Flying Green: Work in Progress

Author: **Christian Keszthelyi**

Hands are itching to flip the switch to sustainable operations in the aviation industry. Gargantuan research efforts and money are being invested into developing green planes, and while the outlook is positive, changes shall only take off in the mid to long term. **THINK** *talks to* ***Dr Robert Camilleri*** *and* ***Aman Batra*** *about industry expectations and their current research.*

As a senior lecturer within the Institute of Aerospace Technologies at the University of Malta (UM), Dr Robert Camilleri oversees research projects, chiefly focused on greener aviation technologies. Hybrid planes should be a logical solution, but the challenges are gigantic, as Aman Batra, a research support officer and PhD student with the Institute of Aerospace Technologies at UM, says.

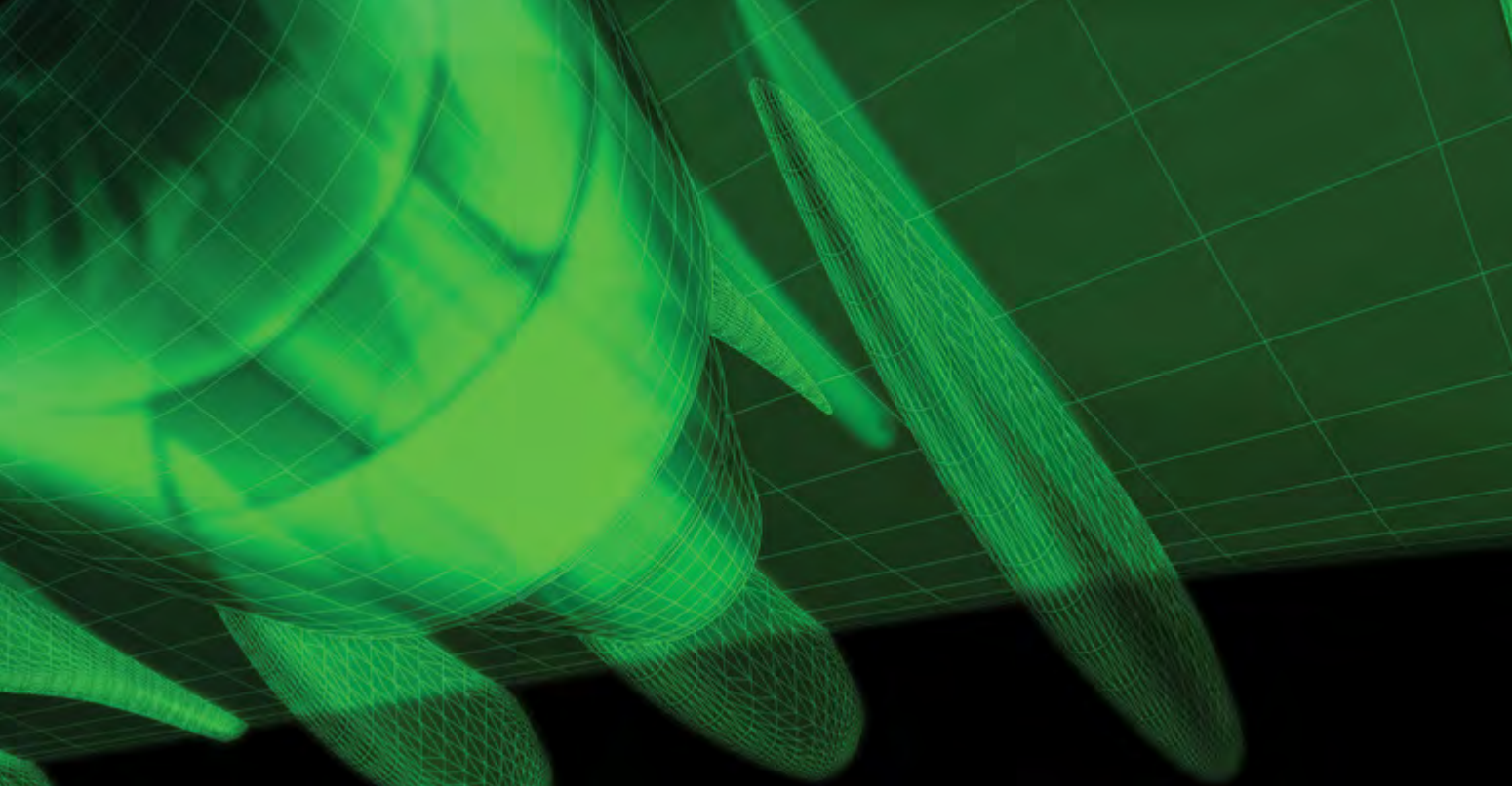
While a greener aviation industry would deliver immense added value towards a net-zero future, the global industry's carbon emission weight is yet tiny: 2-3%, when vehicles on the roads could cut a 9-15% slice out of the global pie, Camilleri tells **THINK**. But this highly resilient industry, which performed a quick rebound after the tragic events of 9/11 and the COVID-19 grounding, will grow more prominent. 'Only 10% of the world's population has access to air-bound travelling. However, as more countries come out of poverty, the impact of aviation on the environment is bound to increase,' Camilleri says. This will boost the carbon emission weight of aviation significantly. It is time we made it greener.

CUTTING EMISSIONS

The European Union is also aware of the industry's nature. As one of the fastest growing sources of greenhouse gas emissions, the European Union is allocating significant funding towards the aviation sector to reduce emissions by at least 55% by 2030, descending to 1990 levels. But how do we do this?

