



HEKATE

Hybrid Regional Aircraft Challenges

March, 16th, IRM2023-ETSII (Madrid)

Speaker: Daniel Izquierdo and
Miroslav Vasic



Co-funded by
the European Union

EUROPEAN PARTNERSHIP



Summary

11.01

People



11.02

**Brief project
introduction**



11.03

Contacts

Project coordinators



Daniel Izquierdo

High/Low voltage Power Electrics Expert – Airbus DS

AD role in HECATE, : Project technical coordination of several WP, technical research contribution across several WPs.

Short bio:

MSc and PhD in Industrial engineering.

Airbus DS -Electrical Expert



Miroslav Vasić

Associate Professor

Power Electronics

UPM role in HECATE : Optimized design of high frequency magnetic components

Short bio:

MSc and PhD in electrical engineering

IEEE Senior Member



02

Brief project introduction

Consortium • Objectives and
targeted Performances



In a nutshell

34M€

EU requested contribution

53M€

Total Eligible Costs*

68M€

Total Costs*

37

Total number of partners (incl. one affiliate)

11

Countries

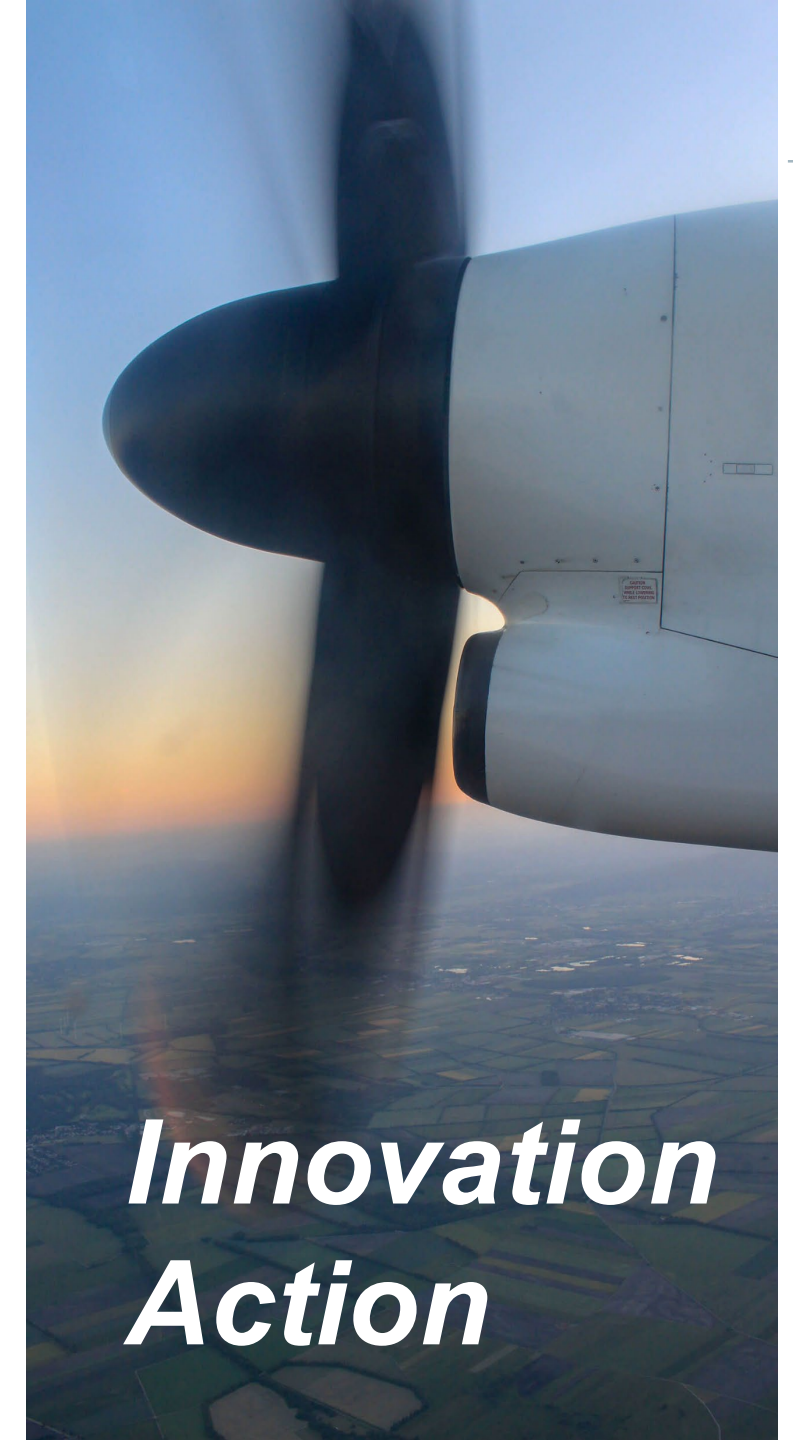
36

Months duration

** with UK partners, without IKC*



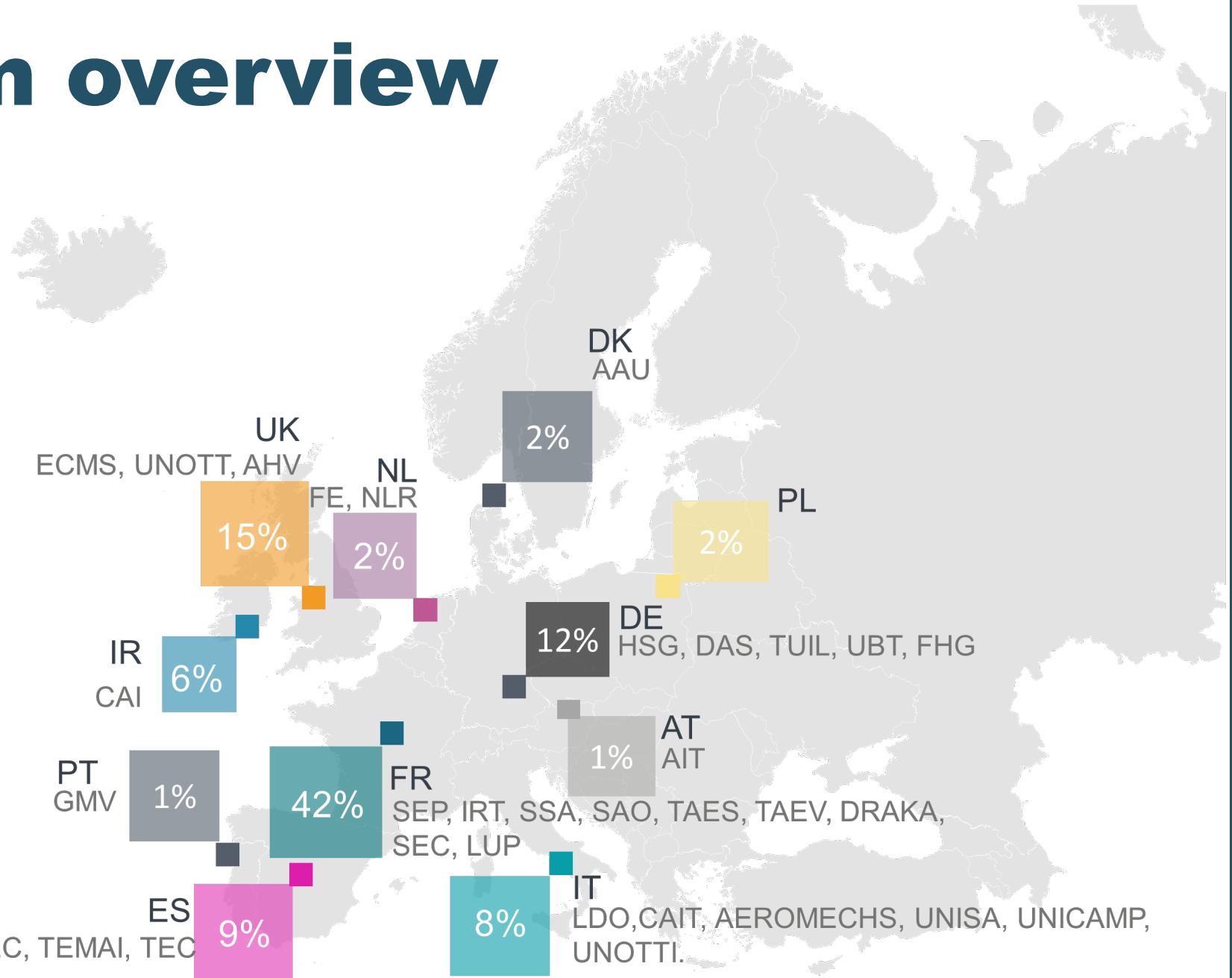
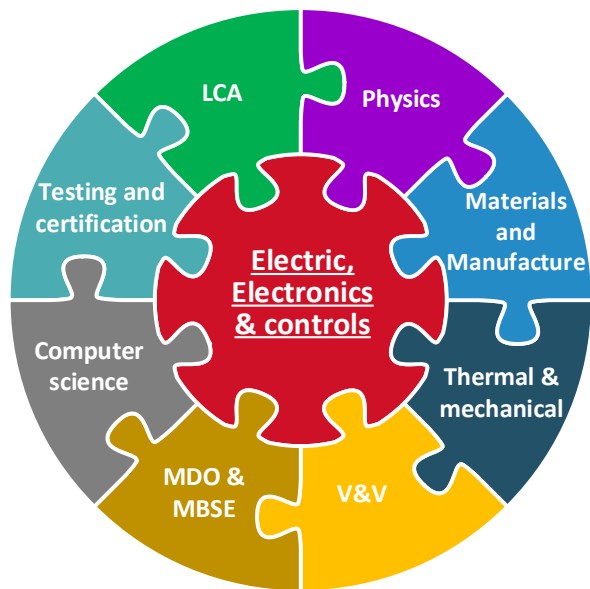
“HECATE aims to deliver transformative technologies to electrical distribution for future Hybrid Electric Aircraft”



