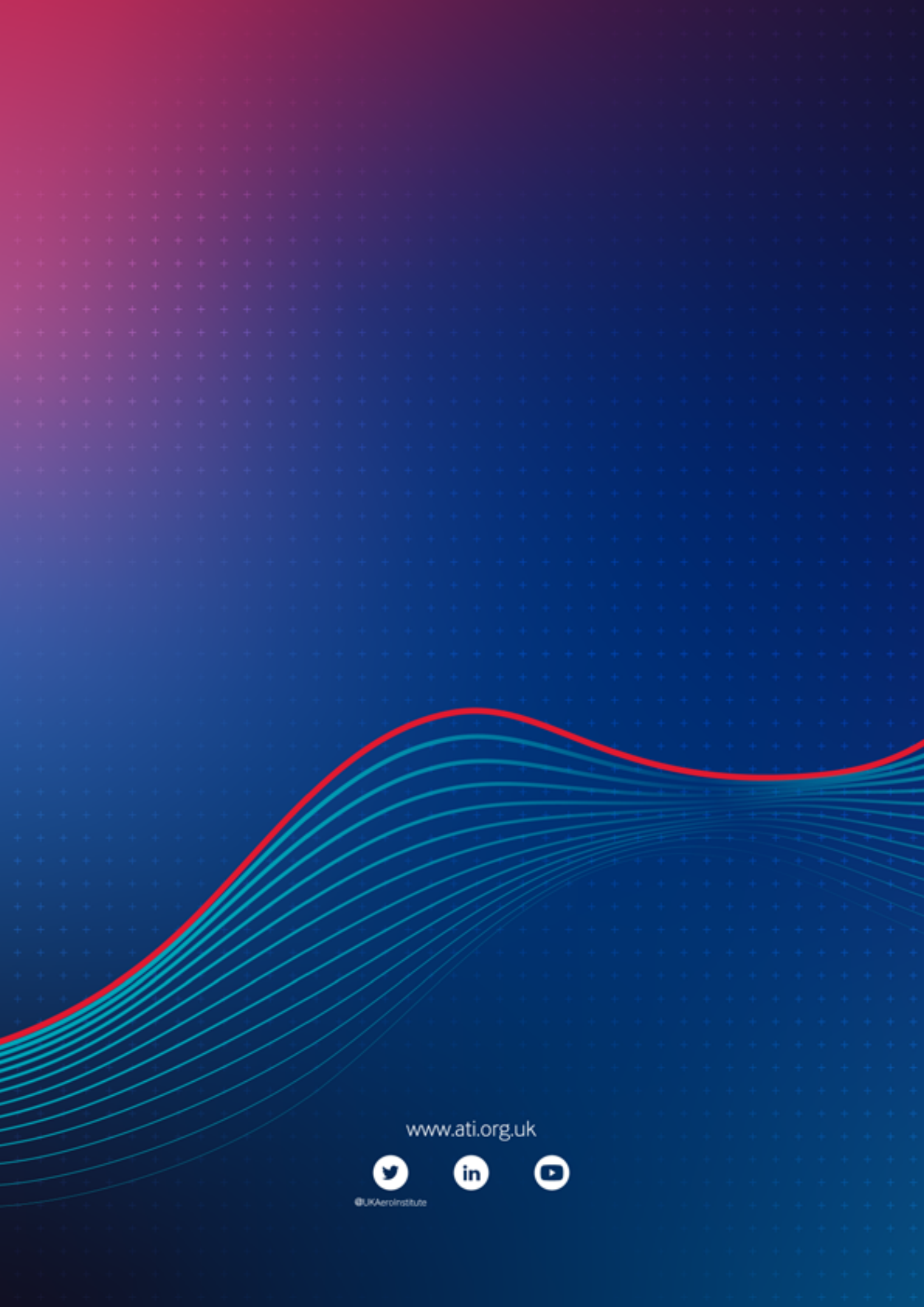


# GLOSSARY

| | |
|---|---|
| **ACARE** | Advisory Council for Aviation Research and Innovation in Europe |
| **ACCEL** | ATI-supported project: Accelerating the Electrification of Flight |
| **ADS** | Trade association for UK aerospace, defence, security and space |
| **AGP** | Aerospace Growth Partnership |
| **AIRTeC** | ATI-supported project: Aerospace Integrated Research and Test Centre |
| **AM** | Additive manufacturing |
| **AMRC** | Advanced Manufacturing Research Centre |
| **ARA** | Aircraft Research Association |
| **ARC** | ATI-supported project: Aerospace Research Centre |
| **ARCADE** | ATI-supported project: Aerodynamic Research Testing Capability & Data Enhancement |
| **ASCEND** | ATI-supported project: Aerospace and Automotive Supply Chain Enabled Development |
| **AWIC/AIRTeC** | ATI-supported project: Advanced Wing Integration Centre/ Aerospace Integrated Research and Test Centre |
| **BEIS** | Department for Business, Energy & Industrial Strategy |
| **CASTFAST** | ATI-supported project: Advanced Fast Make Casting Facility |
| **Cell-EBM** | ATI-supported project: Electron Beam Melting Development Cell |
| **CHASM** | ATI-supported project: Capitalising Heuristic Advanced Sub-system Maturation |
| **COAST** | ATI-supported project: Critical Oil and Air System Technologies |
| **COGS** | ATI-supported project: COmposite Gears and Shafts |
| **COLIBRI** | ATI-supported project: Collaboration Across Business Boundaries |
| **CONVERGENCE** | ATI-supported project: Delivering increased efficiency through Industry 4.0 technologies |
| **CORDITE** | ATI-supported project: CORe Design Intelligent TEchnology |
| **CRIAQ** | Consortium for Research and Innovation in Aerospace in Quebec |
| **DELICE** | ATI-supported project: Design of Engineered Lightweight Innovative Casings for Engines |
| **DfT** | Department for Transport |
| **DIT** | Department for International Trade |
| **DigiProp** | ATI-supported project: Digital Propulsion |
| **DRAMA** | Digital Reconfigurable Additive Manufacturing Facilities for Aerospace |
| **ECLAIR** | ATI-supported project: Enabling $CO_2$ reductions by better bLeed AIR management |
| **EDI** | Equality, diversion and inclusion |
| **FA3D2** | ATI-supported project: Future Automated Aircraft Assembly Demonstrator |
| **FANTASIA** | ATI-supported project: Future Noise Technologies and Systems Integration Analytics |
| **FAST** | ATI-supported project: Fuel Architecture and Systems Technology |
| **FRoMHAA** | ATI-supported project: Flexible Robotic Machining |
| **GARTEUR** | Group for Aeronautical Research and Technology in Europe |
| **GTC** | GKN's Global Technology Centre in Bristol |
| **H2GEAR** | ATI-supported project: Hybrid Hydrogen & Electric Architecture |
