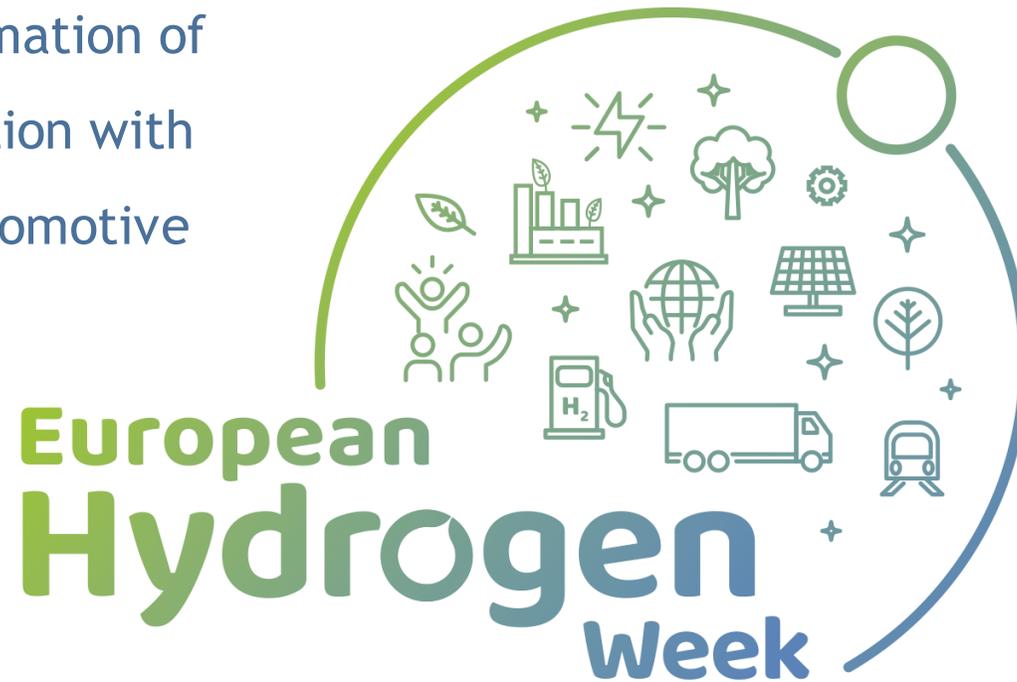


# GIANTLEAP

Giantleap Improves Automation of  
Non-polluting Transportation with  
Lifetime Extension of Automotive  
PEM fuel cells

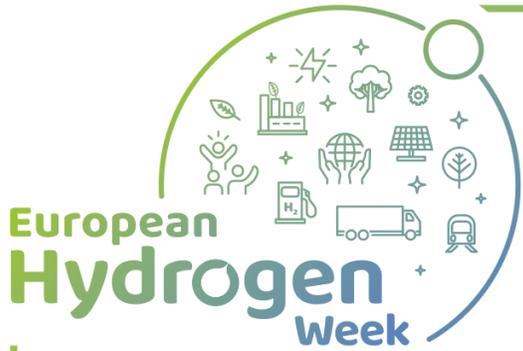


Dr. Federico Zenith  
SINTEF

<http://giantleap.eu>  
[federico.zenith@sintef.no](mailto:federico.zenith@sintef.no)

#PRD2020  
#CleanHydrogen





# Project Overview

**Call year: 2015**

**Call topic:**

FCH-01.2-2015,  
Diagnostics and  
control for  
increased fuel  
cell system  
lifetime in  
automotive  
applications

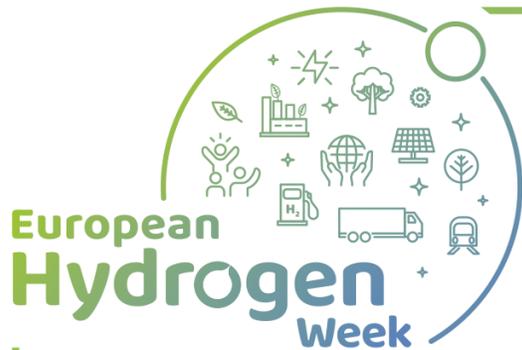
**Project dates:**  
1 May, 2016 – 31 October, 2019

