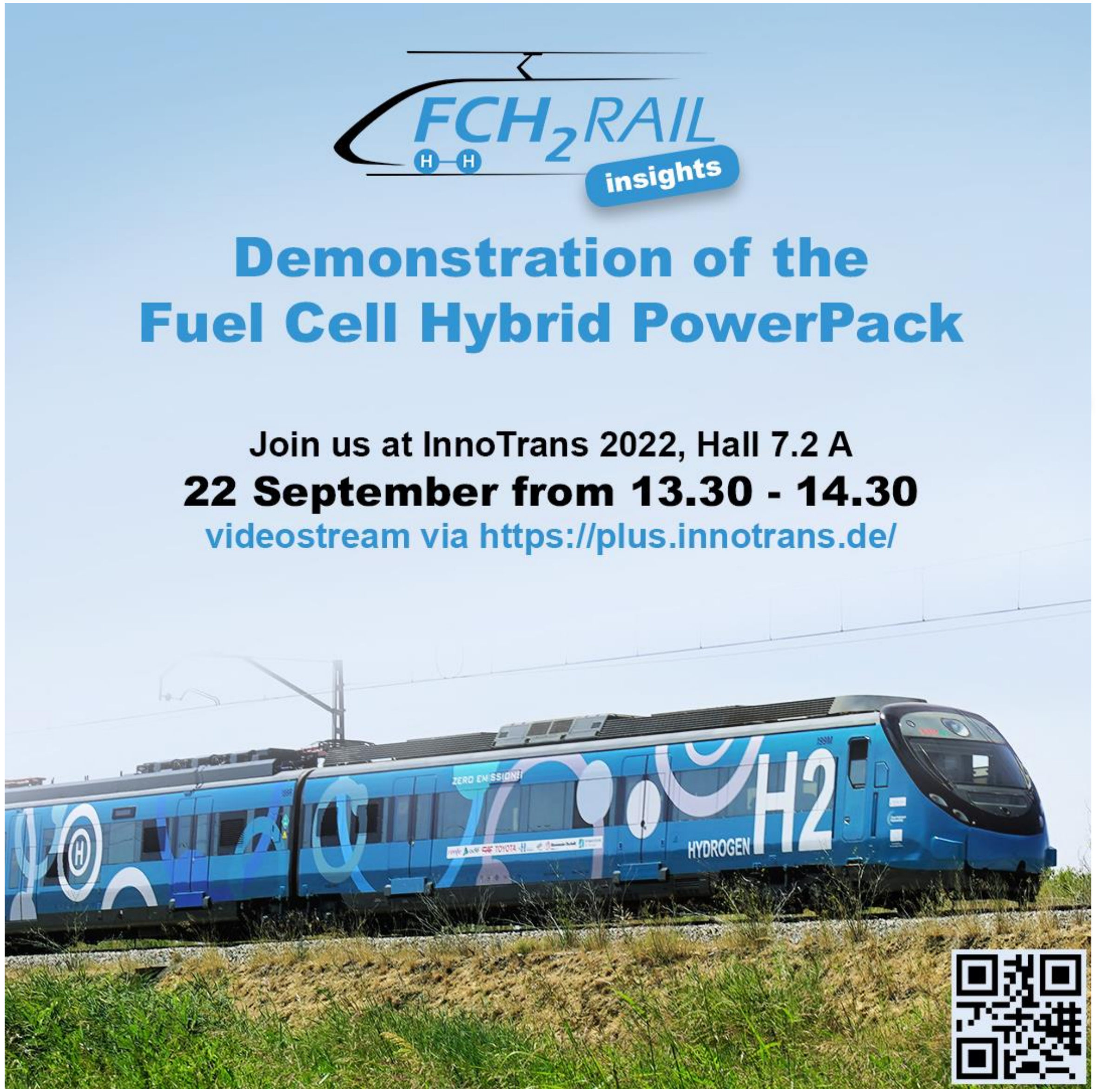

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101006633. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Clean Hydrogen Partnership

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Demonstration of the Fuel Cell Hybrid PowerPack

22.09.2022, InnoTrans 2022, Berlin & Video Stream

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101006633. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research.

Project Partners

Centro Nacional del Hidrógeno

TOYOTA

renfe

DLR

CAF

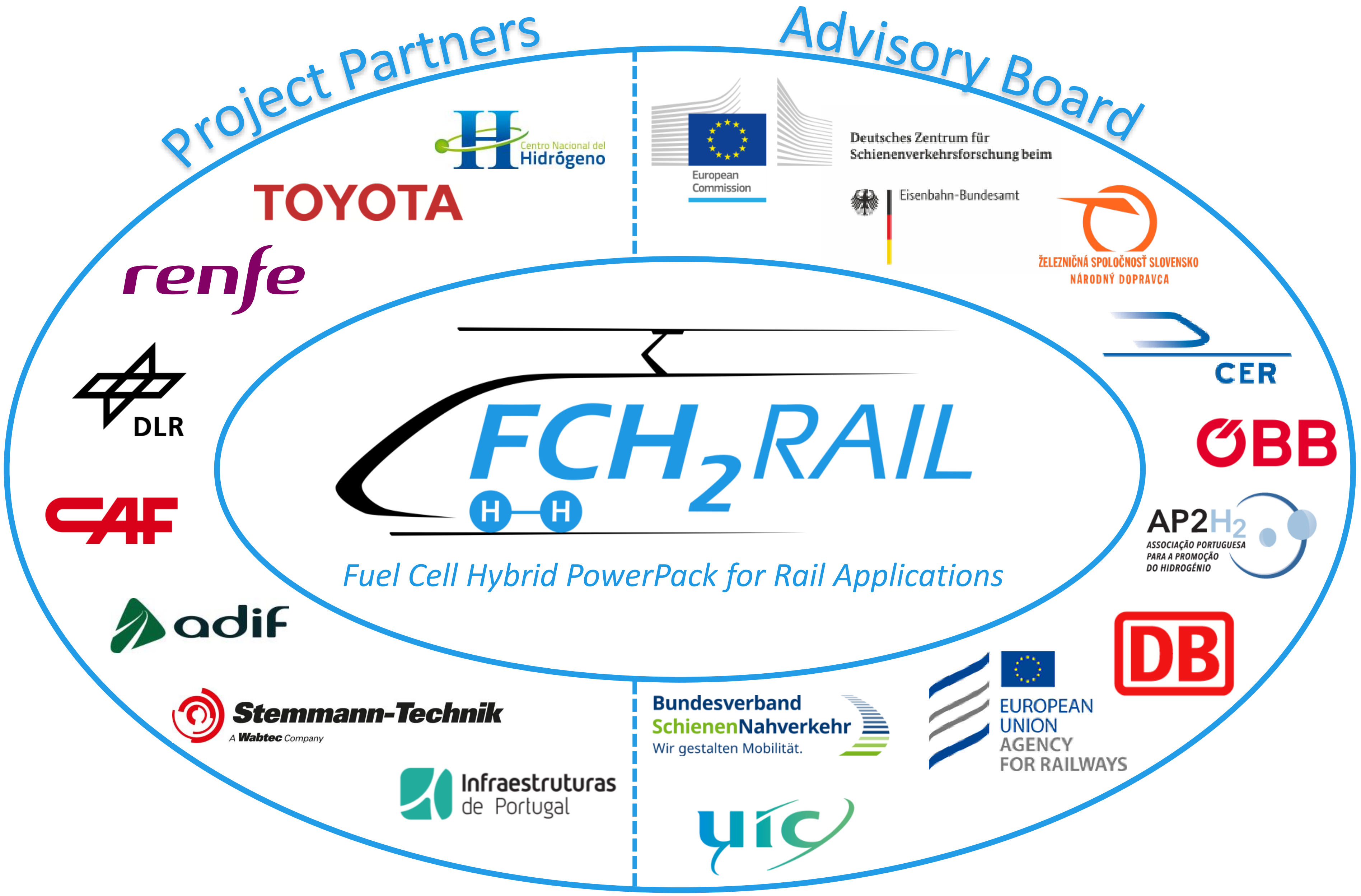
adif

Stemmann-Technik
A Wabtec Company

Infraestruturas de Portugal

FCH_2RAIL

Fuel Cell Hybrid PowerPack for Rail Applications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European Commission
Deutsches Zentrum für Schienenverkehrsforschung beim
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AP2H2
ASSOCIAÇÃO PORTUGUESA PARA A PROMOÇÃO DO HIDROGÉNIO
DB
EUROPEAN UNION AGENCY FOR RAILWAYS
Bundesverband SchienenNahverkehr
Wir gestalten Mobilität.
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Fuel Cell Hybrid PowerPack for Rail Applications

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FCH_2RAIL

Fuel Cell Hybrid PowerPack for Rail Applications

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Clean Hydrogen Partnership

What do we do today?

