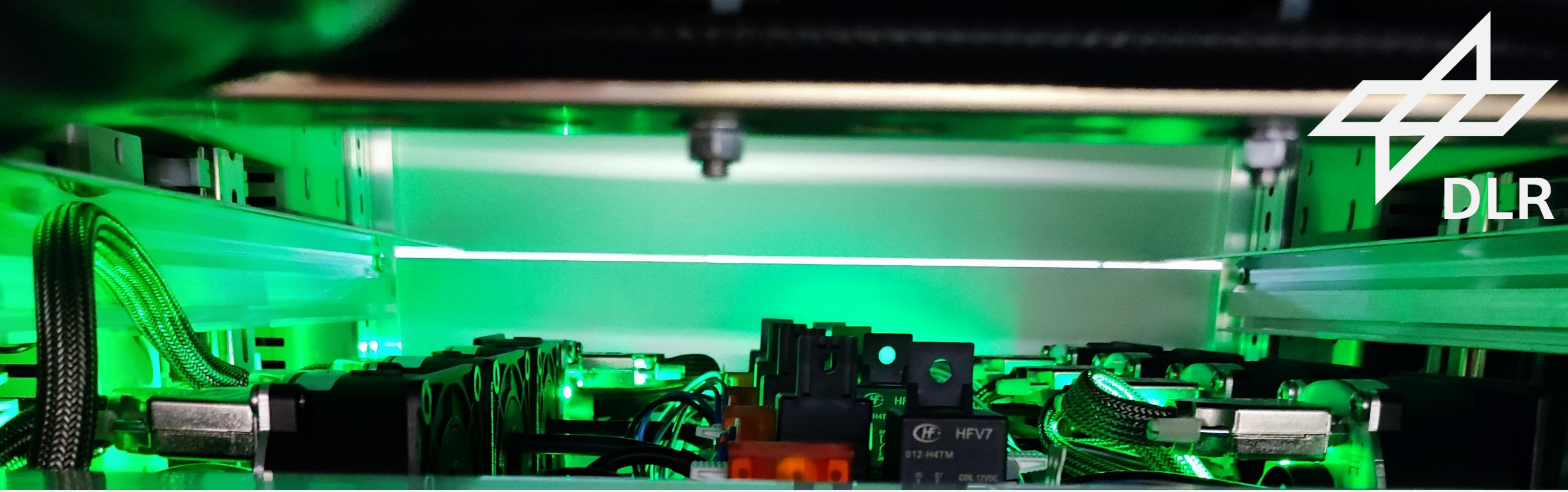

DC Miniature Grid to Test Electrical System Configurations of Future Electric Aircraft

1. MOTIVATION

2. RESEARCH OBJECTIVES

3. DC TEST RIG

4. EXEMPLARY USE CASES

1. MOTIVATION

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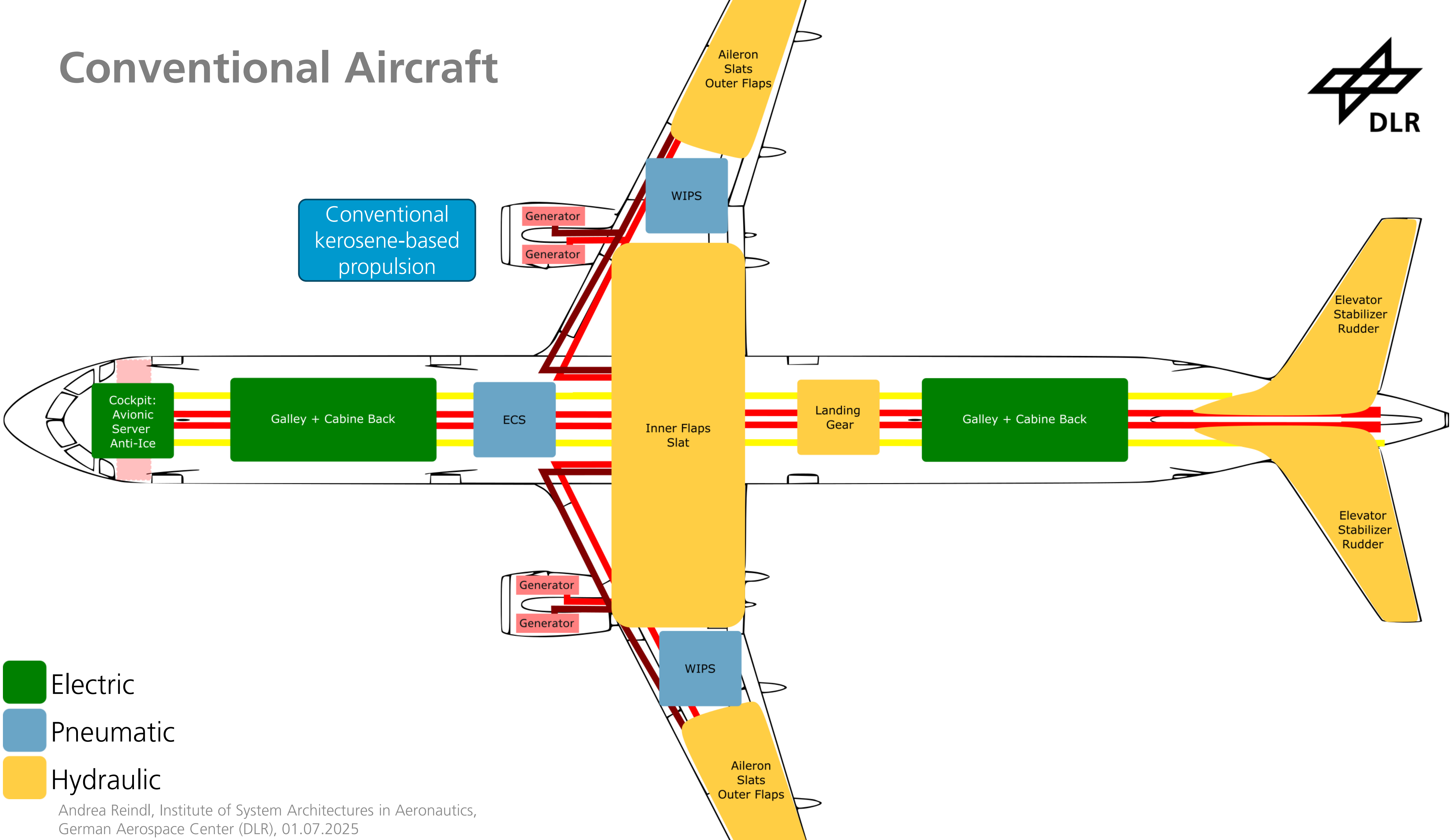
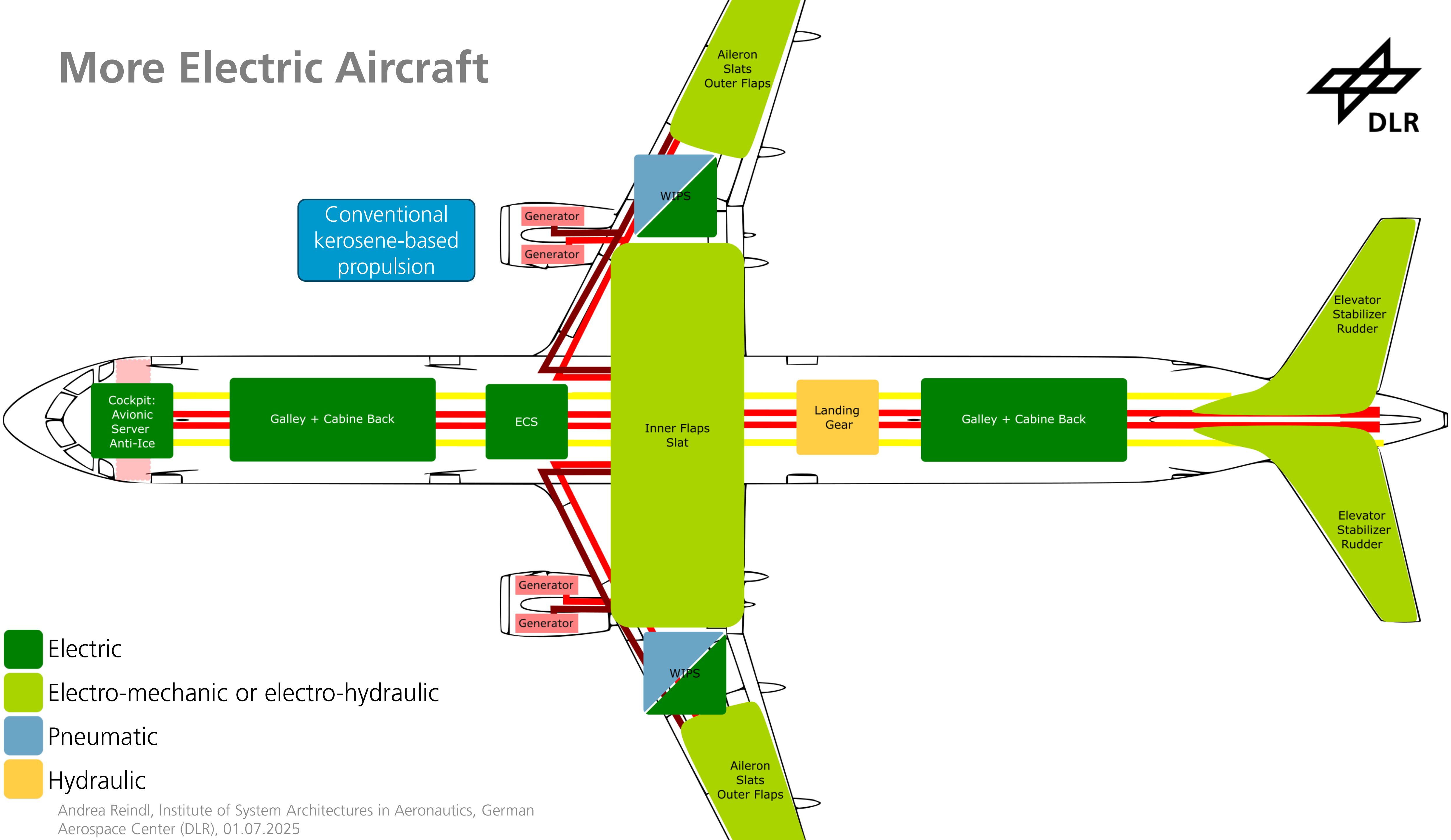
3. DC TEST RIG

