Bavarian e-tonomous AIR Mobility (BeAM)

bavAIRia

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Bavarian Ministry of Economic Affairs, Energy and Technology

Foreword

Bavarian e-tonomous AIR Mobility: BeAM

Mobility is a central factor in the competitiveness of urban areas. The further development of our transport system is therefore a major challenge. We need to improve existing means of transport and, at the same time, enable their seamless integration with new traffic systems. Airborne systems will play an important role here. What used to be a vision of the future is now taking shape. In future, environmentally-friendly "air taxis" will fly (semi-)autonomously with electric propulsion systems. It is important for Bavaria to be able to compete in the global marketplace. We have the right foundations in place for this. We have excellent research facilities and innovative companies at the cutting edge of many of the technologies on which such flying systems are based. "Air taxis" will be a focal point in which key technologies can be bundled and from which new business fields can be developed. The Bavarian Air Mobility Strategy is geared to creating optimum conditions for industry and research. We will open up test markets, conduct feasibility studies and establish a legislative framework. We are supporting the development of electric and autonomous flying in Bavaria through the "Bavarian Aeronautical Research Programme". The special publication "BeAM" is to provide further momentum!

Dr. Markus Söder

Minister-President of Bavaria

New times in aviation – BEAM takes off

Autonomous Electric Flying in Bavaria

Like no other technology, electrification is changing aviation. It not only makes aircraft more silent and less polluting, it also enables new aircraft concepts like distributed propulsion, and also is the base for autonomous flying, vertically-launched air taxis and delivery drones.

The Bavarian State Government has set itself the goal of making Bavaria a leading pilot- and production region for individual autonomous air traffic.

Looking at the huge economic potential which experts see in this new Urban Air Mobility (UAM) sector due to the worldwide interest and huge potential market volume of this field and its role in an electric mobility concept on the ground and in the air this development can help Germany keep her leading position in developing future transports technology concepts like in the past - cars, aircraft, fast trains etc.

Just a few years ago, many observers said that electric flight would come at some point, but no chance in the near future for flying with the blessing of the authorities - autonomous flying vertical takeoff small aircraft. Others in the field of electrical aviation were convinced that the electric flight would only be able to grow to an economy of scale if the new vehicles will be flown autonomously. Today, almost everyone - pilots, politicians and media - speaks about autonomously flying eVTOL (Electric Vertical Take-Off and Landing) Air Taxis.

Electric aircraft, for a long time just a theoretical dream, become reality. The electric revolution has inspired and changed aviation more than any other development in the last 60 years. With small electric motors so-called „distributed propulsion“ are possible, and thus more efficient aircraft designs. Up to now a large high drag engine or turbine did hang at front of the plane and the designers had build the plane around it.

Now you can first design a highly efficient aircraft and then place suitable electric motors where the thrust is needed and helps to control the aircraft by differential power.

For example, you can build the most aerodynamically efficient wing and fully stabilize its inherent instability with computer-controlled electric motors like the NASA X-57 Maxwell plane. But independent drive units eVTOL (electric Vertical Take Off and Landing) become so possible.

But it is not just the electric motors themselves that are important, but also the advances in computer science and Artificial Intelligence (AI). Only together these technologies are creating a disruptive moment in aviation. With them the new,

digitally controlled e-aircraft fly vertically and autonomously.
This makes it possible that soon not only a few eVTOLs will fly around but soon thousands of these machines will be used for manned and unmanned air transport. Thus, an „economy of scale“ is created, which pays off the huge investment in these aircraft.
That's why Google, Airbus, Boeing, Daimler, Siemens, Bosch and many others are investing in these new eVTOLs and related infrastructure.
Bavaria is ahead in many areas of these technologies and has so good chances that it will stay that way with the right support. Not only top players - start-ups and established multinationals like Volocopter, Lilium, Siemens, and Airbus are active here, also many suppliers developing the components for the electric flight and the autonomous operations are based in Bavaria. In addition, universities such as the Technical University of Munich, and organisations like the state owned BavAIRia want to ensure that the right biotope is developed to develop the necessary technologies.
With test areas and the connection to other segments of autonomous mobility (key players like Audi and BMW located in Bavaria), this can become a veritable fertilizer for the growth of the new green traffic technology in the third dimension.
This magazine BeaM (Bavarian E-Tonomous AIR Mobility) will help answer the most important questions and make electric autonomous flying in Bavaria attractive and an economic factor.

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bavAIRia: Extended test range for Unmanned Aircraft Systems (UAS) planned for new operations profiles

By 2035, the world-wide market volume for emission free passenger transport is expected to grow to 75 b$. Meanwhile, the fast-growing market for UAS is creating new jobs especially in "beyond visual line of sight" (BVLOS) operations in various fields of new services. The Bavarian Government is supporting new developments in this future oriented domain.
Bavarian Companies and research centers have developed world class solutions. Consequently, these advantages must be further developed, therefore test areas for practical operational testing are needed all over Germany.
The Bavarian Aerospace Cluster bavAIRia e.V. has been working for over five years in organizing the UAS Forum in this field. Beside conferences, workshops and networking events, they also managed the first German UAS Test Range at different locations. It´s now time to shift into second gear. The experimental Airport Oberpfaffenhofen near Munich, Germany Bavaria is a great asset, as it has testing experience with the German Aerospace Center (DLR) including UAS applications from bavAIRia members.

Objectives for the extended Test Range for unmanned, Electrical Flying (TUEF) in Bavaria

Building the pilot region for Air Taxis and UAS, a dedicated test range for developing hardware, software and adequate procedures within a realistic operations environment is fundamental. The following objectives are essential:

- Development, testing and operation of UAS, Air Taxis and electrical powered Aircrafts
- Components and procedures for safe integration into airspace
- Testing of new applications under realistic operational/ environmental conditions
- Extending step by step exiting VLOS test area to BVLOS area
- Use of existing infrastructure and expansion with new features for automatic landing / charging facilities ■

State Secretary F.-J. Pschierer (currently Bavarian Minister of Economic Affairs) Sept. 2015, H. Steinberg (Member of the Board bavAIRia) E.V. Lauschner (bavAIRia), A. Kohle (CFO Grob Aircraft Systems), F. Seibel (CEO), A. Busse (CFO Quantum Systems) at the opening of the German Test facility for UAS in Mattsies, Bavaria ■

Benefits of New Test Area

Bavaria and Germany, both benefit from the vast opportunities this new facility offers to improve existing and new business ideas. New ways of cooperation between research, universities and industry, including start-up companies, can flourish even more with the close vicinity of practical test facilities supported by the local government. A strong interest for partnership between industry, university and

start-up companies exists. Investment partners for infrastructure are also available. ■

bavAIRia, as project coordinator, invites all interested members of the community to join forces for the sake of developing a market for safe, unmanned electrical air traffic world. ■

State Secretary F.-J. Pschierer (former Minister for Economic Affairs) at the opening of the German Test facility for UAS in Mattsies, Bavaria ■

9. UAS Forum at Technical University of Munich (TUM), Dec. 2017 ■

Next Steps

Currently, the analysis of requirements of future users is taking place followed by the finalization of financial planning and funding. Furthermore, discussions about installing a safe airspace of 60 km length is being conducted as well as measurements for a safe integration and cooperation within the existing airspace. New technologies using mobile networks including LTE 5 will be introduced.

bavAIRia e.V.

bavAIRia, the Bavarian Aerospace Cluster is representing, since 2006, over 300 members (75% are SME) in the field of Aerospace in Bavaria. It is located in Oberpfaffenhofen, near Munich, Germany. The overall objective is to foster the cooperation between industry, small and medium enterprises (sme), universities, research institutes and politics and improve the overall international competitiveness of this sector.

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bavAIRia Paris Air show exhibition Stand 2017 with J. Heitzmann, A. Gundel, (Members of the bavAIRia Board), P. Schwarz, (Managing Director), Team C. Labitsch, E. V. Lauschner ■

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Electric Urban Air mobility Rises Around The World

The world of transportation is changing faster than ever, and electric drive technology and autonomous operations are driving this change in all areas on the ground, the water and in the air. As individual transport on the ground is confronted with more and more difficulties, all players look for new opportunities. So the urban air traffic will be a part of an overall solution. Airliner manufacturers like Airbus, Boeing, Embraer are investing in this field as well as multinational electronic companies like Siemens, Bosch, GE, and Intel, as well as the Internet companies like Google, Tencent and last but not least the car manufacturers from Audi to Geely and Mercedes up to Toyota are all investing in Urban Air Mobility (UAM). About three years ago UBER the globally successful ride sharing company started a hype with its Elevate Program and with this launched the entry of other players which will be essential for the success of this new form of mobility - as they are necessary to build up the new infrastructure. City governments like LA, Paris and Shanghai are interested as well as logistic companies like the Chinese JD, Amazon and DHL and last but not least even traditional transport companies like DB (The German Railway) look into this field.

The SITUATION

As so many companies and investors go UAM obviously also the consulting companies like McKinsey and Morgan Stanly look into this field and try to judge the development volume of this new market and they are predicting fast growing future. By 2035 -2040 the world-wide market volume is expected between 500 billion to 1.5 trillion (Morgan Stanley) USD for emission free transport - including autonomous flying Urban Air Taxis and the fast-growing market for UAS especially in "beyond visual line of sight" (BVLOS) operations in various fields of new services. This new technology will create millions of new jobs and opportunities. ■

The Volocopter- Made in Germany - was the first manned Multicopter which flew ■

Like in several other countries the Bavarian government is supporting new developments in this future oriented domain. Bavaria has a long tradition in aviation, with companies like Airbus, Eurocopter, Grob etc., which means also aviation oriented universities like the TUM (Technical University Munich) and a large number of mid-size supplier companies. The Bavarian government supports this by the state owned company BavAIRia e.V. which manages the AEROspace cluster. As many eVTOL companies are ramping up around Munich - BavAIRia e.V. now has the task to create the right environment to let them grow and keep their leading role in this booming part of the aviation market. On the following pages we introduce BavAIRia and some Bavarian e-aviation players.

Bavarian Prime Minister Markus Söder exploring the Simulator of the Bavarian eVTOL comnpany AutoflightX ■

Bavarian companies and research centers have developed world class solutions. Consequently, these advantages must further be developed. Therefore test areas for practical operational testing are needed all over Germany.

The Bavarian Aerospace Cluster bavAIRia e.V. has been working for over five years in organizing the UAS Forum in this field. Beside conferences, workshops and networking events, they also managed the first German UAS test range at different locations. It's now time for shifting into second gear. The experimental airport Oberpfaffenhofen near Munich, in Bavaria Germany is a great asset, as it has testing experience with the National Research Agency DLR including UAS applications from bavAIRia members. ■

Test areas for autonomous electric flying in Bavaria

Building the pilot region for Air Taxis and UAS, a dedicated test range for developing hardware, software and adequate procedures within a realistic operational environment are fundamental. The following objectives are essential:

- Development, testing and operation of UAS, Air Taxis and electrical powered aircrafts
- Components and procedures for safe integration into airspace
- Testing of new applications under realistic operational/ environmental conditions
- Extending step by step exiting VLOS test area to BVLOS area
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The eHANG 216 an competitor made and flown in China ■

At the same time the Bavarian city of Ingolstadt together with the partners Audi and Airbus is launching an incentive to become a Test Region for integrated New Urban Mobility – which includes Urban Air Mobility.

Bavaria and Germany both benefit from this new facility and the vast opportunities to improve existing and new business ideas. New ways of cooperation between research, universities and industry, including start-up companies, can flourish even more with the close vicinity of practical test facilities supported by the regional government. ■

International developments

Why is it so important for Germany as a technology country to be on board with these new technologies for Urban Air Mobility? State of the art technologies for electric propulsion and battery development, as well as artificial intelligence, two of the most promising fields of technology are the basis for UAM. So those regions in the world where these technologies are developed will be the key players of the future transport technology on the ground and in the air.

And there are players around the world competing. Kitty Hawk, the Google financed eVTOL company, is testing its prototypes in Las Vegas (US) and New Zealand. eHang is already flying passengers in a test mode in China. Dubai and Singapore want to start test areas for eVOL Air Taxis in the next year and Norway is about to electrify its regional Air Transport.

This is an international competition where only the best technology worldwide will win and at the moment Bavaria has a good starting position. ■

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Bavaria- Partner of the World and Business Location with Future

The Free State of Bavaria ranks among the most economically strongest regions of Europe. Thanks to an offensive economic policy and a first class infrastructure, Bavaria is and remains a location with future. A productive network of "global players" and a wide class of efficient small and medium-sized enterprises exists to ensure growth and employment for almost all sectors.

The Free State of Bavaria covering more than 70,000 km² is the largest Federal state in Germany in terms of area and with a population of 13 million people is the second largest Federal state after North Rhine-Westphalia in terms of inhabitants. Apart from the indisputable advantage as a living and leisure location, Bavaria enjoys an excellent reputation worldwide primarily as a high-tech and service location. Compared with other countries in Europe, nearly all national economic data has reached peak values. ■

Successful race to catch up

In an unprecedented race to catch up, Bavaria has developed from being an Agrarian state with an above average level of unemployment and a below average economic value-added at the end of the Second World War into a first rank economic power. A low rate of unemployment compared with all other federal states, a far higher proportion of self-employed persons and a high level of immigration primarily during the last ten years verify this fact. The rapid upswing in Bavaria has been accompanied by an above average employment dynamic. As a result, the number of employees subject to social insurance contribution regulations has increased by almost one quarter and is thus considerably greater than in all other federal states. ■

Germany and Bavaria ■

Offensive economic policy

In the context of an offensive economic policy, the Bavarian state government is pursuing four strategic primary objectives:

- Cost relief of the economy in global competition
- Release of free enterprise dynamics for the benefit of more growth and employment
- Support of the economy in the structural change in the line of „new products, new enterprises, new markets“
- Through further development and expansion of the infrastructure

based on the motto „Save – reform – invest“, the state and administration in Bavaria are being made fit for the future. ■

New Element „Cluster policies“

This is the next logical stage in the offensive of Bavarian innovative policies geared towards the „High-Tech-Offensive“ and the „Future of Bavaria“ offensive. Through the application of cluster policies, the existing state measures for the promotion of innovation are being expanded by organising the networking of economy and science.
These clusters can basically be subdivided into:

Nuremberg ■

European Patent Office ■

Munich Airport ■

Munich Exhibition Centre ■

Wieskirche ■

■ *High-Tech clusters*
e.g. biotechnology, aviation and aerospace, medical engineering, environmental technology
■ *Production oriented clusters*
e.g. automotive, energy, engineering, logistics, sensors
■ *Cross-sectional technologies*
e.g. nanotechnology, new materials, mechatronics
The cluster policy should create momentum to intensify the dynamics between companies and research establishments and optimise possibilities for cooperation ■

Prepared for the future

The structure of the Bavarian economy is robust and future-oriented. A productive network comprising „global players“ and a wide class of efficient small and medium-sized enterprises in the industrial, handcraft and service sectors ensures economic strength. The industrial sector is dominated by the industries of automotive and mechanical engineering, biotechnology and medical engineering as well as energy and transport technology. In the service sector, Bavaria holds leading positions in Germany as an insurance, banking and stock exchange centre. The infrastructure is first rate in the key sectors of transport, energy and telecommunications. The large number of foreign companies that have been set up in South Germany within the last few years and decades, bears testimony to Bavaria's high degree of attractiveness as an international innovation location for high-quality research and development activities and productions.
And last but not least, Bavaria has a variety of attractive „soft“ locational factors: world class culture, intact environmental conditions, high recreational value, a cosmopolitan outlook, interior security as well as social and political stability. ■

Source:
Bavarian Ministry of State for Economy, Infrastructure, Transport and Technology

Institute of Flight System Dynamics

Contributions to meet the Challenges of the third Revolution in Aviation

To fly has been a dream that haunted humankind since its dawn. For centuries, however it remained a mere wish. It was a general view that the complexity is so high, that only large institutions spending tremendous amounts of money and dedicating large efforts could succeed in making the dream of flying come true. After multiple attempts of Samuel Pierpont Langley, heavily supported by the Smithsonian Institution, failed in late 1903, there was the conclusion that it would take many more years until powered flight was a reality.

