Wissenschafts- und
Wirtschaftsplattform

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SCIENCE AND INDUSTRY PLATFORM
for climate-friendly aviation engines and their mission-oriented integration

an initiative of the cross-state aviation centre OST[1]

Technische Universität Berlin

Brandenburgische Technische Universität Cottbus - Senftenberg

TECHNISCHE UNIVERSITÄT DRESDEN

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1. Objective of the SCIENCE AND INDUSTRY PLATFORM

In the context of the EUROPEAN GREEN DEAL and the FLIGHTPATH 2050 – EUROPE'S VISION FOR AVIATION, aviation is facing disruptive technological upheavals. By 2050, the entire aviation industry must be reorganised in a climate-neutral way.

The new SCIENCE AND INDUSTRY PLATFORM for climate-friendly aviation propulsion systems and their mission-oriented integration will synergistically intensify cross-state cooperation between science and industry in the field of sustainable aviation in the Eastern German states with the support of the Berlin-Brandenburg Aerospace Alliance e.V. (BBAA) and the Kompetenzzentrum Luft- und Raumfahrttechnik Sachsen/Thüringen e.V. (Aerospace Technology Competence Centre Saxony/Thuringia, LRT). The primary goal of the open platform is the strategic research and development of climate-friendly aviation propulsion systems tailored to specific flight missions and their system integration.

The focus of the new SCIENCE AND INDUSTRY PLATFORM is the research, development and production of competitive aviation propulsion systems with regard to greater electrification and hybridisation, taking into account alternative sustainable fuels such as hydrogen or Sustainable Aviation Fuels (SAF). The focus is particularly on drive components such as lightweight electric machines, heat exchangers and cooling systems or energy storage systems.

To this end, complementary research and development projects are to be initiated within the framework of international, national and regional funding programmes (such as the European Regional Development Fund, Industrial Collective Research, the Aeronautics Research Programme, programmes of the German Research Foundation or Horizon Europe), particularly with the participation of regional SMEs. The new SCIENCE AND INDUSTRY PLATFORM sees itself as a long-term strategic partner for research institutions and SMEs as well as large companies in the aviation sector – modelled on the national, open platform FOREL[1], which was initiated in 2013 and is now established with over 120 partners. Building on a unique, forward-looking research infrastructure such as chesco, HepCo, SML and CARA[2] as well as strong interdisciplinary and complementary expertise paired with continuous technology and development screening, the platform promotes the early professional exchange on innovative topics between industry and research stakeholders as well as political representatives at state, federal and European level. The platform specifically involves SMEs in the formulation of research topics, the initiation of research projects and the composition of associated research consortia. As a source of impetus and ideas, it also supports SMEs in implementing new solutions from science in publicly funded research and development projects at national and international level. This strategic approach enables locally based SMEs in particular to participate strategically in research developments and innovation strategies over longer periods of time. Furthermore, in the interests of synergetic and efficient technology transfer, the platform facilitates cross-project exchange and access to the German

[1] FOREL: Forschungs- und Technologiezentrum für Ressourceneffiziente Leichtbaustrukturen der Elektromobilität (Research and Technology Center for Resource-Efficient Lightweight Structures for Electromobility)

[2] chesco: Center for Hybrid Electric Systems Cottbus, HepCo: Testing environment Hybrid Electric Pro-pulsion Cottbus, SML: Smart Mobility Lab of TU Dresden, CARA: Large-scale research facility Computer for Advanced Research in Aerospace

Aerospace Industries Association and the relevant state and federal ministries, as well as to the relevant research organisations, European partnerships such as Horizon Europe, Clean Aviation, Integrated Air Traffic Management, Clean Hydrogen and Industrial Battery Value Chain (see Figure 1).

The platform is coordinated by the initiators TU Berlin, BTU Cottbus-Senftenberg and TU Dresden as well as the DLR institutes for "Electrified Aero Engines" (Cottbus) and "Software Methods for Product Virtualisation" (Dresden) in close cooperation with the Berlin-Brandenburg Aerospace Alliance e.V. (BBAA) and the Kompetenzzentrum Luft- und Raumfahrttechnik Sachsen/Thüringen e.V. (Aerospace Technology Competence Centre Saxony/Thuringia, LRT). The coordination is to be flanked by subsidised accompanying research projects and pilot projects.

