INTERNATIONAL SYMPOSIUM ON ELECTRIC AVIATION & AUTONOMOUS SYSTEMS

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ABSTRACT BOOK

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International Symposium on Electric Aviation and Autonomous Systems 2023

ISEAS'23 Abstract Book

International Sustainable Aviation and Energy Research Society (SARES)

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International Symposium on Electric Aviation and Autonomous Systems (ISEAS – 2023)

Edited by Prof. Dr. T. Hikmet Karakoc, Prof. Dr. Oleksandr Zaporozhets, Prof. Dr. Andrzej Leski, Asst. Prof. Dr. Ali Haydar Ercan, Asst. Prof. Dr. Alper Dalkıran.

ISBN: 978-83-63539-94-8

This book includes abstracts submitted International Symposium on Electric Aviation and Autonomous Systems 2023.

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Symposium Founding Chair

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Message from the Symposium Chairs

It is our great pleasure to invite you to the International Symposium on Electric Aviation and Autonomous Systems (ISEAS) which will be held on Online and On-site (Hybrid) Platform on 05 - 07 July 2023.

Aviation is considered as one of the major sources of environmental problems and considered a prominent cause of sustainability. Future trends in aviation could constitute a major impediment to having sustainable development in economic, social and environmental perspectives. Sustainable aviation is a long-term strategy aiming to offer innovative solutions to the challenges facing the aviation industry.

As we are in an era in which there is a continuous progress in aviation, we would like to invite researchers, scientists, engineers, practitioners, policymakers, and students to this international Symposium to exchange information, present new technologies and developments, and discuss the future direction, strategies and priorities in the field of sustainability.

ISEAS aims to handle a broad range of electrification of aerial vehicles all-electric aircraft, electric generation and storage in aerial vehicles, and so on.

ISEAS will include several keynote presentations, specialized sessions, and oral and poster presentation sessions from the participants on different subjects related to electric use in aviation.

We look forward to welcoming you to this remarkable event in July 2023.

Best wishes,

T. Hikmet Karakoç, Paweł Stężycki, Krzysztof Zaremba, Mirosław Kowalski

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KS01
Technological and Operational Perspectives for the Greening of Aviation

Luiz Manuel Braga da Costa Campos, Professor, Dr. Eng.

Instituto Superior Tecnico, Lisbon University

Abstract: The focus on the greening of aviation is expressed in policies like "Fit for 55" of the EU and "Net Zero 2050" of ICAO. Those objectives depend first (i) on the implementation of breakthrough technologies and (ii) on their operational adoption on large scale. Thus there is the need of technology development process to consider nor only (i) feasibility and efficiency but also (ii) certification and operations. The usual promising technologies related to batteries, fuel cells, hydrogen burning turbines and synthetic aviation fuels will be considered, as well as some more exotic possibilities like on-board hydrogen production and superconductivity. All classes of aircraft will be considered, from the smallest UAMs and private aircraft, to the single and twin-aisle jetliners, with regional aircraft in between. For each class of aircraft will be considered the most promising technologies to reduce environmental impact (noise and emissions) and also the associated certification/safety and operational ussies. The relative contribution to emissions of each class of aircraft, the timescale of maturation of each technology and the replacement of existing fleets will determine the rate of which greening of aviation can be implemented.

Keywords: green aviation, batteries, fuel cells, hydrogen fuel, aircraft classes.

KS02
Electric Airplanes of the Warsaw University of Technology – Past and Present

Tomasz Goetzendorf-Grabowski, Prof. Ph. D. Eng.

Warsaw University of Technology, Warsaw, Poland

Abstract: In recent years, there has been a strong development of the use of electric motors to drive flying objects. Also at the Warsaw University of Technology, a number of projects of electric-powered aircraft, both manned and unmanned, have been developed. The first attempts, however, were already made in the past decades. At the beginning, electric drives were used in small UAVs to now be used in larger structures, including manned ones. The history of selected airplanes developed at Warsaw University of Technology will be presented.

Keywords: UAV, electric propulsion, history.

KS03
Review of Antonov Visions for the Following Decade

Sergii Fil, Dr., Dmytro Berbenets, Andrii Khaustov, Oleksandra Urban

Antonov Company, Kyiv, Ukraine

Abstract: The aviation industry has come a long way since the Wright brothers first took flight. The aviation industry has seen a rapid evolution over the past few decades, with advancements in technology and materials leading to safer, faster, and more efficient aircraft designs.
Looking ahead to the next decade, we clearly see that the future of aviation will be shaped by continued innovation, sustainability, emission reduction and improved passenger experience.
We expect to pay more focus on developing aircraft that use alternative fuels, such as biofuels, electric and hybrid-electric propulsion, etc., and lighter materials for aircraft construction to reduce carbon emissions and minimize the environmental impact of air travel.
It is essential to monitor the most promising technological breakthroughs in the aviation industry, including advanced materials, propulsion systems, and avionics. Developing advanced aircraft requires the incorporation of emerging technologies into the design, manufacturing, and testing processes.
We willing to focus on composite materials, aerodynamics, weight reduction, and energy efficiency. Another direction in aviation design to pay attention shall be the use of automation and advanced avionics, including digital communication, navigation, and cockpit displays. And finally, the development of advanced aircraft shall require an extensive testing phase to ensure safety and reliability as well as creation of absolutely new types of regulatory requirements.
Another area of advancement shall be the use of artificial intelligence and automation in air traffic management. This technology will enable air traffic controllers to handle more flights with greater precision, reducing delays and increasing safety.
Finally, to ensure the successful integration of emerging technologies into advanced aircraft, a comprehensive training program must be developed for pilots, engineers, and technicians.
We expect to see more innovative safety features, such as improved automation and pilot assistance systems based on artificial intelligence, to help pilots avoid accidents and ensure safe flights.
The development of advanced aircraft shall require extensive research and development, optimized design processes, rigorous testing, and innovative training programs.
In conclusion, the future of aircraft design in the next decade will be shaped by several factors, including ecology, sustainability, passenger comfort, competition, and safety. Designers will need to focus on these areas, while also being mindful of emerging technologies, changing customer needs, and regulatory requirements. The successful implementation of these factors will result in the next generation of aircraft.

Keywords: aircraft design, technological breakthroughs, artificial intelligence.

KS04
Contribution of Ivchenko-Progress to Green Aviation

Sergiy Dmytriyev, Maksym Kirichkov and Igor Kravchenko, Dr. Sc., Prof., Corr. Member of the National Academy of Sciences of Ukraine (Applied Mechanics)

Zaporizhzhia Machine-Building Design Bureau Progress State Enterprise Named After Academician O.H. Ivchenko (Ivchenko-Progress SE)

Abstract: Engines for many types of airplanes, helicopters and UAVs are created at IVCHENKO-PROGRESS SE more than 75 years. The company has many years of experience in the creation of gas turbine engines (GTE) for various applications, a modern scientific and production base, one of the largest experimental and testing complexes in Europe, consisting of 17 test stands and more than 90 experimental installations.