Just a week later, it was up to a small enterprise, the Wright Cycle Company from Dayton. Ohio, to kick off the first revolution in aviation by successfully demonstrating powered flight of a manned aircraft. It was more engineering ingeniousness, passion, dedication and the hard and excellent work of Wilbur and Orville Wright rather than money that lifted the Wright Flyer off the ground in the windy dunes of Kitty Hawk – far away from public attention.

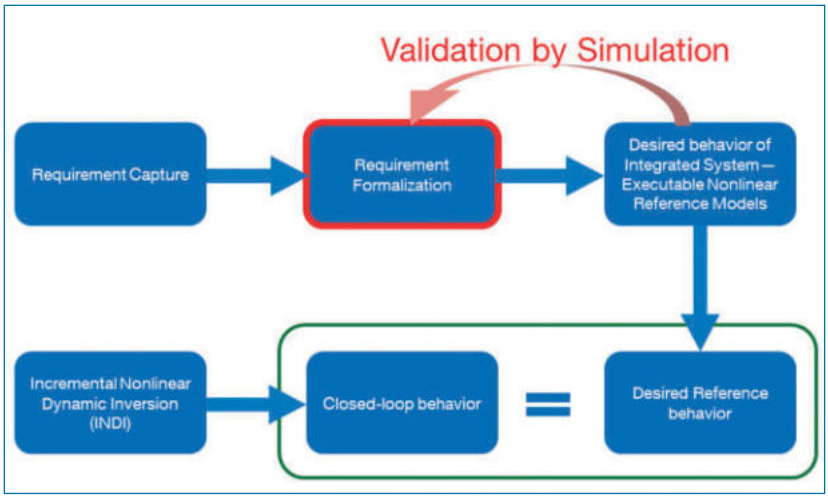
From that day on, almost all aircraft looked the same – wing, fuselage, and empennage. The choice to make was high or low wing aircraft and only some rare daredevils were even more unconventional by putting the empennage to the front.

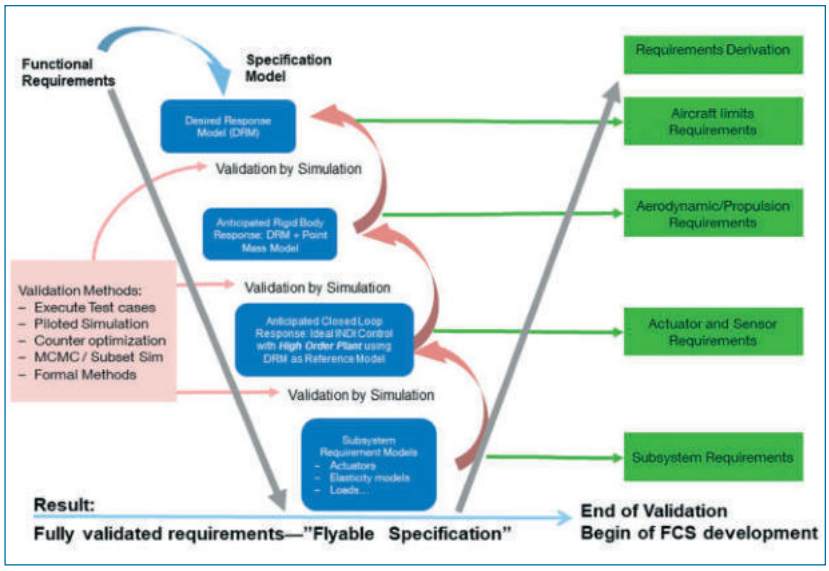
While pioneers and entrepreneurs drove aviation in the early days, the two world wars and the following cold war turned it a governmental and public industry with gigantic amounts of funding involved. The second revolution – the introduction of the jet engine – was a child of that era.

So the simple rule resulting from the first two revolutions was: All aircraft look the same and aviation is tremendously expensive.

However, the high level of commonality in the configuration of all the vehicles facilitated the strategy used in the past to make flying safer. Learning from accidents, new rules, design and production guidelines were continuously established leading to very detailed specifications in the airworthiness code and the related "mainstream" acceptable means of compliance on how an aircraft must be built. – In retrospective, many address this approach as "Certification by Design".

Over the last couple of years, the third revolution started – first with silence, now boldly. Electrification and Automation of Aviation is spurred by rapid innovations in non-aerospace domains – high-integrity computing power, capable sensors, and highly efficient power electronics, all becoming available at low weight, volume and cost. This does not only enable new markets and applications like unmanned aerial systems or air taxis, it also helps to reduce the entry level costs to dimensions which are again within the reach of start-ups and small and medium sized enterprises. This coincides with more and more venture capital from successful self-made entrepreneurs that follow visions with excitement rather than conservatively hiding behind piles of justification documents. – The cutting edge of aerospace is returning to small companies and innovators where it once started, tremendously increasing dynamics and leading to a rejuvenation of parts of the industry. However, now all the new vehicles look very different –





eVTOLs featuring many propellers, tilt mechanisms, different topologies of lifting surfaces, new types of propulsion systems and many more innovations. This immediately means that it is no longer possible to cover all configurations by a set of detailed design rules. Therefore, FAA and EASA, at least in the small aircraft domain (Part 23) replaced the old airworthiness code by a slim set of performance objectives. This marks a shift in paradigm from "certification by design" to "certification by performance" – in a way a revolution by itself. And especially FAA is very proactively endorsing industry consensus standards as acceptable means of compliance, increasing agility and speed at which aerospace can follow the state of the art in other domains.

However, this also means that it is no longer possible to count on the learning curve from previous aircraft.

That raises many questions – What are the right requirements? Are those consistent, complete, unique and correct? How do I design my system? How would I prove compliance of the implementation with the performance requirements?

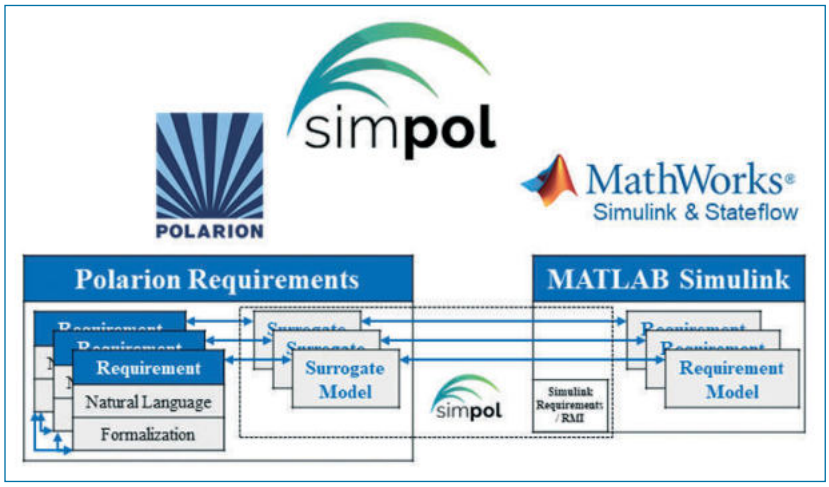
In the past, with a steady evolution, most of the answers came from experience on previous projects as well as directly from certification requirements. Now with many new disruptive changes and radically different configurations, new ways are required for properly addressing those questions.

The Institute of Flight System Dynamics of Technische Universität München is providing new processes and tools to ensure a high maturity at very early project stages, a fact based validation of the requirements and continuous verification and traceability of their correct implementation over the development process. The toolchain roots on the MathWorks software suite together with SIEMENS Polarion extended with further solutions for configuration management, verification, Hardware-in-the-Loop testing and continuous integration. It is important to mention that it is a fit for purpose process, which is currently applied to support different industrial product developments.

The first cornerstone is the use of simulation – the immediate answer would be "well, everyone is doing that". However, the specialty here is not the simulation of an existing physical system but an executable implementation of the desired system behavior of the future vehicle before its development commences. This can be used to validate if requirements that seem independent when available in textual form are non-contradicting and compatible to each other. It allows to get a much more intuitive and illustrative assessment of requirements than textual formulations. Furthermore, already here issues related to the technical feasibility of a new system may be uncovered. Then, these executable "Dynamic Specification Models" and "Requirement Assessment Models" can be used to derive hard fact based numeric requirements on systems, subsystems, components and items, e.g. for actuator bandwidth and rate.

To uncover weaknesses and flaws in requirements and designs, two methods are used – Subset Simulation and Counter Optimization. Those methods assume that most requirements in a performance based probabilistic environment specify the admissible probability at which an inequality constraint may be violated.

Subset Simulation is a stochastic propagation method using Impor-



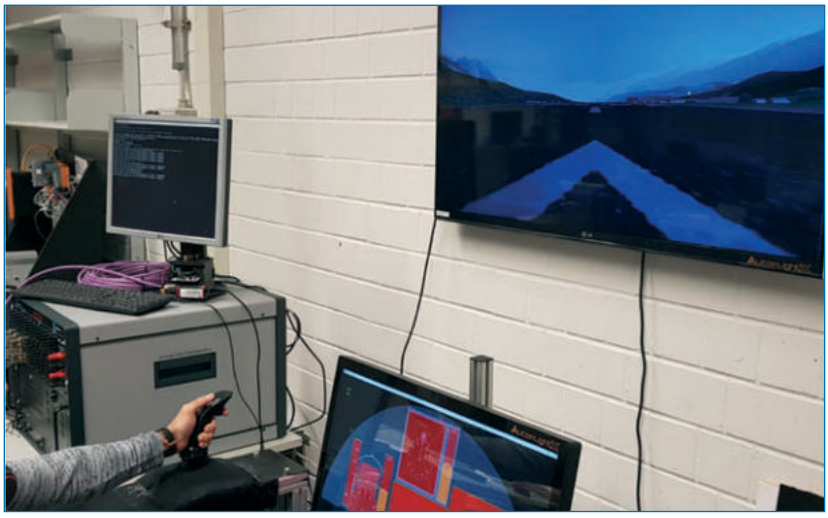
tance Sampling to drastically decrease the number of samples required compared to a conventional Monte Carlo Simulation while still providing valid predictions with the same coefficient of variation by splitting simulations to assess low probabilities into a chain of subsequent higher conditional probabilities. Its specific strength is the analysis of uncertain systems where the distributions of the contributing parameters are known. The TUM Institute of Flight System Dynamics was the first to apply this in aviation – however, the methodology is well established and widely accepted in other domains like finance and insurance math or for risk and safety assessment in civil engineering.

Counter Optimization uses optimal control methods specifying time histories of available system controls and disturbances to intentionally violate requirements. It builds on falcon.m, the optimal control framework of the TUM Institute of Flight System Dynamics, available for download from the institute homepage. The Optimal Control Problem (OCP) is discretized using collocation.

Fault trees and minimum cut sets for logics and state machines are automatically generated by leveraging the property proving capabilities of Simulink DesignVerifier. A tool called ExCuSe (Exclusion of Cut Sets), which has been developed at TUM-FSD, performs this task.

Bidirectional traceability is ensured by SIMPOL, another tool available for download on the institute homepage that links artefacts between POLARION as the requirements management tool and the MathWorks domain, where also extensive use is made of the Simulink Test Manager.

For Hardware-in-the-Loop Simulation, a TechSAT ADS2 based system is used, which is fully integrated in the development process. Beyond normal bus and discrete and analog signal stimulation, multi constellation and multi frequency GNSS can be stimulated in a closed loop manner as well as static and dynamic pressure. For characterizing gyro error models, a turn table is available.

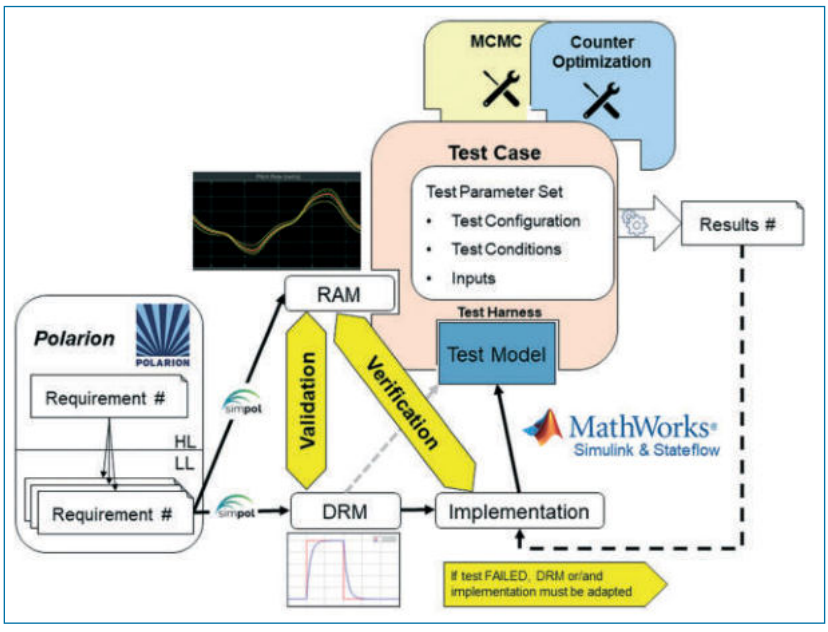


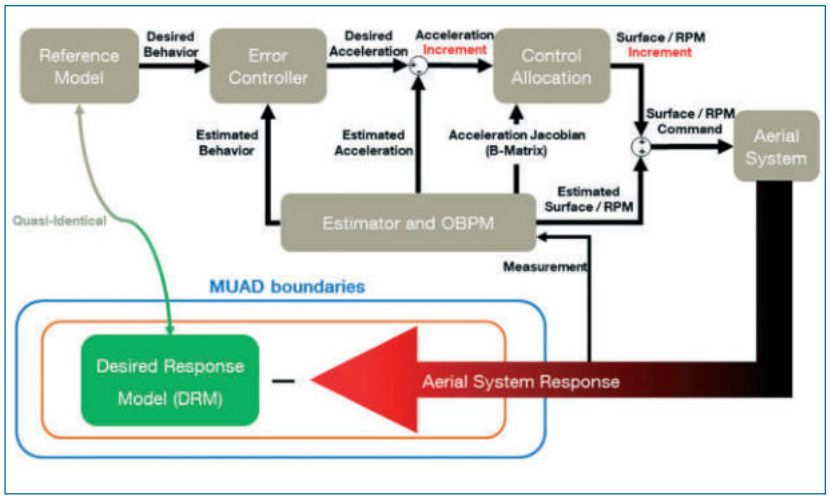
The whole development process is integrated into a GIT based Continuous Integration Framework.

Implementation of Software Based Functions is performed in a process following DO-178C and its supplements. A vast number of automatic checks helps to ensure standard compliance.

For flight control functions, the availability of dynamic specification models is leveraged by incremental dynamic inversion, a modern control methodology that proves to be very robust to uncertainties and which allows the computation of classical linear stability metrics. The controller design is split up in reference model, error controller, control allocation, controller parameter design and the supervisory tasks consisting of moding, voting and monitoring.

