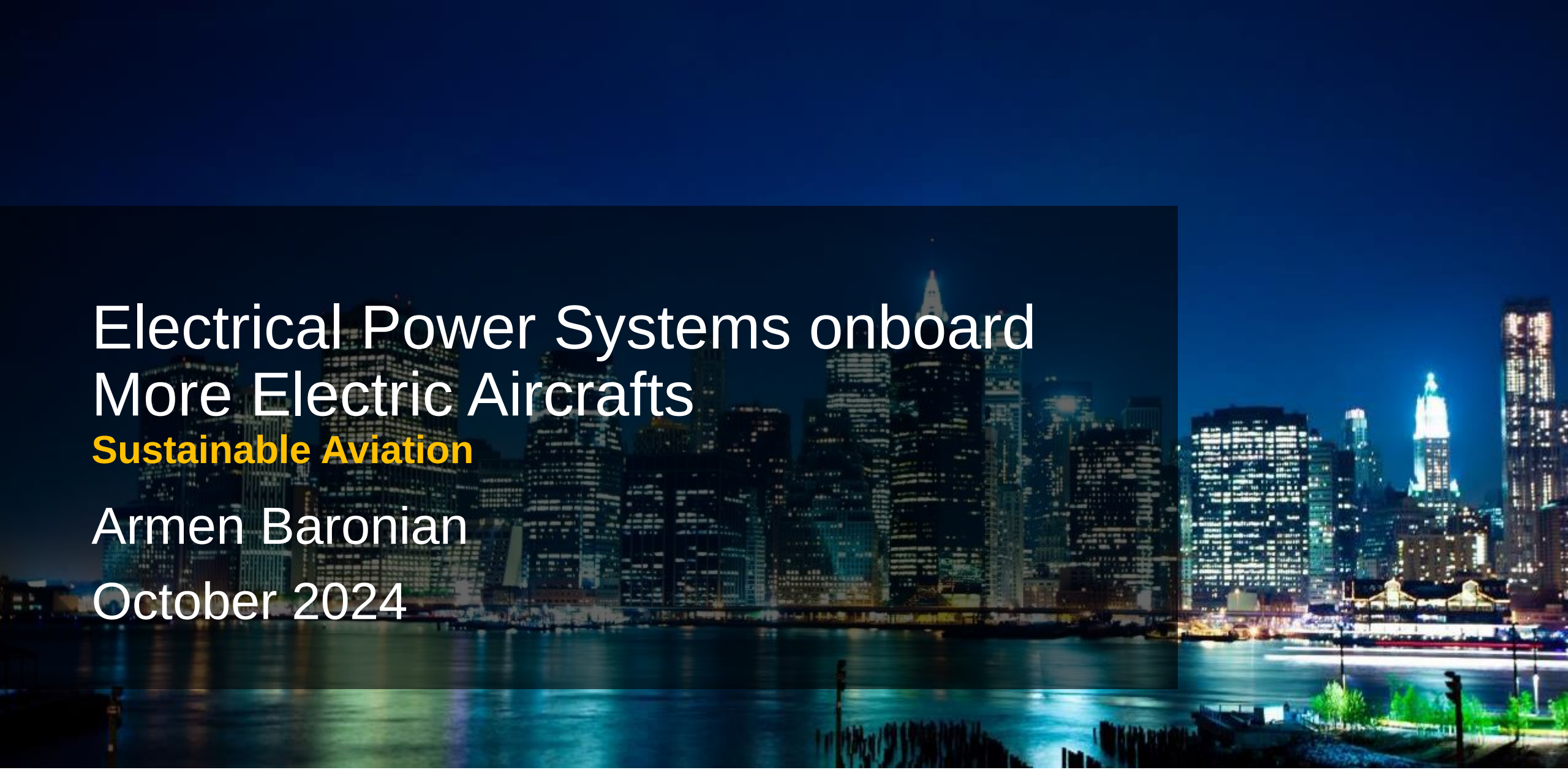


Electrical Power Systems onboard More Electric Aircrafts

Sustainable Aviation

Armen Baronian

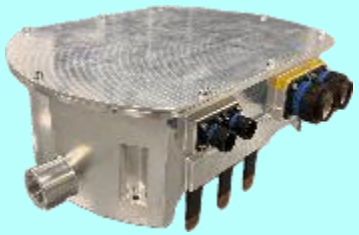
October 2024

Aerospace Electrification Focus Areas

DC/DC Auxiliary Converter

- TRL 4
- SiC
- 800 VDC to 28 VDC
- 5 kW block
- Air & liquid cooled
- 2.12 kW/kg
- 1.9 kW/liter
- Eff. : 95.7-96.4%

DC/AC Motor Drive

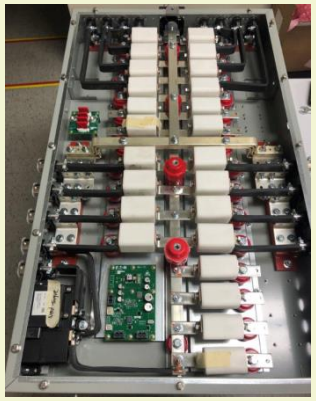


- TRL 4
- 800 VDC input
- 175 kVA
- Air & liquid cooled
- 26 kVA/kg
- 35 kVA/liter
- Efficiency: 99.4%

Axial Flux Propulsion Motor

- TRL 4
- Integrated Motor Drive
- 6500 rpm
- 100 kW continuous
- 120 kW peak
- 5 kW/kg
- Efficiency: 94.5%

Electrical Distribution Syst.



- Electrical power distribution system optimization tool for eVTOL and commercial/military aircrafts
- High-Fidelity System Simulation, protection & coordination

Solid-State Power Controller

- Single input/output
- 28-800V DC / 50-500A range
- Bi-directional
- Non-isolated
- 50,000 cycles

