

# Fit-4-AMandA Future European Fuel Cell technology: <u>Fit</u> for <u>Automatic Manufacturing and Assembly</u>

### FIT-4-AMANDA

**Programme Review Days 2019** Brussels, 19-20 November 2019



## **FUEL CELLS AND HYDROGEN** JOINT UNDERTAKING

Thomas Wannemacher Proton Motor Fuel Cell GmbH

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## **PROJECT OVERVIEW**

- **Call year: 2016**
- **Project dates: 1<sup>st</sup> March 2017 29<sup>th</sup> February 2020**
- % stage of implementation 01/11/2019: ~80%
- Total project budget: 2,999,185 €
- FCH JU max. contribution: 2,999,185 €
- **Other financial contribution: None**
- **Technische Universitaet Chemnitz, UPS Europe SA**



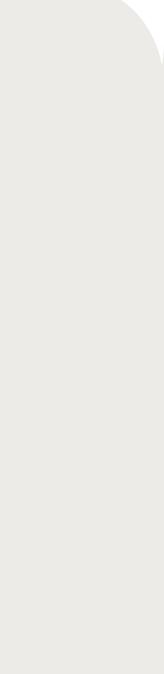




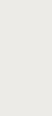
### Call topic: FCH-01-1-2016 Manufacturing technologies for PEMFC stack components and stacks

# Partners: Uniresearch BV, Proton Motor Fuel Cell GmbH, IRD Fuel Cell A/s, Aumann GmbH, Fraunhofer IWU,

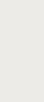


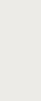












## **PROJECT SUMMARY – Project Objectives**

- Project Acronym: Fit-4-AMandA
- Assembly
- **Project Main Objective:** develop, validate and demonstrate step changes in term of cycle time, manufacturing cost, yield and reliability in two critical steps in the production PEMFC systems, i.e. the production of the MEAs and the assembly of the stacks.









### Project Full Title: Future European Fuel Cell technology: Fit for Automatic Manufacturing and

## **PROJECT SUMMARY – Project Objectives**

### **Project technical objectives:**

- Establish the technological roadmap to scale up from less than hundred stacks/year to 50,000 stacks per year. Redesign (adaptation) of current MEA and stack design to optimise the designs for manufacturability. Development of an alternative concept to graphitic BPP based on a metallic BPP technology. Development of fast inline non-destructive quality assurance (NDT-QA) test methods for automated
- 1. 2. 3. 4.
- production of MEAs and stack assembly.
- **Design and development of an automated processing** unit/system for the manufacturing of key/critical stack 5. components, i.e. MEAs.
- Development, manufacturing and testing of technology and machine system for the automatic assembly of 6. **PEMFC** stacks.
- 7. Validation of the developed designs, hardware, tools and software for the automated production of MEAs and automated stack assembly and the fast-inline NDT-QA test methods.
- Integration and field testing using one of the first prototype stacks manufactured by the automated processes 8. into a light commercial vehicle









## **PROJECT SUMMARY – Positioning vs State-of-the-art**

### **Global positioning vs international state-of the art**

**Characteristics and Key performance indicators (KPIs)** Production time for one stack (throughput time) Automated production process steps

Testing time (automated and manually)

Costs per stack

Reduction of scrap (e.g. broken Bipolar Plates per Stack during production)

Non accepted tests: Rework and unbundling of stack

Tightness and leakage of the stack

### **Application and market area**

The project targets will result in strong reduction of the cost of the PEMFC stacks. The achievement of the CAPEX targets will allow the introduction and roll out of PEMFC technology in specific automotive applications (e.g. urban delivery van, city buses and regional buses).





Fit4AMandA targets	Baseline
<0.5 Hours	40 hours
90% automation grade	10% automation grade per stack
per stack	
1 hour	1 day
>50%	100%
0	10 per stack
0	Every 10 <sup>th</sup> stack needs to be reworked
0	Every 10 <sup>th</sup> stack needs to be reworked