The test cases and conditions along with the Requirement Assessment Models, which are defined very early during requirement capture, are consistently applied throughout the whole development cycle – from requirement validation, via verification in different design stages (prototyping, code, processor in the loop, hardware in the loop, aircraft in the loop) to flight testing. Traceability between tex-





tual requirements, formalized requirements (in terms of Requirement Assessment Models), function implementation, test case, condition and harness and test results is managed by SIMPOL.

More than 30 postgraduate researchers at different levels support the described process at the TUM Institute of Flight System Dynamics. Among others, current applications are transition UAVs, eVTOL aircraft and conventional fixed-wing aircraft of different sizes and maneuverability. Having collected significant experience by flight testing of transition UAS, we have moved well along the learning curve.

Based on the methods and processes mentioned above, the TUM Institute of Flight System Dynamics offers unique capabilities for the specification and development of complex functions for novel aerial vehicles. Especially when no experience is available due to application of disruptive technologies, concepts and configurations, the fact driven process introduced above helps to significantly reduce the development risk and supports the whole system development form original system specification to verification. ■

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German UAV manufacturer Quantum-Systems

Quantum-Systems GmbH was founded in 2015 in Munich and is specialized in the development and production of automatic, electric vertical take-off and landing (eVTOL) fixed-wing drones for civilian use.
40 employees are working intensively on combining reach and electric efficiency with the ability to vertically take-off and land (VTOL) without additional equipment.

CEO Florian Seibel: "Our passion is the continuous development of unmanned aircrafts. With our complete solutions, increased yields in agriculture, planning security in infrastructure projects and civilian safety functions can be easily achieved."

Quantum-Systems Tron UAV with LiDAR Scanner setup ■

Unique feature – eVTOL fixed-wing system

The eVTOL fixed-wing UAVs of Quantum-Systems unite the benefits of helicopters and airplanes in one new innovative aircraft. It has both, the convenient handling of a helicopter and the sophisticated aerodynamics of an airplane. The systems therefore are up to 100 times more efficient than regular multi-copter-drones but equally easy to control.

The aircrafts provide a space efficient and safe way to launch and land in even the most difficult areas. High payloads for a variety of sensors (RGB, LiDAR and NDVI combinations) in addition to the long enduring and efficient construction provide an ideal platform for civil use. If it is agricultural research (e.g. crop health), industrial inspection (e.g. pipelines or hazardous areas like the nuclear hazard in Chernobyl), volumetric calculations of stockpiles or security and surveillance missions - The product fields are widely spread.

The Trinity UAV in long duration flight over Bavaria ■

Quantum-Systems offers two models with this technology. The Tron UAV has a maximum payload of 2 kg and the Trinity / Trinity F9 UAV, the smaller sister, offers 550g payload for various sensor configurations. The design enables flight times of up to 90 minutes per battery charge. Thanks to the proprietary mission

planning software QBase, the preliminary planning of the mission is straightforward and process-oriented. The entire work process enables very large areas to be covered in the shortest possible time and all spatially relevant data to be acquired.

„The intellectual property of our hardware and software is not dependent on third-party products and enables us to optimize the entire system for the needs of our customers.“ confirms Florian Seibel.

In Autumn 2018 Quantum-Systems introduced an enhanced version, the Trinity F9 to the market. This model is identical to its base model but with added Post-Processing Kinematics (PPK) which enables the operator to boost accuracy of the GPS signal to 2-5 cm compared to the standard GPS accuracy of ~1-3 meters.

Together with the Trinity F9 an addon for the mission planning software QBase was published and extends the range of functions with Live Air Traffic visualization. This feature increases situational awareness for the drone operator during flight. Especially for beyond visual line of sight (BVLOS) missions this feature is mandatory to guarantee safe UAV operations.

Laser-assisted sensors, so-called LiDAR scanners, are also being used more and more frequently in the drone industry. Known from the automotive sector, these sensors are in demand for all tasks that require detailed point clouds. For example, a ground relief under the densest vegetation can be mapped with centimeter precision within a few minutes (the same applies, for example, to industrial plants such as pipelines or power lines). The Tron UAV in particular is successfully serving a niche here, since it can cover an area of 900 hectares in a single flight. The size and weight of the sensors pose special challenges to the UAV and Tron is unrivalled in its class in terms of flight time and transport safety of the expensive equipment.

CEO & Founder of Quantum-Systems GmbH Florian Seibel ■

The products are already available worldwide and resellers receive a detailed product demonstration in order to be able to provide support for their customers.

New potential sales partners are invited to inform themselves firsthand about the products of Quantum-Systems GmbH at a so-called „Demo Day“.

Details can be found at www.quantum-systems.com

Company profile:

Industry: Electric automatic VTOL capable drones

Year of foundation: 2015

Employees: > 40

Turnover 2017: 1.2 mil Euro

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Volz Servos – German Manufacturer of Actuators since 1983

In 35 years – now in 2nd generation – Volz Servos has established itself as the world-market leader and expert when it comes to compact, highly efficient electro mechanical actuators. Through a wide and diverse product portfolio, Volz actuators are utilized in various industries and applications, from medical and laboratory devices, robotic applications and unmanned systems (UAVs) to manned aircrafts.

An actuator is a device which converts a control signal into mechanical movement, for example moving the elevator and vertical rudders of an UAV or operating the throttle of an engine. Therefore, every actuator comprises a DC motor, a gear train and control electronics governed by microprocessors and sensors. Using intelligent firmware and engineering, Volz actuators can meet the highest customers' demands. Volz developed full brushless actuators, using brushless DC motors and contactless, wear free position sensing systems to reduce the maintenance and minimize down-times.
Volz specializes in adapting its products to meet customer requirements and in developing completely new solutions. This includes mechanical solutions such as adaptation to HALE (High Altitude Long Endurance) applications - 90,000ft altitude or for deep sea projects down to 6,000m /20,000ft water depth as well as actuators with electromagnetic clutches for optionally piloted vehicles (OPV).

The wide and diverse product portfolio of Volz Servos is used in various industries and applications ■

Even with the smallest DA 15-N customers can easily reach MTBR of 2,000 operating hours and more. The various health monitoring capabilities are either communicated through a serial RS 485 or CAN Bus interface. The servo is e.g. used in the Textron Aerosonde, Insitu ScanEagle as well as in the Zipline project, delivering blood in Rwanda.

Customized actuators for special purposes - Volz Servos is specialized in adapting its products to meet customers' requirements ■

One of the unique selling points of Volz is that all actuators are "Made in Germany" under stringent quality controls (ISO 9001:2008) and are individually tested before delivered to customers worldwide. Based on those quality features, precision and the continuous urge for innovation, Volz is a valued partner for global companies, research institutes as well as high tech start-ups. Together with the Institute of Flight System Dynamics at the Technical University of Munich (TUM), the German Aerospace Center (DLR) and other institutes, Volz has already developed several innovative products. Just to name one of the projects, currently Volz is developing a fully automatic test-flying device under the German Federal Aviation Research Program ("LuFo") together with the TUM. This will make flight testing more accurate and efficient.
By moving to a new headquarter in Offenbach am Main (20min to Frankfurt Airport) with more capacity and a larger production site, Volz is preparing for the future and underlining its position as the market-leader and reliable partner for the industry. ■

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How can Safety & Reliability minimise costs across the complete product lifecycle?

At Delta System Solutions GmbH, we believe that the electrification and autonomy of air vehicle systems are key enablers for the air transportation system of the future. However, transportation by autonomous air vehicles is still in its infancy and any early accidents would lead to a loss of trust in the technologies, stunting the growth of the industry. This is why the intelligent application and use of both safety and reliability activities are more important than ever.

According to Delta System Solutions co-founder and partner, Stuart Baskcomb: "*The Safety and Reliability methods in themselves are not complicated. The intelligent part comes from knowing how best to apply them to a product or service in order to optimise the design and minimise costs over the entire development and operational lifecycle.*"

An optimal design efficiently complies with certification & customer requirements with no unnecessary elements. Insufficiencies in design can (at best) lead to late, expensive changes to achieve compliance with certification and customer requirements. Unnecessary redundancy means unnecessary development and operational costs. A smart approach to Safety & Reliability (S&R) assessments avoids over-conservatism, as well as minimising the risk of nasty surprises during operations. If this is conducted by somebody with good S&R experience, the desired results can be achieved very efficiently.

Delta System Solutions co-founder and partner, Robert Muirhead, believes that Delta System Solutions would be a good choice for somebody looking for S&R support, because: "*We established Delta System Solutions GmbH specifically to conduct aviation Safety and Reliability assessments. Our know-how comprises both products and operations and, with this holistic view, it is possible to achieve the most efficient system. One additional bonus is that the use of an independent specialist company like us will make the Design-Safety independence argument unambiguous, whilst of course maintaining our customers' high levels of quality*".

„Lilium Jet Flying (credit: Lilium GmbH)" ■

How can we help?

We are independent Aviation S&R specialists with an established reputation through our contribution to the successful certification of a variety of Aerospace products & services.

We have the experience and knowledge it takes to perform any or all aspects of your S&R assessment needs. Our expert service can also provide an independent audit of existing S&R analysis, as well as training/consultancy for your own staff.

For further information or to arrange a meeting with one of our team to discuss your individual needs, email us now at BeAM@delta-system-solutions.com. ■

About Us

The company was established in 2013 by 2 experienced Engineers. Our head office is based in Munich and we have an engineering office at the Zentrum für Luft- und Raumfahrt in Wildau, near Berlin. We are ISO 9001 certified by TÜV and hold an AÜG permit to loan our staff to clients in Germany.

Contact:

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Augsburg Innovation Park with the Technology Centre Augsburg

Location factor innovation competence

The new challenge in the aerospace industry is faster and more economical production, automation, greater flexibility and above all increased resource efficiency in the use of energy and materials throughout the entire production and use cycle of the aircraft.

To meet these challenges, Augsburg has founded one of the largest economic development projects.
The Augsburg Innovation Park with the Technology Centre Augsburg is an economic development measure of the city of Augsburg and the Region of Augsburg, supported by the Free State of Bavaria, the Economic Chambers as well as further institutions.

Technical Centre Hall in the Technology Centre Augsburg, Photo: © Wolfgang Hehl ■

The goal is to support innovation and technology transfer for businesses in the field of aerospace, lightweight construction, fibre composites, mechatronics and automation, digitization, industry Technology companies can settle in the 70-hectare Innovation Park or work closely together with research institutions as a project group in the 12,000-m² Technology Centre Augsburg in order to improve production processes and products. 40 users such as start-ups, regional businesses and global players are already on site.
In the modern event area, over 15,000 specialists have exchanged information and experience on technological topics in the past 2 years. 13 technology-oriented research institutions from the above-mentioned technology fields are active in the Park and provide important contributions to moving the aerospace industry forward – such as the DLR German Aerospace Centre, the AMU Application Centre for Material and Environmental Research, the Fraunhofer Research Institute for Casting, Composite and Processing Technology IGCV and the ITA Institute of Textile Technology Augsburg as well as the central offices of the Bavarian and federal cluster institutions in the fields of carbon fibre, the environment, mechatronics, digitization and aerospace.
The innovation competence is also supported by excellent specialists provided by the university, technical colleges and further educational institutions.

Simulated aerial image, Innovation Park, Photo: © KCAP Architects & Planners ■

Welcome to the Augsburg Aerospace Area! ■

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Stadt Augsburg

Augsburg – a leading production centre

Factors that favour Augsburg

Augsburg Inner City
Photo: © Ruth Plössel ■

LOCATION FACTOR PRODUCTION COMPETENCE

The economic region of Augsburg is a leading production centre of the European aerospace industry with our 20,000 people employed within one hour from Augsburg. Pioneering companies like Messerschmitt and Piccard are writing aerospace history here.

We offer a unique concentration of small specialists and world market leaders with competences in aircraft construction throughout the entire value creation chain. Here the essential components of renowned products are produced, such as parts of ARIANE rockets or AIRBUS and BOEING airplanes or complete aircraft such as AIRBUS HELICOPTERS.

This is all made possible by production factories, large system integrators and global players of the industry. Particular competence is available in the field of carbon fibre materials. Here companies like the SGL Group, Coriolis and Premium Aerotec, research institutions like the ITA Institute of Textile Technology Augsburg, the MRM Institute for Materials Resource Management and the Fraunhofer Research Institute for Casting, Composite and Processing Technology IGCV as well as network structures like Carbon Composites e.V. and MAI Carbon are world-leaders in many activities.

Air Park / Airport Augsburg
Photo: © Siegfried Kerpf ■

LOCATION FACTOR AEROSPACE-RELATED SPACE AVAILABILITIES IN THE AIR PARK

Besides the Augsburg Innovation Park, aerospace-related business can also find an ideal location for production, research and office space in the Augsburg Air Park – and at attractive conditions. This commercial area has construction-ready properties and is connected to public transportation and fiberoptics. Companies can position themselves as airport service providers here right next to the international City Airport Augsburg or find a generous space for their aerospace-related production companies. The Airport of Augsburg is appealing due to its maximal flexibility (no slots), suitability for all weather conditions (ILS) and short distances for international business travel or maintenance or training flight traffic. ■

Augsburg inner city
Photo: © Ruth Plössel ■

LOCATION FACTOR QUALITY OF LIFE

Augsburg offers not just good working conditions but also the best quality of life and excellent prospects for the future at an attractive cost of living. High security, intact nature, a state theatre, a university clinic, an international school, diverse cultural offerings, multicultural population and 2000 years of history can satisfy the most various needs. ■

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The Special Airport Oberpfaffenhofen

WHERE TRADITION MEETS VISION

The development of innovative mobility concepts has a long tradition in Bavaria – not only in the automotive industry, but also in aviation. A prime example of this are the former Dornier production facilities at the Special Airport Oberpfaffenhofen. Today, numerous aerospace industry companies are located here in close proximity to the largest base of the German Aerospace Center (DLR) in Germany. Exactly 50 years ago, an aircraft was developed in Oberpfaffenhofen that is still considered a sensation by many today: the Dornier Do 31. It was the world's first vertical take-off and landing aircraft and it took off from German soil – and broke several world records.

The development, production and maintenance of aircraft, as well as the areas of education and research, continue to define this location. The process chain ranges from production (primarily for Airbus), R&D and maintenance (especially for Dornier aircraft types) to additional training at the AERO Bildung aviation education centre.

Dornier's Do 31 at Oberpfaffenhofen Airport

Today, Oberpfaffenhofen, rich in tradition, is also the stage for the urban air mobility of the future: for electric aviation, unmanned and urban flying via air taxi. Urban air mobility is in a state of flux – and the innovations and visions developed at this site open another chapter in the airport's success story.

Perfect conditions

Oberpfaffenhofen is and remains synonymous with pioneering spirit. Social, economic and technological changes are having a massive impact on the aerospace industry. For example, the global market volume for zero-emission passenger transport by air taxi is forecast to reach around USD 75 billion by 2035. And this figure does not even include the growing market for unmanned aircraft. The future of air mobility is also a central concern for politicians. The Bavarian State Government is planning its own test site for electric, autonomous and urban aviation, as required for the development of new types of air taxis. A well-equipped test site is also a central requirement of the Unmanned Aviation Advisory Board of the Federal Ministry of Transport.

The benefits of being a TUEF: Test site for unmanned and electric flight

As the special and research airport of the Free State of Bavaria and the Federal Republic of Germany, the Special Airport Oberpfaffenhofen is predestined as a test site. For over a year now, test flights of innovative aircraft types have been taking place in Oberpfaffenhofen. And demand is growing steadily. The research airport also benefits from its test site status and its cooperation with the DLR.

