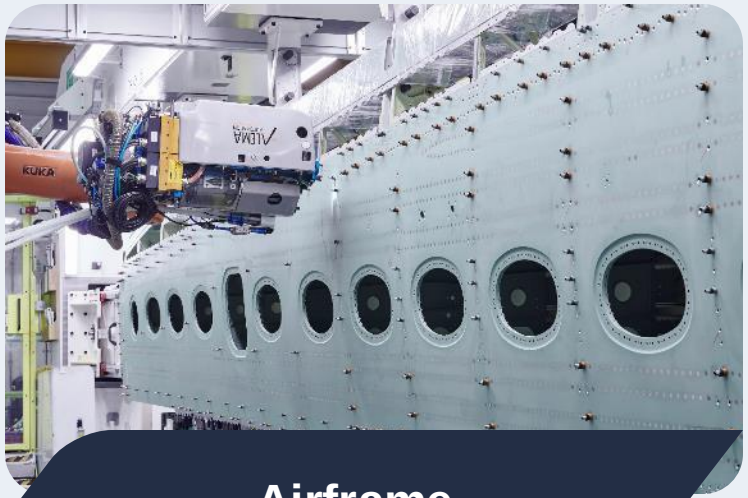
GKN AEROSPACE

Hydrogen Electric Aircraft
Vätgaskonferensen 2024

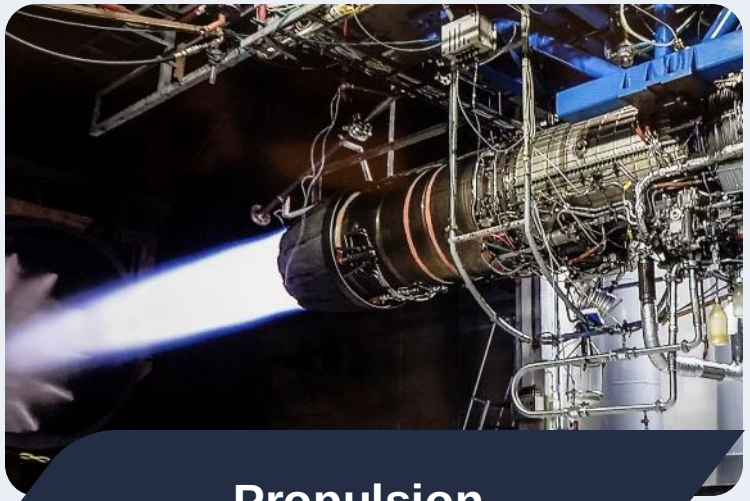
Jurisdiction	Export Classification	Date
UK	PL9009.c	12/12/2024
Sweden	NSR	12/12/2024
Netherlands	NSR	12/12/2024

GKN Aerospace
More than a manufacturing organisation



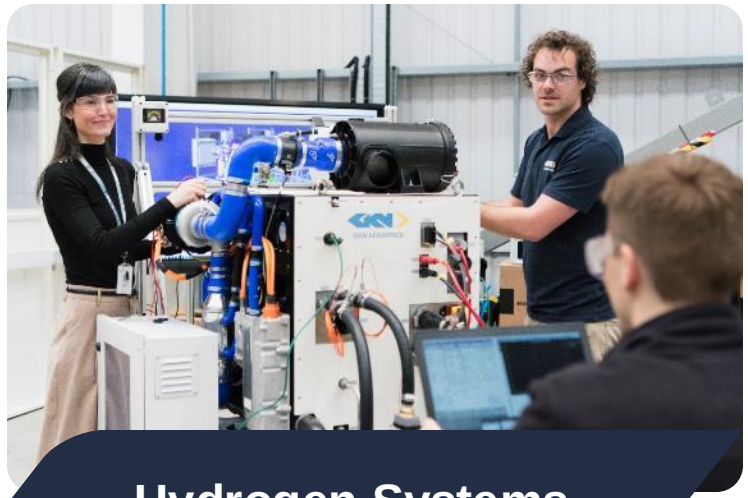
Airframe

- Global Tier 1 partner for integrated Aerostructures development
- Recognised world leading Electrical Systems capability
- Former OEM experience (Fokker)



Propulsion

- Trusted partner to all major OEMs, RRSPs with design authority
- OEM of the RM12 engine
- Former OEM experience (Volvo Aero)



Hydrogen Systems

- Newly formed organisation
- Leading the development of a sustainable aviation supply chain
- Thinking like an OEM, acting as a Partner