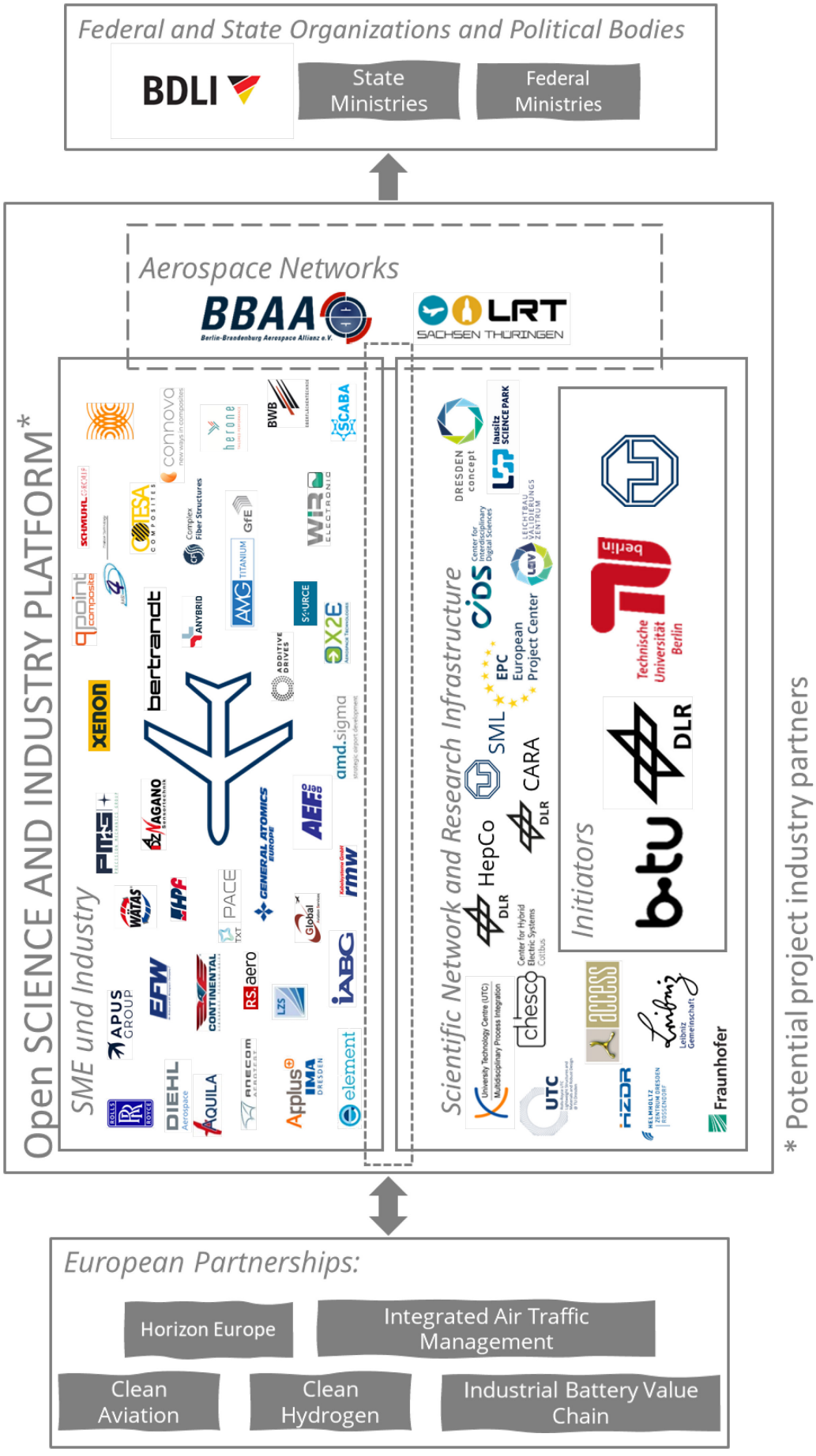

Figure 1: Structure and categorisation of the SCIENCE AND INDUSTRY PLATFORM

2. Existing competences and synergy potential

The initiative to establish a SCIENCE AND INDUSTRY PLATFORM proposed in this white paper is in line with the German government's plans to promote technological priorities in the Eastern German states in particular and to improve structural conditions and structural change locally by strengthening non-university research and federal institutions.

