Cryogenic Hydrogen Tech Aircraft

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CONTENTS

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A closer look at our partner's thoughts and progression

1. What have been your achievements and milestones in 2020?
2. Challenges for the current year.
3. A reflection of the future of air transport and the rise of hydrogen and other non-polluting solutions.

1. In 2020 we have fine-tuned the specifications and requirements applicable to the cryogenic tank; this has requested strong collaboration with the system owner DLR, and the aircraft designer Pipistrel. Main achievements and milestones in 2020 have been the single components (exchangers, valves, electronic control) design, supply and test . Safety analysis have been performed ; Design trade-offs on the architectures and conceptual design safety compliant.

2. 2021 is a pivotal year: manufacturing and testing of the cryogenic storage in ALAT facility, independently of the aircraft system. These two steps are critical : manufacturing requests very strong knowledge and quality control – and many steps of the manufacturing are complex. Testing (both environmentally and functionnally) are seen as an achievement and we'll be able to finally confront the design to the empiric realty. We also have to move forward on collaboration for the integration and tests from 2022, where all the partners will collaborate even closer. Finally, the Ground System that will be used to fill the cryogenic tank will be manufactured and also tested.

3. HEAVEN participates in the rise of Hydrogen mobility. McKinsey Report to FCH JU (Hydrogen-powered aviation, a fact-based study of hydrogen technology, economics, and climate impact by 2050) shows that short / medium range aircraft (50% of the aviation CO2 emissions) can be converted to H2, and this is a cost efficient mean of decarbonization. Important aircraft manufacturer, such as Airbus has announced development of short / medium range aircraft for 2035. National and Europeans policies also strongly support the Hydrogen solution, in particular for aviation. HEAVEN paves the way of these developments. In ALAT, we can see early markets for general aviation, as direct application of HEAVEN cryogenic storage, eager to develop H2 aircrafts and other vehicles. Ground Heavy Duty Vehicles (HDV) applications are also very close to HEAVEN tank (close embedded fuel mass, power, etc.).

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H2FLY

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1. Main goals of the H2fly for this year will be the finishing of the safety assessment process after aerospace recommended practices since this will have the biggest impact on the change of the system design. We will finalized the definitions and technical requirements for the safe integration of liquid hydrogen and hydrogen field proton exchange membrane (PEM) fuel cell systems within the aircraft. After that, the manufacturers could start with the building of the parts, so that a build up of the system can start soon. Even if this is not the main focus of the H2Fly for now, we always try to prepare the systems for a use for large aircraft since this is the only way to meet the challenges of future environmental friendly drive technology in aviation.

2. The main focus of the H2Fly is the development of an everyday, emission-free drive for the general aviation with a long range by using Hydrogen Fuel cell technology. The necessary cross-country communication is very important for the success of this multinational EU project. With our efforts we try to build a team of ideas to overcome these hurdles and to develop this important technology together.With the extensive experience of the H2Fly in the development of climate-friendly hydrogen fuel cell drives for aviation, we try to give our partners clear specifications and requirements in the field of system design and solutions for safety issues without losing sight of the economic wishes of an industrial company. The mail goal for the H2Fly for this year is to bring the technology to a level, that it is able to integrate into the aircraft Hy4. The challenges with the documentation, the implementation of the mitigation actions from the safety issues and the certifiability of the system will motivate us to show the public what is possible with teamwork.

3. Today, the H2Fly is already able to transport 4 people emission free from A to B. This enables the hydrogen fuel cell technology which is installed in the Hy4 and will be revise and improve in Heaven project. The endurance which will be achieved due to the liquid storage technology will be impressive.

With a upscaled drive, which based on one which will be developed in this project, we can think about to transport 70 passengers over 1000 km, completely free of pollutants and quietly, without having to compromise on range or refueling times for aircraft operators. With this project, the H2Fly form the basis for the future development of larger, more climate-friendly engines for general aviation. It is the responsibility of our generation to ensure that in the future as many people as possible will live on a healthy earth and be able to be mobile in a climate-friendly manner.