Positioning to be the most **trusted** and **sustainable** partner in the sky

Hydrogen Systems
The Journey So Far

e-VOLUTION
(£300k)
2017

H2GEAR
(£54M)
2020

2021

2022

FIA '22

2023

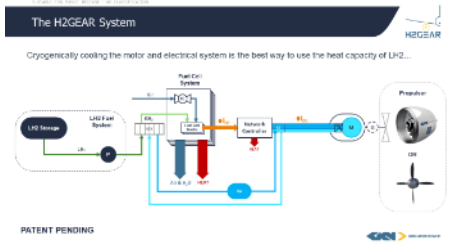
HyFIVE
(£40M)
2024

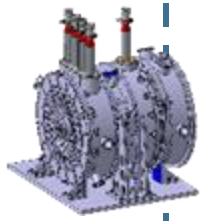
H2FlyGHT
(£44M)
2025

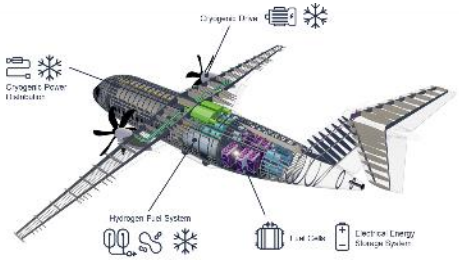
capability

