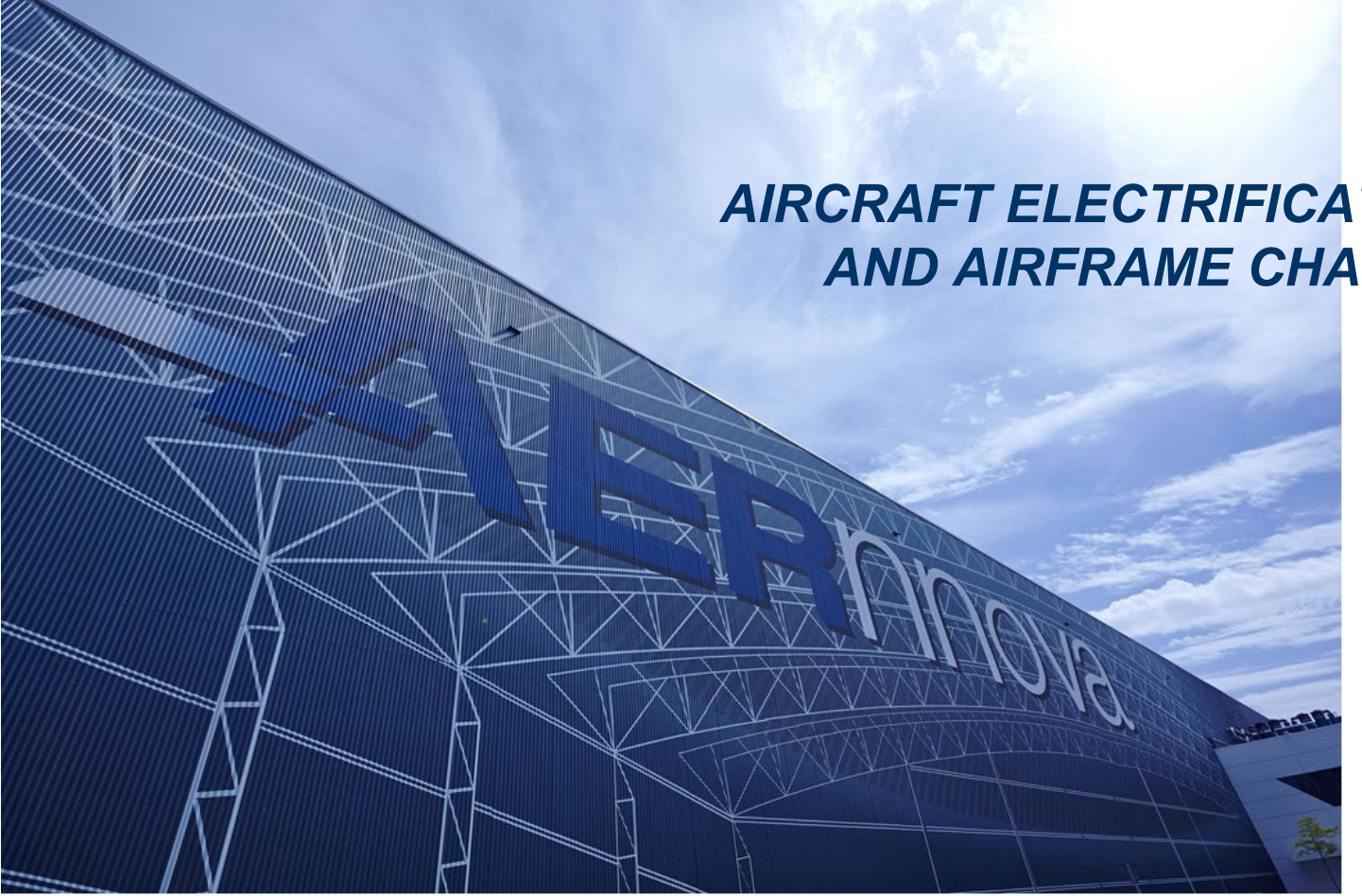


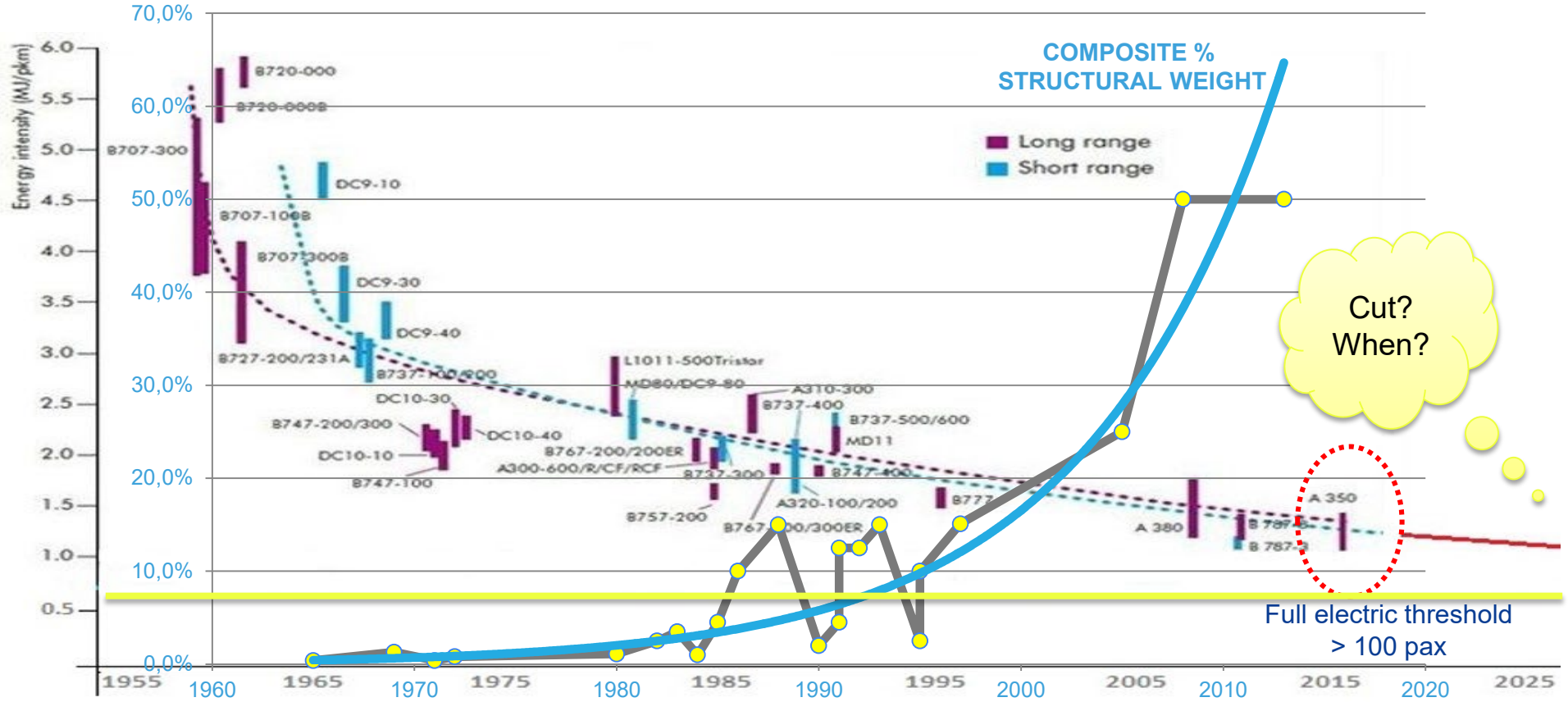
AIRCRAFT ELECTRIFICATION TRENDS AND AIRFRAME CHALLENGES

Miguel A. Castillo

Bilbao, Spain 6.10.22

- AIRCRAFT EFFICIENCY TRENDS
- ELECTRIC PROPULSION AND AIRFRAME DESIGN
- HYBRID ELECTRIC PROPULSION SYSTEMS
- HEART 19 & LILIUM JET
- CONCLUSIONS