***Innovation
Action***

Consortium overview

Profile	Total	Grant
IND	73%	68%
SME	8%	7%
RTO/Univ.	19%	25%

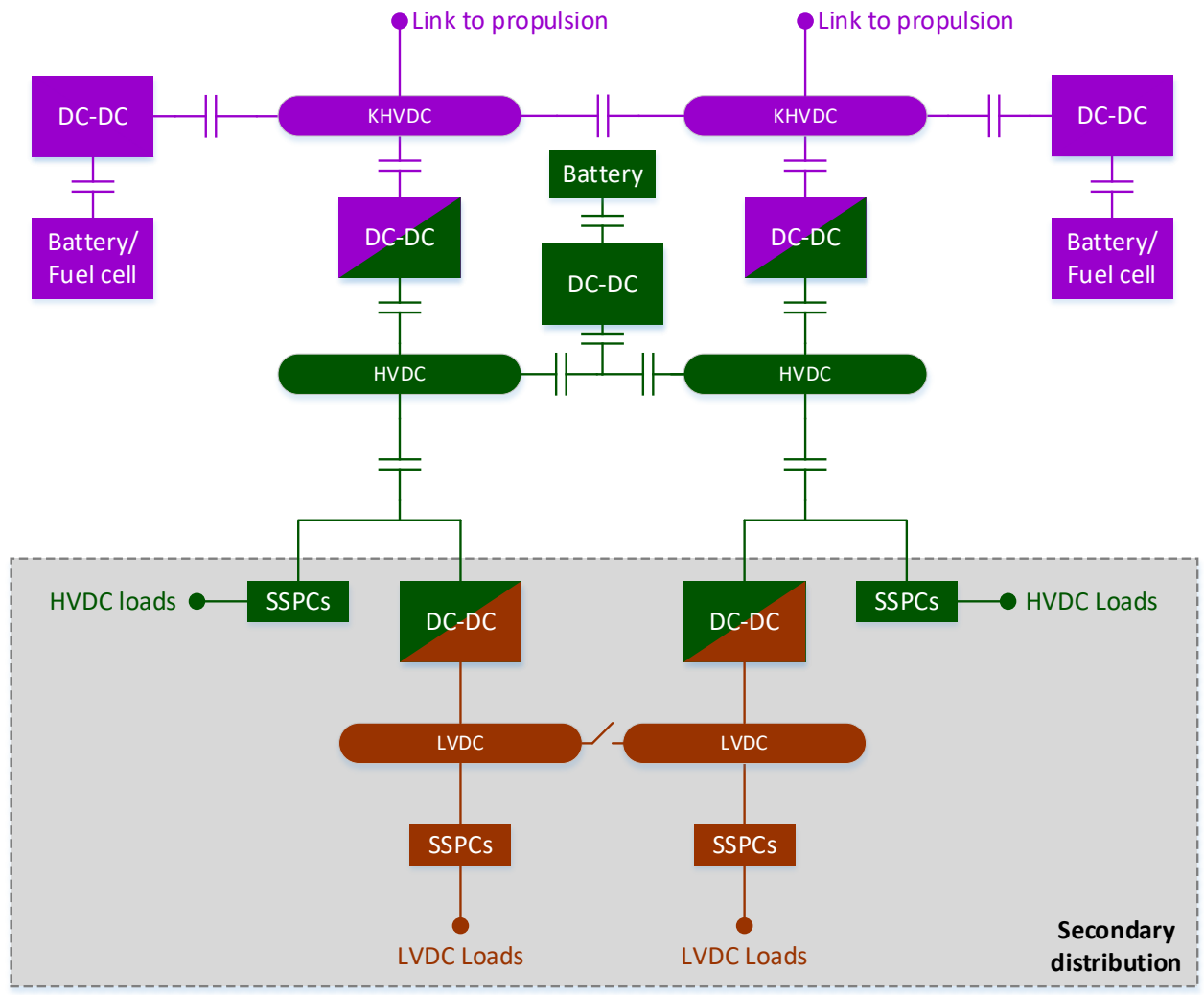


E-THRUST

**Electrical Distributed Propulsion System Concept for
Lower