Mark Kelk,
Senior Business Development Manager
Cranfield Aerospace Solutions Ltd

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CRANFIELD AEROSPACE SOLUTIONS

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Capability

- UK CAA Part 21 J - Design Organisation (DOA) Approvals for Complex Aircraft Modifications,
- UK CAA Part 21G - Production Organisation (POA) approvals,
- Part 145 - aircraft Maintenance Organisation (MOA) approvals
- Whole aircraft concept design development,
- 30+ years' experience

Designed & manufactured sub-scale blended wing flight test vehicle

NASA

BOEING

"Red Team" on flight safety documentation for Spirit of Innovation world-record breaking electric aircraft

Rolls-Royce

Design of structure to install and operate jet engine/electric generator inside RJ100 aircraft cabin

AIRBUS

Rolls-Royce

Designed & built full scale ground test eVTOL

Rolls-Royce

Designed & supported the certification of modifications to convert BAE 146 to the national atmospheric research aircraft

Met Office

WHY HYDROGEN?

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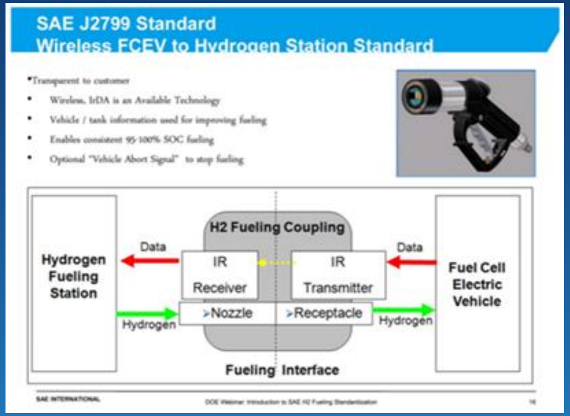
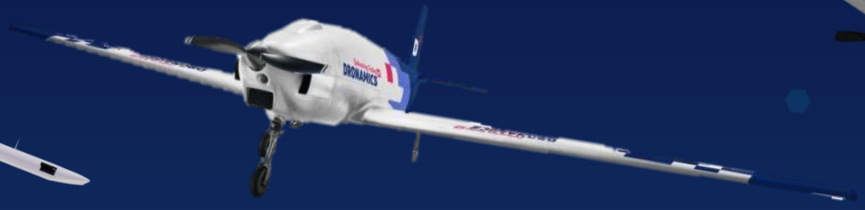
- Target aircraft (BN Islander) needs 60mins flight time + 45mins reserve to capture 80%+ of existing operators.
- Batteries have 1/10th energy density of conventional aviation fuel and degrade over time.
- Hybrid-electric solutions can be beneficial in cars, but the added weight means their adoption in aircraft results in minimal CO_2 benefit.
- Hydrogen has 3 x energy density of conventional aviation fuel and produces zero CO_2 emissions – the most credible solution for aviation.
- Turnaround times are key for operators and hydrogen will be fueled in a similar fashion to current Jet A1.
- Gaseous H_2 offers lower range potential than liquid but will be easier to produce at small airfields in the near future.



4 PHASE STRATEGY

Prove → Exploit → Scale → Optimise

1 | 2 | 3 | 4



	H_2 conversion to existing aircraft platform	Adapt technology to multiple platforms to drive sales volumes		Clean sheet aircraft design, optimised for zero emissions
Type	B-N Islander (6-8 seats)	e.g. large UAV, eVTOL, other aircraft platforms		Up to 19 seats passenger & cargo aircraft
Market entry	2027	2027/2030		2032+
Powertrain size	2 x 250kW	125kW – 250kW	250kW – 500kW	2 x 500kW – 1MW

THE IDEAL HYDROGEN LAUNCH AIRCRAFT

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- The Islander is a successful, in-production, short-sector, high utilisation aircraft that typically flies short-hop operations in eco-sensitive locations.
- The Islander is internationally certified (UK CAA, EASA, FAA, TCCA, etc) and is type accepted and operated around the world.
- Aircraft is unpressurised, making modifications simpler and more cost effective.
- Conversion of an existing twin engine aircraft presents a much lower risk to getting regulatory approval.
- Flexible interior with options for cargo and medivac configurations.
- Integral underwing hardpoints allow for multiple weights and sizes of hydrogen tanks, creating pathways for increased hydrogen capacity and hence range.