## **PROJECT PROGRESS/ACTIONS - Redesign Stack Design**

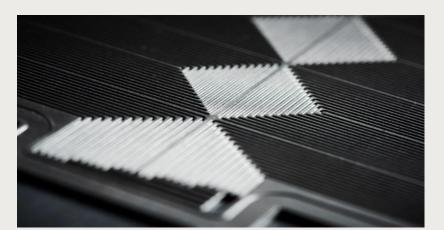


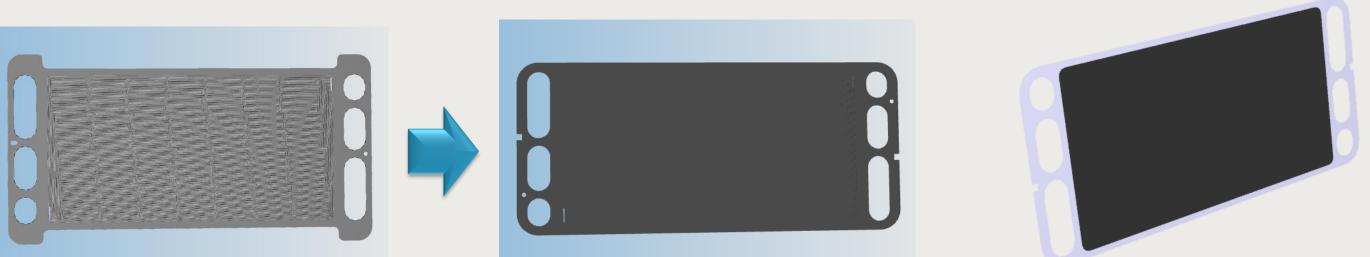
### **Achievement to-date**

**Previous PM** Stack Design

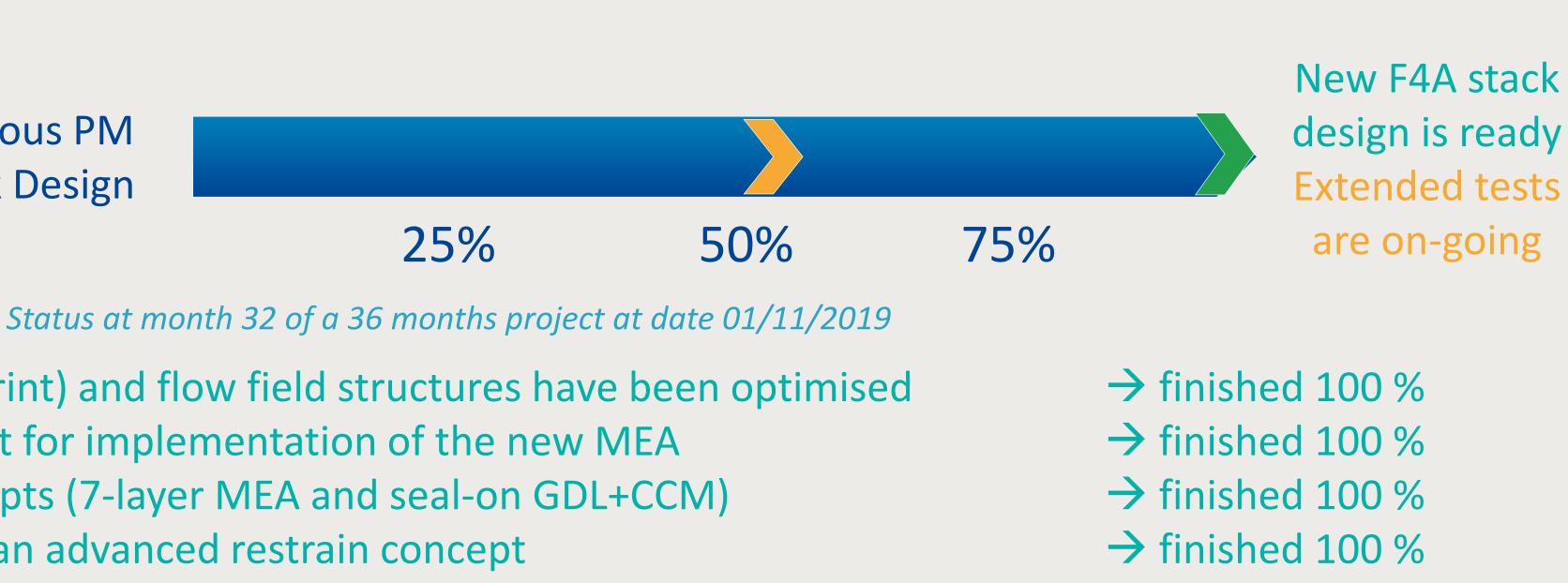
- Bipolar plate design (footprint) and flow field structures have been optimised
- Redesign of sealing concept for implementation of the new MEA
- Development of two concepts (7-layer MEA and seal-on GDL+CCM)
- Design implementation of an advanced restrain concept
- New stack design is currently being tested
- First indications are promising...