The platform will make a significant contribution to strengthening local companies and – in coordination with local business development organisations – promote the establishment of further aviation companies in Eastern Germany. It will also improve co-operation between companies and the research and educational institutions that are established or being established and act as a nucleus for start-ups.

The complementary skills and experimental infrastructures of the platform – in addition to the two established German aviation centres in the north and south with a focus on civil and military aviation – offer ideal conditions for the open-technology research and development of future aviation propulsion systems and their mission-appropriate integration in various aircraft classes. The region is set to play a pioneering role in the research, development and production of increased electrification and hybridisation, taking into account alternative sustainable fuels such as hydrogen or Sustainable Aviation Fuels (SAF) in aviation.

New materials, lightweight engineering methods, electrification, hybridisation and new energy sources offer great potential for alternative propulsion systems, but their impact on system design and behaviour, safety and reliability as well as new certification requirements must be evaluated. Experimental platforms of various scales are also used for this purpose. These can be used to develop and test the airworthiness of sub-technologies through to complete systems. In addition to existing unique test facilities, test fields and an experimental aircraft for general aviation, a flying, modular research platform is being set up that offers the possibility of integrating different drive, storage, control and regulation technologies into one system to carry out relevant functional tests and to examine them under real mission conditions.

The scientific players of the SCIENCE AND INDUSTRY PLATFORM – TU Berlin, BTU Cottbus-Senftenberg and TU Dresden as well as the DLR Institutes for "Electrified Aero Engines" (Cottbus) and for "Software Methods for Product Virtualisation" (Dresden) have been cooperating as long-standing partners of the internationally and nationally established Rolls-Royce research network for more than 20 years. As part of this strategic research cooperation, they have built up complementary, site-specific expertise in the field of climate-friendly aircraft engines and their system integration, which complement each other perfectly.

2.1. TU Berlin and the Berlin Aviation Region

The TU Berlin stands for a holistic approach to the aerospace system. The Institute of Aerospace of the Faculty of Transport and Mechanical Systems therefore consists of six chairs that can cover all central facets of aerospace. The breadth of the system in research and teaching is expanded through strategic co-operation with major research institutions. The university has strong regional and national links with SMEs and industry through numerous innovative research projects with a direct link to industry and with industry involvement. It will use this approach to utilise findings for the benefit of other modes of transport.

Based on research-intensive disciplines such as aerodynamics, propulsion technology, aircraft construction and aerospace engineering, aerospace research at TU Berlin will in future focus on the sustainability, robustness and transdisciplinarity of air transport in an intermodal environment. A lifecycle-based approach is intended to make the entire air transport sector more effective and efficient at both component and system level. In line with the faculty's motto "People at the centre of technical systems", TU Berlin's transdisciplinary approaches involve all stakeholders, including users, in the overall system design. These focal points and objectives are expressed, among other things, in the development of eco-efficient aircraft at overall system level with elastic configurations and distributed drive concepts. Interdisciplinary research on this and on the design and production of efficient gas turbines is continuously being carried out together with companies such as Siemens Energy, Rolls-Royce Deutschland and MTU Aeroengines, which are represented in the Berlin area, and a large number of SMEs. The topic of 'Urban Air Mobility' plays a central role, especially in densely populated areas. The formation of so-called swarms offers numerous starting points for greater electrification and satellite-supported control, e.g. of drones, to support regional logistics and for satellite-supported data provision of weather, navigation and geodata in real time. The research institutes and companies based in the Berlin area offer an ecosystem with numerous potential connections. The potential of different levels of hybridisation with electrical components and alternative energy sources and converters such as fuel cells must be assessed differently depending on the application and their optimal integration into aircraft must be adapted accordingly. The shortening and virtualisation of approval processes and new approval aspects of generatively manufactured components or electrified drive systems using hydrogen are also future issues.

