Aircraft interiors INTERNATIONAL

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In this issue

INSIGHT: BUNK SEATS
Enhancing passenger space without reducing seat count: is the only way up? Experts explore the prospects for bunk seating returning to the skies

ANTENNA ADVANCES
Following delays in the development and rollout of several next-generation antennas, significant progress is now being made towards faster and more efficient inflight connectivity

INTERVIEW: DELTA
Allison Ausband, Delta's EVP and chief customer experience officer, discusses industry recovery, sustainability and post-pandemic travel

AIRCRAFT INTERIORS EXPO 2022

SHOW ISSUE

The world's biggest cabin event returns to Hamburg this year! Enjoy a preview of the hottest launches

2030s cabin design

EXCLUSIVE: WE DELVE INSIDE THE FLYZERO HYDROGEN CONCEPTS, AND FIND SUSTAINABLE CABINS THAT WILL INSPIRE THE INTERIORS SECTOR AND HAVE AN EVEN WIDER IMPACT ON AVIATION

fly zero

A CONSORTIUM OF UK AVIATION BODIES AND EXPERTS IS COLLABORATING ON A FAMILY OF AIRCRAFT DESIGNED TO HELP THE INDUSTRY ACHIEVE NET-ZERO 20 YEARS AHEAD OF IATA'S 2050 TARGET. LET'S DELVE INTO FLYZERO, A FUTURE VISION OF SUSTAINABLE AIRCRAFT AND CABIN DESIGN

Words by Marisa Garcia

For environmental and economic reasons, the airline industry urgently needs to cut its reliance on fossil fuels. For decades, the industry has been taking steps toward being more fuel-efficient in order to address rising fuel costs. This urge to save fuel has spurred innovation, leading to new aircraft and engine programmes, the development of lightweight materials and structures, and a rethinking of cabin design, prioritising lower weight and optimal space usage while ensuring passenger comfort and reducing waste. That economic pressure continues as the aviation industry adjusts to the effects of the pandemic and the recent spike in oil prices. Few industries would benefit as much as aviation from having more environmentally friendly and efficient operations, but what is the best way to achieve these aims?

IATA projects that demand for air passenger journeys in 2050 could exceed 10 billion. That level of demand

"FlyZero's goals are lofty, but if successful, they will help shape the future of global aviation"

ABOVE: A PREMIUM ECONOMY CABIN CONCEPT FOR THE LONG-HAUL MIDSIZE AIRCRAFT

would require the aviation industry to mitigate 21.2 gigatons of CO_2 between now and 2050 in order to meet the Fly Net Zero commitment passed during the 77th IATA Annual General Meeting, held in Boston in October 2021. To cut that level of emissions, IATA believes the industry needs alternative tools, including advances in alternative sustainable aviation fuels (SAF), new technologies, and carbon offsets.

Could commercial aviation do better by aiming for zero CO_2 emissions flights? The UK has stepped up to the environmental challenge by supporting the ambitious FlyZero programme, exploring technologies that can sustain true zero CO_2 commercial aviation by 2030.

Led by the Aerospace Technology Institute (ATI) and funded by the UK government's Department for Business, Energy & Industrial Strategy (BEIS), the 12-month FlyZero strategic research programme assembled national experts to study the design challenges, manufacturing demands, operational requirements and market opportunity of potential zero-carbon emission aircraft concepts. The FlyZero programme also has the support of leading companies and institutions in aviation and beyond, including Airbus, Rolls-Royce, GKN Aerospace, Spirit AeroSystems, GE Aviation, Reaction Engines, NATS, easyJet, Belcan, Mott Macdonald, Eaton, High Value Manufacturing catapult (MTC), and Capgemini.

Leading the development of the cabins and passenger experience was Ben Orson, founder of specialist design agency, Orson Associates, with support provided by Cranfield University and Central St Martins University.

FlyZero's goals are lofty, but if they prove successful, they will help shape the future of global aviation, putting the UK at the forefront of sustainable flight in design, manufacture, technology and skills. And the benefits extend beyond the UK: the FlyZero programme's research and creativity could seed future success in alternative energies, new aircraft, and sustainability programmes for the global aviation industry.

THE OPTIMAL FUEL

From the early stages of the project, FlyZero has focused on liquid hydrogen as the optimal fuel for future flight. Hydrogen supplies three-times the energy per kilogram of fuel as kerosene, about six-times that

SUSTAINABLE MATERIALS

The FlyZero team has delved into the topic of sustainable cabin materials, including both structural elements (ceiling and sidewall panels) and the large variety of non-structural furnishings used in cabin interiors.