The enterprise has been engaged in the task of reducing emissions from gas turbine engines into the environment for many decades. For more than 40 years there has been a unique school of creating low-emission combustion chambers, and work is constantly being done on methods and means of reducing noise.

The main directions of the IVCHENKO-PROGRESS contribution to the Green Aviation.

1 Medium-term, for existing GTEs:

- application of new design solutions and materials to reduce noise from GTEs;
- improvement of the parameters of the gas-dynamic cycle, affecting the reduction of fuel consumption, and as a result - the reduction of harmful emissions into the environment;

2. Long-term, for future GTEs:

- creation of efficient hybrid turbo-electric propulsion, including those operating on fuel cells;
- creation of GTEs operating on new types of fuel (SAF, hydrogen, mixed fuel, etc.).

Keywords: gas turbine engine, hybrid turbo-electric propulsion, hydrogen, fuel cells.

KS05
Review and Analysis of the Integration Properties of an Aircraft with a Hybrid Power Plant

Vasyl Loginov, Prof. Dr. Sc.

JSC "FED", Kharkiv, Ukraine

Abstract: A review of scientific and technical research in the field of aviation to achieve the goals of ACARE and Flightpath 2050 is made. It is emphasized that today environmental protection in the conditions of a large number of impact factors is and will continue to be a key driver in the development of the aviation industry as a whole. Achieving the adopted development programs can be realized only with comprehensive improvement of the airframe and power plant, including on the basis of research into new breakthrough constructive and schematic solutions. They include the physical principles of power plant operation, in particular, the new scheme of the hybrid turbo-electric power plant (HTEPP). An overview and analysis of the integration properties of the aircraft with HTEPP were carried out. It is shown that the assessment and analysis of the efficiency indicators of the HTEPP as part of the aircraft is becoming highly relevant. The theory and practice of researching the efficiency of such

facilities require aviation engineers to have the necessary additional knowledge on the border of several specializations, such as electrical engineering, electrochemistry, and others.
The introduction of hybrid-electric technology significantly expands the design space of modern aircraft. The full potential of electric technologies will be used through the synergistic and systemic integration of subsystems of the regional aircraft. Ways of development of electrical technologies at enterprises in Ukraine are shown. Recommendations were provided for the formation of the concept of creating aviation HTEPP for a turboprop regional aircraft.

Keywords: integration subsystems, hybrid power plant, parametric shape, life cycle cost, operating efficiency.

KS06
Introduction to Sustainable Aviation Fuels and the European policy context

Cesar Velarde Catolifi-Salvoni, IECAC Climate Change and Capacity-Building Specialist

European Civil Aviation Conference (ECAC), Paris, France

Abstract: Founded in 1955 as an intergovernmental organization, the European Civil Aviation Conference (ECAC) seeks to harmonize civil aviation policies and practices amongst its Member States and, at the same time, promote understanding on policy matters between its Member States and other parts of the world. ECAC's mission is the promotion of the continued development of a safe, efficient and sustainable European air transport system and Sustainable Aviation Fuels (SAF) is addressed in its work programme.
The Keynote presentation will provide an introduction to Sustainable Aviation Fuels (what are, why are needed and how can be produced) and an overview of what European States are doing on the policy side to promote its development. ECAC has published in February 2023 a Guidance on SAF, which is aimed at sharing information about SAF and providing advice to policymakers.

Keywords: aviation, climate change, sustainable aviation fuels, environment, renewable energy.

KS07
The Global Landscape: ICAO Work on Sustainable Aviation Fuels

Blandine Ferrier, ICAO Environment Officer, ICAO EUR/NAT Office

International Civil Aviation Organization (ICAO), Paris, France

Abstract: The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations that coordinates the principles and techniques of international air navigation, and fosters the planning and development of international air transport to ensure safe and orderly growth. [2] ICAO headquarters are located in the Quartier International of Montreal, Quebec, Canada.

Sustainable aviation fuels (SAF) are defined as renewable or waste-derived aviation fuels that meets sustainability criteria1. Technical analysis done at ICAO shows that SAF has the greatest potential to reduce CO_2 emissions from International Aviation.
The Keynote presentation will address ICAO work to facilitate SAF development and deployment through four main streams:
1) Globally accepted environmental Standards for SAF
2) SAF policies and goals
3) Capacity Building and Assistance to ICAO Member States
4) Outreach of information and best practices

Keywords: SAF, policies, goals, standards, best practices.

KS08
National Case-Study: SAF Promotion in Spain

Inmaculada Gómez Jiménez, Dr.

Researcher and policy expert for the Spanish civil aviation authority at SENASA, Madrid, Spain

Abstract: Since 2009, Spain has been assessing and working for promoting the production and use of sustainable alternative fuels in aviation. Implemented actions include feasibility assessments, setting public-private stakeholder's platforms, facilitating research and deployment, dissemination and communication, and foreseeing regulatory instruments.
Since the first agreements at ICAO level mentioning the use of alternative fuels as a key element for ensuring the sustainability of the international aviation, Spain has explored the feasibility and potential for producing feedstock, intermediate products, sustainable aviation fuels (SAF), as well as the related logistics and final use of those fuels, together with the relevant stakeholders.
One of the main challenges (also one of the key opportunities) is the need to involve in a single forum stakeholders outside the aviation sector, at private but also at public level (agriculture, environment, energy, industry, academia, civil society, etc.), seeking a broad knowledge and consensus. Spain stablished in 2010 a platform that was the seed for cooperative projects and generated knowledge about the potential and bottlenecks, followed by a Climate Change Law with specific provisions. Nowadays, Spain continue the efforts focused in the area of renewable hydrogen and efuels.

Keywords: SAF, policy, regulatory instruments.

KS09
EASA Activities in the Field of Sustainable Aviation Fuels (SAF)

Daniel Brousse-Rivas

European Union Aviation Safety Agency (EASA)

Abstract: The presentation aims to present several activities in the field of Sustainable Aviation Fuels (SAF) that the European Union Aviation Safety Agency (EASA) is undertaking.

Keywords: SAF, safety.

KS10
International Experience and the Current State of SAF use in Ukraine

Sergii Boichenko, Prof. Dr. Sc.

NTUU Igor Sikorsky Kyiv Polytechnic Institute, Ukraine

Abstract: Aviation fuel supply – a system of technological and organizational operations providing for the provision of delivery, storage, pumping, metering, dispensing and refueling aircraft (aircraft) with aviation fuel as in its pure form, and in a mixture with anti-water crystallization additives; monitoring quantitative and quality characteristics of aviation fuel and anti-water crystallization additives.
Sustainable Aviation Fuels is a biofuel used to power aircraft that has similar properties to conventional jet fuel but with a smaller carbon footprint. Depending on the feedstock and technologies used to produce it, SAF can reduce life cycle GHG emissions dramatically compared to conventional jet fuel.
The main world trends and developments of the Ukrainian Chemmotological Scientific School of in the field of alternative aviation fuels are presented.