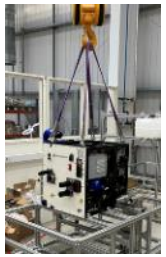
feasibility

scalability



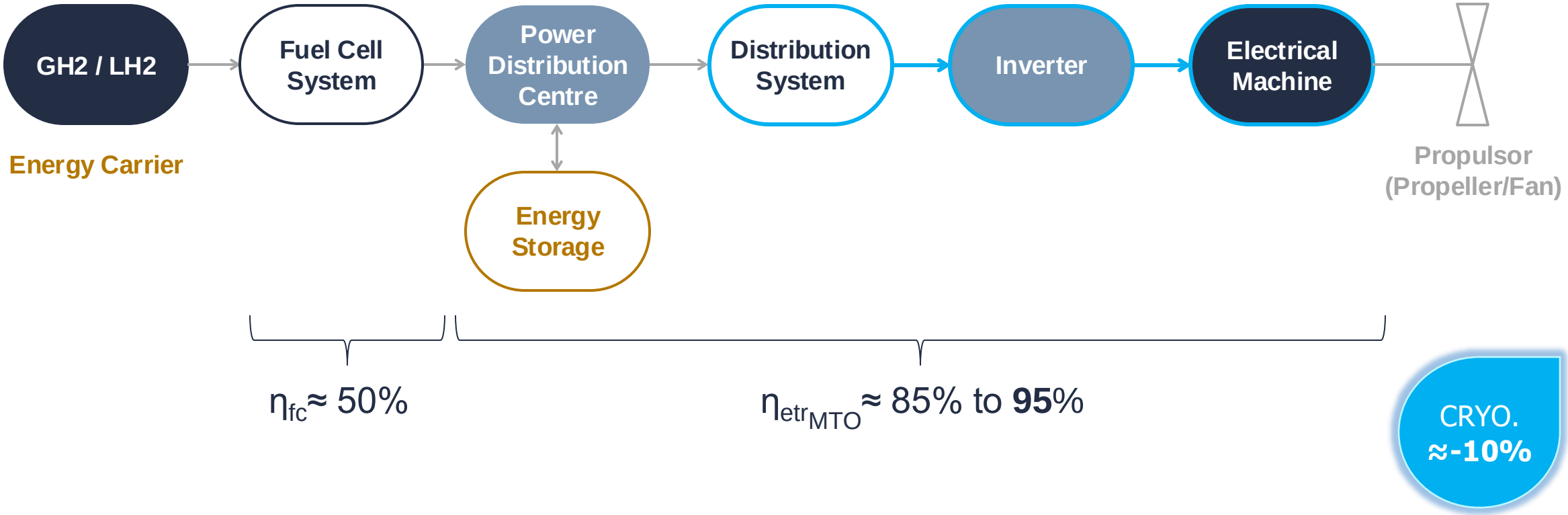






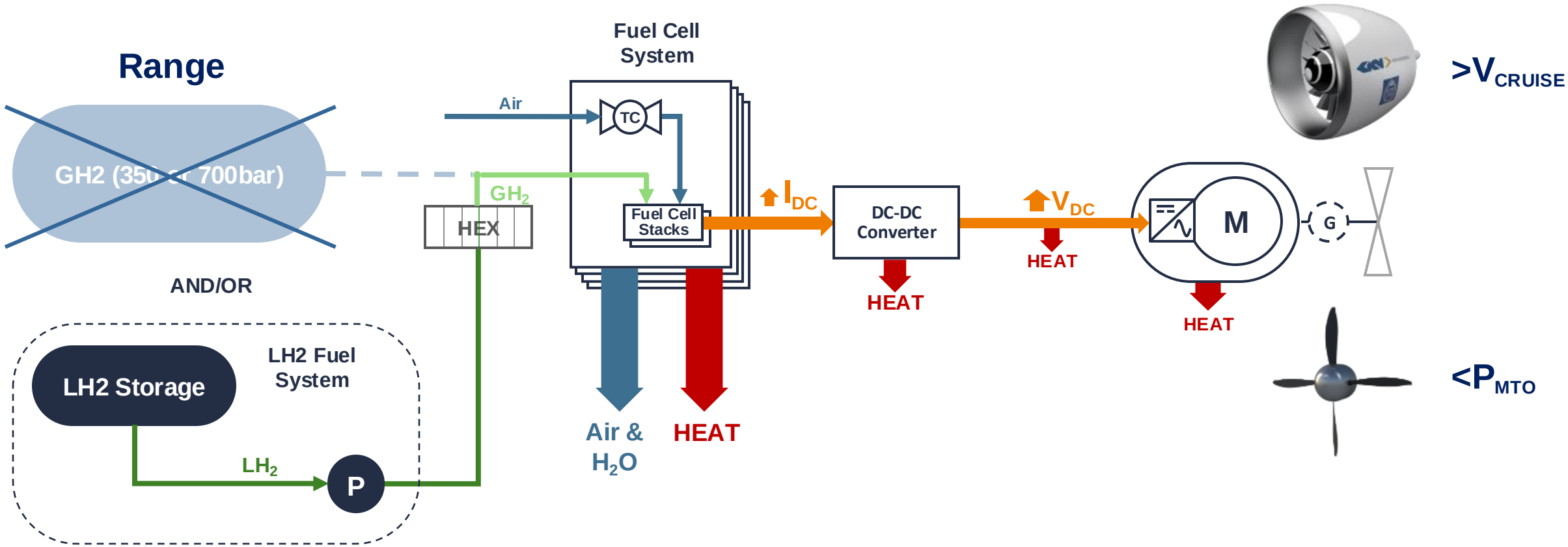
Hydrogen Electric Propulsion (H2EP)

Recap on Powertrain efficiencies



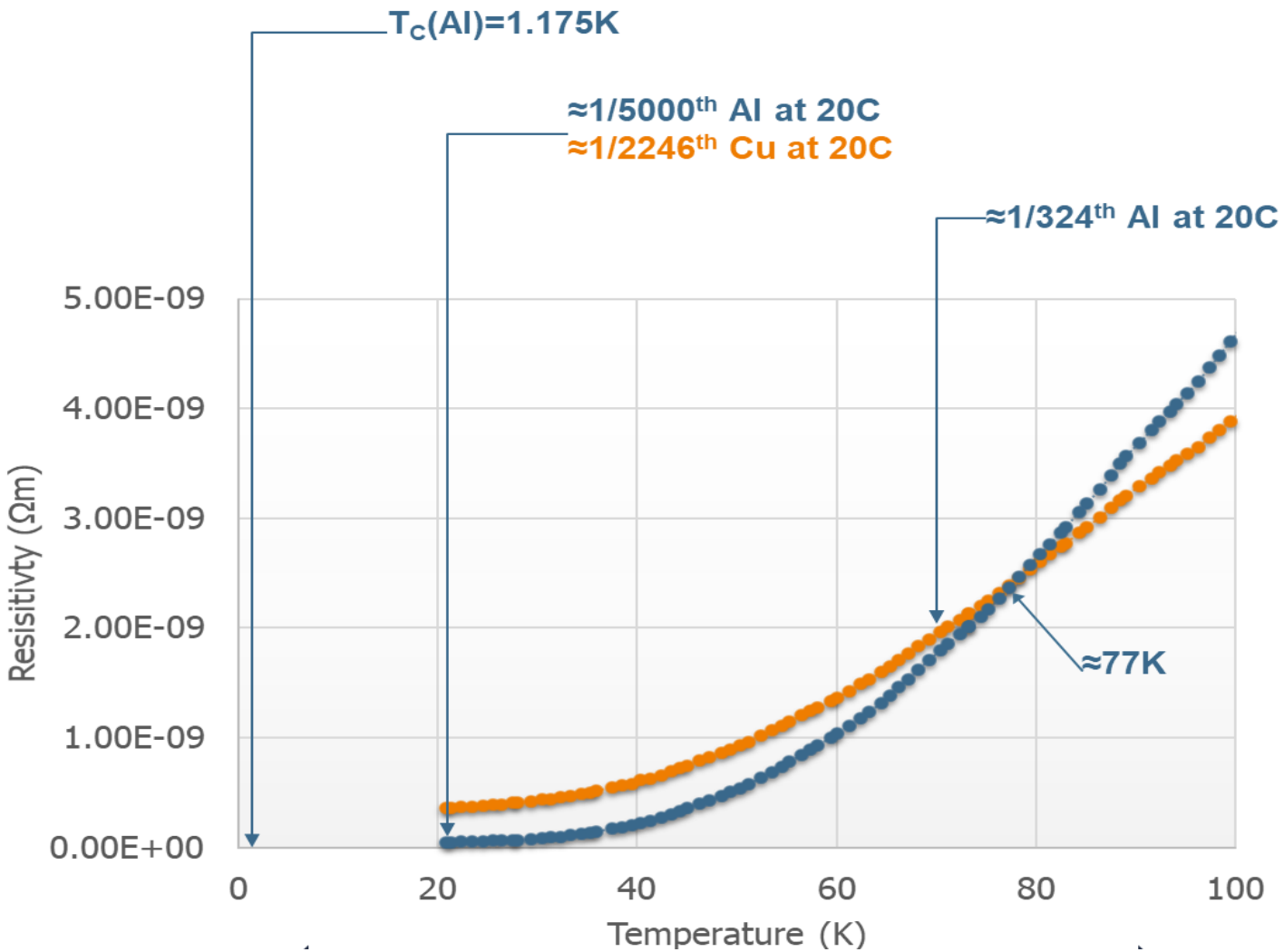
Cryogenic electrical systems can enable **higher efficiency** (≈95%) and **lower** total system **mass**