Fuel Consumption, Fewer Emissions, Less Noise**

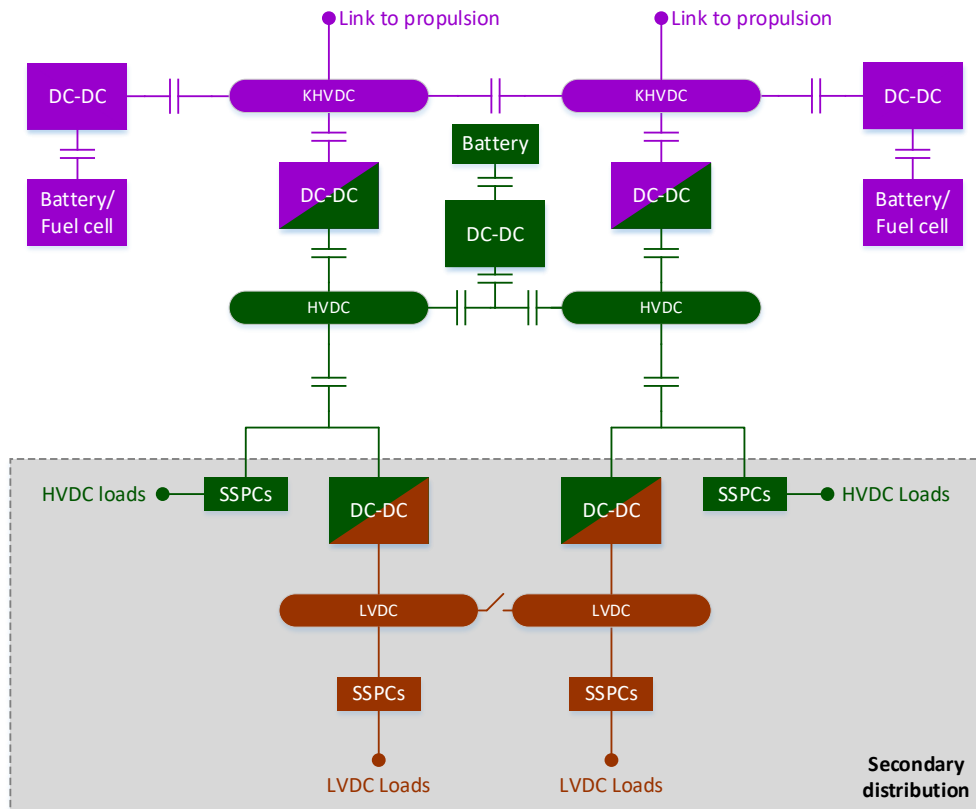


Electrical architecture



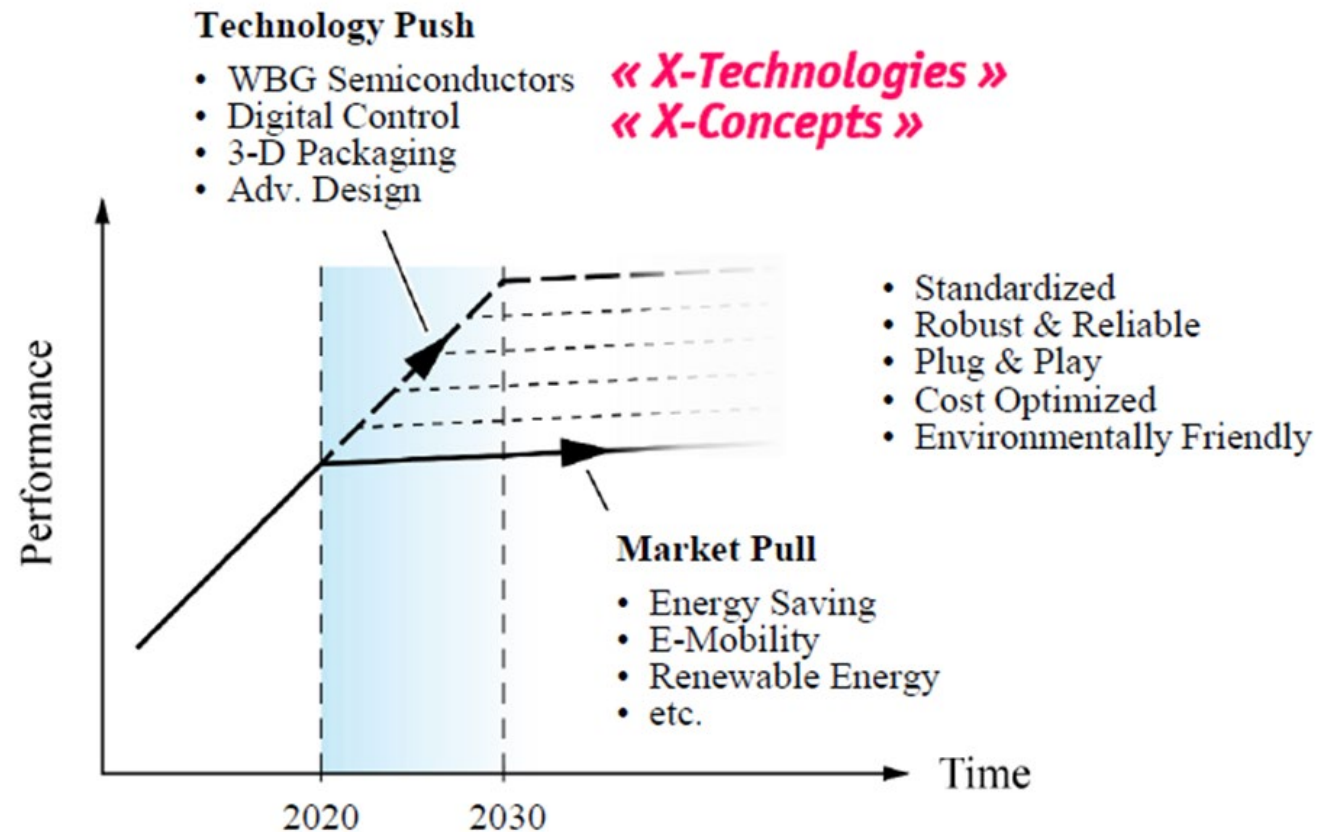
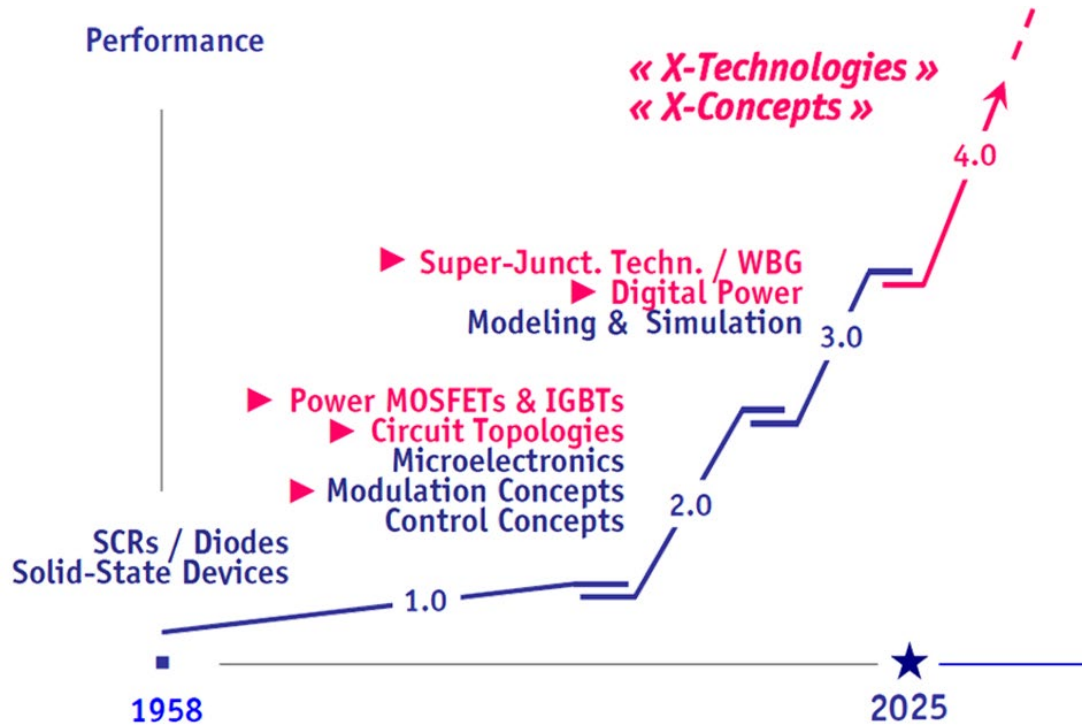
Paradigm Change