The test site for unmanned and electric flight (TUEF) will be another important and unique selling point for the special airport. In order to create an ideal setting for this market of the future, the airport's existing capabilities are to be expanded: Plans include new designated flight boxes, upgraded navigation and tower technology, increased cooperation with air traffic control, test infrastructure with take-off and landing pads and a flight test environment and airspace control to enable parallel operation of conventional and innovative urban air mobility.

Eagle, Lilium GmbH's electric air taxi (EVTOL) and the company's founders

A prominent user of the test site – and one of the most important players at the airport – is Lilium. As a former Munich start-up company, Lilium has developed rapidly and has been based at the Special Airport Oberpfaffenhofen airport since the beginning of 2018. The company's air taxis are completely developed, assembled and tested in Oberpfaffenhofen.

Trinity F9, electric unmanned aerial vehicle (UAV), from Quantum-Systems GmbH

The test site is used by other innovative companies, such as Quantum-Systems GmbH, which is also based at the airport. Universities also use the test site for applied research and corporate cooperation, led by the Technical University of Munich. Other users include the DLR and the Aerospace Cluster bavAIRia e.V. with its UAS Forum and the German Experimental Centre for Unmanned Flight (DEU). In addition to technology, the development mandate for unmanned and urban aviation also includes the creation of administrative, licensing and aviation law framework conditions. Special Airport Oberpfaffenhofen cooperates closely with the government of Upper Bavaria as well as with the responsible ministries, aviation authorities and the air navigation service providers Austro Control and DFS.

With friendly support

Special Airport Oberpfaffenhofen is a key economic contributor to the region: around 8,000 people from the aerospace industry work at the location, which boasts a network of expertise and know-how that is unique in Germany if not in Europe. Its complete process chain spans science, research and development to production. Also, thanks to the support of the Free State of Bavaria and the Starnberg district, combined with the ambitious projects from local companies, strong foundations are being created for future growth: The airport is being transformed into an urban and autonomous campus that promotes innovative urban air mobility and meets the aspirations of Germany, Bavaria and the region. There is certainly plenty of potential for attracting companies to the campus – there are around 400,000 square meters of approved development space on the site.

EDMO-Flugbetrieb GmbH
A joint project from BEOS AG & TRIWO AG

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The asto Park Oberpfaffenhofen – Campus of Technology

Digitally connected, electrically and autonomously flying... this is how many people imagine the aerospace industry of the future. With Autoflight X, Quantum-systems and Lilium, Oberpfaffenhoffen is already the location for e-tonomous AIR Mobility and the hotspot for researching and testing future-proof solutions.

The research and establishment of air taxis is already a reality around the asto Park, the internationally known aviation location and cradle of the German aerospace industry. This is where the urban mobility of the future is being tested. The asto Park is at the forefront of digital, electrical and autonomous mobility.

At the Mobility Conference of the Metropolitan Region of Munich, the special prize "Innovation" was awarded to the asto park-based company Lilium. Lilium is currently in the process of conquering the third dimension of locomotion with its air taxi. Prof. Florian Holzapfel from the TUM reports that flying cars, recently were still part of the realm of science fiction, while today the first ones are already in the air. The market is exploding, says Holzapfel, and there is an incredible spirit of optimism. „It's such a cool time as it has not been for a long time," enthuses the professor. At the presentation of their autonomous aircraft in front of the Bavarian State Chancellery, Quantum-Systems and Lilium were able to signal that Bavaria should become the leading location for the development and construction of air taxis. Improving mobility, as air transport is clean, cheap, flexible and quiet, and the creation of additional jobs are key issues in this context. In a first step, a test field for autonomous flying will be set up in Oberpfaffenhofen, where companies based in the asto park will be able to test their electronic aircraft. The long-term vision is, that taxis could be used as a supplement to public transport.

While the Aero-Taxis are still in the development phase, drones like those from Quantum-Systems are already flying around the world. Drones are already providing valuable services in the areas of parcel services, medicine deliveries to remote areas and pest control on plantations in Malaysia.

The asto Park and the research airport in the southwest of Munich are again officially the hotspot of aerospace, according to the Federal Ministry of Transport. Oberpfaffenhofen is one of the twelve nationally important airports. Innovative technologies in aerospace, satellite navigation, IT, mechanical engineering, robotics and automotive are developed and produced around the asto Park. Furthermore 8,000 sustainable jobs have been created. Here in the asto Park, young companies as well as established technology companies, which want to use the dynamics of the location and bundle their activities, are addressed.

In the immediate vicinity of the international aviation group RUAG, the satellite manufacturer OHB and the DLR with its Galileo control and robotics centre, more than 80 technology companies have settled in the asto park. The internationally operating companies in the asto Park are the ESA BIC Incubator, the aircraft manufacturer Dornier-Seawings, Telespazio, OHB as well as companies such as the Diehl Group, Dassault Systèmes, Microchip, SII, Mynaric, Valeo, Vectoflow, pro-beam and Coherent. ■

astopark
BUSINESS INNOVATION CENTER

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AEE GmbH – Specialist in autopilot systems

Mode Control Panel - Allows crew to select which parts of the aircraft's flight is automatically controlled ■

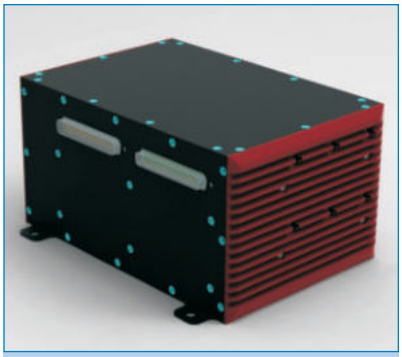
The Aircraft Electronic Engineering GmbH is a certified development, production and maintenance organization for avionic systems.

In the course of the current trend to autonomous flight systems, AEE developed together with international aviation companies and in close collaboration with TU Munich an autopilot system based on a founding project of the DLR. Many companies like RUAG, Lilium, AutoflightX, Grob SE and so on benefit from this new system.

The systems consist mainly of a Flight Control Computer and a Data Concentrator Unit can individually and easily added by different monitors, a Mode Control Panel and a Safety Pilot Monitoring Panel.

The Flight Control Computer establishes a high-performance computing platform, with the capability of high-performance communication over multiple interfaces at the same time.

The Mode Control Panel is an instrument panel that controls an advanced autopilot and related systems. The MCP is called such because it contains controls that allow the crew of the aircraft to select which parts of the aircraft's flight are to be controlled automatically.



Flight Control Computer. Can be extended by different interfaces ■

The company internal know how allows to react on individual customer requirements. This ensures that e.g. different interfaces can be implemented and configurated. ■

Extensive product range

In addition, as a result of the long-standing specialisation in electronical detail and complete solution, AEE GmbH developed a lot of other products.

AEE focuses on order-related development and projects in the whole field of avionics. ■

Founding projects

Furthermore, AEE is involved in different founding projects like a cost-effective Electronic Standby Instrument which allows acrobatic moves or an Engine Data Monitor. AEE always cooperates with well-known aviation companies. ■

Services

- Project management / -planning
- Conception and project definition
- Research and development
- Prototype development
- Single and series production
- Complete solution
- Training and documentation
- Service and support
- RTCA DO160G and DO 178C certification ■

Certificates

- EASA Part 145 (Ref.No.DE.145.0202)
- EASA Part 21G (Ref.No.DE.21G.0054)
- EASA Part 21O (Alternativ Design Organisation)
- DIN EN ISO 9001:2015 ■

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Exploring the third dimension

Ingolstadt region is pioneering solutions in the Urban Air Mobility Initiative

The experts agree: Anyone who wants to plan the future of urban transport, needs to find new pathways. The use of airspace, the "3rd dimension", is one of them. Air mobility (e.g. flying vehicles) as a means of transport, may provide a new, effective form of mobility.
This is where Ingolstadt and its region fit in. In the course of drawing up its digitalisation strategy in February 2018, the city council unanimously decided to become a pilot city by providing test areas for various forms of digital mobility. Ingolstadt is participating in the EU Urban Air Mobility Initiative together with the Free State of Bavaria, other administrative districts in the region and numerous stakeholders from industry, research and innovation. The aim: To explore the third dimension. ■

Various areas of application

Urban Air Mobility (UAM), an initiative supported by the European Commission, aims to conduct practical studies to explore the use of aircraft for urban mobility. Pilot projects will examine which areas of application are appropriate and how the regulatory framework conditions should be organised at the European and national levels. The public will be actively involved in the feasibility studies, and the issues of noise and safety will also be taken into account. Testing could take place in different sectors which provide a direct benefit to the public; for example, in emergency services, for the transport of blood reserves and organs, in the area of public safety and traffic monitoring or in passenger transport (air taxi). ■

Ideal location conditions

Ingolstadt is perfectly suited to be a research site for UAM. However, the city is taking a holistic approach in its digital strategy; in addition to Urban Air Mobility, several other digitalisation projects are also in progress – including in the areas of autonomous driving, artificial intelligence, science and research, medicine and biotechnology, and economy and trade. Ingolstadt also offers outstanding infrastructural conditions. Two major, international mobility companies are based here: Audi and Airbus. In addition, there are numerous mid-sized companies. The Technische Hochschule Ingolstadt and the emerging Fraunhofer Application Center form a functioning research network. Just minutes away from the city centre, the Ingolstadt-Manching Airport provides an air field for possible trials and test runs and brigkAIR, a branch of Ingolstadt's incubator "brigk", will also be opened nearby. brigkAIR will focus specifically on mobility in the third dimension. Ingolstadt also has the advantage of a central location; all of Bavaria's large cities lie within a 100 km radius of it and, therefore, are within air taxi range. In addition to flight routes into the city and the region, Ingolstadt's central position and the accessibility of other large cities, fulfils an important criterion.
„Ingolstadt is always ready to try out promising technology to improve the quality of its citizens. A pilot scheme for air taxis is the perfect fit for us and increases our profile as a national centre for pioneering digital and autonomous mobility. We are thus once again, underlining our claim that we are a leading site for industry, research and development", explains Dr Christian Lösel, Lord Mayor of Ingolstadt. ■

Over 40 project partners

The UAM Initiative is led by Airbus and Audi, with the participation of Eurocontrol and the European Aviation Safety Agency. In June 2018, a manifesto of intent was signed at the Bavarian Ministry of Economic Affairs in Munich. Among the signatories present, were the Lord Mayor of Ingolstadt, Dr Christian Lösel, as well as representatives of the European Commission, the Bavarian state government and the sur-

In Berlin, Ingolstadt's mayor, Christian Lösel, Bundestag member Reinhard Brandl, Grazia Vittadini from Airbus, Minister of State for Digitalisation Dorothee Bär, German Transport Minister Andreas Scheuer and Abraham Schot from Audi signed a joint declaration for UAM. Photo: BM Verkehr ■

rounding administrative districts. Other well-known institutions and companies which have been involved from the very beginning, include the German Aerospace Center, Munich Airport, the Fraunhofer Application Center, Klinikum Ingolstadt, Technische Hochschule Ingolstadt and the Katholische Universität of Eichstätt-Ingolstadt. In addition, numerous other partners have since joined the project (42 in total, see info box). Any companies, academic institutions and associations that would like to participate in the initiative are welcome to get in touch (e-mail: uam@ingolstadt.de). ■

"Entirely new possibilities"

The bid received significant support just one day after the manifesto of intent was signed in Munich. In Berlin, another declaration was signed by the Transport Minister Andreas Scheuer, the Minister of State for Digitalisation Dorothee Bär, Abraham Schot from Audi and Grazia Vittadini from Airbus together with Lord Mayor Lösel and Reinhard Brandl, member of the German parliament. The German Transport Minister, Andreas Scheuer, said: "Germany has always been a pioneer in aviation. Air taxis are no longer a vision; instead, this is the take-off for a new dimension of mobility. They open up entirely new possibilities, for example, for patient transport in cities and metropolitan areas. And they represent a great opportunity for companies and new start-ups, which are already actively and successfully driving forward development. With testing in real-world operation, Ingolstadt is recognizing and taking advantage of these opportunities – in terms of being a strong location for innovation." The Minister of State, Dorothee Bär, Federal Commissioner for Digitalisation, emphasised the significance of the pilot project: "By global comparison, Germany is a country with a small surface area. We cannot widen all of our roads to six or eight lanes. This is of course why air taxis will be a part of mobility in the future, and at an affordable price." "Networked, electric and autonomous cars will make road traffic in cities more comfortable, cleaner and will save space – which means better quality of life for the people. Mobility in the third dimension can make a valuable contribution to this in the future," underlined Audi's current CEO, Abraham Schot. "We really appreciate the commitment made by the city of Ingolstadt and support the development of the region as a testing ground for air taxis," said Schot. The city of Ingolstadt is working closely with Audi, including on projects involving autonomous driving. ■

Collaboration with administrative districts

The city of Ingolstadt will not take on the challenges of digitalisation alone, but will work closely with the Region 10 administrative districts. At its association meeting, the Ingolstadt Region planning association agreed to become a model region for digitalisation. The city of Ingolstadt and the Eichstätt, Neuburg-Schrobenhausen and Pfaffenhofen administrative districts want to lay the foundations for establishing a digitali-

Signatories of the Manifesto of Intent of the UAM Initiative (EIP-SCC): Dr Vassilis Agouridas (EIP-SCC UAM Initiative Leader (Airbus)), Dr Reinhard Brandl (Member of the German Parliament), Dr Christian Lösel (Lord Mayor of Ingolstadt), Dr Marion Kiechle (Bavarian Minister of Science and Art), Franz Josef Pschierer (Bavarian Minister of Economy, Energy and Technology), Gerhard Eck (State Secretary for the Interior), Josef Zellmeier (State Secretary for Housing, Building and Transport). Photo: StMWi ■

sation region. Mayor Lösel reiterated: "I am very grateful to the district administrators and the districts for joining us on this path to becoming a model region for digitalisation." The state secretary in the Ministry of Economic Affairs and former district administrator of Neuburg-Schrobenhausen, Roland Weigert, said: "The megatrend of digitalisation has the same revolutionary impact that the invention of the steam engine had in its time. If we want to preserve the prosperity and security of the region for the future, competence qualification in the area of digitalisation is strategically significant. And therefore, I see no alternative but to embrace this initiative for the model region for digitalisation." Anton Knapp, District Administrator of Eichstätt, explained: "The bid for the Urban Air Mobility project demonstrates how well positioned this region is. We should take advantage of this optimistic atmosphere of change and we should support all initiatives." Martin Wolf, District Administrator of Pfaffenhofen also stressed: "The critical question will be how our region can remain at the high level that we find ourselves at today. There is still no digitalisation region in Bavaria; we have the opportunity to take on a pioneering role here. It is crucial that we approach the initiative together, as an entire region." ■

