

PEM Fuel Cells Manufacturing - Stack

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Head of Manufacturing Development



About Intelligent Energy

A fuel cell engineering company focused on the development and commercialisation of its PEM fuel cell technologies for a range of markets including automotive, stationary power and UAVs.

We are headquartered in the UK, with additional offices and representation in the US, Japan, India, and China.





Intelligent Energy fuel cells

Two distinct architectures

- Air Cooled (AC) for low power applications
- Evaporatively Cooled (EC) for higher power

Common advantages

- Low temperature
- Low noise
- Zero emission at point of use
- Scalable
- Robust, metallic plate construction
- Designed for manufacture





World-class facilities

Access to state of the art, research, development and production facilities

- 2 semi automated stack production lines
- 600 square metres of fully hydrogen-enabled test space
- 90 test stations covering 5W-100kW power range systems
- 8 environmental chambers, including 2 walk in
- Close partnerships with 3rd party test houses
- Acoustic chamber facility





Our technology & Sectors

Across a wide range of sectors and applications

UAVs

- Our technology provides a unique solution
- Fuel cells offer extended flight times and quick refuelling
- Fuel cells are a natural solution for UAV manufacturers moving into larger UAVs with heavier payloads



Motive

- Our expertise opens up a range of opportunities in the motive sector, for range extenders and prime power



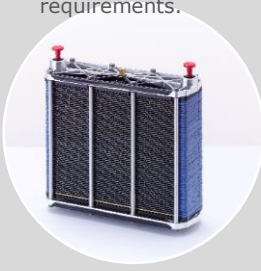
Stationary Power

- Back-up power and diesel replacement, for telecom towers, construction and a range of other sectors
- Field proven in India, with a tower uptime of close to 100%



AC64 fuel cell stack

- The AC64 Air Cooled fuel cell runs on hydrogen and ambient air to produce clean DC power in a simple, cost-effective, robust and lightweight package.
- The modularity of our proprietary product design allows for scaling to meet precise customer power and form factor requirements.





Air Cooled Products

Focusing on Air Cooled fuel cell technology up to 20kW



**AC64
fuel cell stack**



**AC64 lightweight
fuel cell stack**



Fuel cell power for UAVs



**Fuel Cell Modules
FCM 801**



**Fuel Cell Modules
FCM 802/4**



ZERE Project and Metropolitan Police Scooter Trial

- Development a 4kW fuel cell system based on Intelligent Energy's air cooled architecture
- Exploitation of 4kW fuel cell system via 2 wheel scooters, partnered with Suzuki
- Fleet trial of five fuel cell scooters with Metropolitan Police
- Scooters based at Alperton (North West Traffic Unit), for the use of Police Community Support Officers within the Roads and Transport Policing Command
- Trial endorsed by Greater London Authority, running from Sept 2017 for 18 months





