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2023

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Pathways to Decarbonising Flight

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AEROSPACE TECHNOLOGY INSTITUTE | ATI HUB Catalysing innovation

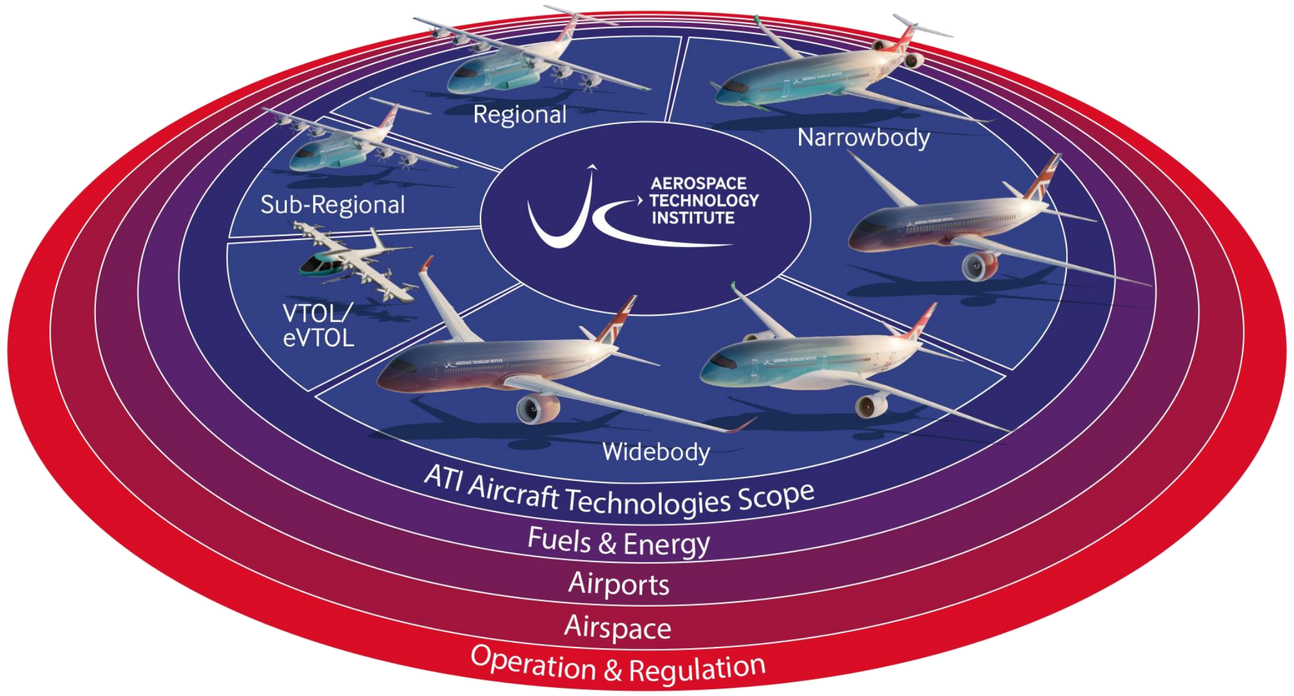
Aerospace Technology Institute

Transforming aerospace through technology and innovation

- Established in 2014
- Independent, not for profit organisation joint funded by government and industry
- Defines the national aerospace technology strategy
- £5bn+ investment through the ATI programme is enabling step changes in technologies
- Supports a sustainable and competitive UK aerospace sector
- Strengthens the ecosystem & drives innovation

Destination Zero

The ATI technology strategy Destination Zero sets our path towards achieving Net Zero carbon emissions for commercial aircraft by 2050 and supporting the competitiveness of the UK industry in sustainable design, manufacture, assembly and operations of future aircraft.



Pathways to decarbonising flight

1. A possible pathway to decarbonising the sector exists but we have to overcome some key challenges.

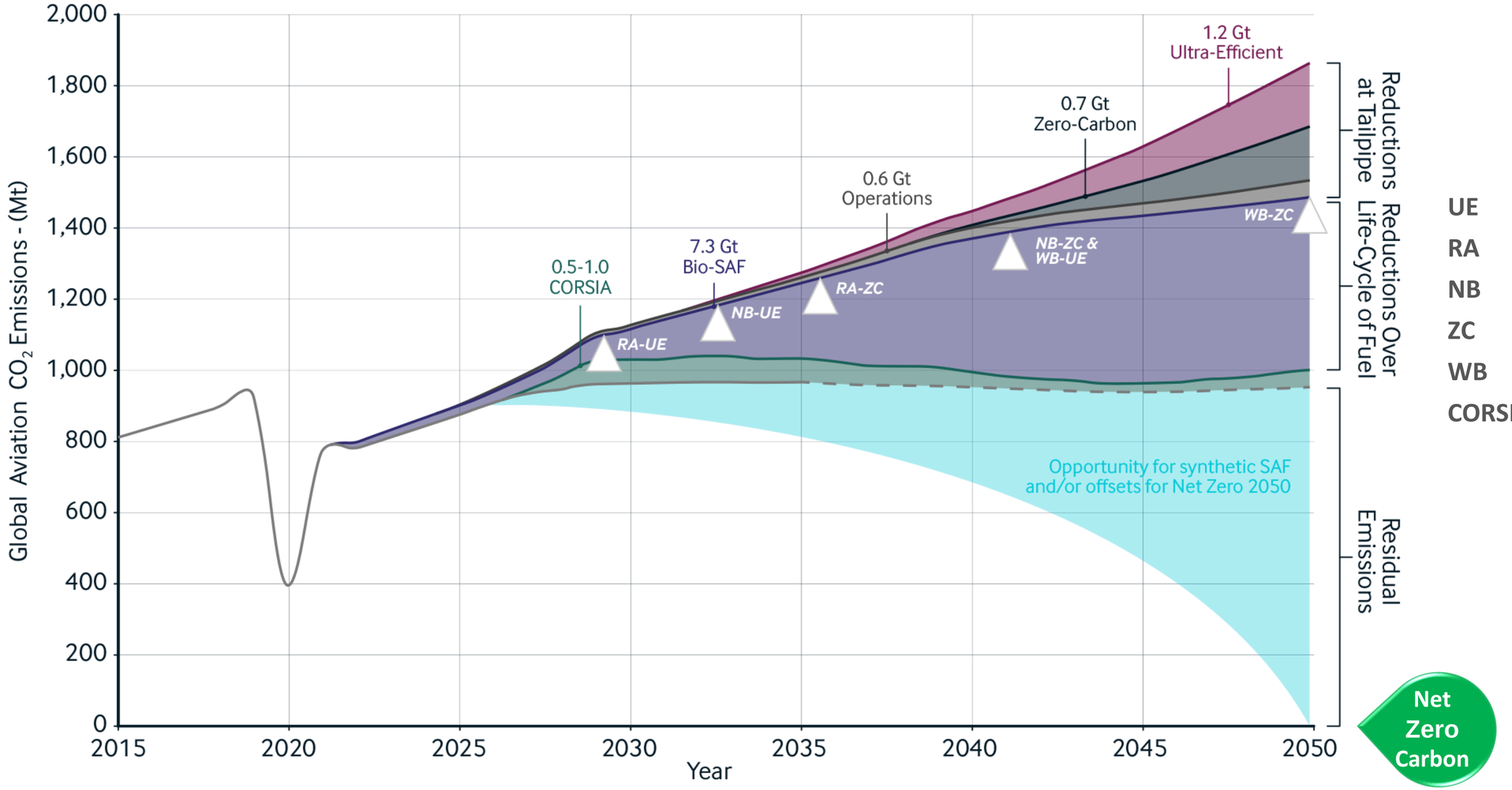
2. The transition to net zero offers significant opportunities.