Keywords: chemmotology, reliability, fuel supply, SAF, hydrogen, ecologistics.

KS11
Liquid Hydrogene Technologies and Applications in the Aviation Section

Gianluca Valenti, Prof. (Associate), Ph.D.

Politecnico di Milano, Italy

Abstract: The ongoing energy transition will change gradually the energy infrastructure not only in terms of sources but also of end-use vectors as well as of the technologies spanning from one end to the other of the infrastructure itself. Hydrogen will be a primary energy vector, especially in those sectors in which electricity cannot be extended easily, including… the aviation. On aircraft, it could be stored as a compressed gas or, alternatively, as a cryogenic liquid achieving higher energy densities. This talk provides an overview of the hydrogen rationale and the liquefaction fundamentals; then it focuses on the technologies applicable to airport and airplanes to produce and store liquid hydrogen, outlining the trends in the short- and medium-term future.

Keywords: hydrogen, storage, airplane, airport.

KS12
Sustainable Aviation Fuels and their use for Large Long-Range Aircraft

Renata Adami, Prof., Ph. D., Dr. Eng.

Department of Physics E.R. Caianiello – University of Salerno

Abstract: Sustainable Aviation Fuels (SAF) are renewable or waste-derived aviation fuels. Up to now, they provide the only viable replacement of traditional kerosene in the near term for very large aircraft and very long distances. SAF are produced via a variety of paths and techniques, using different resources such as waste oils, agriculture residues, biomass or waste. They can also be produced from non-fossil CO2, namely synthetic fuels or e-fuels. SAF have the advantage of being "drop-in fuels", therefore do not require changes in aircraft, neither for the engines nor for the fuel tanks, and fuel infrastructure or airport facilities. The composition of the advanced biofuels is currently mostly paraffinic and they are blended with conventional commercial and military jet fuel in variable amounts, depending on the fuel type; some biofuels have the addition of aromatics and lower blending percentages are needed. Moreover, since fuel plays also the role of lubricant, the effects of their use on joints and seals need to be considered. The evolution of aircraft engines as well as the fuselage design are a pre-requisite to improve the compatibility with SAF, with the consequent reduction of blending percentages and addiction of aromatics.

Keywords: sustainable aviation fuels, biofuels, synthetic fuels, chemical pathways, blending.

KS13
An Overview of the Possibilities, Current Status, and Limitations of Battery Technologies to Electrify Aviation

Rosa Maria Arnaldo Valdés*, Victor Fernando Gómez Comendador, Maria Zamarreño Suarez, Francisco Perez Moreno, and Raquel Delgado-Aguilera Jurado

Universidad Politécnica de Madrid, Spain

Abstract: This work aims to discuss the feasibility of including battery technologies to electrify aviation, highlighting their great potential, but also outlining some of the main technological challenges that will be faced in the coming years. The work is framed within the EFACA (Environmentally Friendly Aviation for All Classes of Aircraft) project, a project funded by the European Commission through the Horizon Europe Programme, which focusses on the analysis and development of new technologies to make aviation more sustainable. The first step in determining which applications of battery technology are most suitable for each type of aircraft is to have an overview of these technologies; understand the main challenges when including batteries in aviation (battery performance, safety issues, problems in battery manufacturing, and disposal); and study the performance metrics characteristic of each type and establish a battery classification. From batteries, based on such important characteristics as their specific energy requirements or operating profiles, it is possible to define aircraft types according to the different applications and extend the study to aircraft classes. This work presents a summary of all the aforementioned topics, from a first presentation of batteries, their possibilities in the electrification of aviation and the main technological challenges, to a classification of batteries according to their performance metrics. This is followed by a characterisation of which types of aircraft could use these technologies and what technological developments should be achieved to continue progress towards a cleaner aviation.

Keywords: environmentally friendly aviation, aircraft classes, battery technology in aviation, electrification of aviation.

KS14
High Performance Electrical Machines and Associated Technology Bricks

David Gerada, Prof. Dr. Sc.

Department of Electrical and Electronic Engineering, University of Nottingham, Nottingham, UK

Abstract: Electrification is a key enabler to meet the future global emissions targets for transport applications. Being at the heart of the electrified architectures, electrical machines covering a broad power range from tens of kW all the way up to multi MW class are being researched and developed to reach unprecedented performance metrics to help accelerate the market uptake of cleaner transport. This presentation gives an overview of the research targets, performance requirements, and challenges for such machines. Innovations in the constituent technology bricks such as motor topologies, materials, high frequency loss reduction, and advanced thermal management techniques are discussed together with the respective technology readiness levels (TRL) and motor-level performance entitlement. Deriving from the presenter`s first-hand experience case studies are presented.

Keywords: electrification, electrical machine, clean transport.

KS15
The Potential of a Proton Exchange Membrane Fuel Cell Powered Light Aircraft Employing Cryogenic Hydrogen

John Olsen, Prof. Dr. Sc.

The University of New South Wales, Sydney, Australia

Abstract: In this work, we consider the possibility of using cryogenically stored liquid hydrogen LH2 as a new fuel source to power an existing light aircraft. We also consider the possibility of using a fuel cell stack to liberate that energy as electrical energy to power the propeller via an axial flux, permanent magnet, synchronous motor. Such an aircraft requires a cryogenic tank (as high-pressure tanks are too heavy), a boost controller, and a battery. We briefly consider their packaging within the constraints of a typical light aircraft. We later outline the operation of the fuel cell stack showing that the operating points for maximum power and maximum efficiency differ. We discuss the role of the boost converter in matching the electric motor with the fuel cell stack before briefly outlining the fuel cell control problem.

Keywords: cryogenic hydrogen, fuel cell stack, boost controller, battery, axial flux permanent magnet synchronous machine

KS16
The Future of Electric Airplanes at the Warsaw University of Technology

Cezary Galiński, Prof. Ph. D. Eng.

Warsaw University of Technology, Warsaw, Poland

Abstract: Significant experience gained in the previous projects dedicated to electric airplanes allowed Warsaw University of Technology identifying several promising research areas. They have a potential do deliver both scientific and practical achievements. During the presentations two of these areas will be discussed together with accompanying projects.
First of them is dedicated to exploring the effect of flight altitude on performance of electric propulsion system. Usually, it is assumed that this effect does not exist in systems working without combustion. However, this assumption seems not to be proved. On the other hand, a few doubts are associated with this assumption. Therefore, the project dedicated to check if this assumption is true will be presented.
Second topic discussed in this presentation is associated with exploring properties of hybrid gas-electric propulsion system applicable in very light aircraft. Previous experience has proven that this is the most promising type of the electric propulsion system. Fully electric systems are not competitive because of underdeveloped technology of magazines of electricity. On the other hand, hybrid systems using hydrogen fuel cells confront serious legal problems associated with storage and handling of the hydrogen. Therefore, only hybrid gas-electric propulsion systems are ready to deliver competitive propulsion with significant electric component. The project dedicated to this kind of propulsion will be also presented.