FCH2RAIL Project in Brief → Technical overview → Testing the Fuel Cell Hybrid PowerPack → FCHPP Integration in Demonstrator Train → Feedback, Q&A

Holger Dittus

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Role in FCH2RAIL:
Project coordinator
Leader of dissemination activities

Eva Terron

CAF

Role in FCH2RAIL:
Technical coordinator

Jose Maria Olavarrieta

Centro Nacional del Hidrógeno

Role in FCH2RAIL:
Leader & Responsible for the FCHPP test bench

Fabien Bouyssou

CAF

Role in FCH2RAIL:
Responsible for the FCHPP Integration and Testing in Demonstrator Train

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FCH2RAIL project in Brief

Holger Dittus, DLR

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FCH2RAIL Project in Brief

- Start date: 01 January 2021
- Duration: 48 Months
- Total budget: **13.3 Mio €**
- H2020 Innovation Action funded by Clean Hydrogen Partnership
- 7 technical Work packages, 29 Milestones, 43 Deliverables
- **2 Demonstrators**: Fuel Cell Hybrid Power Pack and Bi-Mode Train

- 8 Beneficiaries from Belgium, Germany, Spain and Portugal:

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Technical overview

Eva Terron, CAF

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FCH2RAIL Objectives

To boost the development of the hydrogen technologies in railways, extending the use cases for FC trains

1. Develop, build, test and homologate a Fuel Cell Hybrid PowerPack (FCHPP)
2. Demonstrate the FCHPP in a Civia EMU
3. Evaluate the competitiveness of fuel cell traction against existing diesel solutions
4. Identify and benchmark innovative solutions to improve energy efficiency
5. Propose a normative framework for hydrogen in railway vehicles

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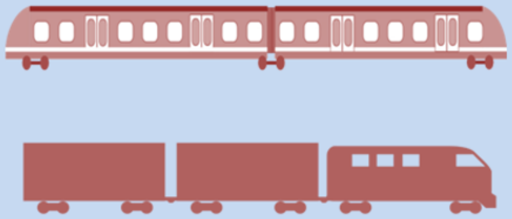
Developing the Fuel Cell Hybrid PowerPack

Step1- Definition of the requirements

Railway use cases



© https://pixabay.com

Analyis of applications and service profiles

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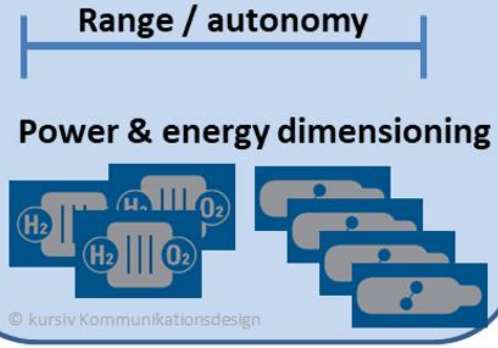
Derivation of FCHPP requirements



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Different use cases have been analysed in Spain, Portugal, Germany and Slovakia

- DMUs
- Mainline locomotives
- Shunting locomotives

Many services have been analysed

- Spain and Portugal: 10 of 73 services
- Germany: 13 of 1417 services

Very different characteristics

	min	max
Non electrified section (Km)	80	730
Altitude (m)	20	1000
Av. Distance btw. Stations (Km)	2	25

Global requirements are defined:

- Power & energy
- Autonomy or range

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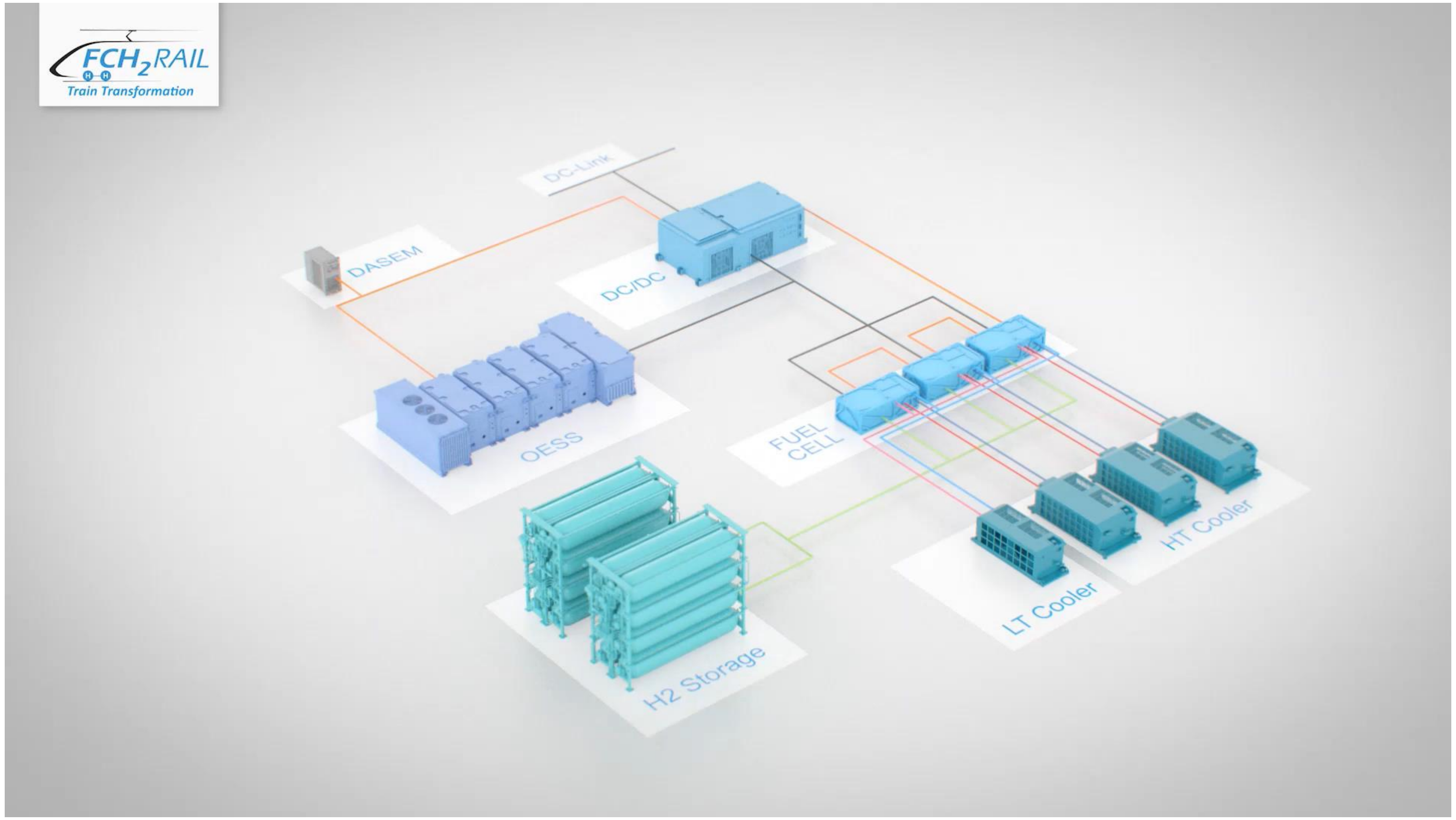
Developing the Fuel Cell Hybrid PowerPack

Step 2- Definition of the components and architecture

- Architecture
  - Scalable and modular
  - Applicable for different rail applications (Multiple Unit, Mainline and Shunting Loco)
  - Suitable for retrofitting existing trains
- Components
  - Fuel Cells (TOYOTA)
  - OESS (CAF)
  - DC/DC converter (CAF)
  - DASEM (CAF)
  - Cooling system (Third Party)
  - H2 Storage system (Third Party)