- DC distribution!! (Tesla was wrong?)
- DC breakers
- High frequency isolation
- GaN and SiC



Are these ideas X-technology, and why?

What are X-technologies?



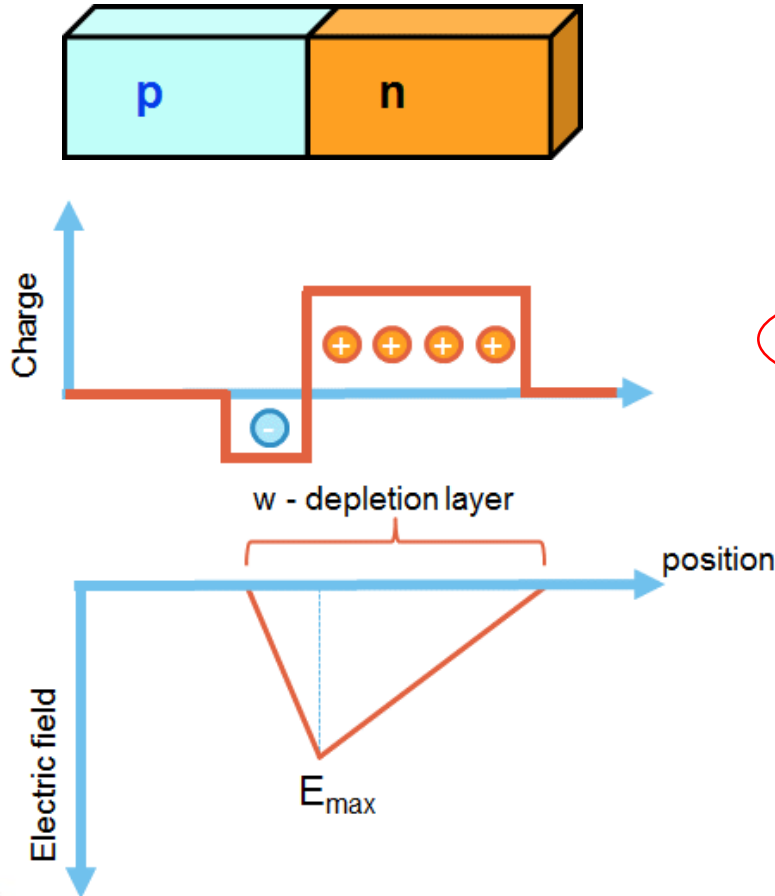
⚡ Idea by prof. Johann Kolar, ETH



J. Kolar, "Power Electronics Design 4.0", ECPE Expert Discussion on "Design Automation and Next Generation Measurement Technologies in Power Electronics", July 2019

Wide Band Gap Devices (SiC and GaN)

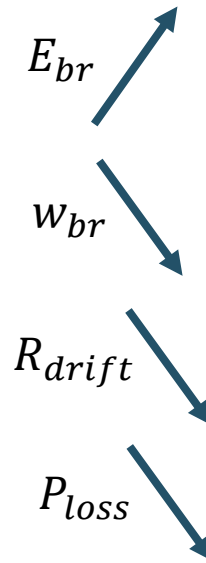
Motivation



$$V_{br} \approx \frac{E_{br}^2 \epsilon_s}{2qN_D}$$

$$w_{br} \approx \frac{E_{br} \epsilon_s}{qN_D}$$

$$V_{br} \approx w_{br} E_{br}$$



Just to refresh your memory...

Material	Critical Electric Field ($E_{critical}$)
Si	$0.3 \times 10^6 \text{ V/cm}$
GaN, SiC	$3 \times 10^6 \text{ V/cm}$

This is the main reason for the SiC and GaN superiority!