 $\rightarrow$  ~ 50 %

### > Without the results of the current tests, no statements can be made about the stack performance (KPI)!

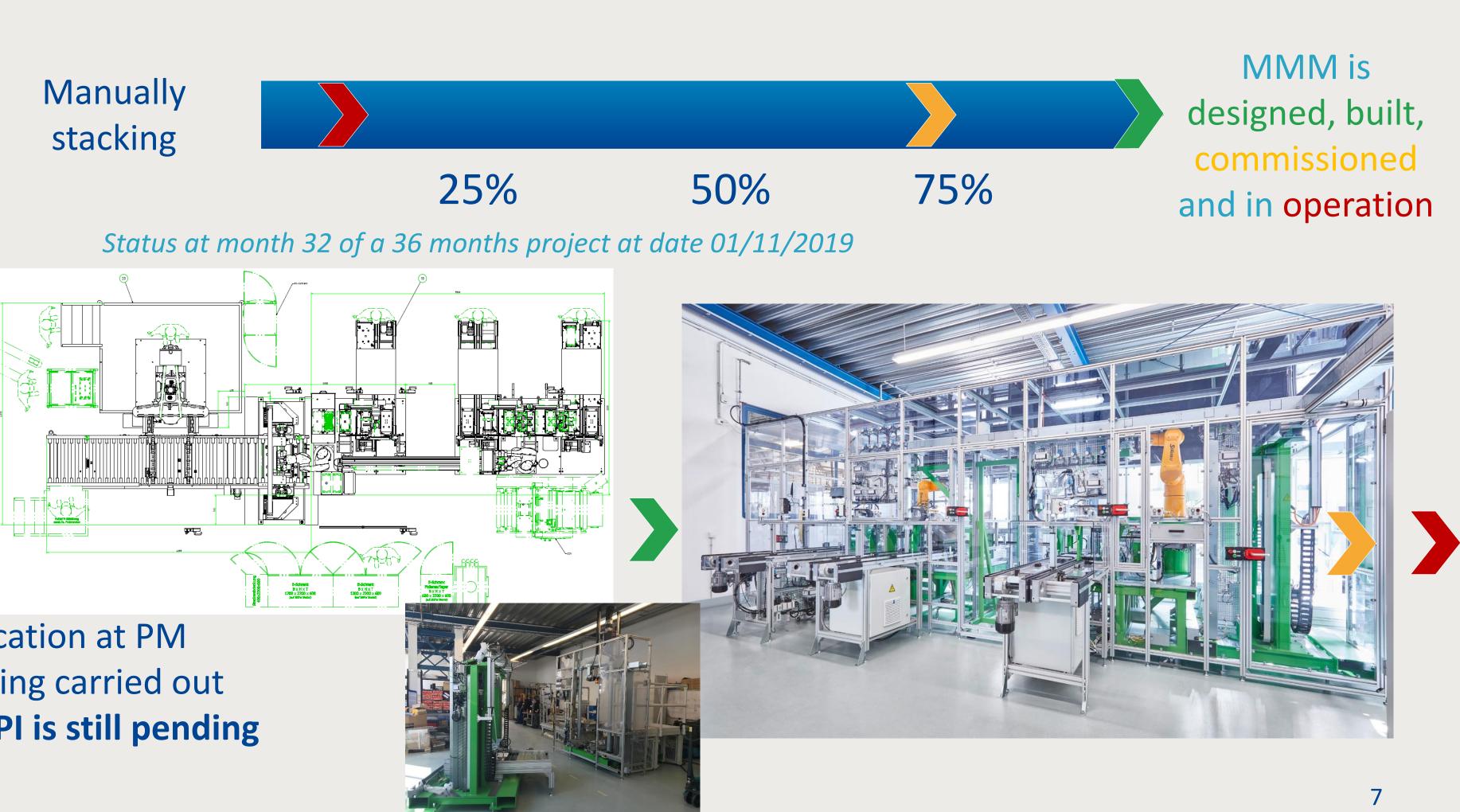


## **PROJECT PROGRESS/ACTIONS – Mass manufacturing machine (MMM)**

### **Achievement to-date**







- Machine is now at the final location at PM
- Currently commissioning is being carried out
- Final approval and proof of KPI is still pending