Alternatives have been found for many materials, including bio-derived plastics and composite reinforcements that can replace fossil-derived incumbents. Grape waste leather could be used in seat covers and a bio-elastomer material applied on armrests and other touchpoints without sacrificing comfort. Aerogels could act as a structural thermal and noise insulator, which the team say would outperform any other existing material in the combination of these properties, replacing sidewall insulation blankets and increasing usable cabin space.

of ammonia, and around sixty-times that of a battery. The project's findings suggest that this fuel source is well-suited to powering a new generation of zero-carbon emission commercial aircraft, including long range, high-capacity designs that were previously felt to be unfeasible.

However, the FlyZero programme also explored the development of battery capability and hybrid options incorporating fuel cells, batteries and electric motors, as they present advantages for regional and sub-regional air travel. Batteries would also provide auxiliary power.

Though promising, liquid hydrogen as a fuel source presents unique challenges, including storing and distributing cryogenic fuel at -253°C on board. Operationally, FlyZero requires the development of technologies for stable and reliable hydrogen combustion in gas turbines. The FlyZero programme also needs to find means of efficient energy conversion and thermal management of hydrogen fuel cells and hybrids, and to minimise other climate impacts of hydrogen use, such as NOx and contrails. Logistically, there will be a need to develop a sustainable hydrogen fuel production infrastructure. Out of respect for the laws of aerodynamics, the programme also needs to minimise the mass and drag inherent in the aircraft structures.

It might all be too much, or it might be beautiful.

AIRCRAFT CONCEPTS

These challenges shaped the 27 scout aircraft concepts developed early in the project, and then the three final airframe designs considered most viable for various commercial aviation needs.

The long-haul Midsize aircraft benchmarks against the Boeing 767, with accommodation for 279 passengers, and a range of 5,250nm – sufficient to connect any two points on the globe with just one stop. The short-to-mid-haul Narrowbody concept benchmarks the A320, with space to accommodate over 180 passengers in one class of service, and a range of over 1,500nm. The Regional concept benchmarks the ATR 72, being able to carry 75 passengers at similar speeds and comfort as today's regional aircraft, with a cruise speed of 325 knots and a range of 800nm.

Of the three aircraft concepts, the FlyZero project expects to see the most significant positive impact from targeting at least narrowbody aircraft size and capability – the category that accounts for 51% of aviation's carbon emissions. By comparison, widebody operations account for 42% of emissions, and regional for 7%.

LEFT: THE REGIONAL CONCEPT BENCHMARKS THE ATR 72, AND IS INTENDED TO CARRY 75 PASSENGERS UP TO 800NM

BALANCED *ideas*

The Midsize FlyZero concept could carry up to 279 passengers globally in just one stop. The liquid hydrogen is stored in cryogenic fuel tanks at -253°C in the aft fuselage and two smaller 'cheek' tanks along the forward fuselage. The cheek tanks also serve to keep the aircraft balanced as the fuel burns off, and eliminate the need for any additional aerodynamic structures.

"Larger-diameter fuselages offer new opportunities"

"Each of these concepts has unique requirements on the fuselage that drive the cabin configuration," explains Malcolm Foster, chief aircraft designer on the FlyZero project. "The regional version is a fuel-cell-powered high-wing aircraft that needs as short a cabin as possible, driving a five-abreast seating configuration rather than the traditional four-abreast.

"The narrowbody is perhaps the most unusual, with large hydrogen tanks, aft-mounted engines, and an unusual aerodynamic configuration, including a low-drag laminar airflow fuselage that tapers from 3.5m diameter at the front of the cabin, to 5m diameter at the rear pressure bulkhead," adds Foster. "The large aft diameter is specifically a benefit of the large hydrogen tanks in the tailcone. Finally, the mid-size proposes a new concept of single-hop global travel, necessitating a wider, more open cabin than is normally experienced in this size class."

ABOVE: A VISION OF BUSINESS CLASS IN THE MIDSIZE FLYZERO AIRCRAFT. THE CABIN IS DESIGNED FOR PRODUCTION FEASIBILITY

INSET: BEN ORSON IS LEADING THE DEVELOPMENT OF THE FLYZERO CABIN DESIGNS AND PASSENGER EXPERIENCE

One of the critical targets for the programme was to ensure that zero-CO_2 aircraft technologies would be a match for the best conventional aircraft available in the 2030 timeframe.