Keywords: electric propulsion, hybrid-electric propulsion, properties investigation.

KS17
Fault Tolerant Estimation of UAV Dynamics in the Presence of Sensor/Actuator Faults

Chingiz Hajiyev, Prof. Dr. Sc.

Istanbul Technical University, Faculty of Aeronautics and Astronautics, Istanbul, Türkiye

Abstract: A new fault tolerant estimation method of Unmanned Aerial Vehicle (UAV) dynamics in the presence of sensor/actuator faults with both adaptivity and robustness is proposed. This article addresses the subject of making a choice between the adaptive and robust methods when sensor/actuator fault occurs. An adaptive method with Q-adaptation and robust method with R-adaptation are presented. Fault detection in the Kalman filter is based on the chi-square distribution of the normalized Quadratic Innovation Function (NQI). After detection of fault it is proposed to run simultaneously both, R-adaptive and Q-adaptive Kalman filters and compare their estimation performances to distinguish the sensor and actuator faults. As a performance criterion the sum of the quadratic differences between estimation and extrapolation values of robust and adaptive filters is proposed to use.

Keywords: unmanned aerial vehicle, fault tolerant estimation, robust adaptive Kalman filter, sensor faults, actuator faults.

KS18
Hydrogen PEM fuel cells for aviation, and their reliability considerations

Xin Gao, Ph.D.

Institute for Internal Combustion Engines and Fuel Cells (ivb), Technische Universität Braunschweig

Abstract: This talk will firstly give a review on our efforts in the past 4 years working on the abovementioned 4 indexes, as well as an overview of the research and industrial communities. Then our short-term and media-term solutions and proposals on tackling with the reliability challenges will be the rest part of this talk.
Among them, reliability affects the rest three key indexes deeply and significantly. Screening open literatures, there is still a big gap between the state of the art (SoA) reliability and the aviation requirements. Therefore, its enhancement is seen urgent. In general, reliability of a system can be strengthened either through system robust design or via operation strategy optimization.
Electromobility and especially airmobility is increasing its share among all transportation sectors. Along the process, hydrogen-electric propulsion relying on polymer electrolyte membrane (PEM) fuel cells as a most promising and key disruptive solution, is gradually stretching its popularity among aircraft belonged to more segments. However, in the trend, aviation still put stringent requirements on the 1) efficiency, 2) specific power, 3) specific energy, and 4) reliability, of these fuel cell systems.

Keywords: aviation, PEM fuel cells, hydrogen energy, thermofluids, TEG&TEC, reliability.

001
Hydrogen Storage in a Commuter Aircraft: Combining Classical Engineering Design Process with Model Based System Engineering for CFRP Pressure Vessel Integration

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Abstract: For the integration of hydrogen storage in the center wing of the APUS i-5, the requirements for the storage system are specified and the boundary conditions are analyzed. High pressure storage tanks with increased gravimetric storage density are designed for the resulting installation space. First, an analytical dimensioning of the required laminate structure is carried out. In combination with the design, this is transferred to numerical manufacturing and structural simulations and implemented in exemplary manufacturing technology. The pre-designed tank can be integrated into a Model-Based Design model, from which the flight range and any necessary system adjustments to increase the range are derived.

Keywords: hydrogen, MBSE, tank, 700 bar, virtual-physical engineering.

002
Review of Liquid Hydrogen Tanks Design Principles for Short and Medium-Range Civil Flights

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Abstract: The aviation industry plays a significant role in global transportation but has raised concerns about its contribution to climate change due to greenhouse gas emissions. Decarbonizing the aviation sector is crucial to align with global climate goals, as aviation emissions have a disproportionately higher climate impact and could triple by 2050 if no mitigation actions are taken. Liquid hydrogen has emerged as a promising sustainable fuel alternative for aviation due to its high energy density and zero carbon emissions. Its combustion only produces water vapor, eliminating carbon dioxide emissions associated with conventional fossil fuels. Advancements in hydrogen production, storage, and distribution technologies have increased the potential for scalable and sustainable hydrogen infrastructure for aviation. However, challenges such as hydrogen availability, infrastructure development, and safety considerations need to be addressed for widespread adoption. Cryogenic tank design plays a crucial role in storing cryogenic fluids like liquid hydrogen. Different insulation strategies, including vacuum insulation, multilayer insulation, powder insulation, and foam insulation, are used to minimize heat transfer and pressure increase in cryogenic tanks. Liquid hydrogen tanks also need to consider phenomena such as ortho-para conversion and cryo-pumping, which can lead to pressure increases and heat transfer. While boil-off is a major concern in ground tanks, it is less critical in aircraft tanks due to the ability to utilize some of the boil-off gas. Overall, the design strategies

and concepts behind the storage of liquid hydrogen for aircraft are essential for enabling a sustainable and environmentally responsible path forward in the aviation industry.

Keywords: liquid hydrogen, cryogenic tanks.

03
NEEDED – Next Generation Data-Driven Reference European Models and Methods Towards Silent and Green Aircraft Operations Around Airports: Project Overview

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Abstract: The NEEDED project addresses several of the expected outcomes of the European Commission HORIZON-CL5-2022-D5-01-12 call "Towards a silent and ultra-low local air pollution aircraft". The project delivers the next generation data-driven reference European models and methods to estimate noise and emissions of current and future aircraft around airports.

NEEDED aims to:

- improve the accuracy/granularity of the required input data (operations, aircraft trajectories and associated flight parameters) for noise and emissions assessments around airports
- develop advanced emissions inventories for current and future aircraft technologies, while delivering more accurate pollutant dispersion models,
- extend the applicability of the ECAC Doc. 29 noise calculation method towards future aircraft technologies, and improve the modelling accuracy for lower L_{den} thresholds
- perform more accurate assessments of the number of people around airports exposed to noise and emissions using dynamic population maps.

This paper will provide information on the noise related aspects of NEEDED.

Keywords: noise and emissions assessments around airports, noise calculation method, pollutant dipresion models, dynamic population maps.

04
Concepts of Commercial Aircraft with Hybrid Propulsion

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Abstract: In order to reduce carbon dioxide emissions, new technologies are being sought in commercial aviation. The top-level objective of the IMOTHEP project is to assess the potential offered by hybrid electric propulsion (HEP). The goal is also to build the corresponding aviation sector-wide roadmap for the maturation of the concepts. The four aircraft concepts are focused on regional and short-to-medium range aircraft missions. SMR (Small/Medium range) Conservative is based on existing Airbus A320. Turbo-electric propulsion consists of two gas turbines driving generators that power electric motors distributed along the wing. SMR Radical with a turbo-electric drive is designed using an innovative tailless system, with the fuselage partially serving as a wing. Regional Conservative is based on ATR-42-600 construction. The propulsion is integrated using a parallel hybrid power plant system that consists of two gas turbine engines, generators and electric motors. Regional Radical is also based on ATR-42. Series/Parallel partial hybrid electric consists of one gas turbine engine which drives a fan and generator. Distributed fans are driven by electric motors that are powered by the generator and/or batteries. This paper presents an overview of four hybrid aircraft concepts and simplified wing structure geometry, proposed for the Regional Radical version. Examples of strength calculations for the wing structure for the critical load case are also presented.