| **HIVES** | ATI-supported project: High Temperature Hydraulic Forge |
| **HVMC** | High Value Manufacturing Catapult |



| | |
|---|---|
| **HyFlyer** | ATI-supported project |
| **HyFlyer II** | ATI-supported project |
| **iCAP** | ATI-supported project: Innovation Capabilities |
| **IDP** | ATI-supported project: Initial Demonstration Platforms |
| **IFAR** | International Forum for Aviation Research |
| **INCEPTION** | ATI-supported project: Integrated flight Control, Energy storage and Propulsion Technologies for electric aviation |
| **ISCF** | Industrial Strategy Challenge Fund |
| **LUCIA** | ATI-supported project: Large UltraFan Composite Integrated Aerostructures |
| **MASCOTS** | ATI-supported project: Manufacturing and Advanced Simulation of Rapid Tow Shearing |
| **MASTER** | ATI-supported project: Metallic Aerospace Structures Technologies for Eco-social Returns |
| **MAXIM** | ATI-supported project: Multi Axial Infusion Materials |
| **MEGCAP** | ATI-supported project: More Electric Generation & Controls for Aircraft Power |
| **MTC** | Manufacturing Technology Centre |
| **NATEP** | National Aerospace Technology Exploitation Programme |
| **NCAM** | ATI-supported project: National Centre for Additive Manufacturing |
| **NCC** | National Composites Centre |
| **NCCAT** | ATI-supported project: National Centre for Combustion and Aerothermal Technology |
| **NCPP** | ATI-supported project: National Centre in Propulsion and Power |
| **OAAM** | ATI-supported project: Open Architecture Additive Manufacturing |
| **PACE** | ATI-supported project: Proving Advanced Engine Concepts |
| **PERFORM** | ATI-supported project: Disruptive Textile Technology for Aerospace Applications |
| **POSTIE** | ATI-supported project: Physical Optimisation of Structural Topology for Integrating Engines |
| **PPV** | ATI-supported project: Product & Process Verification Centre of Excellence |
| **R&D** | Research and development |
| **R&T** | Research and technology |
| **REINSTATE** | ATI-supported project: Repair, Enhanced Inspection, and Novel Sensing Techniques for increased Availability and Through life Expense |
| **RTS** | Rapid tow shearing |
| **SAF** | Sustainable aviation fuel |
| **SAFAM** | Single-aisle future aircraft model |
| **SCENIC** | ATI-supported project: Supply Chain Manufacturing Centre |
| **SME** | Small or medium-sized enterprise |
| **SMPP** | ATI-supported project: Scaleable Multi-Platform Power Systems |
| **TRL** | Technology readiness level |
| **UCAIR** | ATI-supported project: UK ATI Cabin Air |
| **UHBR** | Ultra High Bypass Ratio |
| **UHBR Thermals** | ATI-supported project: Addressing oil heat management |
| **WIFAM** | Widebody future aircraft model |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