Scalable Integrated Power Electronics for Fuel Cell Regional Aircraft

Fraunhofer Institute for Integrated Systems and Device Technology (IISB), Erlangen, Germany

Dr.-Ing. Markus Meindl, 16th EASN Conference, 27-30 October 2026, Toulouse, France

Three worlds. One Future Aircraft.

A convincing image or (non-physics-based) simulation is not a prototype.



AI-generated illustration

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EU-Aviation Projects with Fraunhofer IISB involvement

Clean Sky

Gauging the **EN**vironm**E**ntal **S**ustainability of electr**I**c aircraft **S**ystems

CLEAN AVIATION PHASE 2

AMBER: **2 MW** Multi Power train **I**nnov**A**tive for hy**B**rid-**E**lectric **R**egional **A**pplication

Construction of **N**ovel **CER**tification meth**O**ds and means of compliance for disruptive technologies

Hybrid **E**lectric Regional **A**ircraft **D**istribution **T**echnologies

Hybrid-**E**lectric **R**egional **A**rchitecture

Hydrogen Fuel Cell Electric **Po**wer **T**rain **De**monstration

NExt generation high po**W**er fuel cells for air**BORN**e applications

THErmal **MA**nagement **for** the **H**ybrid **E**lectric **R**egional **A**ircraft



CLEAN AVIATION PHASE 3

Modular, Scalable, and Technology-**O**pen **D**esign for Future **A**viation **BAT**teries

Arc Fault Detection, low EMI and Reliability for **POWER** Electronics in Electric **AIR**crafts

On-board **SY**stems **R**elevant for h**Y**bridization of Regional aircraft**S**

CLEAN AVIATION PHASE 4

Advanced **R**eliable **C**ryogenic power module **T**ested for aircraft **I**nverter **C**ircuit

Hybrid-electric **EU**ropean ground demonstrator **R**eady for **E**ngine flight test in **C**lean **A**viation

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Roadmap hybrid-electric aircraft

GENESIS (02/2021-08/2023)

Partners:

Technical University of Denmark

TU Delft

FAU Friedrich-Alexander Universität Erlangen-Nürnberg

Bern University of Applied Sciences

SMARTUP ENGINEERING

MAHYTEC

ACCUREC

PM Fuel Cells · Power Systems

Rotterdam The Hague Airport

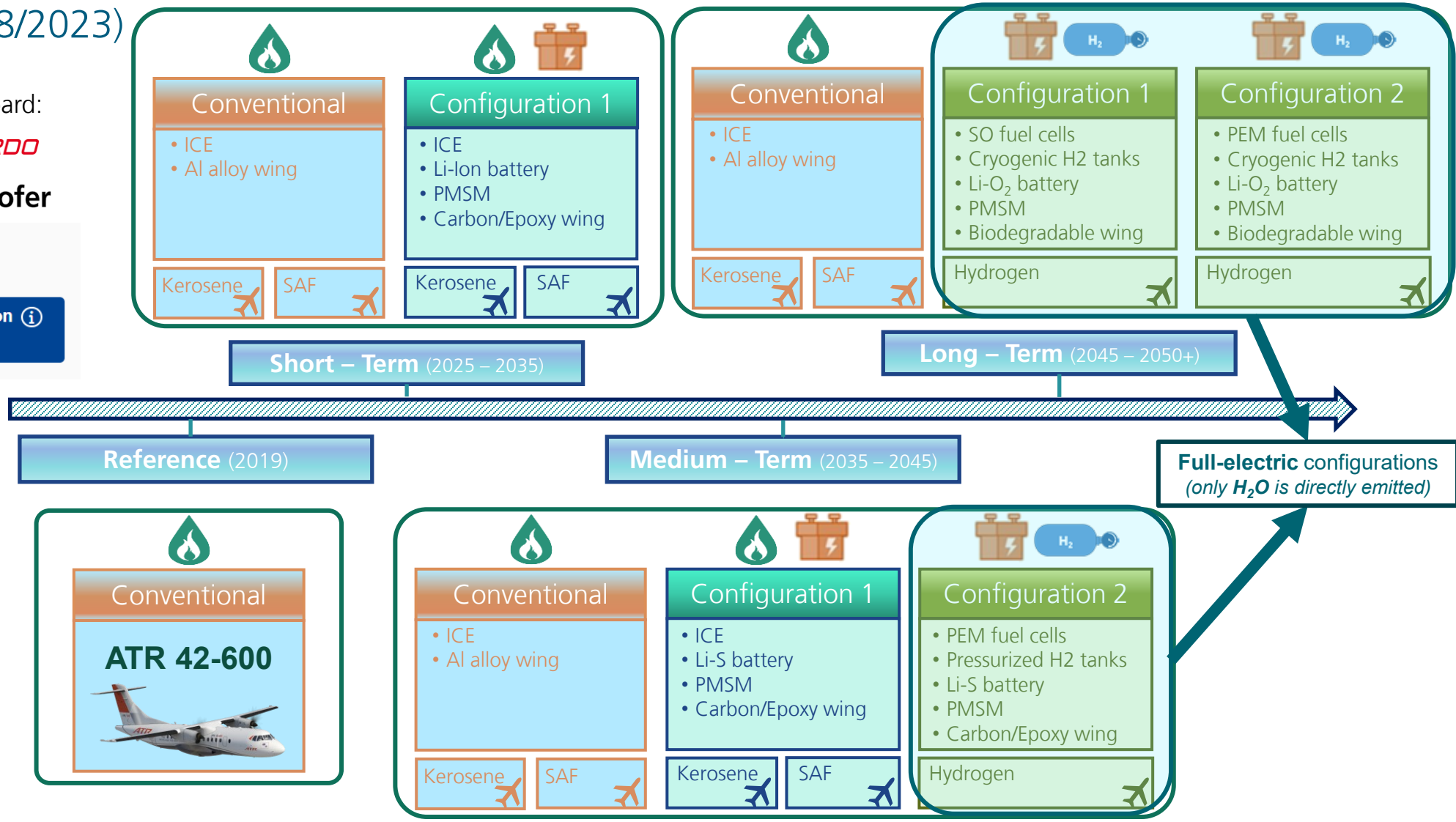
Advisory Board:

LEONARDO

Fraunhofer

Total cost
€ 1 598 121,25

EU contribution
€ 1 598 121,25



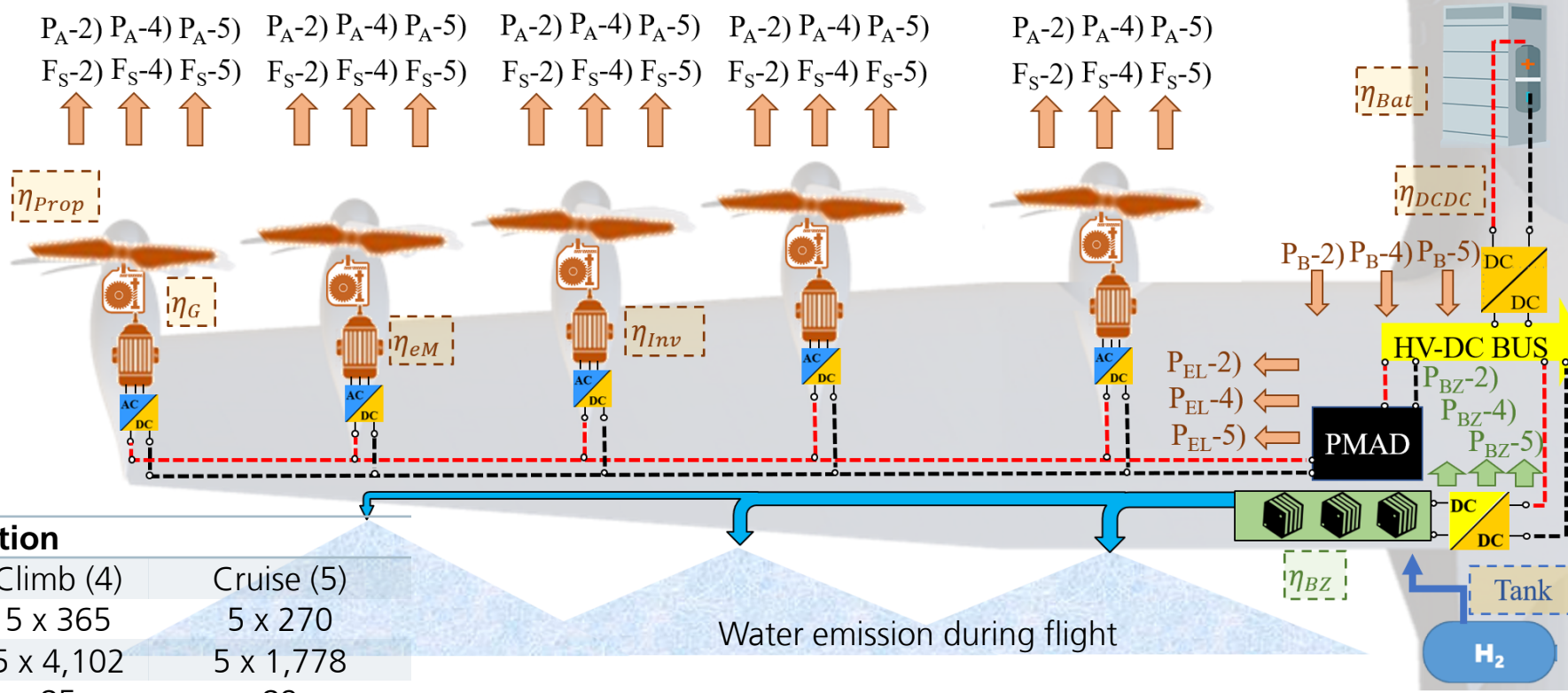
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A Example
FC-Bat-Hybrid

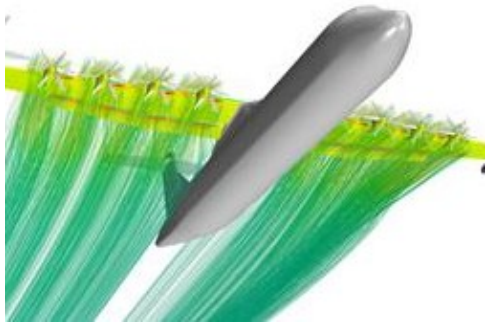
*P_A: Power drivetrain (Antrieb in German)

*F_S: Force thrust (Schub in German)



FC-Bat configuration

	Take-off (2)	Climb (4)	Cruise (5)
*P_A [kW]	5 x 391	5 x 365	5 x 270
*F_S [N]	5 x 6,209	5 x 4,102	5 x 1,778
η_{Prop} [%]	79	85	89
η_G [%]	97	97	97
η_{eM} [%]	95	95	95
η_{Inv} [%]	99	99	99
η_{Bat} [%]	96	96	96
η_{DCDC} [%]	98	98	98
P_{eM} [kW]	510	443	313
P_B [kW]	1,585	1,212	546
P_{EL} [kW]	2,743	2,365	1,681
η_{BZ} [%]	48	47	46
P_{BZ} [kW]	1,158	1,153	1,135