Let us first understand how we power aircraft. The most common way of flying is kerosene-fuelled jet turbines with a high power-to-weight ratio. As a specific technology, turbines are immensely powerful; every turbine has three rows of 72 blades – one blade generates the power of a formula one car. The performance is massive.

'The beauty of the gas turbine is that it condenses all of that ability to generate power in a fairly small device [when compared to the plane]. But it generates emissions: CO_2 and carbon monoxide – and also several NOxes: nitrogen oxides and nitrogen dioxide. These pollutants contribute to climate change, cause acidic rain, and speed up overall global warming,' Camilleri says. Cutting back on these emissions with new technology is welcome and needed, but challenging.



HYDROGEN'S PROMISE

Hydrogen is emerging as a possible substitute for kerosene. Should we use hydrogen, the underlying technology that lifts a plane into the air would remain roughly the same. As much as hydrogen is a tempting alternative, there are serious challenges relating to the production, shipping, and storage of the chemical.

Hydrogen is generated from water electrolysis; an electrical current is driven through the water to separate the H_2O molecules into building blocks. For this, we need to use seawater instead of freshwater to not push the use of drinking water out of balance in a world where 2 billion people lack access to safely managed drinking water at home. Once energy starts going through the water, it must be generated from renewable sources. If it is not, hydrogen production would leave an immense carbon footprint.

Hydrogen is also very inefficient to store in gas format as it occupies a lot of space. Therefore, it needs to be turned into liquid form, which requires it to be cooled and maintained to -252 degrees Celcius, which further energy. The trade-off of generating hydrogen and turning it into liquid form for better storage and shipping might outweigh the benefits of using it as a fuel to fly planes.

Let us suppose all these challenges were met and we have a distribution network of green hydrogen setup. 'The final part of the puzzle is that the aircraft itself needs to be modified to host the storage tank and the gas turbine itself needs to be able to burn hydrogen, which burns at a different rate when compared to kerosene. The change will not happen quickly. We need at least 50-70 years to build the entire infrastructure to have enough renewable energy to kick-start hydrogen production, which sustains aero transport,' Camilleri says.

HYBRIDISING AVIATION

This is where the UM's Iterate Project plugs into the big picture to offer a short-to-mid-term solution that would bridge the gap between emissive aviation today and the net-zero future. Ideally, the transition should be similar to the introduction of hybrid cars in the early 2000s, when Toyota first came out with the Prius. 'Back then, people already knew that road transport would end up moving towards electric vehicles, but we did not have the technology. Therefore, Toyota started creating hybrid vehicles (vehicles that use more than one means of energy, for example combining a diesel engine with an electric motor) to offer a greener alternative to internal combustion engines. Our project is looking at the possibilities of establishing a methodology to create the first "Toyota Prius" for aviation,' Camilleri says.

The project looks into different scenarios of combining existing aero technologies such as gas turbines with an electric powertrain, hence the idea of a hybrid plane, to ensure that less fuel is burnt and a smaller carbon footprint is left by flying. As taking off consumes

Dr Robert Camilleri
Photo by James Moffett

> *Until batteries enable completely electric flying, we are looking into establishing hybrid solutions of both fuel and electricity to traverse a highly emissive era of aviation to a close to net-zero future.*

most of the energy during a flight, a possibility would include using gas turbines for take off, whilst cruising could utilise electric drives. Today, this approach seems feasible for smaller, regional flights – not for long-haul flights yet. But an electric drive means batteries. And batteries bring with them steep challenges.

For one thing, batteries have 40 times less energy density than fuel. Therefore a battery-powered plane would be heavy. If a plane were to carry batteries, proportionally, a 70-seater jet would need to be shaved to a 20-seater to accommodate the heavy load of batteries. The Iterate Project also looks into the feasibility of reducing the number of passengers from a business perspective. What level of aircraft hybridisation would balance the environmental and social corporate responsibilities of airlines with the economic demands?

Batteries raise another question: how do we charge them quickly? Airlines are incentivised to spend as little time aground as possible. If an aircraft gets stuck on the ground charging, it is not being utilised: hard cash cutting into profits saved on green flying. Charging must be quick and powered by renewable sources for an electric or hybrid plane to be cost effective. These scenarios create further challenges.

'First of all, if you are charging the aircraft, you are also using the current grid, which must be powered by renewable energy in its entirety to reduce pollutants. Second of all, in fast charging, batteries will overheat. Proper technology has to come to the surface for cooling the batteries to enable quick charging,' Camilleri adds.

Empirical evidence suggests that the energy density of batteries improves by 3% every year. This is a far cry from the revolution we saw in electronics, which followed Moore's Law that the number of transistors in a dense integrated circuit doubles every two years.

'The importance of batteries is yet to be understood by the wider public. If we talk about green transport or any other industry where you want to store energy, you need a battery or other types of energy storage components. This aspect has great potential, therefore increased funding and research are going into this field. We expect energy density to increase. Until batteries enable completely electric flying, we are looking into establishing hybrid solutions of both fuel and electricity to traverse a highly emissive era of aviation to a close to net-zero future,' Batra says.

The authors would also like to acknowledge the project: "Setting up of transdisciplinary research and knowledge exchange (TRAKE) complex at the University of Malta (ERDF.01.124)" which is being co- financed through the European Union through the European Regional Development Fund 2014 – 2020. www.eufunds.gov.mt

Further Reading:

European Commission (2022, August). *Aviation and the EU ETS*. Climate Action https://ec.europa.eu/clima/eu-action/european-green-deal/delivering-european-green-deal/aviation-and-eu-ets_en