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DLR

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1. The role of DLR in the HEAVEN project is the system designer, developing a high-power fuel cell system fuelled by liquid hydrogen for an electric powertrain of a 4-seater aircraft, the Hy4. To that end, DLR is in charge of the conceptual design of the overall architecture of the powertrain, the development of the high-power fuel cell system and the systems coupling.

In this regard, during 2020 different milestones have been achieved. The conceptual design of the overall powertrain has been determined, as well as the functional requirements and technical specifications. In addition to that, the conceptual design of the fuel cell system and the drive train have been also designed.
Besides, in order to ensure safety operation to flight operation and conditions, the hazardous and catastrophic events on fuel cell and hydrogen storage level have already been determined by means of the failure hazard assessment.
In concern to the system development a short stack fuel cell test rig has been developed at the laboratory. The design, selection and acquisition of the components has been carried out, as well as the finalization of the building up and the commissioning of the test rig, identifying the control loops and control variables, as well as the operation strategy.

2. The next work will focus on the fuel cell system development, including the selection and determination of the balance of plant components and their assembly to a full-scale system. In addition to that, the operation strategies will be determined and the system controller will be developed. The challenge is to reach a Fuel cell system with high performance and robust operation ability. For this we are in close exchange with the Stack Developer and Partner Elring Klinger.

Besides, the hydrogen buffer tank architecture will be finalized and there will be work related to the different system coupling of the Fuel cells with the Batteries and the LH2-Tank and their testing. To those purposes, in order to constant feedback and periodic technical meetings will take place with the other partners of the project.

3. According to the Flightpath 2050, the Europe's vision for aviation, by the year 2050, the technologies and procedures available will have to allow a 75% reduction in the carbon dioxide emissions per passenger kilometer, a 90% reduction in the nitrous oxide emission and the perceived noise of flying aircraft reduced in a 60%. Furthermore, taxiing, the movement of aircrafts on the ground, should be emissions free. Although these are really very ambitious goals, we consider that the technology is here and that it is possible for up to 100 passengers to fly 1000km in a zero-emission aircraft. In the Heaven project we are developing an electric powertrain for a four-seater aircraft, the Hy4, that will fly powered by fuel cells and liquid hydrogen. The Hy4 will demonstrate that this technology is ready to fly without burning fossils fuels and that it is possible to scale up the technology for passenger aircraft.

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1. In 2020 PVS focused mostly on system integration and safety assessment. One of the biggest challenges is the design of the modifications to the aircraft structure needed to integrate the liquid hydrogen tank designed by ALAT. This required careful consideration of the available space, possible conflicts with other systems without compromising structural integrity or increasing the overall aircraft weight excessively.

Safety assessment is a crucial part of the design process to make sure that the design of each system accounts for the effect of their failures and how these interact and propagate at aircraft level.

2. 2021 sees the start of the effort for the design of the integration of the fuel cells developed by DLR and EK and the necessary airframe modifications. Logistics and planning for system coupling and integrated systems tests will also be part of this year's effort for PVS.

3. Hydrogen-based propulsion answers the non-negotionable societal and environmental requirements for zero-emission quiet and community friendly aviation. When applied on the small aircraft and miniliner segments, liquid-hydrogen based energy storage coupled with next generation of fuel-cell systems could deliver a commercially viable airplane product with an entry into service around 2030, with capability of operating multiple segments before refuelling. We are bullish to initiate clean-sheet airplane designs that further enhance the technology capabilities researched in HEAVEN.

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1. For EK a major aspect was the development and conceptual design of the next generation NM5 fuel cell stack support which is a major step towards a more robust and user as well as industrialization friendly design. The stack support allow simpler implementation of the stack into a system environment and a number of further advantages, particularly in the area of system suspension. The new design also allows for stationary media-, power- and data interfaces which reduce complexity for the system integrator tremendously

2. For 2021 the challenge will be to realize the first prototypes of the new NM5 Evo design, to test them and to supply the stacks to the project partner for system integration. Given the corona context presence in the lab and related work can be difficult and will be challenging for the consortium as a whole.