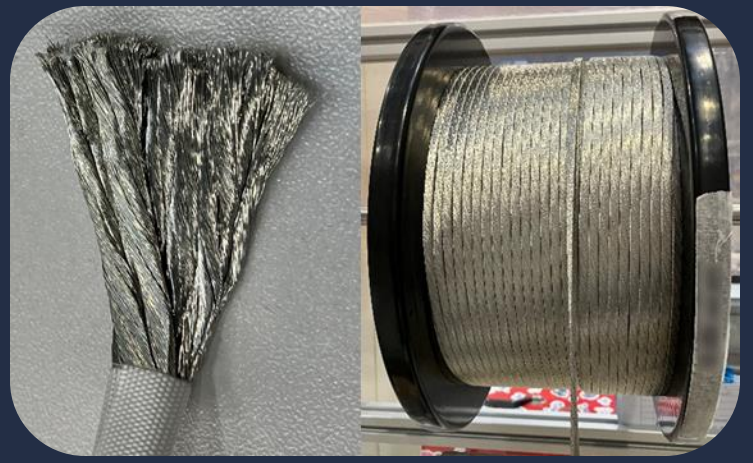
System Overview 1
Conventional Hydrogen Electric Propulsion (H2EP)



Conventional hydrogen electric systems are **not scalable** and will excessively consume LH2