Evaporatively Cooled Technology



2008

10kW Range Extender
PSA Peugeot Citroen



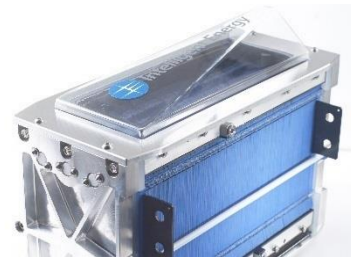
2012

30kW Range Extender
London FC Taxi



2015

100kW Primary Power
Prototype OEM supercar

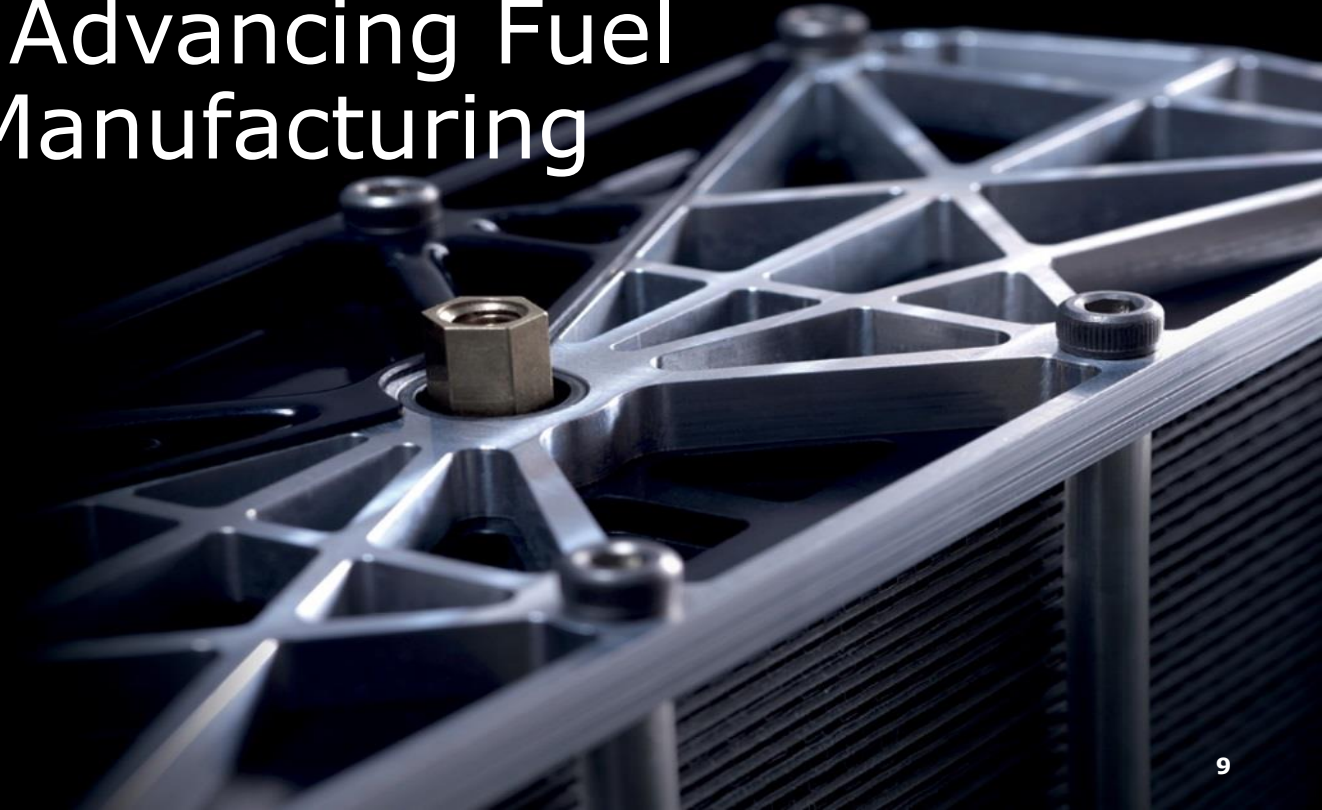


2018

30-100kW+
Range Extender & Primary Power
On and off-highway



Roadmap - Advancing Fuel Cell Stack Manufacturing





Advancing Manufacturing

FCEVs are now entering the mainstream, but to drive continued adoption need to ensure fuel cell stacks are robustly productionised and remain cost competitive in the future

Must be able to mass manufacture and produce in volume

Key Drivers

- Reliability
- Durability
- Cost
- Efficiency
- Scalability



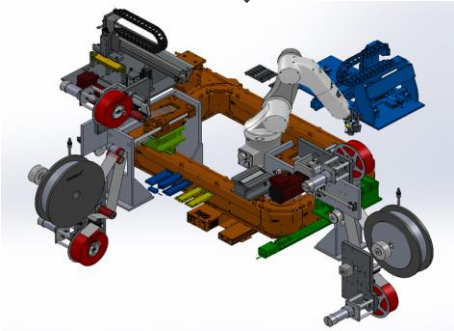


Advancing Manufacturing – Stack Assembly & Test

- Transition to fully automated stack assembly and test, aligned with automotive best practices