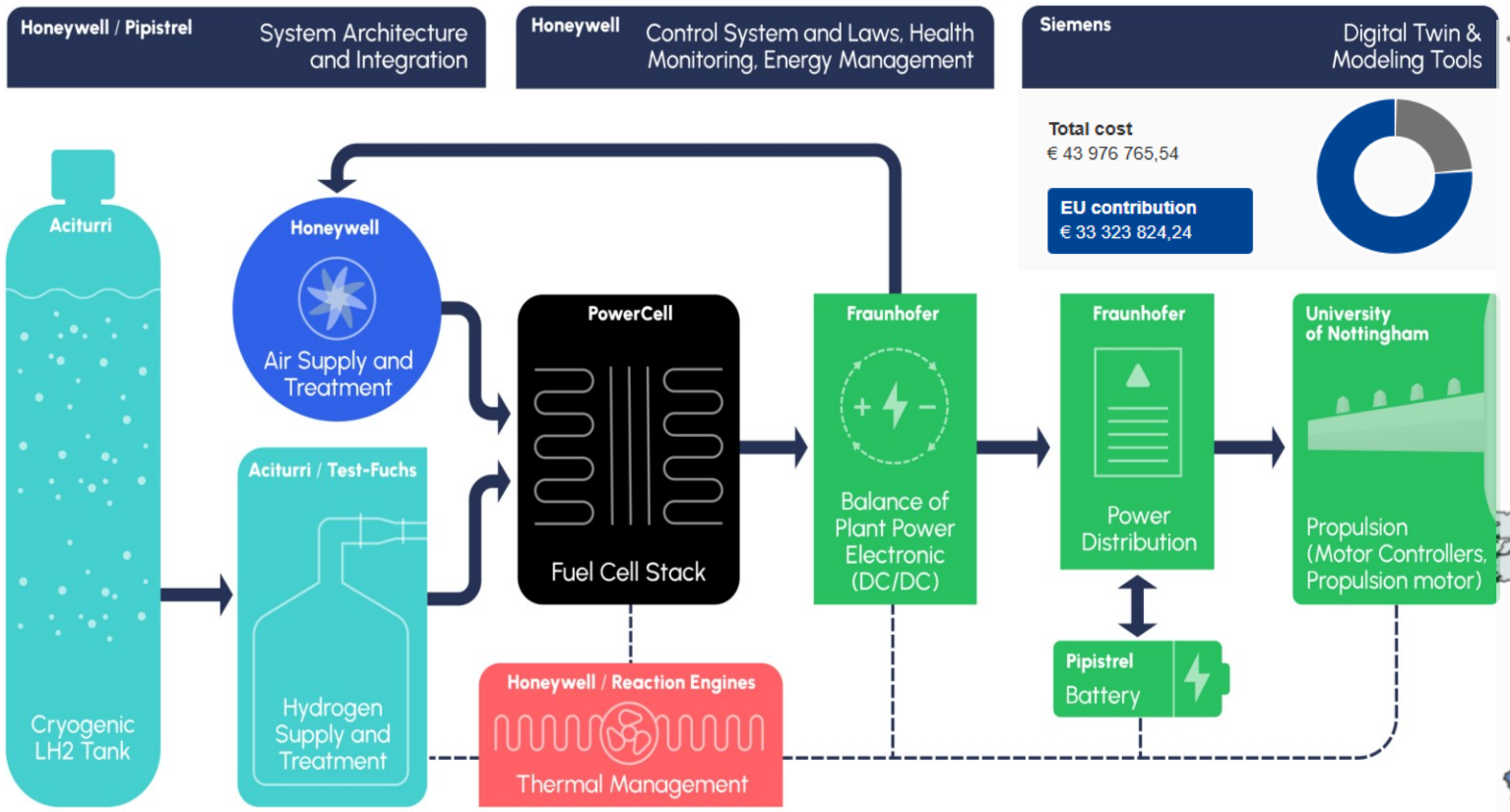


Detailed results are available online

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An example: NEWBORN Project

NExt generation high poWer fuel cells for airBORNe applications. Jan 2023 – Mar 2027





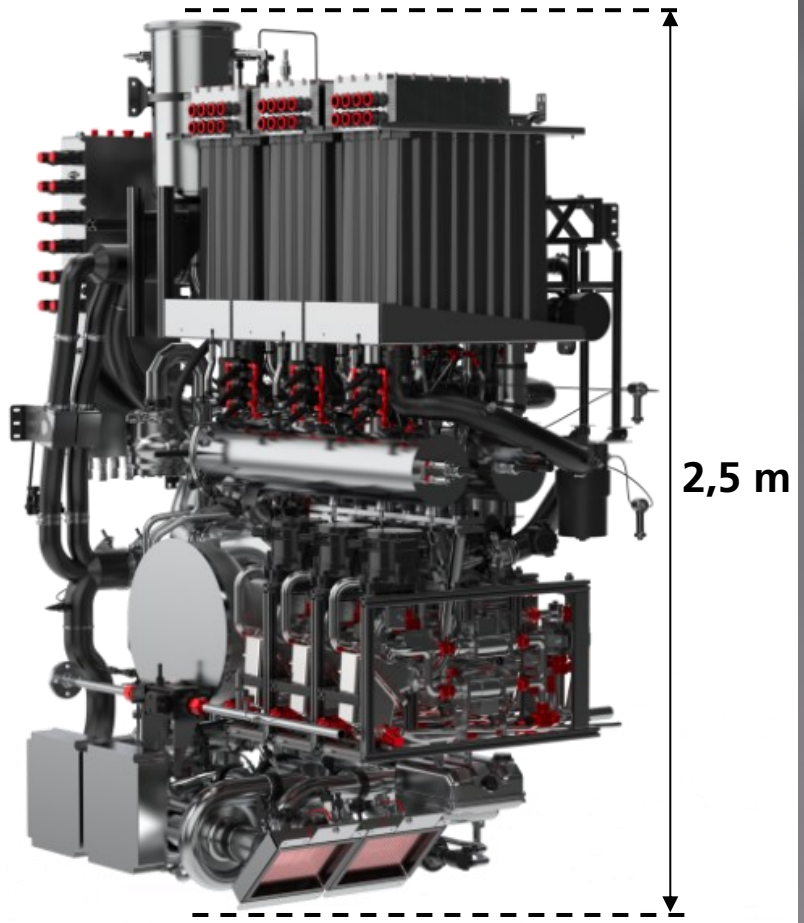
Key differentiators to other projects:
Designed for complete controllability – pressure, temperature, humidity, flow rates, power flows, handling of failure modes, and service life.