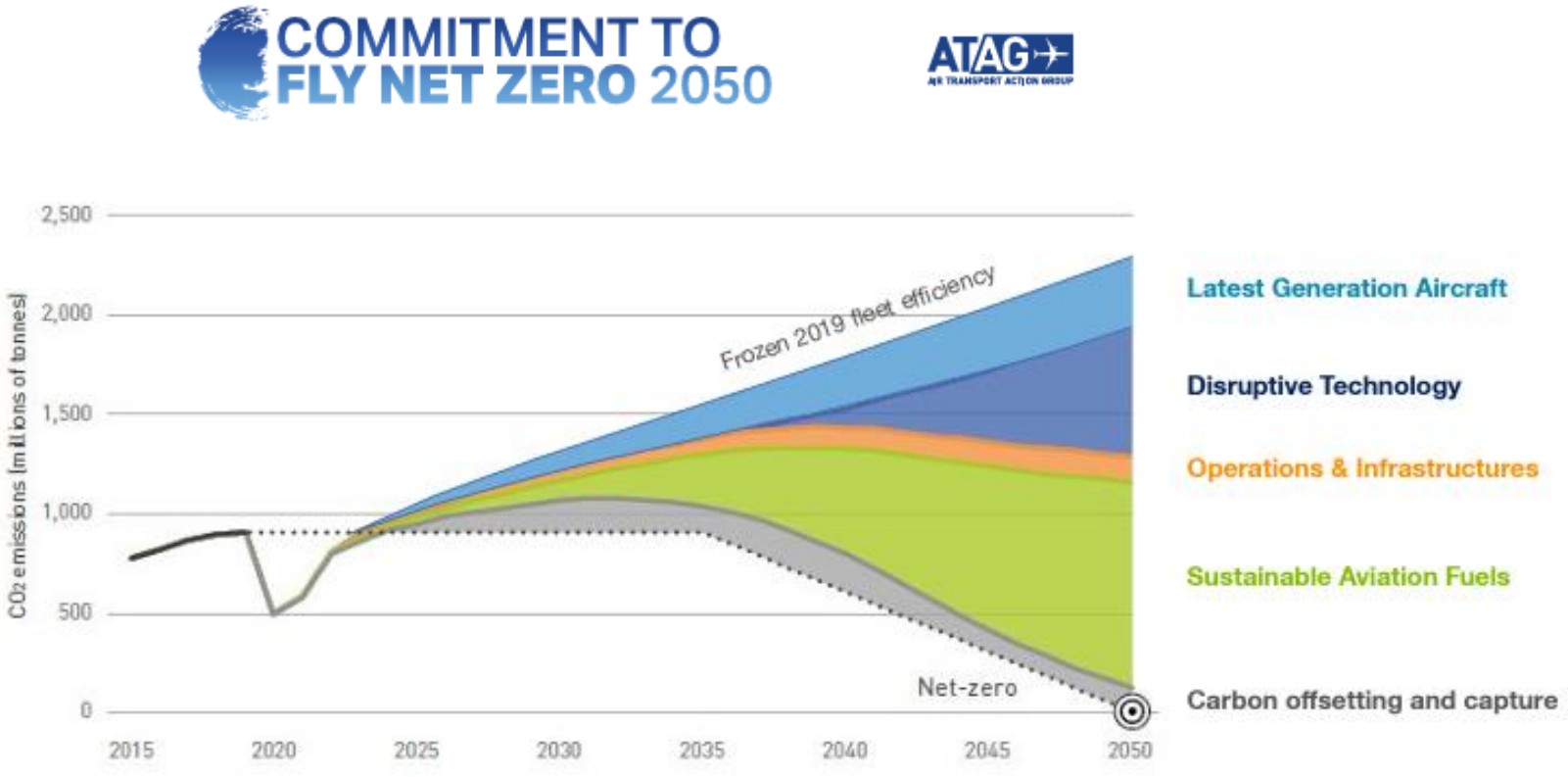
Thermal Management Syst.

- End-to-end capability from design through verification of systems to manage waste heat
- Liquid and vapor compression cooling

Eaton Business Needs

Powering Business Worldwide

Towards More Sustainable Air Travel



Market Needs

- Develop and mature **advanced technologies** such as SSPC for high power requirements
- Ambition to bring a **hydrogen-powered aircraft** to the market by 2035
