ZAL MAGAZINE 2023

FUTURED

Future. Created in Hamburg.

FROM H_2 TO AI

Check out current research projects at ZAL TechCenter. And discover promising approaches that will change aviation soon.

WIFM? WHAT'S IN FOR ME?

Find out about ZAL's expansion: how the Open Hangar Space and the integration of a start-up ecosystem will affect collaboration at ZAL TechCenter.

PAPER OR DIGITAL?

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FUTURED.

ZAL MAGAZINE

['fjuːtʃəd]

FUTURED is an adjective … describing what
we do. We shape the future of aviation.
Every day. Together. The FUTURED magazine
is a part of this, showing what we strive
for, what we implement, and how we do it.
We are progressive, passionate, and visionary.
We are futured.

Future. Created in Hamburg.

Dr. Melanie Leonhard, Senator for Economics and Innovation in Hamburg, and Roland Gerhards, CEO at ZAL GmbH.

“WE MUST CONTINUE TO DRIVE INNOVATION”

Since the beginning of the year, Dr. Melanie Leonhard has been the first female senator to hold the office of the Ministry of Economy and Innovation. In this role, Melanie Leonhard is also an active member of the ZAL shareholders’ meeting, which means she plays a key role in steering the future and agenda at ZAL.

GERHARDS Ms. Leonhard, you have an affinity for maritime. As a historian with a doctorate, your work covered the history of the Rickmers entrepreneurs, a shipowning and shipbuilding family. What aviation issues will you be promoting?

LEONHARD Aviation – like maritime – is a key industry in Hamburg. Both contribute significantly to the prosperity of our region. Our goal is therefore to continue to be attractive for companies and skilled workers. To achieve this, we must continue to drive innovation. ZAL plays a central role in this. I consider the expansions with ZAL II and ZAL III as well as the stronger integration of start-ups via the Sustainable Aero Lab to be extremely important.

GERHARDS Politics, business, and science are pulling together in Hamburg. This is something that the international aviation community envies us for, as people keep telling me. But will that be sufficient? An innovative environment is of little use if people and know-how are lacking.

LEONHARD I agree with you there. We need more skilled workers, well-trained people who want to work and live in Hamburg. As a city, we are therefore working on the further development of our skilled labor strategy. It is clear that we must continue to make efforts and that the solutions are complex. However, there are already strong initiatives such as ProTechnicale and the NAT Natural Sciences and Technology program which show how we can attract more women and young talents, for example. But we will also have to make our focus more international.

GERHARDS A special challenge awaits us in the area of hydrogen. As a crucial element in the energy transition, all areas need to be staffed with infrastructure and specialist personnel. These range from production and storage to transport and application.

LEONHARD Yes, and I am convinced that the establishment of the ITZ, an innovation and technology center for aviation and maritime focused on hydrogen and fuel cells, can accelerate both issues: the development of hardware and know-how in parallel. A very good move, I think, from which ZAL will also benefit.

GERHARDS We have high hopes that the partial integration of ITZ Nord into ZAL will develop a boost for small and medium-sized enterprises and start-ups, so that previously interested players will dare to take the step in practice. We are also looking forward to the synergies that will result from the integration of maritime and aviation.

LEONHARD I feel the same way, there is still a lot of potential in this. We will only be able to implement complex topics such as emission-free mobility if we work together.

GERHARDS Allow me to finish with the question: assuming you’re traveling to New York – by plane or ship?

LEONHARD *(laughs)* On the way there by ship as the anticipation gradually increases during the time on the water. And on the way back by plane, it can be quick, because I also love being in Hamburg. ◂

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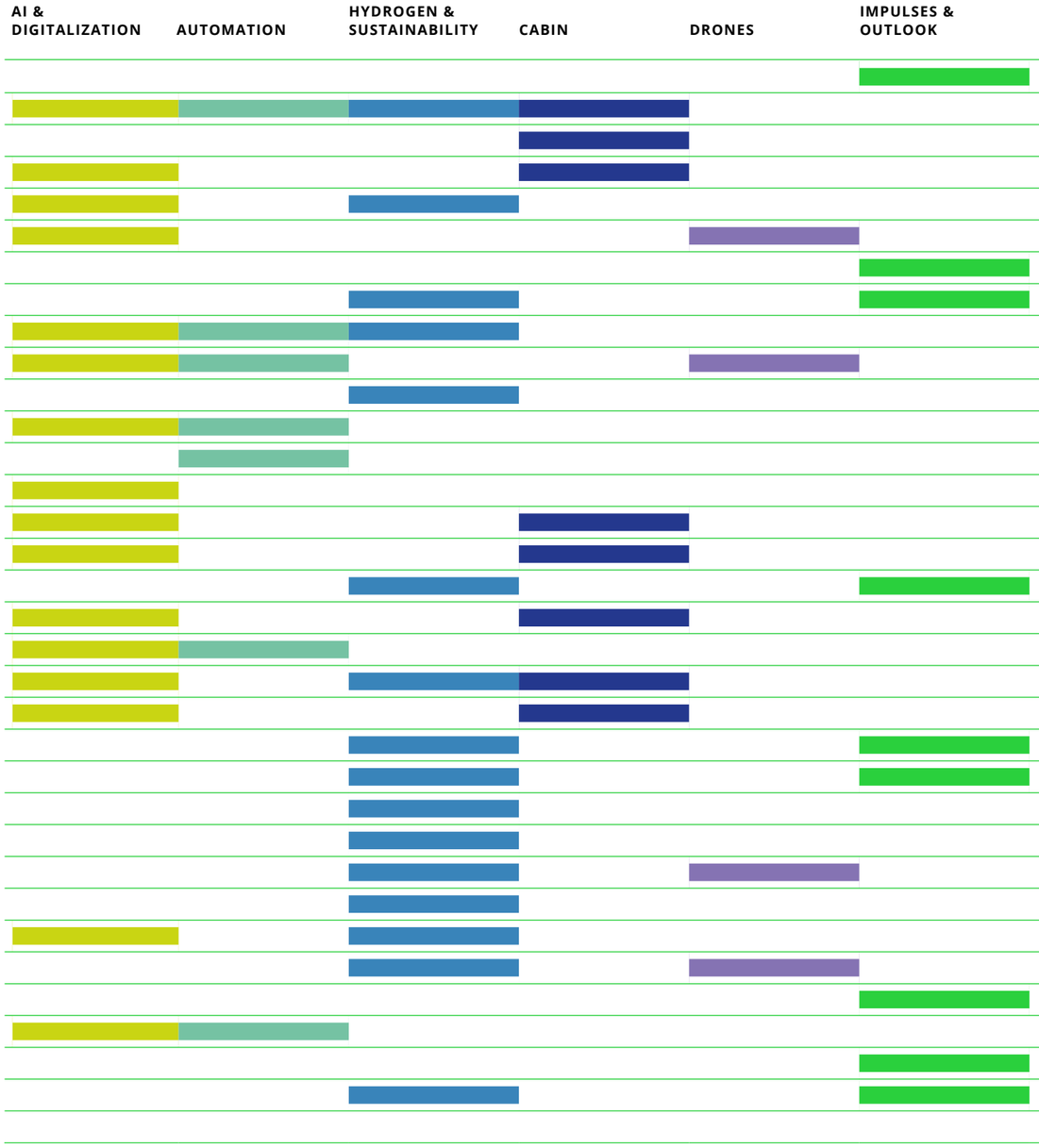


ZAL TechCenter is a regular host for school groups, students, and other future young professionals. We asked:

WHAT DOES AVIATION MEAN TO YOU?

Flying, even with rockets, allows people to explore the world.

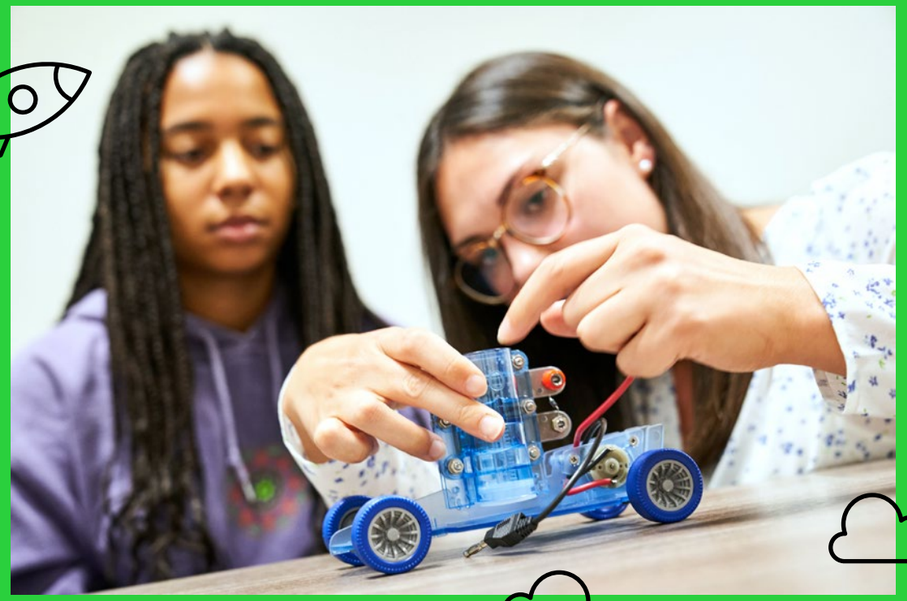
PER, 15

Why don’t we use solar energy when flying above the clouds?

ENRICO, 12

I’d rather not fly and protect the animals and nature.

IDA, 8



Aviation means fast mobility but also heavy environmental impact. Research is important to change that.

MATILDA, 16

Young visitors come to ZAL TechCenter as part of various initiatives: Mint/NAT, Girls’ & Boys’ Days, class trips, proTechnicale, Hamburg Aviation Young Professionals, DroneMasters Academy, New Flying Competition, and others.

Register now for ZAL’s annual Girls’ and Boys’ Day.

Aviation means: future, globalization, access to new countries and people, technology and innovation, hydrogen (hopefully soon). In addition, it takes up a large share of the economy. It is impossible to think of our world today without flying.

LUISA, 16

You’ll discover that the answers and statements are already influencing what we do at ZAL today. Just browse through the next pages to see what we mean.

Airbus CRT team in Hamburg.

DISRUPTIVE TECHNOLOGIES FOR THE FUTURE AIRCRAFT

Airbus Central R&T is Airbus Group's cross-divisional function for the development of "upstream" technologies in support of Airbus' technology strategy and consists of scientists and experts in five areas (materials, communications, artificial intelligence, electrification, and virtual product development). Its approximately 150 researchers are spread across Europe, with research labs in France, the UK, and Germany.

At ZAL in Hamburg, a team of 12 to 15 scientists and experts supported by interns and students work on topics related to communication, electrification, and virtual product engineering. Developments can be prototyped and investigated in the three laboratories, the Fuel Cell Lab, the Virtual Reality & Human Centered Technologies Lab and the Electronics Lab.

FUEL CELL RESEARCH

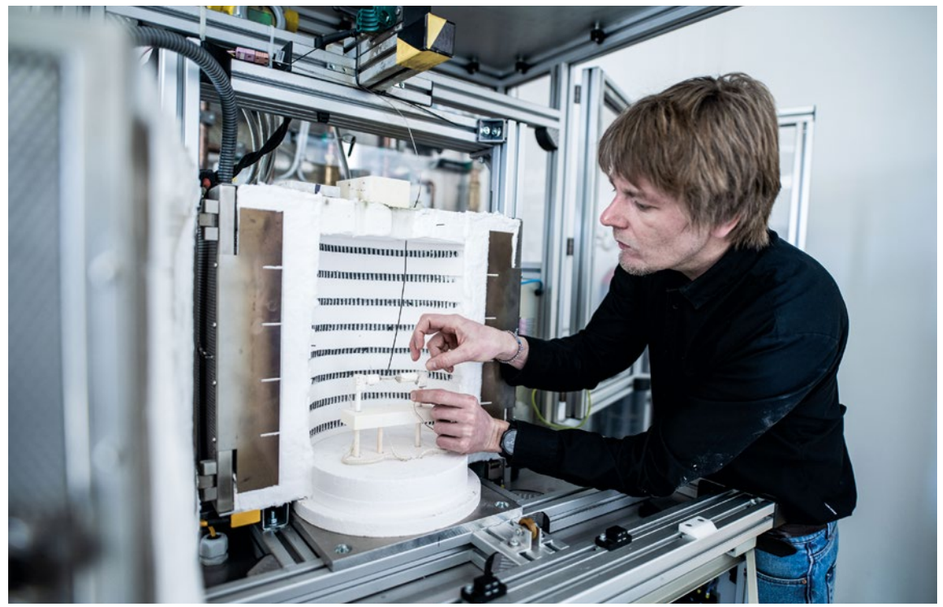
The main subject of the electrification group's current research is to work on the development of novel high temperature solid oxide fuel cell (SOFC) concepts. The technology offers a high potential to increase the electrical efficiency of newly developed aircraft propulsion systems, especially when coupled with a gas turbine, but even when implemented just as an APU system in any airborne vehicle. Additionally, the SOFC offers an increased flexibility for the supplied fuel, because it relies not only on pure hydrogen, but can also cope with lighter hydrocarbon-based fuels or maybe even SAF.

Originally developed for stationary power applications, the SOFC's technical readiness level, especially for large-scale mobile applications, i. e. aircraft, is low compared to the state-of-the-art fuel cell technology (PEMFC, baseline for the ZeroE program). The basic research is consequently focused on decreasing the fuel cell weight while maintaining or even increasing its power output. With the help of advanced numerical methods and additive manufacturing and current collection technologies, a new cell design is under development and experimentally tested (single cell test bench in the picture), which will be the core for a new type of high temperature (SOFC) fuel cell concept.

COMMUNICATION AND SENSING TECHNOLOGIES

The communication and sensing group identifies and researches novel technologies that impact the architecture and operation of future aircraft. The research activities involve identification of use cases, conceptual design studies including theoretical and numerical assessments as well as the development of technology demonstrators.

For example, the evaluation from 5G to 6G mobile radio communications will support connecting aerial vehicles to terrestrial and non-terrestrial networks offering new solutions for the passenger connectivity and aeronautical radio ▸



Airbus XRE Fuel Cell Testbed.

navigation, communication, and surveillance services. One of our tasks, in that regard, is to assess and contribute to these developments in cooperation with Airbus' internal and external partners.
Also, we are currently supporting Zero Emission efforts of Airbus by performing research on novel sensing solutions for liquid hydrogen propulsion systems. The figure below shows a demonstrator currently developed by the group to test new fill level gauging methods for aeronautical liquid hydrogen tanks.

METHODS FOR AIRCRAFT AND INDUSTRIAL SYSTEM DESIGN

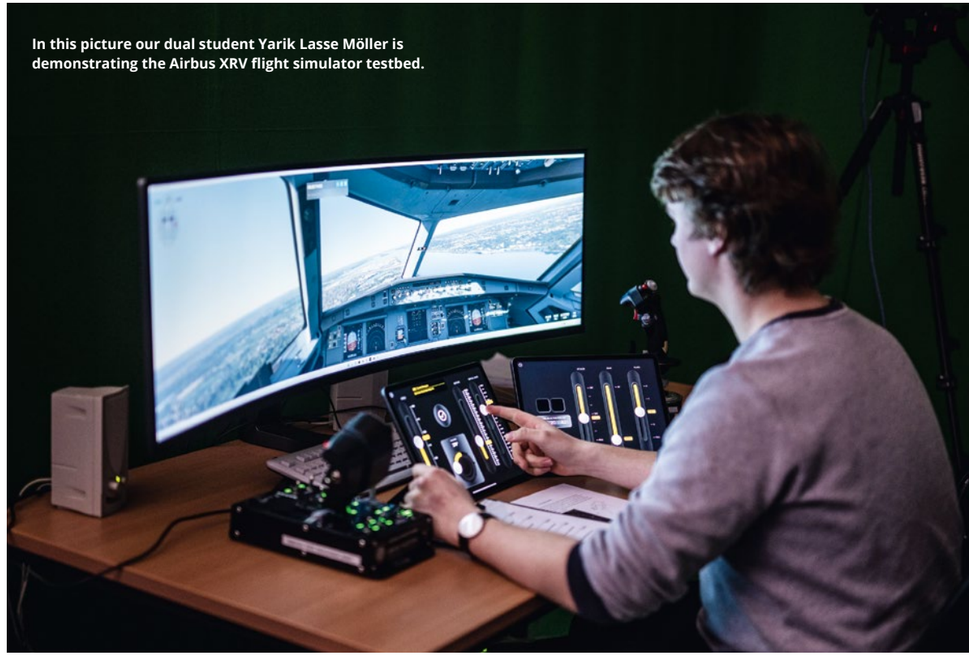
At the Virtual Product Engineering group we develop new disruptive system engineering methods that enable us to perform multi-disciplinary analysis and optimization of novel aircraft configurations and their logistic and manufacturing systems. This enables several approaches: We can assess the resilience in an industrial system, simulate approaches to link industrial system human factors with MBSE models and by that enable the assessment of organizational resilience. Furthermore it enables us to use new approaches and algorithms making semantic checking to exploit the link between industrial system and product possible. We can also use generative design approaches to create and optimize architectures in MBSE models. The following IT approaches allow us to launch and explore large co-design architecture trades on the fly.