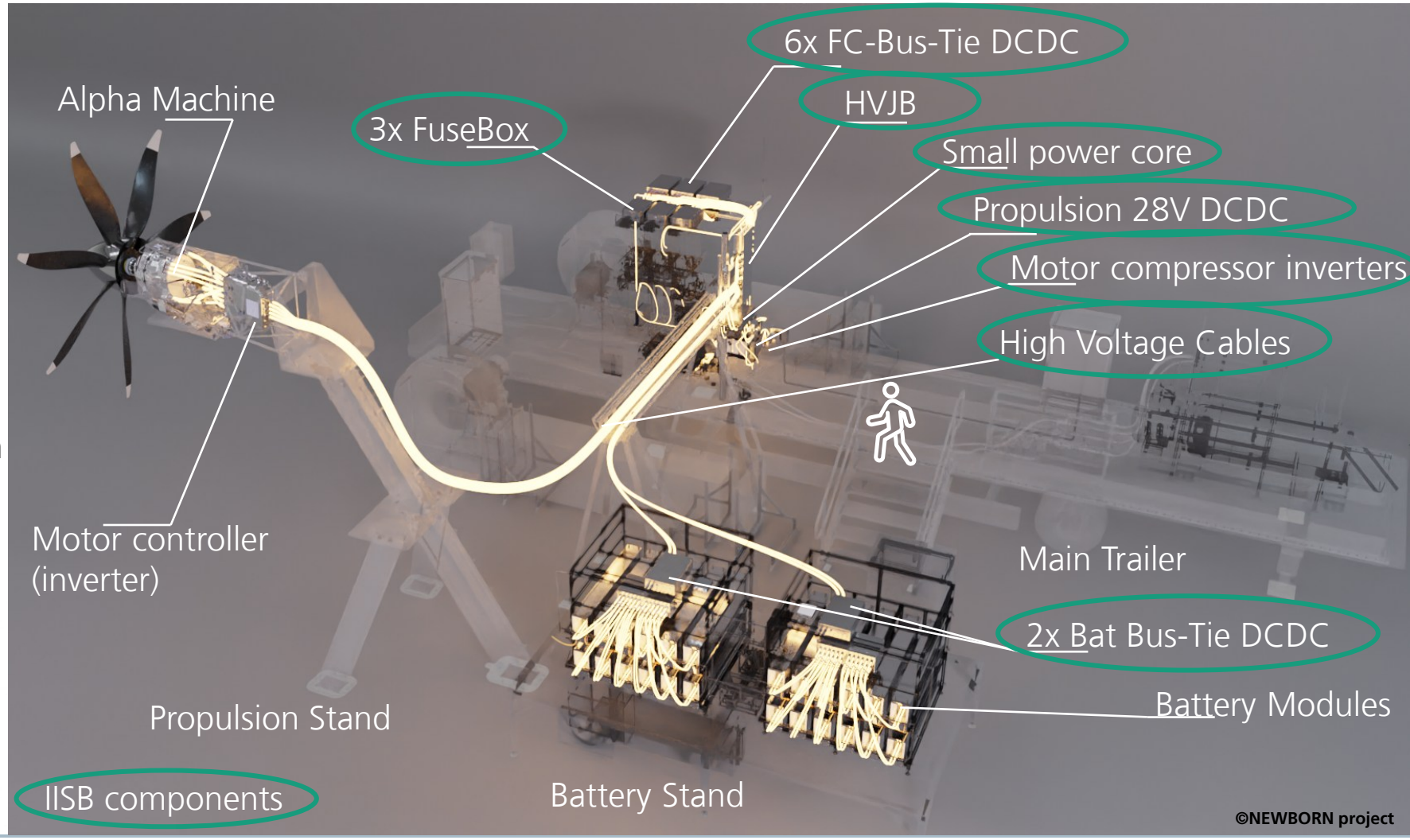
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NEWBORN Project – Ground Demonstrator Test 2026

HV-Bus NEWBORN-Demonstrator (1 MW Shaftpower)

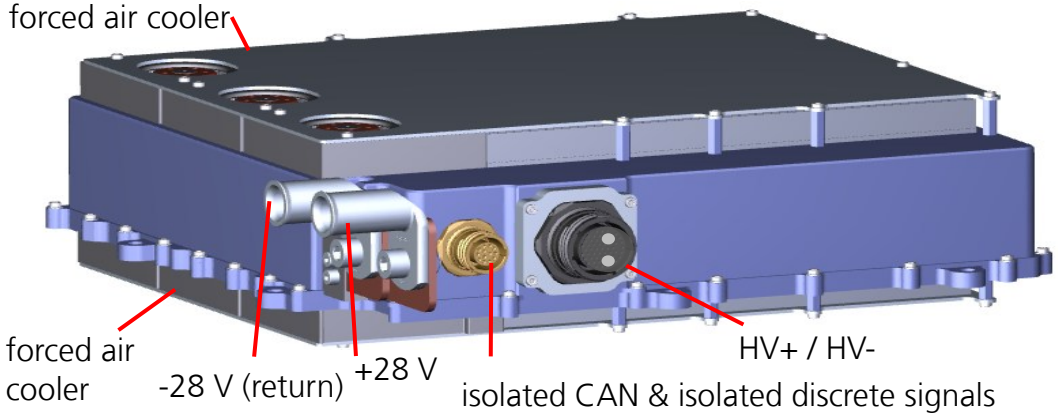




Exemplary prototypes for power electronics in electric aircraft

Developed in Project NEWBORN

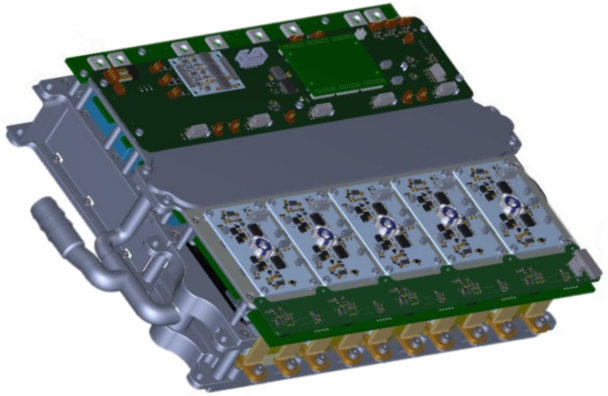
CAD isolated 28 V DC/DC triple (3-1) fail safety concept



HV:	500 V…850 V
LV-current:	400 A_{PEAK}
LV-power:	11 kW
Galvanic isolated:	2500 Vrms
Modi:	Precharge HV-Bus Charge 28V Batterie
Cooling:	Forced Aircooled
Safety:	(3-1) safety concept, 1700V SiC MOSFETS
Units:	3 x 130 A
Weight:	~ 8 kg (without aircooler)
Power density:	1,4 kW/kg
If a unit fails:	7,3–7,84 kW available

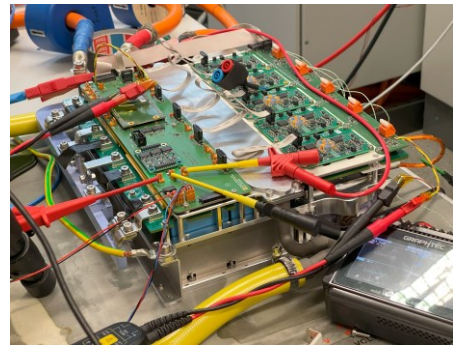


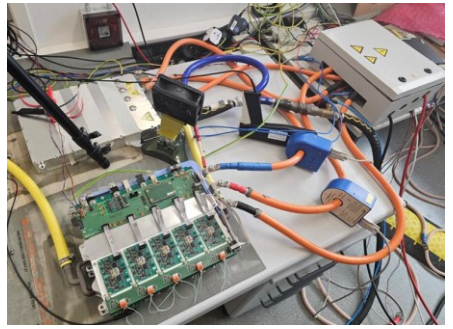
CAD halfbridge multiphase Buck/Boost converter