4. EXEMPLARY USE CASES

Conventional Aircraft

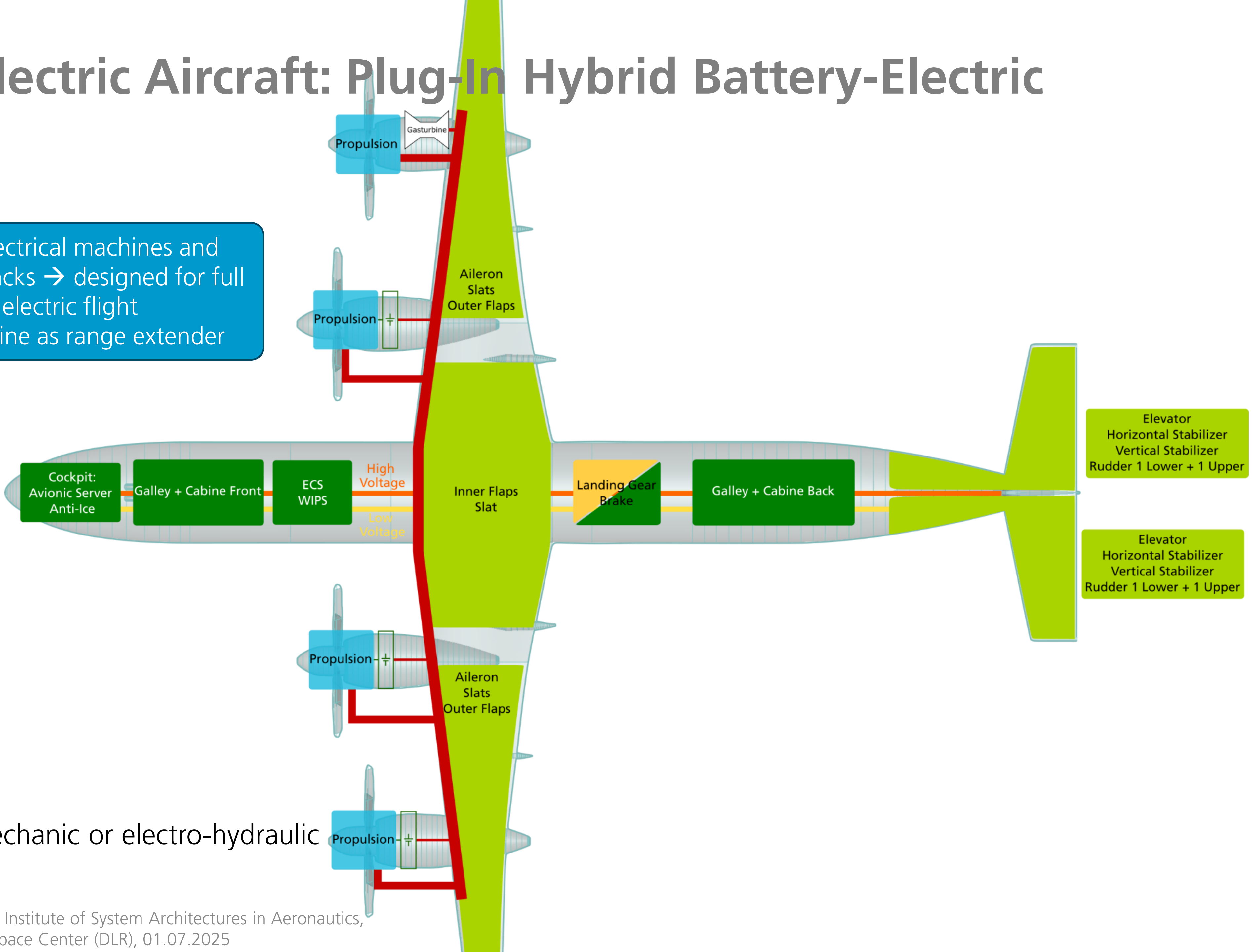


More Electric Aircraft



All Electric Aircraft: Plug-In Hybrid Battery-Electric

Four electrical machines and battery packs → designed for full electric flight
Gasturbine as range extender



Electric
Electro-mechanic or electro-hydraulic
Hydraulic

Andrea Reindl, Institute of System Architectures in Aeronautics,
German Aerospace Center (DLR), 01.07.2025

POWER RATING ELECTRICAL SYSTEM

DLR

CONVENTIONAL

Type	A320	A321	A380
Maximum passenger capacity	180	220	853
Installed electrical power	~100 kW	~150 kW	~600-800 kW

MORE ELECTRIC AIRCRAFT

Type	A350	A321 (under research)	B787
Maximum passenger capacity	440	220	250
Installed electrical power	~1000-1400 kW	~700 kW	~1500 kW

ALL ELECTRIC AIRCRAFT

Type	EXACT PHEP (under research)
Maximum passenger capacity	250
Installed electrical power (on-board & propulsion)	~17.5 MW = 17500 kW

Propulsion & On-board System

Andrea Reindl, Institute of System Architectures in Aeronautics, German Aerospace Center (DLR), 01.07.2025

Why DC Grids are promising

+ No synchronization needed
+ No reactive power

→ simpler control

→ smaller cable cross-section

→ less wiring weight

+ Fewer transformers
+ Lower conversion losses (e.g., in motor control)
+ Batteries/fuel cells integrate naturally

1. MOTIVATION

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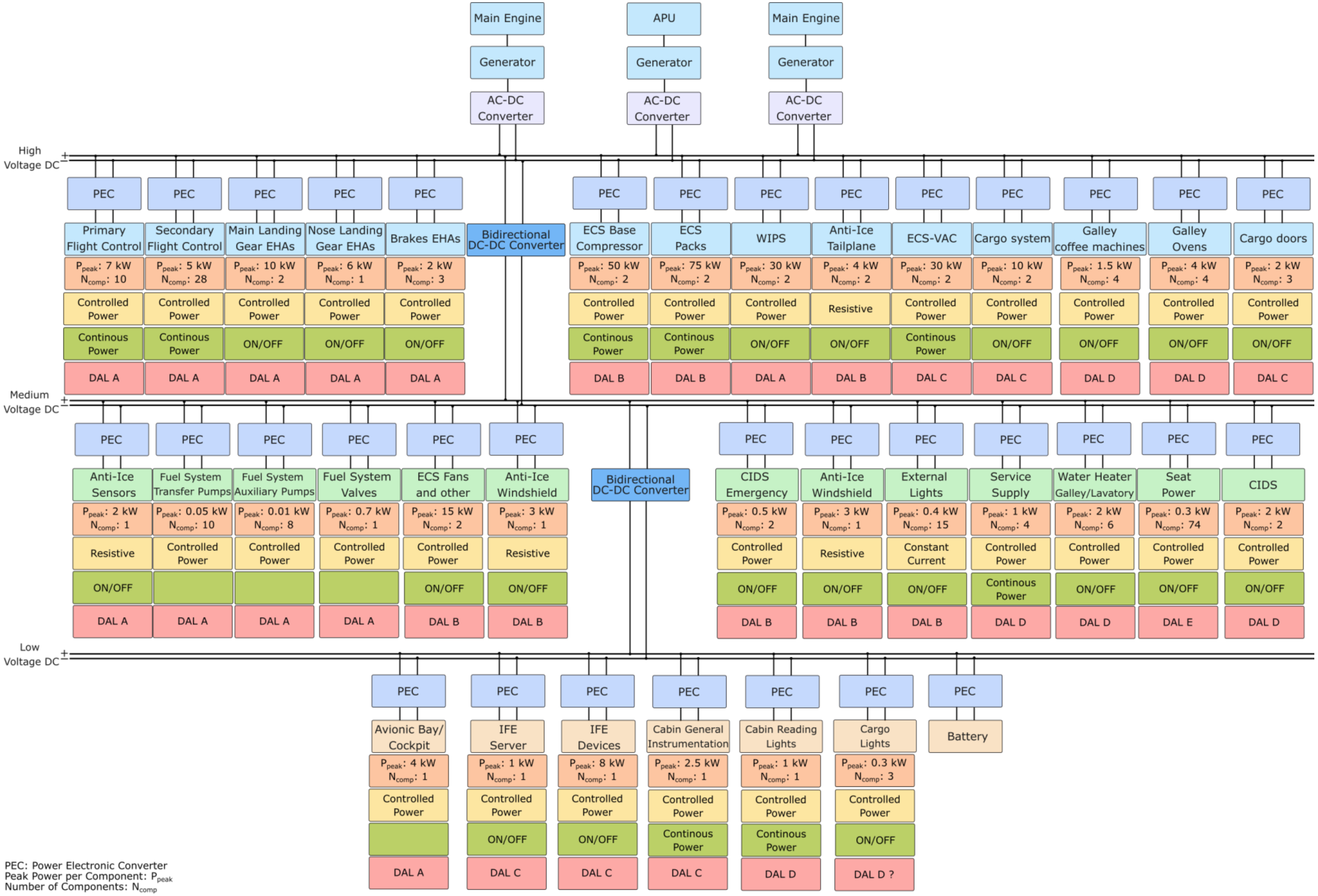
4. EXEMPLARY USE CASES

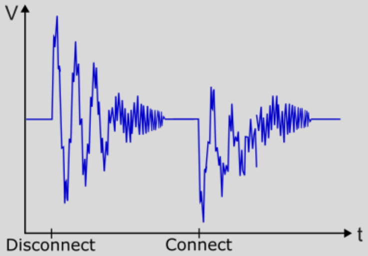
How does load shedding affect DC grids?