Key Enablers

- Format & handling of materials (e.g. flexible non-rigids)
- Reel-to-reel manufacture and component sub-assembly
- In-line inspection at production rate
- Materials non-uniformity classification – cause & effects
- Digitised Quality Control, down-stream & up-stream
- Stack test handover QC & Commissioning at rate direct to line shipment





DIGIMAN – addressing the challenge

- **DIGIMAN** = **DIGI**tal **MAN**ufacturing and Proof-of-Process for Automotive Fuel Cells
- FCH-01.1-2016 topic: Manufacturing technologies for PEMFC stack components and stacks
- Start Date: January 2017
- Duration: 36 months
- EU Contribution: €3.5M fully funded

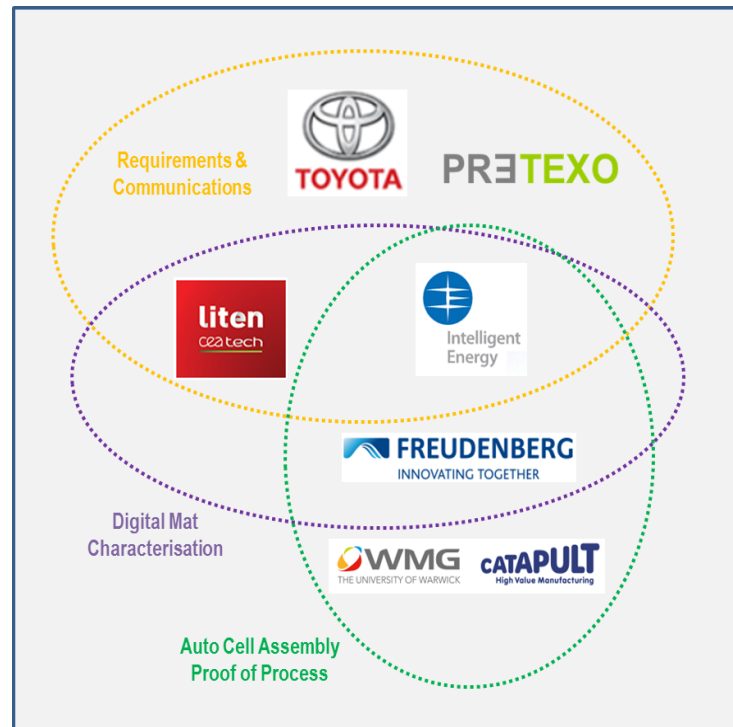


Horizon 2020
Programme



DIGIMAN Project Consortium

- **CEA Tech – LITEN**, France
 - Project Coordinator & Materials Characterisation WP leader
- **Intelligent Energy Ltd**, United Kingdom
 - Technical Coordinator & Digital Manufacturing WP leader
- **Toyota Motor Corporation** – Europe, Belgium
 - Requirement Setting & Proof of Process Measurement WP leader
- **Freudenberg Performance Materials**, Germany
 - GDL Digital QC & Converting WP leader
- **Warwick Manufacturing Group**, United Kingdom
 - Automated Cell Assembly PoP Development WP leader
- **Pretexo**, France
 - Knowledge Management, Communication & Dissemination WP leader