Conventional Cryogenic
aka Hyperconducting



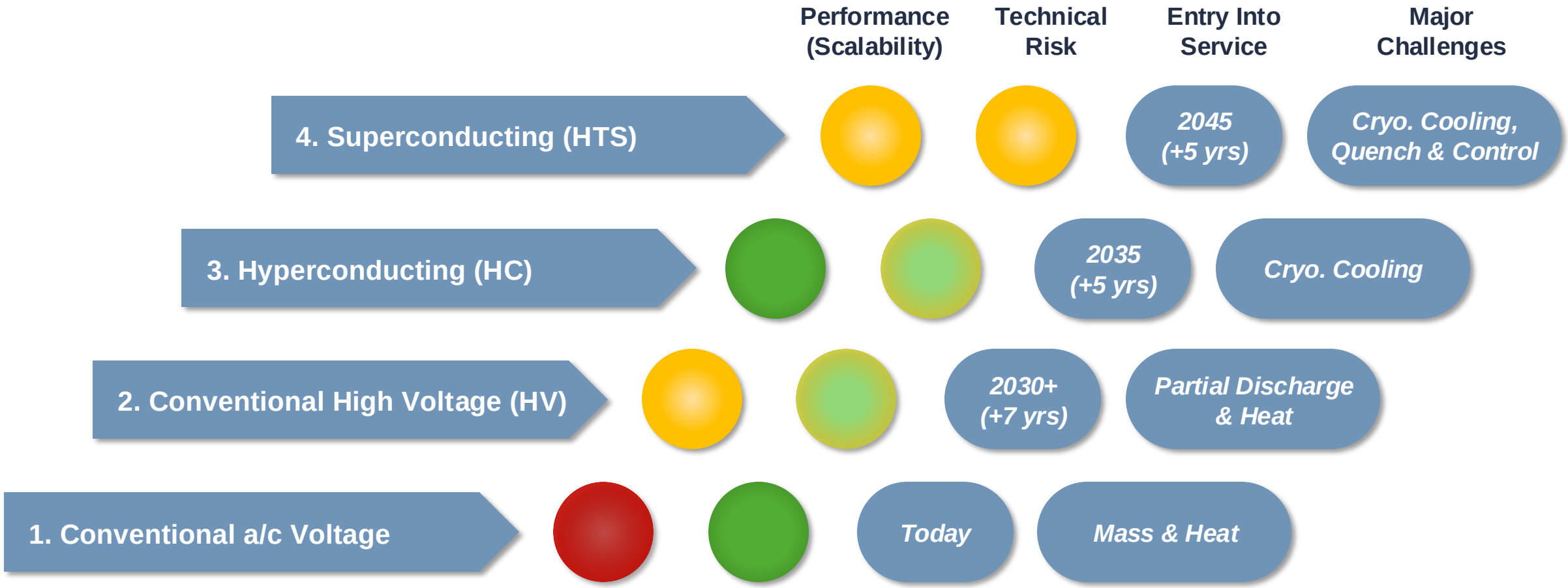


^ Newly developed GKNA Hyperconductors

Hyperconductors are:

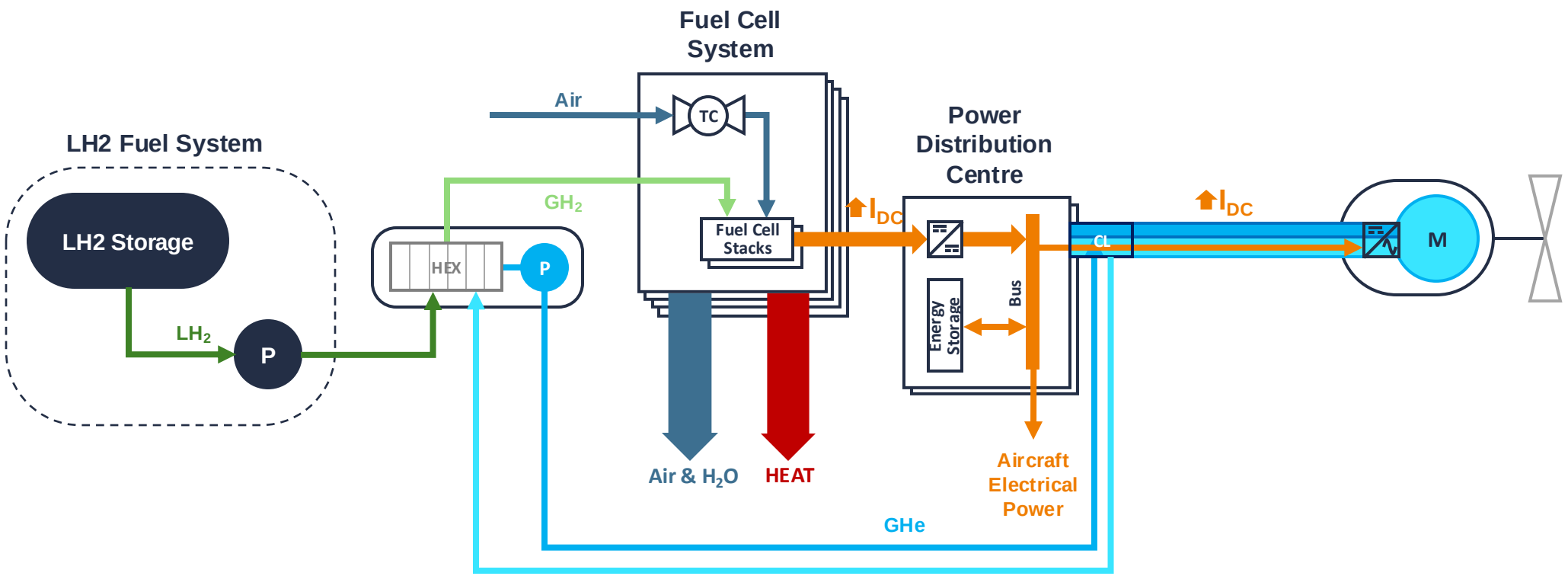
- Normally conducting, metals or metaloids with high chemical purity, which have a much lower specific resistivity for cryogenic temperatures (< 100K), exhibiting a non-linear characteristic
  - In contrast to the poor thermal conductivity of superconductors, hyperconductive materials also hold significantly enhanced thermal conductivity