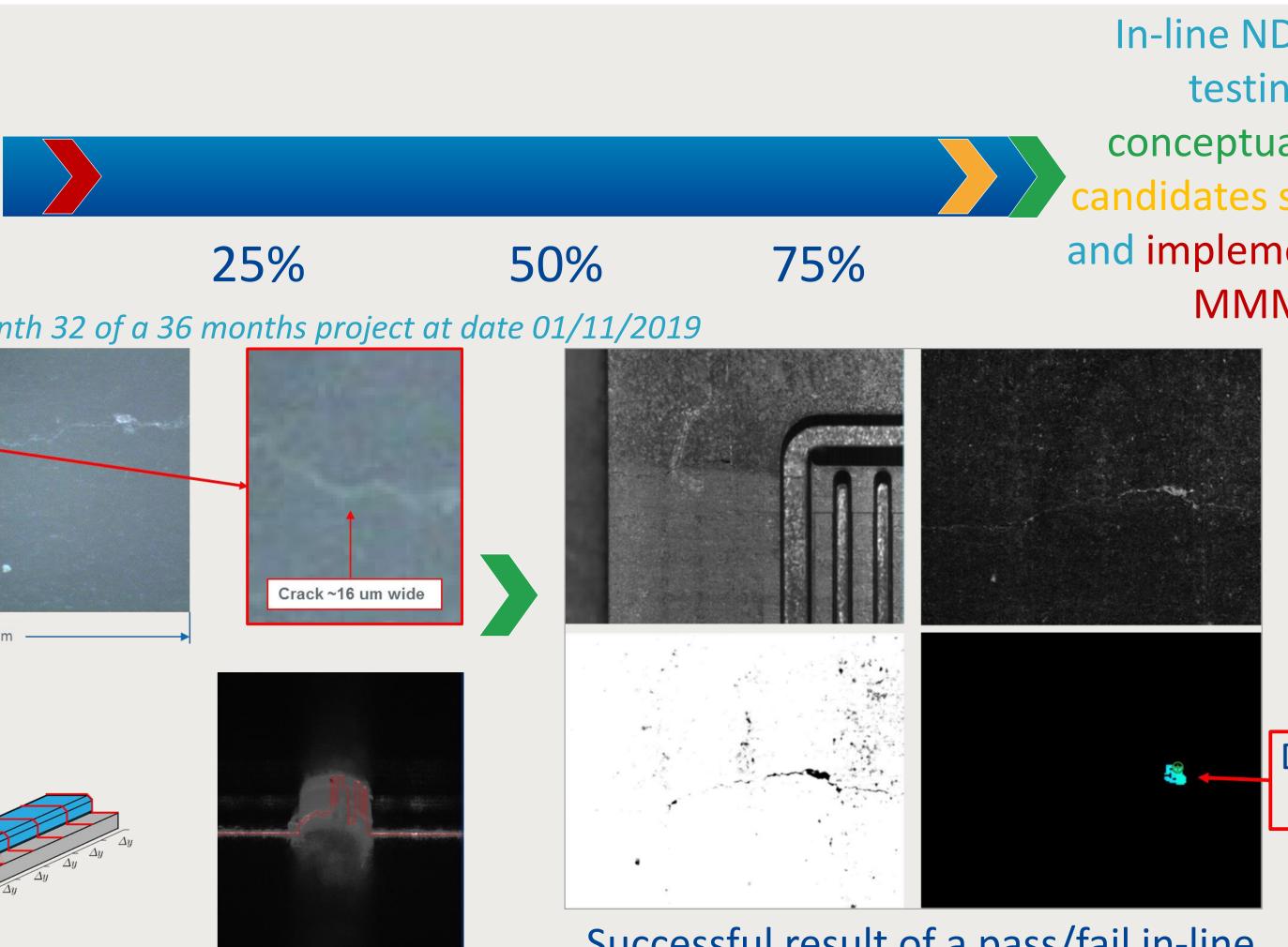


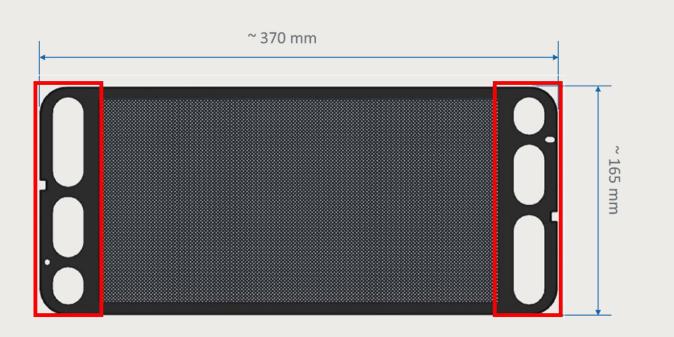


## **PROJECT PROGRESS/ACTIONS – Fast inline test methods**

### **Achievement to-date**

In-person visual inspection of components

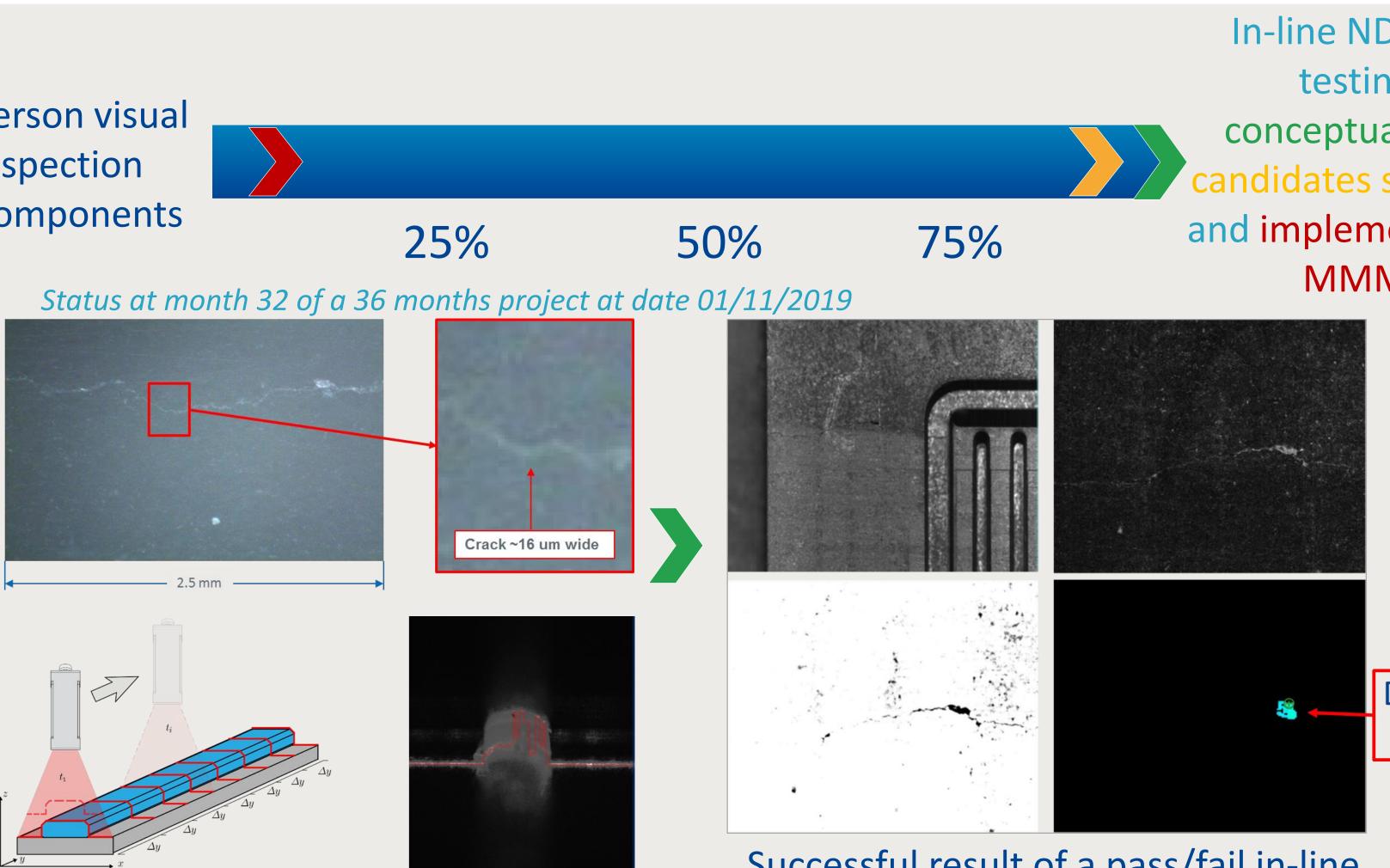


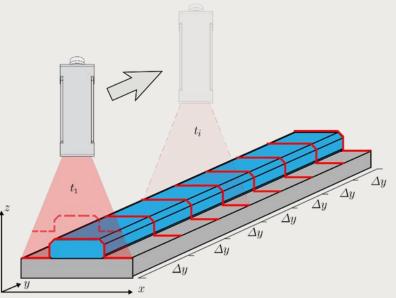


- Measurement area: ~600 cm<sup>2</sup>
- Defects: length few mm, width 10's of  $\mu m$
- Time: >10 s/plate
- $\rightarrow$  Compromise necessary



\*) Top: offline detection; bottom: unsuccessful in-line profile measurement of sealing bead





Feasibility tests<sup>\*</sup>) (integrity and seal test)



Successful result of a pass/fail in-line test

## **Risks and Challenges**

Risks have been identified during the proposal definition and During the project lifetime others unforeseen risks materialized:

### FORESEEN RISKS (examples):

- Failure in bringing the BPP and the MEA production from MRL6/7 to MRL8/9.
- Technical risk of tolerance summation when stacking >100 components