Keywords: hybrid propulsion, electric motors, wing structure.

05
Residual Convolutional Neural Network for Continuous Identification of Aircraft Noise

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Abstract: Continuous aircraft noise monitoring systems are the key to a strategic approach to noise management in the vicinity of airports and helipads. They support shaping the spatial distribution of the emitted noise, e.g. by providing data to optimize the use of approach and departure paths, the distribution of aircraft types during the day etc. in the annual perspective, taking into account alterations in the airport operating patterns and the fleet served. In the single-operation scope noise monitoring systems allow for indicating anomalous aircraft movements which often become an issue from the perspective of a local community, and thus are of interest to airport authorities. The latter class of problems requires a system to quickly, automatically and accurately identify whether the limit-exceeding noise event is caused by the aircraft operation. Due to the often-delayed access to airport operation logs, the system should operate with minimal or no non-acoustic data. The paper proposes the architecture of a noise detection method, meeting the above requirements and attempts to assess its effectiveness. Proposed approach involves using the residual convolutional neural network for solving the task. The network operates on 1/3 octave noise input data, returning the similarity of the input sound to the aircraft noise. The accuracy of the proposed method determined for a single data frame using mixture of real-life measurements exceeds 95% for a frame length of at least 30 seconds. The proposed method gives promising enough results that it can be implemented in a test environment

on a larger scale. In parallel, further work is progressing, focusing mainly on improving the quality of training data and fine-tuning the hyperparameters of the network.

Keywords: aircraft noiseб monitoring system, noise detection method, neural network.

06
Facilitating Airport Noise Control: The Noise Management Toolset

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Abstract: Airports are responsible for managing aircraft noise and, in collaboration with all stakeholders involved, such as Civil Aviation Authorities, airlines and local city authorities should develop an effective program for mitigating airport noise impact and the corresponding operational regime.
In the ANIMA project the classification of airports was proposed according to the phase in which noise management is performed at an airport. Airports can be classified as "Starting the journey", "Followers" and "Frontrunners". Airports in the first group and some in the second usually lack sufficient human, technical and economic resources to address the complex problem of noise management. The other airports will normally have more resources, but they need to go a step further in management, towards citizen participation. In both cases, they lack effective tools to address the problems identified. One of the results of the ANIMA project was an initial version of the Noise Management Toolset (NMT).
ANOTEC further developed the NMT, with the aim of providing different stakeholders with a tool, both technically and economically affordable, that helps in addressing their needs related to airport noise management. This paper presents the main features of the NMT and describes its versions.

Keywords: airport noise management, reduction of airport noise impact, land use planning, airport noise mapping.

07
Optimization of Quadcopter Energy Consumption: Insights from Wind Condition Analysis and Trajectory Planning

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Abstract: In this paper, we address the critical challenge of energy consumption in quadcopters—an issue hindering the full potential of these unmanned systems. Utilizing a proven dynamic model for reliable energy consumption estimation, we conducted rigorous simulations under diverse flight paths and wind conditions. By incorporating different operational constraints, the simulations provided insights into energy consumption across various phases of flight. The results demonstrated significant potential for energy savings, particularly, the study highlighted optimal strategies for surveillance

applications, identifying efficient flight paths to cover designated land areas with minimized energy usage. Future investigations will extend to diverse UAV configurations and practical applications, further exploring energy conservation strategies in quadcopter systems.

Keywords: quadcopter, energy efficiency, unmanned systems, electric aviation.

08
Study of the Load Spectrum of the Lightweight Electric UAV

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Abstract: The paper concerns the study of the load spectrum of popular lightweight UAV Skywalker X-8, which was adopted by the authors for photogrammetry missions. The analysis is based on the collection of 10 autopilot logs creating the data-base for the analysis of dynamic behavior of X-8, and especially for analysis of the load spectra. There are presented in the paper the Incremental Load Spectra concerning all individual flights as well as the load spectra representative for the whole flight session. Another aspect of research concerns the differences between the load spectrum for entire flight (where take-off and landing phase is performed in a manual mode, while photogrammetry task is performed in an automatic mode), and the load spectrum only for photogrammetric task, which is autonomous.

Keywords: lightweight UAV, load spectrum, electric propulsion, Skywalker X-8.

SS09
New Supersonic Aircraft Emission and Air Pollution Assessment at Airport Operational Scenario

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Abstract: This Environment Impact Assessment (EIA) study for Concorde implementation into operation at US Airports, particularly at Dulles International Airport, has shown that the contribution of aircraft emissions to local air quality (LAQ) occurs mainly during only two operational modes, *queuing* and *low speed ground run prior to take-off*. The ICAO document 9889 'Airport Air Quality Manual' contains advice and practical information to assist ICAO Member States in implementing best practices with respect to airport-related LAQ. For estimating impact of air pollution, one may assume that the short-term peak hour situation will be the most critical. The nature of operations and traffic at any airport, especially of regional airport size, will give relatively less adverse effects from the long-term average concentrations.

Whereas past analyses provided only a change in global LTO emission, the results presented here provide estimates of the area at and around an airport, where a given threshold concentration is exceeded due to aircraft emissions. The calculations indicate that it is technically feasible to carry out such standardised airport dispersion calculations in the context of CAEP stringency analyses. The variation of exceedance area with applied threshold concentration and with total emission is consistent with theoretical estimates. The calculations provide both absolute exceedance areas and relative changes, and they allow to apply different threshold concentrations in the post-analysis. The potential benefit of these novel parameters for CAEP work is subject to further exploration. On results of the analysis of the studies made by CAEP/MDG for the airport LAQ metric and for the Concorde EIA in US airports there are three simplified cases defined: for the assessment of queuing and low speed ground run prior to take-off the aircraft in stationary (moving speed equal to zero) conditions with two aside engine operation modes – idle and maximum; a moving source case is considered for the assessment of taxing aircraft with engine in idle mode; a moving source case is considered for the assessment of taking-off aircraft along runway with engine in maximum mode: emission for NOx and engine jet performances should be defined for maximum operation mode. Principle for the new supersonic aircraft is its similarity with Concorde in airplane geometry, absence of the flaps, it means the wake dynamics at taking-off and landing should be expected quite similar with Concorde. Very new engine – different from previous Olympus – will be installed, evidently with smaller temperatures and speeds of the exit jets, so the buoyancy effect of the jets is expected much less. So as the emission indexes are expected much less than were measured for the Olympus engine. These details provide the expectations that the LAQ impact assessment for the new supersonic airplane should be less than in case of Concorde.

Keywords: supersonic airplane, emission, air pollution, assessment scenario.