3. Successful transformation will include both new aircraft technologies and alternative fuels.

4. There is support for the transition.

1. A possible pathway to decarbonising the sector exists but we have to overcome some key challenges.

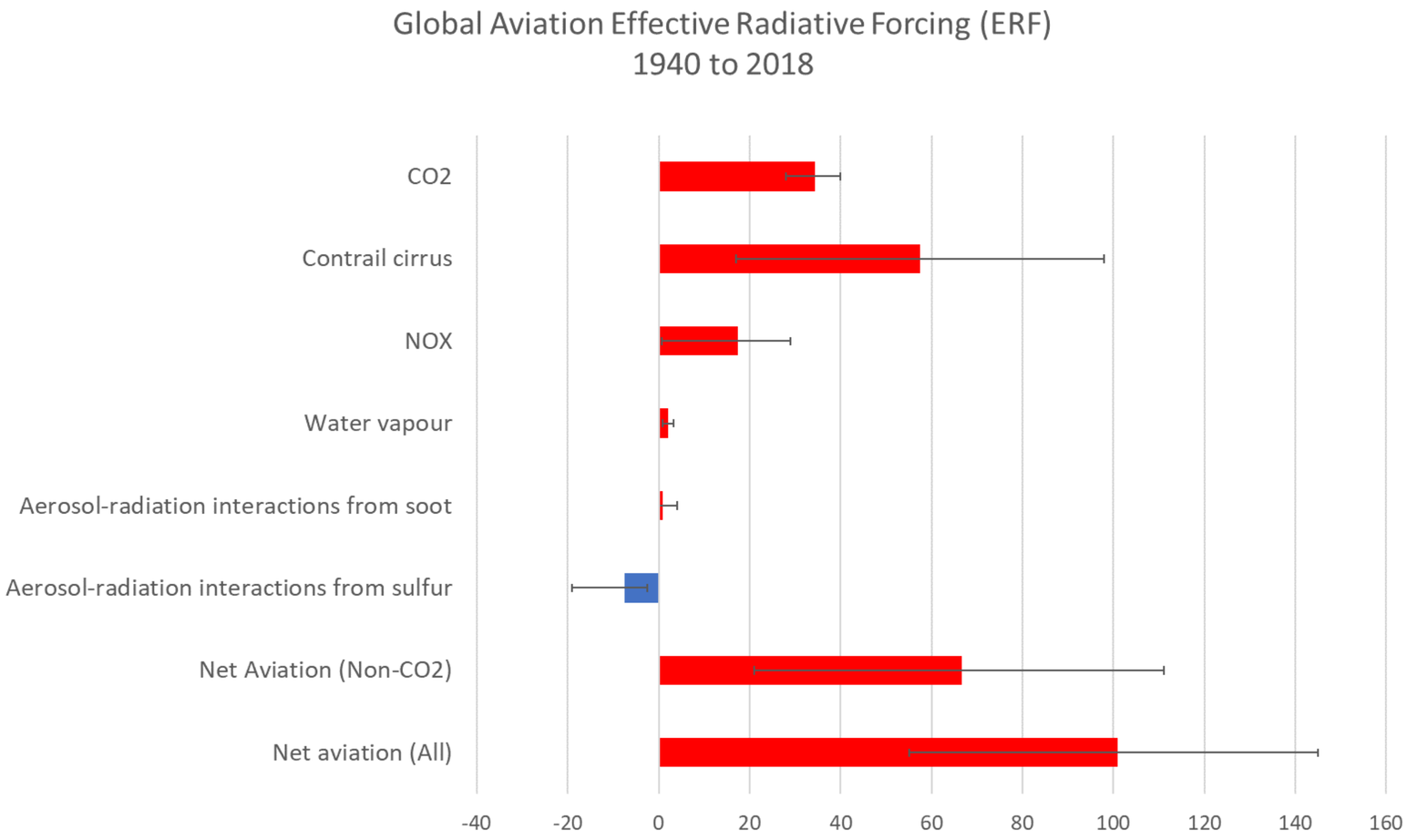
The Challenge: Pathways to decarbonisation



UE	Ultra-Efficient
RA	Regional Aircraft
NB	Narrowbody
ZC	Zero-Carbon
WB	Widebody
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation

Source: ATI. Insight 18, Modelling the Road to Net Zero. July 2022. insight-aviation-emissions-modelling.pdf