2.2. BTU Cottbus-Senftenberg and the Brandenburg Aviation Region

BTU Cottbus-Senftenberg's Faculty of Mechanical Engineering, Electrical and Energy Systems has been researching and teaching aviation propulsion systems, micro gas turbines, combustion processes and much more for over 20 years. The activities primarily take place at the Institute of Transport Engineering, which comprises eight chairs. In recent years in particular, interdisciplinary research with institutes and chairs of computer science, electrical engineering and production engineering has been increasingly promoted. In this context, the Institute of Energy Systems has successfully carried out initial projects in the field of analysis, simulation and FMEA of (hybrid) electric aircraft propulsion systems. The BTU's expertise is complemented by collaborations and joint professorships with non-university research institutions such as the German Aerospace Centre. The BTU works on highly innovative research topics with a strong focus on rapid industrial implementation, which is why there are numerous co-operations with SMEs and industrial companies. The co-operation with Rolls-Royce Germany, which has existed since 2003, is particularly noteworthy. Due to its outstanding expertise, Rolls-Royce accepted BTU in 2005 as the first German university to become a University Technology Centre (UTC) for Multidisciplinary Process Integration in its international research network, which has led to increased national and international cooperation with the other network universities.

The European Union's goal of making aviation operations climate-neutral by 2050 is also reflected in BTU's future research strategy. Climate neutrality will only be achieved through close interdisciplinary research, particularly between the disciplines of mechanical engineering, electrical engineering and computer science. BTU is very well prepared for this through its previous and ongoing research projects at EU, national and local level. The establishment of the chesco research centre will create the conditions for rapid innovation cycles in the research and development of hybrid-electric drive sys-

tems, which will significantly support the achievement of the climate neutrality target. chesco will focus on researching entire drive systems and their components and will become part of the BTU Lausitz Science Park. CHESCO GmbH was founded for the operational realisation of projects for holistic, cross-functional research. This will enable close links to the other BTU centres for artificial intelligence (Lausitz Centre for Artificial Intelligence, LZKI), sensor technology (iCampus) and energy technology (Energy Innovation Centre, EIZ), SpreeTec NeXt (plastics) and the PtX Lab of the Federal Ministry for the Environment. The involvement of local companies as part of the structural strengthening and transfer programme also supports the expansion of their product portfolios and the establishment of new companies.

In order to counter the ever-increasing shortage of skilled workers and to provide young scientists with the essential knowledge and skills for hybrid-electric propulsion technology in aviation, BTU launched the international Master's degree programme "Hybrid Electric Propulsion Technology" in the winter semester 2024/25. It provides a comprehensive understanding of this interdisciplinary subject area, combining elements of mechanical engineering and electrical and control engineering with a focus on system design, analysis and effective problem solving.

2.3. TU Dresden and Aviation Region Saxony

Building on the aircraft industry which was re-established in the middle of the 20th century, particularly in Dresden, Saxony has developed an efficient industry that is recognised worldwide thanks to its large pool of qualified engineers and an excellent research landscape. With 160 companies and research institutions employing almost 7,000 people and generating an annual turnover of around 1.4 billion euros, the Saxon aviation industry is one of the drivers of innovation in the fields of aircraft equipment and conversion, component manufacturing for aircraft engines, aircraft and space objects as well as testing of aerospace structures. The expertise of Saxony's aerospace players and a further 60 players from Thuringia are pooled in the network Kompetenzzentrum Luft- und Raumfahrttechnik Sachsen/Thüringen e.V. (Aerospace Technology Competence Centre Saxony/Thuringia, LRT), which was founded in 2001.

The TU Dresden has a portfolio of institutes and professorships related to aerospace that is unique in Germany.

On the one hand, there are institutes in the Faculty of Mechanical Science and Engineering that explicitly conduct research and development in the fields of aircraft structure and technology as well as propulsion technology. On the other hand, the research field of lightweight engineering in connection with materials research and textile technology with a 70-year tradition is of great importance. In this context, the Rolls-Royce University Technology Centre (UTC) Dresden "Lightweight Structures and Materials and Robust Design", which was established at the TU Dresden in 2006, should be highlighted. The Dresden UTC is part of a worldwide network of 29 Rolls-Royce UTCs with which the TU Dresden researchers are in close contact. With a view to the increased electrification of aircraft, the Faculty of Mechanical Science and Engineering is currently expanding existing collaborations in the aviation sector with partners from the Faculty of Electrical and Computer Engineering. In addition, Dresden is recognised for its high level of expertise in the field of digitally supported design, dimensioning and testing of aircraft components as well as system integration and can also point to extensive preliminary work in the field of hydrogen technology, from production and mobile storage to use for environmentally friendly propulsion technologies for aircraft. On the one hand, this has resulted in a variety of participations by Saxon partners as suppliers and partners in national and international co-

operations in the field of established and new propulsion technologies and, on the other hand, in the constant founding of start-ups. The Institute of Lightweight Engineering and Polymer Technology at the Faculty of Mechanical Science and Engineering is the initiator and spokesperson for the national, open platform FOREL "Research and Technology Centre for Resource-Efficient Lightweight Structures for Electromobility". FOREL is an established platform – primarily aimed at the automotive industry – of renowned German research institutions and commercial enterprises with over 120 stakeholders. It enables pre-competitive, project-related exchange between all partners involved and systemic co-ordination of more than 50 national and international research projects.