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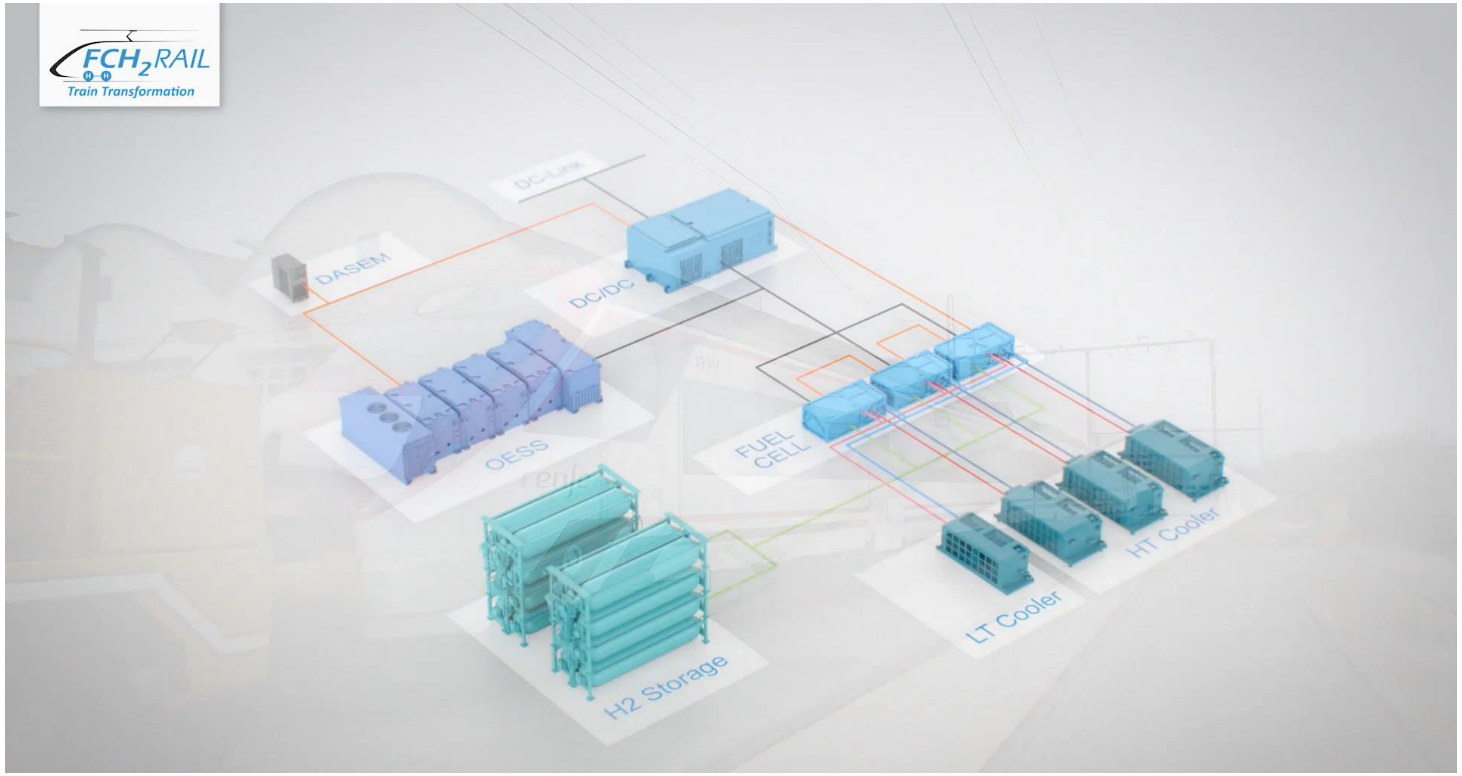
Developing the Fuel Cell Hybrid PowerPack

Step 2- Definition of the components and architecture (II)

Design of the integration in the train demonstrator is adding more requirements

- Mechanical
- Electrical
- Hydraulic



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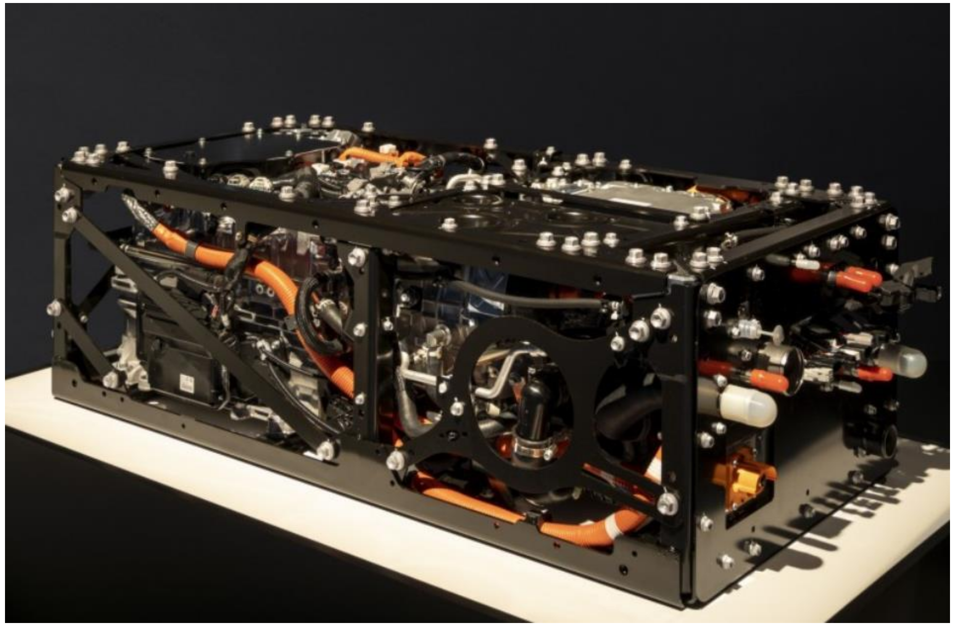
Developing the Fuel Cell Hybrid PowerPack

Step 3- Detailed design, manufacturing and testing the subsystems

- Components tested at origin and ready for installation



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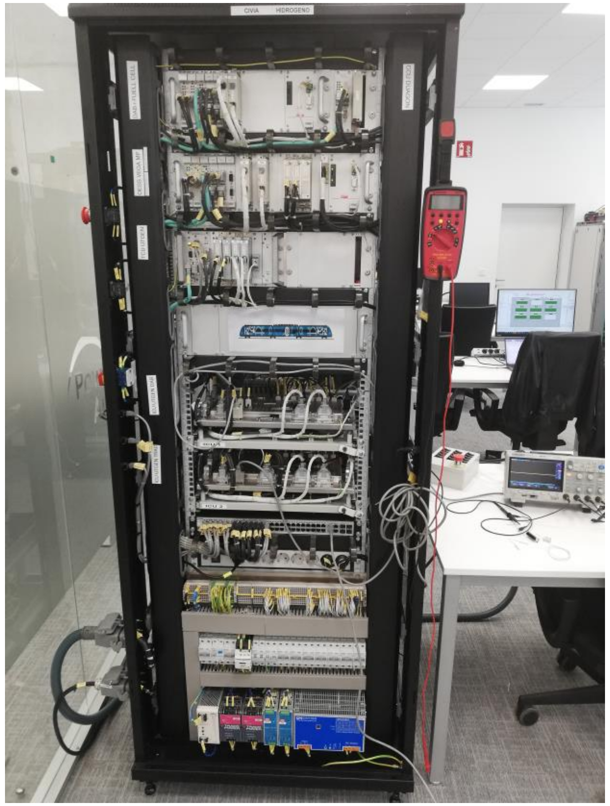
Developing the Fuel Cell Hybrid PowerPack

Step 4- Development of the HIL



- HIL test bench developed in CAF, including
  - Electronic controllers of the subsystems of the Fuel Cell Hybrid PowerPack
  - New Train Control and Monitoring System (TCMS)
  - Traction control unit of the existing traction equipment in the CIVIA train
  - TCMS of the CIVIA train
- Functionality of the new FCHPP is extensively tested
- Integration of the new FCHPP with the existing traction equipment and the existing train control is also tested