PARTNERING WITH SILICON VALLEY

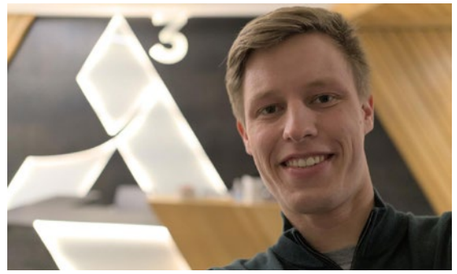
Our products at Airbus bring people closer together, helping them unite and progress. True to this spirit, we have now also established a strong collaboration with our Airbus innovation center in Silicon Valley – Acubed. Our dual student Karl Henning has been seconded into Silicon Valley to jointly develop a software prototype for industrial system analysis, combining Acubed expertise on the analysis of existing industrial systems with Central R&Ts DISM platform for multidisciplinary analysis of aircraft and industrial systems.

Find out more about Acubed.

Airbus XR fill level gauging demonstration tank.



In this picture our dual student Yarik Lasse Möller is demonstrating the Airbus XRV flight simulator testbed.



Karl Henning at Acubed in Sunnyvale, USA.

CENTRAL R&T WORKS ON UPSTREAM TECHNOLOGIES THAT OFFER AN OPPORTUNITY FOR ANY AIRBUS CHALLENGE AND REDUCES THE RISK ON PROMISING TECHNOLOGIES.

HUMAN-MACHINE COLLABORATION

For the collaboration of humans with digital co-workers, for example in a single-pilot cockpit or in the assembly of aircraft together with workers and robots, the Human Centered Technology team is developing novel cognitive models. They enable the implementation of more intuitive and human-like behavior in digital assistants and robots. Our team consists of psychologists, computer scientists, and engineers and works closely with scientific institutes in neuropsychology and cognitive sciences. In our laboratory, we conducted experiments with a flight simulator last year to derive the mental stress of pilots from physiological measurement data. This is an important prerequisite for predicting pilot behavior and, if necessary, offering support through digital assistants. ◂

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A NEW LIFE FOR AN OLD A320 AIRCRAFT

Arrival of a former Lufthansa Group A320 fuselage section at ZAL TechCenter.

It is a long, fascinating, but also challenging way for an old aircraft to become a research test facility. A significant milestone was passed when the low loader truck – carrying a 20-meter segment of a retired A320 aircraft from the Lufthansa Group – reached ZAL Tech Center in the early morning hours.

The night before, the convoy had started at the Lufthansa Technik base at the Hamburg airport – passing some popular sights of Hamburg downtown like the Kennedy Bridge and the Atlantic Hotel – before crossing the river Elbe – and finally reaching its new "home" – the ZAL.

THE AEROGRAFT PROJECT

This aircraft section is building the major part of a new test facility (mock-up) that is currently under construction. It will be used in the framework of an EU-funded research project called AEROGrAFT. The project consortium is composed of Lufthansa Technik (lead), Christian-Albrecht University of Kiel, TU Dresden, and the companies Sixonia Tech GmbH, Phi-Stone AG, and Naturality. As part of the Graphene Flagship initiative (funded by the European Commission), the AEROGrAFT project is about developing an innovative aircraft cabin air filtration system based on graphene providing enhanced filter performance – effectively capturing volatile organic compounds as well as particulate matter, dust, and bacteria.

AEROGRAPHENE MATERIAL

The filter material – called aerographene – is made by coating a removable porous ceramic template with graphene resulting in a structure composed of hollow graphene nanotubes. Besides this sophisticated material development, this project also utilizes the unique electrical characteristics of this material in order to establish smart functions like automated pollution detection and filter self-cleaning. The final research goal is the development of a smart and sustainable air filtration system for aircraft cabins. The new A320-based test stand will provide the ability for system performance and certification tests in a real aircraft system environment and allows maximum flexibility of multiple test scenarios in a realistic system context.

FUTURE VISION FOR THE A320 MOCK-UP

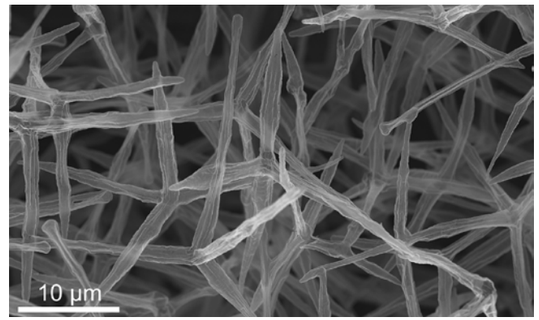
In a second step, the mock-up itself will be further developed by Lufthansa Technik to stepwise grow into a sustainable test and development platform for future research activities. Research topics such as wireless data communication, satellite connectivity solutions, digital cabin twins, or resource-efficient cabin components will be located here, enabling the way for new technological insights and innovative future products made by Lufthansa Technik. ◂

Find further informations on the AEROGrAFT website.

ALMOST TWINS

There were once two A320s that left the Airbus factory one immediately after the other. Both sister aircrafts entered service with the Lufthansa Group. The former D-AIQE flew for Germanwings, the D-AIQF for Lufthansa. And even today, the two sisters do not part ways. Thus, both aircrafts are changing their purpose to enter the service of applied aeronautical research. The D-AIQE is currently being converted into a cabin model at ZAL, while the D-AIQF forms the basis for the Hydrogen Aviation Lab.

Start at the Lufthansa Technik base.



A SEM picture of aerographene – hollow graphene nanotubes.

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SMART GALLEY TAKES OFF

Florian Zager-Rode and Christian Hornemann discussing a system concept for the future galley.

Diehl Aviation has been a part of the ZAL TechCenter since day one. The people working here coming from different departments of the Product Innovation and Digitalization division, representing different product groups and functions. Diehl further operates a laboratory for small test campaigns and demonstrators, while large-scale tests are conducted at the specialized sites of Diehl.

The key mission of the ZAL team is to create innovative products and services for aircraft cabins, combining Diehl's capabilities in production of light-weight structures, aircraft system, and cabin electronics. Integrating these technologies and bringing them to the market at acceptable costs is the daily challenge for Diehl's ZAL team. To this end, the team works in close cooperation with other Diehl sites in Laupheim, Frankfurt, Dresden, and Munich. Products include the aircraft lavatory and galley, which are produced in Hamburg.

A current project is a future galley incorporating all technological advances, enabling better service and lower emissions. The so-called eSmartGalley enables airlines to collect, process, and transmit data for predictive health management and other data-driven services. Remote maintenance functions enable specialists from the ground to solve galley issues in the air with minimal impact on cabin crew operations.

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"The EcoDemonstrator campaign has demonstrated our ability to be agile and advance R&T results quickly to a flying prototype. The team at ZAL performed well, both as design lead of the campaign and as integrator for the other involved Diehl locations Frankfurt, Gilching, and Laupheim."

Carsten Laufs, Head of Product Innovation and Digitalization

Innovative insulation, flow-optimized ducting, 3D-printed air guides and a modern power management with solid-state-power-control, door as well as latch detection make the eSmartGalley energy efficient, lightweight, and quiet.

In order to advance these technologies, Diehl has included the EcoDemonstrator flight trials in Boeing. The ZAL team has designed a galley that took to the air on board a B777. Designed at ZAL, the monument was built at the Diehl Aviation Hamburg site in close proximity to ZAL. Systems were contributed by Diehl Aerospace (power management) and the colleagues from Gilching (cooling unit) and Laupheim (ducting). The monument was then shipped to Seattle and installed in the aircraft.

The eSmartGalley is a perfect example for applied research and technology activities. Although not resulting in an actual product, several elements are used in customer projects and the experiences in the flight campaign have helped these technologies achieve the required maturity. ◂

Testing the Smart Lock Door.

EcoDemonstrator aircraft landing in Frankfurt with Diehl eSmartGalley inside.

SUPPLY CHAIN TRANSPARENCY AND PROTECTION OF COMPANY SECRETS

BECAUSE EVERYONE IN THE SUPPLY CHAIN CONTRIBUTES SIGNIFICANTLY TO THE ECOLOGICAL FOOTPRINT.

More information on blockchain-based solutions can be found here in the interview with Andreas Kötter.

If a product is to be optimized regarding its footprint, then a so-called LCA (life cycle assessment) is usually conducted first. Here, information about the materials used, raw materials, processes, energy required, transport routes, packaging, etc. is collected and evaluated. The ecological environmental impact of a product can thereby be obtained. This process alone requires an extensive collection of data.

PROBLEM DESCRIPTION

The project with a major customer from the production of industrial vehicles also proved that a holistic and efficient collection of the necessary data with a subsequent life cycle assessment can only succeed by automating the data flow. For this, there needs to be a possibility in the supply chain to not only collect one's own data, but also the data of partners and suppliers along the value chain. Because everyone in the supply chain contributes significantly to the ecological footprint.

OUR SOLUTION

For this purpose, Capgemini Engineering has designed a decentralized platform (CDX) that makes it possible to collect and evaluate any kind of product information from the entire supply chain. The prerequisite is that the participants in the supply chain are registered on this platform and enter their batches, components and complete products there. This takes place fully automatically and creates the bridge between the digital and the physical world. Now the manufacturer can be contacted and further information about the product can be requested. It is up to the manufacturer which information is provided and to what level of detail. In this model, everyone remains anonymous and retains power over the transmission of their data. All communication partners are also anonymized.

WHAT DOES THIS MEAN FOR THE LIFE CYCLE ASSESSMENT OF A PRODUCT?

For the life cycle assessment of a product, this means that all information from the entire supply chain is available. It provides a much higher level of transparency for the product concerned. The ability to request, for example, an LCA of a specific component on the supply chain also creates added value, as this data itself no longer needs to be collected or extrapolated. This results in the potential to not only share these and other product-related and relevant information "on demand," but also to get paid for this additional service from the perspective of the component LCA provider. As this can be an additional revenue driver, it has a positive impact on the quality and resilience of this information.

CONCLUSION

As a growing number of companies are confronted with sustainability and the introduction of the Supply Chain Due Diligence Act, and this work can only be solved within whole supply chains, our approach was to create a platform for exactly this, combining data protection, product secrecy and supply chain transparency for a transformation towards sustainable product development. ◂

Read more about DIBIChain.

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Martin Gromniak from ZAL GmbH's automation team works towards certifiability of AI in an aviation context.

WOULD YOU FLY AI? HOW TO CERTIFY AI SYSTEMS

Listen to the audio version of this text.

In aviation there are high hopes for AI. Potential applications range from runway recognition to the autopilot of the future. Other applications could be the planning of consumption-optimized flight routes or visual quality control during aircraft assembly. However, in order to be applied in aviation, procedures must be developed to certify AI systems and thus prove their safety.

A key component of certification is the explainability of AI algorithms. This means that the decisions made by the AI must be made comprehensible to humans. Explanations addressed to a user enable him or her to check the AI's decisions for plausibility and to better understand the system.

LEARNING TO IDENTIFY LANDING SITES FOR DRONES

In the project VeriKAS (LuFo VI, funded by the Germany Federal Ministry for Economic Affairs and Climate Action), ZAL GmbH and other partners address the question of how AI systems can be made certifiable and what role explanations can play in this. In the project, two use cases are developed in which AI supports humans in decision-making.

A KEY COMPONENT OF CERTIFICATION IS THE EXPLAINABILITY OF AI ALGORITHMS.

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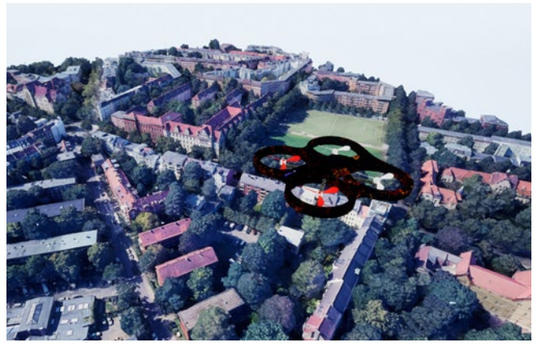
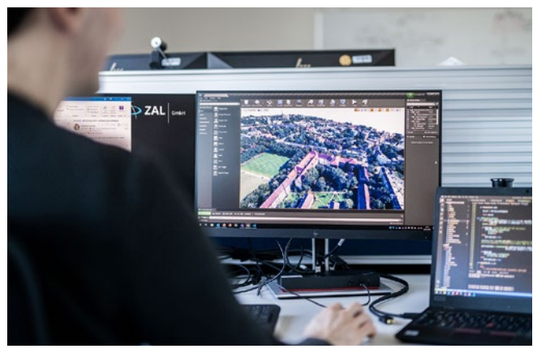


A 3D version of Hamburg Altona is the virtual training environment for the drone's neural network.



AI support for drone operators: identifying the perfect landing spot made easier.

The first use case is the automatic detection of possible landing sites for a drone in an urban area. The aircraft is equipped with a camera for this purpose and the captured images with it are evaluated by a neural network. The operator of the drone is then shown a map with possible landing sites. In addition, for each possible landing site there is a compact explanation of which criteria were relevant for the evaluation, for example the flatness of the ground or the recognition of the surface being a roof or a green area. Based on this information, the drone operator selects a landing point. The drone then performs the landing maneuver using a (conventional) autopilot. For the training of the neural networks, a simulation environment is used, which contains an approx. half-square-kilometer 3D model of a part of Hamburg. In the simulation, the drone repeatedly performs landings, receives feedback on how good a selected landing point was, and thus learns to identify good landing sites over time.

DETECTING FOREIGN OBJECTS

The second use case is located in the aircraft production process. During aircraft assembly unwanted objects, so-called "foreign object debris" (FOD), are forgotten in the aircraft and later lead to damage. These can be tools, for example. For this use case, an AI is being developed that analyzes images from a camera depicting the assembly process, providing the production worker with information about where FODs are located. In addition, a comparison with known objects will indicate which FODs are involved.
Based on the two use cases, a certification process will be developed that certifies the safety of AI applications and thus paves the way for the autopilot of the future. ◂

BIGGER, BETTER, VISIONARY

ZAL is expanding in two steps, with an extension and a new building. The extension to the ZAL TechCenter is in full swing. The new building wing is scheduled to be available by next year – with new conference rooms and hangar space for collaborative projects as well as plenty of space for two DLR institutes.

Anchor Tenant

Two DLR institutes will move into the annex currently under construction: the Institute of System Architectures in Aeronautics and the Institute of Maintenance, Repair and Overhaul.

Listen to the audio version of this text.

Open Hangar Space

The newly created hangar space will provide room for project-related research work by alternating partners. The advantages: ZAL integration with the greatest possible flexibility in terms of technical equipment, team size, and project time.