The Challenge: Non-CO_2 emissions

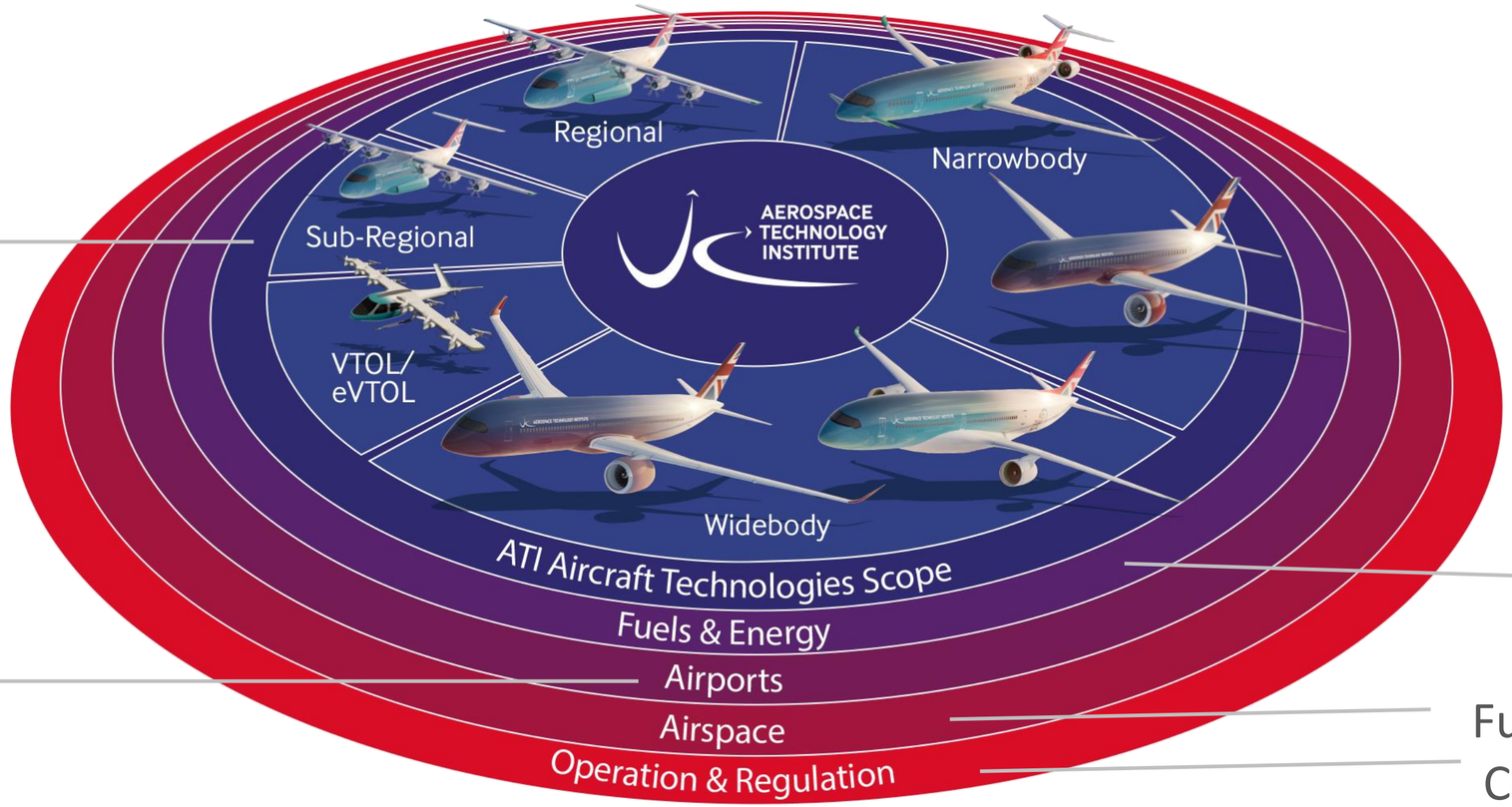


- **The warming effect of contrails is likely to be high**, but uncertainties are large
- NOx has complex interactions with other atmospheric compounds but overall is likely to have a warming effect
- **Non-CO_2 emissions could have a higher impact than CO_2**, but uncertainties are large

The Challenge: Global and sector-wide

Ultra Efficient & Zero Carbon Technologies

Multi- Fuel Infrastructure



Production, Infrastructure, Certification, Incentives for SAFs & Hydrogen + Renewable Energy

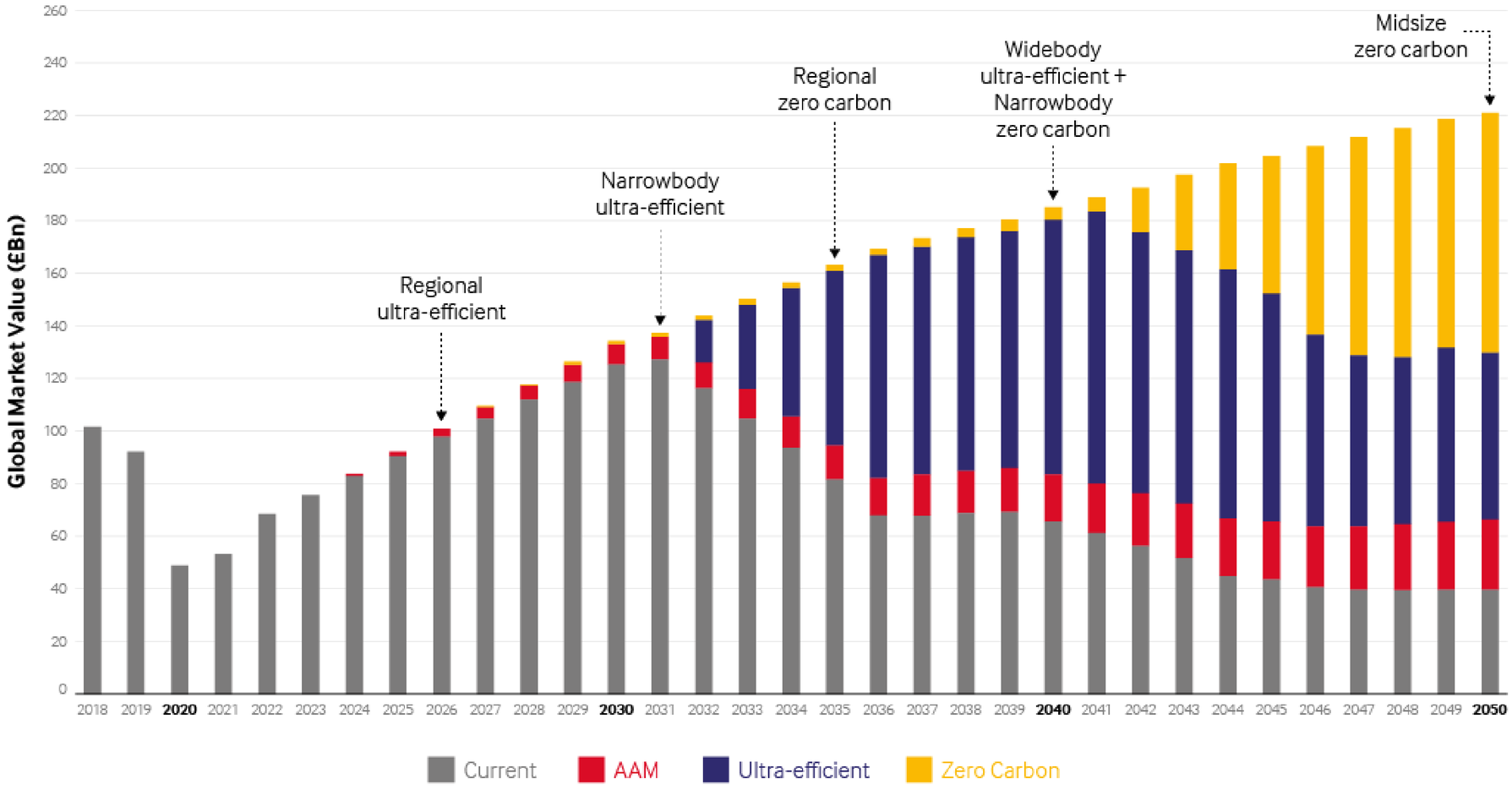
Fuel Optimisation & Contrail Avoidance

2. The transition to net zero offers significant opportunities.

The Opportunity: Market

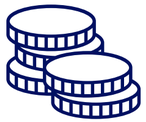
There are strong growth opportunities in aerospace, particularly in zero-carbon and ultra-efficient technologies

Global aerospace market New deliveries, 2022-50 [£bn]



The Opportunity: Social and economic

Market opportunity
Commercial aerospace deliveries totalling £4.6tn globally by 2050[1]



UK Exports
£10.9 bn from aerospace in 2022[2]