- **Hydrogen as a fuel for turbines, for electric motors via fuel cells**
- Developing advanced solutions for hydrogen fuelled aircraft (aerodynamics / airframe / **propulsion / hybridisation**)

Powering Business Worldwide

Eaton Aerospace Group Electrification Strategy

Goal:

Establish Eaton as credible player in electrification space

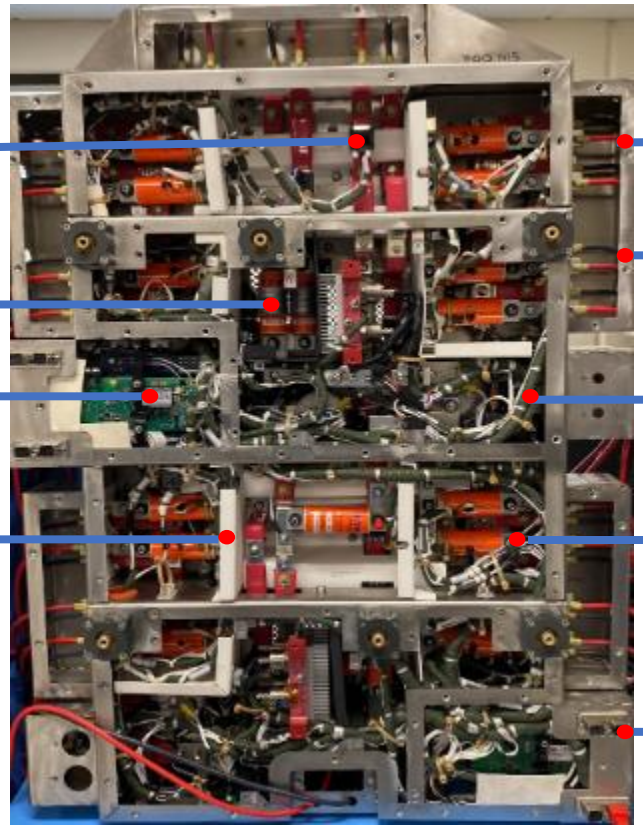
Set the stage to scale up technologies/power to **meet future needs of single-aisle electrified aircrafts**