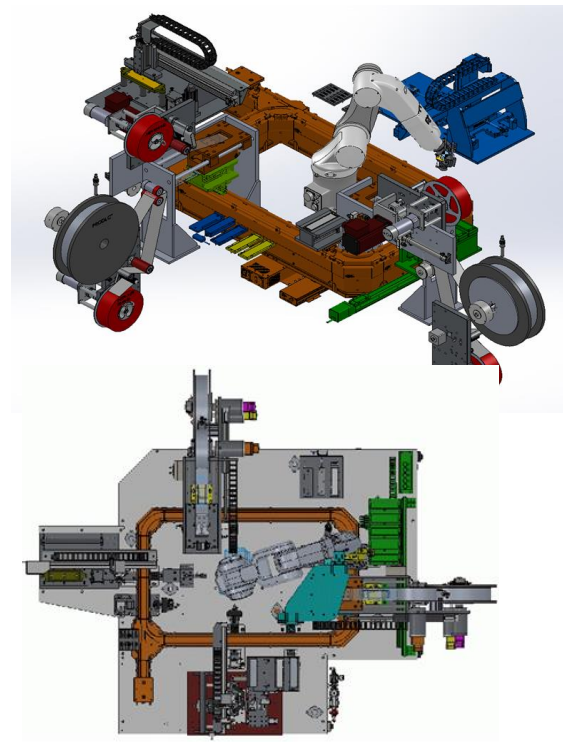




Objectives of DIGIMAN programme

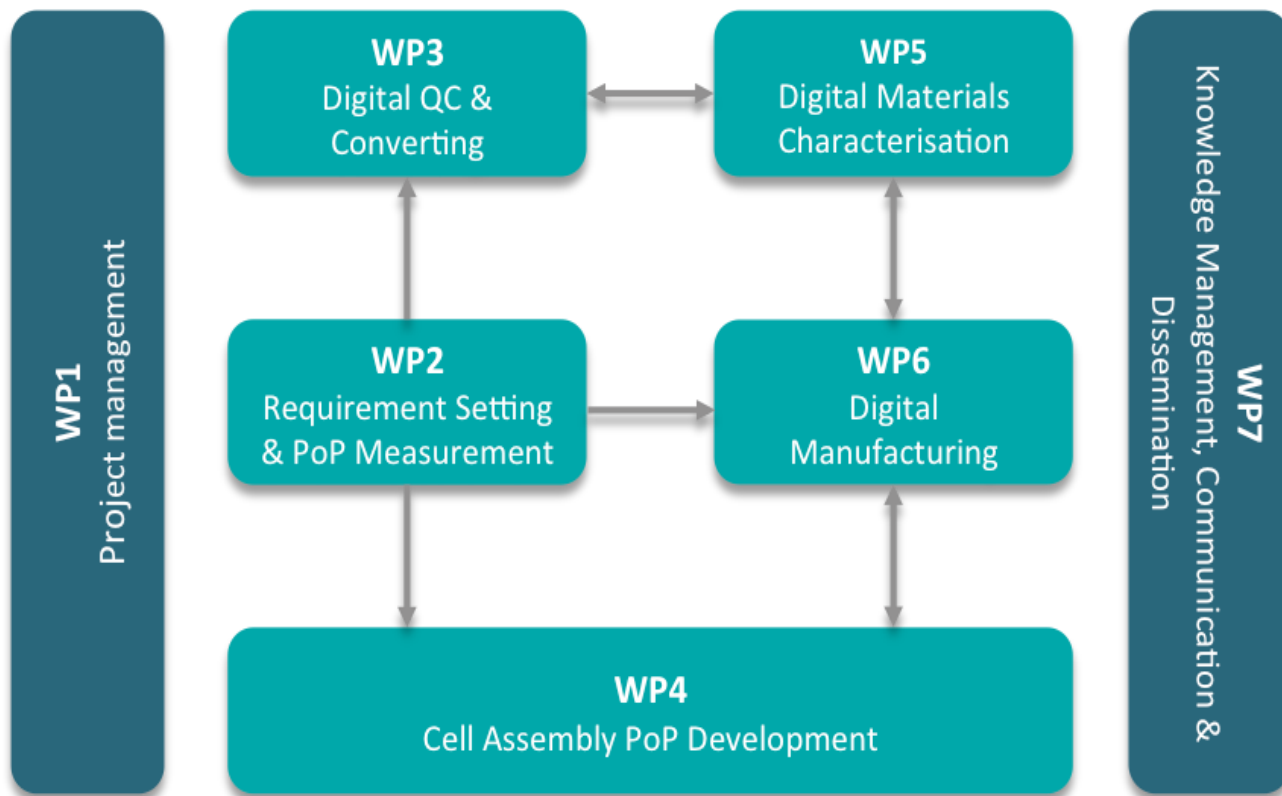


- Develop a ready to deploy, **next generation automated assembly** processes for **next generation stacks**
- Demonstrate **automotive best practice** creating a robust platform for PEM fuel cell stack production
- Integrate **digital manufacturing techniques** with advanced **automated production technology** to check and ensure the quality of production
- Develop **digital cause & effects** capabilities via Industry 4.0 methods
- Demonstrate for a single line a total stack power output of >5MW