HV- nominal:	810 V…850 V
HV- min/max:	800 V / 900 V
Max-current:	625 A
Efficiency:	> 98 %
Weight Power Core:	12 kg
Power density:	far beyond 20 kW/kg
Modules:	XM 1700 V SiC-HB-Modul







Back-2-Back-Test in laboratory



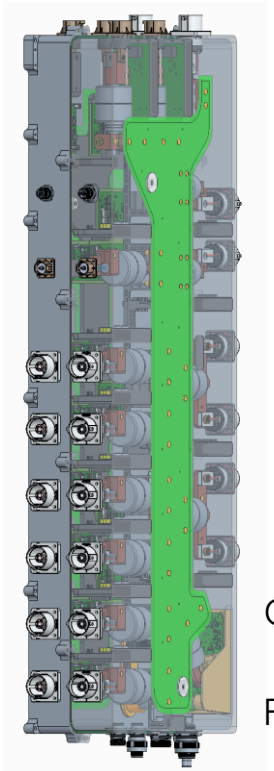
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Exemplary prototypes for power electronics in electric aircraft

HV-Junction Box

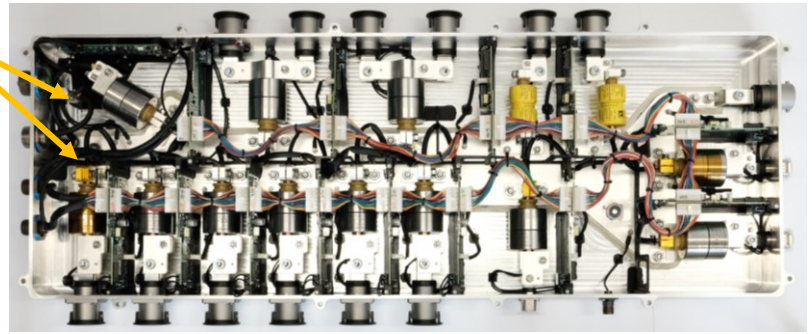




Weight ~45 kg

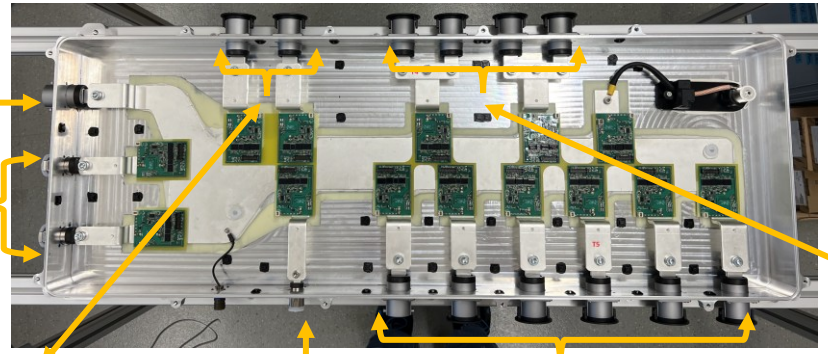
- Insulation requirements
  - Air gaps > 5 mm
  - Creepage distances > 7 mm