Innovation Service

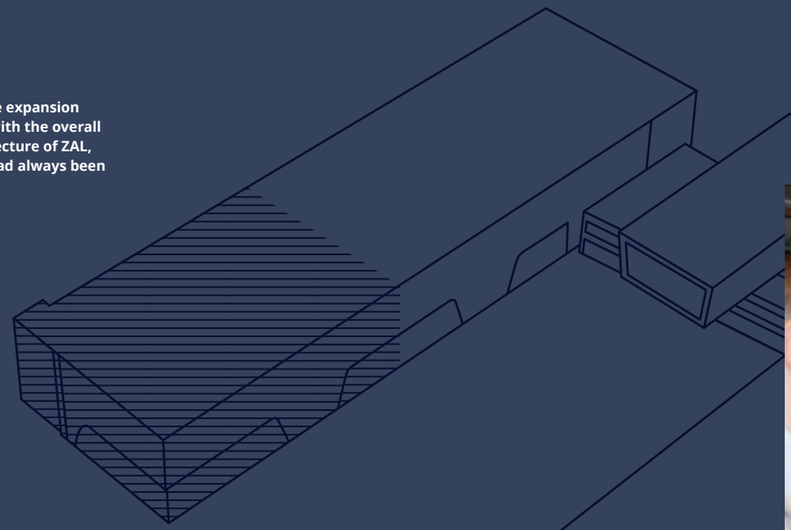
**ZAL offers engineering services on the topics of decarbonization, automation, and intelligent cabin and acoustics.
Innovation managers support partners in close cooperation with specialist engineers from the idea to the prototype.**

Flex Offices

**Meetings, office work, events: here, partners can cowork flexibly and temporarily at ZAL.
A particularly attractive feature is the proximity of hangars, laboratories, and the workshop.**

Ready to move in? Check out our live webcam.

In the end, the expansion will blend in with the overall overall architecture of ZAL, as though it had always been there.



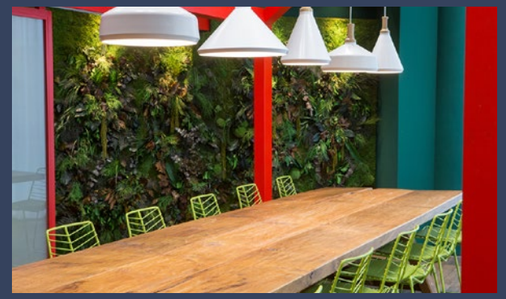
THE FORMATION OF A CAMPUS

"We are expanding ZAL according to the principle 'bigger, better, visionary.' This means that we not only want to grow for our partners, but also offer more options!" says Roland Gerhards, CEO at ZAL GmbH. In practical terms, this implies that flex offices for coworking as well as a so-called Open Hangar Space for practical work will be created as a part of the newly developed space. The offer is meant to enable alternating parties to carry out temporary projects at ZAL. The composition of the teams, their size, the equipment needed and the duration of the use of the space can be flexibly arranged. If required, the ZAL Innovation Service offers technical support, e. g. in the area of prototype construction, or methodical coaching by innovation managers.
In addition, ZAL is being expanded to include a startup ecosystem. Players from Hamburg's innovation landscape form the basis of this. Their intention is to bundle existing synergies of the location and make them accessible for aviation in concrete projects on site at ZAL. For example, start-ups are brought together with coaching and funding programs and financiers, measures that are intended to support the settlement of technology- and hardware-savvy, mature start-ups. In this way, ZAL is to develop into a campus where start-ups can network with research partners and potential customers. The resulting new projects can be implemented on site in the flexible working environment. Any engineering support or agile coaching is available as needed.

In the future, collaboration with start-ups will play an increasingly important role at ZAL.

Where the brightest and most innovative ideas can flourish.

The expansion promises more creative space for researchers.



The Sustainable Aero Lab is one of the puzzle pieces that will eventually become the innovation ecosystem of ZAL.

Together with the expansion of the building the Sustainable Aero Lab will help to expand research and technology activities and at the same time strengthen international collaboration. Here, the Sustainable Aero Lab will be one of the channels to constantly connect start-ups worldwide with the facilities and stakeholders at ZAL. Ideally, this will result in a fully institutionalized pathway to ensure ZAL stays a place where the brightest and most innovative ideas can flourish through open innovation and collaboration. Together with Hamburg Aviation, ZAL has been an associated partner of the Sustainable Aero Lab since its inception. ZAL's CEO Roland Gerhards was one of the first people to join the high-ranking panel of permanent Lab mentors. Since then, ZAL has connected directly with numerous international start-ups and welcomed several founders and mentors to the ZAL TechCenter already. Of those, several have asked to discuss potential collaboration, even including renting lab and office space or engaging in joint research projects. This is a best-case scenario come true, as it makes the ZAL community more diverse and more international, with an inclusive approach where all companies and institutions in the building profit from gaining access to new potential partners. ◂

Bringing together promising start-ups with experienced mentors.

Over 50 companies have already been accelerated in the program.

SUSTAINABLE AERO LAB

Founded in December 2020, the Sustainable Aero Lab is the world's leading fast-track program dedicated to accelerating companies in sustainable aviation. The Sustainable Aero Lab does this by globally identifying and bringing together promising start-ups with experienced mentors and investors in live sessions and one-to-one coaching, opening doors and finding customers, new projects, and partners. Participation in the Lab is free to all start-ups, and admissions roll without set starting dates.

In the first two years since its inception, over 50 companies have been accelerated in the program, with numerous collaborations and investments made. Its mentors are highly recognized individuals from aviation, industries, and venture capital who are motivated to share their experience and help companies build a new ecosystem of sustainable aviation.

In addition, Sustainable Aero Lab serves as a platform to publicly discuss and promote zero-emission aviation technologies, including developments such as SAF and hydrogen. ◂

A selection of DLR concept aircraft.

NEXT GENERATION AVIATION CONCEPTS

Which technologies will be essential for future aviation? Facing revolutionary changes such as the requirement for climate neutral mobility, automated factories of the future and evolving demands of the global passengers, concrete scenarios are required to identify the potentials of technologies as well as the technology vectors and boundary conditions for technology development. With the need to exploit all synergies, holistic next-generation aviation concepts are being investigated at the DLR Institute of System Architectures in Aeronautics covering aircraft design, certification, manufacturing, operations, and infrastructure. More than 20 aircraft concepts are already available and permit, for example, a comparison of sustainable aviation fuel options with hydrogen direct burn and fuel cell solutions. In regional, national, and European collaborations, the most promising models are the basis for more detailed technology research and innovations in collaboration with partners. Like this, the concept planes are refined to become high-fidelity digital platforms for interactive technology research. At ZAL, joint research e.g. on hydrogen and future manufacturing are being conducted with partners such as Airbus, Lufthansa Technik, ZAL GmbH, Hamburg's universities, and DLR institutes and start-ups. ◂

AT ZAL, JOINT RESEARCH IS BEING CONDUCTED WITH PARTNERS SUCH AS AIRBUS, LUFTHANSA TECHNIK, ZAL GMBH, HAMBURG'S UNIVERSITIES, AND DLR INSTITUTES AND START-UPS.

AUTOMATED MANUFACTURING AND PLANNING IN HAMBURG

A virtual factory helps to examine new aircraft configurations for their manufacturability and simultaneously optimize production at a time when no real aircraft is available. But even in a virtual factory, not everything is done digitally. That's why last year DLR set up and tested partial aspects in the laboratories – together with Airbus, Diehl, Dassault, the universities in Hamburg and other industrial partners and start-ups – at the Center for Applied Aeronautics Research Hamburg (ZAL). To this end, DLR is making a robot-assisted pre-assembly station available to its project partners in the physical and digital world. Here, the experts test how collaborative robots automatically install the systems and assemble lager modules. The results flow directly into the algorithms of the virtual factory. This is a first step toward Industry 4.0, in which the virtual and real worlds are completely linked. The experimentally validated digital platform is established to explore future manufacturing technologies in particular for cabin and fuselage applications. ◂

Test environment at ZAL TechCenter.

Robot-assisted pre-assembly station.

COLLABORATIVE DIGITAL ENGINEERING

Holistic solutions have been targeted since decades but today the decisive step-change is in reach: the digital thread. Across the entire aviation sector, digital models and data are becoming available e.g. in the context of Industry 4.0. It is becoming possible to create future aviation concepts as a system-of-systems and to concurrently incorporate aircraft design, manufacturing, and operations, for example. In order to tie the thread from various sources and standards and to make it exploitable in practical design, research is being conducted on digital engineering methods such as semantic web technologies, artificial intelligence and the magic link between model-based systems engineering and multidisciplinary design optimization. DLR's research in the ZAL TechCenter is pronouncing processes for the application of digital methods. With the ambition to reliably capture wide parts of the aviation system, it is not only required to link high-fidelity digital content but also to join all the different experts in collaborative digital engineering processes. The essential knowledge to interpret computing results and to formulate new design problems needs to be mobilized. Hosted in Hamburg, decentralized design processes with more than 20 partners have been demonstrated with 70 software tools and covering three levels of the supply chain. ◂

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LISTENING CLOSELY

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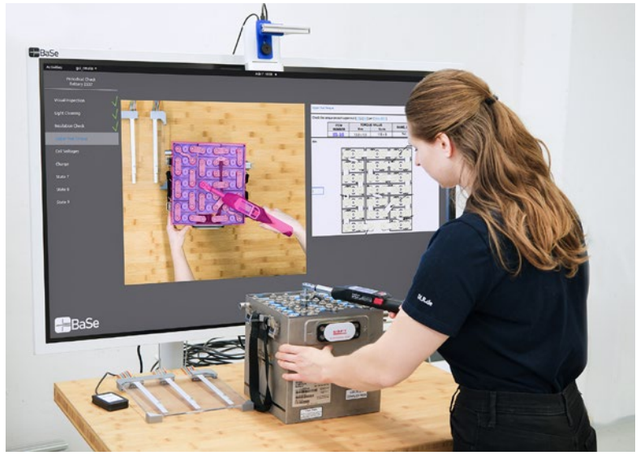
In order to detect anomalies in the operation of technical components before system failures and damages occur, sophisticated on-board sensor technology is usually necessary. However, for unmanned aerial vehicles (UAVs) this poses a problem: the entire sensor system must be permanently installed on the vehicle. This reduces the remaining payload capacity and the overall efficiency.

A drone is prepared for audio recording in the anechoic chamber at the ZAL.

A new approach now aims to monitor the electric engines of UAVs during landing and take-off – without any on-board sensors. For this purpose, researchers from the DLR Institute of Maintenance, Repair and Overhaul are working on measuring the acoustic signature of UAV propellers. They fed a neural network with hundreds of sound recordings, enabling the algorithm to detect and evaluate anomalies itself. Basically, after learning what a healthy propeller should sound like, it can now detect possible damages to the rotor blades just by listening to them. ZAL provided support with an anechoic chamber – a small recording laboratory that DLR researchers equipped with various microphones to find the best possible setup.
The long-term goal is ambitious: to be capable of performing system diagnostics even in non-protected environments such as on the apron without interrupting ongoing operations – a significant advantage, especially for large fleets. Operators would thus be able to carry out maintenance work precisely when irregularities are detected, instead of following a rigid time schedule. Other industries have also recognized the potential. Acoustic monitoring is already used in German chip manufacturing plants to make delicate processes more reliable. In aviation, it has the power to take maintenance a decisive step further and support autonomous UAV operation. ◄

Listen to two recordings from the ZAL anechoic chamber – one with a normal propeller, the other with a trimmed rotor blade. Can you hear the difference?

THE HUMAN IN THE LOOP



Extended reality not only offers guidance to the worker – it also enables the tracking of manual activities.

HUMANS WILL PLAY A DECISIVE ROLE IN THE MAINTENANCE OF AIRCRAFT SYSTEMS FOR THE FORESEEABLE FUTURE.

Whenever people are to be trained in the handling of safety-critical systems, simulations are the preferred choice. They are intended to reproduce real-life requirements in as much detail as possible, but without exposing people to danger. Pilots, for example, complete a large part of their flight training in simulators. Using a real aircraft would be far too risky and expensive.
Training also plays an important role in aircraft maintenance. The DLR Institute of Maintenance, Repair and Overhaul is therefore intensively researching the possibilities of extended reality (XR) applications. The technology, which has experienced a lot of hype in recent years, by no means solves all problems, but it does create completely new possibilities for integrating people into complex processes. It helps with training, but also offers guidance and support in later maintenance operations, effectively incorporating the human into the loop. With XR, for example, data from ultrasound examinations can be visualized directly on components to guide maintenance personnel to the right place.
First of all, however, intensive fundamental research is still necessary: for example, it must be clarified how realistically the systems shown in XR should be represented. And how do you actually measure realism in the first place? These questions do not see humans as mere end users, but rather as the starting point for system design. Accordingly, if processes adapt to people instead of vice versa, then ultimately the entire maintenance operation becomes safer and more efficient. Because – no one doubts this at present – humans will play a decisive role in the maintenance of aircraft systems for the foreseeable future. ◄

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DLR AT ZAL FUEL CELL LAB

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The Energy System Integration department from DLR's Institute of Engineering Thermodynamics investigates fuel cell propulsion concepts for aircraft applications at ZAL TechCenter. By combining experimental characterization of fuel cell systems and components with numerical methods, critical operating states as well as the influence of individual components on the overall powertrain system are examined. Thus, the Institute of Engineering Thermodynamics identifies technology gaps and upcoming research and development tasks to meet the strict requirements of the aviation industry.
The combination of laboratory tests on fuel cell systems together with numerical calculations has proven itself in 2022. Among other challenges, we were able to improve our fuel cell aircraft propulsion system design methodology, AirFuCS-CALC (Aircraft Fuel Cell System Calculator). For example, measurement campaigns in our fuel cell laboratory regarding the operations of fuel cell stacks and their air compressor have helped to further validate AirFuCS-CALC. By scaling components of our laboratory fuel cell system to the requirements of regional aircraft in the Megawatt-power class, we were able to prove that air compressors could make the greatest contribution to reduce the mass of fuel cell powertrains for aviation applications.
With these skills and know-how, the Energy System Integration department develops operating strategies and predicts system performance over the flight mission for electric aircraft propulsion with hydrogen and fuel cells.
In order to integrate more complex systems such as multi-fuel cell systems (MFCS) into the AirFuCS-CALC design methodology, further test benches will be developed and operated in the coming year. The focus is on the dimensioning of ancillary units for MFCS and the dynamic properties of the overall system. ◄

Customizable test bench for aerospace fuel cell systems.

The team of Dassault Systèmes, DLR, and other partners stand next to a manufacturing cell for human-robot collaborative assembly, which is also part of the ECN testbed for sustainable aviation.

Find out more about the Engineering Collaboration Network.

ENGINEERING COLLABORATION NETWORK

The German Aerospace Center (DLR) is working with the technology company Dassault Systèmes on the Engineering Collaboration Network initiative to find out how industry can benefit from working together digitally.

To do so, DLR and Dassault Systèmes set up the groundwork with the 3DEXPERIENCE software platform developed by Dassault Systèmes in ZAL at the end of last year. With the help of a cloud-based, integrated collaboration environment, all parties involved can work together, communicate, and thus directly track changes in aircraft design, for example. The common goal is to optimize the value creation process of the economic ecosystem of aviation and aerospace in order to enable sustainable flying and thus meet the societal requirements for a climate-neutral future. This goal can only be achieved if innovative technologies and concepts are jointly developed and tested. Therefore, the initiative is inviting partners, especially at ZAL, to participate and share their expertise to achieve something greater. ◂

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Dassault Systèmes and DLR sign the Memorandum of Understanding at ILA 2022 (from left to right): Dominic Kurtaz, Managing Director Eurocentral at Dassault Systèmes, Anke Kaysser-Pyzalla, Chair of the DLR Executive Board, and Markus Fischer, DLR Divisional Board Member for Aeronautics.

Virtual design reviews of the future iMOD validation platform.

INTELLIGENT MODULAR ROBOTICS AND PRODUCTION DESIGN

Looking into the future of manufacturing aeroplanes, the production of the fuselage will change fundamentally. High rates of automation and high volumes of production will create new technical challenges. To be prepared and to shape the future, we are developing and applying cutting-edge physical as well as digital technologies at ZAL TechCenter in Hamburg. We work on developing and maturing the right technologies and bringing bits and pieces together. As a result, the iMOD station will come to life at the end of 2023. It is the heart of the demonstration and will serve for both basic research and as an industrialization platform.