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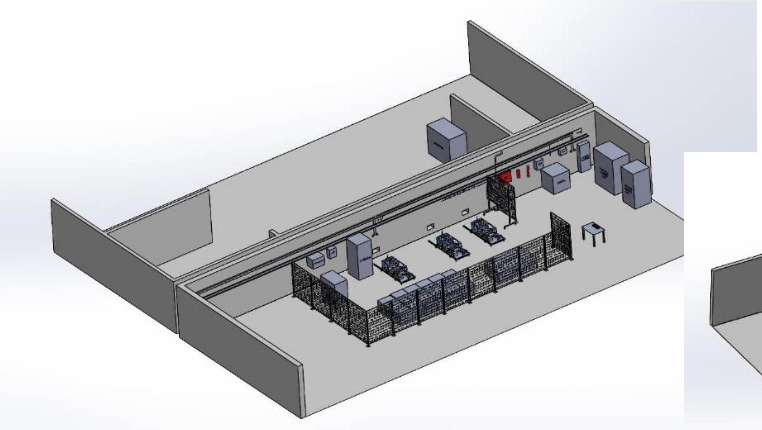
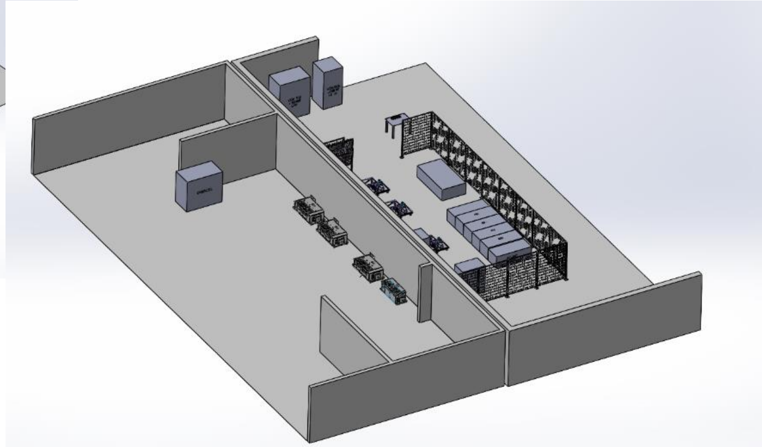
Developing the Fuel Cell Hybrid PowerPack

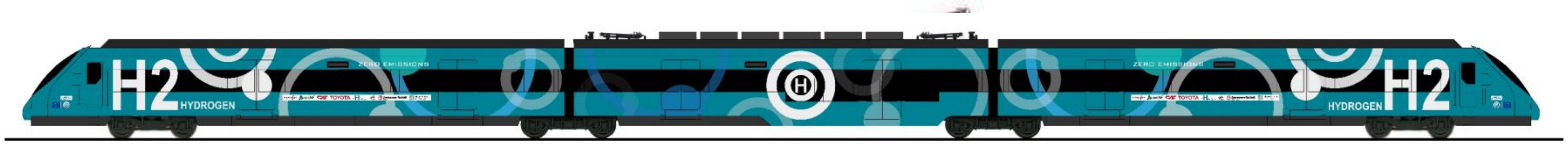
Step 5- Testing the real FCHPP

2 demonstrators have been developed

1. Full scale Test bench for the Fuel Cell Hybrid PowerPack (FCHPP)
2. Civia EMU converted into a Bi-Mode FCH train







Both demonstrators are running in parallel!

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Testing the Fuel Cell Hybrid PowerPack

Jose Maria Olavarrieta, CNH2

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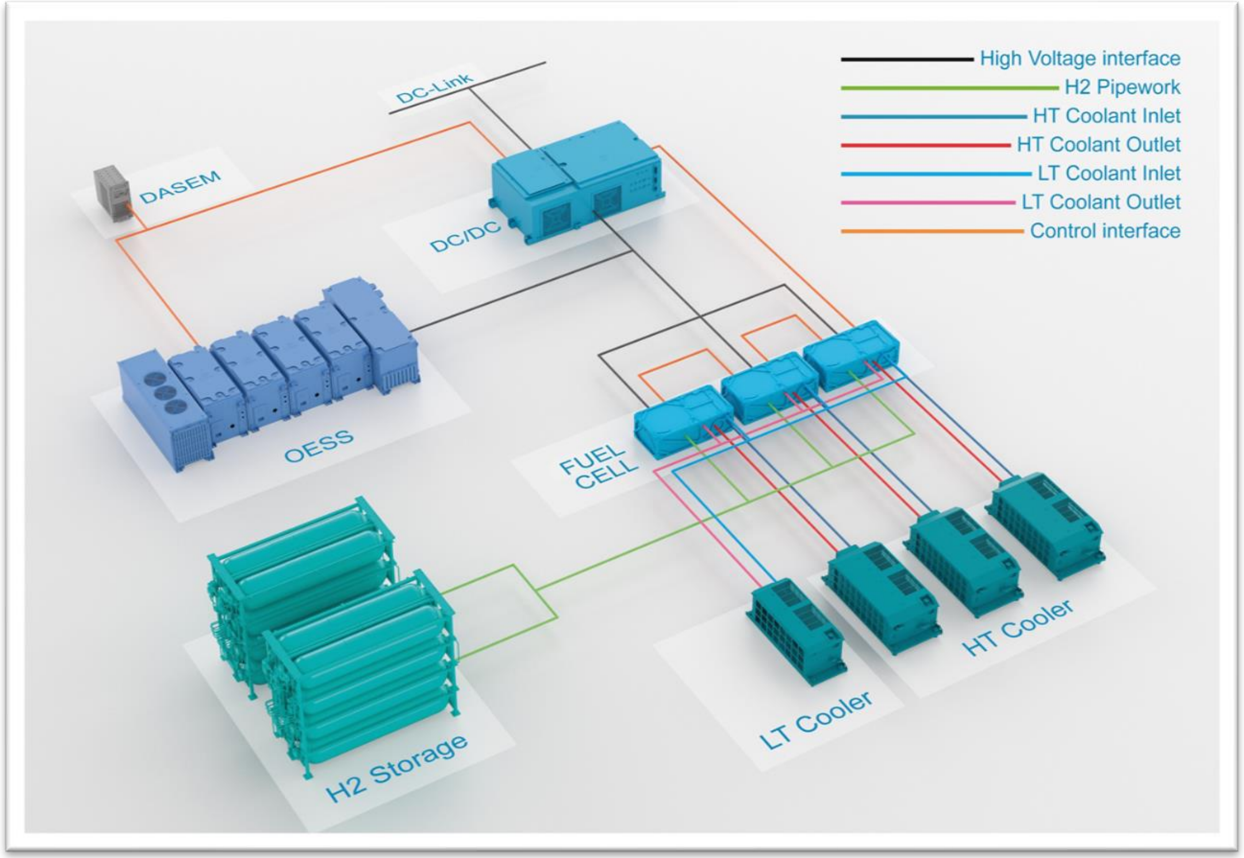
MAJOR CHALLENGES

- How to test a H_2 train propulsion system without a train?

- How or where is this tested? Who has a test bench for this?

- Who is able to provide all the H_2 supply installations, main and auxiliary systems and subsystems, safety installations, etc?



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MAIN OBJECTIVES

- To test a complete Fuel Cell Hybrid PowerPack.
- To demonstrate operation and performance of the Fuel Cell Hybrid PowerPack.
- To know how the individual equipment performs before the integration into the train.
- To optimize the controls and energy management system.