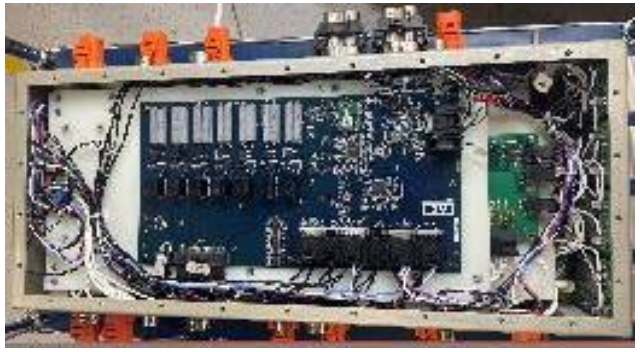
	eVTOL / eCTOL	NextGen Bizjet / Regional	NextGen Single Aisle
			
	• Fully Electric • E-propulsion • Electric distribution	• Hybrid Electric • E-propulsion • Electric distribution	• Hybrid Electric • Jet + E-propulsion • Electric distribution
Revenue potential:	Limited	Modest	Significant
Investment:	Significant	Significant	Significant

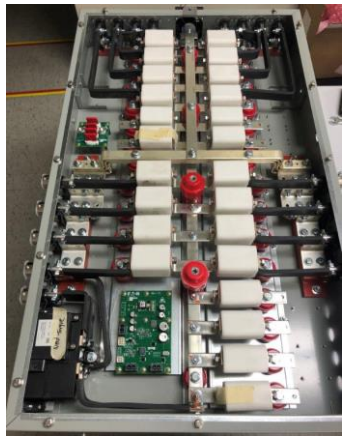
Modular and Transferrable Investment

eVTOL / eCTOL segment offers short-term test bed opportunities w/ modest revenue potential to position Eaton for high-value NGSA