The core application of this station is the development of new ways to efficiently drill and fasten circumferential and longitudinal joints. Furthermore, its design resembles an actual production station to enable out-of-production-cycle training. Our goal is to use the gained knowledge for the production of the A321 XLR. The demonstration is accompanied by latest digital applications, such as modelling, mixed reality, virtual commissioning, and other cutting-edge technologies.

By involving working students and graduates into the project we develop a new generation of young professionals working on a new level of future automation and digitalization. We are proud to say that five Ph.D. theses and various Bachelor and Master theses were compiled within this framework.

iMOD is a joint research approach by Helmut-Schmidt University, Airbus, ZAL GmbH, CTC GmbH, HDE Consult GmbH, IFA University of Hanover, Fraunhofer IFAM, and Capgemini. ◄

Read more about iMOD.

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THE DIGITAL TRANSFORMATION IS HAPPENING FROM PLANNING TO EXECUTION – END2END.

Mixed reality and smart tool applications tested in A320 MSN4.

MIXED REALITY DEMONSTRATOR

Augmenting the real world with additional information in order to simplify tasks has been an Airbus ambition for several years. The Fuselage Industrial Line environment is close to serial conditions, enabling development and demonstration without disturbing the production. Using early versions of software, we are able to showcase it and exchange with our customers in engineering and on the shopfloor to further improve the system to their needs.

Use cases are guided work instructions that are displayed in IoT devices. Even the location of parts for installation purposes is visible directly in the field of view of the worker. This is one great example, where early feedback is needed in order to ensure mature technologies and acceptance by the future user.

Another example is individual context allocation and computer vision applications paired with smart tools, such as a screwdriver. The system provides additional data to guide through the manufacturing process and support quality checks. This is not only to avoid mistakes, but is also interesting to use and improves the safety of our colleagues, which leads to a further use case: the ergonomic analysis. Combined with virtual reality applications, we support engineering to find solutions that lead to avoidance of unhealthy movements. System developers and future applicants work hand in hand to help bring innovation to our production lines. The digital transformation is happening from planning to execution – End2End. ◄

Test of new augmented reality applications in an industrial environment.

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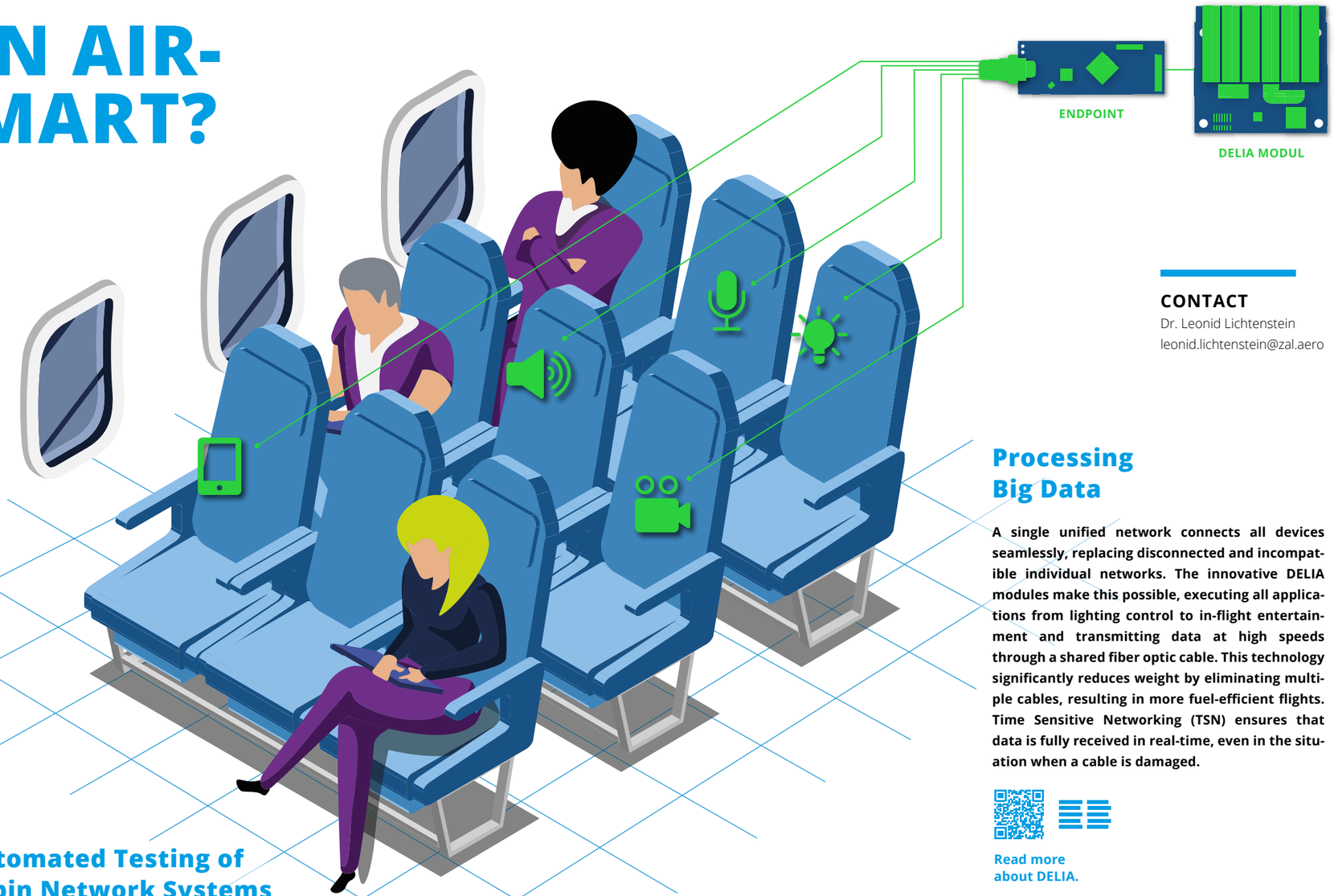
WHAT MAKES AN AIR-CRAFT CABIN SMART?

Picture a flight where you can control your individual cabin experience: lighting, temperature, and entertainment options – everything is personalized to your liking. Smart monitoring supports the crew and ground personnel, thereby also reducing turnaround times. The backbone of this vision is the integration of so-called smart technologies into the digital cabin system. But have you ever tried to integrate a new device from a third party into your digital smart home? Well, that situation is not too different from a modern cabin. Imagine speakers for audio effects, microphones for active noise cancellation, or sensors for crew support in cabin operation: whatever innovations developers want to bring to the cabin, the devices are to be integrated into the cabin network without interfering with other functionalities. And that's where the recent projects of ZAL GmbH come in.



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A Digital Cabin Multi-Tool

To connect end devices to a digital cabin network, ZAL GmbH developed the ZAL Endpoint. The Endpoint represents an interface between network nodes, like the DELIA module, and other end devices. It features a single-pair Ethernet interface for low-weight wired connectivity, the Zephyr Operating System for real-time functions and fast development. The ZAL Endpoint provides various connectors and is flexible and adaptable to a multitude of use cases. At the same time, it supplies power to end devices and also ensures real-time data transmission using Time Sensitive Networking (TSN).

Read more about use cases here.

Processing Big Data

A single unified network connects all devices seamlessly, replacing disconnected and incompatible individual networks. The innovative DELIA modules make this possible, executing all applications from lighting control to in-flight entertainment and transmitting data at high speeds through a shared fiber optic cable. This technology significantly reduces weight by eliminating multiple cables, resulting in more fuel-efficient flights. Time Sensitive Networking (TSN) ensures that data is fully received in real-time, even in the situation when a cable is damaged.

Read more about DELIA.

Endpoint Performance

Some applications require a more powerful edge computing device. For example, when complex video effects are to be displayed or when a camera is to be used to detect unwanted behavior or forgotten objects. For those more demanding use cases, ZAL GmbH developed a more powerful version of the ZAL Endpoint: the Endpoint Performance. It is based on a mobile dual-core CPU with an AI co-processor. Experimenting with complex use cases in a digital cabin has never been easier!

Automated Testing of Cabin Network Systems

When a new digital technology is integrated into an aircraft cabin, it needs to be thoroughly tested. ZAL GmbH experts work on streamlining the testing process by building an automated pipeline for continuous integration of test routines for a cabin network. For example, when new cabin technologies or sensors are being developed for the cabin, their software can be automatically built, distributed, and tested. This way, the development cycles can be reduced.

Priority on the Data Highway

Time Sensitive Networking (TSN) is a collection of industry standards that extends conventional Ethernet with various procedures and protocols. The idea is to avoid delays or losses in data transmission and thus guarantee high reliability – especially when the network load is high. In the cabin, TSN enables a shared network for different systems. One example is the Passenger Announcement System, which is only allowed to transmit with minimal delay to avoid echo effects and thus ensure easily understandable voice transmission. This is particularly relevant when it comes to passenger safety announcements. Data traffic is therefore prioritized.

Read more about TSN.

CREATING SOLUTIONS WITH TOMORROW'S TECHNOLOGY

The Bremen-based company, AES Aircraft Elektro/Elektronik System GmbH, has come a long way since its inception a quarter of a century ago. Today it is a renowned global supplier of aerospace and maritime products. Founded in 1997 with the vision of implementing customer needs in the rapidly expanding aviation industry competently and efficiently, AES products can now be found in numerous passenger aircraft and VIP jets.

Its product portfolio ranges from LED lighting systems and power supplies to communication and information systems for aircraft cabins. Along with highly innovative and comprehensive products, the company's success is thanks to its electronic design services. The company's electrical engineering services include integral electrical designs as well as consulting and support in the area of qualification and certification.

INNOVATIVE AVIATION TECHNOLOGIES MADE IN NORTHERN GERMANY

Its corporate headquarters are located in Bremen, and the company maintains a second location in Hamburg. The Hamburg branch has been based in the ZAL Center of Applied Aeronautics Research since 2021. "Memberships and engagement in various aviation associations such as AVIASPACE, Hamburg Aviation, and Hanse-Aerospace e.V. demonstrate close ties between both Hanseatic cities (Bremen and Hamburg), including the desire to play an active role in strengthening the aerospace industry in northern Germany," explains Dr. Jörn Burkert, CEO of AES. "The leading technological research and development center for civil aviation provides the perfect environment for our vision." AES has also already recorded its first successes at ZAL as part of a cooperation with Airbus in the Beluga second life project.

SOPHISTICATED SOLUTIONS FOR PREMIUM CUSTOMERS AND EXCEPTIONAL AIRCRAFT

Anyone flying on holiday in an Airbus aircraft will almost certainly encounter a product from AES GmbH. This is not only true on holiday flights, but business flights, too – leading German politicians come across AES' products as well. Two out of three Airbus aircraft use products developed on its two locations, in Bremen and Hamburg. There have been numerous innovations at AES over the past 25 years. The first pure white LED light, for example, was developed and approved for Airbus in Bremen. AES, led by its team at the ZAL TechCenter, handles the complete equipping of lighting systems and special requests, especially for private jets and custom orders.
Germany's federal government has a fleet of aircraft on standby, meaning high-ranking German politicians benefit from AES lighting during their foreign state visits. The most modern government aircraft relies on AES technology – namely the A350-900, which entered into operation at the end of 2022. The Hamburg location fulfills the wishes of many exclusive customers. This could be a sparkling night sky made of LED lights embedded into the ceiling of the aircraft, lamps fitted with golden frames, or specially illuminated make-up mirrors. Equipment such as fax machines and microwaves can only be put into operation in an aircraft with a great deal of know-how and individual conversions. These are also requirements that AES has already implemented into VIP aircraft.

DIGITIZATION AND INCREASINGLY COMPLEX SYSTEMS FOR THE AIRCRAFT OF TOMORROW

Systems have become more and more complex over the years – and so have AES' designs. Lighting systems have been complemented by digital control systems and in-flight entertainment systems. Many new electronics components have made way to its portfolio: network technology, communication equipment and power management systems. Its aim is to design aircraft cabins of tomorrow digitally with systems working closely together, using its innovations and technologies.

ITS AIM IS TO DESIGN AIRCRAFT CABINS OF TOMORROW DIGITALLY WITH SYSTEMS WORKING CLOSELY TOGETHER, USING ITS INNOVATIONS AND TECHNOLOGIES.

COMBINING CREATIVE IDEAS WITH SKILLED ENGINEERING

AES is currently working on touchless gesture controlled lighting and Li-Fi data transmission. This relatively new and unused technology does not transmits data via radio waves (WIFI), but rather with undetectable light pulses from lamps. This is advantegous because fewer cables are required, making an aircraft lighter, and at the same time eliminating disturbing radio waves. A newly developed spotlight by AES can be turned on and off as well as dimmed via hand gestures. AES' Touchless Flush Switch is a seamless solution. The integrated IR sensors track hand movements, which activates the switch. This provides a contact-free solution, reducing the spread of bacteria and viruses on board the aircraft.

FUTURE-ORIENTED THINKING

AES is a forward-thinking company, which continually adapts itself to meet the challenges of the changing times. As a result, the goal of achieving energy neutrality by 2025 is a major objective for the company. Last year, its Bremen headquarters was equipped with a rooftop photovoltaic system. AES's affiliate Solares Energy GmbH, installed this system.
The AES team is also venturing into equipping satellites and ships, in addition to its work in the aviation sector. "Utilizing our core competencies with electronics, we strive to extend our expertise into other industries," says Vahit Ezer-Hagemann, CEO at AES. ◂

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All episodes of the Hamburg Aviation Green Podcast can be found here.

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EPISODE #1: ROLAND GERHARDS

ACCELERATING INNOVATION TOWARD NET ZERO

Our first episode is with Roland Gerhards, CEO of ZAL in Hamburg. Roland is a veteran of the aviation industry, having worked at Airbus for 15 years on the A380, A350, and A330 programs. ZAL is one of the world's foremost centers for applied aviation research. In this episode Roland Gerhards gives insights into what it's like to run an institute that is at the forefront of R&D in sustainable aviation, why it's important to offer engineers free lunches, and how ZAL approaches R&D to make it faster and more productive.

EPISODE #2: MICHAEL EGGENSCHWILER

MAKING AIRPORTS MORE SUSTAINABLE

How can changes in airport operations contribute to aviation's goal of reaching net zero? What role should offsets play? What can airports do to decarbonize? Has the Covid pandemic influenced the conversation around sustainable aviation? These were among the many pressing questions we discussed on this episode with Michael Eggenschwiler, CEO at Hamburg Airport. With many years of experience in aviation both at airlines and at northern Germany's largest airport, Michael brings his own personal view to the wider conversation around sustainability.

EPISODE #3: MARIO VESCO

START-UPS: FASTER PATHS TO NET ZERO

While the aviation industry aims to reach net zero by 2050, many of the technologies needed to get there are still years away. What role can start-ups play in getting those crucial developments available faster? How can we actively harness the creativity of young businesspeople and researchers? Are start-ups better at innovation than corporations? How can government create better conditions for them to flourish? Answering these and many more questions on this episode is Mario Vesco, Venture Manager at Sustainable Aero Lab. The lab's aim: speed up innovation and R&D around decarbonization. The lab has worked with 50+ start-ups to date.

THE FUTURE OF AVIATION IS ABOUT ACOUSTICS, TOO!

Cabin noise is a complex issue familiar to everyone who flies. Whether it's the captain's hard-to-understand voice, singing party travelers in the back row, noise from the galley or the lavatory door, the already colorful soundscape is overlaid with the loud drone of the engines. But how can cabin noise be tackled? ZAL GmbH's acoustics expert, Patrick Cordes, explains how acoustic simulations ensure a smooth travel experience and what insights we can use from the development of VIP cabins for future hydrogen airplanes.

When it comes to innovations in aviation, the topic of sustainability is omnipresent. The question arises as to whether acoustics will still play a role in the future?