Wide Band Gap Devices (SiC and GaN)

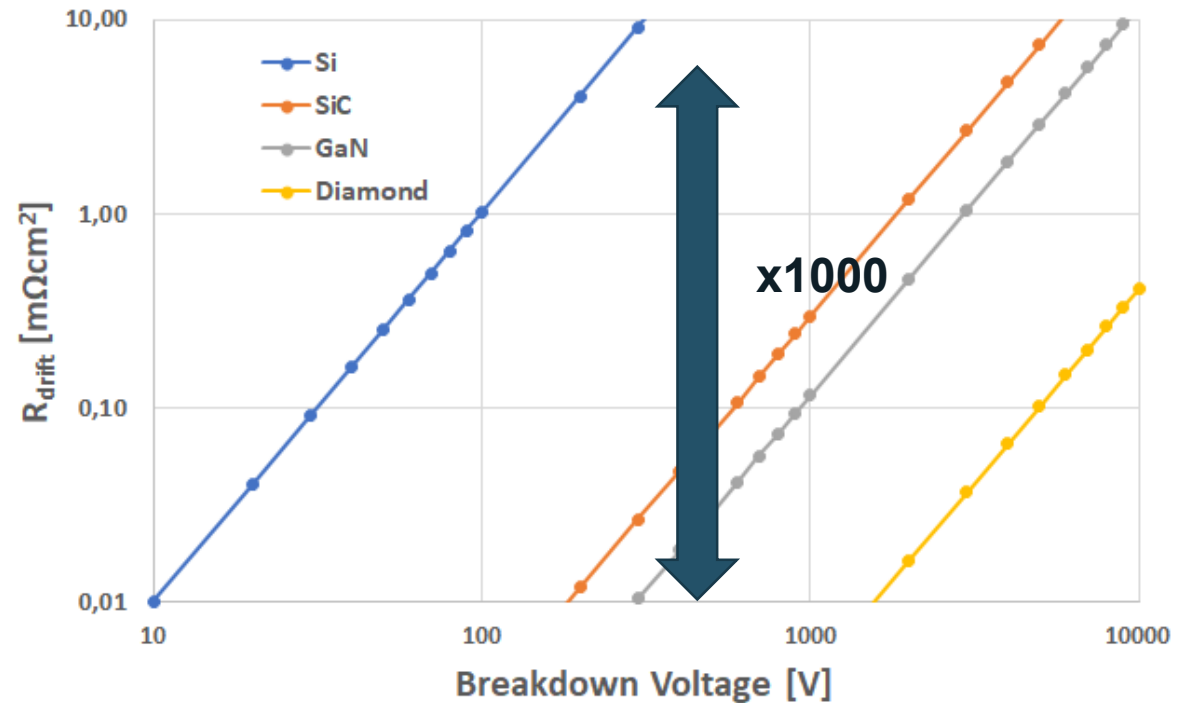
⚡ Technological Limits – 1D approximation

We start with:

$$\begin{cases} V_{br} \approx \frac{E_{br}^2 \epsilon_s}{2qN} \\ w_{br} \approx \frac{E_{br} \epsilon_s}{qN} \end{cases}$$

$$R_{drift} = \frac{w_D}{qN_D \mu_D}$$

$$R_{drift} = \frac{4V_{br}^2}{\mu_D E_{br}^3 \epsilon_s}$$

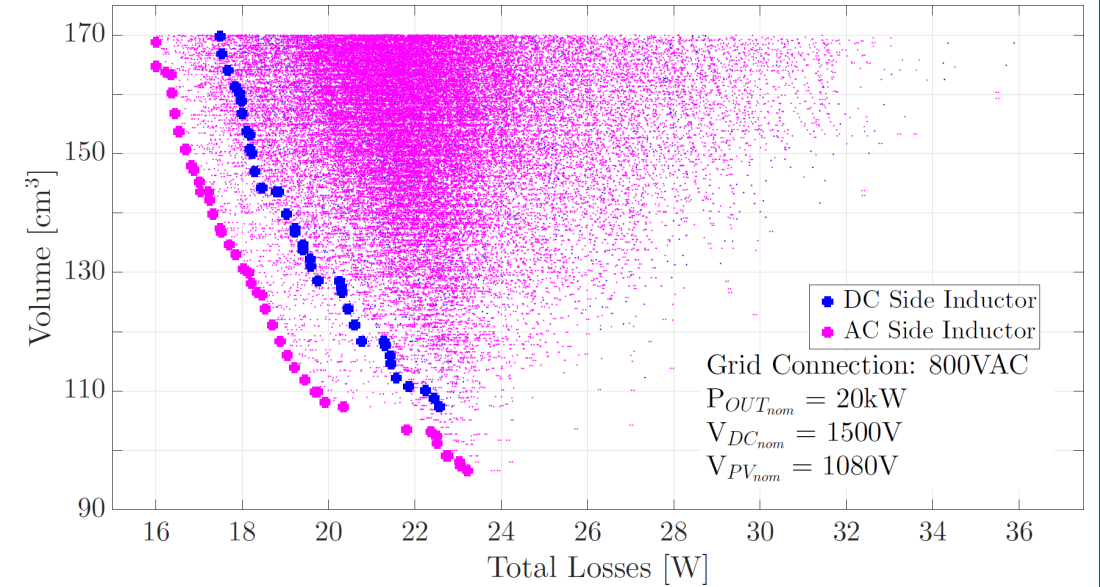
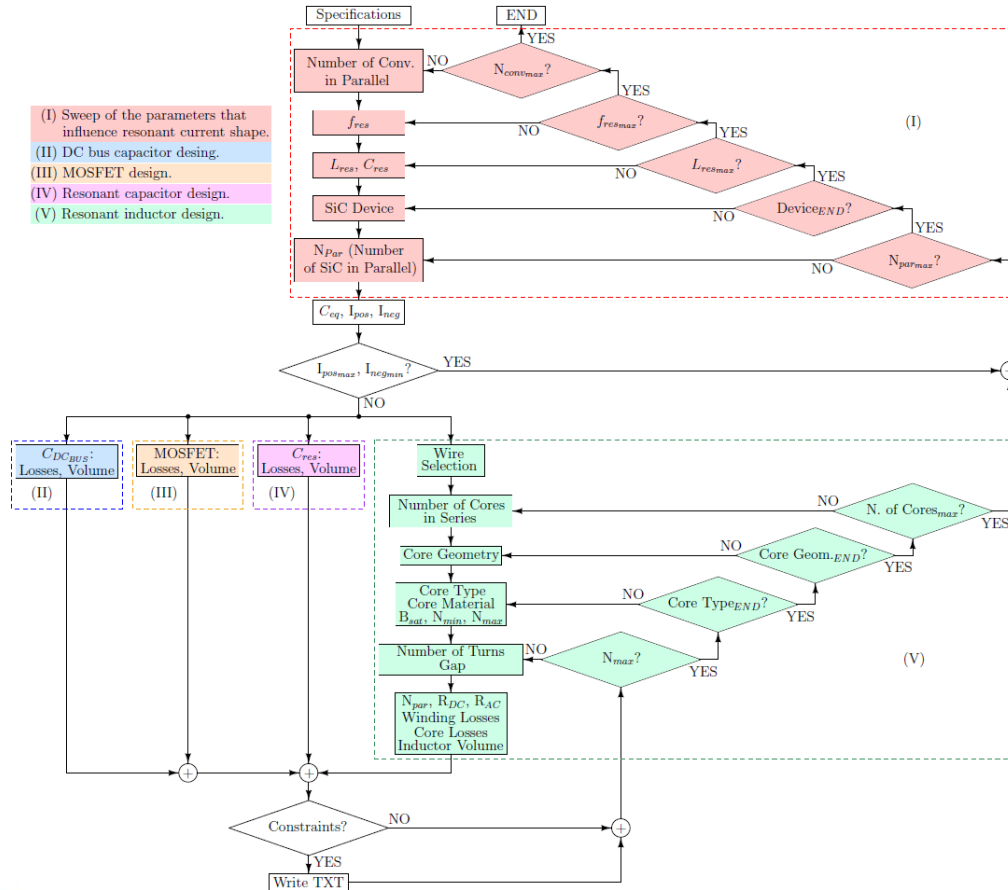