In addition, the "Friedrich List" Faculty of Transportation and Traffic Science, which is the largest academic competence centre in the field of transport sciences in Germany, conducts research on the entire transport system in the aviation sector with a focus on route optimisation and management as well as mobility system planning. The "Friedrich List" Faculty of Transportation and Traffic Science is also the initiator of the Smart Mobility Lab (SML), a research campus for the development of technologies for automated and cooperative mobility in the air and on the road.

Together with a large number of non-university research and cultural institutions, TU Dresden forms a unique science and technology campus focussing on research, education and transfer in the DRESDEN-concept alliance.

2.4 Orientation and strategy of DLR in aviation propulsion technology in Eastern Germany

The German Aerospace Center (DLR) is the aerospace research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport, digitalisation and security is integrated into national and international collaborations. In addition to its own research, DLR is responsible for the planning and implementation of German space activities as a space agency on behalf of the federal government. DLR also acts as the umbrella organisation for the largest national project management agency.

DLR participates in the cross-state aviation cluster in Eastern Germany with its research institutions in Cottbus (EL – Institute of Electrified Aero Engines), Berlin (AT – Institute of Propulsion Technology, Engine Acoustics Branch) and Dresden (SP – Institute of Software Methods for Product Virtualisation) in the development of future, climate-friendly aircraft propulsion systems.

DLR is dedicated to research into new, lower-emission aircraft engines for civil aviation and is thus aiming for the climate-friendly and quiet air traffic of the future. It pursues a holistic system approach to alternative aircraft engines with research in the areas of

- Individual components for electrified aircraft engines
- Overall architecture of propulsion systems
- Aviation requirements and environmental impacts
- System control of hybrid and electrified drive topologies

and thus closes gaps in the portfolio of German aviation propulsion research.

The EL Institute in Cottbus makes a significant contribution to the structural change in Lusatia towards a high-tech location for future aviation technology, is integrated into a broad competence and research network within and outside the DLR and thus opens up engineering expertise from other disciplines for the Lusatia region. It co-operates with chesco at BTU Cottbus-Senftenberg to provide industry and research with a holistic test environment for the development of hybrid-electric or fully electric aircraft engines. Industry is supported by joint research projects at national and international level. In addition, there is close co-operation with the BTU Cottbus-Senftenberg in order to train qualified young scientists for the aviation challenges of tomorrow.

In Berlin, the Institute AT concentrates its research on understanding the generation of noise from different types of aircraft engines, the effect of these sources on those affected in the far field and the development of concepts for noise reduction in existing and future engine concepts.

In Dresden, the Institute SP is concerned with the research and development of informational/technical and software-methodological foundations for the description and realisation of the virtual product in aviation on the basis of high-quality, multidisciplinary simulation processes. The aim is to bundle research expertise in the field of software development for product virtualisation in close cooperation with colleagues from the aviation institutes.

2.5. Differentiation of the platform from international and national activities

In the field of hybrid-electric aviation, a number of current initiatives and projects are being driven forward worldwide, but also in Europe in particular. One example of this is the collaboration between the German Aerospace Centre (DLR) and MTU Aero Engines to research aircraft engines with fuel cells as part of a demonstrator[3]. An aircraft for regional transport with a hydrogen-based fuel cell drive is being investigated in a project between the companies H2FLY and Deutsche Aircraft[4]. Airbus presented the ZEROe initiative[5] at the end of 2020, in which various hybrid configurations based on hydrogen are to be investigated and brought into service by 2035. As part of the EU Clean Aviation Joint Undertaking (JU)[6], key technologies for climate-neutral air transport have been under investigation since 2023. There are also various projects and initiatives in the USA, such as the recently launched partnership between General Electric and NASA to develop hybrid-electric propulsion systems[7] or the