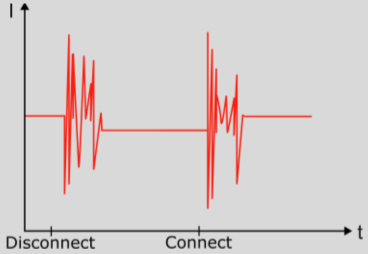


Andrea Reindl, Institute of System Architectures in Aeronautics, German Aerospace Center (DLR), 01.07.2025

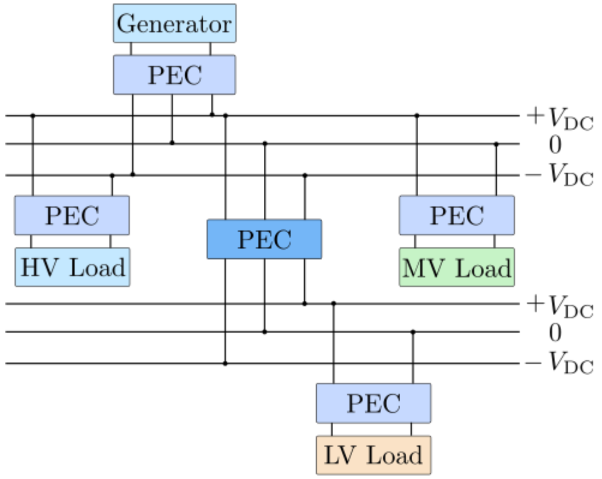
What are the research objectives of the test bench?

Analysis of the behavior in the event of load shedding and reconnection of individual or multiple loads

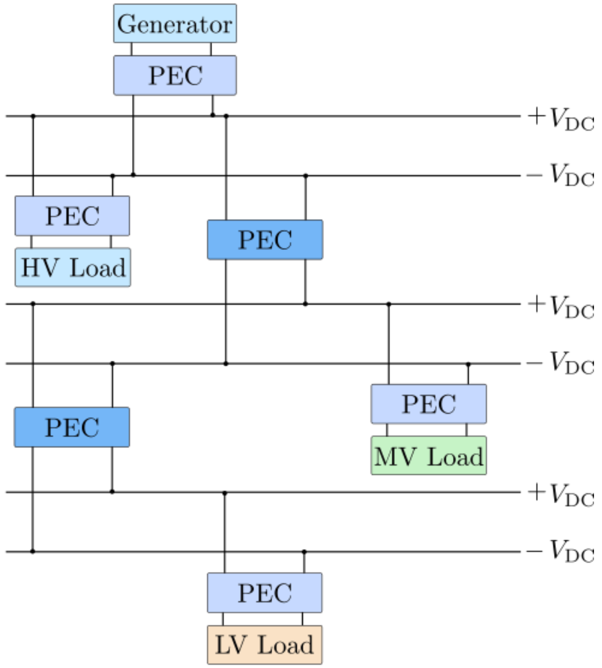




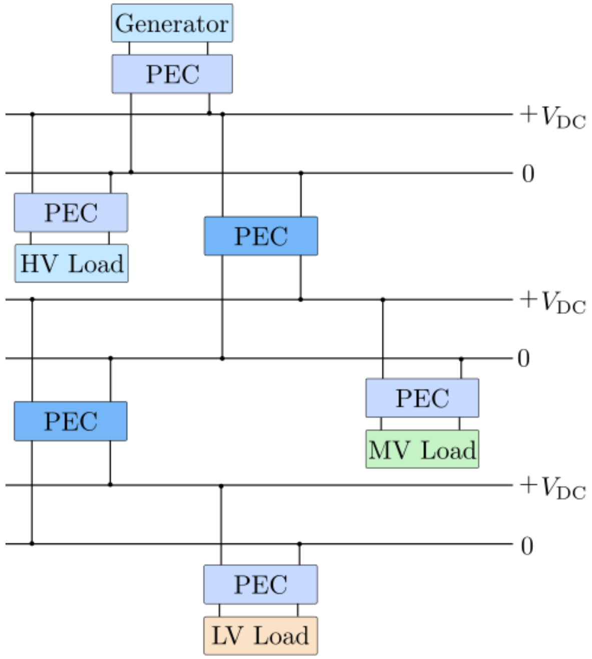
What is the architecture of the DC grid?



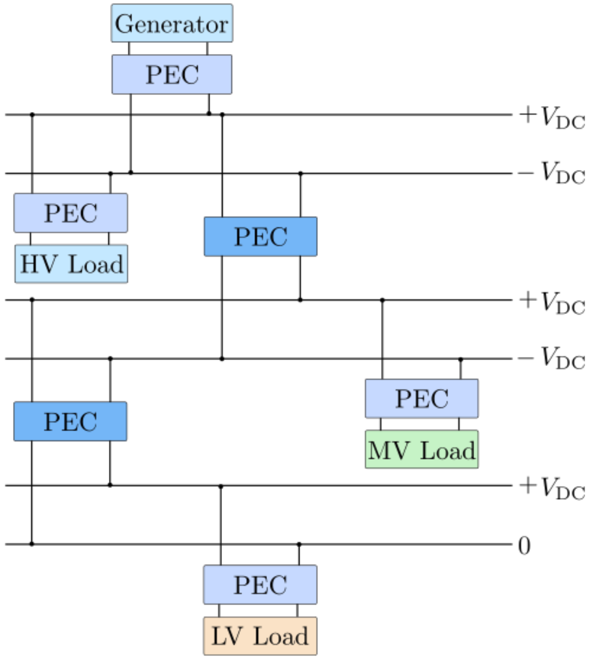
a, Bipolar, three wire



b, Bipolar, two wire



c, Unipolar



d, Hybrid forms, e.g.,
bipolar HV and MV grid, unipolar LV grid

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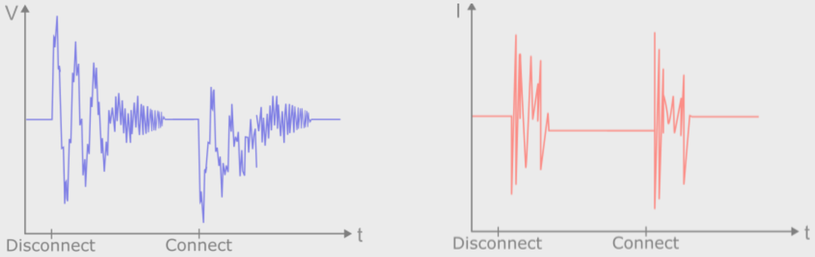
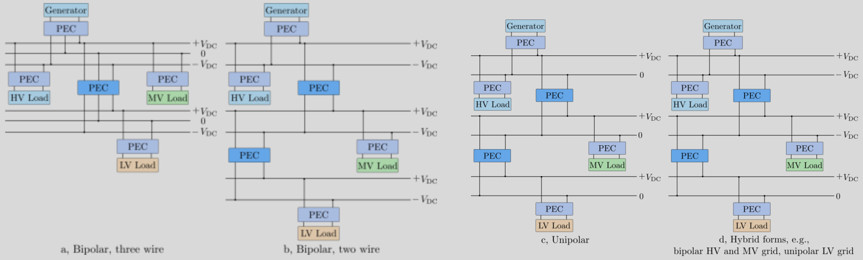
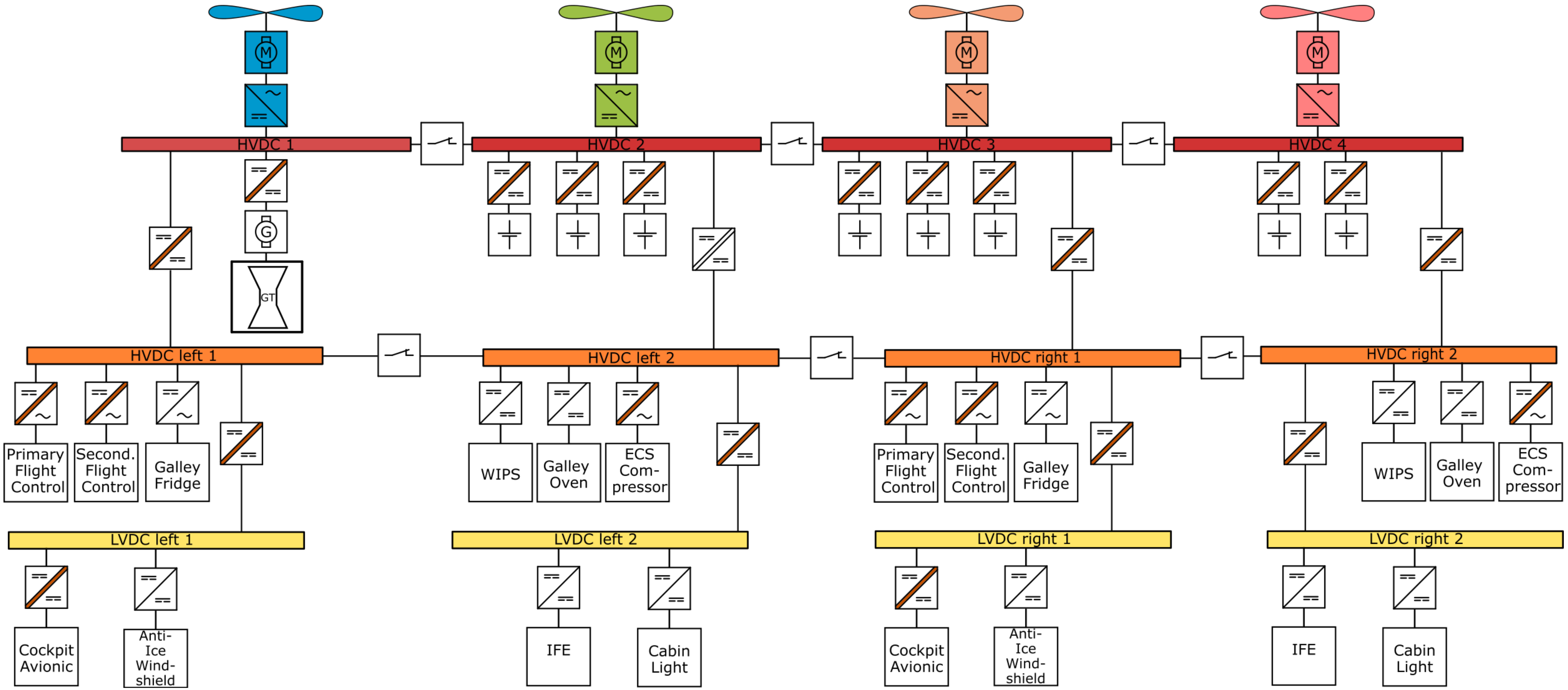


Investigation of various DC grid architectures in terms of power quality and their behavior in the event of a fault



Are isolated or non-isolated DC/DC converters required?