3. ElringKlinger adopted early on a development strategy for a broad variety of zero emission drive train technologies. Within the focus of this strategy fuel cell stacks with an extremely high power density were developed and industrialized. In view of current legislative and societal requirements and the perspective of Hydrogen to become one of the key energy carriers, ElringKlinger is ideally positioned to meet future challenges. One of the main fields of application for fuel cell technology on the short run will undoubtedly be heavy-duty transport. The developments in this field can be observed in the EU-project "H2Haul" in which ElringKlinger is one of the fuel cell supplying partners.

Considering the future of air transport: EK has entered in October 2020 into an agreement with Airbus for a long-term partnership within the area of fuel cell technology.

Interview with Enrique Girón

"It is the first time that a fuel cell and a liquid hydrogen tank have been included in a piloted platform, and this give us an advantage over other initiatives"

Enrique Girón is project manager at FCH JU, a unique public-private partnership supporting research, technological development and demonstration activities in the field of fuel cells and hydrogen.

From a transport perspective, what is the European Commission's strategy to effectively tackle the fight against climate change?

The European Commission has established a plan to decarbonize all transport by 2050, with gradual objectives. Aeronautics only has three alternatives: SAFs (low emission fuels), , e-fuels and hydrogen, each with a different problematic but only one with zero CO2 inflight emissions. Even with hydrogen, if you burn it, you produce NOx and the typical contrail seen behind airplanes. The best system under development is the fuel cell and hydrogen system, but this innovative and disruptive solution requires technologies that are not yet available with the required performances.

What projects are on the table that undertake this enormous task?

The EU, through two agencies, Clean Sky Joint Undertaking (CS JU) and Fuel Cells and Hydrogen Joint Undertaking (FCH JU), is clearly promoting these technologies. In Heaven a modular fuel cell that will adapt to aeronautical requirements in terms of power density is being developed; and it is one of the first attempts to include a liquid hydrogen tank in an airplane (the Hy4, designed by DLR, based on the Taurus G4, manufactured by Pipistrel). These two systems must be brought together to communicate, ensuring that the hydrogen arrives to the fuel cell at the correct flow, temperature and pressure. There are a lot of interfaces that need to work together. It is a first step towards reaching the goal of having a flight demonstrators for regional (short haul) aircraft by 2028. The study commissioned by CS JU and FCH JU showed that for airplanes of up to 1,000 km and 100 passengers, the liquid hydrogen and fuel cell combination could be used, and is economically comparable with other zero-emission alternatives. If the distance is greater, the use of fuel cells is more challenging and it will probably need to be combined with or replaced by hydrogen burning turbines.

In this context, what is the added value of projects like Heaven?

To my knowledge, it is the first time that a fuel cell and a liquid hydrogen tank have been combined in a piloted platform, and this gives us an advantage over other initiatives. There are other hydrogen aircraft under development but they all use compressed hydrogen and some combine it with internal combustion engines (e.j. ZeroAvia, from the USA). The goal of the EC is for all projects to have a commercial exploitation plan. Elringklinger develops the fuel cell and Air Liquide the hydrogen tank; hopefully they will be able to sell these developments in the future to aircraft manufacturers or to their suppliers.

Beyond aviation, what is the EC's strategy to make transport a more sustainable industry?

Within the FCH JU program there is a very powerful project for light vehicles (H2ME) and city buses (JIVE). The following steps are being aimed at hydrogen trucks, which take advantage of the fuel cell and hydrogen for its better range performance and lower weight. There is also a commitment to the development of emission-free trains, so that when they leave the catenary they are propelled with fuel cells and hydrogen. Likewise, there are several maritime projects, where perhaps the more pressing question is whether to use pure hydrogen or combined with other elements such as ammonia or Liquid Organic Hydrogen Carriers (LOHC).

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