[3] https://www.dlr.de/content/en/articles/news/2020/03/20200805_dlr-and-mtu-aero-engines-study-fuel-cell-propulsion-system-for-aviation.html
[4] https://de.deutscheaircraft.com/news/deutsche-aircraft-and-h2fly-join-forces-to-explore-hydrogen-powered-flight
[5] https://www.airbus.com/en/innovation/zero-emission
[6] https://www.clean-aviation.eu/
[7] https://www.geaviation.com/press-release/other-news-information/ge-aviation-selected-nasa-hybrid-electric-technology

company Honeywell[8], which is currently developing electric and hybrid-electric propulsion systems. At the same time, drives are being developed that are suitable for the use of fully synthetic SAF, so-called "near drop-in" fuels[9]. Near drop-in fuels offer advantages over drop-in fuels, which are similar to the aviation fuels currently used, both in terms of their efficient production and in the optimisation of the burner technology in the engine to reduce soot and particulate emissions by up to 90 percent and NO_x emissions by almost 100 percent[10]. This list illustrates the importance of the topic. However, the linking of competences opens up numerous opportunities that are to be addressed with the establishment of this cluster.

3. Tasks of the SCIENCE AND INDUSTRY PLATFORM

To achieve the goals of the SCIENCE AND INDUSTRY PLATFORM , the following tasks are to be addressed:

1. support the development of future and sustainable aviation propulsion systems (based on the use of hydrogen, sustainable fuels and electrification) and their integration into various aircraft classes through innovative, product-orientated research activities and close cooperation between science, SMEs and industry.
2. cross-system research and accompanying analyses on alternative, climate-friendly aviation propulsion systems with a focus on greater electrification and cross-technology benchmarks. Incorporating the expertise of the participating institutions in system technologies (such as electric motors, power electronics, gas turbines and fuel cells), lightweight engineering, digitalisation, manufacturing and production as well as automation in the relevant areas.
3. use and expansion of existing and newly established infrastructure for the partial and holistic testing of future aircraft on the ground (also under altitude conditions) and in the air with test centres such as DLR EL Cottbus, the Smart Mobility Lab in Hoyerswerda – SML, the Center for Hybrid Electric Systems Cottbus – chesco – and regional airfields such as Schönhagen and Kamenz to support and accompany the relevant certification processes.
4. joint realisation of real laboratories for the creation and testing of construction and certification regulations and definition of corresponding requirements in close coordination with the authorities LBA and EASA.
5. using the potential of high-performance computing at the Dresden site to link real and digital development processes, such as the digital twin, for early optimisation.
6. technology transfer to existing SMEs and industry to increase the attractiveness for new companies to locate here and for spin-offs.
7. training and further education of junior staff for the tasks and challenges of future, more electrified aviation systems to strengthen the economy and create new jobs in Eastern Germany.

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[8] https://aerospace.honeywell.com/us/en/learn/products/electric-power/hybrid-electric-electric-propulsion

[9] Stadlbauer, Martin: Revolutionäre Antriebskonzepte. Luft- & Raumfahrt, Hrsg.: Deutsche Gesellschaft für Luft- und Raumfahrt – Lilienthal-Oberath e. V., 2, 2023

[10] https://www.flugrevue.de/zivil/burn-baby-burn-was-sind-die-treibstoffe-der-zukunkft/

Figure 2 describes the forecast for the development of low-emission aircraft propulsion systems on which the objective is based.