CORDES A very big one, actually! We are currently focusing on hydrogen to make aviation more sustainable. This means aircraft will have to change. Due to their higher efficiency, we are currently seeing the rise of short to medium-range aircraft concepts using propellers. For instance, Airbus has introduced an open-rotor concept as part of their ZEROe strategy. These types of engines produce very different noise spectra than the current jet engines. Consequently, we must rethink acoustics and the design of noise control onboard.

Why is acoustics important, isn't it a secondary issue?

CORDES Two points are crucial here. First, acoustics research not only makes aircraft cabins quieter but also lighter. We investigate which acoustic measures, used in which areas, achieve what effects. Thus, we can apply the measures more effectively. This has the potential to save weight and therefore fuel. A tangible effect for the overall sustainability of aviation. Secondly, the success of these new airplane concepts will be the acceptance among travelers. Noise level plays an important role, influencing the comfort we experience during a flight. Would passengers choose to "fly hydrogen" if these aircraft were significantly louder and the conventional option was available? I doubt it. And this is exactly where we can help.

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"Would passengers choose to 'fly hydrogen' if these aircraft were significantly louder? And this is exactly where we can help."

Patrick Cordes, Head of Advanced Materials

How will modern acoustics research meet this challenge?

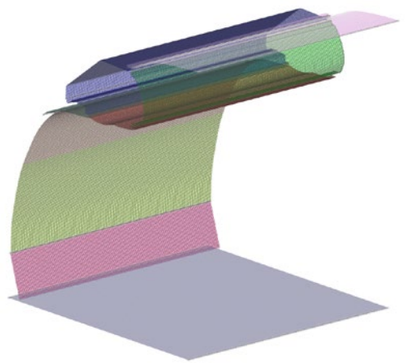
CORDES Good cabin acoustics are the result of a long chain of various individual precautions, ranging from seat fastening to cabin lining. In acoustics, we speak of transfer paths, i. e., ways that a noise can take to get from its source into the cabin. Based on the type of transfer path, different measures need to be taken in order to yield a reduction of the transferred energy. These measures may be classical glass wool insulations, but also novel acoustic metamaterials, active noise control measures, or new vibration insulations may also play crucial parts in the future.

How do you identify these transfer paths?

CORDES To simplify, there are two ways that noise (we describe it as energy) can enter the cabin: through air and through vibration. It's important to determine how noise is transferred and how much each path contributes to the overall noise level. We use a combination of experiments and simulations to do this. With simulations, we can test different solutions before the cabin is built, allowing us to take measures to reduce noise from the start.

With new engines and presumably additional hydrogen tanks, a hydrogen aircraft might have a completely different cabin design. How do you simulate something unknown?

CORDES We need flexible approaches for these challenges that can quickly adapt to new materials or aircraft designs. Currently, we are developing a simulation workflow based on VIP cabins. (Entirety Project, ZAL in collaboration with Lufthansa Technik and the Hamburg University of Applied Sciences). VIP cabins typically have unique customized designs and often include unusual components. One of the main challenges in developing VIP cabins is that they are typically built only once, which means that experimental validation can only take place after the cabin is completed. Consequently, an accurate simulation is crucial. Our methodology is to combine various sub-simulations at the material and component level, and ultimately to create a complete simulation of the cabin.
Thus, simulation can help to accelerate any cabin development and to forecast the effect of new components on the cabin acoustics. And at the same time, it provides passengers with a pleasant travel experience – hopefully in hydrogen-powered aircraft soon, too. ◂



A numerical model of a cabin sidewall used for acoustics simulation.

SMART AIRCRAFT ASSEMBLY

Prototype for joining upper and side panels.

As part of Fraunhofer's commitment to push the boundaries of aircraft manufacturing, Fraunhofer IFAM collaborates with industry leaders such as Airbus as end user and project lead, Broetje Automation, CENIT, and 3D.aero. Under tight cooperation, we have developed a fully integrated cyber-physical facility that automates the assembly of large fuselage composite panels.

The first step is to extract geometrical data from the panels via cameras and to compare these with nominal data. Based on the resulting deviations, deformation movements are calculated for the grippers holding the panels by using algorithms to predict forces. This is then repeated iteratively until the measured deviation is within manufacturing tolerances. All this happens while the status of the facility is being monitored through a digital factory twin. Furthermore, the developed system includes several innovative features, such as:

- a multi-camera-based markerless photogrammetry system
- adaptable and modular grippers and actuator systems for fuselage-panel handling
- an information system capable of deterministic real-time communication
- an automated assembly procedure that complies with built-in stress requirements

Likewise, our collaboration with the ZAL GmbH in Hamburg has been instrumental in the development of this prototypical system, which represents a significant advancement in aircraft manufacturing technology.

LIKEWISE, OUR COLLABORATION WITH THE ZAL GMBH IN HAMBURG HAS BEEN INSTRUMENTAL IN THE DEVELOPMENT OF THIS PROTOTYPICAL SYSTEM, WHICH REPRESENTS A SIGNIFICANT ADVANCEMENT IN AIRCRAFT MANUFACTURING TECHNOLOGY.

MARKERLESS PHOTOGRAMMETRY

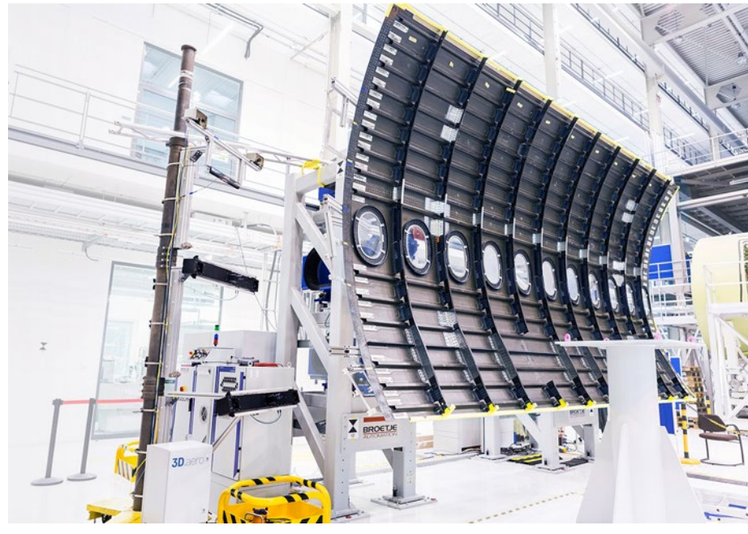
The markerless photogrammetry system developed in cooperation with 3D.aero uses multiple images to measure the shape and position of the parts, eliminating the need for permanent laser trackers, which represent the state of the art. In so doing, the time-consuming and error-prone manual fixing of reflector targets has been avoided and replaced by a system of 3D.aero's SurfEyes that can measure and process data in short over one second versus several minutes.

INFORMATION SYSTEM WITH REAL-TIME HARDWARE AND SOFTWARE INTERFACES

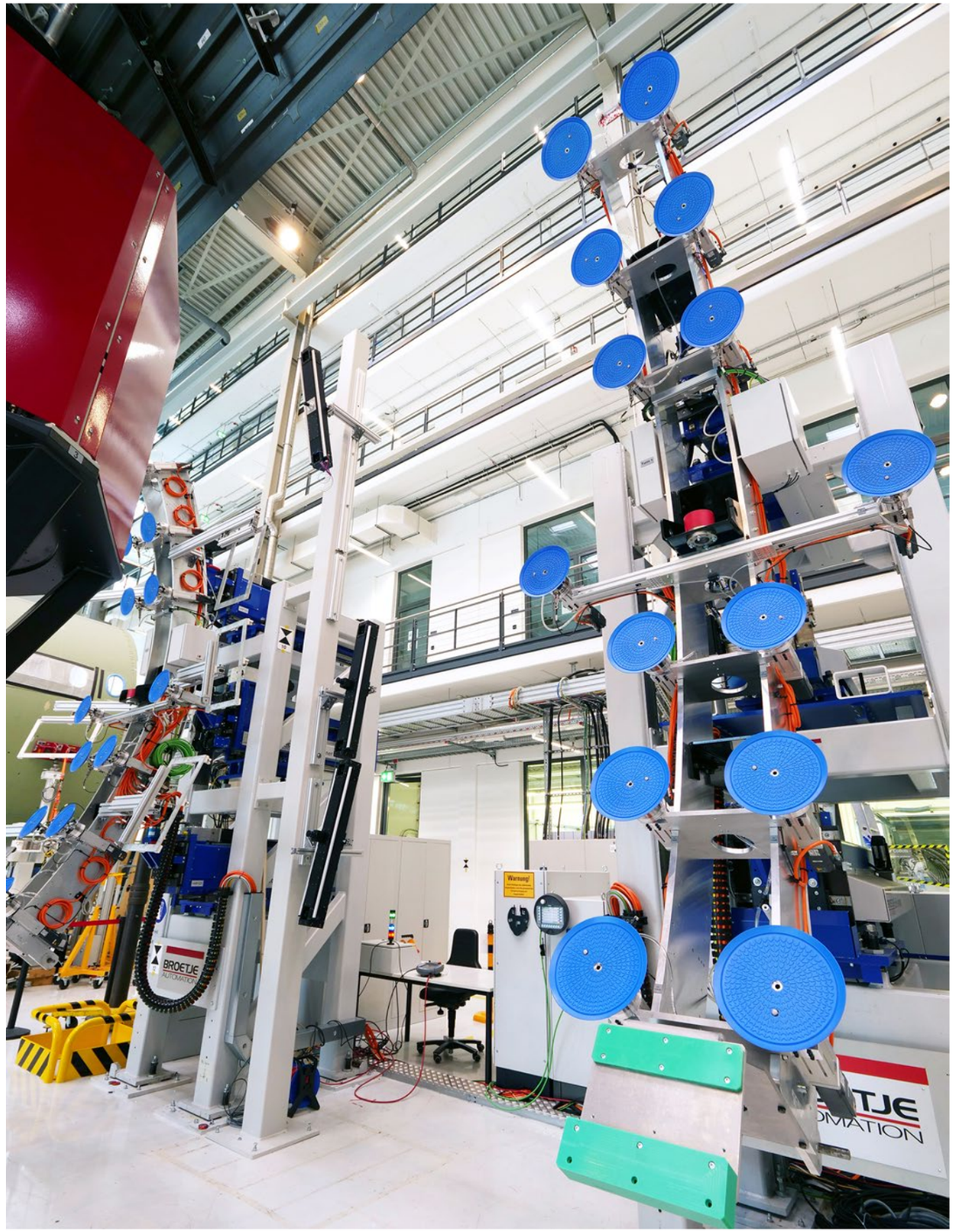
A deterministic real-time communication system has been developed by Fraunhofer IFAM using standard components and a real-time operating system (RTOS). It is capable of transmitting data between critical systems reliably and accurately without the need for proprietary controllers or communication boards, making it highly scalable and customizable for a wide range of applications. This system represents a significant advancement of real-time data communication for the IoT era and offers numerous benefits, including improved system performance, reduced maintenance costs, and increased flexibility in hardware and software integration. Additionally, the integration of the OPC-UA standard for the non-critical components and its combination with semantic data models and a digital twin as done by CENIT enables unified information models and data analytics.

ADAPTIVE SHAPE AND POSE CORRECTION WITH ADAPTIVE MODULAR PANEL HANDLING FIXTURE

The use of adaptive and modular concepts in handling fuselage panels enhances assembly flexibility and efficiency. This involves the modular gripper system and Broetje's Eco-Positioner, which can correct component shape and position in terms of force. ▸



3D.aero's SurfEyes measuring the panels back interface edge.

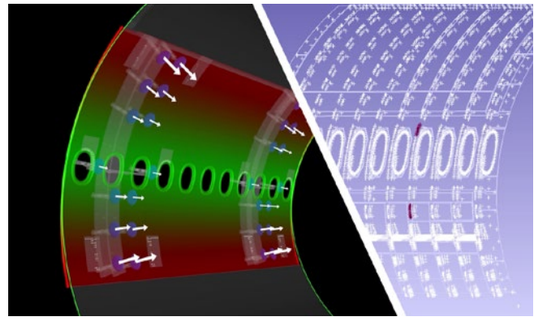


Watch a video about the Fraunhofer IFAM project BiSconA.

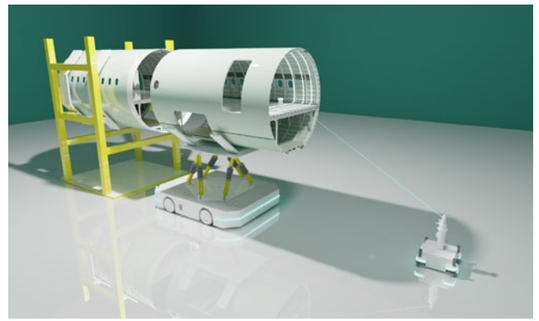
The automated assembly process is designed to reduce the risk of damage or failure during assembly by accounting for the internal stresses of the parts. This is achieved by adaptive correction algorithms, which ensure that the fuselage panel is correctly aligned and shaped during assembly. Therefore, an empirical model has been developed to predict induced forces and plan dependent actuator movement iteratively, considering the interactions between the handling system, panel shape, and measured forces. This approach enables the assembly process to adapt to variations and unique character of the panels, while ensuring that the built-in stresses of the materials are accounted for. Overall, the use of these adaptive shape and pose correction algorithms represent a significant advancement in the field of aircraft manufacturing, with the potential to improve the efficiency and reliability of the assembly process.

Looking into the world of tomorrow, the utilization of deep learning and neural networks to improve the accuracy of the force prediction in the shape adjustment process would reduce lead times and stress. The use of structured lighting to measure panel interfaces, as initiated by 3D.aero, would provide more precise and accurate data directly on the interfaces of the panels, further enhancing the accuracy of the assembly process.

Fraunhofer IFAM's next step is the joining of fully assembled sections and the mobilization of the process through modular handling systems and automatic guided vehicles (AGVs). This approach offers numerous benefits, including increased flexibility, possibly faster assembly times, and improved shopfloor efficiency. Therefore, this will be a key component of upcoming R&D projects, which aim to develop a mobile assembly line for aircraft manufacturing.



Fraunhofer IFAM's representation of markerless photogrammetry-based shape correction.



Fraunhofer IFAM's vision of mobile joining of sections.

The presented investigations were conducted as part of the project BiSconA ("Built-in-Stress conformal Assembly"; LuFoV3-FKZ: 20W1724B), funded by the Federal Ministry for Economic Affairs and Climate Action. Project partners are Airbus Operations GmbH, BA Assembly & Turnkey Systems GmbH (Broetje Automation), CENIT AG, Fraunhofer IFAM, 3D.aero GmbH. ◂

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The ZAL TechCenter offers HAW Hamburg the ideal platform for getting started with experimental research in the field of hydrogen.

RESEARCH FOR SUSTAINABLE AIRCRAFT

The Hamburg University of Applied Sciences (HAW Hamburg) qualifies young aeronautical engineers with Bachelor of Engineering and Master of Science degrees as well as PhDs in cooperation with partners. Sustainable aviation is playing an increasingly important role in professional education and research. Students are familiarized with research processes at an early stage and are also given the opportunity to develop the necessary technology skills. Several research projects with sustainability in mind have been launched recently.

OPTIMIZING THE HYDROGEN AIRCRAFT WITH MODEL-BASED SYSTEMS ENGINEERING

Liquid hydrogen as aircraft fuel offers the potential for a significant reduction of emissions. A major challenge of hydrogen aircraft system development is the evaluation of different system architectures regarding system and operational requirements as well as lifecycle costs. In the framework of the MIWa research project, HAW Hamburg and the DLR Institute of System Architectures in Aeronautics (DLR SL) together with Centerline Design GmbH, are establishing a digital model of a commercial aircraft with integrated liquid hydrogen systems using the graphical systems modeling language SysML among the model-based systems engineering approach. The resulting models will be modular and linkable with each other in order to obtain a digital, parameterized and reconfigurable system architecture description. Thus, the consequences of different mission objectives as well as system requirements can be estimated on a model-based foundation at a very early stage of development.