- Establish **integrated European supply chain** for key fuel cell components
- Deliver **operational** and **supply chain** cost reduction





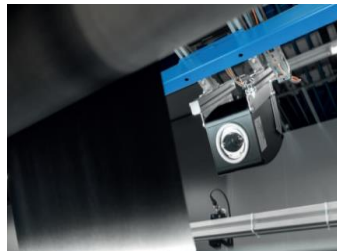
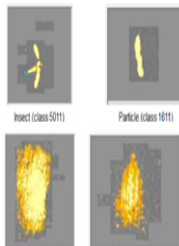
DIGIMAN Technical Interactions (Work Packages)





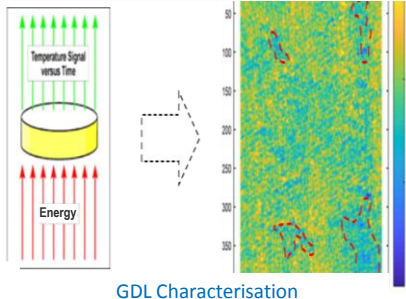
DIGIMAN Progress

Digital QC & Digital Converting

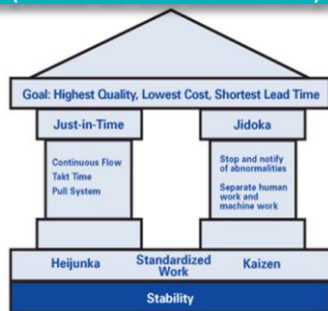


Digital Defect Classification – Vision System – GDL Defect Detection & Mapping

Digital Materials Characterisation

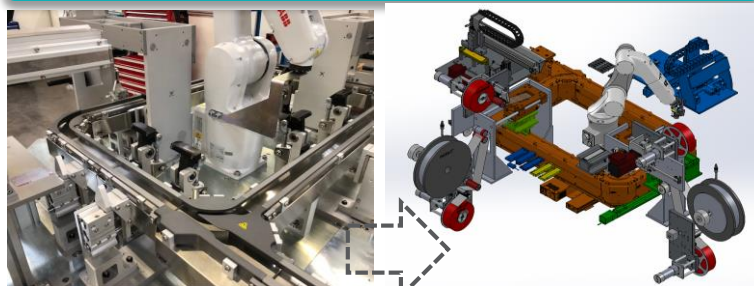


Requirements Setting (Voice-of-the Customer)



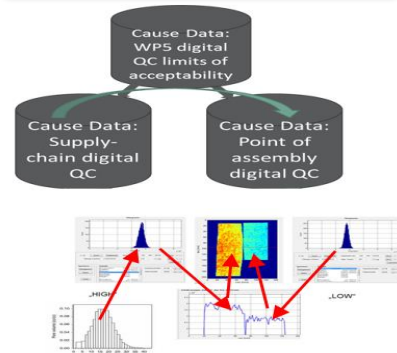
Toyota Production System
"House"