Opportunities for electrical technology enhancement
Current View



Hyperconducting offers **low** system **mass** and **heat** generation at **acceptable risk**

System Overview 2
Centralized cryogenic H2EP architecture



CRYO.
≈-10%

HEAT
>-10%

CENT
vs. DIST.
≈-15%

Hyperconducting enables **benefits** through a **centralized system**

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H2GEAR Demonstrators

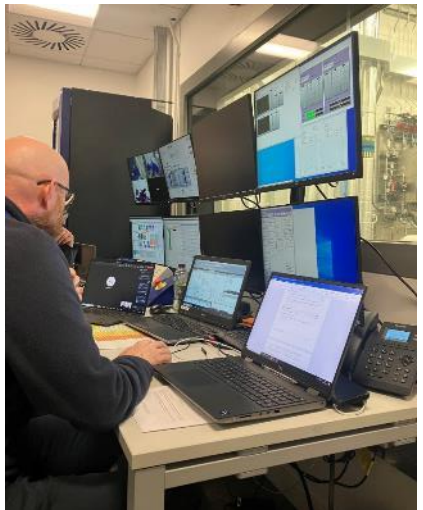
H2GEAR
Demonstrator Builds

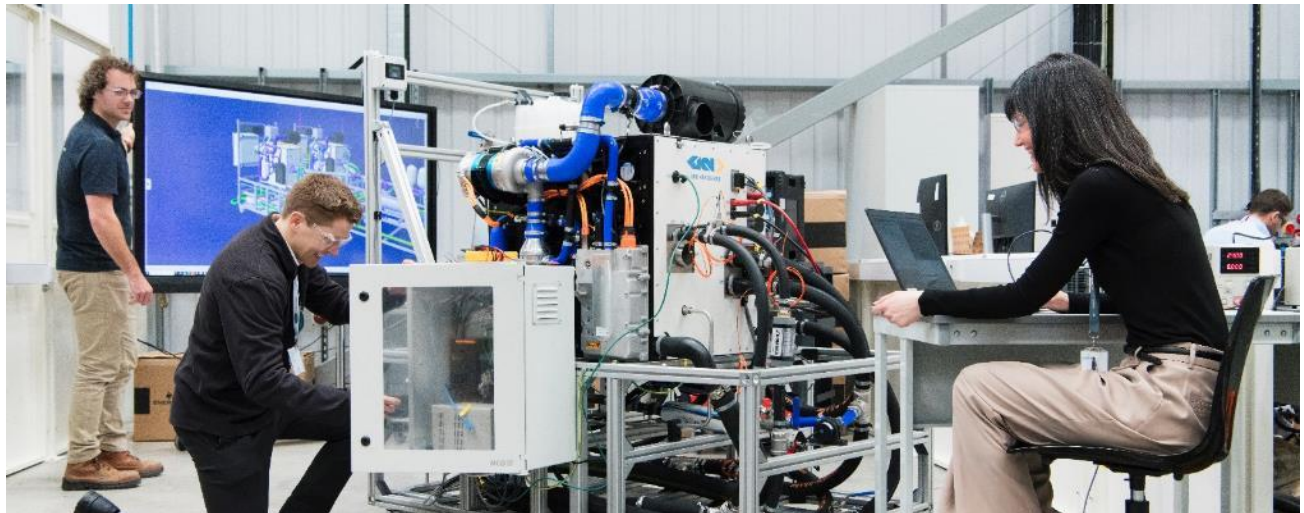
Test ↓ Sub → System	Fuel Cell Power Generation System	Electrical Network System	Motor & Drive	Cryogenic System	Integrated Control
Demo Electrical Machine – Q2 2024			Sub-scale cryo proof of concept	Motor cooling proof of concept	
Build 1 – 2024 (TRL4 Motor & Drive)			Full scale segment Cryo inverter (iso)	Full scale cooling LN cooled inverter	
Build 2A – 2024 (Cryogenic Conduit)		Cryo conduit proof of concept			
Build 2B – 2024 (Cryogenic He/H2 sub-system)				H2/He HEX & H2 heating	
Build 2C – 2024 (Energy Storage Components)		Energy buffer component demo			Power Condition Control
Build 3 – 2023 (LC Fuel Cell Power System)	Sub-System				FCPGS Control
Build 4 – 2024 (Power Conditioning Sub-System)		DC/DC Converter component demo			Electrical Network Control
Build 5 – 2025 (LC+ Fuel Cell Power System)	Sub-System Increased Tech				FCPGS Control
Build 6 – 2025 (TRL5 Integrated Motor & Drive)			Full scale multi segt. Integrated inverter	Full scale cooling He cooled inverter	Integrated Motor Control
Build 7 – 2026 (Integrated Ground System Test)	Integrated Sub-System	Integrated Sub-System	Integrated Sub-System	Integrated Sub-System	Full System Control