A MAJOR CHALLENGE OF HYDROGEN AIRCRAFT SYSTEM DEVELOPMENT IS THE EVALUATION OF DIFFERENT SYSTEM ARCHITECTURES REGARDING SYSTEM AND OPERATIONAL REQUIREMENTS AS WELL AS LIFECYCLE COSTS.

SUSTAINABILITY REQUIRES NEW AIRCRAFT CABINS

In the project ReCab HAW Hamburg studies the resource-efficient and sustainable aircraft cabin together with Lufthansa Technik AG, Diehl Aviation and TUHH. In complex socio-technical systems, such as aircraft cabins, the assessment capability of cabin equipment and processes is crucial. Therefore, HAW Hamburg aims to develop a holistic cabin concept of the future. By considering today's medium- and long-haul flights and new technological and procedural approaches, new innovative concepts will be developed that will minimize the resource consumption, reduce complexities or increase the involvement of passengers in delivery process. With a new sustainability navigator, the impact assessment of technological and procedural approaches will be easier in future.

The CATECO project spotlights the acoustics of future aircraft cabins. Future hybrid-electric regional and short-haul aircraft will be powered by propellers. However, propeller-driven aircraft pose a major challenge due to the high noise levels expected in the cabin. Active noise control may reduce this noise very efficiently. Together with Airbus and DLR SL, HAW Hamburg is researching the integration of active noise reduction in future cabin management systems. Such cabin management systems will offer common communication and computing platforms that are able to host various cabin services, such as public address, passenger calls as well as lavatory and galley management. Key technologies are high data rates and open industrial communication standards like Time Sensitive Networking. The main project idea is to move the system intelligence from a central instance to the actuators on the edge of the system.

Researchers at HAW Hamburg develop model-based methods for the design of hydrogen aircraft systems.

A NUCLEUS FOR OUR GREEN AVIATION LAB

HAW Hamburg plans to expand its joint research with research partners from ZAL in the next month. For example, a prerequisite for flying with hydrogen is measuring the amount of liquid hydrogen stored in the aircraft. Today, there are no fuel sensor technologies available that meet the requirements of certification and cryogenic temperatures. To achieve this goal, HAW Hamburg and Autoflug GmbH will develop fuel sensors to measure the mass of liquid hydrogen in the framework of the Precise project. In the joint project BeHyPSy with ZAL GmbH and HSU, an innovative concept of a hydrogen based hybrid-electric powertrain for light sport aircraft will be investigated. HAW Hamburg will support the system development in design, optimization, and testing using numerical and model-based methods.

With these new projects, HAW Hamburg aims to establish new test rigs in the Open Hangar Space of ZAL II to intensify the collaboration with its partners. In addition, academic courses with young students may also take place in this application-oriented research atmosphere to set new impulses in the ZAL TechCenter. ◂

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IN THE SKY, ON LAND, AND AT SEA

THE RESEARCH AND DEVELOPMENT OF INNOVATIVE PRODUCTS IS CLOSELY LINKED TO THEIR APPEARANCE. SUSTAINABLE PRODUCT DESIGN IS OUR CONTRIBUTION TO PRESERVING OUR ENVIRONMENT FOR FUTURE GENERATIONS. AT THE INTERFACE BETWEEN RESEARCH RESULTS AND EXPLOITATION FOR MARKET LAUNCH, WE HELP TO MAKE THE PRODUCT ATTRACTIVE TO THE LARGEST POSSIBLE TARGET GROUP.

“We really appreciate the short links to the other ZAL-located companies and are looking forward to keeping up the successful collaboration in many further joint projects and R&T projects.”

Torsten Kanitz, CEO at Industrial Design Studio Hamburg

“Our focus is intelligent industrial design: deeply understanding our customers’ projects and needs, finding highest quality solutions and supporting them to get exactly what they are happy with.”

Imme Kuhnert, Head of Industrial Design & Lighting Simulation

Find out more about Industrial Design Studio Hamburg.

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ENABLING HYDROGEN FOR AVIATION & MARITIME

ZAL INNOVATION TALK – 5 Years From Now. Listen to this episode and learn about the synergies between aviation and maritime concerning hydrogen applications.

Currently, many companies want to make their business more sustainable and future-proof. The hydrogen sector is very promising here. But many players lack relevant know-how. In addition, shortage of skilled personnel, as well as missing access to gas supply and test facilities for hydrogen jeopardize the practical realization of these business visions. Thanks to ITZ, there is a solution here.

ITZ NORD EXPLAINED

The Hydrogen Innovation and Technology Center (Innovations- und Technologiezentrum Wasserstoff – ITZ) is implemented by the Federal Ministry for Digital and Transport (BMDV). There are four ITZ sites located in Germany. Their aim is to create a development, research, and testing environment, that are not or not sufficiently available on the market yet. Besides, existing networks are to be strengthened and established in order to pool knowledge and enthusiasm for hydrogen. The target groups are start-ups, founders, and small and medium-sized enterprises. On an international level, the ITZ is to help set technical and economic standards.

ITZ NORD ON AVIATION & MARITIME

The ITZ Nord (Bremen/Bremerhaven, Hamburg, and Stade) mainly concentrates on its core areas of maritime and aviation. The focus is on the development and integration of fuel cell systems and corresponding components, the hybridization of drive trains, refueling concepts, logistics, storage and processing of green hydrogen and hydrogen-based fuels, as well as the testing of components and systems. Furthermore, competences on standardization and certification issues are pooled with the close involvement of classification societies. ◂

Watch here how ITZ Nord enables aviation and maritime in hydrogen technologies.

ZAL GOES ITZ

At ZAL TechCenter hydrogen experts provide technical advice and support for implementation of maritime and aviation projects. Moreover, interested parties have access to hydrogen test infrastructures, gas supply including gaseous and liquid H_2, N_2 or O_2, and a prototype workshop. Networking opportunities with highly motivated in-house partners researching the same topics come free of charge.

FUELING HYDROGEN

The implementation of the ITZ is an important step in the development of a hydrogen ecosystem in Germany. The fact that aviation and maritime are being thought of together in Hamburg makes sense, because both industries are facing similar issues. They are systemically important parts of the global economy, are experiencing steady growth in traffic, and have been dependent on fossil fuels. Thus, both industries face the challenge of building a hydrogen infrastructure to become more sustainable.

NEW FUEL MEANS NEW CHALLENGES

A complex undertaking. After all, filling an aircraft or ship with a new type of fuel requires new types of equipment and infrastructure that are compatible anywhere in the world and at the same time meet safety requirements. For aviation, this means: EASA and FAA will have to agree on common standards for hydrogen systems, which will require extensive testing and research in advance. Due to the significantly higher volume of the new fuel, H_2 will only make sense to use in aircraft in liquid form at -253 °C. But what does that mean for refueling and storage? Could existing gas pipelines be used for logistics? And can hydrogen be stored in large gas tanks at the airport so that it can only be liquefied before refueling? How costly and reliable would such a liquefier then be, and what would it need to look like for daily industrial use? What additional hardware, which may not even exist today, would still have to be built?

SOLUTIONS ON THE WAY

Some of these questions are being researched in the Hydrogen Aviation Lab by Lufthansa Technik, DLR, Hamburg Airport, and ZAL. The core of the lab is a former Lufthansa Airbus A320, which is being converted into the world's first demonstrator for refueling operations with hydrogen on this scale.

Another player looking at hydrogen refueling is California-based Universal Hydrogen, founded by former Airbus technology chief and "Silicon Valley" scion Paul Eremenko. The idea here is to get hydrogen onto planes in retrofittable, cartridge-like containers – the advantage being that airports would not have to build their own infrastructure. A major disadvantage would be a challenging logistics chain and a complex redesign in aircraft equipment. Irrespective of this, this solution would also first have to be certified by the FAA and EASA to open a market. The regulatory side thus plays a key role – as is so often the case in aviation.

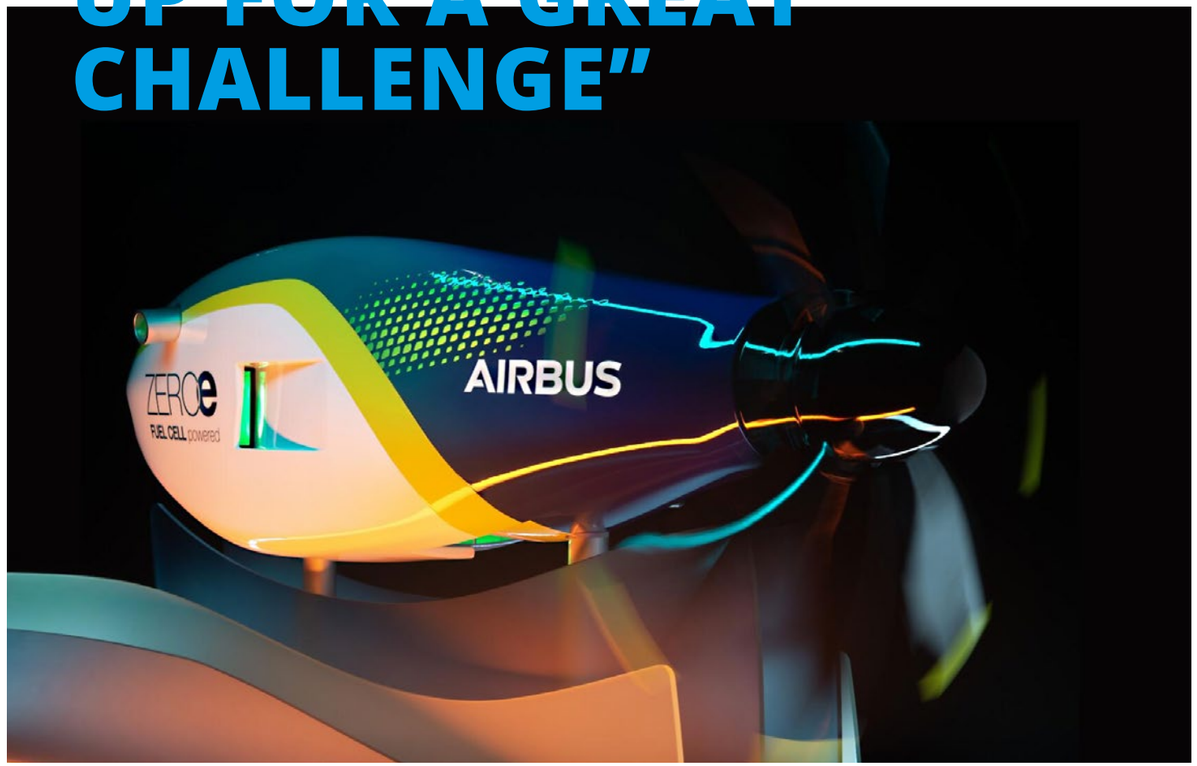
(AIR)PORTS WITH POTENTIAL

However, part of the vision of zero-emission flying takes place on the ground. And this is where ground services at airports could play a decisive role in the economic success of H_2. After all, once the fuel is on site, it could also be used for other applications – for example, ground power units or aircraft tractors. It is also much easier to implement on the ground. Especially if it were possible to work permanently with gaseous hydrogen here, which does not have to be cooled down to -253 °C. The (air)ports have exciting potential for hydrogen applications and could have a significant impact on the profitability of the new hydrogen ecosystem. ◄

EVER THOUGHT ABOUT THIS?

If we want to build a hydrogen ecosystem for aviation in Europe, we need far more airports equipped for hydrogen refueling than are flown to. The reason is the strict safety requirements in commercial aviation, where alternate airports must be designated for each route. An example of this comes from Scotland's Loganair, which serves much of the UK's regional routes and is one of the busiest airlines when it comes to testing new technologies. Loganair serves numerous routes such as the "island hopping" Orkney routes, which in terms of sheer flying distance would be ideal for all-electric regional jets. These are expected to go into production ahead of the H_2 models. But the alternate airport for the Orkney capital of Kirkwall is Aberdeen, more than 200 kilometers away – and thus out of range for all-electric flying in the foreseeable future. So if an infrastructure dilemma in hydrogen operations is to be avoided, implementation and operation must be straightforward and economical, not only for airlines but also for airports.

"WE SET OURSELVES UP FOR A GREAT CHALLENGE"



ZEROe Fuel Cell Engine Model.

Find out more about the Airbus Summit here.

When announcing our ambition to develop the world's first ZEROe aircraft by 2035, we set ourselves up for a great challenge. To propel this aircraft, we are working on two ways of using hydrogen. First, via direct combustion in a gas turbine, and second, by using fuel cells to convert the hydrogen into electricity in order to power a propeller engine. To maintain a broad scope we are developing both options before finally determining which system will power our future aircraft. Regarding the fuel cell option, we revealed the development of a hydrogen-powered fuel cell engine at the Airbus Summit 2023.

POWERING THE FUTURE OF AVIATION

For this development, the fuel cells manufactured by our joint venture with ElringKlinger, Aerostack, are incorporated into a fuel cell system at the ZAL Techcenter in Hamburg. After design, assembly and testing in Hamburg, the fuel cell system is further tested in combination with the other components making up the propulsion system in our recently revealed E-Aircraft System Test House in Munich.

Fuel cells are a potential solution to help us achieve our decarbonization ambition and we are focused on developing and testing this technology to understand whether it is feasible and viable for a 2035 entry-into-service of a ZEROe aircraft.

Learn more about our zero emission journey.

"Fuel cells are a potential solution to help us achieve our decarbonization ambition."

Glenn Llewellyn, VP Zero-Emission Aircraft, Airbus

The technology will be tested on the A380 MSN1 flight test aircraft for new hydrogen technologies toward the middle of the decade. The flight test aircraft for new hydrogen technologies is currently being modified to carry liquid hydrogen tanks and their associated distribution systems.

PAVING THE WAY TO A HIGH-EFFICIENCY MULTI-MEGAWATT FUEL CELL SYSTEM

One of the main difficulties in achieving this goal is to reach an electrical output high enough to provide enough energy for the electrical engines to power the aircraft. The first step to overcome this difficulty has been achieved in the last years by our development of fuel cell stacks and their combination in fuel cell systems. Based on this knowledge, we managed to design and develop the first fuel cell engine demonstrator on a lab-scale basis that reaches the megawatt class and comes closer to our ultimate goal. We enjoyed significant learnings that will help us develop future engines. By continuing to invest in this technology we are giving ourselves additional options that will inform our decisions on the architecture of our future ZEROe aircraft, the development of which we intend to launch in the 2027–2028 timeframe.

CONTRIBUTING TO THE AMBITION: RIGHT HERE, RIGHT NOW!

Hauke Lüdders is the Head of the Fuel Cell propulsion systems development at Airbus. He is one of the early movers in Airbus, being enthusiastic about bringing sustainable energy sources, in particular fuel cells, on board Airbus commercial aircraft. Hauke and the majority of his team is based in and around ZAL providing a significant impact towards the ambitious goal of a ZEROe aircraft. Airbus identified hydrogen as one of the most promising alternatives to power a ZEROe aircraft, because it emits no carbon dioxide when generated from renewable energy, with water being its most significant by-product. Hydrogen fuel cells, especially when stacked together, increase their power output allowing scalability. In addition, an engine powered by hydrogen fuel cells produces zero NOx emissions or contrails, thereby offering additional decarbonization benefits. ◂

Hauke Lüdders

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PIONEERING A CIRCULAR CARBON ECONOMY WITH DIRECT AIR CAPTURE

Delivery of the first DAC10 unit to the launch customer Jones Food Company in Bristol / UK in February 2023. Missing in the picture are our three dual students supporting the launch.

In the long term, CO_2 sourced from the air will play a key role in a net-zero emission economy, including as a carbon source for energy, fertilizers and chemicals. With the Airbus carbon capture technology that has been developed as the life support system for the ISS, we are able to capture CO_2 from ambient air and turn it into a feedstock for valuable things "made from air." At our venture we listen to commercial markets and engineer scalable carbon removal technologies that seamlessly integrate into existing hardware.