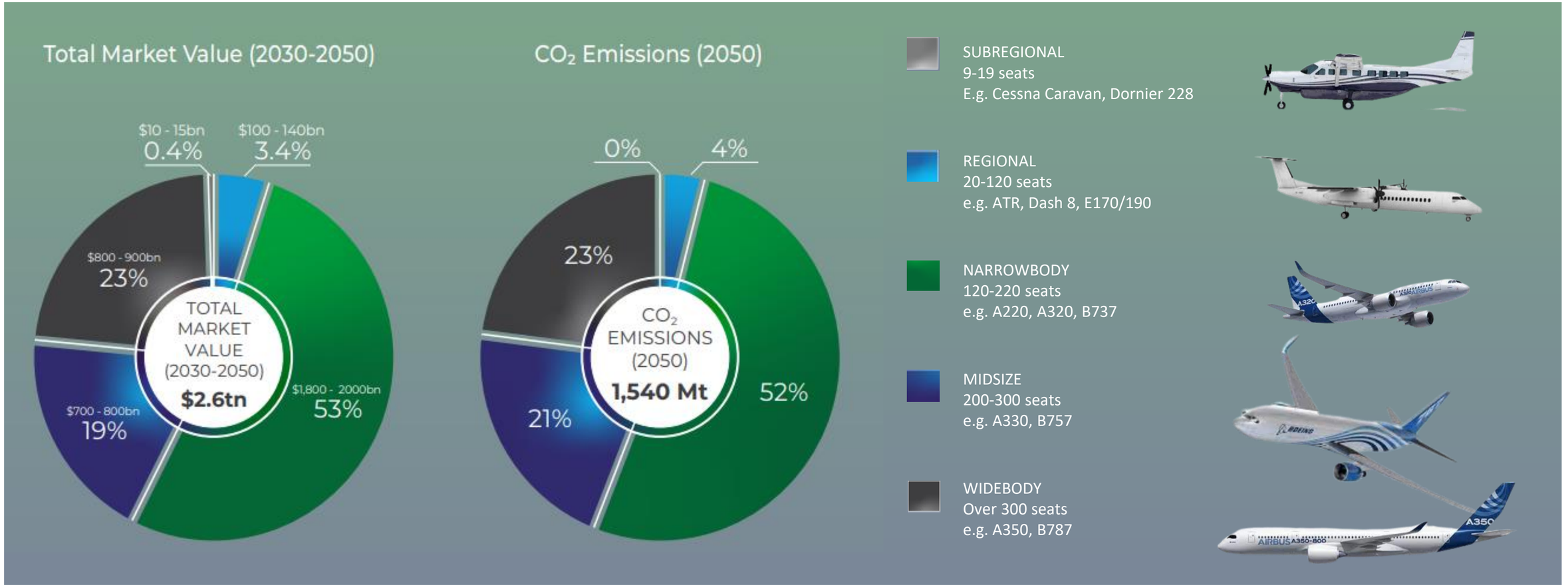
Jobs
The UK aerospace sector directly employed 111,000 in 2022[3]

Apprenticeships
25,0000 new apprenticeships by 2030[3]

1. Funding Growth in Aerospace, ATI & PwC, November 2022
2. Statista 2023
3. Facts and Figures 2022, ADS 2022 (link)

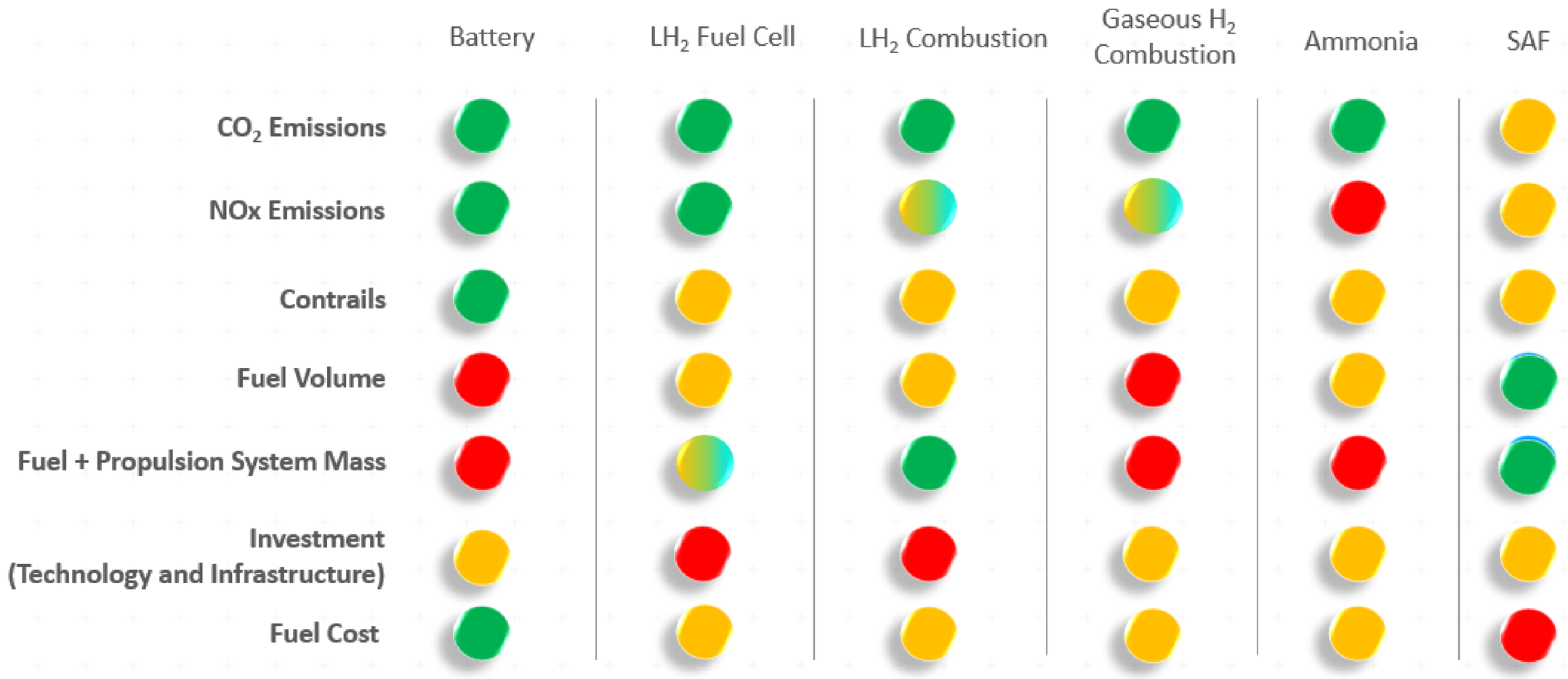
3. Successful transformation will include both new aircraft technologies and alternative fuels.