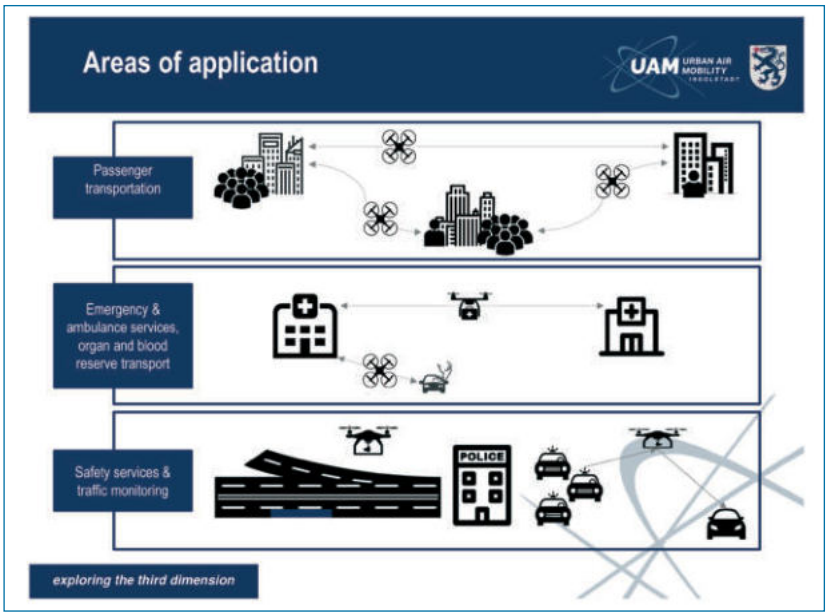
70 attend the kick-off

As the first step, (June/July 2018) the interested project partners came together. The second phase then began with a kick-off workshop (end of July 2018), in which all the participants presented their different ideas for the first time. This was only about finding concrete application examples and establishing the necessary structures and the legal and technical requirements for their implementation. Around 70 representatives from approximately 40 companies, institutions and organizations attended the kick-off workshop. Several working groups were also organized at this meeting ("Infrastructure and Technology", "Strategy and Economy", "Use Cases and Public Relations"). In October, all the participants assembled for another meeting, at which they caught up on the preliminary findings and discussed the further course of action. A concept paper clarifying open questions regarding routes, financing, safety, noise, approvals etc., is scheduled for the end of the second phase. At this point, it is still too early to tell when this will be concluded. Only then will a decision be made about whether or not this theoretical concept will lead to a practical model test (third phase). ■

Test flight in Amsterdam

For the first time, Audi, Airbus and Italdesign presented their "Pop.Up Next" project in action at the Drone Week in Amsterdam at the end of November. The innovative air taxi concept com-

The joint "air taxi" project from Audi, Airbus and Italdesign was presented for the first time in Amsterdam at the end of November. Photo: Audi ■



bines a self-driving electric car with a passenger drone. During the first official test flight, the flight module successfully set the passenger capsule down on target on the vehicle platform which then drove away from the test site autonomously. The air taxi is still a 1:4 scale model, but Audi customers could be using a comfortable and efficient air taxi service in large cities as early as the next decade – multimodally, in the air and on the road. The city of Ingolstadt also used Drone Week to present and introduce the Ingolstadt initiative and the planned projects to an expert audience. ■

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Project partners of the Urban Air Mobility Initiative in Ingolstadt (in alphabetical order)

- Airbus
- Airbus Gesamtbetriebsrat
- Audi AG
- Audi AG Gesamtbetriebsrat
- Bauhaus Luftfahrt
- Bayerischer Städtetag
- Bayerisches Rotes Kreuz
- Bayerisches Staatsministerium für Wirtschaft, Energie und Technologie
- Bayerisches Staatsministerium des Inneren, für Sport und Integration
- Bayerisches Staatsministerium für Wissenschaft und Kunst
- Bayerisches Staatsministerium für Wohnen, Bauen und Verkehr
- BEE appliance GmbH
- BFFT aeromotive GmbH
- brigk – Digitales Gründerzentrum Ingolstadt
- Bundesministerium für Verkehr und digitale Infrastruktur
- Bundeswehr – Wehrtechnische Dienststelle
- Deutsche Bahn AG
- Deutsches Zentrum für Luft- und Raumfahrt
- DGB Stadtverband Ingolstadt
- EASA – Europäische Agentur für Flugsicherheit
- Eurocontrol
- European Innovation Partnership on Smart Cities und Communities
- Flughafen München
- Globe UAV GmbH
- Handwerkskammer für München und Oberbayern
- IHK München und Oberbayern
- IMA – Flugplatz Ingolstadt-Manching
- INDRA Navia AS
- INVG – Ingolstädter Verkehrsgesellschaft
- IRMA – Initiative Regionalmanagement
- Italdesign
- Katholische Universität Eichstätt-Ingolstadt
- Klinikum Ingolstadt
- Landkreis Eichstätt
- Landkreis Neuburg-Schrobenhausen
- Landkreis Pfaffenhofen
- Media-Saturn-Holding
- MTU Aero Engines AG
- Quantum-Systems
- Rohde & Schwarz
- Stadt Ingolstadt
- Technische Hochschule Ingolstadt

Key technology for electric flight

Hybrid-electric drive systems are clearing the way for sustainable aviation and new mobility concepts in the air

Air traffic will continue to grow around the world in years to come. This makes the task of further reducing the long-term negative impact of flying – particularly the CO_2 emissions from fossil fuels – that much more imperative.

Siemens is developing the key technology that will bring about these improvements: hybrid-electric drive systems. They will be an essential part of efforts to develop an environmentally conscious form of flight, one with fewer pollutants and lower noise emissions.

Equipped with hybrid-electric drive systems, plane engines can generate their power from non-fossil fuels or electricity instead of exclusively using fossil fuels. Completely new technologies like fuel cells could also be used to generate power.

Hybrid-electric drive systems can be more efficient than conventional systems if individual components for various flight phases are optimized: the gas turbine for cruising flight and batteries and electric drive systems that provide support during the peak performance periods required by climbs. Energy can be recovered while the plane is landing.

These systems also create a new world of freedom for the designers of planes and power plants. Separating energy generation from thrust

DA40 with a serial hybrid drive system following its maiden flight in November 2018: The joint project of Diamond Aircraft and Siemens eAircraft demonstrates the technical feasibility of a decentralized drive architecture. ■

production makes it possible to physically separate the drive systems. Such airplane designs can reduce air drag. Separated drive systems can also take over the functions of an airplane's directional control.

This strength of hybrid-electric and electric drive systems is being applied by the developers of current air taxi concepts, ideas that have been presented in recent years as a sustainable way to complement municipal transport systems. e-VTOL will be designed to ease the pressure on truck and train transports. This may be an appealing idea to many large metropolitan areas: In the wake of urban spread, urgently needed climate protection and the ever-increasing demand for mobile lifestyles, current mobility models have reached the end of the line.

The electric motor will be a key technology for air taxis as well. Distributed electric drive systems will facilitate nimble, stable maneuvering: through the individual control of rpms or the torque of every power plant or, if the electric drive systems is designed as small, lightweight tilt rotors, through vector thrust in various directions. And they will do so while producing comparatively little noise and pollution – naturally assuming that a corresponding energy mix is in place.

In the process, flying electric drive systems could help improve the carbon footprint of not only the aviation industry, but also of the entire transport sector.

Siemens has already made very good progress in its work to develop electric drive systems for aviation in a range of performance classes.

As part of the partnership concluded with Airbus in 2016, Siemens is focusing on developing hybrid-electric drive systems for regional and short-hop planes as well as for the electric octocopter CityAirbus.

Siemens drive systems are already being used in the area of light and sports aircraft. A 260kW electric drive system, the SP260D, is being tested on board the Extra 330LE. The performance potential of the drive system was underscored in 2017 when the electri-

Air taxi CityAirbus: the demonstrator of Airbus' four-seat e-VTOL is being jointly developed with Siemens. It will be powered by eight distributed motors. ■

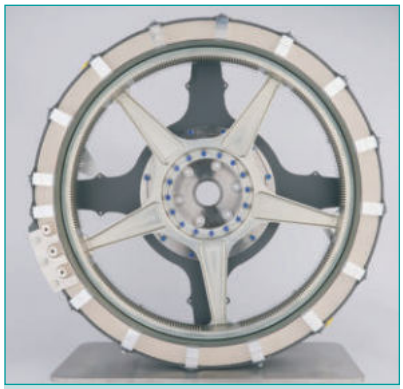
cally retrofitted aerobatic plane set climbing and speed records for its class and completed the first solely electric towing job for a glider. In the spring of 2018, a hybrid-electric Magnus eFusion completed its maiden flight – fully electric Magnus eFusions equipped with Siemens drive and battery systems have been flying since 2016.

International companies like Bye Aerospace, Smartflyer, Eviation and RS.aero are development partners and customers for other drive systems in the range of 50 to a quarter megawatts and integrate Siemens technology into innovative aircraft concepts.

Despite these successes, huge technological leaps must be taken before the future of hybrid-electric power plants is reached.

It will require a tenfold increase in today's standards before a plane the size of an A320 can be lifted into the skies by hybrid-electric drive systems. "Up to now, you have been able to get about a kilowatt of power from a kilogram of electric machine," says Dr. Frank Anton, head of the eAircraft unit at Siemens. "For commercial aviation, you will need 10, 12 kilowatts, and, actually, 20 would ideal." The SP260D has already produced potentially record-breaking power density of 5 kW/kg. To boost this level even further, Siemens is using high-tech material and technologies of the future. Siemens expects to receive the test results from the development of a 2 MW drive system in the summer of 2019. It is confident that its power density will set new standards.

Fully electric glider tow: The Extra 330LE is a test plane for a 260 kW electric drive system with potentially record-breaking power density. ■



Innovative design: the Siemens SP200D with exceptional torque density has been optimized for use in the e-VTOL. ■

Developers are facing challenges not just in terms of size and weight, however. The technology must meet the highest safety standards in order to receive the necessary authorization.

The technology for air taxis and (hybrid-) electric fixed-wing aircraft will have to be systematically enhanced before it reaches the stage of product maturity. One next destination on the technology roadmap for Siemens is commuting. In Bavaria, where Siemens eAircraft has concentrated its forces on locations in Erlangen, Munich and Ottobrunn, the development unit works with partners who have far-reaching expertise in aviation and the development of electrical systems. The groups are working jointly on concept studies. They already agree on one point: Mobility and aviation will have a future only with the help of electric and hybrid-electric drive systems.

SIEMENS
Ingenuity for life

Dr. Frank Anton

Dr. Frank Anton, Executive Vice President of eAircraft at Siemens AG – the physicist who has been a manager at Siemens for many years initiated the innovative project to develop electric and hybrid-electric power systems for aviation at Siemens AG. The passionate pilot and flight instructor also likes to slip behind the yoke himself.

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Unmanned Aerial Systems in Research and for Research Applications

Technological evolution in electronics and software engineering has let to tremendous performance improvements and significant miniaturisation of electronic components. Increasingly smaller sensors, computing and communication systems still at enhanced performance levels, enable the use of smaller aircraft systems also for complex or even completely new missions and tasks. Even in the consumer segment, it is nowadays possible, to complete tasks with advanced drones, that have not thought feasible in the past.

Considering these technological advances, research is confronted with two main questions in the domain of unmanned aerial vehicles:

1. Do technological developments lead to completely new designs and applications for advanced unmanned systems?
2. Is it also favourable to utilize unmanned aerial systems in research tasks?

The research on unmanned aerial systems is integral to a multitude of research activities at Technical University Munich, among others in the domain of aircraft design. At the Institute of Aircraft Design researchers are working on the following scientific topics:

a) Design environment for unmanned aerial vehicles (UAV)
b) Advanced UAV configurations
c) UAVs as demonstrators for novel aircraft technologies ■

Design environment for unmanned aerial vehicles (UAV)

UAVs as well as consumer drones are used in most application cases to carry sensors or other payloads, while the majority of applications is focussed on optical sensors for pictures, videos, surveillance as well as cartography. For these applications the UAVs mainly acts as the airborne "carrier" for the payload in a way to optimize the quality of the pictures/videos. The optimum result during the task is thus depending on the optimum interplay between the "carrier" respectively aircraft and the sensor itself. Smaller sensors with less performance may be carried by smaller aircraft, which have to fly lower, but at the same time are lighter and less costly. At the same time, the covered area per time unit for such a system is much lower than for bigger aircraft that fly at elevated altitudes carrying bigger sensors with higher performance. The optimisation problem of an Unmanned Aerial System (UAS) therefore is no longer a search for the best aircraft, but rather for the best combination of aircraft and payload system. In addition, further systems like communication systems for data transmission affect the mission effectiveness of such a system.

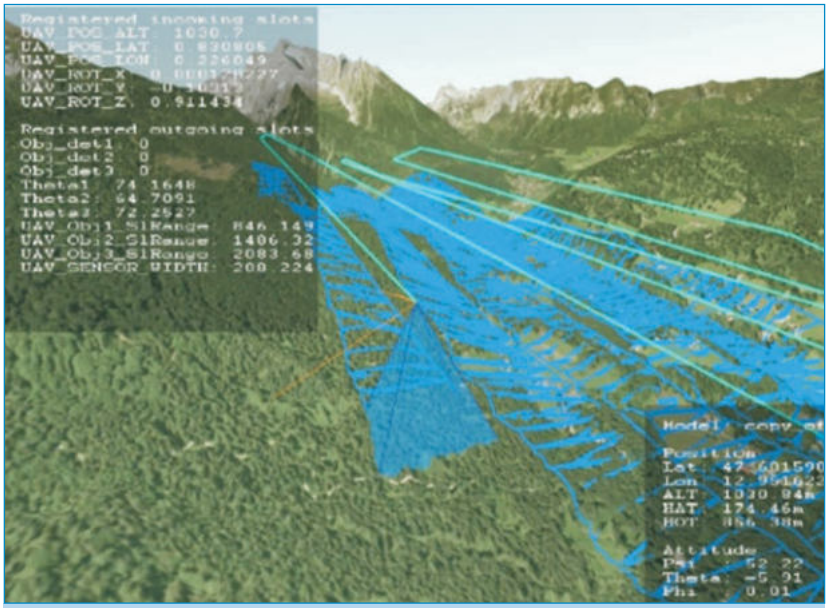

Fig. 1: *Simulation of a UAV on a search mission in mountainous terrain* ■

To tackle those strong couplings between the different systems in a UAS design, the Institute of Aircraft Design is working on new approaches to optimal designs for UAVs under consideration of the sensor and payload system as well as other affected systems like the communication system and the electrical propulsion and energy systems. In order to derive optimum designs in this systems engineering task, a novel UAS design environment has been established, which allows for an integrated assessment of the UAS interacting with its (virtual) environment (terrain, buildings, weather, multiple types of targets) as part of the design process. Only through

Fig. 2: *Transition-UAV: high efficiency in cruise flight while providing vertical take-off and landing capabilities* ■

such an integrated approach, leading to a full mission simulation and mission performance evaluation, an overall optimum in the UAS design may be found. ■

Advanced UAV configurations

The increasing performance of electrical components, motors and actuators does enable complete new configurations especially in the domain of small aircraft, as they are used in unmanned aerial applications. Combining these new propulsion and control technologies in combination with novel structural design and production technologies as 3d printing or advanced composite materials

Fig. 3: *UAV Iron Bird – System testing on component and overall system architecture level* ■

allows for completely new capabilities and functionalities of the air vehicles. One example of this new and advanced class of UAVs are full electric transition UAVs, which combine the vertical take-off and landing capabilities of helicopters and multicopters with the superior cruise performance of fixed wing aircraft (the classical aircraft design). This combination allows for hybridisation well beyond the hybrid-electric propulsion system towards hybrid flight capabilities.