28V BoP DCDC and back up



Ground Charge

FC Compressor 1,2

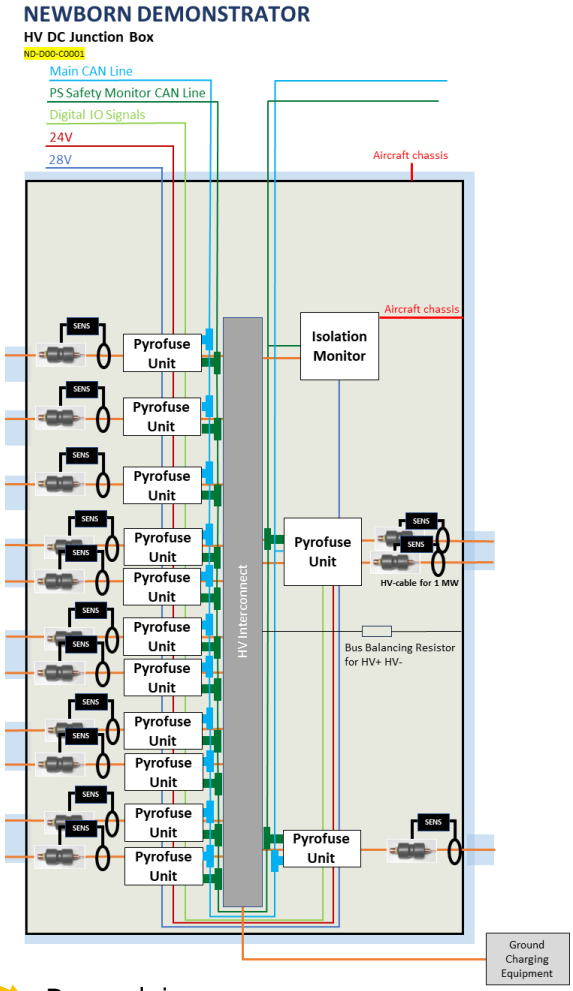


Battery DCDC

HV Auxillary

Fuel Cell 1, 2, 3

Propulsion



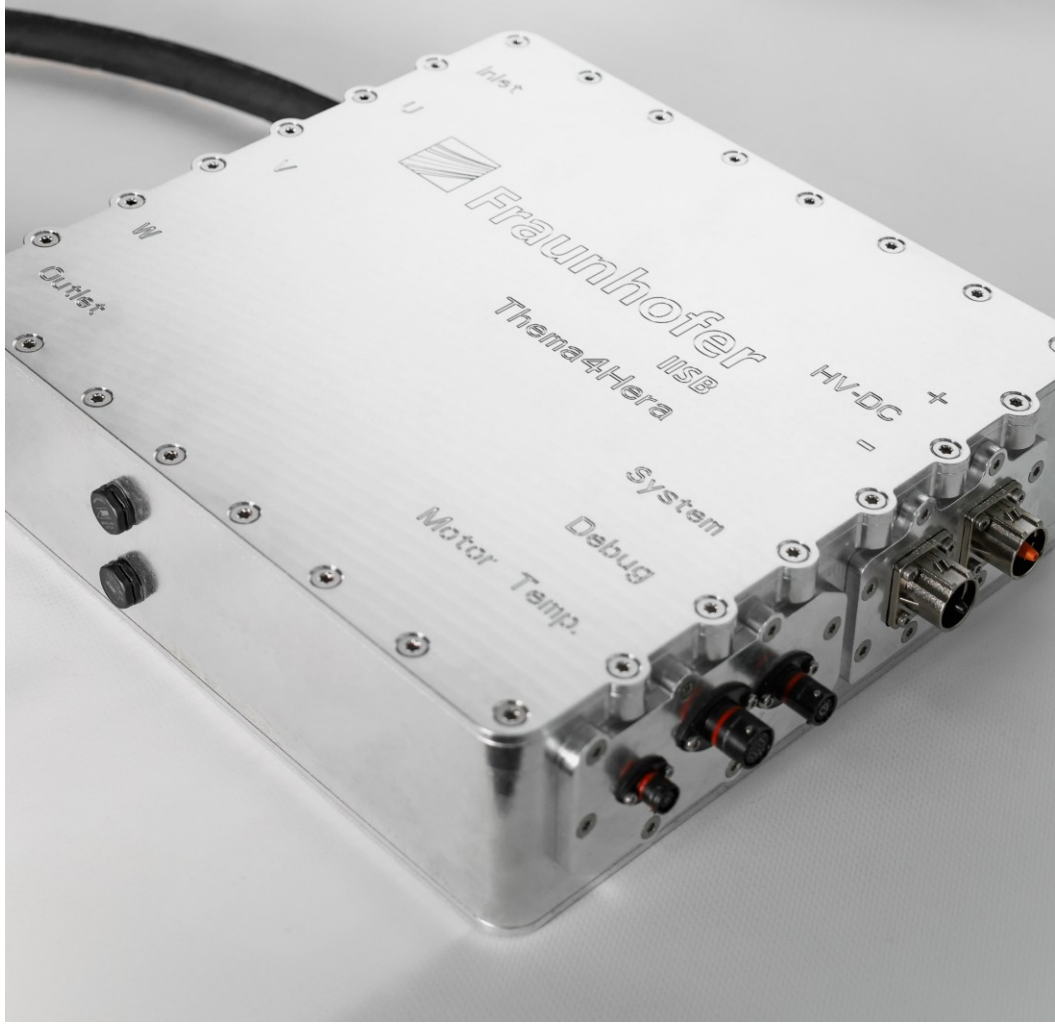
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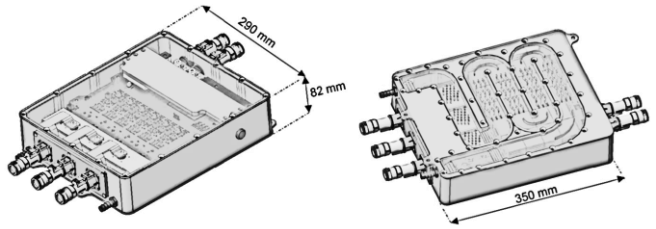
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Inverters – The Present

High-Performance SiC Air Compressor Inverter

Topology	B6 SiC Inverter	
Power modules	State-of-the-art commercial-off-the-shelf	
Nominal inverter output power P_{AC}	54 kW (max. 72 kW)	25 kW
Nominal phase current I_{RMS}	200 A_{RMS}	85 A_{RMS}
Nominal DC link voltage U_{DC}	800 V (max. 850 V)	560 V (max. 850 V)
PWM switching frequency f_{PWM}	typ. 25 kHz (up to 80 kHz)	
Cooling	Water-Glycol based fluid cooling	
Max. flight altitude	30,000 ft / 9,144 m	
Control board HW/SW	Project specific derivative	
Speed control algorithm	Sensorless FOC	
Housing	Sealed aluminum	