PIONEERING A CIRCULAR CARBON ECONOMY

Direct Air Capture (DAC) could help to contribute to a sustainable circular carbon economy by capturing carbon dioxide (CO_2) directly from the atmosphere. The idea is that captured CO_2 can come full circle, such that it could be used in the production of carbon-negative materials, power-to-liquid (P2L) eFuels, fertilizers, green carbon fibers, building materials, and more. In a nutshell, DAC could be offered as a service to companies that not only want to reduce their direct and indirect carbon footprint, but also "sink" CO_2 from the atmosphere into sustainable practical applications.

DERIVED FROM INTERNATIONAL SPACE STATION (ISS) LIFE SUPPORT SYSTEM

The lightweight and compact DAC device – has been specially developed in-house and driven by Airbus Scale, bringing together teams from Airbus Commercial Aircraft and Airbus Defence and Space. One of the key advantages of the derived terrestrial DAC unit, being self-contained and only a few meters long, wide and high – about the size of a mobile burger stall – is that it can be brought on-site exactly to where the end customer may need the CO_2 for various scenarios, such as those mentioned above.

SUSTAINABILITY ADVANTAGES FOR THE VERTICAL FARMING INDUSTRY

For the vertical farming / controlled environment agriculture industry in particular – which consumes about 200,000 tonnes of CO_2 annually – DAC technology promises tantalizing benefits by supporting indoor plant growth and photosynthesis using CO_2 taken from the surrounding air. Currently, the CO_2 used by this industry is not only produced by burning propane gas (or some other fuel), but it is subsequently transported hundreds of kilometers over land or sea from where the CO_2 was originally captured, all the way to the actual point of use – consuming even more energy with additional associated CO_2 emissions. The potential scope for CO_2 emissions reductions and overall energy – and cost – savings with the portable DAC innovation are therefore considerable.

MODUS OPERANDI …

So how does technology actually work? Antje Bulmann, permanent Airbus Scale team member and leader of the project, explains: "The CO_2 is captured through an adsorption-based DAC, which splits the capturing process into two steps: firstly, a fan sucks in air which passes over a solid amine-based filter that selectively binds the CO_2. Airbus has patented a solid-amine resin, which efficiently captures CO_2 even at low concentration levels. This phase continues until the amine resin is saturated with the greenhouse gas. In a second step, the filter is regenerated through the application of heat, which desorbs the CO_2 into a pure stream and releases the treated air. This air can then be transferred and used for other applications."

MODULAR APPROACH FOR FUTURE GROWTH

Antje Bulmann adds: "We already know from our various discovery calls with potential customers in the vertical farming sector, but also in other segments, that our current DAC size – capable of capturing around ten tonnes (about 5,000 cubic meters) of CO_2 per year – might be suitable as a first step."

The modular DAC architecture will allow it to grow as future market needs require. The introductory "DAC10" proof-of-concept version will in future enable the stacking of multiple modules together to create a larger DAC – a proposed "DAC100" – which will still be easy to transport and have an estimated CO_2 capture capacity approaching 100 tonnes per year. Looking even further ahead, a 1,000-tonne "DAC1000" version is even being suggested.

So what does all this mean for the average person? Antje Bulmann is optimistic when it comes to the future: "One day you'll be able to take an eFuel-powered carbon-neutral flight across the Atlantic in a plane with materials partly made from CO_2, carrying and wearing items that are made from CO_2 and eating fresh salads fertilized with CO_2 from the air!" ◂

Read more about DAC technology.

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FROM 30 MINUTES TO 10 HOURS' FLIGHT TIME

Listen to the audio version of this text.

ZAL GmbH quadrupled the flight time of its drone by converting the battery operation to pressure-stored hydrogen in combination with a fuel cell. Thus, the flight time increased from 30 minutes to over two hours. However, this is only a fraction of what is possible with liquid hydrogen (LH_2).

A project called LiquiDrone* is currently testing the conversion of a drone to liquid hydrogen. 12 liters of liquid hydrogen (the equivalent of about 850 grams) are to be stored safely at a temperature of -253 °C for the duration of the mission and made available for electric drone propulsion via a fuel cell. The focus of ZAL GmbH is the provision of the test platform "ZALbatros," an Unmanned Aircraft System (UAS) already tested with a compressed hydrogen tank, as well as the development of an energy management system for the optimized use of the tank contents. ZAL GmbH will continue to handle the liquid hydrogen, the overall integration, and the execution of the system tests. If the project is a success, the research partners expect the flight time to be extended to more than ten hours. ◂

* The LiquiDrone project is funded by the German Federal Ministry of Digital Affairs and Transport (BMDV). The four research partners (RST Rostock-System Technik GmbH, BaltiCo GmbH, University of Rostock – Chair of Engineering Mechanics/Dynamics, and ZAL GmbH) started their research in June 2022.

Sample model of a tank for liquid hydrogen.

Read more about ZALbatros.

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HYDROGEN POWER FOR DELIVERY DRONE

Watch Wingcopter 198 here, the world's first triple-drop delivery drone.

The vision of using delivery drones to improve or even save lives is both widely known and challenging. One company that has succeeded in making this happen is Wingcopter. With its same-named drone, the company has proven that it can successfully deliver medical supplies to regions that are geographically hard to reach. The delivery drones feature flight efficiency and high resilience.

In the future, the plan is for the battery-powered drones to also take off on green hydrogen, making them not only emission-free but also even more powerful in range. The wingcopter's conversion to hydrogen will take place at ZAL TechCenter. As part of a development partnership with ZAL GmbH, a solution is being developed that will fit into the existing technical ecosystem of the delivery drone. ◂

PREPARING FOR THE FUTURE

A decommissioned Lufthansa Group A320 is to become Hamburg's Hydrogen Aviation Lab.

The A320 Hydrogen Aviation Lab is a pioneering research project of Lufthansa Technik, the German Aerospace Center (DLR), ZAL Center of Applied Aeronautical Research, and Hamburg Airport. It focuses on maintenance and ground operations of hydrogen use cases in commercial aviation.

The currently planned range of components to be installed into the Hydrogen Aviation Lab encompasses an internal cryo-tank for liquid hydrogen (LH_2), a fuel cell system, a conditioning system and a broad variety of pipes and interfaces between the various installations. Lufthansa Technik personnel will carry out the majority of these installations into the used Airbus A320, here and there supported by employees of the other project partners.

In addition, the Hydrogen Aviation Lab will also encompass ground infrastructure, for example an external LH_2 refueling unit. A main challenge of the project is to find suitable commercial off-the-shelf solutions to be used, as most LH_2 hardware is designed for industrial processes with high demand. If, in the future, other types of components become the focus of research, Lufthansa Technik can retrofit them into the aircraft as well.

Moreover, it is important to note that the Hydrogen Aviation Lab will not only consist of the physical aircraft, but also of its digital twin. Led by DLR, all afore-mentioned LH2 installations will also be modeled digitally in order to investigate forms of digital health monitoring and predictive MRO that can subsequently be validated with the physical project setup.

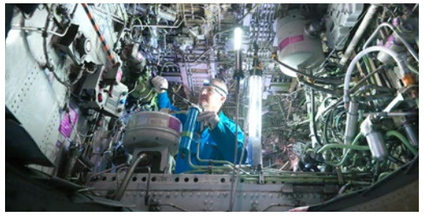
In general, the project plan is to investigate aspects such as time-efficient refueling with liquid hydrogen, safe and efficient repair of the relevant components, and how to deal with the relevant components as well as with incidents. In doing so, the project will not only prepare the partners for this promising future technology early on, it is also eager to deliver interesting impulses for aircraft, engine or component OEMs and their future designs for hydrogen-powered aircraft. Thus, the Hydrogen Aviation Lab will evolve into a platform for various follow-on research projects regarding the use of hydrogen in commercial aviation.

Additional challenges to be investigated in the Lab focus on cooling and insulation, boil-off, inertization and staff training. Those aspects, with today's knowledge, will pose great challenges not only for MROs, but for anyone who has to deal with this future aircraft technology on the ground. All of them bring up new questions and challenges the industry needs to address. ◂

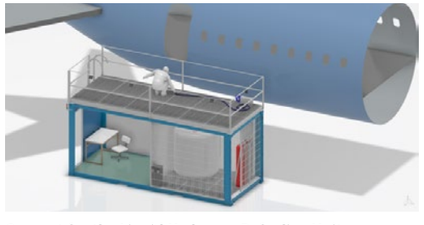
"We want to be ready for hydrogen ground operations in aviation."

Gerrit Rexhausen, Lufthansa Technik, Project Lead Hydrogen Aviation Lab

To highlight its new role as a scientific field laboratory, the A320 has been adorned with an entirely new livery. To foliate the aircraft skin, Lufthansa Technik used around 950 square meters of foil, and it took two weeks of work to complete.



Complex puzzle: one main work package is the integration of the hydrogen components and their interconnection. In the cargo compartment, for example, the researchers have to define special space budgets for the hydrogen piping and other connection lines, such as for the power electronics.



Concept for the Liquid Hydrogen Refueling Unit.

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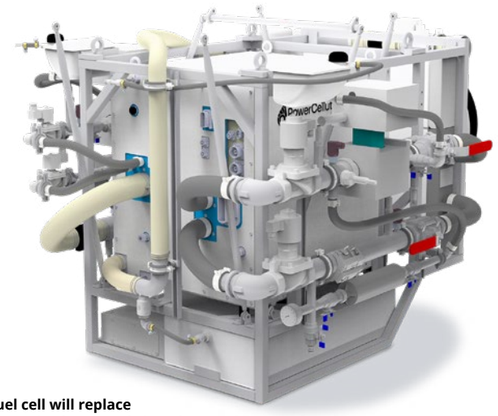
DOUBLING DOWN ON RESEARCH: THE HYDROGEN AVIATION LAB AND ITS DIGITAL TWIN

IN ADDITION TO SETTING UP THE A320 LABORATORY, DLR IS ALSO PRESSING AHEAD WITH THE DEVELOPMENT OF THE DIGITAL PLATFORM, WHICH REPRESENTS THE DIGITAL TWIN. HERE, DATA AND THE HYDROGEN SYSTEM PARAMETERS FLOW TOGETHER AND CAN BE ANALYZED BY THE EXPERT TEAMS.

The German Aerospace Center (DLR) is using the Hydrogen Aviation Lab's unique environment to research hydrogen system designs and assess future operational challenges.

INTEGRATING THE HYDROGEN SYSTEM INTO THE AIRCRAFT

In order to ensure the full functionality of the A320 Hydrogen Lab, DLR supports with the design and engineering of the on-board hydrogen storage system. Due to the higher density, the hydrogen is stored in the liquid phase (LH_2). A small LH_2 tank with about 200 l capacity is used to supply the fuel cell with hydrogen. After draining LH_2 from the tank, it is evaporated and heated to ambient temperatures using an electrical evaporator. Afterwards the gaseous hydrogen (GH_2) is routed to the fuel cell. To allow the filling and draining of the LH_2 tank and secondary functions like pressurization of the tank and to enable conditioning of the system before and after the test, an armature panel is used. Due to last year's investigation of the A320 structure, the tank, evaporator and panel are installed in the rear part of the passenger cabin of the A320.



A fuel cell will replace the APU in the rear of aircraft.

In addition to setting up the A320 laboratory, DLR is also pressing ahead with the development of the digital platform, which represents the digital twin. Here, data and the hydrogen system parameters flow together and can be analyzed by the expert teams. This includes, for example, analyzing the installation spaces for system integration, evaluating sensor data and identifying the interactions of the new hydrogen systems with the board systems of the A320. The advantage of this virtual environment is a simple and fast extension of the hydrogen infrastructure and the analysis of further aspects from operation, maintenance, and design. First data and models of the A320 were already integrated into this virtual environment last year.

ENGINEERING THE FUEL CELL SYSTEM

DLR's Institute of Engineering Thermodynamics is developing the fuel cell system for the Hydrogen Aviation Lab, which will replace the original auxiliary power unit (APU) of the A320 in its functions and duties. For this purpose, the APU of the A320 was completely removed to clear the space for the integration of the fuel cell system. The main requirement is to use existing airframe and aircraft interfaces for mechanical integration and for supplying the fuel cell system with hydrogen and atmospheric oxygen. In addition, the electrical energy generated by the fuel cell system has to be fed into the A320's distribution network.
Together with the DLR Institute of System Architectures in Aeronautics, the DLR has reverse engineered the APU compartment of the A320 to provide information about dimensions and to generate a CAD model for the design layout of the fuel cell system and its integration.
Researchers at the DLR Institute of Engineering Thermodynamics are simulating and experimentally validating effects on system design, working points, and operation procedures of the fuel cell system in an aircraft environment, to identify robust operation procedures using liquid hydrogen as a fuel.

INVESTIGATING MAINTENANCE CHALLENGES

When designing new systems, it is essential that the maintenance effort is already taken into account during the design phase. But how does one estimate the maintenance requirements of hydrogen systems that do not yet exist? Researchers at the DLR Institute of Maintenance, Repair and Overhaul, in cooperation with Lufthansa Technik, ZAL GmbH, and other DLR institutes, have developed an elaborate modeling of a large number of components of the hydrogen system architecture, which is being designed in the Hydrogen Aviation Lab. This is probably the most detailed analysis of these new systems to date. It enables the estimation of maintenance tasks and efforts, intervals, and cost increases associated with the maintenance of hydrogen systems. The model is easily scalable if specific parameters are defined for H2 systems in the future.
The institute is also exploiting the possibilities of the Hydrogen Aviation Lab's realistic environment in other projects. One is dedicated to the detection of hydrogen leakages, which represent a serious safety risk. With a widely ramified sensor network, the goal is to localize even small leakages. Another focus of the research is on potential applications of extended reality applications. In this way, it would become possible to visualize sensor network data even in difficult working environments, making work for maintenance staff safer and more efficient. ◂

Digital twin in virtual reality.

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ENVIRONMENTALLY FRIENDLY INTO THE FUTURE

High-performance, scalable hydrogen power trains are necessary for low-carbon propulsion of aircraft. Developing these systems for fixed-wing UAVs and small airplanes is the goal of the joint research project H2-FINITY. The ensuing combination of hydrogen tank, fuel cell, and electric motor is putting into practice on a small scale what will possibly be the future of commercial aviation.

MOTIVATION

Aviation is at a turning point. Environmental and economical requirements demand new technologies, products, and services that support the goals of sustainability and climate neutrality. One key component is the use of hydrogen as an energy source. Examples for existing efforts to develop hydrogen solutions for the air transportation sector range from clean aviation at the European level to the Hydrogen Aviation Lab recently established in Hamburg. But large aircraft also bring large problems that require equivalent efforts and time frames.

H2-FINITY has been designed to address a different question: how can small and medium-sized enterprises (SMEs) contribute to technological progress and create a future-oriented product that uses hydrogen as its primary source of energy to address the market of small aerial vehicles? Here, the systems are not as complex, the design space is not as limited, and regulations are not as strict as in commercial aviation. The task is the development of a scalable power train for small aerial vehicles with a take-off mass between 25 kg and 250 kg. This does not only include most civil unmanned flight vehicles – a market sector that is expected to see an enormous boost in the coming years – but also the new 120 kg-class of manned aircraft.

HIGH-PERFORMANCE, SCALABLE HYDROGEN POWER TRAINS ARE NECESSARY FOR LOW-CARBON PROPULSION OF AIRCRAFT.

Visit the H2-FINITY website here.

INNOVATION

The power requirements for commercial aircraft are still outside the range of today's fuel cell technology, whereas smaller H2 fuel cells are already available with promising performance and at reasonable costs. Thus, these systems are suitable for unmanned aerial vehicles (UAVs), also known as drones.

H2-FINITY has been designed to address the main challenge of a hybrid electric power train for small aircraft: combining cutting-edge components to a mature, scalable propulsion system that can be used in real-world applications. What sounds rather mundane in theory proves to be a challenging undertaking: understanding the interactions between the components, optimizing the overall system, integrating it into the vehicle, ensuring reliable operation under various conditions, safe handling of gaseous or liquid hydrogen, certification aspects and solving practical problems like refueling and maintenance. To optimize performance and automate operations, the UAVs developed within H2-FINITY will take off from and land on a mobile runway system.

Meeting at ZAL: the team works on integrating power train components into a test vehicle.