These new architectures are designed at the Institute of Aircraft Design utilizing the design environment for UAVs, enabling the design synthesis as well as the performance assessment of such novel configurations. Originating from the "virtual product" demonstrator concepts are being build utilizing rapid prototyping techniques established at the institute to perform early concept verification through ground and flight testing. ■

UAVs as demonstrators for novel aircraft technologies

Unmanned aerial systems do also provide unique features for the test and demonstration of novel aircraft technologies. While manned demonstrator aircraft always require a minimum size in order to carry the human on board during testing, unmanned aerial systems are providing a higher flexibility in size and also functionality. On the one hand, smaller demonstrators may be realized much cheaper and faster, while they may also be used for more radical approaches and technologies, which could increase the risk for the demonstrator vehicle in early demonstration phases.

At the same time, utilizing a UAV as a demonstrator vehicle also poses new challenges to the user. Besides well known questions regarding scalability of results from sub-scale testing to full scale applications also topics like quality and precision of results as well as reproducibility need to be addressed. TUM has assembled a wide range of expertise in the utilization of UAVs in demonstrator programmes. In the course of the EC funded H2020 research project FLEXOP (Flutter Free FLight Envelope eXpansion for ecOnomical Performance improvement) a modular flying demonstrator with 7m wing span for the inflight testing of highly flexible wing structures is currently being build up. The project targets for the demonstration of novel control concepts to fly highly efficient wing structures beyond their classical operational envelope. This could lead to further reductions in aircraft weight leading to a better vehicular efficiency. Testing beyond the flutter boundary will lead to an increased risk for the demonstrator air vehicle due to a possible structural failure of the wing. A risk which is addressed more easily with an unmanned demonstrator.

Fig. 4: *Unmanned demonstrator for highly flexible wing concepts (EC H2020 Project FLEXOP)* ■

Unmanned flight does enable a multitude of new potentials and novel applications in aviation as well as in every day's life. The Institute of Aircraft Design at TUM does address these important questions in multiple research activities as well as part of the teaching courses and student activities. ■

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Elektra Solar GmbH on its way to the stratosphere

Elektra Solar is a "spin-off" of the DLR Institute for Robotics and Mechatronics

At the forefront of the development are solar power-driven aircraft that distinguish themselves through their extremely lightweight design, their virtually silent and low vibration flying, no CO_2 emissions and their intended ability to fly unmanned into the stratosphere.
On the way, Elektra Solar has cleared the first hurdle as, in the late summer of 2018, the first independent flight, including take-off and landing, were successfully completed. To be on the safe side, a pilot was on board who, however, did not need to intervene in any phase of the flight.

Elektra Solar E1 ■

With its many years of experience in the fields of aircraft design, avionics, electronics, autonomous flying, robotics and the development of safety-related software systems, Elektra Solar also offers its support in the preparation of aircraft platforms for customer-specific applications.
In addition to aircraft platforms, Elektra Solar is also recording an increasing demand for system components such as autopilot,

Elektra Two Solar ■

propulsion and solar systems. The aircraft of the company have, up until now, been available in the variants OPS (Optionally Piloted System), and UAV (Unmanned Aerial Vehicle) with wingspans from 11 to 25 m.

The important technical data:
Elektra One
Wingspan: 13 m
Weight: 320 kg
Cruising speed: 80 km/hour
Max. flight duration: 7 hours
Altitude: 8 km (as an UAV)

Elektra Two
Wingspan: 25 m
Weight: 600 kg (OPS variant), 400 kg (UAV)
Cruising speed: 75 km/hour (OPS variant), 70 km/hour (UAV)
Flight duration: 20 hours (as an OPS variant), virtually unlimited as an UAV
Altitude: 20 km (OPS), 22 km (UAV)

Thanks to the company's close proximity to the airfield in Penzing near Landsberg, in the past, various preliminary tests were able to be carried out there. As the aircraft are not propelled by internal combustion engines, the inhabitants in the area of the airfield are not subjected to any noise nuisance. Up to now, Landsberg and the air base in Penzing have proven themselves to be the ideal locations for this future-oriented technology.
In future, the aircraft of the Elektra Solar company will be used in, amongst other things, not only the areas of highly accurate 3D town and landscape models but also in the exploration of the stratosphere using appropriate, customer-specific sensor technology. Another important market will be telecommunications due to the increasing penetration of the internet. Here, it is intended to deploy Elektra Solar aircraft platforms that can circle virtually unlimited in time at greater heights than HAP (High Altitude Platform) and to serve as relay stations for data transmission. Finally, the aircraft systems of Elektra Solar also represent the optimum basis for the intelligent, interconnected mobility of the future (ground / air / space). ■

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Airbus in Bavaria: Urban air mobility, electric propulsion and unmanned vehicles

From flying vehicles to helicopters on demand, Airbus' portfolio of ground-breaking projects is helping to make Urban Air Mobility (UAM) a reality. Airbus has established Bavaria as one of its prominent hubs for many of its activities in this space.

Airbus firmly believes in the potential of air mobility to transform our cities for the better. By pushing the limits of technology in the fields of connectivity, artificial intelligence, autonomous systems and electric propulsion, the company's aim is to develop sustainable mobility systems that bring minimum environmental impact and maximum societal benefit. To this end, Airbus is harnessing its expertise across the company to develop solutions that will help ease urban congestion and offer viable alternatives to connect cities and regions. Bavaria is home to some of Airbus' numerous sites across the globe which are working on identifying solutions to the future's most pressing urban air mobility challenges.

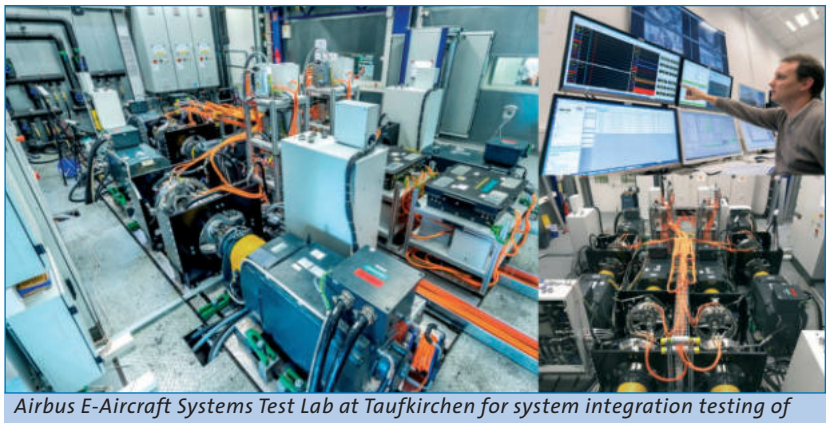
For Airbus, Urban Air Mobility (UAM) is not just about developing new electric vertical take-off and landing (eVTOL) vehicles. In some ways, that's the simple part for a well-established aircraft manufacturer which has been designing, manufacturing and certifying flying platforms for nearly 50 years. For example, via its helicopters division, Airbus has had a decades-long presence in the market of vertical take-off and landing (VTOL) with a broad range of helicopters for different missions. And in Bavaria, Airbus Helicopters' Donauwörth site is the centre of the German helicopter industry.

In 2019 the CityAirbus is entering the test programme at Manching airfield near Ingolstadt. ■

The real challenge for Airbus, however, lies in safely integrating this new class of vehicles in the urban environment. This is why Airbus isn't merely embarking on the development of vehicles - as it has been doing for decades in Donauwörth - but on a quest to co-create an entirely new market that sustainably integrates urban air mobility into the city context while addressing environmental and social concerns. Airbus believes that the hurdles are less about technology and business models, and more about urban integration, public acceptance and automated air traffic management.

As a testament to its commitment in this space, Airbus made the move to create a new UAM Unit in June 2018 to host its ongoing UAM activities across the company, from Voom an on-demand helicopter mobility service in Brazil and Mexico, air traffic management and infrastructure development, to partnership building and pilot projects. The Unit also steers the development of Airbus' ongoing electric vertical take-off and landing (eVTOL) technology demonstrators, Vahana and CityAirbus.

The Bavarian element in this field is CityAirbus, a four-seater, electrically powered, eight-rotor aircraft that can take off and land vertically. CityAirbus is designed to transport up to four passengers to major destinations in large cities via fixed routes, such as from the city centre to the airport. The vehicle has been developed and manufactured at Airbus Helicopter's Donauwörth. "Power on", the first run of the electrical systems took place in October 2018,



Airbus E-Aircraft Systems Test Lab at Taufkirchen for system integration testing of CityAirbus electric propulsion system developed in collaboration with Siemens AG. Testing of the full system on ground aims to verify the electric propulsion system functionality and performance considering its electric and mechanical dynamic subsystems interactions at mission envelope. Therefore the electric propulsion system under test consist of the electrical power unit (8x120kW motors), 800VDC power distribution units, (4x30kWh) Li-Ion battery stacks and the air vehicle flight control system. ■

with the first flight anticipated in early 2019. It will be followed by an extensive test programme. The vehicle's electrical systems have been tested at Airbus' ground test facility in Taufkirchen near Munich.

Taufkirchen is also home to the Airbus E-Aircraft Systems House, which aims to foster and accelerate electric-hybrid systems, and is currently running system integration ground tests in support of flying demonstrators, notably E-Fan X and CityAirbus.

Airbus' E-Aircraft Systems Programme pushes electric and hybrid-electric technologies towards the required performance of up to 45 MW at alternating current level, which is what is needed for electric and hybrid-electric flight of a short-range passenger aircraft. The engineers accelerate technology steps and mature technology readiness. Airbus has been developing, building and testing innovative hybrid propulsion systems and sub-systems components since 2010, because it recognises that from cleaner, quieter travel to completely new types of vehicles and operations, the impetus for electrification in aviation is exponential.

However, the challenge of making UAM a reality is bigger than any one company. It requires close cooperation between private and public stakeholders to set up the necessary infrastructure and regulatory frameworks that will ensure sustainable societal benefits. The certification of a vehicle and the overall transport system, operational security, and the regulations for commercial operation in cities is one of the greatest challenges of implementing UAM. By working and discussing with cities and regulatory bodies, Airbus is using its expertise in aircraft certification, airspace integration, and air traffic management to stimulate dialogue on evolving legislation and regulation.

This is why in 2017, Airbus was appointed to lead the UAM Initiative of the European Innovation Partnership on Smart Cities and Communities (EIP SCC). It is city-centric, citizen-driven initiative focused on UAM interfaces with public transport; ATM/UTM (Air Traffic Management/Unmanned Air Traffic Management) concepts for UAM and its integration in view of single sky operations; determining the required UAM infrastructure; and mobility as a service. The initiative aims to give rise to partnerships that will facilitate project applications and could lead to applied demonstrator studies in EU cities. To date, 17 European cities are onboard, with 12 projects scheduled to start in 2019, ranging from an exploration of air taxi use to how drones might benefit logistics hubs or deliver critical medical supplies.

One city involved in this collaboration is Ingolstadt. Ingolstadt and the surrounding region are increasingly noted as a centre for autonomous and digital mobility. In addition to the industrial presence of Airbus and Audi, the Technical University has distinguished itself in its mobility expertise and research in the field of new mobility concepts. Together with local research institutions and business incubators, these partners have formed a centre of excellence for autonomous and digital mobility and artificial intelligence. In Ingolstadt, UAM solutions will be tested and evaluated in a joint effort by local authorities, industry, academia and the citizens.

Acting as a test bed for the UAM Ingolstadt initiative is the Airbus Drone Centre in Manching. A key enabler for flight testing of unmanned aircraft and their enabling technologies such as UTM, and anti-collision systems, the Airbus Drone Center is situated in the controlled airspace of the Ingolstadt Manching Airport and works in collaboration with the German Armed Forces' WTD-61 test facility. The centre is open to third parties – from small and medium enterprises to academia.

Airbus and its partners in the UAM area will set up a completely new market for mobility services which will generate a strong push for new jobs and technologies in Bavaria. The Bavarian government's efforts to boost research and technology for UAM is contributing to the common goal of making Bavaria a centre of innovative mobility concepts. ■

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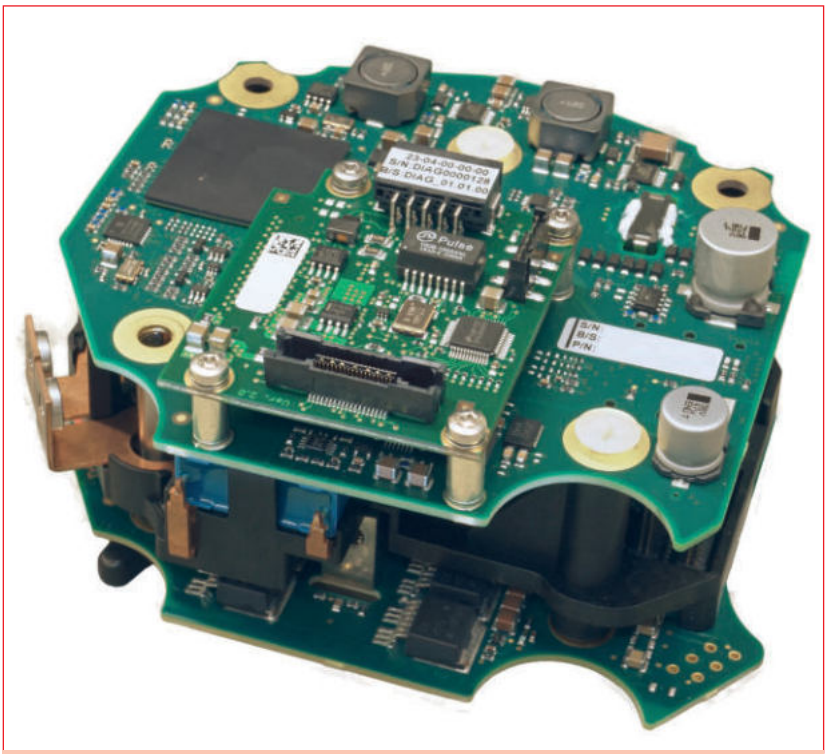
Smart Flying with new technologies

Silver Atena – System Supplier for Electric Flying

The 2018 Digital Summit held this December has reconfirmed that aerospace engineering and electromobility play a key role in the future strategies of both the German administration and the State government of Bavaria. The summit, on ‚Smart Flying with new technologies', featured presentations and discussions on innovative air transport options. Both well-established companies in the aircraft industry and numerous start-ups are already working on mobility concepts based on autonomous electric air taxis.

Autonomy and electric drives not only break new ground in terms of technical implementation, but also licensing and the legal framework in civil aviation, which are by no means clear at the moment. Though a large number of UAVs (unmanned air vehicles) are already used in military applications, full autonomy is still a long way off given that today's UAVs are operated exclusively with an operator on the ground.

Autonomous electric air taxis for private transport will not emerge overnight. The overall legal framework, especially, must be clarified first. But piloted electric air taxis do appear to be technically feasible now, and logistics in particular – as one possible field of application – could take on a pioneering role.