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THE TEST BENCH IMPLEMENTATION PROCESS

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THE STARTING POINT

Week 0
(February´22)

Facilities at CNH2 (prototypes area)

Clean and clear

Nothing implemented

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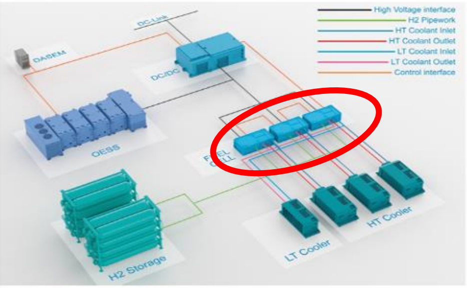
TME FUELCELL MODULES PLACING

Week 1



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SAFETY BARRIER INSTALLATION

Week 02
Week 03

Safety barrier

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H_2 SUPPLY PANEL PLACING

Week 03
Week 04

Mechanical installation and electrical connection process of control and monitoring instruments

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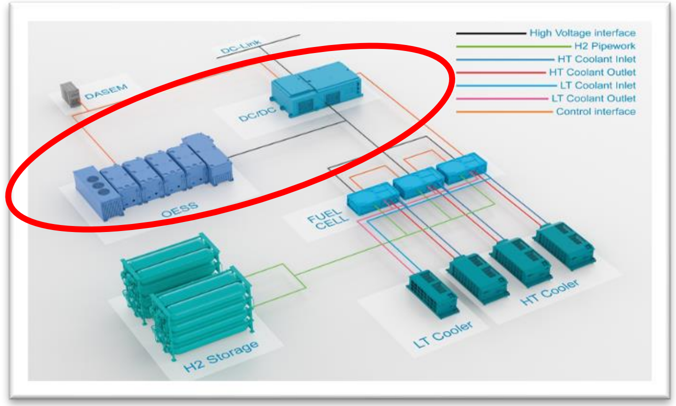
OESS & DC/CD INSTALLATION



FCH2RAIL insights

Week 05

OESS and DC/DC placing, mechanical installation and electrical connection process

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HT & LT COOLING SYSTEMS INSTALLATION

Week 06

Cooling systems mechanical installation and electrical connection

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THE TEST BENCH COMMISSIONING PHASE

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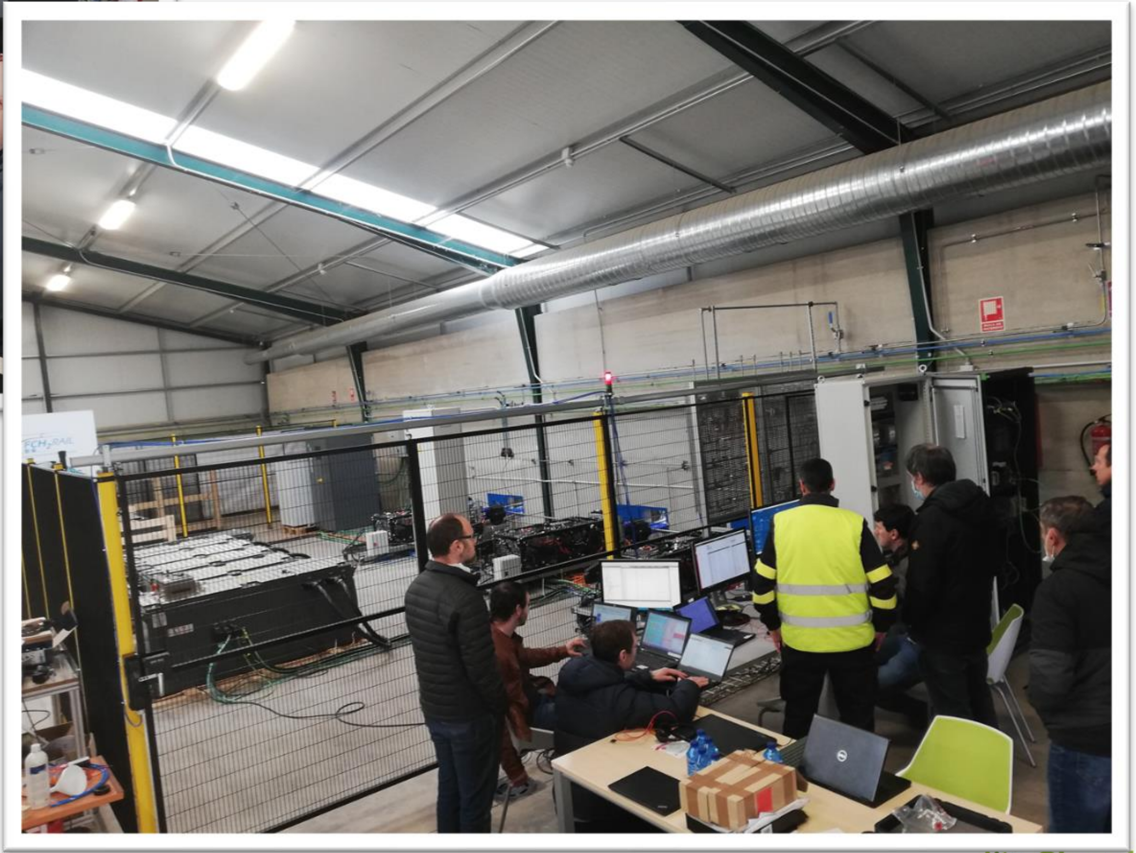
COMMISSIONING PHASE

CNH2, CAF, CAF PA and TOYOTA crew in commissioning phase

Week 08



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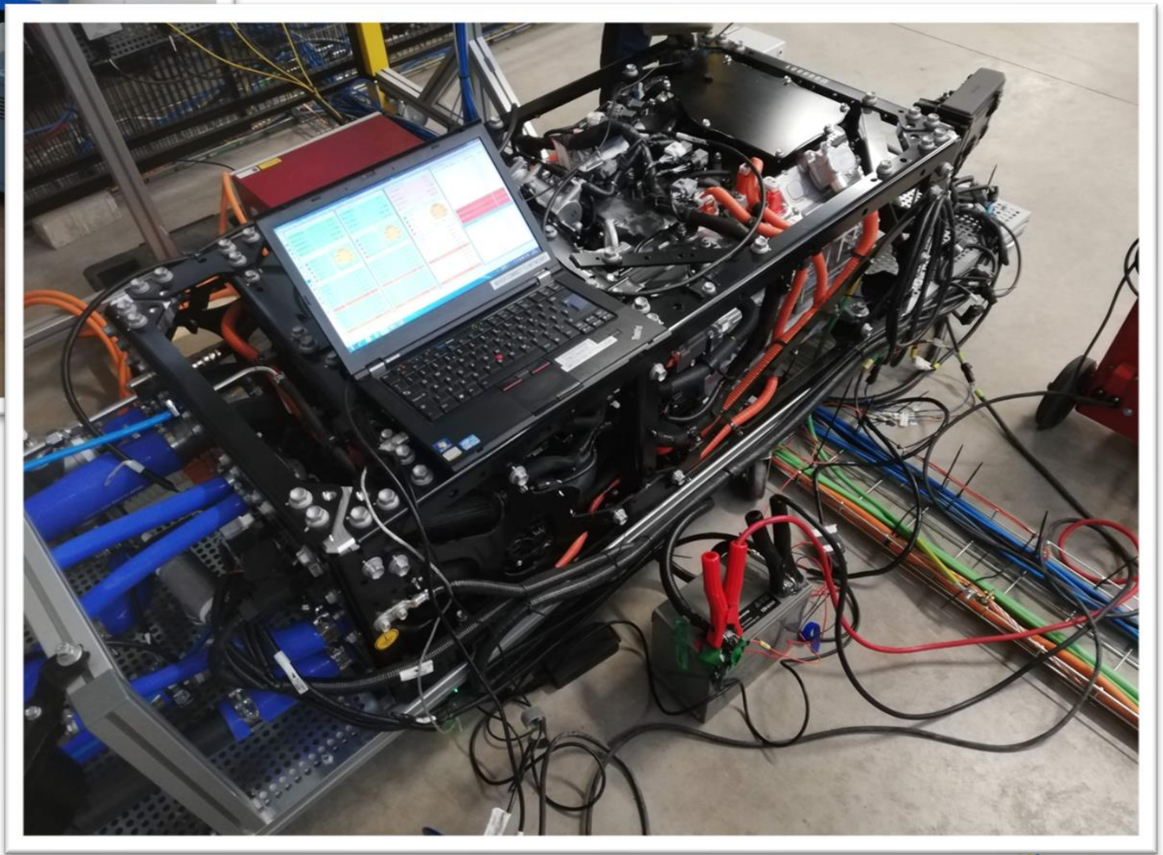
COMMISSIONING PHASE

Week 08

Cooling system connection/communication process (commissioning)



Fuel Cell Modules connection/communication process (commissioning)

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COMMISSIONING PHASE

FCH2RAIL insights

Week 08

DC/DC converter commissioning

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THE TEST BENCH
VIDEO DEMONSTRATOR

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FCH2RAIL
PowerPack Testing

MAIN RESULTS

- Many tests on different system levels were perfomed:
  - Standard polarization curves for fuel cells, etc.
  - H_2 consumption test, driving cycle test, ramp-up test, etc.
  - Tests related especially to the specific use cases / service profiles / railway profiles, etc.
- 220 kg of green H_2 consumed so far.
- Detailed knowledge of the systems and subsystems performance was obtained.
- Control and energy management system was optimized.
- Full functionality and requested performance of the Fuel Cell Hybrid PowerPack is achieved.