Power Generation
Fuel Cell System Testing

Status

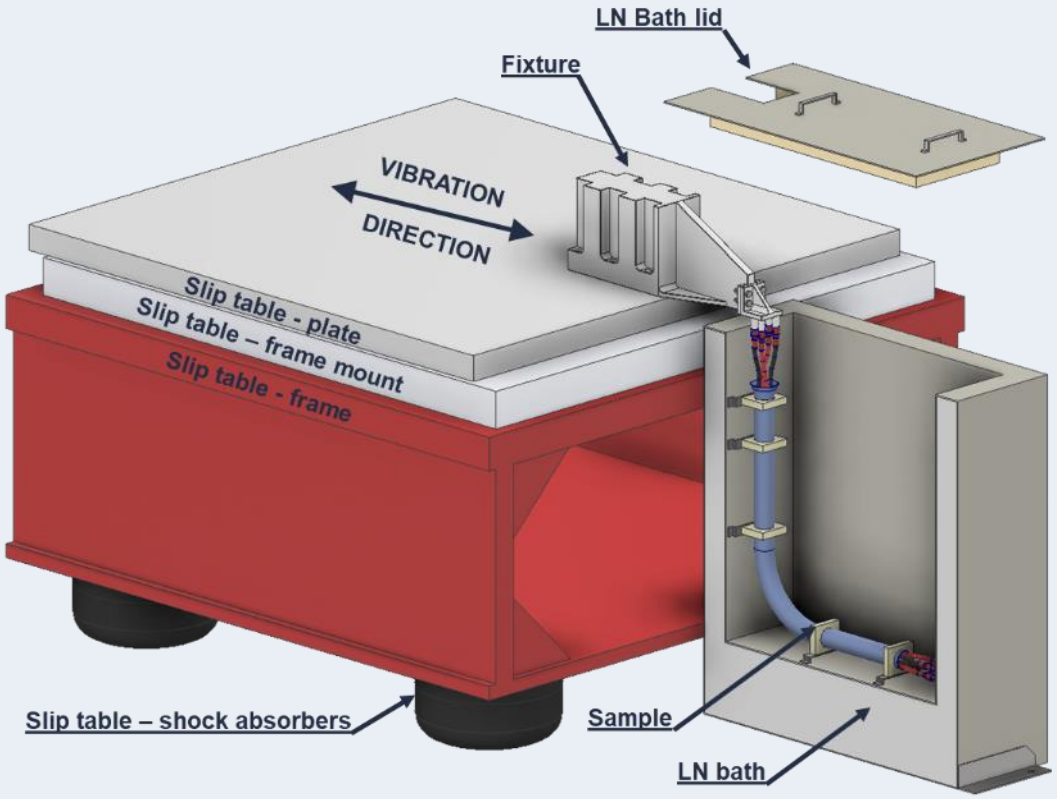
- Collaborated with IAAPS (University of Bath) to develop fuel cell power system test facilities
- Delivered the first GKNA-Integrated fuel cell power generation system
- Operated the system at all required power settings for a nominal aircraft application
- The system met all GKNA expectations
- Transitioning from ~220 kW to ~380 kW





Power Distribution
Vibration Tests on Hyperconducting Cables

Vibration Test Setup:



Test conditions based on existing aircraft test standards

- Insulation Resistance
- Dielectric Strength
- Continuity

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Cryogenic Drive System
Initial Demonstrator Motor Build

The first **hyperconducting** machine is now on test

New Capability

GKN Aerospace opens a ‘Cryolab’ at the UK GTC

Dedicated cryogenics team

- Assembled from across sectors
- Cryogenic design & test expertise

Capability

- Two large test cryostats and one calibration cryostat
- Thermal cycling tests
- Helium permeability testing
- Cryogenic electrical testing
- Cooling capacity down to 10 K

Driving essential skills development in **cryogenics** for the future of aerospace

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Revised Scalability Projections

GKNA96 Concept

Notional aircraft derived performance specification:

- 96 passengers, single class, 3+3 seating arrangement
- High wing, fan-on-wing configuration – low noise and improved CG management
- Installed power ~8 MW driving two low pressure ratio fans of 2.6 m diameter
- Range: 3000 km
- Mach 0.65 @ 35,000 ft
- CS25 compliant