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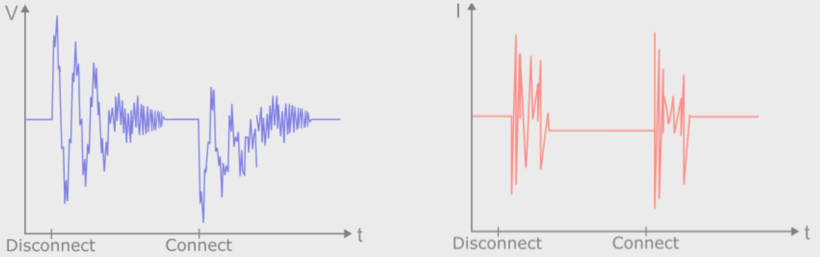

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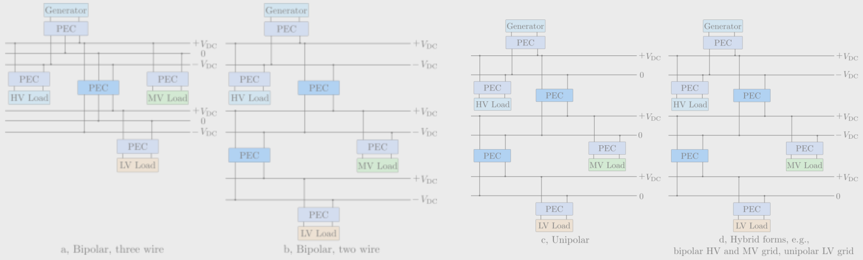
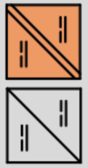


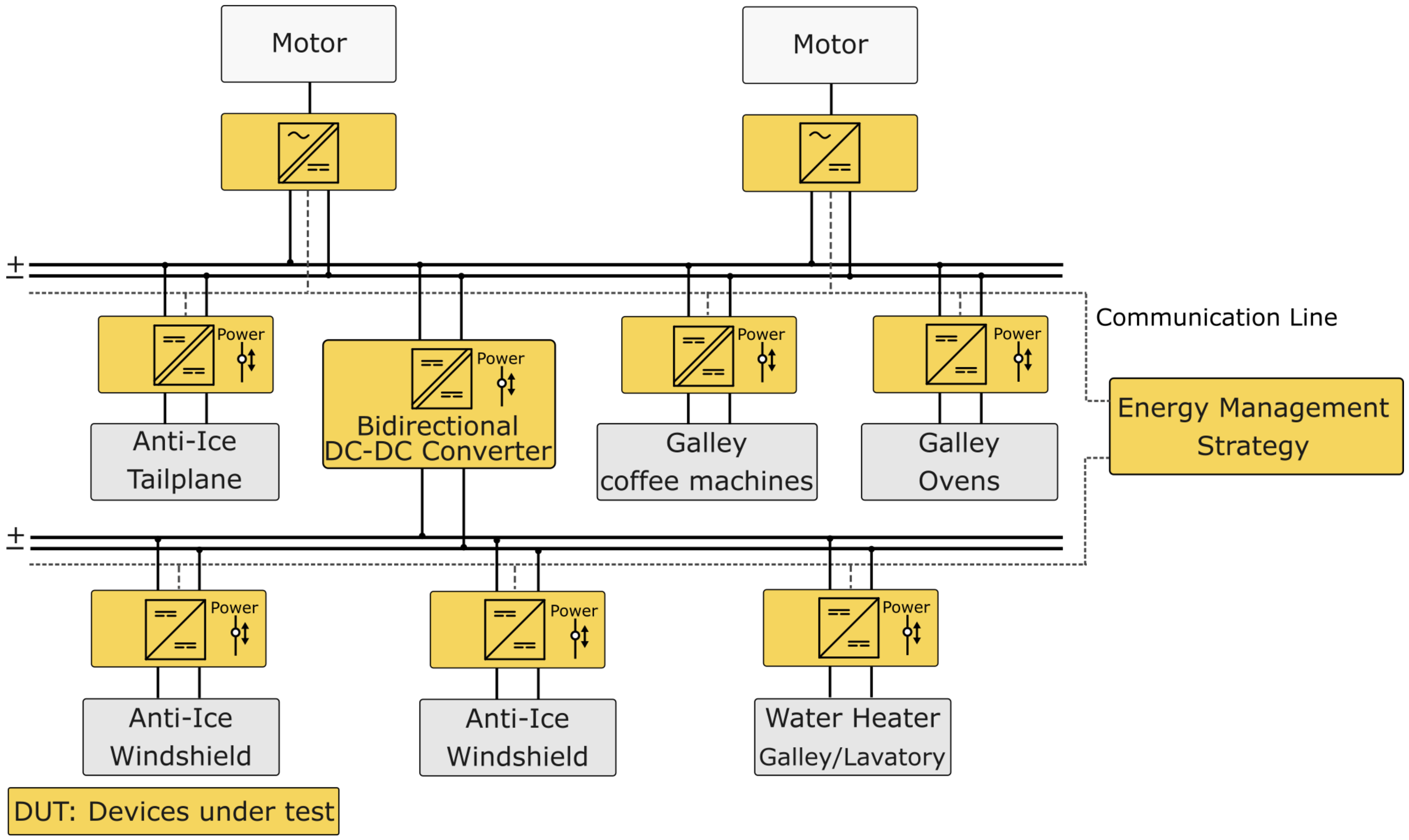
Comparative evaluation of isolated and non-isolated DC/DC converters and inverters



Isolated DC/DC Converter

Non-isolated DC/DC Converter

Which inverter or DC/DC converter topologies are used and which energy management strategies are applicable?



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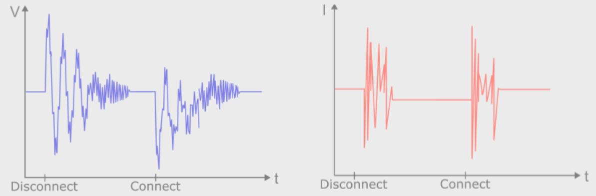

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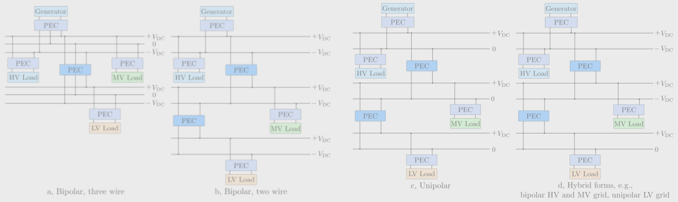

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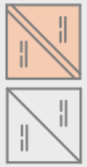
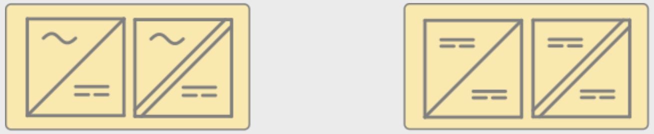


Isolated DC/DC Converter

Non-isolated DC/DC Converter

Hardware-in-the-loop: Integrating various DC/DC converters and inverters as devices under test and investigation of energy management strategies