### **UNFORESEEN RISKS (examples):**

- **Higher costs of the vehicle**
- Strong delay due to insufficient core component supply





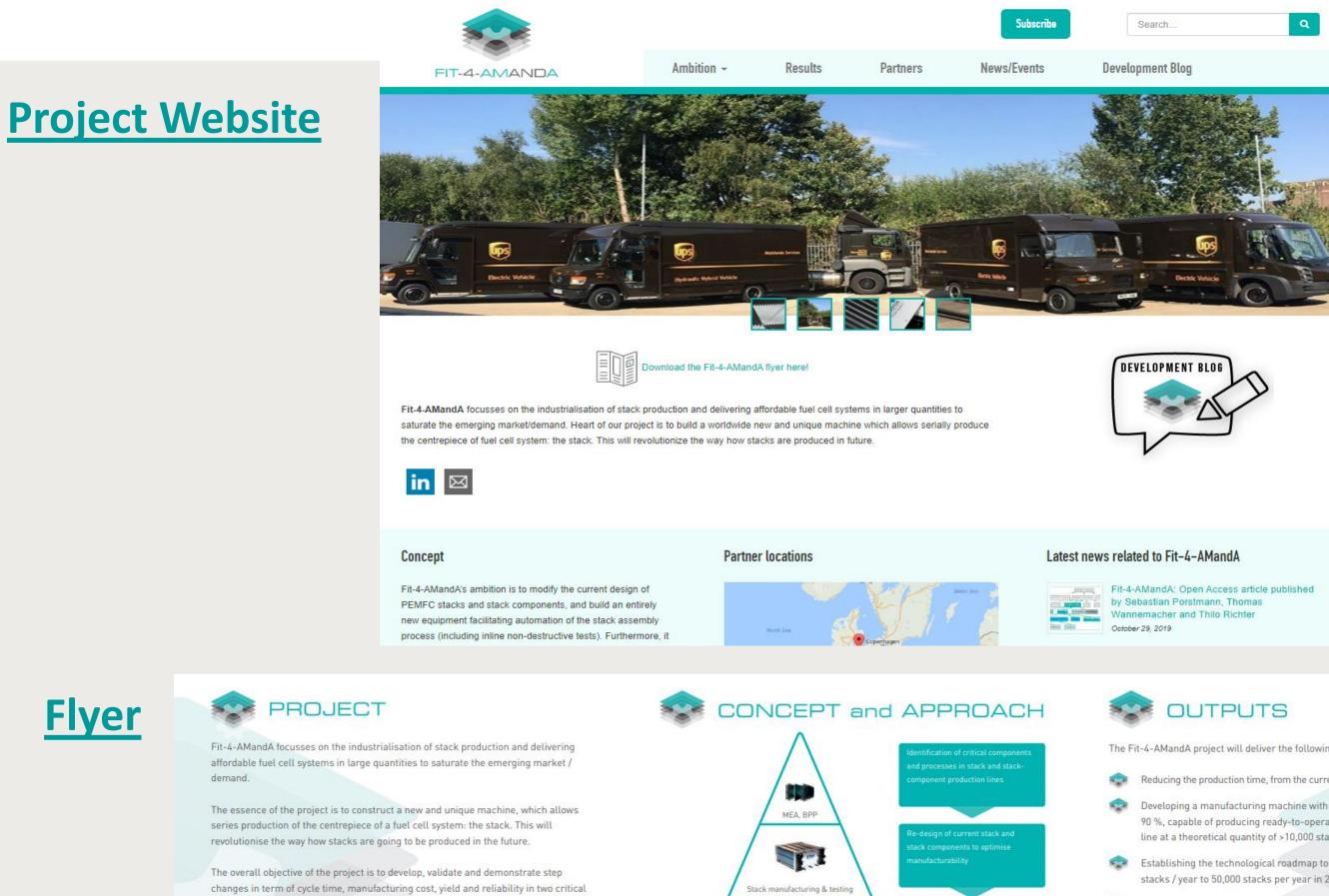


**MEASURES to MITIGATE:** 

- Strategies for alternative solutions
- **Reorganisation of the sequence of WP tasks**
- **Flexible MMM design for easy adoption of** different concepts (fall back options)



## **Communications Activities**

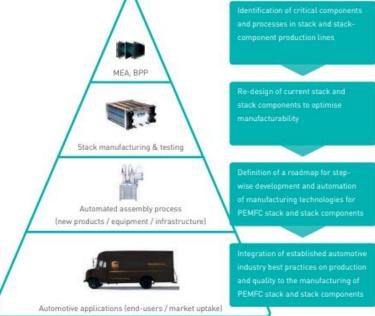




assembly of the stacks.



steps in the production of PEMFC systems, i.e. the production of the MEAs and the





184	Fit-4-AMa
	by Sebast
	Wannema
	October 29

The Fit-4-AMandA project will deliver the following outputs:

- Reducing the production time, from the current 40 hours to 30 minutes per stack;
- Developing a manufacturing machine with an automation grade of more than 90 %, capable of producing ready-to-operate fuel cell stacks in one assembly line at a theoretical quantity of >10,000 stacks / year;
- Establishing the technological roadmap to scale up from less than hundred stacks / year to 50,000 stacks per year in 2020 and beyond;
- -Reducing the stack costs by roughly 50 % through economies of scale and increased automation;
- Integration and field testing using one of the first prototype stacks manufactured by the automated processes into a light / medium commercial vehicle provided by UPS.