Where to focus? Aircraft



Source: Flyzero Market Forecasts and Strategy

Where to focus? Fuels



Source: Flyzero Fundamentals assessment

Benefits and challenges of SAFs

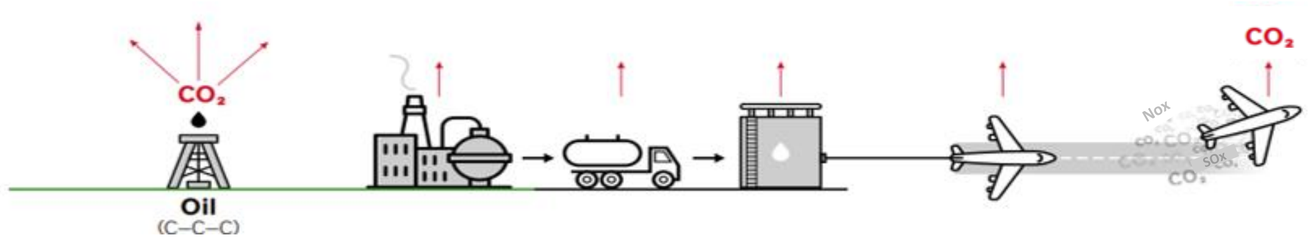
Benefits

- **Carbon savings** of at least 40% relative to kerosene
- **Drop-in fuel** if mixed with kerosene
- **Little** aircraft **adjustments** needed

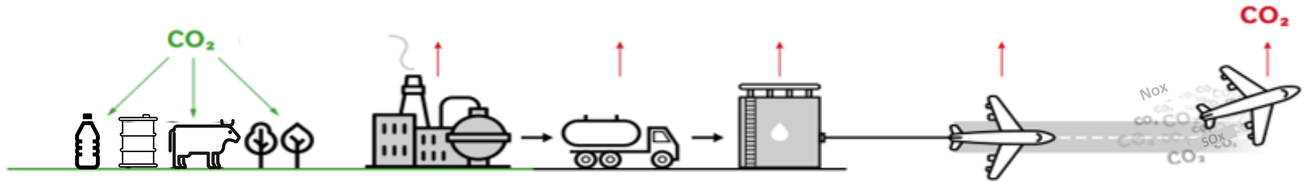
Challenges

- **Availability -** In 2022 only 0.1% of the overall volume of jet fuel available was SAF.[1]
- **Cost -** During 2022 the cost of SAF was around 2.5 times higher than the price of conventional jet fuel.[1]
- **Feedstock** – Waste feedstocks are limited. If biomass was solely used, the amount of land needed for SAF to replace all the UK's aviation fuel is over 50% of that available in the UK for agriculture.[2]
- **Establishing robust sustainability criteria -** Variations exist between countries
- **Aircraft and infrastructure modifications** are required to use 100% SAF.