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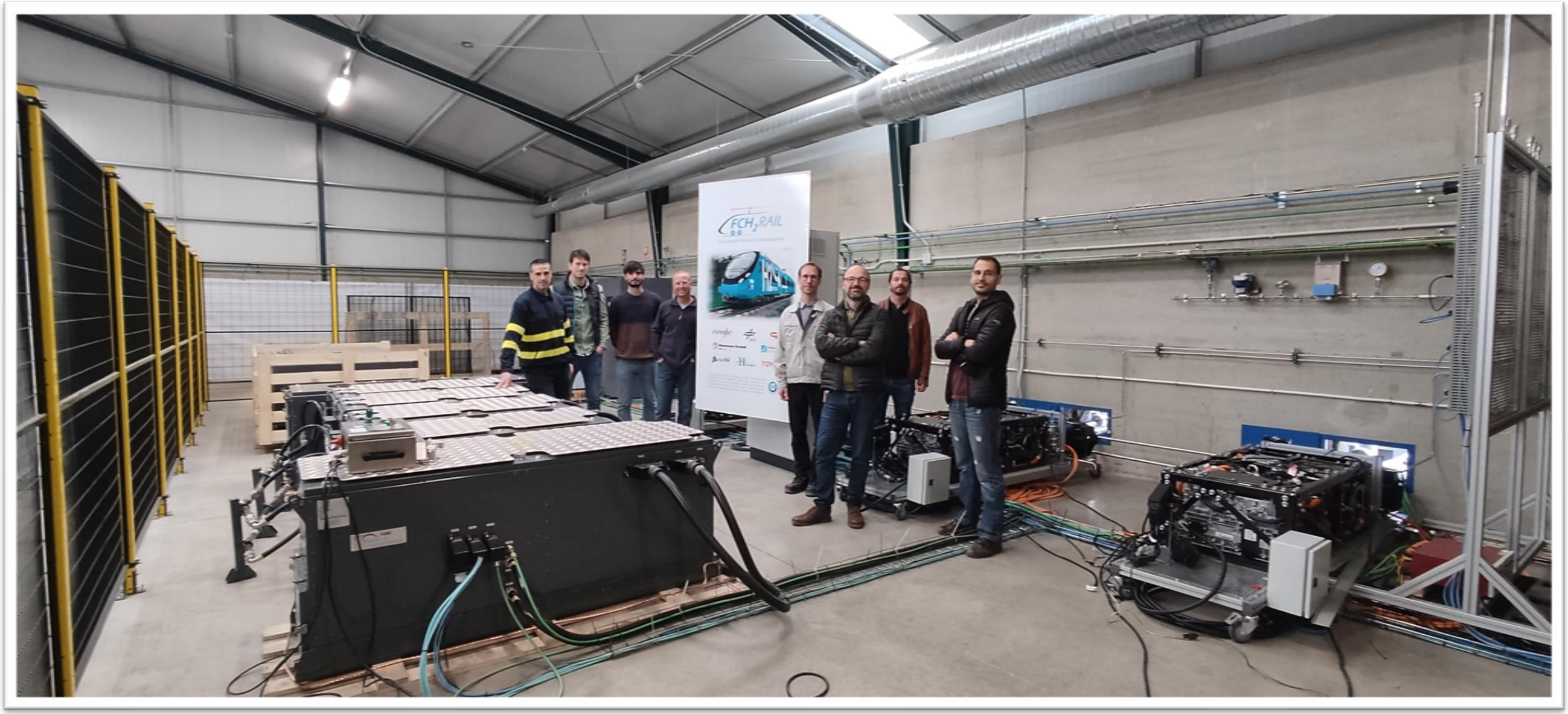
THANK YOU TO THE TEST BENCH CREW



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FCHPP Integration in Demonstrator Train

Fabien Bouyssou, CAF

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Train Demonstrator TimeLine

According to Grant Agreement objectives signed with JU:

- January 2023: Implementation and Integration in Demonstrator
- August 2023: Start of Track Testing

Thanks to one Power Pack not in use and available since M17:

FCH2RAIL Results, as of today: Need of a Quick Implementation!

- June 2022: Implementation and Integration in Demonstrator of one PP
- July 2022: Start of Track Testing with one PP

High interest of getting both CNH Testing Bench and Train Demonstrator in use at the same time!

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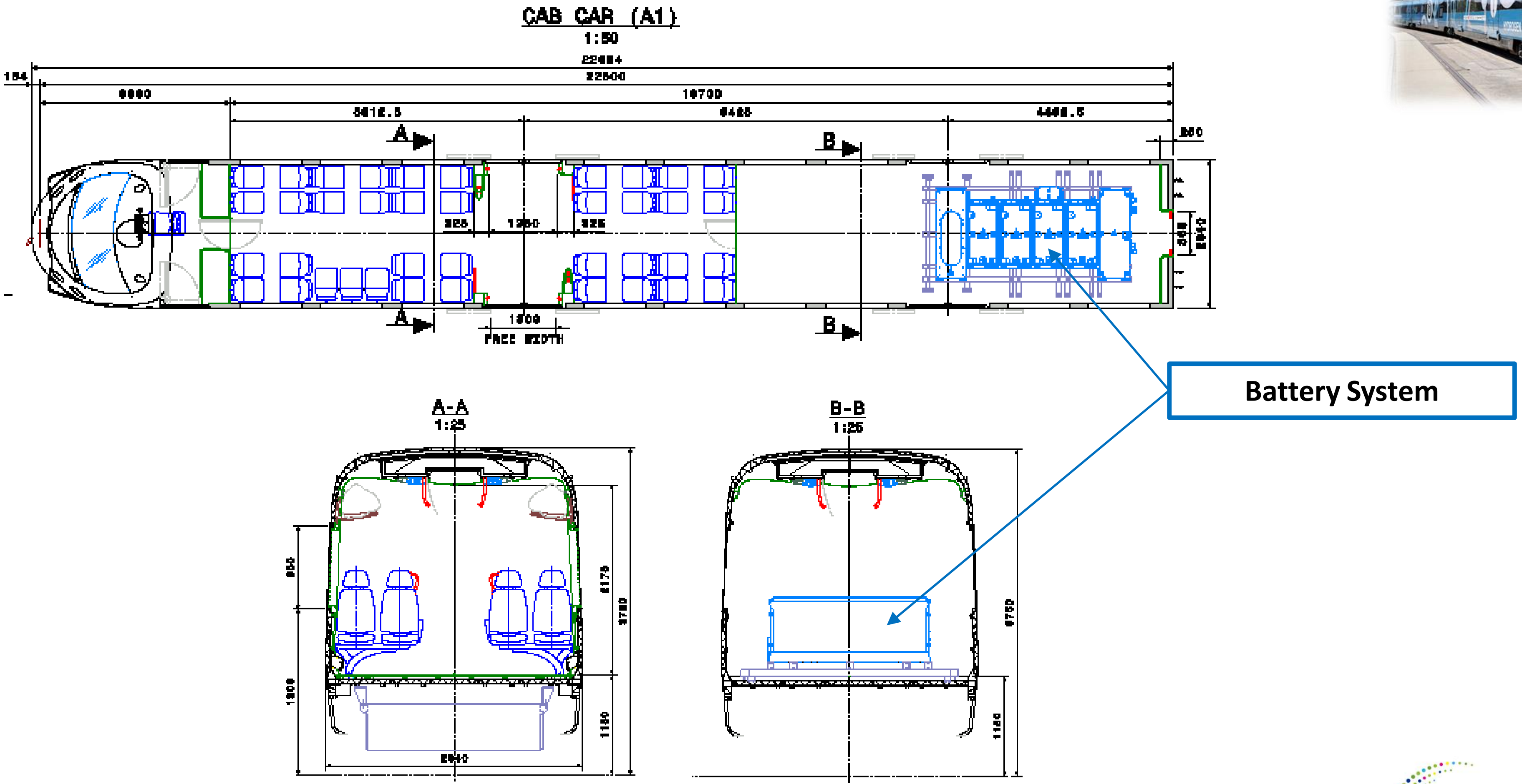
Train Demonstrator Modification Concept

FCHPP integration in Car A1/A2 (cab cars) due to battery weight!