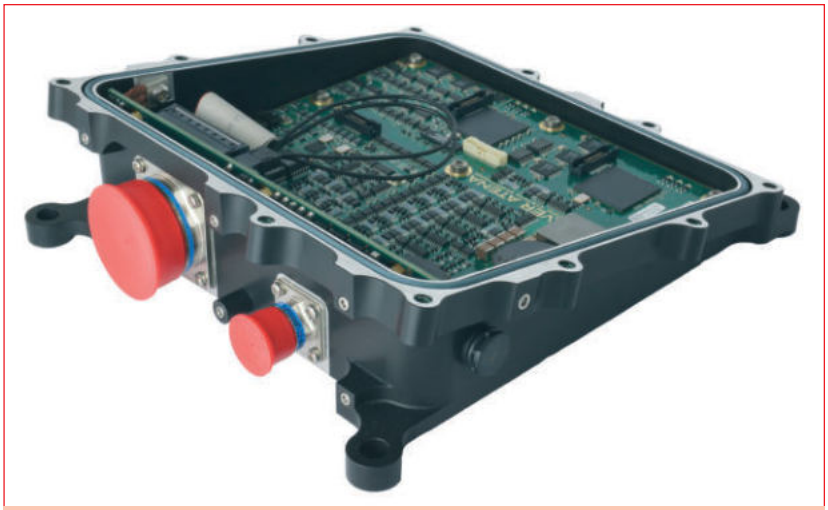


Space-saving control unit for a 5-kW electric engine, © Silver Atena

Extensive portfolio

As a supplier of safety-critical electronic devices and power electronics, Silver Atena has positioned itself early in the electric and autonomous flying arena, and has much to contribute from its many years of experience in developing and manufacturing equipment compliant with international aerospace standards and regulations. The company has been a sought-after equipment supplier in the aviation industry for decades and is beavering away on the new technical challenges of vertical take-off light electric aircraft. Silver Atena's current portfolio offers customers of tomorrow's aviation industry certifiable technical solutions in key areas of electric and autonomous flying: electric drives and actuators, power supply and distribution including battery management, and avionics computer platforms for flight control and route planning. Alongside its range of engine control units and starters/generators, the company also offers hybrid drive solutions.

Silver Atena



As an example, a flight-control computer can be implemented on this powerful computer platform for highly-automated control of manned or unmanned small aircraft and helicopters. © Silver Atena

Taking energy to the limit

In addition to the generation and storage of electrical energy, the decisive factor in the success of electric flying is the efficient utilisation, i.e. the efficient conversion of electrical energy into drive power while always taking account of total weight. Storage capacity and efficient utilisation both contribute to a positive overall result. Battery storage capacity is certainly still a limiting factor, but efficient, lightweight drives can at least partially compensate. Studies carried out at Silver Atena show that hybrid drive systems make it possible to improve overall drive efficiency, for example by increasing propeller efficiency.

While the basic laws of physics still apply, low-loss use of the limited energy on board an aircraft is THE deciding factor in the competitiveness and acceptance of electromobility. Efficiency is another factor, determining range, payload and power limits. In recent years, Silver Atena has developed some innovative concepts for battery and energy management in on-board networks in both the automotive and aviation sectors, making optimum use of the technical possibilities without losing sight of cost and weight. One example is the company's DC/DC converters, which are among the most efficient in the industry. Equipped with state-of-the-art semiconductor technology, Silver Atena units deliver over 98% efficiency across the entire operating range – a level unparalleled in the industry.

Helping to advance electric drives

Drive technology in particular is one of the keys to mastering the challenges posed by new forms of transport. Vertical take-off and landing (VTOL) concepts require maximum performance at minimal weight, which then enables the aircraft to achieve the maximum possible range. In other words, the concept type dictates whether operation requires more or fewer electric motors, which, moreover, must be highly efficient and fail-safe. But even traditional single-engine small aircraft equipped with an electric motor benefit from high specific efficiency through higher ranges and/or more payload. These electric motors are regulated by inverters, which provide the engine with the energy it requires. Along with the inverter – one of Silver Atena's core development skills – optimum coordination of the engine-inverter combination is becoming increasingly important. Consequently, Silver Atena is working with partners on an optimal overall design for an electric drive consisting of an electric motor, an inverter, gearbox (possibly), cooling and housing. Only interdisciplinary cooperation makes it possible to develop an optimal overall system in which even the basic design parameters of the aircraft manufacturer have to be scrutinised and potentially optimised.

Silver Atena develops and delivers inverters for highly dynamic electric drives. With voltages of up to 900 V and outputs of up to 500 kW,

DMCU, a compact high-performance duplex motor controller for a low-voltage electric propulsion system.© Silver Atena

Silver Atena provides the aircraft industry with technical solutions for autonomous electric air taxis (Bildquelle: 123RF)

the inverter portfolio accommodates a host of electric drive applications. Using a modular approach with tried and tested modules, Silver Atena can provide rapid solutions with low technical risks that meet the stringent safety requirements of the aviation industry from the outset. The inverters can be flexibly adapted based on available installation space as well as for air or water cooling, producing a specific output of up to 15 kW/kg.

Flight control and route planning

If the aviation pioneers of the 21st century are anything to go by, pilotless flying taxis will take off at some point in the future. For operators, this cuts out a proportion of the costs. For customers, it will be a cheaper transport option. Ultimately this offering should not be aimed at the well-heeled alone, but should appeal to anyone as a real alternative to road taxis.

In future, as on a standard scheduled flight, the control will be taken over by an on-board computer, which then uses autopilot functions to handle every manoeuvre from take-off to landing. This computer platform can also independently take over route planning, ferrying air taxi passengers fully autonomously to their desired destination.

Silver Atena's Universal APC (Avionics Platform Computer) is a powerful platform for highly automated flight control of both manned and unmanned small aircraft and helicopters. The Universal APC was developed with anticipated safety classifications and approval requirements in mind, and therefore covers a wide range of application scenarios. Featuring a wide variety of interfaces, it can be integrated in many different avionics architectures.

"Our role in the development of these innovative aircraft is safety-critical systems developed and tested to aviation standards, combining high performance with low weight and compact design," says Josef Mitterhuber, Silver Atena MD. "We not only deliver concepts, but also develop prototypes and mass produce electronic system components that can quickly and safely overcome technical hurdles in the development of new air taxi mobility designs."

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AutoFlightX – the future of aerial mobility

When Lisa Liu arrives at Munich airport by international flight, she realizes that she only has 25 minutes to her appointment close to Oberpfaffenhofen. Rush hour has just started and she is sure that she will not make it by taxi, as the 60km ride will take at least one hour and ten minutes. Luckily, she is able to catch an aerial taxi from AutoFlightX booked via her smartphone that can make the 48km beeline for Oberpfaffenhofen in 15 minutes. After directly accessing the Vertiport without leaving the security area, Lisa is boarding her aerial taxi, together with two other passengers heading in the same direction. After a smooth ride they arrive at the intended Vertiport close to Oberpfaffenhofen where a bus is leaving in 3 minutes, bringing Mrs. Liu to her appointment – just in time.

Of course, the story of Lisa Liu is happening some time in the future – but a future much closer than expected by many.

When Tian Yu founded AutoFlightX in early 2018, he already had this vision in mind and thoroughly selected Munich as the perfect location for his latest venture. Based on his experience with Yuneec, the E-Spyder and the E430 – the world's first two-seater electric trainer aircraft – the entrepreneur was very much aware of the ideal conditions to be found in Munich: The combination of people, know-how, network of partner companies and research institutions, regulatory boundary conditions, and the well-renown "German engineering skills" are unique around the world.

The Bavarian prime minister Markus Söder flying in the simulator of the prototype aircraft of AutoFlightX. ■

Due to all these benefits, AutoFlightX – a German GmbH – was able to attract international financial investment and cooperation with internationally renowned players in aviation, right to the heart of Bavaria. Using these assets, the company already had a first successful flight of the V24, an eVTOL tech demonstrator. Besides, AutoFlightX built up a simulation environment and a simulator – for its first manned eVTOL prototype – that has already been flown by Bavarian prime Minister Markus Söder.

Tian Yu, founder and CEO of AutoFlightX, in front of the V24, an eVTOL tech demonstrator of AutoFlightX. ■

Now, the next step for AutoFlightX is a full-size prototype to be flown in the currently prepared flight-test area around Oberpfaffenhofen airport that will provide a perfect environment due to its well-developed infrastructure for testing fully automatic operations.

As we are currently very busy focusing on the technical development of our first eVTOL aircraft, we can only recommend to stay tuned for what will be happening in 2019! ■

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Europe's future digital airspace: Huawei's contribution

Drones equipped with electric propulsion systems have seen rapid development in recent years. So have their civilian uses: initially used as toys, a number of practical applications such as surveillance and delivery are being explored, with passenger transport for medium distances expected for the near future.

Such systems are expected to run autonomously or remotely controlled. This involves high bandwidth data needs, which will increase further with passenger transport services. On top of the need for reliable remote control, passengers expect access to their usual data services while travelling.

This requirement makes cellular mobile networks the first choice for flight control and flight traffic management. Cellular networks provide an excellent solution for control, management, and data services by one infrastructure. ■

Future scenarios: requirements & solutions

At Huawei, we have developed a scenario for low-altitude air traffic using stretched-out, geo-fenced air roads with the support of cellular networks. To meet all the requirements, the cellular network coverage needs to be extended into the medium air space. The current set-up using a terrestrial LTE system and an Air-To-Ground LTE system for high flying aircrafts leaves a gap between 300m and 3000m without any available communication system *(see fig. 1)*. The 300m upper limit of terrestrial cellular networks is the result of the down-tilt of LTE antennas, which helps to save radio energy by not releasing it into the empty air space. To prepare for a digitally enabled sky, however, we will need to do more than just turning the antenna systems up.

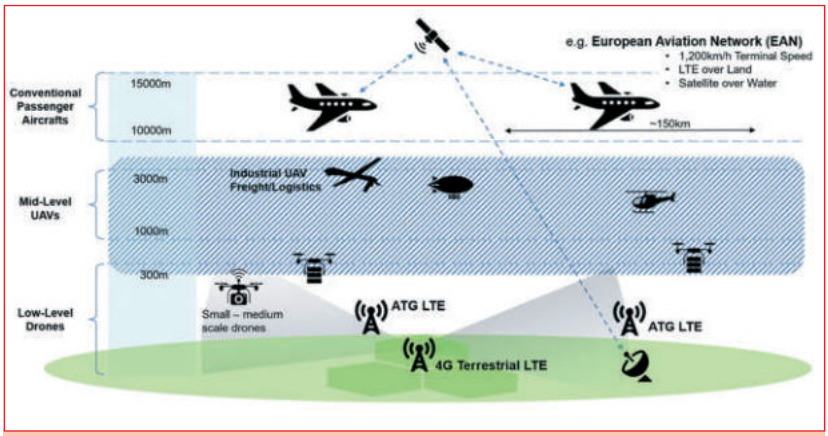

Fig. 1: *Coverage of terrestrial and air to ground (ATG) LTE networks leave a gap between 300m and 3000m* ■

At Huawei, thanks to our global platform, we have been able to carry out an in-depth investigation of the performance of cellular networks for drone applications. The free open SpeedSky platform was developed for this purpose, enabling a three-dimensional analysis of the radio link performance through real-time flight tracking.

One key field of research is mobility management. Findings related to air traffic control include the degradation of the cell handover time, which doubles at an altitude of 100m already *(see fig. 2)*. Cellular network planning uses beam antennas to minimise the number of installation sites. A cell is formed by the main lobe of the down-tilted antenna, though side lobes cannot be suppressed completely. While side lobes do not play a practical role in the terrestrial environment, they are critical for the free air space. Flying devices identify more neighbour cells for handover than on the ground. Combined with the motion of the device, the frequency of cell handovers increases, but the number of cell handover failures increases as well. This behaviour in turn degrades the latency of the system.

5G mobile communication will offer numerous improvements for inter-machine communications. To reap the full benefits of this for the digital sky of the future, we will need to carry out more experimental work, working together as a consortium bringing together all stakeholders to develop the corresponding technologies and standards. ■

A blueprint for the connected airspace: research & collaboration for connected cars

The A9 motorway between Munich and Nuremberg is one of the most heavily used roads in Europe. Without speed limits, it is a very challenging environment for autonomous vehicles. In a project funded by the German government, Huawei and its partners Audi,

BMW, Rohde&Schwarz, Elektrobit, IPG, TUM/Fortiss and Cognition Factory gained key experience by using 5G technology for the communications, control and in-car entertainment in a real-life road environment field trial *(see fig. 3)*. Low latency, high reliability and high data rates could be demonstrated at high vehicle speeds.

This experience could easily be transferred for use in drones and eVTOL (electric vertical takeoff and landing) air taxis.

Discussions with our partners from the automobile industry highlighted the need for a platform for structured debate between original equipment manufacturers (OEMs) and the ICT industry. This is why in 2016, we created the 5G-Automotive-Association (5GAA) together with the other founding members Audi, BMW, Daimler, Ericsson, Intel, Nokia and Qualcomm. Today, it has more than 100 global members, organised in 5 working groups.

This initiative could serve as a model for future collaboration bringing the ICT industry and the aircraft, drone and eVTOL industries together to jointly develop requirements, use cases, evaluations, standards and test beds. ■

Bavaria: at the heart of our European research effort

Munich is home to Huawei's biggest research site. Work carried out at the local facility contributes to leading research in fields including 5G communications, Cloud and Big Data analytics. In addition to the A9 motorway field trial, Bavarian projects with Huawei involvement include for instance a 5G trial at the TUM hospital and the 5G Vertical Industry Accelerator (5G VIA) developed in cooperation with the Bavarian State Government, City of Munich, Technische Universität München (TUM), and M-Net. ■

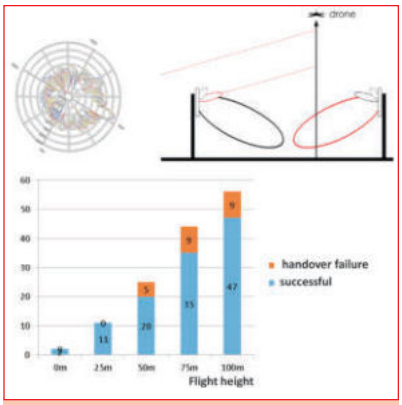

Fig. 2: *Increasing attempts for handover at increased flight height results in double handover time at 100m already* ■

Background: about Huawei

Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. With integrated solutions across four key domains – telecom networks, IT, smart devices, and cloud services – Huawei is committed to bringing digital to every person, home and organisation for a fully connected, intelligent world.

Huawei's end-to-end portfolio of products, solutions and services are both competitive and secure. Through open collaboration with ecosystem partners, Huawei creates lasting value for our customers, working to empower people, enrich home life, and inspire innovation in organisations of all shapes and sizes.

At Huawei, innovation focuses on customer needs. Huawei invests heavily in basic research, concentrating on the technological breakthroughs that drive the world forward. Huawei has more than 180,000 employees and operates in over 170 countries and regions. Founded in 1987, Huawei is a private company fully owned by its employees.