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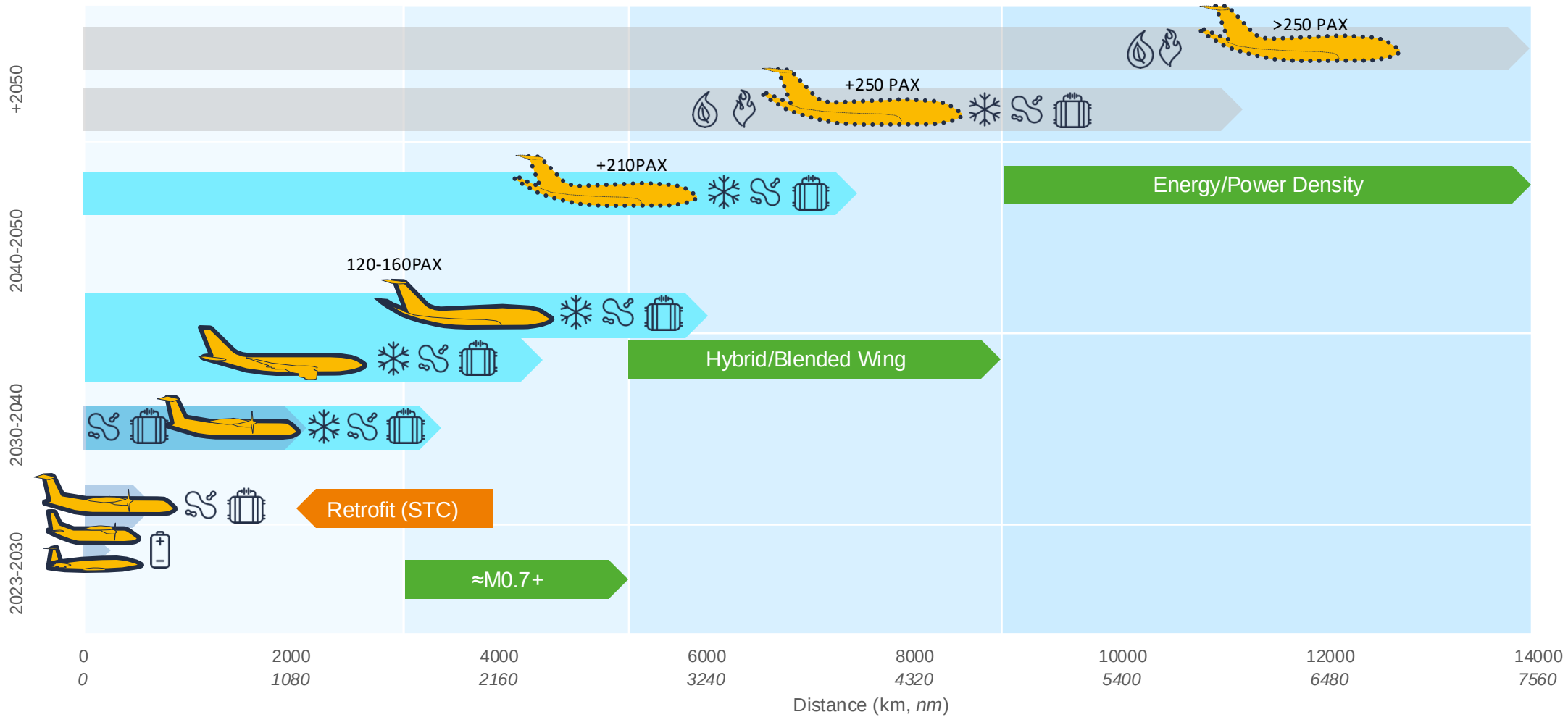
The potential of hyperconducting H2EP

A speculative view on potential new future platforms…



Significant improvements in performance enabling new platforms by 2035

GKNA160 Concept

Notional aircraft derived performance specification:

- 160 passengers, single class, 2-4-2 seating arrangement
- High wing, fan-on-wing configuration – low noise and improved CG management
- Installed power ~16 MW driving four low pressure ratio fans of 2.6m diameter
- Range: 4000 km
- Mach 0.7 @ 35,000 ft
- CS25 compliant

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Power to Deliver Together…

Hydrogen Electric Propulsion is:

- **Attractive and more so when using synergetic cryogenics,**
- ***Scalable***

Success of the product further enabled by:

- **Synergetic Heat Dissipation**
- **Fuel Cell Performance**
- ***Flying technology demonstration!***

Non-product Enablers require collaboration

- **Politics: Aircraft can be zero emission!**
- **Economics: Fuel and Operation**
- **Infrastructure: Capacity & availability**
- **Public opinion: *Safe demonstrations…***

simon.taylor@gknaerospace.com
GKN Technical Fellow,
Director New Air Vehicle Concepts, Chief Engineer Flight Demo. (a.i.)

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