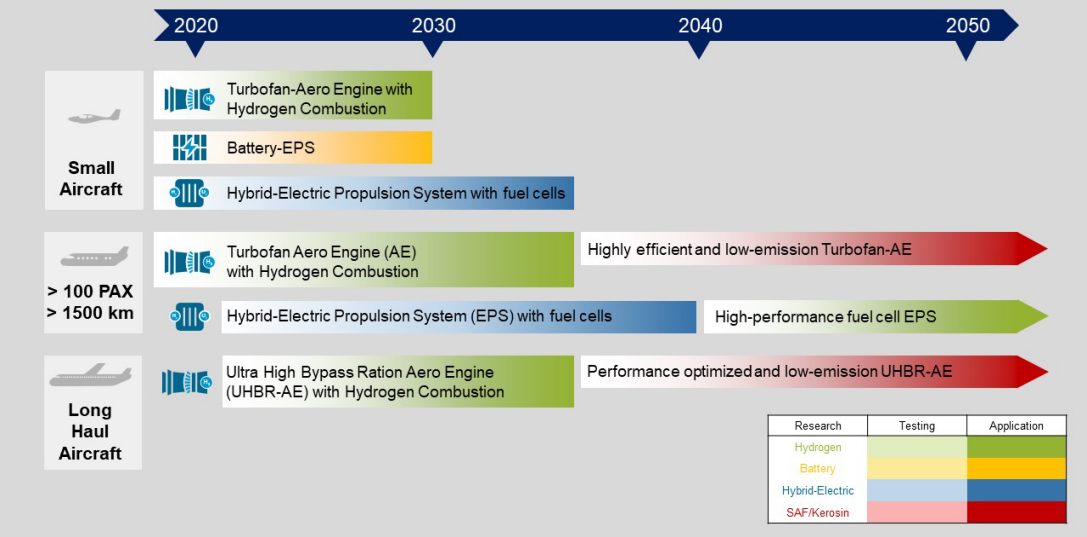

Figure 2: Forecast for the development of low-emission aircraft engines [Source: DLR]

4. Transfer potential from the region

The Berlin-Brandenburg-Saxony region offers a particularly broad and complementary spectrum of commercialisation options like hardly any other region in Germany. Berlin plays a leading role in Germany in the area of business start-ups, particularly in the field of IT technologies and digitalisation, while Saxony, as a state of engineers, sets standards throughout Europe, particularly with regard to the establishment and settlement of high-tech manufacturing companies and engineering service providers. In recent years, Brandenburg has established itself as a particularly attractive location for settlements in the field of sustainable mobility.

The region's university and non-university research institutions play an important role in the implementation and utilisation of innovative ideas. On the one hand, in many cases, long-term collaborations have developed between research players and companies established in the aviation industry, which guarantee the utilisation of sustainable technologies and new products. On the other hand, a large number of spin-offs have been initiated from the research landscape, which generate a high rate of innovation from their close networking with research institutions and are also attractive partners for aviation companies outside the region.

There are also long-established contacts between the research landscape and industrial companies in other sectors, which offer great potential for expanding the respective business areas in the direction of aviation. The research institutions regularly take on the role of enablers by linking small and medium-sized companies in particular with new subject areas in the aviation industry in the field of climate-friendly drives. In turn, findings from aviation research can also be introduced into ground-based mobility and transport.

In contrast to other locations in Germany, the players in Berlin, Brandenburg and Saxony benefit from their proximity to Poland and the Czech Republic and can draw on an additional potential of skilled labour, which represents a decisive locational advantage, especially for the establishment of larger

companies. On the other hand, in addition to contacts with Western European players, there are already decades of co-operation with research institutions and companies in Poland and the Czech Republic that are active in the field of aviation.

By bundling the country-specific complementary competences of the players in the initiative proposed here, current obstacles to cross-border cooperation in research alliances and transfer activities are to be removed. In particular, joint contributions to sustainable structural change in the Eastern German coal-mining region are to be initiated and established in the long term in order to create the basis for an incubator of a Central European economic area.

The following regional and supra-regional companies and associations act as an economic incubator group due to existing aviation co-operations: Additive Drives, ADZ Nagano, Apus, Anecom, Anybrid, Aumo, BBAA, Bertrandt, Boysen Group Compact Dynamics, Connova, Cotesa, Deutsche Aircraft, Diehl Aerospace, Engineering System International, East4D, Elbe Flugzeugwerke, ElringKlinger, EKPO Fuel Cell Technologies, ERFURT Bildungszentrum Unternehmensverbund, GKN, H3 Grob Aircraft, Herone, Hightex, HPF Werkzeugbau, Hutchinson Aerospace, IMA Materialforschung und Anwendungstechnik, IABG, Jena-Optronik, Lange Aviation, Liebherr Aerospace, LRT, LZS, MT Aerospace, MTU Aero Engines, N3 Engine Overhaul Services, PACE, Premium AEROTEC, Qpoint, Rolls-Royce Deutschland, rmw Kabelsysteme, SCABA, Schaeffler, Schmuhl Faserverbundtechnik, thoenes, TREAMS, WätaS, Xenon.