**Total project budget:**  
3 617 291.46 €

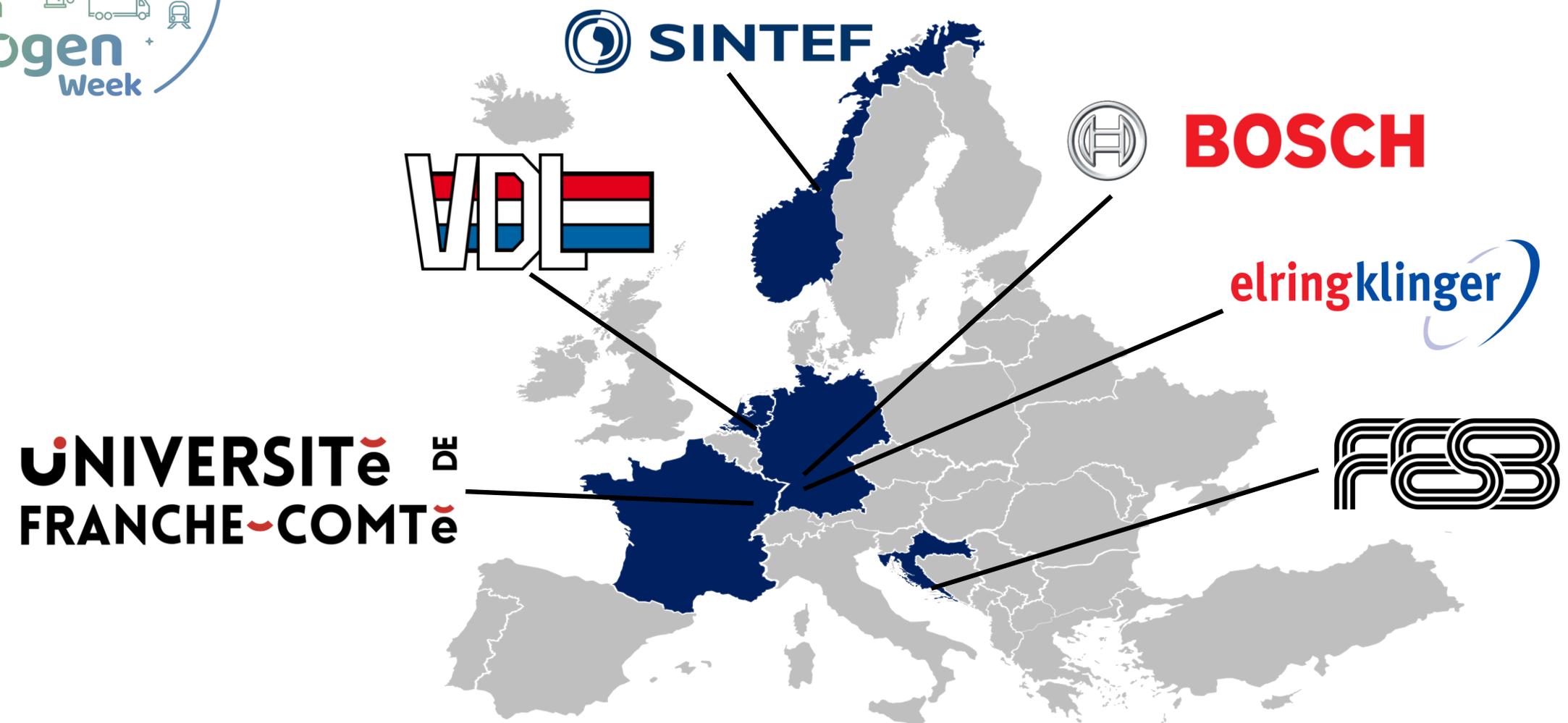
**GIANTLEAP**

**Stage of implementation:**  
100%

**FCH JU contribution:**  
3,260,270.50 € (90%)  
(No other financial contribution)



# Partners



#PRD2020  
#CleanHydrogen



# Project Summary

## Objectives

- Diagnostics and Prognostics of automotive hydrogen fuel-cell systems
- Advanced control algorithms
- Demonstration of a prototype