Zero CO_2 emissions & less air pollution

Noise reduction and less vibration

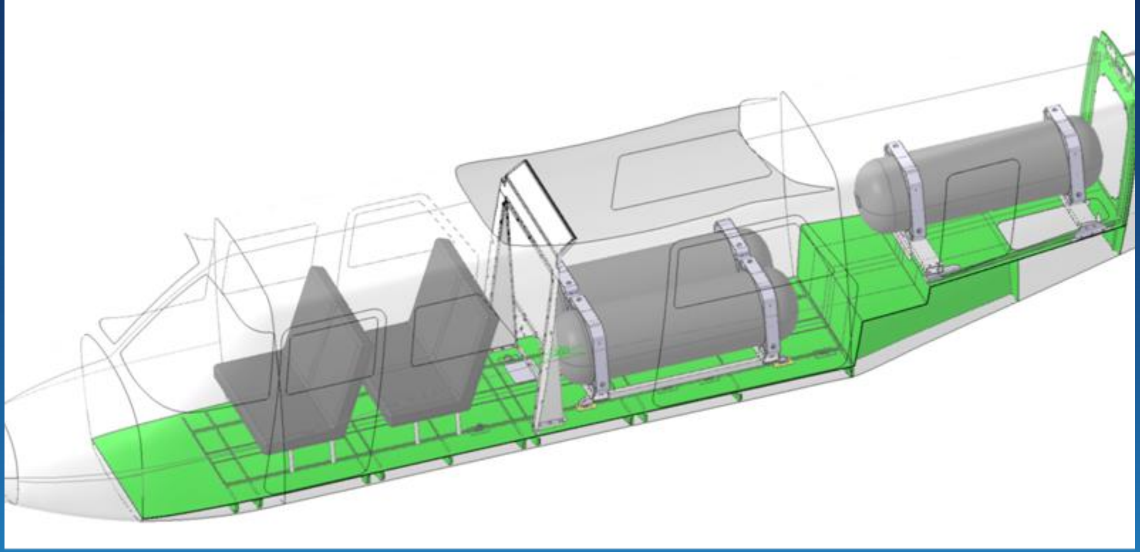
6 to 8 passengers

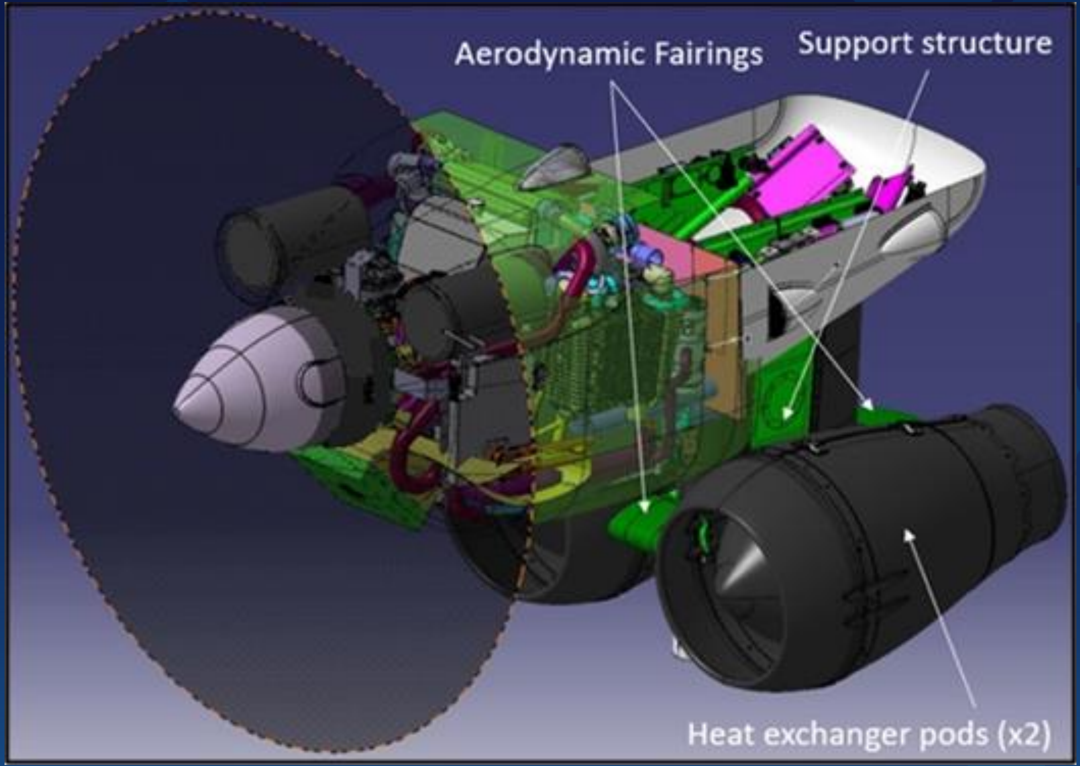
Entry into service by 2026

[1]CAeS calculations

DEMONSTRATOR

- To reduce the risks, one side only will be modified to test the equipment.
- Modified nacelle re-packaged to include all balance–of-plant equipment other than the thermal management units
- Hydrogen will be stored in tanks within the fuselage; not under the wing as per the product
- To achieve the cooling demands, 2 off, units will be used and attached either side of the under-carriage leg as shown





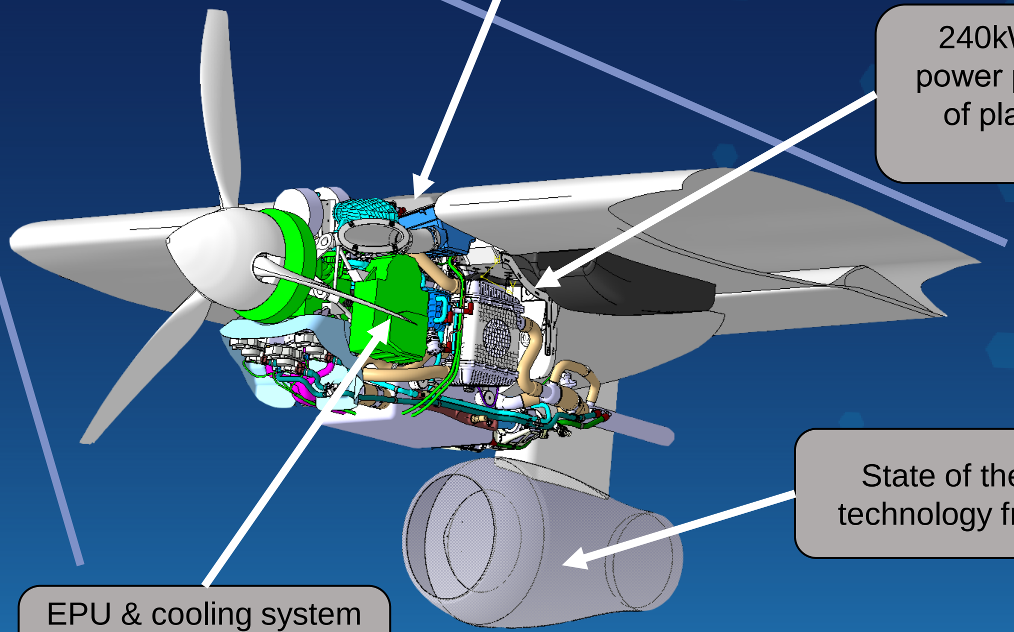
DEMONSTRATOR DELIVERABLES

- Performance testing of Thermal Management Unit/Heat Exchanger successfully completed.
- First Electric Propulsion Unit (EPU) built and passed end-of-line testing, formal qualification testing starts this month
- Focus is now on ensuring parts are delivered to schedule.
- On-going discussion with Cranfield University, Cranfield Airport and UK CAA regarding airside refueling.

Thermal management units under test

G-HYUK will be the demonstrator aircraft

‘PRODUCT’ CONFIGURATION



Additional technologies,

- Updated Human Machine Interface
- Introduction of a high power electrical system,
- New 3-bladed propeller turning at a slower speed.
- High pressure, low weight hydrogen gas tanks
- Hydrogen distribution system around the aircraft.