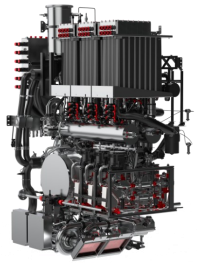


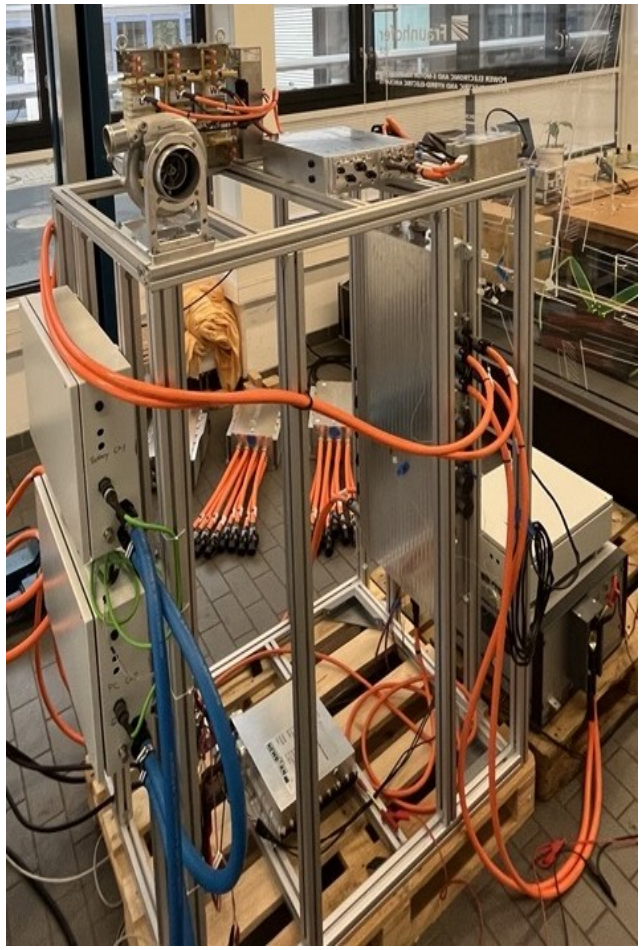


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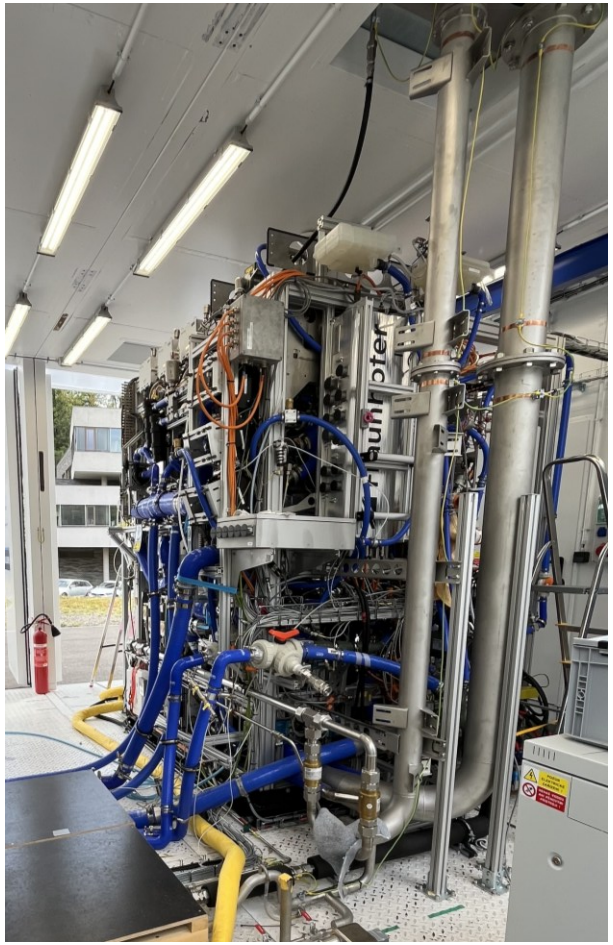
NEWBORN (interim) Results

Credit: NEWBORN consortium

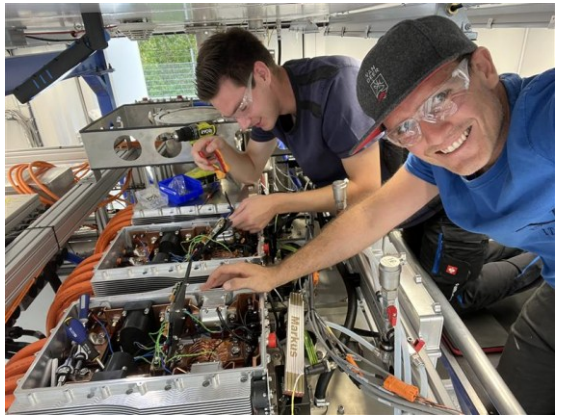




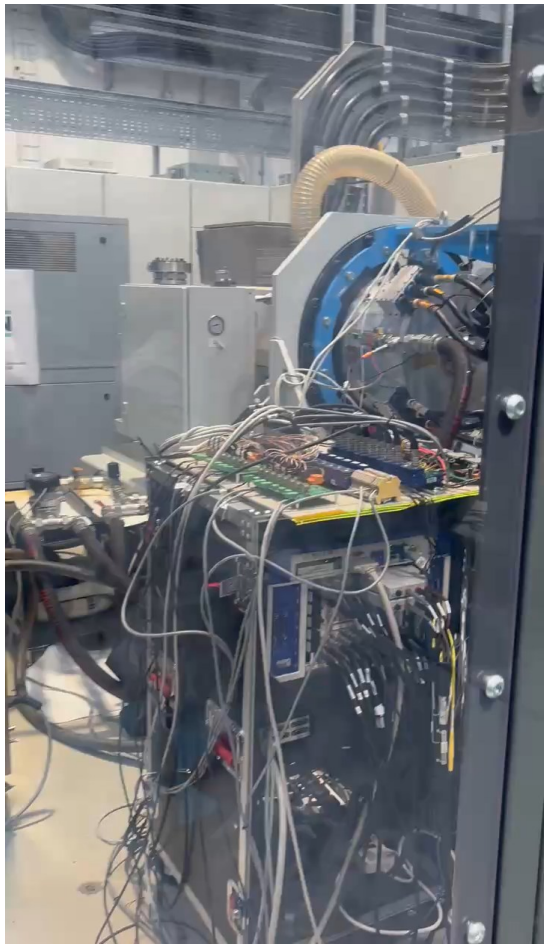
Fraunhofer IISB & NEWBORN consortium



Honeywell Aerospace & NEWBORN consortium







University of Nottingham & NEWBORN consortium

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NEWBORN (interim) Results: Fuel Cell Power Source System (FCPSS)

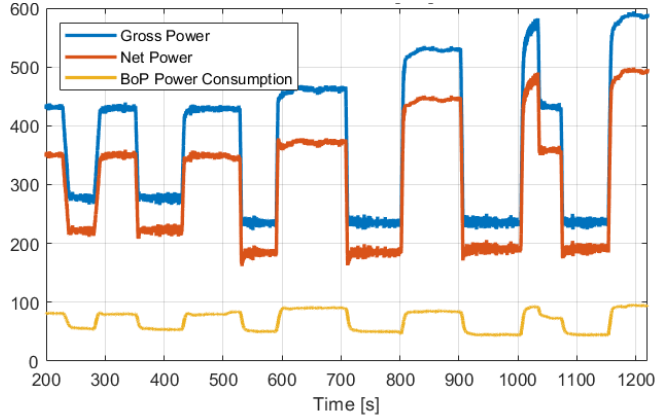
Credit: NEWBORN consortium



Fuel cell power source system successfully running.

>30 successful tests
~10 hours under power

Stable across fast transients.