## State of the Art

- **Project start:** Low availability of hydrogen buses ( $\approx 70\%$  in CHIC & other projects)
- **Today:** high reliability of fuel cells - system is the problem

## Application

Range extender for battery bus



# Project Progress - Technology Readiness

## Achievement to-date

3



6



9

25%

50%

75%

Technology Readiness Level (TRL)

3. Experimental Proof of Concept
4. **Validation** in laboratory (FESB/UFC)
5. Validation in **relevant environment** (SINTEF/ElringKlinger)
6. **Demonstration** in relevant environment (Bosch)
7. Demonstration in **operational environment** (Bosch/VDL)
8. System **complete & qualified** (VDL)
9. Actual system **proven** in operational environment (R-Net, line 436 from Rotterdam Zuidplein)



# Project Progress - Durability

Achievement to-date

10 000 h

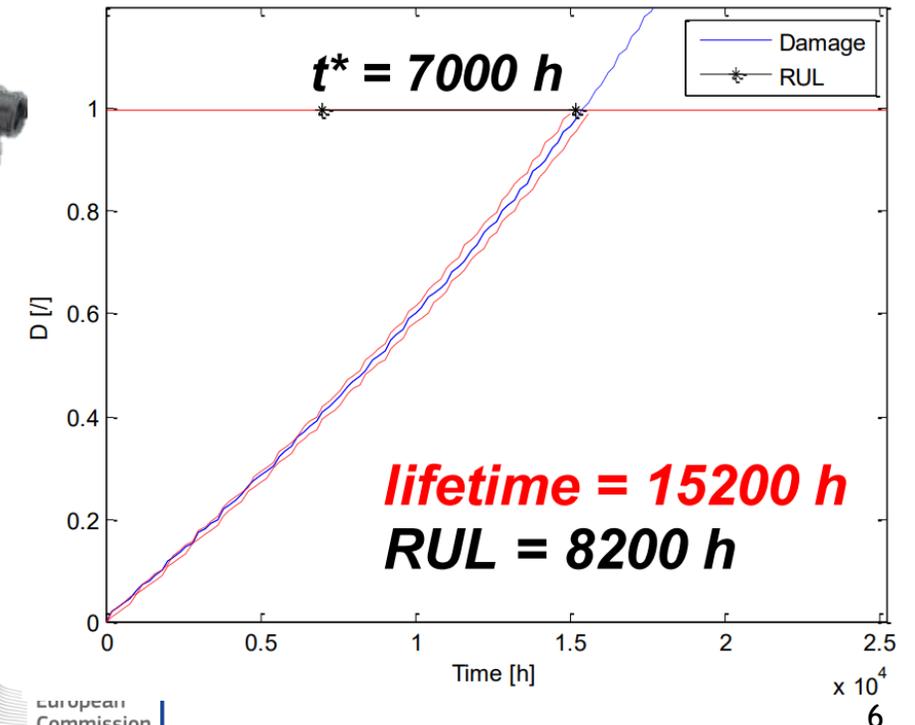


12 000 h



15 200 h

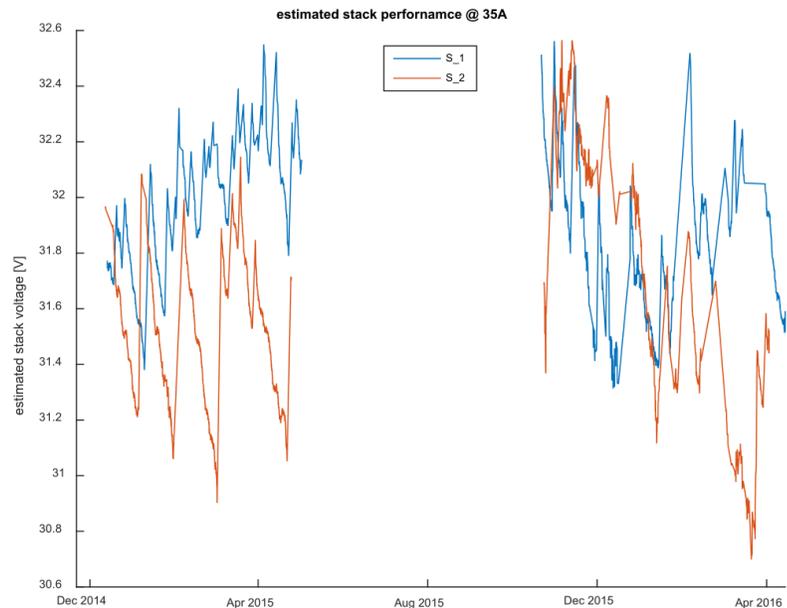
- Some heavy-duty stacks already > 30 000 h
- Giantleap uses *car-derived* stacks
  - System is easily replaced
- EU targets:
  - AWP 2015:  $2 \times 10\,000$  h
  - MAWP 2017:  $2 \times 8\,000$  h
  - MAWP 2020:  $2 \times 10\,000$  h
  - MAWP 2023:  $2 \times 12\,500$  h
- Giantleap number estimated by prognostic algorithm



# Fuel Cell Rejuvenation

Previously noted voltage recovery after shutdowns (SAPPHIRE project)

- Systematic study at FESB



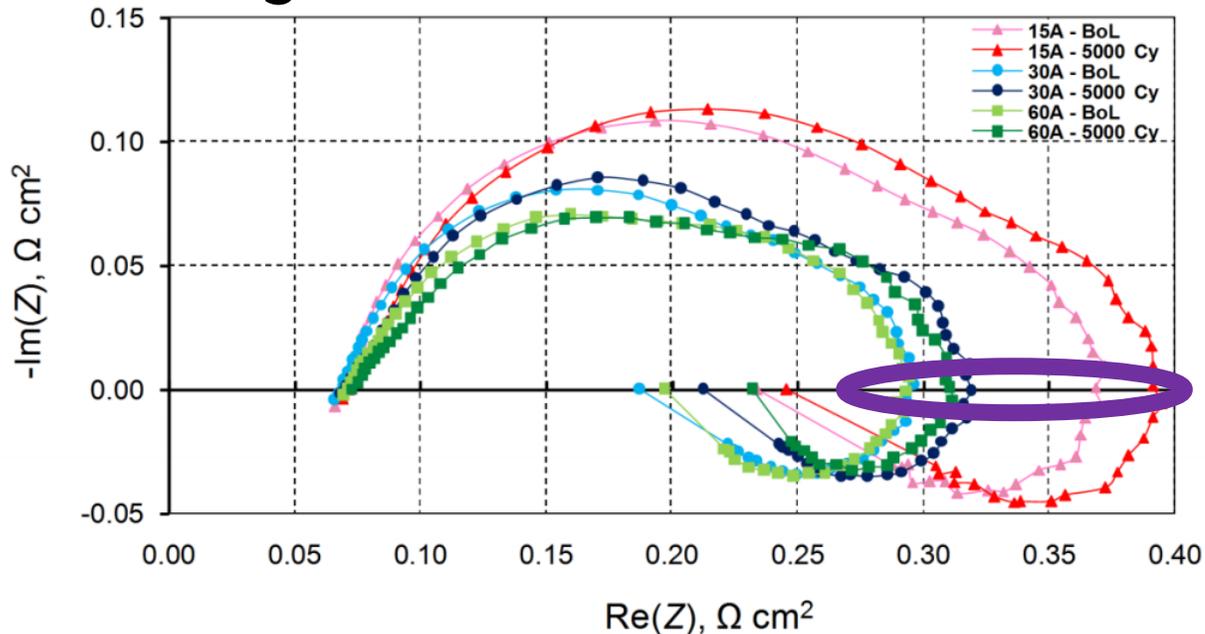
Factors for rejuvenation:

- Allow "soak time" when stopping
- Soak without extra cooling
- Very long soak times unnecessary
- Allow current to flow
- Have oxygen in cathode

- <https://doi.org/10.1002/fuce.201900174>

# Low-Frequency Impedance

- FESB identified key parameter
- Low-frequency intercept
- Prognostic variable



SINTEF applied process control

- Relay feedback
- Nonlinear parameter estimation
- Backward-Euler integration

Tested on ElringKlinger stack

- Convergence in seconds
- No extra equipment
- Minimal disruption

- <https://doi.org/10.1016/j.ijhydene.2019.04.004>

# Balance of Plant

## FC System Failures

- Stack is most expensive item
- Stack actually robust
- Bosch especially impressed compared to combustion engines

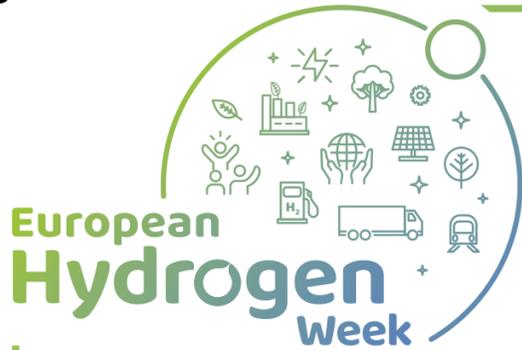
## Balance of Plant

- Compressors, humidifiers, etc.
- Cheaper, but less reliable
- Failures can cascade to stack



## UFC data analysis

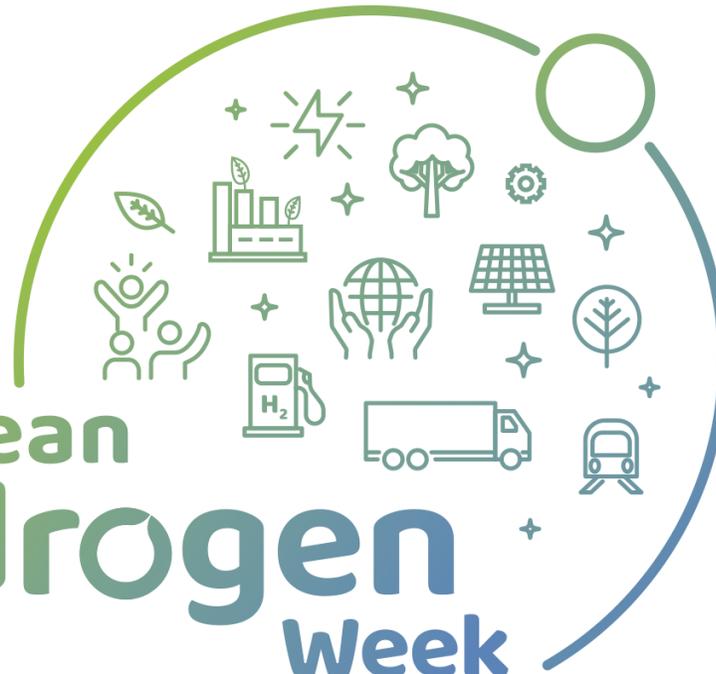
- Transients beyond surge line
- Bosch added bypass valve



# Dissemination Activities

- 4 articles published in scientific journals
  - 2 more in review, 2 more in preparation
- 18 presentations at 14 international conferences
- 28 public deliverables
- Workshop at VPPC 2017 (Belfort) and booth at Hanover Fair 2019
- Patent NL2020382B1 by VDL for trailer connector
- Web site [giantleap.eu](http://giantleap.eu), with *all public deliverables*
- All publications are Open-Access and stored on Zenodo.org
- Data for all experiments published on Zenodo
  - *Data is licenced as open source (ODbL)*

# European Hydrogen Week



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