THE TAKE-AWAY

H2-FINITY demonstrates that even small companies can team up and innovate together. The project can also be seen as a blueprint that joint research allows SMEs to step out of the role of low-tier suppliers and to acquire system competence of their own. Last not least, it shows that there are still exciting possibilities for young professionals to shape challenging, future-oriented innovation and technology in aviation.

ACKNOWLEDGEMENTS

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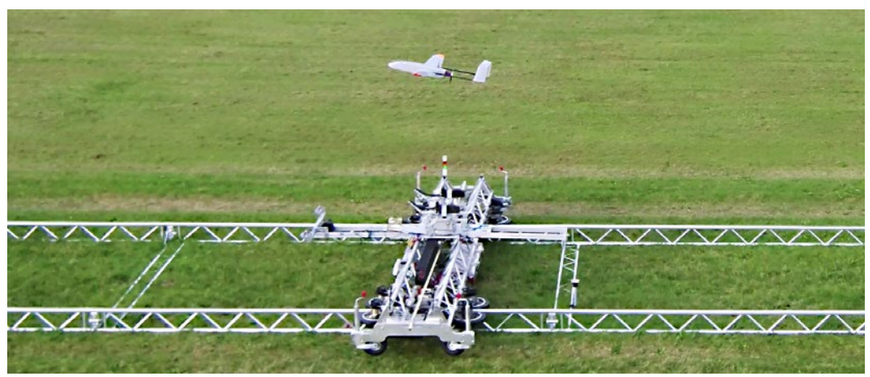

The mobile runway system for fully automated drone launch, landing and turnaround.

WE EMPOWER FUTURE TECH TALENTS

At the proTechnicale School Winter Camp in February 2023, participants met their mentors Susanne von Arciszewski (left) and Anna Matzat (right).

Since 2010, the non-profit SOPHIA.T gGmbH has been empowering young women with innovative tech education programs, namely proTechnicale Classic, a gap year for female high school graduates and proTechnicale School, a digital program for female students attending high school. Since 2016, the home base of proTechnicale is the ZAL TechCenter. A perfect place to connect, inspire, and empower young talents. "The fact that proTechnicale is located at the ZAL TechCenter is a 'win-win-win' situation," confirms Roland Gerhards, CEO of ZAL GmbH, "for the proTechnicale participants, the local companies and ZAL GmbH itself." proTechnicale is funded primarily by the Hamburg Ministry of Economics and Innovation, but also by foundations, companies, and private individuals throughout Germany.

proTechnicale School and Classic aim to attract more women to studies and professions related to STEM (science, technology, engineering, mathematics). Over 90 percent of the graduates of proTechnicale Classic to date have chosen STEM-related studies as a result of the program. The uniqueness of the concept is based on the combination of the transfer of technical knowledge and practical experience. On top of that, there is a strong focus on personal development, such as boosting self-confidence as well as reflecting on one's own personal strengths and goals. "The founder of proTechnicale, Manfred Kennel, decided to include personal development workshops and philosophy," explains Friederike Fechner, managing director of SOPHIA.T gGmbH and project manager of proTechnicale. Thus, the opportunities and relevance for the future job market were recognized early on. "In our experience, young women have all the important future skills that are needed for STEM studies, but the variety of choices can be overwhelming and in most cases, young women lack STEM-role models with whom they can identify. That is where we come in with proTechnicale and make our contribution."

PROTECHNICALE SCHOOL IS AIMED AT HIGH SCHOOL GIRLS FROM ALL OVER GERMANY OR FROM SIMILAR TIME ZONES.

TWO PROGRAMS – ONE GOAL

Learning – and at proTechnicale Classic also living – in a safe space are important components. Moreover, proTechnicale places a strong emphasis on interpersonal exchange – in mentoring programs as well as in networking sessions with women from the STEM world. Although the number of Classic participants is limited to a maximum of 15 proTechnicalees, the launch of the digital proTechnicale School program in 2022 now allows adding 30 to 40 more young women each year. Both programs have already won various awards, most recently the "Hidden Movers Award" 2022 from the Deloitte Foundation.

PROTECHNICALE CLASSIC – TECH ORIENTATION GAP YEAR

proTechnicale Classic is a gap year after high school focusing on study orientation highlighting the areas of aerospace, renewables, programming, and personality development. The program starts annually on October 1 in Hamburg. The number of participants is limited to 15 female high school graduates from Germany and around the world. During the gap year, the proTechnicalees live together in project-owned shared apartments in Hamburg. Most of the classes take place at the ZAL TechCenter. In addition, they visit several universities and get a taste of corporate life during internships in Germany and abroad, while strengthening their personalities. The participants lay the foundation for their professional network during company speed datings at ZAL TechCenter, on field trips, and during fireside chats with female STEM role models. Peer mentoring rounds off the program, pairing a current participant with an alumna.

Learn more about proTechnicale here.

PROTECHNICALE SCHOOL – DIGITAL STUDY ORIENTATION

proTechnicale School is aimed at female high school students from all over Germany or from similar time zones. The participants are enthusiastic about STEM topics, motivated to develop their skills, and exchange ideas with like-minded people. Up to 20 young women can participate in the digital program where they meet regularly once a week plus one saturday a month. There are two runs each year, starting on March 1 and September 1. For a total of five months, they take part in various courses covering aerospace, renewables, personal development, and networking. In addition, they are in close contact with many STEM role models and entrepreneurs. Their curriculum also includes programming, social entrepreneurship, and a mentoring module.

PROTECHNICALE CAREERS

After proTechnicale, the graduates take different paths; they study mechanical engineering, aerospace engineering, biotechnology, or physics, they found their own companies, or train to become pilots. "By empowering, inspiring, and connecting female STEM talents, our programs make an important contribution," explains Friederike Fechner. ◂

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"WE ARE READY TO SHAPE THE FUTURE"

Find out more about Siemens Aerospace.

Siemens and ZAL have established a long-lasting strategic partnership over several years to collaborate on cutting-edge research and development projects in the aerospace industry. Together, we are working on projects related to sustainable aviation, including the development of advanced materials, aerodynamics, and propulsion systems, as well as improving energy efficiency and reducing noise pollution. Our partnership represents a significant step forward in advancing aerospace technology and highlights the importance of collaboration between industry and research institutions.

At the very beginning, it was just a small idea: aerospace in your pocket. Our intention was not only to create a virtual exhibition of our holistic Siemens approach but also a virtual meeting room for customers and our aerospace colleagues.

CHALLENGES THAT WE'VE FACED

Siemens has been an expert in automation for many years and supports customers on their way to digital excellence with a focus on sustainability and innovation. We offer solutions for the specific requirements of the aerospace industry. New planes will be lighter, faster, and more efficient. These aircraft of the future place new demands on product design, production planning, engineering, and execution, as well as service.

HISTORY OF ORIGINS

So one of our first steps was to specify and develop all design, manufacturing and controlling stations according to an aircraft lifecycle, including the machine builder's interests.

AEROSPACE IN YOUR POCKET – WELCOME TO OUR NEW DIGITAL WORLD – AEROWORLD.

Take a look at AEROWORLD.

AIRCRAFT DESIGN

Fly it before you build it. In our software room, we show our customers how the aerospace industry can benefit from digitalization. With intelligent tools for product design, production planning and execution as well as seamless communication between all systems.
Here, they can discover how to benefit from merging the virtual and the real world and see the possibilities provided by the digital twins of product, machine, plant, and the entire production. The virtual version of an airplane represents every detail and can be used to simulate, test and optimize the airplane before production even starts.

PART MANUFACTURING

The first station in our manufacturing hall is the SINUMILL, a digital twin of a real milling machine equipped with best-in-class automation products. There, we can for example demonstrate high-end part manufacturing with SINUMERIK ONE, our digital native CNC. Our customers can experience how Siemens is able to support the process of maximizing productivity, to innovate faster, be on the leading edge of digitalization, and unleash a new way of thinking.

ADDITIVE MANUFACTURING

Additive manufacturing is perfect for aerospace. Freedom of design prevails, the parts are light, and printing spare parts is easy. So our AEROWORLD includes this cutting-edge technology, of course. And best of all, you can walk through our digital AMEC straight from the AEROWORLD Showroom.

CNC ROBOTICS

Robots can be used not only for drilling and milling technologies, but also for additive manufacturing applications – highest path accuracy, flexibility and mobility are guaranteed.

ASSEMBLY

Best-in-class solutions for composites manufacturing, pre-assembly and final assembly processes, including automated guided vehicles and cranes – our controllers ensure maximum efficiency for high-end applications in machine and system automation. Motion control is our expertise. Aerospace manufacturers benefit from a high degree of flexibility, convenient engineering, and rapid commissioning.

ENGINE MANUFACTURING

At this station we demonstrate to our customers how we optimize engine production and shape accuracy and surface quality. We are experts in high-end grinding, milling, and turning technologies used to manufacture engine components in the most efficient way.

DIGITAL CONNECTIVITY AND POWER

Our customers can benefit from our unique expertise in industrial communication and networking. Our industrial communication portfolio permits the optimal networking of automation components based on professional infrastructure planning and implementation.

CONTROL ROOM

This is where best-in-class solutions, for smart infrastructure, industrial services and cloud technologies take place. Manufacturing operations management (MOM) is a holistic solution that provides full visibility into manufacturing processes to steadily improve manufacturing operations performance. MOM consolidates all production processes to improve quality management, advanced planning and scheduling, manufacturing execution systems, R&D management, and more.

ADVANTAGES

We take our customers on a journey, a tour through a virtual aerospace manufacturing hall, where we prove our know-how each and every single step of the way. ◂

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THE EXECUTIVE BOARD NOW WITH FOUR CHAIRMEN IN THE ZAL E.V.

ZAL e.V. bundles the interests of medium-sized and smaller companies within the shareholder structure of ZAL and offers them opportunities to influence decision-making processes on an equal footing with the major shareholders such as Airbus Operations GmbH and Lufthansa Technik AG.

Our member companies are innovative partners for the development and industrialization of future aviation technologies, thus making an important contribution to strengthening the world's third largest location for civil aviation.

As a shareholder, we actively support the current strategy and orientation of ZAL and are pleased about the ZAL TechCenter's expansion. Modern new work concepts and the greatest possible flexibility in technical equipment are essential for successful project-based research work.

In June 2022, the new extended board was elected at the annual general meeting. The concrete implementation of the association's organizational possibilities is tied to the two positions of the first and second chairmen of the executive board. Jörg Manthey, first chairman in his function as delegate of HECAS e. V., represents the voice of the association in the quarterly meetings of the ZAL supervisory board. Thorsten Reimetz, second chairman in his function as an exemplary supplier, represents the association at the ZAL shareholders' meeting, which takes place once a year. The third person, Sebastian Corth, represents the interests of the board in his function as a board member of Hanse Aerospace e. V. Currently, the chairmen are focusing particularly on topics related to digitalization and hydrogen applications. And Dr. Martin Spieck from the company Thelsys GmbH, which is also a member of the ZAV e. V., focuses on research and innovation in joint R&D projects. ◂

ZAL e.V. board from left to right side: Sebastian Corth, Thorsten Reimetz, Jörg Manthey, and Dr. Martin Spieck.

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AERTEC SOLUTIONS GMBH
ALTEN TECHNOLOGY GMBH
ALTRAN DEUTSCHLAND S.A.S. & CO. KG
CLUSTER ERNEUERBARER ENERGIEN HAMBURG E.V.
CTC GMBH STADE
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LATÉSYS GMBH
SAFRAN ENGINEERING SERVICES GMBH
SFS GROUP GERMANY GMBH
SILVER ATENA
TESA SE
THE AIRCRAFT PERFORMANCE COMPANY GMBH
THELSYS GMBH

Roland Gerhards, CEO ZAL GmbH, welcomes the participants.

MAKING CHANGE HAPPEN

We invited key players in aviation to talk about Change. And they did: Airbus, Boeing, H3 Dynamics, Loganair, and Lufthansa CleanTech Hub. They all joined ZAL Innovation Day 2022 to discuss how to navigate through turbulent times.

Since 2017, the flagship event of ZAL has combined impulses from aviation research with networking. The program usually consists of workshops, live demos, ZAL tours, as well as researchers and futurists who come up with gripping talks on stage.

In case you missed the event or simply want to recall the key findings, here's your chance. Our recording of the presentations gives you insights into the exciting topics covered at the last event: global players' approaches to sustainable aviation, the green aviation that is already happening, the development of new technologies, and the impact of start-ups driving change.

Also, don't miss what futurist Dixon has to say. He reveals the pitfalls you can avoid when forecasting the future. And it's not just the content of his presentation that's interesting, but also the way he delivers it. Due to an injured ankle, the Brit was unable to travel to the event and joined on a separate screen – life-size and in real-time communication with the host and audience. ◂

Watch the short film of the last event.

Next year you can also expect a comprehensive program. You are welcome to register at event@zal.aero to make sure you don't miss any news.

"All of the stakeholders need to have like this set of cojones and they need to go."

Erin Beilharz, Managing Director CleanTech Hub at Lufthansa Group

The presentation in full length.

The Lufthansa Group has a great deal of know-how in the aviation industry. But one company alone – however large it may be – cannot bring about the change we need. Erin emphasizes how important it is for start-ups, governments, investors, and the aviation industry to work in concert. Her creed: success depends on the combined ambition of all. One current example is the Hydrogen Aviation Lab.

"I want to address some confusion: it's definitely 2035!"

Glenn Llewellyn, Vice President Zero Emission Aircraft at Airbus

Glenn explains Airbus' ambitious plan to bring a zero-emission aircraft to the commercial market. This requires a lot of research and development. An A380 serves as a test platform. The big advantage is that the model's size means it can tolerate major modifications, such as a fifth engine for hydrogen testing.

The presentation in full length.

“It’s a team sport. There is not one single solution.”

Dr. Michael Haidinger, President Boeing Germany, Benelux, Central & Eastern Europe

Boeing follows four strategies for decarbonizing aviation by 2050. Fleet renewal, operational efficiency, renewable energy, and advanced technology. According to Michael, his company believes in SAF, especially concerning long-haul flights. Thus, by 2030 all aircraft are supposed to be compatible with SAF. The shorter the distance, the more electrification and hydrogen scenarios are going to take place.

The presentation in full length.

“The world can change faster than you can hold a board meeting.”

Dr. Patrick Dixon, Chairman of Global Change Ltd., author & Europe’s leading Futurist

The presentation in full length.

According to Patrick, the future is all about timing. The best strategy on earth does not work when it’s five years too early or too late. However, events can crush strategies. Thus, we must admit to ourselves that the future is not determined by innovation but by events triggering them. The Covid pandemic proved, for example, that the pharma industry can innovate four times faster than usual, if needs be. As for how this translates to aviation, Patrick offers several answers, one of which is that to accelerate change in aviation, we cannot work virtually.

“Policy can be driven by emotion.”

Andy Smith, Head of Sustainability Strategy at Loganair Ltd.

The Scottish airline Loganair is the UK’s largest regional airline, with 35 destinations. The airline has shown in the past that it can act profitably even in challenging enviroments (remarkably, they operate the world’s shortest flight route with a duration of approx. 80 seconds). With the 2021 GreenSkies initiative, Loganair set itself the goal of having its operations carbon neutral by 2040. Speaker Andy Smith shares his experiences on how sustainable practices can be implemented in aviation.

The presentation in full length.

“We designed down to get into the air faster.”

Taras Wankewycz, Founder & CEO of H3 Dynamics

Taras and his company H3 Dynamics are on a mission to decarbonize air mobility. Their approach is to solve big technical and regulatory challenges with small-scale systems first, before facing the final goal of crewed hydrogen aviation. This “Darwinian” method has the advantage that each intermediate step also yields a usable product. Like their fully autonomous drone-in-a-box platform or their hydrogen propulsor nacelle.

The presentation in full length.

IMPRINT

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THIS MAGAZINE WAS PRINTED IN A CLIMATE-NEUTRAL AND RESOURCE-SAVING WAY.

Tell us! Do you like the new magazine? And would you like your ZAL project to be included in it next time?

Future. Created in Hamburg.

ZAL