Fit-4-AMandA | Newsletter #4 - April 2019

View this email in your browser



### Facts & Figures

**Newsletters** 

Future European Fuel Cell Technology: Fit for Automatic Manufacturing and Assembly Acronym: Fit-4-AMandA Duration: 36 months Start date: 1 March 2017 Total budget: 2,9 M€ EC Funding: 2,9 M€ Website: www.fit-4-amanda.eu

### Fit-4-AMandA - Consortium

The consortium consists of 7 partners.

Consortium

Uniresearch BV, Proton Motor, IRD, Aumann, Fraunhofer, Technische Universität Chemnitz, UPS.

### Fit-4-AMandA - 5th General Assembly



The fifth General Assembly of the Fit-4-AMandA consortium took place in February 2019. The meeting was hosted by Uniresearch in Delft, The Netherlands.

### FCH 2 JU

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735606. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY.



### Fit-4-AMandA Experimental machine system ready for shipment to Proton Motor

After several weeks of intensive commissioning and functional testing, the experimental machine system for fuel cell stack assembly is now ready for relocation from the plant manufacturer Aumann Limbach-Oberfrohna GmbH to the stack manufacturer Proton Motor Fuel Cell GmbH.



The focus of the work done during the recent past was the testing of all functional assemblies and thus technologies for the assembly of the seal-on MEAs and the fuel cell stacks. A special challenge was the system for the automatic provision of components. These are supplied on a carrier in a type-specific stackbox.

The highly adhesive GDLs need intermediate non adhesive layers. In the machine the GDLs have separated. The GDL is

handled under the camera for position measurement. The separating layer is dropped. The result of the optimization is an improved intermediate layer i terms of rigidity and flatness. Read more ...

### Are we chasing the right horse?

Following the presentation of Thomas Wannemacher (Proton Motor) during the Manufacturing workshop organised by the INSPIRE team in Marseille, a debate started on the topic of the usefulness of graphitepolymer bipolar plates. According to some, metallic bipolar plates are a clear winner due to their superior electric conductivity, mechanical properties, ease of mass manufacture and the smaller cell pitch. Furthermore, due to the fast processes the capability of producing very high volumes in appropriate short time is given, combined with a potential of moderate production costs. Others refer to the still developing coating systems needed to keep the corrosion processes under wraps. Certainly, Proton Motor has to have a good reason to stay with the graphite-polymer alternative.

To provide some perspective, there are two obvious routes in the exploitation of fuel cells: low current density operation leveraging the high efficiency and ensuring endurance when compared to conventional power sources and high current and power density capability requested by the automotive industry to sever the umbilical cord to oil and meet the stringent yet sorely needed targets imposed on CO2 emissions. While the entire fuel cell industry will surely benefit from the pursuit of ever higher power densities at lower catalyst loading, there are many areas with more conservative needs.

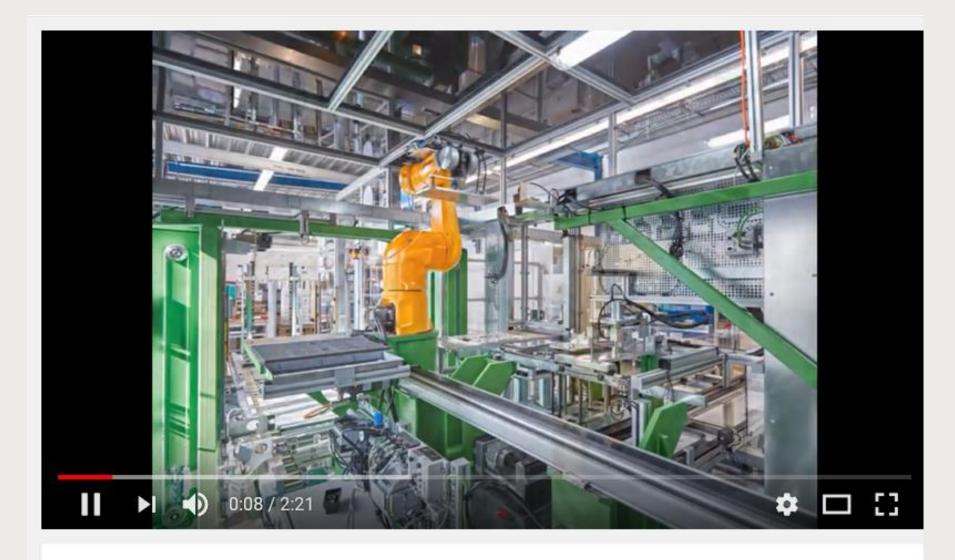
In the Fit-4-AMandA project, UPS expect that the delivery vans will last





## **Communications Activities**

**Development blog:** since the start of the project, all major achievements and milestones have been reported and are easy to check on the website



Fit-4-AMandA Stack Production Video





6 views



### August 2018 - Feasibility study completed for FC technology in

### commercial EVs



ted determined to co stack, the energy distance of 200 k studied and corre were calculated. type of driving cy velocity and accord car route) was al

The energy capacity of a high voltage battery was determined to cover, together with the produced PEMFC stack, the energy demands of the vehicle to travel the distance of 200 km. Influence of the driving cycle was studied and corresponding energy demands of the vehicle were calculated. To avoid focusing only on one tour (one type of driving cycle), a cycle based on average values of velocity and acceleration (from UPS' standard package car route) was also used for computations. Read more in deliverable 6.1...

### December 2018 - FC-Integration concept and performance

### requirements are ready



As part of the re-power offered by Proton Motor and EFA-



The goal of this report is to provide a list of methods suitable for the fast in-line tests of fuel cell components and subassemblies. Read more in deliverable 5.1...



### August 2018 - The experimental machine system is ready



The purchasing process is completed. The experimental machine system is assembled. The pneumatic and electrical installation is completed. The experimental machine system is now ready to start with mechanical tests of the functional units and to put it step by step into operation. Read more...