Cell Assembly PoP Development



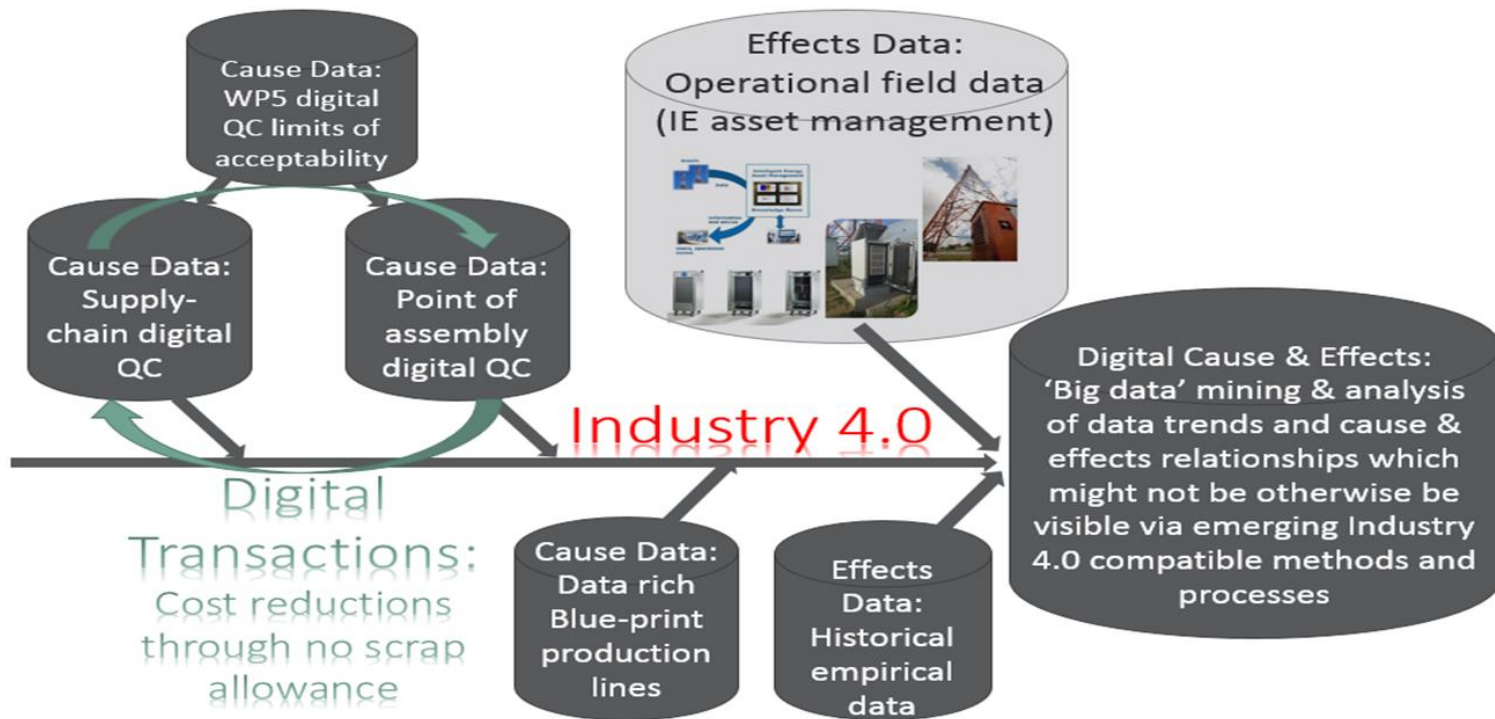
Proof of Process Demonstrator > Blueprint Design