Eaton Maturing Technology through Demonstrator Programs





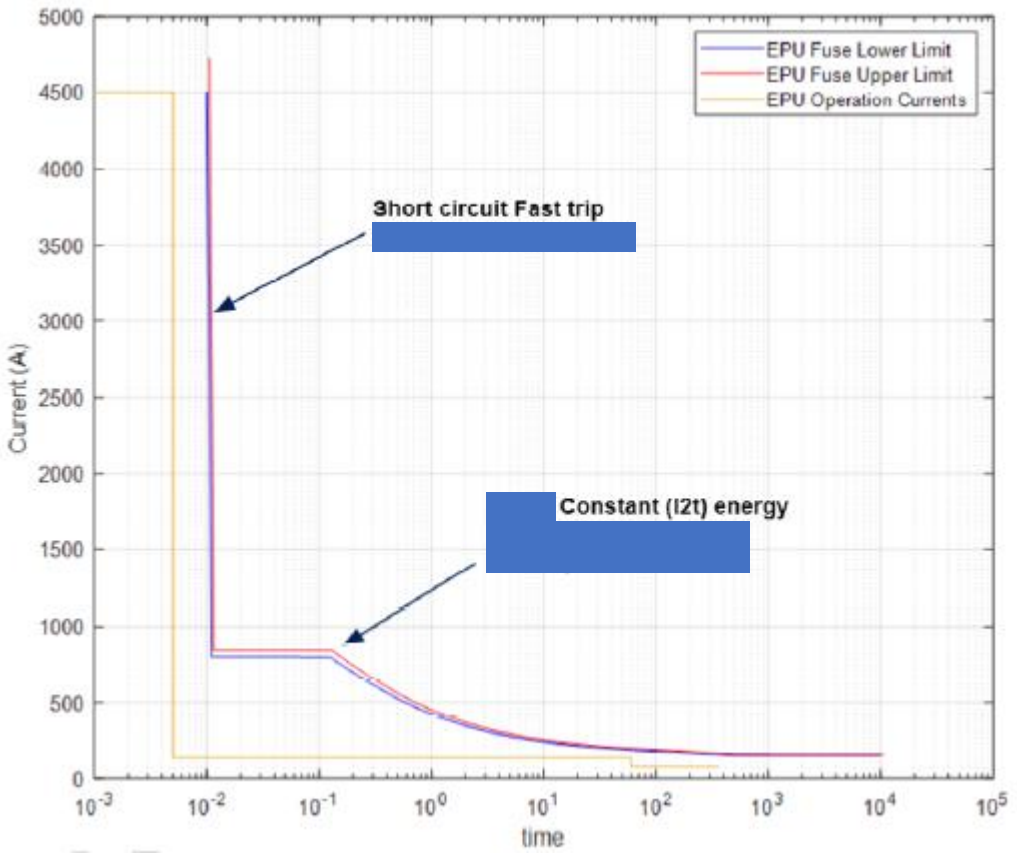


Problems to be Solved by Eaton Aero

Technical

- Electrical power system design
- Metric for evaluating different architectures
- Resiliency with minimum weight penalty
- Selective coordination and protection for new developments
- Component high voltage ratings
- New power sources and loads

Can we leverage adjacencies with stationary power systems and microgrids?



Other Challenges

- More stringent requirements from OEMs
- Reliability and safety estimates for new technologies
- Lack of aero standards for high-voltage

Failure Case	Mean probability per Flight Hour (FH^{-1})	Failure classification
Loss of line	< 1 x 10^{-5}	MAJ

Backup

Future of Short and Medium Range Aircraft

Market Opportunity

Demand

42,600 New Commercial Jets Over Next 20 Years

per Boeing

26,860 single-aisles to be delivered for **$1380B**

per FlightGlobal

25%

Electrified Aircrafts

		Development Programs	Example platforms	2050 market size ($B)
EVTOL	 **Heavy cargo & military transport**	<10	*Bell APT* *Beta ALIA-250c*	**< $5B**
	 **Large urban air mobility (UAM)**	~200	*Bell Nexus* *Archer Maker* *Vertical Aero VA-X4*	**$6B**
Fixed wing	 **Commercial Single-Isle ***	~25	*Eviation Alice* *Embraer STOUT* *NGSA*	**$200B+**
	 **Large military**	1	*Boeing* *Lockheed* *Northrop*	**< $5B**

25%

Opportunity

Electric Powertrain

$50B

* A single-aisle aircraft is an airliner arranged along a single aisle, permitting up to 6-abreast seating in a cabin less than 4 metres (13 ft) in width.

Electrified New Generation Single-Aisle Aircraft: Significant Market Opportunity

Eaton Aerospace Group Summary

Eaton

- Headquarters: Dublin, Ireland
- Chairman & CEO – Craig Arnold
- Customers in more than 175 countries
- Over 85,000 employees

Aerospace Group

- $3.0B* in 2022 sales
- 41 global facilities with a JV in China
- Approximately 11,300 employees

*Aerospace segment as reported

Total sales $20.8 Billion USD

Net income $2.5 Billion USD

INDUSTRIAL: 2022 sales of $6.4B

- Aerospace
- Vehicle
- Filtration
- eMobility

ELECTRICAL: 2022 sales of $14.3B

- Power distribution & circuit protection
- Power quality, backup power & energy storage
- Life safety and security
- Structural solutions
- Control & automation
- Harsh & hazardous environments solutions