- Direct consequence of E_{br} !
- Very optimistic prediction!



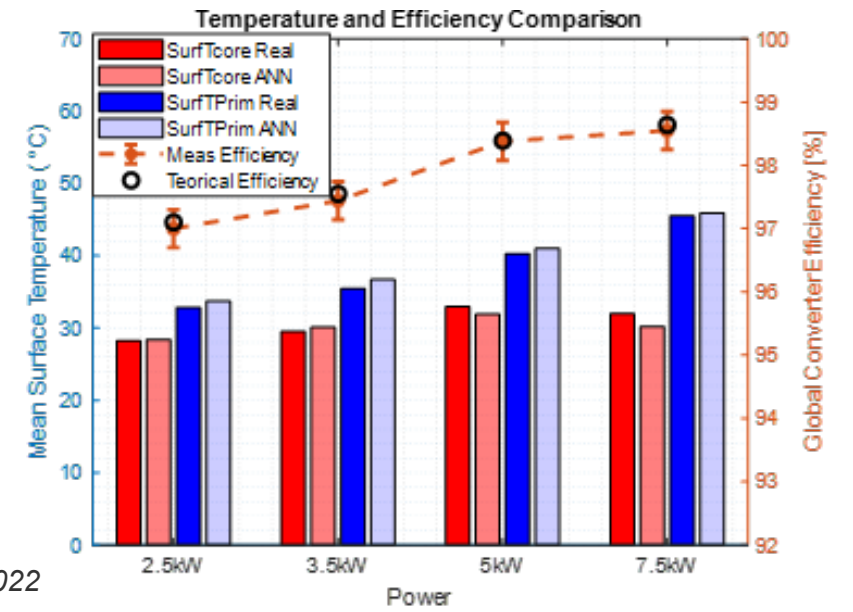
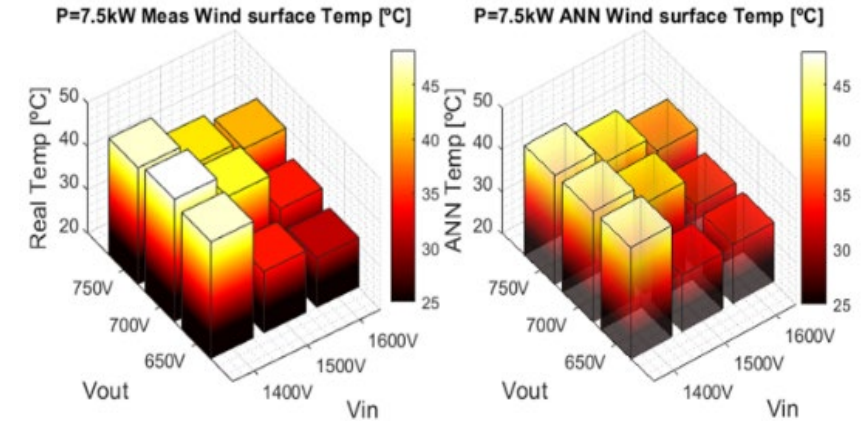
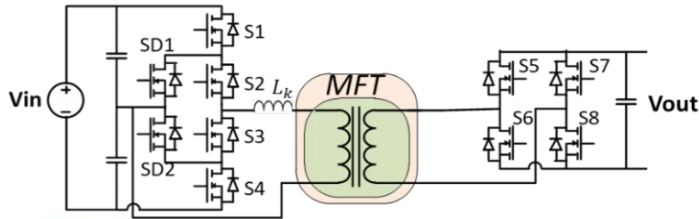
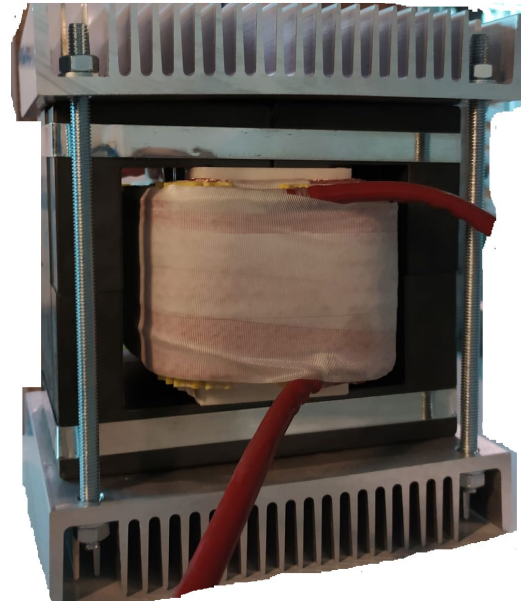
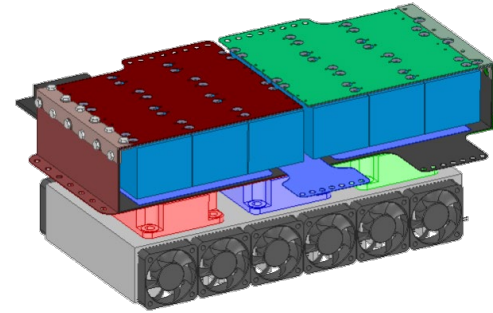
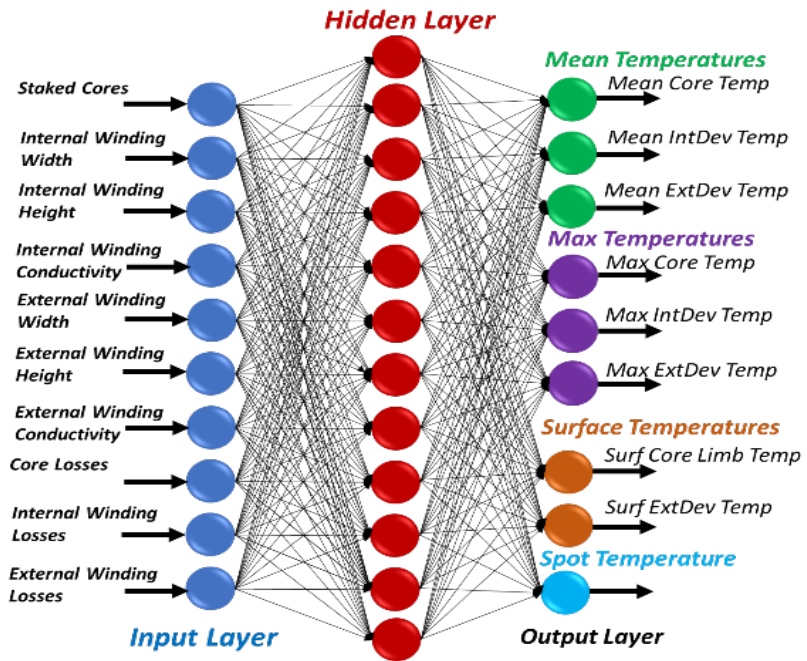
Optimizations