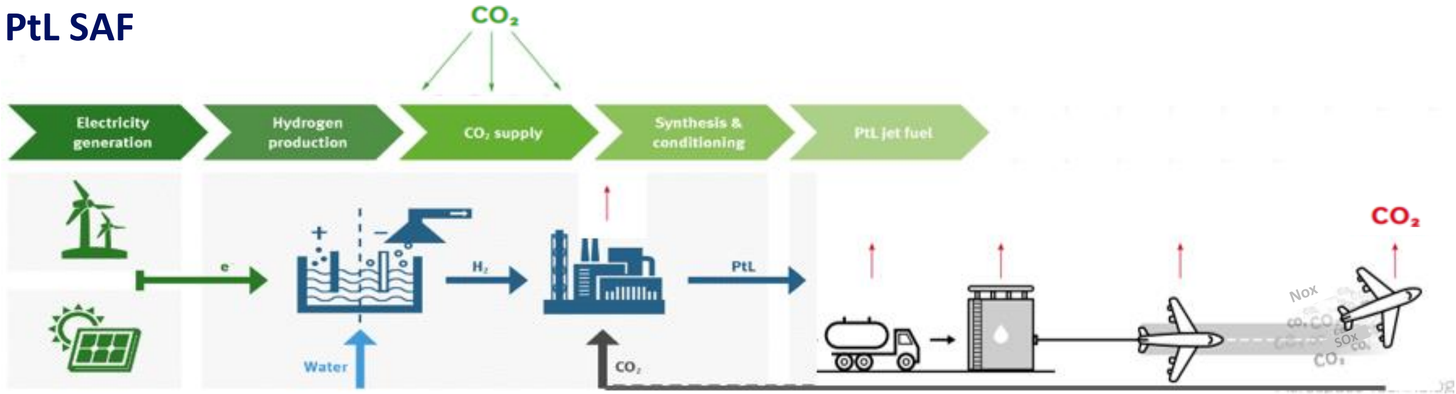
CAF



SAF



PtL SAF

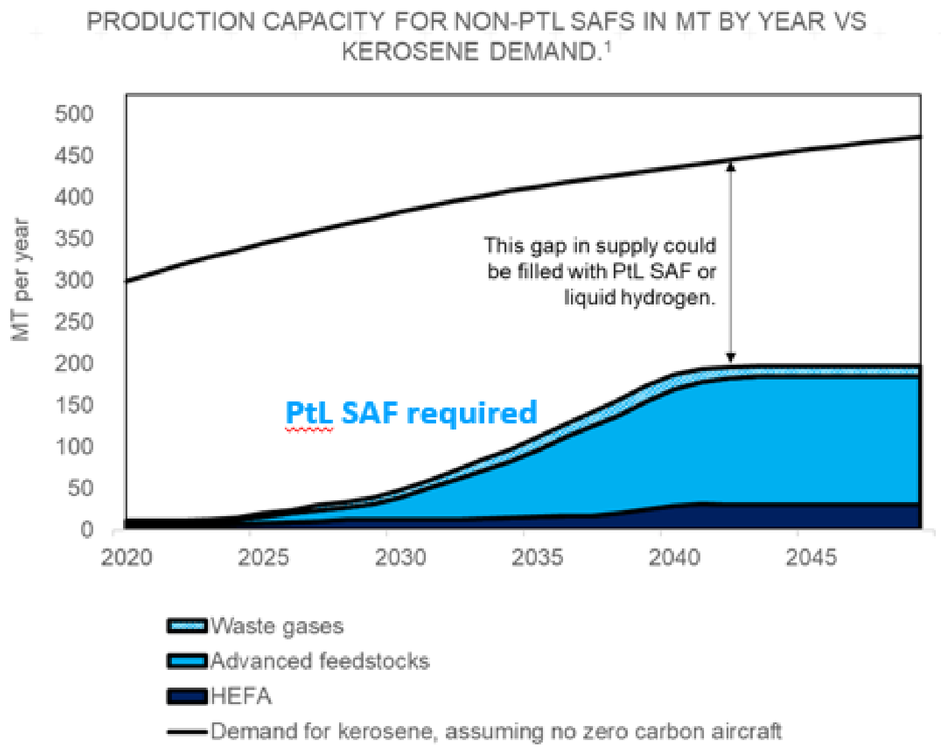


1. IATA
2. The Royal Society, Net Zero aviation fuels: resource requirements and environmental impacts

Hydrogen vs. SAF

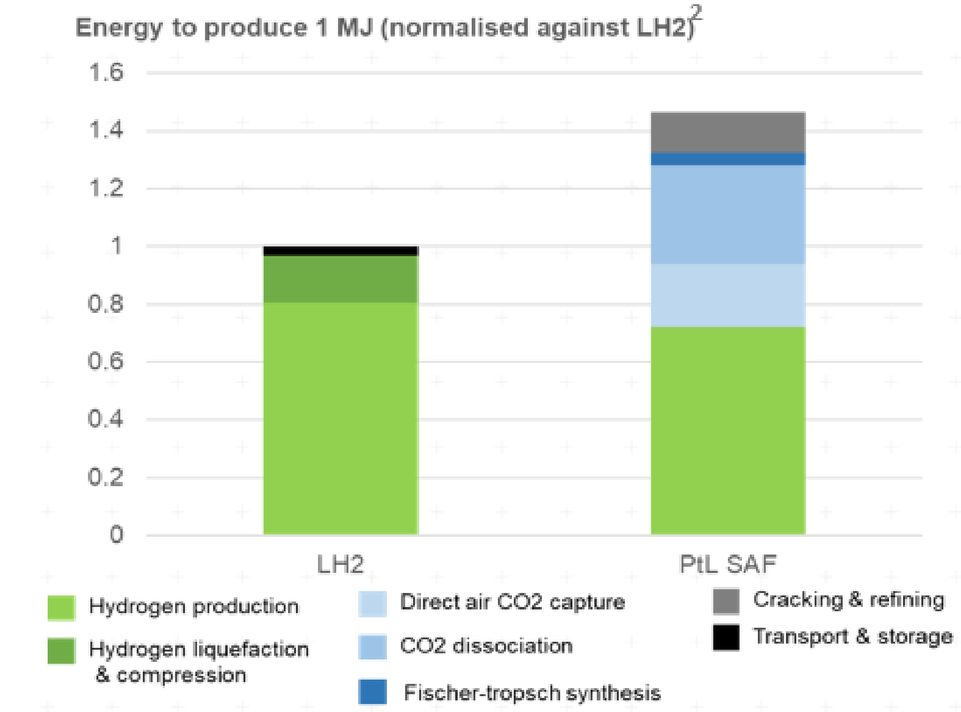
Bio-SAFs are limited bio feedstocks (waste, crops)

World Economic Forum view of SAF ramp-up in EU[1]



Hydrogen is more energy efficient than PtL SAF

Energy to produce 1MJ (normalised against LH_2)[2]



1. World Economic Forum (2021), Guidelines for a Sustainable Aviation Fuel Blending Mandate in Europe
2. FlyZero (2022)

Hydrogen: Key technology development

Aerodynamic structures

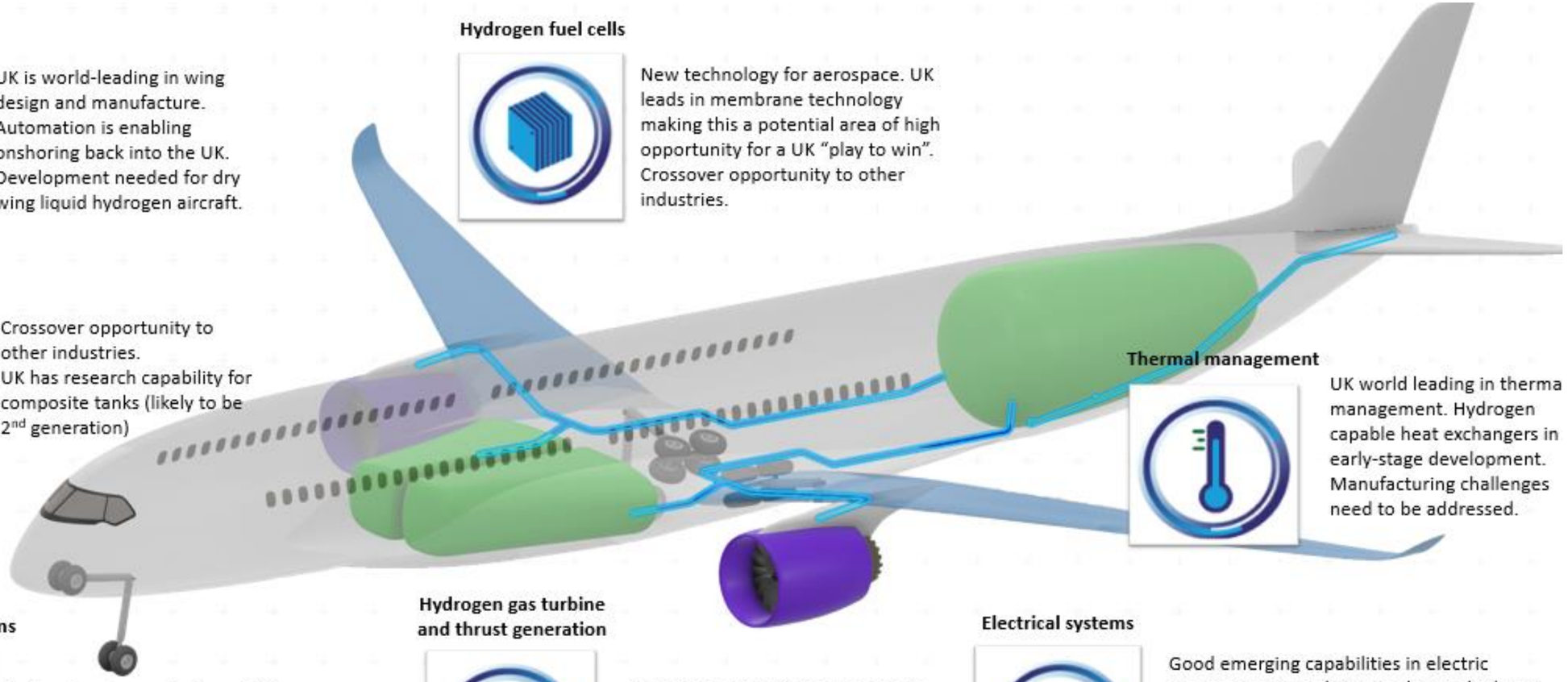
UK is world-leading in wing design and manufacture. Automation is enabling onshoring back into the UK. Development needed for dry wing liquid hydrogen aircraft.

Hydrogen fuel cells

New technology for aerospace. UK leads in membrane technology making this a potential area of high opportunity for a UK “play to win”. Crossover opportunity to other industries.

Hydrogen tanks

Crossover opportunity to other industries.
UK has research capability for composite tanks (likely to be 2nd generation)



Thermal management

UK world leading in therma management. Hydrogen capable heat exchangers in early-stage development. Manufacturing challenges need to be addressed.

Hydrogen fuel systems

Active development of capability. Knowledge of hydrogen and cryogenics is a gap.
Crossover opportunity to other industries.