5. Teaching, training and further education

Due to the numerous interdependencies between technical, economic and legal requirements, the development of aircraft requires engineers to have a very diverse education. In order to take account of the complexity of the subject, curricula have been developed at the Universities of Technology in which students can learn the interrelationships on the basis of a broad catalogue of subjects. Extensive compulsory elective courses allow students to set individual specialisations, e.g. in drive technology or in lightweight and aircraft construction.

The positive experience of hybridisation and electrification of ground-based mobility systems is now also having an impact on development goals in the aviation sector. However, the opportunities to increase the efficiency of the overall system through measures such as the integration of electrical components or the use of hydrogen are offset by new requirements in terms of the skills and knowledge of developers. It is therefore necessary to adapt studies and teaching in order to recognise the potential of new technologies for efficient energy conversion and the resulting challenges for safe integration into the overall vehicle.

Due to these complex content requirements, there is a compelling need to increase students' interdisciplinary communication skills and flexibility. This is where the use of the distributed, complementary competences at the various university locations comes in handy. This can support both holistic education and the national networking of teachers and students. The availability of a broad-based teaching staff will also make it possible to create further training programmes for employees in the relevant industrial sectors. The aim is to enable students to independently assess the impact of new technologies on their daily work.

In order to address the new requirements in terms of course content, the participating institutions will jointly analyse any necessary changes and additions to the teaching portfolio and coordinate the curricula. The coverage of teaching content that is required but not offered locally will be achieved by utilising courses at the partner locations (e.g. integration of compulsory elective modules for relevant

fields of study). In the short term, cross-location exchange is promoted through the development of lecture series and the organisation of excursions. Relevant industrial companies are involved in a targeted manner in order to continuously establish practical relevance and convey future development perspectives.

In the medium term, multilateral study programmes will be established and integrated into the official study programme. Students will complete teaching units at the partner locations based on their home location. In addition to the opportunity to study a broader catalogue of subjects, students will also get to know alternative forms of teaching and learning at other locations. Successful practical examples at an international level, such as summer schools with Politechnika Warszawska and Politechnika Śląska, show the high potential that can be further increased by the regional focus on the Eastern German states. The innovations that are being worked on in the planned joint research activities are to be integrated into teaching via problem-based project formats. These will be jointly supervised and planned by the participating lecturers across all locations.

The reorganisation of aviation poses new challenges not only for original equipment manufacturers (OEMs) but also for suppliers and maintenance companies. A training programme is being developed to familiarise employees with the resulting requirements. This will cover both technical content, such as the operation of hybrid drive systems or the properties of new materials, as well as certification aspects that go beyond the requirements for conventional aircraft.

6. Challenges for the certification of alternative drive systems

For new hybrid-electric or purely electric propulsion systems in aviation, the expected significantly increased integration of the propulsion system into the airframe will lead to a merging of certification requirements (e.g. CS-23, CS-25) for aircraft with the regulations for propulsion certification (CS-E), which poses new and special challenges for the verification of certification. Existing and evolving (CS-ADR-DSN, PANS-ATM) as well as new (PTS-VPT-DSN, AMC & GM to U-Space) certification requirements for ground and airspace infrastructure must also be taken into account for the mission-appropriate integration of these climate-friendly propulsion systems.

Standard load cases are to be defined as a starting point for the concept and design of the systems, subsystems and components within the drivetrain. This makes it possible to update or redefine the regulations. Furthermore, the area of safety analyses is a highly relevant topic. In this context, realistic tests must be carried out in order to confirm simulation results or improve modelling and advance system integration.

The first step is to review existing analysis methods and already validated simulation procedures for certification in terms of their validity for the verification of electric-hybrid drive concepts. The result is then either proof of the validity of current certification tests or the necessary path to defining new test standards for new drive systems. Another topic is the reliable redundancy that is indispensable in aviation, which takes over in the event of subsystem failure and must fulfil the existing high safety requirements. The research infrastructure, including the test and experimental laboratories currently under construction at BTU Cottbus (chesco), DLR (HepCo, CARA) and TU Dresden (SML), will be utilised for these verification processes.

In general, the new drive architectures mean that new systems, subsystems and components are being installed and integrated whose reliability and probability of failure still need to be confirmed. In the qualification of components in particular, the extent to which the requirements of international

regulations realistically reflect the test conditions for components within the electric-hybrid drive concept must be checked. It is highly likely that these test standards (such as regulation RTCA DO-160) will need to be fundamentally updated or expanded.

Impressum

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