AIRCRAFT ENERGY INTENSITY EVOLUTION
BIG TRANSPORT AIRCRAFT > 150 pax

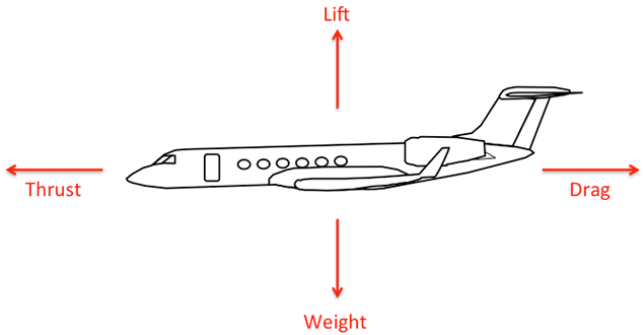


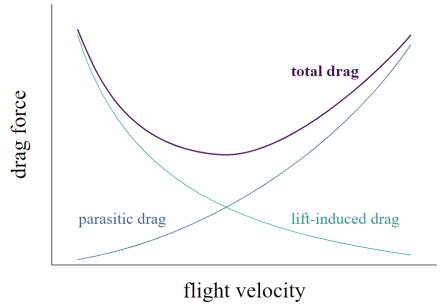
ULTRA EFFICIENT AIRCRAFT

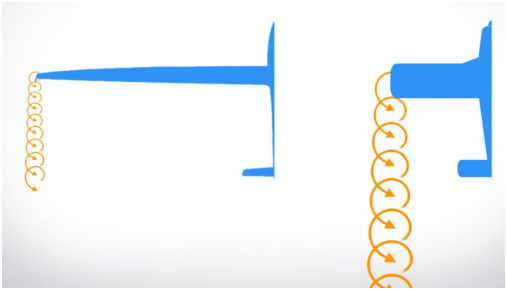
Light Weight Structures and Aerodynamic Drag Reduction

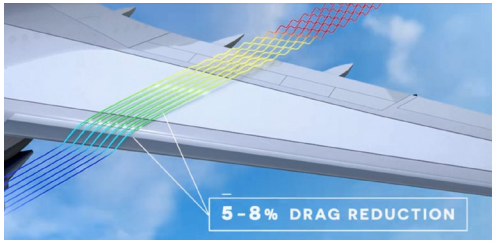
New Materials, new configurations, new manufacturing processes

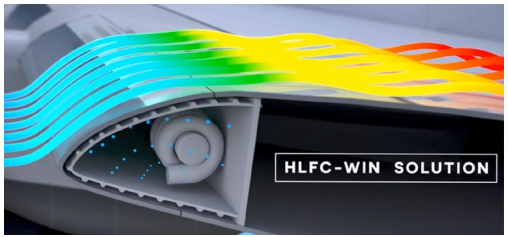
Aerodynamic Efficiency L/D, high aspect ratio wings, reduced Friction drag by laminarity.