Digital Manufacturing





DIGIMAN Digital Manufacturing & “Big Data” Management



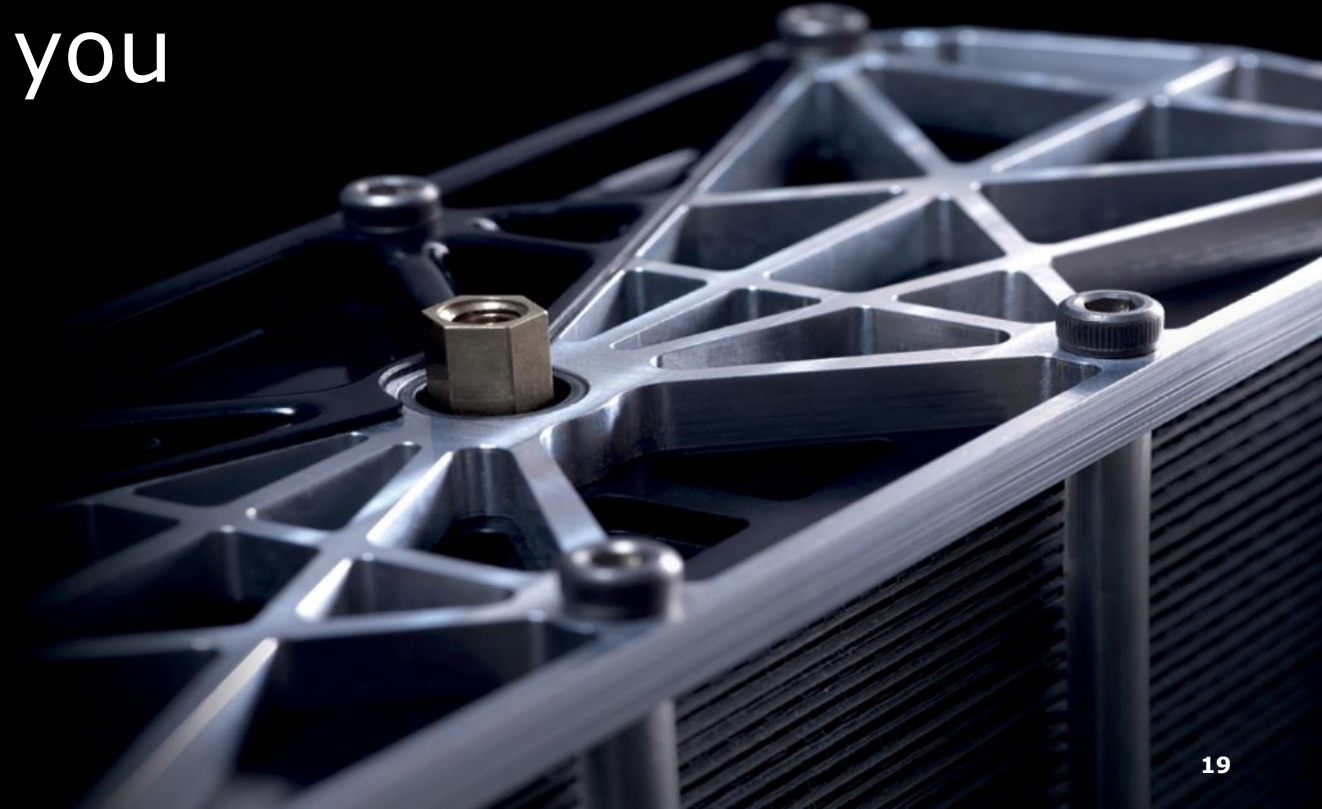


Summary

- Fuel cell manufacturing has started to address automotive standard QC requirements and scalability, which will also lead to further cost reduction opportunities
- Key enablers are:
 - Novel handling techniques for none rigid light weight materials
 - Reel-to-reel manufacture and sub-assemblies
 - In-line QC inspection at rate
 - Non-uniformity classification – defect cause & effect
 - Digital QC, Industry 4.0 through the supply chain and field operations
 - Stack end-of-line QC / commissioning for direct to line shipment
- Europe is playing a full role with support of Government, NGOs and Industry, and by involvement in EU funded programmes such as DIGIMAN



Thank you





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