10
Highly Accurate and Confident Basic Aircraft Noise Assessment Scenario

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Abstract: Noise is and will be one of the noteworthy phenomena accompanying air transport. Taking into account the constant increase in air traffic, a number of attempts have been made to reduce the aviation noise exposure. The traditional approach to this problem is to identify and classify the main sources of aircraft noise and to define the reduction measures for them. For this purpose, more and more stringent restrictions are introduced successively in stepwise manner, based on the aircraft noise certification process.
Noise performances assessment at aircraft level will be done for the classes of aircraft with revisiting aircraft configurations taking into account new on-board energy storage and management systems and efficient green operations. The flight management system will integrate new functions for trajectory optimisation, adapted climb-cruise-approach profiles driven by airline constraints, weather effects, traffic en-route, formation flight, or ground operation management to include zero-CO_2 push back and taxiing phases, etc. The efficiency of new designs and flight management systems will be shown by comparison with existing airplane types (basic airplane flight noise scenario) in operation, first of all for single flight noise event. For higher confidence and accuracy of the assessment the basic airplane

flight noise scenario is assessed by measurements and calculation in similar conditions equal to current regional airport.
For regional turboprop airplane the prototype is combined by assessment of ATR-72 and Dash-8 in operation at few regional airports in Poland. Noise measurements were done by continuous noise monitoring systems accompanied with ADS-B data processing and analysis for more adequate flight performances assessment during departure and arrival flight stages.
For regional jet airplane the prototype is based on Airbus-220 and their Boeing and Embraer analogues.
Aircraft noise exposure is calculated with the tools verified by ICAO/CAEP for their accordance to ICAO Doc 9911: IsoBella (Aircraft noise exposure calculations, designed by NAU, verified during CAEP/13 working cycle) and AEDT 3.0 (a software system from US FAA that models aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality consequences at the regional, national, and global levels) with BADA (Base of aircraft data, which provides theoretical model specifications and related specific datasets to accurately simulate the behaviour of any aircraft).
Basic airport noise scenario for assessment of the contribution of a basic type of the airplanes and for the new airplane designs required by Clean Aviation program will be formulated as for regional airport so as for the hub to show the difference in noise exposure between these two important types of the airports especially for noise impact assessment countrywide or at higher area of assessment.

Keywords: Clean Aviation program, noise, assessment scenario.

11
Novel Aircraft Emission and Fuel Burn Assessment Scenarios at Aircraft, Airport and Fleet Levels

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Abstract: The generation of commercial passenger aircraft to be developed in the next decade has a potential to realize a step-change in energy efficiency on the board during the flight. This task of efficiency assessment as for energy consumption as for the impact on environment may be divided into the following subtasks: 1) Overview of the available and promising technologies in terms of fuel/energy consumption, emission and noise. The benefits, challenges and limitations are planned to highlight. 2) A list of metrics and indications for analysis of fuel/energy, emission and noise interdependencies and trade-offs will be determined at airport and global scales. Additionally, significant factors like operational and technological will be taken into account as well as non-environmental interdependencies. 3) To collect, summarize and analyse the experience gained in the assessment of fuel/energy, emission and noise interdependencies at technological level for defined classes of aircraft. 4) The results of fuel/energy, emission and noise interdependencies for reference fleet and aircraft with novel types of fuel and propulsion system will be compared with ACARE 2050 noise and emission goals. In result possible technological gaps and efforts for overcoming difficulties will be defined.
Assessment of Local Air Quality (LAQ) at airports (emission inventory analysis and air dispersion – at airport level) and Global Air Quality (GAQ) for air traffic routes (cruise emission inventory analysis and its effect on global issues like climate change – cruise flight level): to assess LAQ and GAQ from NO_x, SO_x, volatile organic compounds (VOCs), non-volatile particulate matter (nvPM), carbon dioxide (CO_2) and other new specific pollutants/sources (full list will be proved during the research) that occur below 900m above ground level around predefined airport scenario from the dominant emissions

sources by categories: a) aircraft emissions; b) aircraft handling emissions; c) infrastructure- or stationary-related sources; and d) vehicle traffic sources; to assess GAQ emission inventory and air dispersion will be calculated with the tools verified by CAEP for their accordance to ICAO Doc 9889: PolEmiCa (Pollution and Emission Calculations, designed by CEPA, verified during CAEP/12 working cycle) and AEDT 3.0 (a software system from US FAA that models aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality consequences at the regional, national, and global levels) with BADA (Base of aircraft data, which provides theoretical model specifications and related specific datasets to accurately simulate the behaviour of any aircraft). Air traffic scenarios will be defined with BADA including the novel EFACA aircraft designs.
The management of airport LAQ and the relevant emissions is fundamentally targeted at achieving and maintaining compliance with local regulation on permissible levels of pollutant concentrations (standard limits). To understand the actual impact of these emissions, it is necessary to determine the pollutant concentration (mass per unit volume, which may be measured in ppm or mg/m^3) at the point where exposure takes place. In general, the LAQ is determined by comparison of the exposure concentrations with standard limits. An airport with a history of non-compliance with LAQ regulations can be subject to pressure from regulators and communities when planning permission for infrastructure expansion is needed. In contrast, the aircraft noise management primarily addresses mitigating adverse response from noise affected communities. Compared to conventional aircraft, fully electric aircraft emit few or none of the pollutants that adversely affect local air quality. In particular, NOx and fine particulate matter will be greatly reduced due to the reduction in fossil fuel combustion. Fully electric or hybrid-electric aircraft could significantly reduce the emission of pollutants and GHGs in areas surrounding airports. Aircraft powered by a traditional jet turbine or turboprop engines can produce large amounts of pollutants such as NOx, volatile organic compounds (VOC), sulfur dioxides (SOx), and GHGs. Aircraft powered by piston propeller engines emit larger amounts of CO than jet turbine or turboprop aircraft.

Keywords: novel aircraft, emission, fuel burn, assessment scenario, aircraft fleet, airport.

12
Emission dispersion of PMx, NOx and CO during LTO cycle

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Abstract: On December 11, 2020, leaders in Europe reached an agreement to decrease the European Union's greenhouse gas emissions by a minimum of 55% below 1990 levels by 2030. Although aviation only contributes approximately 3% to the overall emission of harmful gases resulting from human activities, the concentration of these gases, such as carbon monoxide, within the confined airspace of an airport may affect the health of employees working on the airport apron and the surrounding area. Therefore, it is crucial to have data not only on the level of greenhouse gas emissions but also on the amount and spread of harmful gases like CO and NOx, as well as particulates PM2.5 and PM10 and their concentration. The airport authority must possess knowledge of the precise quantity and concentration of these hazardous emissions within the airport to implement measures that will reduce their levels. Awareness of the directions of spread and concentration of dangerous exhaust gases from aircraft engines could also aid in designing new airports. This presentation displays the findings of PM2.5 and PM10 measurements taken at various points throughout the airport. Additionally, the propagation of emissions resulting from aircraft engines operating within the airport was modeled using specialized software. Two methods are presented for estimating the amount of CO and NOx emissions released by aircraft engines during the takeoff and landing cycle (LTO) within the airspace of a medium-sized airport. The first method is based on the total amount of aircraft annually operated at the airport, while the second method is more precise and focuses on a particular airline that operates

at the airport annually. Implementing the recommendations derived from these methods can assist in introducing operational and technical procedures to reduce harmful emissions during the LTO cycle in the airport airspace

Keywords: aircraft engine emission, concentration of nitrogen oxides, carbon monoxide, PM2.5, PM10, engine exhaust.