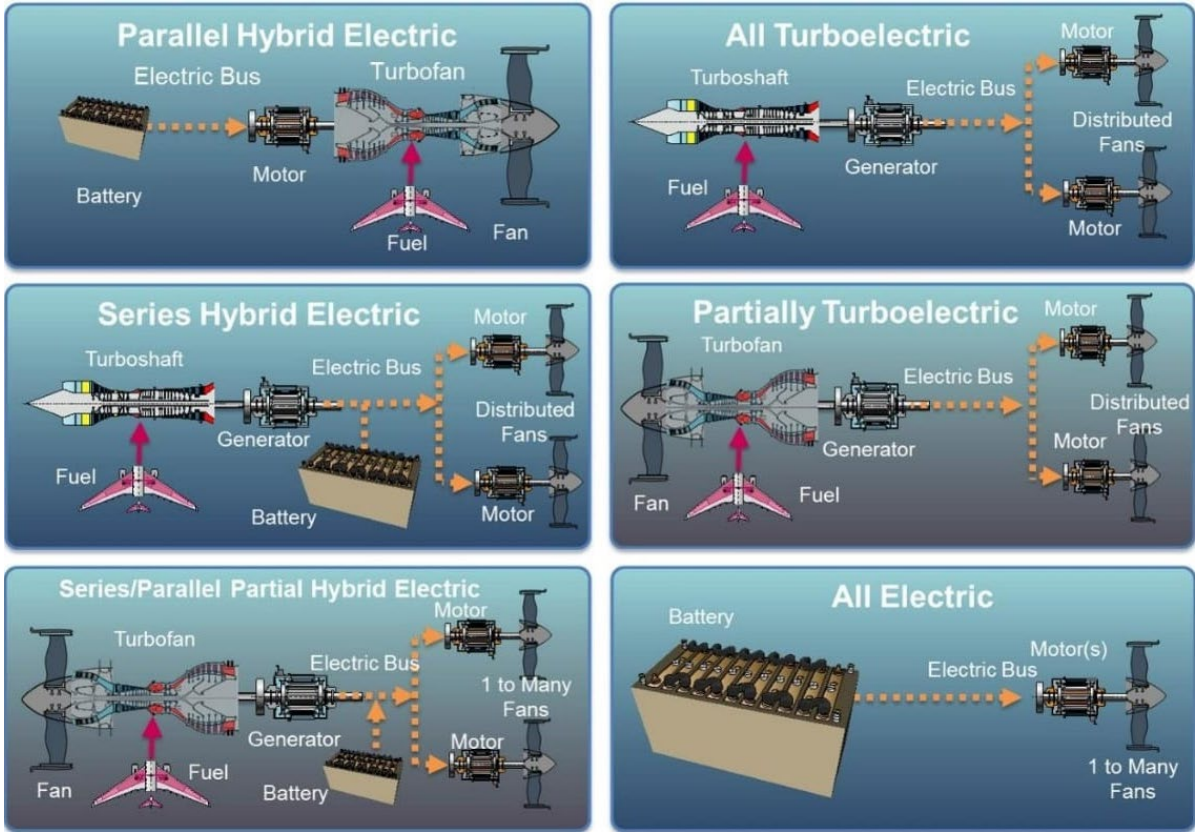






Clean Sky 2, LPA, HLFC-WING project funded Under Horizon Europe by Clean Aviation JU

HYBRID ELECTRIC POWER UNITS



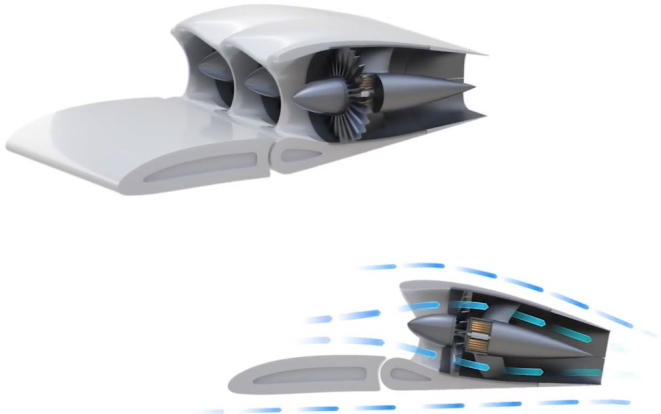
"Electric Propulsion Architectures", Clean Aviation SRIA, 12.21, p.34

ELECTRIC PROPULSION AND AIRFRAME DESIGN

Distributed Propulsion

Image taken from Clean Aviation SRIA, page 13. Dec. 2021

Lilium Ducted Electric Vectored Thrust (DEVT)