Hydrogen gas turbine and thrust generation

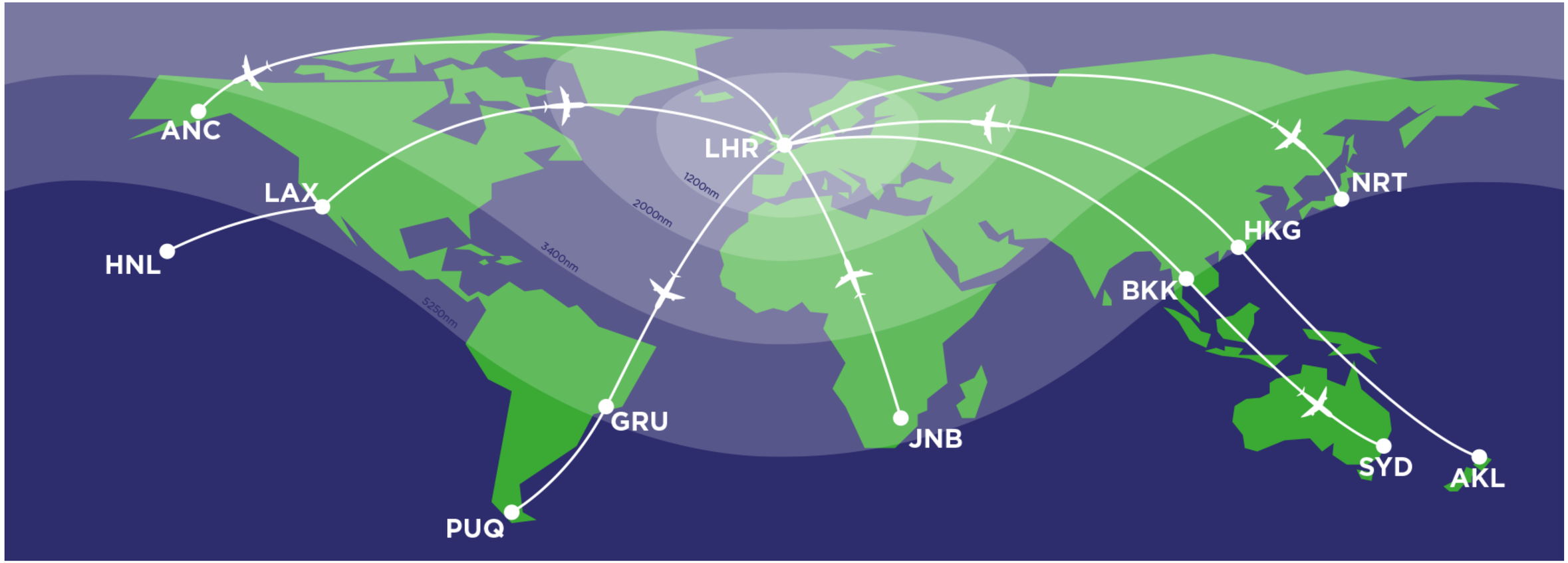
Aerospace gas turbines will have to be modified to burn hydrogen. Good emerging research capability. Limited industrial activity to date.

Electrical systems

Good emerging capabilities in electric aerospace motor design in the UK, built up from academia and industrial start-ups. Opportunity to scale up and capture market. Many developments common for UE aircraft and UAM aircraft. Some cross-sector funding (DER) already available.

Liquid hydrogen and global connectivity

Liquid hydrogen's low weight and high energy density makes global connectivity possible with just one stop

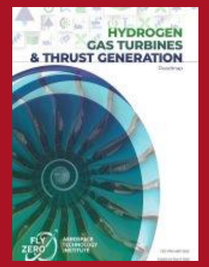


A family of hydrogen powered aircraft with ranges from up to ***5,250nm*** could address 92% of tailpipe carbon emissions. If a single-stop was introduced for all segments above 5,250 nautical miles, then tailpipe carbon emissions could be fully eliminated.

4. Support is being provided for the transition.

Supporting the sector

Technology Strategy & Roadmaps Insights & Reports



Funding Programme

ATI Strategic Programme

- £1m - £50m (indicative)
- Average duration: 3 years
- Usually 3-5 partners
- Must be Industrially-led
- Capital projects can be led by academia or RTOs

ATI SME Programme

- Projects up to £1.5m
- 12 to 36 months in duration
- SMEs receive a minimum of 50% of the project grant funding
- Consortia applications encouraged

Tools & Data

- Fixed Trade Calculator
- Infrastructure Database
- Market Model Online Tool
- Tooling Directory

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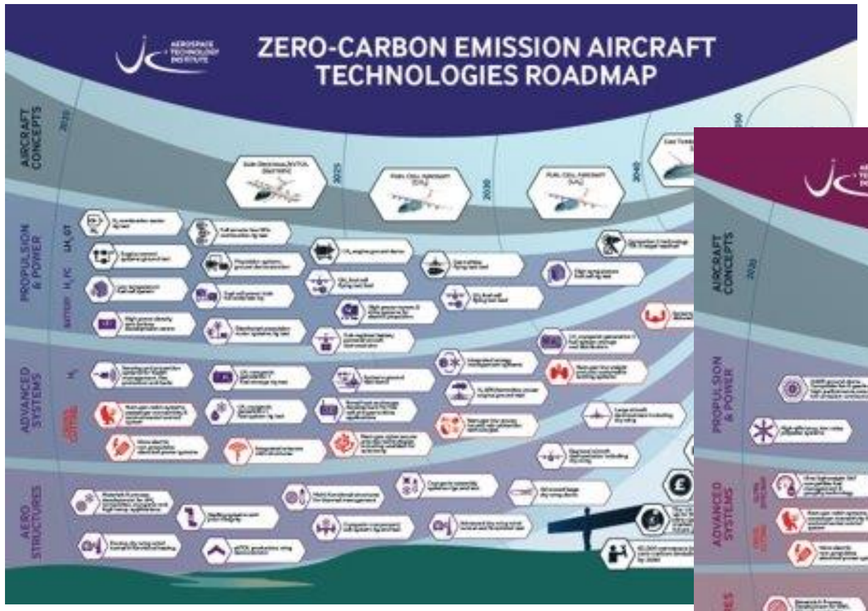
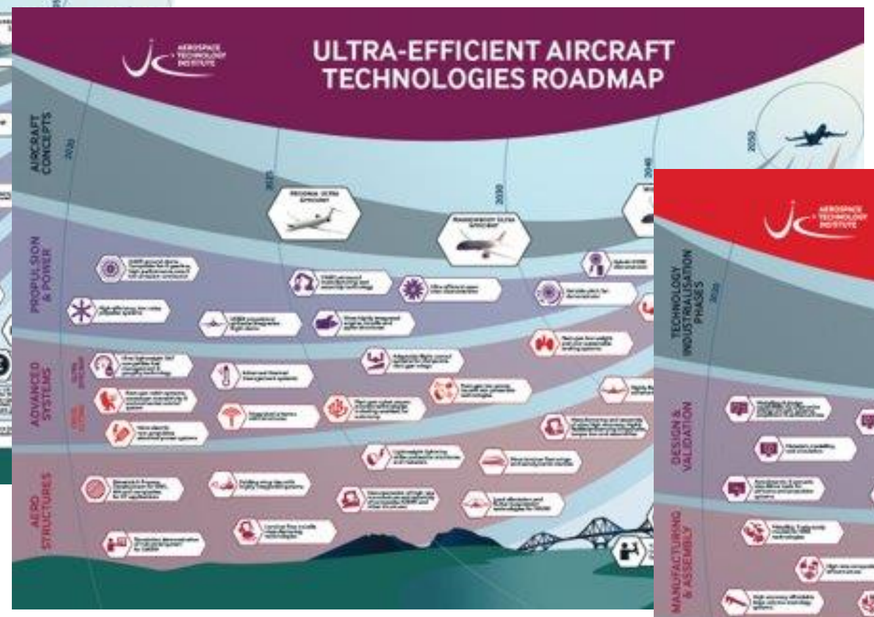
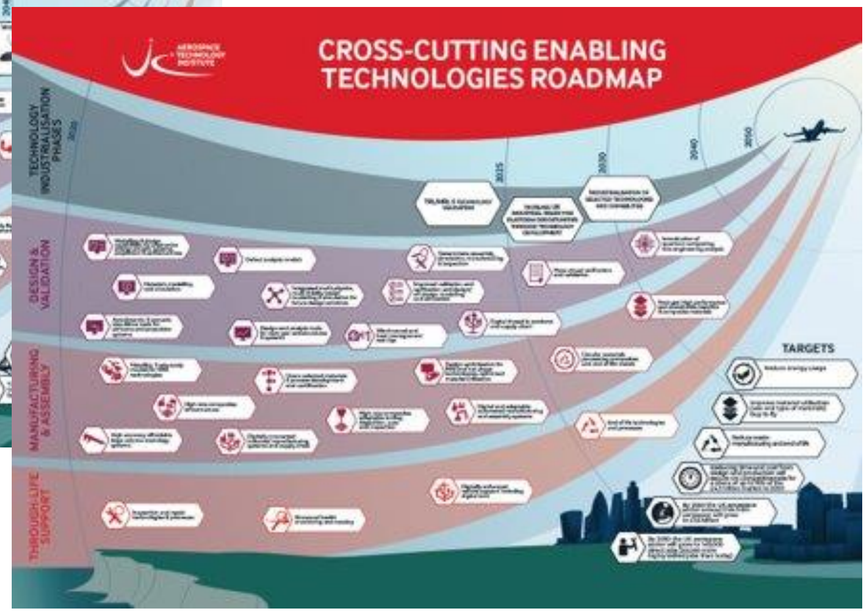
ATI technology roadmaps