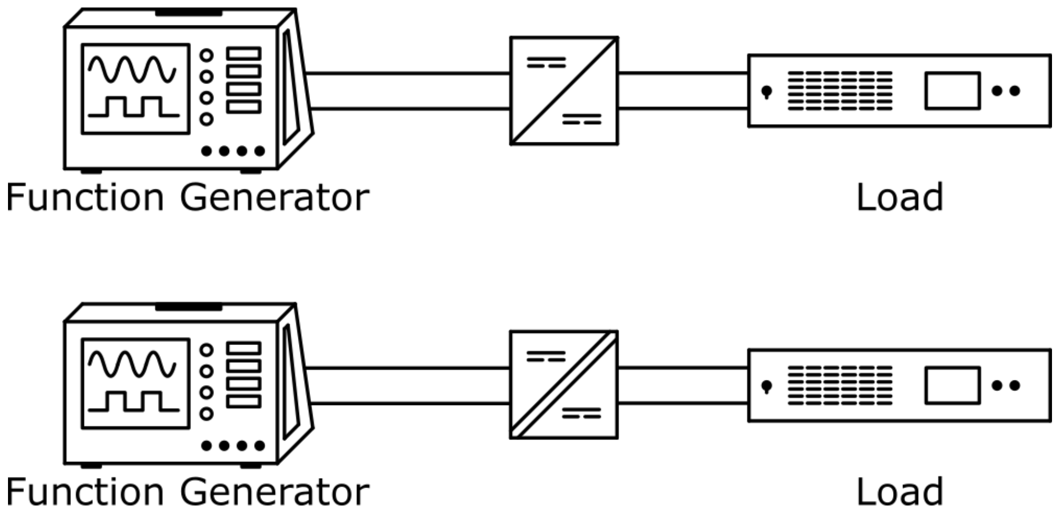


Inverter

DC/DC Converter

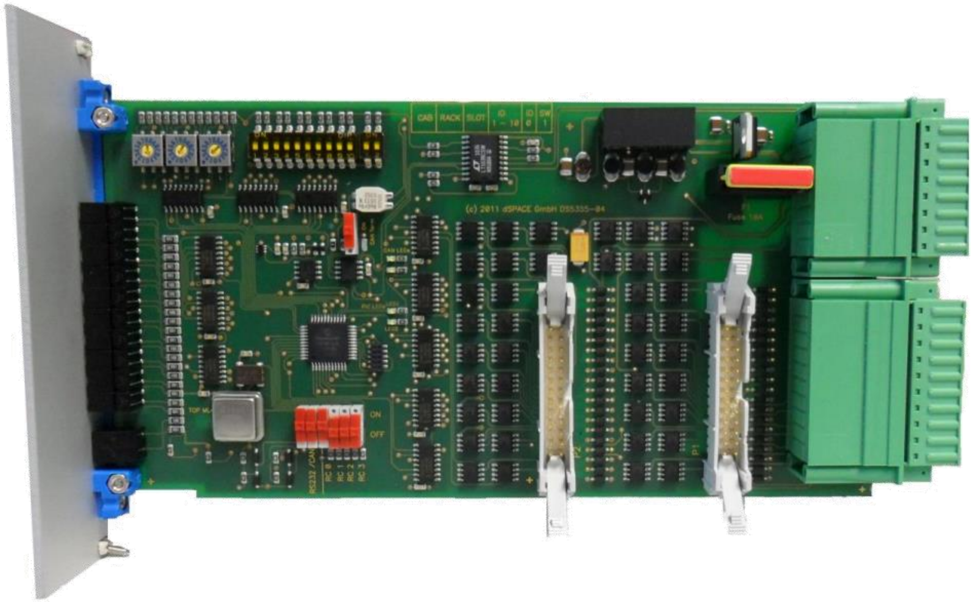
Failure Injection

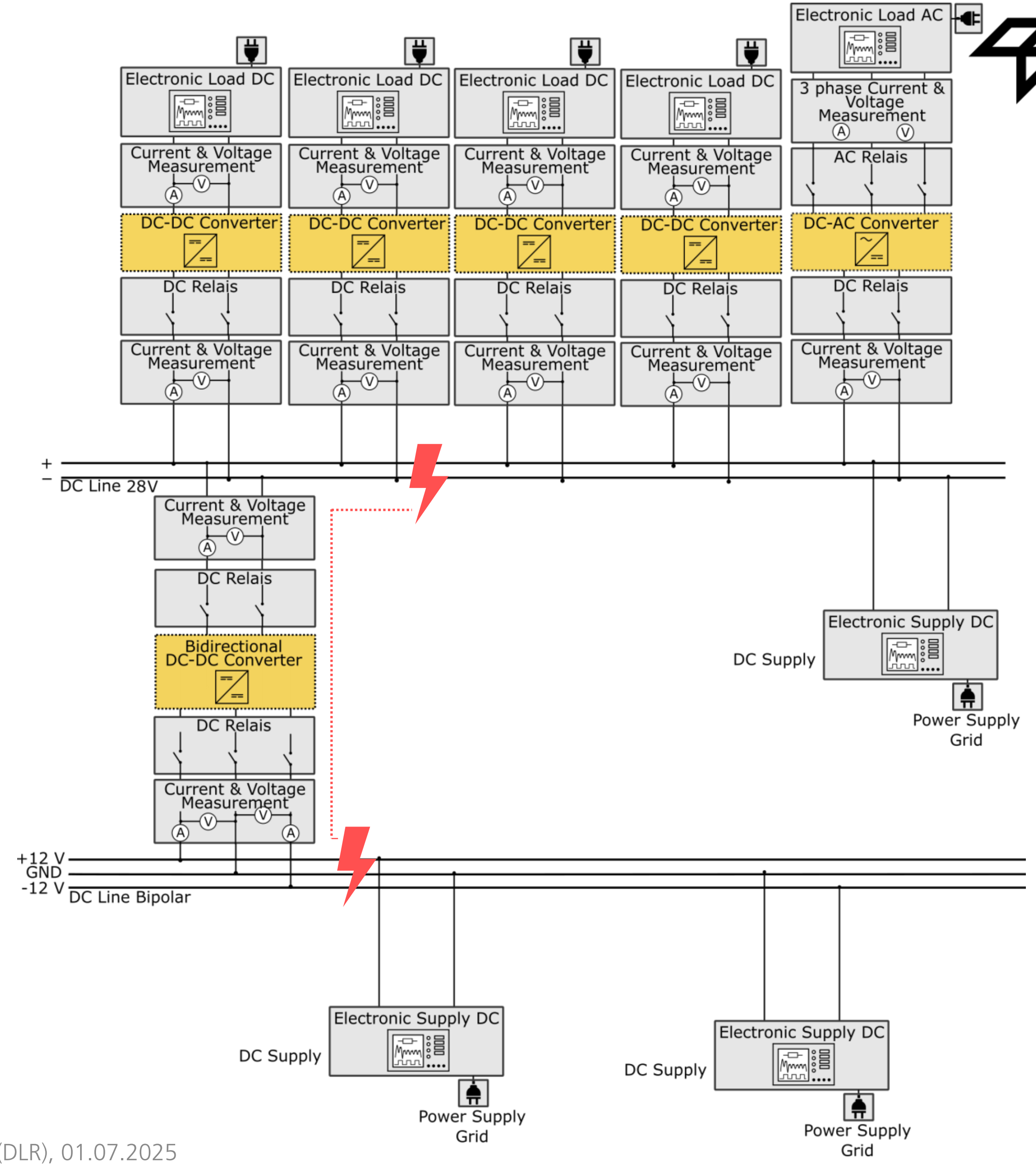
Use Function Generator to Investigate Different Behavior



High Current Failure Injection Unit

- Possible faults:
  - Reverse polarity
  - Short circuit
  - Missing connection to GND
  - Overcurrent
  - Overvoltage





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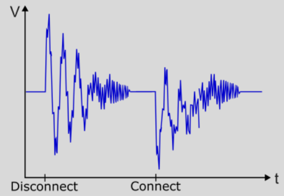

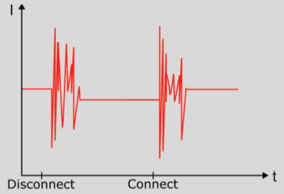

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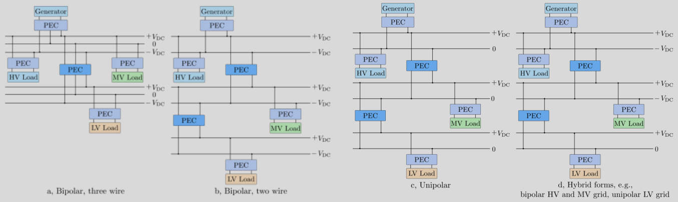

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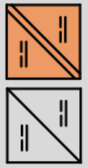

Isolated DC/DC Converter

Non-isolated DC/DC Converter

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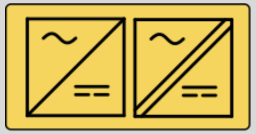
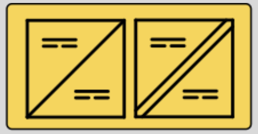