13
Noise Assessment Scenarios for New Airplane Climate Efficient Designs

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Abstract: The EU concept of environmentally friendly aviation by 2050 (compared to 2000) provides for the use of new technologies: to reduce the perceived aircraft noise by 65%, nitrogen oxide emissions - by 90%, carbon dioxide by - 75%. Achieving these goals requires changes in aircraft design, improved aerodynamic configurations and the use of innovative engines. A list of new aircraft types in a forecasted fleet for air transportation till 2050 includes promising technologies to be realised in designs for long-range, middle-range, short-range, regional and urban mobility flights, etc. A disruptive new aircraft configuration shall not only drastically reduce fuel consumption and related air polluting emissions, but at the same time will improve noise emissions by shielding the remaining noise sources from the ground. Design and optimisation of disruptive solutions and conventional solutions for engine integration towards maximised efficiency in reduction of aircraft impact on the environment: sustainable alternative fuels and liquid hydrogen fuels for conventional aviation engines; making use of distributed propulsion to compensate for efficiency losses due to an increasing number of system components in a hybrid-electric architecture; the integration of distributed propulsion systems on radically new airframe configurations maximising synergetic effects with the aircraft aerodynamics. This can be done by optimising the number of propulsion systems, their positioning relative to the aerodynamic surfaces and their technical specifications in order to maximise aerodynamic efficiency while at the same time minimising aerodynamic noise.
To perform the noise simulations for the airport air traffic scenario any new aircraft has to be "acoustically assembled" by including novel noise sources specific to the new EFACA aircraft technologies and configurations using *data-driven methods*. Novel noise sources and common noise sources will be combined for the overall aircraft via contributing with low-fi (semi-empiric) models and generating the ANP data for them. The noise, aircraft flight profile and flight path computation methodologies implemented in current tools like Ukrainian IsoBella and/or US INM/AEDT will also be used, because it is compliant with ECAC Doc 29 and the standard AIR 1845 SAE A-21. Comparison with existing airplane types (basic airplane flight noise scenario) in operation must show the effect for single flight noise event. For higher confidence and accuracy of the assessment the basic airplane flight noise scenario will be assessed by measurements and calculation in similar conditions equal to current regional airport.
Basic airport noise scenario for assessment of the contribution of a basic type of the airplanes and for the new airplane designs required by Clean Aviation program will be formulated as for regional airport so as for the hub to show the difference in noise exposure between these two important types of the airports especially for noise impact assessment countrywide or at higher area of assessment. Also, important factor for noise exposure and impact analysis is the changes of aircraft fleet with time. It will be done also for regional and hub airport.

The result of the work undertaken should be a significant improvement in the possibility of providing extensive information on the degree of aviation noise hazard in specific areas, development of new practical indications of actions leading to the reduction of aviation noise, verification of existing guidelines and methods of conduct, development of guidelines that can be applied in the future.

Keywords: modelling noise scenario, airplane, airport, aircraft fleet.

14
Assessment of Sustainable Energy Options for Airfield and Aerodynamic Environments

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Abstract: This research paper presents a comprehensive assessment of sustainable energy types suitable for airfields and aerodromes. The primary objective of this study is to utilize the Analytic Hierarchy Process (AHP) methodology to evaluate and prioritize different energy types based on key criteria such as feasibility, environmental sustainability, and real-life implementation in airfield and aerodrome environments. By analysing the scientific merits and practical applications of each energy type, this study aims to provide valuable insights into the most suitable sustainable energy solutions for these facilities. Real-life case studies and successful implementations of energy types, including waste-to-energy, biomass gasification, solar power, and hydrogen technology, will be examined to demonstrate their effectiveness in enhancing energy efficiency, reducing carbon emissions, and promoting a greener aviation sector.

Keywords: sustainable energy, airfield, aerodrome, Analytic Hierarchy Process (AHP), solar power.

15
Study of the Effectiveness of the Operation of the Multi-Component and Multiphase Queue System as the Implementation of Maintenance and repair of Aircraft by an Aviation Repair Enterprise

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Abstract: The result of the study is that for modeling the processes of maintenance and repair of aircraft by divisions of an aircraft repair enterprise, it is advisable to use models of multicomponent and multiphase queue system (QS). Such models can be of both Markov and non-Markov types, and are capable of serving flows of non-priority and non-uniform requirements (generally).

The same service channels (depending on the types of service requirements) can have different capacity. The value of the source of mixed requirements entering the system has an intensity equal to the sum of the intensities for each of the QS components.
The service process in the QS of each component consists of K_E phases with the corresponding delay T_i, the total service period is equal to the sum of the delays T_i.
T_i - have certain probability distributions with corresponding parameters, and will be generalized by the Erlang distribution with the probability distribution parameters of the CE order stages.
The article considers several two-component QS:
- QS with $M/E_4/2/3$ in the first component and $M/E_3/1/2$ in the second component without restrictions, when the requests do not leave the service channel during service and the queue during the service waiting period;
- CMO with M/E4/2/3 in the first component and M/E3/1/2 in the second component, with restrictions on the time spent during the maintenance and waiting period.
The study of the functioning of these QSs made it possible to determine the probabilistic and temporal characteristics of the components and the QS as a whole.
Dependence graphs of the probabilistic and temporal characteristics of the QS were built using a simulation model of the system dynamics in the Any Logic environment (with Java SE). It is made possible to simplify the calculations of the probabilities of QS states.
The proposed approach to modeling the maintenance and repair of aircraft by the production units of an aviation enterprise as a multi-component and multiphase queuing system allows us to determine the effectiveness of the functioning of the QS and obtain arguments for improving the efficiency of this enterprise in modern conditions.

Keywords: multicomponent and multiphase queue system, aircraft maintenance and repair.

16
Composite Gradient Coatings Design for Ensuring Electromagnetic Compatibility of on-board and Ground Electronic Equipment

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Abstract: It is shown that the experimental sample of the three-layer coating has reflection coefficients of the electromagnetic field with a frequency of 2.45 GHz of 0.12-0.13, the overall shielding coefficient is 16.5-17.2, the shielding coefficient of the industrial frequency magnetic field is 14.2-4.6.

Keywords: composite material, electromagnetic compatibility, electromagnetic shield.