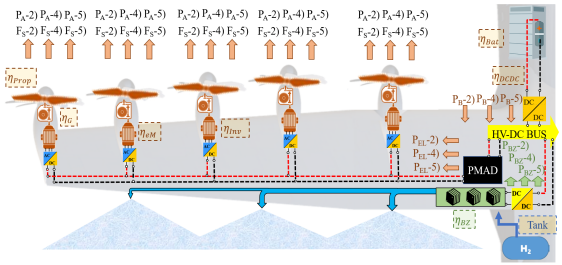


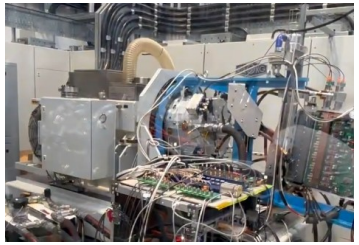
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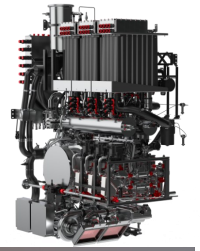
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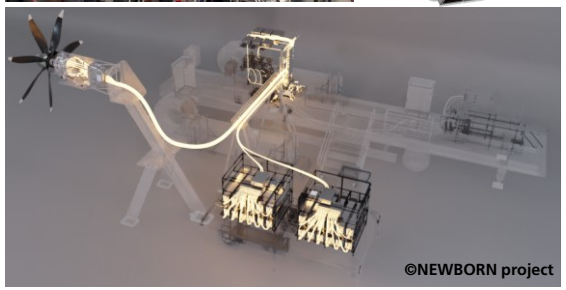
Pathway from Aircraft Demonstrators into Aircraft Integration Possibilitis

Components developed and tested on the ground → Future Aircraft need scalable integrated Systems



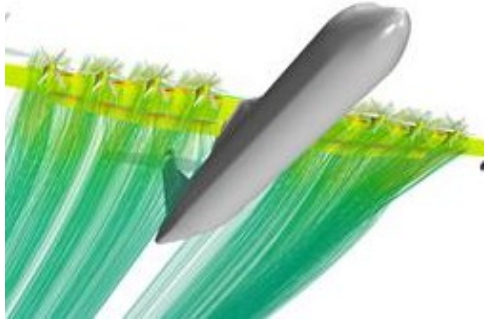








….2019-2023…
Concepts, calculations and simulations



…2023 – 2030…
Safe Ground Testing and Certification











…2030 – 2045…
Integrated scalable Systems for 19 PAX to 100 PAX Future Regional Aircraft



Fuel Cell System with Integrated
BOP and DCDC´s 600kW class





HV-Battery for
HV-Bus Stabilization



E-Motor with Gearbox
and integrated Inverter

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Recommendations for future research

A summary from lessons learned

- **There are many breakthrough ideas with significant potential…**
  - Cryocooled power electronics
  - Superconductivity
  - …
- **There are many nearer-term focus items still relevant for more mature propulsion technologies**
- **Safe Integrated Systems**
- **Safe Thermal Management**
- **Certification and Manufacturing Readiness**

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Thanks for your attention!

Q&A



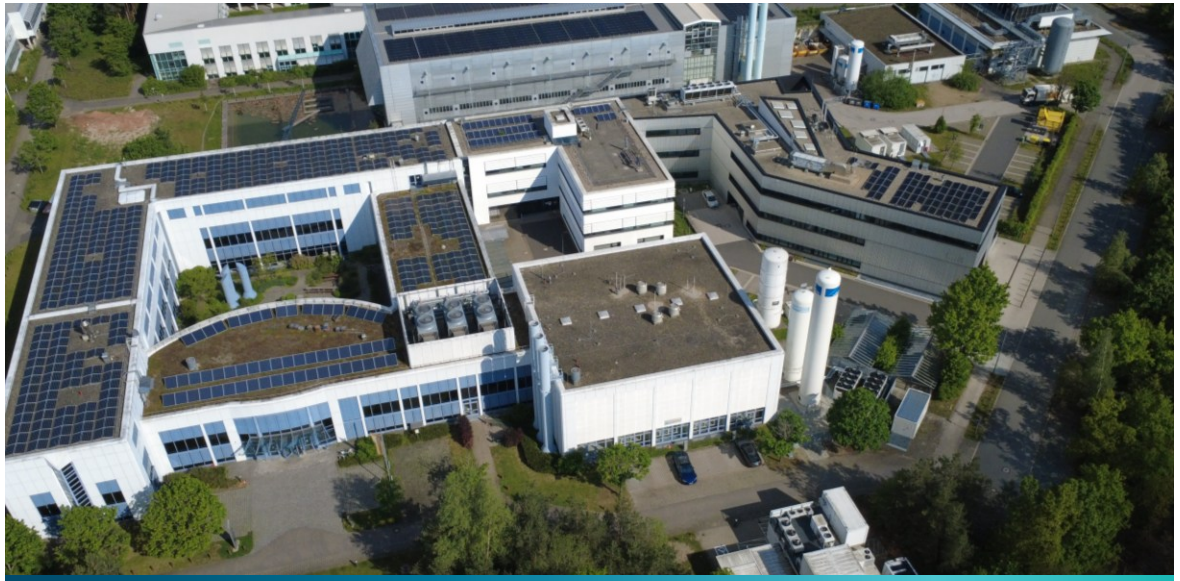
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Markus Meindl

Fraunhofer IISB – The Power Electronics Institute of the Fraunhofer Gesellschaft

Fraunhofer is one of Europe's leading organization for applied research, with 32,000 employees across 75 institutes.



Fraunhofer Institute for Integrated Systems and Device Technology (IISB)

- Main Location: Erlangen, Germany
- 500+ Employees
- Contact persons: Dr.-Ing. Markus Meindl, Florian Hilpert

Relevant expertise:

- High-Voltage solutions for aviation applications
- Power modules for SiC and GaN power semiconductors
- Reliability and lifetime testing of power electronics
- Isolated DC/DC converters (e.g., 800V → 28V)
- Non-isolated DC/DC converters for fuel cell/battery systems
- Drive inverters (> 100 kW …. 1.5 MW)
- E-motor development and prototypes / 1 MW test bench
- Control of electric drives
- On-board chargers
- Battery systems and battery management systems
- System integration and load management of fuel cell systems/ fuel cell compressors/fuel cell laboratory
- Design and control of DC HV supply networks
- Cryogenic power electronics for superconducting applications

Energy materials and UWBG semiconductor technology; Institute for Applied Physics, TU Freiberg
Prof. Johannes Heitmann

Semiconductor production technology, Institute of Electron Device; FAU-Erlangen-Nürnberg
Prof. Jörg Schulze

Power Electronics Systems, Chair of Power Electronics FAU-Erlangen-Nürnberg
Prof. Martin März

Intelligent Energy Systems; Institute of Electronics for Electrical Storage University of Bayreuth
Prof. Vincent Lorentz

Production Technology Institute of Manufacturing Automation and Production FAU-Erlangen Nürnberg
Prof. Jörg Franke

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