October 2019: "Overcoming the Challenges for a Mass

### Manufacturing Machine for the Assembly of PEMFC Stacks"

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as Diffusion Layer (CDL) Membrane	lataliyet	

Our Fit-4-AMandA colleagues have published the open access article: "Overcoming the Challenges for a Mass Manufacturing Machine for the Assembly of PEMFC Stacks" in the Journal 'Machines'. Authors: Sebastian Porstmann (Fraunhofer IWU), Thomas Wannemacher (Proton Motor), Thilo Richter (Aumann)... Read more... June 2019: Automatic mass manufacturing machine delivered to

Proton Motor.



The automatic mass manufacturing machine has been delivered to Proton Motor. Read more...







## **Dissemination Activities**

### **Conferences / workshops**

• 6 Presentation at conferences

**4** workshops

One published and more are currently under preparation



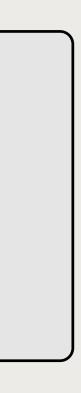


### **Publications in international peer**reviewed scientific Journals

### **Public deliverables**

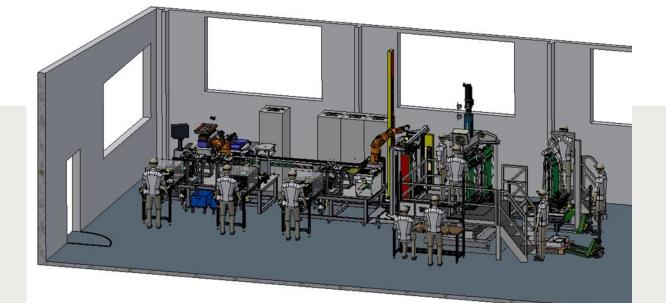
□ 3 Deliverables published in the project web-site:

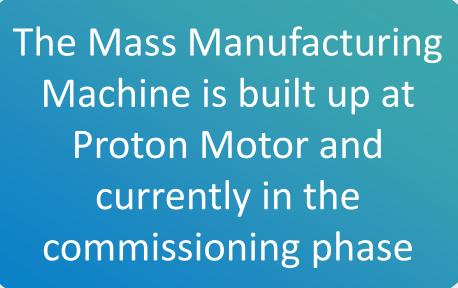
https://fit-4-amanda.eu/downloads/





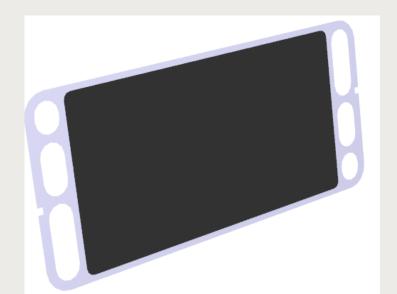
## **Project Results (Timeline)**





2019

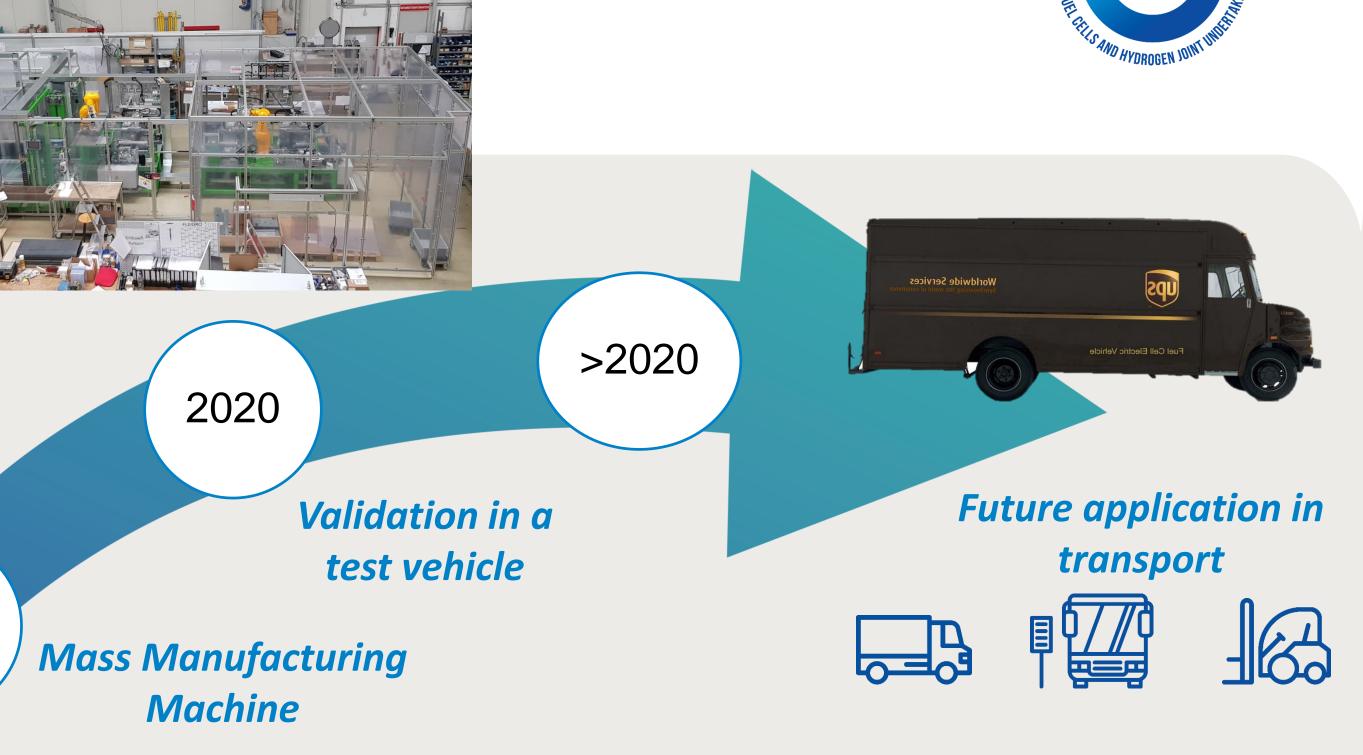
2018



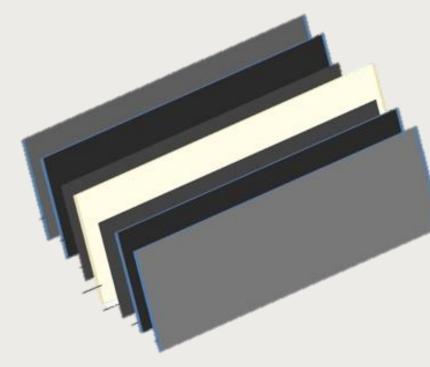
A new stack design is developed and capable of being processed automatically



New stacks design



Stack components and concept optimization have been successfully carried out

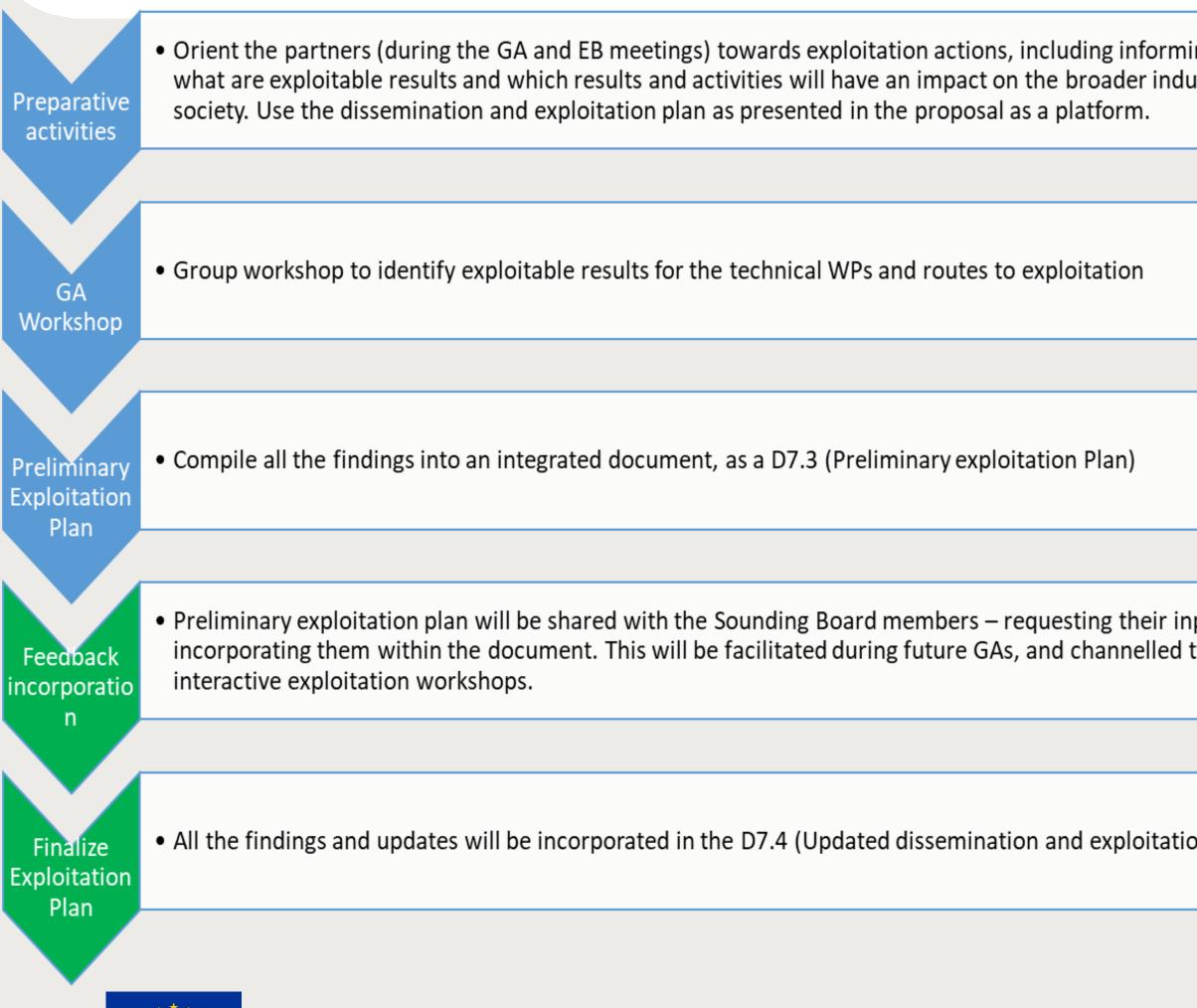








## **EXPLOITATION PLAN/EXPECTED IMPACT**







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		Innovation	Partner bringing them to the Ma
	1	Automatic assembly machine for PEMFC-stacks	Aumann
	2	PEMFC components, MEA and BPP, for mass manufacturing	IRD Fuel cells
nd	3	Scalable PEMFC stacks in high batch sizes	Proton Motor
	4	Protocols, Turn-key services	TUC
an).			





## SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programmes

- MAMA-MEA : Exchange of ideas regarding QC techniques; characterisation of MAMA-MEA functional layers during demonstrations of QC hardware; co-development of *zero-loads*
- INSPIRE: Templates; Exchange of ideas during INSPIRE's FCH JU PEMFC development workshop
- TAHYA: Hydrogen tank hardware recommendation
- Not realised yet:  $\rightarrow$  REVIVE: Exchange of experiences in real life operation of mobile applications