Eaton's Aerospace Group

- $3B* in 2022 sales
- 41 global facilities with a JV in China
- Approximately 11,300 employees
- Headquarters: Irvine, California
- Division headquarters located in:

Jackson, Michigan
- Fluid & Electrical Distribution Division

Fort Worth, Texas
- Fuel & Motion Control Systems Division

Versailles, France
- Interconnect Technologies Division

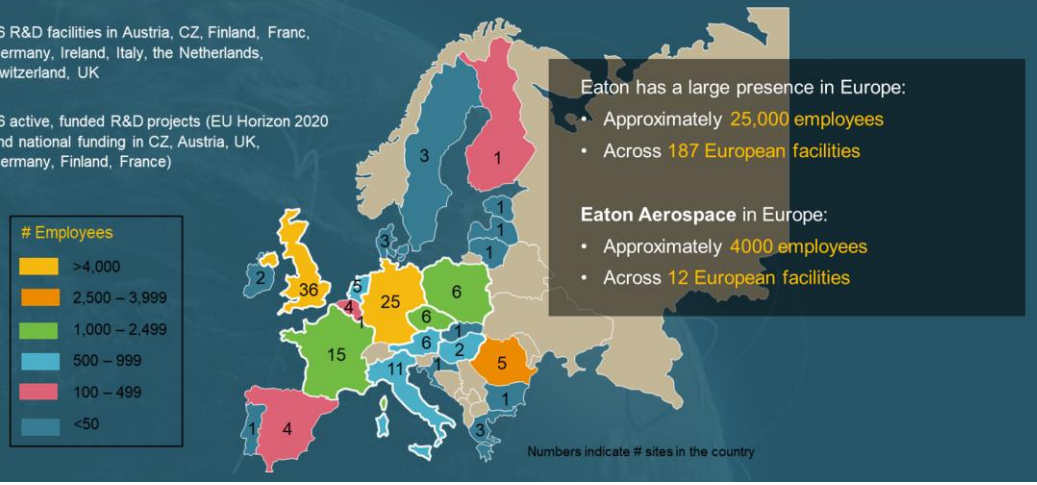
Davenport, Iowa
- Mission Systems Division

*Aerospace segment as reported

Eaton in the European Union & UK

19,000 employees in 145 sites

- 26 R&D facilities in Austria, CZ, Finland, Franc, Germany, Ireland, Italy, the Netherlands, Switzerland, UK
- 16 active, funded R&D projects (EU Horizon 2020 and national funding in CZ, Austria, UK, Germany, Finland, France)



Eaton has a large presence in Europe:
- Approximately 25,000 employees
- Across 187 European facilities

Eaton Aerospace in Europe:
- Approximately 4000 employees
- Across 12 European facilities

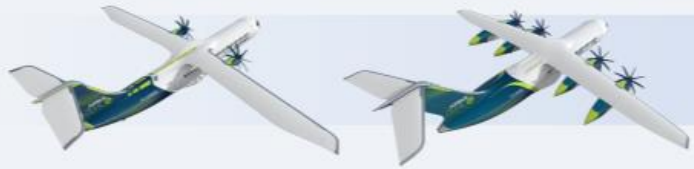
EATON
Powering Business Worldwide

Technology & Design disruption

Ecosystem

ZEROe 100 Pax - 1000 NM

H2-based technologies & ecosystem



Future

SHORT & MEDIUM RANGE MARKET

LONG TERM AMBITION

Game changer built on H2 established technologies & ecosystem

Legacy

- Sustainability: 50% SAF compatible now (target 100% in 2030)
- Value for customer: XLR, ULR
- Preparation of the future (eg new entrants)

SAF Ecosystem

New Short & Medium Range Aircraft

100% SAF compatible

New engine/wing concepts

Digital methods & tools to design & manufacture

Current Portfolio

Incremental Development

Time

AIRBUS

Single line representation of a potential aircraft EPS with electric propulsion system