- Technologies required to enable next-generation zero-emission aircraft
- **largest carbon reduction potential and market opportunity for UK**

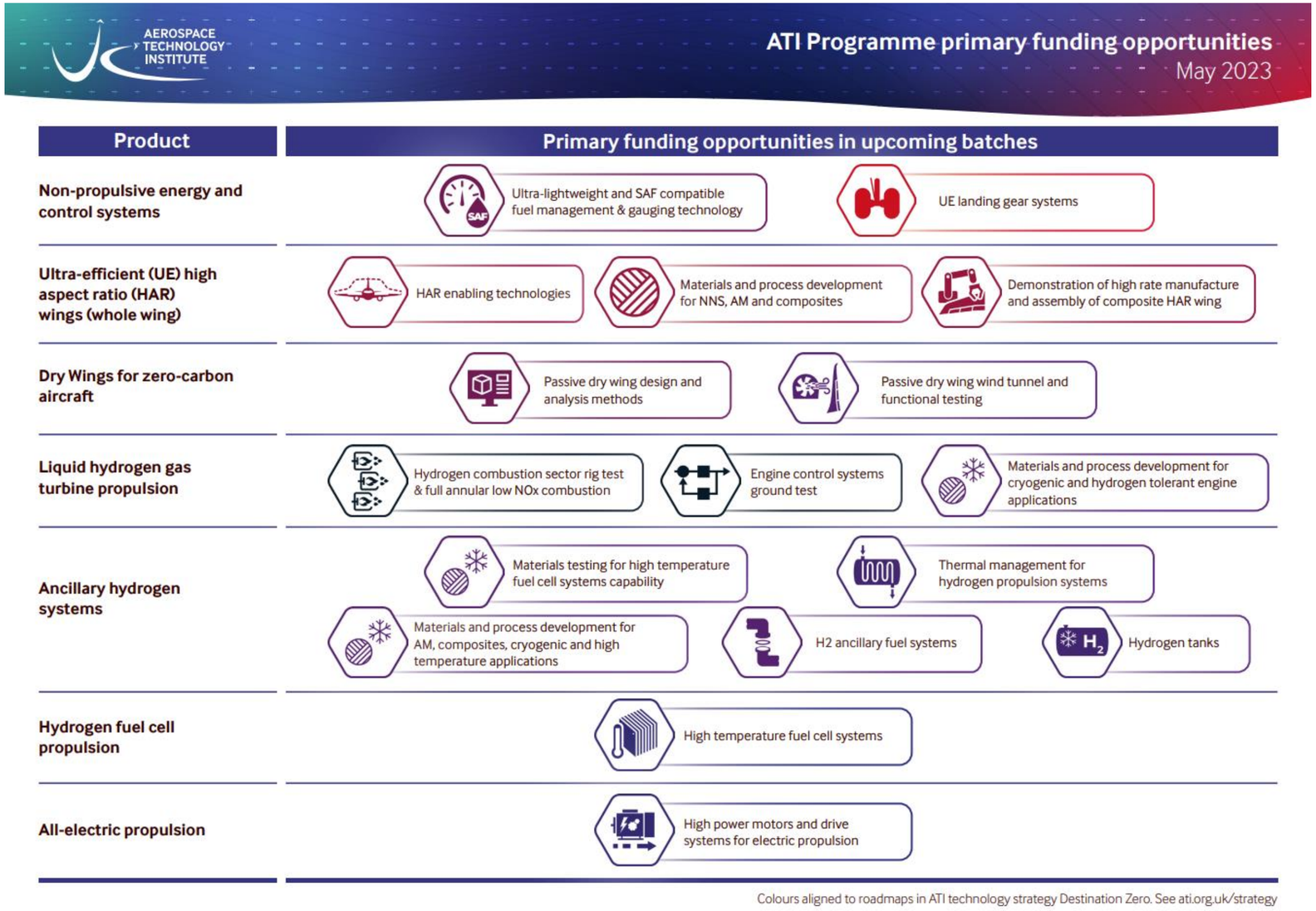


- Technologies to reduce weight, drag and fuel consumption which will benefit all future aircraft
- **Will be exploited on new derivatives of all sizes**



- Vital for novel aircraft platforms and future UK leadership
- **Large spillover potential into other sectors**

Primary funding opportunities



ATI-ProgramATI-Programme-primary-funding-opportunities-May23.pdfme-primary-funding-opportunities-May23.pdf

Pathways to Decarbonising Flight: Summary

- Decarbonisation presents a major sector **challenge**
- The **opportunities** are significant, both in terms of economic and social benefits
- **Technological development** is needed, particularly focused on larger aircraft and alternative fuels
- **Technological and infrastructure advancements** are key
- Support is available, but **further action is key** to accelerate the transition and achieve net zero by 2050

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