Inverter



DC/DC Converter

Failure Injection

1. MOTIVATION

2. RESEARCH OBJECTIVES

3. DC TEST RIG

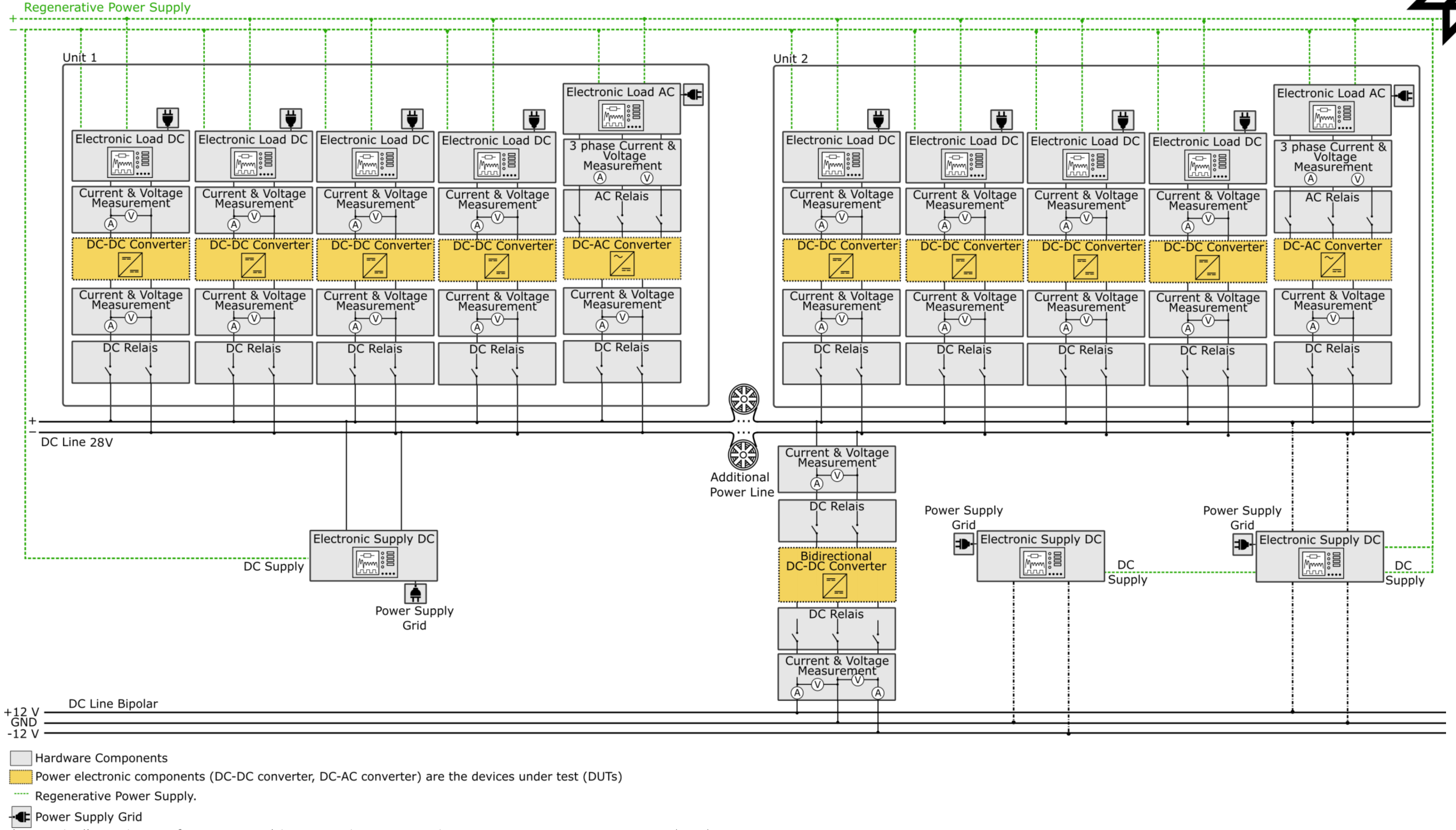
4. EXEMPLARY USE CASES


SCALEXIO
dSPACE
SCALEXIO
dSPACE

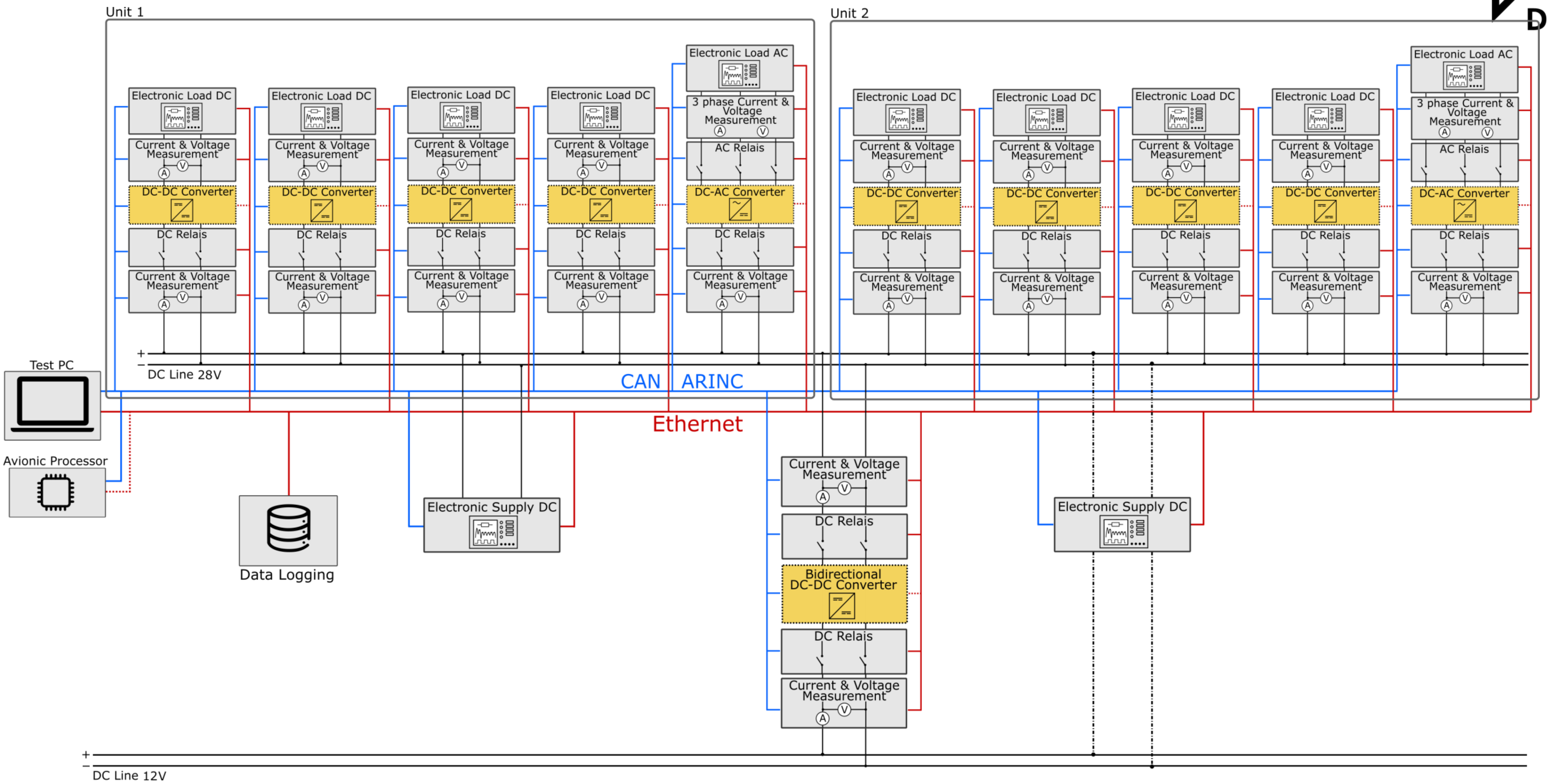
Power Supply
&
Real-Time PC

DC & AC Loads
Interfaces for
HW integration

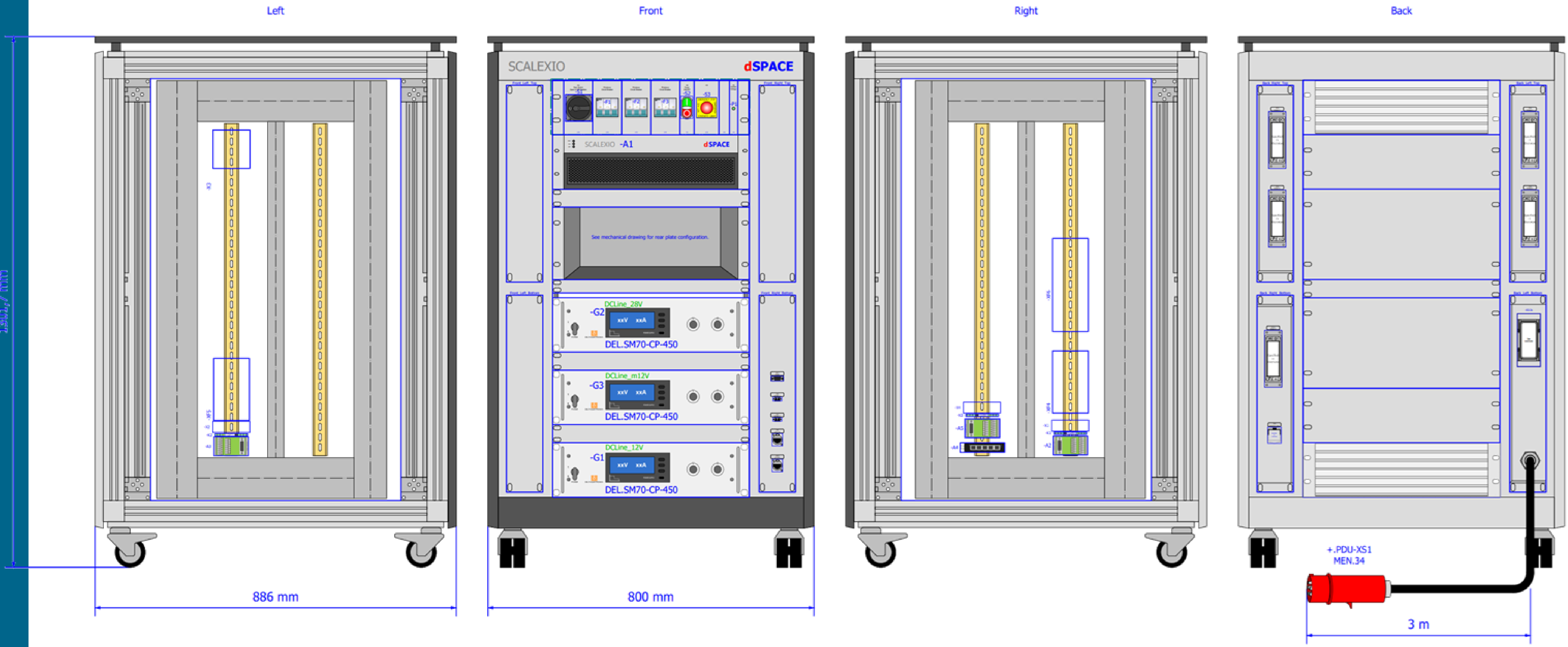