⚡ Reaching the design envelope



Artificial Intelligence

⚡ Empowering the known methodologies



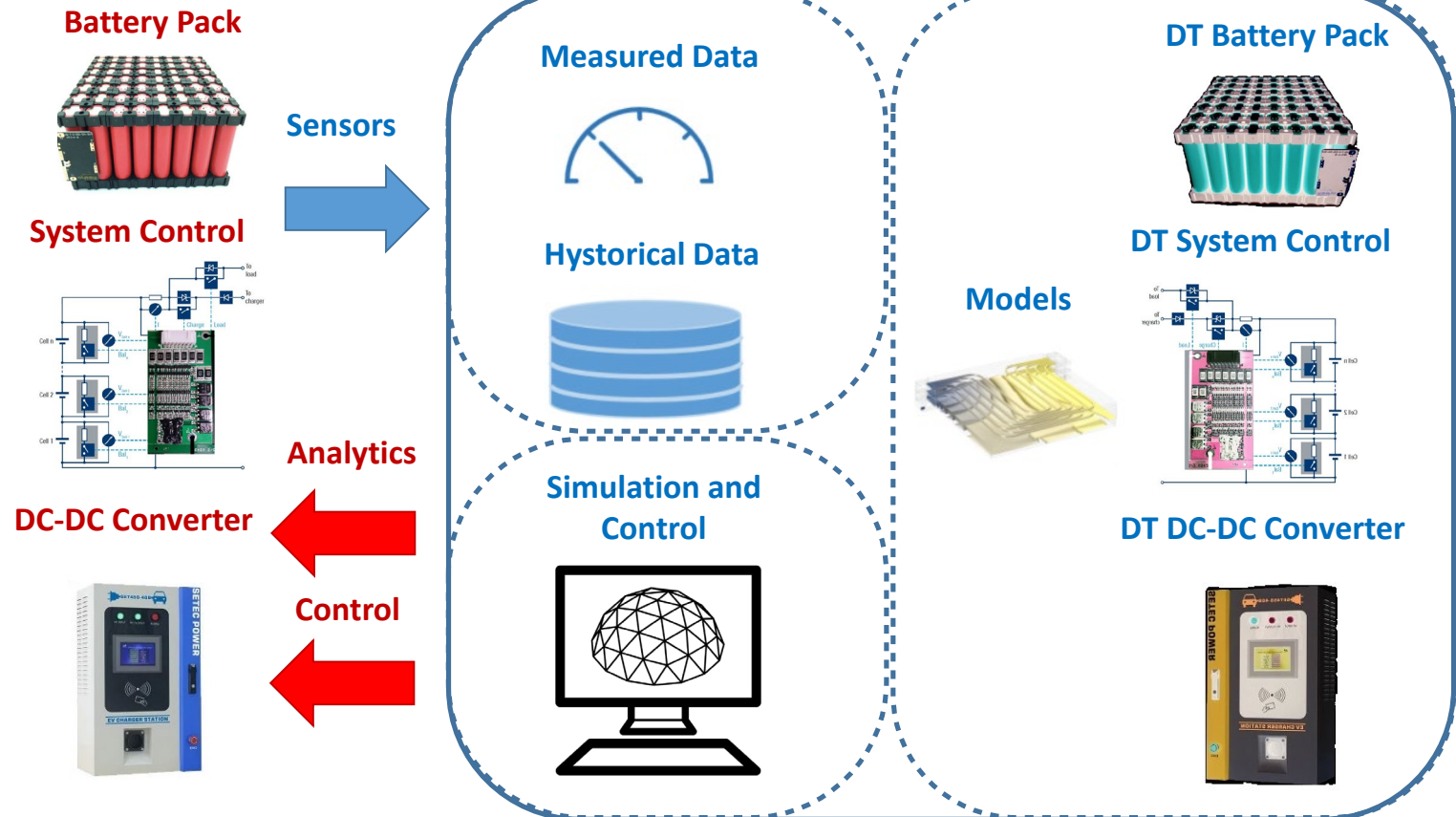
D. Santamargarita, G. Salinas, D. Molinero, E. Bueno and M. Vasić, "Trade-Off Between Accuracy and Computational Time for Magnetics Thermal Model Based on Artificial Neural Networks (ANN)," in IEEE Journal of Emerging and Selected Topics in Power Electronics, 2022