In Europe, Huawei currently employs over 11,000 employees and runs two regional offices and 18 R&D sites. So far, Huawei has established 240 technical cooperation projects and has partnered with over 150 universities across Europe. The company contributes to many large-scale European research projects such as the 5G PPP. ■

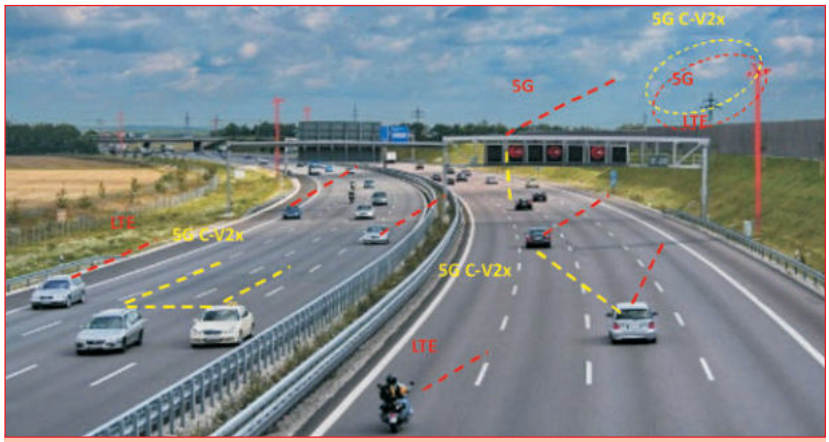

Fig. 3: *A9-project PROVIDENTIA on V2X 5G cellular communication: the image highlights the different communication paths used between different vehicles as well as between vehicles and roadside infrastructure.* ■

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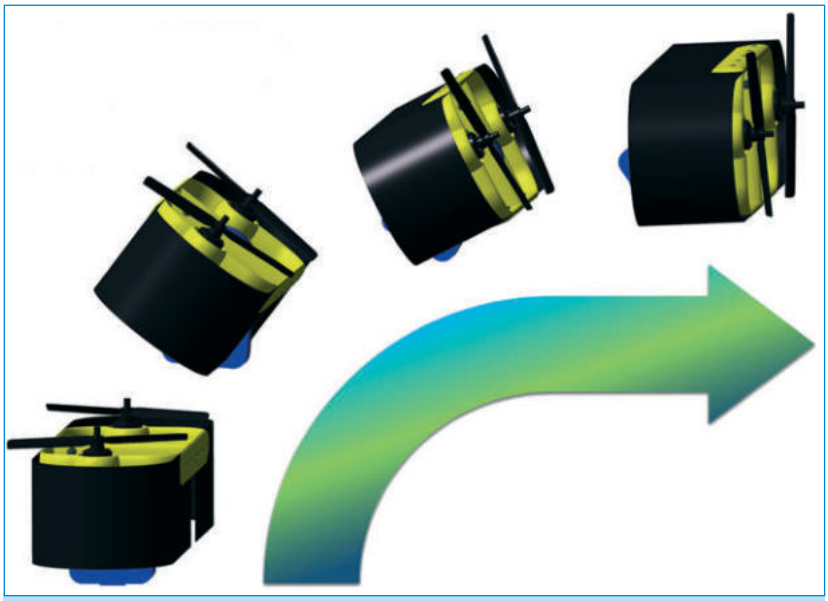
The Way of Drones is Beyond Visual Line of Sight

Syrphus GmbH offers services based on service contracts and working contracts related to unmanned systems and autonomous vehicles. The experience of our employees comes from manned aviation and our expertise in the field of multicopter services. Syrphus is the Latin-Greek name for a species within the family of hoverflies. The hoverflies are beneficial and eat aphids as larvae. With this animal as example, Syrphus creates new ways of flying.

Syrphus-Airframe

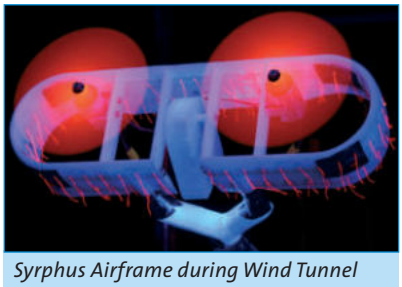
The Syrphus GmbH has invented a new VTOL fixed wing configuration. This concept is very reliable due to its very simple design. Consequently, it can achieve higher ranges than conventional multirotor systems. The drone is controlled by three parts: two propellers and the weight element, which turns back and forth. With ongoing development of smaller electronics, the field of drone operations is more flexible. Equipped with a small camera it can quickly provide a rough overview in chaotic situations. In its small scale, it is very handy. If the mission requires a larger camera, greater range or longer flight time, the concept is scalable. The used material is easily customized, depending on the application. The design provides inherent stability, also at very low velocities. During high aerodynamic angles of attack, the wing prevents stall. Consequently, the full bandwidth from zero to maximum velocity is usable for the Syrphus-Airframe. ■



Transition from Hover to Gliding by Shift of the Weight Element ■

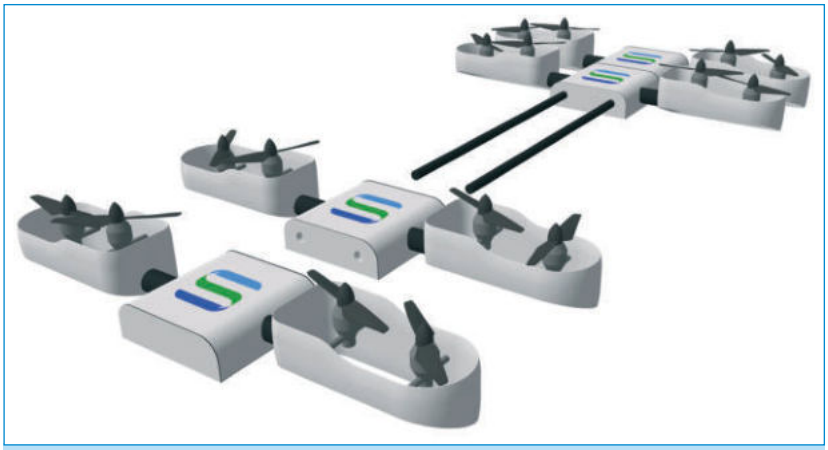
Modular Lift Units Concept

The Modular Lift Units Concept evolve out of combining various Syrphus-Airframes. A module consists of two Syrphus-Airframes and an additional fuselage segment. This drone allow many combinations. A communication rail controls all modules and provides reliable flight. Not only adjustable number of modules, also different sizes of the modules grant adaption to different applications. Depending on the purpose, adaption of the whole aircraft system is possible, in order to achieve optimal efficiency and safety. Size of the payload is variable, too. The payload could be static, such as cameras or special sensors, or alternating. It will also be able to transport cargo in different sizes. Whether small, e.g. medicines or blood bags, up to large deliveries, such as food during catastrophes or spare parts, tools or other industrial



Syrphus Airframe during Wind Tunnel Tests ■

Syrphus GmbH

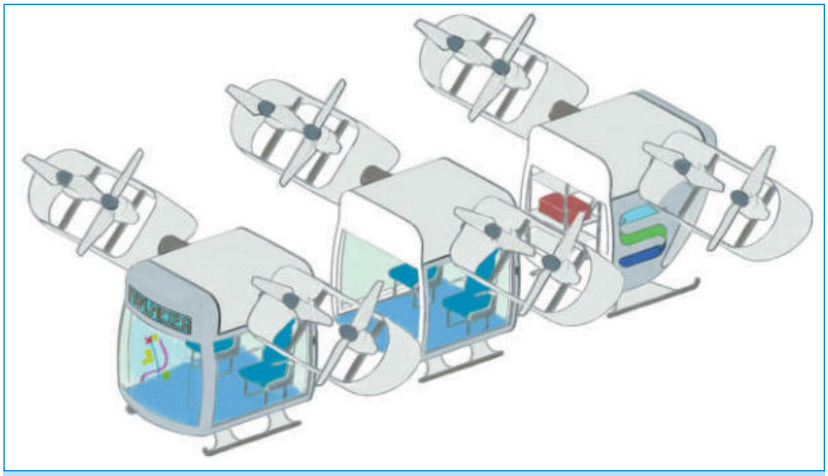


3D Sketch of the Syrphus Modular Lift Concept ■

materials. With appropriate scaling and consideration of all security aspects, the drone even becomes an air taxi. An air taxi that consists of modules and remains adjustable just as easily as possible. ■

First Beyond VLOS Missions in Germany

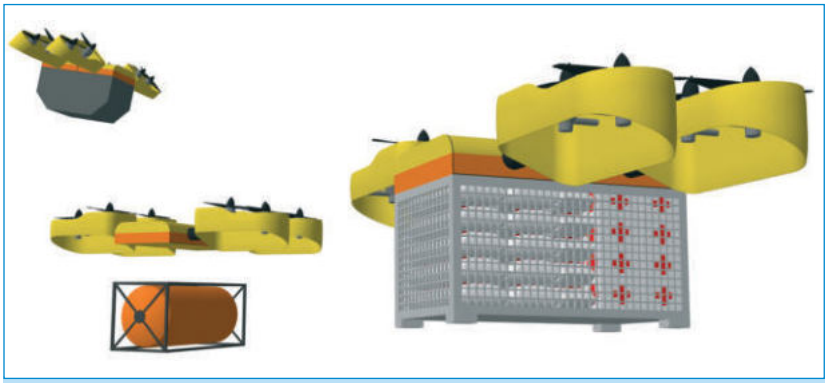
Drones are full of potential and are the main ingredients of many visions and future applications. Many of them involve the creation of footage and imagery from the air, such as pipelines and power line maintenance. The use of drones can significantly improve the work. However, to use the technology efficiently and at no extra cost, the next step in drone operations is flying beyond visual line of sight (BVLOS). A challenge is the technical detail of the flight system, including the data link to the ground control station. In addition to technology, the operational requirements must be ensured. These consist, among other things, of the qualifications of the individual operators and participants. Flight planning take also all necessary permits and correspondence in account, especially in highly regulated areas such as Germany. Combination of technology, planning and legislation is the essence of BVLOS flights. Syrphus GmbH got the first BVLOS mission approvals within Germany. ■



Award Winning Air Taxi Concept consisting of Syrphus Modular Lift Units ■

USIC – U-Space Integration Center

To fulfill all requirements in technology, application and legislation, Syrphus GmbH set up one of the first BVLOS test areas within Germany. The aim of the test site is to carry out tests not only under laboratory conditions. The environment is as real as possible. It covers all possibilities for validating an aircraft, for its use first within the visual LOS and later beyond visual LOS and even beyond radio LOS. With individual objects for testing collision avoidance, different systems are available within the airspace. Additionally, in the airspace an airfield is included, which is equipped for sport aircraft, for simulation of mixed traffic. The airspace, with a size of more than 2.5 to 2.5 km, guarantees the unique possibility to equip flight systems for the flight beyond VLOS. Syrphus offers the use of this test area temporarily to third party manufacturers and provides consulting services concerning testing, validation and certification. ■



Future Concept of the Syrphus Modular Lift Units Concept including several Use-Cases in Action ■

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Safe and secure digital infrastructure and their operation as a common ground of the Bavarian Air-Mobility-initiatives

The digital transformation and its wide-spread impact on society and the environment opens a new round of discussions about innovative mobility solutions in order to sustainably improve today's traffic problems.

A realistic and cost-efficient solution is the establishment of multi-modality and commonly used digital infrastructure supporting all modes of transport domains on ground, in the water and in the air with a focus on robust, safe and secure data communication, navigation and surveillance (CNS).

DLR's subsidiary company DLR GfR mbH is tasked to manage the Galileo Control Center with more than ten years of experience providing the operations and maintenance services for the European navigation satellite constellation, Galileo. The company sees the potential in the transfer of regulations, processes and technologies from the aviation sector to assist with the high density traffic scenarios.

"Our priority is set on safety and security when it comes to the design of system architectures and their operation. To this end, we draw on our long operational experience in the satellite and aviation sectors. Such methodologies, for example, have been developed over decades to deliver flight passenger safely to their destinations", explains Prof. Christian Arbinger, Head of Navigations Services at DLR GfR.

A common digital ground infrastructure for all mobility domains ■

A well-designed common digital infrastructure will, through interconnectivity, enable safe and secure operations within the continuously rising traffic volume. It is exactly this point, where DLR GfR, also with its certification as Air Navigation Service Provider, anticipates by analyzing today's concepts and applying them to generate innovative concepts for tomorrow under the slogan "Air meets Space".

This integrated approach was also followed within the project "Automated Mobility for the Kufstein Region". In 2019, DLR GfR together with their partners are tasked to build up a mobile infrastructure that will enable the validation of automated and coordinated drone flights as well as integrated scenarios with road mobility.

Bavaria will become a forerunner for air mobility with the various upcoming initiatives and their integration within a common digital ground infrastructure. With safety and security as core values, DLR GfR is an important partner for these initiatives. ■

Signal Measurements are conducted for the Detection of Threats like Jamming ■

DLR GfR mbH
A company of DLR

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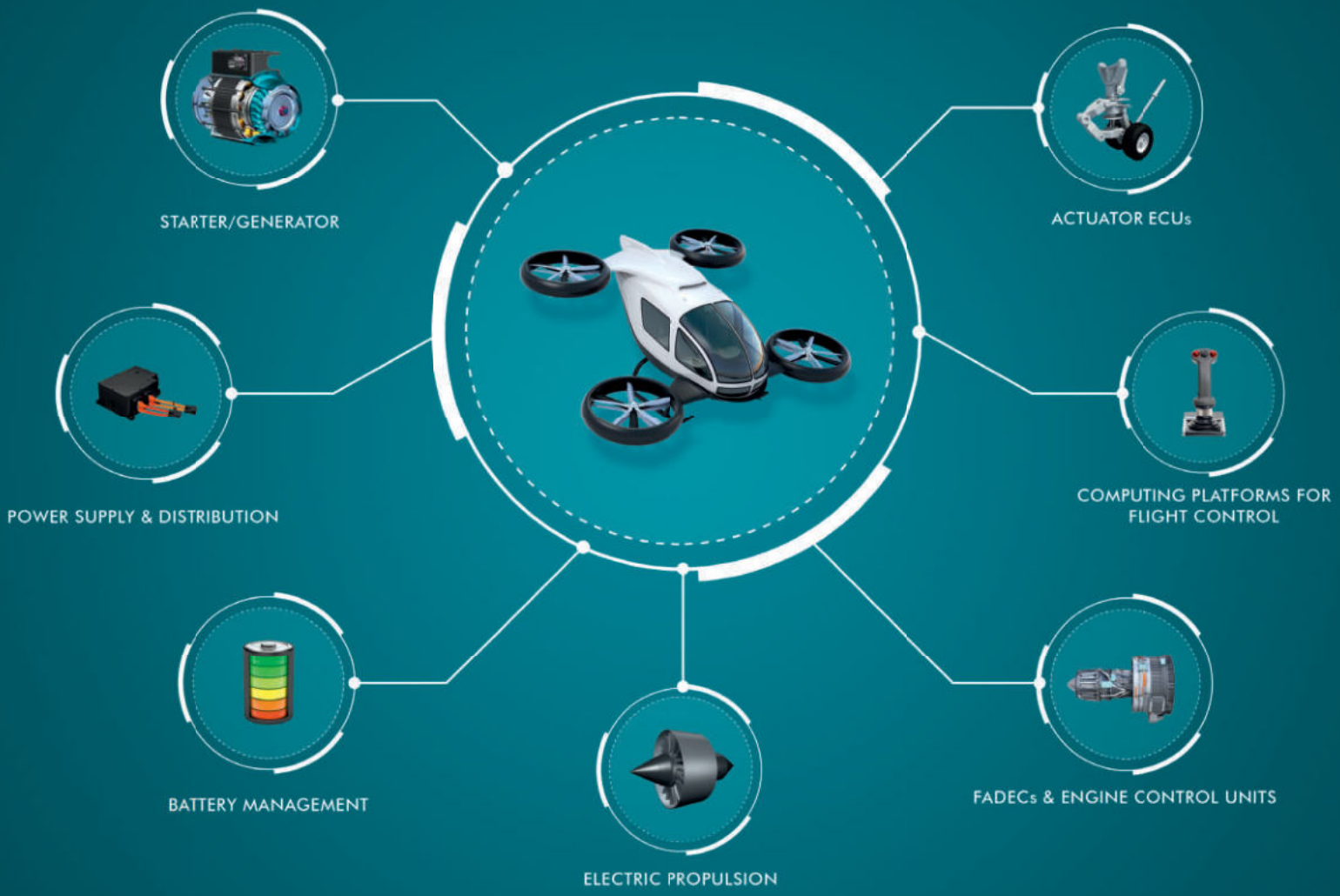

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