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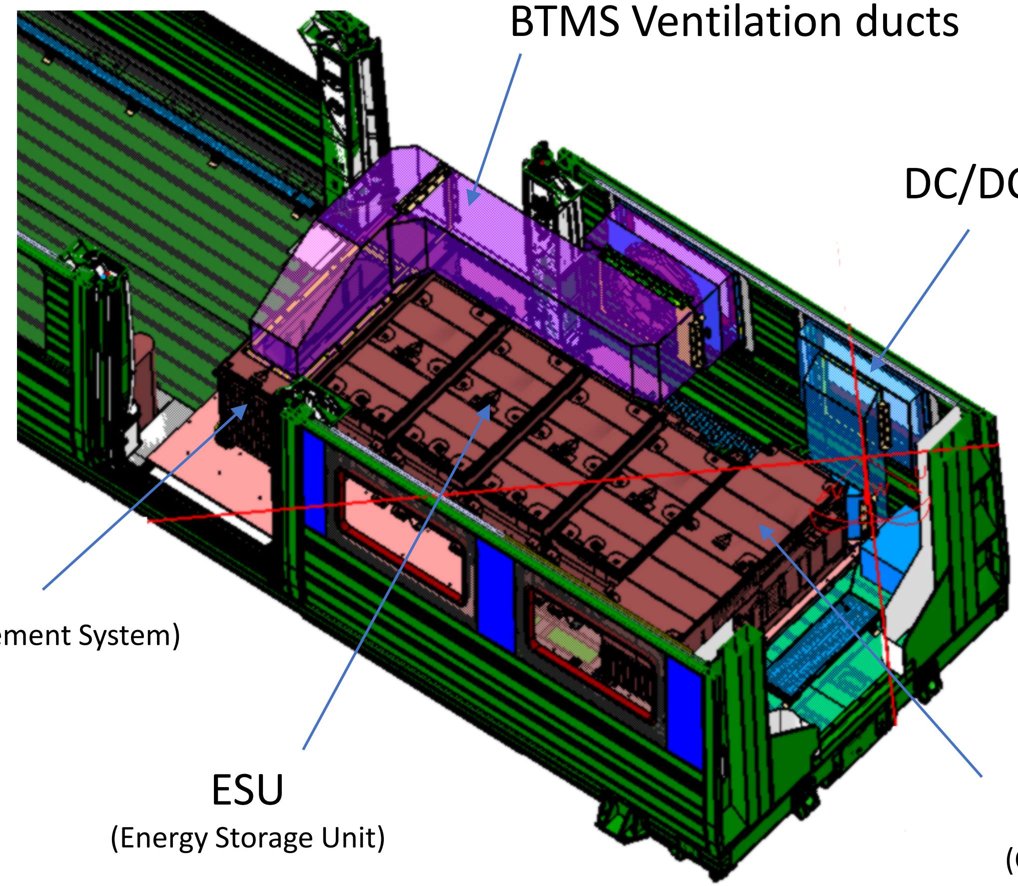
Train Demonstrator Modification Concept

Battery System integration in rear end of A1/A2 cars



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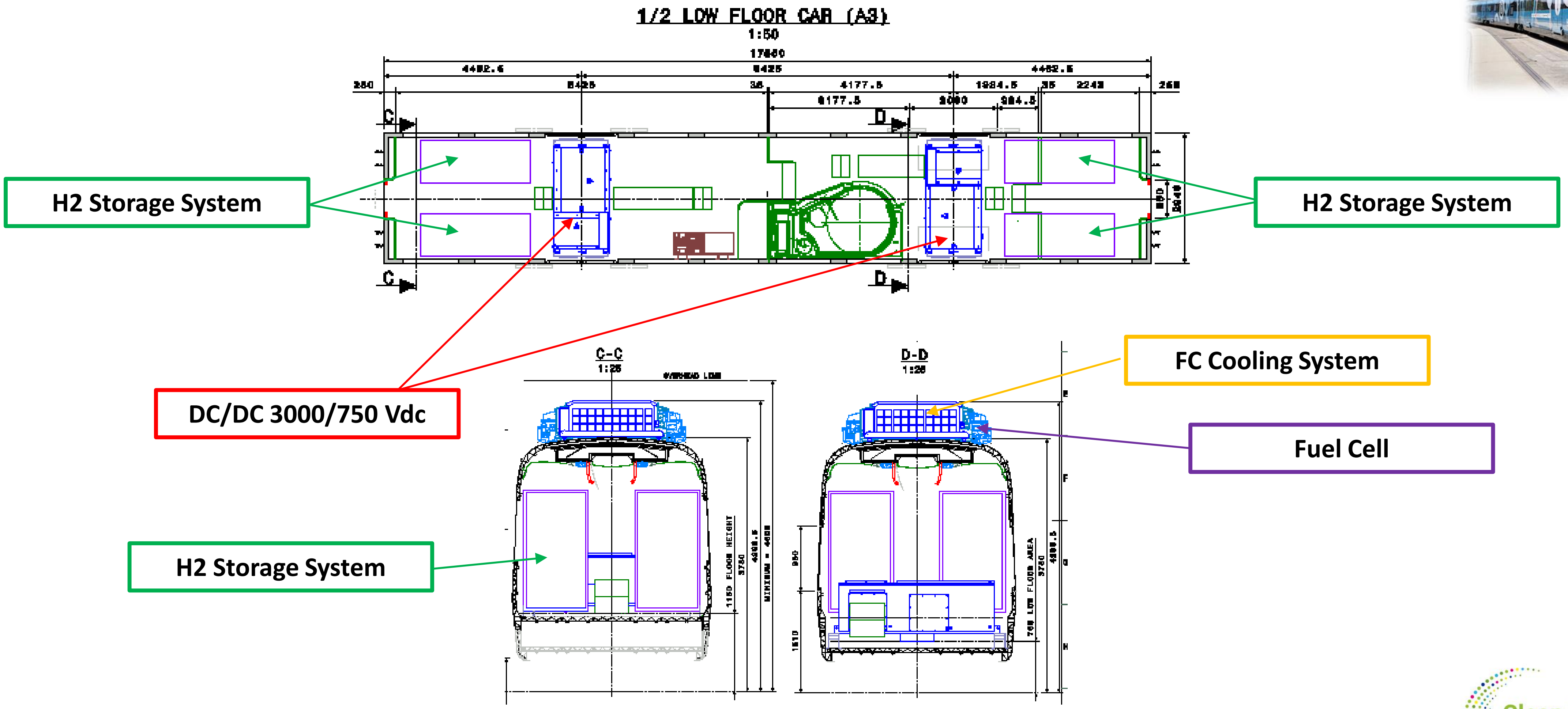
Train Demonstrator Modification Concept

FCHPP Integration in Car A3 (intermediate car)