Digital Twinning

⚡ **New design dimension**

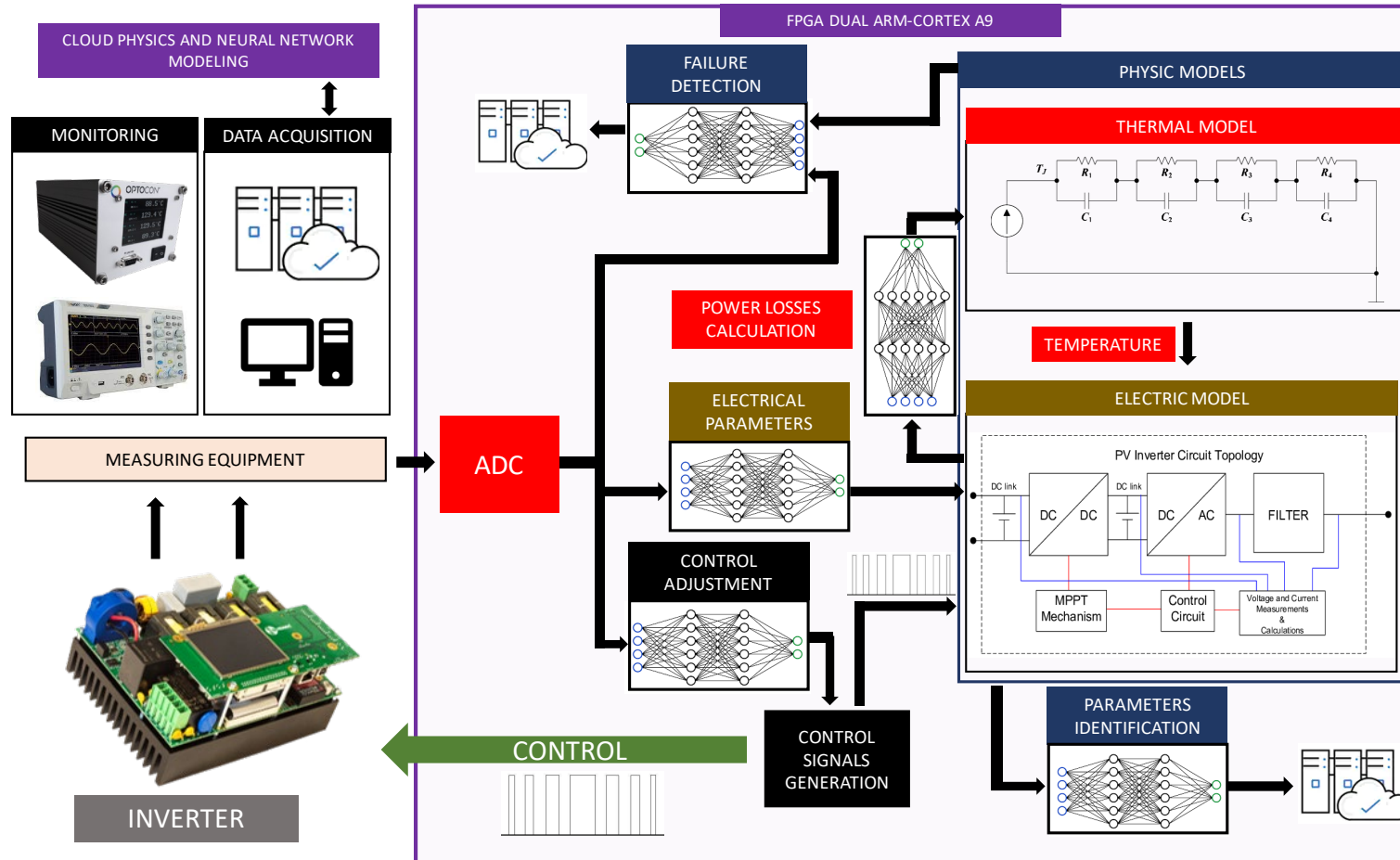
Physical Electrical System

Digital Twin Electrical System



Digital Twinning

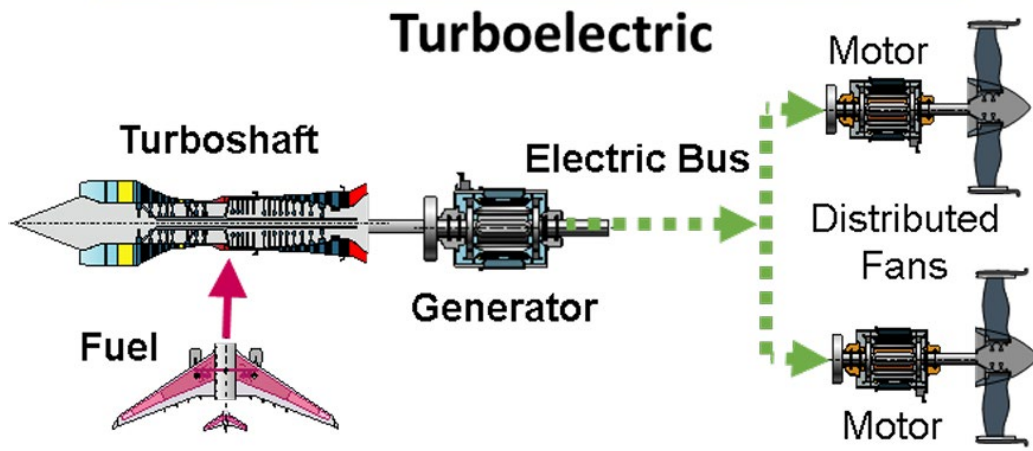
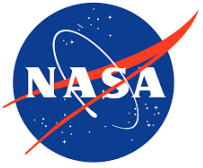
More possibilities



J. M. Barón, A. García, F. Vergara, P. J. Arnaiz and M. Vasić, "Methodology for Designing Embedded Real-Time Electrothermal Models in PYNQ Z1 System on Chip," 2022 IEEE Design Methodologies Conference (DMC), Bath, United Kingdom, 2022

Why we need all this trouble?

⚡ The future in front of us



- Electric Thrust
- Medium Voltage (7,5 kV)
- Power Distribution (50 MW)
- 1000 W/h power capacity of batteries



J. L. Felder, "NASA N3-X with Turboelectric Distributed Propulsion", NASA Glenn Research Center, Fundamental Aeronautics Program Fixed Wing Project
<https://www.rolls-royce.com/media/press-releases/2013/18062013-works-with-eads.aspx>

Thank you!

Contact points for any question:

- › Daniel Izquierdo
- › Company: Airbus DS
- › Email: Daniel.Izquierdo@airbus.com

- › Miroslav Vasić
- › Company: Universidad Politecnica de Madrid
- › Email: miroslav.vasic@upm.es





**Co-funded by
the European Union**

Funded by the European Union under GA no 101101961 - HECATE. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Clean Aviation. Neither the European Union nor the granting authority can be held responsible for them.