Electrical Overview



Overview Communication Interfaces



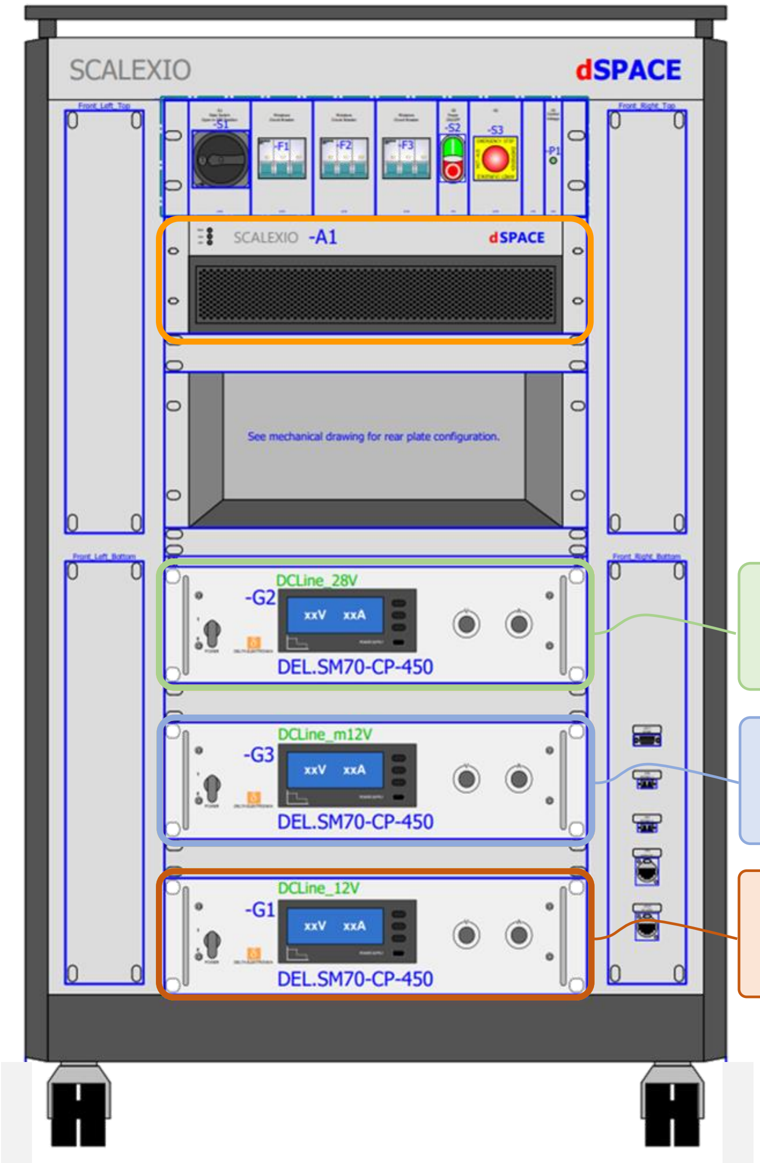
Power Supply & Real Time PC



Power Supply & Real Time PC

Real Time PC

Bidirectional power supply, each:
0-60 V (theo. 70V)
± 450 A
± 15 kW

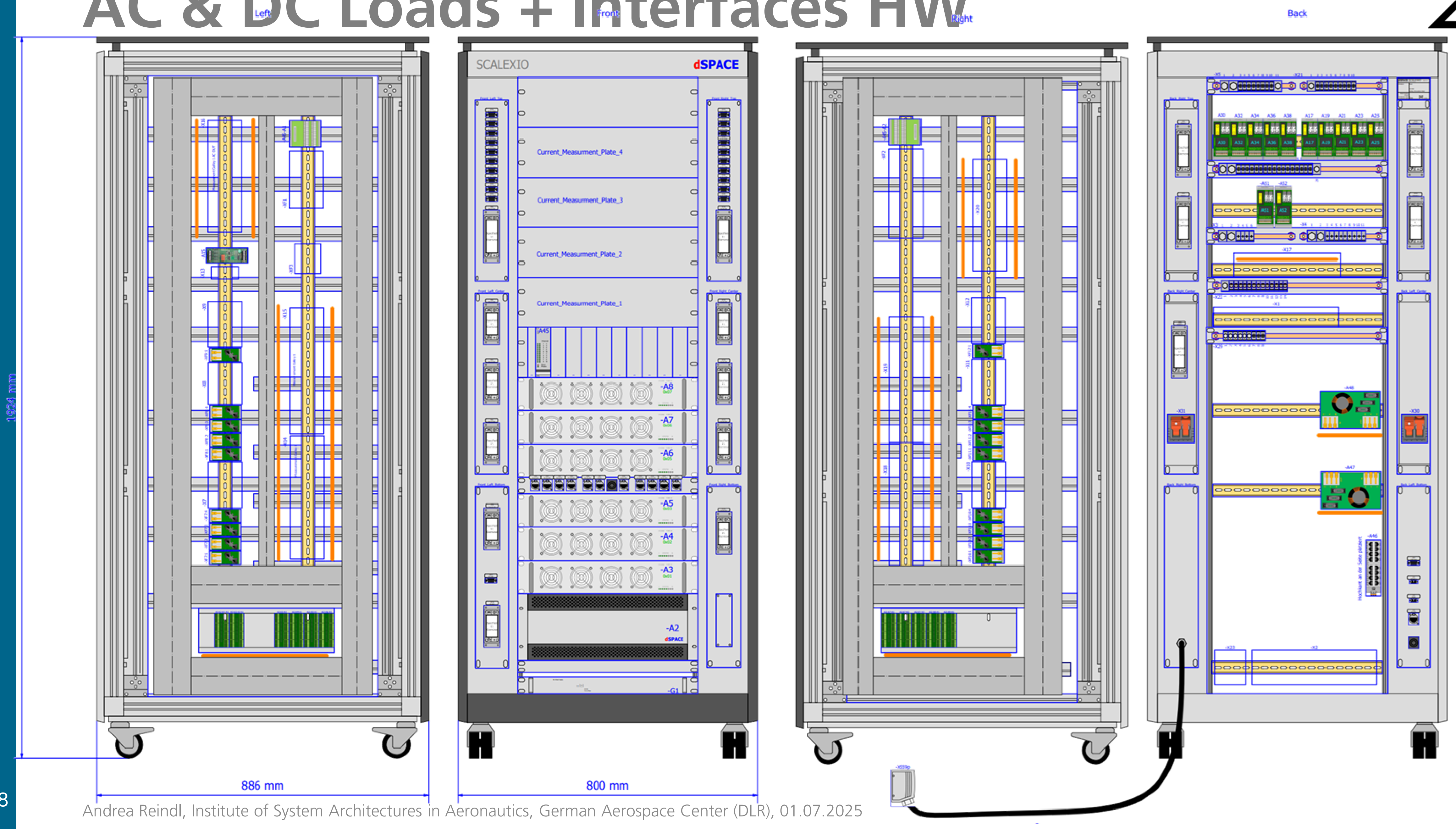


Power supply unipolar (+)

Power supply bipolar (-)

Power supply bipolar (+)