THE AIRPORT CHALLENGE

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- A hydrogen fuel cell (HFC) powered aircraft needs a viable source of hydrogen fuel.
- Hydrogen source needs to be high purity, “5 x 9’s”.
- Airports will need a substantive and robust supply of hydrogen with local electrical power generation and electrolysis presenting an opportunity.
- CAeS and partners are working with airports in the UK and Europe to make airports aware of the infrastructure needs and timeframe, e.g. Groningen Airport as opposite.
- Cranfield University is taking delivery of an electrolyser and mobile refueller in the coming weeks with the aim of getting the refueller approved for airside operations.

Groningen Airport, The Netherlands with a 22MW PV farm (north/south RWY INOP)

STANDARDS & REGULATION- H2 AT AIRPORTS

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Standards & regulation to govern the use of hydrogen at airports is **critical** to viable infrastructure and safe operations.

Airworthiness Authority
Processes & procedures governing all aspects of airport operations

Fire, Rescue & Emergency Response

Servicing & Maintenance of Equipment

Fuel Safety Standards fuel production, sampling, handling, storage and refuelling

Hazardous Materials Regulations

- CAeS is a member of various UK & European working groups looking to establish the necessary standards & regulations and working closely with airports to enable adoption.
- CAeS is also a member of the Hydrogen Challenge with the UK CAA to improve understanding of hydrogen-related risks in aviation, identify gaps in policies and propose new recommendations to develop net-zero policies.

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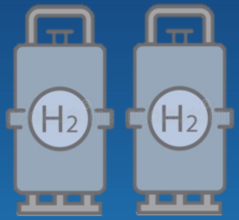
DELIVERY OF GROUND INFRASTRUCTURE

- There is no template for ground infrastructure to support gaseous H_2 at airports.
- The solution will depend upon:
  - ✓ Airport location
  - ✓ Size of existing local H_2 operations. Is there capacity to supply the airport needs? Off-take agreements.
  - ✓ Availability of (or expected availability of) green H_2 in local / regional area?
  - ✓ Local generation near airports for H_2 transport hubs.
  - ✓ Appetite of the airport, operators or owners to invest? Does the H_2 go airside or not?
  - ✓ Level of government / PV financial support to investment in infrastructure?

- The likely first adopters of the H_2 Islander (Loganair, Evia Aero, Skybus, Air New Zealand) are already engaged in understanding & enabling the H_2 infrastructure for their operations, supported by CAeS.

  For example, SATE (Sustainable Aviation Test Environment) at Kirkwall in the Orkney Isles.

- Aviation H_2 demand is initially forecast to be small, ’00s kg/day 2026/27 raising to 000’s kg/day by 2030.




Electrolysis

LETTERS OF INTENT / MoUs

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Skybus	• Existing Islander operator	UK	3
EVIA AERO	• Start-up airline and renewable infrastructure provider	GERMANY	15 + 10 x 19-seater aircraft
MONTE	• Lessor specialising in green sub-regional aircraft, set up by Montrose Global Aircraft Management	UK	40
AIR NEW ZEALAND	• CAeS selected as sole hydrogen partner as part of Air New Zealand's Mission Gen Next Gen Aircraft programme	NEW ZEALAND	23
Torres Strait AIR	• Existing Islander operator; tripartite MoU with MONTE	AUSTRALIA	10
STRATUS 9	• California-based aircraft fractional ownership company	USA	15
LOGANAIR SCOTLAND'S AIRLINE	• MoU in place to establish partnership and collective aim to introduce hydrogen powered Islander into Scotland	UK	
DRONAMICS	• Startup developing large cargo UAV; successful first flight in April 23 with conventional fuel • Feasibility study complete to assess application of CAeS H2 technology to platform	UK / Bulgaria	

LoIs for **106** Islander modification kits + 10 x 19 seat aircraft

SUMMARY

Hydrogen propulsion, particularly fuel cells, presents an exciting opportunity for zero-emissions flight and provides a route to reducing the environmental impact of aviation in the future.

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CHALLENGES:

Operational

- Proving the ‘concept’ and certification
- Range and endurance requirements for airlines in the early years
- Airport infrastructure
- Government and Aviation Regulations

Technical

- Lightweight, high pressure hydrogen tanks.
- High temperature, aviation grade, PEM fuel cells.

Opportunities

- Potential of significantly reduced operating costs for operators and more efficient maintenance.
- Re-opening of regional connectivity to provide quicker travel with reduced or zero emissions!
- Lower noise pollution.

Questions?

cranfieldaerospace.com

@cranfieldaerospacesolutions

@CAeS_UK