www.lilium.com

ELECTRIC AIRCRAFT IN THE COMMUTER CATEGORY: HEART-30

Heartaerospace.com

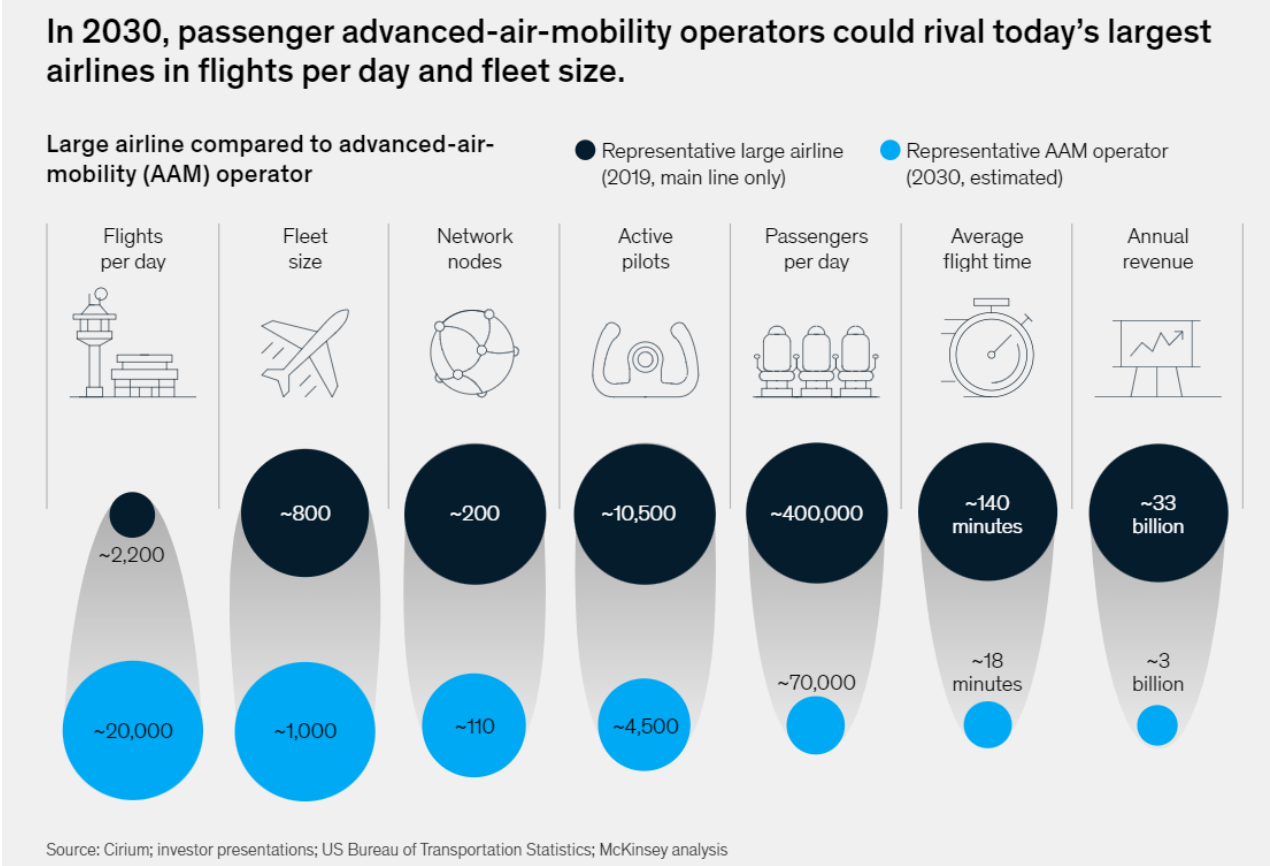
Heart Aerospace is developing of an electric thirteen passenger airliner with an operating range of 400 km, so commuter type of aircraft, with the goal to deliver the first unit fully certified for commercial flight by 2028. Aernnova is part of this project.

- Zero emissions of CO2, NOX and ultrafine particulates.
- Cost-Effective: Comparable unit economics to larger turboprop aircraft
- Short field performance, low-noise operations and minimal ground service infrastructure.

LILIUM JET

Electric vertical take-off and landing jet, 4- 6 pax for Regional Air Mobility

In 2030, passenger advanced-air-mobility operators could rival today's largest airlines in flights per day and fleet size.



CONCLUSIONS: AEROSTRUCTURES AND ELECTRIC AIRCRAFT

NEW CONFIGURATIONS

Aircraft concepts, design and materials that enable new more aerodynamic efficient and low weight aerostructures with competitive manufacturing processes.

ENERGY CARRIER STORAGE

New integrated energy storage systems, battery packs, all-together with the structural components.

Thermal management as a critical compliance requirement

SIDE EFFECTS

Electric effects on airframe structure and systems integration, i.e. anti-icing systems for the electric aircraft as there will be not hot air bleeding from the engines.

Many thanks for your attention, questions?

"What new technology does is create new opportunities to do a job that customers want done."
–Tim O'Reilly