17
Renewable Energy Systems for Airports and Aerodromes: A Comprehensive Patent Review and Technological Analysis

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Abstract: This research paper explores the implementation of renewable energy technologies in various sectors, explicitly focusing on airports and aerodromes. The study investigates seven key renewable energy types: solar collectors, solar photovoltaic, wind energy, wave energy, tidal energy, hydro energy, and geothermal energy. By examining patents filed between 2010 and 2022 using the WIPO Espacenet Patent search platform, the research aims to identify technological advancements, trends, and potential areas of innovation within the renewable energy domain of airports and aerodromes. The findings of this study contribute to the knowledge base surrounding sustainable energy solutions in the aviation industry, offering insights for policymakers, researchers, and stakeholders.

Keywords: Renewable Energy, Airport, Aerodrome, Solar, Wind, Wave.

18
Sector Coupling on a MW Scale or What To Do With 500 Kg of 'Green' H_2 a Day?

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Abstract: The integration of renewable energy sources has created new opportunities for energy storage and utilization, particularly through the use of metal hydrides. This paper will explore the feasibility of sector coupling on a MW scale using a 1 MW electrolyzer and the world's largest (landbased) metal hydride store being built at TU Braunschweig, Germany, with a capacity to produce and store 500 kg of hydrogen a day, respectively. The focus of the „Demonstration Lab" will be on the application of metal hydrides in the energy sector, specifically in the context of sector coupling. The results will provide insights into the technical and economic viability of using metal hydrides to store and utilize surplus energy, particularly in terms of their performance, durability, and safety. The study will also explore the potential of metal hydrides to enhance energy security, reduce greenhouse gas emissions, and promote the growth of a low-carbon economy. The findings will be of particular interest to those involved in the development of metal hydrides for energy storage and sector coupling and are viable for different research fields, such as fuel cell systems and powertrains.
This project called „H_2-Terminal" is located at the research airport Braunschweig and financed by the Federal Ministry of Education and Research (BMBF) Germany under grant number 03EW0016B.

Keywords: renewable energy, energy storage, metal hydrides.

19
Acoustic Airflow Excitation (AAE) for enhanced reactant transport in an *operando* PEM fuel cell

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Abstract: To increase power density and reliability of PEM fuel cells for aviation, more effective transportations of their reaction species are being sought. A promising method for improved reactant delivery and enhanced product water expulsion is acoustic airflow excitation (AAE), where pressure pulses are applied to the cathode airstream. Screening all open literatures, AAE is still in an early stage of research, mainly on its reproducibility. Our work evaluates AAE on an *operando* fuel cell experimentally. The experimental setup includes a single 20 W PEM fuel cell, an oscillation chamber for AAE generation, a microphone setup for AAE verification and a cathode pressure drop sensor for flooding detection. The experiments indicate a high frequency dependency of the oscillation chamber sound output. This dependency renders the importance in sound pressure amplitude verification, which was neglected in previous literature. Additionally, an increase in power density by up to 2.2% could be achieved through AAE in gradual-flooding conditions. However, no significant benefit of AAE on power density or water expulsion could be noticed at dry or already flooded operation conditions, independent on the excitation frequency. Measurements of the sound absorption across the cathode flow field have shown a distinct correlation between the flooding magnitude and loss of sound pressure due to liquid water. Such strong absorption further cements the necessity to apply AAE in early flooding stages for it to remain effective.

Keywords: PEM fuel cells, acoustic airflow excitation, power density.

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Adaptation of Smart Energy Map to Transportation Domain: A Case Study to Small Airfield Buildings and Other Infrastructures

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Abstract: According to the European Commission, buildings in the EU are responsible for 40% of energy consumption and 36% of greenhouse gas emissions. The EU commits to reduce greenhouse gas (GHG) emissions and energy consumption in the EU building sector by 2030 and reach net-zero emissions by 2050. "Hungarian University of Agricultural and Life Sciences (MATE) - Centre for Circular Economy Analysis" has launched the development of a multidisciplinary "smart energy map" in relation to Hungary, showing the potential of locally exploitable sustainable energy sources and the selection of the optimal energy mix based on the location of dwellings and buildings. This smart energy map will take into account geographical, economic, technical, energy supply, and meteorological factors related to the given location. This research paper assesses sustainable energy types suitable for small airfield buildings and other infrastructures. The primary objective of this paper is to utilize the

Analytic Hierarchy Process (AHP) methodology to evaluate and prioritize different energy types based on critical criteria such as feasibility, environmental sustainability, and real-life implementation in airfield and aerodrome environments. By analyzing each energy type's scientific merits and practical applications, this study aims to provide valuable insights into the most suitable sustainable energy solutions for these facilities. Real-life case studies and successful implementations of energy types, including waste-to-energy, biomass gasification, solar power, and hydrogen technology, will be examined to demonstrate their effectiveness in enhancing energy efficiency, reducing carbon emissions, and promoting a greener aviation sector. This paper's outcomes will help develop the smart energy map by considering the feedback on the various energy types and choosing the most ideal green energy supply with regard to many user aspects, which will lead to optimizing the combination of different energy sources in airfield buildings and structures.

Keywords: Sustainable Energy, Airfield, Aerodrome, Analytic Hierarchy Process (AHP), Solar Power.

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Review of Recent Advances in Technologies of LH2 Storage on-Board Aircraft

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Abstract: The work is devoted to the discussion of the recent advances in technologies of liquid hydrogen use in aircraft propulsion systems. The state-of-the-art in the field of liquid hydrogen use in aviation is described. The method of SWOT was applied to assess the potential of using hydrogen fuel as an alternative energy source and analyze the possible threats and opportunities related to its use. Basic physical-chemical properties of hydrogen are analyzed as well as their effect and influence on storage conditions. Type types of reservoirs for liquid hydrogen storage, materials used for tanks production, insulation etc. are considered within this work.

Keywords: Liquid hydrogen, fuel tank, energy content, storage efficiency, aviation fuel, cryogenic temperature, hydrogen storage.

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Modeling the Noise Characteristics of a Regional Turboprop Hybrid-Electric Aircraft

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Abstract: New model for noise prediction of hybrid electric aircraft is presented. This model is demonstrated on the parallel hybrid of An-26 aircraft. The power plant of An-26 modification consists of gas turbine engine and electric engine driving propeller through common gearbox. According to this

model, the flight path is obtained using numerical solution of systems of differential equations, which describes aircraft flight dynamics on all flight segments. The simulation of noise is based on trajectory calculation using height-speed characteristics of hybrid power plant. We make each segment of flight path to comply with limitations imposed by flight operation manual of An-26 through optimization of hybrid-electric aircraft performances. Genetic algorithm was used to find global optimum for parameters of angle of attack function. New criteria for optimization were developed enabling flight with monotonously increasing/decreasing speed and height, level flight, making trajectory angle equal to zero at the end of segment and reaching specific airspeed or height at the end of the segments. Final turboprop hybrid-electric aircraft performances include total thrust and true airspeed which are used for evaluation of contours of maximum A-weighted sound pressure level, effective perceived noise levels and sound exposure levels during take-off and landing of aircraft.

Keywords: differential equations of flight dynamics, hybrid-electric aircraft, noise model, parallel hybrid, noise mapping.