Ben Orson led the cabin development work for the project, providing insights into the practical requirements of passengers and commercial airlines, which have helped inform the aircraft designs.

A SEISMIC CABIN SHIFT

The FlyZero team developed cabins for the final three concept aircraft, with designs that could accommodate established interior products while also offering opportunities to make the interiors as environmentally sound as the aircraft itself. The project embraced practical solutions to creating more sustainable cabins, while leaving room for innovation. A key objective of the cabins team was to ensure that airlines won't have to compromise on their branding flexibility or the passenger experience with a FlyZero aircraft.

"The environments we have created offer greater flexibility and scope than you would expect from an aircraft in each class," Orson explains. This is because larger-diameter fuselages offer cabin designers new opportunities to use space.

"FlyZero's aircraft offer five-abreast seating where you might expect to see four-abreast, and twin-aisle cabins where you might expect a single aisle," Orson adds.

We have seen many alternative cabin concepts over the years, but most have been mere curiosities. The

Think ahead

The FlyZero panel believes that some of today's methods of designing cabin products could have a more sustainable lifecycle. The team says that the heavily branded (operator-specific) designs, the complexity of designs, an industry reliance on materials that are difficult to recycle, and passenger expectations for product updates, means that interiors are challenging to resell, reuse or recycle.

FlyZero proposes that a lifecycle analysis should be conducted in the initial phases of any new cabin design project, with consideration given to how best to mitigate probable end-of-life scenarios. The team says this approach would enable improved sustainability and place less of a burden on airlines, leasing companies and aircraft dismantlers.

"These concepts are feasible and will be with us sooner than we might expect"

FlyZero team, on the other hand, have only created cabin concepts they feel are truly viable.

"We wanted credible, market-ready solutions aligned to the very grounded and engineering-focused technical work of the teams working on the systems and airframes," Orson explains. "Many aspects of the cabin concepts look relatively conventional, and that was the intent. We didn't want distractions from the key message of the project, which is that these aircraft concepts are feasible and will be with us sooner than we might expect."

And yet, there are clear advantages for airlines in these interiors. For example, in the regional aircraft concept, there is room for more extensive luggage storage. The narrowbody aircraft is wide enough at the back, thanks to its unique shape, to accommodate twin aisles, which would speed-up boarding and deplaning.

All three concept aircraft feature micro-LED ceiling panels for illumination, rather than the usual lighting strips. This lighting offers a unique aesthetic, with options for lightweight dynamic signage for seat numbering, crew call and fasten seatbelt signs, and similar features. The panels could also be used for immersive branding or advertising to generate additional revenue streams.

"It is for the airlines to decide what they wish to do within these spaces, but compared to the aircraft we benchmarked against, it is notable that the FlyZero equivalents are more spacious and better suited to novel architectures than their conventional equivalents," Orson states.

"FlyZero has demonstrated an exceptional commitment to the cabin and the passenger experience for such a technologically focused project," he adds. "This is partly to ensure that the design is as appealing for passengers to fly in as it is revolutionary in terms of sustainability. However, we also wanted to explore every aspect of sustainability in aviation, not just eliminating CO_2 emissions. We spoke to a number of airlines during the project and have taken advice on the loading and

LEFT: A LIGHTWEIGHT ECONOMY-CLASS SEAT CONCEPT FOR FLYZERO

BELOW: THE UNIQUE SHAPE OF THE NARROWBODY FUSELAGE ENABLES THE OPTION OF A TWIN-AISLE CABIN

NATIONAL BENEFIT

If it goes ahead, the FlyZero project could bolster the UK's aircraft interiors industry. FlyZero research estimates that the cabin sector is responsible for between 5% and 10% of turnover in the UK aerospace industry.The UK supplies at least 7% of the world's aircraft interiors, including over 30% of all seats, with UK companies able to design and supply almost every component of a cabin. The UK is also home to around one-third of the world's specialist cabin design agencies.

The Aerospace Technology Institute (ATI) estimates there are over 250 suppliers in the UK involved in aircraft interiors, with a combined turnover exceeding £2.0bn, supporting more than 6,000 jobs.

unloading of passengers, accommodating passengers of reduced mobility (PRMs), requirements for cargo, crew arrangements, and a host of other points."