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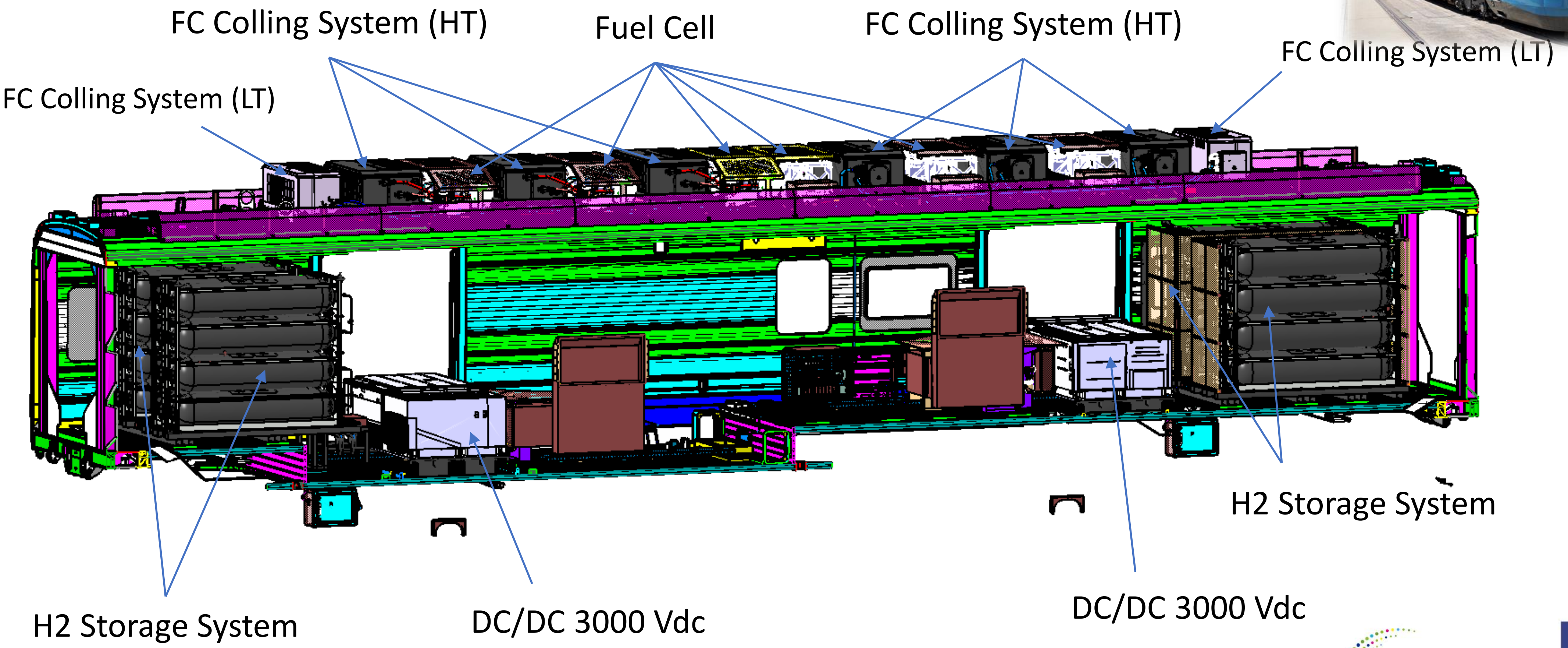
Train Demonstrator Modification Concept

A3 Intermediate Car



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Train Demonstrator Modification Phases

3 Main steps:

1. Dismounting of former “RENFE” equipment and interiors

2. Preparation for PP installation
   1. Soldering operations on roof, brackets installation
   2. Mechanical supports and reinforcement inside the train
   3. Electrical wiring and protections

3. PP equipment installation and connection

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Train Demonstrator Modification Video

Enjoying Concrete Results !

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Train Demonstrator Modification Video

Train Demonstrator Modification Video

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Train Demonstrator Modification Video

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Train Demonstrator Lessons Learnt

Experience leads to lessons learnt:

H2 leaks! That's a fact!

Tightness test criterion is a challenge and experience is a key factor in successful test completion. Need of close involvement of H2 distribution and storage system sub suppliers.

Solaris help (CAF Group) has been fundamental in the 1st testing steps.

H2 dispensation is a new field of competence / knowledge to be developed as Rolling Stock supplier, to offer "turnkey" projects:

- Dispensation technology knowledge
- Need of optimizing refueling times, no "SAE Jx" protocol existing
- Safety related operation, monitoring and control of H2 max temp

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Train Demonstrator Approval Process

Approval Process being started and undergoing.
ISA (Tüv-Süd) and DeBo (BelgoRail) competences involved.

First positive assessment results from Tüv-Süd Rail granted related to testing in San Gregorio external track with 1 PP.

Relying on strong Tüv-Süd experience in H2 Rolling Stock field.

2023

TRL7 train homologation in Spain, Track Testing with 2 PP

Portable HRS in several locations

2024

TRL7 train homologation in Portugal, Track Testing with 2 PP

Train authorization study in Germany

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Feedback, Q&A

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Dissemination Activities

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Up-to-date information and results

www.fch2rail.eu

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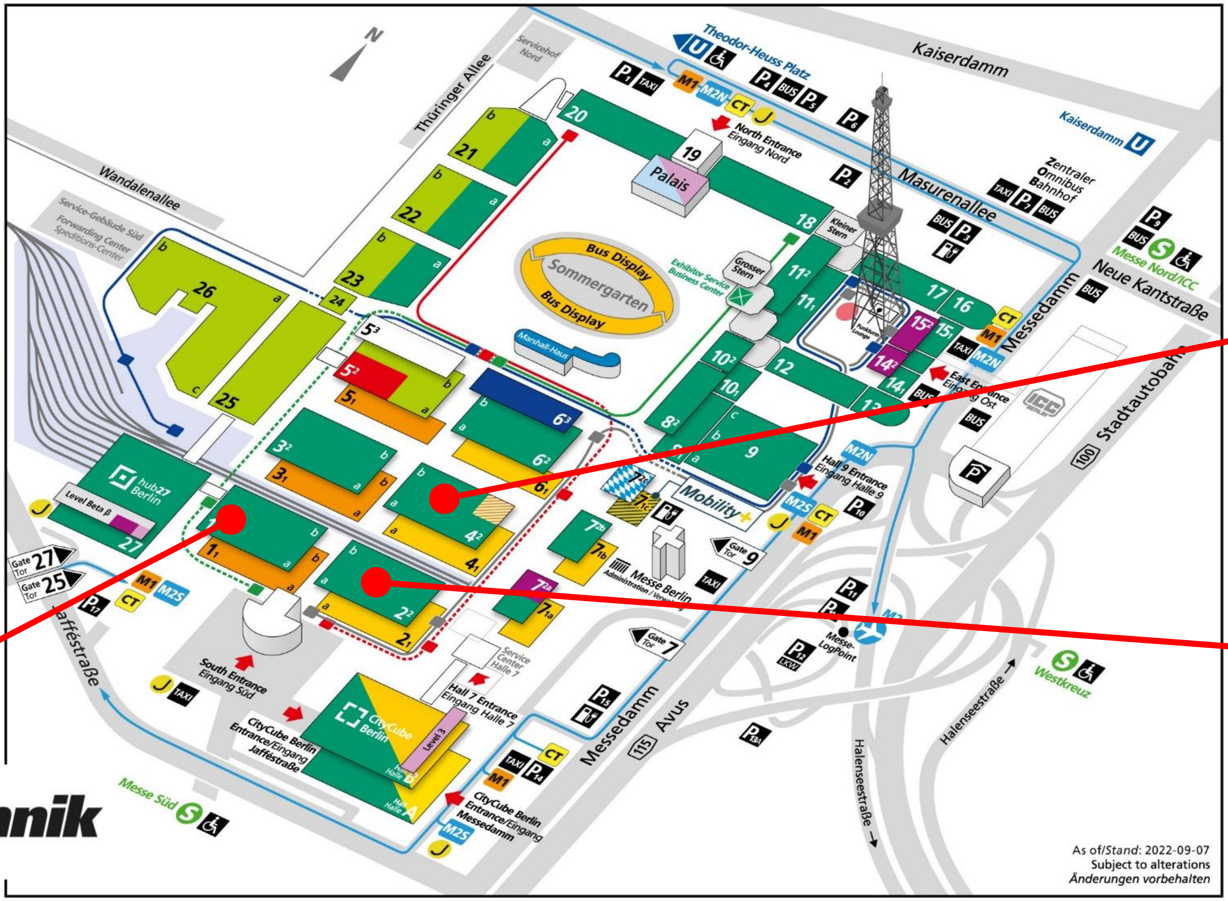
FCH2RAIL partners on InnoTrans 2022



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Hall 4.2, Stand 130

DLR
Hall 2.2, Stand 460

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Hall 1.2, Stand 210

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Thank you for joining!

Project Coordination

German Aerospace Center (DLR)
Institute of Vehicle Concepts

Pfaffenwaldring 38–40
70569 Stuttgart
Germany

Holger Dittus
holger.dittus@dlr.de

Technical Coordination

Construcciones y Auxiliar de Ferrocarriles (CAF)

J.M. Iturrioz, 26
20200 Beasain
Spain

Eva Terron
eterron@caf.net

visit us
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