AC & DC Loads + Interfaces HW



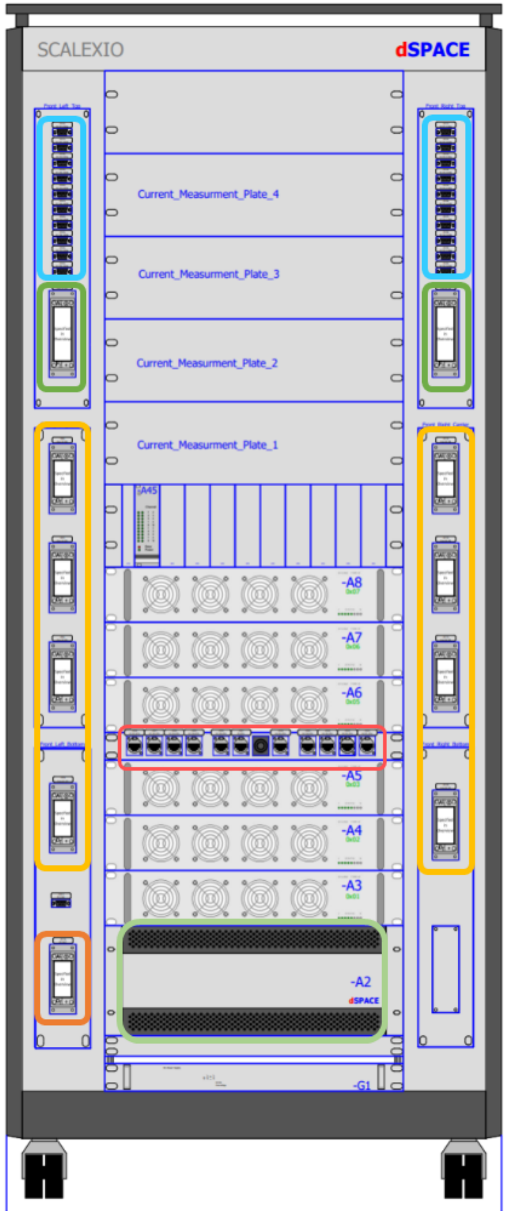
AC & DC Loads + Interfaces HW

Interface AC Load Unit 1

Interfaces DC Loads Unit 1
Load: AC+DC, 60V, 50A

Ethernet Interfaces DUTs

Interface Integration
Bidirectional DC/DC converter between the two grids



CAN Interfaces DUTs

Interface AC Load Unit 2

Interfaces DC Loads Unit 2

Scalexio Lab Box
- Router
- FPGA
- I/O
- CAN
- A/D
- D/A

1. MOTIVATION

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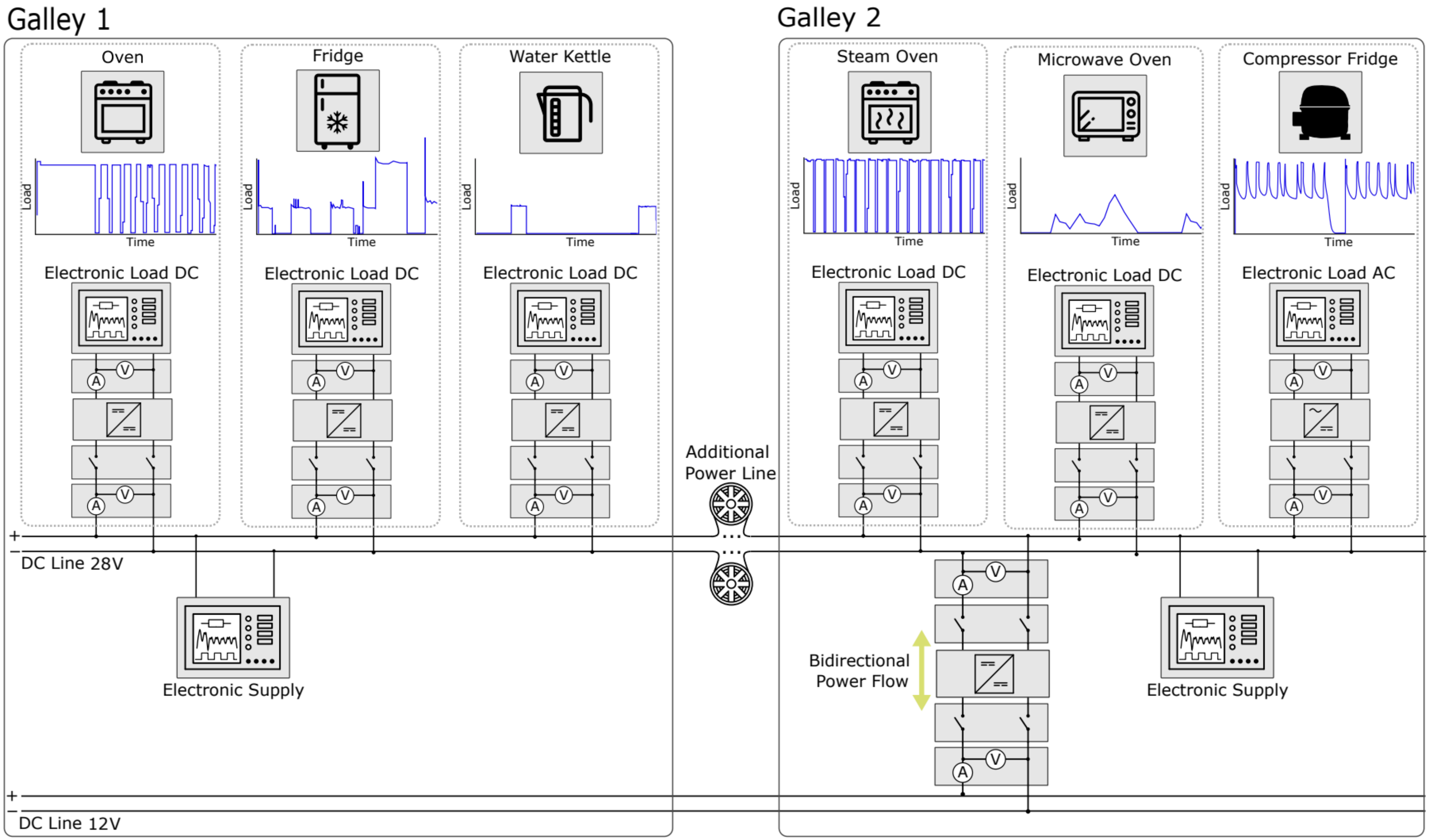
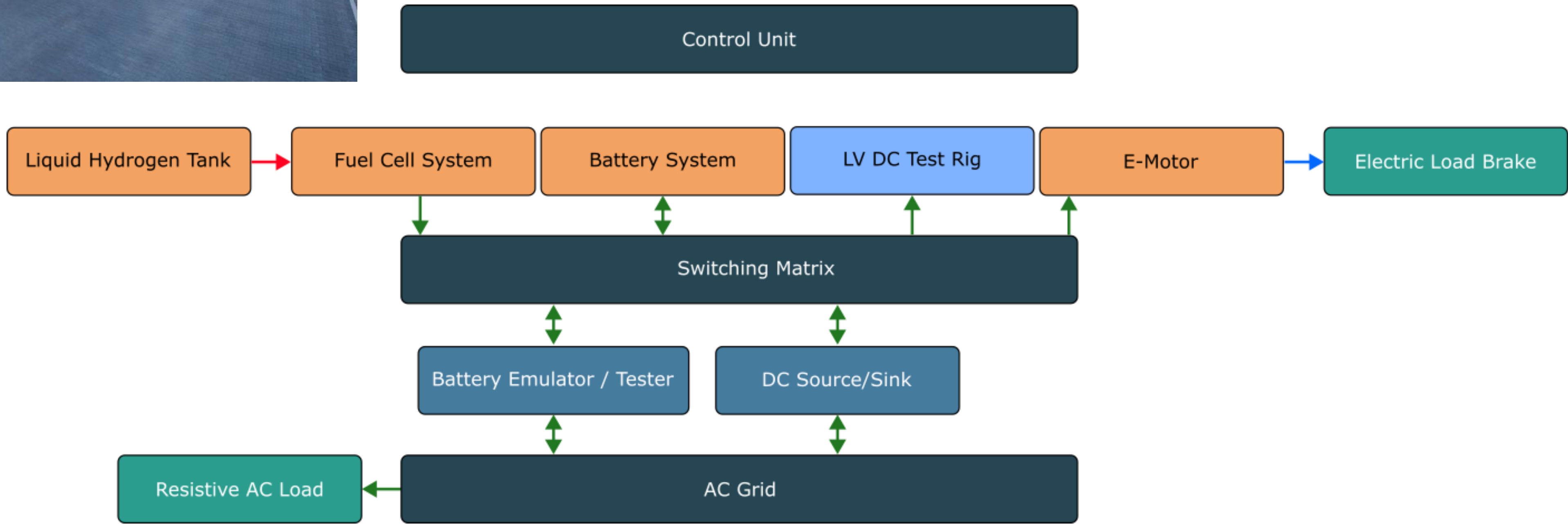
3. DC TEST RIG

4. EXEMPLARY USE CASES

Exemplary Use Case: Energy Management Strategy for Galleys



Exemplary Use Case: Emulation of Low Voltage On-board System in a Fuel Cell/ Battery Based Propulsion System (1.5 MW)



Summary: DC Miniature Test Rig

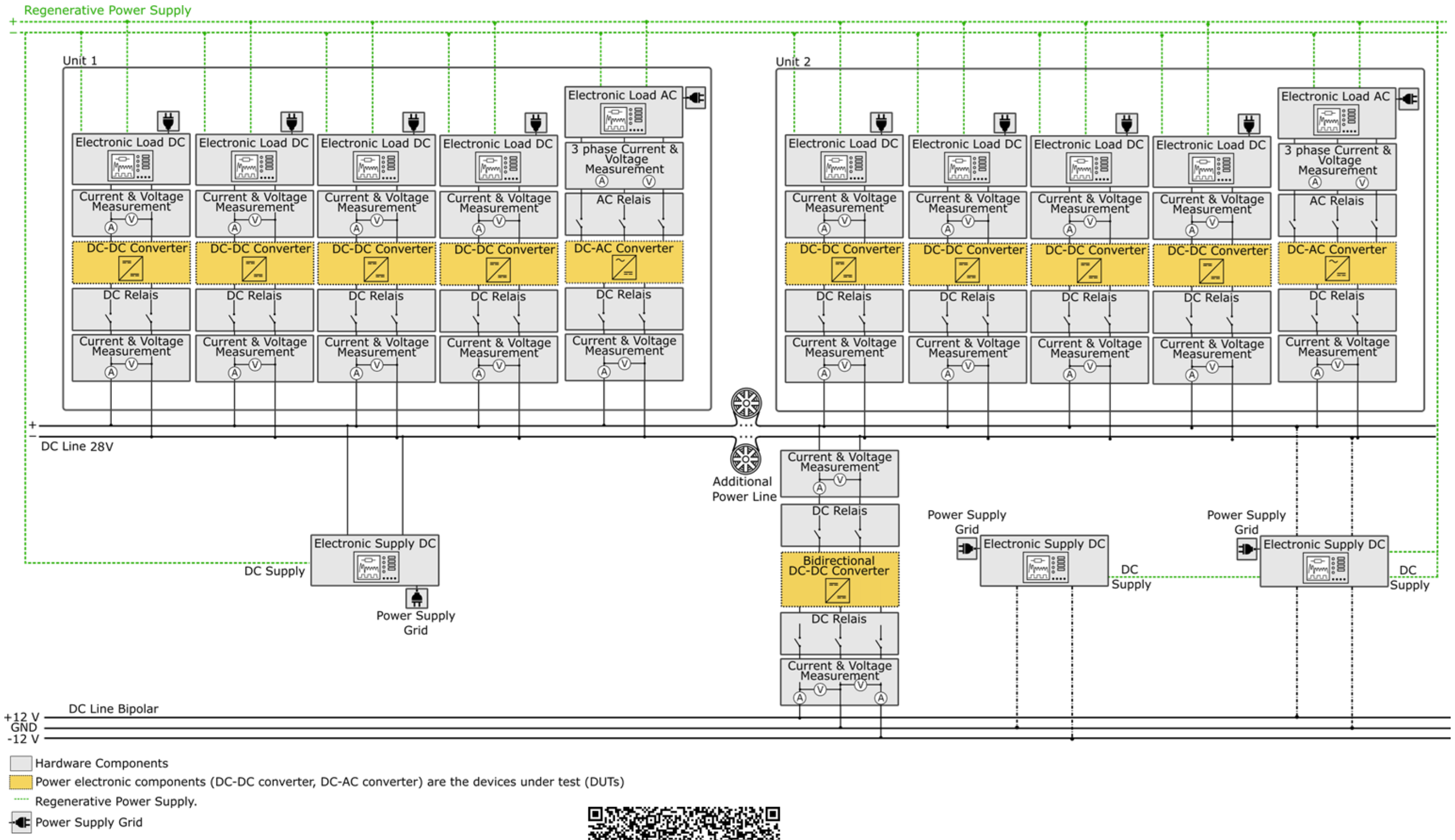
Overall test setup:
-Two Units (Galley 1 & 2)

-8 DC loads (1 kW each)
-2 AC load (1 kW)
-Loads are connected to one of the two DC lines

Two DC grids:
-Different voltage levels
-Connected by a DC/DC converter
-Power flow between the grids possible in both directions

Extensions:
-DC grid with actuators
-Flexible loads (AC & DC)
-Emulation of various loads, incl. aircraft loads
-Simulation of the powertrain with fuel cells and batteries (downscaled)

Flexibility:
-Adaptation to different load profiles and scenarios
-Different operating states and different loads not limited to galley components
-Suitable for different test cases



Contact
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andrea.reindl@dlr.de