For the PRM considerations, Chris Wood, an aviation accessibility consultant and founder of Flying Disabled, provided specialist guidance on accommodating PRM passengers. Flying Disabled is competing in the 2022 Crystal Cabin Awards with Air4All, a system that allows PRM travellers to use their own wheelchair on board.

Reactions to the FlyZero concepts have been positive. "We've had a great reception from airlines, which have seen the advantages of the new designs," Orson says. "For example, compared to the benchmark A320, the wider fuselage of the FlyZero narrowbody, with its twin aisles, mid-cabin entrance zone and 40% increase in overhead bin capacity, provides a huge operational benefit in reducing boarding and deplaning times. Our digital simulations indicate an 18% reduction in these times when compared with an A320."

ABOVE: PAUL DE'ATH, COURSE LEADER FOR INDUSTRIAL DESIGN AT LONDON'S CENTRAL ST MARTINS COLLEGE, GAINED INTERESTING SUSTAINABILITY INSIGHTS AND VIEWPOINTS FROM HIS STUDENTS

SUSTAINABLE DESIGN

FlyZero gives aviation an opportunity to reinvent itself for a greener future. The programme has considered every aspect of the cabin to create greener alternatives, with findings that could be valuable for many other programmes.

As Orson points out, "The most powerful lever that we have to enhance sustainability performance today is reducing the weight of cabin furniture. The weight of the cabin accounts for around 10% of an aircraft's total weight, and weight has a direct relationship with fuel burn. The next greatest opportunity is to limit the resource

"We've had a great reception from airlines, which have seen the advantages of the designs"

consumption and waste creation inherent in the manufacture, maintenance and disposal of cabin products by applying circular product lifecycle principles. The aircraft cabin sector lags a long way behind other industries such as automotive when it comes to applying basic measures – marking materials to enable easier recycling, for example. Around 75% to 80% of a car is recycled at end-of-life. For an aircraft cabin, this figure is around 45% to 50%."

It is timely to think about sustainable aviation throughout the lifecycle. Too often, the aviation industry has relied on iterations of proven designs, which are justifiable in terms of immediate costs and lead times, but which ignore the lingering cost impact of legacy materials and processes.

"There are so many plastics derived from fossil resources, which exhibit high toxicity during manufacture, and are difficult to recycle or safely dispose of at end-of-life," Orson points out.

This issue is often compounded by the presence of fire-retardant additives. More challenging perhaps are materials like carbon fibre. On the one hand, such materials offer compelling weight reduction potential. But on the other hand, they are derived from fossil resources, require a great deal of energy to manufacture, create high levels of production waste, and are very difficult to recycle in ways that retain their original value.

"Aluminium is especially prevalent in aviation, but the impact of its extraction is considerable. Recycling a kilogram of aluminium requires only 5% of the energy of creating virgin aluminium, but supply and certification issues presently limit its consideration," explains Orson. "The aramid panels that make up our sidewalls, overhead bins, flooring panels and seat shells are also currently impractical to recycle in any meaningful way."

TOP: THE 3-2 REGIONAL CABIN

ABOVE: MALCOLM FOSTER, CHIEF AIRCRAFT DESIGNER

BELOW: THE HYDROPONIC SKYGARDEN IN THE NARROWBODY BOARDING AREA IS ALSO A SOURCE OF PRODUCE FOR INFLIGHT MEALS

"Technology will have a role to play in creating greener cabins, which was a key element of our research," he adds. "It's impossible to ignore the value of weight reduction, so technologies that enable a saving are top of the list. In this area, the potential of combining approaches such as generative design and topology optimisation to create more efficient structures, further amplified by advances in metallurgy and additive manufacturing, is extremely exciting," Orson continues.

"Sustainability in the cabin industry is in its infancy compared to other industries. There are several 'low-hanging fruits' that we can access for near-term, high-impact advancement," he adds.

For example, simple measures such as material identification marking would greatly boost the cabin recycling industries. And new digital tools are required that will enable designers to make credible, evidence-based assessments of multiple design options in terms of sustainability, in ways that do not compromise their workflows. Lifecycle Assessment (LCA) can empower designers to make more responsible decisions, but its cost, complexity and unfamiliarity to manufacturers and their customers hamper its uptake in the industry today.

One of the more exciting opportunities of the FlyZero project is to reduce fossil fuel expenditure in propulsion and boost the sustainability of the entire aircraft throughout its lifecycle, both outside and inside the cabin. The environmental benefits will be substantial, even if only a few lofty sustainable design visions take wing.